Noelithic economy and macro-lithic tools of the Central Balkans

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Tesis doctoral

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Abstract

Having worked on my master thesis on the macro-lithic tools from the Neolithic sites of the central part of Serbia or so-called Middle Morava valley, we noticed that there is not enough interest in this archaeological category in the central Balkans. The short research tradition and the small number of researchers have resulted in an insufficient number of published research results. This situation limits the implementation of new methodological approaches, such as those developed in the other parts of southern and central Europe, and weakens the advance in the archaeological knowledge on prehistoric economies.

In order to overcome these problems, we have examined 2174 macro-lithic tools from the 12 Neolithic settlements (~ 5900 - 4650/4600 BC cal) from the Central Balkans. Thus, we have applied economic theory as the theoretical background of the geological, morpho-technical and functional analysis of macro-lithic artefacts (chapter 2).

The study presents settlements, the archaeological context in which the analysed artefacts were found, paleo-environmental and geomorphological settings of the Central Balkans. One part of the thesis displays the results of the petrographic analysis of raw material from other Neolithic archaeological sites from previous studies, and samples from geology outcrops from the Central Balkans. The same part presents the results of our geoarchaeological survey related to macro-lithic artefacts from Motel Slatina and Turska česma, Slatina**.** The petrographic analysis of the studied artefacts also allows us to identify the location and the distance from which raw materials derived, the exploitation method and the existence of territorial borders between supply areas.

Functional analysis has revealed for the first time, an appearance of standardized macro-lithic tools. This result has defined high volume production and characterized economy of the Late Neolithic. These results allow us to observe technological changes among the Early and Late Neolithic macro-lithic societies and economic differences between settlements and regions during the Late Neolithic.

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1. Introduction

1.1. The Neolithic of the Central Balkans

First I would like to present a summary of the Balkan Neolithic. This period is dated from before 5900 to 4600 BC and it is divided into Early, Middle and Late Neolithic phases.

An emergency of the Early Neolithic inhabitants is defined on pottery and its typological and stylistic characteristics are used for establishing periodization, relative and absolute chronology of the Neolithic in the Balkans. The relative chronology and absolute dates of the Early/Middle Neolithic (ENCB – Early Neolithic of the Central Balkans, Middle Neolithic of the Central Balkans, in table 1), presented here were established on the basis of the of the pottery material of the southeast Europe from Cluj to Thessalonica and from Tuzla to Bucharest, as proposed by Tasić, N. N. (Tasić 2009).

Phase	Range (cal.BC)
ENCB	before 5900.
MNCB I	until 5800.
MNCB II	until 5700.
MNCB IIIa	until 5400.
MCNB IIIb	after 5400.

Table 1.1. Absolute and relative chronology of the Early/Middle Neolithic; after Tasić (Tasić N.N., 2009).

The Early and Middle Neolithic in the studied area is presented by the Starčevo culture, which belongs to the Starčevo-Körös-Criş complex and by the Anzabegovo-Vršnik culture towards to south (fig.1.1). The rapid Neolithization is detected first in the south of the Central Balkans around 6300 BC, reaching its central part by about 6200 cal. BC, the north 6000 cal BC (Whittle et al. 2002: 93; Zdravkovski, Kanzurova 2008).

The Early and Middle Neolithic – Starčevo culture

A significant population increase of the Starčevo culture at around 6000 cal BC has been detected immediately after introducing of the Neolithic. It was followed decrease, a few centuries later suggesting migratory wave. The next significant increase of population is indicated at around 5650, and trough after around 5500 cal BC (fig.1.2). These results are similar to what is observed in the Early Neolithic of Central and Western Europe and consistent with prediction of demic diffusion (migration) (e.g.Porčić et al.2016:6, fig.2).

Fig. 1.1. The Early / Middle Neolithic settlements: 1. Kremenilo; 2. Medjureč; 3. Turska česma, Slatina, 4. Tumba Madžari, and local varition of the Middle Neolithic cultures of South-East Europe; adoptet according to Tasić 2000: map 3.1.;WBPP- West Bulgraian Painted Pottery; Map layer downloaded from http://maps-for-free /, accessed on the 24. 9. 2017.

These socioeconomic changes included the adoption of an agricultural life style from the Aegean by indigenous hunter-gatherers as well (e.g.Greenfield 2014:27). However, published studies suggest the possibility of overlapping of the Neolithic and Mesolithic populations in the area of the Iron Gates, while almost no Mesolithic population were detected in the rest of the Central Balkans (Radovanovic 1996; Borić ,Stefanović 2008; Gurova, Bonsall 2014: 96, 97, fig. 1).

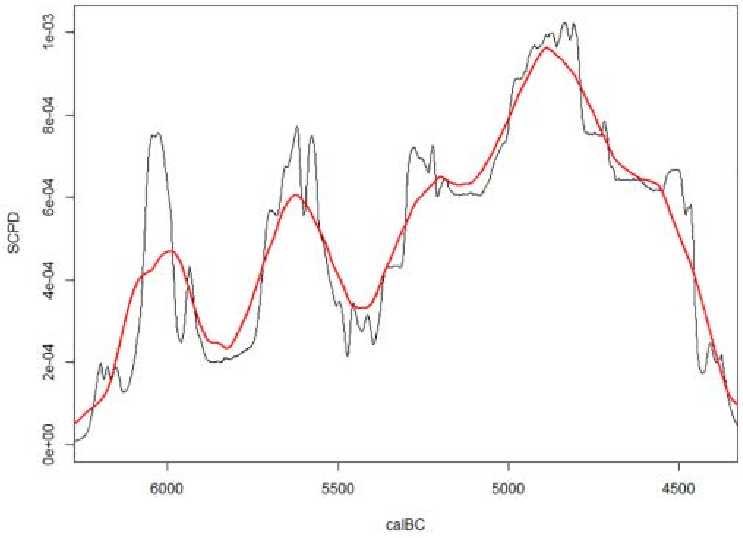

Fig 1.2. SCPD for the Early and Late Neolithic dates from Serbia. Empirical SCPD curve (black) for the sum of Early (Starčevo) and Late (Vinča) Neolithic dates with 200 year rolling mean (red).; According to Porčić et al.2016:8., fig. 3 https://doi.org/10.1371/journal.pone.0160832.g002

Settlements and economy

The Starčevo communities were organized in settlements with simple structures such as pit-dwelling and aboveground houses made of wood, clay and mud, including internal features such as hearths and refuse or storage pits. Occupied areas do not show functional differentiation between domestic and specialized work areas nor specific spaces for the dead. Social distinctions based on socioeconomic differentiation among houses or burials are not stressed (e.g.Greenfield 2008). The palaces were mainly occupied on a temporary bases and less concerned with long term occupations (Bailey 2000; Greenfield 2014:26).

Chipped stone tools show a standardization of shapes. A large quantity of short and long and short blades show cereal gloss with shine, reflecting the importance of agriculture. This activity has not been confirmed in all studied settlements, indicating seasonal occupation and the importance of fishing, hunting or harvesting in the restricted areas. Other occupations were concerned with raw material exploitation and chipped stone production (Šarić 2006a:19,20).

Agriculture focused on emmer, einkorn, lentil, pea and barley (Filipović 2014: Table 1a), while climate and vegetation were better suited for cattle and pigs, which were already known as wild species, than goats and sheep.Available faunal studies show that in the most of the Early Neolithic settlements domesticated fauna predominated over wild species (Bailey 2000; Greenfiled 2008: 112).

A model of intensive mixed farming, combined with small scale cultivation and herding seems likely across Southeastern and Central Europe during the Neolithic. Probably, this explains the lack of storage facilities, low frequencies of domesticated flora in some cases as well as the short time occupation and relative mobility of the Early Neolithic communities (Bailey 2000:139; Greenfield 2014: 28). Periodic settlement abandonment is also explained by the „exhaustion' of arable land, while some settlements are occupied repeatedly (Srejović 1994; e.g. Hršak 2015: 24).

This subsistence economy is accompanied by an exploitation, use and exchange of certain raw materials. Recent studies suggested that sources of salt, which was important in stock-breeding, tanning leather and perhaps in human nutrition, could be one of reason for the occupation, social stratification and cultural mixture along the northen, western and southern borders of the study area, which was marked as salt starving. The abundance of finds in the salt-rich area of Starčevo- Körös- Criş complex confirms this idea (Tasić 2000: maps 3.1.,2). Several authors have pointed to settlement patterns as indirect evidence for the exploitation of salt. Thus, settlements close to salt sources may be unusually numerous, long lasting or wealthy, suggesting that salt is the cause of their success (Tasić 2009; Perić 2012). Moreover, exotic objects found within salt-producing regions might indicate that salt and of high value as an exchange good, which could cause the initial accumulation of wealth and early social stratiication in the Balkans (cf. Urem-Kotsou 2016).

The small quantities of obsidian from the north Carpathian mountains (northern Hungaria and Slovakia) have been detected in some Early Neolithic settlements. The contextual analysis does not suggest that these finds were means of prestige. Rather they suggests contact with the communities in the north and long distribution network (Tripković 2001: 30, fig. 3). Furthermore spondilus finds, detected mainly along the Danube and Tisa rivers (which corresponds to our Northern region), the northern Carpathian region, the western Balkans (which corresponds to our Western region) and rarely along the Vardar valley (which corresponds to our Southern region) hint towards contacts with the Adriatic coast (Dimitrijević, Tripković 2002: fig. 1; Tasić 2000). The Early Neolithc settlements at this area has also reaveled the chipped stone items made of Balkan flint, which outcrops lay in the northern Bulgaria. This finds can be also observed in the same context of the remote exchange Gurova, Bonsal 2014).

A limited number of jadeite/nephrite objects have been also identified (e.g.Antonović, Stojanović 2009: tab. 1; fig. 1). Their small size would indicate that raw material was not locally produced. The exact number of the objects made of this type of rock(s) detected in the Neolithic context is not clear, given that determined microscopically by archaeologist, not by petrographer. In some cases, they might have been included and examined among a group with serpentinite objects, because of similar quality, hardness and appearance (Prinz 1988; Balaban 2013)

Recent research indicates that the copper mine at Rudna Glava was exploited since c. 6100 cal BC (Borić 2009: table 1). Even this date are not accepted, some Early Neolithic settlements located in the immediate vicinity of copper bearing regions introduced a small quantity of azurite and malachite lumps and decorative objects, such as beads and pedants. This suggests that their inhabitants were familiar with the physical characteristics of these minerals (e.g.Antonović 2006a:85, fig. 3).

Mortuary practice

Burials are infrequent during the Early and Middle Neolithic and it seems that only a small portion of the population was buried within the settlement. While neonates are buried in several cases in pots, no special grave constructions have been observed so far. However, some burials are covered or encircled by stone blocks, or found next to large rocks. Multiple burials consist of two or more individuals in which children frequently accompany adults. Almost all burials are crouched inhumations placed on their right or left side, with no differentiation according to age or sex. More exceptional are some burials with burned bones as well as disarticulated secondary skulls and burials without skulls. Burial offerings are rare, and may consist of 1–2 vessels, usually placed near the head, bone awls, flint, and in one case, the remains of animal skulls Pottery fragments sometimes cover the burial. (e.g.Borić 2015).

Differences between the Early and Middle Neolithic burial practices are the most clearly visible across the study area in the coexistence of mortuary practices in the Iron Gates. Unlike, Mesolithic forager traditions, forty neonate burials, placed in small pits at the Early Neolithic Lepenski Vir recall the rites of early Neolithic communities and Anatolia, and might have been introduced to the Danube Gorges through contacts with these regions. After 5900 BC, with the start of the Middle Neolithic crouched burials are dominant. The ultimate origin of this tradition was probably the Near East although the lack of clear rules regarding burial position and orientation could suggest small and fragmented social groupings. (Stefanović, Borić 2008; e.g.Borić 2015).

The Middle Neolithic in the south: the Anzabegovo-Vršnik culture

The Middle Neolithic settlement of Tumba Madžari belongs to the Anzabegovo-Vršnik cultural group, which is part of the Balkan-Anatolian cultural complex (fig. 1.1). This site was occupied during the major economic and cultural flourishing of this group is in the period from 5800 to 5200 cal BC or according to relative chronology, during Anzabegovo-Vršnik II – IV cultural phases (Kanzurova, Zdravkovski 2011: 143). We have included this site as a large number of artefacts (n=172) has allowed an examination of regional economic differences.

This cultural group was detected in the northern Macedonia. The settlements were located on slopes, below river terraces and forming tell (also so called tumba or magula) on the margins of fertile valleys. Aboveground rectangular and square structures were built of wood and plastered with mud. The dwellings can be grouped around an open space in the middle of the settlement, as observed in Tumba Madžari (fig. 1.1) (Gimbutas 1976: 32-37). Ovens, hearth, grainstore, storage pits as well as stable-grainstore were detected within the buildings. In some cases dwellings also produced altars and table-altars which seem related to cult activities indicating multifunctional use of these buildings (Kanzurova 2011).

Emmer, einkorn, barley, oat, pea and lentil have been identified in paleo-botanical studies. Apple, cherry, wild grapes and hazelnut were included in dietary as well (Renfrew 1976: 304, 307; Marinval 2006). The percentage of domestic animals is high, while goats and sheep are the dominant species (Bököny1976: 313- 374).

Burials are rare and have been documented within the settlements. It is about a grave of a child/baby in a crouched position and the jawbone of a woman in her forties. (Kanzurova, Zdravkovski 2011:143).

The Late Neolithic – Vinča culture

The Late Neolithic Vinča culture is dated to the period from 5400 to 4600 cal BC. It extended over an area of 300 km^2 across the Central Balkan (fig. 1.3). The relative and absolute chronology used here (table 1.2) has been established based on pottery material, stratigraphic sequences and radiometric data (Garašanin 1979, 1990; Jovanović 1994; Borić 2009). Despite recent evidences that metallurgy was present from its beginning, the Vinča culture is labelled traditionally as the Neolithic culture. We decided to maintain this concept due to consistency and compability with previous literature.

Phase (Milojčić 1949)	Phase (Garašanin 1979)	Range (cal.BC)
Vinča A	Vinča-Turdaș I	5400/5300 - 5200
Vinča B	Vinča-Turdaș II - Gradac	5200 - 5000
Vinča C	Gradac – Vinča Pločnik I	5000/4950 - 4850
Vinča D	Vinča Pločnik IIa, II b	4850 – 4650/4600

Table 1.2. Absolute and relative chronology of the Late Neolithic; (Borić et al.2018: 337).

Settlements and economy

The stratigraphy of Vinča settlements suggests long term occupation. Structures were located often above each other, but settlements are mostly interpreted as flat. Pit-dwellings and abundance of large pits are characteristic of the initial phase of the settlements (Tripković 2003: 450). In the level above ground houses - made of wattle, daub and planks - later period Vinča culture evidences were detected, together with traces of re-use of building material and a gradual enlargement and renovation of households (Bogdanović 1988, Crnobrnja 2009; Tripković 2009). Recent researches have revealed ditches as one of the features of the settlements (Crnobrnja 2012; Perić 2017; Borić et al.2018). They had defensive as well as symbolic meaning, as some authors have suggested (cf. Crnobrnja 2012).

The houses were grouped in rows around an open area, indicating some kind of urban planning (Tringham et al. 1992., Petrović 1982:T.VII, Тасић 2008: 28-29, Crnobrnja 2009: 8-9). Recent data on three settlements (Gomolava, Uivar and Divostin) indicate that the size of population varied between 70 to 2684 people (Porčić 2011., 2012: table 3).

A correlation between the distribution, size of the houses, exotic goods and malachite finds indicates different economic grounds in the north and south of the Vinča culture. The houses of the settlements in the northern part (which corresponds to our Northern region) are smaller than the structures in the south (which corresponds to our Eastern and Western region) and contain exotic materials such as spondylus and obsidian. It seems that population in the north was more competitive and individualized. This is confirmed by exchange networks for exotic goods. Unlike them, the houses in the south were extended or multifamily households. They reflect relatively closed societies oriented towards corporate work and collective values. Furthermore, copper or malachite finds are predominant within the large houses. Probably, they reflect the status of the households, linked with the larger labor force and surplus (cf.Porčić 2012).

It has also been suggested that the sedentarism caused new socioeconomic organization, as the need to supply a growing population consequently impacted in food production, accessory items of technology, and non-subsistence goods, and led to greater investments of labor and a restructuring of activities, resulting in an economic intensification (Kaiser, Voytek 1983: 329). Furthermore, this generated a model according to which the household is the primary unit of social and economic organization (Tringham et al. 1985: 427; Tringham, Krstić 1990: 602-615).

Fig. 1.2 shows a population decrease at the end of the Starčevo culture, followed by the population increase at the beginning of the Vinča culture. This process culminated around 4800 cal BC and decreased gradually afterwards. (Porčić et al. 2016:6, fig 6). The estimated population size of some sites indicates certain demographic potential for a hierarchical and complex society (Porčić 2012: 176, 178).

Fig. 1.3. The Late Neolithic settlements: 1. At; 2. Potporanj; 3. Motel Slatina; 4. Turska česma, Slatina, 5. Gumnište; 6. Benska bara; 7. Kremenilo; 8. Vranjani; 9. Čelina; adoptet according to Porčić 2012: fig. 1. Map layer downloaded from http://maps-for-free /, accessed on the 24. 9. 2017.

Emmer and einkorn were the

principal crops during this period, but their importance may have varied between sites. Biter vetch, flax and free-threshing wheat were more relevant in this period than during the Early Neolithic. Lentil is present in moderate quantities. Barley, pea and free-threshing wheat are scarce, while grass pea and broomcorn millet are rare and probably present crop impurities (Filipović 2014: 199, 210).

Wild species had still an important role, but with considerable variation between sub-regions and individual sites. The zooarchaeological data reveal an increase in the importance of cattle in the later part of the period, largely at the expense of caprines. This resulted in the large-scale herding during the second half of the Vinča period, which should be expected among individual communities (Orton 2012: 24, 31,33).

Rudna Glava copper mine was exploited from the very beginning of the Vinča culture. Natural channels of ore veins were followed and extracted by heating and abruptly cooling the rock mass. Grooved stone maul-pebbles were employed in crashing rock mass, while red deer antler was used as picks or mattocks (Borić 2009: table 1).

The Late Neolithic domestic context produced traces of malachite, azurite, copper beads, bracelets and chisels. Evidence of copper slags, dated in the sixth millennium B.C., from the site of Belovode indicates the earliest proven and absolutely dated "proper" metallurgical process in the Balkans and Europe. This site is around 50 km away from the site of Rudna Glava, but there is a probability that another mining sites existed in the same part of Serbia (Borić 2009; Radivojević et al. 2010). The analysis of copper-based objects from 79 archaeological sites reflects models of human interaction and corporation on the Balkans during 6200 BC to 3200 BC. Observations also suggest that the emergency and changes of copper supply networks correspond to cultural and social changes documented on archaeological material (Radivojević, Grujić 2018).

Immediately as the Vinča culture was established, intensive exchange of obsidian, Spondylus and Glycymeris appeared in its northern part. This activity continued during the whole period, indicating stable exchange routes, although the direction from where Spondylus and Glycymeris items emerged is unclear (Tripković 2002: 36; Tripković, Dimitrijević 2002, 2006). Unlike this, jadeite and nephrite finds are scarce (Antonović, Stojanović 2009).

Given that the Vinča culture population occupied almost the same area as the Middle Neolithic communities, there is a possibility that salt exploitation continued during the Late Neolithic as well (Tasić 2012).

Craft specialization

Procurement of stone raw material became selective, focused on material quality rather than on quantity and a great effort was made to procure non-local resources (Voytek, Keiser 1983: 339).

Pottery production suggests changes. This process was part of household activity and included the use of non- local sources, the specific preparation manner of raw material, pot making and firing. Material from settlements of Motel Slatina and Vinča suggested a high level of bowl standardization. Unlike them, storage vessels did not show such a feature (Voytek, Keiser 1983: 339; Vuković 2011).

Standardization of the chipping stone industry increased. It has been stressed particularly on blades for sickle and endscaper, (Voytek, Keiser 1983: 343 Šarić 2006: 19).

Consequently, a question arises about craft specialization on an individual level within the household as well as on the community level, which might indicate a controlled production organization.

Mortuary practice

There are only a few intramural graves and Late Neolithic cemeteries (Garašanin 1979: 159). Intramural inhumation is associated with settlements of Vinča, Turdaș and Partșa, while cemeteries have been detected at Gomolava, Botoš. Skeletal, crouched inhumation is dominant, and the bodies are in an east-west orientation. Grave-goods consist of powdered malachite and copper ornaments as well as polished stone axes, flint and pottery vessels. However, some female burials are not accompanied by grave-goods. (Garašanin 1979: 159, 160; Borić 2015).

1.2. Objective of PhD

Having worked on my master thesis on the macro-lithic tools from the Neolithic sites of the central part of Serbia or so-called Middle Morava valley, we noticed that there is not enough interest in this archaeological category in the central Balkans. The short research tradition and the small number of researchers have resulted in an insufficient number of published research results. This situation limits the implementation of new methodological approaches, such as those developed in the other parts of southern and central Europe, and weakens the advance in the archaeological knowledge on prehistoric economies.

Macro-lithic tools represent a basic source of information in order to understand the economy of Neolithic communities, particularly in the central Balkans. This claim is supported by the number and the typological variety of artefacts, produced to meet everyday social needs in various activities. The functions of these tools depended on the material properties and the morphology of the tools, achieved through suitable manufacturing techniques: chipping, pecking, polishing, sawing and drilling.

It has been previously suggested that the Neolithic macro-lithic tools from the Central Balkans were employed in grinding and food preparation, processing materials such as bone, wood, stone, in ceramic production, mining, and fishing. Finally, their ritual and aesthetic values have also been underlined (Jovanović 1982; Antonović, 1992, 2003; Живанић, 2010).

The intention of this thesis is to explore an economic characteristic of the Neolithic societies of the Central Balkans based on the study of macro-lithic tools, their origin, raw material used in manufacturing and function. First of all, this will also allow us:

- to detect economic changes through time and space that concerns particularly to the Vinča period, due to a large number of settlements and objects;
- to define and confirm regional economic differences during the Late Neolithic, which have been previously indicated by pottery analysis (Srejović 1973; Garašanin 1979.);
- to identify distance exchange patterns;
- to identify standardization of the macro-lithic objects;
- to define if the Vinča culture had highly organized production and society.

These aims are pursued through unpublished material from three Early Neolithic, one Middle Neolithic and nine Late Neolithic settlements (fig. 1.1, 1.3).

1.3.Structure of PhD

Chapter 2 outlines the theoretical background, methodological structure, analytical techniques and experimental program, which results are associated with functional analysis of macro-lithic tools. **Chapter 3** presents 12 settlements and macro-lithic tools found in their archaeological contexts as well as their degree of preservation, as this parameter is also an indicator of the intensity of tool use within the settlements. **Chapter 4** describes paleoecological context and geomorphological characteristics of the Central Balkans. **Chapter 5** is devoted to results of petrographic analysis including the results of petrographic analysis of raw material from other Neolithic archaeological sites from previous studies, and samples from geology outcrops from the Central Balkans **(subchapter 5.1);** the results of our geoarchaeological survey related to macro-lithic artefacts from Motel Slatina and Turska česma, Slatina **(subchapter 5.2),** and results of geo-archaeological analyses are required in order to identify the location and the distance from which raw materials derived, the exploitation method and the existence of territorial borders between supply areas (**subchapter 5.3**). **Chapter 6** presents the results of functional analysis of macro-lithic tools. **Chapter 7** pays attention to economic organization, technological changes among the Early and Late Neolithic macro-lithic artefacts **(subchapter 7.1)** and economic differences between settlements and regions during the Late Neolithic. Finally, conclusions are summarised in **Chapter 8**.

1.4. Acknowledge

A great many people have contributed to this thesis from conception to completion. The research was undertaken independently, nonetheless, it depended heavily on support from colleagues and friends from both countries Serbia and Spain. I have analyzed unpublished material from seven museums in Serbia, Macedonia and Bosnia and Herzegovina.

Thanks to Slaviša Perić from the Archaeological Institute from Belgrade that provided me with almost half of the studied material from Motel Slatina, Turska česma, Slatina, Medjureč and Pavlovac. He also provided me with accommodation and working space in Vranj, while I was analyzing material from Gumnište.

During my time in Vršac studying the Potporanj and at the macro-lithic collections, Ivana Pantović of the City Museum of Vršac went out of her way to assist me, facilitating me the access to the collection and providing me with space and documentation. Momir Cerović offered me access to Benska bara collection in the National Museum. Šabac gave me all help I need, space for work, advice, documentation and pleasant chatting during the breaks. Gordana Berić – Ković from the same museum introduced me to the other colleagues and offered me a shatter in her warm home and chance to meet her family with whom I spend a great time. Thanks also go to *Ljiljana* I Miloje Mandić from National Museum, Užice kindly and selflessly offered me collections from Vranjani and Kremenilo, useful literature, advice, necessary documentation and aid in any moment. I spent a pleasant time with them having a useful conversation, while their interesting professional memories made me particularly happy.

Savo Derikonjć from Hometown Museum, Priboj, provided me with the macro-lithic tools from the settlement of Čelina, along with invaluable information and advice. He also met me with the history of this beautiful mountainous part of western Serbia, and kindly showed me the surroundings of Priboj and took me to the Neolithic copper mine Jarmovac as well as to Čelina, introducing me to the topography as a necessary element in understanding the life condition of this Neolithic community.

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Dušica Petrašinović from Geological and Hydrometeorological School "Milutin Milanković", Belgrade agreed to help me with geological determination and took a trip to some of the listed museums whenever it was necessary.

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2. Economic theory and methodology

In following lines we will present economic theory as the theoretical background of the geological, morpho-technical and functional analysis of macro-lithic artefacts. This theoretical-methodological approach has been defined by Prof. R. Risch, and developed together with S. Delgado-Raack, J. Adams, L. Dubreuil, C. Hamon, and H., Plisson (Risch 1995; 2002; 2008b; 2009; 2011; 2016; 2018; Adams *et al*. 2009; Delgado-Raack 2008; Delgado-Raack, Gomez-Gras & Risch 2009; Delgado-Raack & Risch 2009, 2016).

2.1. Economic theory

The economy represents the maintenance and reproduction of society. It is defined by the formula of the basic economy schema, which includes basic economic factors, in the case of the production of goods:

Labour object (LO)+ Labour force (LF)+ Labour means(LM) = Product (P)

Thus, the aim of any production process is the exploitation of labour object (LO) and its transformation into a product (P), which can be used or consumed. This activity involves human labour force (LF) and labour means (LM), which includes all the technical means used in the exploitation and transformation of material. Any production requires a social organization and economic structure. Social organization is conditioned by the environment, which determines the material resources available and their physical conditions necessary for social reproduction. All societies reproduce themselves through three processes: *a. Basic reproduction that is biological reproduction of society; b. The production of object as the result of human labour and technology; c. Maintenance, of human labour and technology*. This increased the social value of the objects without modification of their original use value (e. g. Castro et al. 1998; Risch 2008b: 521, 522, fig. 3).

Thus, the analysis of all finds should follow a sequence which includes a transformation of raw material into an object, its use and consumption (Risch 2008b: 521, fig. 2).

The transformation of material depends on energy. Energy presents a qualified unit of social activity, applied according to the priority in the economic system. It results in energy expenditure and energy gain that form a useful social product. The balance is expressed in a surplus and in an energy deficit. The appearance of the surplus depends on social organization and results in an increase of material or immaterial goods. It can appear as economic growth, technological development, population decrease, more effective organization of work or just better climate condition. In this case, it is defined by the term *surplus gain* or *over-production* and includes commonwealth. However, an occurrence of the restricted social use of the result of work and individual appropriation of social production, which became consequently private property indicate *surplus profit* or *added value*. In this work, we are dealing with the Neolithic culture which was developed by cooperative affluent society. Such society is characterized by cooperative networks and decision making, commonwealth consumption, and no clear sign of socio-economic division. These features allowed population growth, building large-sized settlements and extensive social network (Risch 2002: 7; 2008b: 521, 523 fig. 2; 2016; 2018). This context can be observed through the main economic variables are the labour means, household, production, distribution, and exchange. A household, as the basic unit of social organization, was involved in the production and the implementation of technology (LF + LM). The final product is consumed at two levels. The first is an individual level (P1). The second level is the product (P2) used in an exchange (fig. 2.1). The final product can be considered as an

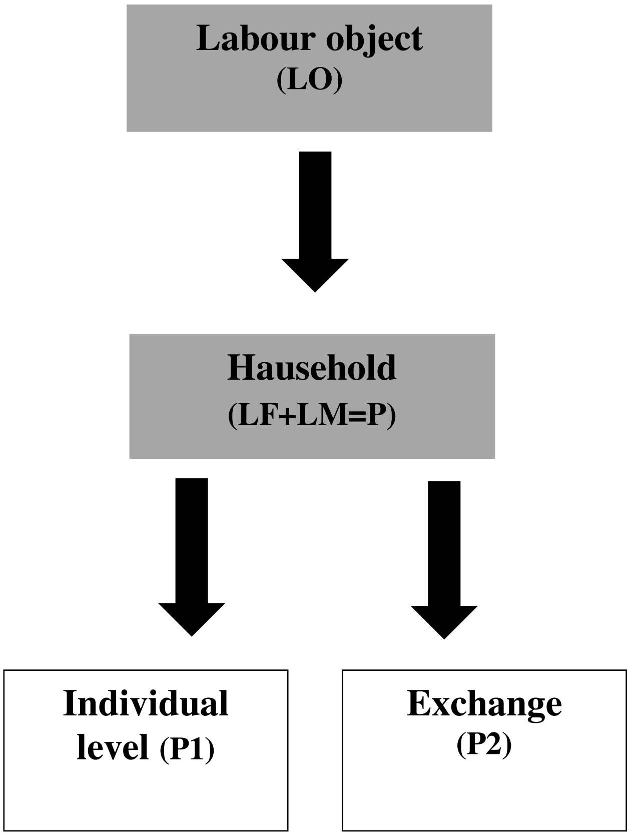

Fig. 2.1. Economic structure of the Neolithic on the central Balkan (LF: labour force, LM: labour mean; P: product)

object with social value, which is determined by two factors. The first factor is the production value, based on the accessibility to natural resources, and the implementation of production and distribution. It includes the workforce, with physical limits and technological development. The second factor is the use-value. This social aspect is based on properties, and quality, and has also been shaped by transport means, and distance, and social and political factors (Tringham, Krstić 1990: 602-615; Risch 2011: 101,102).

2.2. Methods

The aim of the study is to place the macro-lithic tools in the production process and their values in the social reproductive system. In order to reach this aim, the research would be conducted at two levels. First, empirical level focuses on morpho-metrical and petrological characteristics of the objects and surface transformation. Provided data would be compared with the results of experimental research. At the second level, the object will be placed in an environmental and socioeconomic context. (Risch 2008b; 2009, 526) (fig.2.2 and 4).

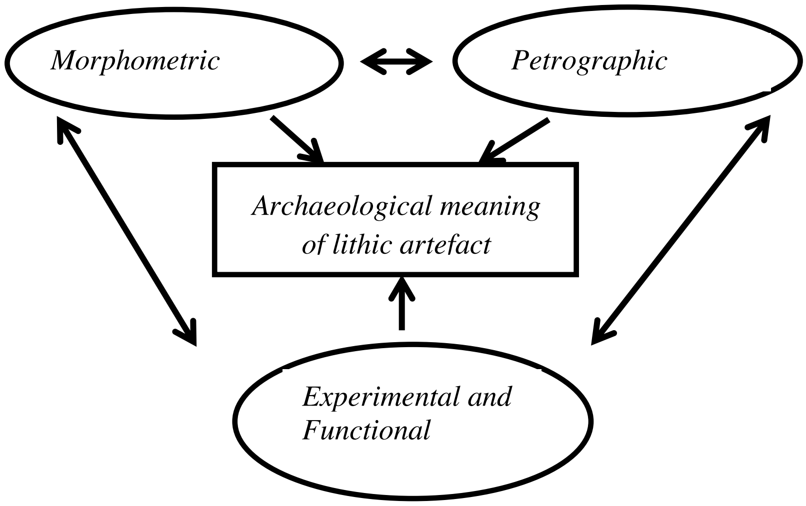

Fig. 2.2. Methodology of analysis of macro-lithic tools; according to Risch 2002: 37, fig.1.2.

The location of the active surfaces is also recorded considering that each artefact can be conceived as having six sides (obverse, reverse, top, bottom, right and left).

2.2.1. Orientation of the macro-lithic artefact

In following lines we present a hierarchy of criteria according to which an artifact is placed in front of the observer. This system has been developed due to the morphometric variety of the macro-lithic tools and has been already applied in previous studies (Risch 2002; Delagdo-Raack 2008).

The orientation criteria are as follows:

1. The longitudinal axis of an artefact is positioned vertically towards the observer.

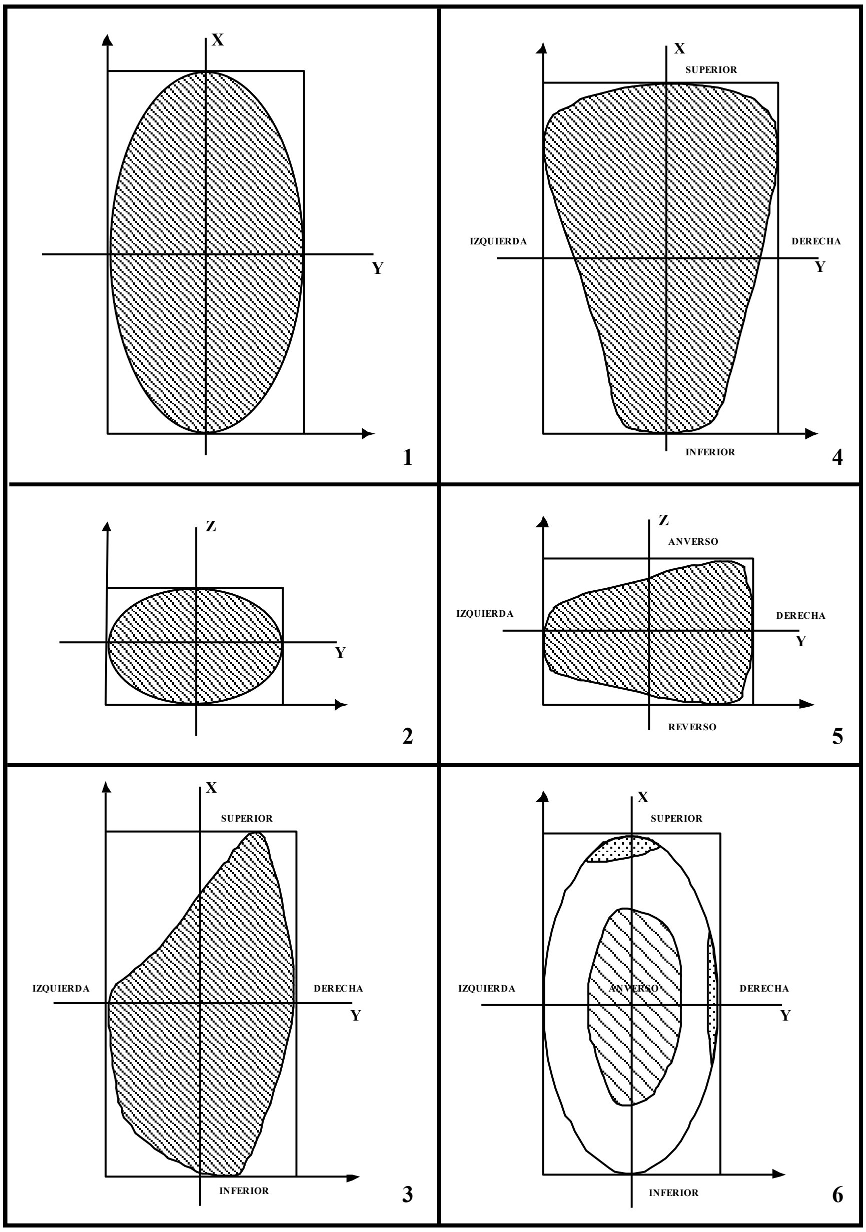

Fig. 2.3. Criteria for orientation of macro-lithic artifact for the analytical description (1: criterion 1; 2: criterion 2; 3: criterion 3; 4: criterion 4; 5: criterion 5; 6: criteria 6, 7 and 8).

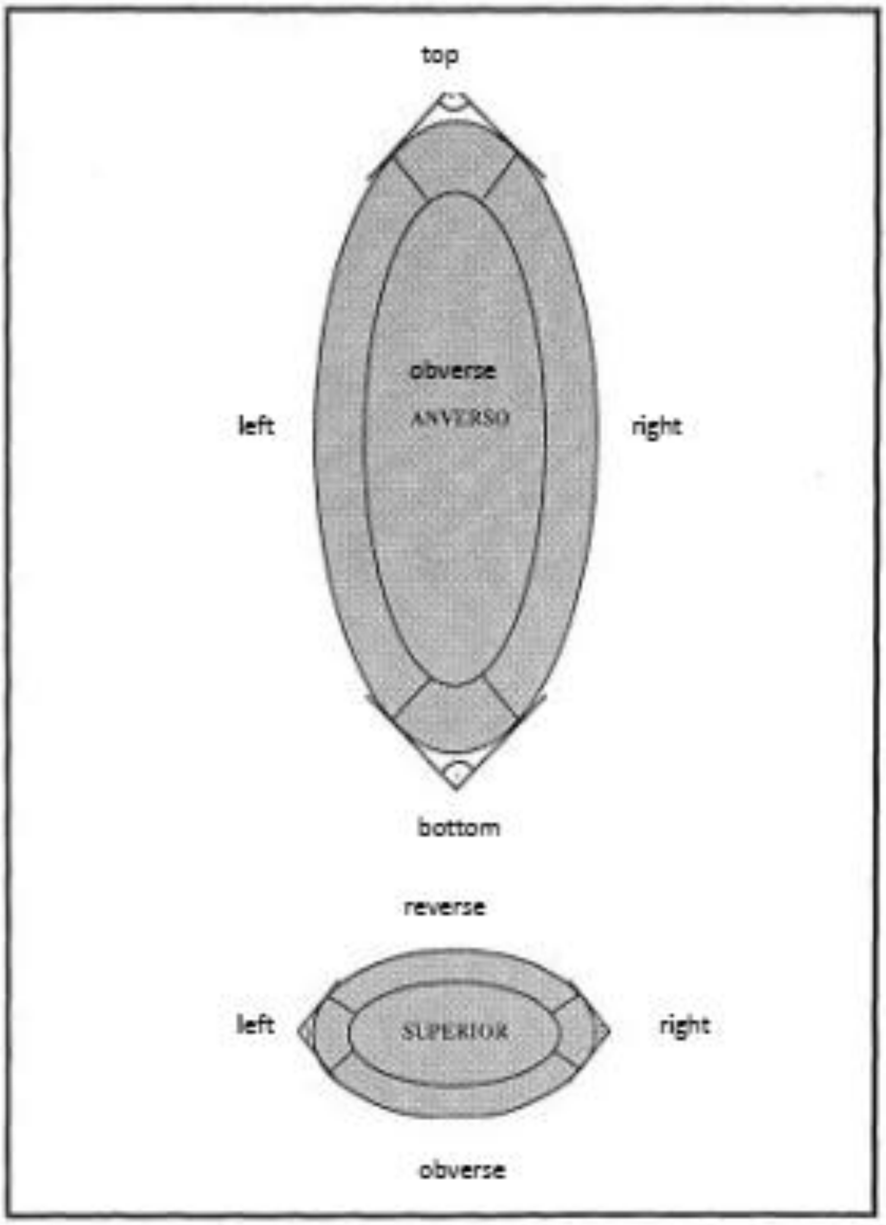

Fig. 2.3. Position of the sides of the artefacts.

2. The transverse axis is placed horizontally. Criteria 1 and 2 define the depth of the object and represent its thickness. Asymmetric items (objects with substantial differences between the maximum and minimum size of longitudinal, transversal axis or depth) can be presented by another series of morphometric criteria:

3. The longest longitudinal axis is placed on the right side of the transverse axis.

4. The maximum of the transversal section (the widest one) is located at the top of the longitudinal axis.

5. The maximum of the depth axis (the thickest one) is located in the upper part of the longitudinal axis.

As these rules having been applied, there are still several alternatives for positioning. Thus, functional criteria 6, 7 and 8 will be applied. The active surface is located hierarchically towards the obverse, top and right sides.

Fragmented artefacts may also be positioned according to the established criteria.

Drawing of the macro-lithic artefacts follows the same principles. Furthermore, the drawing of sections and views of the different surfaces adopts DIN standard of graphic representation of objects. This starts from the rotation of the pieces on the X, Y and Z axis, unlike the American norm, commonly used in archaeology. This has been caused by the morphological description system of the pieces.

2.2.2. Preservation of the artefacts

The analysis includes observations about the state of preservation of the artefacts and the number of fragments. Thus, we have formed three groups.

The first group includes complete **(ENT)** objects and items, which are only slightly damaged **(DMG)**, but this has not affected their morpho-metrical characteristics

The second group involves the objects which are preserved >1/3

ENA: the reverse side is missing
END: the left side is missing
IMF: middle and bottom part of the object are preserved
FSM: top and middle part of the object are preserved
MRI: missing right side and inferior part
MLI: missing left side and inferior part
PLS: preserved left side only
MIR: missing inferior part and reverse side
MAI: missing obverse and inferior part
DAR: both the obverse and reverse sides are damaged

The third group consists of items which are preserved < 1/3.

FGT: only fragmented item.
FGS: only top part of the object is preserved
FGM: only the middle part of the object is preserved

2.2.3. Petrology

Determination of geology includes a definition of rock structure, mineral composition, granularity, porosity and cementation. These elements impact on the behaviour of a tool involved in the work. The previous studies show that an object is commonly made of geology suitable to carry out the predicted task, which is associated with the quality of the product, rate of wear, frequency of re-preparation of the working part, design, as well as use and multi-functionality of the tool (Dubreuil 2001, Adams 2002, 19, 20 ; Schneider, La Porta 2008: 24; Adams et al. 2009, 45; Delgado at all. 2008, 1827 – 1829).

Our study collection consists of 32 rocks and was examined macroscopically by Dušica Petrašinović petrographer of the High School of Geology and Hydrogeology, Belgrade, while one part of the studied material has been examined microscopically by to Francisco J. Fernández, David Gómez-Grass from Geology Department and Roberto Risch from Prehistory Department , all from the UAB, Barcelona (subchapter 5.1.) The rock types recognized within these analyses are the following:

ATU: andesite tuff
ALV: (meta)alevrolite
AMP: amphibolite
AND: andesite
BAS: basalt
BRE: breccia
DIA: diabase
ESM: mica schist
CAL: limestone
GLI: claystone
CCT: quartzite
CGL: conglomerate
DIO: diorite
GAB: gabbro
GBD: gabbro-diorite
GNE: gneiss
GRD: granodiorite
GRA: granite
MAR: marble
LWS: light white stone
MAL: marl
MCG: microconglomerate
MSD: mata-psamita
PER: peridotite
QDI: quartzitediorite
SKA: skarn
SDS: sandstone
SPI: spilite
PZE: slate
SER: serpentinite

TRC: trachyte

SHA: shale

SCH: schist

2.2.4. Classification

Macroscopic observations allow classification of the tools of the Central Balkan settlements into six functional groups. This classification is based on the form of the objects, use wear traces and characteristics of the rocks, such in the case of fine and coarse-grained abraders. A similar typological system has been already applied in previous studies (Risch 1995; Adams 2002; Antonović 2003; Живанић 2010). The analysed artefacts have been labelled with codes and entered in a column named ITEM.

Functional group 1: consisted of the macro –lithic tools involved in the pounding and grinding process.

MOL: grinding slab; a large, passive part of grinding equipment. One or two active sides with traces of abrasion appear on the obverse as well as reverse sides;

MUE: handstone; a handhold, active tool with one or two abrasive working surfaces on the obverse as well as reverse sides;

MOR: mortar; a large passive tool with a concavity, appearing on the obverse and sometimes on the reverse side. It was used for pounding and grinding resources by a wooden or stone pestle;

Functional group 2: includes other macro -lithics involved in the abrasive process.

ALS: abrader; a small, coarse-grained tool with one or more active surfaces;

ALS –PIA: a fine-grained abrader with one or more active surfaces;

LOS: abrasive slab; a large artefact with one or more abrasive active surfaces;

Functional group 3: includes pebble tools with or without traces of manufacturing as well as perforated artefacts with a polished edge. They were used in percussion processes and the active sides were detected on one or more sides of the artefact. The working sides can show various use traces, which occurred during different activities, indicating that in such cases we are dealing with multifunctional tools.

APE: abrader - hammer -stone; a tool with two or more active surfaces, which show traces of abrasion and percussion;

PEC: hammer-stone; handhold pebble tool with traces of percussion on one or more active sides. Traces include flake negatives (NO), which were caused by strong blows, and can be also followed by pits (GA), dents (GO) and;

RET: retouching tool; handhold pebble tool with traces of percussion, such as pits (GA) and dents (GO) on one and more active sides;

RET-PEC: multifunctional tool; Two or more active surfaces are with use traces typical for a hammer-stone and a retouching tool;

HAM – hammer; a massive pebble tool used for crushing. One or two active surfaces are with large flake negatives;

HAM-RET: multifunction tool; Two or more active surfaces with use traces typical for a hammer and a retouching tool;

HAM-PEC: multifunction tool; Two or more active surfaces with use traces typical for a hammer and a hammer-stone;

HAP – a perforated axe;

HPA – a broken, perforated artefact, which was secondary used as hammer and retouching tool or a hammer-stone was used secondary used as hammer and retouching tool or a hammer-stone;

MTP: perforated mattock; The perforated tool with pointed working part;

PEC - REP: multifunction tool; Two or more active surfaces are with use traces typical for a hammer-stone and retouching tool (by pressure);

PST: pestle; an elongated pebble artefact; Pulverizing, grinding and crushing produced one or two working surfaces on the top and bottom sides;

PST-ALS-ANV: pestle-abrader-anvil; a multifunctional tool characterized by the passive and two or more active surfaces with traces of abrasion, percussion and use traces characteristic for anvils;

PST-ANV multi-functional tool used as pestle and anvil; One or two active surfaces are characterized by use traces typical for pestle and passive side on which are visible traces characteristic for an anvil

PST-HAM: multi-functional tool; Two or more active surfaces show use traces typical for pestle and hammer;

PST-PEC: multi-functional tool; Two or more active surfaces show use traces typical for a pestle and a hammer-stone;

PST-RET: multi-functional tool; Two or more active surfaces with use traces typical for a pestle and retouching tool (direct retouching);

RPE 1: re-used polished edge; One or two active sides show flake negatives (NO);

RPE 2: re-used polished edge; One or two active sides show dents (GO) and pits (GA);

Functional group 4: consists of polished tools with cutting edges, set in varies position in relation to the axis of the longitudinal section of an object.

ADZ: adze; asymmetrical tool with cutting edge sets below to the axis of the longitudinal section of an object;

CHI: chisel; tool with cutting edge with a narrow body and parallel, longitudinal sides;

HAC –axe; symmetrical tool with cutting edge sets in the plane to the axis of the longitudinal section of an object;

REN – celt; asymmetrical tool with cutting edge sets above to the axis of the longitudinal section of an object;

Functional group 5: includes the tools with specific propose.

ALS (CRG)[1]**:** coarse-grained abraders with grooves; This tool shows one or more abrasive active sides with one or more grooves;

ALS –PIA (CRG): fine-grained abraders with grooves; The use of one or more working surfaces formed one or more grooves;

ANV: anvil; passive artefact used as a base for manufacturing macro-lithics and chipped stone tools. Passive surfaces are with dents;

ANV – RET: multifunctional tool; Passive side with use traces typical for an anvil and one or two active surfaces with use traces typical for a retouching tool;

ANV – RET - ALS: multifunctional tool; Passive side with use traces typical for an anvil and two active surfaces with use traces typical for a retouching tool and a coarse-grained abrader;

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[1] The database of this type is marked as CRG column TIPO. Abrasive artifacts with one or more elongated, U section groove.

ANV- ALS: multifunctional tool; Passive side with use traces typical for an anvil and one or more active surfaces with use traces typical for a coarse-grained abrader;

ANV-LOS: large multifunctional tool; Passive side with use traces typical for an anvil and with one or more abrasive active surfaces;

DS: door post; An object with a concavity on the obverse side. It was used as a base for the door
construction and facilitate the door function

HOE: hoe; Elongated, massive pebble object with the narrow active side on the top. The surface of the item shows the natural surface of selected cobblestones. This artefact was used for digging soil.

MZ: mace; rounded perforated artefact.

REP: retouching tool (by pressure); This cobblestone tool was used for maintaining the working edge of chipped stone tools;

SS: shaft straighteners; This elongated artefact is characterised by a U morphology groove in a central part of the obverse side.

SW: spindle weight (whorl); This is a perforated discoidal item. It was positioned on a hand spindle (drop spindle), aiming to keep the speed and uniform rotation of the spindle.

WD: weight for digging stick; Perforated massive cobblestone present weight for a digging stick which was used for digging out the corms and roots

Functional group 6: includes objects with symbolic, cult meaning or aesthetic value etc.

FIG: figurine;

PED: pedant;

BEA: beam;

BRA: bracelet;

AMU: amulet;

DPP: discoid perforated plate.

LID: lid;

WFN: weight for the fishing net;

In the next step, the analysed tools have been classified according to their wider characteristics, which are related to raw material, the morphology of the item or group of artefacts. These codes have been entered into column TIPO.

CAR: pebble
CGR: grooves
CUP: object of cult
DIS: discoidal object
ESP: object with aesthetic value
PA: perforated artefact
REP: type of grinding slab with one elevated part of the obverse side.
SAP: abrasive raw material
TCE: polished edge tools

2.2.5. Morphology

The morphology and size played a significant role in the selection of raw material. Depending on the complexity, the form of the rock could be transformed additionally by various manufacturing techniques (abrasion, flaking, retouching, polishing, perforating and sawing) and by use. The study of morphometry is based on a previously established recording system of macro-lithic artefacts (Risch 1995, 2002; Delgado-Raack 2008; Delgado-Raack & Risch 2016). All active and passive surfaces are classified according to their longitudinal and transversal profiles. As three basic shapes are distinguished, concave (CV), flat (RT) and convex (CX), a maximum of nine combinations are possible (CV/CV, CV/RT, RT/CV, RT/RT, etc). For purposes of simplicity, the six possible variants of different profiles have been unified into three classes:

flat (RT)
concave (CV)
convex X)

while a combination of the longitudinal and transversal axis show the following profiles:

flat (RT/RT),

concave (CV/CV),
convex (CX/CX),
plano-concave (CV/RT, RT/CV),
plano-convex (RT/CX, CX/RT) and
concave-convex (CV/CX, CX/CV).

It should be mentioned that this classification has been applied in the analysis of morpho-metrical characteristics of the working edges of the polished edge tools.

2.2.6. Metrics

In this analytical step, the size of the artefacts is recorded. The weight is expressed in grams (g), and the length, width and thickness are expressed in millimetres (mm). The active surfaces are also registered metrically, measuring length, width, and the convexity or concavity if required. The area of surfaces can be conceived as a cycle or ellipse, and calculated accordingly.

2.2.7. Functional analysis

The functional analysis represents a link between material traces of human labour and social organization of production and reproduction. This includes identification of use-wear traces, as a consequence of the production/consumption processes within economic context (Risch 2008b: 522, fig. 3). The objective is to understand human work and it should enable archaeology to answer three basic economic problems: 1. What is being produced? 2. How is it being produced? 3. Who produces it? Functional analysis also allows an application of economic theory that explains the social organization of production (fig. 2.2). Finally, use-wear traces appearing on the active surfaces are described following the standard methodology proposed for the functional analysis of macro-lithic artefacts (Adams *et al.* 2009).

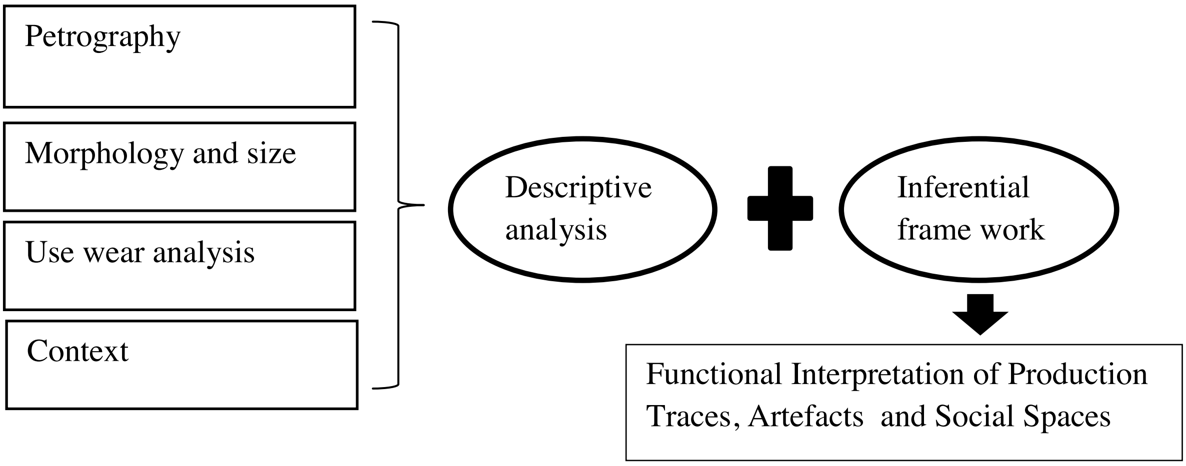

Fig. 2.4. Analytical steps for a functional interpretation of macro-lithic artefacts; according to Adams et al. 2009: fig. 6.1.

In order to reach the aim, two scales of observations of the surface modifications have been applied. The first scale is macroscopical and refers to changes visible by the naked eye. The second scale represents the changes of grains, minerals and space between them, which are visible at a mesoscopic level (Adams at all. 2009:48, fig. 6.2). Mesoscopic changes have been documented by the USB microscope Micro Capture, Version 2.0: for (2M) 20x – 200x, and stereo-microscope Olympus SZ 61 with tubus and digital camera. Thus, active and passive sides and changes detected on their surfaces are classified as:

1. Natural surfaces with no manufacturing and use

IR: irregular or rough surfaces.

LI: Smooth surfaces due to natural processes (water or wind action).

RO: fractured surfaces due to anthropogenic or post-depositional processes.

2. Manufactured surfaces with general forms.

PU: traces of fiction

TR: traces of percussion (fig. 2.5)

RE: traces of flaking and retouching

PK: traces of pecking (fig. 2.6)

RT: traces of retouching (fig. 2.8)

FE: traces of flaking (fig. 2.7)

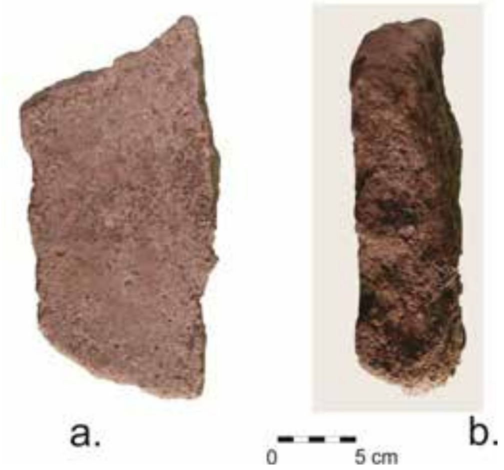

Fig. 2.5. a. grinding slab, orthogonal projection, b. lateral side of grinding slab with traces of percussion

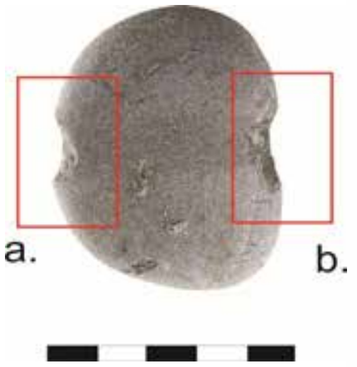

Fig. 2.6. weight for fishing net: a. and b. traces of pecking.

fig. 2.7. tool with traces of secondary modification: traces of flaking

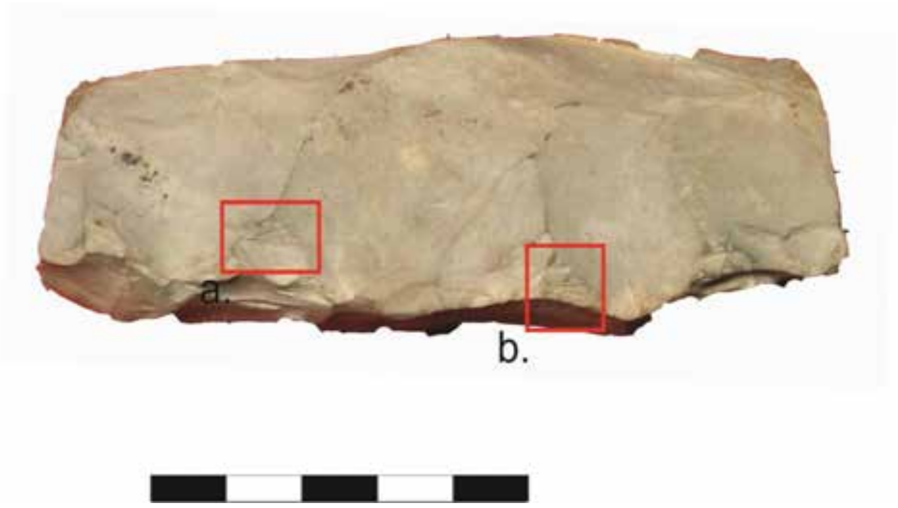

Fig. 2.8. semi-finished product: traces of retouching

3. Use traces on the active sides

AL: use-wear traces caused by friction.

GO: dents caused by percussion.

GA: pits caused by percussion.

GR: groove

NO: flake negatives caused by percussion (axes, adzes, celts)

MNO: micro-flake negatives

MGA: micro-pits

PS: lines caused by pressure (e.g. pressure retoucher).

SH: shine

SC: scratches

MSC: micro-scratches

FA: frosted-like appearance

4. Active worked surfaces with specialized forms.

CA: concave surface, circular produced by the use (eg, in MOM).

FL: sharp cutting edge (e.g., in HAC).

FC: facet

5. Worked surfaces with specialized passive sides and residues.

CA: cavity, deepening of the surface of the item that does not play an active role;

CL: bright thermal alteration – calcination;

CO: discolouration of the surface upon contact with other materials;

IP: Drilling, this can be unfinished in some cases;

GP: grooves produced by pecking (e.g. weights for fishing net)

PE: drilling of an item because of decorative or practical purposes (e.g., hanging);

TE: dark thermal alteration;

PL: surface covered by burned plaster;

DL: unidentified layer dark in colour, probably generated in a contact with unknown material;

HD: wear traces caused by a handle.

In the final step geology, morphology, and metrical variables, as well as use traces, will be combined in a specific sequence of analytical steps:

1. Correlation between geology and the size of the artefacts;
2. Correlation between the size of the artefacts and number of active sides;
   (this analytical step is implemented in chapter 6.4.1)
3. Correlation between morphology and the size of the artefacts;
4. Correlation between the shape and size of the active surfaces;
5. Correlation between geology and shape of the profile of active surfaces or

working edges;

6. The proposition of functional patterns of active surfaces, based on steps 4. and 5. their position on the artefact or working edge;
7. Confirmation of functional patterns through the use-wear analysis;
8. Association of different functional patterns on tools;
9. Correlation between functional patterns and the general size and volume of the tools;
10. Distribution of tools and their functional patterns in the settlements and association with other artefact types (this analytical step is implemented in chapter 7).

Only complete active surfaces should be included in this analysis.

Finally, all information obtained from production traces is linked to space, where the object was uncovered. Data on zooarchaeology, palaeobotany etc., from the same context, provide an environmental image. These results present a connection between studied objects, social life and socioeconomic organization.

2.3. Experimental examination

The experimental examination attempts to replicate the form of the artefacts and to test function, kinetics, use-wear traces, and the mechanical properties of the rocks. The objective of this approach is to achieve an interpretative framework of macro-lithic technologies. All the information obtained from the analyses of raw material, production traces, archaeological context and from experimental tests will be combined in the interpretation and reconstruction of the economy of Neolithic societies in the central Balkans. This subchapter presents a series of experiments related to different topics. Three experimental programs have been performed and offer answers:

1. on the use of macro-lithic tools in pottery production;
2. mechanical properties of raw material used for abrasive tools;
3. development and meaning of percussive traces on hammer-stones.

2.3.1.The use of macro-lithic tools in pottery production

The first program will shed light on the implementation of macro-lithic tools as smoothers and polishers used in pottery production during the Late Neolithic of the central Balkans. We have been inspired by the record from the Franchti cave (Stroulia 2003), which includes four polished edge tools made of basalt and serpentinite with faceted working edges associated with scratches, suggesting that these objects might be employed as smoothers for the pottery surface (Stroulia 2003: 6, 22, fig. 14/39, 42, 46, 47;). Another reason is the lack of data on the use of macro-lithic tools in pottery production in the studied area. Data on stone pottery polishers come only from the settlement of Vinča – Belo Brdo[2]. As it is known these tools present a small river pebble, with a natural shape, unaffected by previous manufacturing processes. This characteristic made this object invisible and unattractive to the researchers. Thus, we have defined our aim as follow:

- to accumulate empirical data and analyze use –wear traces on macro-lithic tools, used as smoothers and polishers, aiming to establish a comparative collection of use-wear patterns;
- to define a link between the type and level of changes and time necessary for their development on the active surfaces of the stone polishers;
- to define the morphology of use traces generated by the smoothing depending on clay temper and the level of moisture in the clay.

In order to reach the objective, we have employed a hand-made sandstone axe as a smoother, one small amphibolite pebble as a polisher and three vessels made of fine and coarse tempered clay, which were dried for c. 72 h. Their dimensions are 88 x 83 x 35 mm, and 56 x 76 x 42 mm and 55 x 88 x 56 mm.

The surfaces of fine-grained vessels were smoothed by the axe. The working edge of the axe shows scratches and grain-extractions after 10 min of use (fig. 1.4). The item has been used for 50 minutes more and no morphological change of use traces has been detected (fig. 1.5).

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[2] Oral announcement provided by Dr. D. Antonović from the Institute of Archaeology in Belgrade. The objects were found during the excavations in 1998. According to the stratigraphic position those finds belong to the Viča-Pločnik II cultural layer.

Having been smoothed, the surfaces of the pottery were polished by amphibolite polisher with one flat surface (fig. 1.6). Such morphology of the active side allows good contact with the processed surface. Peripheral active parts of the tool present shine and differently orientated shallow scratches after 16 minutes of use (fig. 1.6/a, c, d).

Additional 14 minutes of polishing produced scratches all over the working surface of the tool (fig. 1.6/a, e).

Deep, disordered scratches appeared on the surface of the stone polisher after c. 12 minutes of the activity.

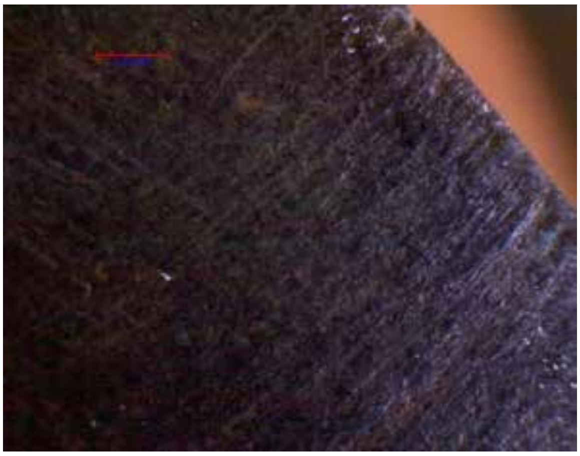

Fig. 2.4. Axe: scratches on the working edge, occurred after 10 min of the use.

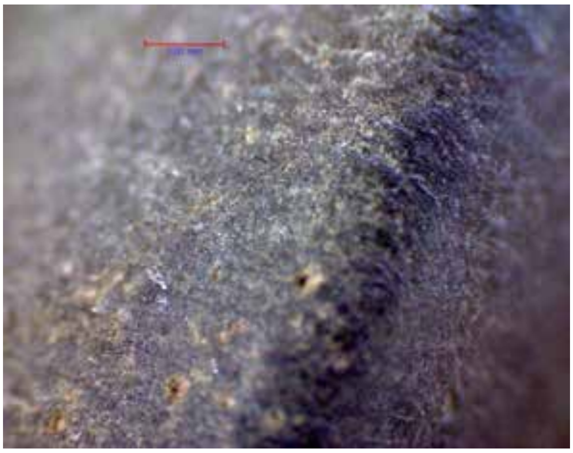

Fig. 2.5. Axe: scratches on the working edge, occurred after 50 min of the use.

Conclusion

The implementation of the axe in smoothing of the surface of fine-tempered pottery caused scratches and grain extractions, while levelling of the working edge has not been observed. We assume that grain extraction after 60 minutes of work will be continued, causing a negative impact on smoothing of the surface. Furthermore, various pottery temper caused the different types of use-wear traces on the polisher. Polishing of fine tempered vessels generated shine on the surface of the stone polishers, very soon as the activity had begun. The shine was followed by micro-scratches. The contact with coarse-grained clay made scratches deeper.

The experiment resulted in a comparative collection, considering the objects originating from an archaeological context. This will reveal pottery workshops and

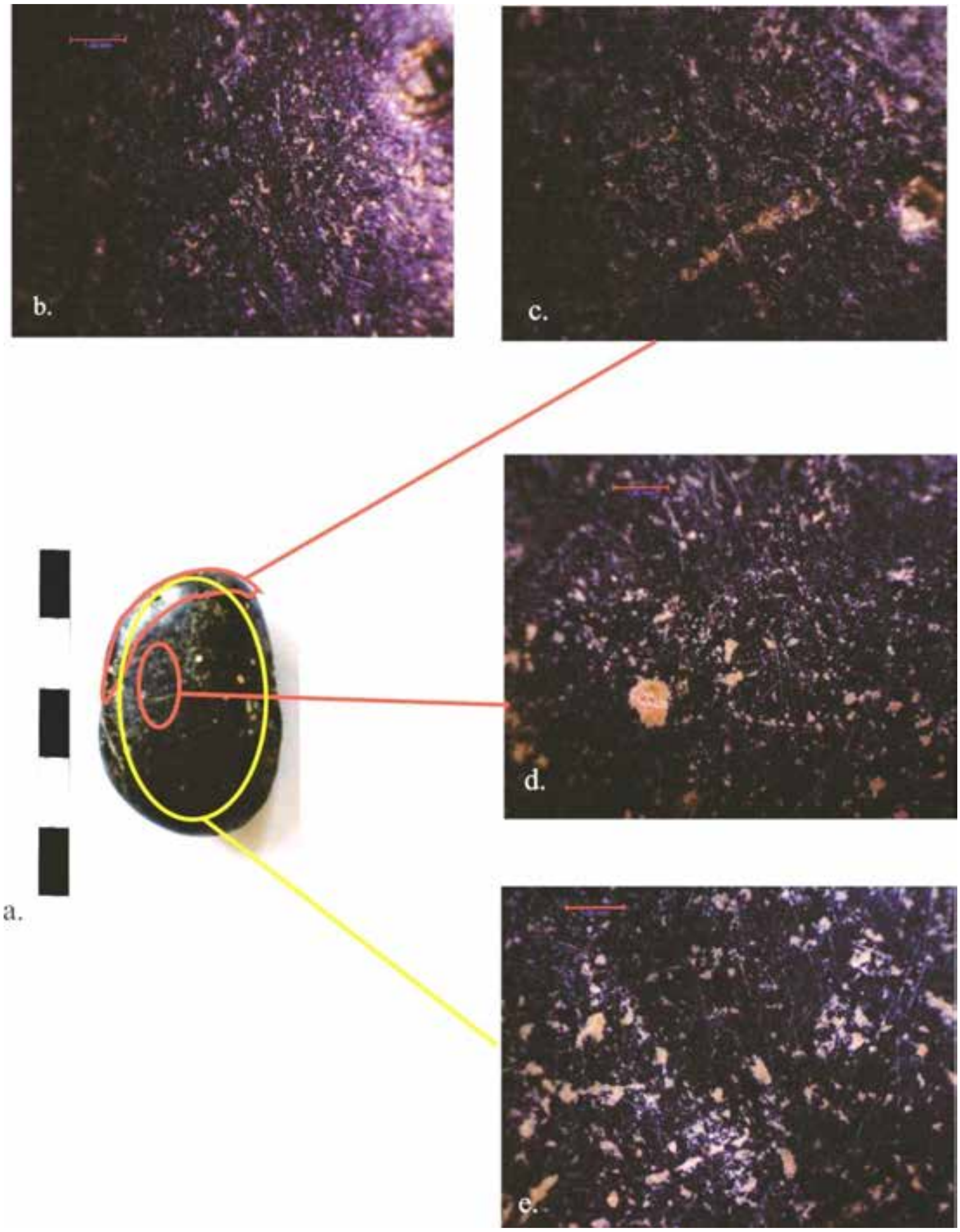

Fig.2.6.Stone polisher: development and distribution of use wear traces on the working edge of stone polisher (a.),unused surface (b.), use traces developed after 16 min of the tool implementation (c.-d.), use traces developed after 30 min of the tool implementation (e.).

possible technological varieties in pottery production within the settlement or between settlements.

Parallel to this, the time necessary for the appearance and the development of certain types of use-wear traces on stone polishers was measured. We believe that this can define the wear level of the working surfaces of the objects from the archaeological context more accurately. Generally speaking, this experiment can assist in completing an economic picture of the Neolithic settlements on the Central Balkans. Parallel to this, further examinations can reveal of the place the tools in the chaîne opératoire as well as the link between pottery technology and type of material used in surface processing.

2.3.2. Macro-lithic artefacts: examination of mechanical properties of rocks

The aim of this experiment is to answer the question of a selection of raw materials in the abrasive process and to reveal their place in the economy of the Late Neolithic in the Central Balkans. In order to reach this objective, we have applied manual mechanical examination of mechanical properties of rocks, which include the surface roughness and resistance to friction. As it is known from previous literature, these characteristics affect the mechanical behaviour and a function of the tools (Delgado-Raack et al. 2009).

Materials and methods

Six experimental abraders gabbro variety a and b (fig.2.7/6 and 2.10), sandstone variety a and b (fig.2.7/3- 4), amphibolite (fig.2.7/8), gabbro-diorite (fig.2.7/5) and andesite (fig. 2.10) were prepared for the examination of their characteristics and quality. Varieties of sandstone (a and b) are distinguished based on the type of cement. Sandstone variety b has a fine and homogeneous structure (fig. 2.7/7; fig. 2.11, 20). Turbulent chemical reaction in contact with diluted HCl indicates carbonate cement. Varieties of gabbro are related to different geographical origins of this rock. These rocks are typical raw material for abrasive and grinding tools from the Late Neolithic settlements of Motel Slatina and Slatina – Turska česma (the Central region)’ as well as andesite, materials found among abrasive and grinding tools from the Late Neolithic settlements of Gumnište (the Southern region) and gabbro variety b from Čelina (the Western region) (for more

Fig.2.7. Experimental equipment: 1. vernier scale; 2. quartzite hammer-stone; extra sample: 3 sandstone; experimental abraders: 4. sandstone variety b ; 5. gabbro-diorite; 6. gabbro variety a; 7. sandstone variety a ; 8. amphibolite.

Fig.2.8. Extra sample: 1a., processed surface; 2b. measured central part of processed surface.

details see chapters 3 and 5). Their mechanical properties were tested using them against contact material, sandstone object (extra sample) (fig. 2.7/3; 2.8) of 31 x 20 x 17 mm in size. We used grinding to remove a layer of material from its surface. It should be said that the examination was conducted on this stone due to its hardness. We believe that the examination with very hard material can let us make more conclusions on the behaviour of the tested raw material compared to those which are much softer.

Fig.2.9.Experimental abrader: andesite, Gumnište.

Fig. 2.10. Experimental abrader: gabbro variety b, Čelina.

An experimental program

The index of rock resistance to friction (RF index) was determined by the thickness of a layer of material of 2 mm (TL) (fig. 2.8/ 2) removed from the extra sample in the process of grinding, in a certain period of time (TU) (expressed in minutes):

$$\text{RF index} = \text{TL} / \text{TU}$$

This period of time was necessary to achieve TL value (expressed in millimeters). The auxiliary measurements of the removed layer (TL`) from the extra sample are taken at intervals of 15 minutes (fig. 2.8/2) by a vernier scale.

The central part of the processed surface of the extra sample was measured by a vernier scale (fig. 2.7/3b). Grinding of the extra sample was done under the same pressure and rate. Given that the examination was manual, values of the rate and pressure are a subjective impression. This layer presents the TL value as an unchanging constant. The time necessary to reduce smoothen the working surface is marked by the DU value. The worn-out working surface of the abrader was re-pecked and re-sharped by quartzite hammer-stone (fig. 2.7 /2).

Results

We present the obtained results in table 2.1. These values are related for each experimental abrader and include the time necessary to remove 2 mm of material from extra sample, frequency of re-pecking of the working surface of experimental abrader, the size of the active surface and value of RF index.

Furthermore, these experimental tests have provided a collection of use traces produced by abrasion on the active surfaces of abraders made of various geology in contact with stone (fig. 2.12–17). They can serve as comparative examples considering archaeological collections of similar items.

rock sample	thickness removed (mm)	experiment duration (minutes)	interval between percussion (minutes)	RF	size of surface (mm)
sandstone ***variety b***	2	110	8,5	0,018	79x57
sandstone ***variety a***	2	45	8-9	0,044	88x49
amphibolite	2	105	7,5	0,019.	90 x 57
gabbro-diorite	2	68	6	0.044	70 x 38
gabbro ***variety b***	2	25	5	0.08	71 x 43
andesite	-	-	-	-	67 x 61

Table 2.1. Quantitative results of experimental tests.

The andesite abrader has been broken after 20 min of work (fig. 2.17), probably due to the small size of the working surface that was 67 x 61 mm. Thus, the provided results will be excluded from further analysis.

Moreover, re-pecking of the working surface has also provided data on the hardness and fracture toughness of the examined rocks, which were collected respectively.

The results were expressed subjectively as high, average and low values. The the working surface of gabbro abrader ***variety a*** has proved to be the most resistant to polishing. Strong blows of the hammer - stone formed deep dents on the working surface. This delayed the process of re-pecking of the active surface for up to 15 min. The hardness of sandstone abrader *variety a* required more physical strength for the re-pecking of the working surface, also causing its frequent repeating. Sandstone *variety b* has fine-grain structures, but its grains are larger than grains of sandstone *variety a*. This characteristic classifies this raw material as far more efficient. The low level of fracture toughness has enabled easy re-pecking of the working surface, while the level of abrasiveness was high.

Gabbro-diorite proved to be a brittle material. The working surface of this abrader was pecked easy, but its capacity for the development of roughness was very low. However, the last feature did not affect the value of the RF index. Opposite to this, gabbro *variety b* also belongs to very hard materials which require energy for re-pecking the working surface. However, its capacity for the development of roughness was lower than the capacity of the gabbro-diorite object.

Amphibolite shows different behaviour. Its fracture toughness and hardness require a lot of energy to re-peck the working surface, whereby it damaged easily quartzite hammer - stone.

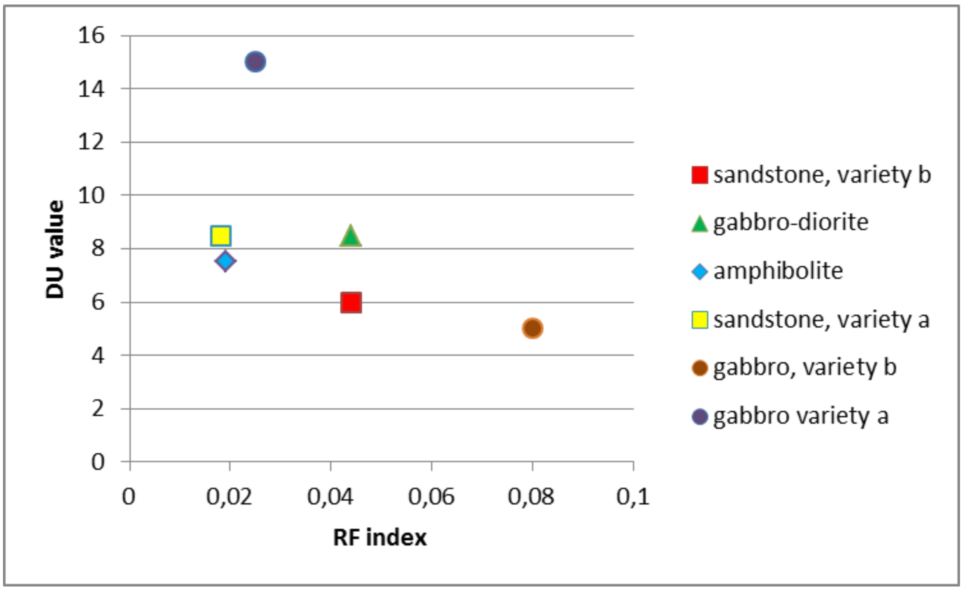

Fig.2.11. Mechanical values: correlation between RF index, DU values and geology; N= 6

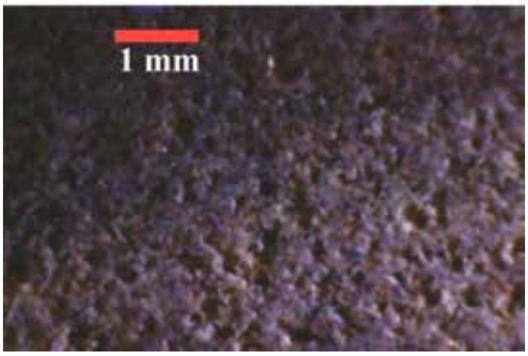

Fig. 2.12. Abrader: levelling, sandstone variety a

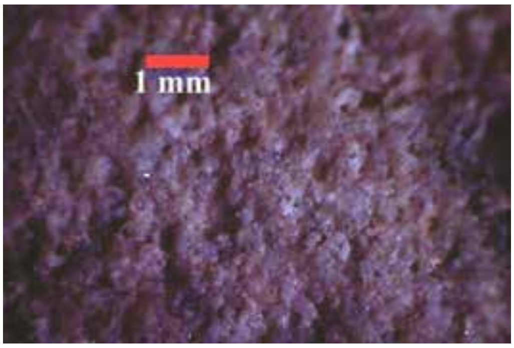

Fig.2.13. Abrader: levelling and grain rounding, sandstone variety b.

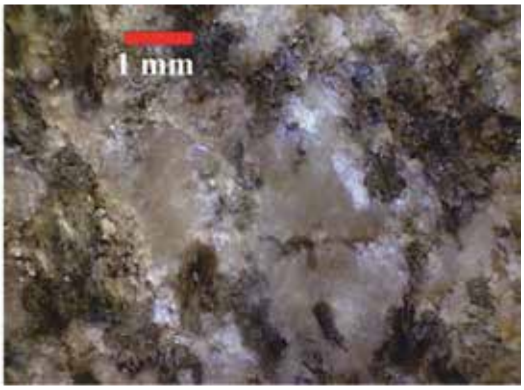

Fig. 2.14. Abrader: levelling, amphibolite.

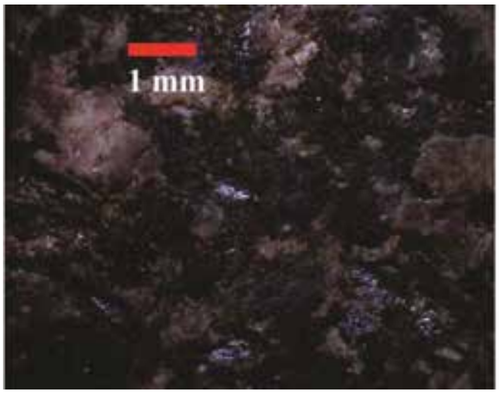

Fig. 2.15. Abrader: levelling, gabbro variety a.

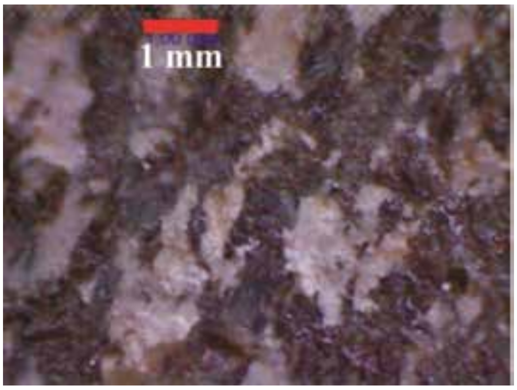

Fig. 2.16. Abrader: levelling, andesite.

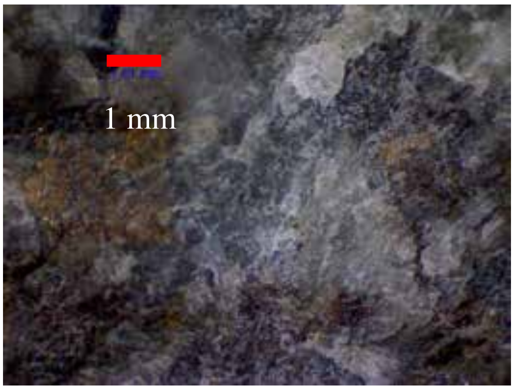

Fig. 2.17. Abrader: levelling, gabbro variety b.

mechanical values	**material**	**RF index**	**DU**	**hardness/ fracture toughness**	**the roughness of and resistance to friction the rock**
Group I	sandstone **variety b**	0,044	6	low/low	hight/ low
	gabbro-diorite	0,044	8.5	low/average	hight/ average
Group II	amphibolite	0,019	7.5	hight/high	low/average
	sandstone **variety a**	0,018	8.5	hight/high	low/ average
Outlier I	gabbro **variety a**	0,025	15	low/average	low/ hight
Outlier II	gabbro **variety b**	0.08	5	low/low	hight/ low

Table 2.1 Mechanical values: groups of the analyzed material based on the desirability for work.

Conclusion

Observations suggest that rocks with various mechanical properties have been used in abrasive processes. A correlation between RF index and DU values has resulted in two groups. The first group consists of gabbro-diorite and sandstone *variety b*, as materials are less resistant to friction and the average DU value. Mechanical characteristics of gabbro-diorite and sandstone variant b enable quick and easy maintenance of the working surface. It could be said that abrasive tools and grinding equipment made of these raw materials are defined as effective and suitable for work (table 2.2; fig.2.11). The second group includes amphibolite and sandstone *variety a* which is characterized by the low RF index and the average DU value. Regardless of different geological origin and structure both rocks are extremely hard and tough, by which amphibolite stands out. Thus, these rocks have been defined as difficult for work (table 2.2; fig.2.11).

The outliers represent gabbro *variety a* and *b*. Gabbro variety a is characterized by an average level of RF index and extremely high value of DU factor. No significant resistance to the re-pecking of the working surface has been identified. Therefore, this rock is defined as preferable for work (table 2.2). Gabbro *variety b* is characterized by an average level of RF index and the extremely high value of DU factor. No significant resistance to the re-peck process of the working surface has been identified. Therefore, this rock is defined as the preferable raw material for work (table 2.2).

This test indicates that rocks with various working efficacy were used in abrasive processes during the Late Neolithic of the Central Balkans. The examined samples also show different hardness, which affected the maintenance of their active surfaces, although we assume that the same feature can influence time and energy necessary in their manufacture. We can also say that this method has been proven as successful, practical and economical. It can be easily applied in a further examination of raw materials and provides the results about the efficiency of stone tools involved in various technological processes in the wide territory aiming to define the economic differences and distribution.

2.3.3. Percussion tools: development of percussion use traces

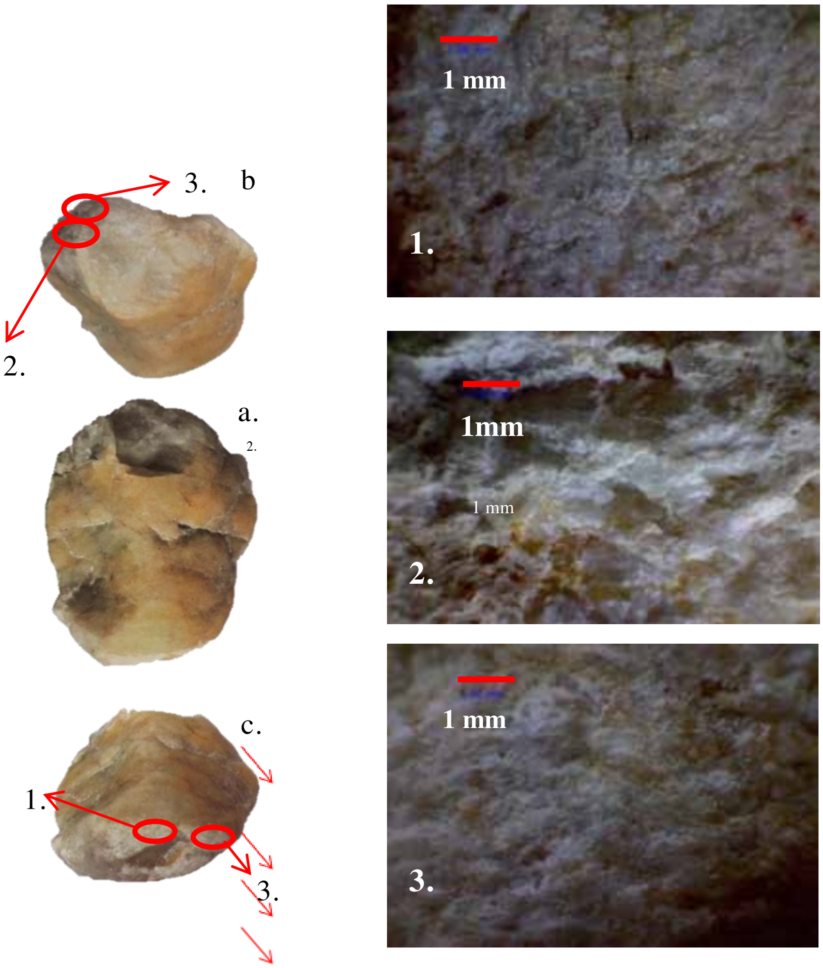

Fig. 2.25. Hammer-stone: distribution and development of macro and micro use trace, flake negatives (NO) (a,b) grain levelling (1.) and frosted appearance(2.) and grain rounding (3.)

Here, we focus on typology and development of percussion use traces detected on the quartzite hammer-stone used for re-pecking the working surfaces of six examined samples during the mechanical tests (subchapter 2.3.2): gabbro variety a and b, sandstone variety a and b, amphibolite, gabbro-diorite and andesite. Duration of the experiment was 353 min.

Observations show two types of macro - use traces. They include flake negatives (NO), among which large ones were generated on the top side which was mainly employed. Flake negatives (NO) could be a consequence of hard blows, prolonged use or fatigue of material[3] (fig. 2.25/a, b). The second type of use traces includes dents (GO) and pits (GA) (fig. 2.25/b,c). In previous literature, they have been linked to a mature phase of the use of the tool (Delgado, Risch 2009: 239, fig. 4; Delgado, Gomez-Gras 2017: 58). The same results defined frosted like-appearance of the working surface (fig. 2.25/2) also in mature or use phase (Adams et al 2009; Delgado, Gomez-Gras 2017), while grain rounding (fig. 2.25/ 3) suggests worn-out working surface. Furthermore, an occurrence of flat grains and micro-dents (fig. 2.25/1) presents a phase between the previous two.

In sum, it could be said that the mechanical test and analysis of the development of percussion traces have also resulted in comparative collections of use-wear patterns, developed on various geology in contact with stone during abrasive process and percussion, which can be useful in our further work.

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[3] Fatigue of material is an engineering term that defines progressive brittle cracking under repeated alternating or cyclic stresses of intensity considerably below the normal strength https://inspectioneering.com/tag/fatigue.

Chapter 3:

Archaeological context and macro-lithic material

3. The archaeological context

The central Balkans are divided into four topographic and geological units: Northern, Central, Western and Southern. This chapter will present 12 Neolithic settlements detected in the various regions (fig.5.1) and 2174 macro-lithic tools found in their archaeological contexts. It also includes information on the quantity of tool types found in each settlement and their degree of preservation, as this parameter is also an indicator of the intensity of tool use within the settlements.

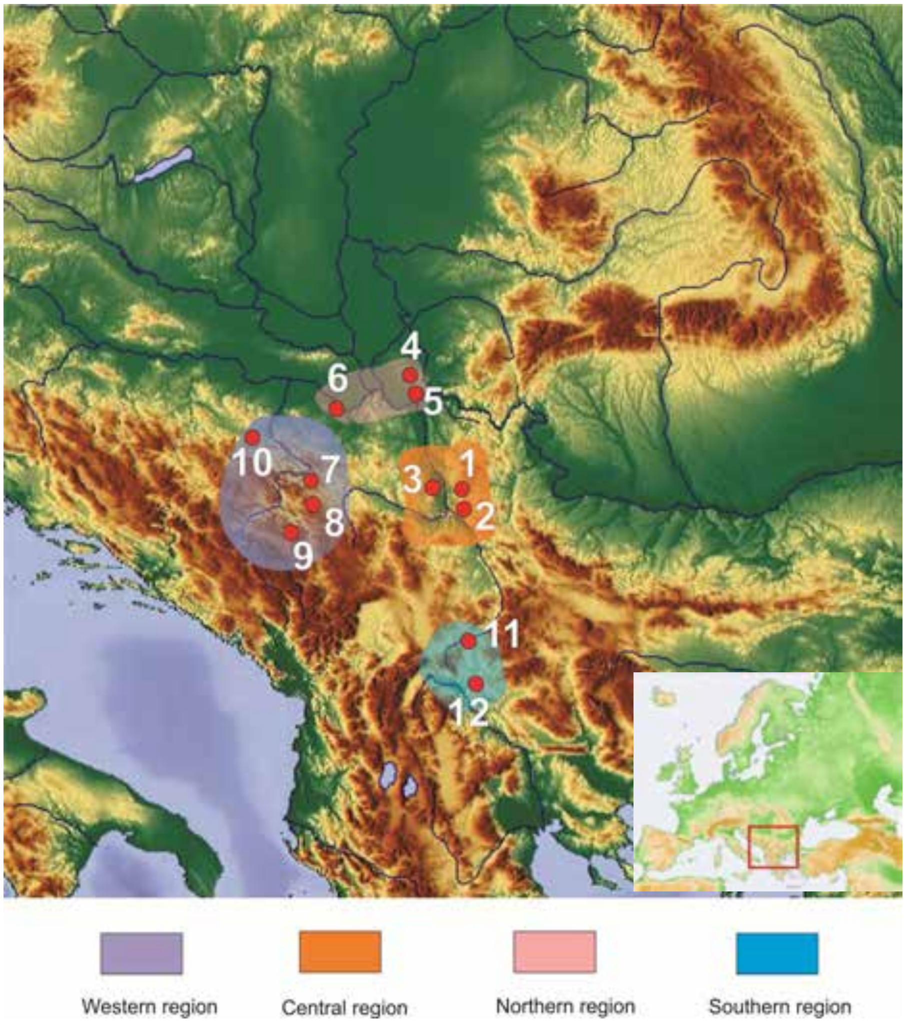

Fig. 3.1. Position of the regions and settlements: 1. Motel Slatina; 2. Turska Česma,Slatina; 3. Medjureč; 4. At; 5.Potporanj; 6. Benska bara; 7. Kremenilo; 8. Vranjani; 9.Čelina; 10. Koraća Han; 11. Pavlovac; 12. Tumba Madžari.

3.1. Northern region

3.1.1. At, Vršac

The multilayer site of At (fig. 3.2) covers a surface of 16 ha. It is located on a fluvial terrace, surrounded by an alluvial depression, in the NW periphery of the town of Vršac, in the vicinity of the Vršac Mountains. It was registered back in 1888 and the first archaeological excavation, which had a preventive character, was conducted in the period between 1975 and 1977. An area of 200 m² was excavated by the Institute for Protection of Monuments of Culture, Novi Sad (cf.Pantović 2014: 68).

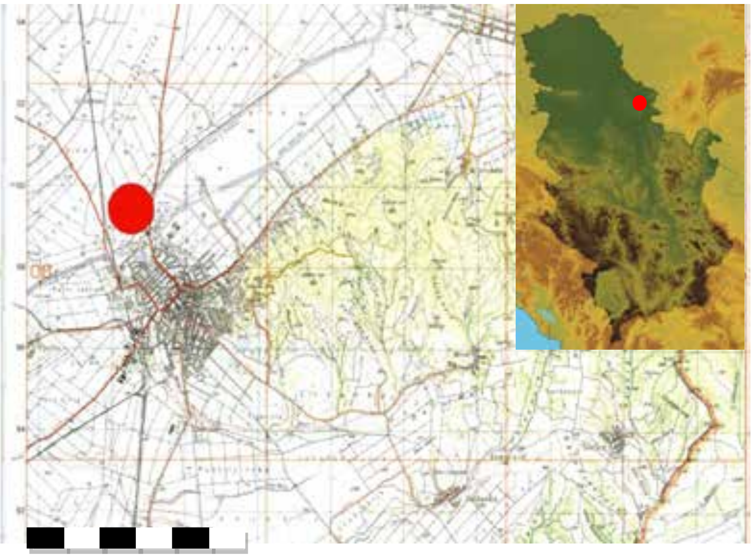

Fig. 3.2. At: position of the site, military topographic map section Vršac 4, 1 : 50 000.

The site was occupied during the Upper Paleolithic, the Early and Late Neolithic, the Bronze Age and the Late Iron Age and Sarmathian material. In recent times, it has been extensively used for agriculture, and between the two world wars, it was used as a vineyard which resulted in layers being significantly disturbed.

The Late Neolithic horizons belong to the Vinča Pločnik I – IIa phase, and perhaps also to the IIb phase. These phases correspond partly to Vinča C and D (proposed by Borić, Borić et al. 2018: 337). This indicates a long occupation of the site. The layers revealed remains of above-ground houses (cf. Pantović 2014: 68).

A field diary, a short report on excavations and published analysis of Vinča amulets provide some evidence of the archaeological context (Joanovics 1977: 18 -20;Pantović 2014).

Trench 4, in the central part of the Late Neolithic settlement, revealed remains of an above-ground house (object 2). Its inventory consists of pottery, amulets (Pantović 2014: 117), chipped stone artifacts, animal bones, and an axe (HAC, L- AT-5). A bone awl and a tool with traces of secondary modification (UNK, L-AT – 16) were uncovered beneath the remains of an oven or a hearth. A pit, from the same context, contained ash, animal bones and a pestle (PST, L-AT – 14). A celt (REN, L- AT-13) was also found in the area, but without a defined position.

Remains of a house were documented in trench 5 in the eastern periphery of the Late Neolithic settlement. This structure produced a small number of finds such as pottery, animal bones and two adzes (ADZ, L- AT-9 and L- AT-8), as well as an axe (HAC, L- AT-6), and a retouching tool (RET, L- AT-15)[1].

Trench 6 was excavated in the next year It represents an extension of the trench 5, and produced the Early and Late Neolithic horizons, partly disturbed by a Sarmathian grave. The Late Neolithic strata provided four pits and remains of a hearth. No cultural content has been observed in three pits, suggesting soil exploitation. The fourth pit contained fragmented pottery, a clay model of a house and a large number of natural stones (gneiss, sandstone and quartzite)[2] (Joanovics 1977: 19, 20).

According to the discovered features and rocks, this part of the settlement might be interpreted as an area in which raw material was prepared for pottery production.

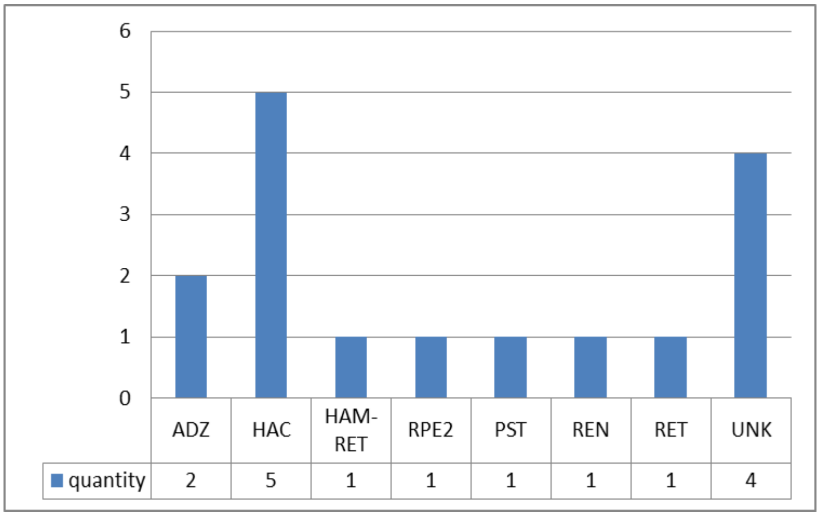

Fig 3.3. At: macro-lithic objects; N=16.

We have analyzed 16 objects found only in the Late Neolithic layers during the excavation of 1976. Most finds consist of axes (HAC) and tools with traces of secondary modifications (UNK) (fig. 3.3). The macro-lithic tools (n=13)

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[1] Documentaion of the City Museum Vršac, Vršac. The rest of the field documentation seems to be lost.

[2] Documentaion of the City Museum Vršac, Vršac. The rest of field documentation do not exist.

tend to be complete, particularly the polished edge tools (adzes, axes and celts), a pestle, a hammer-retouching tool and re-shaped polished edge tools. However, taking into account the extension of the excavated area of the settlement, it seems that these macro-lithic tools were mostly rejected.

However, most of the collected material has never been analysed nor published. Analysis of anthropomorphic figurines and clay amulets are exceptions (cf.Pantović 2014: 68). This data is insufficient to reconstruct the Neolithic economy of the settlement of At. The long occupation of the site during the Neolithic and its topographic characteristics suggest various activities which could have focused on crop growing, herding as well as the exploitation of wild resources.

3.1.2.Kremenjak - Utrine – Potporanj

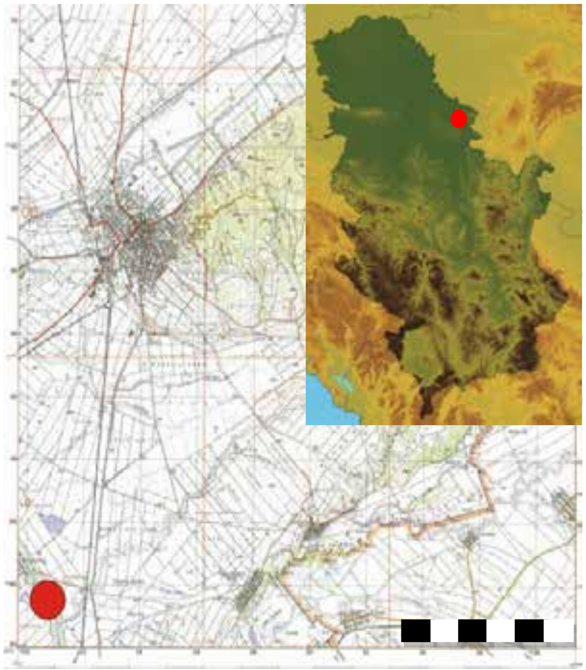
Fig. 3.4. Potporanj: position of the site, military topographic map section Vršac 4, 1 : 50 000.

The settlement of Potporanj – Kremenjak occupied a low land area of c. 100 ha (fig. 3.4) on a fluvial terrace, surrounded by fertile soil and freshwater surface, whose level was higher than today. This is confirmed by the location of the Neolithic sites detected in the surroundings. Chapman (cf. Pantović 2014: 69) points out that it was probably the largest Late Neolithic site, not only in southeastern Europe but also in the Middle East. Mileker (cf. Pantović 2014) detected the settlement back in 1888 at the eastern edge of the village of Potporanj, 12 km south from the town of Vršac (fig. 3.4,5). The Vršac Mountains are located in the eastern hinterland of the settlement. This orogenic massif is naturally connected with the southern Carpathians, a forest area rich in different kind of rocks and minerals. Miliker was also the first who conducted an excavation in the site in 1899[3]. This

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[3] Documentaion of the City Museum Vršac, Vršac.

site has been excavated again in 1957, due to construction of Danube - Tisa - Danube (DTD) channel, while the small trench excavations were carried out in 2011 and 2012 (fig. 3.6) (Pantović 2014: 69). So far, an area of c. 200 m² has been uncovered.

The thickness of the cultural layer varies between 2,5-3,4 m (Brukner 1960: 230;). Unfortunately, construction of the channel Danube - Tisa - Danube (DTD) destroyed a large part of the site. The Late Neolithic settlement belongs to the developed phase of the Vinča - Tordoš I-II, Gradac and probably Vinča-Pločnik (5400/5300 - 4650/4600 cal BC).

Fig.3.5. Potporanj, documentation of the City Musem, Vršac.

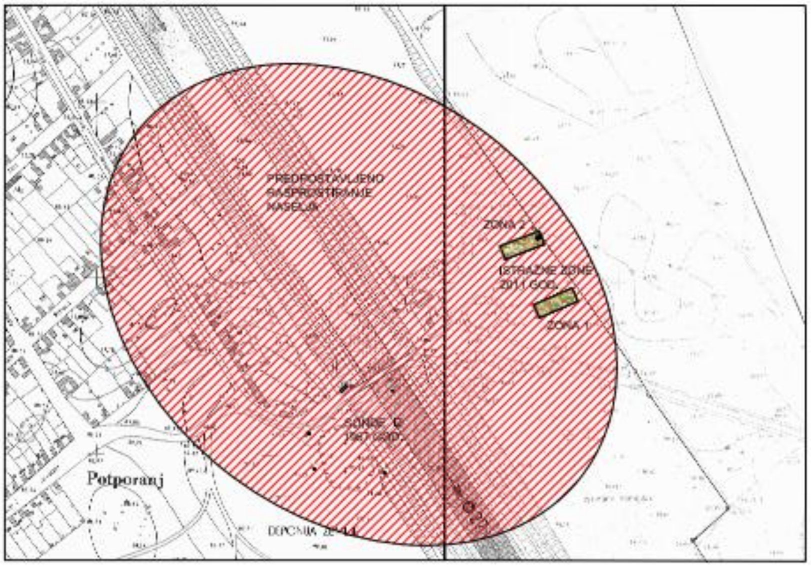


Fig. 3.6. Potporanj:size of the site and position of trenches from 1957 and 2011.

According to Srejović, it might be older than the eponymous settlement of Vinča (cf. Пантовић 2010: 10). Observations also suggested that The Late Neolithic stratum was disturbed by activities of the 1st-2nd centuries AD (fig. 3.10) (Pantović 2014: 69).

Excavations confirmed the existence of quadrangular above-ground buildings.

During 1957, squares 10, 11, 16 and 17 in trench II revealed a concentration of burnt daub at a relative depth between 1,23 to 1,73 m. Such context produced a re-used polished edge tool (RPE, L - PO – 54) and a tool with traces of secondary modifications (UNK, L - PO – 8) (fig.3.9). Moreover, a burnt daub, ground floor indicates the presence of a house at a relative depth between 1,23 and 1,48 m in squares 16 and 17, which also produced fragmented pottery, a deer antler and three tools with traces of secondary modifications (UNK, L - PO – 26, L - PO – 35, and L - PO – 37). The same area, at a relative depth between 1,48 and 1,94 m produced remains of a hearth, fragmented pottery and a mortar (L - PO – 32).

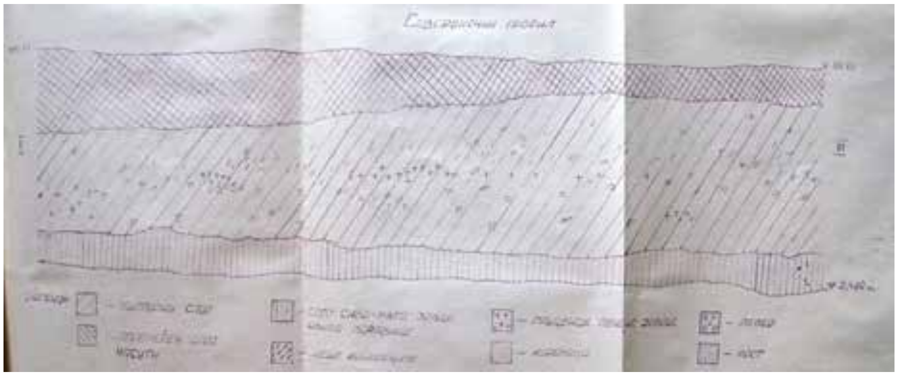


Fig. 3.7. Potporanj: trench II, norhteastern profile, excavations 1957. documentation of the City Museum Vršac, Vršac.

However, the explorations in 2011 and 2012 identified disturbed layers of the Late Neolithic in the eastern periphery and in the central part of the site due to activities in I – II century AD (fig. 3.6,8). This context is associated with animal bones, fragmented pottery, ground floor and burnt daub (fig. 3.8) and a small number of macro-lithic tools such as a chisel (CHI), retouchers (RET), schist identified as raw material (IND), tools with traces of secondary modifications (UNK) and a flake (LAS).

Given that the finds have not been defined in detail according to their stratigraphic context, thus the studied objects are treated as a whole.

In total 130 tools macro-lithic tools have been analysed, which were found during 1957, 2001 and 2002 campaigns, as well during the first excavation carried out by Miliker in 1899. Although the artefacts from Miliker's excavation lack proper documentation, we have examined them because of their interesting morphometrical and functional characteristics and their relevance for the interpretation of the side.

The analysis revealed that tools with traces of secondary modifications (UNK), flakes knocked off from polished edge tools (LAS) and re-used polished edge tools (RPE 1 and 2) are numerically more important (fig. 3.8 a, b).

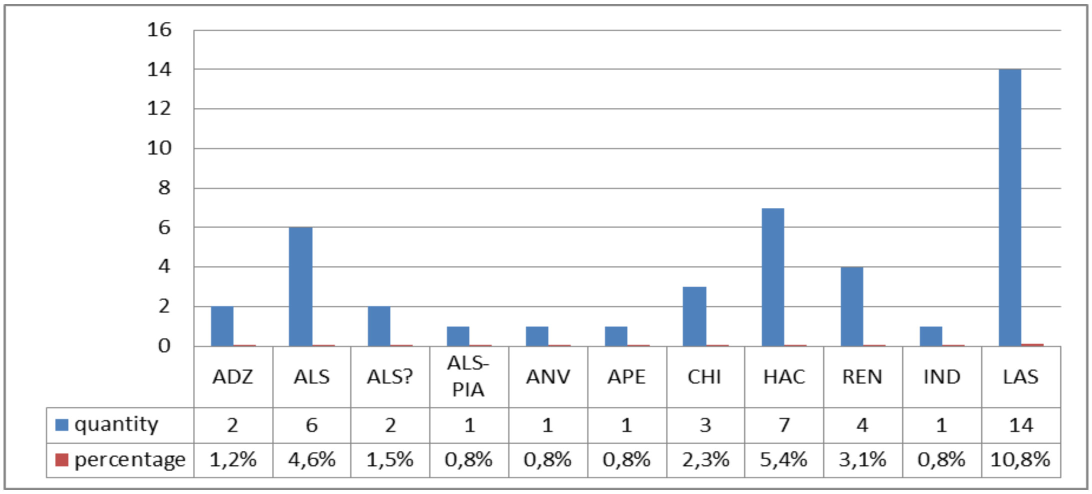
Fig. 3.8. Potporanj: trench 1A, ground of 11th arbitary layer, 2011.; photo taken from profile GC. Photo documentation of the City Museum Vršac, Vršac.

Most of the analyzed macro-lithic tools are complete (fig. 3.10). Particularly well preserved are tools with traces of secondary modifications (UNK) and percussive tools (PEC) (fig. 3.11).

Few objects are broken and fragmented (fig. 3.10), among which certain artefact types are especially affected. High fragmentation suggests an intensive implementation mainly of polished edge tools (adzes-ADZ, axes-HAC, chisels-CHI and celts-REN), tools with abrasive surface (grinding slabs – MOL, mortars –MOR, abrasive slabs–LOS, coarse-grained abraders – ALS and fine-grained abraders –ALS-PIA) and retouching tools (RET) (fig. 3.11). A low percentage of fragmented and broken macro-lithic tools suggests a selective collection of the finds. The impression is that mostly complete and specific types of tools were collected.

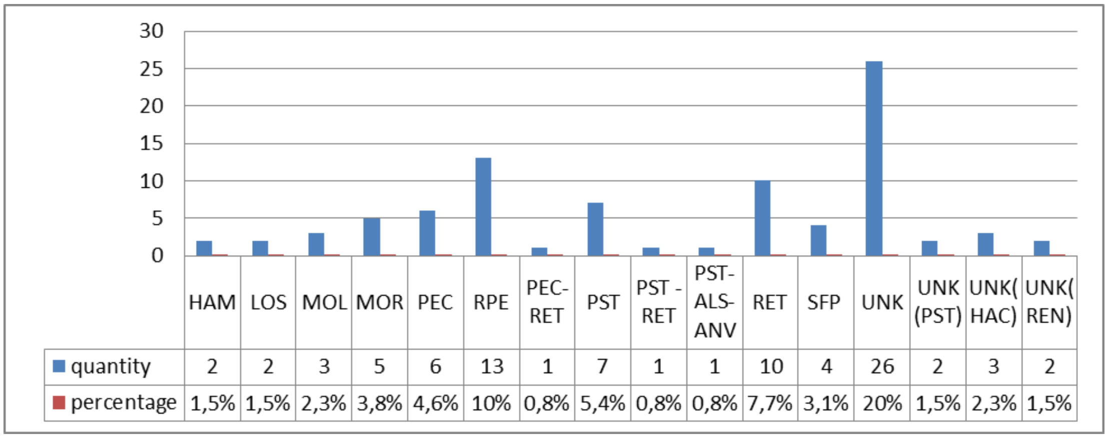
Most of the finds have not been published. Exceptions are anthropomorphic figurines and some macro-lithic tools. Polished edge tools, hammers and perforated tools were analysed typologically. The results suggest typological and chronological parallels with the Early and Late Neolithic cultures (Joanović 2003).

A preliminary study indicates manufacturing of pottery using ground shells as clay temper (Antonović 2003: 61) as one of the productive activities developed in the site. It can be also said that a large number of the tools with traces of secondary modifications (UNK) and flakes knocked off from polished edge tools (LAS) suggests manufacturing of macro-lithic tools within the settlement (fig. 3.9 a,b). The absence of information on other finds complicates the reconstruction of the economy of this settlement. Vicinity of a river and the Vršac mountain can indicate fishing and hunting, while suitable conditions for agriculture and herding can be also



	ADZ	ALS	ALS?	ALS-PIA	ANV	APE	CHI	HAC	REN	IND	LAS
🟦 quantity	2	6	2	1	1	1	3	7	4	1	14
🟥 percentage	1,2%	4,6%	1,5%	0,8%	0,8%	0,8%	2,3%	5,4%	3,1%	0,8%	10,8%

Fig.3.9.a Potporanj: macro-lithic objects,graph 1; N= 130.



	HAM	LOS	MOL	MOR	PEC	RPE	PEC-RET	PST	PST - RET	PST-ALS-ANV	RET	SFP	UNK	UNK (PST)	UNK(HAC)	UNK(REN)
🟦 quantity	2	2	3	5	6	13	1	7	1	1	10	4	26	2	3	2
🟥 percentage	1,5%	1,5%	2,3%	3,8%	4,6%	10%	0,8%	5,4%	0,8%	0,8%	7,7%	3,1%	20%	1,5%	2,3%	1,5%

Fig.3.9b Potporanj: macro-lithic objects,graph 2; N= 130.

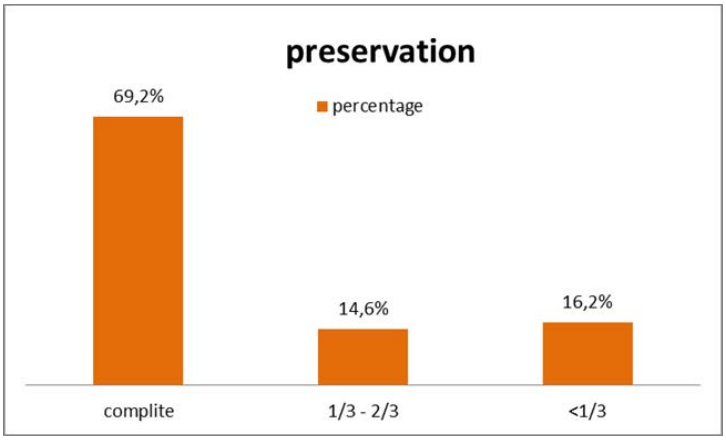


Fig.3.10. Potporanj: preservation; N= 130.

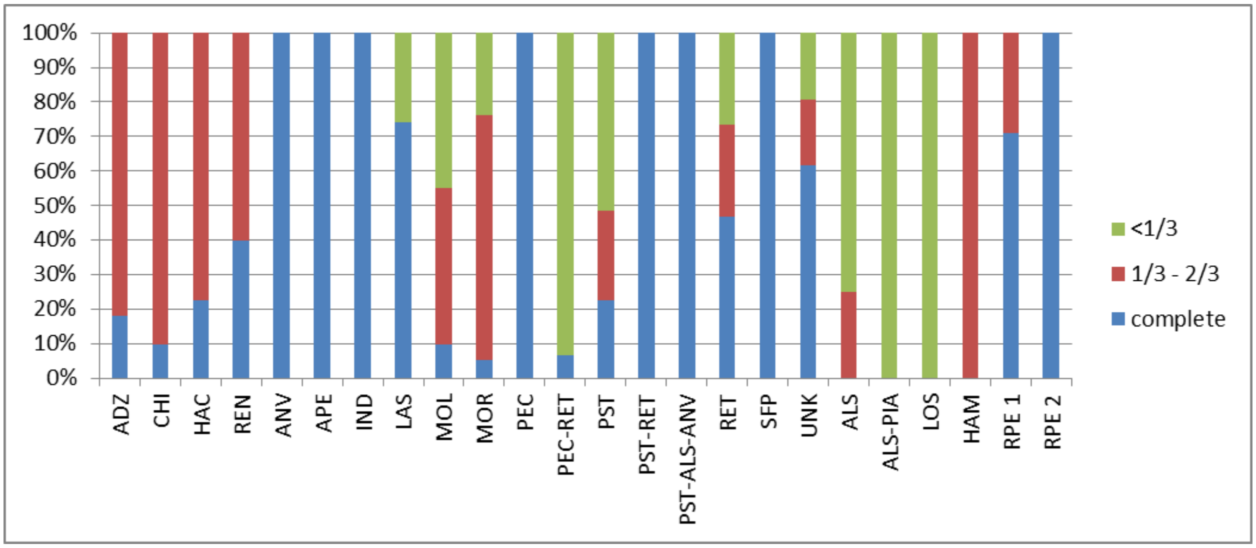


fig. 3.11. Potporanj: preservation of tools according to type; N= 130.

expected. These were important economic activities taking into account the size of the settlement and consequently a large number of inhabitants.

3.1.3. Jela, Benska bara, Šabac

The site of Benska bara was located in the center of the town of Šabac and presented its highest point, with an altitude of 82,67 m a.s.l.. However, the site has been destroyed due to the development of the town (fig. 3.12).

It is assumed that the inhabitants of the Neolithic settlement probably occupied a river island surrounded by the Sava and Kamičak rivers. The soils in the area are formed by loess and prehumus (Васиљевић 1963: 121; Трбуховић, Васиљевић 1983: 26) (Fig. 3.12). This site was discovered in the second half of the 19 th century. C. 1900 m² were investigated between 1962 to 1970 in the course of preventive

Fig. 3.12. Benska bara: position of the site, military topographic map section Valjevo 1, 1 : 50 000.

excavations. Cultural layers of 2,5 m thickness and several occupation phases were excavated: the Early, Middle and Late Neolithic, the Middle Eneolithic, the Early Bronze Age, the Early and Late Iron Age. However, observations suggest that stratigraphy was partly disturbed (Трбуховић, Васиљевић 1983: 26; Stojić, Cerović 2011: 148).

Chronologically sensitive finds such as anthropomorphic figurines, pottery and prosopomorphic lids, indicate a long lasting occupation during the Late Neolithic period, spanning the Vinča – Tordoš I-II, the Gradac and probably the beginning of the Vinča – Pločnik phase These phases correspond to Vinča A - B and partly to Vinča C (proposed by Borić, Borić et al.2018: 337). The finds from the Early Neolithic, Baden culture and Early Iron Age are sporadic. Most of the chronologically sensitive material belongs to the Vinča culture, with elements of the Potiska culture and maybe the Sopot, Lengyel and Butmir cultures to a lesser extent (Stojić, Cerović 2011: 152 ,153; ibid 2011: 155,156, 160, sl. 75- 79, 83 – 87, 162 – 164, 168 - 171). In the lines below, we will focus on the contexts of the Vinča culture horizons. As the material has not been defined in detail chronologically and stratigraphicaly, it is treated as a whole.

Semi-buried dwellings were detected in the early phase of the Vinča culture and above-ground dwellings in the Late Vinča period (Трбуховић, Васиљевић 1983: 26).

The finds from this site have been published in the edition «Cultural strategy of Prehistoric sites of Šabac region»[4] and presented according to archaeological units (squares and arbitrary layers), due to partly disturbed cultural layers (Stojić, Cerović 2011:148). Thus, we present the analysed stone artefacts following the same scheme, which however, does not allow to fix the stratigraphic position of 71 objects out of 338 artefacts. In any case, all the artefacts belong to the Vinča culture. However, the studied assambledge represents only a part of the macro-lithic collection. Grinding slabs and handstones have been mentioned in a report published in 1963 (Васиљевић 1963). Furthermore, we had limited access to material because most of the finds have never been unpacked and classified after excavations. This material was not accessible during our investigation.

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[4] This publication is part of a series of publications aiming to present unpublished movable finds stored in the museums of Serbia.

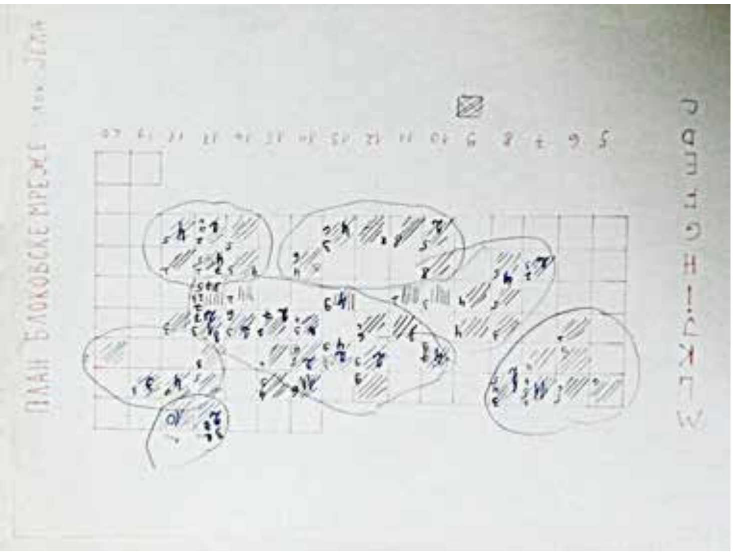

Fig. 3.13. Benska bara: plan of block net, excavations1970.Documentation of National museum of Šabac, Šabac.

A pit in a square G/9 produced Late Neolithic pottery and a celt (REN, L - BB – 30) (fig. 3.14) (Stojić, Cerović 2011: 156). A flake (LAS, L - BB – 243) was found in a pit, in square HI/10. The Late Neolithic house in square HI/18 yielded a semi-finished product (SFP, L - BB - 219), a fragmented amphora and anthropomorphic figurines. Pit 21 produced a coarse-grained abrader (ALS, L – BB – 334) (idem 159, 160). Square I/16 revealed a pit with a coarse-grained abrader (ALS, L - BB – 105) (fig. 3.14). A house in square L /10 – 13 yielded a semi-finished product (SFP, L - BB – 228), fragmented pottery, antropomorhic figurines, a bone awl and a fragmented bone needle (fig. 3.14) (ibidem 2011: 169).

The rest of the analysed objects (73,7%) were found in squares A/5 -7, B/ 2,3, 5,6, C/9, CD/1, D/9, E/8, L/6,7 and M, G (lines 6,8,10-12,14,15,17-19), H and HI/18 (lines 6,7, 12-17,19), I (lines 5 -10), K (lines 11- 14, 17-19) and J (lines 9 - 18, 20)
and L (lines 5,6,8,9-15,18,19) (fig. 3.14) [5].

The analysis of the finds according to the suggested stratigraphy of the Vinča settlement, have not been done yet, thus the material is treated as a whole. We have analyzed 338 artefactsts found in 1962, 1967 and 1970. Many are percussion tools (re-used polished edge tools -RPE 1, perforated mattocks -MTT, hammers –HAM, a hammer- pestles - HAM-PST and a retouching tool - hammer - RET-HAM), tools with traces of secondary modifications (UNK), polished edge tools (axes - HAC, celts – REN, the adzes – ADZ, chisels - CHI) (fig. 3.14 a, b).

Most of the finds are complete, suggesting low detrition (fig. 3.15). Many are tools with traces of secondary modification (UNK) and celts (fig. 3.16).

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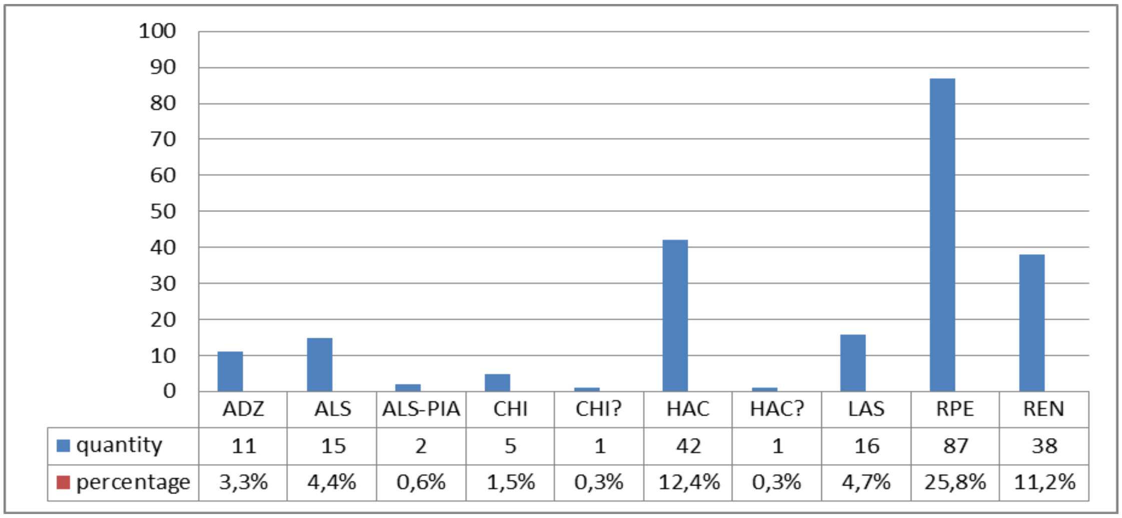
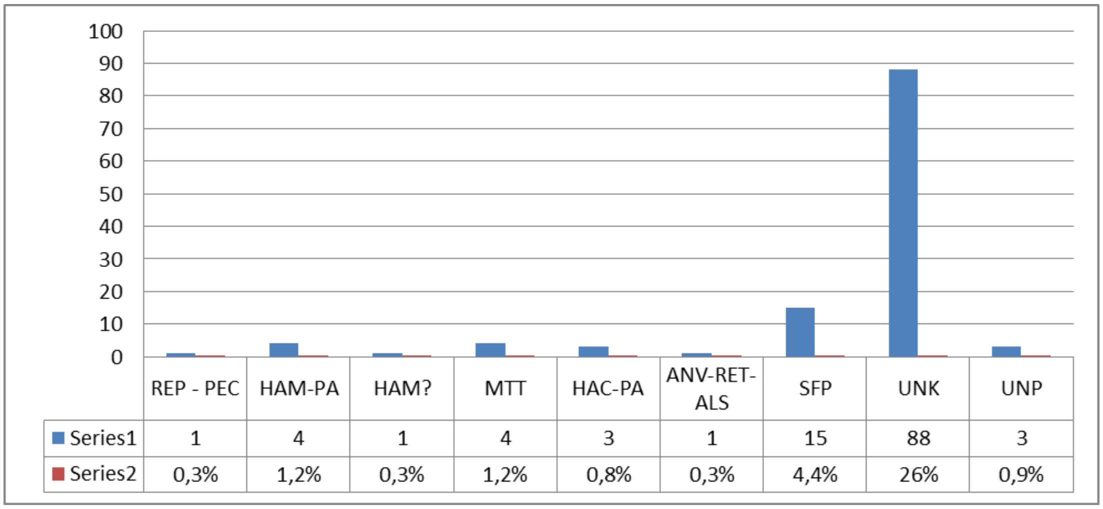
[5] Documentaion of National museum of Šabac, Šabac.



	ADZ	ALS	ALS-PIA	CHI	CHI?	HAC	HAC?	LAS	RPE	REN
■ quantity	11	15	2	5	1	42	1	16	87	38
■ percentage	3,3%	4,4%	0,6%	1,5%	0,3%	12,4%	0,3%	4,7%	25,8%	11,2%

Fig.3.14a. Benska bara: macro-lithic objects,graph 1; N= 338.



	REP - PEC	HAM-PA	HAM?	MTT	HAC-PA	ANV-RET-ALS	SFP	UNK	UNP
■ Series1	1	4	1	4	3	1	15	88	3
■ Series2	0,3%	1,2%	0,3%	1,2%	0,8%	0,3%	4,4%	26%	0,9%

Fig.3.14b. Benska bara: macro-lithic objects,graph 2; N= 338.

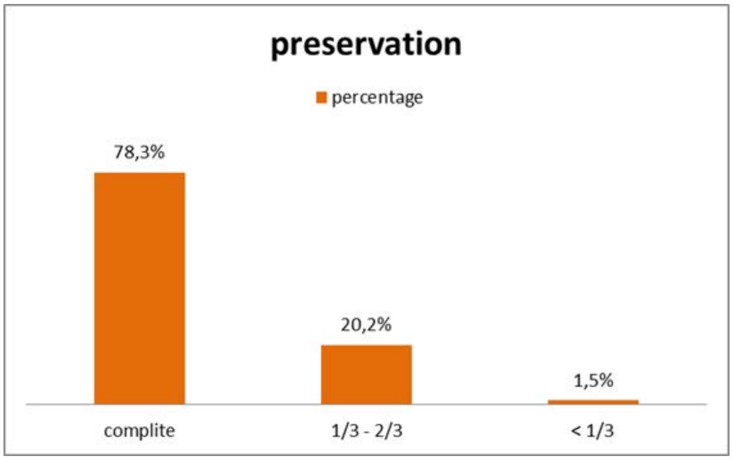


Fig.3.15. Benska bara conservation; N=338

No specific analysis of the economic organization of the settlement has been proposed so far, although it probably represented a typical Late Neolithic community (Васиљевић 1963).

Since then, the finds have not been analysed again. Topography indicates that this settlement occupied a peninsula, well defended by river courses. Moreover, we suppose that life and economy were focused mostly on the rivers, which enabled also easy transport and communication with remote areas. Observations also show intensive use of re-used polished edge tools (RPE) (fig. 3.15a), a type of percussive tools, which was also employed in a certain number at Potporanj (fig. 3.6b). This indicates similarities in the economy of both settlements, which are also placed in similar environmental contexts. The semi-finished products among which an axe L - BB – 156 and celts L - BB – 125, 151 have been recognized (SFP), tools with traces of secondary modifications (UNK) and flakes knocked off from polished edge tools (LAS) are indicative of the manufacturing of the macro-lithic tools within the settlement (fig. 3.15a, b).

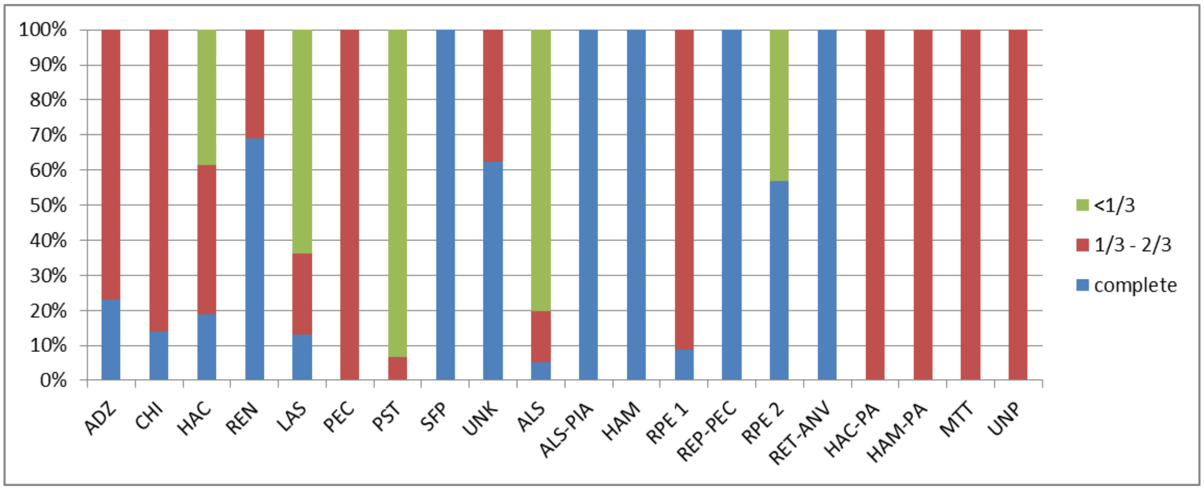


fig. 3.16. Bensak bara: preservation of tools according to type; N=338.

3.2. Central region

3.2.1. Dunjićki šljivari, MeĎureč– Jagodina

The site of Dunjićki šljivari covers several hectares on a gentle slope, 2 km to the north of the village of MeĎureč (fig. 3.18). The site was discovered in 2003.

The excavation of trench I (36 m²) during 2007[6] confirmed the existence of a single layer Early Neolithic settlement (c.5900 cal.BC) The thickness of a cultural layer varies from 0,60 to 2 m. It produced remains of a semi-buried dwellings (fig.3.19,20)[7] pottery, animal bones, bone tools and chipped stone tools and 25 pieces of crystal rock (Perić 2009).

The 71 objects analysed from this settlement correspond to various tools types, although different abrasive tools (coarse-grained abraders – ALS, abrasive slabs-LOS, fine-grained abraders, ALS-PIA) and retouching tools (RET) represent the most common artefacts (fig. 3.21).

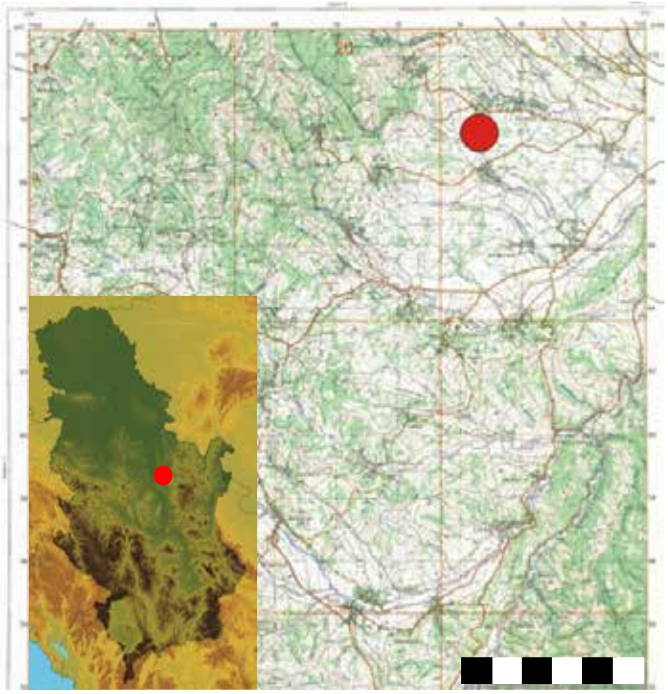


Fig. 3.17. Dunjićki Šljivari, Medjreč: position of the site, military topographic map section Kruševac 3, 1 : 50 000.

Slightly more than half of the studied material is broken and fragmented, suggesting an intensive use (fig. 3.22). High levels of fragmentation are provided by celts (REN), retouching

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[6] The excavation was carried out by Institute of Archaeology as part of the project "Permanent archaeological workshops – middle Morava valley in Neolithisation of SE Europe".
[7] Personal comunication of Slaviša Parić, director of the excavations at the Dunjićki šljivari site, in 2007.

Fig.3.18. Dunjićki šljivari, Medjureč: excavations in 2007.; Pfoto documentation Archaeological institute, Belgrade.

Fig.3.19. Dunjićki šljivari, Medjureč: excavations in Trench I; Photo documentation Archaeological institute,

tools (RET) and pestles (PST), retouching tools (by pressure) (REP), tools with the traces of secondary modifications (UNK) and fine-grained abraders (ALS-PIA, ALS-PIA?) (fig.3.23).

Complete objects are mainly unused raw material (IND), semi-finished products (SFP, SFP?) and flake knocked of a polished edge tool (LAS) (fig.3.23).

Most of the archaeological material of this site has not been analysed and published. Thus, insufficient data does not allow to reconstruct the Neolithic economy of the settlement of Medjureč. Topographic characteristics suggest various activities sich as crop growing, herding as well as exploitation of wild resources. The results of functional analysis of macro-lithic tools, which were incorporated and presented in our unpublished master thesis, suggest that these artefacts were used mainly for processing materials such as wood, bones, stone and probably food grinding. Finds of semifinished products (SFP) and tools with traces of secondary modification (UNK) and flakes knocked of tools off polished edge tools (LAS) confirm manufacturing and re-making the tools of polished edge tools at the site (Живанић 2010: табла 29 - 31).

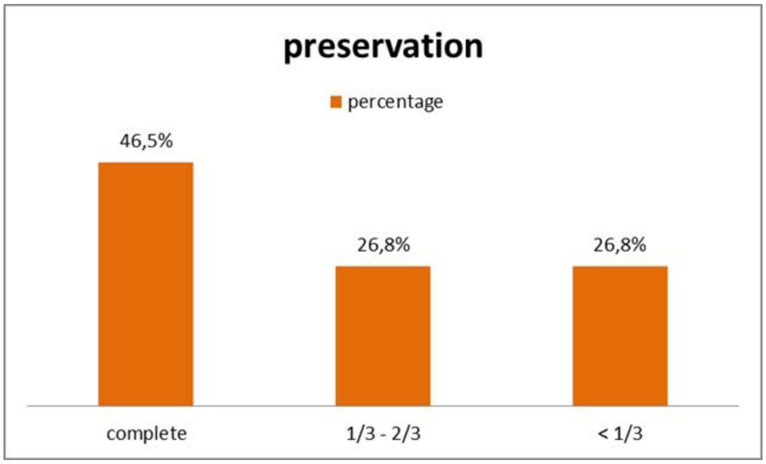


Fig.3.21. Medjureč: preservation of the macro-lithic tools; N=71.

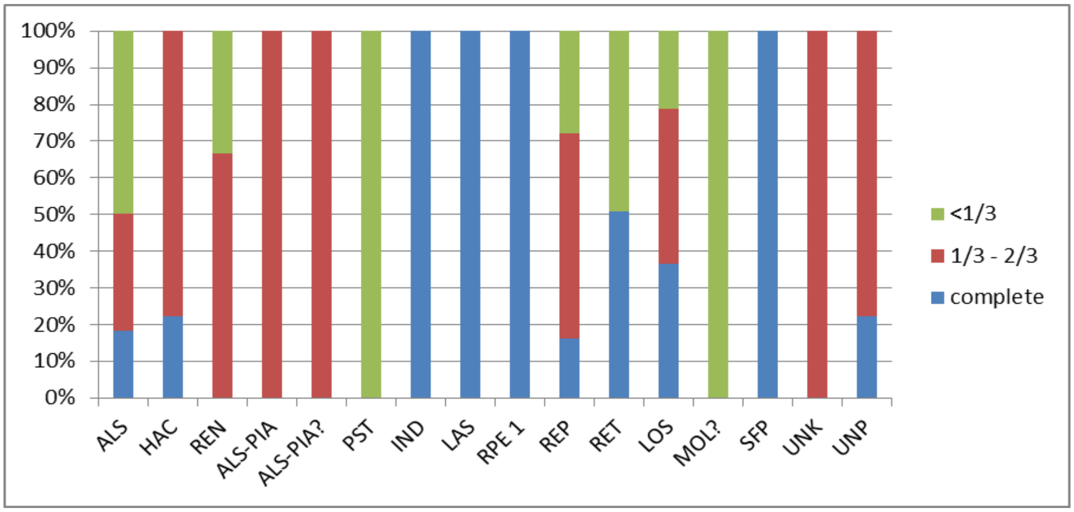
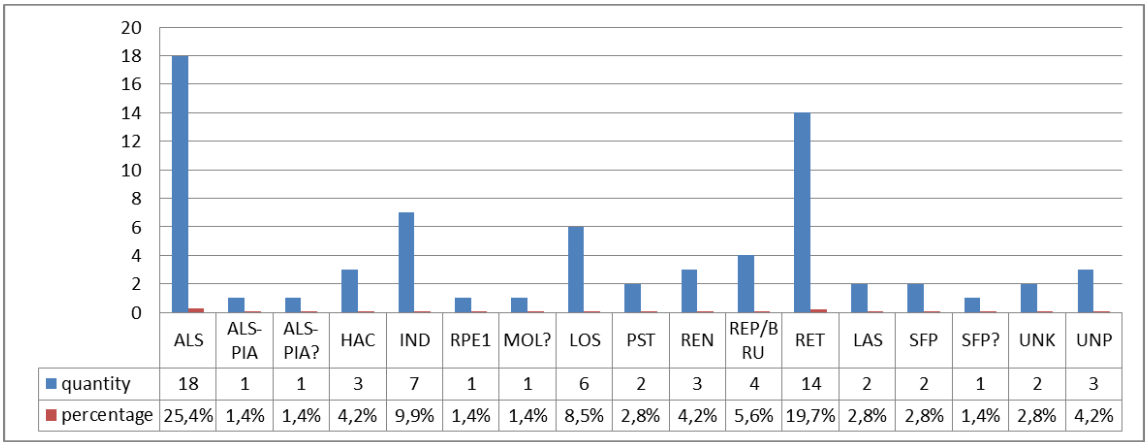


Fig. 3.22. Medjreč: preservation of tools according to type; N=71.



	ALS	ALS-PIA	ALS-PIA?	HAC	IND	RPE1	MOL?	LOS	PST	REN	REP/BRU	RET	LAS	SFP	SFP?	UNK	UNP
🟦 quantity	18	1	1	3	7	1	1	6	2	3	4	14	2	2	1	2	3
🟥 percentage	25,4%	1,4%	1,4%	4,2%	9,9%	1,4%	1,4%	8,5%	2,8%	4,2%	5,6%	19,7%	2,8%	2,8%	1,4%	2,8%	4,2%

Fig.3.20. Medjureč: the macro-lithic objects; N= 71.

3.2.2. Turska česma, Slatina, Drenovac – Paraćin

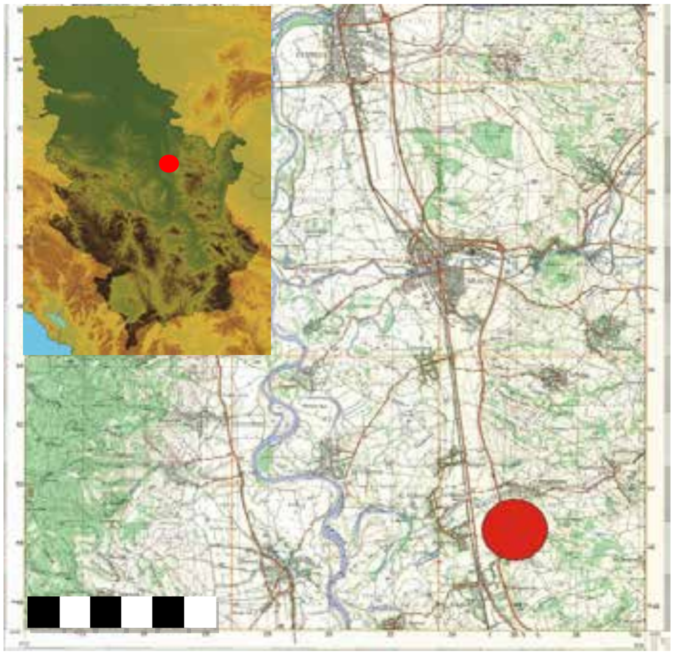


Fig. 3.23. Turska česma, Slatina: position of the site, military topographic map section Kruševac 4, 1 : 50 000.

The site of Turska Česma, Slatina is situated c. 10 km south of Paraćin, near the village of Drenovac and 3.5 km eastern from the Velika Morava River (fig.3.23, 24) and occupies an area of more than 40 ha. It is separated by the highway Belgrade–Niš, in two topographic units. The eastern hilly area turns down as a gentle slope toward the west, to the plain around the Velika Morava River. A dried river bed of the Drenovac stream, oriented in the east-west direction, with two springs in its vicinity, lays at the eastern part of the settlement (fig. 3.24).

Fig.3.24.Turska česma, Slatina: the southeast part of the site Photo documentation: Regional museum Paraćin.

The site was first recorded in 1966. An area of c. 1100 m^2 was excavated on several occasions between the 1960`s and the present day. The cultural layer, which has a maximum thickness is of 6,7 m, produced the Early and Late Neolithic horizons (6100–5900 cal.BC and 5300–4700/4500 cal.BC). Geomagnetic surveys were carried out in parallel with further excavations undertaken between 2008 and. 2013. This survey identified 189 anomalies, that might correspond to debris from structures or houses measuring c.5–7m x 10–12m. They extend over an area of 10ha. Taking into account surface finds and the geomagnetic anomalies, the settlement of the latest Vinča phase has been estimated to include c. 700 structures or houses. The majority of structures are oriented south-west to north-east. Researched areas show regular as well as irregular distributions of anomalies. Regular areas represent houses, which are set in parallel rows, with 2–6m between structures and up to 10m between rows, suggesting the presence of streets. This spatial organisation resembles urban settlements. This research also resulted in the discovery of ditches. The largest ditch, interpreted as a boundary, was identified along the western limit of the settlement, with a second, smaller ditch parallel to it. A small curvilinear anomaly might be a minor ditch encircling a sub-section of the north-eastern part of the settlement (Perić *et al*. 2016**;** Perić 2017). A semi-buried dwelling has been detected in the Early Neolithic horizon, while above-ground dwellings were characteristic of the Late Neolithic (Vetnić 1972: 125 - 139; Perić 2008: 29 - 44).

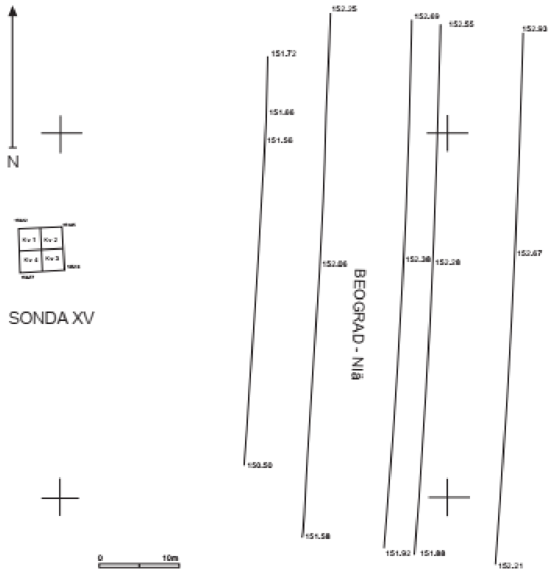


Fig. 3.25. Turska česma, Slatina: position of trench XV in relation to the Belgrade - Nis highway (Perić 2008: 30, fig.1)

Trench XV (36 m^2) explored an area in the western part of the settlement between 2004 and 2006 (fig. 3.26). This

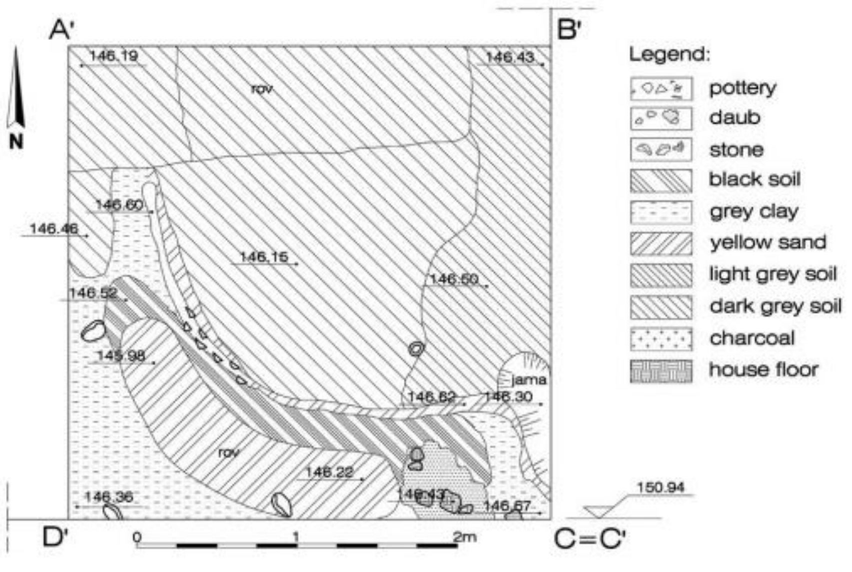


Fig. 3.26. Turska česma, Slatina: Trench XV, base of quadrant 3 with layer of yellow sand(Perić 2008: 30, fig.1)

exploration confirmed the continuation of the Early and Late Neolithic layers (Perić 2008: 44).

Most of the Early Neolithic finds were concentrated on the bottom of the semi- dugged dwelling near the western cross-section of quadrant 3 in the southern part of the trench XV. This horizon yielded fragments of bowls and pots. The number of decorated pottery fragments is very small and mainly includes impressa technique with the wheat grain motif. Single or double application or incised lines are found sporadically. The other finds consisted of fragments of clay bracelets and of partly damaged clay amulets (Perić 2008: 38; Plate I-II 1-12,13; III, IV, 1-2, 13; Plate V, 4a, 7 3, 5-13). This semi -dugged structure revealed macro-lithic tools such as a coarse-grained abrader – anvil (ALS-ANV, L - Dr – 169) a retouching tool (by pressure) (REP, L - Dr – 186) and three weights for fishing nets (WFN).

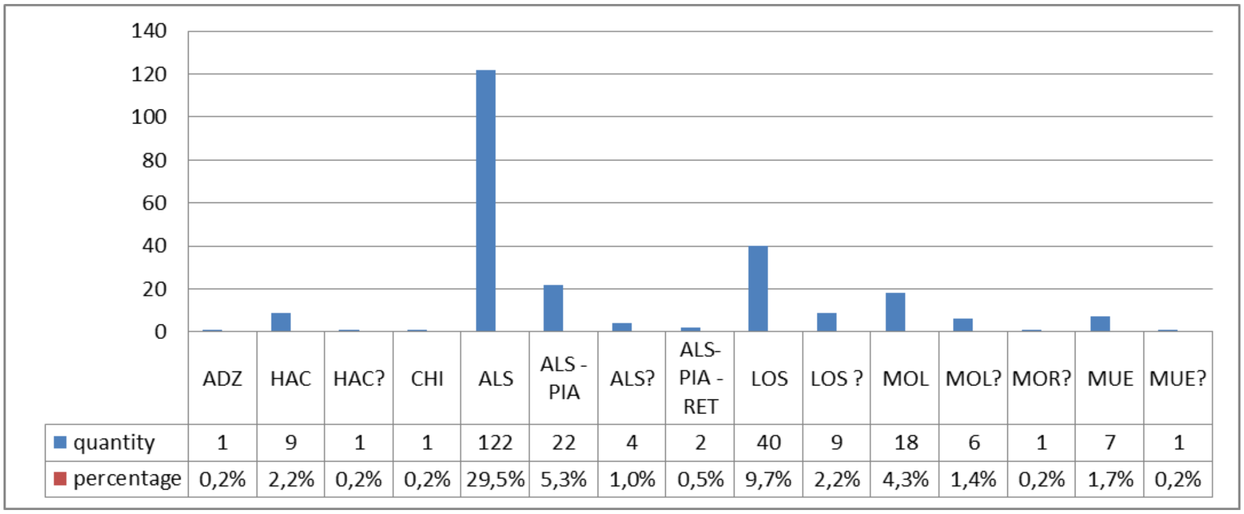
The latest Late Neolithic horizon produced remains of Hause 1, measuring 2,33 × 2,10 m (arbitrary layer 9). This feature was partly recovered, as its eastern part was under the eastern profile of the trench. An abrasive slab (LOS, L - Dr – 1) and a tool with traces of secondary modifications (UNK, L - Dr – 15) few bone needles and awls (Vitezović 2007) were detected in the space around the building.

The earliest Late Neolithic horizons presented remains of the above-ground objects, including ground floor, burnt daub, ash and charr, a hammer (HAM, L - Dr – 111) a tool with traces of secondary modification (UNK, L - Dr – 113) and one anvil (ANV, L - Dr – 109) a fragmented, ritual *clay bread*, pottery, animal bones, and chipped stone tools. The early horizons of the Late Neolithic in trench XVI (67 m^2), placed east of the high-way, included pit, marked as unit 172. This feature produced a weight for fishing nets (WFN, L - Dr – 342), a grinding slab (MOL, L - Dr – 381) and various objects made of different materials such as a clay bead, altars, a clay weight, an obsidian blade, a blade, scapers, a core as well as a bone awl, and an astragalus. The bottom of the pit marked as unit 143 presents a concentration of material which represents its original content. This object includes coarse-grained abraders (ALS, L - Dr – 379 and L - Dr – 369), a clay weight, amulets, clay objects of the unknown purpose, a foot of a clay table as well as a blade and a scaper.

The pit produced a coarse-grained abrader (ALS, L - Dr – 344), and fragmented pottery, clay objects such as a bead, anthropomorphic figurines etc.

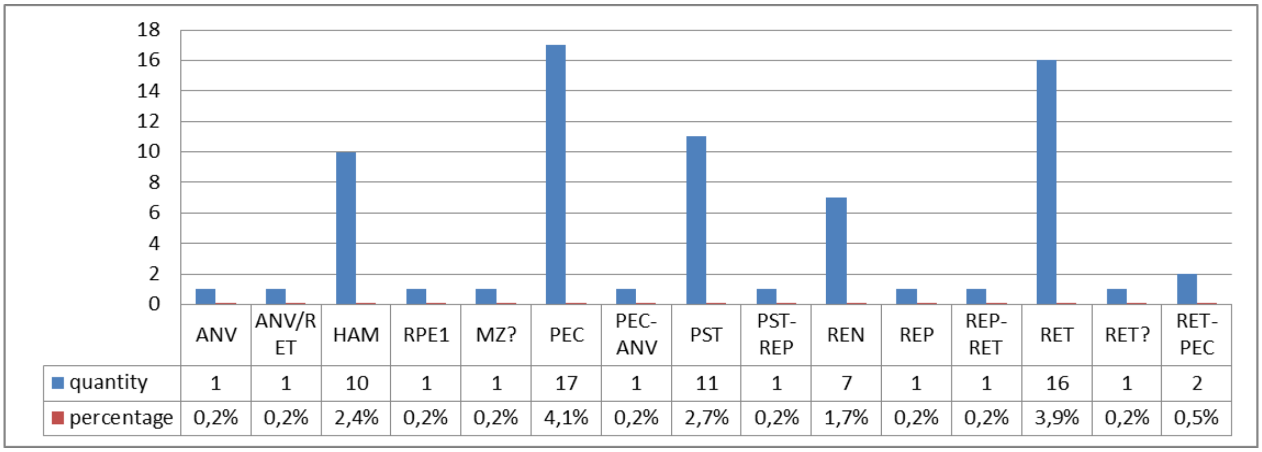
The late Vinča horizon in the northwestern part of trench produced a house with remains of its southeastern wall, which layed in a north-south direction. Only part of this object was uncovered, while the rest was visible under the southwestern profile. In the southwestern part, this feature has been intersected by large pit, measuring: 3,53 x 2,50 m.

The latest horizon produced remains of a burnt construction. This house revealed grinding slabs, found *in situ,* in the vicinity of an oven, suggesting a space purposed for food preparation (Perić et all. 2013). However, all massive stone objects, such as grinding slabs and mortars, reminded in their original position on the excavation. In the frame of archaeological interventions, the whole house was removed and pecked for its future exhibition. Thus, these finds were not accessible for our examination. The house produced slabs (LOS, L - Dr – 258 and



	ADZ	HAC	HAC?	CHI	ALS	ALS - PIA	ALS?	ALS- PIA - RET	LOS	LOS ?	MOL	MOL?	MOR?	MUE	MUE?
🟦 quantity	1	9	1	1	122	22	4	2	40	9	18	6	1	7	1
🟥 percentage	0,2%	2,2%	0,2%	0,2%	29,5%	5,3%	1,0%	0,5%	9,7%	2,2%	4,3%	1,4%	0,2%	1,7%	0,2%

Fig. 3.27a. Turska česma, Slatina: macro-lithic tools, graph 1; N= 416.



	ANV	ANV/RET	HAM	RPE1	MZ?	PEC	PEC-ANV	PST	PST-REP	REN	REP	REP-RET	RET	RET?	RET-PEC
🟦 quantity	1	1	10	1	1	17	1	11	1	7	1	1	16	1	2
🟥 percentage	0,2%	0,2%	2,4%	0,2%	0,2%	4,1%	0,2%	2,7%	0,2%	1,7%	0,2%	0,2%	3,9%	0,2%	0,5%

Fig.3.27b. Turska česma, Slatina: macro-lithic tools, graph 2; N= 416.

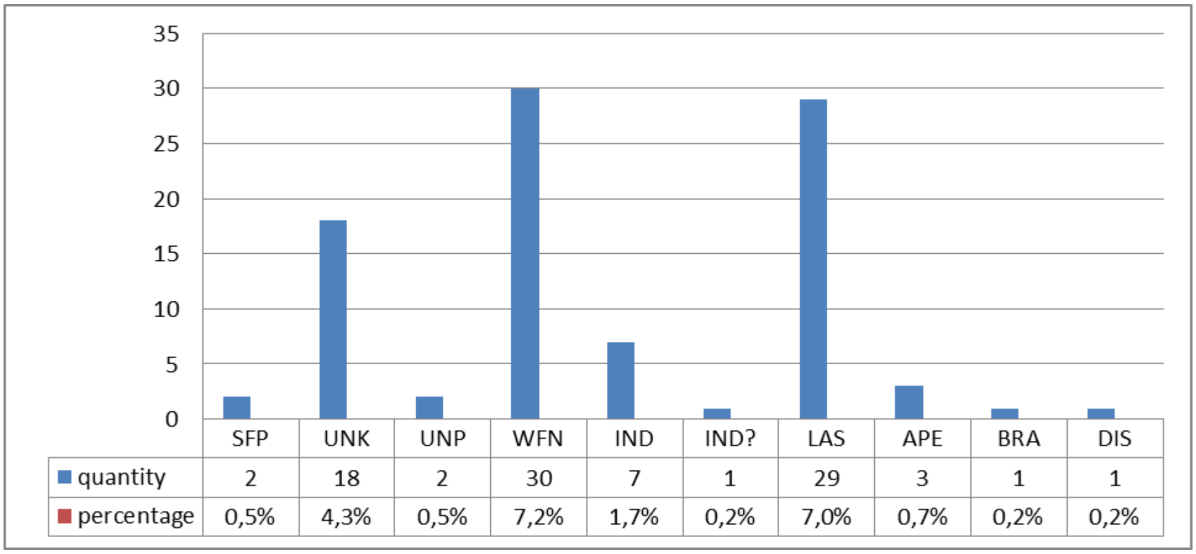


Fig.3.27c. Turska česma, Slatina: macro-lithic tools, graph 3; N= 416.

L - Dr – 259) and a coarse-grained abrader (ALS, L - Dr – 207) were detected at a relative depth of 0,85 m. These items were associated with a clay weight, a bone tool as well as a broken artefact, which we assume was part of a mortar (MOR?, L- Dr – 211). The fragmentation does not allow us a precise determination.

The Early Neolithic layer produced a small number of tools (n=5), while the rest of the studied material has not been defined stratigraphically and chronologically in detail; thus, we will study all the materials as one complex.

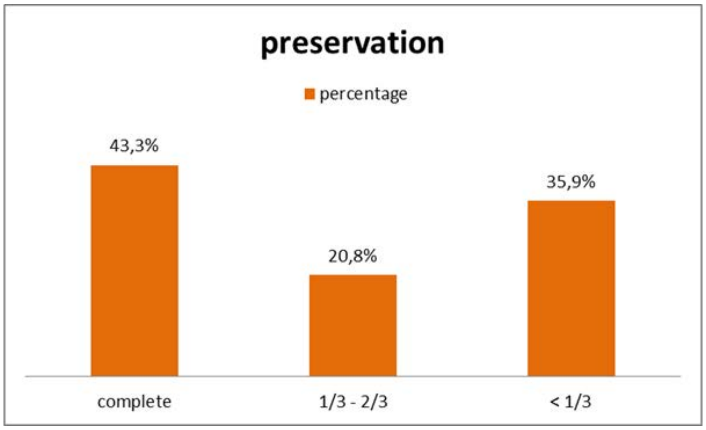


Fig.3.28. Turska česma, Slatina: preservation of the macro-lithic objects; N=416.

In total, we have analyzed 416 objects from this settlement, coming from the excavations carried out in 2004 – 2007 and 2011.

Most of these items are abrasive tools[8], weights for fishing nets (WFN),

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[8] coarse-grained abraders – ALS, abrasive slabs-LOS, fine-grained abraders, ALS-PIA;

percussion tools[9], grinding stones (MOL), and polished edge tools[10] (fig. 3.28 a -c).

Most of the artefacts are fragmented and broken, indicating their intensive use (fig. 3.29). Many are tools with abrasive surfaces, including grinding slabs (MOL, MOL?), a possible mortar (MOR?), handstones (MUE), abrasive slabs (LOS, LOS?), and fine-grained abraders (ALS-PIA) and percussion tools[11] (fig. 3.30a, b).

The group of the complete objects includes mainly polished edge tools (an adze - ADZ and celts - REN), coarse-grained abraders (ALS), anvils.[12] and flakes knocked off from polished edge tools (LAS) (fig. 3.30a, b). This result concerning fragmentation can be caused by a systematical collection of the finds, which was followed during systematic excavations[13].

The finds from Turska česma, Slatina have been partially analysed and the record suggests various economic activities. The functional analysis of bone and macro-lithic tools found during the excavation carried out from 1968 to 1972[14] and from 2004 to 2006[15] indicate processing of leather, food, weaving and spinning, interweaving ropes, fishing, hunting, wickerwork, soil cultivation, and the working on wood, stone and clay (Vitozović 2007; Живанић 2010, табла 14 - 18).

The Early Neolithic chipped stone artefacts present an expedient industry based on the available raw material. Small numbers of exotic items made of flints coming from the Moesian platform and from Ludogorie (north Bulgaria) are imports introduced from the east but are too few to confirm a developed exchange network (Gurova 2016: 51).

Functional analysis of chipped stone artefacts reveals a high proportion of sickle elements, suggesting agricultural practices. The practice of Early Neolithic agriculture on the site is supported by the palaeo-botanical data, such a small number of domestic crops, mainly cereals and pulses. The same cereal spectra, and a higher proportion of pulses (as well as flax) are recorded in the Vinča layers. This data is consistent with the presence of a larger number of sickle elements in

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[9] percussive tool –PEC, hammers - HAM, retouching tools – RET, retouching tool- hammer- stone- RET-PEC, pestle-PST;

[10] axes -HAC, adzes - ADZ, celts – REN;

[11] hammers – HAM, percussive tools- PEC, a pestle – PST, retouching tools – RET and a fine-grained abrader– retouching tool ALS-PIA – RET;

[12] an anvil – ANV, an anvil – retouching tool -ANV-RET and a percussive tool – anvil – PEC-ANV;

[13] This conclusion is based on our participation in the excavation.

[14] Documentation of the excavations carried out during 1968 to 1971 is missing and did not allow insight of cutural development of the Neolithic settlement (Vitozović 2007).

[15] Bone tools found during campaings 2004 – 2006 did not show cultural and chronological differences and have been analysed all together (Vitozović 2007).

the later (Vinča) phases of Drenovac. The density of the structures would not have allowed place for garden plots. Residential and associated activities were allocated to the space enclosed by the ditches. The size of the settlement and its presumed population indicate that arable land must have been located beyond the settlement (Perić 2017).

It has also been concluded that the Early Neolithic population practiced husbandry, collected wild plants and river sources, and hunted wild animals (Gurova 2016: 54, Figs. 12–16; Table 4 and 7; Stojanovic, Obradovic 2016: 92).

The results of the zoo-archaeological analysis of over 5,000 identified specimens (NISP[16] = 5149) from the Late Neolithic horizons show that domestic species represented c.

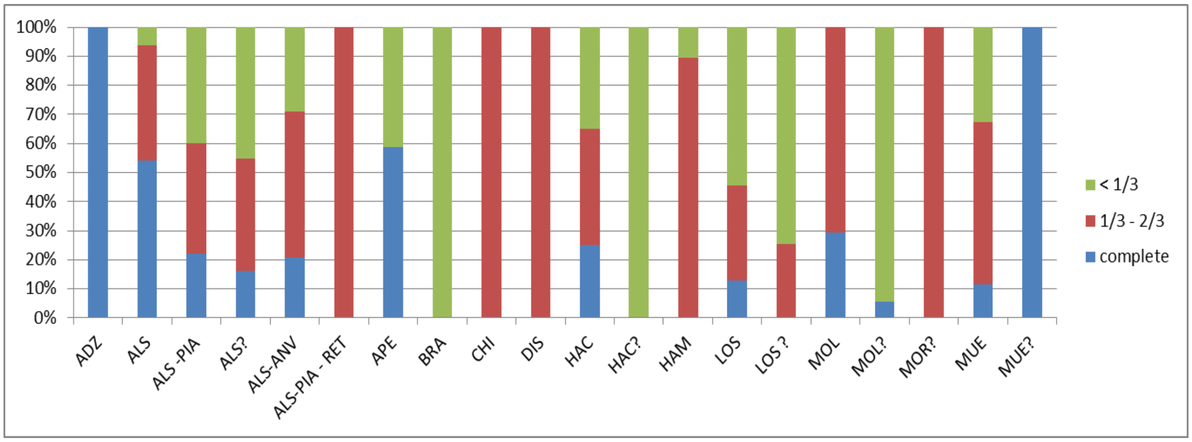

Fig.3.29a. Turska česma, Slatina: preservation of tools according to type; N=416.

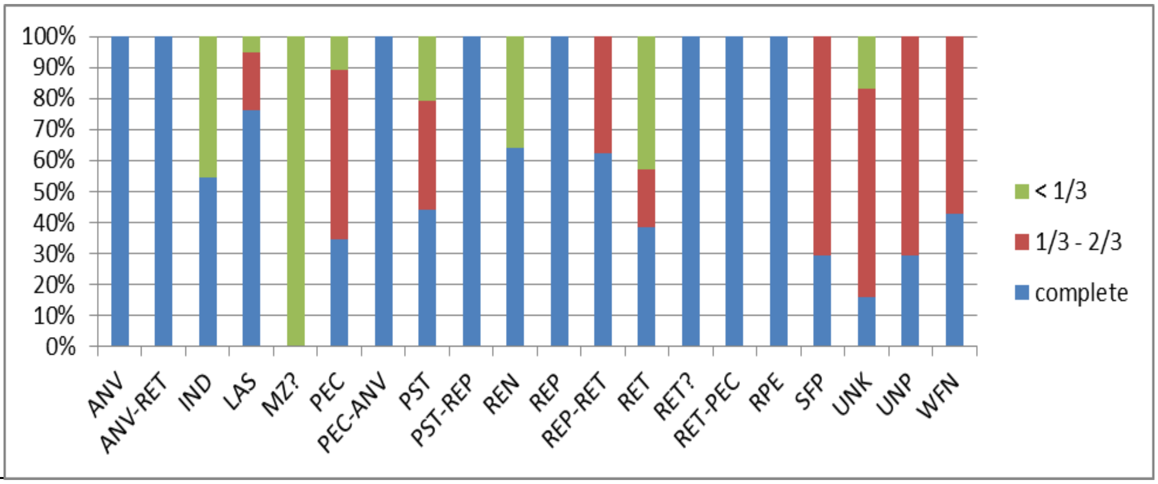

Fig.3.29b. Turska česma, Slatina: preservation of tools according to type; N=416.

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[16] Nur

85%. The record shows cattle was the most common domestic animal with c.30 %. Caprines are presented in slightly less percentage, and are followed by domestic pigs. Among the wild species, remains of deer and wild boar are the most numerous, while roe deer, wolf, wild cattle, beaver, bear, fox, badger and wild cat have been registered in a small number. According to the relative representation of species, as well as to the analysis of the age of the most economically important animals, it could be concluded that the economic strategies in the Late Neolithic settlement of Turska česma, Slatina relied on the breeding of domestic animals (both large and small cattle), while that hunting had a minor imortance during the Late Neolithic[17].

These results are coherent with the topography and the environmental context. The fertile plain and the course of the Velika Morava river towards the west, offered important food sources for the inhabitants of Turska česma, Slatina, as well as for domestic and wild animals. Probably forested, the hilly area in the east was the home of wild animals and a source for wood. Springs and small, now dry river bed, which runs across the settlement, additionally supplied the inhabitants with fresh water.

3.2.3. Motel Slatina – Paraćin

The archaeological site of Motel Slatina is located 1.5 km to the east of the town center of Paraćin. The site covers an area of c. 40-50 ha on a gentle slope, between the Karadjordje Hill, on the north and the Crnica River to the south. Its western border is marked by the Serbian Glass Factory, and its eastern border by the Glavica suburb and its cemetery (fig. 3.31,32).

The site was first registered in 1961 (Vetnić 1974: 139). Excavations were carried out during the 1960s, in 1985 – 1986, during the 1990s and at the beginning of this century. In total, an area of c. 900 m² has been explored. The cultural layers belong to the Roman period, the Early Iron Age, and the Late and Early Neolithic (5400/5300 - 4650/4600 cal.BC;

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[17] Stojanović, I.: Economic and Social Importance of Animals in Vinča Settlements in the Middle Morava Valley, Ph.D thesis, Archaeology department, Faculty of Philosophy, University of Belgrade. writing in progress.

c. 5900 – c. 5400 cal.BC). The research carried out at the beginning of this century enabled to distinguish three Late Neolithic horizons, which also represent three development phases of this settlement (Vetnić 1972; Srndaković 1994; Madas1988; Перић 2002).

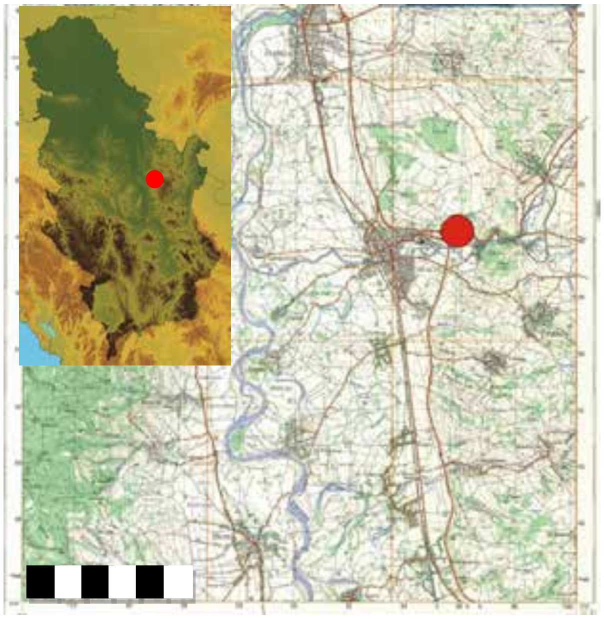


Fig. 3.30. Motel Slatina, Slatina: position of the site, military topographic map section Kruševac

The settlement is characterized by above-ground dwellings in younger, Late Neolithic strata (fig.3.33) and semi-digged dwellings in the oldest Late Neolithic horizons (fig.3.36). Above-ground structures were mainly recognized through the concentration of construction material such as stones, burnt daub and ground floor. These elements were either not homogeneous or the structures were only partly recovered due to the small size of trenches. Thus, it was not possible to determine the size of the above-ground features.


Fig. 3.31. Motel Slatina:the central part of the site; Photo documentation Hometown museum of Paraćin.

An area of c. 800 m² was explored between 1985 – 1986. In the following lines, we will present the analyzed objects found within the features discovered in this excavation campaign.

A structure with stone foundations, found in trench III revealed a tool with traces of secondary modifications (UNK, L - MS – 71) and an abundance of fragmented pottery.

An above-ground building O-5 with stone foundation (fig.3.33) was discovered in trench III-IV. This object produced a part of an oven foundation, made of a 2 cm burnt clay layer,

Fig. 3.32. Motel Slatina: trench 3-4, object 5, excavation 1985, Photo documentation of Hometown museum of Paraćin.

pottery, a large pot in vertical position, animal bones, one deer antler and burnet daub. This construction reveals a fragmented anthropomorphic stone figurine (FIG, L - MS – 18) a fragmented percussive tool (PEC, L - MS – 40), three fragmented fine-grained abraders (ALS-PIA, L – MS – 10, L – MS - 11, and L – MS – 14) of which the first two have grooved working surfaces and a celt (REN, L – MS – 55), with a working edge narrowed additionally by flaking.

Trench IV yielded structure O-4 with a stone foundation. This context included large vessels and a pestle (PST, L - MS – 48). Objects found in square D of the same trench included a coarse-grained abrader (ALS, L - MS – 6) and a perforated object of unknown use (UNP, L - MS – 64).

The oldest construction horizon in trench XI revealed a feature partly destroyed by fire and a concentration of finds within it. This concentration consisted of pottery fragments, animal

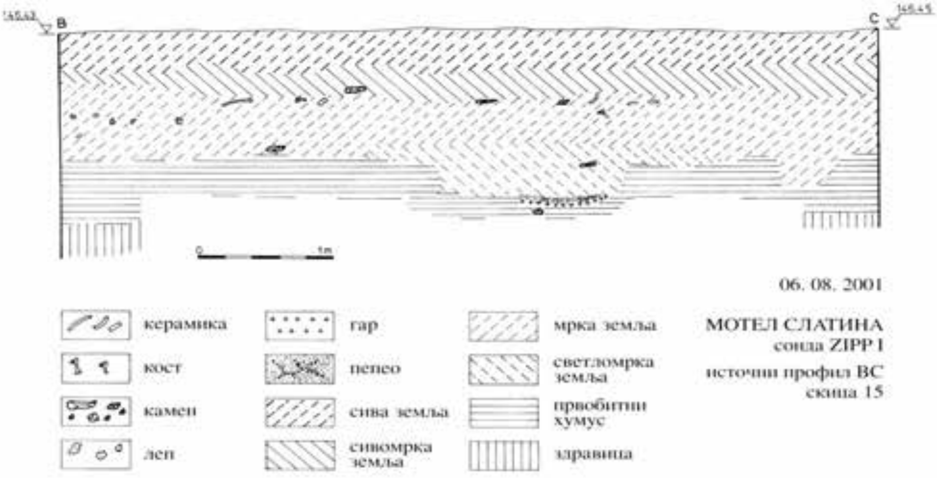


Fig. 3.33. Motel Slatina: trench ZIPPI, eastern cross-section BC; according to Перић 2003: 264,сл.1.

bones and a large vessel, remaining *in situ*. The central part of the trench produced burnt daub, stones, an adze (ADZ, L- MS – 1), two re-used polished edge tools (RPE2, L - MS – 33, and L - MS – 35), a maze (MZ, L - MS – 39), a hammer (HAM L - MS – 26), and a piece of sandstone, identified as raw material (IND). The same trench revealed pit 9 with two percussive tools (PEC, L - MS – 44, and L - MS – 45).

Trench ZIPP I (18 m^2) in the northern part of the settlement revealed a cultural layer of 1,80 m thickness, formed by two structural horizons (fig. 3.34). The older horizon produced burnt daub fragments and remains of above-dwelling with imprints of the wattle and a hearth. The remains of an aboveground dwelling with a hearth belong to the younger horizon. This horizon also produced large fragments of burnt daub with impressions of wooden elements. They were detected at 0.40-0.60 m of relative depth and concentrated along with the southern profile (Перић 2003 – 2004: 264) (fig. 3.34). Both horizons included abundant fragmented pottery, chipped stone, bone tools and macro-lithic tools, such as coarse-grained abraders (ALS, L - MS – 113, L – MS - 112, L - MS – 103), a grinding slabs (MOL, L – MS- 156 and L – MS- 89), a hammer (HAM, L – MS-147), and raw material (IND, L - MS -169).

The second trench ZIPP II (16 m^2) was placed in the vicinity of trench ZIPP I. Its vertical stratigraphy resembles the stratigraphy in trench ZIPP I. The thickness of the cultural layer is

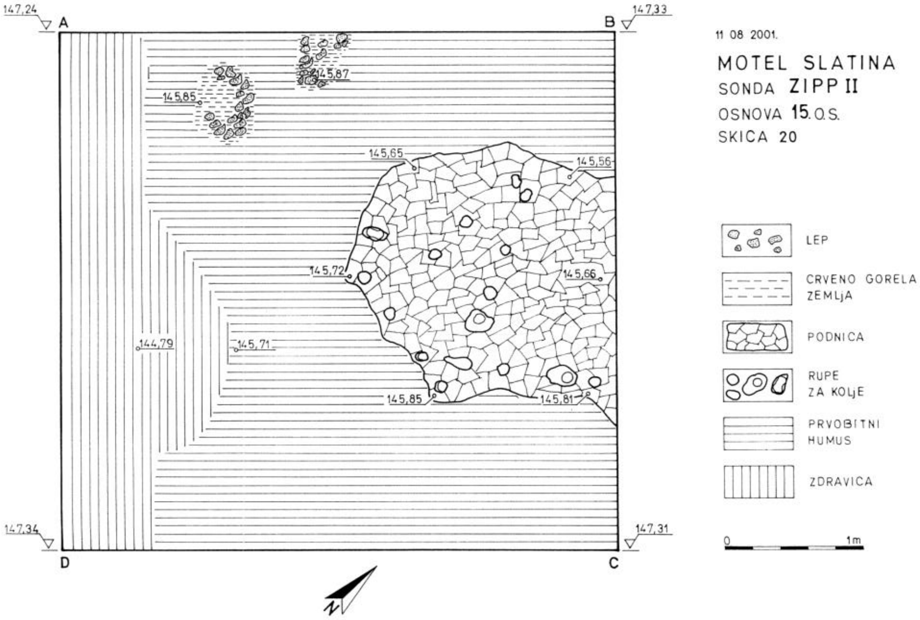


Fig. 3.34. Motel Slatina: trench ZIPP II, basis of trench with ground floor remaines; according to Перић 2003: 265,сл.2.

Fig.3.35. Motel Slatine: semi-digged objects dug into subsoil, trench ZIPP III; according to Перић 2003 – 2004: 265, сл.3.

2,55 m (Perić 2003 – 2004: 264). An abundance of fragmented pottery, chipped stone tools, bone tools and 29 macro-lithic tools came from the construction horizons. Numerically frequent are abrasive tools (ALS, LOS, ALS-PIA), while the rest are polished edge tools and tools with traces of secondary modifications (UNK), grinding tools, hammers (HAM), percussive tools (PEC), and semifinished products

The younger stratum of trench ZIPP II yielded a concentration of natural stones, fragmented pottery, burnt daub, three fine-grained abraders (ALS-PIA, L - MS - 127, L - MS - 128, and L - MS – 130), and a tool with traces of secondary modifications (UNK, L - MS – 170), at a relative depth of 0,60 m (Перић 2003 – 2004: 264). A grooved smoother (ALS-CRG, L - MS – 133) and a tool with traces of secondary modifications (UNK, L - MS -173) were found between the wall and the floor of a building, belonging to the early settlement horizon (fig. 3.35). This layer also presented a pit in the western part of the trench. It included ash, lampblack, the protom of a zoomorphic altar, animal bones, flakes of chipped stone, a celt (REN, L – MS – 166), and a coarse-grained abrader (ALS, L - MS – 157).

Trench ZIPP III (27 m^2) produced an above-ground structure with hearths corresponding to the younger horizons already identified in trenches ZIPP I and II (Перић 2003 – 2004: 265). They revealed fragmented pottery, two well-preserved vessels, a clay weight, a coarse-grained abrader (ALS, L MS– 111), and raw material for a tool with an abrasive surface (IND, L - MS – 152) (fig.3.36). s

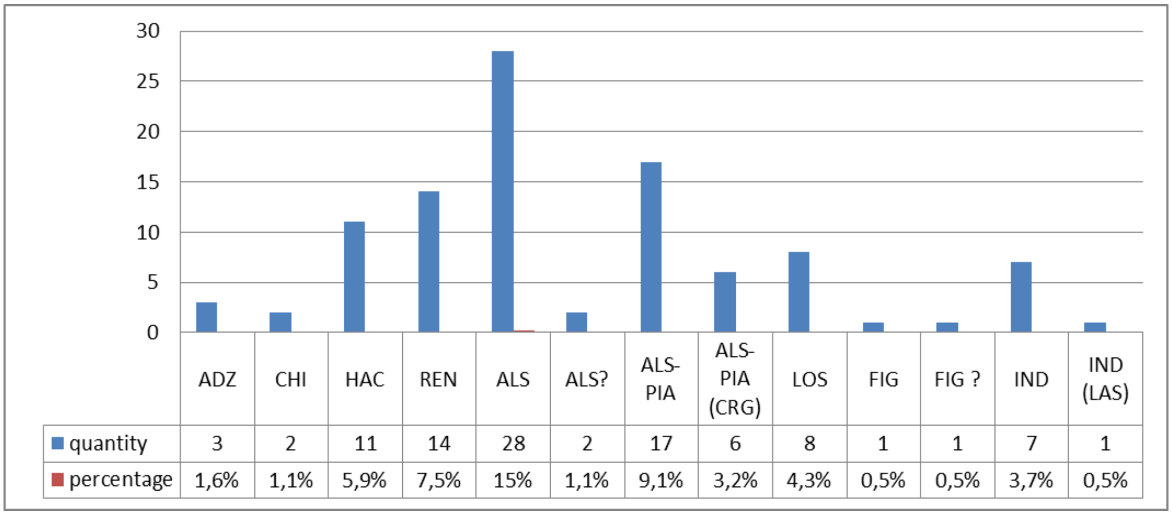
We have analysed 187 macro-lithic tools found during the excavations of 1985 – 1986, 2001 and 2002, all belonging to Late Neolithic horizons. Unfortunately, the objects found during 1985-1986 were only partially collected due to the recording strategy used.

The analysis of the objects from this Late Neolithic settlement show that most are abrasive tools (coarse-grained abraders – ALS, abrasive slabs-LOS, fine-grained abraders -ALS-PIA, grooved fine-grained abraders – ALS-PIA-CRG), tools with traces of secondary modification (UNK), polished edge tools (axes -HAC, adzes - ADZ, celts -REN and chisels - CHI) and percussion tools (a percussive tool–PEC, hammers- HAM, retouching tools - RET, and pestles - PST) (fig. 3. 37 a, b).

The results show that more than half of the examined tools are broken and fragmented, suggesting their intensive use (fig. 3.38). Most are coarse-grained abraders (ALS), fine-grained abraders (ALS-PIA), abrasive slabs (LOS), grinding slabs (MOL, MOL?) and a handstone (MUE) as well as percussion tools, such as hammers (HAM, HAM?), pestles (PST), and percussive tools (PEC) (fig. 3.39).

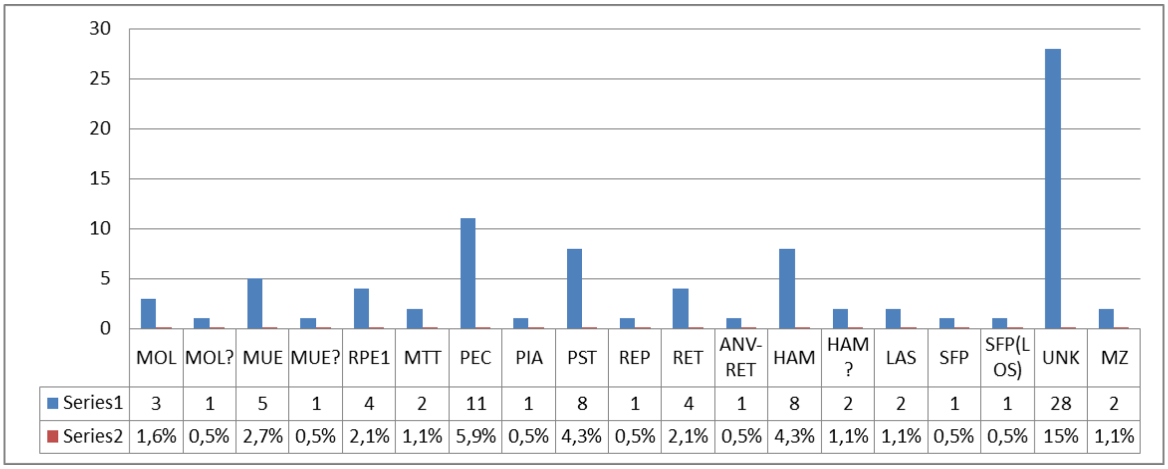
Many complete artefacts (fig. 3.38) are semi-finished products (SFP, SFP-LOS), tools with traces of secondary modification (UNK) and celts (REN) (fig. 3.39). The ratio between complete and fragmented and broken items is very similar to those from the Neolithic settlement of Turska česma, Slatina, which probably is influenced by a systematic collection of the finds during the recent excavations.

The results of analysis of the finds uncovered during excavations at beginning of this century (trenches ZIPP I – III) show that the oldest horizon produced abundant of black polished pottery, biconical bowl with a short upper part of a recipient and a rounded profiled bowl without a separated neck and with a barely defined rim in the oldest stratum. The decoration is modest, and consists of the so-called blacktopped decoration, channelling and burnished ornaments (Перић 2003 – 2004: 266, сл. 5).



	ADZ	CHI	HAC	REN	ALS	ALS?	ALS-PIA	ALS-PIA (CRG)	LOS	FIG	FIG ?	IND	IND (LAS)
🟦 quantity	3	2	11	14	28	2	17	6	8	1	1	7	1
🟥 percentage	1,6%	1,1%	5,9%	7,5%	15%	1,1%	9,1%	3,2%	4,3%	0,5%	0,5%	3,7%	0,5%

Fig.3.36a. Motel Slatina: macro-lithic tools, graph 1; N=187



	MOL	MOL?	MUE	MUE?	RPE1	MTT	PEC	PIA	PST	REP	RET	ANV-RET	HAM	HAM ?	LAS	SFP	SFP(LOS)	UNK	MZ
🟦 Series1	3	1	5	1	4	2	11	1	8	1	4	1	8	2	2	1	1	28	2
🟥 Series2	1,6%	0,5%	2,7%	0,5%	2,1%	1,1%	5,9%	0,5%	4,3%	0,5%	2,1%	0,5%	4,3%	1,1%	1,1%	0,5%	0,5%	15%	1,1%

Fig.3.36b. Motel Slatina: macro-lithic tools, graph 2; N= 187.

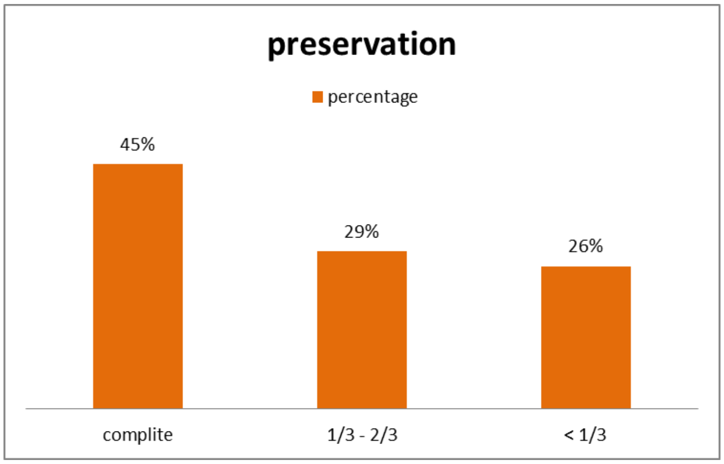


Fig.3.37. Motel Slatina: preservation of the macro-lithic objects; N=187

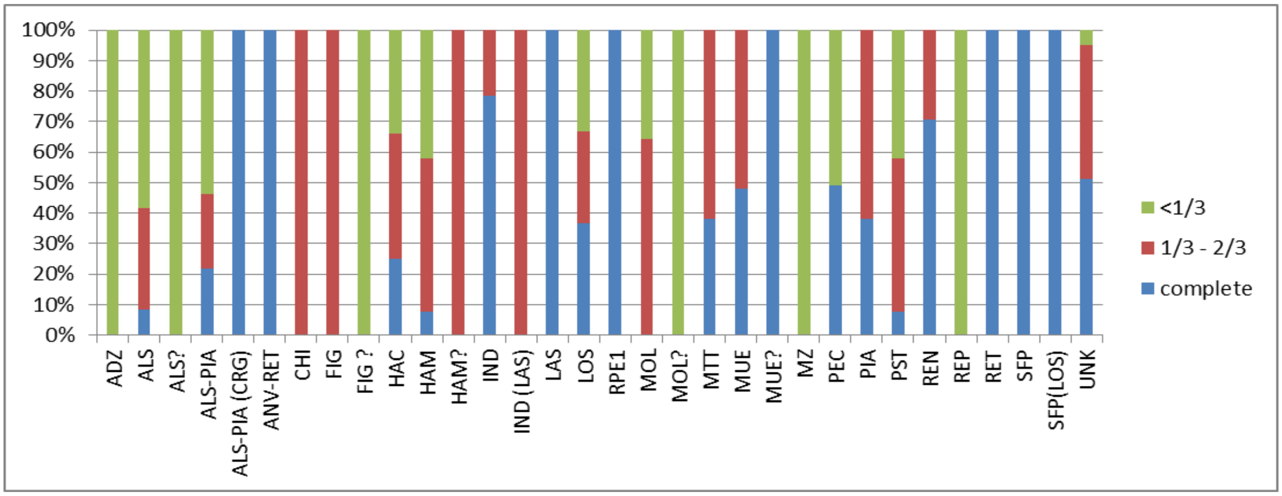


Fig.3.38. Motel Slatina: preservation of tools according to type; N=187

The middle layer yielded an increase of anthropomorphic figurines and a number of forms of black-polished ceramics, first of all, bowls of various sizes with developed profiles, a ring-like, cylindrical or leafy neck. Channelling is the dominant technique of decoration (Перић 2003 – 2004: 266, сл. 6).

The youngest horizon is characterized by anthropomorphic and zoomorphic figurines and a decrease in the quality of ceramics and of pottery with the grey surface. Pottery forms show mainly bowls with everted rims and biconical bowls with a reverted rim (Перић 2003 – 2004: 266, сл.8). The ornamental system was limited and consists of plastic ribs and channelling of rims of shallow bowls (Перић 2003 – 2004: 266, сл. 9).

The Neolithic settlement had been placed in the plain, between the hills to the North and the river course to the South. These elements provided favourable conditions for the development of different economic activities. Movable finds have been partially analyzed and published. Faunal assemblages contain remains of domestic animals, dominated by cattle (c. 70% of the domestic animals) and the rest are sheep, goats and pigs[18]. The remains of aurochs, red deer, roe deer and wild boar have been identified among wild species and confirm that hunting was part of the economy of the inhabitants of this settlement (Cvetković 2004: 77, 80).

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[18] Only samples, found during excavations in 1997 and 2000 have been analysed.

The analysis of bone and macro-lithic tools suggest various activities such as processing of food, leather, clay, bone, plants, fishing, and working of wood and stone (Vitozović 2007; Живанић 2010, табла 19 - 26, Т. IX - XIII, XIX/1-7; сл.5).

Late Neolithic pottery recovered during the 1962 excavations, displays a high level of standardization, while bowls are „more standardized“ than storage vessels. This indicates different productions at the household and a more specialized, socially controlled and organized level (Vuković 2011: 95).

3.3. Western region

3.3.1.Kremenilo, Višesava, Bajina Bašta

The prehistoric multilayered site of Kremenilo was located along the eastern low bank of the Drina River, in the vicinity of the village of Višesava, back in 1959 (fig.3.40,41). The remains of this prehistoric settlement cover a surface of 10 ha. The site was excavated on several occasions between 1961 and 1968 and an area of 800 m² has been explored. The cultural layer, with a thickness of 2,30 m, produced Early/Middle Neolithic materials (Starčevo IIb-III phases correspond to *phases MNCB III* a-b: around and after 5400 cal.BC, as proposed by Tasić, Tasić N.N., 2009) at a relative depth from 2 – 2,30 m, and Late Neolithic remains (Vinča-Tordoš and Vinča-Pločnik, 5400/5300 - 4650/4600 cal.BC). The humus

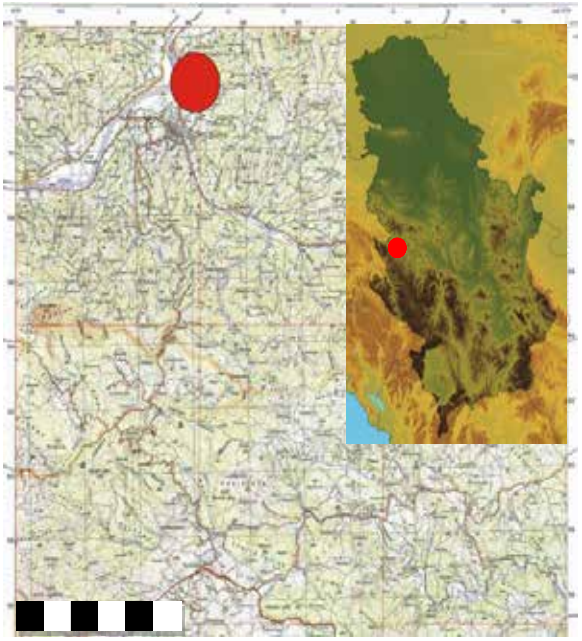

Fig.3.39. Kremenilo: position of the site military topographic map section Titovo Užice 1 , 1 : 50 000.

Fig. 3.40. Kremenilo: excavations 1963. Eastern part of excavated area, sector 2. Photo documentation of National museum of Užice, Užice.

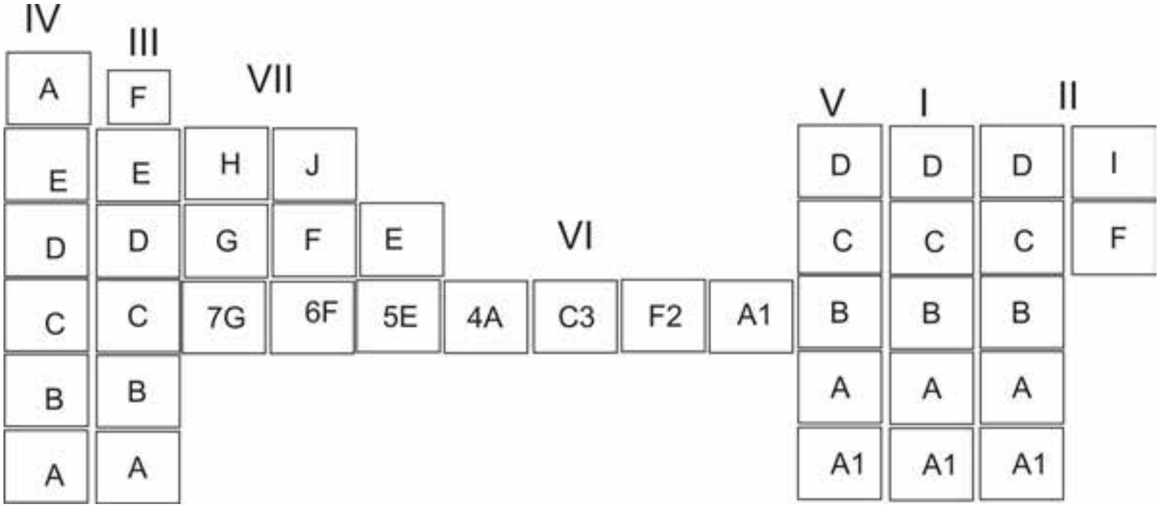

Fig.3.41. Kremenilo: layout of the trenches excavated in 1967 - 1968; Documentation of National museum of Užice, Užice.

layer contained finds dated to the transitional period from the Neolithic to Metal Ages

The Starčevo horizon in trench III (fig. 3.41, 42) presented a specific burial practice. Two human skulls were found beneath the remains of a roughly semi-elliptical object, with a coated floor made of clay, measuring 1,50 x 0,80 m. The better-preserved skull is attributed to the mature individual of unknown sex. Grave goods consisted of fragmented pottery, scapers and a knife, as well as a (meta)alevrolite tool with traces of secondary modifications (UNK, L– KR – 35), and a claystone semi-finished, polished

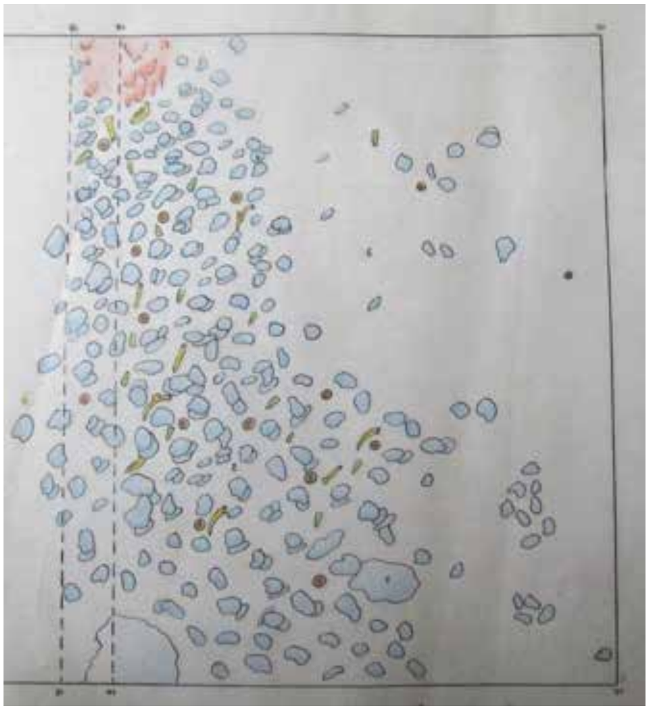

Fig. 3.42 Kremenilo: trench I, square C, arbitrary layer 3, excavations 1965. Documentation of National museum of Užice, Užice.

edge tool (SFP, L - KR-113) (Zotović 1990:60). A pebbled surface of c. 3x3 m, pottery, clay weights and one figurine were discovered in the vicinity of this burial[19]. The finds from the pebbled surface also include a re-used polished edge tool (RPE2, L - KR-172), tools with traces of secondary modification (UNK, L - KR-164, L - KR-171), (RPE2, L - KR-205, L - KR-203 and L - KR-112, and L - KR-149), and an axe (HAC, L - KR-192). Other artefacts were a re-used polished edge tool (RPE2, L - KR-174), tools with traces of secondary modifications (UNK, L - KR- 164, L - KR-171, L - KR-174), and an axe (HAC, L - KR-98). The layer beneath the pebble
the surface produced a tool with traces of secondary modification (UNK, L - KR-146), re–used polished edge tools (RPE2, L - KR-205, L - KR-203, L - KR-112, and L - KR-149), and an axe (HAC, L - KR-192). However, it should be said that one fragment of the Late Neolithic vessel, which was detected in this area, indicating a possible minor disturbance of the Early Neolithic layer. The same trench produced an Early Neolithic buried dwelling with a calloted oven, a retouching tool (RET, L - KR-79) and a tool with traces of secondary modifications (UNK L - KR-154)[20].

Type of macro lithic tool	inventory	Inv.No
tools with traces of secondary modifications (UNK)	L - KR-177, 4439	
	L - KR-176, 4438	
	L - KR-187, 4465;	ter.in.: 293
	L - KR-189 ,4464;	ter.in.: 293
	L - KR-188,4465;	ter.in.: 293
	L - KR-190, 4465;	ter.in.: 293
	L - KR-157,4462;	ter.in.: 287
	L - KR-126, 4431	
	L - KR-106, 4422	
retouching tool (RPE2)	L - KR-150, 4468	
joiner planer (REN)	L - KR-191,4469;	ter.in.: 293
semi-finished product (SFP)	L - KR-128, 4430	
retouching tool-percussive tool (RPE2)	L - KR-125, 4432	
Weight for digging stick (WS)	L - KR- 103,	ter.in.:292

Table 3.1. Macro-lithic tools from a concentration of finds in the *Early / Middle Neolithic layer; N=14.*

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[19] Documentation of the National Museum Užice, Užice.

[20] Documentation of the National Museum Užice, Užice.

The Starčevo horizons in trenches VI and VII produced (fig. 3.36) three pits and a pestle (PST, L - KR-219), a celt (REN, L - KR-28), and an adze (ADZ, L - KR-46).

Trenches I and II (fig.3.42) produced the Late Neolithic above-ground houses 1 and 2 in the eastern part of the settlement, during the excavations of 1963 and 1965. Macro-lithic tools (table 3.1) and eleven perforated, clay weights were found only in house 1 (trench I, square C arbitrary layer 2).

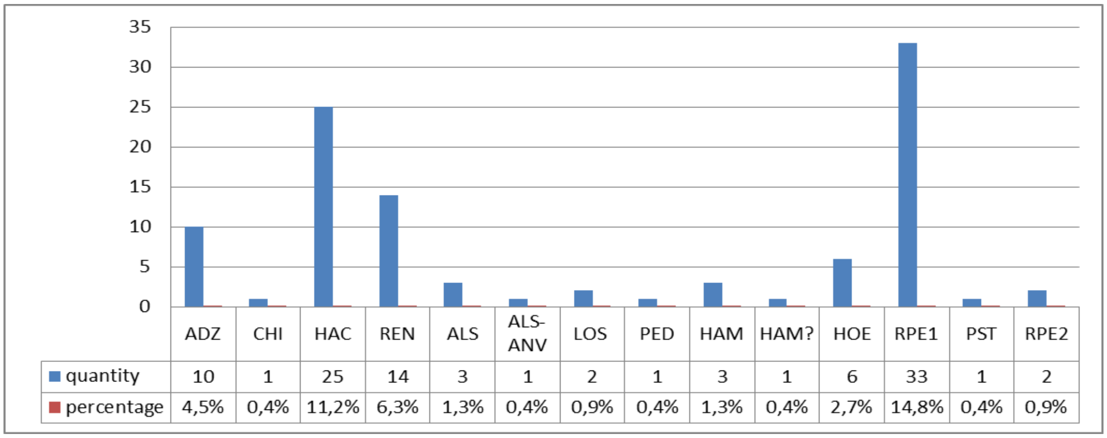
Trench VI (fig. 3.42) revealed burnt daub, fragmented pottery and macro-lithic tools such as a hoe (HOE, L - KR-39), a hammer (HAM, L - KR-40), a semi-finished product of polished edge tool (SMF) L - KR-26, a tool with traces of secondary modifications (UNK, L - KR-11), as well as eight axes (HAC, L - KR-17, L - KR-18, L - KR-14, L - KR-19, L - KR-29, L - KR-15, L - KR-30 and L - KR-44). A tool with traces of secondary modification (UNK, L - KR-11) was detected within the house foundation.

Trench I (squares B, C and D, arbitrary layers 3 and 5) (fig. 3.42, 43) produced tools with traces of secondary modifications (UNK, L - KR-88, L - KR-4, and L - KR-2), a re-used polished edge tool (REP2, L - KR-6), an adze (ADZ, L - KR-66), and a celt (REN, L - KR-80).

Type of the macro-lithic tool	inventory	Inventory number
axe (HAC)	L - KR-136	ter.in.:333
	L - KR-53	4532; inv.br.421
raw material (IND)	L - KR-52	4531; inv.br.421
flake (LAS)	L - KR-132	4533; ter.in.:421
pedant (PED)	L - KR-102	ter.in.: 394
Semi-finished product (SFP)	L - KR-152	4518; ter.in.:39
Semi-finished product (SFP)	L - KR-168	4455
Semi-finished product (SFP)	L - KR-175	4445
tools with traces of secondary modifications (UNK)	L - KR-151	4517
	L - KR-169	4456
	L - KR-178	4519; ter.in.: 394
	L - KR-179	4519; ter.in.: 394
	L - KR-193	4534; ter.inv.: 421

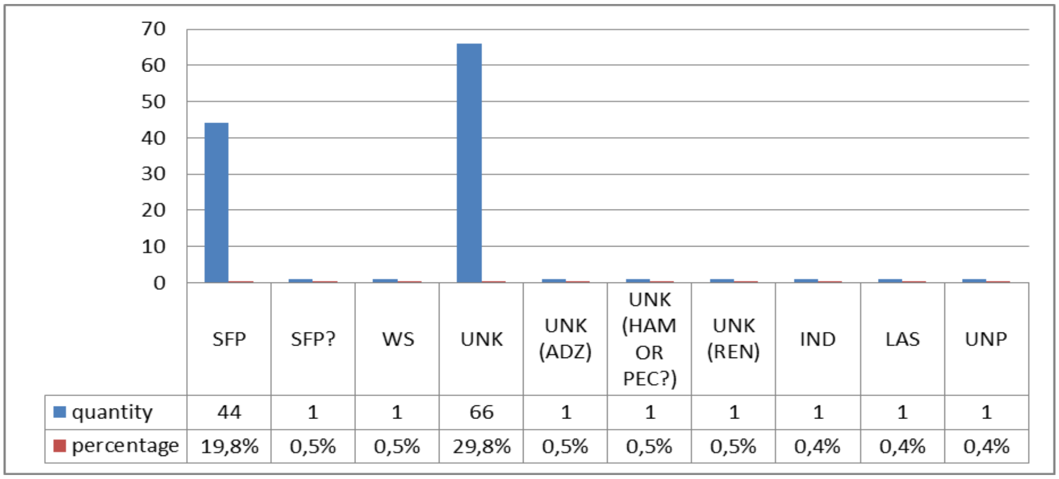
Table 3.2. Macro-lithic tools from the Early/Middle Neolithic hause 1; N= 13.

No finds from this site have been analyzed so far. Only macro-lithic tools allow us to start reconstructing the economy of the Neolithic settlement of Kremenilo. In view of the topographic characteristics of the area suggest developed husbandry has been suggested (Zotović 1989: 55).



	ADZ	CHI	HAC	REN	ALS	ALS-ANV	LOS	PED	HAM	HAM?	HOE	RPE1	PST	RPE2
🟦 quantity	10	1	25	14	3	1	2	1	3	1	6	33	1	2
🟥 percentage	4,5%	0,4%	11,2%	6,3%	1,3%	0,4%	0,9%	0,4%	1,3%	0,4%	2,7%	14,8%	0,4%	0,9%

Fig.3.43a. .Kremenilo: macro-lithic tools, graph 1; N= 221.



	SFP	SFP?	WS	UNK	UNK (ADZ)	UNK (HAM OR PEC?)	UNK (REN)	IND	LAS	UNP
🟦 quantity	44	1	1	66	1	1	1	1	1	1
🟥 percentage	19,8%	0,5%	0,5%	29,8%	0,5%	0,5%	0,5%	0,4%	0,4%	0,4%

Fig.3.43b .Kremenilo: macro-lithic tools, graph 2; N= 221.

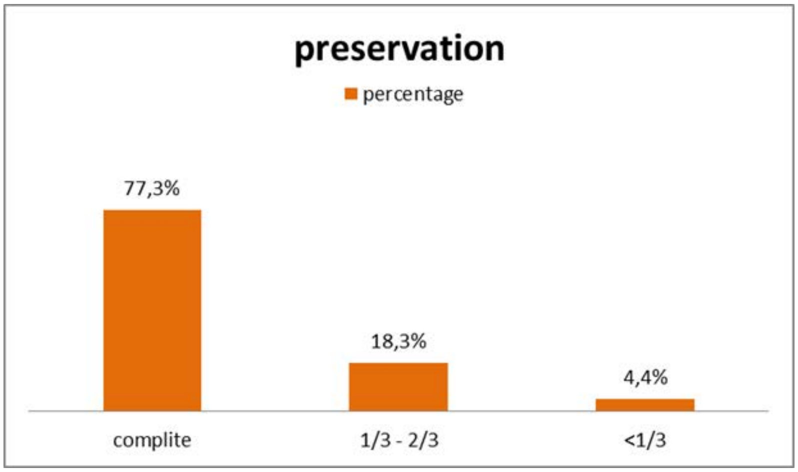


Fig.3.44. Kremenilo: preservation of the macro-lithic tools; N= N=221.

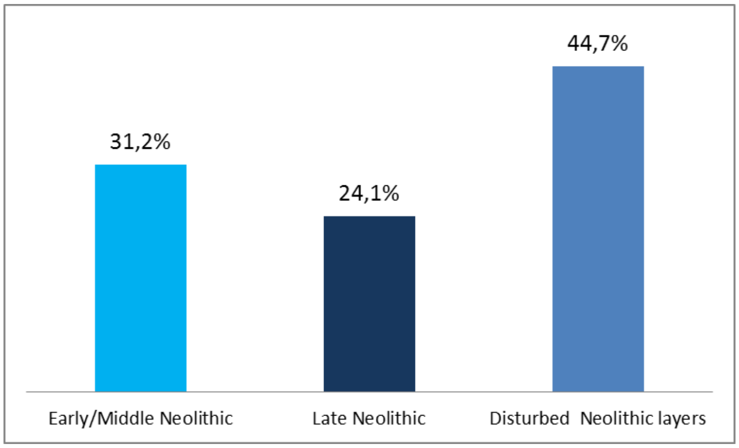


Fig.3.45. Kremenilo: distribution of the macro-lithic tools according to layers;N=221.

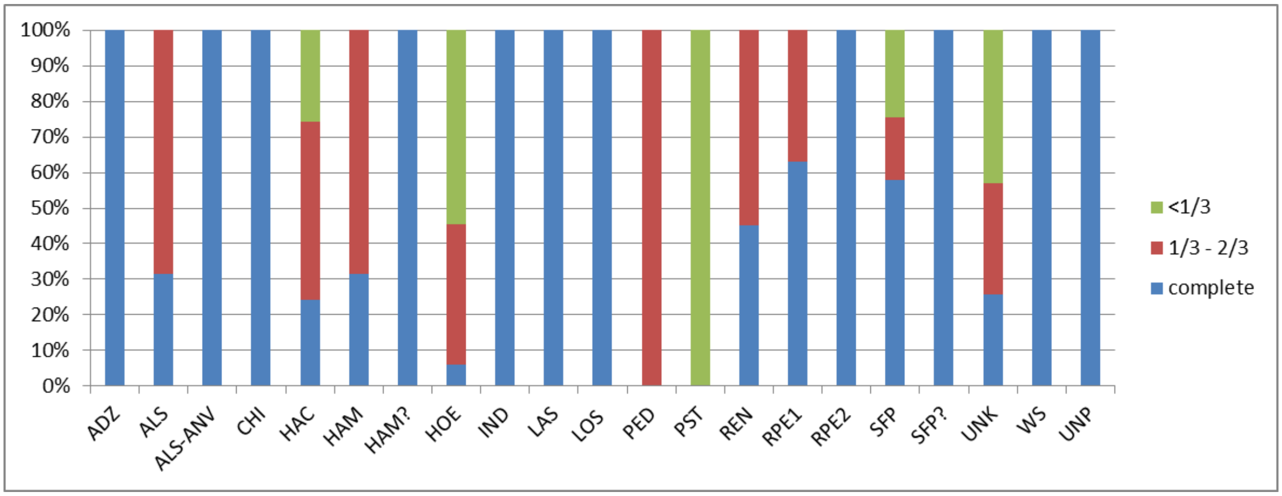


Fig. 3.46. Kremenilo: preservation of tools according to type; N=221.

We have examined 221 items found in 1963, 1965, 1967 and 1968. Around 31 % of all the analysed objects were detected in the Early/Middle Neolithic layer and c. 24% of all of the studied objects were detected in the Late Neolithic layer. C. 44% of the analyzed material was recovered from the disturbed Neolithic layers (fig. 3.46). No typological differences have been observed between layers.

The studied collection is dominated by tools with traces of secondary modifications[21], semi-finished products (SFP), percussion tools[22] and polished edge tools[23] (fig.3.44 a,b).

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[21] UNK, UNK-REN, UNK-ADZ

The artefacts are mainly complete (fig. 3.45). Many of them are tools with traces of secondary modifications, re-used polished edge tools (REP2), adzes (ADZ) and semifinished products (SFP) (fig. 3.47).

Broken and fragmented objects, which suggest intensive use, are presented in low percentage (fig. 3.45). This group is dominated by tools with traces of secondary modifications (UNK) and axes (HAC) (Fig.3.41) (Zotović 1963, 18 - 20; 1989, 40, 68). Low percentage of fragmented and broken artefacts can indicate the selection of the finds due to recovery process.

3.3.2. *Kraljevina, Vranjani, Požega*

The Neolithic settlement of Kraljevina was detected in the southern part of the village of Vranjani in 1968. This site of c. 1,5 ha is located in the central part of a fertile plain, surrounded by hills and mountains. The plain is intersected by a small river course. Its water level fluctuates during the year, flooding the surroundings (fig. 3.48).

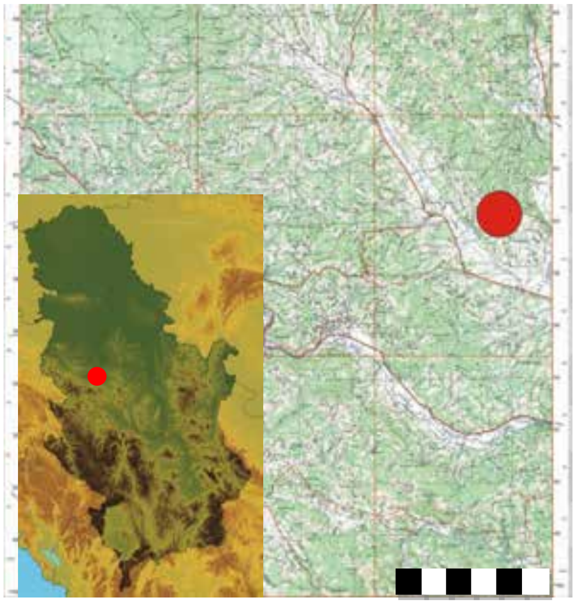

Fig.3.47. Vranjani: position of the site; military topographic map section Titovo Užice 2 , 1 : 50 000.

During 1970 and 1973 an area of 184 m² was excavated. The record revealed a Late Neolithic layer, with a thickness varying between 0,30 and 0,50 m, indicating a short-term occupation. The pottery analysis shows, that the settlement belongs to the Vinča – Tordoš phase (Zotović 1989: 55, 61; Mandić 2012:18 -20) (fig. 3.50).

We have analyzed the material found during both campaigns. This collection consists of 14 complete macro-lithic tools, while only one axe is broken. (Zotović 1979: 6 – 15; Mandić 2014: 8, 13).

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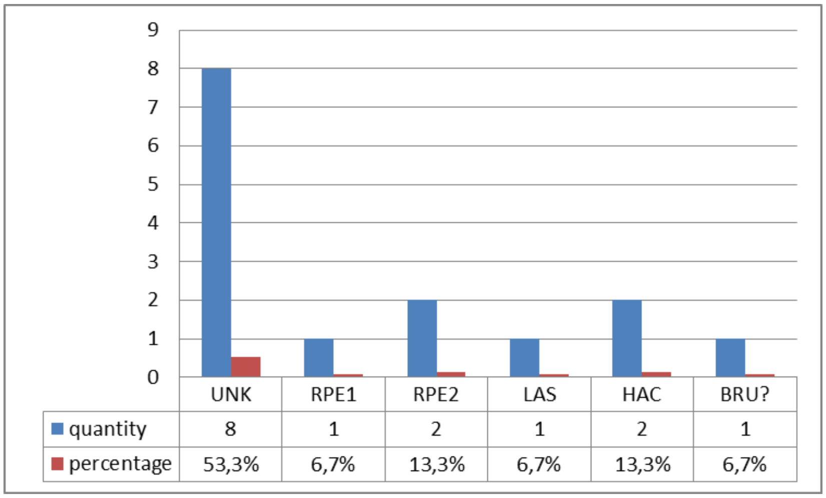
[22] re-used polished edge tools - RPE 2, retouching tool – RET, retouching tool- percussive tools - RET-PEC, percussive tools – PEC;

[23] axes- HAC, a celt – REN, adzes-ADZ and a chisel – CHI.

A quartzite object (L - V – 11), might be used as ceramic polisher. A semi-buried dwelling produced two axes (HAC, L - V – 8, – 9) , a (direct) retouching tool (RET, L - V – 14), and a tool with traces of secondary modification (UNK), a rounded clay weight, pottery fragments and several fragmented figurines (fig.3.49) (Mandić 2012: 18).



	UNK	RPE1	RPE2	LAS	HAC	BRU?
🟦 quantity	8	1	2	1	2	1
🟥 percentage	53,3%	6,7%	13,3%	6,7%	13,3%	6,7%

Fig.3.48. Vranjani: macro-lithic objects; N= 15.

Topographic characteristics of the area and the small number of animal bones, mainly herbivores, show that this was a typical agricultural settlement. Burnt daub suggests the existence of above-ground houses, while a large pit indicates a dug-in dwelling. Smaller pits were used for soil exploitation (Zotović 1979: 7 – 15). The abundance and diversity of pottery such as coarse tempered pithoi, bowls, and amphorae suggest that pottery was produced locally. This activity was present in this area until recently. Abandoned pits could be seen, from which clay and quartzite had been exploited (ibid 1979:7- 15).

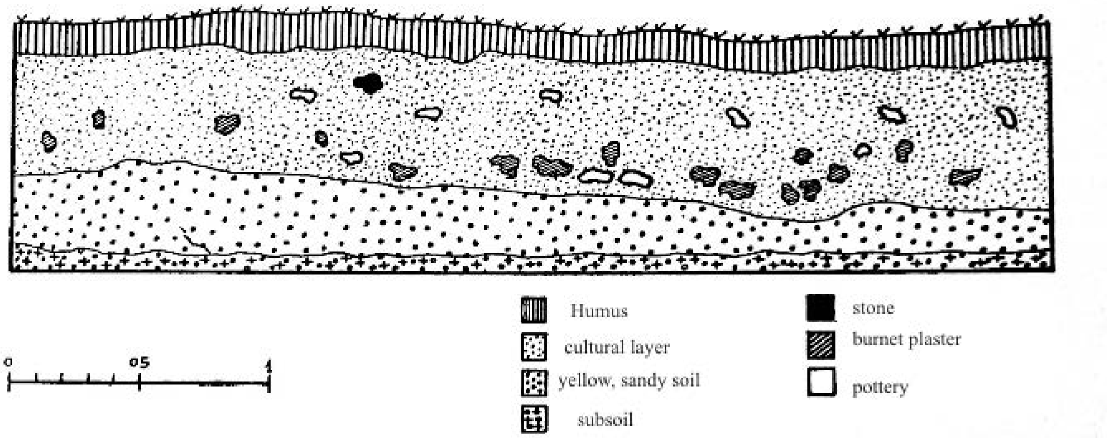


Fig. 3.49. Vranjani: north profile, trench III, square A, the Late Neolithic settlement; Буђић 1974, 5, сл.1.

Archaeological contexts also produced chipped stone tools, anthropomorphic figurines and clayed weights.

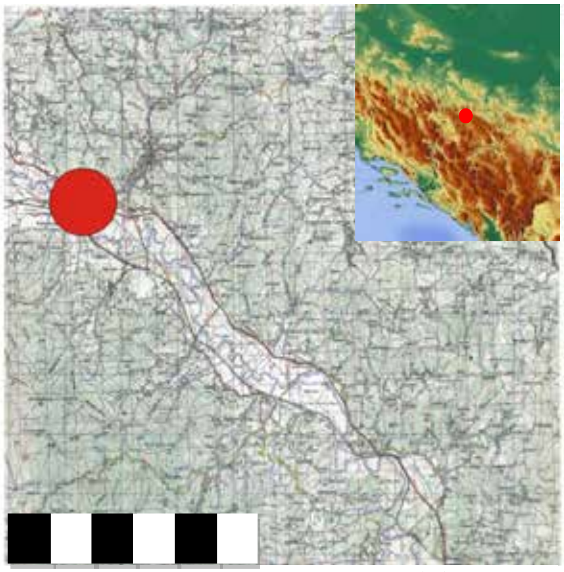


Fig.3.50. Koraća Han: position of the site; military topographic map section Doboj 4, 1 : 50 000.

3.3.3. Koraća Han – Tuzla

The late Neolithic settlement of Koraća Han was located in a hilly area, 2 km south of the Gračanica town (fig. 3.50). Two small river courses are in the vicinity of the site. Small trench excavations of 7 m^2 revealed the Vinča horizon in 1971, in which the chronological phase has not been determined. The only cultural layer produced fragmented pottery, animal bones, chipping stone tools, burnt daub and one figurine (Kosorić 1972:5-7).

We have analysed 35 macro-lithic tools, among which tools with traces of secondary modifications (UNK) are frequent (fig. 3.52).

Most artefacts are complete (fig. 3.53). They consist of a re-used polished edge tools (RPE2), a pestle (PST), and a perforated axe (HAC-PA) (fig. 3.53).

The broken and fragmented tools represent worn-out objects, which include tools with traces of secondary modifications (UNK), celts (REN), an adze (ADZ), and a coarse-grained abrader (ALS) (fig. 3.54).

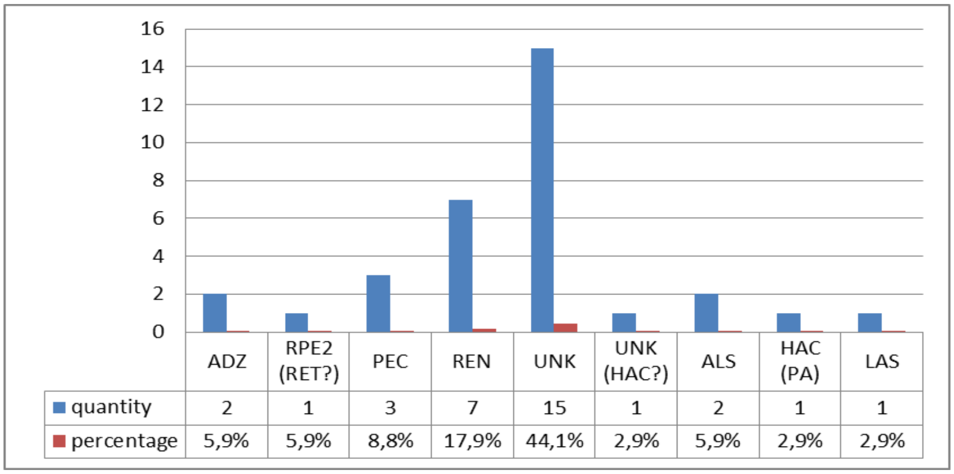


Fig.3.51. Koraća Han: macro-lithic objects; N=35.

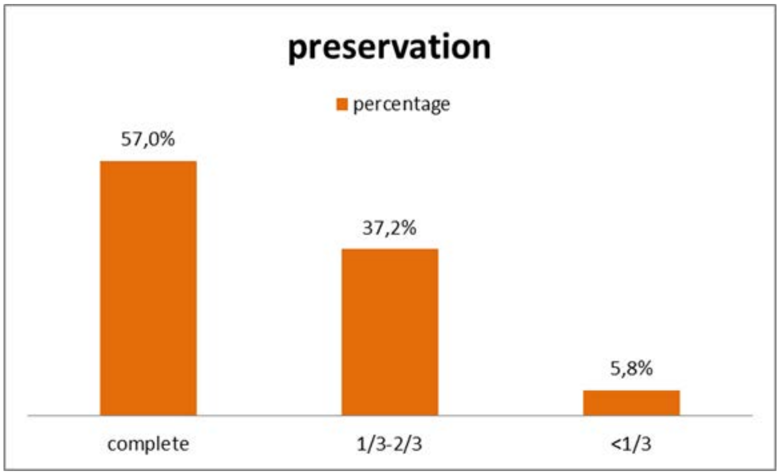


Fig.3.52. Koraća Han: preservation of macro-lithic objects; N=35.

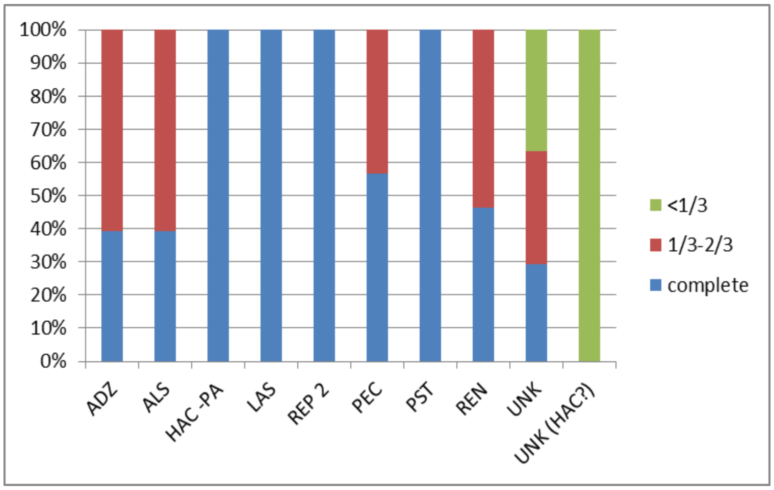


Fig.3.53. Koraća Han: preservation of tools according to type; N=35.

3.3.4. Čelina, Priboj

Fig.3.54. Čelina: position of the site; military topographic map section Priboj 3 , 1 : 50 000.

The site of Čelina is located on the slope of a hill, above the Lim river, on the northwestern outskirts of the town of Priboj (fig. 3.55,56). Nowadays, this area is forested, and therefore it is hard to estimate the size of the site. The explorations started in the middle of the 1990`s, and have continued during this century. Information on the explored surface is missing. According to the available documentation a surface of 151 m² was explored during campaigns 2010 – 2011. This hilly settlement, was inhabited during the final Late Neolithic[24], which was characterized by fortifications and social changes, which indicate the disappearance of the Neolithic world (Derikonjić 1996: 6, 21, 23, 24).

Excavations revealed above-ground dwellings.

Trench II (fig. 3.56) explored the eastern part of the site, and produced pit 4 with a weight for fishing nets (WFN, L -Če -18), pit 2 with a percussive tool (PEC, L - Če -31), a flake knocked off a semi-finished product (LAS, L - Če -32), and a weight for fishing net (WFN, L - Če -33), and pit 6 with a weight for fishing net (WFN, L - Če -71).

Fig. 3.55.Čelina: panorama of the site and river valley. Photo documentation of the Hometown museum of Priboj,

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[24] This phase is not in accordance with the recent relative and absolute chronological scheme provided by Borić (Borić et al.2018: 337), which we have accepted (see: Introduction, table 1.2).

Tranches I-III (fig. 3.57) revealed the remains of house 2[25] (fig. 3.58), including grinding slabs (MOL, MOL?, L - Če -96, L - Če – 91), a mortar (MOR, L - Če – 20) , an abrasive slab (LOS, L - Če – 63), a retouching tool (RET, L - Če - 22) , a weight for fishing nets (WFN, L - Če – 21), an axe (HAC, L - Če – 28), a flake knocked of a polished edge tool (LAS, L - Če – 29), and a semifinished product of polished edge tool (SMF-ADZ, L - Če – 30).

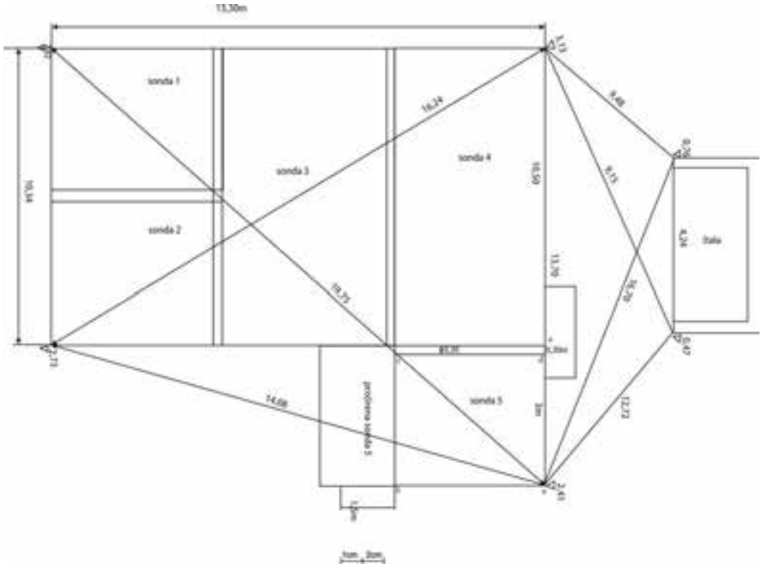

Fig. 3.56.Čelina: layout of the trenches, Documentation of Hometown museum of Priboj, Priboj.

Some 19,8% of all of the analyzed artefacts come from house 2 (fig. 3.57), in the

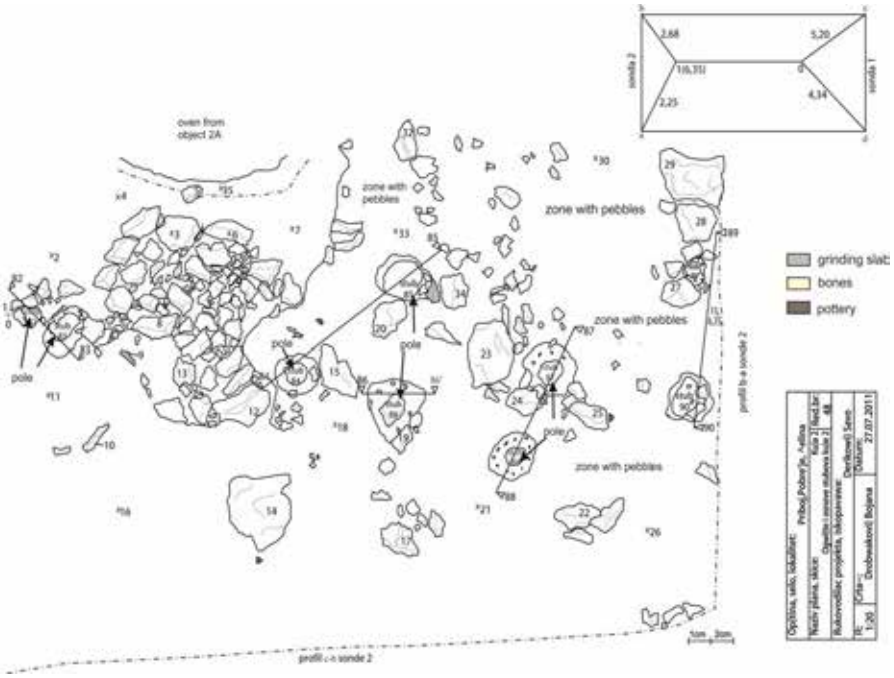

Fig. 3.57.Čelina: Hause 2, Documentation of Hometown museum of Priboj, Priboj.

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[25] We have st of the
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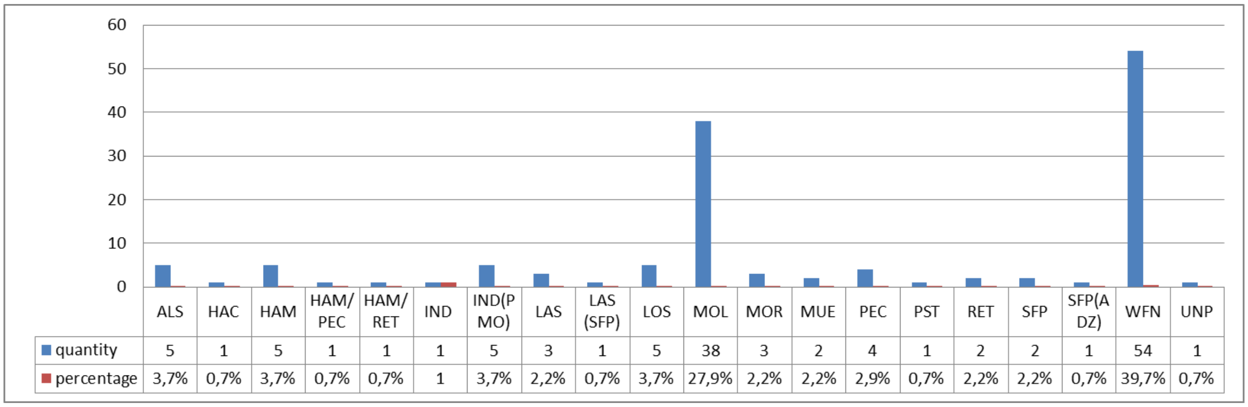
western part of the area explored in 2011. Weights which resemble to the weights for fishing net[26] were found *in situ* within the house. According to Derikonjić S., the director of excavations, these objects were used as weights for a roof construction[27]. The rest are fragmented grinding slabs[28], a percussive tool (PEC, L - Če – 16), a retouching tool (by direct retouching) (RET, L - Če – 17), a hammer (HAM, L - Če – 109), a pestle (PST, L - Če – 13), a coarse-grained abrader (ALS, L - Če – 12) , a hammer – percussive tool (HAM-PEC, L - Če – 108) and a hammer - retouching tool (by direct retouching) (HAM-RET, L - Če – 10).


Fig. 3.58. Čelina: tranches I – V, western part, profile A-A`(trench V), excavation 2011; Photo documentation of the Hometown musem of Priboj.

We have analyzed 136 macro-lithic objects, found during an excavation carried out in



	ALS	HAC	HAM	HAM/ PEC	HAM/ RET	IND	IND(P MO)	LAS	LAS (SFP)	LOS	MOL	MOR	MUE	PEC	PST	RET	SFP	SFP(A DZ)	WFN	UNP
■ quantity	5	1	5	1	1	1	5	3	1	5	38	3	2	4	1	2	2	1	54	1
■ percentage	3,7%	0,7%	3,7%	0,7%	0,7%	1	3,7%	2,2%	0,7%	3,7%	27,9%	2,2%	2,2%	2,9%	0,7%	2,2%	2,2%	0,7%	39,7%	0,7%

Fig.3.59. Čelina: macro-lithic objects; N=136.

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[26] WFN, L - Če – 11, 14, 15, 48-53, 101 – 106;

[27] Personal communication

[28] MOL, L – Če –7, 54, 93, 107;

2010 – 2011 (fig. 3.57, 59). The analysis show a variety of tool types, which are dominated by weights for fishing net (WFN) and grinding tools[29] (fig. 3.60).

The majority of stone objects are complete (fig. 3.61). Many are semifinished products (SFP), net weights (WFN) and percussive tools[30] (fig. 3.62).

Fragmented and broken objects are a minority (fig. 3.61). This suggests intensive employment of tools such as artefacts with an abrasive surface[31] (fig. 3.62). Ratio between broken, fragmented and complete objects is more or less similar to the results obtained in the Late Neolithic settlements of the Central region, which are also recent excavations with a systematic artefact recording (fig. 3.38 and 45). It should be mentioned that our recording system has been defined based on total number of the macro-lithic tools and their fragmentation.

Information on other artifact categories is limited. Observations show that pottery is abudant. The large amount of animal bones shows that a cattle breeding was important in this settlement. Archaeological excavations also provided an unusualy large amount of bone tools. The presence of bone needles indicates wool processing, while bone hooks, net weights and projectiles confirm hunting and fishing (Derikonjić 1996: 40, 45, 46, 69, сл.33, 12 – 14; 47, сл. 34 / 11-16).

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[29] grinding slabs – MOL, handstones – MUE, and mortars – MOR;

[30] a pestle –PST, retouching tools - RET, a hammer-percussive tool, a hammer-retouching tool – HAM-RET;

[31] abrasive slabs-LOS, grinding slabs – MOL, mortars –MOR and handstones – MUE.

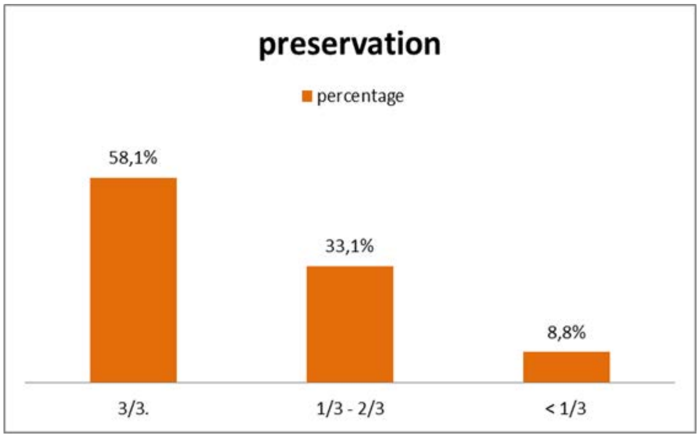


Fig. 3.60.Čelina: preservation of macro-lithic objects; N=136.

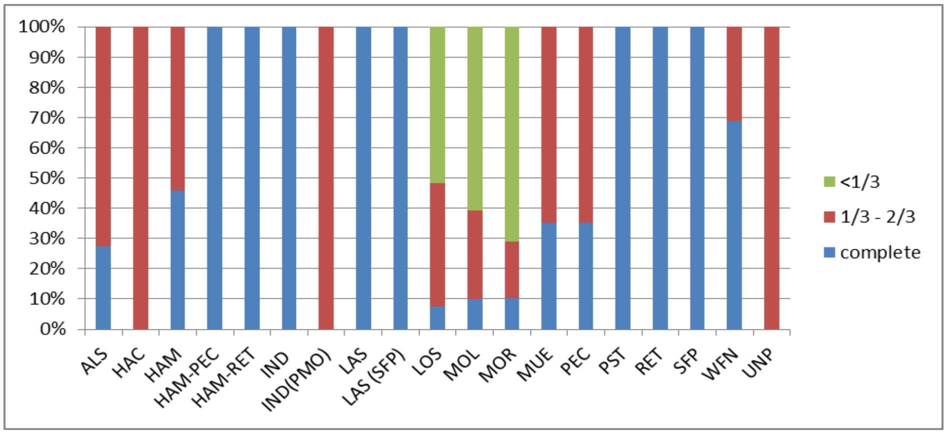


Fig. 3.61.Čelina: preservation of tools according to type; N=136.

3.4. Southern region

3.4.1.Tumba Madžari, Skopje

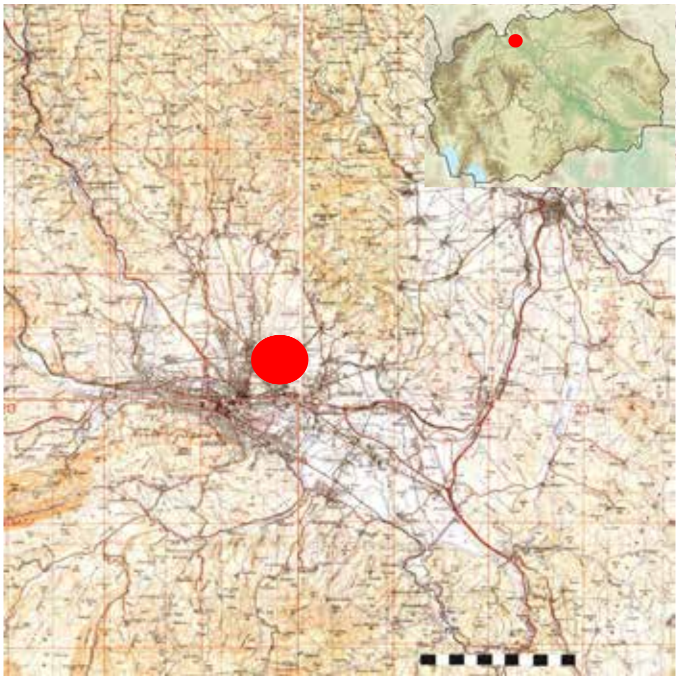


Fig. 3.62. Tumba Madžari: position of the settlement; military maps Kumanovo, Skopje, Titov Veles and Uroševac, 1: 100 000.

Fig. 3.63. Tumba Madžari: panorama of the site with open air museum.

The site of Tumba Madzari is located about 8 km to the east of Skopje and 3 km away from the left bank of the Vardar River. This small tell of c. 3 ha, was discovered in 1962/3. At the present day, houses cover two thirds of the area, but in previous years, the site dominated the surroundings (fig. 3.63 - 65). A low hill, which stretches to the east and northeast, lays in the vicinity of the settlement. This small orogen formation provides the necessary security, for water rise of the Katlanovo Lake.

The archaeological excavations were conducted during the 1970`s and 1980`s as well as during this century. Research confirms a single Middle Neolithic layer (5800 to 5200 cal. BC). Its thickness varies between 2,40 m and 2,80 m (including pits). Above-ground dwellings were found grouped around a central, empty space (Kanzurova, Zdravkovski 2011: 140; Канзурова 2011: 8; 2001a: 35).

Fig. 3.64. Tumba Madžari: free reconstruction of the settlement; Kanzurova 2011: 47.

House 1 (fig. 3.66) was investigated during 1998. It was divided by a wall, with two ovens standing on either side of it. A grinding slab set upon a small, cylindrical, clay pedestal had a central position within the eastern part of the house. Three clay altars were detected in the northern part. Two of them were marked as altar-ovens. The third one was associated with a grinding slab with blank working surface, and marked as an altar-grinding slab (Канзурова 2011:51 – 53, 69 сл. 43). Other finds include 45 vessels, such as pitoi, and ascos, antropomorhic and zoomorphic figurines, fragments of anthropomorphic cylinders, various-sized models of house-altars and a clay figurine of the Great Mother (idem 2011: 51 – 55 сл.26; Kanzurova, Zdravkovski 2011: 4,5). This context also produced an axe (HAC, L - TM – 134) and a celt (HAC, L - TM – 136).

Excavations carried out during 1984 revealed a square house (House 3). Its dimensions were 7 x 7 m and it was oriented in a north - south direction (fig. 3.66). A grain storage structure was detected in the south- western part of the house. Movable inventory includes an amphora, painted, fragmented pottery, altars, fragmented clayed figurines, and a bone awl. A celt (REN- L - TM – 146, 1172 and L - TM – 147, 1171) was detected on the level of the floor of the dwelling (Канзурова 2011, 63, 69 сл. 43). Furthermore, a bead (L - TM – 162, 907) was found close to an amphora filled with wheat, while a celt (L - TM – 101, 467) was found beneath the floor. During the same campaign a semi-finished spindle whorl (SFP-SW, L - TM – 160) was also detected in one of the houses (no data on specific position).

House 7 was excavated during 1989 -1990 and 1993 (fig. 3.66). We have analysed finds found during 1993, which only produced macro-lithic tools. This dwelling, shaped as a cyrillic Г (G), was orientated in a north – south direction. Two ovens, pottery (Канзурова 2011: 90 сл. 65), and a celt (REN, L - TM – 139) were found within the structure. House 12 (fig. 3.66)

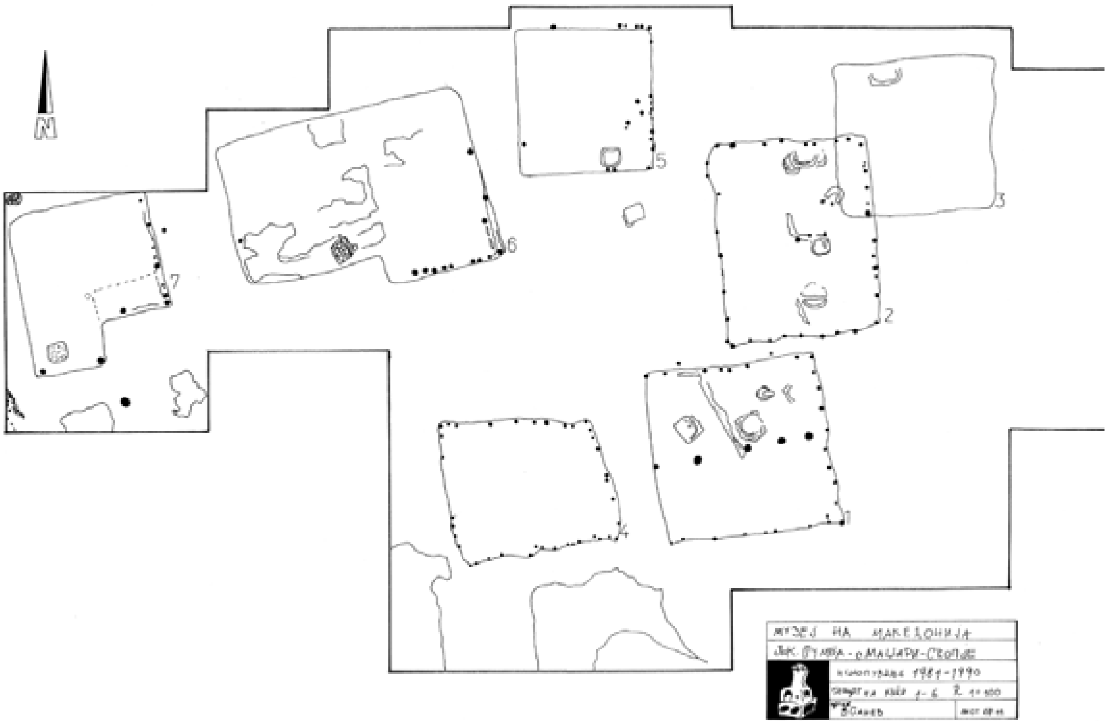


Fig. 3.65.Tumba Madžari: Basics of the houses discovered between 1981 – 1990 ; Kanzurova, Zdravkoski 2011, 141, fig.3.

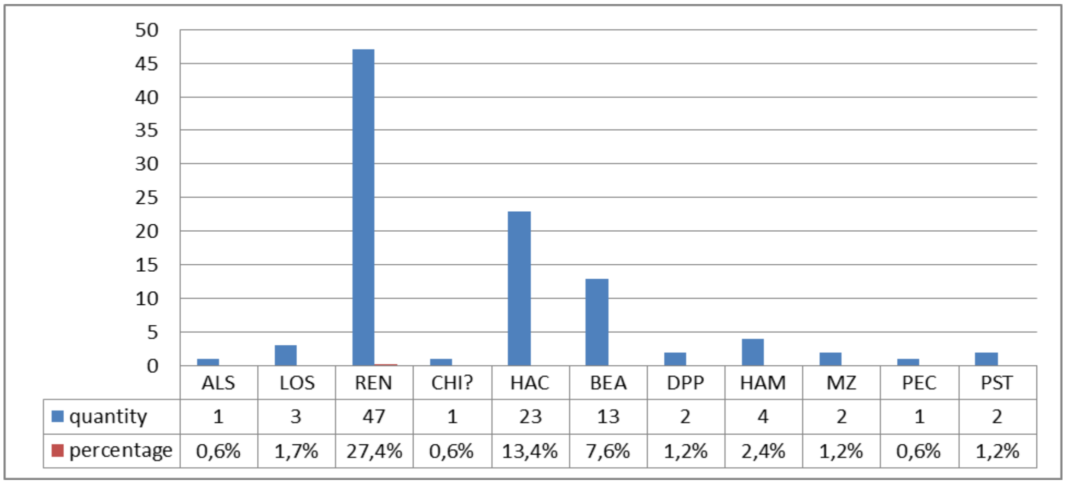
excavated during 2007– 2008, and produced various macro-lithic artefacts (table 3.3) and different internal features, according to which it is supposed that the building might have been used as a storage structure for one or more families (fig. 3.66 - 67) (Канзурова 2011, 107; Kanzurova, Zdravkovski 2011,144 - 151).

Fig. 3.66.Tumba Madžari: system of "grain storages", 2007, hause 12. Kanzurova, Zdravkoski 2011: 145, fig.11.

An area in the north, outside of house 12, revealed several macro-lithic artefacts, such as a (direct) retouching tool (REP-RET) L- T-10, three net weights (WFN, L- TM-10, L- TM – 27 and L - TM – 158), limestone identified as raw material (IND, L-TM – 52, L - TM – 159 and L - TM – 157), hammers, (HAM, L- TM – 57 and L- TM – 16), an anvil (ANV, L- TM – 17), a celt (REN, L-TM – 1), and a semi-finished spindle whorl (SFP-SW, L- TM – 30).

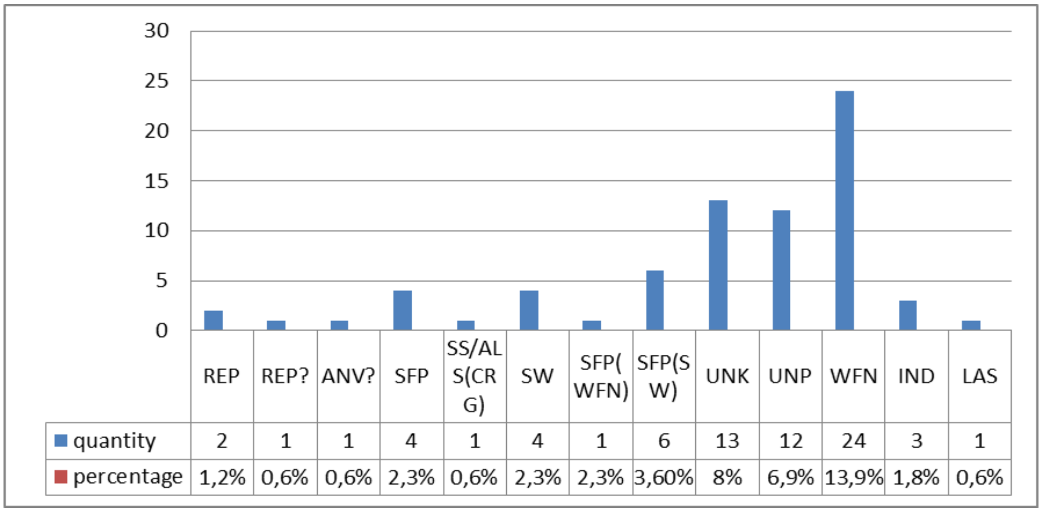
Type of the macro-lithic tool	inventory	distribution	other finds
bead (BEA)	L – TM - 166 - 170, 764/1- 5	north of the second group of grain storages	
coarse-grained abrader (ALS)	L – TM - 165, 885,	/	/
semi-finished spindle weights (SFP-SW)	L – TM – 45, 855 L – TM – 161, 852	/	/
pestle (PST)	L – TM -11,793	/	/
weights for fishing net (WFN)	L – TM -151,785	east of oven.	/
weights for fishing net (WFN)	L-TM-152, 797 L-TM-154, 758 L-TM - 155, 786	area between the oven, the fourth group of grain storage and pits for poles of the build construction	/
celt (REN)	L – TM – 26, 750	west of the oven	/
weights for fishing net (WFN)	L- TM – 15, 677	pit	fragmented pottery, animal bones
weights for fishing net (WFN)	L- TM – 156, 798		
celt (REN) celt (REN) axe (AXE)	L- TM – 25, 674 L - TM – 163, 846 L- TM – 56 ,824	around the pole pits of the building construction	legs of altar table type, a bone amulet, bone needle
celt (REN)	L- TM – 19, 847	close to the altars	antler
celt (REN)	L- TM – 54, 668		/
axe (HAC)	L- TM – 9, 670	hearth	
axe (HAC)	L- TM – 23,814	north of the second group of grain storage	/
pestle (PST)	L- TM – 11, 793	east of the second group of grain storages	/
axe (HAC)	L- TM – 24,749	between two groups of grain storage and the pits for poles of the building construction in the east	/
amulet (DPP)	L- TM – 5, 855	between the third group of the grain storage and the pits for the poles of building in the west of the construction	/
object with unknown propose (UNP)	L- TM –28, 857	pit	fragmented pottery, animal bones and weight
object with unknown propose (UNP)	L- TM –20, 751	inside of one of the grain storage in the space with the first group of grain storage and hearth	
celt (REN)	L- TM –12, 848	southeast of the first group of grain storage and hearth	
object with unknown propose (UNP)	L- TM –21, 754	space between the second and third group of grain storage and hearth	

Table 3.3. Tumba Madžari:context of macro-lithic tools in the hause 12; N=29.



	ALS	LOS	REN	CHI?	HAC	BEA	DPP	HAM	MZ	PEC	PST
🟦 quantity	1	3	47	1	23	13	2	4	2	1	2
🟥 percentage	0,6%	1,7%	27,4%	0,6%	13,4%	7,6%	1,2%	2,4%	1,2%	0,6%	1,2%

Fig. 3.67b. Tumba Madžari: macro-lithic objects, graphic 1; N=172.



	REP	REP?	ANV?	SFP	SS/ALS(CRG)	SW	SFP(WFN)	SFP(SW)	UNK	UNP	WFN	IND	LAS
🟦 quantity	2	1	1	4	1	4	1	6	13	12	24	3	1
🟥 percentage	1,2%	0,6%	0,6%	2,3%	0,6%	2,3%	2,3%	3,60%	8%	6,9%	13,9%	1,8%	0,6%

Fig. 3.67a. Tumba Madžari:: macro-lithic objects, graphic 2; N=172.

In total, we have analyzed 172 objects found in the 1980`s, 1990`s and during the first decades of this century. The results show a variety of tool types among which most of them are polished edge tools (celts – REN, axes -HAC), net weights (WFN), beads (BEA), tools with traces of secondary modifications (UNK, UNK-REN?), and semifinshed products (SFP, SFP-SW, SFP-WFN) (fig. 3.67a, b).

Most of the artefacts are complete (fig 3.69). This group includes mainly net weights (WFN) and semi-finished products (SFP) (fig. 3.70). Broken and fragmented or intensively used tools are mainly celts (REN), axes (HAC) and tools with traces of secondary modifications (UNK) (fig. 3.70). We believe that the result of the typological analysis and the level of conservation is influenced by the recovery process followed during excavations. The impression is that mostly complete and specific types of tools were collected.

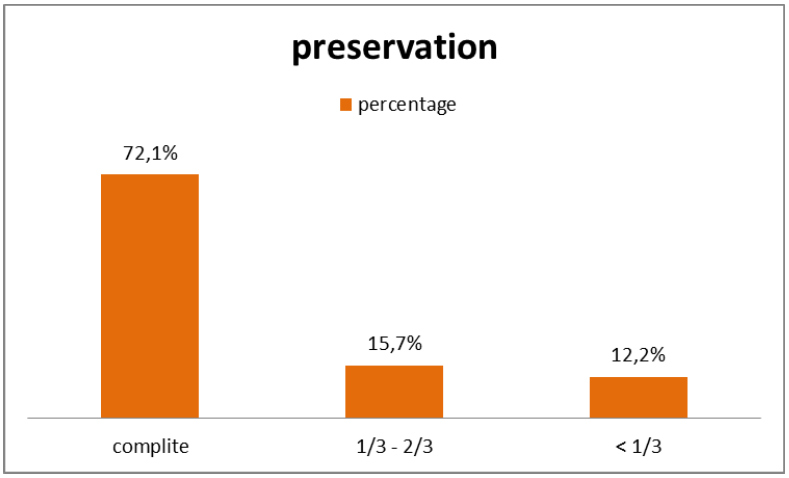


Fig. 3.68. Tumba Madžari: preservation of macro-lithic objects; N= 172.

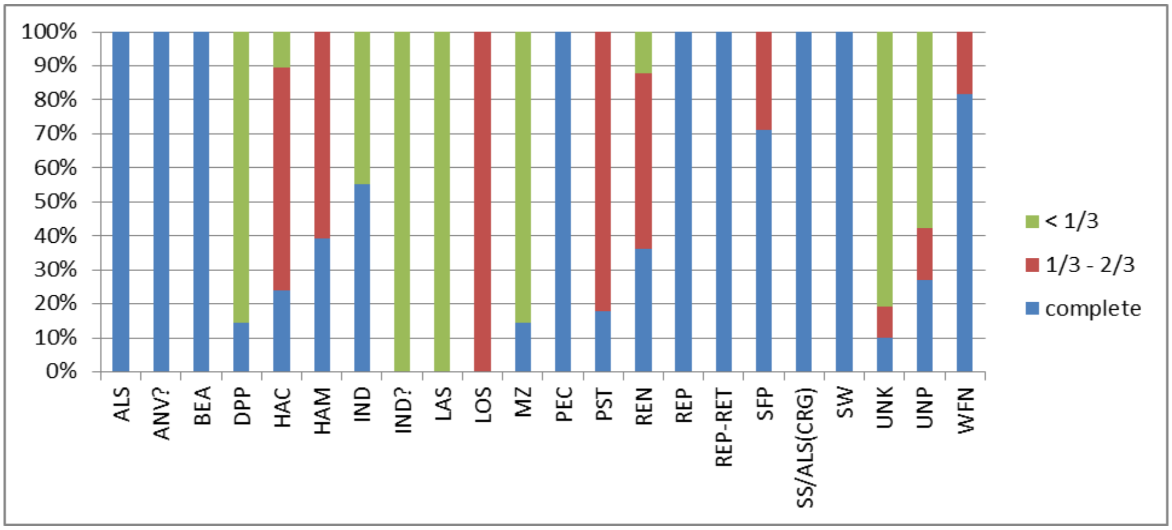


Fig. 3.69. Tumba Madžari: preservation of tools according to type; N= 217.

Despite that the finds have only be analysed partly, it can be said that seed remains suggest the preeminence of *Triticum diccocum*[32], a species suitable for food cultivation. A species of freshwater mussel (*Unio sp*.) is also present at the site (Commenge 2009: 235). According to these finds as well as the detected grain storages, agriculture was practiced, while the altar-ovens with grinding tools indicate the importance of food grinding (Канзурова 2011:51 - 53, 69 сл.43).

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[32] *P. Marinval pers. Com.*

3.4.2.Gumnište, Pavlovac - Vranje

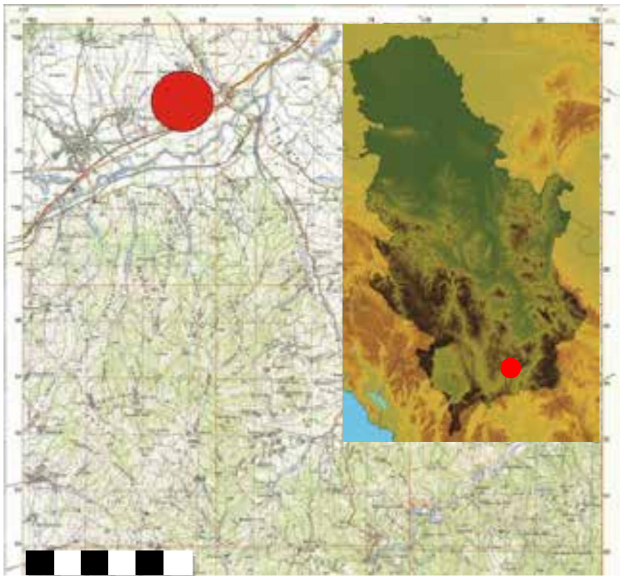

Fig. 3.70. Gumnište: position of the site, military topographic map section Kumanovo 2, 1 : 50 000.

The site of Gumnište is situated on a mild slope between the village of Pavlovac (8 km southern from Vranje) and the Južna Morava River (fig. 3.71). It encompassed an area of 20 ha. The site was registered by the American research expedition led by V. Fuchs in 1933 (e.g. Perić et al. 2016) (fig. 3.71).

An area of 36 m² was excavated during the first excavation in 1955. (National Museum, Belgrade). The results show a cultural layer of 1,50 meters thickness, containing the finds from Early and Late Neolithic and from the Early Bronze Age. New excavations were carried out in 1960. Two trenches 4x3 m were excavated (Block A and Block B) (Stalio 1967). The results of the excavations were never published.

Fig.3.71. Gumnište: excavation in 2011; Photo documentation Archaeological institute, Belgrade.

2011 a surface of 2400 m2 was explored. This excavation suggested multi-layered Neolithic site which includes a Starčevo phase (IIIa MNCB[33] according to N. N. Tasić, c.5700 – 5400 cal.BC) and at least two Vinča culture strata which, correspond to the Vinča-Tordoš II and Vinča – Pločnik I phase. These phases correspond partly to Vinča B and C (proposed by Borić, Borić et al. 2018: 337).

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[33] Middle Neolithic of the Central Balkans

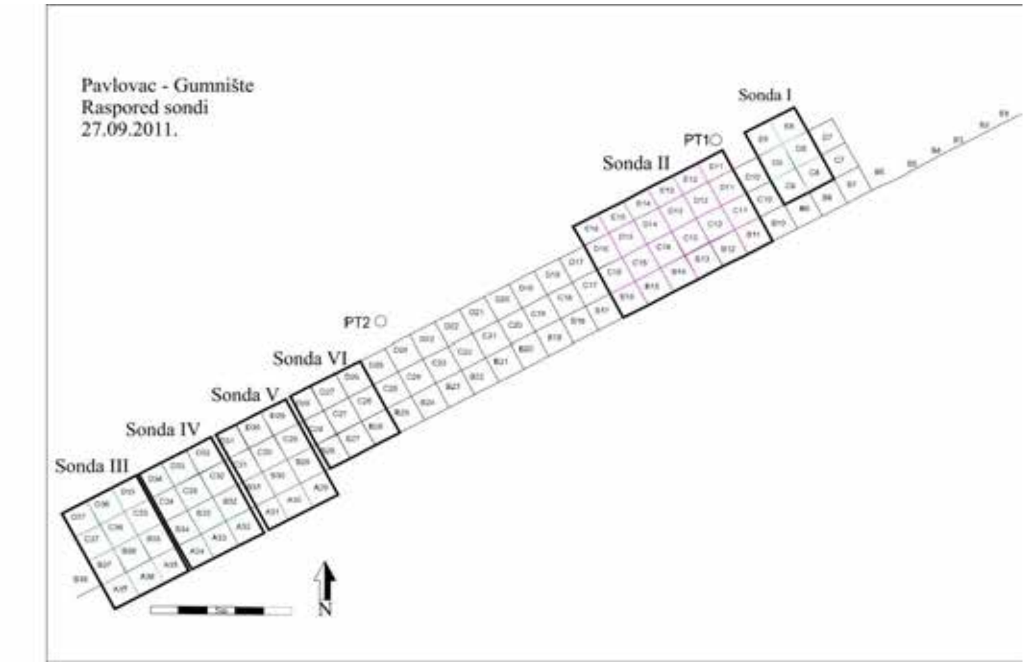

Fig.3.72. Gumnište:layout of the trenches and control profiles excavated in 2011; Documentation of Institute of Archaeology, Belgrade.

The cultural layer reached a thickness up to 1,75 m, suggesting long occupation of the site (Perić et al. 2016).

Above ground dwellings were confirmed in both campaigns (Stalio 1967;Perić et al. 2016). Pits, hearths as well as the remains of ovens were also detected during the excavations in 2011. The context produced various finds such as pottery, anthropomorphic figurines botanical remains, animal bones, antlers, loom objects, bone tools, chipped stone tools and spindle whorls.

In the lines below we will present the studied material found in the Late Neolithic cultural layer of trench II (29 x 17 m) (fig. 3.73). It should be said that

this trench shows vertical stratigraphy with two Vinča horizons containing above-ground structures and pits detected in the earlier layer.

However, building elements were not discovered *in situ*. Unit 2, in the north-eastern part of a square C 14, produced a fine-grained abraders (ALS-PIA, L - P – 56), fragmented grinding slabs (MOL, L - P – 226, L - P – 8), and a fragmented coarse-grained abrader (ALS, L - P – 36). The other finds are a zoomorphic figurine, an anthropomorphic figurine, animal bones, fragmented pottery, natural stone, a clayed spindle whorl, bone tools and perforated astragaluses (fig. 3.74).

Unit 6 in square C12 shows another concentration of finds. In its southeastern part, the unit was overlapped by unit 2 detected in the previous mechanical layer, which produced an altar and a fragmented handstone (MUE, L - P – 239) beneath concentration of natural stones as well as fragmented grinding slabs (MOL, L - P – 192, L - P – 173 and L - P – 140) and fragmented abrasive slabs (LOS, L - P – 291 and L - P – 240), fragmented anthropomorphic figurines and a beaker.

Unit 5, in squares D12-13 (fig. 3.75,76), produced fragmented pottery, animal bones, and macro-lithic tools, such as an abrasive slab (LOS, L - P – 250), a percussive tool (PEC, L - P – 172), and fragmented abrasive slabs (LOS, L - P – 201, L - P - 212, L - P – 284).

Unit 14, detected in the western part of the square C12, at a relative depth of 0,80 m, with dimensions of 0,70 x 1,70 m, revealed two horns, a fragmented oxe skull, a shallow ceramic bowl, a fragmented grinding slab (MOL, L - P – 74), and a fragmented grinding equipment (MOL?, L - P – 77).

Fig.3.73. Gumnište:, trench II, square 14, unit 2; Photo documentation Archaeological institute, Belgrade.

Fig.3.74. Gumnište: trench II, square D12, 13, unit 5. Photo documentation Archaeological institute, Belgrade.

Fig.3.75. Gumnište: trench II, square D12, 13, unit 5:Photo documentation Archaeological institute.

Units 116 and 205 have been detected in squares D12 and C 13, and probably present a large pit. Its content included small pieces of burned daub, animal bones, chipped stone tools, fragmented pottery as well as macro-lithic tools such as the grinding slab (MOL, L - P – 282), coarse-grained abraders (ALS, L - P – 60, L - P – 62), fine-grained abraders (ALS-PIA, L - P – 64, L - P – 75, L - P – 65), and an axe (HAC, L - P – 42).

Studied material has not been defined stratigraphicaly; thus it is treated as a whole. The 447 Late Neolithic macro-lithic objects from trench II, which have been analysed, show an important typological diversity. Most are coarse-grained abrasive tools (ALS), abrasive slabs (LOS), and fine-grained abraders (ALS-PIA), and grinding equipment (grinding slabs- MOL, MOL?, handstone-MUE, MUE? and mortar-MOR) (fig.3.77a).

Most of the tools are fragmented, indicating their intensive employment (fig. 3.78). Many are coarse-grained abraders (ALS), abrasive slabs (LOS), and fine-grained abraders (ALS-PIA), grinding slabs (MOL, MOL?), and handstones (MUE, MUE?) (fig. 3.79 a,b)[34]. The complete objects consist mostly of fine-grained abraders (ALS-PIA) and celts (REN) (fig. 3.79a, b).

This ratio between complete and broken and fragmented tools is a consequence of a systematic collection of finds.

The preliminary analysis of the finds indicates, that the inhabitants of the Neolithic settlement focused on herding of large livestock – i.e. cattle. It appears that hunting was of minor importance. The botanical remains confirm the presence of domestic species such as wheat (*T. Monococcum*, *T. Dicoccum* and *Triticum* sp.), barley (*Hordeum* sp.) lentils (*Lens culinaris*), and pea (*Pisum sativum*). Crop growing has also been confirmed by chipped stone tools with silica gloss. Botanicla remains also confirm the gathering of wild species, such as cornel (*Cornus mas*), blackberry / raspberry (*Rubus sp.*), elderberry (*Sambucus nigra*), apple/mug (*sp./Pyrus Malus sp.*), cherry (*Prunus avium / cerasus*). An abundance of flakes, nodules and chunks of flint confirm the production of the chipped stone tools within the settlement, while ceramic spindle whorls and weights indicate wool processing and textile production (Perić et al. 2016).

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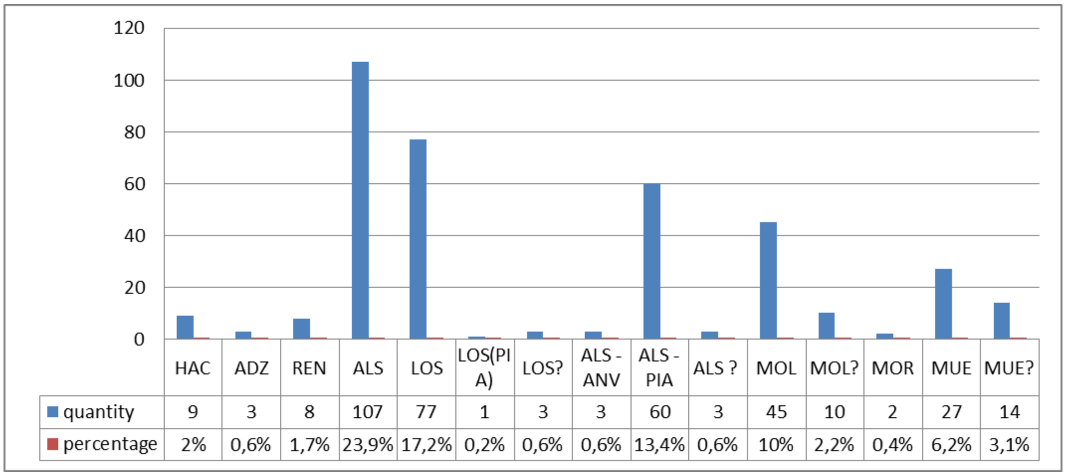
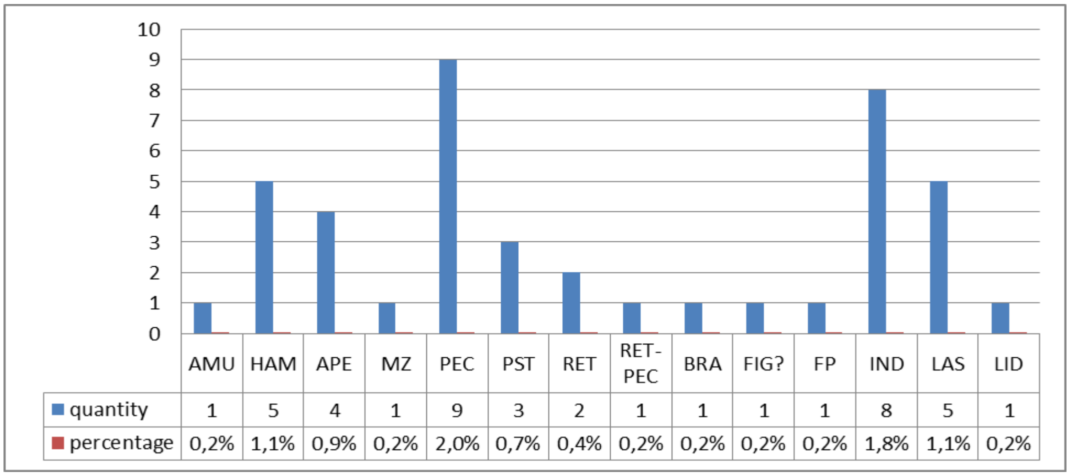
[34] A brief report was published in Perić et al. 2016: 256, footnote 44.



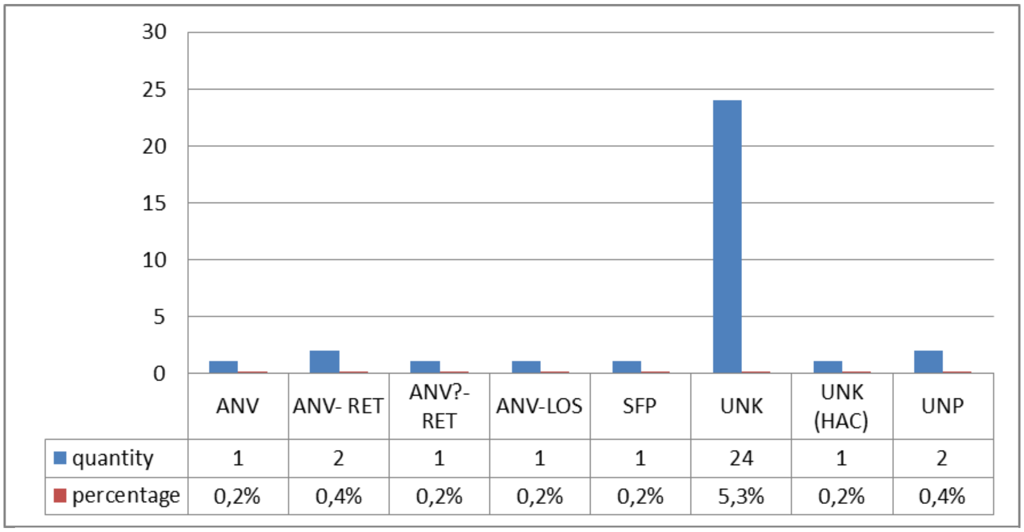
	HAC	ADZ	REN	ALS	LOS	LOS(PIA)	LOS?	ALS - ANV	ALS - PIA	ALS ?	MOL	MOL?	MOR	MUE	MUE?
■ quantity	9	3	8	107	77	1	3	3	60	3	45	10	2	27	14
■ percentage	2%	0,6%	1,7%	23,9%	17,2%	0,2%	0,6%	0,6%	13,4%	0,6%	10%	2,2%	0,4%	6,2%	3,1%

Fig.3.76a. Gumnište: macro-lithic objects, graph 1; N=447.



	AMU	HAM	APE	MZ	PEC	PST	RET	RET-PEC	BRA	FIG?	FP	IND	LAS	LID
■ quantity	1	5	4	1	9	3	2	1	1	1	1	8	5	1
■ percentage	0,2%	1,1%	0,9%	0,2%	2,0%	0,7%	0,4%	0,2%	0,2%	0,2%	0,2%	1,8%	1,1%	0,2%

Fig.3.76b. Gumnište: macro-lithic objects, graph 2; N=447.



	ANV	ANV- RET	ANV?-RET	ANV-LOS	SFP	UNK	UNK (HAC)	UNP
■ quantity	1	2	1	1	1	24	1	2
■ percentage	0,2%	0,4%	0,2%	0,2%	0,2%	5,3%	0,2%	0,4%

Fig.3.76c. Gumnište: macro-lithic objects, graph 3; N=447.

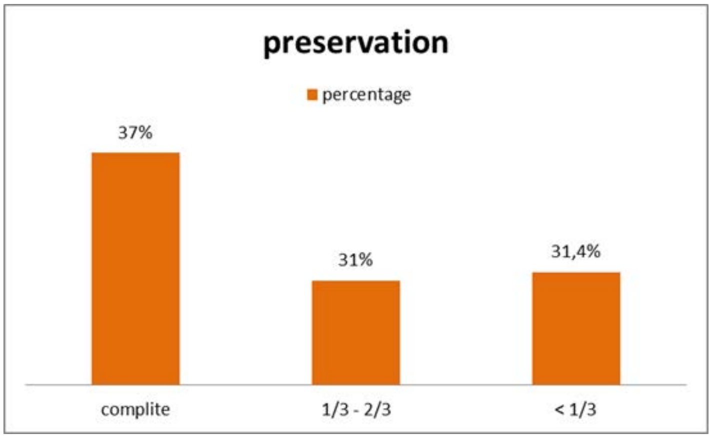


Fig.3.77. Gumnište: macro-lithic objects; N= 447.

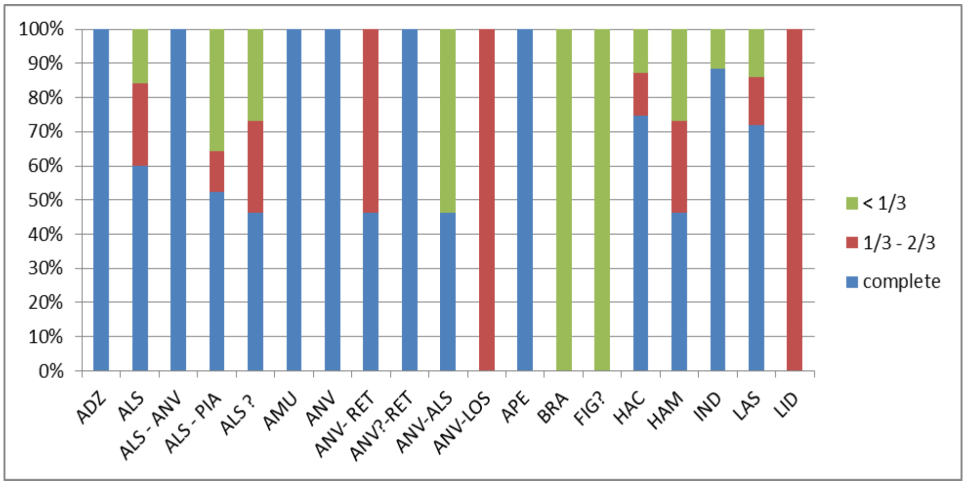


Fig.3.78a.. Gumnište: preservation of tools according to type, graph 1; N= 447.

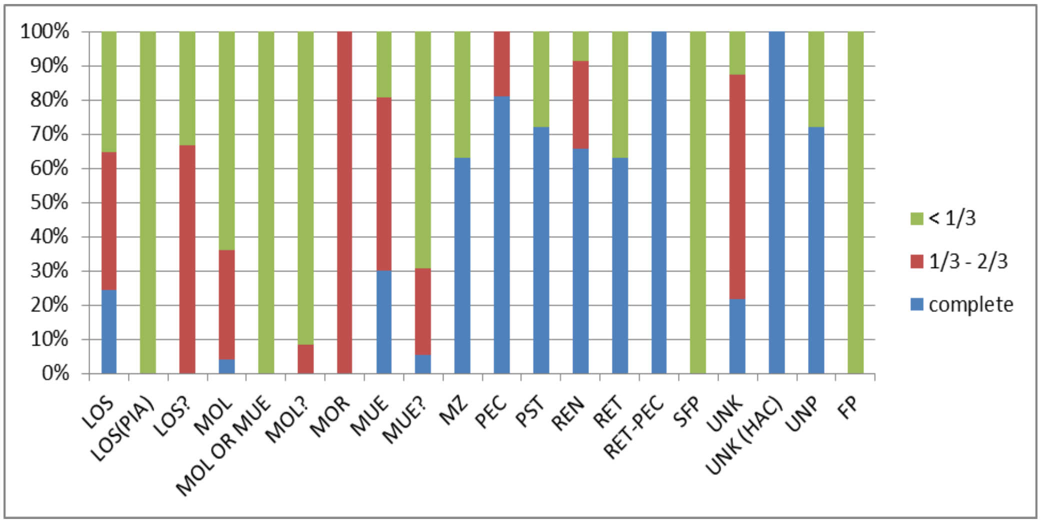


Fig.3.78b. Gumnište: preservation of tools according to type, graph 2; N=447

3.5. Recovery of macrolithic assemblages

Given that our objective is the study of the economic organisation of Neolithic communities, macro-lithic recording strategies are a major issue. The main difference between settlements, where artefacts were collected systematically or not, is the proportion of broken artifacts. Where a systematic recording strategy prevailed, fragments reperesenting less than 1/3 of the original tools, make up between c. 27-32% of the collections (table 3.4). Sites, where a selective or partial strategy was followed, fragments only represent between c. 2-16%. Motel Slatina is the only exception. Here, the high number of fragments (26%) mirrors the combination of old and new, more systematic excavation method. The difference in recovery of macrolithic assemblages or recovery process would imply, that in non-systematically excavated settlements, between c. 10 and 25% of the originally deposited artefacts are missing.

However, different recovery of macrolithic assemblages can also be evaluated in terms of artefact density. Given that the thickness of the stratigraphy is similar in most sites (2-3 m) or remains unknown to us (table 3.4), artifact density can be obtained by considering the relation between the number of artefacts and the surface excavated in each site (fig 3.79). This correlation is high with regards to selective lithic recording strategies (R^2= 0,698), which would suggest that a similar quantity and, possibly, types of artefact fragments have not been collected in the different excavations considered in this investigation. Instead, the correlation is low with regards to sites where lithic tools and fragments have been recorded thoroughly (R^2= 0,31). It must be concluded that the different recovery processes do have a major effect on the density of tools we have been able to record in each site. Consequently, the different quality of the collections could affect the approach to the economic organisation of each settlement. However, as this difference is mainly the result of a non-systematic collection of fragments, it is possible to estimate the amount of means of production not recorded. Obviously, those artefacts more prone to break, such as large grinding slabs, can be expected to be underrepresented in settlements where a partial or a selective sampling strategy has been followed. Hence the variables of fragmentation and sampling strategy need to be taken into account in the discussion of the paleo-economic organization of the Neolithic communities (chapters 7 and 8). The observed correlations and patterns also suggests that the use of macro-lithic tools and, hence, the intensity of production in the different Neolithic settlements was variable. Although, the size of the settlement and, it follows, of the communities appears as the determining variable of the economic strength of each of them, some settlements seem to have produced a much larger quantity of tools and, hence, of wealth than others.

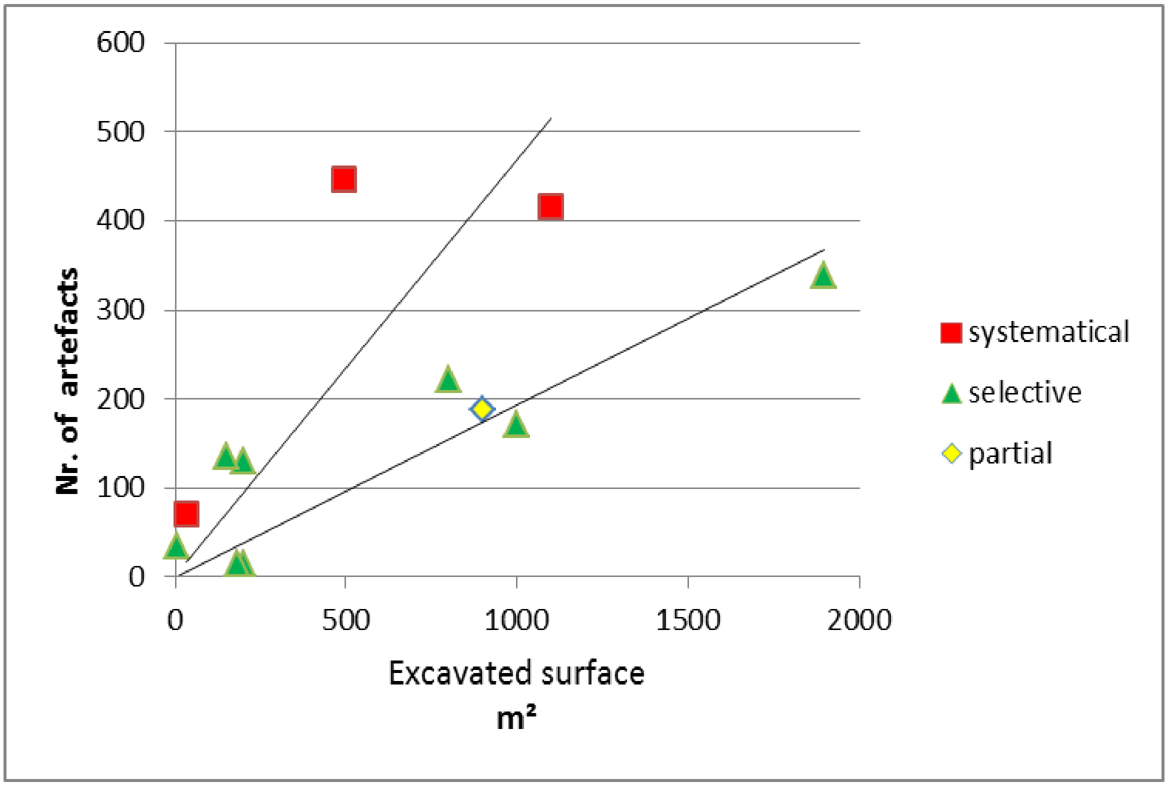


Fig.3.79. Density of macrolithic artefacts in excavated settlements, according to different recording strategies; selective: R^2=0,698; systematical: R^2=0,3174.

Settlement	**Region**	**ha**	**Excav. surf. (m^2)**	**Cultural layers (phases and numbres)**	**Thickness of layers (m)**	**Num. of analys. macro-lithic tools**	**% of fragments (≤ 1/3)**	**Recording strategy**
At	Northern	16	200	LN (VP I-IIa and IIb?) (**3?**)	-	16		*selective*
Potporanj	Northern	100	c.200	LN (VT I-II, Gr. and VP?) (**4?**)	2,5-3,4	130	16,2	*selective*
Benska bara	Northern	-	1900	LN (VT I-II, Gr. and VP?) (**4?**)	2,5	338	1,5	*selective*
Medjureč	Central	several	36	EN (1 layer)	2	71	26,8	*systematical*
Turska česma	Central	40	c.1100	EN, LN (VT-VP) (**6**)	6,7	416	35,9	*systematical*
Motel Slatina	Central	40-50	c.900	LN (VT-VP)(**5**)	2,55	187	26	*partial*
Kremenilo	Western	10	800	EN/MN - LN (VT I-II, Gr, VP?) (**5?**)	2,30	221	4,6	*selective*
Vranjani	Western	1,5	184	LN (VT) (**1 layer**)	0,50	15		*selective*
Koraća Han	Western	-	7	LN Phases are not specified	-	35	5,8	*selective*
Čelina	Western	-	151	LN (**1 layer**)	1,5	136	8,8	*selective*
Tumba Madžari	Southern	3	c.1000	MN (**1 layer**)	2,80	172	12,2	*selective*
Gumnište	Southern	20	493	LN (VTII and VP I) (**4**)	1,75	447	31,6	*systematical*

Table 3.4. Neolithic settlements from the Central Balkans from which macrolithic artefacts have been studied. Lithic recording strategies can be classified as ***selective*** *– only some tools were collected;* ***partial*** *– some find categories were collected systematically; or* ***systematical*** *– all artefacts were collected during excavations.* **EN–Early Neolithic; MN–Middle Neolithic; LN-Late Neolithic; VT-Vinča-Turdoş; VP- Vinča-Pločnik;**

Chapter 4.

Paleoecology, Geology and Geomorphology of the Central Balkans

The primary needs of each community are survival and reproduction. In order to meet the primary objectives of life, human beings, depending of their social organization and technological development, study, understand and use the natural condition for their own purposes. Using their experience and knowledge, the chosen path led them to independence in relation to the nature.

As the amount of sources[1] became larger, choices increased, regardless to distance. The exploitation of given choices required a specific social organization, and the independence to nature increased. In other words, we can understand social independence and natural choice as two correlated and complementary elements of production. Furthermore, production creates and formes the economy that finds its expression in the material culture of a particular territory (fig.4.1).

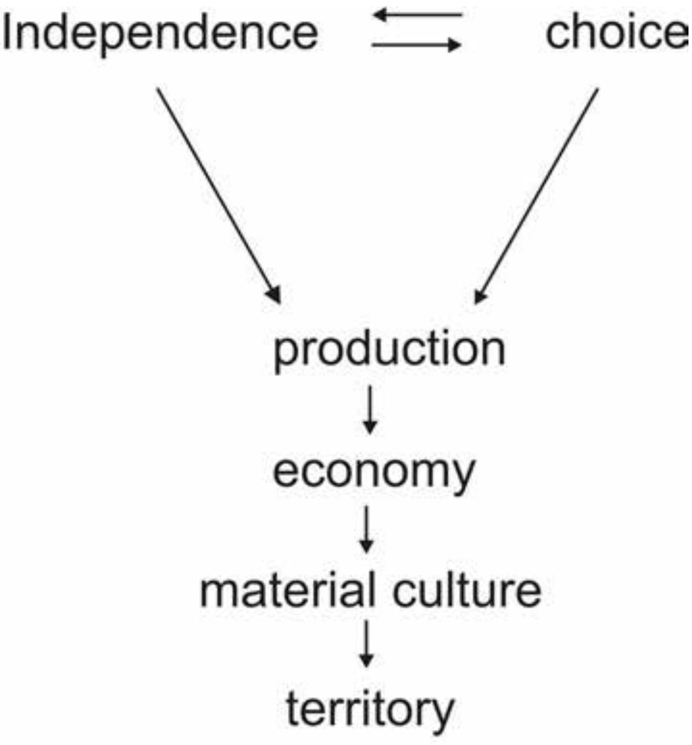


fig. 4.1.Basic steps of meeting the primary objectives of human life

Consequently, it is necessary to understand natural processes that formed the environment of human communities. With regards to macro-lithic tools, we must underline the structural complexity of geology and geomorphology of the central Balkans. This region was formed through different processes: tectonic movements, volcanism and marine transgression and regression. Therefore the area is characterized by a diverse relief, petrology and edafology.

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[1] The meaning of source is not strictly linked to raw material source and procurement but also to circulation of the material regardless of the level of its processing.

4.1 Paleoecology of the Central Balkans

The central Balkans have two distinct topographic areas. The first spreads south of the Sava and Danube rivers and is mostly formed by hilly – mountain relief intersected by valleys, and large and small rivers. Broader or narrower lowland zones appear close to the rivers courses. The northern part of the central Balkans is formed by the lowlands of the Pannonian plain, covered by fine eolian and alluvial sediments. Rare orogenic formations, large and wide water flows are further topographic characteristics of this area.

Climate is continental in the north and temperate in the south except on the mountains where rather cold and long winters dominate. Winters last approximately three months and until recently had a lot of snowfall. Summers can be hot and dry, with temperatures rising up to 40 °C. Depending on the altitude, the mean annual temperature ranges from 10.9 ° C to 3 ° C. Most of the rain falls in May and June, and the driest months are February and October.

Broadleaf and mixed forest vegetation dominates the central Balkans. Tundra appears in the upper forest zone. Depending on local conditions, there are meadows, bogs and stepps.

Contemporary vegetation evolved out of the Tertiary dry savanna - steppe biotope. Tropical and subtropical climate enabled the appearance of plants belonging to the families of the *Proteaceae* and *Myrtaceae*, as well as *Cinammomum, Myrica* and *Passania*. During the Pliocene species such as *Pterocaria, Glyptostrobus, Buettneria, Alnus, Juglans, Corylus , Picea, Abies, Typha, Fagus, Pinus, Quercus* and *Acer* occupied the area. Pliocene vegetation was a mixture of shrub communities, evergreen coniferous and deciduous forest, while aquatic and marsh vegetation occupied lowlands and basins between the forest complexes. Pliocene flora was a blend of present-day Balkan flora, and it was richer than East Asian and North American flora today (Janković et al. 1984: 4 - 6; Mitrović-Petrović, Andjelković 1992e:118 - 119).

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During the Pliocene this area was the habitat to faunal species such as bovids, and predators such as *Gobicyon macrognathus, Crocuta miocenica, Anchitherium aurelianense, listridon, hyanides, gyrafides and canides*. Shallow, warm lakes with blurred, loose bottom were the home for different water species: *Smerdis, Leuciscus, Prolebias*, and *Serranidea cyprinodontidae*. The snails remains from the later periods indicate shallow water and a hot and humid climate. Since the second half of the Pliocene a gradual climate cooling began, that resulted in the Great Ice Age. It marked the end of the Tertiary and the beginning of the Quaternary (ibidem 1984; ibidem 1992e).

Climate during the Pleistocene Ice Ages was colder, except in the interglacial periods. It was still warm enough to give shelter to many cold-sensitive plants. There was a significant difference between the northern and southern slopes of the mountains. Glaciers were formed mainly on the northern sides. Here vegetation could reach higher altitudes. In other words, despite the glacial period, forest vegetation continued to develop. During the Great Ice Age the central Balkan was a refuge place for thermophilic Tertiary plants and subtropical species of southern Europe. Therefore, this area was characterized by a rich flora, greater in diversity than the flora of the Apennine and the Iberian Peninsulas, which usually are considered to belong to the richest floristic regions in Europe. During the Great Ice Age (*c*. 2.58 million years ago) the vast polar cap reached the central European plains. South of it border climate conditions allowed the development of tundra and highland tundra vegetation. These plant species occupied all lowlands that were not covered by ice and mountains, which were not affected to a full extent. We should take into account, that the mountainous character of the Balkan Peninsula impedes the influence of Mediterranean climate. On the other side, the Alps and the Carpathian massifs, that surround the Balkan Peninsula on the north, limit the thermic influence of the Atlantic Ocean and airstreams from the Asian subtropical areas (Janković1984: 5-15).

The paleoecological picture of the central Balkans during the Ice Age is based mainly on pollen analysis from postglacial highland lakes and mountains in Serbia. Vojvodina, the northernmost lowland region, was under the direct negative impact of the northern European iced cap. A glacial mosaic vegetation, consisting of birch, larch, pine forests, deciduous trees - primarily oak - as well as tundra and steppe-tundra developed in the Vojvodina. Instead, the lowland and highland areas south of the Sava and Danube rivers were covered by local steppe and tundra flora. Also the valleys, lowlands and areas between the mountains' ranges provided the habitat for steppe vegetation. However, forest vegetation existed in all glacial periods. The forests consisted mostly of different types of oak, beech, willow, pine and elm, which extended from 500 to 1500 m a.s.l.. The tundra vegetation occurred above 1500 m in hight. *Lepus timidus, Dicrostonyx torquatus, Ochotona pusilla, Marmot, Alopex lagopus, Coelodonta antiquitates, Mammuthus primigenius, Rangifer tarandus* were the faunal species that inhabited this area (Janković et al. 1984: 30, 45 – 50; Stevanović, Marović, Dimitrijević 1992: 230) .

During the interglacial periods and the Holocene, warming and humidity increased. Tundra and steppe vegetation moved to higher altitudes. Steppe vegetation occupied partly plains and hills affected by drought. On other side, oaks and beech forests occupied larger space. Balkan`s endemic pines (*Pinus peace* and *Pinus heldreichii*) extended in the lowlands, while the highland vegetation migrated upwards. *Dicerorhinus merckhi, Megaloceros gigantus, Dama dama, Panthera cave, Panthera pardus, Meles meles* and *Castor fiber* inhabited mainly this region during the last glacial period. In the late Pleistocene, the lowland area north of the Sava and the Danube rivers was inhabited by various faunal species: cave hyenas (*Crocuta crocuta spelaea*), the cave lions (*Panthera spelaea*), cave bears (*Ursus spelaeus*), wolves (*Canis lupus*), mammoths (*Mammuthus*), wooly rhinos (*Coelodonta antiquitatis*), bisons (*B. bonasus*), giant deers (*Megaloceros*)and horses (*Equus ferus caballus*). These faunal records confirm a steppe tundra environment (Janković et al. 1984: 50; Stevanović, Marović, Dimitrijević 1992: 230; Dimitrijević, , Dulić, Cvetković 2013.).

Postglacial vegetation and climate reconstruction (according to Gigov in Janković 1984) are based on pollen analysis from the Tara mountain (western Serbia).These results are applicable for the area of Serbia south of the Sava and the Danube rivers. Pine forest phase – *the Preboreal period* (*c*. 9000-7000 BC) was characterized by pine, oak, birch and spruce pollen. In Serbia, this vegetation phase was determined at altitudes of 1100 to 1200 m a.s.l. A mosaic type forest formed at lower altitudes. The Preboreal climate was cool and continental (referring to the height of 1000 to 1200 meters a.s. l.) (Janković et al. 1984: 62, 67, fig. 9).

The drier and warmer climate of *the Boreal period* – Oak phase (*c*.7000-5000 BC) favored the development of oak, whose pollen dominated above 1000 to 1200 m.a.s.l. The beginning of the Boreal in the northern region was a turning point in pedogenesis and vegetation history. Pollen diagrams suggest a mixture of oak forests and steppe meadows. This period was marked by the great migration of thermophilic communities from the southern part of the Balkan Peninsula to Central Europe. The ground water declined sharply and the river flows stabilized. The fertile soil - chernozem - encompassed a broad area, while at the same time the extension of forest-steppe soils narrowed. (Benac, Garašanin, Srejović 1979:17; Janković et al. 1984: 62, 67- 68, fig. 9).

The Atlantic period is characterized by fir, beech , pine and spruce (*c*.5000 - 3000 BC). The hot and humid Atlantic climate favored the development of oak, which occupied the area at 600 - 800 m a.s.l. The fir zone was established at 850 - 1200 m a.s.l. and the spruce zone appeared at the 1400 m a.s.l.. Weather conditions also generated changes in lowland areas. In the northern lowlands, continental climate became milder, causing significantly wide spread of mixed oak forest. The sudden increase of the underground water level generated erosion, lakes, marshes and ponds in previously dry regions. These changes also affected the soil quality. Chernozem degraded into forests soil, marsh soil was created in sandy areas and meadow black soil formed on the loess plateaus (Benac, Garašanin, Srejović, 1979:17; Janković et al 1984: 68, 72, fig. 9).

During the Neolithic period, the central Balkans` oasis landscape of continental loess and fertile lands formed primarily along the Morava and the Vardar rivers. Vertisol covered the largest part of the undulating terrains along alluvial zones, between 100 and 250 m a.s.l. This soil indicates grassy areas and steppe fields, favorable for the Early Neolithic population. Forest soil was formed at higher altitudes (250-600 m a.s.l.). Above 650 m a.s.l. only barren, skeletal soil could develop. Red soil (terra rossa) formed in karst areas (Benac, Garašanin, Srejović, 1979:19). The late Neolithic population did not choose particular topographic areas to settle. Therefore, the settlements remains were found on the loess terraces, gentle hills surrounded by wetlands, on the slopes near the rivers or at the dominant position. The stratification of the older \ middle Neolithic (Starĉevo culture) settlements by the Late Neolithic ones is not rare case (Opaĉić – Ristić 2005: 72 – 112).

The results of pollen analysis from some Neolithic settlements in Serbia show that these settlements were surrounded by vegetation such as: oak, pine, birch, linden, hazel, alder, grass, valerian, thistle, and artemisia. On the other hand the analysis of carbonized seeds indicates the plants used mainly in dietary: emmer wheat (*Triticum dicoccum*), cornel tree (*Cornus mas L.*), wheat (*Triticum*), lime tree (*Tilia sp.),* pea (*Pisum sativum*), oak (*Quercus* sp.), einkorn wheat (*Triticum monoccocum*), flax (*Linum*), lentil (*Lens culinaris*), bread wheat (*Triticum aestivum)* etc (Nikolić, D., 1988: 39 – 44; Marinova, E., et al 2013: 471 - 474).

Analyses of archaeozoological material from some Serbian Neolithic sites indicate domesticated fauna species such as: cattle (*Bos taurus*), sheep / goats (*Ovis / Capra*), goat (*Capra hircus*) and pig (*Sus scrofa*). Archeaozoological records show diversity in wild fauna species such as: aurochs (*Bos primigenius*), red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), gray wolf (*Canis lupus*), wild board (*Sus scorfa fair.*), fishes (*Pisces sp.),* European beaver (*Castor fiber*), Dzungarian horse (*Equus przewalskii*), red fox (*Vulpes vulpes*). However, the records from some Neolithic sites suggest higher percentage of wild animals remains than domestic ones, suggesting that wild fauna contributed significantly to satisfy everyday needs. (Lazić 1988: 24 – 38; Cvetković 2004: 75 – 83).

4.2 Geology and geomorphology of the Central Balkans

4.2.1. Northern region

The dominant topographic feature of the Northern region is formed by the southern part of the Great Pannonia plain. This area is intersected by numerous river courses, among which the Danube and the Sava rivers dominate.

The Archaeological sites of ***At*** and ***Potporanj, Vršac*** (fig.4.2/ 4,5) are located in the vast plain in the vicinity of the Vršac mountains. This elevated tectonic block consists mainly of Paleozoic rocks: schists, gneisses, phyllites and granites (general geological map of Serbia 1:100.000; Ćalić et al, 2012: 51).

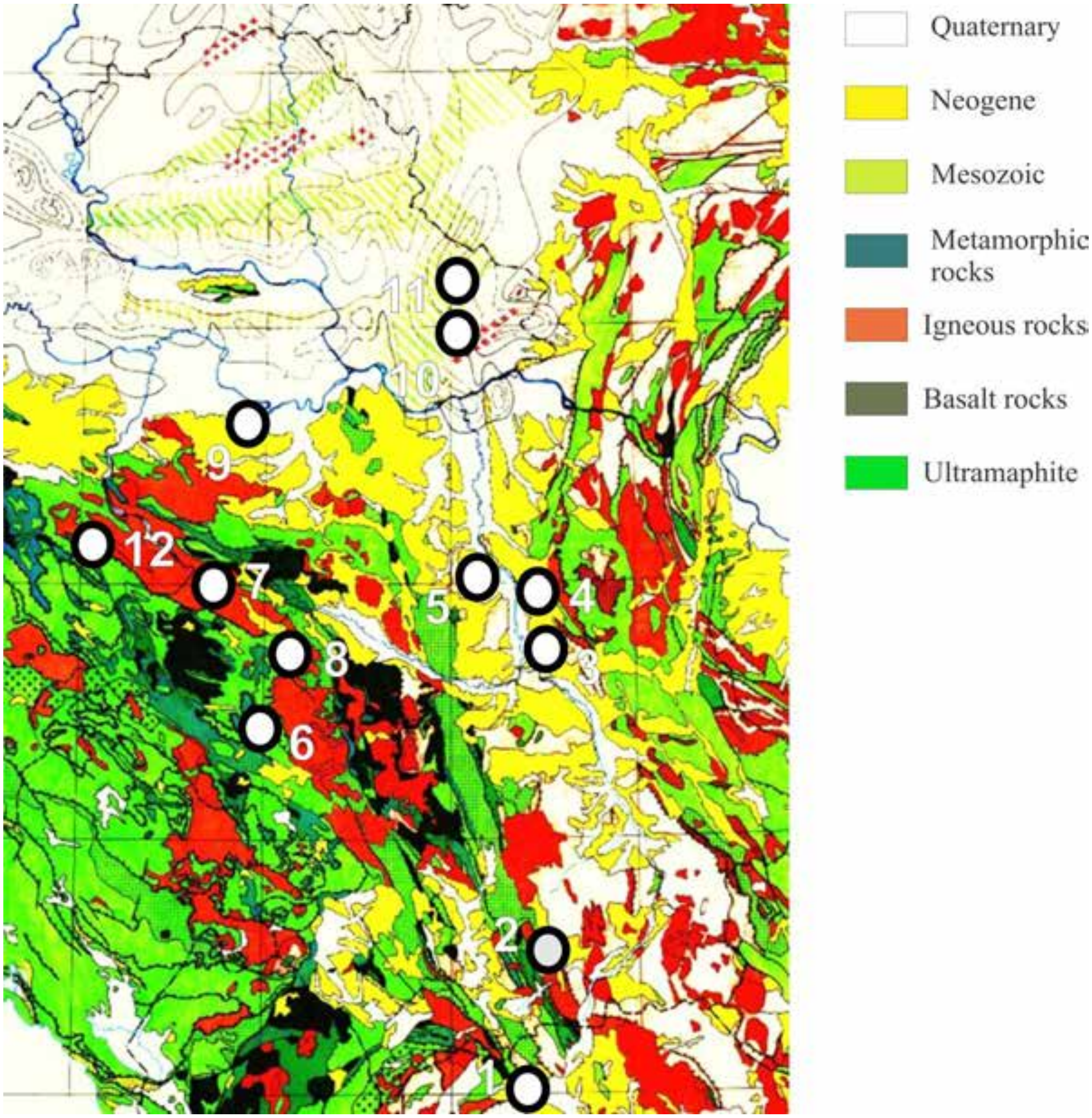

fig. 4.2. Archaeogeological map of the Central Balkans: 1.Tumba MadĎari2. Pavlovac; 3. Turska česma, Slaina;4. Motel Slatina; 5.Medjureč; 6.Čelina; 7.Kremenilo, Višesava; 8.Vranjani; 9.Benska bara; 10. Potporanj; 11. At; 12. Koraća Han. According to: https://asak.rs/geoloska-karta-srbije/

During the Paleozoic this area was covered by the Tethys Sea. Marine environment was replaced by brackish environment during the Sarmatian stage (the low Miocene). Petrologicaly, this change was characterized by the appearance of alevrolite, marls, shale and sandstones, pyroclastic materials and various traces of bogs. In the same era, the uplift of the Alps, the Carpathians, Dinarides and Balkanides disintegrated Paratetiys into several marine basins. Sedimentation and tectonic movements around 11.6 Ma (the early Upper Miocene) formed the integral Pannon Lake (Ćalić et al, 2012: 54, 56).

In the early Pliocene, about 4.5 My, Paludin Lake covered this area. Various types of clays, sands and lignite represent this geomorphological phase. Disappearance of Paludin Lake during the Pleistocene generated the initial Pannonian Plain relief and the dynamic development of pre-river courses. The Quaternary was marked by formations of river terraces, composed of mainly of gravel, sand, loess, tuff accumulation. (Janković et al. 1977: 326; Stevanović 1977: 357-418; Ćalić et al. M, 2012: 56).

Geographically, the site of ***Benska bara, Šabac*** (fig.4.2/ 6; fig.4.3/10) belong to the north-eastern part of the Dinaric region, but its topographic characteristics obliges us to include this area in the northern region (cf. Ĉalić 2012: 66). The upper Perm in this area, was characterized by continuous sedimentation of limestone in a shallow sea. Petrologically, for this period, dolomite, shale, and slate are typical. During the Mesozoic, a marine basin formed. Petrologically, the Triassic is characterized by siltstone, sandstones, marls, etc. It should be noted that the volcanic formations on this territory belong to the southern, neighboring Ibaric basin (Pantić, Marinković, 1977: 29, 31; Andjelković, Filipović 1977: 143; Andjelković, Mitrović – Petrović and Urošević 1991: 65; ibid 1992: 12, 35, 61; ibid 1992: 27, 58; ibid 1989: 91, 106, 124, 135, 167, 221).

In the middle Jurassic, Old Cimmerian tectogenesis formed the hilly - lowland terrain, which consisted of limestone, sandstone, marl and conglomerates. Unique limestone cover was broken by erosion and deduncion causing the appearance of the Paleozoic formations. In the Oligocene, Pyrenaic tectogenesis generated a lacustrine depression in the north, causing the Paratetis sea ingress app. 16.0 My and a bay formation. This period was marked by the deposition of sands, clay, marl, limestone, gravel and large blocks of granite, limestone and shale. After 5.332 My (Pontus era) receding of Pannon Lake caused the formation of a plains and mountains (ibidem 1977; ibidem 1977; ibidem 1977; ibidem 1991; ibidem 1992; ibidem 1989).

4.2.2.The Central region

There are three Neolithic settlements located in the central region, precisely in the middle Morava valley: ***Medjureč -Jagodina, Motel Slatina – Paraćin and Sltina, Turska česma - Drenovac*** (fig.4.2/ 1 - 3)***.*** Middle Morava valley or Paraćin – Jagodina basin is a central valley in the northern part of the Balkan Peninsula. This area is wide open to the north towards the Pannonian Basin and it is connected to the southern part of the Balkan Peninsula by the South Morava flow. These topographical features influenced the formation of an important communication route in this part of Europe.

The valley is bounded to the south by mountains consisting mainly of gneiss, and phyllite mica shist formed during the Paleozoic. The eastern and the northern boundaries are represented by the Paleozoic orogen formations and consist of limestone ranges, schist, red sandstone and breccia. The Paleozoic volcanic activity in the eastern part of the area created a gabbro formation which is 3.5 km long and 1.5 km wide. The western part of the Central region provides granite, mica-schist gneiss and amphibolite. Huge blocks of quartz are visible in the same side, under the lacustrine deposits (Milivojević 1951: 1, 2; Marković 1954: 23, 25; Geological map of Kragujevac - Zajeĉar).

The Triassic of the central region is poorly studied. It is assumed that during this period marine basins were formed, which were limited by Morava mainland along the direction of east-west. This period is represented by limestone and dolomite rocks. Volcanic activity, in the eastern part of the valley, formed andesite, rhyolite and volcanic tuff (Marković 1954: 25; Andjelković, Mitrović – Petrović, Urošević 1992b: 10, 32, 33, 58).

The mountain`s lacustrine depression were developed during the oligomiocen. The Oligocene lacustrine deposits consisted of sandstones, marls and schists. They covered a wider area, reaching the altitude between 225 m to 500 m. The Miocene tectogenesis and orogen movements lowered the northern part of the Great Morava depression, causing the appearance of the Pannonian bay. Miocene formations consisted of limestone, sand and marl (Marković 1954: 25; Andjelković, Mitrović – Petrović, Urošević 1992: 75, 78, 97, 155). In the upper Miocene, the elevation of blocks caused marine regression and connection of the bay with the plain. Gradually the Pontic lake was formed at this area. The presence of the lake during the Pliocene is evidenced by deposits of sandstone and clays, reaching the altitude up to 540 m. Abrasion platforms, that presented the shores, are visible along the rim of Paraćin - Jagodina basin. They were formed in older rocks and older lacustrine deposits and reached the altitude from 440 m up to 640 m. (Milivojević 1951: 4, 6; Andjelković, Mitrović – Petrović and Urošević 1992: 166, 168,189, 220).

Here we would emphasize that the Quaternary of the central and the southern regions is characterized by the same geomorphological processes. During the Pleistocena began the creation of river - lake sediments, and river terraces were created during the Holocene. Among them a broad alluvial plains and talus slopes were formed (Rakić:1977: 405, 407).

4.2.3 The Western region

This is a predominantly hilly are with a plain in the north. This region is intersected by numerous smaller and larger river flows among which the Drina river is the largest. During the geological past this area was part of the Dinaric region, which was structured by a system of basins with their own development. The Neolithic settlements were located in some of these basins and their geomorphological development will be introduced in the lines below.

The sites of ***Kremenilo, Bajina Bašta and Vranjani, Požega*** (fig.4.2/ 7, 8; map 2/8,9) belong to the western part of Dinar area. Terrestrial environment with lacustrine basins, river beds and deltas were formed during the early Carbon and Perm. Evolution during the Triassic period is characterized by two sea phases, carbon sedimentation and a lacustrine phase, which was followed by fine-grained clastic sedimentation. At the end of this period, during the Old Cimmerian phase, generated terrestrial environments were generated..This change was represented by diversity of lithology: quartz sandstones, alevrolite, quartz breccia, limestone, dolomites, marls, magnesite, clays and tuffites and porphyry. The Jurassic was characterized by dynamic processes of the ground differentiation and erosion. Geologically, this period is rich in various rocks: peridotite, diabase – chert, formations composed of sandstone, cherts, diabase, spilite, melafira, limestone, amphibolite, green schists, gneisses, phyllites and serpentines peroksenite and gabbro. However, during the Cretaceous the Austrian tectogenesis formed a marine basin, whereby conglomerates, micro sandstones and limestones were created. At the end of the Cretaceous Laramian tectogenesis created and designed the terrestrial environment by creasing, horizontal movements, pulling over and marine regression. This turbulent geological processes resulted as well in formation of quartz sandstones, phyllites, breccias, schists and quartzites (Mojsilović, S., et al, 1978: 15 - 30.; Andjelković, Mitrović – Petrović, Urošević1992a: 18 – 20, 67; ibid, 1992b: 27, 58, 84, 110; ibid, 1989: 44, 73, 92, 103).

The Oligocene and Miocene were characterized by forming the lacustrine basins, block movements and volcanic activity. This geological processes generated various geological materials such as sedimentary rocks (conglomerate, coal,sandstone, limestone, marl, alevrolite, shale and mud breccia), dacito-andesite and clastic material (tuff, tuffits, serpentinite, and quartzite). For following periods there are insufficient data. (Mojsilović, et al, 1978: 30; Andjelković, Mitrović – Petrović, Urošević 1991: 55 – 62, 86).

The Quaternary of this area is characterized by the formation of river terraces, spring, alluvial, proluvial, diluvial sediments and talus (Mojsilović et al, 1978: 31 - 32).

The site *of* ***Čeline, Priboj*** (fig. 4.2./ 9) is located in the southwestern part of the Dinaric area. In this area the Triassic volcanic activity formed a marine basin and various petrology such as limestone, sandstones, shale, dolomites, volcanic tuffs, tuffits, cherts, schists, and dacito - andezite (porphyry, porphyrities). The Jurassic is marked by terrigenous formations that consisted of igneous rocks (gabbros, diabase and peridotite), metamorphic rocks (serpentinite, harcburgita, serpentinisanih harcburgita) and sedimentary rocks (shale, marl, shales, cherts and sand – cherts). The Cretaceous tectonic movements formed the dry land. But during the Miocene terregenius environment was reduced by appearance of the lake, causing the formation of an island between the lacustrine basins. The Tertiary land got mountainous character, characterized by limestone formation (Andjelković, Mitrović – Petrović, and Urošević 1989: 45 – 46, 106, 161; 1991: 11, 34, 65, 132; 1992a: 21, 45 – 49, 76-78; 1992: 27, 58 ,87, 110; see paloegraphic maps of Badenian, Sarmatian, Pannonian, Pontian century).

Quaternary formations are not specifically expressed. They consisted of delluvium, alluvium and talus. (General geological map of Srbia 1 : 100 000, Prijepolje sheet, K 34 – 16).

Koraća han, Tuzla is located in northern – east of Bosnia and Herzegovina (fig.4.2/ 10). This area was covered by Panonnian sea until the Upper Eocene. The Paleozoic formations of limestone are presented in the south-eastern part of the area. The Mesozoic is consists of the Triassic clastic and carbonate rocks (limestone, dolomites and sandstones) and the Jurassic sedimentary, is composed of metamorphic and igneous rocks (marls, shales, alevrolites, amphibolite, cherts, serpentinite, peridotite,gabbro-dolerite, spilite and diabase). But the Upper Cretaceous tectonic movements elevated underwater level and caused the appearance of *cordilleras* with shallow water sedimentation. On the wider area basins with pelagic sedimentations begun to form. These processes were partly interrupted by volcanic flows consisting in basic rocks. The end of this period was marked by flysch formations. Petrologically the Cretaceous is represented mainly by sedimentary rocks such as breccia, limestone and marl. (Ćirĉić et al, 1988, 1991: 19 - 28 ; Andjelković 1988: 306 – 307)

During the Eocen, flysch sedimentation was replaced by carbonate sedimentation. During the Upper Eocene orogene movements caused intense ground ruffling and marine regression. Following periods in the Tertiary were marked by lacustrine phase and freshwater sedimentation. The Paleogene was characterized by salt deposits and various sedimentary rocks such as coal, sand, clay, marls, alevrolite, shale, limestone and conglomerates (Ćirĉić et al, 1988, 1991: 28 - 49; Andjelković 1988: 306 – 307). This phase was interrupted by the Miocene marine transgression and neotectonic movements that created shallow water formations. In following period intensive faulting shaped present-day terrestrial environment consisted of horst systems and valleys (Andjelković, M., 1988: 306 – 307).

4.2.4.The Southern region

In this region two reliefs zones can be spotted. The area in the north has a hilly-mountain character while the second one, in the south, has lowland-hilly relief. It is connected to the Central region by the South Morava river and to Aegean area by the Vardar river.

The archaeological site of ***Gumnište*** Vranje (fig.4.2 / 11) is located in hilly-mountain part of southern Serbia. These orogenic formations are part of Rhodope and the Dinarides massifs which are intersected by the valley of the Morava river. The valley has a composite character and consisted of the series of valleys, cliffs and gorges (Milić, S. Ĉ, 1967a: 33).

The margins of this area consists of Paleozoic rocks: granite, slate, micashist gneiss, amphibolite, marble, quartz and grano-diorite. There is an assumption that during the Middle Jurassic there was formed a broad hilly - mountainous land was formed. Upper Cretaceous period was marked by active tectonic and paleographic evolution. In the first phase epirogenic motion lowered the ground and formed the sea environment. During the early Paleogene ground was elevated, and the seawater was replaced by the lake - wetland environment. The margins and bottom of the valley are consisted of various petrological material formed during this period: conglomerates, breccia, coarse-grained and fine-grained sandstones, shale, marls, alevrolites and limestone as well as serpentinites, phyllites, gneisses, quartz- micashist, dacite, schist and amphibolite etc. The end of this period was marked by the formation of limestone, chalcedony lenses, quartz conglomerate and sandstone. (Milić, 1967b: 43 – 57; Terzin, et al, 1963 – 1969; Pantić, Marinković,, 1977: 15; Andjelković, Mitrović – Petrović and Urošević 1989:

115, 142, 143; Andjelković, Mitrović – Petrović and Urošević 1991: 8, 97; Andjelković, Mitrović – Petrović and Urošević 1992: 32, 52,78).

In a broad geographical sense, the archaeological site of ***Tumba Madžari***, Skopje (fig.4.2/12; fig.4.3/1) is located in the wide the Skopje valley, intersected by the Vardar river. In the north, the Skopje valley is connected to the Kumanovo valley. In the west, the east and the south the valley is closed by mountain ranges, intersected by gorges, rivers and streams flows (Jovanović, S., P., 1930: 1). The Triassic in this area began with the ground lowering marine transgression, underwater volcanism and limestone sedimentation. Lithology of this period is diverse: limestone, schists, gabbro, peridotite, serpentinite, cherts, sandstones, slates, jasper, tuff, diabase and trachyte. During the early Jurassic began a marine regression and a long continental phase began. The ground ruffled and the mountains eroded to the sea level. During the Upper Cretaceous ground lowering triggered the short marine transgression from the south. This event was marked by emergency of flysch, limestones, conglomerates, sandstones, marls, serpentinite, gabbro, iron ore, calcite and magnesite. This process was interrupted by intense ruffling during the Eocene. At the end of this period another marine transgression in the south formed a bay in the Skopje Valley. But the final appearance of the valley was formed during the Oligocene-Miocene faulting. The series of volcanoes, especially in the north-east part were formed during the Upper Oligocene and early Miocene. A saline lake water filled up the area in the second half of the Miocene, and in the same period volcanic activity gradually extinguished. Oligocene is represented by conglomerates, marl, sandstone and limestone. The Neogene lithology is represented by basalt, marls, sands, shale and sinter. (Luković, M,T, 1930: 6 - 44; Krstić, Savić, Jovanović, 2012: 45).

The basic mass of the margins of the Skopje Valley consisted of Permian schists, which is bound to the rocks of different origin and age. Granite gneisses and marble settled along the west side of the valley. The composition of the north-western area includes more marbles (ordinary and dolomite), but above it there are crystalline limestone, tuffites, quartz conglomerates, serpentinite. The northern rim of the valley is composed of amphibolites, phyllites, marbles and, in some parts, schists are associated with diabase, gabbro and diabazic porphyr. Quartzites, phyllites, amphibolites and quartz conglomerates dominate in the south-western part. The depressions were filled up by the Neogene and recent lacustrine, fluvial and alluvial deposits (Luković 1930: 6 - 44).

The Quaternary processes are similar to those already described in relation to the central region due to their similarity.

Various geological processes generated different rocks at the Central Balkans. Diversity of material is more expressed in the south of the Danube and Sava rivers, where the Central, Western and Southern regions are positioned. Thus, we believe that these areas represented main sources for the supply of raw material during the Neolithic at the studied area.

Chapter 5

Raw material sources in the Central Balkans and their exploitation

5.1. Neolithic raw materials

Petrographic analysis of the macro-lithic artefacts is an initial step towards the identification of the sources of the exploited raw materials, as well as to the functional analysis of the tools. It determines the material features of rocks such as structure, texture and mineral composition. These characteristics affect the mechanical behaviour of the objects, i. e. their shaping, the development of wear and the efficiency of tools. The petrographic analysis also allows approaching the selection, circulation and value of raw materials (Risch 1995, 2011; Adams et al.2009; Delgado-Raack et al 2009). These elements are necessary in order to reconstruct the Neolithic economy of the central Balkans.

All the raw materials analysed in this study have been classified macroscopically with a hand loupe (10x) with the assistance of Dušica Petrašinović, petrographer of the High School of Geology and Hydrogeology, Belgrade. She offered a short general macroscopic description of the rocks is offered. Microscopic analysis of petrographic thin section has been carried out on eight selected samples at the Autonomus University of Barcelona. They correspond to different rock types, which proved particularly difficult to classify macroscopically. These analyses were undertaken by Francisco J. Fernández, David Gómez-Grass (Geology Department) and Roberto Risch (Prehistory Department), all from the Autonomous University of Barcelona. The tools chosen for microscopic analysis come from the Late Neolithic settlements of Gumnište (Southern region), Turska česma, Slatina (Central region), Benska bara and Potporanj (Northern region).

We have also included the results of petrographic analysis of raw material from other Neolithic archaeological sites from previous studies, and samples from geology outcrops from the Central Balkans, in order to present characteristics of all geology, which has been identified in our thesis.

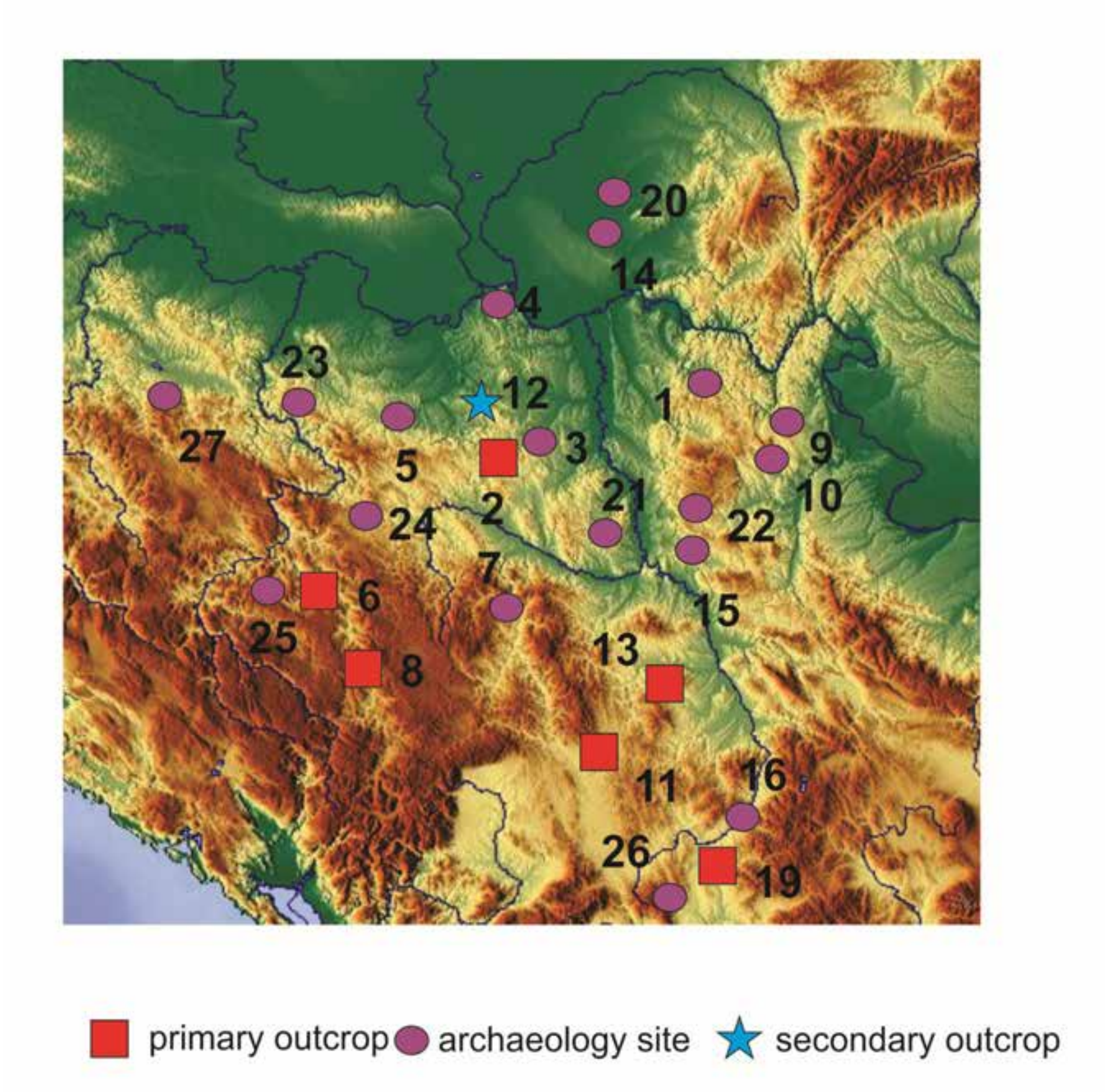

Fig.5.1. Map with primary outcrops, and archaeology sites and : secondary deposit 1.Belovode; 2. Ţdrelica; 3.Selevac;4. Vinča; 5. Čučuge;6.Zlatibor mountain; 7. Divlje Polje; 8. Sjenica; 9. Bor; 10. Rudna Glava; 11. Dudin Krš.12. Nevade, Mt. Rudnik; 13. Kuršumlija; 14. Potporanj; 15. Turska česma; 16. Pavlovac; 17. Čukar; 18. Benska bara; 19. Vranjska bara; 20.At; 21.Medjureč;22.Motel Slatina; 23. Kremanilo; 24. Vranjani; 25. Čelina; 26. Tumba Madţari; 27. Koraća Han.

5.1.1. Igneous rocks

This group of rocks was formed through the cooling and solidification of magma. In terms of their modes of occurrence, igneous rocks can be intrusive (plutonic) or extrusive (volcanic).

Fig.5.2, Granit, Turska česma, Slatina, from our studied collection

Intrusive rocks are formed by the cooling of magma and light crystallization in depth.

1. Granite (GRA) (fig. 5.2) includes felsic, massive, hard and tough intrusive rocks. Geological studies of various types of granite have been conducted in Sjenica, southwestern Serbia and Ţdraljica, central Serbia (fig. 5.1 /2,8) (Resmić – Šarić 2004 – 2005; Milovanović et al. 2012).

A ***fine-grained garnet-bearing granite*** from Sjenica contains albite, chlorite and quartz (fig. 5.3) (Milovanović et al. 2012: 99).

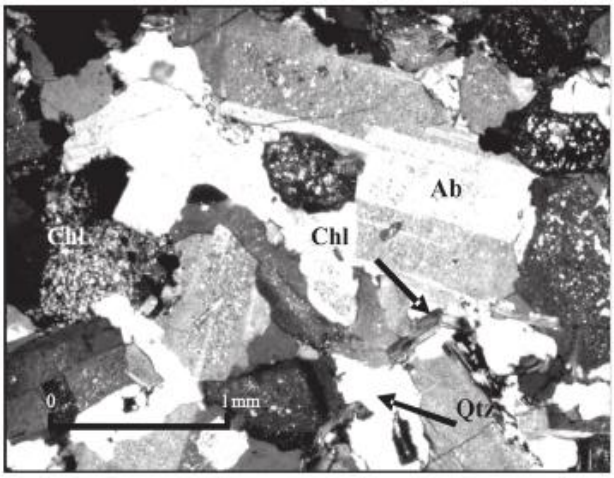

*Fig. 5.3, The geology site in souranding of SjenicaMicrophotograph plagiogranite (N+ . Abbre-viations: **Ab** – albite, **Chl** – chlorite, **Q** – Quart; according to Milovanović et al. 2012.*

Geological studies of ***leucocratic granodiorites*** and ***granites*** from Ţdreljica, central Serbia, are hypidiomorphic medium- to coarse-grained in texture. Poikilitic, perthitic and granophiric textures are also observed. These rocks consist of quartz, K-feldspar, albite (0–6.9 % An), chloritised biotite and amphibole. Accessory minerals are apatite, magnetite, and zircon, while sericite and chlorite are alteration products (Resmić – Šarić 2004 - 2005:75).

2. Granodiorite (GRD) displays felsic to intermediate composition and an aphanitic texture similar to granite. This rock contains more plagioglase feldspar than orthoclase feldspar, a large amount of sodium (Na) and calcium (Ca). It is rich plagioclase, potassium feldspar, quartz and minor amounts of muscovite mica as the lighter coloured mineral components. Minor amounts of oxide minerals such as magnetite, ilmenite and ulvöspinel, as well as some sulfide minerals may also be present. Geological characterisation of g***ranodiorite*** from Vranjska banja, Southern Serbia (fig. 5.1/19) has grey, massive textures, built of biotite, hornblende, orthoclase, feldspar and quartz. Structures are grainy, sometimes porphyric (cf. Majstorović et al 2016).

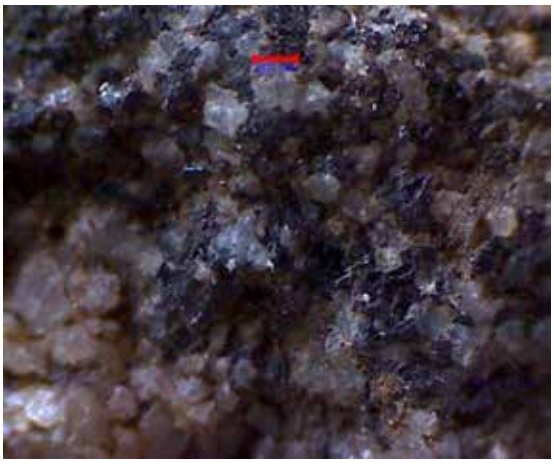

Fig.5.4, Quartzdiorite, Gumnište, southern Serbia, our studied collection

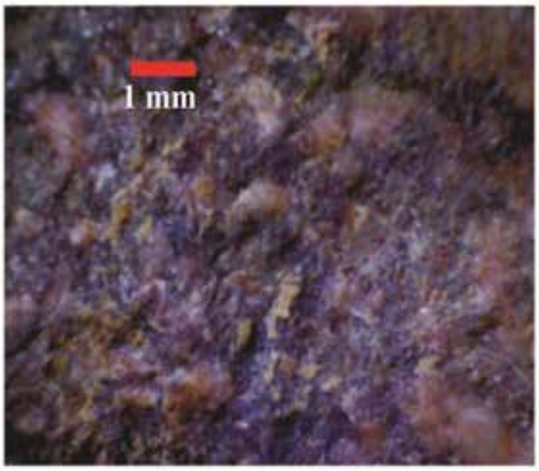

Fig. 5.5, Gabbro,the Čukar hill, central Serbia, our studied collection.

3. Diorite (DIO) displays grainy, sometimes porphyric structures and a mostly massive, decayed granitece texture. These rocks are dark grey, greyish green, green, and sometimes dark green in colour.

Geological studies show that most samples of ***diorite, quartz diorite*** (fig. 5.4) and ***quartz monzodiorite*** from the Ţdraljica, central Serbia and Kuršumlija, south Serbia (fig. 1.1/2,13) display a hypidiomorphic granular

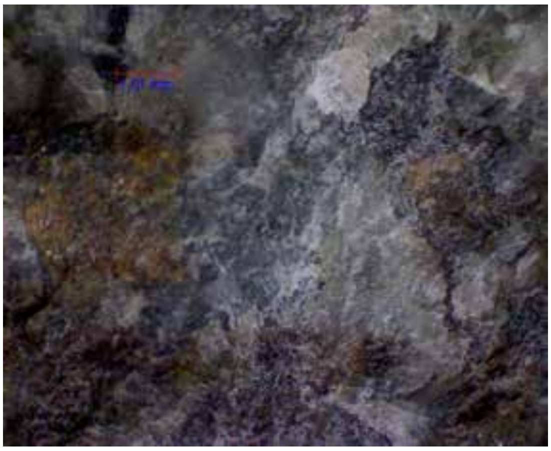

Fig. 5.6, Gabbro, Priboj,western Serbia, studied macro-lithic objects.

texture and some show a cumulitic fabric. They are predominantly composed of amphibole and plagioclase (47.3–51.7% An). Quartz, biotite and K-feldspar are subordinate. Accessory minerals include zircon, apatite, and opaque minerals (Šarić 2011: 135).

4. Geological studies of samples of ***quartzdiorites (QDI)*** and ***quartzmonzodiorites*** Ţdreljica, central Serbia show a medium-grained, hypidiomorphic texture. The main minerals are plagioclase (48.1–42.2 % An) and magnesiohornblende, while K-feldspar is very rare and occurs only as interstices in quartzmonzodiorites. Accessory minerals are sphene, apatite, zircon and opaque minerals (Resmić – Šarić 2004 - 2005:75).

5. Gabbro (GAB) refers to a large group of dark, often coarse-grained rocks (fig. 5.5-6). They are characterized by a massive texture that could be sometimes striped and flat, to irregular. Gabbro (GAB) is greenery, dark green, green and sometimes black. Geological characteristation of gabbro from Čukar hill, Paraćin, and Ţdraljica, central Serbia, and characterisation of the artefacts from Late Neolithic mine Rudna Glava, eastern Serbia will be presented in following lines (Dolić et al.1981; Jovanovic 1982; Resmić – Šarić 2004 -2005)

Various types of pyroxene ***gabbro*** from the Čukar hill, in close vicinity of the Late Neolithic settlement of Motel Slatina, Central region (fig. 5.14) are associated with rare anorthosite wires (Dolić et al.1981). Pyroxene gabbros are medium grained rocks, consisting of saussuritized plagioclase, augite (2V = - 58 c: Ng = 48) partly replaced by uralite. Its chemical composition includes: SiO_2 = 47, 08%, TiO_2 = 0,40 %, $Al_2 O_3$= 13,20 %, Fe_2O_3 = 3, 29%, FeO = 3,51%, MnO = 0,10%, MgO= 12, 24%, CaO=13, 25% Na_2O = 0,50%, Ka_2O = 0,30%, P_2O_5= 0,20%, H_2O+ = 4, 24%, H_20- = 1,08% (ibid 1981: 20, 21, Table I/3, 45). Some specimens are reddish in color due to iron oxide.

Several mining tools, the Late Neolithic mine of Rudna Glava, eastern Serbia have been analyzed and described as follows (Jovanovic 1982: 128; petrographic analysis accomplished by Djordjević, G.).

Sample 1 (**IN 1047)** ***olivine gabbro,*** (fig. 5.1/10) consists mainly of diallage, plagioclases which belong to the labrador – bytownite type with c. 70% anergite. They are partly transformed to paragenite. The olivine is a minor component in relation to previous minerals. The olivine crystals on the edge and along the crack are usually transformed into serpentine. The rock structure is hypidiomorphic – grain or gabbro structure (Jovanovic 1982: 128).

Plagioclases are predominant in serpentinite gabbro, as sample **IN 1052** (fig. 5.1/10). They belong to the labrador – bytownite type with 68-70% anergite. Diallage[1] and epidote are secondary minerals. Tremolite is rare. The structure shows a gabbro relict (ibid: 128).

Sample 2 (IN 1052) olivine gabbro (fig. 5.1/10) shows that plagioclases are predominant. The diallage appears, while the olivine occurs in small quantities and is partly transformed into magnetite along the cracks. The structure is hypidiomorphic – grain or gabbro structure (ibid: 128).

Plagioclases, diallage and olivine are often observed in argilitized s***ample 4*** (***IN 1046) uralitized and serpentinized (changed) gabbro***. The olivine, pennine, epodite and actionolite occur very seldom. The structure shows a gabbro relict (ibid: 128).

Uralitized pyroxenes and plagioclases are dominant in ***Sample 3 and 5 (IN 1048, 1053)*** uralitized ***(changed) gabbro produced plagioclases*** (fig. 5.1/10)**.** The hornblende occurs very seldom. Hornblende, epidotite and shorite occur very seldom and it shows a gabbro structure (ibid: 128).

The petrographical study of ***gabbro*** from Ţdraljica, central Serbia (fig. 5.1/2) presents coarse-, rarely fine-grained and poikilitic to coarse-grained ophitic and orthocummulitic texture, and contains plagioclase (fresh: 63.8–97.6 % An or albitized: 3.7–19.6 % An), clinopyroxene and, very rarely, totally serpentinized olivine. Accessory minerals are magnetite, sphene (titanite) and apatite. Secondary[2] minerals are epidote, uralite, chlorite, tremolite, calcite, serpentine, pyrite and, rarely magnesiohornblende (Resmić – Šarić 2004 - 2005: 75).

6. Gabbro-diorite **(GBD) (**this rock originally was classified as andesite**)** was identified by F.J. Martínez Fernández, D. Gómez-Gras, and R. Risch, (UAB, Barcelona). Sample ***UAB-SER-3*** corresponds to tools with abrasive surfaces (abraders, grinding slabs) from the Late Neolithic settlement of Turska česma, Slatina, Central region (fig. 5.1/15).

This rock has of granular alotriomorphic texture Rock composed of biotite and brown amphibole (together 70-80%), as well as altered interstitial feldspar (probable plagioclase with secondary clinozoisite aggregates). Minor minerals: moscovite (<1%) (fig. 5.7-8).

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[1] A variety of diopside

[2] A secondary mineral is one resulting from the weathering of a primary mineral, either by an alteration in the structure or from reprecipitation of the products of weathering (dissolution) of a primary mineral.

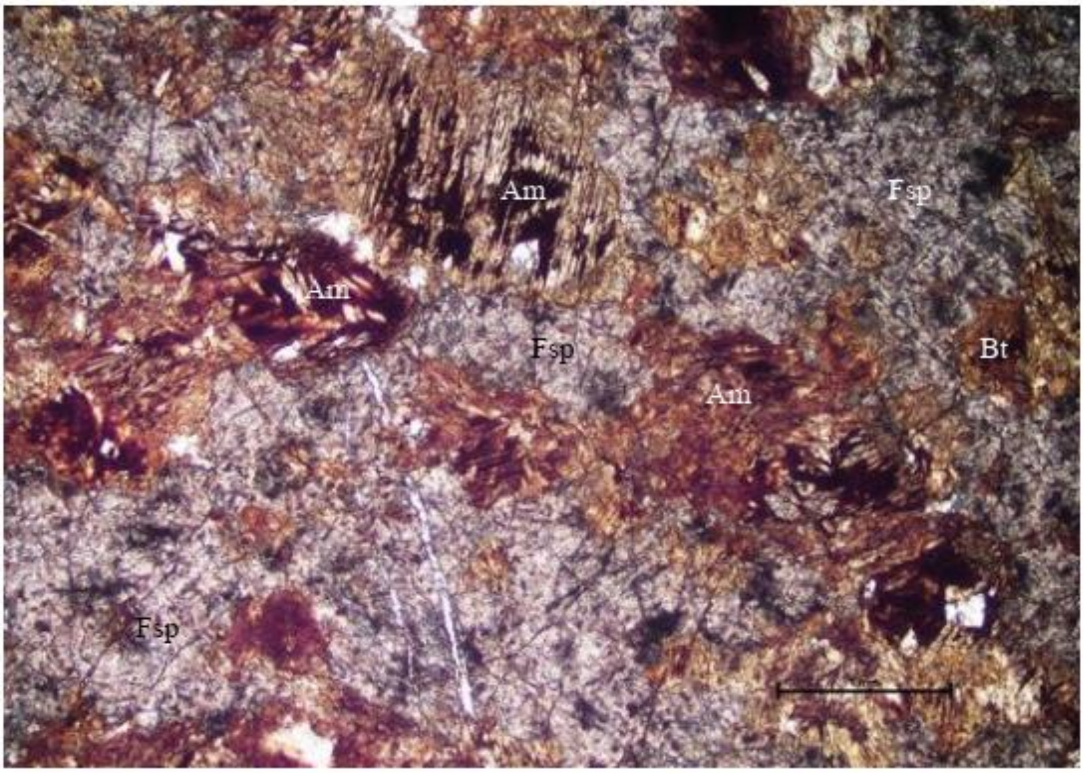

Fig. ***5.7.*** *Thin section of gabbro-diorite (UAB-SER-3). General view of the rock under plane polarised light.*

7. Diabase (DIA) is characterised by diabasic or ophitic texture and fine- to medium-grained texture, and dark grey colour. One-third to two-thirds of this rock consists of calcium-rich plagioclase feldspar; the remainder is mostly pyroxene or hornblende. The larger pyroxene grains may completely enclose plagioclase.

Several diabase artefacts from the Late Neolithic settlement Vinča (***samples DV–14*** and ***sample DV–6***) have been sampled and analysed (fig.5.1.19/4) (Antonović, Resmić-Šarić, Cvetković 2005: 61, fig 2E).

Sample DV–14 is black in colour and displays an ophitic texture and a homogenous and massive structure. It is built of plagioclase and clinopyroxene, as main minerals. Subordinate[3] are metallic minerals, while chlorite, epidote and calcite are secondary. In addition to isolated grains, radially distributed clinopyroxene crystals can also be noted. Accessory and secondary minerals make up together approximately 10 % of the volume of the rock. (Antonović, Resmić- Šarić, Cvetković 2005: 61, fig 2E).

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[3] Less presented minerals

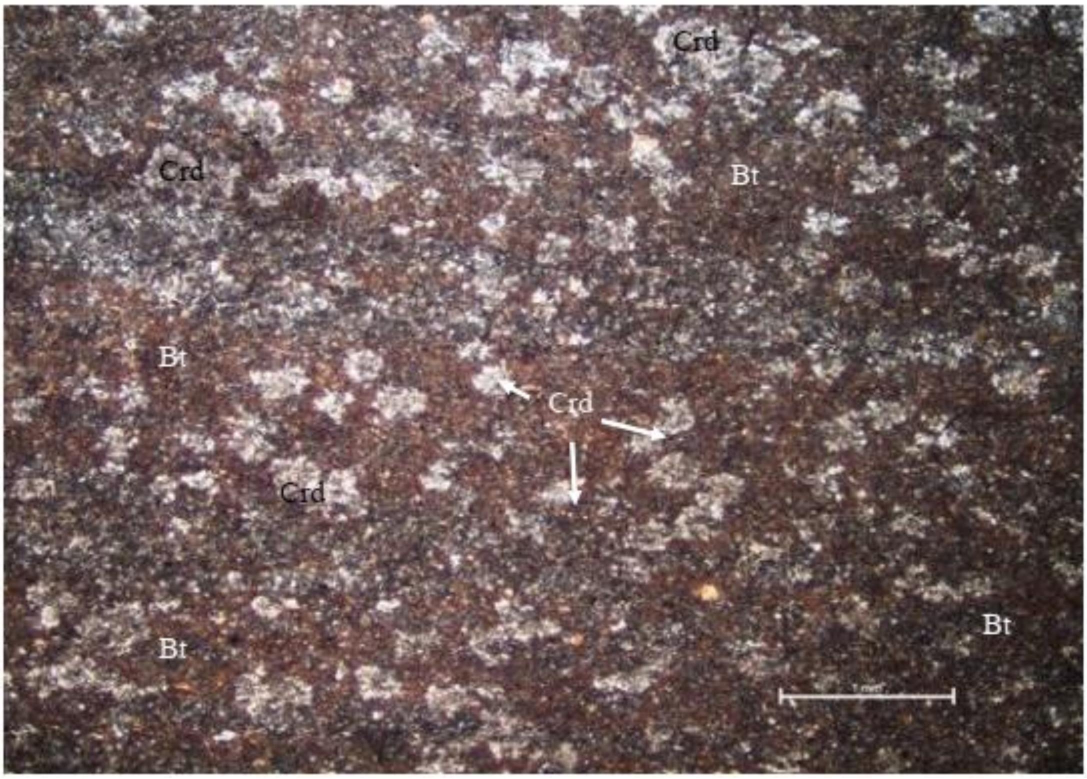

Fig. 5.8. Thin section of gabbro-diorite (UAB-SER-3). General view of the rock under plane polarised light.

Sample DV–6 is greyish-green in colour, and shows a nematoblastic and granoblastic fine-grained texture and a massive in fabric, with rare elements of schistosity. The rock is composed of chlorite, amphibole, epidote, feldspars, which are most probably represented by albite, quartz and a small amount of opaque minerals. All femic minerals (iron, magnesium or calcium-rich minerals) are associated in very fine-grained aggregates, where it is often very difficult to distinguish between individual crystals and make up over 75 % of the volume of the rock, while the rest is composed of feldspars and quartz. Other metallic minerals are very small and they are always present as isolated crystals (Antonović, Resmić- Šarić, Cvetković 2005: 61, fig 2F).

Geological study of ***diabase*** from Ţdraljica, central Serbia shows ophitic, intergranular or intersertal textures, (fig. 5.1/2). The main mineral phases are plagioclase (70.2–85.7 %) and augite, while accessories are magnetite, sphene (titanite) and altered glass (Resmić – Šarić 2004 - 2005: 75).

8. Peridotite (PER) are ultrabasic rocks, usually poor in silicon, aluminum, alkali and calcium and rich in magnesium and iron. Their colours depend on the composition and freshness degree. Fresh peridotites are dark green to yellowish-green, glass up to greasy shine. Partially or completely altered peridotites get green, dark green and even black. However, peridotites are very rarely fresh and usually serpentinized.

Extrusive rocks present the mode of igneous rocks that were formed through the cooling of magma at the surface. This process is fast, resulting in a porphyry structure of the rock.

9. Spilite (SPI) is a fine-grained, often aphanitic rock, green in colour. It builds basins, most often consolidated as pillow lava. Spilite is composed of low-temperature minerals: albite, chlorite, calcite, epidote, sphinx and relict of monoclinic pyroxane.

10. Basalt (BAS) is a fine-grained extrusive rock, which displays porphiric, massive or fluid texture and an isotopic structure. These rocks are dark-coloured and can present a conchoidal breakage. In the following lines the results of geological characterisation of samples from Dudin Krš, Kosovo and Ţdraljica, central Serbia will be presented (Memović et al. 2002 – 2003).

Metabasalts from Dudin Krš (fig. 5.1/11) shows blastoophitic, intersertal to pilotaxitic texture. The rocks express the effects of low- to medium-temperature metamorphism. The major mineral constituents are relics of primary clinopyroxene, and an association of albite, chlorite, epidote and pumpellyite (Memović et al. 2002 – 2003: 87).

Basalt from Ţdraljica (fig. 5.1/2) has glomeroporphyritic, ophitic, aphyric and intersertal textures. Phenocrysts are built by albitized plagioclase (7.7–11.7 %), relics of augite, opaques and serpentinized olivine, while the groundmass is composed of chloritised glass and microlites of plagioclase (Resmić – Šarić 2004 - 2005: 75).

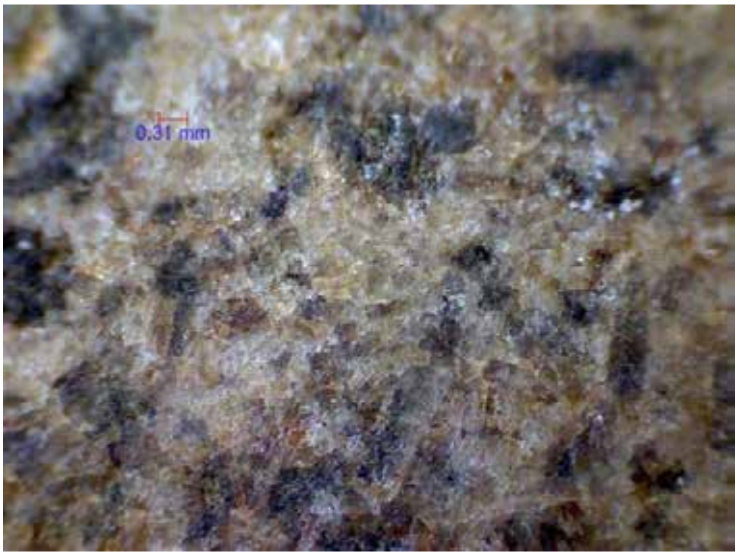

Fig.5.10, Andesite, Medjureč,Central Serbia, from our studied collection.

11. Andesite (AND) (fig. 5.10-11) is a rock of intermediate composition with aphanitic to porphyritic texture. They could be dark green or greyish, and after decomposition is oxidized mostly and become greyish-yellow, greyish-green and greyish red. Geological studies of various types of this rock include samples from the surroundings of Bor, Eastern Serbia (fig. 5.1/9).

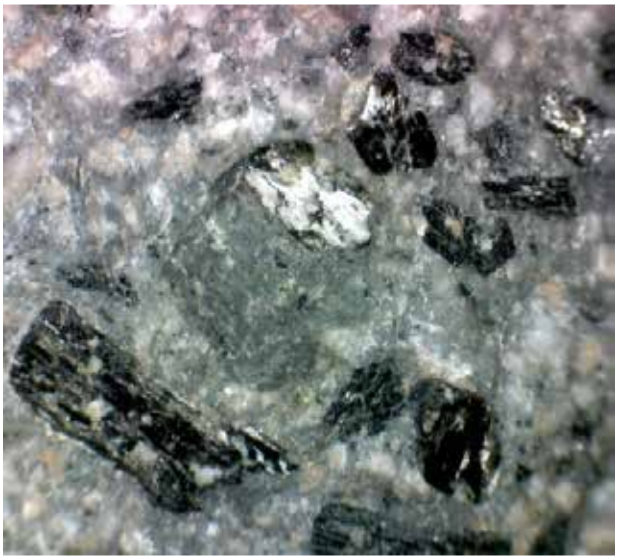

Fig.5.11, Andesite, Timok eruptive complex, Eastern Serbia.

Hornblende andesite contains often some biotite and minor augite. Plagioclase in the Turonian volcanogenic products is mainly andesine (45%–48% an) or medium acidic labradorite. The hornblende is frequently conspicuously coarse, often longer than 1 cm. It generally corresponds to common hornblende, or locally to basaltic hornblende (ĐorĎević 2004 - 2005: 65).

Pyroxene basaltic andesites are dark grey rocks of porphyritic texture, characterized by mm sized phenocrysts. The structure is most commonly massive and sometimes vesicular. Plagioclase and clinopyroxene are the most abundant phenocrysts, while orthopyroxene and amphibole occur in small amounts or are completely subordinate (Banješević 2004 - 2005: 17).

Hornblende andesite contains often some biotite and minor augite. Plagioclase in the Turonian volcanogenic products is mainly andesine (45%–48%) or medium acidic labradorite. The hornblende is frequently conspicuously coarse, often longer than 1 cm. It generally corresponds to common hornblende, or locally to basaltic hornblende (ĐorĎević 2004 - 2005: 65).

The amphibole andesites are most frequently massive rocks, rarely with vesicular or banded structure, sometimes with very well exposed tabular or rectangular jointing. Their colour varies from grey, pale green to green-grey. The texture is hypo- to holocrystalline porphyritic, often with a fluidal groundmass. Amphibole and plagioclase phenocrysts are always present, clinopyroxene is subordinate, while orthopyroxene and biotite occur only rarely (Banješević 2004 - 2005: 18).

Andesite has also been identified among the samples analysed at the UAB (sample **UAB-SER-2**). In this case, it was used as grinding equipment and come from the Late Neolithic settlement of Gumnište, Southern region (fig.5.1/16; fig. 5. 12-13. This rock is formed mainly by phenocristals (70%; of max. 1 mm) composed of idiomorphic and occasionally embayed and zoned plagioclase (50%), biotite and brown hornblende (both represent c. 20%). Phenocrystals are embedded in perlitic and hyaline mesostasis. Minor minerals are sphene (fig. 5.12 -13).

12. Andesitic tuffs (ATU) are commonly often red or brown rocks and their cavities are filled up with many secondary minerals, such as calcite, chlorite, quartz, epidote, chalcedony. In microscopic sections, the nature of the original lava can nearly always be made out of the shapes and properties of the little crystals which occur in the decomposed glassy base.

13. Trachyte (TRC) displays an aphanatic to porphyritic texture. It is the volcanic equivalent of syenite. The mineral assemblage consists of essential alkali feldspar. Plagioclase, quartz or a feldspathoid such as nepheleni are present on occasion. Biotite, clinopyroxene and olivine are accessory minerals.

5.1.2. Sedimentary rocks

This group includes the largest variety of rock types and were formed by the accumulation and lithification of sediment or by the precipitation from solution at normal surface temperatures. They appear widespread among the Neolithic macro-lithic tools in the central Balkans. Sedimentary rocks can be very compact and resistant to impacts with a hardness of 6–6.5 after Mohs’ scale. Their structure varies from fine to coarse-grained (Antonović 2003: 139). Some fine-grained rocks, such as flint allows conchoidal fracture, that makes them suitable for chipping and shaping into different forms.

14. Flint (FLI) is a hard, sedimentary cryptocrystalline form of the mineral quartz categorized as a variety of chert. This rock is usually black, grey, green, brown and white.

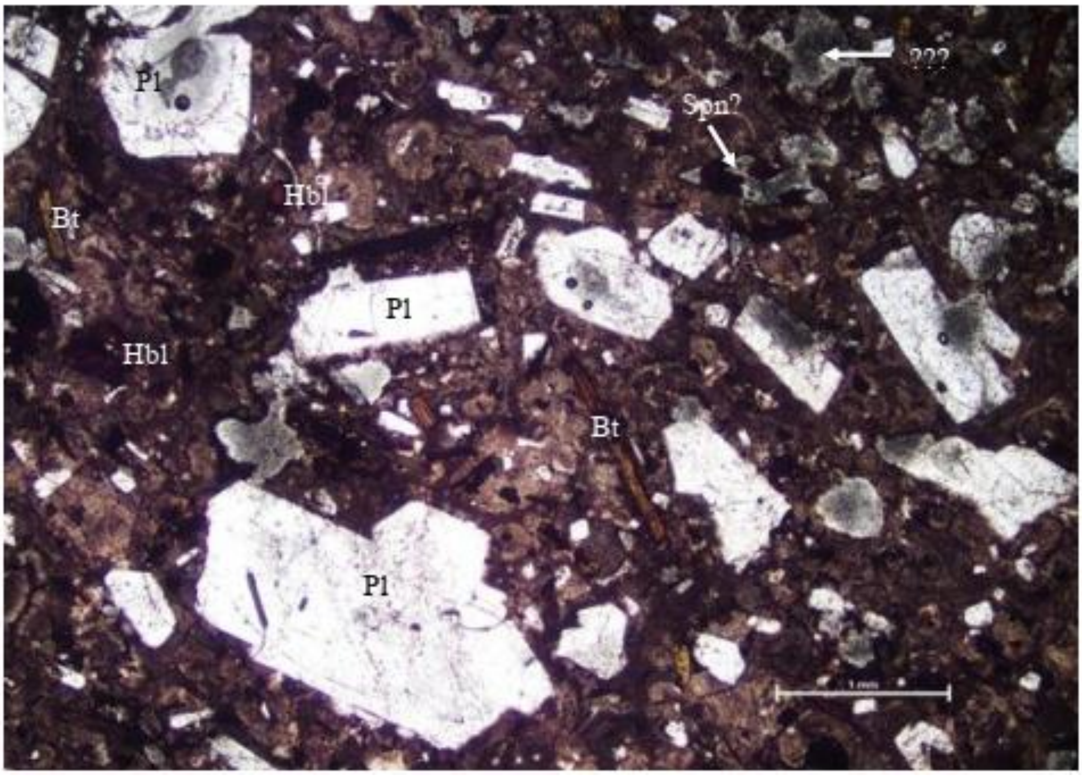

Fig. 5.12. Thin section of andesite (SER-2). Phenocrystals of plagioclase, biotite and hornblende appear in a perlitic and haline matrix under plane polarised light.

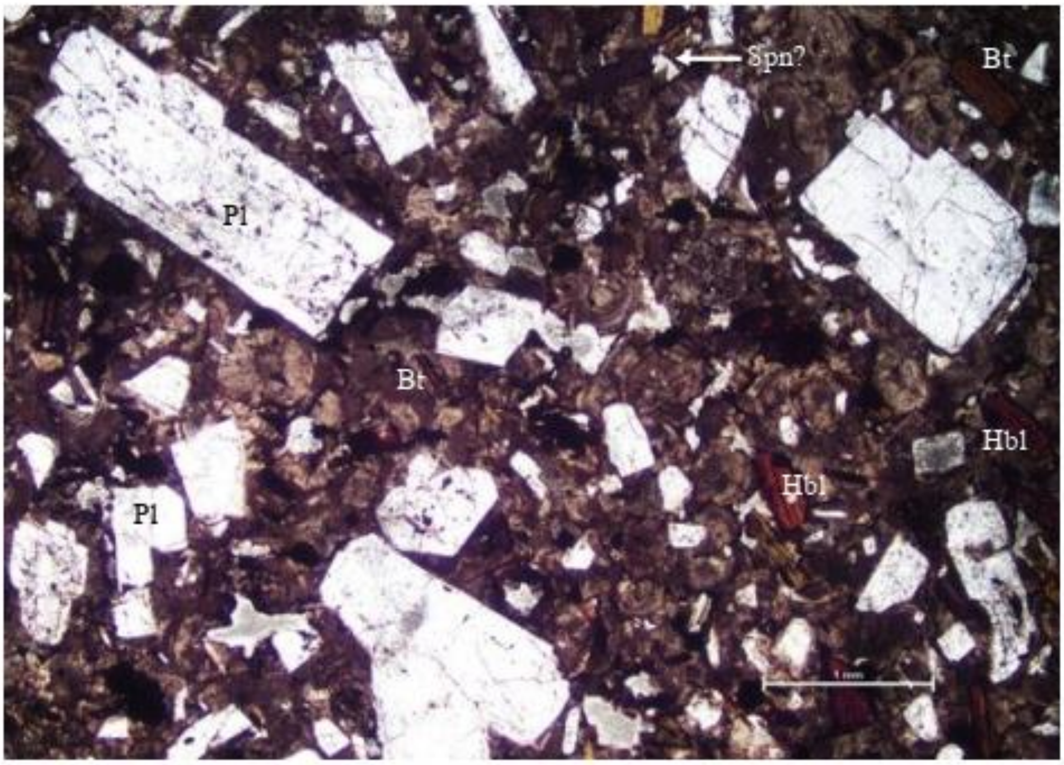

Fig. 5.13. Thin section of andesite (SER-2). Phenocrystals of plagioclase, biotite and hornblende appear in a perlitic and haline matrix under plane polarised light.

15. Light white stone (LWS) is a term used in Serbian archaeological literature, established by Antonović D., due to the lack of more precise petrological determinations of a group of macroscopically similar rocks. This group includes rocks such as magnesite, altered and metamorphosed tuffs, white ash-tuffs, porcelanite or cherty shale and diatomaceous earth. In some cases, the petrographic analysis could not provide a precise determination. These rocks are light, porous and relatively soft, showing different shades of dirty white and yellow-white colour. They are mostly fine-grained, compact and tough displaying a conchoidal fracturing pattern and various hardness –from 4 to 6 according to Mohs' scale (cf.Antonović 2003: 137). Analysis of the finds from Neolithic settlements of Vinča, Divlje Polje, Čučuge, Selevac in the central and western Serbia as well as the Zlatibor mountain, western Serbia, show following results (Antonović 2003; Antonović, Resmić- Šarić, Cvetković 2005; Ilić et al. 2011):

Three samples of ***silicified magnesites*** *(*DV–1, DV–2, DV–4), from the Late Neolithic settlement of Vinča, (fig. 5.14, fig.5.1/4) are microcrystal-line to cryptocrystalline in texture, while their fabric is massive. (Antonović, Resmić- Šarić, Cvetković 2005: 61, fig 2G). Artefact type is not mentioned in a cited text bellow, but we suspect that they refer to polished edge tools, as this raw material is used commonly for manufacturing these types of tool.

Fig.5.14Magnesite, the Neolithic settlement of Vinča; according to Antonović, Resmić- Šarić, Cvetković 2005.

From the same settlement are s***ilicified micritic dolostone (IB81)*** and ***sedimentary magnesite*** **(*IB16).*** The petrographic analysis accomplished by N. Kreminac, N. Vasković and D. Pešić, from the Geoinsitute in Belgrade). The first sample consists of dolomite, calcium dolomite, nests of radial calcedone, which are up to 2 mm in size, and organic material. Calcite is rare. ***Sediment magnesite*** **(IB 16)** is a compact, whitish, middle tough and hard rock (5,5 according to Mohs). It consists of grains of carbonite, which are up to 0,02 mm in size, with nests of fine-grained silica (re-crystallized clacedone; Antonović 2003: 45).

Sample ILA q 8 is a ***whitish unidentified fine-grained rock*** from the Late Neolithic settlement of Čučuge (fig. 5.1/5). The petrographic analysis eas also accomplished by A. Antonović, from the Geoinstitute in Belgrade). It does not show calcium carbonate. The rock consists of crypto-crystalized silica, calcedone, partly opal, probably clay material, serecite, altered biotite and micro-organisms. The size of the grains is almost submicroscopical and not clearly visible (cf. Antonović 2003: 46).

A whitish unidentified fine-grained rock from the Neolithic settlement of Divlje Polje (fig. 5.1/ 7), displays calcedone structure and consists of quartz with slightly magnesium, dolomite and quartzite (cf. Antonović 2003: 47).

Geology studies of ***magnesite*** from the Zlatibor mountain, western Serbia (fig. 5.1/6) is a white, dense microcrystalline cryptocrystalline rock with a conchoidal fracture. It consists of carbonates such as dolomite, calcite, while the other accompanying minerals are mainly silica (quartz, chalcedony, opal) (Ilić et al. 2011: 114).

Microscopical analysis of sample ***10/04-368***, coming from the Late Neolithic settlement of Selevac (fig. 5.1/3) corresponds to a ***porcelanite***. It shows chert claystone **(GLI)** with re-crystallized radiolaria (cf. Antonović 2003: 48).

A polished edge tool of so-called “light white stone” was sampled and analysed by F.J Martínez Fernández, D. Gómez-Grass, and R. Risch at the UAB. It (sample ***UAB-SER-1*)** turned out to be a ***dolo-micritic dolostone*** (fig.5.18- 22)**.** It corresponds to a polished edge tool of the Late Neolithic settlement of Turska česma, Slatina (fig.5.1/17 Micritic, silicified dolostone with bioclasts, probably foraminifera (fig. 5.17-21). Some bioclasts, as well as fractures, appear to be silicified (1%). Unidentifiable high relief minerals, formed of opaque particles, occasionally disposed of in circles, appear disseminated in the micritic matrix (7%).

Probably here we are dealing with epidote. The rim of the thin section, which also corresponds to the surface of the artefact, is formed by micro-crystalline, strongly interpenetrated and serrated quartz.

The second sample (***UAB-M-2369***) can be classified as ***chert or felsite***. It belongs to a polished edge tool from the Late Neolithic settlement of Benska bara (fig 5.1/18), Northern region. This rock has a very fine-grained, isotropic texture. It is formed by inter-growing low birefringence, grey coloured minerals (crossed nicols), probably quartz and feldspar.

16. Claystone (GLI) is composed of clay-sized particles and show cleavage roughly parallel to the bedding plane. They often are classed as clay shales.

17. Sandstone (SDS) (fig.5.15) is a clastic sedimentary rock composed mainly of sand-sized (0.0625 to 2 mm) mineral particles or rock fragments. This rock consists of minerals such as quartz, muskite husk, subordinate feldspath, carbonate, etc. They are bound by natural cement of different composition: carbonate, marl, clay, dolomite, silicon, limonite (hardwood), organic minerals (bituminous) etc.

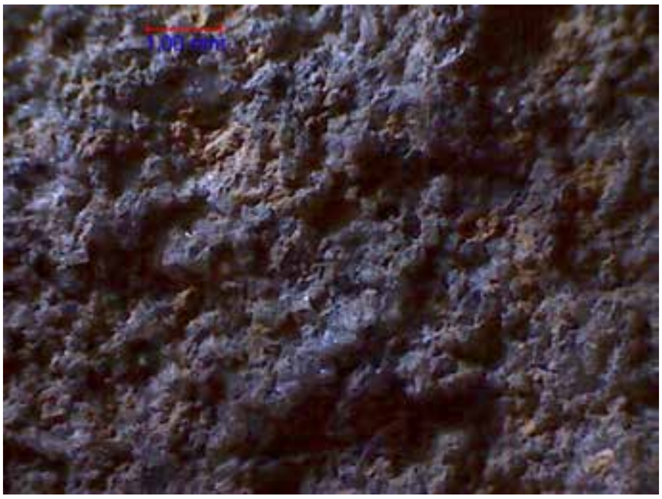

Fig.5.15, Sandstone, studied macro-lithic tools.

18. Conglomerate (CGL) (fig. 5.16) consists of rounded large fragments of rounded rocks (size of grain > 5 mm), which are bound by natural cement of different composition: carbonate, silicon, laporous, etc.

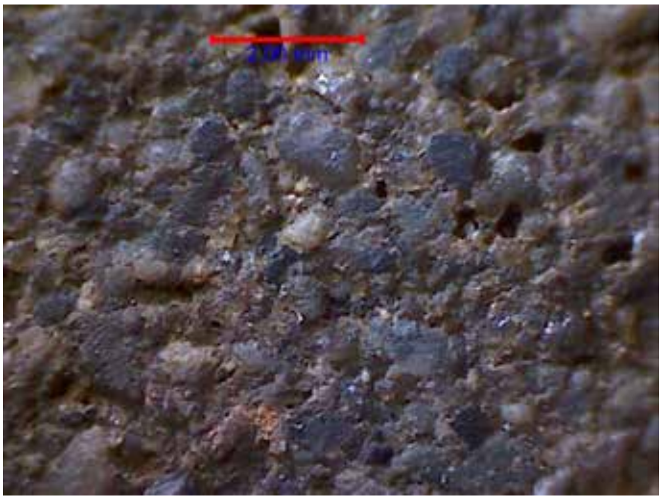

Fig.5.16 Conglomerat, studied macro-lithic tools.

Fig. 5.17. Thin section of dolo-micritic dolostone (SER-1). General view of the micritic silicified matrix with bioclasts under plane polarised light.

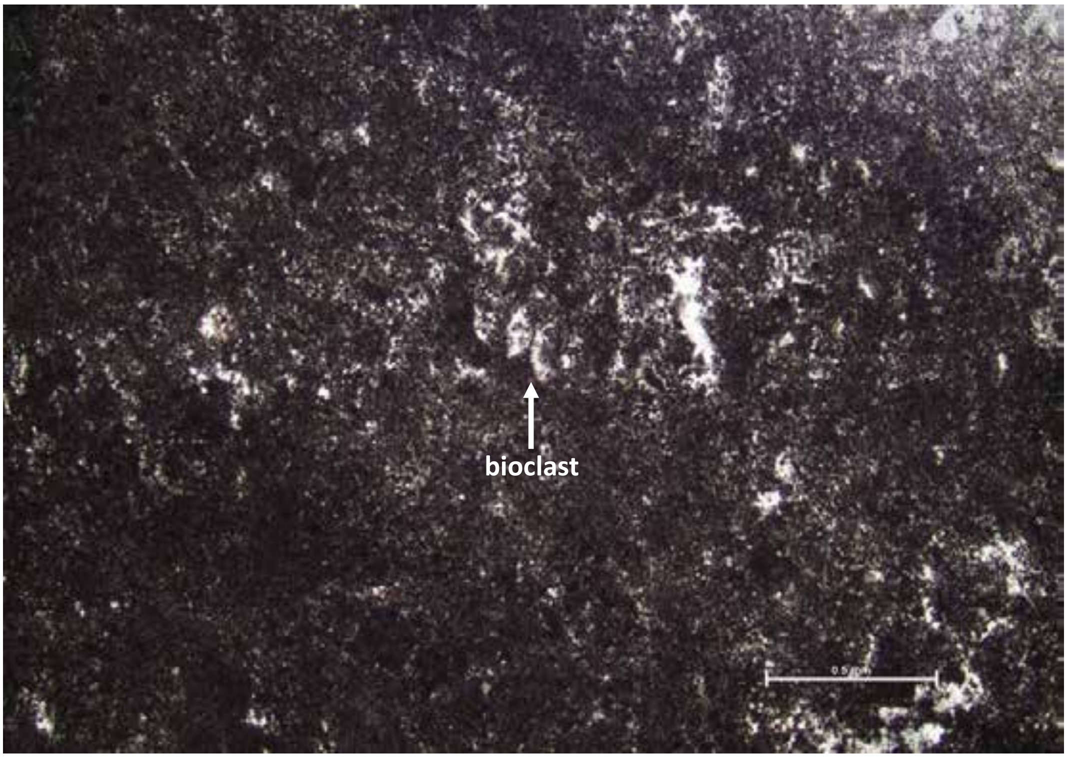

Fig. 5.18. Thin section of dolo-micritic dolostone (SER-1). General view of the micritic silicified matrix with bioclasts under plane polarised light.

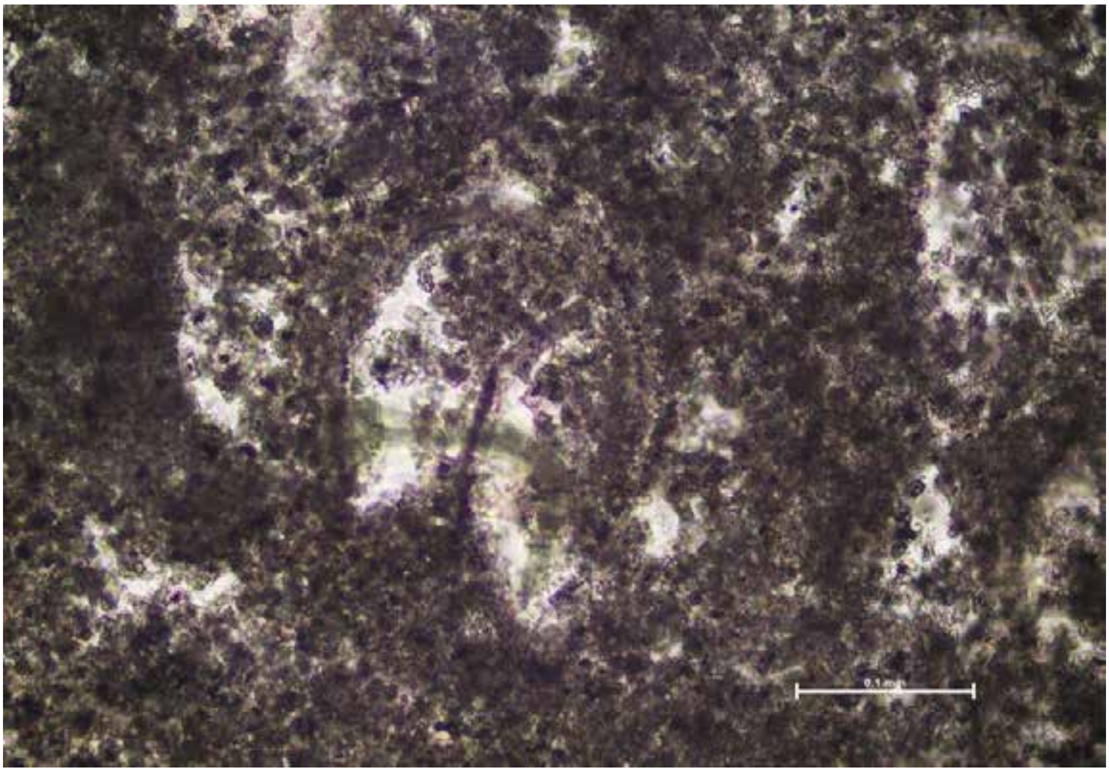

Fig. 5.19. Thin section of dolo-micritic dolostone (SER-1), detail of previous view with bioclast in the centre.

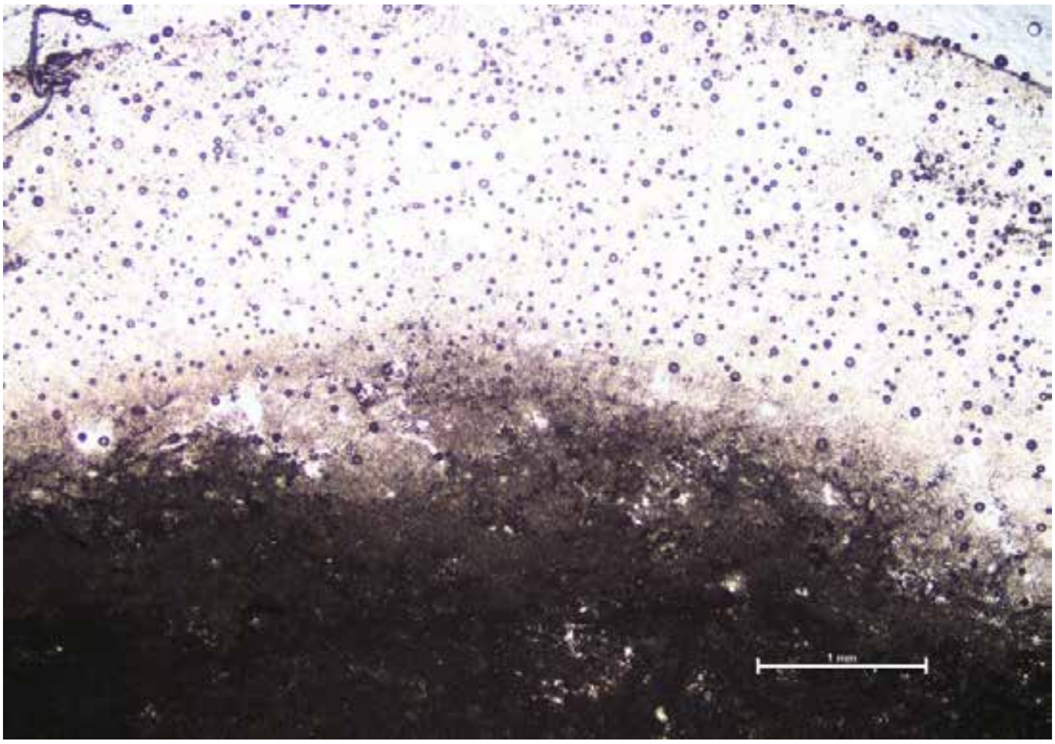

Fig. 5.20. Thin section of dolo-micritic dolostone (SER-1). general view of the outer rim formed by a micro-crystalline quartz matrix and embedded high-relief minerals (cf. epidote) under plane polarised light.

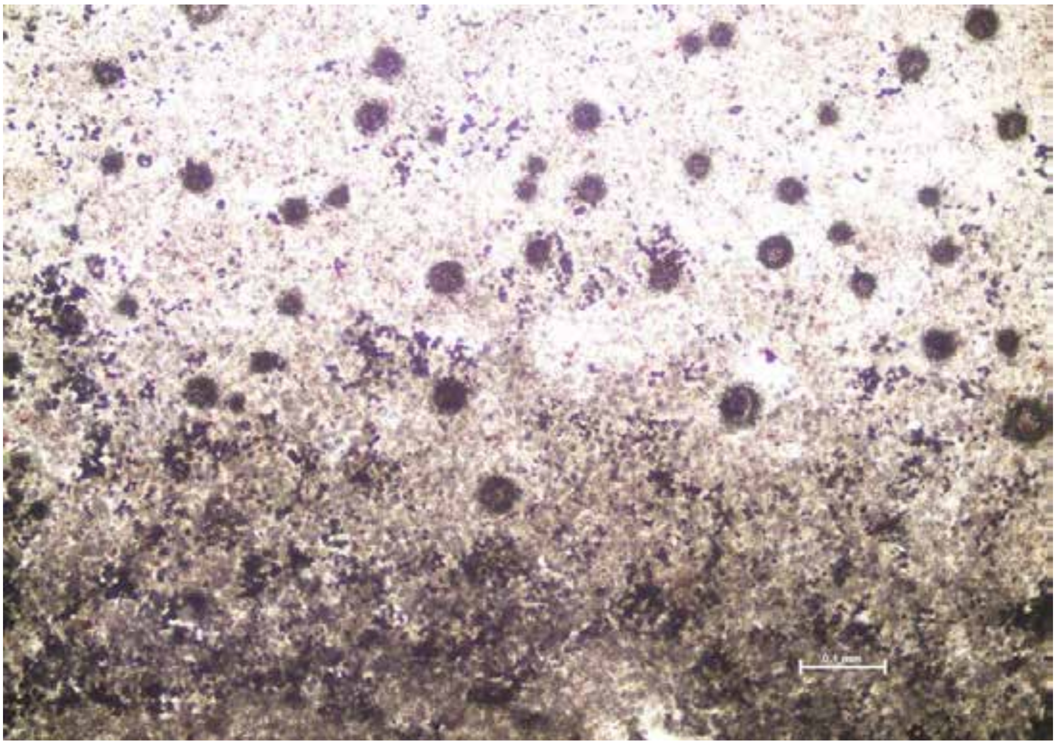

Fig. 5.21. Thin section of dolo-micritic dolostone (SER-1), detail of the micro-crystalline quartz matrix with embedded high-relief minerals (cf. epidote) under plane polarised light.

19. Micro-conglomerate consists of relatively coarse-grained sand (size of the grain is between 2- 5 mm) which are bound by natural cement very fine silt or clay cement.

20. Breccia (BRE) is a rock composed of broken fragments of minerals or rock cemented by a fine-grained matrix that can be similar to or different from the composition of the fragments.

21. Limestone (CAL) is the most widespread sedimentary rock in general. This rock consists of calcite that can contain iron, mangane, manganesite, andmagnesium, clay, sand, organic matter, etc. Limestone may be crystalline, clastic, granular, or massive, depending on the method of formation.

22. Marl or ***marlstone (MAL)*** is a calcium carbonate or lime-rich mud or mustone which contains variable amounts of clays and silt. The dominant carbonate mineral in most marls is calcite, but other carbonate minerals such as aragonite, dolomite and siderite may be present. Marl was originally an old term loosely applied to a variety of materials, most of which occur as loose, earthy deposits consisting chiefly of an intimate mixture of clay and calcium carbonate, formed under freshwater conditions.

23. Shale (SHA) is a fine-grained, clastic sedimentary rock composed of mud that is a mix of flakes of clay minerals and tiny fragments (silt-sized particles) of other minerals, especially quartz and calcite.

24. Alevrolite (ALV) is an old name for ***siltstone***, which is the same as a lutite (Latin root) or a pelite (Greek root). In this classification, it is relevant that the grain size is equivalent to **silt.** This rock is fine-grained, dark-greyish green, dark-grey to black, or light-greyish green in colour. It has aphanitic appearance and massive fabric, with elements of schistosity. Although alevrolite items could be of ***meta-siltstone*** or ***blasto-mylonitic gneiss,*** which is not possible to distinguished macro-scopically.

Samples 2952, 1901**,** and ***1810*** are ***silicified siltstone*** from the Late Neolithic settlement of Selevac (fig. 5.1/ 3). The first sample is fine-grained with calcite, quartz, muscovite and clay minerals. The second sample consists of muscovite and iron oxide, while the third consists of muscovite and iron oxide. **Sample *2929*** is a contact metamorphic rock which consists of fine-grained quartz, clay minerals and some calcite. **Sample *2899*** is a metamorphosed silified siltstone or clay, with quartz. (cf. Antonović 2003). Artefact type is not mentioned in the cited text, but we suspect that they refer to polished edge tools, as this raw material is used commonly for manufacturing these types of artefacts.

5.1.3. Metamorphic rocks

Metamorphic rocks result from the alternation of existing rock through pressure and/or temperature. Metamorphism is a series of physical-chemical processes in the rock which were created under conditions different from the ones in which it was created. The rock adapts to new

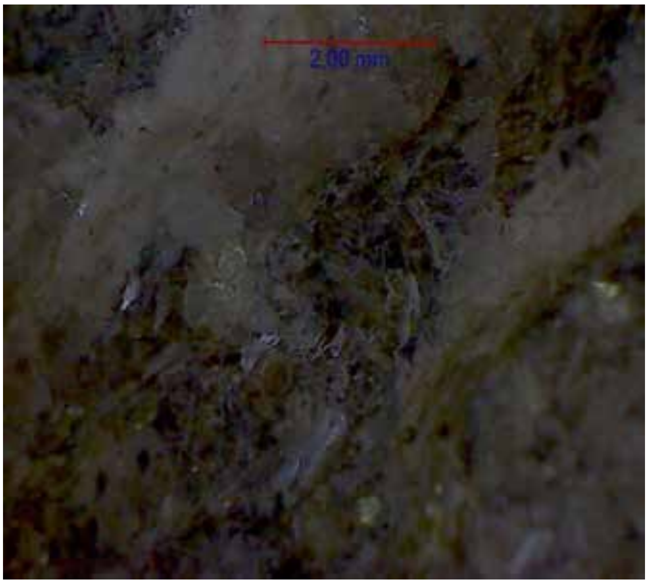

Fig. 5.22, Schist, studied macro-lithic objects.

conditions, changing its mineral and chemical composition and circuit: structure and texture. The metamorphic changes are pressure, temperature and the presence of fluids and gases.

24. Quartzite (CCT) is a hard, non-foliated metamorphic rock which was originally pure quartz sandstone or chert. This rock displays massive texture, granoblastic structure. Pure quartzite is usually white to grey, though quartzites often occur in various shades of pink and red due to varying amounts of iron oxide (Fe_2O_3). Other colours, such as yellow, green, blue and orange, are due to other minerals. Quartz grains are toothed coalesced that gives great hardness to the rock. Q***uartzites*** from Vranjska banja (fig. 5.28/15) are milky white and contain quartz, feldspar and sometimes and some mica (Majstorović et al 2016: 2).

25. Schist **(SCH)** (fig. 5.22) is a medium-grade metamorphic rock with medium to large, flat, sheetlike minerals in a preferred orientation. Schist displays lepidoblastic, porphyroblastic and fine-grained granoblastic texture. The most important minerals of schist groups are muscovite, chlorite, actinolite, thermolite, then epidot, chlorosite, quartz, etc. There are many varieties of schist and they are named for the dominant mineral comprising the rock, e.g. mica schist, greenschist (green because of high chlorite content), garnet schist etc. Petrographic studies of various types of these rocks include Vranjska Banja and the mountain Fruška Gora (cf. Majstorović et al 2016; Korikovsky, Karamata 2010).

Geological studies of ***the schistose metasandstones,*** the Fruška Gora mountain (fig.5.1/14) are phengite–chlorite–quartz and phengite–calcite–chlorite–quartz rocks, often with relicts of psammitic textures; more rare varieties are phengite–chlorite–quartz phyllite (Korikovsky, Karamata 2010: 2). ***The glaucophane bearing schists*** come from the same mountain (fig.5.28/14) and contain the following minerals: zonal Na amphibole of the glaucophane–riebeckite series, actinolite, pumpelleyite, epidote, chlorite, and very rare minor amounts (1–2%) of quartz. The rocks contain no sodic plagioclase (ibid 2010: 4).

26. Mica-schist: **(ESM)** is a rock composed essentially of mica and quartz, and having a thin parallel-banded or foliated structure, with lamellae rich in mica alternating with others which are principally quartz. In some cases mica composes nearly the whole of the rock, in others, quartz preponderates so that they approach quartz-schists and quartzites. The mica may be muscovite or biotite.

27. Slate (PZA) is a very fine-grained, foliated, homogeneous metamorphic rock derived from an original shale type sedimentary rock composed of clay or volcanic ash through low-grade regional metamorphism.

28. Geological characterisation of ***amphibolites (AMP)*** from Vranjska banja (fig. 5.1/15) are dark green to black. They occur as lenses or interlayers in gneiss, very rare in mica shist thicknesses up to a few meters. They are built by hornblende and plagioclase. Structures are nematoblastic, rare granoblastic and porphyroblastic. (Majstorović et al 2016: 4).

29. Skarns (SKA) or tactites are calcium – bearing calc-silicate rocks. Colour of skarns depends on the mineral composition and can be are green, white, red, sometimes black. The minerals commonly present in a skarn include iron oxides, calc-silicates (wollastonite, diopside, forsterite), andradite and grossularite garnet, epidote and calcite. Many skarns also include ore minerals.

30. Serpentinite (SER) was formed by serpentinization. This chemical reaction converts anhydrous ferromagnesian silicate minerals (pyroxene, olivine) into hydrous silicate minerals (serpentine) plus some other possibilities like brucite and magnetite. These rocks display massive and schistose texture and can be dark green, green to colourful.

Petrographic characterisation of ***serpentinite*** from central Serbia displays primary minerals such as olivine, bronzite, diallage, magnetite, chromite, which have been transformed into various serpentine minerals such as antigorite,bastite, talc, spinel group minerals, magnesite and other carbonates (Kureševič, Vušović 2012: 2).

31. Marble (MAR) is rock, commonly with massive texture, that could be schistose as well. The minerals commonly present in marble include muscovite, quartz, albite, chlorite, graphite. Furthermore, *pure marble* contains more than 95% vol. of carbonate minerals; a marble containing less than 95% of carbonate minerals is classified *as impure marble*.

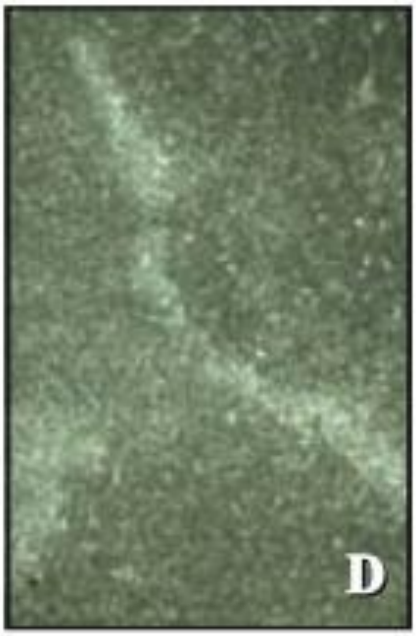

Fig.5.23. Metasiltstone, the Neolithic settlement of Vinča; according to Antonović, Resmić- Šarić, Cvetković 2005.

32. Metasiltstones (**meta-alevrolite** according to the traditional Slavic geological terminology) **(ALV)** from The Late Neolithic settlement Vinča (fig. 5.1/4) are fine-grained, granoblastic, with elements of blastoalevrolitic and nematoblastic texture and massive fabric (fig. 5.23). Tool type has not been mentioned in the cited text, but we suspect that this refers to polished edge tools, as this raw material is used commonly for manufacturing these types of artefacts. More intensely metamorphosed ***sample DV–11*** is composed mainly of epidote and quartz. Extremely small and subhedral epidote crystals are most abundant – sometimes they form up to 70 % of the rock volume. Epidote is mostly presented in small prismatic crystals, uniformly distributed in the groundmass. Quartz occurs as very small aggregates, and very rarely as independent isometric minerals. It makes up approximately 30 % of the rock volume of the rock. Also observable are the lens-like aggregates which are richer in quartz.

Poorly ***metamorphosed*** **siltstones *UZ–9*** and ***UZ–3*** from the same settlement consist of quartz crystals that are 0.02–0.04 mm in size, muscovite-sericite, a small quantity of biotite and feldspar, quite a lot of organic matter, and some limonite. Cement is siliceous. Sample **UZ–3** consists of quartz, muscovite-sericite, a small quantity of carbonate and ample quantities of organic matter with some limonite. The crystals range in size 0.01–0.03 mm and are bound together with siliceous cement (Antonović, Resmić- Šarić, Cvetković 2005: 57, fig 2D).

In order to detect the possible raw material source and its correlation with archeological finds a sample of ***metamorphosed siltstone*** has been collected in the village of Nevade, the Rudnik

Nevade, the Rudnik mountain (fig. 5.24,10/ 2). The rock consists of a lot of quartz, muscovite and slight amount of carbonate. The size of the grain varies between 0,02 to 0,03 mm (Antonović 2003: 42 – 43).

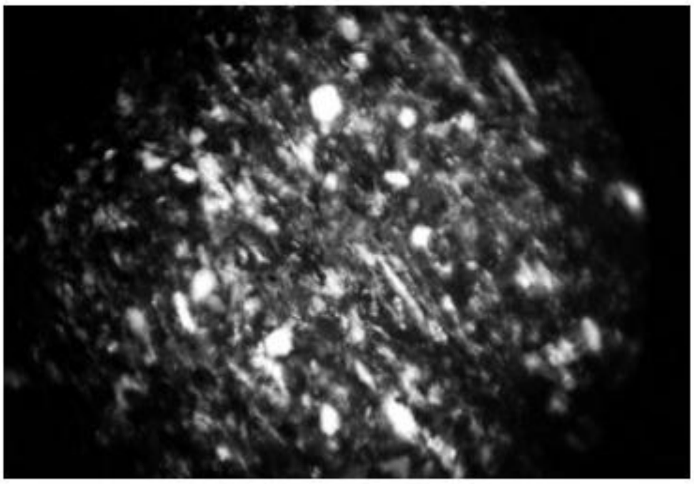

Fig.5.24. Metamorphosed siltstone, pebble sample of the outcrop of Nevade; according to Antonović 2003.

33. Gneiss (GNE) is medium- to coarse-grained rock and may contain abundant quartz and feldspar.

The petrographic analyses carried out by Francisco J. Fernández, David Gómez-Grass, and R. Risch, at the UAB, suggest that we are dealing with a specific type of very fine-grained gneiss:

Garnet-bearing felsic meta-igneous foliated rock: blasto-mylonitic gneiss (sample UAB-M-427) has been identified in relation to a re-used ground-edge tool, which was transformed into an axe, in the Late Neolithic settlement of Slatina, Turska česma, Central region (fig. 5.1/15). This rock is a highly complex metamorphic rock, which seems to be derived from an igneous protolith. A fine-grained, oriented matrix, mainly constituted by plagioclase and some quartz, wraps around coarse-grained aggregates of randomly oriented, pale amphibole plagioclase, and garnets, the latter with abundant inclusions of plagioclase and quartz (>60%). Secondary biotite (<1%) occurs in the mentioned aggregates, often associated with calcite (<1%). Local development of fine-grained quartz and plagioclase simplectites appears mainly in the vicinity of the garnets (c. 5%). Large amphiboles show a diablastic intergrowth (5-10%). The mechanical resistance in this rock derives from the intimate intergrowth between plagioclase and quartz, which defines the foliation.

A very fine-grained ***dioritic gneiss*** (sample **UAB-M-2398**) was used as a polished edge tool in the Late Neolithic settlement of Benska bara, Northern region (fig. 5.1/18). Probably there is a genetic relation with UAB-M-427, regarding its origin and composition, although the texture of this rock is different: much fine-grained and more strongly oriented (foliated).

Streaks of a polycrystalline mineral with a medium to high relief (epidote?) dominates in the rock (>60%). A low relief mineral with grey (crossed nicols), first-order birefringent (plagioglase) is second in abundance (c. 30%) and occurs also oriented, interwoven with the precious mineral. Quartz represents c. 1-5%.

Sample M-2046 was taken from a polished edge tool of the Late Neolithic settlement of Slatina, Turska česma, Central region (fig. 5.1/15). It is very similar to UAB-M-2398. All three rocks might be genetically related. Their protoliths could have been fine-grained igneous rocks, of intermediate mafic-felsic composition, which subsequently were strongly deformed and recrystallized under low-temperature conditions.

Hornfelsic metapelite (sample ***UAB-SER-4***) was used for a polished edge tool from the Late Neolithic settlement of Potporanj (fig. 5.1/14). Macroscopically, this sample has been identified as (siltstone). Although petrographic analyses show that in this case, we are dealing with former schist or slate, strongly recrystallized due to a late thermal event. Porphyroblastic, somewhat altered cordierite (5-10%) stands out in a fine-grained matrix, which shows a remnant recrystallised foliation. The matrix is composed of non-oriented, newly formed biotite, formed of a re-crystallisation that obliterates the former foliation. The matrix also contains zircon (>1%) and opaques (1-2%) (fig. 5.25 - 26).

34. Meta-psammite (MSD) or *meta-sandstone* is sandstone that has undergone metamorphism to some degree

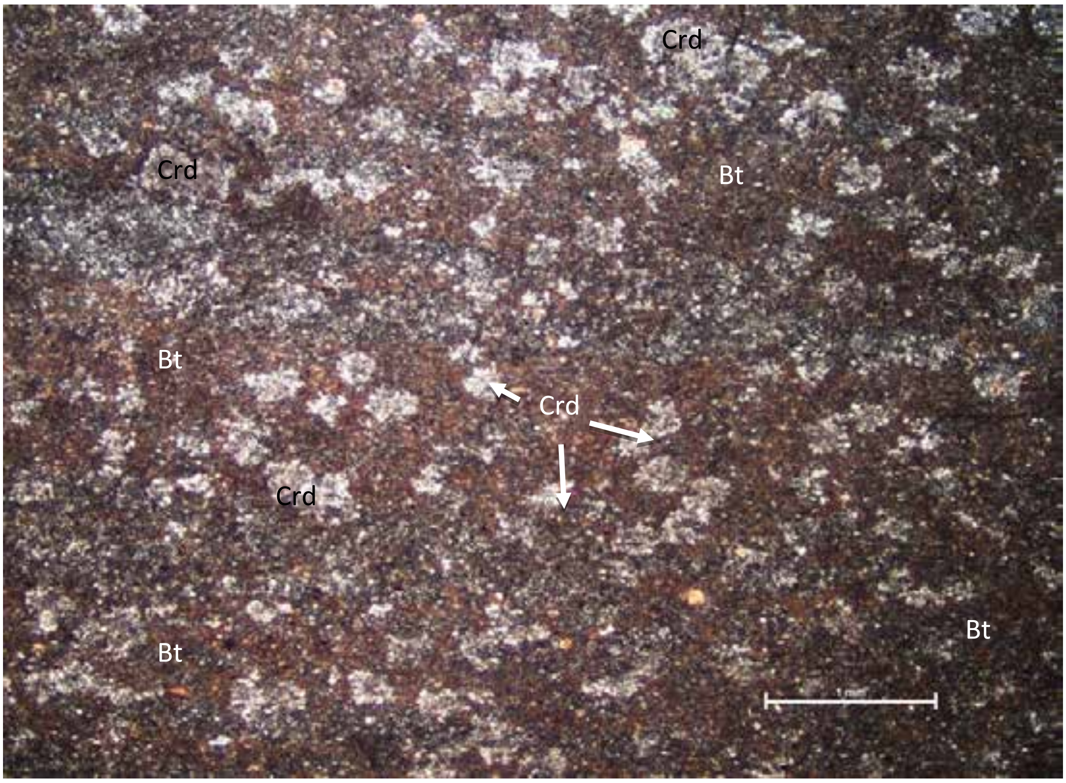

Fig.5.25. Thin section of hornfelsic metapelite (SER-4). Cordierite grains are visible in a non-oriented biotite matrix.

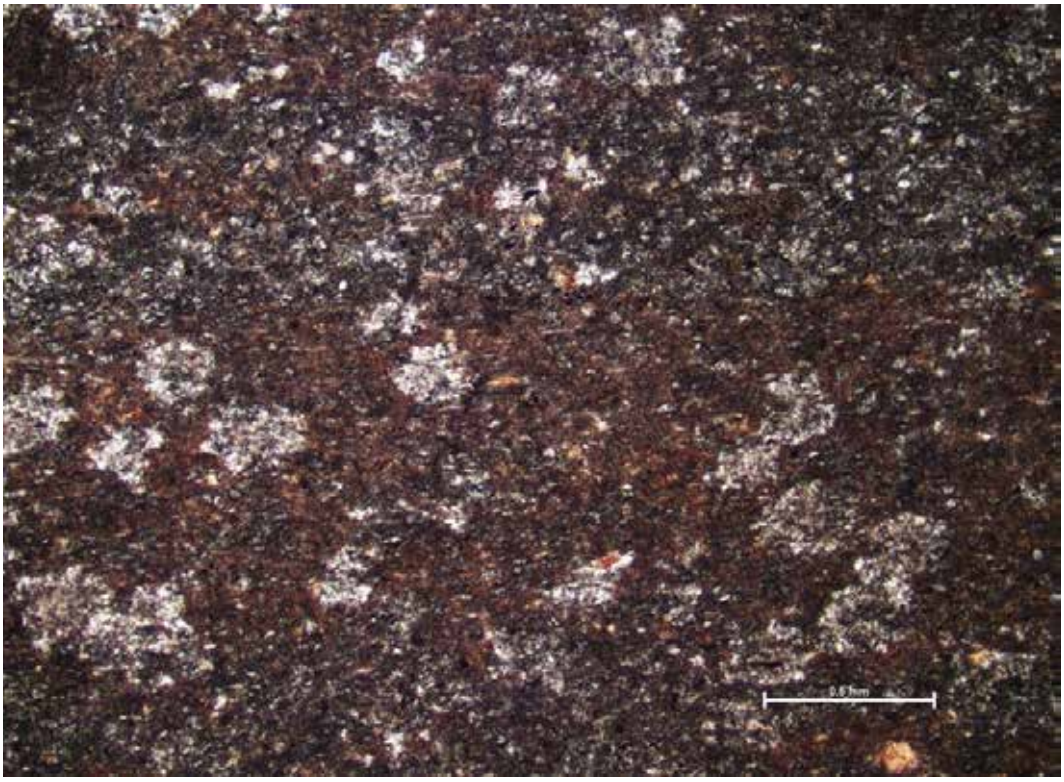

Fig. 5.26. Thin section of hornfelsic metapelite (SER-4). Enhanced view of the cordierite grains and biotite matrix.

5.2. Geo-archaeological survey of the Central region

A geo-archaeological survey was conducted together with Roberto Risch, from the Dept. of Prehistory of the UAB, in the middle Morava valley, as well as in the Slatina, Lugomir, Jošanička, Ždreljica, and Županjka rivers and in the Kalenićka river valley, which are all located to the West of the Morava. The aim of this survey was to test in what we have defined as the *Central Region* of our study, the assumptions which can be made on the origin of the raw materials of the Neolithic settlements, based on the available geological cartography of the central Balkans. As most of the macro-lithic artefacts were made of cobble stones (clasts) obtained from secondary deposits, the standard geological information is often miss-leading, as fluvial formations might offer the same rocks at a much closer distance from the prehistoric settlements. Geomorphological studies and cartography can prove useful to locate these deposits, but they rarely offer a petrographic description of their clast material. Consequently, archaeology is obliged to carry out the survey of fluvial terraces or other secondary formations, keeping in mind the rock types, their size, and degree of rounding selected and implemented by the Neolithic communities. Rounding is defined in this study according to Leser (1977) as rounded, sub-rounded, sub-angular and angular (fig. 5.2.1).

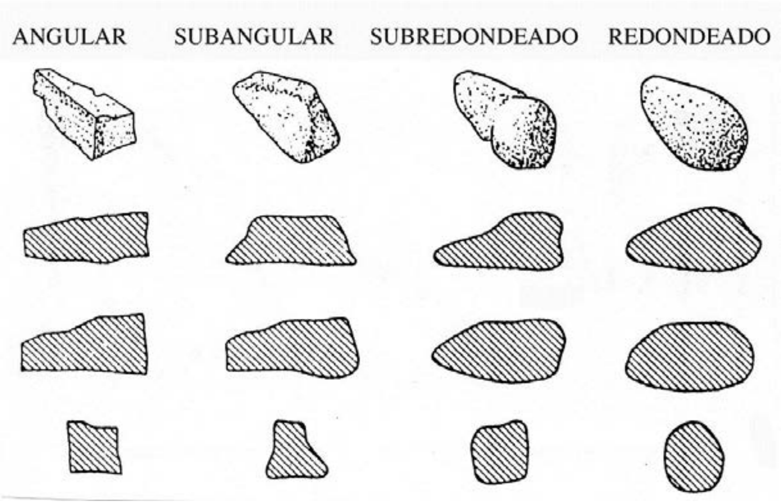

fig. 5.2.1, Classification of clast rounding according to Leser (1977).

This type of geo-archaeological survey of secondary deposits follows a well-established protocol, which was developed for the first time in the Southeast of the Iberian Peninsula and follows geomorphological as well as petrographic criteria (Risch 1995, 2002, Howard 1993). At specific locations along river courses and at naturally or artificially sectioned fluvial terraces, around 100 clasts are determined in terms of rock type, size and degree of rounding. Petrographic determination is carried out in the field with a hand loupe (10-20X) and samples of the main rock types are taken, so that the classification can be checked in the laboratory and through thin section.

At the next level of the geo-archaeological analysis, the natural characteristics of the clasts are compared with the archaeological artefacts found in the settlements, treating these as another location in the survey. The quantitative and qualitative correlation between the surveyed natural deposits and the archaeological assemblages, in terms of rock type, size and rounding, allows a probabilistic approach to the possible origin of the raw materials. When we are dealing with the exploitation of clasts, it is necessary to approach the sources of raw materials in terms of the *social accessibility* of a given rock for a specific community (Risch 2002, 51, 83-85). Usually, several secondary deposits can contain a required type of rock, but very few will present them with the required size, shape or rock fabric. Moreover, the probability of clast exploitation increases in those deposits where a selected rock type does not only have the required characteristics, but where it is available in the highest frequency. The correspondence between the availability of raw materials in nature and their selection by prehistoric communities, defines the *social accessibility* of a given resource.

In order to determine the possible origin of the rocks used we visited ten locations. In all cases, except locations 2 and 10, clast counts were carried out according the grid method proposed by Howard (1993). All petrographic results are included in table 5.1, which appears after brief description of the ten visited locations.

Location 1: Village of Čepure, Paraćin, gravel extraction site on the right bank of the Velika Morava river

Coordinates: 0527942 E, 4852311 N

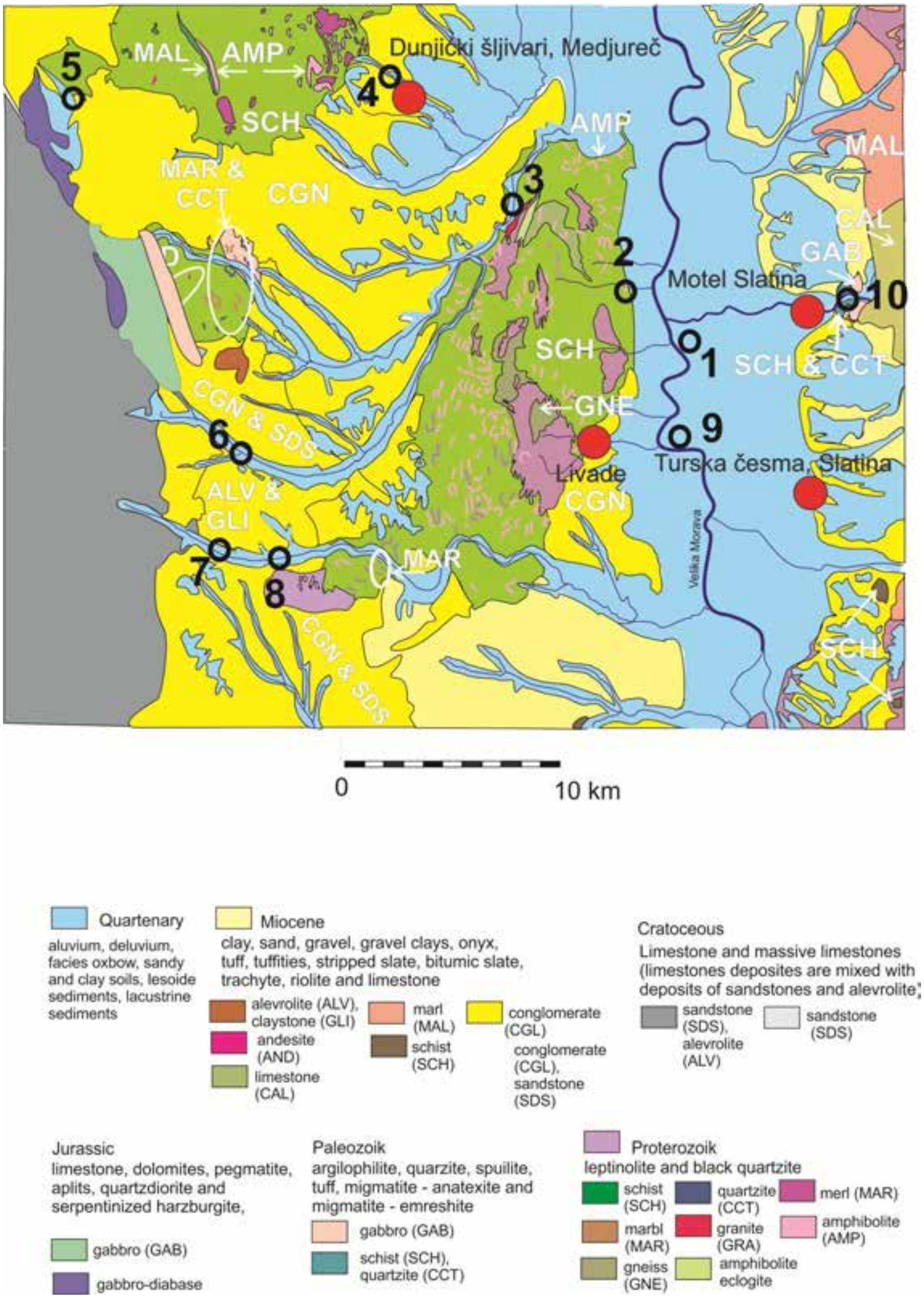

Fig. 5.2.2, Geological map and position of locations and Neolithic settlements in the Central region adopted after: geology map L - 34 – 7 Paraćin and Kraljevo L -34-6: 100 000.

Clasts from this location (fig 5.2.2/1, fig. 5.2.3) are rounded; their size tends to be less than 30 cm. A local women, owner of a gravel pit, told us that large cobbles can only be found on the bottom of the Velika Morava river.

The Morava deposits (see also location 9) are characterised by a large variety of igneous and metamorphic rocks, while sedimentary rocks are rare. The absence of carbonated rocks should also be noted, while quartz and quartzite represent around 40% of the available materials (table 5.1).

Location 2: Village of Raševica, Paraćin, Slatina stream

Coordinates: 0532824 E, 4856879N

The catchment area of the small Slatina stream (fig 5.2.2/2, fig.5.2.4) lays in the Juhor mountain, which forms the western limits of the middle Morava valley, near the town of Paraćin. In order to identify which rocks are transported into the Morava from these hills of metamorphic composition with some volcanic intrusion (andesite), a survey location

fig 5.2.3, Location 1: gravel extraction site on the right bank of the Velika Morava river.

fig 5.2.4, Location 2: village of Raševica, Paraćin, Slatina stream

fig 5.2.5, Location 3: Kolonija, Jagodina, the Lugomir river.

was chosen at the bottom of the hills, few km before the Slatina river joins the Morava.

As expected most of the clasts derive from metamorphic formations, mainly slate, which easily breakable and is not suitable for macrolithic tools. Cobbles of vein quartz, quartzite, and mica-schist are detected in the stream and its immediate vicinity (table 5.1). Andesite was not identified and is probably a minor component in the catchment area of the Slatina stream.

Location 3: Kolonija, Jagodina, the Lugomir river

Coordinates: 0520994 E, 4864623 N

This clast count was carried out in the lower part of the Lugomir river (fig..5.2.2/3,fig 5.2.5), as it should contain most of the geological resources available on the northern slope of the Juhor mountain. Rocks from this location are angular and subangular, while only amphibolite is rounded; the size of clasts ranges between 5-30 cm.

Metamorphic rocks, such as gneiss, schist, mica-schist and amphibolite, are predominant. Volcanic and sedimentary rocks are completely absent (table 5.1). The presence of hornfels needs to be confirmed through thin sections. The presence of amphibolite seems relevant, as it might have been used for axe manufacture, apart from hammer-stones

Location 4: village of Medjreč, Jagodina, the Jošanička river

Coordinates: 0532827E, 4856879 N

fig 5.2.6. Location 4: village of Medjreč, Jagodina, the Jošanička river

This location (fig..5.2.2/4, fig 5.2.6) was selected in order to determine the raw materials available at close proximity to the Early Neolithic settlement of Medjreč.

Rocks from this location are angular, subangular and subrounded; size is from 5 to 20 cm

The variety of rocks in the Jošanička river is very limited. Vain quartz is practically the only suitable material for macro-lithic tool production. Amphibolite shows very marked planar texture, which limits its use as hammerstones and, particularly, as ground-edge tools (table 5.1).

fig 5.2.7, Location 5: village of Donja Sabanta, Kragujevac, the Ždreljica river

Location 5: village of Donja Sabanta, Kragujevac, the Ždreljica river

Coordinates:_496327 E, 4867249 N

The Ždreljica river (fig..5.2.2/5, fig 5.2.7) collects materials from the Gledić and Crni Vrh mountains.

fig 5.2.8. Location 6: village of Sibnica, the Županjka river.

Rocks from this location are angular, angular, subangular and only andesite is rounded; the clast size ranges between 5 to 25 cm.

This clast deposit includes carbonated materials, which have not been found in the previous locations. Sandstones and micro-conglomerate, but most of all light and impure marble (containing Fld-Plg, and some Qtz, apart from Ca) appear in large amounts. Gabbro-dioritedolerite rocks are also abundant. However, macroscopical analogies have not confirmed our assumption that these rocks were used for grinding equipment at the Late Neolithic settlements of Motel Slatina and Turska česma Central region. Contrary, highly siliceous rocks are rare (table 5.1).

Location 6: village of Sibnica, the Županjka river

Coordinates: 0505266 E, 4849195 N

As expected, in the second location chosen upstream along the Županjka river (fig..5.2.2/6, fig 5.2.8), very similar rock types as in location 5 have been identified, although with slight mineralogical variations. While marble is less frequent, carbonated meta-psamites represent over 40% of the fluvial deposit. Non carbonated sandstone is also abundant. Mafic igneous rocks are more fine grained than in location 5 and have therefore been classified as basalt. However their importance is very limited, as is also granite. Quartz and quartzite are practically absent in this case (table 5.1).

Clasts from this location are, subangular and subrounded, and 5 to 20 cm in size.

Location 7: village of Prevešt, the Kalenićka river.

Coordinates: 0503469 E, 4844429 N

This location has been selected in order to identified a secondary source of meta-siltstone/alevrolite, as the deposits of this rock have been detected as the nearest to the studied sites of Turska Česma, Slatina, Motel Slatina and Medjureč at this area (chapter 5.3, fig. 5.3.11) This raw material was used for polished edge tools (chapter 5.1).

Rocks from this location are rounded, subrounded and subangular. Their size varies between 5 and 25 cm. Silicified sandstones continue to be abundant in this location, as well as gabbro. Carbonated metamorphic and sedimentary rocks are also present, though in much lower proportions than in the previous location. Our geological survey has not confirmed the presence of meta-siltstone/alevrolite in the secondary deposits (table 5.1). Consequently, the provenance of these rocks, which were of crucial importance to the production of polished edge tools, remains unknown.

fig 5.2.9, Location 8, village of Oparć, Kalenićka reka.

Location 8, village of Oparć, Kalenićka river.

Coordinates: 0508796 E, 4843903 N

Location 8 is positioned in the middle part of Kalenićka river fig..(5.2.2.2/8) and has been chosen for the same reason as the location 7.

This clast count was carried out in the lower part of the small Kalenićka stream (fig 5.2.8). As expected, rock types and sizes are very similar. Only the proportion of impure (containing Fld-Plg, and some Qtz) marble is higher. Presence of meta-alevrolite has not been revealed (table 5.1).

fig 5.2.10, Location 9: village of Drenovac, Paraćin, pebble extraction site at the left bank of the Morava river.

Location 9: village of Drenovac, Paraćin, pebble extraction site at the left bank of the Morava river, c. 10 km upstream of location 1.

Coordinates: 0508798 E, 4843906 N

ROCKS TYPES	**Loc. 1 %**	**Loc. 2**	**Loc 3%**	**Loc 4%**	**Loc 5%**	**Loc 6%**	**Loc 7%**	**Loc 8%**	**Loc 9%**
basalt						6,5			
gabbro	9,6				14,1		20,8	3,1	10,7
grano-diorite	2,6								1,3
diorite (incl. diabase)					19,2				1,3
granite	7,9					2,2		3,1	4,0
porphyry	13,2								4,0
white vain quartz	17,5	+	8,3	68,7	2,6				24,0
black quartz	4,4								4,0
andesite	3,5								4,0
limestone					9	10,8	2,8		
sandstone (carbonated)					2,6		8,3	12,5	
sandstone (non-carbonated)	3,5		3,6		2,6	17,4	20,8	28,1	1,3
red silicified sandstone	0,9								4,0
conglomerate							1,4		
micro-conglomerate					19,2	6,5	5,6		
slate	4,4	+++					13,9	9,4	6,7
schist	10,5		19,0	13,3			2,8	3,1	6,7
gneiss	0,9		26,2						
mica-schist		+	20,2						
quartzite	17,5	+	6,0						21,3
green quartzite/serpentinite?						2,2	2,8		
amphibolite		?	15,5	18					1,3
marble					23	2,2	6,9	6,3	
impure marble					6,4	2,2	6,9	15,6	
metapsamite	3,5				1,3	6,5	1,4	9,4	4,0
carbonated metapsamite						43,5	5,6	9,4	
hornfells?			1,2						
unknown									1,3
Total	100	–	100	100	100	100	100	100	100

Table 5.1. Clast counts and petrographic classification from surveyed secondary deposits of the Central Region.

A second survey location was chosen along the Morava river (fig..5.2.2/9, fig 5.2.10), given the importance of its clast deposits in terms of quantity and variety of rocks. Moreover, this location is very close to the large Vinča settlement of Turska česma (Drenovac).

Clasts from this location are mostly rounded and subrounded, while subangular shapes are rare. In this case we have found larger sized cobble stones, with a maximum size up to 30 cm or even 40 cm in length. Nevertheless, the majority of the rocks measure less than 25 cm. This indicates the difficulty to obtain large clasts in the Central Region, for example, for the manufacture of grinding slabs.

Rock types and amounts are practically identical to location 1, confirming the large variety of rocks, but also the lack of carbonated materials. Granite and porphyry are less frequent than in location 1.

Location 10: Paraćinska Glavica, Paraćin,

This location has been selected as a possible gabbro exploitation close to the site of Motel Slatina. This hill represents older Paleozoic gabbro formation, located about 800 m on the east of the settlement Motel Slatina (fig.5.2.2/10, fig. 5.2.11) and presents the eastern part of a dominant elevation called Paraćinska Glavica (Paraćin hill). It is intersected by the gorge of the Crnica river in the east - west direction, creating two independent elevations, in the north of the Strana hill, and in the south of the Čukar hill (fig. 5.2.10). It consists of plutonic rocks represented by various types of pyroxene gabbro with rare anorthosite wires.

First, we have explored the northern and southern bank of the Crnica river, in a distance of about 300 m. The southern bank of the river is a very steep rim of the northern slope of the Čukar hill. The bank is overgrown with weeds and destroyed partially by modern building works, and also devastated by the construction of the main road Paraćin - Zaječar, while the preserved part is covered with a soil layer and forest undergrowth, so that lithological material is rarely available. The northern bank of the Crnica river is low and covered by soil. Schist, red Permian sandstones and limestone were documented at point 1, in a very small area of a few square meters. Gabbro was documented occasionally and in small quantities (coordinates:

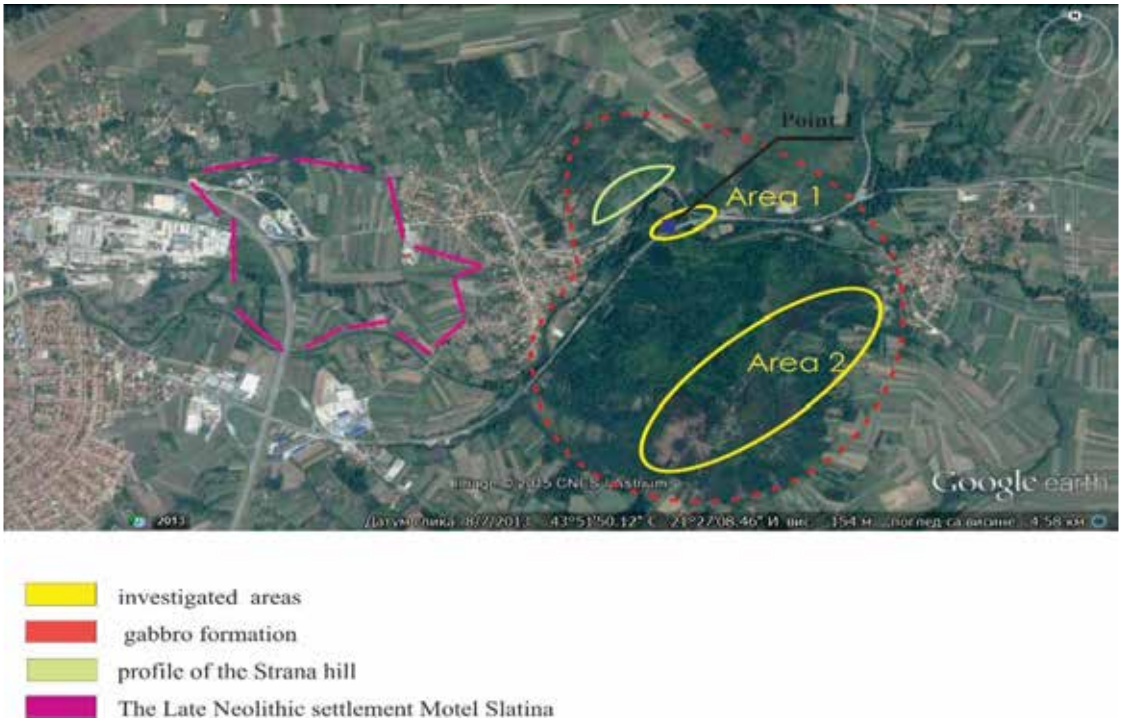

Fig. 5.2.11. Central region: positions of the Late Neolithic setllement Motel Slatina and gabbro hill with explored areas.

N43º51`55. 79 N 21º27`21.79 E), (fig. 5.2.11- 13; fig. 5.2.10/ area 1)[1].For that reason we have rejected the possibility that gabbro was exploited in this part of the Čukar hill.

We have also examined the possibility of a gabbro outcrop exploitation at the western and eastern slopes of the hill (fig. 5.2.10/area 2)[2]. The slopes are forested and steep traces of recent exploitation, conducted during the 50s of the 20th century, can be recognized from the upper part of the slope back to the top of the hill. Therefore, we excluded the possibility to identify traces of the primary exploitation. Recent traces present relatively broad and deep, oval depressions, variable in their size. Exposed profiles produced angular pieces of gabbro, different in size. Their morphology occurred as a result of rock decomposition and exogenous processes (fig.5.2.14).

However, gabbro pieces drawn our par ticular attention as they are visible on the longer part of the dirt road that leads from the foot of the eastern slope to the top of the hill (fig.5.15).

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[1] The team members were: Vesna Vučković (Hometown Museum ”Paraćin”, Paraćin) and Slaviša Perić (Archaeological Institute, Belgrade).

[2] The team members were: Vesna Vučković (Hometown Museum ”Paraćin”, Paraćin), Nevena Cvetković, geologist and Sonja Perić, archaeologist (Regional museum “Jagodina”, Jagodina)

They were also detected infrequently on the dirt road on the western slope, due to a thick layer of soil. On the dirt road on the western slope we gathered a few gabbro samples. Their dimensions are: 22 x 11 x 11.2 cm, 18 x 9.5 x 7 cm and 25.9 x 1, 7 x 4, 4 cm (fig. 5.2.16 / 1 a, b; 2a, b; 3a, b;). Their morphology is relatively regular, even ergonomic shapes drowns our attention (fig. 5.2.17/1b). The transformation into the form of abrasive and grinding tools would be achieved easily and with little effort. Some samples have a narrowed lower part, suitable for placing and fixing into the ground (fig. 5.2.16/1-3). They are coarse- grained homogenous rocks, slightly ophitic, and bright gray-greenish colored.

The size and shape of the clasts are similar to the abrasive or grinding tools. A naturally concave surface of one of these samples *x*suggests that the morphology of the work surface of abrasive or grinding tools might not be exclusively formed by use, but was favored by the natural form of the rocks.

It should be mentioned that the natural shape of raw material is resemble toforms of abrasive tools and grinding tools. Suitable natural morphology additionally allows a straightforward and efficient shaping of objects. Data on raw material and types of tools also suggest planned choice of resources.

Fig. 5.2.12. Central region: point 1, gabbro hill and northern river side.

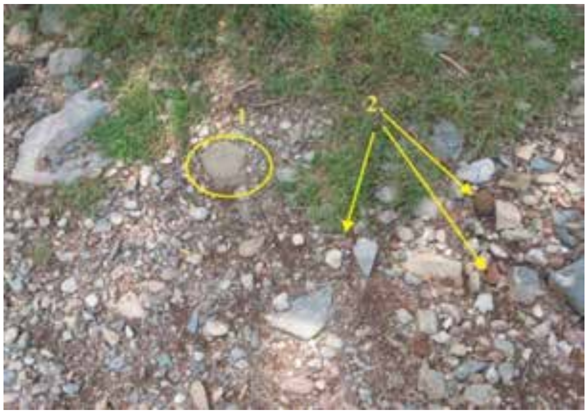

Fig. 5.2.13. Central region: point 1, river pebbles: 1. gabbro; 2. red sandstone.

Fig. 5.2.14. Central region: point 1, collected rocks: 1,3,5,6 gabbro; 2. schist; 3. limestone.

Fig. 5.2.15. Central region: Hill Čukar, traces of recent exploitat1on, gabbro profile, eastern slope (fig.5.22/area 2).

Parallel to this, we have examined a geological profile of a southern slope of the hill Strana (fig.5. 2.10). It produced also gabbro and schist, which was identified on both Late Neolithic settlements, Motel Slatina (n=2) and at Slatina, Turska česma (n=1). Furthermore, geological exploration also mentions gabbro, argilophyllite and sericite phyllite (Dolić et al. 1981: 20). along the middle Morava valley and in the valleys west of the Juhor mountain (774 m a.s.l.), In sum, the geo-archaeological survey and clast counts carried out in the Central region has allowed to distinguish three clearly differentiated geological areas, in terms of the available raw materials.

The Morava valley offers a largest variety of igneous and metamorphic rocks, including volcanic andesite, and plutonic granite and porphyry. Contrary, carbonated rocks are rare, as well as (mica-)schist, gneiss and amphibolite. The latter ones are to found north and northwest of the Juhor mountain, where, instead, igneous rocks, apart from vein quartz, are absent. Finally, in the hilly region of Levač, all the streams (Ždreljica, Županjka and Kalenićka) carry important amounts of carbonated rocks, both sedimentary and metamorphic. The presence of marble, particularly in the deposits of the Ždreljica stream, might be of interest, when considering the

Fig. 5.2.16. Central region: Hill Čukar, dirt road on the eastern slope.

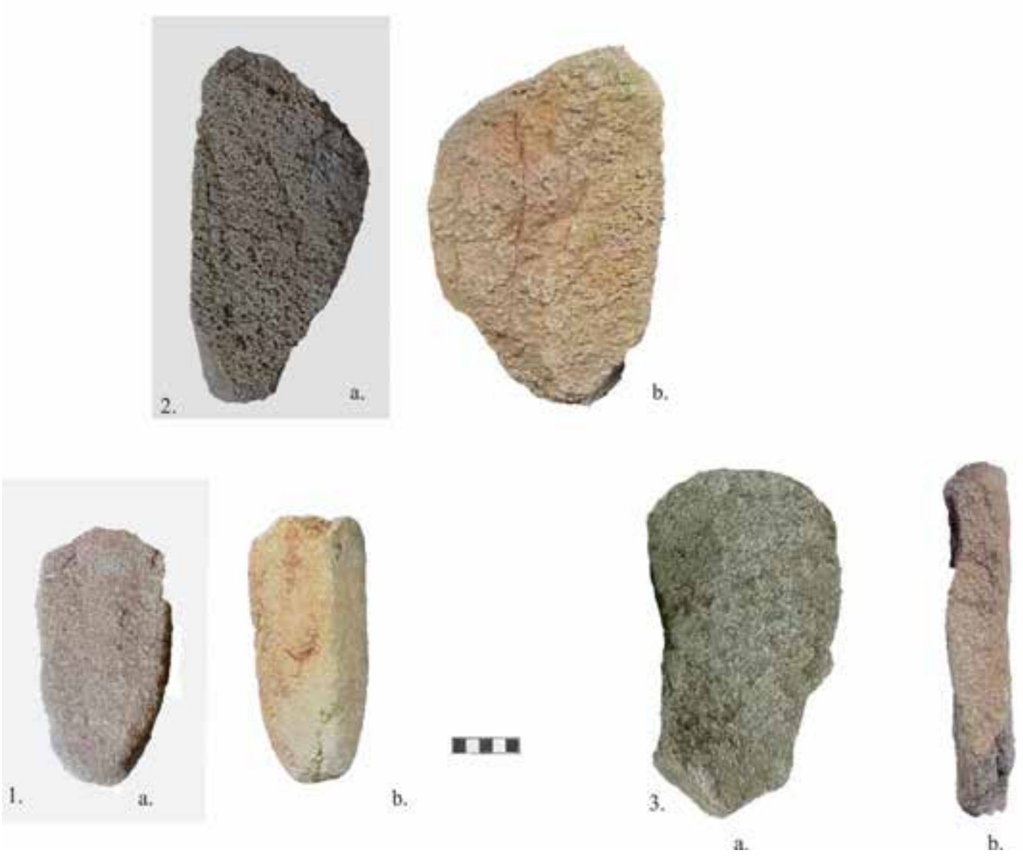

Fig.5.2.17. Central region: Hill Čukar, gabbro samples collected from eastern erosion layer; 2c, 3c micro-photos of natural gabbro surface.

origin of the raw materials used for the manufacture of figurines. The results of these geo-archaeological surveys will be relevant for the interpretation of the raw materials found in the Neolithic settlements discussed in chapter 5.3.

5. 3. Procurement and distribution of raw materials

Geo-archaeological analyses are required in order to identify the location and the distance from which raw materials derived the exploitation method and the existence of territorial borders between supply areas. During the last years geo-archaeological as well as ethnographic researches have confirmed that river beds in the vicinity of settlements were the main source of raw material (Prinz 1988: 256; Risch 1995; Hampton 1999: 224; Stout 2002; Antonović et al 2005: 66; Antonović 2003:18). Some results show that the quality of certain rocks was recognized and appreciated over distances of hundreds of kilometres (Christensen, et al., 2006; Risch 2011; Szakmánz et al. 2009.). However, the long-distance exchange could involve complex mechanisms of social needs and relationships (Pétrequin et al. 2017; Risch 2011: 114).

This chapter focuses on the rock types used for manufacturing macro-lithic tools in the settlements of our study (see chapter 3). Important differences in the selection and use of raw material between sites are observed. Aiming to explain this variety, geo-archaeological analyses have been carried out. The aim of this chapter is to understand the selection, exploitation and implementation of certain rocks. In this sense, our approach consists of three stages, including the results of an experimental examination (fig. 5.3.1). The initial stage is tool production[1], where we focus on the *correlation between geology and tool type*. This has allowed us to separate specific activities based on the importance of certain rocks in the manufacture of different tools. The second stage of the analysis includes the *correlation between wear of the tools and their geology*. This provides insight into the intensity of the use and the correlation between geology and stress of specific activities. Here, tests of the mechanical behaviour of raw material are also addressed. The final stage *is procurement*. It is based on the distance between raw material deposits and settlements. It reveals patterns of raw material exploitation, according to the sites and regions, including possible contacts with other communities and exchange. The final result of these steps is an identification of economic

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[1] 1 For the meaning of the term production see Adams 2009: 44.

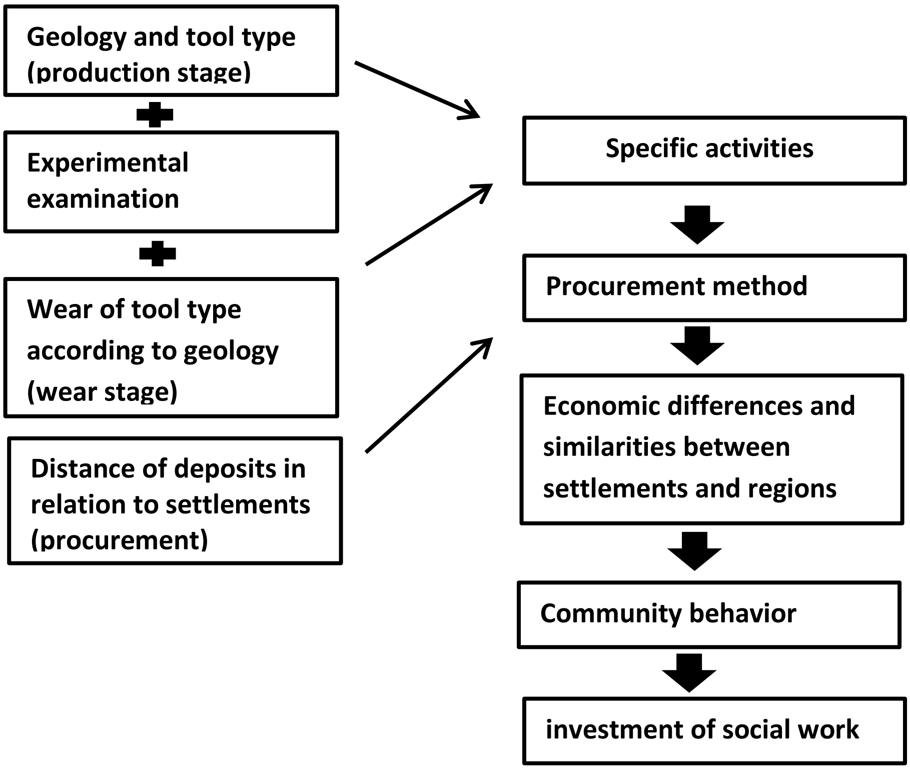

Fig. 5.3.1 Analytical steps of geo-archaeology analysis.

differences and similarities between settlements and between regions. The *community behaviour* relates to contact with other communities and remote exchange. The *social work investment* varies depending on the interaction between communities.

5.3.1. Northern region

This region presents a unique area in terms of geology because it offers little else than sedimentary rocks. The Late Neolithic settlements of *At* and *Potporanj* are located at a small distance from each other. Both settlements lay on a Quaternary alluvial fan consisting of sands, clays and gravels. Thus, their surroundings only present a limited range of rocks. The Vršac Mountain located few kilometres to the east offers schist (fig. 5.3.2).

The results show that tools from the site of *At* are mainly of (meta)alevrolite and claystone, while sandstone and schist are also present (fig. 5.3.3). They were used mainly for manufacturing polished edge tools (adzes – ADZ, axes – HAC, a celt – REN) (fig. A1.1) The correlation between geology and tool types indicates links between sandstone and percussive tools (hammer-retouching tools -HAM-RET and re-used polished edge tools -RPE

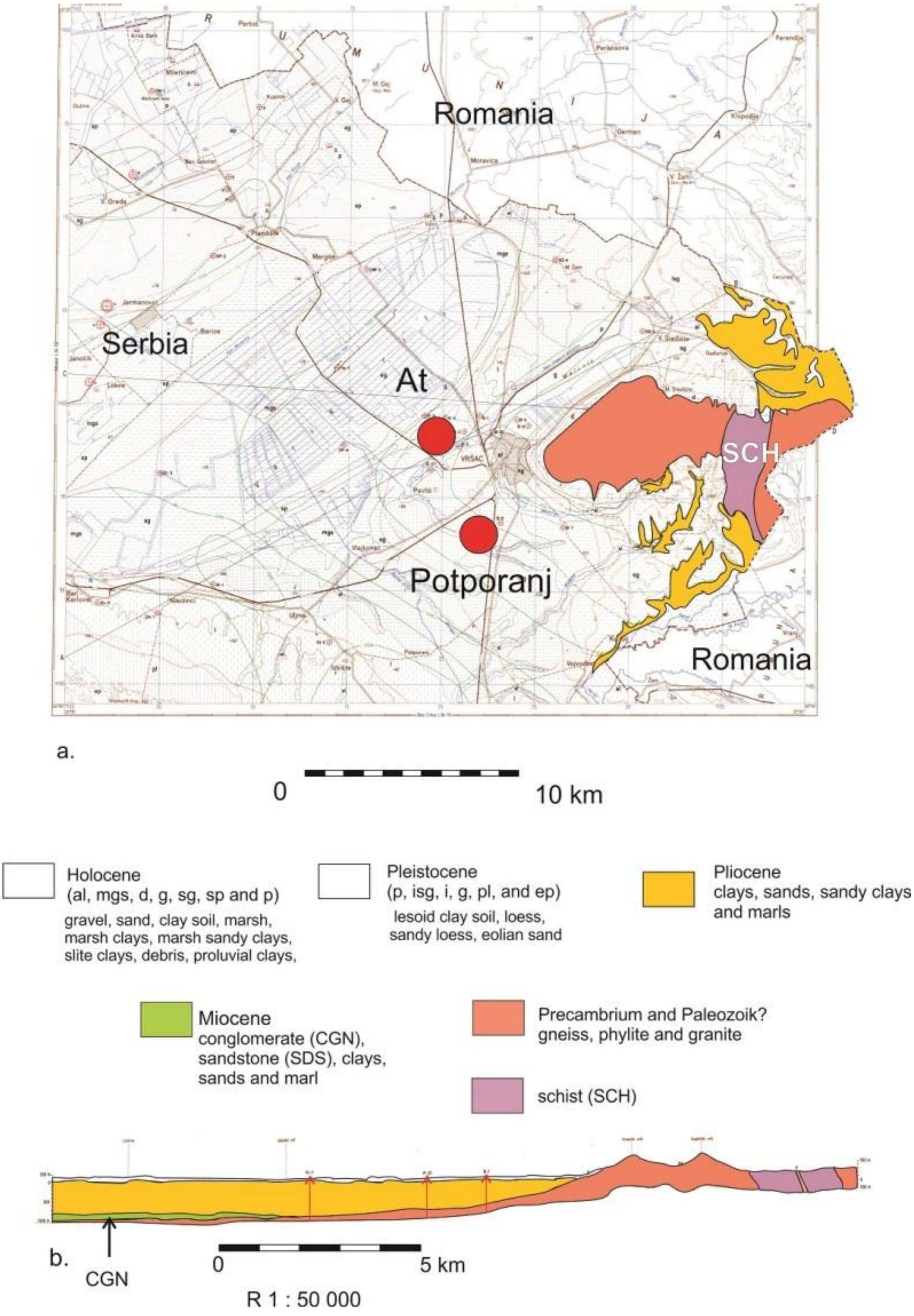

Fig.5.3.2. Geological map and position of the sites At and Potporanj; adapted after geology sheet L34 - 103 Vršac 1: 100 000.

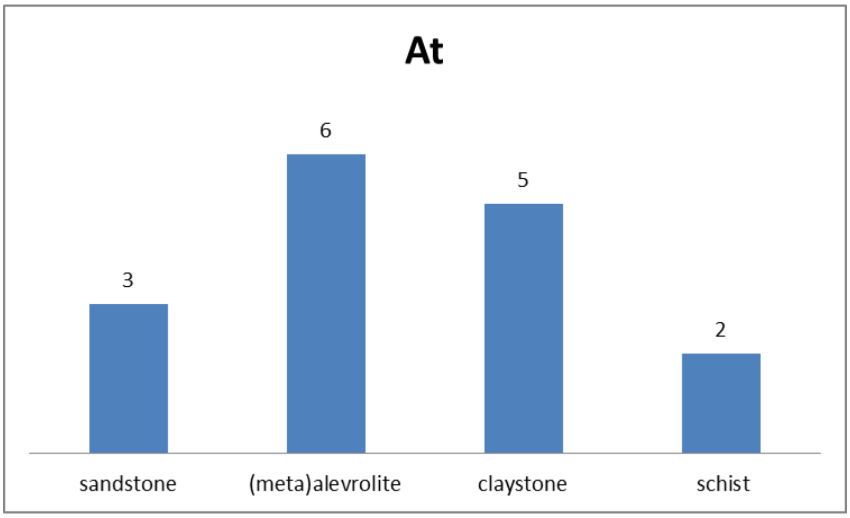

Fig. 5.3.3. At: geology; N=16.

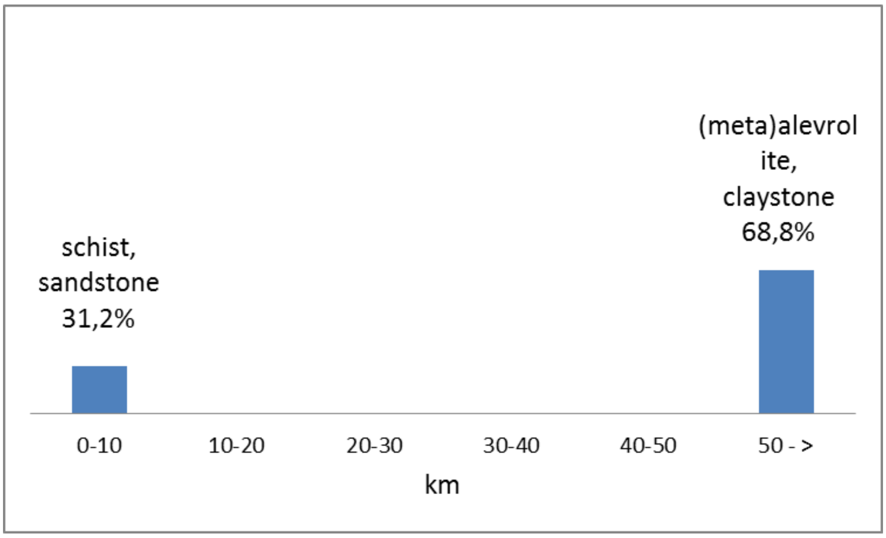

Fig. 5.3.4. At: Raw materials and source distance.

2), as well as between celts (REN) and claystone. Regardless of the geology, artefacts are well preserved, particularly those made of schist (fig. A1.2,3).

Schist is locally found, while sandstone originates from Miocene deposits and was probably collected in rivers (fig. 5.3.4). Instead, (meta)alevrolite and claystone were brought from distant areas. Although Cretacious claystone and (meta)alevrolite are documented on the geological column in the area towards the west,[2] they were probably not accessible in prehistoric time.

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[2] see geology sheet Ali Bunar L – 34 – 102, http://geoliss.mre.gov.rs/OGK/RasterSrbija/OGKWebOrig/listovi.php?karta=Alibunar

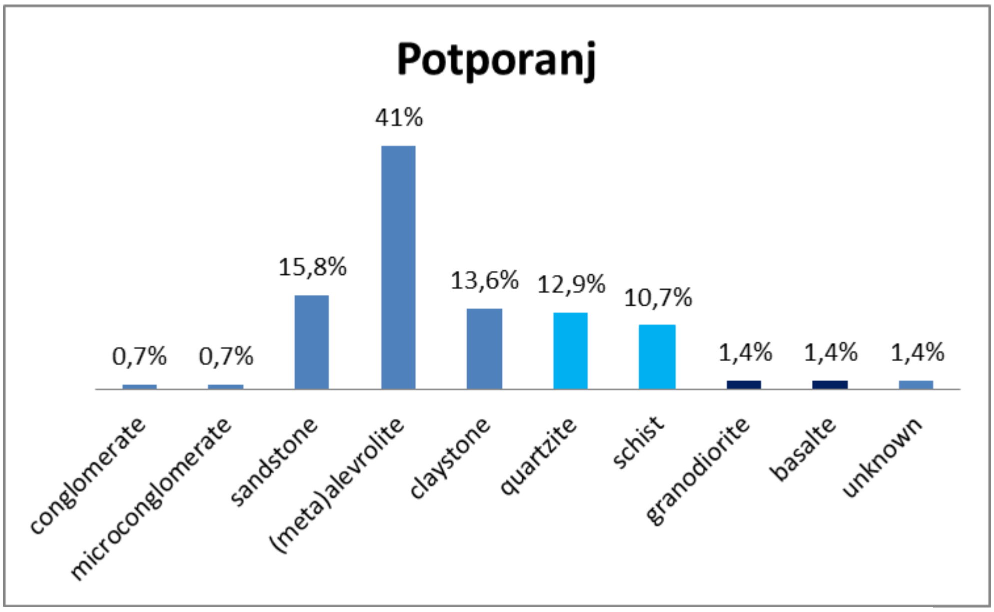

Fig. 5.3.5. Potporanj: geology; N=138.

Around 71% of the assemblage from the Late Neolithic settlement of *Potporanj* is dominated by sedimentary rocks, such as (meta)alevrolite, sandstone, conglomerate, micro-conglomerate and claystone (fig. 5.3.5). Sedimentary rocks are used in manufacturing polished edge tools (axes -HAC, adzes-ADZ, chisels - CHI and celts -REN), grinding tools (mortars - MOR and a grinding slab – MOL), percussion tools (pestles – PST, re-used polished edge tools -RPE) as well as the abrasive tools (coarse-grained abraders –ALS and a smoother – ALS-PIA) (fig. A 1.3). Given the relative softness of these rocks, they can be easily shaped and maintained, through flaking and grinding. For that reason, they were widely used in the central Balkans.

About 23 % of the studied tools are made of schist and quartzite (fig. 5.3.5). These rocks were used for manufacturing grinding tools (mortars -MOR, a grinding slab -MOL), percussion tools (retouching tools - RET, percussive tools –PEC, a smoother - percussion tool – APE and a re-used polished edge tool -RPE) and axes – (HAC)(fig. A 1.3). Igneous rocks such as basalt and granodiorite were implemented occasionally (fig. 5.3.4). These hard rocks were used for manufacturing percussion tools (a percussive tool– retouching tool - RET-PEC, a retouching tool - RET and a pestle - PST) (fig. A 1.3).

The correlation between geology and tool type indicates certain patterns. Mainly hard rocks, such as quartzite and basalt, were implemented as retouchers (RET) and percussive tools (PEC). Quartzite also relates to percussive and multifunctional tools (a smoother - percussion tool – APE, and a pestle – coarse-grained abrader – anvil - PST-ALS-ANV), while a pestle-retouching tool (PST-RET) was made of schist. Furthermore, abrasive tools

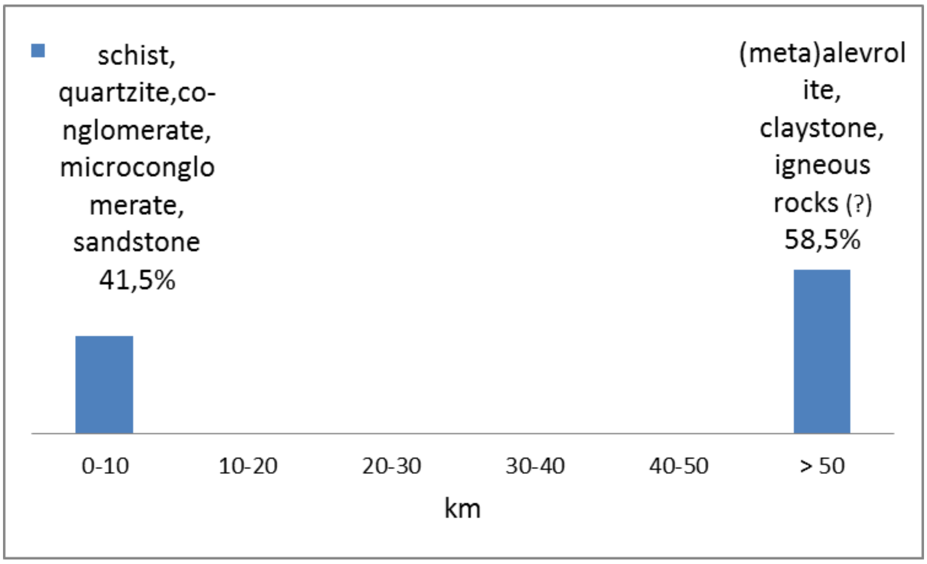

Fig. 5.3.6. Potporanj: Raw materials and source distance.

(abrasive slabs - LOS and a fine-grained abrader - ALS-PIA) were made of sandstone, while a coarse-grained abrader (ALS) was made of schist. (Meta)alevrolite is linked mainly to polished edge tools such as adzes (ADZ), celts (REN) and re-used polished edge tools (RPE) (fig. A 1.3).

Generally, quartzite and (meta)alevrolite tools are well preserved, suggesting low wear. On the other hand, a significant percentage of the sandstone, claystone and schist tools are broken and fragmented, indicating intensive use (fig. A 1.4). The nearest source of schist has been documented c. 10 km in the east of the site, as the crow flies, in the Vršac Mountain. Quartzite, claystone, gabbro and diabase were probably collected from the Fruška Gora km Mountain, which is 118 km towards the west[3]. (Meta) alevrolite probably came from an area c. 80 towards the southwest[4]. Furthermore, peridotite deposits have been detected 300 km in the southwest (Western region)[5]. Although these peridotite items could be of the Alpine jade, which recent study shows in surrounding areas (Petrequin et al 2017: 292-296; fig. 1,4). This might indicate long-distance exchange.

Benska bara is a Late Neolithic settlement placed in the southern part of the Northern region. It is located on a fan-shaped alluvial plain between the Sava and the lower Drina

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[3] see geology sheet Novi Sad L – 34 – 100. http://geoliss.mre.gov.rs/OGK/RasterSrbija/OGKWebOrig/listovi.php?karta=Novi_Sad.

[4] see geology sheet Beograd :L – 34 – 113 http://geoliss.mre.gov.rs/OGK/RasterSrbija/OGKWebOrig/listovi.php?karta=Beograd

[5] see geology sheet http://geoliss.mre.gov.rs/OGK/RasterSrbija/OGKWebOrig/listovi.php?karta=Gornji_Milanovac

rivers. Recent erosion and modern watersheds transformed this area into an erosive river-denudation plain (fig. 5.3.7).

The lowlands are formed by the spacious alluvial planes of the rivers Sava and Drina and its right tributaries (Carević, Jovanović 2009: 131). Around 96% of the material is made of sedimentary rocks (fig. 5.3.8). These rocks were mainly implemented to manufacture polished edge tools (axes -HAC, adzes -ADZ, chisels- CHI, and celts -REN), percussion tools (re-used polished edge tools - RPE, a retouching tool (by pressure) - hammer - REP-HAM, a pestle -PST, a percussion tool - PEC, a perforated axes - HAC-PA, a perforated mattocks -MTT) and small abrasive tools (coarse-grained abraders - ALS and a fine-grained abraders -ALS-PIA) (fig. A 1.5). Various igneous rocks such as granite, diabase, cf. peridotite and gabbro represent c. 0.3-0.6 % (fig.5.8). These rocks were implemented for manufacturing percussion tools (perforated axes - HAC-PA, mattocks - MTT and a percussive tool –PEC), while one celt (REN) is possibly made of peridotite (fig. A 1.5).

Metamorphic rocks were rarely used (fig. 5.3.8; fig. A 1.5). Only one hammer (HAM) and one percussive tool (PEC) have been manufactured out of this material (fig. A 1.5).

The results also show a correlation between geology and some tool types. (Meta) alevrolite or fine-grained gneiss was used mainly to manufacture polished edge tools (axes - HAC, HAC?, chisels -CHI, CHI?, adzes -ADZ, and a celt - REN). Sandstone is linked with abrasive tools (a coarse-grained abrader -ALS and a fine-grained abrader - ALS-PIA) and percussion tools (a hammer? -HAM?, a pestle PST, a retouching tool-anvil -RET-ANV, re-used polished edge tools - RPE). Limestone is linked with a multifunctional object

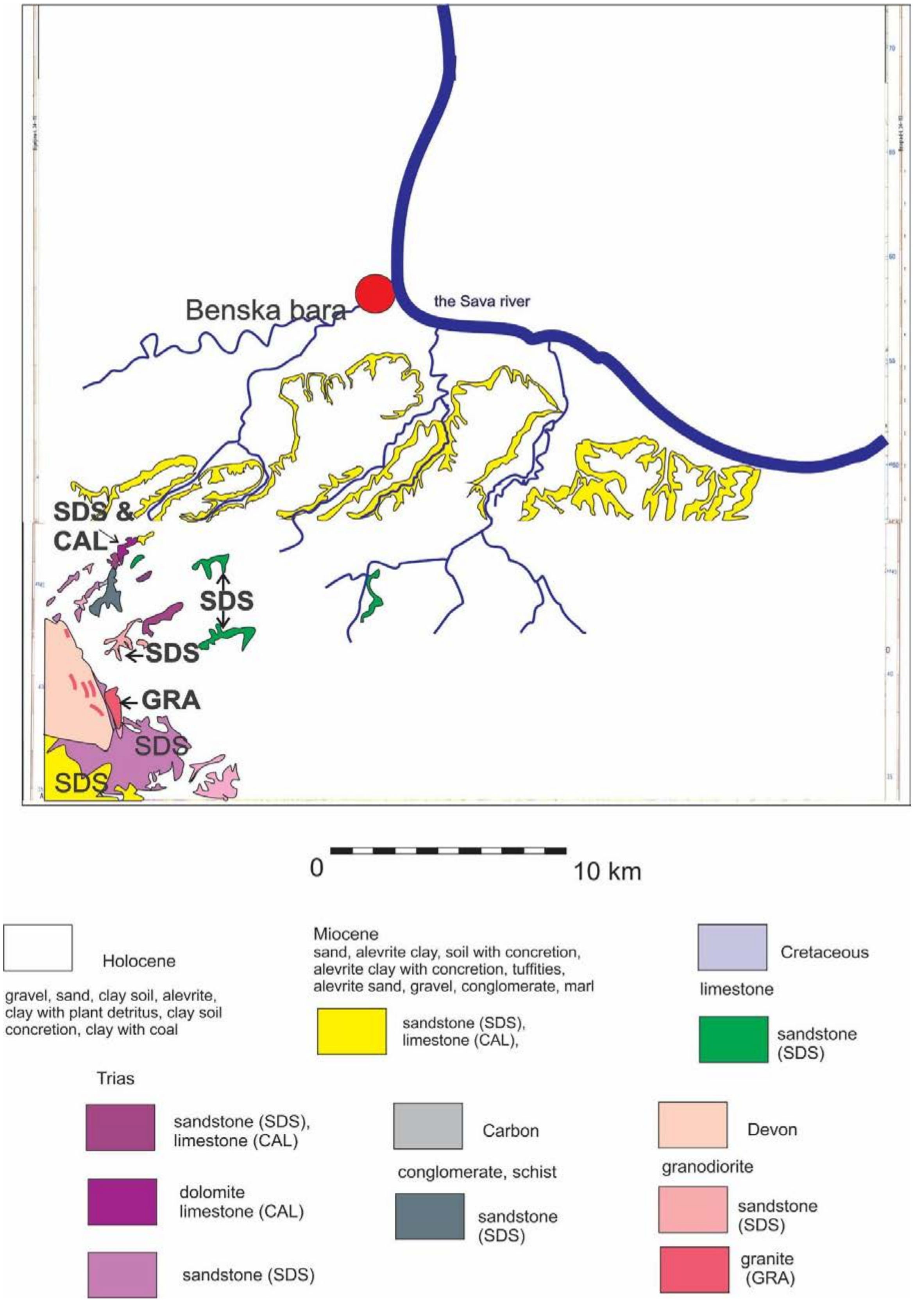

Fig. 5.3.7. Geological map and position of Benska bara; adapted after geological map L34 - 112 Šabac and L34 - 124 Vladimirci 1: 100 000.

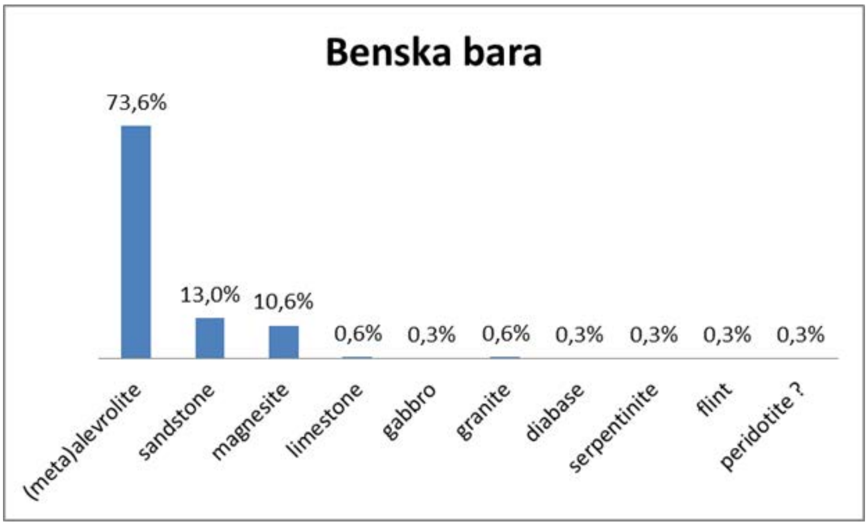

Fig. 5.3.8. Benska bara: geology; N=338.

vations made suggest that sandstone objects and particular igneous tools show a low percussion tool– retouching tool (retouching by pressure) (PEC-REP) (fig.A.1.5). Sandstone objects and, particularly igneous tools show a bad preservation level, indicating their intensive use (fig. A.1.6). The raw materials used in Benska bara cannot be found in the primary position near the settlement. Limestone, sandstone and granite are available between 11-18 km towards the southwest. However, small rivers running from this area towards the Sava could carry these materials. We suppose that flint was also collected from these river beds. The Jurassic serpentinite has been detected only in a geology column (see: geology sheet L 34 – 112 Šabac http://geoliss.mre.gov.rs/OGK/ RasterSrbija/ OGKWebOrig/ listovi.php?

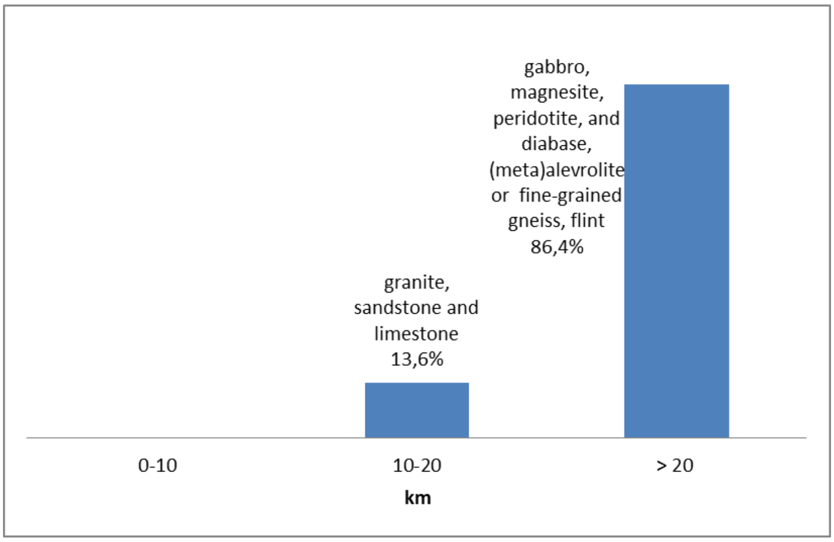

Fig. 5.3.9. Benska bara: Raw materials and source distance.

karta=sabac) indicating that it might have been collected from the bed of the river too. Unlike this, (meta)alevrolite, fine-grained gneiss, gabbro, diabase, magnesite and peridotite were brought from other areas. (Meta) alevrolite or fine-grained gneiss layers have not been documented. Rich deposits of igneous rocks and magnesite lie in the mountains up to 20 to 70 km south of Benska bara as the crow flies but it is not clear if they were submitted to some type of metamorphism, as we have observed in the thin sections (see chapter 5.1.). The nearest metamorphic formations are located c. 30 km away to the south (Mojsilović et at. 1975: 22, 25, 26) (fig. 5.3.9). The presence of magnesite and cf. peridotite suggest contacts with the communities from the Western region. If this were the case, we could state that took the Late Neolithic community of Benska bara took part in the long-distance trade network. This means that these items could be of the Alpine jade, instead of peridotite which have been recently detected in neighbouring areas (Petrequin et al 2017: 292-296; fig. 1,4). The large quantity of obsidian found in Potporanj also supports the idea of long-distance exchange network, in this case with the Tokaj -Prešov in the Carpathian area during the Late Neolithic (Tripković 2001). Recent results suggest that some rock types such as greenschist, white slate stone, (meta)ultra-basite, granite-metagranite from tell Gorsza, in northwest Hungary originated from a so-called Sava -Vardar area which would include Croatia, Serbia and Bosnia (Szakmánz et al. 2009). However, none of these rocks has been identified in the present study. We might expect that some of these rocks come from and passed through the Northern region, as part of the exchange on the way to tell Gorsza.

5.3.2. Central region

The Central region is rich in various rock types formed during different geological periods. Observations show that limestone, sandstone and conglomerate are the most common rocks in the east, while the western part is characterized mainly by metamorphic and igneous deposits (fig. 5.3.10).

The Early Neolithic settlement *Medjureč* is located in the northern part of the Central region, where Pliocene lake deposits and schist are common (fig.5.10) (Milojević 1951, 2,8).

Observations show that metamorphic rocks were used to manufacture around 66 % of the examined tools such as coarse-grained abraders (ALS), abrasive slabs (LOS), fine-grained abraders (ALS-PIA), axes (HAC) and a celt (REN) (fig. 5.3.11; A 1.7).

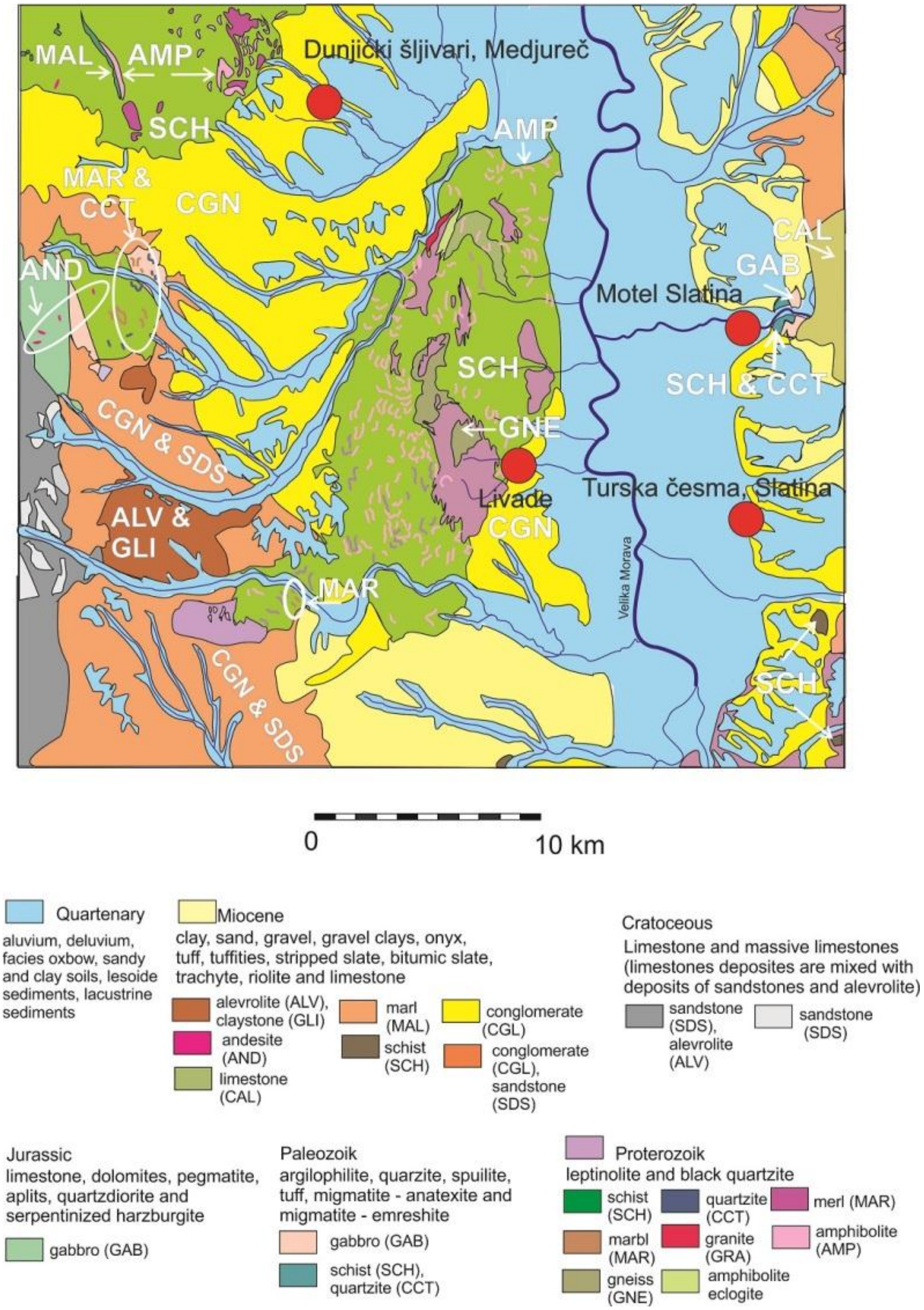

Fig. 5.3.10. Geological map and position of settlements of Medjureč, Motel Slatina, Turska Česma and Livade; adopted after: geology map L 34 – 7 Paraćin 1: 100 000.

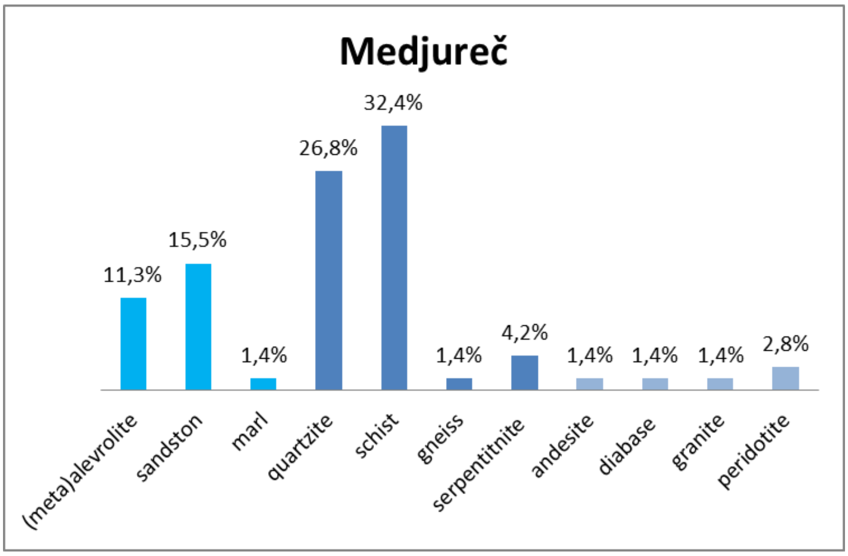

Fig.5.3.11. Medjureč: geology; N=71.

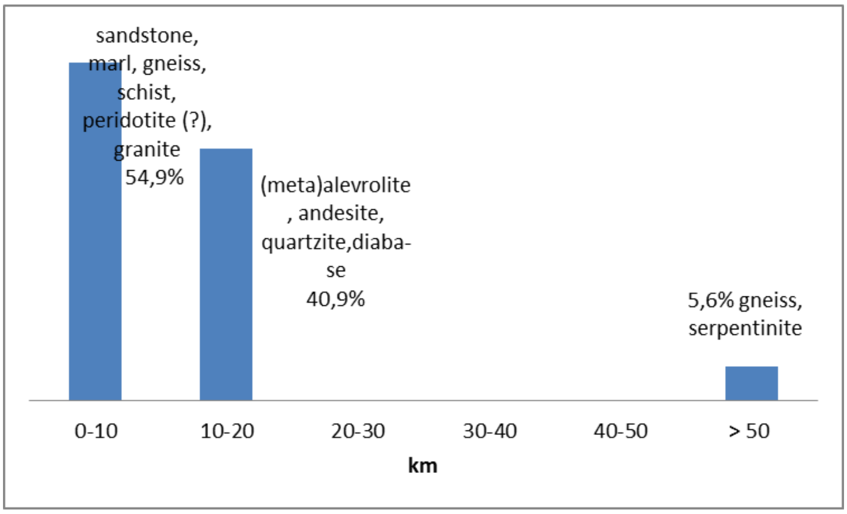

Fig.5.3.12. Medjureč: Raw materials and source distance.

Around 26 % of the tools are made of sedimentary rocks, first of all (meta)alevrolite (fig. 5.3.11; A 1.7). This includes polished edge tools (axes –HAC and a celt -REN), a re-used polished edge tool (RPE) and coarse-grained abraders (ALS) (fig. A 1.7).

About 7% of studied objects are made of igneous rocks such as andesite, diabase, granite and peridotite (fig. 5.3.11). They are implemented in manufacturing a celt (REN), pestles (PST) and retouching tools (by pressure) (REP) (fig. A 1.7).

The results of the analysis indicate a connection between geology and certain tool types (fig. A1.7). Quartzite is linked to retouching tools (RET) and semi-finished products of polished edge tools (SFP). Schist was mainly used for abrasive tools (coarse-grained abraders -ALS, a fine-grained abrader - ALS-PIA and abrasive slabs - LOS) and an object that probably presents a semi-finished product of polished edge tools (SMF?). (Meta)alevrolite is

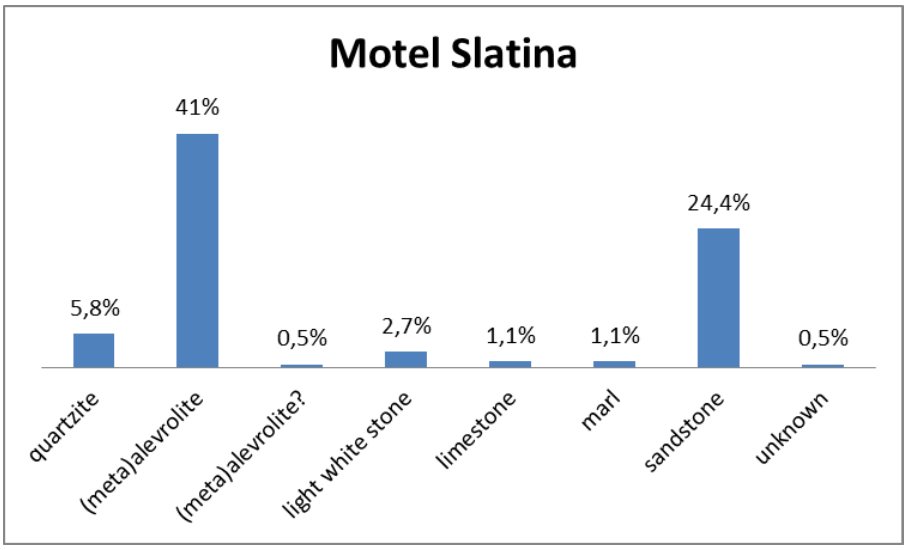

Fig.5.3.13a. Motel Slatina: sedimentary rocks and unknown geology, graph 1; N= 187.

linked to flake negatives (LAS) knocked off the polished edge tools and a re-used polished edge tool (RPE). Gneiss relates to a grinding tool (MOL?), while sandstone corresponds to an object that might be an abrader (ALS-PIA?) (fig. A 1.7).

Raw materials were obtained primarily from the surroundings of the settlement. Schist has been detected in a river, which flows in the vicinity of the site. Mica –schist and marble deposits lay c. 4 to 8 km to the West, as the crow flies. Granite and gneiss deposits have been observed c. 6 and 7 km to the Southeast, while (meta)alevrolite layers are detected c. 13 km to the Southwest. Rocks such as andesite, quartzite and diabase[6] were brought from areas that are c. 13 and 11 km in the West and Southwest. It is also possible that another source for raw materials was the river beds c. 6 km as to the South. Taking into account the obstacle in the determination of peridotite, there is a possibility that instead peridotite we are dealing with eclogite, which is available in a deposit c. 6 km to the South as the crow flies (fig. 5.3.10 and 14). The question of sources of serpentine remains unanswered.

The results indicate that only quartzite objects show significant levels of good conservation, while the rest are mainly fragmented and broken, indicating their intensive use (fig. A 1.8).

The Late Neolithic settlement *Motel Slatina* is located in the eastern part of this region on the Miocene clay, sandy and gravelly soil (fig. 5.3.10).

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[6] Diabase is presented only in geology column, in the Gledićke mountain, the western part of the Central region (see: geology sheet L 34 – 7 Paraćin 1: 100 000, http://geoliss.mre.gov.rs/OGK/Raster Serbia/ OGKWebOrig/listovi.php?karta=Paracin).

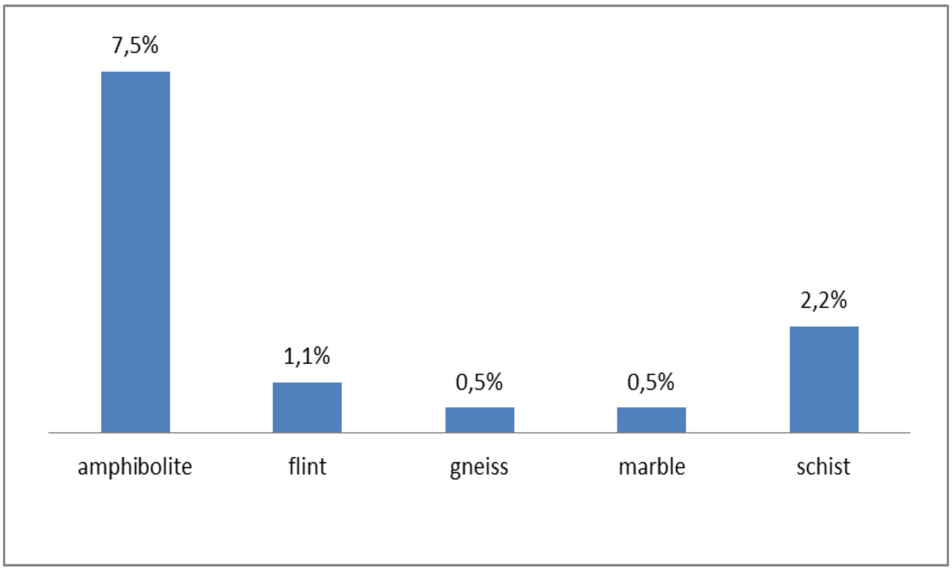

Fig. 5.3.13b. Motel Slatina: metamorphic rocks, graph 2; N= 187.

Around c.70% of the artefacts of this site are made of sedimentary rocks such as (meta)alevrolite, sandstone, light white stone and limestone (fig. 5.3.13a). They were used mainly for manufacturing small abrasive tools (coarse-grained abraders - ALS and fine-grained abrader -ALS-PIA), polished edge tools (axes –HAC, celts – REN, adzes – ADZ and chisels - CHI) percussive tools (re-used polished edge tools -RPE, hammers -HAM, HAM?, pestles – PST, retouching tools – RET and perforated mattocks – MTT) and a grinding slab (MOL) (fig. A 1.9).

Around 18% are tools made of metamorphic rocks such as amphibolite, quartzite, schist, flint, gneiss, marble, and marl. These rocks were employed mainly to manufacture abraders (ALS), grinding slabs (MOL), handstones (MUE) and percussion tools (pestles –

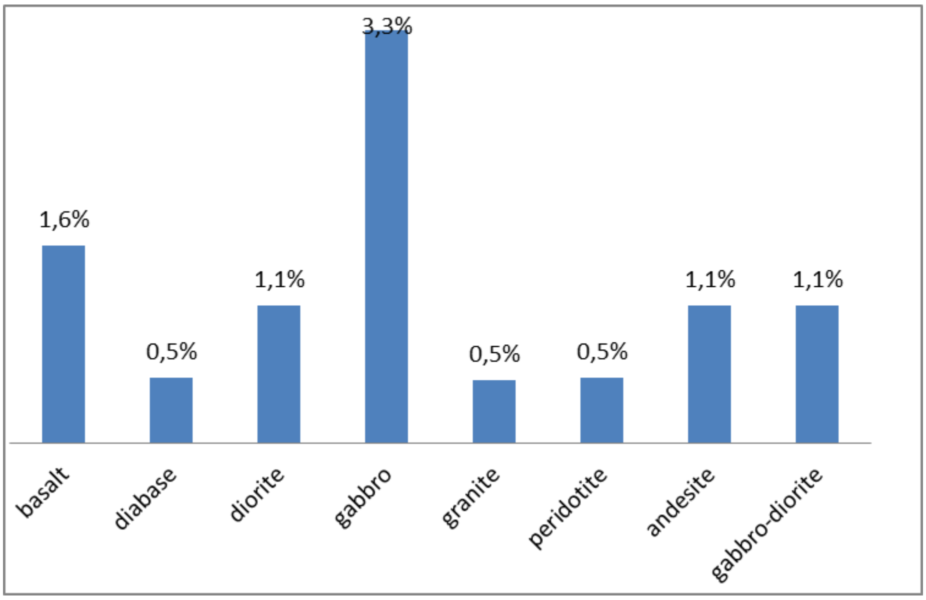

Fig.5.3.13c. Motel Slatina: igneous rocks, graph 3; N=187.

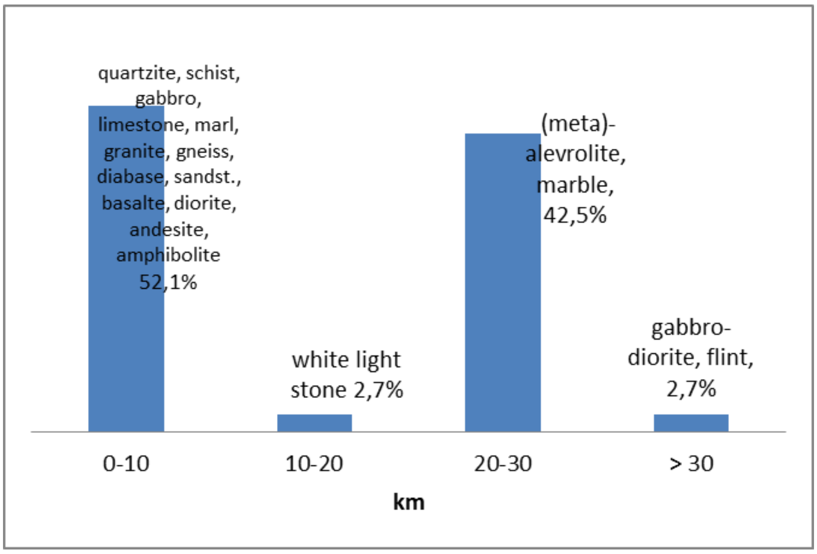

Fig.5.3.14. Motel Slatina: Raw materials and source distance.

PST, percussive tools – PEC, and a hammer - HAM) (fig. 5.3.13b; fig. A 1.9).

Igneous rocks such as diorite, basalt, diabase, gabbro, peridotite and granite represent c.11% (fig. 5.3.13c). Objects such as abrasive slabs (LOS), a coarse-grained abrader (ALS), axes (HAC), pestles (PST) and a mace (MZ) are made of these rocks (fig. A 1.9).

A correlation between geology and tool type indicates a connection between sandstone coarse-grained abraders (ALS), a grinding tool (MOL?), hammers (HAM, HAM?) and an object that might be a part of a figurine (FIG?). (Meta)alevrolite was suitable for manufacturing polished edge tools (adzes - ADZ, a chisel – CHI and celts - REN), re-used polished edge tools (RPE), tools with traces of secondary modification (UNK), fine-grained abrader (ALS-PIA), a multi-functional tool anvil-retouching tool (ANV-RET). It has been recognized among the flake negatives (LAS) knocked off the polished edge tools. Marble was implemented in manufacturing a figurine, while schist was used for a probable grinding tool (MOL?) and gabbro for mazes (MZ). A retouching tool (by pressure) was made of basalt and a semi-finished product (SFP) of amphibolite (fig. A1.9).

The tools are poorly preserved regardless of geology. It can be said that light white stone items are the most preserved. However, this conclusion should be taken with consideration due to the small number of items (n=5) (fig. A 1.10). The results suggest that 19% of the implemented geology such as quartzite, schist, gabbro, and limestone come from the immediate vicinity or c 800 m to the east (fig.5.3.10). Amphibolite, marl, granite, gneiss, diabase, basalt, sandstone, diorite and andesite pebbles were available in secondary deposits of the Velika Morava river. Geological cartography of this area shows that marl deposits have been documented c. 6 km to the northeast. While an amphibolite deposit has been detected c.7 km to the west as the crow flies. The deposits of gneiss and granite are 12 and 14 km to the west.

More than 45% of geology comes from the distance longer than 20 km. (Meta) alevrolite and sandstone present the biggest part of this group, and their deposits are between 23 and 26 km to the Southwest. Claystone has been detected at the same distance as (meta)alevrolite, while marble comes from 24 km in the same direction. Furthermore, geology exploration suggests that a claystone source has been detected c. 14 km to the south of the site (Dolić et al. 1981: 27). Diabase deposits have been presented only in geology column in the eastern part of the Gledićke mountain, which is c. 30 km to the west of the settlement[7] (fig. 5.3.10,14).

An andesite layer is found c. 28 km to the northwest of this settlement (fig. 5.3.10,14). The specific origin of gabbro-diorite and flint is still unknown. There is a possibility that these rocks were brought from the river beds or that they were part of a distribution network.

Furthermore, we can also expect that raw material for large tools such as grinding slabs and abrasive slabs would be selected rather in primary deposits than in river courses to the small size of raw materials detected in the Morava river and other served streams (chapter 5.2).

The Early and Late Neolithic settlements of *Turska česma, Slatina* was positioned on Miocene sandy, clay and gravel soil and on Pleistocene lacustrine and deluvial deposits (fig. 5.3.10).

The Early Neolithic layer produced only five stone objects, which are of sandstone, limestone, andesite and slate. These rocks were implemented in manufacturing small abrasive tools (coarse-grained abraders - ALS, fine-grained abraders - ALS-PIA, a fine-grained abrader – percussive tool - ALS-PIA – PEC and an anvil – retouching tool - ANV-RET), percussion tools (a percussive tool – PEC, retouching tools - RET) (fig. A.1.11).

Around 77% of the objects from the Late Neolithic period are of sedimentary rocks such as sandstone, (meta)alevrolite, limestone, claystone, light white stone and micro-conglomerate (fig. 5.3.15a). These rocks were used for manufacturing small abrasive tools (coarse-grained abraders - ALS, fine-grained abraders - ALS-PIA, a fine-grained abrader – retouching tool -ALS-PIA – RET and a coarse-grained abrader-anvil ALS-ANV), percussion

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[7] see: geology sheet L 34 – 7 Paraćin 1: 100 000, http://geoliss.mre.gov.rs/OGK/Raster Serbia/ OGKWebOrig/listovi.php?karta=Paracin

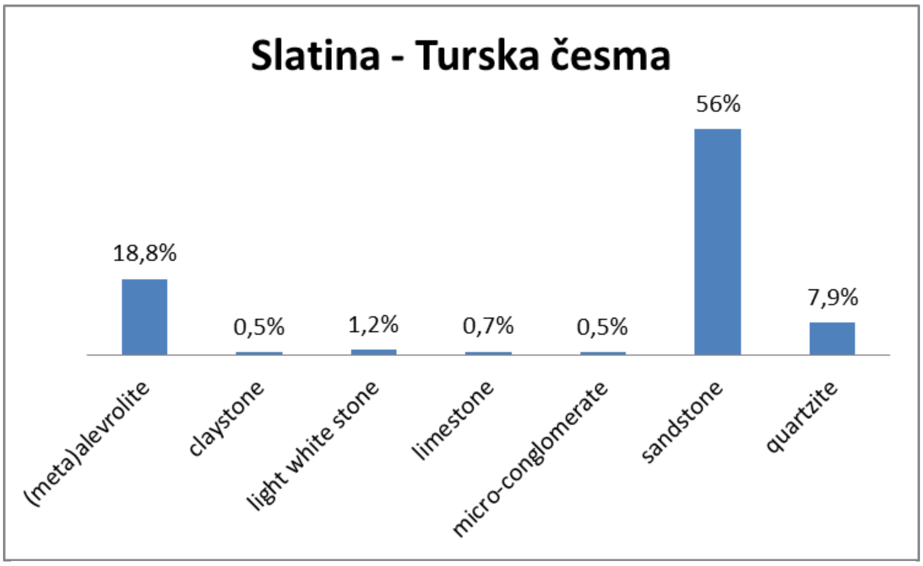

Fig. 5.3.15.a Slatina, Turska česma: sedimentary rocks and unknown geology, graph 1; N=416.

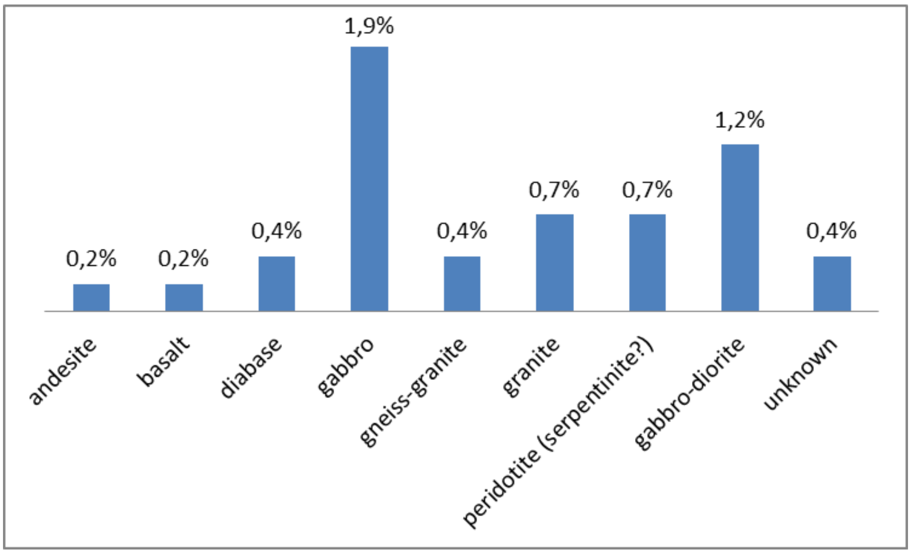

Fig. 5.3.15.b,Slatina, Turska česma: igneous rocks, graph 2; N=416

tools (hammers - HAM, percussive tools -PEC, pestles -PST), polished edge tools (axes - HAC, celts -REN, a chisel - CHI, and an adze -ADZ), grinding tools (grinding slabs -MOL, MOL? and handstones -MUE) (fig. A.1.11).

Around 17 % of all studied tools from the Late Neolithic horizons are of metamorphic rocks such as amphibolite, quartzite, schist, gneiss, and marl (fig. 5.3.15c). For example, these rocks were implemented in manufacturing small abrasive tools (coarse-grained abraders - ALS, fine-grained abrader - ALS-PIA, a fine-grained abrader – percussive tool - ALS-PIA – PEC) percussion tools (percussive tool – PEC and retouching tools -RET, and an anvil

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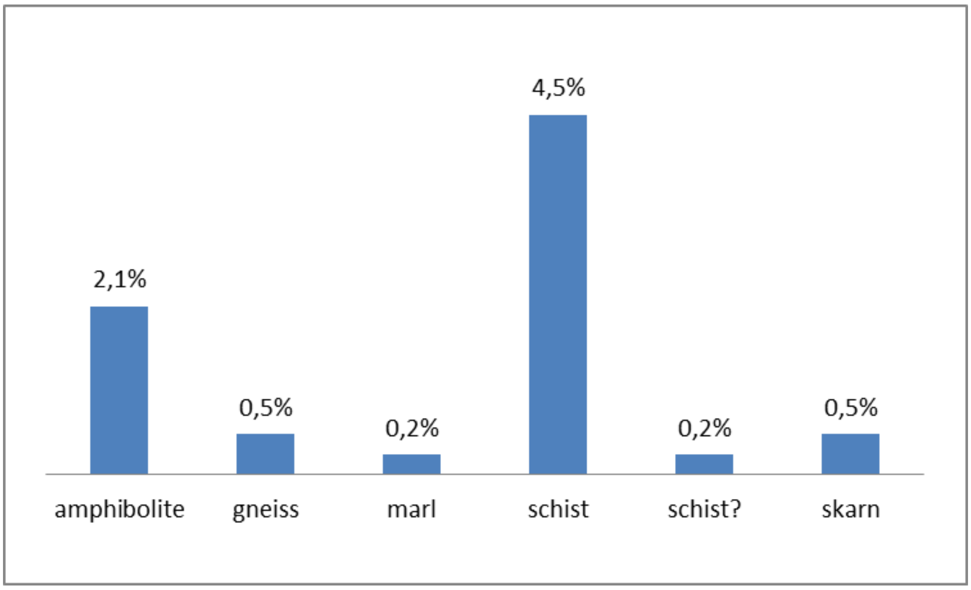

Fig. 5.3.15c,. Slatina, Turska česma: metamorphic rocks, graph 3; N=416

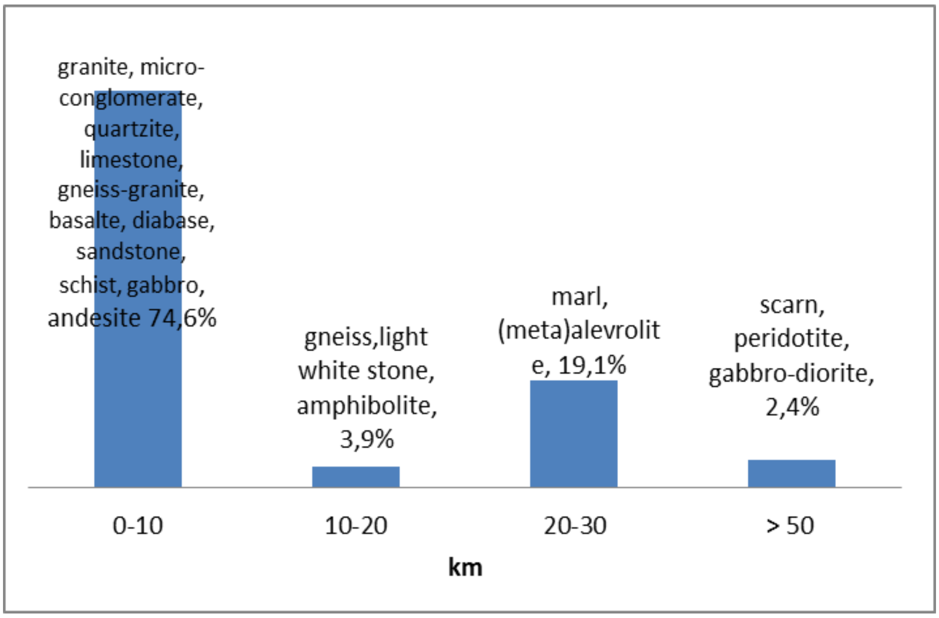

Fig.5.3.16. Slatina, Turska česma: Raw materials and source distance;

retouching tool – ANV-RET), axe (HAC), handstone (MUE) (fig.A1.11).

Around 4% of the tools are of igneous rocks such as gabbro, basalt, diabase, skarn, granite, peridotite and gneiss-granite (fig.5.3.15b). They were employed in manufacturing percussion tools (pestles - PST, retouching tools – RET, a percussive tool– anvil - PEC – ANV), grinding tools (grinding slabs –MOL and handstones - MUE) (fig. A.1.11).

A correlation between geology and tool type indicates a link between sandstone and small abrasive tools (coarse-grained abraders -ALS, fine-grained abraders -ALS-PIA), percussion tools (hammers -HAM), and an anvil – ANV, a retouching tool - RET) and an

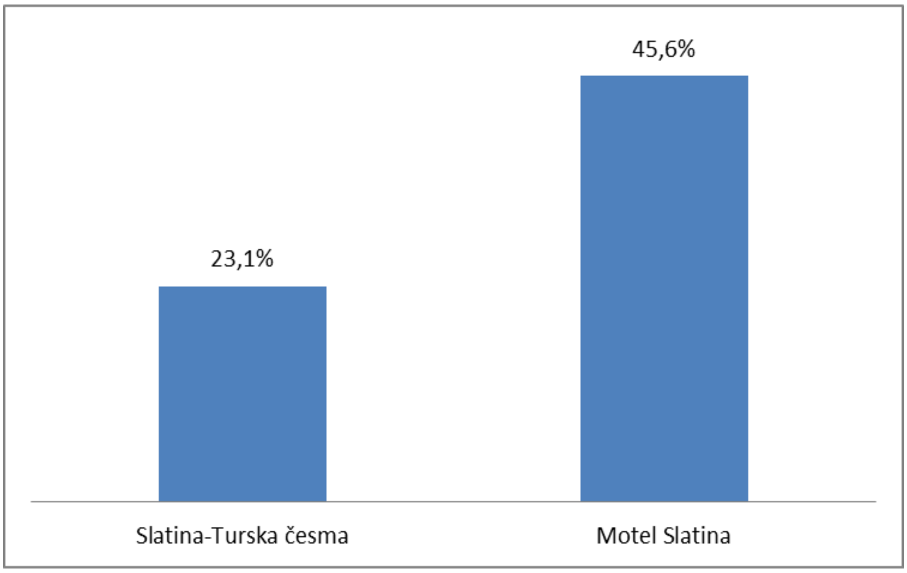

Fig. 5.3.17 Motel, Slatina and Slatina, Turska česma: proportion of dependency on raw material from the western part of the Central region; N=222.

object that probably was used as mortar (MOR?). (Meta) alevrolite was linked with a chisel (CHI), celts (REN) and axes (HAC HAC?,), a pendant (PEN) as well as with the tools with traces of secondary modifications (UNK). This geology was detected mainly among the flake negatives (LAS) knocked off the polished edge tools. Light white stone is connected with an adze (ADZ) and claystone with a bracelet (BRA) and an object that could represent a maze? (MZ?). Quartzite is linked with an anvil-retouching tool (ANV-RET) and fine-grained abrader-percussion tools (APE).

The results indicate that around 74% of material came from an area, which can be found locally, at a distance below than 10 km to the west of the settlement. This large group includes pebbles of granite, microconglomerate, quartzite, limestone, basalt etc, which have been detected during our geo-archaeological survey along the Velika Morava river (subchapter 5.2). Primary deposits of sandstone, gneiss and amphibolite, are located between c. 12 to 18 km to the West. Granite sources are found c. 18 km to the Northwest. Probably, gneiss-granite came from the contact zone in the same area where gneiss and granite appeared, although our geoarchaeological surveys have confirmed that these rocks can be found in the fluvial deposits of the Velika Morava river. Around 21% of the studied objects are made of rocks, whose deposits have been documented in distant areas. This group consists of marl with a source located 20 km to the West as the crow flies. (Meta) alevrolite and clay are found 21 km to the west and diabase sources exist c. 30 km to the West. Gabbro, limestone and schist appear c. 7 -8 to the north. Quartzite probably came from the Pliocene lake cobble deposits of quartzite and igneous rocks. They are visible on the terraces of the

Morava river. Such a terrace is visible in the vicinity of the Drenovac village which is c. km 4 to the west of the site of Turska česma, Slatina (Milojević 1951: 6) Geological research has also identified a claystone source c. 4 km to the south of the settlement (Dolić et al. 1981: 27) (fig. 5.3.10, 16).

The origin of peridotite, gabbro-diorite, skarn, as well as sandstone used for large tools with the abrasive surface in the settlement, remains unknown (fig. 5.3.16). However, we believe that skarn could be found in the river beds, while rocks for large tools with abrasive surface might be preferentially collected in primary deposits, which offered better choice in the size of required raw materials.

The objects from this settlement show a very poor level of conservation, indicating the intensive use (fig. A 1.12).

Geological investigations confirm that amphibolite deposits exist in the southwest of and northwest the region (fig. 5.3.10). An archaeological surface survey detected the Late Neolithic site of Livade in the vicinity of this southwest source (Documentation of Hometown Musem in Paraćin) (fig. 5.3.10). In this sense, we can probably expect an amphibolite distribution centre with skilled workers, from where products reached both Late Neolithic settlements in this region (fig. 5.3.10,14; fig. A 1.9, 11). Furthermore, the results indicate a connection with the western part of the region (fig.5.10). This is stressed particularly for communities by Motel Slatina, where around 45,6% of raw material originated from this area (fig.5.3.10,14,17). It should also be mentioned that diabase detected in both Late Neolithic settlements of the Central region probably derived from diabase-chert. This formation is presented only in a geology column, in the Gledićke mountain, the western part of the Central region.[8]

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[8] geology sheet L 34 – 7 Paraćin 1: 100 000, http://geoliss.mre.gov.rs/OGK/Raster Serbia/ OGKWebOrig/listovi.php?karta=Paracin

5.3.3. Western region

In following lines we will present raw materials detected in the settlements from the Western region. This is the largest studied area and consists of various geological deposits. The north is dominated by the Jurassic metamorphic and sedimentary deposits in the south-west, Triassic sedimentary layers in the central part and Carbone metamorphic and sedimentary deposits in the north (fig. 5.3.21).

The multilayer Neolithic site of Kremenilo, Višesava was surrounded by Carbone sedimentary and metamorphic deposits (fig. 5.3.19).

The results show a scarce variety of raw materials, particularly during the Early/Middle Neolithic (fig.5.18,19). During this phase, around 94% are sedimentary rocks

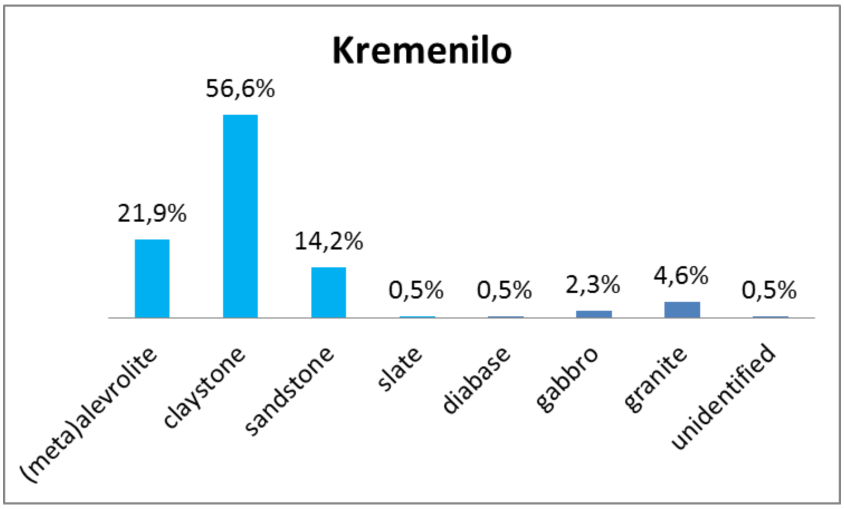

Fig. 5.3.18.Kremenilo: geology from all Neolithic phases; N=221.

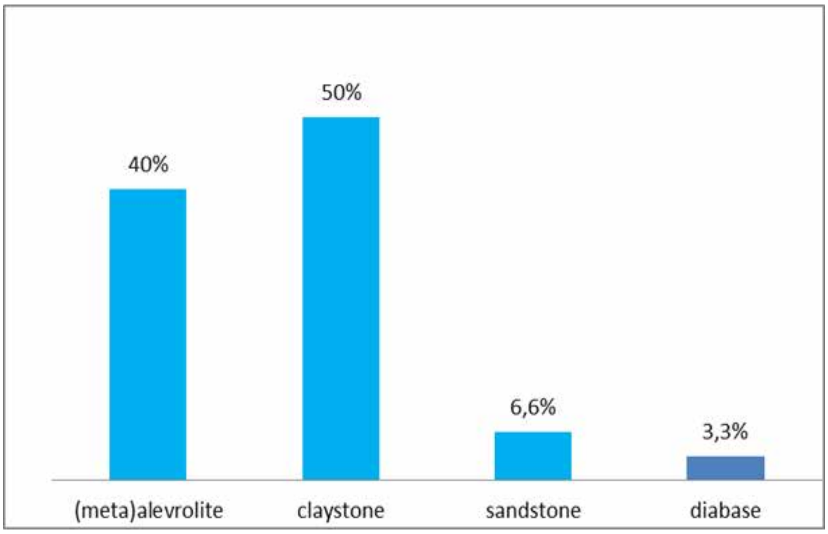

Fig. 5.3.19. Kremenilo: geology from the Early/Middle Neolithic horizon; N=30.

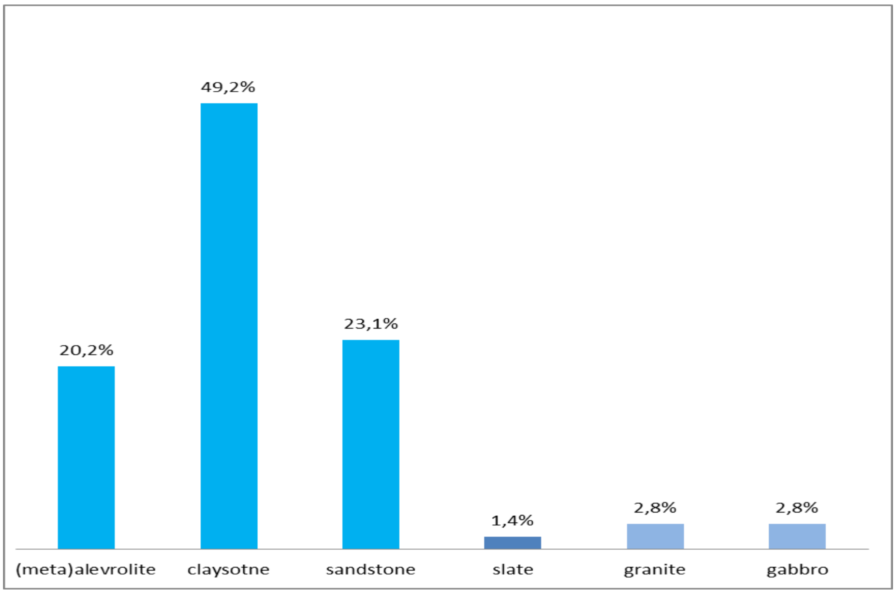

Fig. 5.3.20. Kremenilo: geology from the Late Neolithic horizon; N= 69.

such as claystone,(meta) alevrolite and sandstone, while slate is rare. The rest are igneous rocks (fig.5.19). However, it should be taken into consideration that around 35% of the studied material belongs to the disturbed Neolithic horizon. Due to it, we will present geology only from clear Neolithic layers.

The use of claystone was significant during the whole Neolithic period. It seems that (meta)alevrolite had larger importance in the Early/Middle Neolithic settlement, than during the Late Neolithic. Contrary, sandstone was more favoured during the Late Neolithic than in the Early/Middle Neolithic (fig. 5.3.19,20). Diabase was used only in the oldest settlement, while gabbro and granite occurred in the Late Neolithic horizon (fig. 5.3. 19, 20).

The results show a link between some geology and tool types. In both Neolithic periods, igneous rocks were used mainly as percussion tools (a pestle -PST, hammers –HAM and a hoe -HOE. Sandstone was used to manufacture particularly a multi-functional tool coarse-grained abrader-anvil (ALS-ANV). It was also recognized as raw material (IND), flake negative (LAS) knocked off the polished edge tool and mainly as tools with traces of secondary modification (UNK). Slate is linked to a pedant (PED).

Generally speaking, it could be said that sedimentary rocks were implemented in manufacturing adzes (ADZ) axes (HAC) and celts (REN) and re-used polished edge tools (PRE) in both periods. These rocks have been recognized among semi-finished products of polished edge tools (SMF, SMF?) as well (fig. A 1.13,14). Observations show that igneous tools are mainly broken and fragmented, indicating their intensive implementation (fig. A1.13-16).

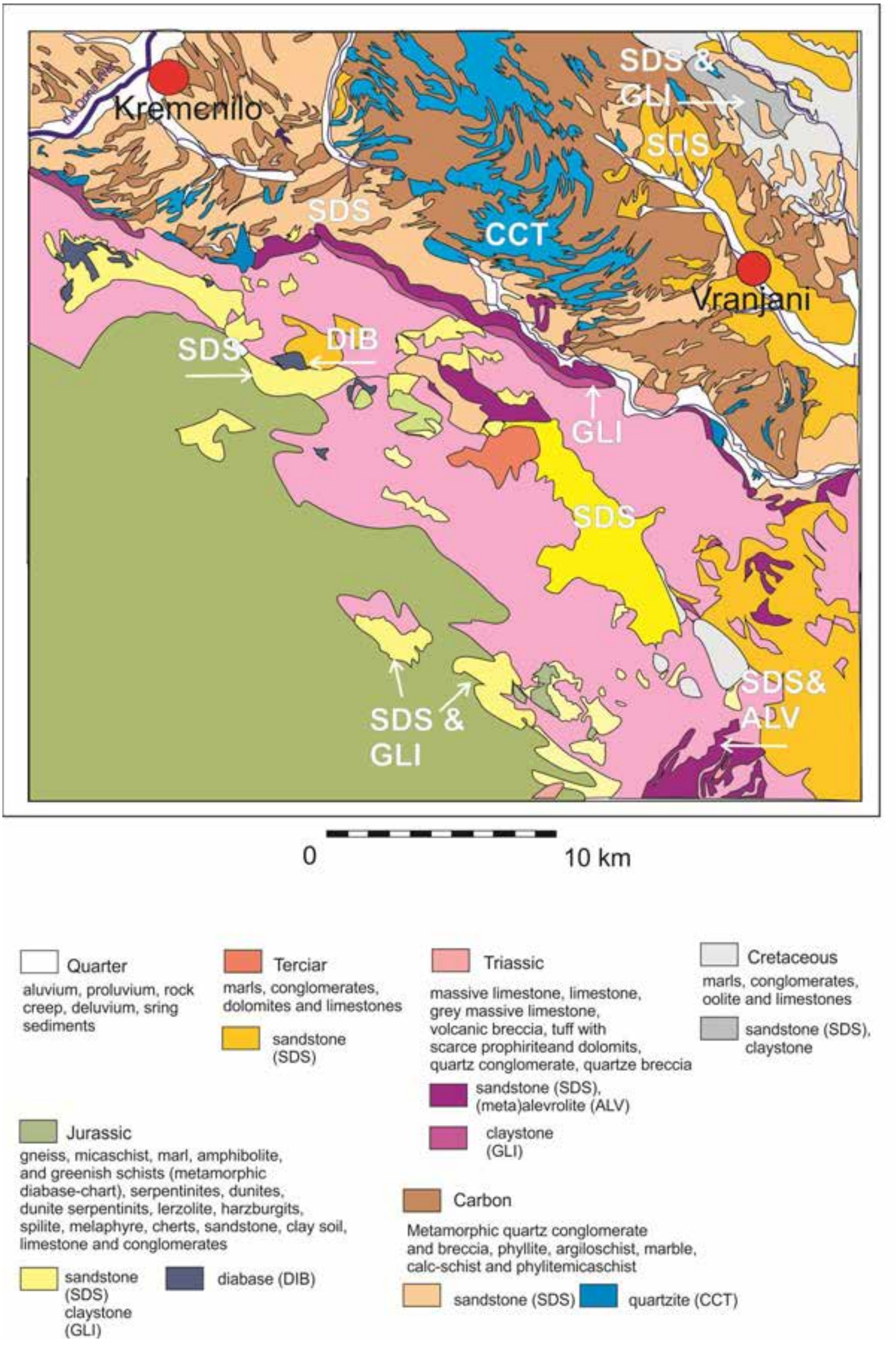

Fig. 5.3.21. Geological map and position of Kremenilo and Vranjani adopted after: geology map L - 34 – 4 Titovo Užice 1: 100 000.

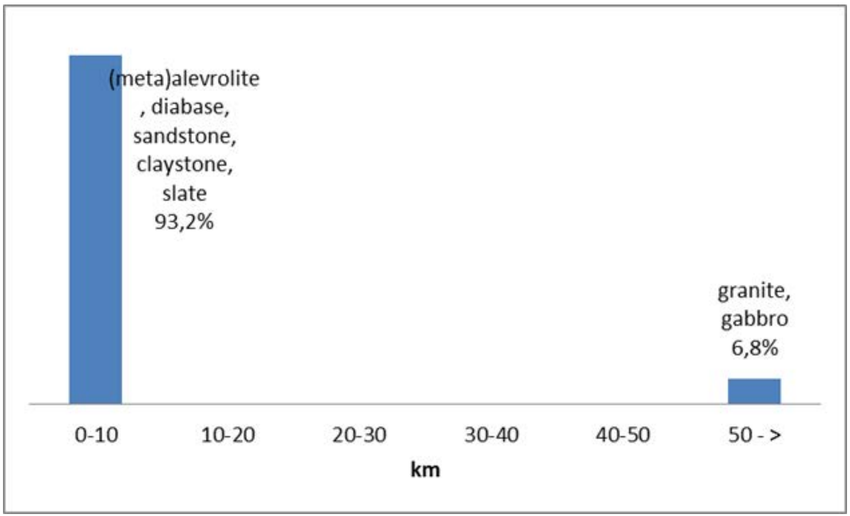

Fig.5.3.22. Kremenilo: Raw materials and source distance.

The results show that most of raw material was found locally. Sandstone was detected in the immediate vicinity of the settlement, while (meta)alevrolite, claystone and diabase deposits are located c. 6 – 7 km to the south-west as the crow flies. Probably, slate was found in Carbon deposits, which are in the vicinity of the site. These deposits contain different type of schists and we assume that slate could be part of it. In spite of the vicinity of sources, quartzite has not been identified among the finds. Instead of it, hard igneous rocks were used, regardless remote distance of their deposits. For example, gabbro and granite layers are at least 70 km away from the settlement in the north-west direction [9] (fig. 5.3.22) (Mojsilović et al. 1965:15, 20).

The Late Neolithic settlement *Kraljevina, Vranjani*, is placed on Quarternary deposits of the Požega Valley, in the northern part of the Western region (fig. 5.3.18). The results show that sandstone was used mainly to manufacture tools such as axes (HAC) and re-used polished edge tools (RPE). This rock has been observed among the tools with traces of secondary modification (UNK) and flakes (LAS) knocked off the polished edge tools. Quartzite item might be used as pottery polisher or a retouching tool (by pressure) (for more details see chapter 3), while (meta)alevroilte was implemented for manufacturing a re-used polished edge tool (RPE). Only one sandstone tool is broken the rest of the tools are complete, indicating that artefacts are not worn out (fig. 5.3.23; A.1.17).

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[9] Gabbro: geology sheet L 34 – 136 Valjevo,
http://geoliss.mre.gov.rs/OGK/RasterSrbija/OGKWebOrig/listovi.php?karta=Valjevo
Granite: geology sheet L 34 – 137 G. Milanovac
http://geoliss.mre.gov.rs/OGK/RasterSrbija/OGKWebOrig/listovi.php?karta=Gornji_Milanovac

Geological information leads us to conclude that the raw material was collected from the immediate vicinity of the Neolithic settlements, such as sandstone, while deposits of (meta)alevrolite and quartzite have been documented c. 6 and 7 km to the south (fig. 5.3.18,24).

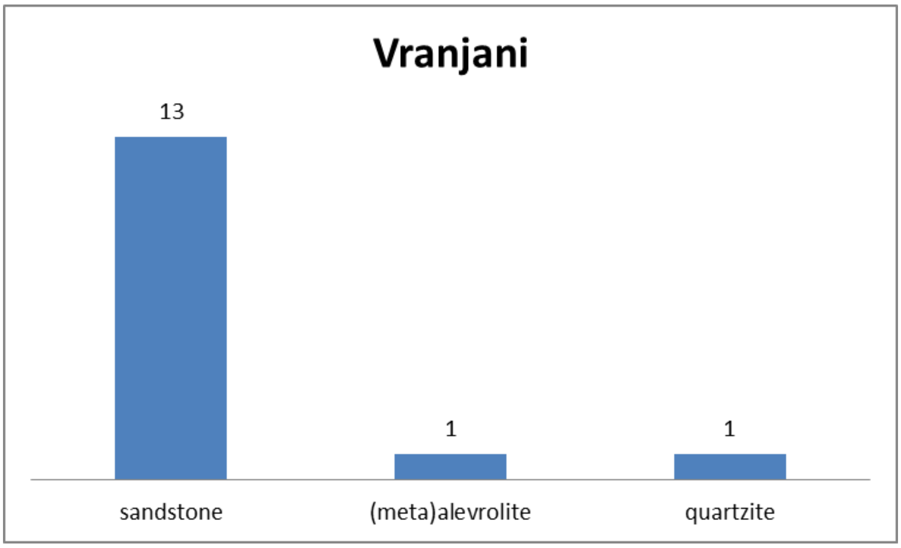

Fig. 5.3.23. Vranjani: geology; N=15.

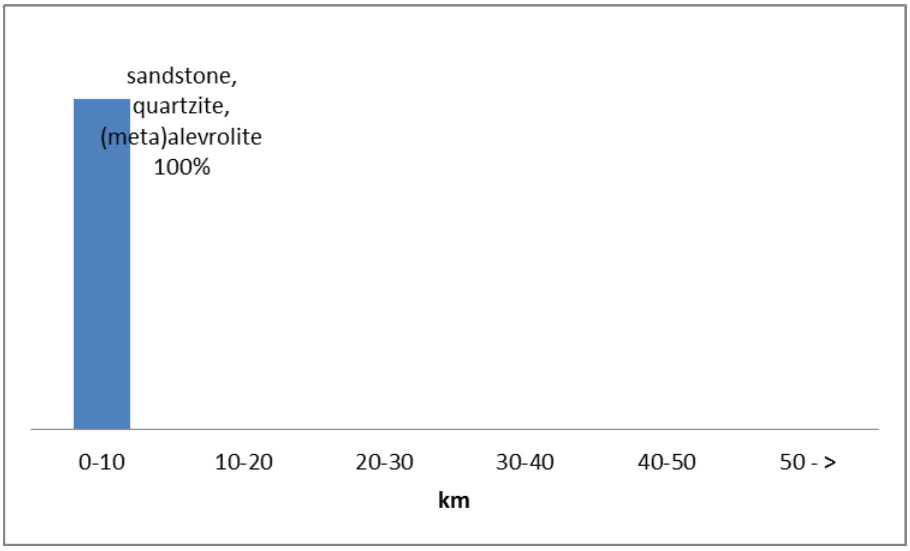

Fig.5.3.24. Vranjani: Raw materials and source distance.

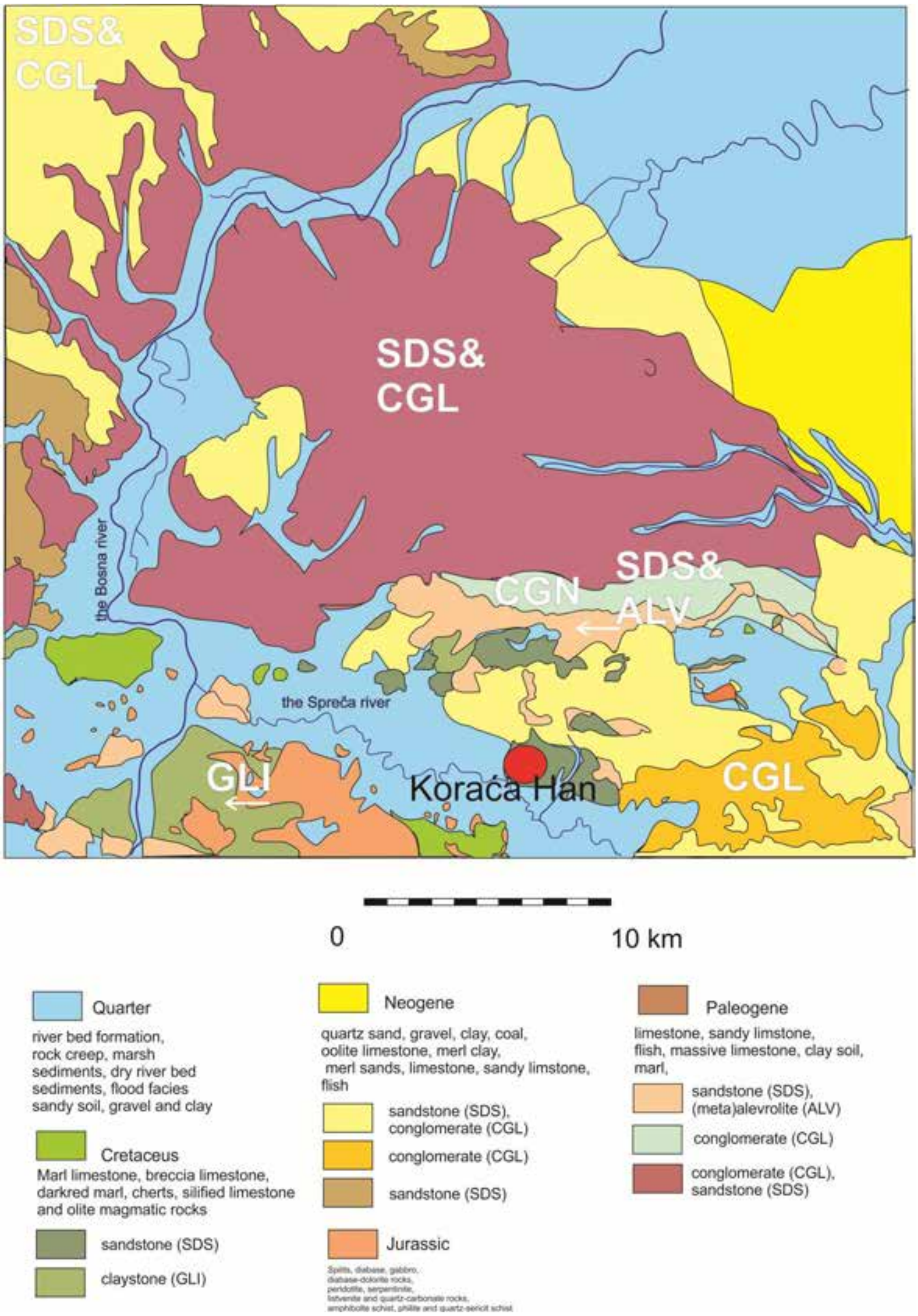

Fig.5.3.25. Geological map and position ofKoraća Han; adopted after: geology map L 34 – 122 Doboj1: 100 000.

The Late Neolithic settlement *Koraća Han* is placed in the western part of the region. The settlement is located on Cretaceous deposits (fig. 5.3.25). The available raw materials are (meta)alevrolite (n=16), sandstone (n=10), light white stone (n=6), schist (n=1) and rock that might be conglomerate (n=1).

The results indicate that the macro-lithic tools from this site are locally available. Deposits of sandstone exist in the immediate vicinity of the site, while deposits of (meta)alevrolite are found c. 1,5 km to the north as the crow flies and light white stone deposits appear c. 4,5 km to the north. Conglomerate deposits can be found c. 1,5 km to the north, although this rock was rarely used (fig. 5.3.26). It seems that schist came from Jurassic ophliolite mélange, whose deposits are found c. 3 km to the south. However, it is more probable that raw material was collected from the nearest river beds, detected in the immediate vicinity in the west and south of the settlement (fig. 5.3.25,26; Hrvatović 2005:72).

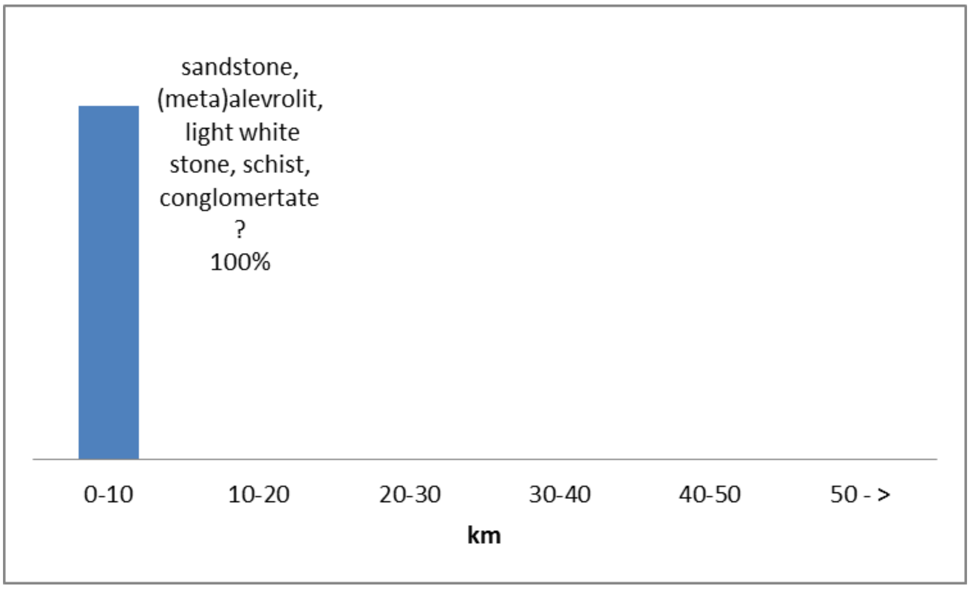

Fig. 5.3.26. Koraća Han: Raw materials and source distance.

Most of the tools are made of sedimentary rocks. Only one perforated pestle is made of schist. A correlation between geology and tool types indicate that (meta)alevrolite was used as raw material for an adze (ADZ), re-used polished edge tool (RPE) and was recognized as a tool with traces of secondary modification (UNK- HAC?). Sandstone was related to a perforated axe (HAC-PA) and flake negative (LAS) knocked off the polished edge tools, while claystone was implemented as a coarse-grained abrader (ALS) (fig. A 1.18).

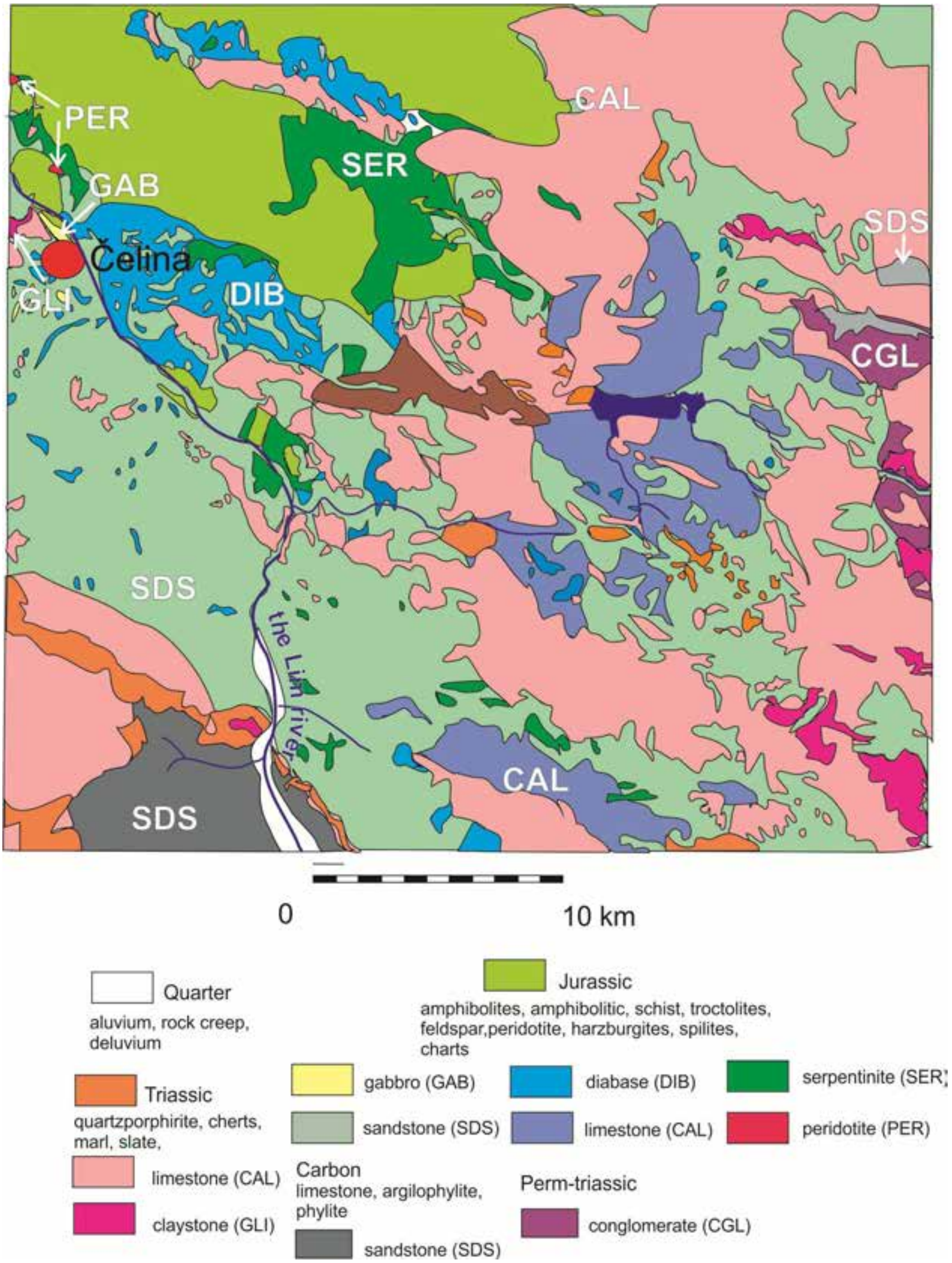

Fig. 5.3.27. Geological map and position of Čelina; adopted after: geology map L34 - 16 Prijepolje1: 100 000.

Tools are more or less complete, regardless of geology. Claystone tools are the best preserved, indicating a low level of artefact wear (fig. A 1.19).

The Late Neolithic settlement *Čelina* is located in the southern part of the Western region and was established on the Jurassic deposits, rich in various rock types (fig. 5.3.27).

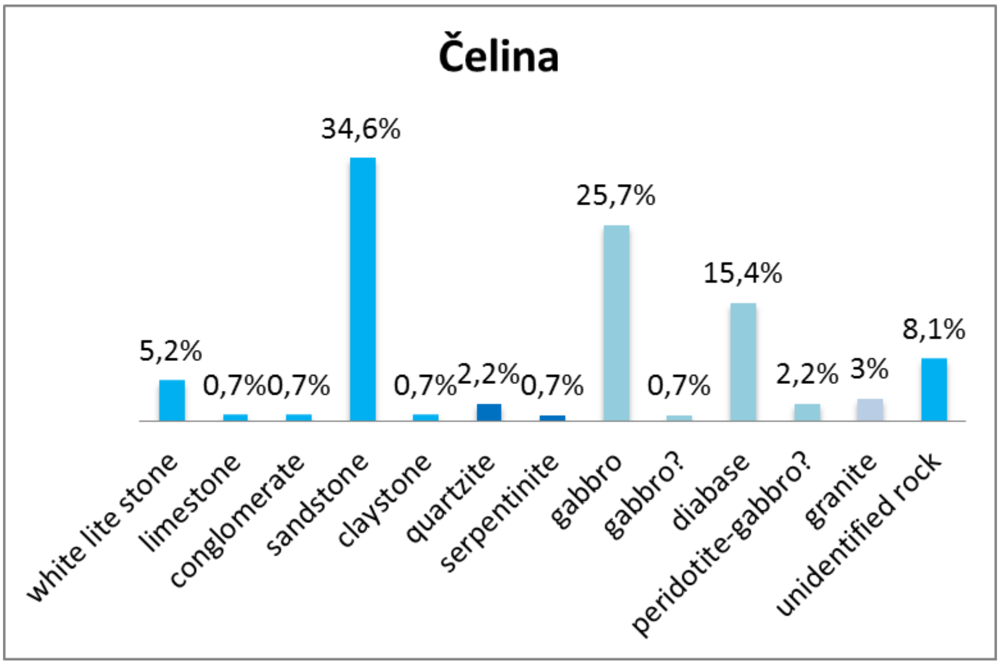

Fig.5.3.89. Čelina: geology; N=136.

In this case, around 47% of all studied stone objects from this site are of igneous rocks such as gabbro, diabase and granite (fig. 5.3.28). These rocks were employed primarily for manufacturing grinding tools (grinding slabs -MOL, mortars -MOR, handstones – MUE) and percussion tools (percussive tools -PEC, a pestle -PST, a hammer -HAM and a retouching tools (by direct retouching) -RET) and a coarse-grained abrader (ALS) (fig. A. 1.20).

Around 41% of all examined tools are of sedimentary rocks such as sandstone, white light stone, conglomerate and limestone (fig. 5.3.29). These rocks have been documented as stored raw material (IND, IND-PMO). Also, an axe (HAC), semifinished products (SFP, SFP-ADZ) and flakes (LAS) knocked off the other macro-lithic tools are of these rocks (fig. A. 1.20).

The results revealed a connection between geology and tool types. Sandstone was employed for abrasive slabs (LOS) and chiefly for weights for fishing net (WFN), coarse-grained abraders (ALS) and hammers (HAM) (fig. A 1.20). White light stone is linked to an axe (HAC), flakes negative (LAS) knocked off the polished edge tools and semifinished products (LAS-SFP, SFP – ADZ), while the light white stone is related to stored raw material

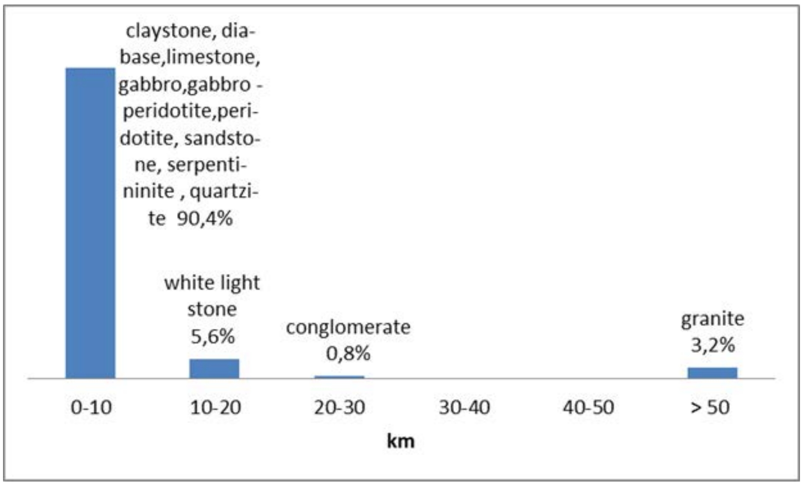

Fig.5.3.29. Čelina: Raw materials and source distance.

(IND). Diabase is recognized as percussion tools (a pestle -PST, objects that might be hammers - HAM/PEC, HAM/RET), while gabbro is linked with a handstone (MUE) and grinding slabs (MOL) (fig. A1.20).

Regardless of geology, the objects are more or less complete. Diabase and light white stone objects are particularly well preserved, while the higher fragmentation of gabbro artefacts suggest intensive use (fig. A 1.21).

The Čelina community used mainly local raw material. Gabbro and diabase deposits are less than 1 km away from the settlement (fig. 5.3.29), although diabase is also observed in the Lim river (fig. 5.3.31). Observations also suggest that diabase occurred as ”pillow lava” from a submarine lava effusion, that can reach 1 m in diameter. It has a specific pillow shape, generated by the rifting process (Documentation of Hometown museum Priboj) (fig.5.3.30), which has been recognized among grinding tools (chapter IV, fig. 1.15/ 6). This suggests that rivers did not affect the primary form of rocks and the possibility that raw material was collected in primary outcrops.

A claystone layer is found c. 1,5 km to the north-west. Furthermore, a small quantity of objects is made of light white stone (n=7). This group of rocks also includes magnesite, a primary deposit of which is located between 10 to 20 km to the east (fig.5.3.29) (Mojsilović et al.1965: 24). The limestone deposits appear c. 5 km to the northwest, while peridotite layers have been detected on c. 6 km to the north as the crow flies. We also assume that gabbro-peridotite came from this area (fig. 5.3.37, 29).

It seems that only granite came from a great distance of c. 65 km to the west as the crow flies. Quartzite was probably collected from the Lim river, but we cannot exclude the possibility that the river was the main source of the most raw materials (fig.5.3.38,29,31).

Fig.5.3.30. Diabase profile, Jarmovac road; 43°33`39.9"N, 19°33`51.4"E

Fig. 5.3.31.The Lim river, fluvial deposits, among which diabase cobbles have been detected.

5.3.4. Southern region

The settlements in the Southern region are located in two neighbouring valleys, including a variety of rock types (fig. 5.3.32, 33).

The Middle Neolithic settlement of *Tumba Madžari* is surrounded by alluvial and deluvium-proluviums deposits (fig. 5.3.33).

Data show that sedimentary rocks were implemented to manufacture around 51% of the artefacts such as polished edge tool (axes –HAC, celts – REN and a chisel - CHI?) (fig. 5.3.32; fig.A 1.22).

Around 27 % of tools are made of metamorphic rocks, such as serpentinite, schist, marble, shale and quartzite (fig. 5.3.32). They are implemented in manufacturing axes (HAC) and celts (REN) (fig. A 1.22).

Around c.10%. of the artefacts of this site are made of igneous rocks (fig. 5.3.32). These rock types were used mainly for manufacturing celts (REN) and an axe (HAC) (fig. A1.22).

A correlation between geology and tool type indicate a connection between limestone with weights for fishing net (WFN), semi-finished products of polished edge tools, spindle whorls and net weight for fishing (SMF, SFP-SW, SFP – WFN), and schist was the selected stone for manufacturing hammers (HAM) (fig. A1.22).

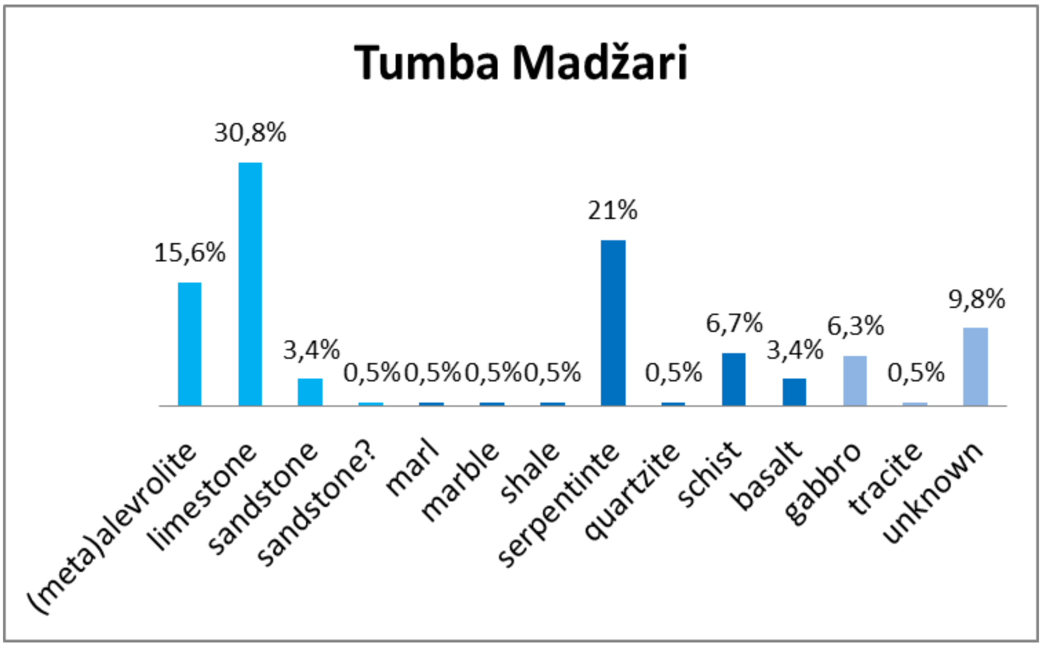

Fig.5.3.33. Tumba Madžari: geology; N=172.

Gabbro, basalt, (meta)alevrolite and schist tools show a poor level of preservation, indicating the intensive use (fig. A1.23).

The Tumba Madžari community used local raw material. The results suggest that c.59% of the implemented geology came from an area which is c. 10 km around the site. Permian schist as the basic mass of the margins of the Skopje Valley was found in the immediate vicinity of the settlement. Marble and marl deposits are located c. 1 km from the site. Shale and sandstone appear c. 2 km to the northwest. (Meta) alevrolite deposits are located c. 3 to 4 km to the north. Basalt is found c. 3km to the west. Serpentinite and gabbro sources appear c. 15 to 20 km to the northwest. Although the northern tributes of the Vardar river could be the convenient path to these raw materials (fig. 5.3.34) (Luković:1930: 6 - 44; Krstić, Savić, Jovanović, 2012: 45;Dumardzanov, Seramifimovski, Burchfiel 2004: 6, fig.5; Dumurdzanov, Petrov, Stojanova 2013: 24 - 29). We assume that quartzite probably was found in the river beds. The source of tracite is unknown (fig. 5.3.34).

Late Neolithic settlement of *Gumnište* was located on Quaternary deposits (fig.5.3.35). Around 59% of the objects are made mainly of sedimentary rocks, such as sandstone, (meta) alevrolite, conglomerate, limestone and claystone. These rocks were used primarily to manufacture small abrasive tools (coarse-grained abraders – ALS and fine-grained abraders - ALS-PIA), polished edge tools (axes – HAC and celt - REN), hammers (HAM) and grinding tools (fig. 5.3.36 a-c; fig.A1.24).

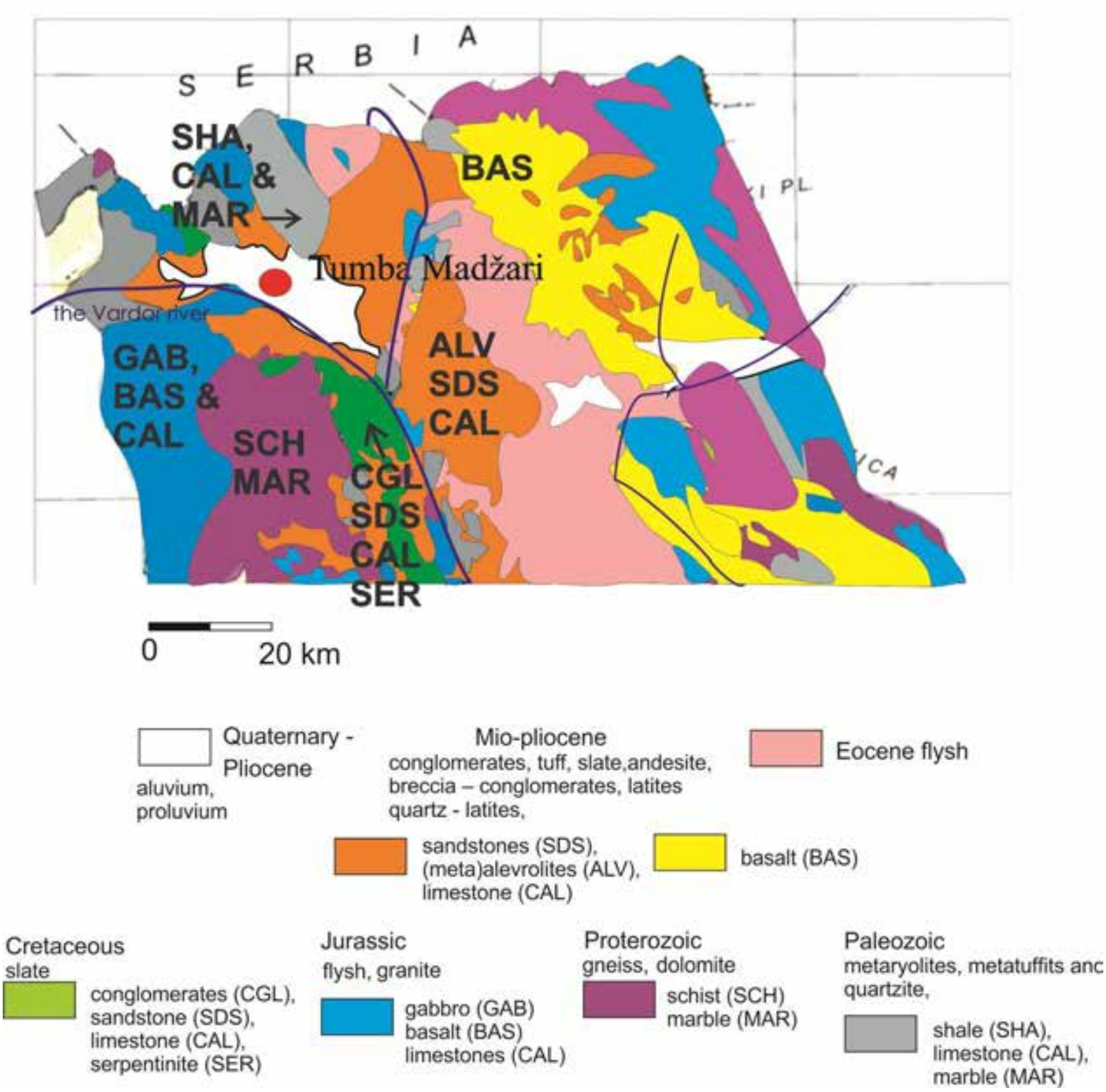

Fig. 5.3.33. Geological map and position of Tumba Madžari. (according to Pendzerkovski et al.: 1970., Dumurdzanov, Petrov, Stojanova 2013: 24, fig.1)

Around 23% of all examined tools are of igneous rocks such as andesite, andesite tuff, diabase, gabbro, quartzdiorite and peridotite (fig.5.3.36c). These rocks have been documented as grinding tools (grinding slabs -MOL, MOL?, handstones -MUE, MUE?), percussion tools (a pestle – PST, a percussive tool– fine-grained abrader- APE, a retouching tool - percussive tool - RET- PEC), and polished edge tools (an adze - ADZ, a celt – REN and an axes -HAC) (fig. A 1.24).

Around 14% of all studied stone objects from this site are metamorphic rocks, such as schist, quartzite, amphibolite, flint and gneiss (fig. 5.3.36b). These rocks were employed primarily for manufacturing small abrasive tools (coarse-grained abraders –ALS and fine-grained abraders – ALS-PIA)

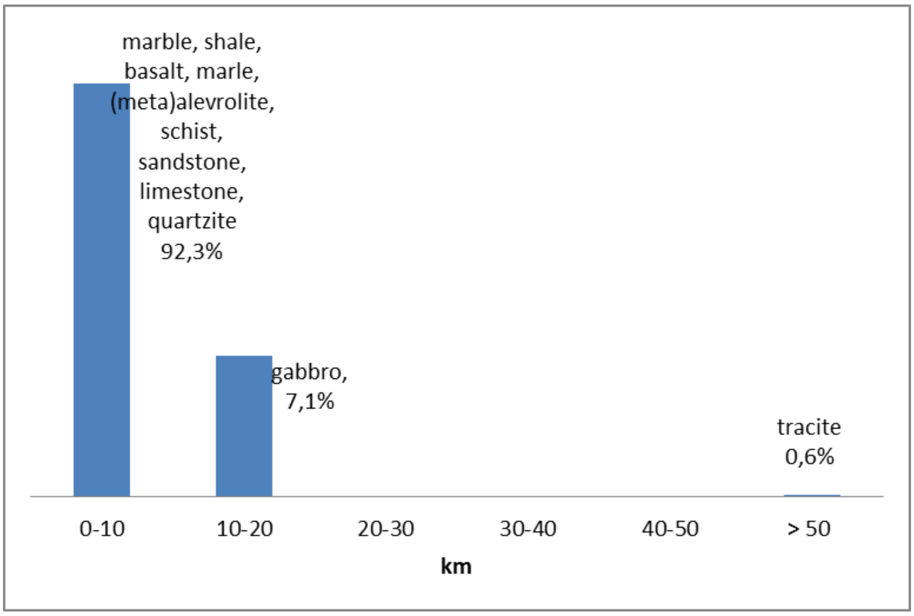

Fig. 5.3.34. Tumba Madžari: Raw materials and source distance.

and percussion tools (anvil-retouching tool – ANV-RET, ANV-RET?, percussive tools – PEC, percussive tool- smoothers – ANV, a pestle – PST, retouching tools – RET) (fig. A 1.24).

The results revealed a connection between geology and tool types. Sandstone was employed for small abrasive tools (coarse-grained abraders-ALS, fine-grained abraders-ALS-PIA), while andesite was mainly used for grinding tools (slabs -MOL and handstones -MUE) (fig. A 1.24).

Regardless of geology, the tools are mainly fragmented and broken, suggesting their intensive use. Although (meta)alevrolite and quartzite objects are particularly well preserved (fig. A 1.25).

The results show that c. 92% of the material is found locally. Schist, sandstone, conglomerates, claystone, andesite-dacite, limestone and chert deposits are located in the Teskovac basin, c. 2,5 km to the south (e. g. Milić 1967a: 48, ск. 3). Claystone and sandstone sources also appear c. 2 km to the west. Gneiss layers appear c. 4 km to the south, while andesite amphibolite and limestone deposits have been detected on c. 5 km to the south-west and west. Conglomerate, micro-conglomerate layers are located c. 7 km to the south-west. (Meta) alevrolite and tuff layers are found c. 12 km to the west. Deposits of andesite are located c. 28

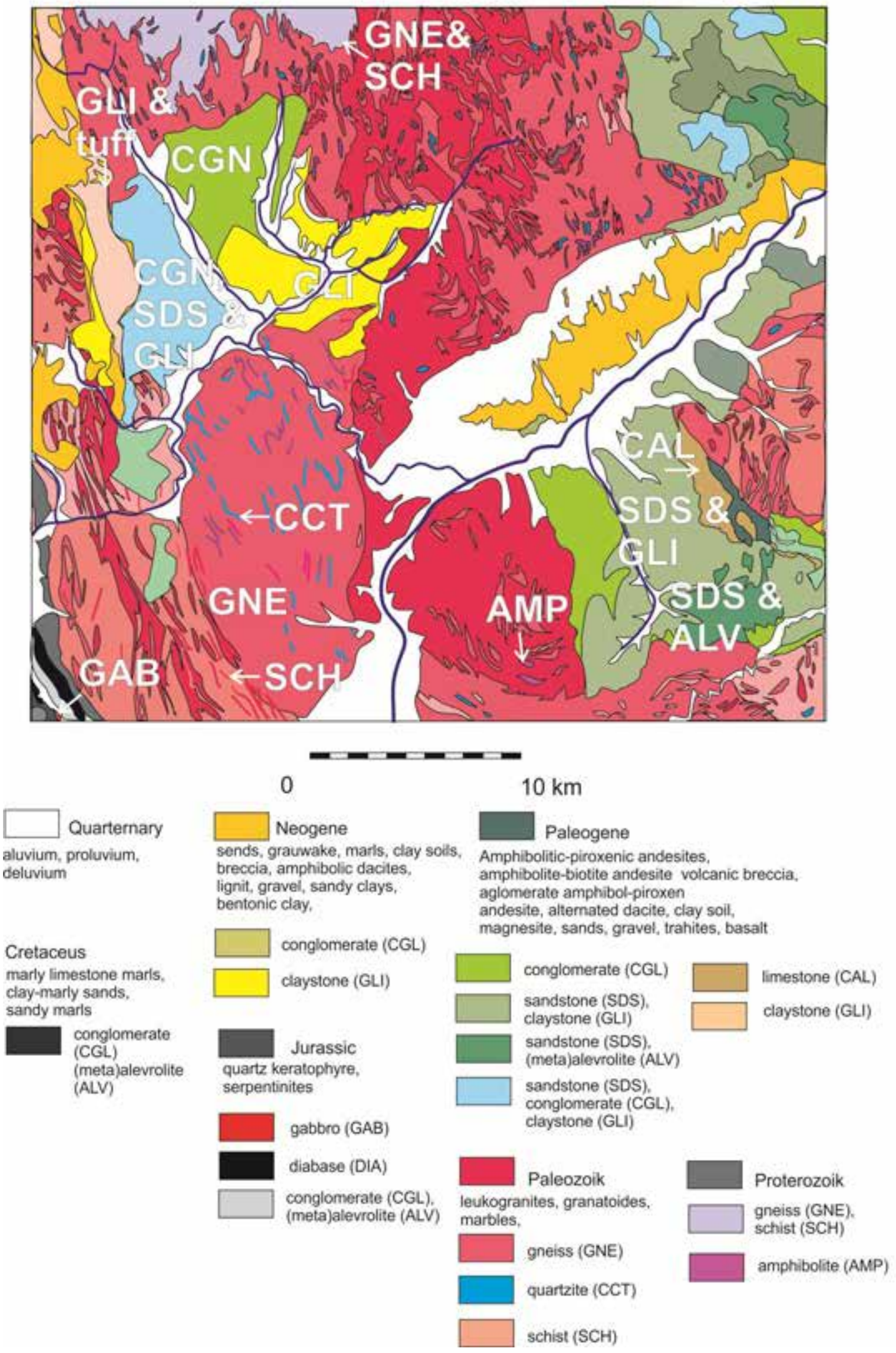

Fig. 5.3.35. Geological map and position of Gumnište, adopted after: geology map L- 34 - 56 Vranje, 1: 100 000.

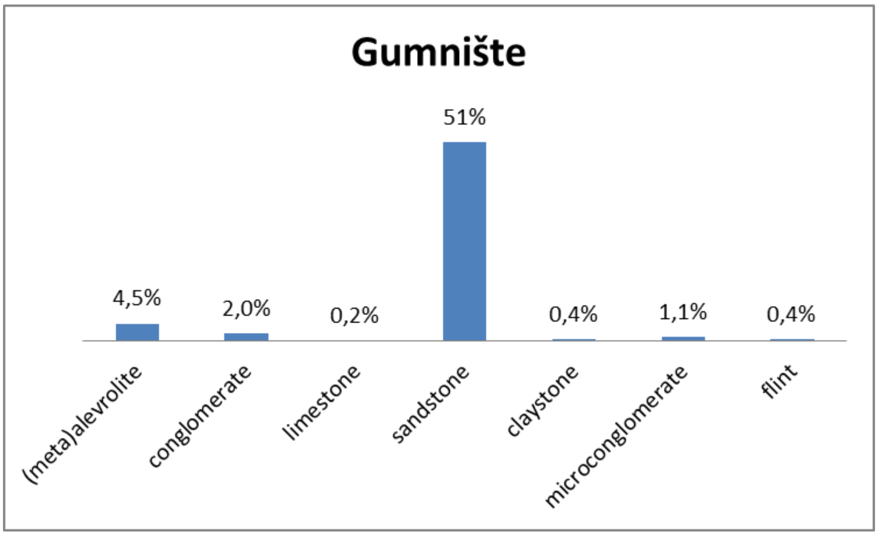

Fig.5.3.36a. Gumnište: sedimentary rocks, graph 1; N=447.

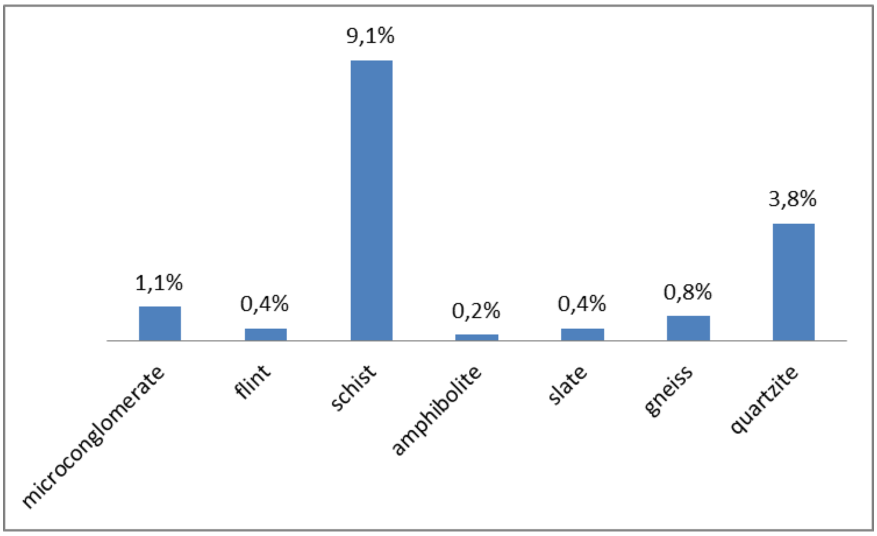

Fig.5.3.36b. Gumnište: metamorphic rocks graph 2; N=447.

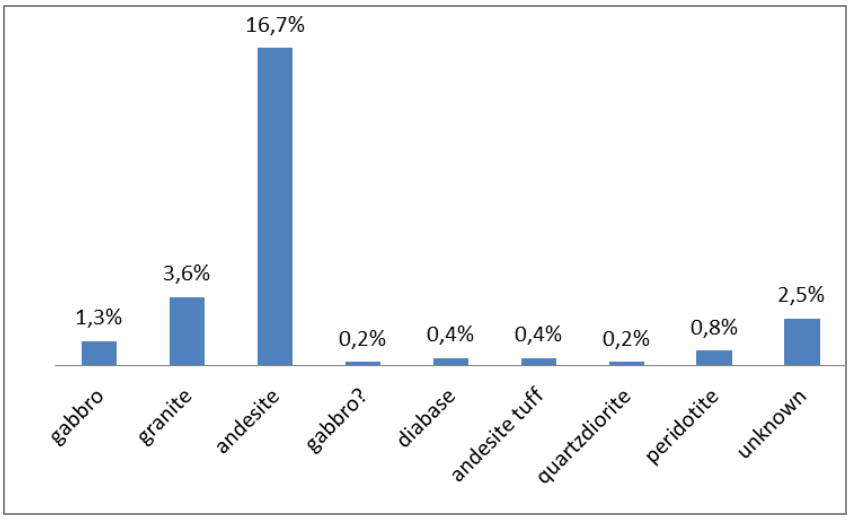

Fig.5.3.36c. Gumnište: igneous rocks graph 3; N=447.

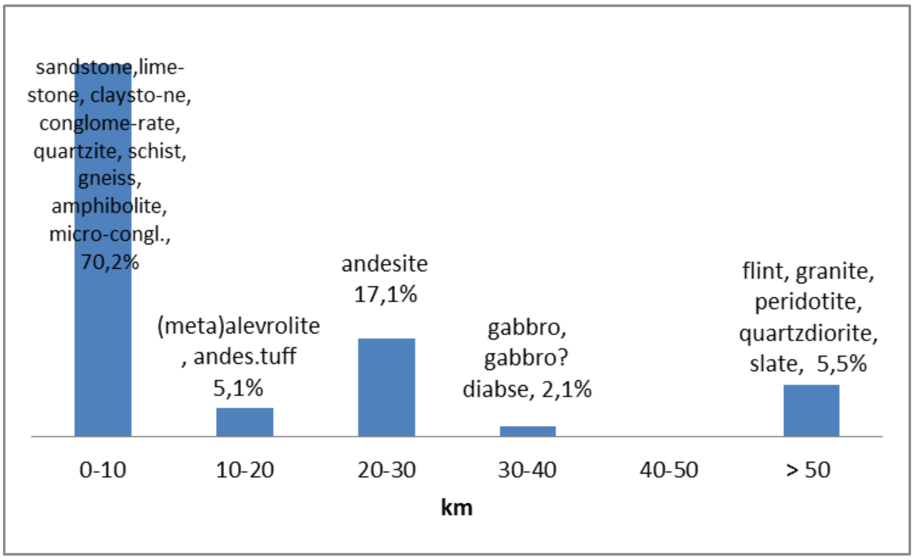

Fig.5.3.37. Gumnište: Raw materials and source distance.

km to the northwest. Gabbro and diabase are located c. 31 - 32 km to the south. However, we should also keep in mind that most of the rocks used as raw material probably were collected from the South Morava river that is in the immediate vicinity of the settlement. The specific origin of granite, flint, peridotite, quartzdiorite and slate is still unknown (fig.5.3.35,37).

In the following lines, we will interpret the results of the geo-archaeology analysis, which steps have been presented at the beginning of the chapter (fig.5.3.1).

Conclusions

Thee geo-archaeological analysis of the macro-lithic artefacts (fig. 5.3.1) leads us to distinguish the social value of rocks, regional economic differences and different procurement methods in the studied area. These procurement strategies inform about the time invested in transport and finally, about the social-economic organization of the communities. The previous results can be summarised as follows:

A. Relations between rock types and tool types, at an over-regional level.

In general, (meta)alevrolite, claystone, sandstone and schist were widely used for the manufacturing of macro-lithic tools, regardless the period, the region and the distance to the nearest of raw material deposit. The use of (meta)alevrolite and claystone were related mainly to the manufacture, use and re-shaping of polished edge tools, while sandstone and schist were more suitable for abrasive tools (fig. A1.1, 3, 5, 9, 11, 13, 14, 18, 22; table A 1.1). The social value of these rocks can be explained in terms of their availability, quality, behaviour and mechanical properties. The characteristics of abrasive tools made of sandstone and schist were tested experimentally (Delgado-Raack et al. 2009; see chapter 2).

B. The relation between rock types and breakage patterns.

The relation between breakage pattern and geology depends on the intensity of the activity carried out with the tools. The intensive implementation has been observed on items made of claystone, (meta)alevrolite, igneous rocks, amphibolite, schist and sandstone, suggesting their high use value (according to Risch 2011). (fig. A1.2, 4, 6, 8,10,12, 15,16,19,21,23,25; table A1.2).

C. Regional differences in terms of raw materials.

This topic is addressed to find out whether the given differences between communities are based on the local availability of rocks or on economic/productive particularities in each region and settlement. The analysis of the Neolithic raw materials has allowed us to identify three geo-economic regions. Despite their intensive implementation in the whole of the Central Balkans, sedimentary rocks were most important to the economies of the Northern region and northern part of the Western region (fig.5.3.3-6, 18,19, 20 - 23). The importance of igneous rocks in grinding technology defines a second area in the south of the Western region and in the Southern region during the Late Neolithic (fig.5.3.29,35). In the Central region, metamorphic abrasive tools were dominant during the Early Neolithic (fig.A1.7), while in the Late Neolithic igneous rocks as well as of metamorphic and sedimentary rocks were used for tools with abrasive surfaces (fig. A 1.9,11). Mechanical analyses have shown that igneous and metamorphic rocks are much more resistant than sedimentary rocks (Delgado-Raack et al 2009; see chapter 2).

Although all economies relayed mostly on local raw material, the production in the Northern and Central region needed to compensate for the lack of certain rocks via exchange networks. This also indicates that these communities did not depend on one source of raw material alone as a reliable supply of raw material. The experimental examination also shows that in the Central region tools with abrasive surface were made of rocks with various abrasive capacities. This can indicate substitution of the low-quality rocks by suitable resources, aiming to improve productivity (see chapter 2).

D. Differences between sites, regions and periods in terms of the distance from where the rocks were obtained and ultimately of the time invested in transport.

The local economy or the economy within the settlements depended on the accessibility to resources, and the extension of the distribution network or production value of raw material (Risch 2011). The analysis of the distance to deposits from the settlements indicates an appearance of distant exchange and various procurement strategies at a regional level, despite the high variability and accessibility of local raw materials. (Northern region: fig. 5.3.8; Central region: 5.3.11,15,18; Southern region: fig. 5.3.28).

Lack of adequate resources within and outside of the Northern region lead to develop an of exchange network between the communities from the settlements of At and Potporanj and the western and southern parts of the region, where the nearest deposits of claystone, basalt, gabbro and (meta)alevrolite are found (fig. 5.3.4,6). The possible identification of specific deposits of greenschist, white slate stone, (meta)ultra-basite, granite-metagranite found at tell Gorsza in northwestern Hungary which originated from the so-called Sava - Vardar area which would include Croatia, Serbia and Bosnia might indicate direct or indirect long - distant exchange between inhabitants of settlements of At and Potporanj and the areas in the Central Europe. The large quantity of obsidian from Potoporanj also supports this idea. The inhabitants from Benska bara were probably engaged in an exchange network with communities living towards the east, in the same region and in the Western region where sources of igneous rocks and magnesite (light white stone) can be found (fig. 5.3.9, 21).

A different exchange pattern can be observed in the Central region. The results show that the two local Late Neolithic distribution centres were involved in a local exchange network. Deposits of igneous rocks towards the west and the presence of amphibolite layers in the immediate vicinity of the settlement of Livade might label this site as regional distribution centre although this site is only known based on the surface survey (fig. 5.3.10; 5.3.13 a-c, 14; fig. A1. 8,10,12). The second distribution centre is the settlement of Motel Slatina, which was located in the immediate vicinity of a gabbro outcrop (fig. 5.3.10). The direct engagement in the exploitation, processing and probably exchange of raw material or products at these two sites could be confirmed by the presence of gabbro and amphibolite abrasive, grinding tools, and unmodified gabbro rocks or gabbro semi-finished products among the studied material from the Late Neolithic settlements in the Central region (fig. A .1.9, 11). Moreover, a selection of similar geology can suggest territorial unity of this region as well (fig. 5.3. 13 a-c,- 15 a-c).

Again a different procurement strategy is observed in the Western and Southern region. Here, raw materials were obtained mainly from local sources. Only gabbro and granite objects from the Late Neolithic settlements of Kremenilo and Čelina, located in the northern and southern parts of the Western region, indicate contact with the communities of the northeast and east part of this region (fig.5.3.18, 19, 21,22,27, 29). Items made of various rocks such as andesite, (meta)alevrolite, tuff, gabbro, diabase, flint, granite, peridotite, quartzdiorite and slate from the Late Neolithic settlement of Gumnište, Southern region might indicate local exchange network with the communities between the northern and southern parts of the region. Although this conclusion should be checked in further explorations (fig. 5.3.35,37).

Various procurement patterns implied differences in the time necessary for transport and probably, in social organisation. Given this, the exploitation of local sources, as the dominant procurement strategy in the northern part of the Western region required only low transport costs. These communities were probably more or less autonomous and self-sufficient at least in terms of raw material (table A1.4). Unlike them, the Late Neolithic inhabitants in the Northern and Central region invested time and energy in a social network, which allowed the transport of raw material, particularly for specific tool types such as polished edge tools and grinding equipment. The economies of these settlements were partly based on long-distance exchange networks. Furthermore, the production value of certain macro-lithic objects was high. We assume that an appearance of large numbers of re-used polished edge tools (RPE) made of (meta)alevrolite and claystone, which were not found locally, could be explained as an attempt of reducing of production costs of materials processed in percussion process in the settlements at the Northern region.

E. Chronological differences in the rocks used for specific tool types.

The small number of the Early/Middle Neolithic settlements and objects has provided insufficient data on the chronological difference in raw material implemented for specific artefacts.

In sum, one can say that the Neolithic societies of the Central Balkans either used local resources, when available or were able to establish extensive exchange networks with neighbouring communities if their own territories lacked adequate rocks.

Chapter 6:

Empirical basis: Analytical methods of production traces observed on the Neolithic macro-lithic objects in the Central Balkans

6.1. Grinding equipment

6.1.1. Grinding slabs

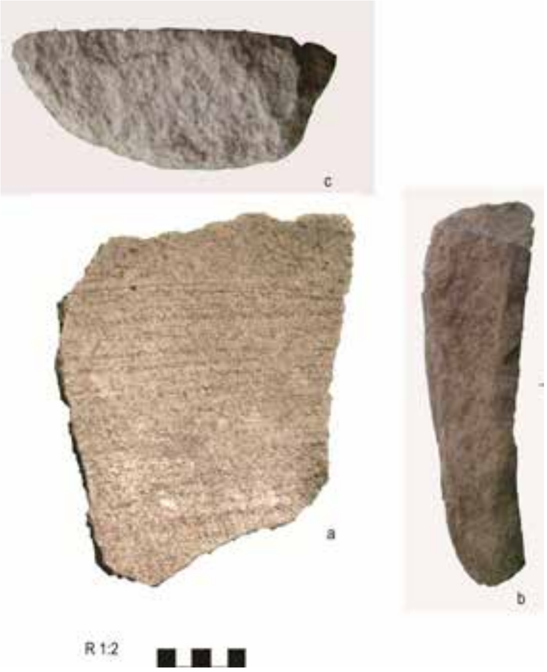

Fig.6.1, grinding slabs: L-DR-271 , c1211, sandstone.

The passive and larger part of a grinding equipment is usually defined with the term *grinding slab*. This tool type is required to process plant foods by crushing, pulverizing, and grinding. Moreover, it can have a ritual, symbolic and even ethnic meaning (Biskowski 2008: 152).

We have studied 130 slabs. They show one, and sometimes two smoothed active sides, located on the obverse as well as the reverse sides. They have been identified in the Late Neolithic settlements of Potporanj (n=2) (fig. 6.14/ 7), in the Northern region, Motel Slatina (n= 4) (fig. 6.14/12), and Turska česma (n= 24), in the Central region, Čelina (n= 44) (fig. 6.16/1, 2, 5, 6, 9 - 11), in the Western region, and Gumnište (n= 55) (fig. 6.14/3, 4, 8), in the Southern region. Only one item comes from the Early Neolithic settlement of Medjureč, in the Central region.

The record shows that 88,3% of the tools are broken or fragmented and only 11,5% are well preserved or complete (fig. 6.2).

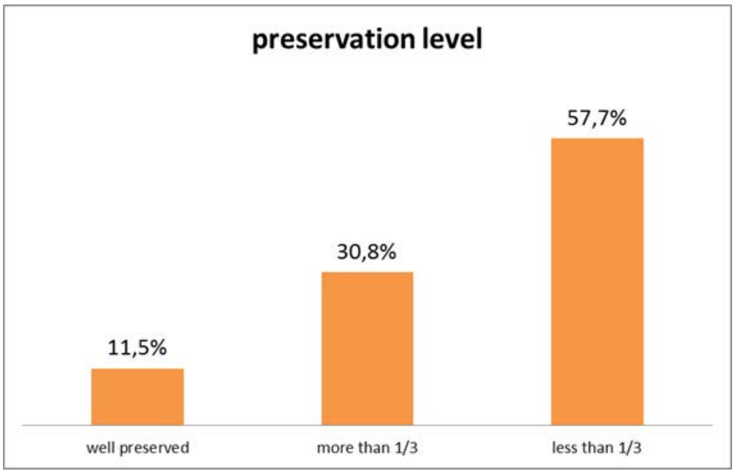

Fig.6.2, grinding slabs: preservation. N= 130.

Despite the poor conservation, the analyzed artefacts provided enough information on the grinding tools from the Central Balkans. Observations show that most of the passive sides (52,5%) present a natural surface (IR) (fig. 6.14/6). Only 22,5% of all passive sides show traces of pecking (PK), while c. 20% were shaped by percussion (TR) (fig. 6.14/2, 4,11), providing specific shapes.

This is the case of a tool L-MS-89, (fig. 6.14/12). A combination of these two techniques (PK-TR) has been recognized in c. 5% of the cases. Top sides usually remain unworked, while traces of modification are chiefly visible on the lateral sides (fig.6.14/4,9-12).

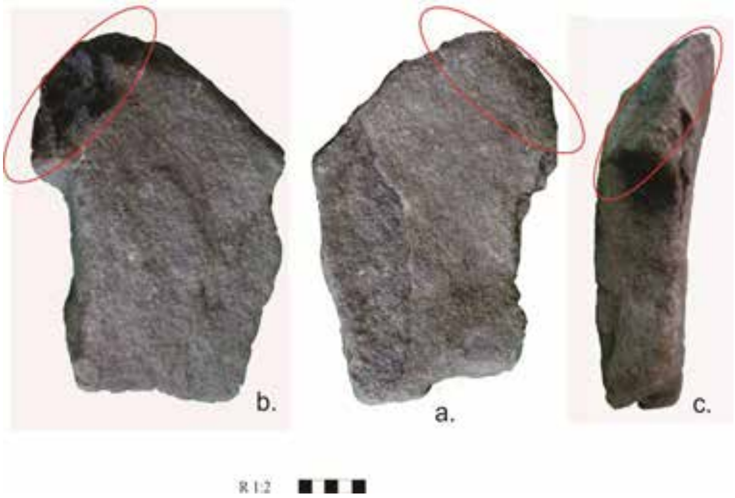

Fig. 6.3. Ginding slabs: manufacturing process, L-MS-169, amphibolite.

Fig. 6.3. shows an example of the process of shaping a massive amphibolite block, probably into a grinding slab. Being unsuitable, the protruded area on the top was removed partly by percussion (fig. 6.1.3a-c). A layer of stone was also removed from the obverse side by pecking, aiming at the preparation of the active surface (fig. 6.3a).

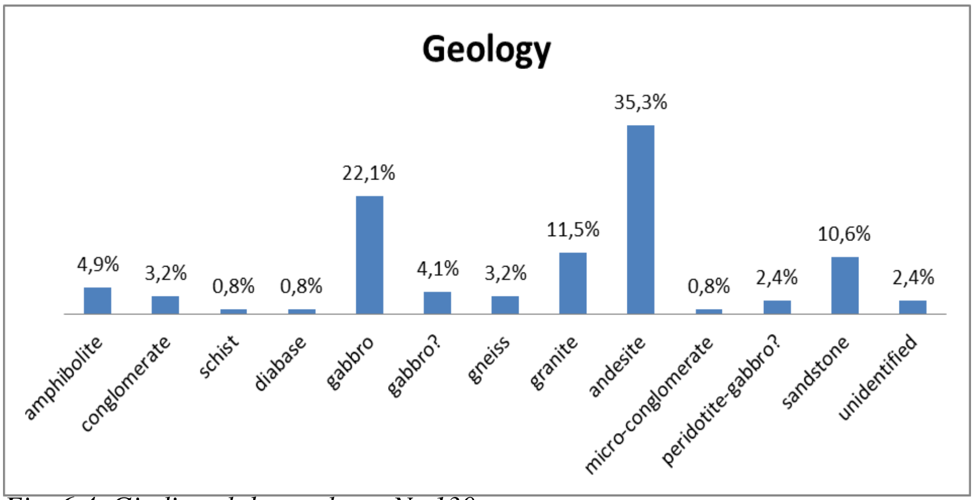

Fig. 6.4. Ginding slabs:geology. N=130.

The macrolithic record shows a considerable diversity in raw materials. Plutonic rocks are dominant and represent 70,3% (n=89). 16,1% (n=21) were made of sedimentary rocks, while 13,6% (n= 20) were made of metamorphic rocks (fig.6.4). Previous studies have confirmed the implementation of sandstone, conglomerate, and igneous rocks, such as gabbro, andesite, granitoporphyry (Prinz 1988: 339; Antonović 1992:16; 2003a: 81, 87, 92, 98;2003b: 13; 14; 2004: 451; 2006.: 26; 2011).

Geology and the size of the tools

The selection of adequate rocks is the first step in grinding technology. As previous studies suggested, various geologies show different mechanical properties, which our experimental tests have also confirmed (see subchapter 2.2.2). These properties affect the efficiency of the tool and consequently, its productivity. Variability of raw material can indicate that these criteria were not taken into account that grinding slabs were used for different tasks (Delgado et al. 2009).

Geology/N	$\bar{X}$	σ	max length (mm)	min length (mm)
schist / 1	-	-	375	-
plutonic / 8	327	55	431	230
sandstone / 5	271	136	468	120

Table 6.1. Grinding slabs: length according to geology; N= 14.

Geology/N	$\bar{X}$	σ	max width (mm)	min width (mm)
diabase/1	-	-	154	-
gabbro / 19	165	52	243	93
granite / 5	197	56	264	114
andesite/ 12	146	42	210	124
metamorphic / 4	178	48	220	109
sedimentary / 9	132	28	170	109

Table 6.2. Grinding slabs: width according to geology; N= 50.

Geology/N	$\bar{X}$	σ	max thickness (mm)	min thickness (mm)
diabase/1	-	-	74	-
gabbro / 19	81	25	143	34
granite / 5	88	51	180	58
andesite/ 12	64	23	110	27
metamorphic/ 4	83	30	119	56
sedimentary / 9	64	17	92	36

Table 6.3. Grinding slabs: thickness according to geology; N= 50

Geology/N	$\bar{X}$	σ	max weight (g)	min weight (g)
schist / 1	-	-	4298,2	-
plutonic / 8	7569,3	2214	11563	4946
sandstone /5	4543,4	4105	10996	924

Table 6.4. Grinding slabs: weight according to geology; N= 14.

In the following lines, we present the results of, first, the correlation between the size of the tools and geology, and, second, the analysis of the degree of use/wear the artefacts according to geology, expressed as wear index (ID). The value of wear index is equal to the relation between the thickness and length (ID= thickness/length). It is assumed that the length did not vary much from the initial use of the artefact, thus it is constant. The thickness presents the moment when the object was discarded and thus the intensity of the use of an artefact.

The artefacts recorded in the Central Balkans display no significant pattern based on a correlation between the size and geology (fig. A 2.3 - 6).

Although the number of measurements is limited plutonic objects are the longest and heaviest. The granite tools are also the widest and thickest (table 6.1 and 6.4).

It should be mentioned, that andesite grinding slabs come from the Late Neolithic settlement of Gumnište in the Southern region, while the gabbro tools are mainly from the Late Neolithic settlement of Čelina in the Western region.

The wear index (ID), resulting from the relation between length and thickness of the slabs does not vary significantly, regardless of geology (table 6.5).

geology/N	morphology	ID value	mean ID value
plutonic / 9	CV/RT, RT/RT	0,17 – 0,42	0,28
sedimentary / 4	CV/CX, RT/CV, CV/CV, RT/RT	0,22 – 0,33	0,26
metamorphic/1	CV/CX	0,11	-

Table 6.5. Grinding slabs: wear index ID value according to geology; N=14.

Active surfaces

Grinding slabs present active surfaces with different profiles, which need to be understood as an indicator of technical standardisation, and/or a diversity of uses. Different uses of the grinding slabs can be identified through their technological variables. In other words, the material transformed and how it is processed has an impact on the morphology of the working surface of the grinding slabs. However, this does not need to be a purely functional relation as, according to Adams (Adams 1999: 493), some archaeological, ethnographic and experimental examples have not indicated a necessary link between the morphology of the working, the diet and technology. We classified active grinding surfaces according to their longitudinal and transversal profile which can be concave (CV), flat (RT) and convex (CX). The transversal profile is used to define subtypes. These shapes are consequences of the perfect adjustment between a grinding slab and a handstone, which is the indispensable technical condition of the processing of cereal or other subsistence goods (cf. Delgado Rack, Risch 2016).

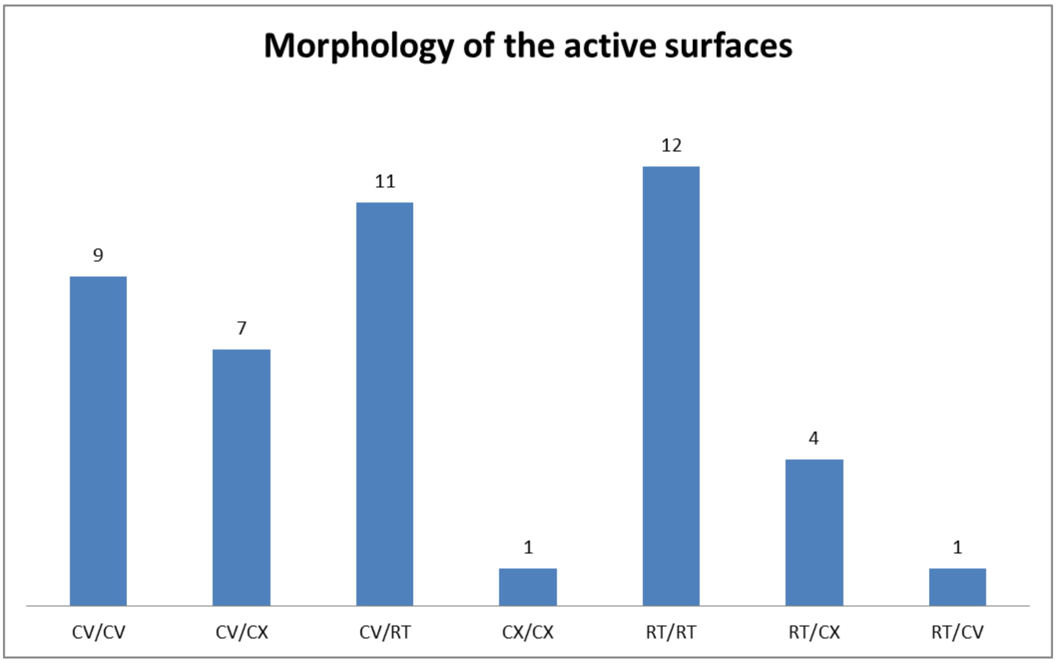

Fig.6.5. Grinding slabs: morphology of the active sides. N= 45.

The most common profiles among Neolithic grinding slabs of the central Balkans are the flat one in the longitudinal and transversal axis (RT/RT) and the concave/flat (CV/RT) active sides. Concave longitudinal, combined with concave, convex and flat transversal profiles (CV/CV, CV/RT, CV/RT) have similar importance (fig. 6.5).

Based on this data, we can present a morphometrical model of the Neolithic grinding tool kit. It is based on the combination between the longitudinal and transverse profiles of the grinding slab and the handstone (fig. 6.6). This model explains the shape of the working surfaces as a mechanical consequence of the metrical relation existing between both artefacts and the movement of the handstones.

In the case of flat (RT/RT) surfaces, the width of a working surface of the grinding slab is expected to be more or less equal to the length of a handstone, which should also show flat (RT/RT) working surface. The movement of the handstone will encompass the whole working area of the grinding slab (fig. 6.6 – RT/RT type 1A) (Risch 2008: PO/14 tab).

A concave/flat (CV/RT) shape of the active surface of the grinding slab occurs when the length of the handstone is equal to the width of the grinding slab (ibidem, PO/14 tab). The limited back and forth movements of the handstone produces the concave transversal axis of the grinding slab (fig.6.6 - CV/RT type 1B).

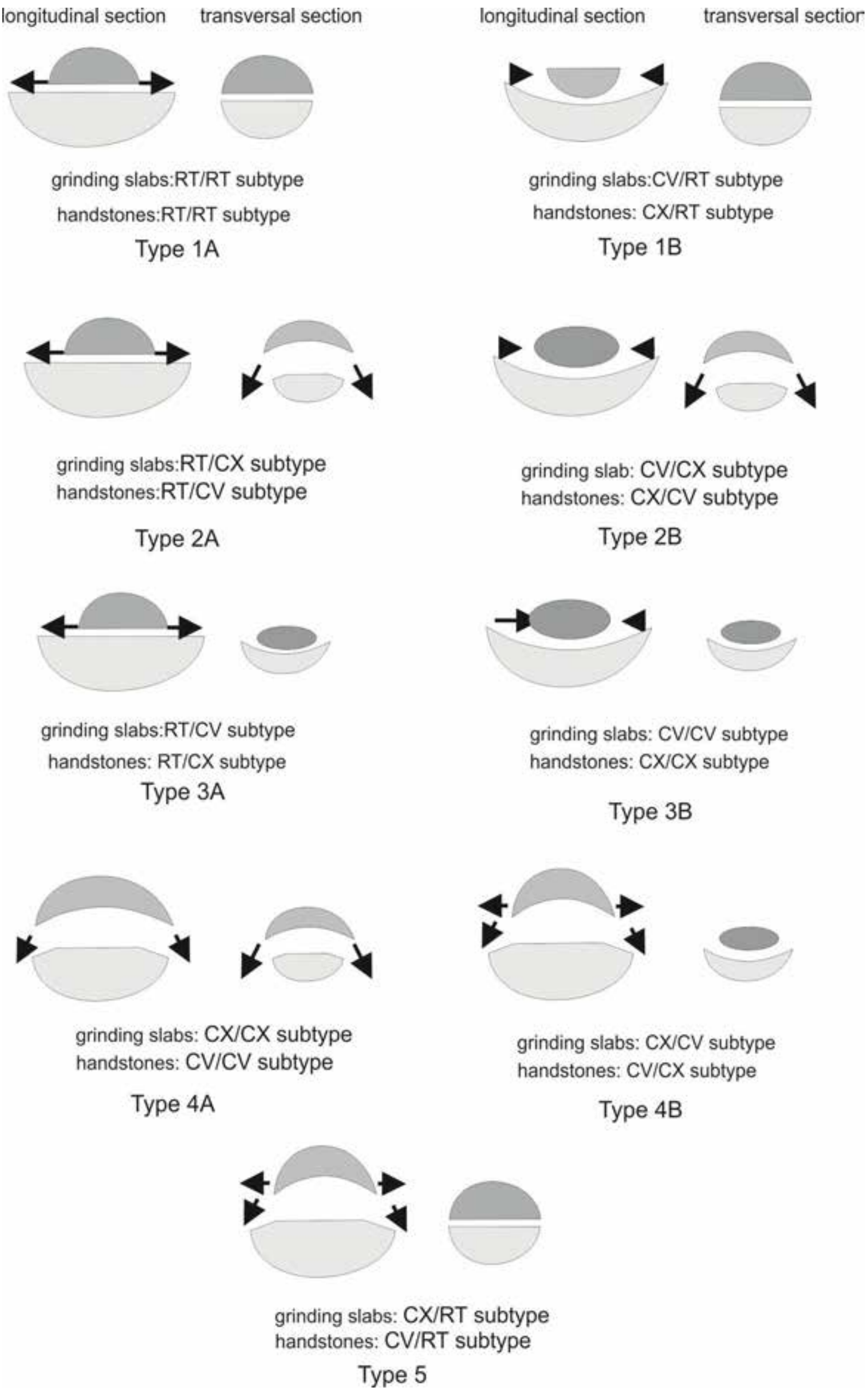

Fig. 6.6, Mechanical coupling of grinding slabs and handstones;modification cf. Risch 2008: 9, P/0 4. Arrows present direction of movements of tools.

A flat /convex (RT/CX) shape of the working surface of the grinding slab develops when the length of the handstone is larger than the width of the slab (ibidem, PO/14 tab) (fig. 6.6 - RT/CX type 2A).

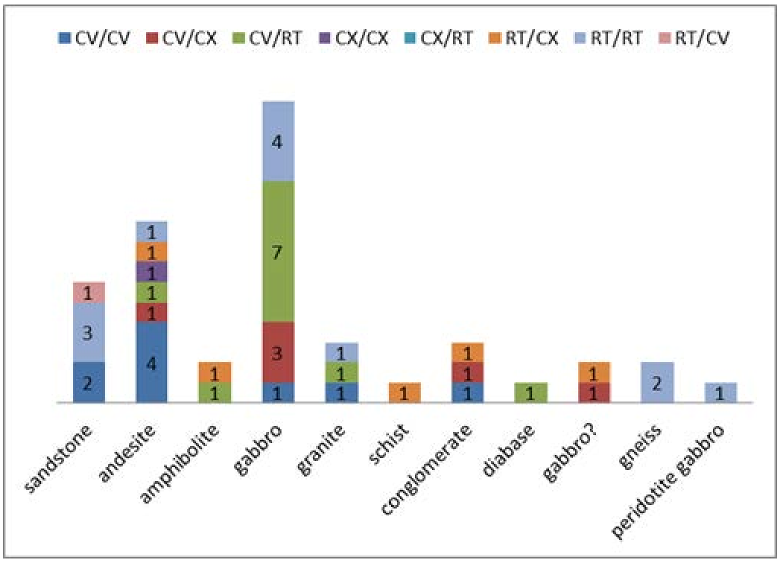

Fig. 6.7. Grinding slabs: correlation between geology and morphology; N= 45.

A CV/CX shape of the active surface develops when the width of the grinding slab is shorter than the length of the handstone with a CV/CX working surface. Rocking movements are performed along the longitudinal axis of the grinding slab (fig. 6.6 - CV/CX type 2B).

A concave (CV/CV) shape of the active surface appears when a working surface of the grinding slab is wider than the working surface of a handstone (idem: PO/14 tab). Limited movements are performed along the longitudinal and transversal axis of the grinding slab (fig.6.6 - CV/CV type 3B).

A CX/CX shape of the working surface developed the grinding slab is larger than the handstone in both axes (fig. 6.6 - CX/CX type 4A) (Risch 2008: PO/14 tab).

However, convex transversal profiles are typical in the Mediterranean Bronze Age. Experimental and use-wear analysis has confirmed that these shapes are highly efficient when operated with wooden handstones or *manos* (Risch 2002).

Two grinding slabs L - PO – 23 and L –Če - 96 present a thickened distal end (type REP) (fig.6.16/11). At the beginning of the working process, the whole working surface of the grinding slab was involved in the work. Later, back and forth movements affected only part of the working surface but did not reach the area placed further away from the person who operated the grinding instrument. Consequently, a plateau started to develop at one end of the slab (fig. 6.14/ 9).

Eight tools made of various rocks (sandstone, gabbro, amphibolite, andesite and granite) have two active grinding surfaces. Their poor conservation did not allow an identification of the shape of their active surfaces.

As we have already seen, width and thickness of all grinding slabs are similar. Yet, the artefacts with concave active sides (CV/CV, CV/CX, CV/RT) were clearly longer and heavier than the items with a flat (RT/RT, RT/CX and RT/CV) active side (table 6.6 – 9; fig. A 2.7- 8).

The correlation between width/thickness and morphology of the active sides indicates that gabbro and andesite tools tend to to have CV/CX active sides (fig. A 2.6, and A2.12 -13).

morphology/N	**$\bar{X}$**	**σ**	**Max length (mm)**	**Min length (mm)**
CV / 10 (CV/CV, CV/CX, CV/RT)	343	77	468	172
RT / 5 (RT/RT, RT/CX, RT/CV)	207	83	300	120

Table 6.6. Grinding slabs: the length according to morphology; N= 15.

morphology/N	**$\bar{X}$**	**σ**	**Max width (mm)**	**Min width (mm)**
CV / 27 (CV/CV, CV/CX, CV/RT)	154	55	323	109
RT / 14(RT/RT, RT/CX, RT/CV)	154	44	220	101
CX/ 1 (CX/CX)	-	-	132	-

Table 6.7. Grinding slabs: the width according to morphology; N= 41.

morphology/N	**$\bar{X}$**	**σ**	**Max thickness (mm)**	**Min thickness (mm)**
CV / 27 (CV/CV, CV/CX, CV/RT)	82	43	264	36
RT / 14(RT/RT, RT/CX,RT/CV)	73	25	119	34
CX/ 1 (CX/CX)	-	-	48	-

Table 6.8. Grinding slabs: the thickness according to morphology; N= 41.

Geology/N	**$\bar{X}$**	**σ**	**Max weight (gr)**	**Min weight (gr)**
CV / 10(CV/CV, CV/CX, CV/RT)	6950,2	3155	11563	1612
RT / 5(RT/RT, RT/CX, RT/CV)	3798,4	3075	7499	924

Table 6.9. Grinding slabs: the weight according to morphology; N= 15.

The correlation between rock type and shape of the active surface shows that grinding stones were not standardised technologically. Similar rocks were used in different ways and *vice versa* (fig. 6.7). Various shapes of the active surfaces appear, for example, on gabbro and andesite tools. However, gabbro slabs tend to have CV/RT shapes, whareas andesite ones developed more CV/CV surfaces. As andesite tools come mainly from the Late Neolithic settlement of Gumnište in the Southern region, and most of the gabbro tools have been found in the Late Neolithic settlement of Čelina in the Western region, this result suggests differences in grinding technology between these two settlements.

In terms of wear intensity, the lowest wear index provided by tools with a concave shaped active surface (CV/CX, CV/CV and CV/RT) (table 6. 10), which means they were more intensively used than the straight ones.

geology/N	geology	ID value	ID value mean
CV/ 9 (CV/CV,CV/CX, CV/RT)	sandston, gabbro, conglomerate	0,11 – 0,33	0,23
RT / 5 (RT/CV,RT/RT)	sandstone, gabbro, peridotite-gabbro?	0,22 – 0,62	0,32

Table 6.10. Grindig slabs: ID value according to morphology; N= 14.

The wear index of the grinding slabs with the flat (RT/RT and RT/RT/CV; mean= 0,32) active sides is lower than index ID of the handstones with the same shape of the active surfaces (mean = 0,51). This might suggest that the grinding slabs were made of durable material and consequently, used for longer period of time than handstones.

Use wear traces

Our use-wear observations are based on the methodological approach, which has been defined and developed by J.L Adams together with R. Risch, S. Delgado-Raack, J. Adams, L. Dubreuil, C. Hamno, and H., Plisson (Risch 1995; 2002; 2008; 2009; 2011; 2016; 2018; Adams *et al*. 2009; Delgado-Raack 2008; Delgado-Raack, Gomez-Gras & Risch 2009; Delgado-Raack and Risch 2009, 2016).

Macroscopically, the working sides of the grinding slabs present a levelled surface. At a microscopical level, observations show levelling with edge rounding (fig. 6.8-9) grain rounding (fig. 6.12) which can be associated with levelling (fig. 6.13) or can be visible in lower zones of the grains (fig. 6.11), striations (fig. 6.8-9), grain extractions (fig. 6.8) as well as levelling on the high topography with grain edge rounding (fig. 6.10).

Grain rounding, levelling with edge rounding indicate grinding of soft materials such as cereals. The high topography with no edge rounding and striations confirms the impact of hard material, probably a handstone.

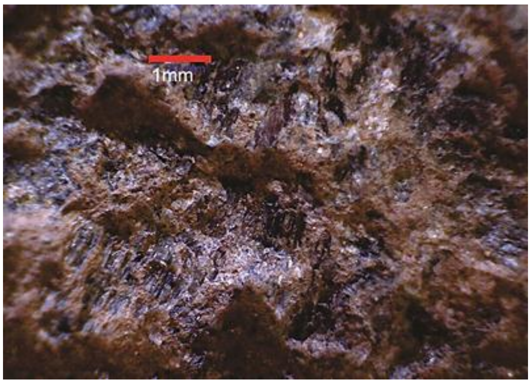

Fig. 6.8. Grinding slabs: grain rounding L – Če - 47, granite.

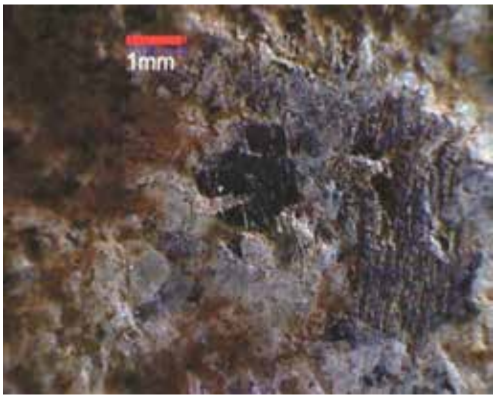

Fig. 6.9. Grinding slabs: levelling and striations L – Če - 47, granite.

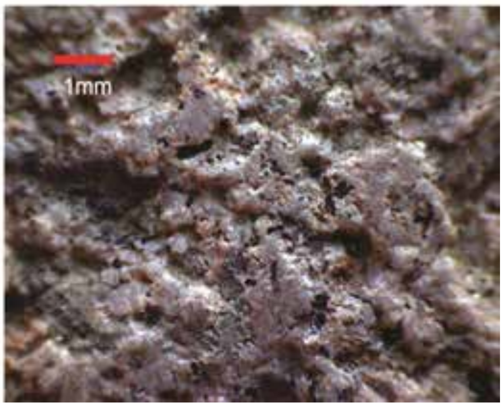

Fig. 6.10. Grinding slabs: levelling on the high topography with grain edge rounding L - P – 32, made of andesite.

Fig. 6.11.Grinding slabs: levelling L – MS – 156, amphibolite.

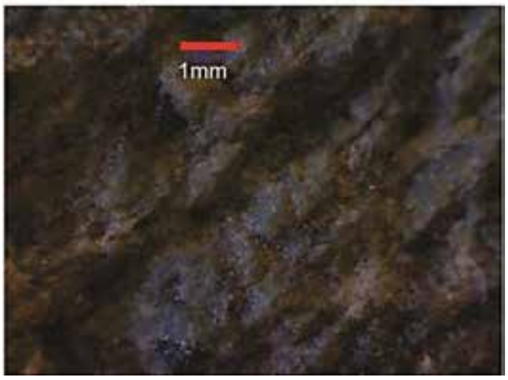

Fig. 6.12. Grinding slabs: grain rounding L – CE - 91, diabase.

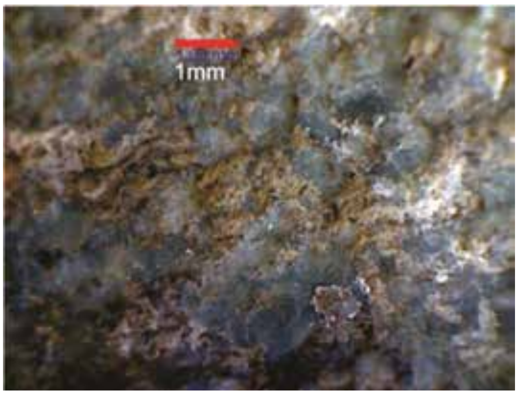

Fig. 6.13. Grinding slabs: levelling L – CE - 91, diabase.

The active surface also presents traces of repecking or sharpening of the grinding slab (fig.6.10), which can be represented by more or lass regular rows, suggesting careful maintenance of the active side and well skilled person manipulating the artefact (fig.6.12).

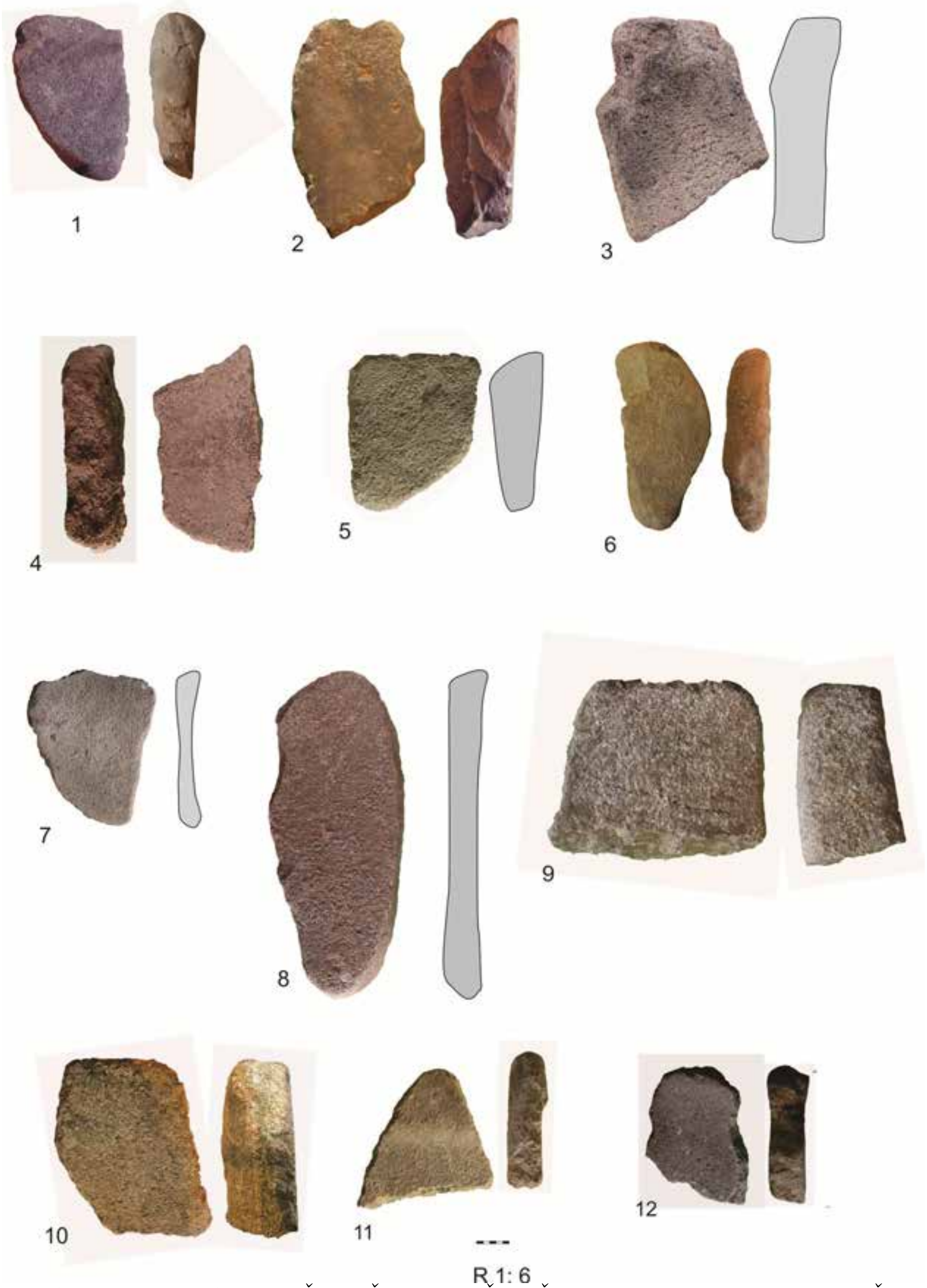

Fig. 6.14. Grinding slabs: 1. L -Če-58, Čelina; 2. L-Če-3, Čelina; 4. L -P-283, Gumnište; 5. L -Če-94; 6. L -Če-91; 9. L -Če-60, Čelina; 10. L - Če – 7, Čelina; 11. L -Če-96, Čelina; 3. L-P-262, Gumnište; 8. L -P-263,Gumnište; 12. L-MS-89, Motel Slatina.

6.1.2. Handstones

The term handstone is usually defined as the active, compatible and handheld part of a grinding equipment (fig.6.15). The obverse and, occasionally, the reverse sides show a smoothed active topography.

Our studied collection includes 44 handstones, all of them coming from Late Neolithic settlements: Motel Slatina (n= 3) (fig. 6.26/4), Turska česma (n= 10) (fig. 6.26/5,8,9) in the Central region, Čelina (n= 2) in the Western region and Gumnište (n= 29) (fig.6.26/1-3,6) in the Southern region.

Fig. 6.15., Handstone: L – P -234, andesite

Despite that c. 40% of all studied objects are broken (fig.6.16), and c. 20% of the items are very fragmented, the rest of the analysed artefacts provided valuable data on the handstones from the Central Balkans. This level of fragmentation can explain the low number of identified handstones (n=44), which is very small, compared to the number of grinding slabs (n=130).

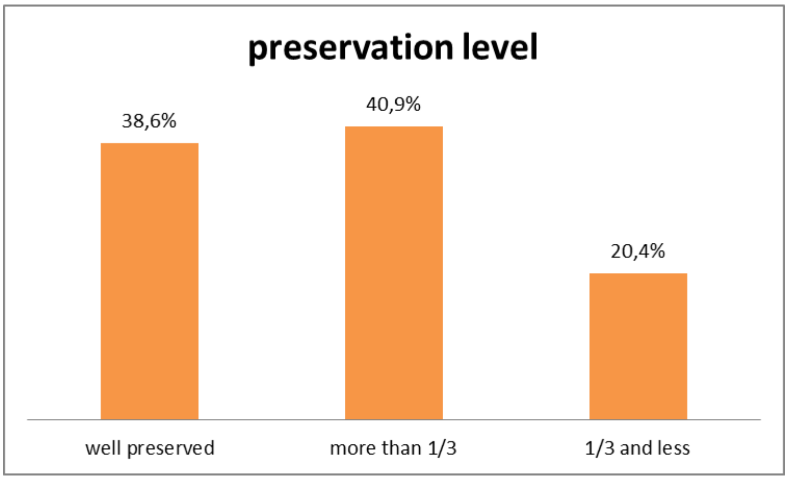

Fig. 6.16. Handstones: preservation; N= 44.

Igneous rocks such as andesite, gabbro and granite are commonly used raw materials, while amphibolite, schist and sandstone are rare (fig. 6.17).

37% of all the analysed passive sides show traces of pecking (PK) (fig. 6.26/3), while 21,5% of the passive sides revealed percussion (TR) (fig 6.26/1-2 and 6) A combination of

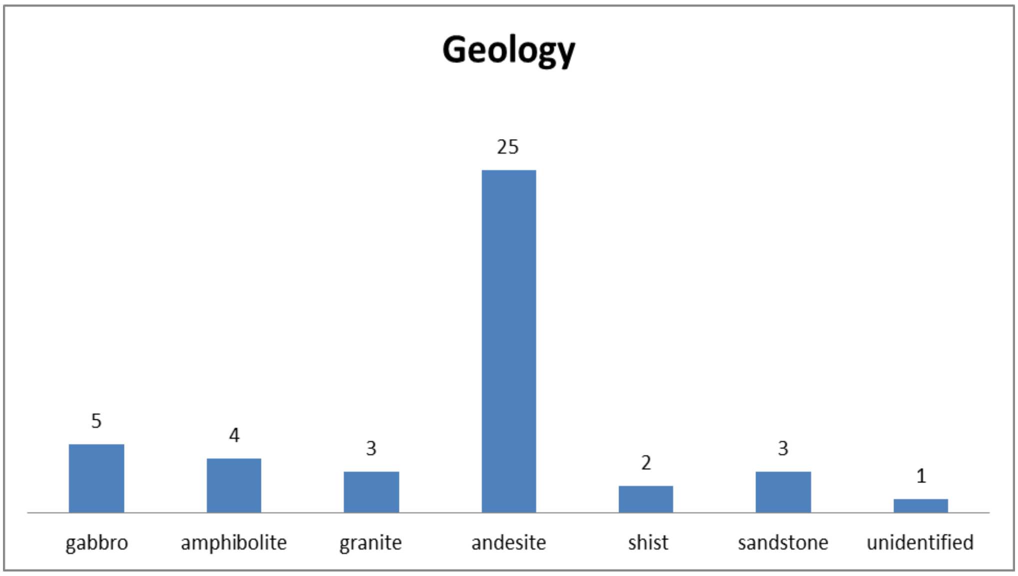

Fig. 6.17. Handstones: geology; N= 44.

these techniques (PK-TR) was detected in c. 21,5% of the passive sides. Observations suggest that flakes were detached through hard percussion from the top and bottom sides of the items, while the passive, convex lateral sides were being shaped by pecking. Some 27,5% of the passive sides were left in their natural state (IR) (fig. 6.26/7).

Geology and size of the tools

geology/N	$\bar{X}$	σ	max length (mm)	min length (mm)
metamorphic / 3	160	50	193	102
plutonic / 4	201	15	220	187
andesite /7	106	21	145	84
sandstone / 3	142	31	172	109

Table 6.11. Handstones: length according to geology; N= 17.

No significant relation has been observed regarding size of handstones and geology. Nevertheless, the relations length/weight and width/lenght of the plutonic rocks suggests a regular linear relationship. This indicates that an increase in the length and width is related to an increase in the weight and lenght of the objects. Regression coefficient of the relation length/weight of the plutonic tools is very high (fig. A 2.16 -17).

The average width and thickness of the objects of different rocks are similar. The metamorphic objects are the longest, while plutonc items are the heaviest (table 6.11- 14 idem).

The wear index) indicates that the plutonic handstones are the most intensively used. Unlike them, andesite objects show very low employment (table 6.15).

geology/N	$\bar{X}$	σ	max width (mm)	min width (mm)
metamorphic / 6	104	41	175	67
plutonic / 7	114	38	172	67
andesite / 19	100	22	144	51
sandstone / 3	104	36	145	75

Table 6.12. Handstones: width according to geology; N= 34.

geology/N	$\bar{X}$	σ	max thickness (mm)	min thickness (mm)
metamorphic / 6	48	20	78	28
plutonic / 7	58	14	80	40
andesite / 19	58	11	77	39
sandstone / 3	59	9	69	50

Table 6.13. Handstones: thickness according to geology; N= 34

geology/N	$\bar{X}$	σ	max weight (g)	min weight (g)
metamorphic / 3	2006,8	2043,6	4329,8	485,8
plutonic / 4	2358,65	108,3	2473,2	2211,8
andesite /7	787,2	370,2	1384,4	311,4
sandstone / 3	960,6	567,5	1612,6	577,2

Table 6.14. Handstones: weight according to geology; N= 17.

geology/N	Length mean, mm	morpholgy	ID value	Mean of ID vaue
plutonic / 4	201	RT/RT,CV/RT,	0,26 – 0,38	0,31
andesite / 7	106	CV/CV, CV/RT, CX/CV, RT/RT,	0,48 – 0,72	0,62
sandstone / 3	142	RT/CX, CV/CV, RT/RT	0,33 - 0,63	0,43
metamorphic/3	168	RT/CX, CX/RT, RT/RT	0,32 – 0,34	0,34

Table 6.15. Handstones: ID value; N= 17.

Active surfaces

As grinding slabs, the handstones also present different profiles of their working sides. They correspond to the techniques and movements used in grinding, and to the shape of the active sides of grinding slab, on which it developes. Thus, the active surfaces of the handstones are also classified according to the longitudinal and transversal profiles.

The most common shapes of the active sides are flat (RT/RT and RT/CX) (fig.6.26/8, 9) and concave (CV/RT and CV/CX) (fig. 6.26/13), while convex shapes appear sporadically (fig.6.18).

Regardless of the morphology of the active sides, the average thickness of the tools is almost the same. Tools with the flat active forms (RT/RT and RT/CX) are the longer and heavier, and tools with the convex (CX/CX and CX/RT) forms are the narrower (table 6.16 – 19).

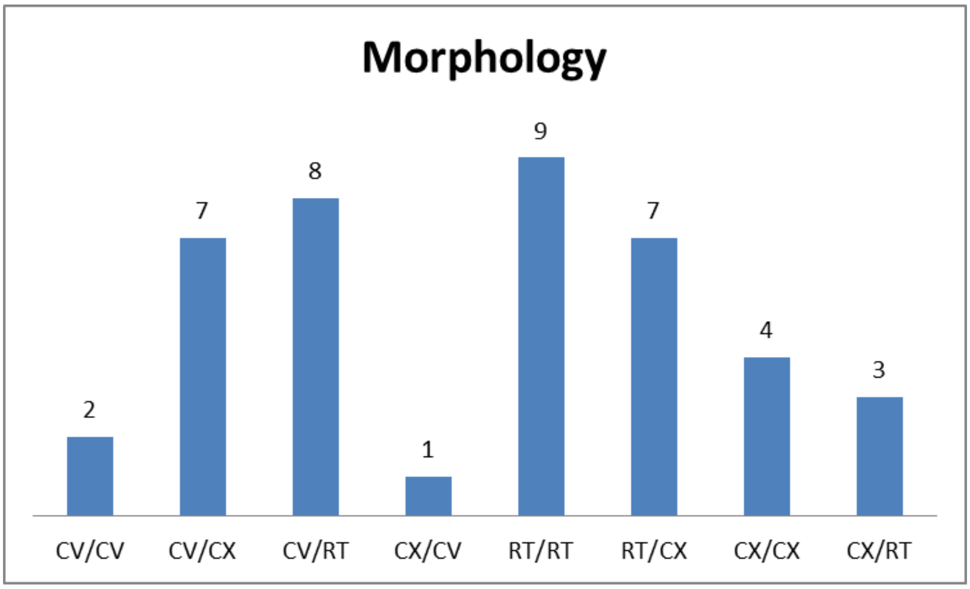

Fig. 6.18. Handstones: morphology of the active sides; N=41.

As it has been said before, a correspondence of the shape of the active surfaces is the main condition for the proper function of the grinding equipment. Table 6.16. indicates matches as well as exceptions, such as in the case of a handstone type 2A and a grinding slab type 4B. This result can be caused by the poor level of preservation of the tools (fig. 6.2 and 16).

We have also distinguished six handstones with double working surfaces. They appear mainly on andesite, while one item is made of amphibolite, and of from undefined rock.

	Relative dimensions	**morphology grinding slabs**	**Num. of grind. slabs**	**morphology handstoens**	**Num. of handstones**
1.	Wg ≤ Lh	1A	12	1A	9
2.	Wg < Lh	2A	4	2A	/
3.	Wg ≥Lh	3A	1	3A	7
4.	Wg > Lh	4A	1	(1A, 4A, 5)	9, 2, 8
5.	Wg ≥Lh	1B	11	1B	3
6.	Wg ≤ Lh	2B	2	2B	1
7.	Wg > Lh	3B	9	3B	4
8.	Wg ≥Lh	4B	/	4B	7

Table 6.16. Handstones: morpho-metrical coupling between grinding tools (Wg: width of the grinding slab; Lh: length of the handstone); N= 86; according to Risch 2008: PO 14tab.

morphology/N	$\bar{X}$	**σ**	**max length (mm)**	**min length (mm)**
CX / 3(CX/CV, CX/RT)	122	37	163	91
RT / 8(RT/RT, RT/CX)	154	58	240	97
CV / 6 (CV/CV, CV/CX, CV/RT)	146	46	193	84

Table 6.17. Handstones: length according to morphology; N= 17.

morphology/N	$\bar{X}$	**σ**	**max width (mm)**	**min width (mm)**
CX/ 7(CX/CV, CX/RT, CX/CX)	88	21	121	67
RT / 13 (RT/RT, RT/CX)	110	33	175	75
CV / 13 (CV/CV, CV/CX,CV/RT)	107	28	147	51

Table 6.18. Handstones: width according to morphology; N= 33.

morphology/N	$\bar{X}$	σ	max weight (g)	min weight (g)
CX/3(CX/CV, CX/RT)	795,1	436	1205	337
RT / 8(RT/RT, RT/CX)	1581,6	1364	4329,8	485,8
CV/6(CV/CV,CV/CX,CV/RT)	1468,2	780	2375,2	311,4

Table 6.19. Handstones: thickness according to morphology; N= 33.

morphology/N	$\bar{X}$	σ	max thickness (mm)	min thickness (mm)
CX / 7(CX/CV, CX/RT, CX/CX)	56	8	70	44
RT / 13(RT/RT, RT/CX)	58	17	80	30
CV / 13(CV/CV, CV/CX,CV/RT)	54	11	73	28

Table 6.20. Handstones: weight according to morphology; N= 17.

The use of these handstones developed flat (RT/RT - RT/RT; - CV/RT-; RT/RT, and RT/CX-CX/CX), convex (CX/CX - CX/CX) and concave (CV/CX - CV/CX) active surfaces. Most of these objects are fragmented (fig.6.22). The size of the only complete item is 117 x 94 x 77 cm and the weight 920 g. The appearance of two working sides suggests that the same handstone was used to work on several grinding slabs or different sides of the same tool (cf. Adams 1993: 336, 341).

No pattern has been recognised concerning the relation between the measurements and morphology. Only the relations length/weight and length/width of the tools with flat (RT/RT and RT/CX) and concave (CV/CV, CV/CX and CV/RT) shapes suggest a regular linear

geology/N	geology	ID value	ID value mean
CV/ 6 (CV/CV, CV/RT and CV/CX)	sandston, gabbro,andesite	0,26 – 0,71	0,23
RT / 6 (RT/RT, RT/CX, CX/RT and CV/RT)	schist, sandstone, granite, amphibolite, andesite	0,31 – 0,72	0,51
CX /3 (CX/RT, CX/CV)	andesite, schist	0,32 – 0,42	0,32

Table 6.21. Handstones: value of wear index ID according to morphology; N= 15.

relationship. This means that an increase in the length and width is related to an increase in the weight of the objects with these shapes The regression coefficient is particularly strong for the relation length/weight of the tools with concave forms (CV/CV, CV/CX, CV/RT) (fig. A 2.17- 19).

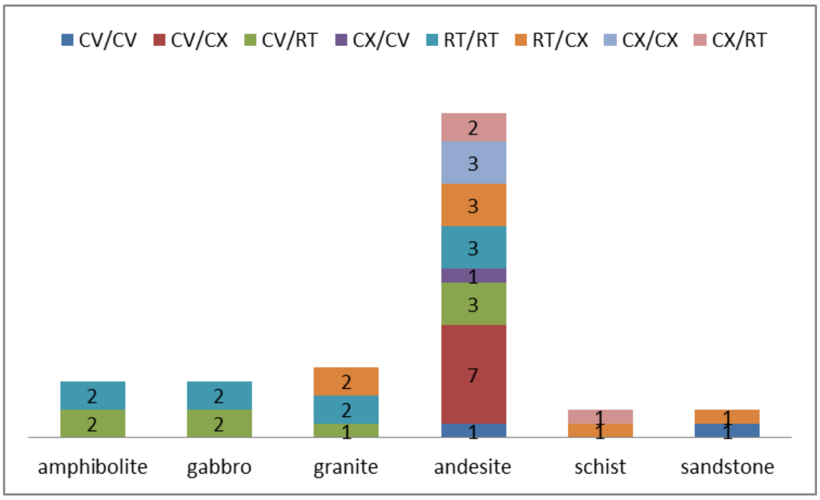

Fig. 6.19. Handstones: morphology of the active sides; N= 40.

Lack of a correlation between rock type and shape of the active surface indicates that the handstones were not standardised technologically. This has been confirmed by the andesite objects, which originate from the Late Neolithic settlement of Gumnište in the Southern region (fig.6.19). Furthermore, the dominance of the flat (RT/RT, RT/CX, CX/RT and CV/RT) (n=10) handstones in the Central region indicates a different technological approach.

Generally speaking, the tools with flat and plano-convex (RT/RT and RT/CX) working surface display very low wear index (ID) (table 6.21).

Use wear traces

All the active sides show abrasive use-wear traces. The convex and of the active surface of the andesite object L – P – 449 shows intersected deep scratches. They run perpendicular to the longitudinal axis of the tool and confirm working on a grinding slab with the concave (CV/CV) working surface. At a mesoscopic scale, this active surface presents levelling, grain rounding on high topography and grain extraction (fig. 6.20 - 21).

The active side of object L-P-234 (fig. 6.15) shows intensive levelling, micro-scratches on the top and bottom and frosted-like appearance (Adams 2002; Adams et al 2009) in the middle of the active side (fig. 6.24 – 25).

The working surface of a gabbro-diorite object L - Dr – 48 (fig. 6.26/5) displays grain rounding, which is visible in the higher as well as in the lower zone of high topography (fig.

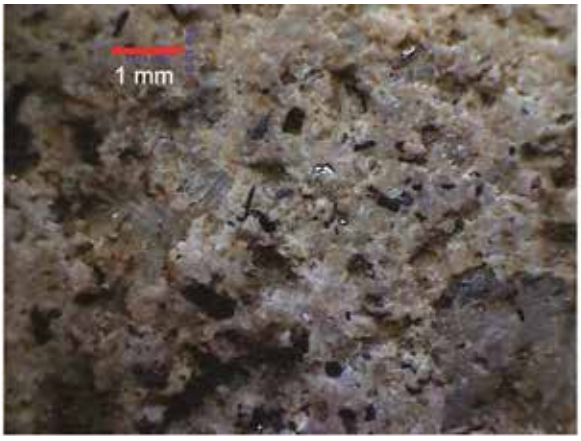

Fig. 6.20. Handstones: smoothed surface (AL), L- P – 449, andesite.

Fig. 6.21. Handstones: smoothed surface (AL,) L- P – 449, andesite.

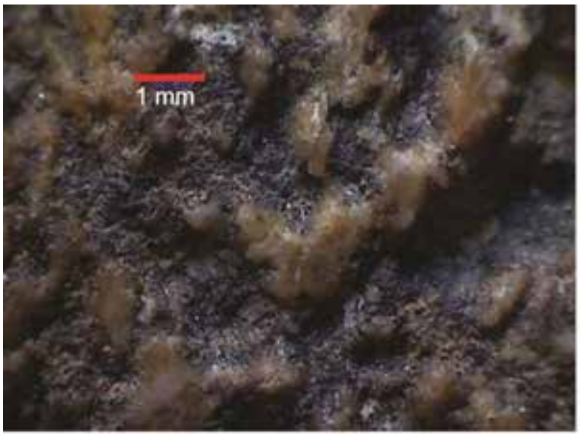

Fig.6.22. Handstones: smoothed surface (AL),L- Dr – 264, sandstone

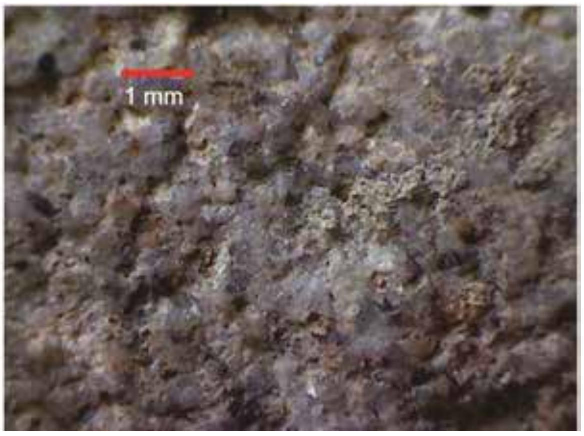

Fig. 6.23. Handstones: smoothed surface (AL), L - Dr – 48, gabbro-diorite.

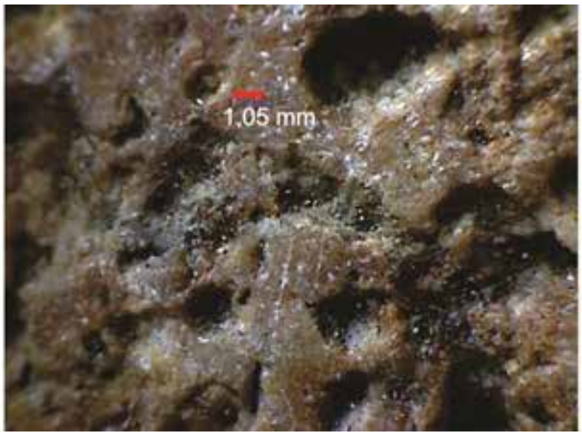

Fig. 6.24. Handstones: smoothed surface (AL), L – P – 234, andesite.

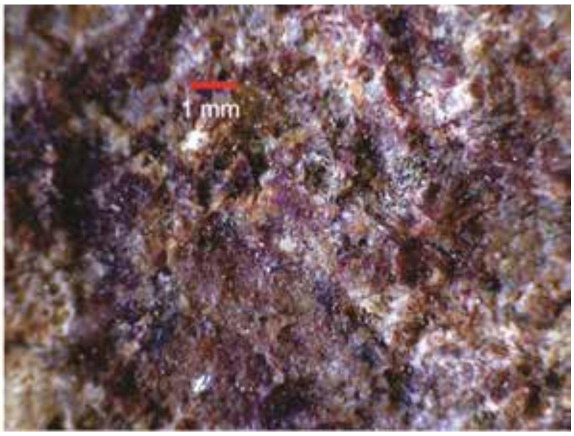

Fig. 6.25. Handstones: smoothed surface (AL), L – P – 234, andesite.

6.22). Grain rounding combined with levelling and grain extraction has been documented on a sandstone handstone L - Dr – 264 (fig. 6.23; 6.26/8).

Grain extraction could be the result of an intentional sharpening of the active surface.

Grain rounding indicates processing of a soft material such as meat or rawhide. Micro-scratches, a frosted-like appearance and levelling suggest a transformation of soft, intermediate material under pressure and in contact with the surface of the stone.

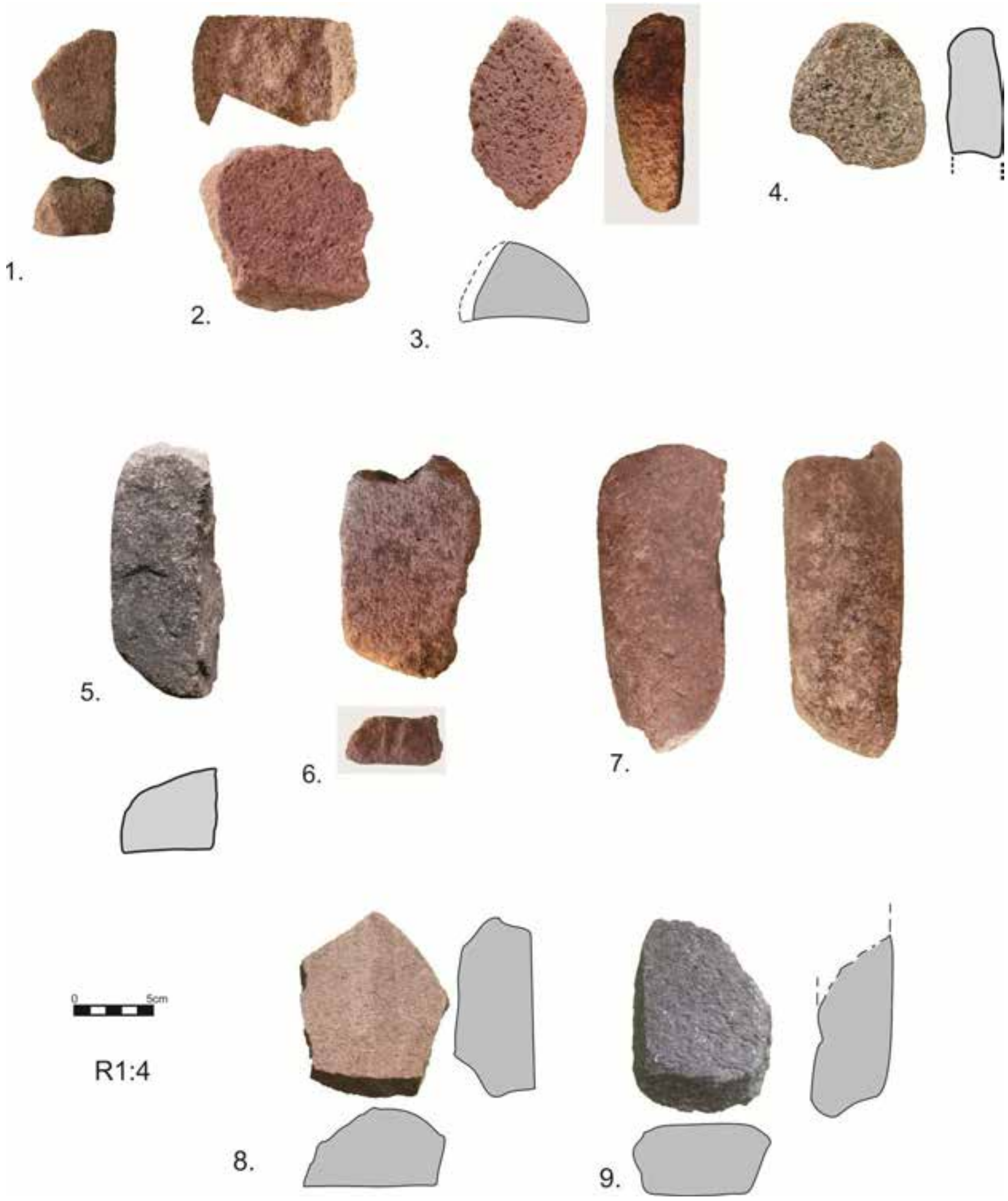

Fig. 6.26. Handstones: 1. L – P - 91; 2. L – P – 9; 3. L – P- 3, Gumnište; 4. L – MS - 186 Motel Slatina; 5. L – Dr – 48, Turska česma, Slatina; 6. L – P – 239; 7. L – P – 218, Gumnište; 8. L – Dr – 264; 9. L – Dr – 236, Turska česma, Slatina;

6.1.3. Mortars

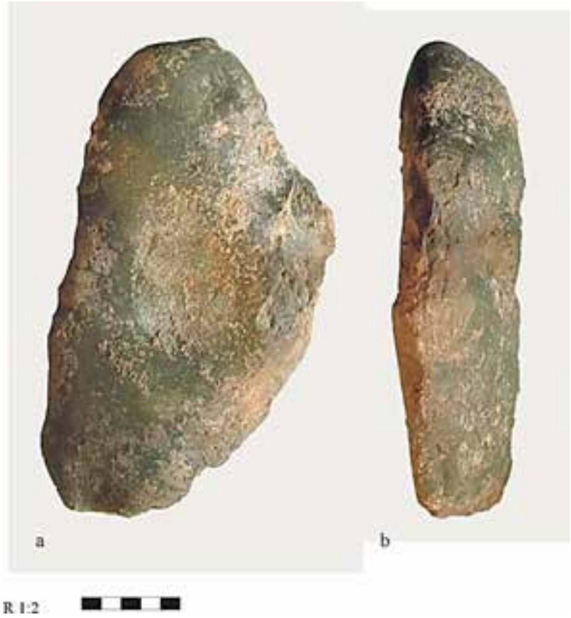

Fig. 6.27, Mortar: L – Če – 20, gabbro.

The mortar is a passive large tool used for pounding and grinding materials with a wooden or stone pestle. A concave basin or hollow is visible on the obverse and sometimes also on the reverse (fig. 6.27).

It has been argued, that the appearance of mortars and their size are connected to the intensification of food processing and longer site occupation. This marked early sedentism in the Levant during Early Natufian. During this period, mortars were found in camps in wetter regions, around the woodland zone (cf.Wright 1994: 252). Ethnographic evidence suggests that mortars do not correlate to specific foods. When it comes to food processing, pounding and grinding can change nutritional value. Both techniques serve for removing fibre, reducing particle size, to aid detoxication and to add or remove nutrients. Experimental examination shows that cereal dehusking is best achieved in a deep mortar. Ethnographic documents show a wide implementation of wooden mortars and pestles in dehusking.

In the central Balkans, mortars (type XIV according to Antonović, Antonović 2003: 61) have also been interpreted as altars and lamps (Srejović, Babović 1983: 157 – 181; Vasić 1986: 271; Radovanović 1996: 278, Fig.5.20, 287, 288).

We have examined 10 tools, which originate from the Late Neolithic settlements of Potporanj (n=5) (fig. 6.30, 32/2-3) in the Northern region, Turska česma, Slatina (n= 1) (fig. 6.31) in the Central region, Čelina (n= 2) (fig. 6.27) in the Western region and Gumnište (n=2) in the Southern region.

Three objects are complete, while the rest are only slightly damaged. One intensively burnt piece might belong to this group of tools according to the morphology but has been excluded from further examinations because of poor preservation. The studied mortars are between 210 to 300 mm long, 133 to 213 mm wide, 38 to 122 mm thick, and they weight between 1600 to 7820 g (table 6.21).

The artefacts were shaped by pecking (PK), such in the case of an object L-PO-58, while the longitudinal sides of item L-PO-31 show percussion and pecking (PK-TR, PK) (fig.6.30).

region/ inventory	**geology**	**length mm**	**width mm**	**thickness mm**	**weight g**	**cavity diam. mm**	**cavity depth mm**
Northern **L - PO - 31**	schist	> 255	213	59	4636,8	105; 99	32;22
Northern **L-PO - 32**	sandstone	> 160	174	122	3734,6	>141	57
Northern **L – PO - 46**	schist	123	171	38	1599,6	80	19
Northern **L – PO - 34**	sandstone	> 205	127	88	2720,8	> 71	>75
Northern **L – PO - 58**	mica schist	> 210	155	59	2247,4	> 121 x >58	58
Central **L- Dr - 211**	sandstone	> 122	> 193	> 68	2596,8	32	-
Western **L – Če - 20**	diabase	240	133	60	2462,8	67 x 52	8
Western **L – Če – 88**	gabbro	> 143	> 210	> 39	1765	54	8
Southern **L – P - 265**	sandstone	300	190	87	7820	100 x 90; 200 x 153	12, 14
Southern **L – P - 266**	sandstone	> 212	>129	> 64	3163	57 x 51	9

Table 6. 22, Mortars: qualitative and quantitative values; N=10

Two artefacts have active sides, one on the obverse and the other on the reverse (table 6.22). The perforated concavities of L-PO- 31 (Fig. 6.30) might indicate that the item was discarded due to detrition.

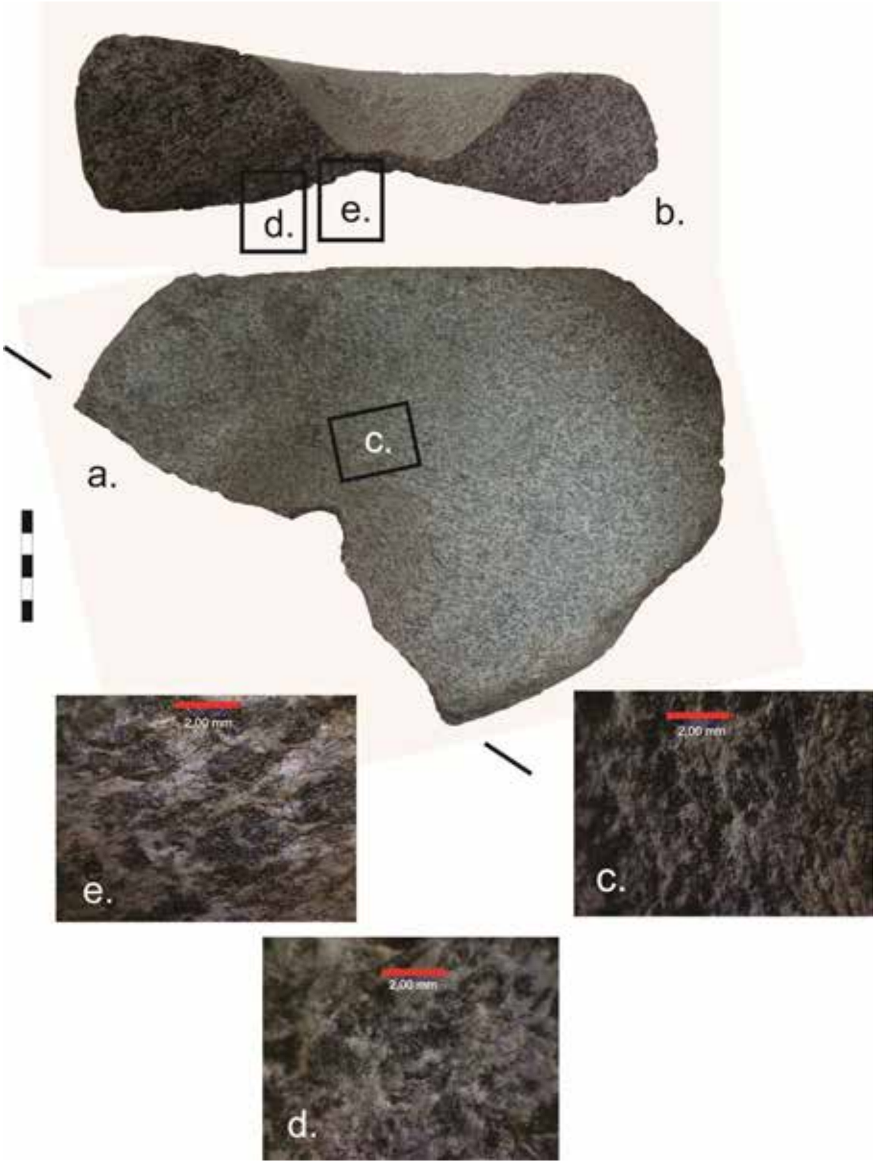

Fig. 6.30. Mortars: smoothed surface of the recipient (AL), L – PO – 31, schist.

Microscopic analysis of use-wear traces show levelling, grain rounding on high topography and grain extraction, but no edge rounding (fig. 6.28).

The surface of the concave basin of item L-Če -88 presents levelling as well as edge rounding, frosted like-appearance and the grain extraction (fig. 6.28). The surface of a hollow on the obverse side of a tool L- PO -31 (fig. 6.30) presents a frosted-like appearance, while its schist texture gives the impression of an occurrence of scratches (fig. 6.30/c). The working surface on the reverse side revealed levelling along the rim (fig. 6.30/c) and a frosted – like appearance on the wall of the recipient (fig. 3.30/d, e). Sandstone item L-Dr-211 is a multi-functional tool used as a mortar and simultaneously as a grinding slab (fig. 6.31a). Traces of repecking are visible around a concavity on the obverse side. Microscopically, this area presents high topography and no rounding (fig. 6.31/1,2,3).

Levelling on the high topography indicates processing of medium-to-hard materials such as bones, shells, minerals or pottery. Edge rounding suggests processing of soft materials, probably with the aid of a stone artefact. The frosted-like appearance suggests repecking of the working surface.

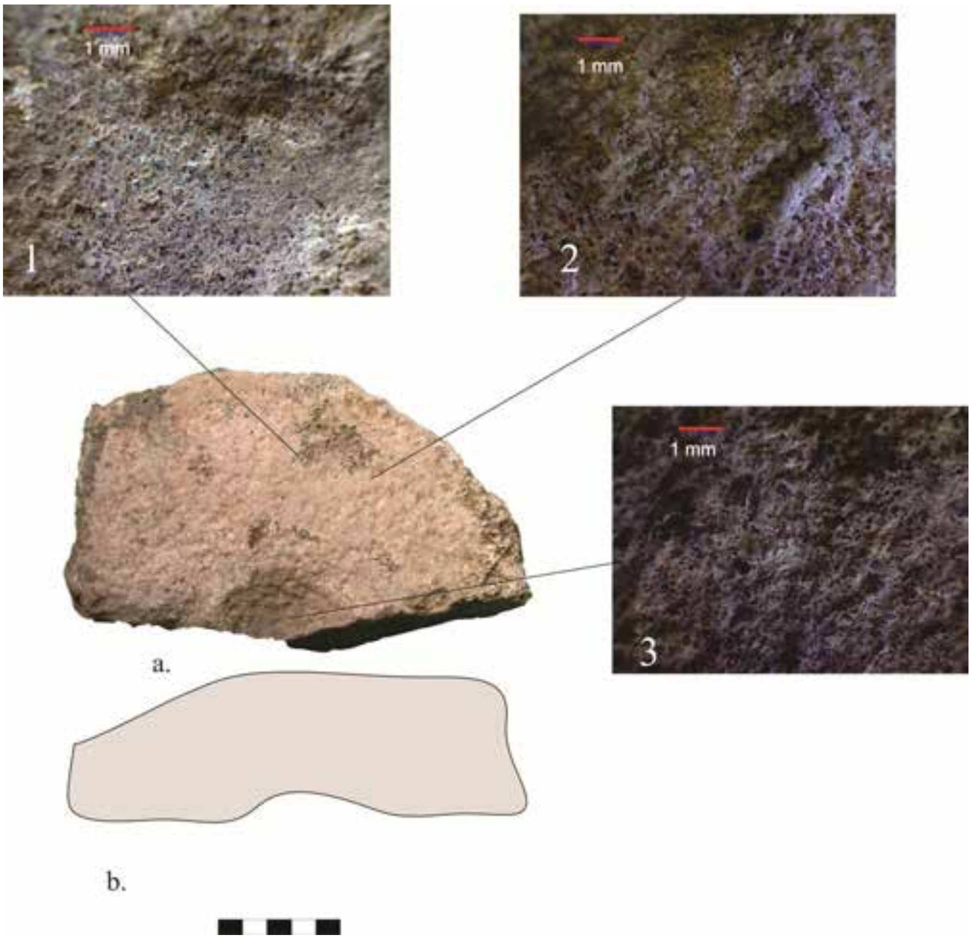

Fig. 6.31. Mortar – grinding slab: traces of pecking (PK-CA): L – Dr – 211, sandstone.

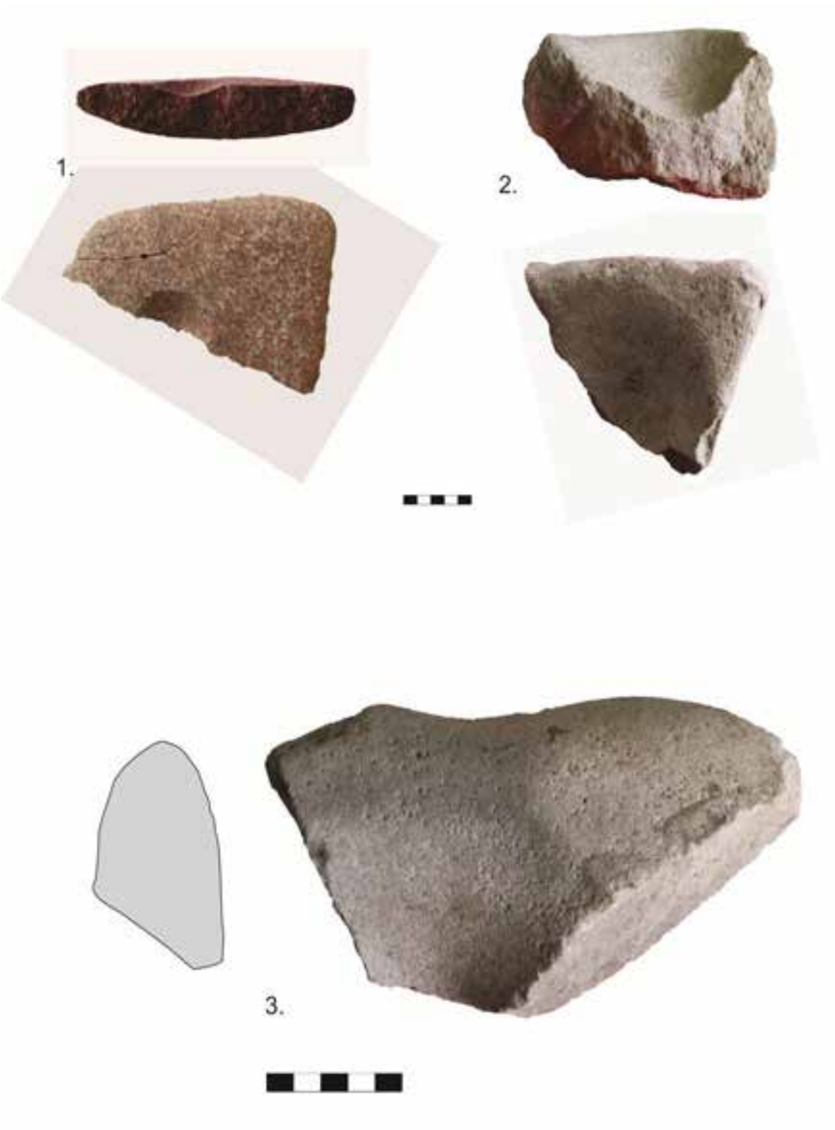

Fig. 3.32. Mortars: L – Če – 88, Čelina; 2. L – PO – 32; 3. L – PO – 34, Potporanj.

6.1.4.Grinding technology in the Central Balkan

The study of grinding slabs (n = 130), handstones (n = 44), and mortars (n = 10) has defined grinding technology and its importance of the Neolithic economy in the central Balkans. Our analysis has focused on geology, metrical values, the morphology of their working surfaces and use-wear. The grinding equipment was made of different sedimentary, metamorphic and volcanic rocks, although plutonic rocks were prefered for grinding slabs. Raw material was collected partly from local deposits, while one part of rocks employed as grinding equipment was obtained from distant sources, indicating a dual procurement strategy (chapter 5.3). Where grinding technology is based on local sources, the domestic context of production of the grinding items can be expected (Risch 2008a: 38).This also explains the observed lack of technological standardisation.

The grinding slabs are more frequent than the handstones and appeared in proportion c. 1: 3. This does not correlate with the results from previous studies, as grinding slabs have a longer use-life than handstones (cf. Delgado, Risch 2016). The lower wear of the slabs confirms that, also in the central Balkans, these tools were used for a shorter period of time than handstones.

Grinding tools were used with various techniques, whereby the concave (CV/CV, CV/CX, CV/RT), and flat (RT/RT, RT/CX, RT/CV) grinding slabs and handstones are the most common. The analysis of the shape of active surfaces shows mainly morphometrical coupling.

Variability in shapes of grinding tools can indicate low technical standardisation. Although some metrical and morphological characteristics of the grinding slabs might indicate the opposite. Concave (CV) shapes of the working sides were determined mainly on the long and heavy grinding slabs. Concave/flat (CV/RT) shapes appeared mainly on the gabbro grinding slabs, while andesitic ones developed more CV/CV surfaces. In chapter 7, we will see that certain shapes are linked with the grinding techniques implemented by particular communities.

Furthermore, the convex transversal profiles (CX/CX, CV/CX, RT/CX) occur on 26,6 % of all grinding slabs regardless of geology (conglomerate, gabbro?, andesite, amphibolite and schist). This might indicate the implementation of the wooden handstones or manos, as R. Risch has noticed in the case of the Bronze age at Iberian peninsula (Risch 2002: 124 – 127).

A recent study of S. Delgado-Raack and R. Risch (Delgado, Risch 2016: 131 - 133) has shown that this technology generated high grinding efficiency. Thus, in the case of our tools, the implementation of such technology might present technical improvement.

The concave (CV) working sides appeared mainly on the handstones which are lighter and shorter than the items with the flat (RT) working sides. This correlation is not caused by intensive use of the handstones associated with concave (CV) surfaces, but their small dimensions.

Ths study of traces reveals how these artefacts have been manufactured, maintained and used. Large clasts were selected from primary and secondary geological deposits for the production of grinding slabs and handstones. Top sides of the grinding slabs are usually unworked, while the lateral sides show chiefly traces of modification, mainly pecking. Instead, the top and bottom sides of the handstones indicate intensive transformations. Traces of repecking or sharpening on the active sides in some cases display work of well-skilled persons. The analysis of the active sides has also revealed grinding of soft materials such as cereals and meat and medium-to-hard materials, which might include bones, shells, minerals or pottery. Artefact L-Dr-211 was used simultaneously as a grinding slab and a mortar.

Diversity of use-wear traces detected on the active surfaces indicate work on various materials. This explains the implementation of different techniques and the occurrence of various shapes of the active surfaces, which was not linked to certain geology. This can explain low standardisation of the Late Neolithic grinding equipment.

6.2. Abrasive tools

6.2.1. Abraders

The term *abraders* is commonly used in English to refer to one of the principal tool categories that appear in prehistoric settlements when macrolithic artefacts are systematically collected and recorded[1]. They comprise a large variety of small-sized, hand-held tools made of various rock types that show use-wear traces produced by sliding and/or rolling friction (fig.6.2.16). Their working, or active, surfaces are related to various activities, such as abrasion, polishing, smoothing, burnishing, grinding, sanding, sharpening, etc. Many attempts have been made to address this functional diversity with a specific artefact type terminology, such as handstone, grinder, abrader, polisher, whetstone, rubber, smoother, or lapstone (e.g., McCarthy 1976; Wright 1992; De Beaune 2000; Adams 2002; Dubreuil 2002; Antonović 2003; Hamon 2006). However, these terms are ambiguous, and their boundaries are unclear, as typological, technological, functional, and petrographic aspects are assessed and combined in different ways to define each tool type. Classificatory discrepancies between authors, usually working in different regions are more than notable, while the equivalences between terms used in different languages are also problematic. This difficulty is apparent when the most commonly used categories within different research traditions are compared. Thus, for example, the English term *abrader*, the German *Schleifstein*, the Spanish *alisador*, or the French *polissoir*, all refer to different work processes. Consequently, the study of small size artefacts with a variety of abrasive or polishing wear traces continues to be problematic, particularly for anybody who is primarily interested in a general identification and classification of these artefacts.

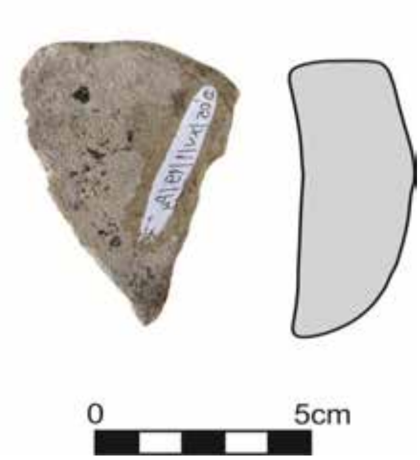

Fig. 6.2.16. Tools with abrasive wear traces L – DR – 91, Turska česma, Central region, sandstone.

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[1] The results of this chapter has been presented at“ The Neolithic tools with abrasive wear traces “ - International conference AWRANA, Beyond use-wear traces: Tools and people held between 29th may – 1st June 2018 at the University of Nice Côte d'Azur - Saint Jean d'Angely Campus (Nice, France), and in paperwork “A functional analysis of abrading stones: a case study from the Central Balkans” by R. Risch and V. Vučković, in press.

In order to overcome this functional and terminological ambiguity, we propose a different approach which draws principally on the mechanical properties of the rocks, and on the characteristics of the working or active surfaces of the artefacts (Risch 1995, 2002; Delgado-Raack 2008, 2013). Such a perspective takes into account that abraders tend to be expedient artefacts, implementing clasts or slabs of variable shape and size, collected from secondary geological deposits. Manufacture traces are usually absent or limited. Expectedly, the size and shape of these tools will be more variable than is the case among other, more curated, macrolithic artefacts, such as grinding tools or axes. It must further be acknowledged that abrasive wear can appear in combination with other types of active surfaces, such as percussion and pounding. As has been noted in previous studies, multi-functional tools are frequent, which were used indistinctly as fine-grained or coarse-grained abraders, anvils, hammerstones, pestles, and more (e.g., Zimmermann 1988; Risch 1995; Delgado-Raack 2013). These tools often do not show any differences in terms of geology, size, or shape in comparison with other tools that have abrasive wear traces. Consequently, the distinctive feature of these artefacts is their active surfaces, rather than their overall aspect. A further advantage of the proposed method is derived from its analytical outline. The possibility to study macrolithic assemblages, irrespective of typological, regional and chronological particularities allows us to compare macrolithic technologies. Such cross-temporal and inter-regional paleo-economic analyses are still rare among macrolithic studies.

In the present study, the proposed methodology will be applied to a sample of 294 artefacts with 358 abrasive surfaces, recovered from ten Neolithic settlements of the Central Balkans. As is the case in many regions, information on macrolithic tools from the Central Balkans is still limited, although they represent a major source of paleo-economic information (Antonović 1992, 1997, 2000, 2003, 59; Живанић 2010). The investigation of the Neolithic settlements of the Central Balkans has confirmed the economic importance of handheld tools with use-wear traces produced by friction. In excavations following a systematic recording strategy, abraders represent between 30 to 60% of the macrolithic assemblages. The aim of the present study is to obtain a better understanding of the variety of these artefacts, and the different tasks carried out with them.

The abraders analysed in this study come from various settlements in the Central Balkans region (fig. 1). A small number (9) has been found in the Early Neolithic settlement of MeĎureč (c. 5900 cal BC) and in the Early Neolithic layers of Turska

Česma (c. 6100-5900 cal BC). Only one tool comes from the Middle Neolithic settlement of Tumba Madžari (c. 5800-5200 cal BC). The largest part of the abraders corresponds to the Late Neolithic period (c. 5400-4600 cal BC). The settlements included in this study are: Benska bara (n of abraders = 5) , Potporanj (2), Čelina (5), Koraća Han (1), Kremenilo (1), Motel Slatina (32), Turska Česma (103), and Gumnište (135). It should be noted that systematical collection of macrolithic findings was conducted during the excavations of the settlements of Turska Česma, MeĎureč, Gumnište, and the new excavations of Motel Slatina. In the other cases, the macrolithic records remain partial.

Results

Analytical step 1: As geology is the main factor determining the mechanical properties and hence, the implementation of rocks as abraders, the first step of the proposed methodology is to identify significant associations between rock types and the morphology and size of each work surface (fig.6.2.17). Although active surfaces appearing on sandstones, the most commonly used rock in Neolithic settlements of the Central Balkans, can combine different longitudinal and transversal profiles and present the largest variability in terms of extension (fig. 6.2.18), certain patterns can be identified when grain size and cement (carbonate or silicified) are taken into account (table 6.2.10). Fine grained rocks (<0,5 mm) are more frequently associated with concave (CV/CV), flat (RT/RT), and convex (CX/CX) surfaces (table 6.2.10). Coarse grained rocks (>0,5 mm) are much more common, and are mostly associated with flat (RT/RT), concave (CV/CV) and plano-concave (RT/CV, CV/RT) active sides (table 6.2.10).

Morphology	**Nr. of the working surfaces**	**Fine grained rocks**		**Coarse grained rocks**		**Si sandstone**		**Ca sandstone**	
		N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
CV/CX, CX/CV	16	3	2,8	13	5,2	6	8,5	3	4,6
CV/CV	121	44	41,1	77	30,7	14	19,7	24	37
CV/RT, RT/CV	38	9	8,4	29	11,6	10	14,1	10	15,4
RT/RT	115	23	21	92	36,7	23	32,4	23	35,4
CX/RT, RT/CX	32	12	11,2	20	8	14	19,7	3	4,6
CX/CX	36	16	15	20	8	4	5,6	2	3,1
Total	358	107	100	251	100	71	100	67	100

Table 6.2.10. Number of abrasive surfaces according to grain size and to cement, which is only recorded in the case of sandstone artefacts from certain settlements.

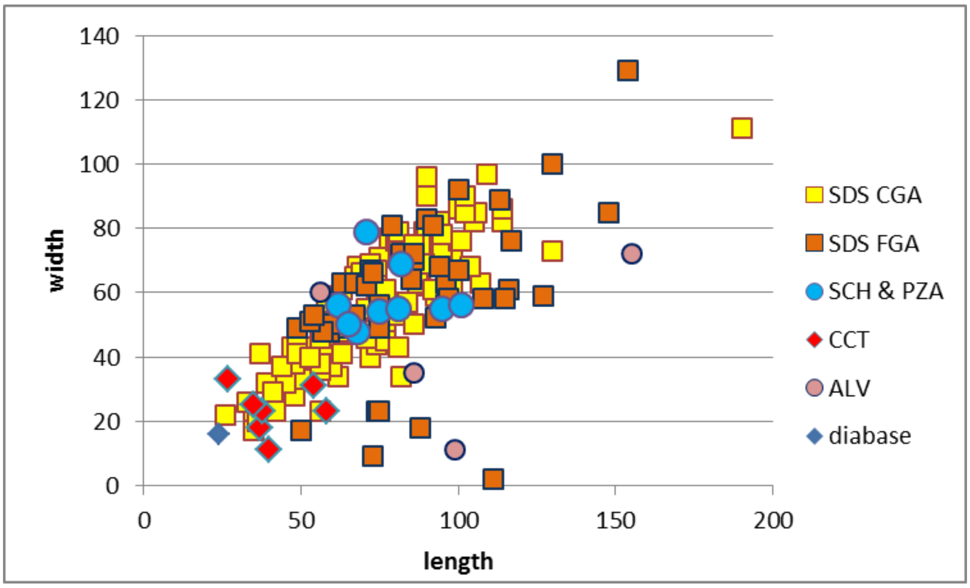

Fig. 6.2.17: Correlation between geology and the size of the active surfaces, coarse-grained sandstone (SDS CGA), fine-grained sandstone (SDS FGA), schist and slate (SCH and PZA), quartzite (CCT), meta-alevrolite(ALV); N= 173.

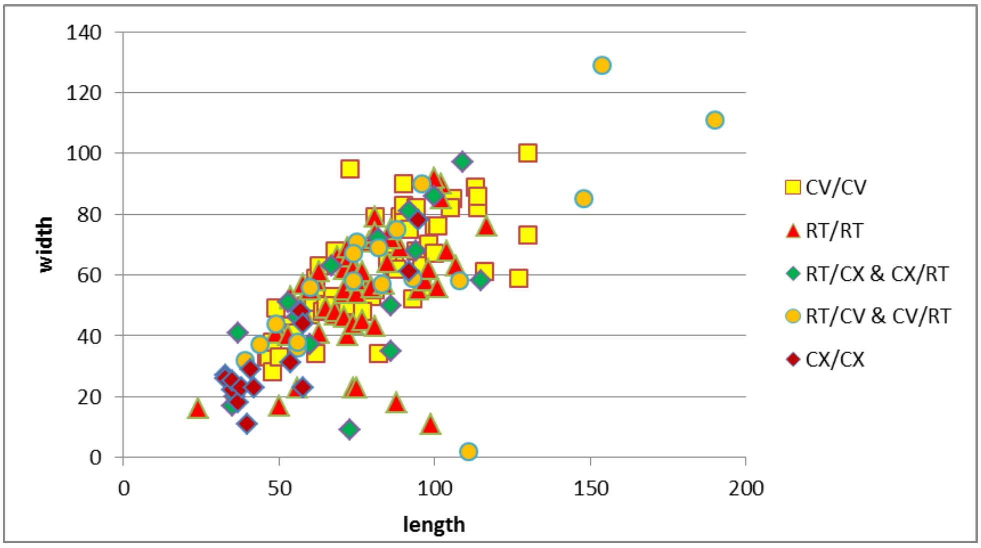

Fig. 6.2.18. Correlation between the size of the active surfaces and morphology; N= 127.

Silicified sandstone tends to show active surfaces with flat (RT/RT), concave (CV/CV), plano-convex (RT/CX, CX/RT), and plano-concave (RT/CV, CV/RT) shapes (table 6.2.10). Conversely, carbonated sandstone is associated mostly to concave (CV/CV), flat (RT/RT), and/or plano-concave (CV/RT, RT/CV) working surfaces. In comparative terms, plano-convex shapes are predominant among silicified sandstones, while concave shapes develop mostly on carbonated rocks. Other shapes do not show any particular association with any of the two types of cement. It can also be observed that carbonated sandstone tools are thicker than the silicified sandstone objects, which is to be expected given that the former are less resistant and will break earlier. T-test have confirmed that differences in thickness exists between these two groups of sandstone abraders[2].

In terms of active surface size, rocks with a low abrasive capacity, such as quartzite, diabase, and part of the silicified sandstones, present small use surfaces (fig. 6.2.17), which tend to be convex (CX/CX) (fig. 6.2.18). Alevrolite/siltstone (ALV) also has a low abrasive capacity, and was rarely used for abrasive purposes. Their active surfaces are slightly larger (fig. 6.2.17), and their shapes can be convex or flat (CX/CX, RT/RT, CX/RT) (fig. 6.2.18).

Analytical step 2: The next methodological challenge should identify possible associations between the size and shape of the active surfaces, independent of geology. As shown in table 2, large abraders frequently develop concave active surfaces, while plano-concave surfaces are less frequent. Abraders with one or more flat active surfaces tend to be slightly smaller. T-test have confirmed that significant differences exist between flat (RT/RT) and concave (CV/CV) active shapes[3].

Morphology	Nr. of artefacts	%	X	σ	cm^2 max	cm^2 min	Nr. of complete working surfaces
CV/CX, CX/CV	12	4,9	35,35	22,73	87,65	4,49	16
CV/CV	86	35,0	41,31	20,68	102,10	10,56	121
CV/RT, RT/CV	29	11,8	48,88	45,49	165,64	1,74	38
RT/RT	77	31,3	33,80	16,23	72,25	3,02	115
CX/RT, RT/CX	20	8,1	35,09	18,99	67,54	5,16	32
CX/CX	22	8,9	15,10	15,73	58,20	6,05	36
Total	246	100	/	/	/	/	358

Table 6.2.11. Number and area of the active surfaces categorized according to morphology.

Much smaller work surfaces appear combined with convex profiles (table 6.2.11), which as already noted, tend to appear on rocks with a low abrasive capacity. In statistical terms, convex (CX/CX) surfaces form a significantly distinct group of active surfaces and it follows, of working processes[4].

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[2] T value= -2,23371; df= 23; P(T<=t) two-tail= 0,029061

[3] T value = 2,148905; df = 106; P(T<=t) two-tail = 0,033918.

[4] The difference between convex (CX/CX) and flat (RT/RT) surfaces can be expressed as: t value = -4,06161; df = 23; P(T<=t) two-tail = 0,000483. The difference between convex (CX/CX) and concave surfaces (CV/CV) is: t value = -5,34994; df = 28; P(T<=t) two-tail = 1,07E-05; finally, the difference between convex (CX/CX) and planoconvex (RT/CX & CX/RT) surfaces is: t value = 2,53405; df = 26; P(T<=t) two-tail = 0,01764).

Analytical step 3: In sum, the morphometric analysis of the abrasive surfaces allows to distinguish the following functional patterns:

Pattern 1. Large concave (CV/CV), fine- and coarse-grained abrasive surfaces dominantly located on the obverse and reverse sides. Most of the carbonated sandstone abraders are included in this group (fig.6.2.27/ 1 – 6, fig. 6.2.16,17,18; table 6.2.11).

Pattern 2. Middle sized surfaces with flat active profiles (RT/RT, RT/CV and RT/CX) (fig. 6.2.27/ 7 – 10, fig. 6.2.16,17,18), appearing preferentially on the obverse and reverse sides of the artefacts. This pattern includes all schist and slate tools (SCH and PZA), and a large part of the coarse grained sandstone (SDS CGA).

Pattern 3. Convex (CX/CX) abrasive surfaces associated with quartzite (CCT) and different varieties of sandstone (SDS) (fig. 6.2.27/ 7 – 10, fig. 1.2,3). These active surfaces can appear on any artefact side.

Analytical step 4: Macroscopically, the levelled surface of the active sides, produced by abrasion is a standard feature on the studied material (n=303; 95%). Shine, scratches, pits and faceted surfaces are sporadic (n= 16; 5%).

Mesoscopically (10-40X) the tools with functional pattern 1 display grain levelling and grain extraction (L-P-337) (fig. 6.2.19), grain rounding, and levelled surface combined with shine or scratches (artefact L-P-243) (fig. 6.2.20). This suggests that these artefacts were used on convex surfaces of very hard materials, such as polished edge tools made of meta-alevrolite. Experimental tests have been carried out and confirm that coarse grained and silicified abraders were very efficient for grinding axes, while fine grained and carbonated abraders were more suited to polish surfaces or to whet bevelled edges[5].

Functional pattern 2 seems to be related to a more abrasive work processes, as suggested by the coarse grained abraders, the relatively high proportion of silicified sandstones, and the use of schist. Mechanical tests have confirmed the high abrasive capacity of this rock, which makes them particularly well suited for grinding and crushing subsistence goods, such as seeds and nuts (Delgado-Raack *et al*. 2009, 1830). Misoscopic analyses confirm the preponderance of grain levelling (artefacts L -P-390 and L-Dr-307) (fig. 6.2.22,23). Rounding of grains is occasionally observed (artefact L-

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[5] The results were presented at "Ground Stone & Society" - An international workshop, the Association for Ground Stone Research (AGSR), Haifa, 2015.

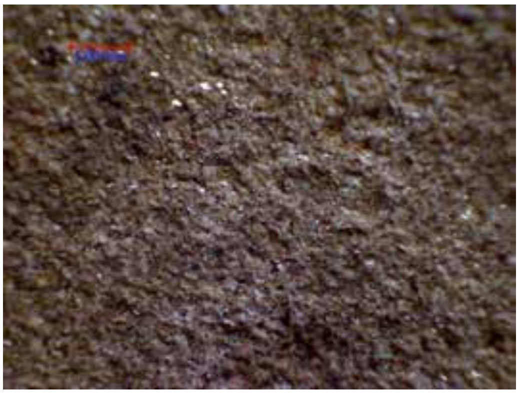

Fig. 6.2.19.Pattern 1: . grain levelling and grain extraction, sandstone (L-P-337)

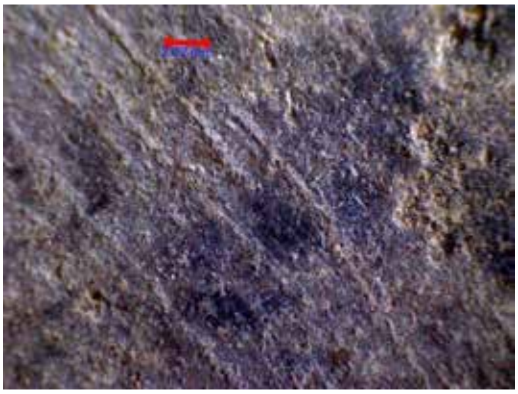

Fig. 6.2.20. Pattern 1: levelling, shine, scratches, sandstone (L-P-243)

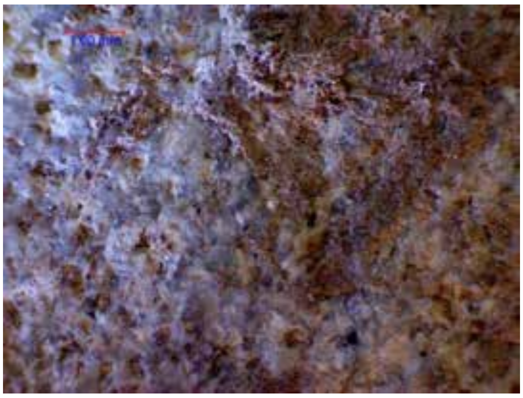

Fig. 6.2.21.Pattern 2: c. grain rounding, sandstone (L- Dr – 2).

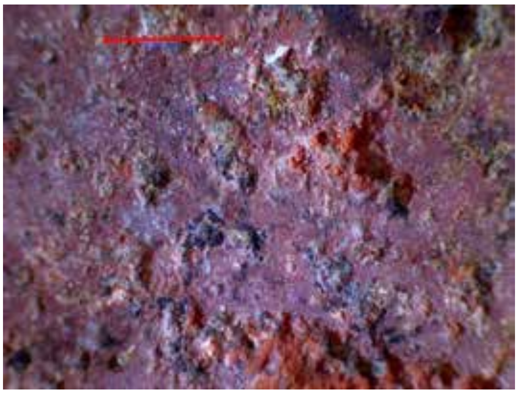

Fig. 6.2.22. Pattern 2: levelling, sandstone (L-P-390).

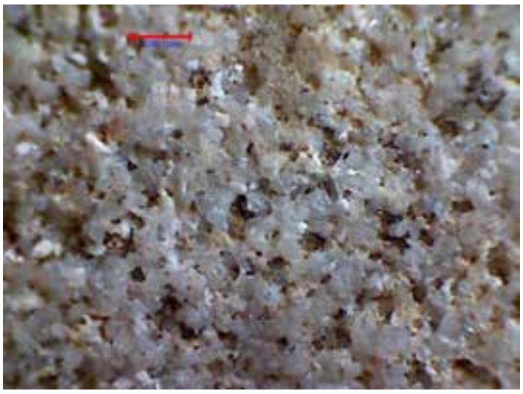

*Fig.1. 6.2.23. Pattern 2: levelling, sandstone (**L-**Dr-307)*

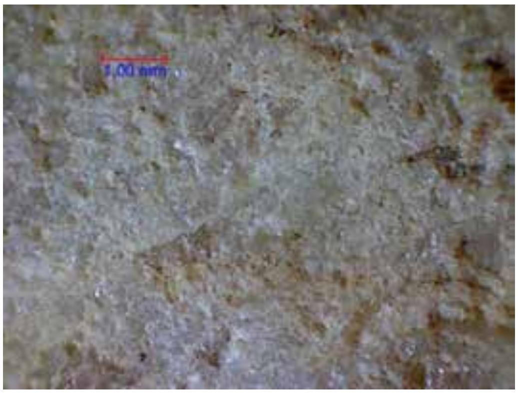

Fig. 6.2.24. Pattern 3: f. levelling and grain extraction, (L-PO-48).

Dr-2) (fig. 1. 6.2.21). These results indicate a processing of medium-to-hard materials, such as plants, on flat working slabs. Abraders that are more or less flat could also be used for wood and bone polishing, as well as for wall plaster or floor sanding, as we have observed ethnographically in northern Ghana. On the contrary, use wear traces do not suggest the work of hide.

Functional pattern 3 is characterised mesoscopically by grain levelling (fig. 6.2.24), indicating that work was carried out on hard surfaces, such as stone. The absence of striations implies the presence of a soft substance capable of polishing the levelled surfaces. This pattern often appears on abraders in combination with percussive surfaces. The highly variable location of the tools abrasive surfaces, as well as the over representation of fine grained rocks in this functional pattern, suggests an activity involving the crushing and pulverising a certain type of soft material in small or concentrated quantities, on concave slabs or mortars. Hide processing can be excluded due to the absence of the characteristic sheen resulting from this activity.

Analytical step 5: The combination or dissociation of use wear traces on artefacts can be used as a criteria to define the level of productive specialisation attached to a functional pattern, as well as to the tools on which the pattern appears. In the case of Balkan abraders, the majority of functional patterns 1 and 2 appear on artefacts with no other active surfaces (55 and 61% of the cases, respectively). Consequently, these abraders only seem to have participated in one type of activity. When abraders present two or more active surfaces, it is likely that they belong to the same pattern. This is the case in 21% of the surfaces adscribed to pattern 1. 24% of traces belonging to pattern 2 combine with each other on the same artefacts. This recurrence of active surfaces of similar geology, shape, and size strengthens the conclusion that we are dealing with tools linked to specific productive activities. Only 7% of the active surfaces belonging to functional patterns 1 and 2 appear combined with each other on the same abraders, while the combination with functional pattern 3 is negligible.

Instead, pattern 3 shows very different behaviour. In 35,7% of cases, two or more of this type of small, convex, active surfaces can be observed on the same artefact. It can appear combined with other abrasive, as well as percussive, wear traces. Hence, although pattern 3 corresponds to a distinct work process, in 86% of the cases it relates to tools which also participated in other tasks. It can be concluded that the activity related to this type of friction, generally, did not lead to the manufacture and use of specialised abraders.

Analytical step 6: Interestingly, when these functional patterns are considered in combination with the artefacts on which they appear, no differences can be recognised in terms of general shape, size or weight of the artefacts (fig. 6.2.24, 25).

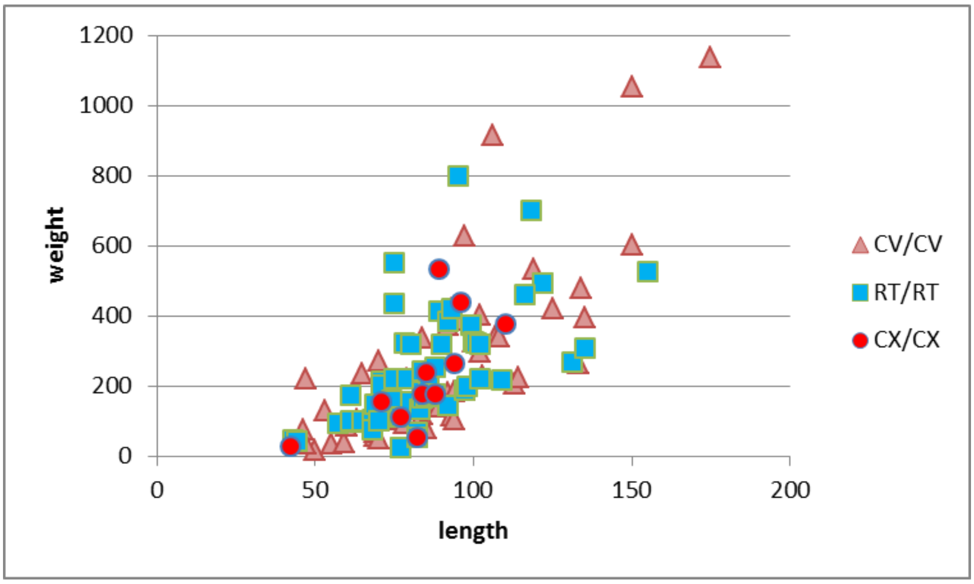

Fig. 6.2.25..Correlation between length, weight and morphology. N=138.

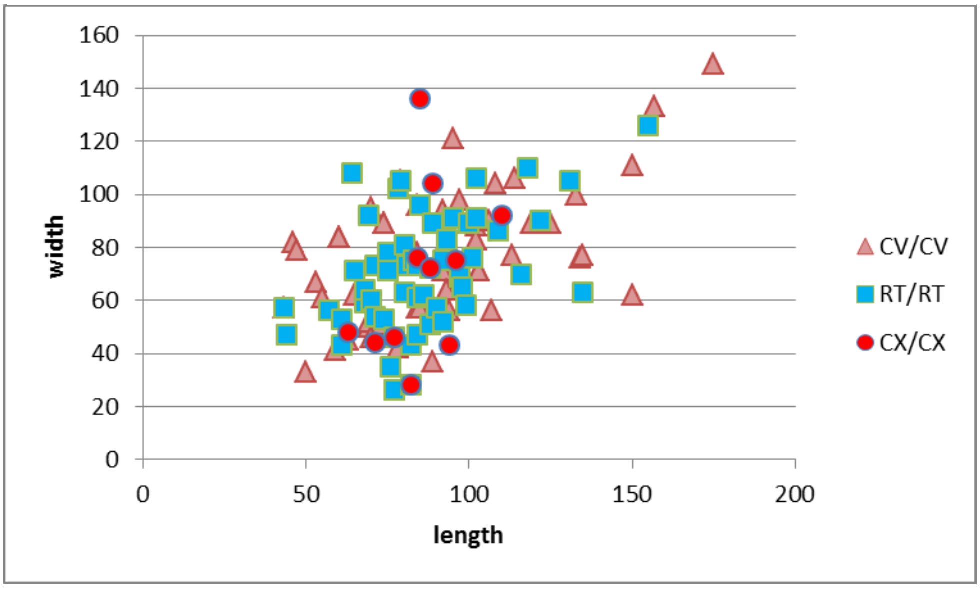

Fig.6.2.26.Correlation between length, width and morphology. N=138.

Only the thickness of abraders with convex active surfaces (CX/CX) belonging to pattern 3 is significantly higher than in case of the other active shapes[6]. Apart from this minor difference, no artefact types can be identified on morphometrical and technological criteria alone.

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[6] The difference in artefact thickness between convex /CX/CX) in comparison to flat (RT/RT) surfaces is significative: t value =2,334146; df = 37 ; P(T<=t) two-tail = 0,025126; as well as difference between convex /CX/CX) and concave (CV/CV) surfaces: t value = 2,656085; df = 145 ; P(T<=t) two-tail = 0,00879).

Summary

The Neolithic abraders of the Central Balkans form a typologically indistinct group of macrolithic artefacts. Only the detailed analysis of their working surfaces in terms of their material properties, morphometric characteristics, and use wear traces has revealed that at least three different abrasive work processes were carried out with these tools. The most important activities appear to have been the grinding, polishing, and sharpening of axes and other edged tools. A second group of artefacts was used to work wood or bone, to process plants, or to sand clay floors and walls. The observation that the active surfaces of these two groups of activities rarely appear combined on the same artefact, confirms that these tools were identified as distinctive work instruments by the Neolithic communities. Finally, a third, smaller group of multifunctional abraders were used to process a still unknown soft material or substance in concave stone basins. Residue analyses are required in order to determine the exact product obtained with these instruments.

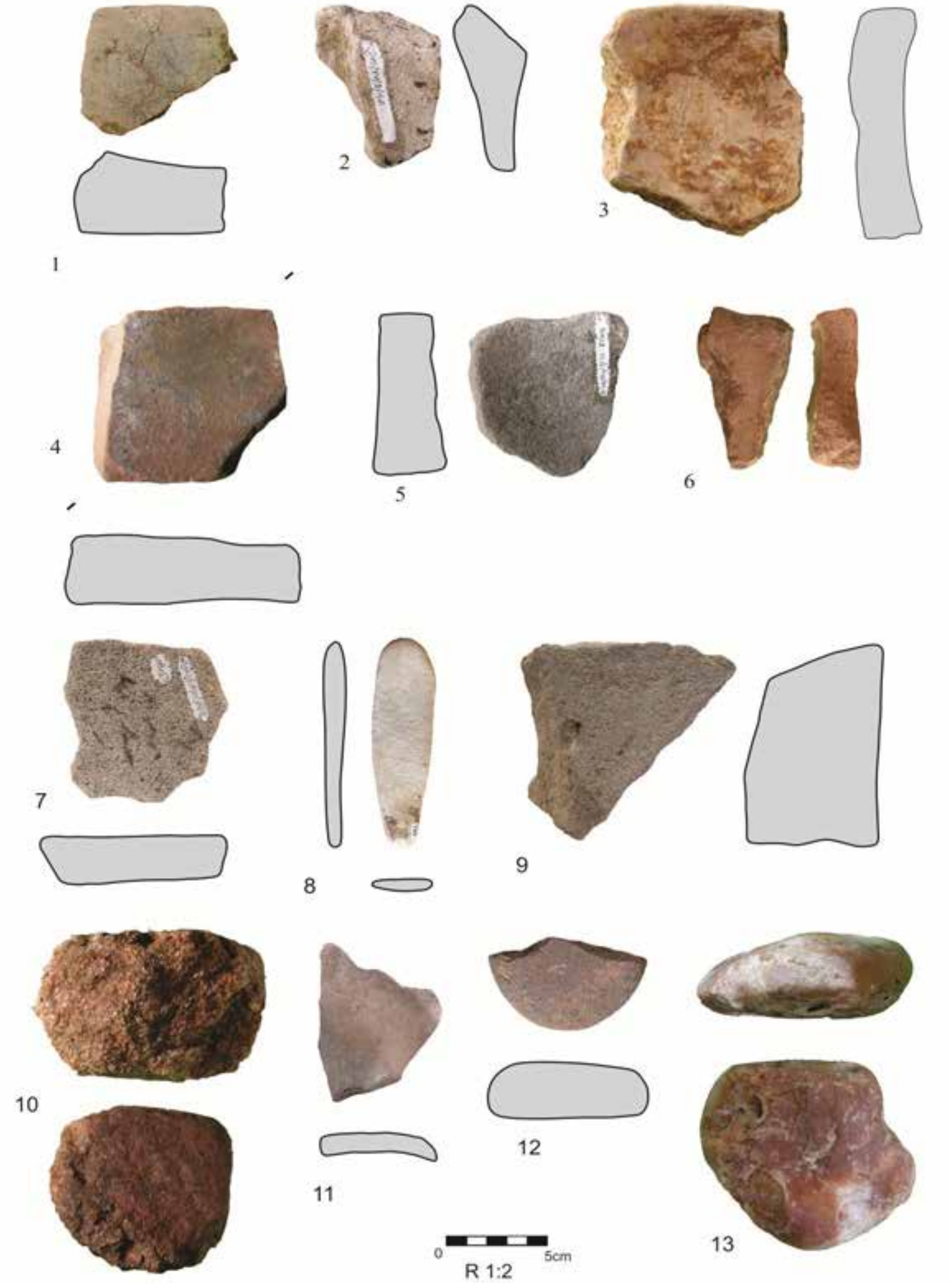

*Fig.6.2.27.***Abraders** *from the Central Balkan Neolithic period according to the identified functional patterns. Pattern 1: 1.Turska česma, Slatina, L-Dr-93; 2. Medjureč, L-Me- 23; 3. Gumnište, L-P-118; 4. Gumnište, L-DR-131; 5. Gumnište, L-P-6; 6. Čelina, L- Če-43; Pattern 2: 7. Turska česma, Slatina, L-DR-2; 8. Tumba Madžari, L-TM-165; 9. Motel Slatina, L-MS-16; 10. Gumnište L-P-199; Pattern 3: 11. Turska česma, Slatina, L-DR-44; 12. Motel Slatina, L-MS-7; 13. Turska česma, Slatina, L-DR-239.*

6.2.2. Abrasive slabs

Fig.6.2.1. Abrasive slabs: L-P -213, sandstone.

Abrasive slabs represent a passive, large tool with traces of abrasion on the obverse and reverse of the artefact (fig. 6.2.1, and 15). In previous studies, these objects are mentioned as stationary grindstones and stationary abraders, which were used mainly in work with hard materials such as stone (Antonović 2003: 59,141; Живанић 2010, table 15, 18, 26, 31).

We have analysed 148 artefacts from the Late Neolithic settlements of Gumnište (n=82) (fig.6.2.15/1-3,5), Turska Česma (n=47) (fig.6.2.15/6, 7,10), Motel Slatina (n=8) (fig.6.2.15/9,11) and Potporanj (n=2). Three fragmented tools were recorded in the Middle Neolithic settlement of Tumba Madžari in the Southern region. Six objects were identified in the Early Neolithic settlement of MeĎureč (fig. 1.15/8,10) in the Central region.

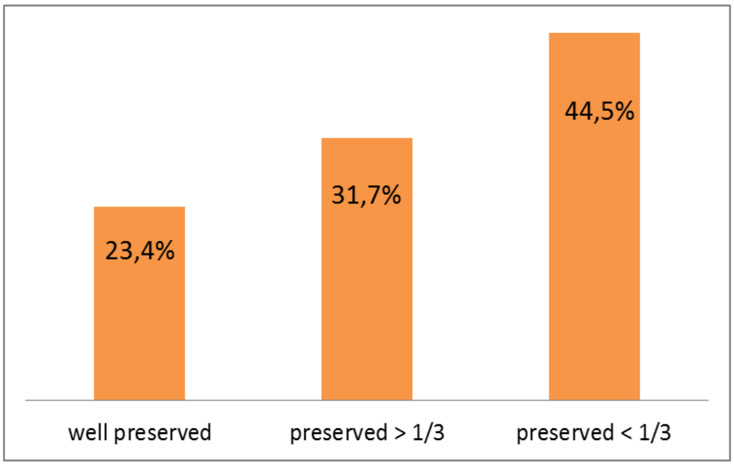

Fig.6.2.2. Abrasive slabs: preservation; N= 148.

The majority of the tools are fragmented and broken, while c. 23% are complete (fig.6.2.2). The correlations between length/weight and width/weight of grinding slabs and abrasive slabs show different patterns (fig. A 3.20-23), whereby abrasive slabs are shorter, narrower, thinner and lighter than the grinding slabs. Differences in use between these two types of artefacts are also indicated by the limited geologal variety of the abrasive slabs, which were mostly manufactured of sandstone. Micro-conglomerate, conglomerate, metamorphic and igneous rocks had minor importance (fig. 6.2.3; subchapter 6.1.1, fig.6.4).

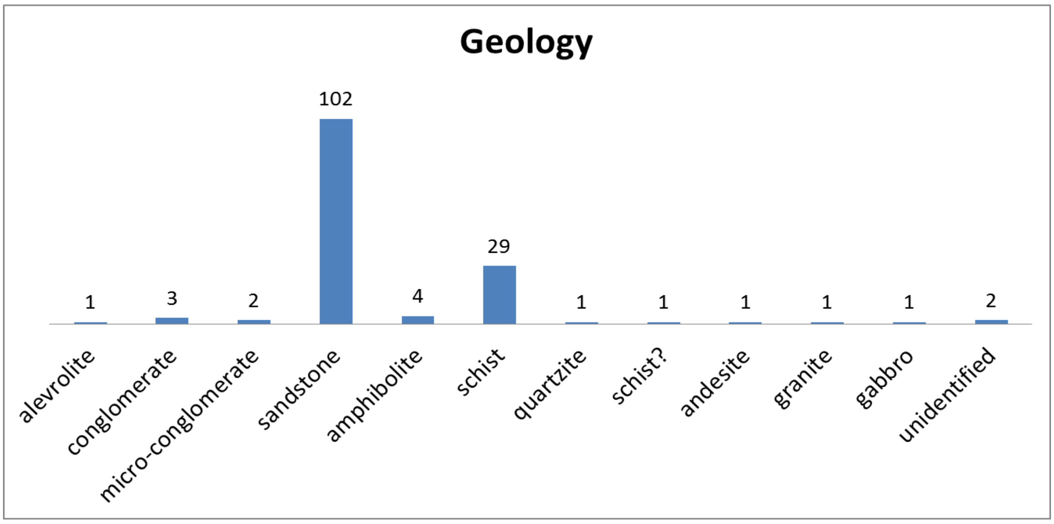

Fig.6.2.3. Abrasive slabs: geology; N= 148.

The objects were shaped mainly by pecking (PK), which has been recorded on 42,3% of all passive sides. Percussion (TR) has been detected on 15,4% of all passive sides (fig. 6.2.15/5,7). A combination of these percussion and manufacturing techniques (TR-PK) has been recorded in 8,3% of the sides (fig. 6.2.15/10). 34% of all examined passive sides reminded unworked (IR).

In the following lines, we describe the artefacts following the methodological steps described in chapter 2.

Geology and size of tools

The analysed abrasive slabs cannot be divided into different morpho-metrical groups based on a correlation between their size and geology. The most frequent sandstone items are short, narrow, thin, light, and elongated in the lateral and transversal sections (table 6.2.1- 4; fig A 3.1-9, 17, 18).

Geology/N	$\bar{X}$	**σ**	**max length (mm)**	**min length (mm)**
amphibolite / 1	-	-	270	-
schist / 8	165	56	218	56
quartzite /1	-	-	176	-
gabbro / 1	-	-	230	-
micro-conglomerate /1	-	-	265	-
sandstone / 23	171	72	370	65

Table 6.2.1. Abrasive slabs: length according to geology; N=35.

Geology/N	$\bar{X}$	σ	Max width (mm)	Min width (mm)
amphibolte / 2	126	50	162	90
conglomerate / 1	-	-	136	-
schist / 12	143	46	274	89
quartzite /1	-	-	105	-
gabbro /1	-	-	142	-
micro-conglomerate /1	-	-	144	-
sandstone / 53	121	39	246	53

Table 6.2.2. Abrasive slabs: the width according to geology; N=73.

Geology/N	$\bar{X}$	σ	Max thickness (mm)	Min thickness (mm)
amphibolte / 2	67	2	69	65
conglomerate / 1	-	-	55	-
schist / 12	61	24	115	30
quartzite /1	-	-	40	-
gabbro /1	-	-	97	-
micro-conglomerate /1	-	-	45	-
sandstone / 53	50	22	157	21

Table 6.2.3. Abrasive slabs: the thickness according to geology; N=73.

Geology/N	$\bar{X}$	σ	Max weight (gr)	Min weight (gr)
amphibolite / 1	-	-	5323,8	-
quartzite /1	-	-	1223,8	-
schist / 8	1989,9	1397	4042,8	238,6
gabbro / 1	-	-	4156,2	-
micro-conglomerate /1	-	-	2889,6	-
sandstone / 22	2725,2	1385,6	13406	497,2

Table 6.2.4.Abrasive slab: the weight according to geology; N=34.

Slabs made of other rocks are similar. Sandstone was the preferred material for some particularly large tools (fig.6.2.4). Our experimental tests suggest that sandstone with silicate cement display good mechanical properties, which is necessary for abrasive activities (subchapter 2.3.2).

Active sides

The active side of the abrasive slabs is usually placed on the obverse of the artefact. Their shape adapts to the shape of the processed surface according to their longitudinal and

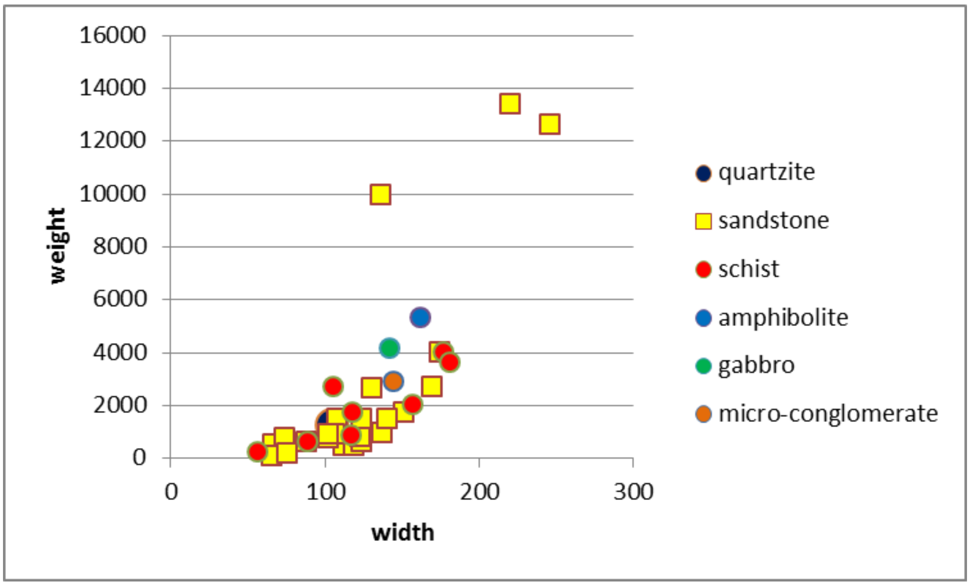

Fig. 6.2.4. Abrasive slabs: correlation between width, weight and geology; sandstone: R^2 =0,3637; shist: R^2 = 0,6161; N= 34.

transversal sections. Three basic varieties can be observed: concave (CV), flat (RT) and convex (CX), and eight subvarieties (CV/CV, RT/RT, CX/CX etc) (fig. 6.2.10). The concave and flat profiles (CV/CV and RT/RT) are most common. The longest, widest, thickest and heaviest tools always present a concave active side (CV) (table 6.2.5 – 8; fig. 6.2.11, A 3.14).

A correlation between the morphology of the active sides and the size of the tools does not show any pattern. The results show regular linear relationships of the objects with flat or concave active sides (CV/CV, RT/RT) (fig. A 3.15 – 18). This means that an increase in the length is related to an increase of the width and weight of these items. Regression coefficients are chiefly on average (fig.A 3.15- 16). The only negative linear relationship results from the correlation between thickness/weight and tools with the flat (RT/RT) working surfaces. This suggests that an increase in weight is related to a decrease in the thickness of these tools. However, the regression coefficient is weak (fig. A 1.18).

Geology/N	$\bar{X}$	**σ**	**max length (mm)**	**min length (mm)**
CV/ 20 (CV/CV, CV/RT)	184,5	69,85	370	65
RT / 14 (RT/RT,RT/CX)	181	60,47	318	117
CX/ 3 (CX/CX,CX/CV,CX/RT)	124,6	21,19	144	102

Table 1.5.Abrasive slabs: length according to morphology; N=37.

Geology/N	**$\bar{X}$**	**σ**	**max width (mm)**	**min width (mm)**
CV/ 20 (CV/CV, CV/RT)	130,8	48,8	274	49
RT / 14 (RT/RT,RT/CX)	108,6	43,96	220	49
CX/ 3 (CX/CX,CX/CV,CX/RT)	118,8	37,45	188	72

Table 6.2.6. Abrasive slabs: width according to morphology; N=83

Geology/N	**$\bar{X}$**	**σ**	**max thickness (mm)**	**min thickness (mm)**
CV/ 20 (CV/CV, CV/RT)	58,3	27,4	157	20
RT / 14 (RT/RT,RT/CX)	48,9	21,84	122	20
CX/ 3 (CX/CX,CX/CV,CX/RT)	48,4	12,7	66	25

Table 6.2.7. Abrasive slabs: thickness according to morphology; N=83

Geology/N	**$\bar{X}$**	**σ**	**max weight (gr)**	**min weight (gr)**
CV/ 20 (CV/CV, CV/RT)	2763,5	3201,79	12654	119,8
RT / 14 (RT/RT,RT/CX)	2428,6	3476,84	13406	238,6
CX/ 3 (CX/CX,CX/CV,CX/RT)	721,8	96,18	814,4	622,4

Table 6.2.8. Abrasive slabs: the thickness according to morphology; N=37

Different functional groups have neither been observed in terms of specific correlations between geology and the size of active surfaces nor between morphology and the size of the active sides (fig. A. 3.19, 20). Observations suggest that the active surfaces of the schist tools (n= 7; mean= 155,4 cm^2) are slightly larger than sandstone objects (n= 22; mean= 111,6 cm^2), while the objects with concave surfaces (CV) show the largest active sides (table 6.2.9). However, none of these differences is significant in statistical terms (t-test).

Geology/N	**$\bar{X}$**	**σ**	max cm^2	min cm^2
CV/ 15 (CV/CV, CV/RT)	181,8	90	314,1	37,7
RT / 12 (RT/RT,RT/CX)	165,1	96,2	350	42,5
CX/ 2 (CX/CV,CX/RT)	159	35,1	184	134,2

Table 6.2.9. Abrasive slabs: the size of the active surfaces according to morphology; N=37

Use traces

Almost all active surfaces present grain levelling (n= 74; 97,3%). Sandstone tools L - P – 16 and L - P – 238 show levelled surfaces associated with pits and shine. Re-pecking of the active surface was recognized on a schist tool L - P – 25.

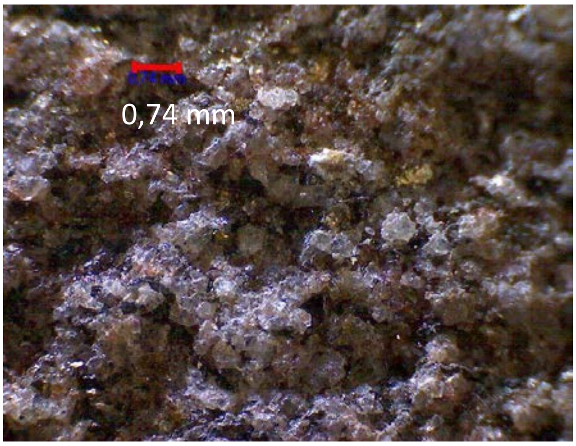

fig. 6.2.11. Abrasive slabs: rounding on high topography, L – P – 1, sandstone.

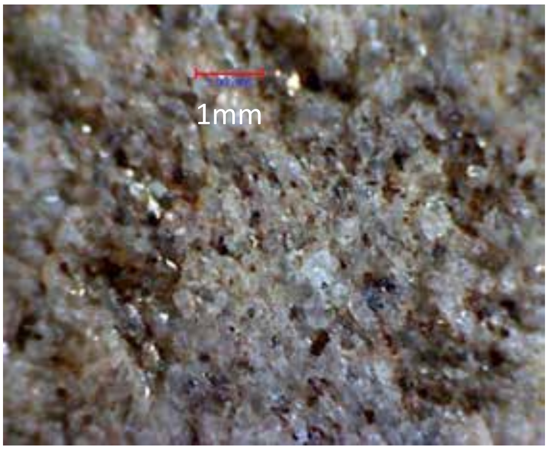

Fig. 6.2.12. Abrasive slabs: levelling, L - Dr – 313, sandstone.

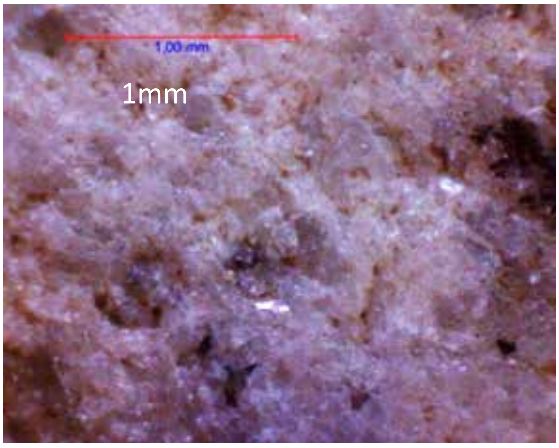

Fig. 6.2.13. Abrasive slabs: frosted like appearance, L - Dr - 399, sandstone.

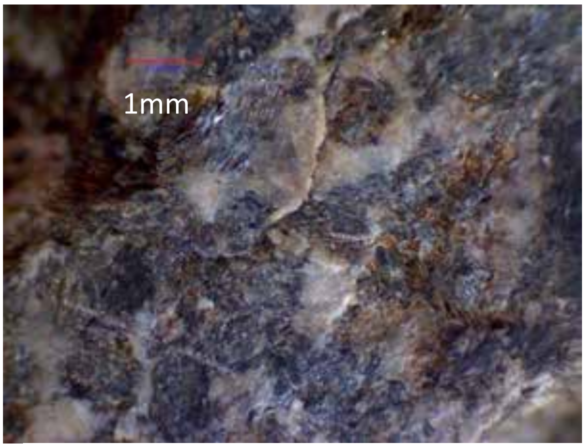

Fig. 6.2.14. Abrasive slabs: levelling, L - Dr – 390, schist.

Under mesoscopical analysis active surfaces show levelling, rounding on high topography accompanied with re-pecking pits, and frosted like appearance (fig. 6.2.11-13). Levelling with no rounding can be associated with disordered micro-scratches (fig. 6.2.14). These results indicate that abrasive slabs were used in processing hard material such as stone and medium-to-hard materials such as wood and bones.

Summary

Our study of the macro-lithic tools in the Neolithic economy of the Central Balkans involved 148 abrasive slabs. These large tools were mainly made of sandstone and used to shape objects by abrasion. The selection of raw materials seems to have been guided by the high abrasive capacity of rocks with quartzite grains and /or silicate cement (subchapter 2.3.2) contained in the rocks. The analysis also confirms that these abrasive slabs are shorter, narrower, thinner and lighter than grinding slabs.

The active surfaces of abrasive slabs tend to be concave or flat in their longitudinal and transversal profiles, suggesting that mainly convex and flat forms of objects were shaped. Mesoscopical observations of the working surfaces show changes, which indicate work on hard and medium to hard materials such as wood, bone and stone. However, the results do not show any functional patterns based on the combined analysis of raw material, metrical values, morphology of their working surfaces and use-wear.

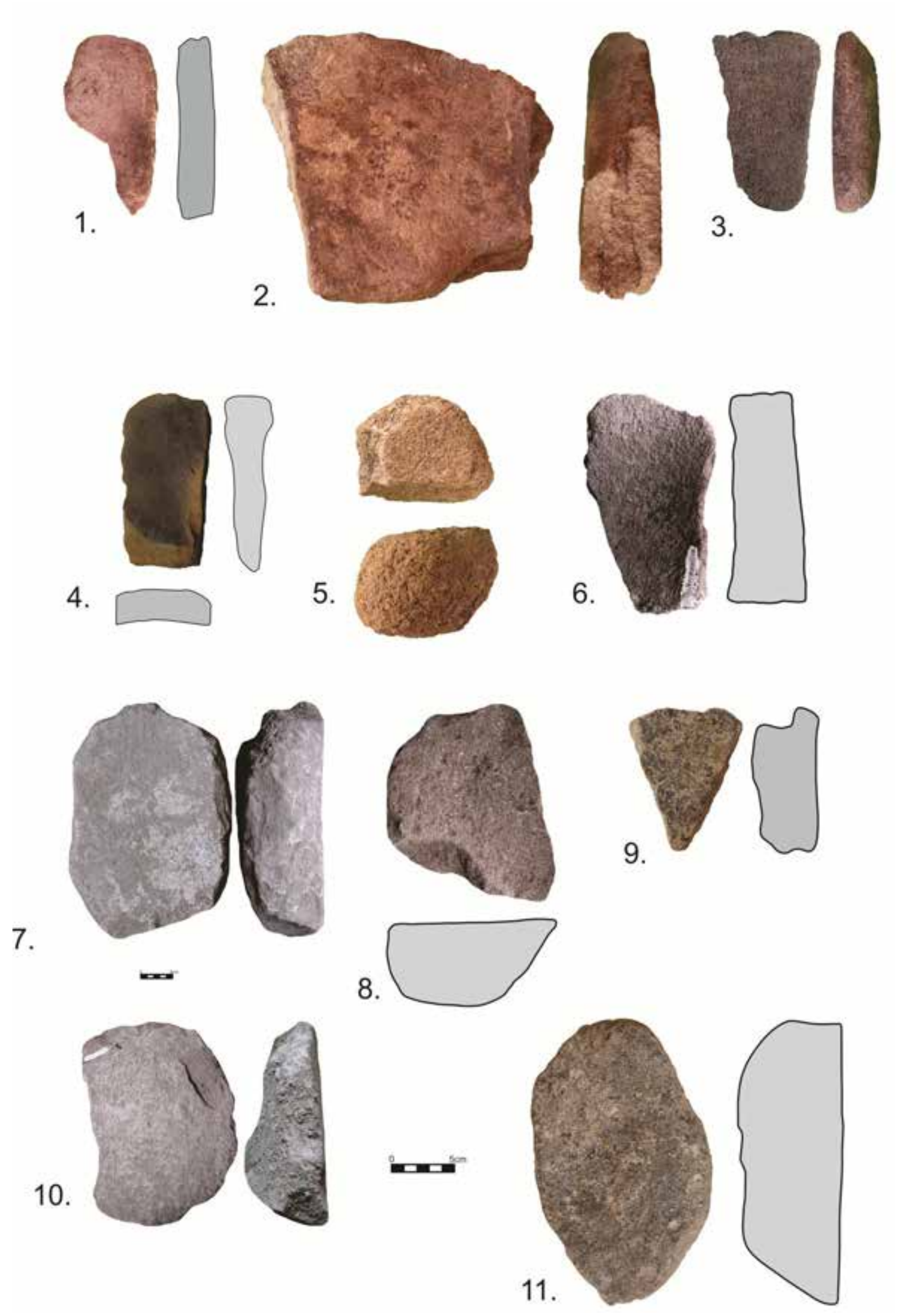

Fig. 6.2.15. Abrasive slabs: 1. L-P- 225; 2. L-P- 18; 3.L-P-165; 4. L-Dr- 221, Turska česma, Slatina;5. L-P- 178 Gumnište;6. L-Dr- 12; 7. L-Dr- 339; 8. L-MS- 112, Motel Slatina; 9 L-Me- 4, Medjureč; 10. L-Dr- 400, Turska česma, Slatina; 11. L-MS-139, Motel Slatina; R1:2: 1- 6, 8,9,1; R1:4:7,10.

6.3. Polished edge tools

6.3.1. Axes

This type of artefact is characterized by the symmetrical position of the working edge in relation to the axis of the longitudinal section of the object (fig. 6.3.1, 24). This technical feature allows axes to work under different angles and perform a variety of activities such as cutting, chopping, scarping and shaping other objects. Thus, they are labelled as a universal cutting tool, which can be used to work on wood, bone, clay. This artefact is characterized by oblique micro-scratches positioned on the working edge. Previous literature has distinguished axes under the same term (Antonović 2003: 54; Живанић 2010).

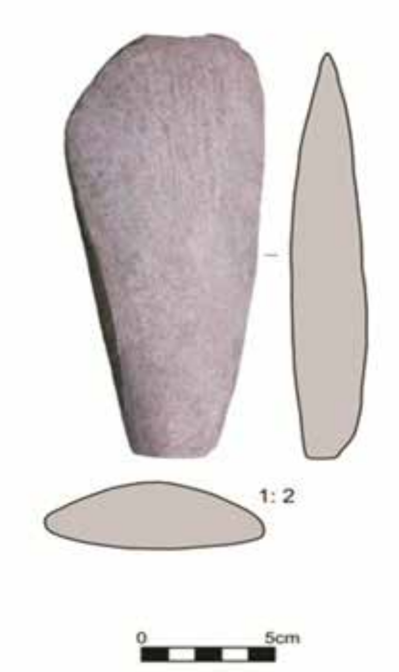

Fig. 6.3.1. Axes: L-MS – 185, sandstone.

The present study has been done on 132 artefacts. These tools are mainly from the Late Neolithic settlements of Benska bara (n=42) (fig. 6.3.20/7,11), At (n=4) and Potporanj (n= 8) in the Northern region, Turska česma, Slatina (n= 6) (fig. 6.3.1; fig. 6.3.20/4), Motel Slatina (n= 9) (fig. 6.3.20/1-3) in the Central region, Čelina (n=2), Vranjani (n=1) and Kremenilo (n=16) (fig. 6.3.20/6) in the Western region as well as in Gumnište (n= 9) (fig. 6.3.20/5,8) in the Southern region. This tool type has also been found in the Middle Neolithic settlement of Tumba Madžari (n=23) (fig. 6.3.20/9,10) and the Early Neolithic horizons of MeĎureč (n= 3), in the Central region and Kremenilo (n=9), in the Western region.

C. 59% of all the tools are well preserved or complete, while c. 40% are broken and fragmented (fig. 6.3.2). The relatively high

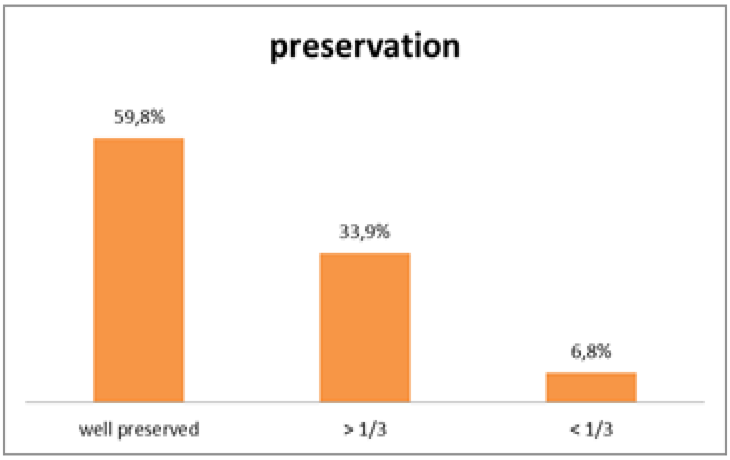

Fig. 6.3.2. Axes: preservation ; N= 132.

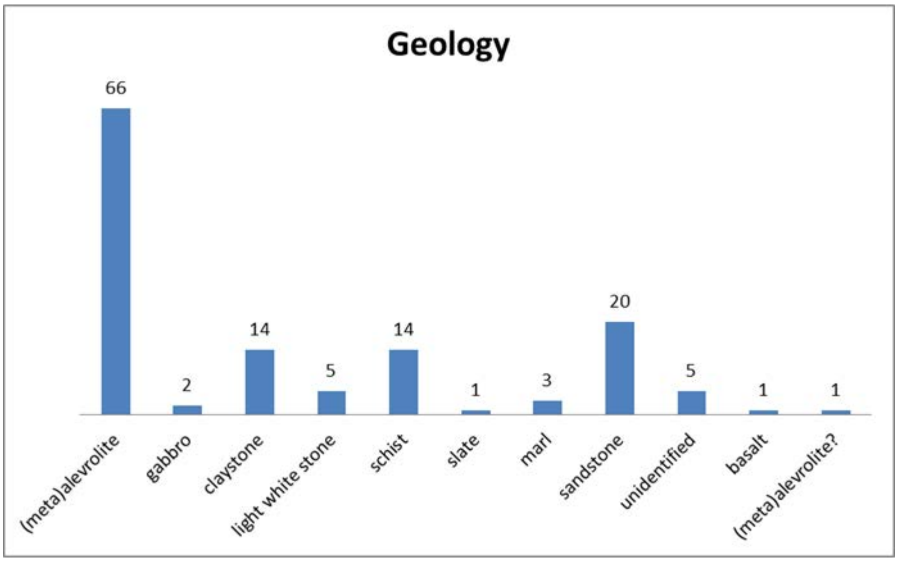

Fig. 6.3.3. Axes: geology ; N= 132.

percentage of complete objects provides enough data in order to study this type of artefact. This also indicates good maintenance and careful handling of tools.

The majority of axeheads were made of (meta)alevrolite, while, schist, gabbro, basalt, slate and marl have minor importance (fig.6.3.3).

47,6 % of all analyzed passive sides are polished. Traces of flaking are visible on 31,1%, while retouching is revealed on 5,8% of all passive sides. 6 % of all passive sides show flaking combined with retouching. As unworked passive surfaces have been detected in only 1,4%, suggesting that we are dealing with primary sources, such in the case of a tool L-BB- 39 from Benska bara (fig. 6.3.20). Sawing has been observed on a (meta)alevrolite tool L - PO- 130.

Geology and size of the tools

Neolithic axes from the Central Balkans are small (mean of size= 76 x 38 x 18 mm; mean of weight= 98,8 gr), while the objects longer than 140 mm, which could be associated with more symbolic meaning, are rare. Correlations between the length/weight and geology might indicate low relations in the case of (meta)alevrolite, sandstone and light white stone. It means that of the increase in the length is related to the increase in the weight (fig. 6.3.4). Width and thickness are related to the increase in the weight in some rock types (fig. A 4.7–11). The

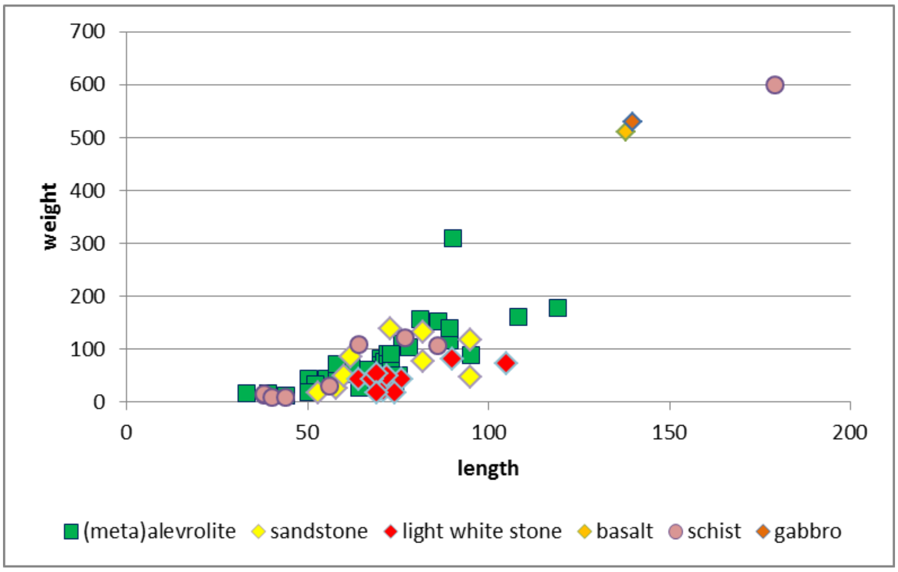

Fig. 6.3.4. Axes: correlation between length, weight and geology; (meta)alevrolite: R^2=0,4236; light white stone R^2=0,1942; sandstone: R^2=0,242; N= 67.

regression coefficients vary from very weak to strong, such in the case of sandstone tools. An exception is the relation width/thickness of the tools made of light white stone suggesting a negative linear relationship (A 4.7-11). This means that an increase in the thickness is related to the decrease in the width (fig. A 4.11).

The size of the axes varies slightly according to geology. Igneous rock (basalt and gabbro) were selected for very long, wide, thick and heavy tools (table 6.3.1 – 4). However, this conclusion should be taken with caution due to the small number of tools made of this rock type (n=3).

The results show that schist tools are mainly short, narrow, thin and light, while the light white stone objects are mainly wide and thin. The sandstone tools are chiefly narrow and thick (fig.A 4.1-4). All the tools are elongated in the lateral and transversal sections (fig. A 4.5-6).

geology/N	$\bar{X}$	σ	max length (mm)	min length (mm)
(meta)alevrolite / 36	70	18	119	33
igneous rocks / 2	139	1	140	138
light white stone / 10	72	6	90	64
schist / 10	69	44	179	38
sandstone / 9	73	15	95	53

Table 6.3.1. Axes: length according to geology; N= 67.

geology/N	$\bar{X}$	σ	max width (mm)	min width (mm)
(meta)alevrolite / 60	33	11	72	12
igneous rocks / 3	46	5	53	43
light white stone / 19	39	11	68	21
schist / 15	32	14	61	14
sandstone / 19	44	16	79	19

Table 6.3.2. Axes: width according to geology; N= 116.

geology/N	$\bar{X}$	σ	max thickness (mm)	min thickness (mm)
(meta)alevrolite / 60	18	5	35	7
igneous rocks / 3	33	6	38	26
light white stone / 19	18	6	31	6
schist / 15	15	7	33	6
sandstone / 19	19	9	50	7

Table 6.3.3. Axes: thickness according to geology; N= 116.

geology/N	$\bar{X}$	σ	max weight (gr)	min weight (gr)
(meta)alevrolite / 36	80	58	310,8	12,4
igneous rocks / 2	520	13	530	510,4
light white stone / 10	39	19	80,8	16,2
schist / 21	112,6	188	599,2	8,2
sandstone / 9	76	44	139	18,2

Table 6.3.4. Axes: weight according to geology; N= 67.

Morphology of the active surfaces

The cutting edges show mainly convex or straight (CX/AG or RT/AG) shapes. This suggests that working edges (AG) are still operative, while irregular forms (CX/CX, IR/AG, IR/CX, and IR/IR) suggest very worn working edges (fig. 6.3.9).

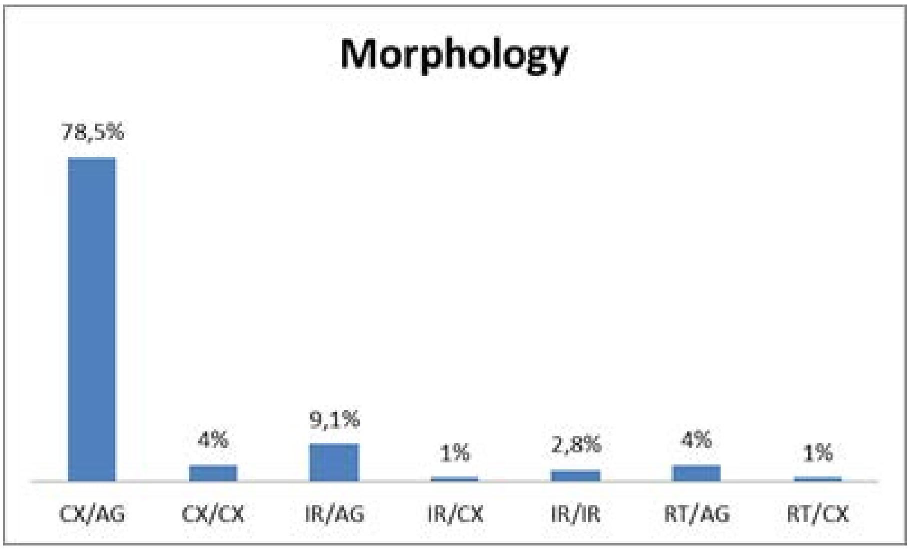

Fig.6.3.9. Axes: morphology; N= 70.

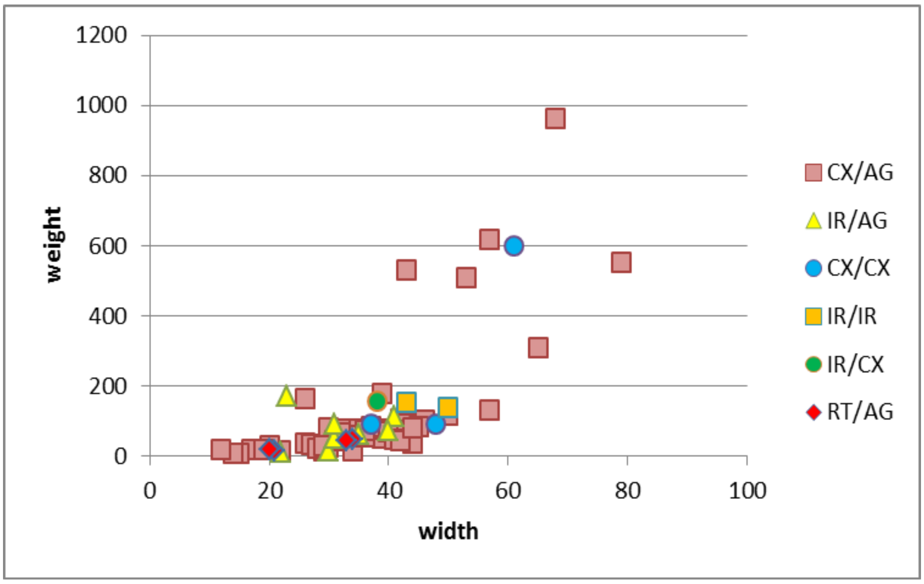

Fig. 6.3.10. Axes: correlation between width, weight and morphology; CX/AG: R^2=0,3089; N= 67.

Sandstone tools have the longest working edge (table A.4.1). No pattern has neither been observed in terms of specific a correlations between the morphology of the cutting edge and the size of the tools (fig. A 4.12- 15).

A specific function has not been also identified based on a correlation between the size of the tools geology and the length of cutting edge (fig. A.4.16 – 19).

(Meta)alevrolite and sandstone tools show regular linear relationships based on correlations between the length of the working edge and the length, width, and weight of the artefacts. This indicates that an increase in the length of their cutting edge is related to an increase in the width and weight of the items. The regression coefficients vary between very weak and strong (fig. A 4.12 – 15; fig. A 4.16-19).

Use-wear traces

The cutting edges of the axes reveal mainly traces of percussion, which are dominated by flake negatives (NO). Working edges can also display micro-scratches (MSC), micro-scratches associated with flake negatives (NO-MSC) and micro-flake negatives (MNO-MSC). The record also displays cutting edges with no alternation (FL), and rarely micro-pits (MGA) (fig. 6.3.11).

No axe functional groups merge out of a correlation between the size of the tools and use traces nor between the size of the artefacts, their geology and use traces (fig.6.3.12; fig.

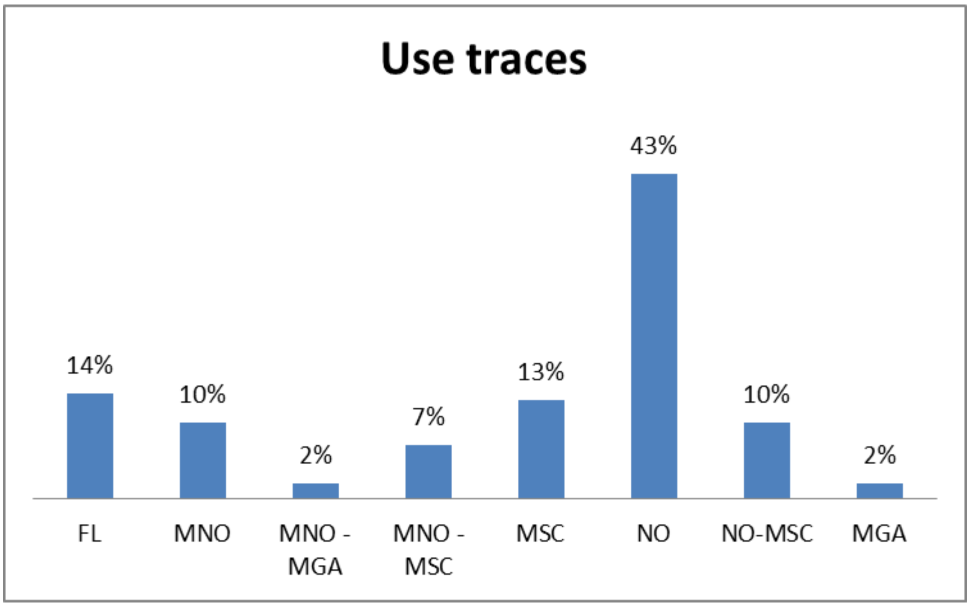

Fig. 6.3.11. Axes: use traces; N=100.

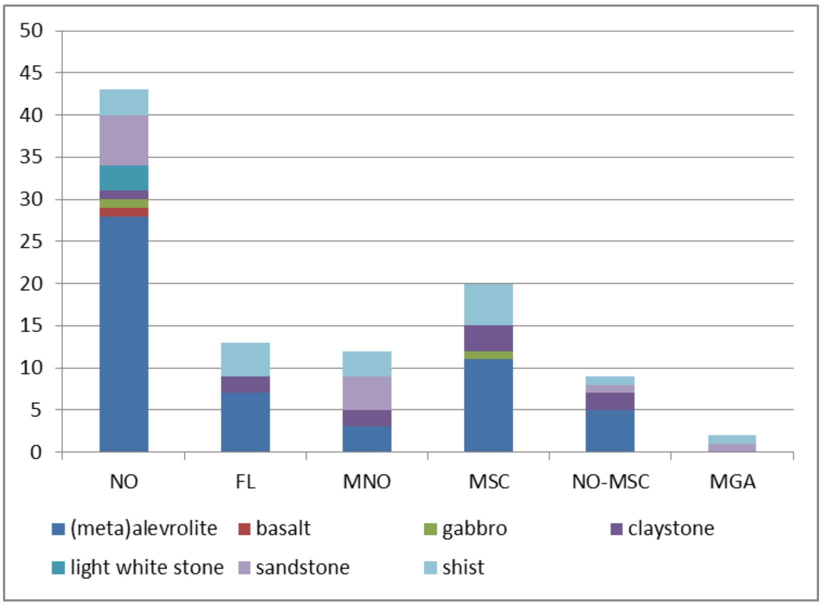

Fig. 6.3.12. Axes: use traces and geology; N=99.

A. 4.20. – 23; table 6.3.11,12). The correlation between the length/weight, width/weight, thickness/weight and the length/thickness, in the case of tools presenting flake negatives (NO), micro-scratches (MSC), flake negatives-micro-scratches (NO-MSC), working edge without use traces (FL), and micro-flake negatives (MNO) indicate regular linear relationship. This means that an increase in the length, width and thickness are related to an increase in the weight of the items, independently of the type of use-wear traces or damage observed on the ground edges. The regression coefficients vary from weak to strong (fig. A 4.20- 23).

No functional group has been identified based on a correlation between the length of the working edge and the size of the tools and use traces (fig. A 4.25-29).

It has only been observed that the working edges with no use-wear traces (FL) are the longest (table A 1.2), confirming that these tools are still at the beginning of their use life. However, this conclusion should be taken with consideration due to the small number of these tools (n=3) (table A 4.2).

The results show that the tools with flake negatives (NO) are the longest, widest and heaviest, while the tools with flake negatives (NO) associated with micro-scratches (NO-MSC) are the thickest (table 6.3.7 – 10). This suggests that the thick artefacts were implоyed in fine work, maybe wood or bone. The heavy, long and wide objects show evidence of percussion, indicating cutting, crushing or chopping.

Use traces /N	$\bar{X}$	σ	length max (mm)	length min (mm)
FL/9	61	23	90	33
MNO /10	68	15	95	40
MSC / 13	81	35	179	44
NO /30	86	39	204	39
NO-MSC / 6	69	11	89	58

Table 6.3.7. Axes: use traces according to length; N= 68.

Use traces /N	$\bar{X}$	σ	width max (mm)	width min (mm)
FL/12	33	16	65	12
MGA / 1	-	-	42	-
MNO /11	30	9	43	15
MSC / 20	35	11	61	14
NO /40	40	13	79	17

Table 6.3.8. Axes: use traces according to width; N= 93.

Use traces /N	$\bar{X}$	σ	thickness max (mm)	thickness min (mm)
FL/12	16	8	35	8
MGA / 1	-	-	20	-
MNO /11	15	8	31	7
MSC / 20	16	6	33	6
NO /40	19	9	50	6
NO-MSC / 9	19	4	28	14

Table 6.3.9. Axes: use traces according to thickness; N= 93

Use traces /N	$\bar{X}$	σ	weight max (mm)	weight min (mm)
FL/9	77,4	101,4	310,8	13,8
MNO /10	54,4	45	158,4	8,2
MSC / 13	110,3	155	599,2	9,2
NO /30	164,2	227	962,6	12,4
NO-MSC / 6	71,8	36	139,4	43

Table 6.3.10. Axes: use traces according to weight; N= 68.

Mesoscopically, working edge presents oblique micro-scratches (MSC) as on a tool L- TM – 24 (fig. 6.3.13). These scratches can be shallow and barely visible, such in the case of tool L – Kr – 29 (fig. 6.3.14). The working edge can show this type of use traces associated with flake negatives (NO-MSC) (fig. 6.3.15), with no edge rounding (fig. 6.3.16), or with edge rounding as in the case of an object L-AT- 6 (fig. 6.3.17).

Tool L – V – 8 presents a faceted working edge.

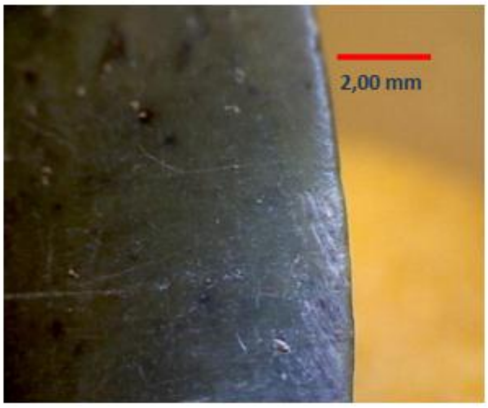

Fig. 6.3.13. Axes: micro-scratches (MSC), L – TM – 24, (meta)alevtolite.

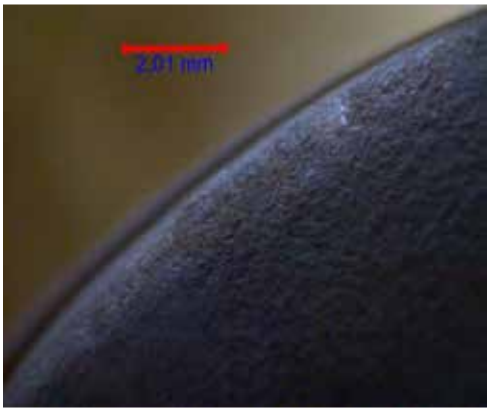

Fig. 6.3.14. Axes: micro-scratches (MSC), L – Kr – 29, (meta)alevtolite.

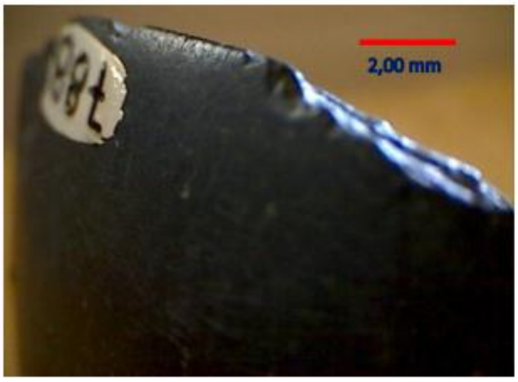

Fig.6.3.15. Axes: micro-scratches and flake negatives (NO-MSC), L – TM – 22, (meta)alevtolite.

Fig. 6.3.16. Axes: flake negatives (NO), L – PO – 57, (meta)alevtolite.

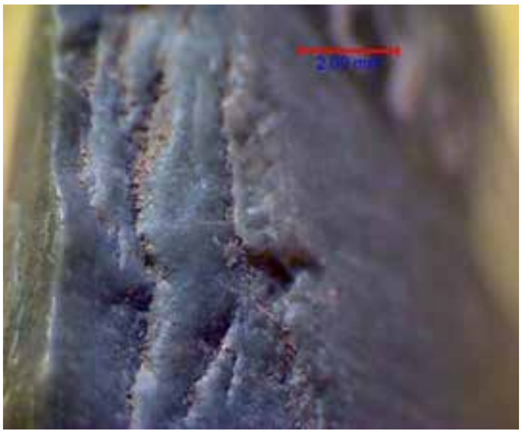

fig. 6.3.17. Axes: stepped fracutres (NO), L – AT - 6, (meta)alevrolite.

fig. 6.3.18. Axes: blunted cutting edge, L – V – 8, (meta)alevrolite.

An appearance of micro-scratches (MSC) and micro-flake negatives (MNO) and edge roundings indicates fine, maybe work with medium to hard materials such as wood or bone. Although micro-scratches can suggest scrapping of clay items, as it has been shown in our experimental program (subchapter 2.3.1). Cutting or chopping has been documented by flake negatives (NO) while blunting of the working edge suggests great bit angle and the durability of raw material of which the axe was made of (Hampton 1999, 68, fig. 2.6).

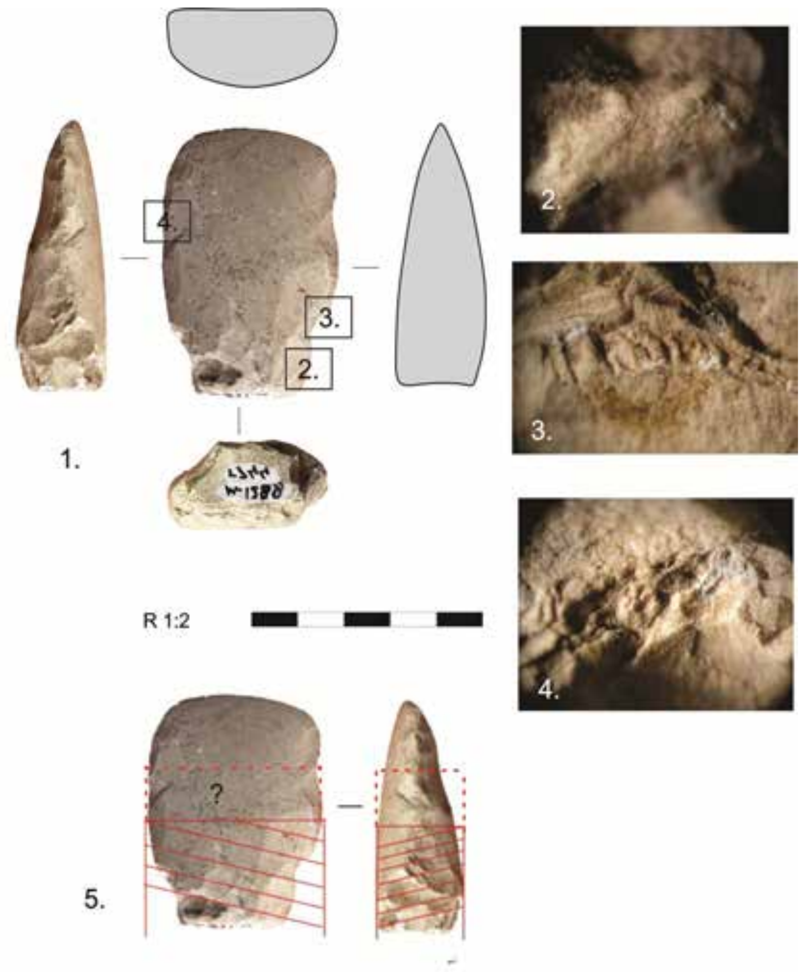

Fig. 6.3.19. Ideal reconstruction of the lenght of a tool inserted into handle; 1. L - MS – 59.

Longitudinal sides of Middle Neolithic object L – TM – 86 and the right side of fragmented tool L - TM – 24 display U sectioned, polished grooves, with one open end (fig.6.3.20/10).

Dimensions of the feature of the first item are 69 x 10 mm. The grooved polished edge tools have been also recognized at the Neolithic settlements of Anza Ia (the Early Neolithic) and Anza IV (the Middle Neolithic) at Macedonia, Divostin in Serbia as well as at the Neolithic settlement of Mondsee in Austria (cf. Gimbutas 1974: 51; Reiter 2013: Abb.77, 85). It is assumed that grooves on the lateral sides of the polished edge tools could be connected with a hafting device (cf. Gimbutas 1974: 51; cf. Smoor 1976: Fig.110, 3; fig 115,3; 181).

Ten axes made of various rock types show traces of handling. These objects are between 60 to 138 mm long, 30 to 53 mm wide, 13 to 38 mm thick and between 49,2 to 510,4 g heavy.

Their working edges present various use traces such as flake negatives (NO), micro-scratches (MSC) and micro pits (MGA).

Distribution of wear traces allows reconstruction of the length at which a tool was inserted into the handle. According to this, it seems that between 1/3 to 2/3 of the length of tool L - MS – 59 (fig. 6.3.19/5) was inserted into the handle. Passive surfaces present grain rounding (fig. 6.3.19/4), which might be a consequence of the impact of soft parts of the handle such as rope which tied additionally the tool and handle. The lateral and bottom sides were narrowed by flaking and retouching, and grain rounding (fig. 6.3.19/4) and rounding on high topography confirm contact with a handle (fig. 6.3.19/ 2 -3).

The analysis of the axes from the Central Balkans has not shown any pattern through different Neolithic periods and correlations between the size of the tools, geology, morphology of the working edge and use traces. Schist tools from the Middle Neolithic settlement of Tumba Madžari, Southern region present only one regional difference, as this geology presents unusual raw material for the rest of the study area.

Summary

The study of 132 Neolithic axes from the Central Balkans has been undertaken to define their main characteristics. These tools were mainly made of (meta)alevrolite and different sedimentary rocks. This selection was related to the mechanical properties of the rocks and their accessibility in the territory. Given its composition and texture (see chapter 5.1.), (meta)alevrolite and the different sedimentary rocks allow easy shaping, re-sharpening or re-shaping of these tools. However, the resistance of these materials to impact seems to have been limited, especially in the case of the sedimentary rocks. (Meta)alevrolite clearly seems to have been the best material available in the Central Balkans and was widely circulated throughout the region. However, its limited mechanical properties or access to resources seem to explain generally only small axes were manufactured. The analysis of the passive sides indicates the method of manufacturing and handling. Flaking, retouching as well as retouching combined with flaking brought the tools to their final shape. Finally, grinding to smooth surfaces was implemented to remove flake scars. Ten polished edge tools, various in size, revealed traces of handling. Grooves on the lateral sides of tools narrowed and notched bottom and passive sides, grain rounding on passive sides is evidence of different methods used for this purpose.

The convex active edge is common, suggesting still operative artefacts. Cutting, chopping and scarping produced a variety of use traces, among which flake negatives (NO) are frequent. Analysis suggests that axes were implemented mainly in work in medium to hard materials such as wood or bone, although processing of clay objects has been also observed.

The analysis of geological, metrical, morphological characteristics of the working edge, and of the use traces does not allow to distinguished different types of functional groups of axes. Schist artefacts from the Middle Neolithic settlement of Tumba Madžari present the only one specifity, as an occurrence of schist was atypical for the rest of the studied area.

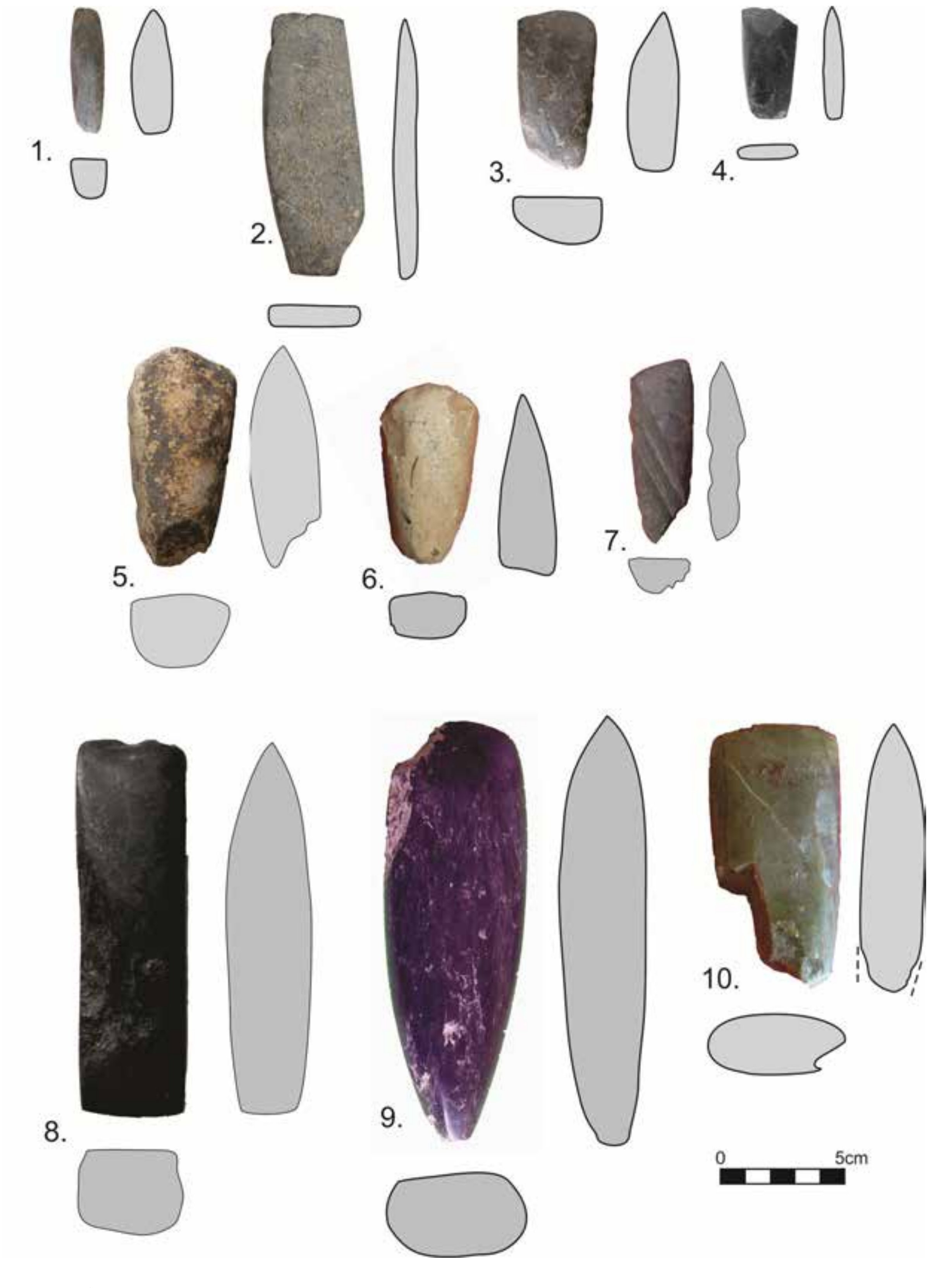

Fig. 6.3.20., 1. L-MS-22; 2. L-MS-25; 3. L-MS-23, Motel Slatina; 4. L-Dr- 171, Turska česma,Slatina; 5. L-P- 310; 8. L-P-301, Gumnište; 6. L-Kr-101; Kremenilo;7. L-BB- 39, Benska bara; 9. L-TM-11, 10.L-TM-24, Tumba Madžari.

6.3.2. Celts

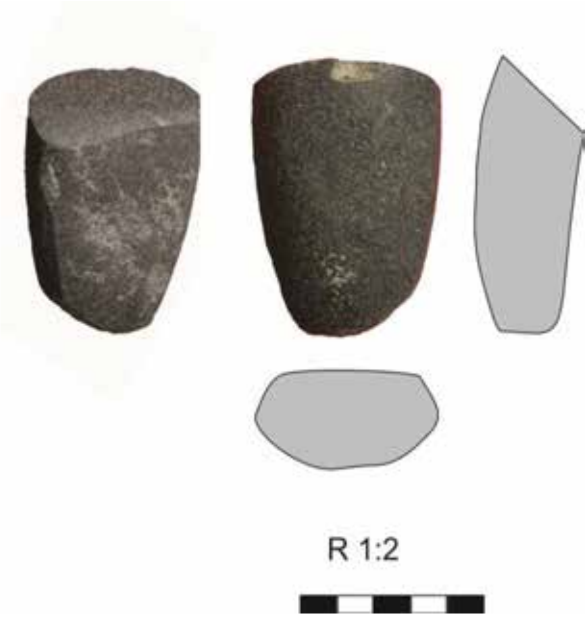

Fig. 6.3.21. Celt: L – TM – 131, Tumba Madžari, Southern region, gabbro.

A celt is related to an artefact, with the cutting edge sets above the axis of the longitudinal cross-section of a tool (fig. 6.3.21, 37). We assume that this feature determines the function, according to which the celts were used chiefly in shaping an object by removing layers of material and probably for chopping, smoothing or deepening the previously processed surface. In previous studies, celts have been classified as adzes due to the asymmetrical position of the working edge and perpendicular position of the tool towards the handle (Semenov 1964; Antonović 2003). However, they have been distinguished as a specific type of adzes classified as Duff Type 4 in a study on Maori adzes from New Zealand, and as *Flachhacke* and *Schuhleistenkeil* adze in german literature (Turner 2000: 185, fig.3.53; cf. Elburg et al. 2013). An experimental examination of a celt replica confirmed that these artefacts were quite suitable for fine woodworking (Elburg et al: 2013).[1] Nowadays, this item has been recognized as a metal part of a complex carpenter celt (jointer planer) used also for fine woodwork (fig.6.2.22; Mulligan, Lippit 2014: 22,23,67).

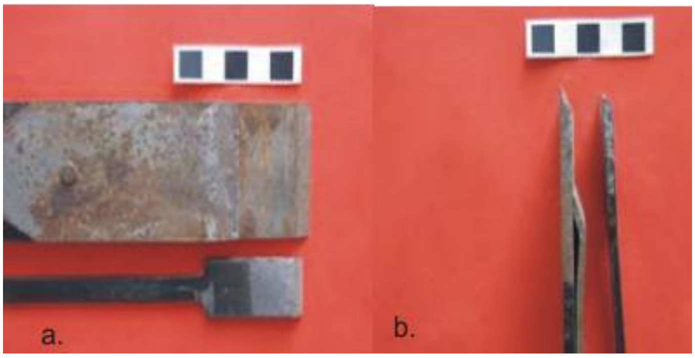

Fig.6.3.22. Celt: metal blade of the carpetner jointer planer: a.ortogonal projection; b.transversal projection.

Our study includes 145 celts. Most of the artefacts have been recorded in the Late Neolithic settlements of Benska bara (n=41) (fig. 6.3.31/9,11,12,16), At (n= 1) and

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[1] https://exarc.net/issue-2015-2/ea/field-trials-neolithic-woodworking-relearning-use-early-neolithic-stone-adzes; https://www.academia.edu/9961363/Woodworking_With_a_Stone_Adze

Potporanj (n= 2) (fig. 6.3.31/15) in the Northern region, Turska česma (n= 6) (fig. 6.3.31/13), Motel Slatina (n=7) (fig. 6.3.31/1) in the Central region, Kremenilo (n=5) (fig. 6.3.31/2,6) and Koraća Han (n=9) in the Western region and Gumnište (n = 10) (fig. 6.3.31/14) in the Southern region. The celts have also been found in the Middle Neolithic settlement of Tumba Madžari, in the Southern region (n = 54) (fig. 6.3.31/4, 7, 8, 10) and the Early Neolithic horizons of Međureč (n = 4) (fig. 6.3.31/3, 5) in the Central region and Kremenilo (n=2) in the Western region. Eleven samples originate from the disturbed Neolithic layers from the settlement at the site of Kremenilo in the Western region.

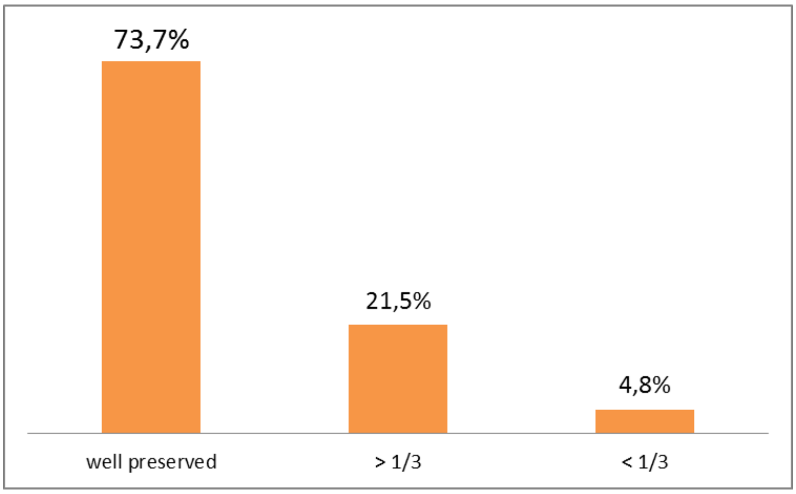


Fig. 6.3.23. Celts: preservation; N=145.

C. 73% of all the studied tools are complete and in that sense, they can provide sufficient data for further analysis. C. 26% of the objects are broken and fragmented (fig. 6.3.23). The high preservation of the artefacts indicates very good maintenance and careful use.

The majority of celts were made of (meta)alevrolite, while schist, sandstone, claystone, and white light stone occurred as well. Basalt, schist serpentinite and gabbro are of minor importance (fig. 6.3.24).

64% of all analysed passive sides display the polished surface. 28% of the passive

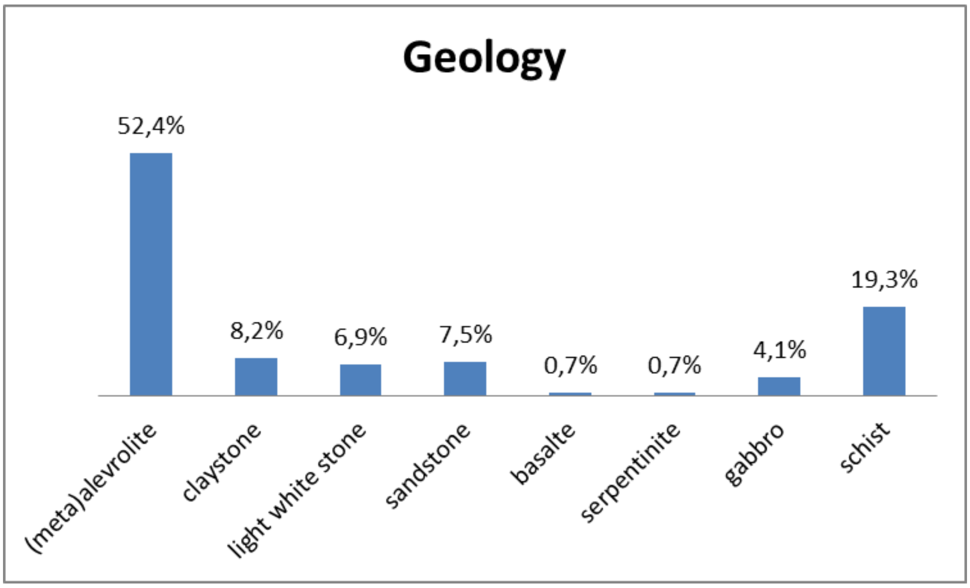


Fig.6.3.24. Celts: geology; N=145.

sides show traces of flaking, and retouching is visible on 4,5 % of all passive sides. Flaking combined with retouching has been detected on 1,2 % of all passive sides. Natural surfaces (IR) of (meta)alevrolite cobblestones and pecking have been detected on some 0,3% and 1,4% of all passive surfaces.

In the lines below, we focus on data provided by quantitative and qualitative analysis of this type of artefact.

Geology and size of the tools

A correlation between the measurements and geology does not reveal any typological or functional differences among the celts. Although the correlations between the length/weight length/width, width/weight, and thickness/weight, and geology display regular relations in the case of (meta)alevrolite and schist. It means that the increase in the length, width, and thickness is related to the increase in the weight. Length is related to the increase in the width. The regression coefficients vary from very weak to strong. (fig. A 4.36 - 40). Although, the correlation between and length/weight, length/width and claystone indicate a negative linear relationship. This suggests that the increase in the length is related to the decrease in the width and weight. The regression coefficients are not strong (fig. A 4.36 - 37).

geology/N	$\bar{X}$	**σ**	**max width (mm)**	**min width (mm)**
(meta)alevrolite / 65	35	9	59	16
igneous rocks / 7	38	8	45	20
light white stone / 20	41	13	63	12
schist / 28	31	10	51	11
sandstone / 11	41	13	64	18

Table 6.3.11. Celt: length according to geology; N= 104.

geology/N	$\bar{X}$	**σ**	**Max length (mm)**	**Min length (mm)**
(meta)alevrolite / 55	66	15	111	37
igneous rocks / 5	77	5	88	74
light white stone / 16	74	20	131	50
schist / 22	55	18	96	29
sandstone / 6	72	28	121	32

Table 6.3.12. Celt: width according to geology; N= 131.

Regardless of geology, the average size of objects is similar (table 6.3.11 -1.14). The schist objects are the shortest, narrowest and thinnest, while the igneous objects are the heaviest (table 6.3.11-14).

(Meta)alevrolite and schist tools are mainly short. Regardless of geology, the objects are narrow and thin (fig. A 4.31- 33). The tools are elongated in lateral and transversal sections (fig. A 4.34 - 36).

Furthermore, the morphology of the cutting edge of a (meta)alevrolite tool L-PO-16 might suggest generating of the working surface characteristic for re-used polished edge tools (fig. 6.3.31/14).

geology/N	$\bar{X}$	σ	max thickness (mm)	min thickness (mm)
(meta)alevrolite / 65	16	4	31	8
igneous rocks / 7	18	7	27	7
light white stone / 20	19	6	36	9
schist / 28	13	5	24	6
sandstone / 11	19	5	27	13

Table 6.3.13. Celt: thickness according to geology; N= 131.

geology/N	$\bar{X}$	σ	max weight (g)	min weight (g)
(meta)alevrolite / 52	64	37	189,2	15,2
igneous rocks / 5	117,8	45	160	69,6
light white stone / 17	65	50	223,8	12
schist / 20	60,6	51	169	4,8
sandstone / 6	80,1	55	182,8	11

Table 6.3.14. Celt: weight according to geology; N= 100.

Working edges

Morphology of the working edges shows limited varieties: the convex (CX/AG) working edge as the most numerous and irregular (IR/AG, IR/CX, and IR/IR) active edges. This shape presents the working edge affected heavily by use.

No pattern has been detected based on the correlation between the size of the tools and the morphology of the working surfaces (fig. A4.41 – 44). A correlation between the length of the working edge, the size of the tools and geology does not also suggest specific use of the celts. These relations show the regular linear relationships, suggesting that the increase in the length of the working edge is related to the increase in the size of the tools. The regression coefficients vary from weak to very strong (fig. A4.45- 48).

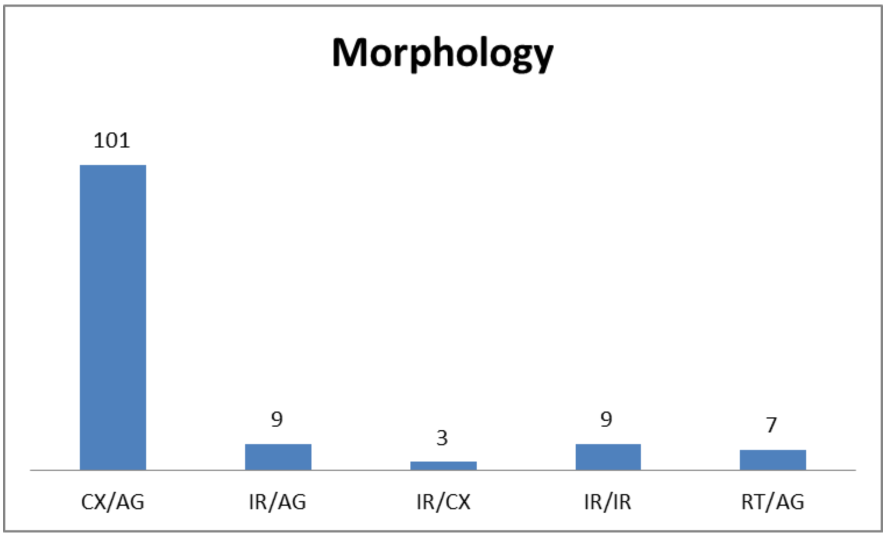


Fig. 6.3.25. Celts: morphology; N= 129.

Use wear traces

A variety of use-wear traces has been observed on the cutting edges. The majority is flake negatives (NO), while flake negatives combined with micro-scratches (NO-MSC), micro – flake negatives (MNO), shine (NO-MSC-SH) and levelled surfaces (AL) have been detected as well, suggesting smoothing of the processed surface (fig. 6.3.26).

However, correlations between the geology and use traces and size of the tools do not show any pattern (fig. 6.3.27; A.4.49-53). The relations length/weight, length/width, length/thickness, width/weight, thickness/weight as well as width/thickness and the tools with most of the types of use traces show regular linear relationships. This means that the increase of the length, width, and thickness is related to the increase in the width, thickness and weight of these tools. The regression coefficients are on the average or weak (fig. 6.3.28; fig. A. 4. 49 - 53).

Observations show that the tools with flake negatives (NO), micro-scratches and shine (NO-NSC-SH) are the longest (n=2). However, this conclusion should be taken with consideration due to a small number of tools with micro-scratches and shine (NO-NSC-SH). Tools with no use traces on the working edge (FL) are the lightest, while the tools with micro-scratches (MSC) are the heaviest (table 6.3.15-18). The results show that tools with micro-fake negatives (MNO) and no use traces (FL) on the working edges are long, narrow and light. The tools with these types of use traces and with flake negatives (NO) appeared on the thin tools. The objects with flake negatives (NO) are mainly heavy (fig. A4. 53–56) Regardless of the type

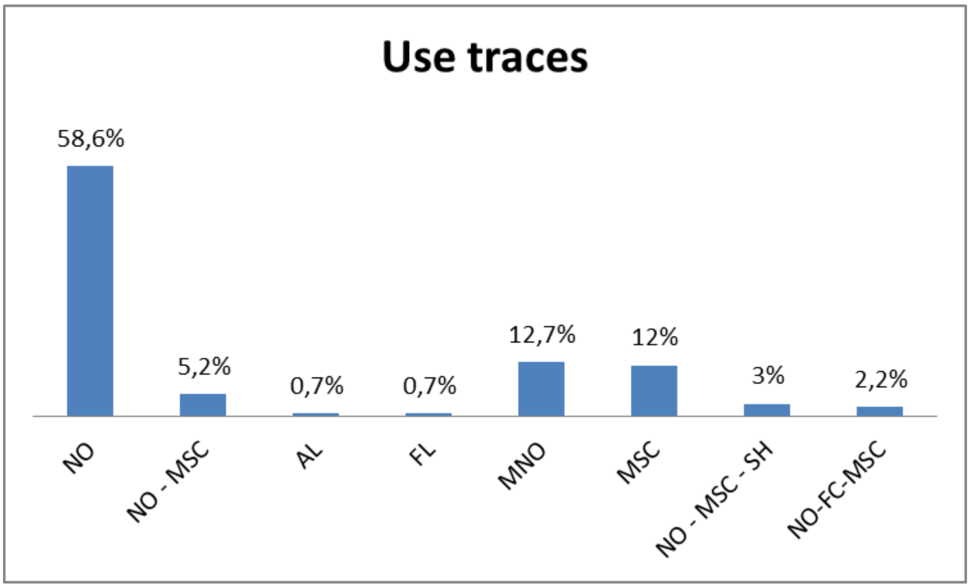


Fig. 6.3.26. Celts: use traces; N= 128.

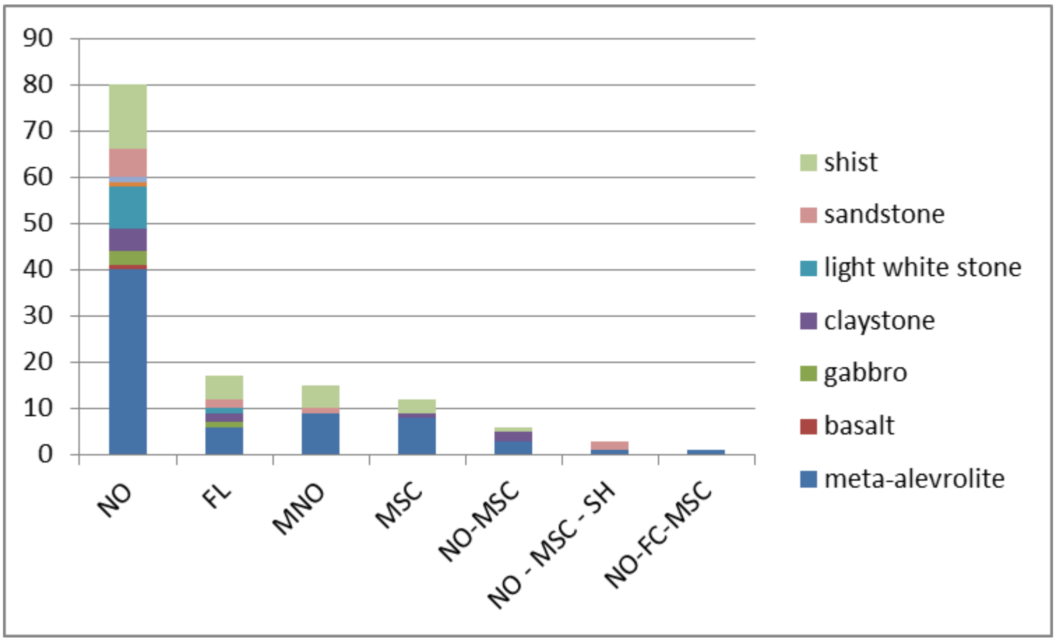


Fig. 6.3.27. Celts: use traces and geology; N= 132.

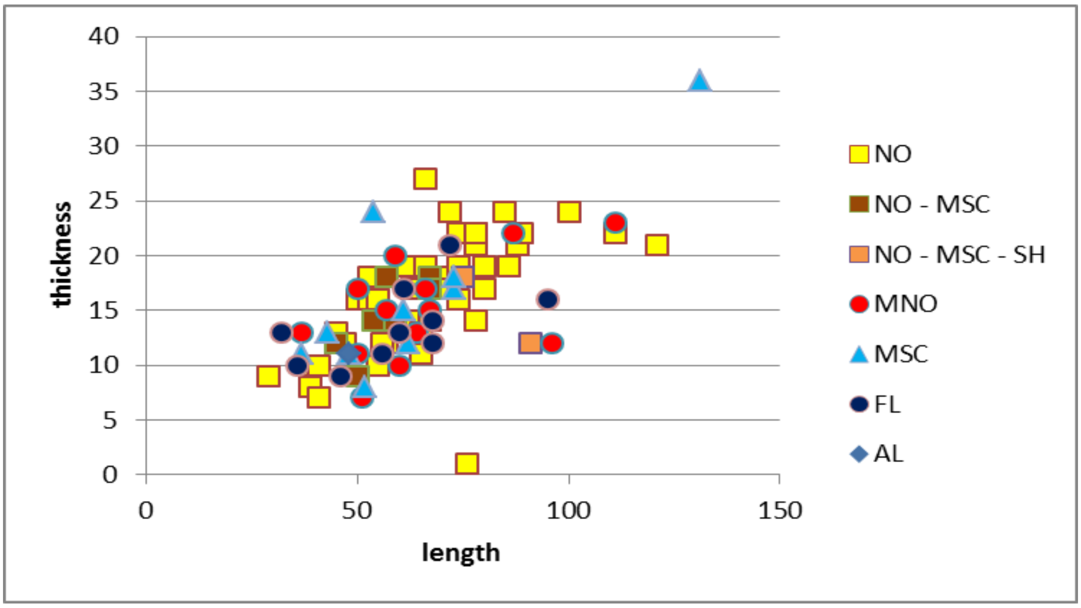


Fig.6.3.28. Celts: correlation between length, thickness and use traces; NO: R²= 0,4796; MSC: R²= 0,7306; NO-MSC: R²= 0,5826; N= 97.

of use traces, the items are elongated in lateral and transversal sections (fig.A4. 57– 58). Observation shows that the working edges without use traces (FL) is the narrowest (table A.4.4). The length of the working edge does not vary significantly according to geology, and the working edges of the sandstone tools are the longest (table A4.4).

Correlations between the length of the working edge and use traces have identified no pattern. The relation of the working edge/width of the tool and use traces shows a regular linear relationship. This means that the increase in the length of the working edge is related to the increase in the width of the tools. The regression coefficients are above the average (fig. A 4.61 - 64).

Use traces /N	$\bar{X}$	σ	length max (mm)	length min (mm)
NO / 52	66	19	121	31
NO-MSC / 6	55	7	67	45
AL / 1	-	-	48	-
FL/11	56	68	95	31
MNO /13	65	20	111	37
MSC / 9	66	26	131	43
NO-MSC-SH /2	83	11	91	75

Table 6.3.15. Celts: use traces according to length; N=88.

Use traces /N	$\bar{X}$	σ	width max (mm)	width min (mm)
NO / 76	37	11	64	11
NO-MSC / 7	37	13	59	18
AL / 1	-	-	27	-
FL/17	27	12	50	12
MNO /16	33	9	47	12
MSC / 10	33	5	40	26
NO-MSC-SH /2	31	4	35	28

Table 6.3.16. Celts: use traces according to width; N= 88.

The length of cutting edge is more or less similar according to use traces. It could be said that the flake negatives (NO) have been detected on the longest cutting edge (table A 4.4).

Use traces /N	$\bar{X}$	σ	thickness max (mm)	thickness min (mm)
NO / 76	16	5	31	6
MSC / 10	16	8	36	8
AL / 1	-	-	11	-
NO-MSC / 7	15	5	27	9
FL/ 17	14	5	22	12
MNO /13	16	5	27	6
NO-MSC-SH /2	15	4	18	12

Table 6.3.17. Celts: use traces according to thickness; N= 88.

Mesoscopically, the working edges show flake negatives (NO) with no edge rounding and with edge rounding, micro-pits, stepped retouch, micro-flake negatives, micro-scratches (fig. 6.3.29 - 30).

Use traces /N	$\bar{X}$	σ	weight max (mm)	weight min (mm)
NO / 52	65	43	189,2	4,8
NO-MSC / 6	48	38	99	12
AL / 1	-	-	24,8	-
FL/ 11	34	27	86,2	4,8
MNO /13	64	43	158,2	14
MSC / 9	68	62	223,8	22,8
NO-MSC-SH /2	59	17	72,6	47,2

Table 6.3.18. Celts: use traces according to weight; N= 88.

Variety of use traces suggests work on different materials by scrapping and percussion. Micro-scratches, perpendicular to the blunted edge, confirms the contact with processed surfaces under the angle of 90 °. Stroulia A. (Stroulia 2003: 23) assumed that such working edge could be a consequence of pottery processing. However, our experimental test related to this activity has resulted in micro-scratches and grain extraction, suggesting that smoothing of the clay surface will not resulted necessarly in faceted active edge of a tool (chapter: 2.3.1). Retouch, scratches and flake negatives (NO) are evidence of work in wood or bone (Stroulia 2003: 23; Semenov 1964).

The longitudinal grooves on the obverse and reverse sides of a small, schist tool L – TM – 69 (45 x 38 x 13 mm) (fig. 6.3.31/10) might indicate that this object was being transformed by sawing. It seems that this technique was implemented to reshape this artefact and avoid its damage and unwanted breakage. Sawing was also implemented on the tool from the Neolithic settlement of Divostin (Prinz 1988: 257).

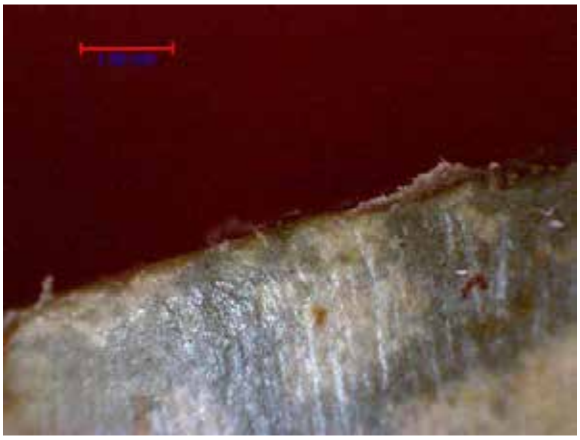


Fig. 6.3.29. Celts: micro-scratches (MSC) and flake negatives (NO), Motel Slatina, L – MS – 177 (meta)alevrolite.

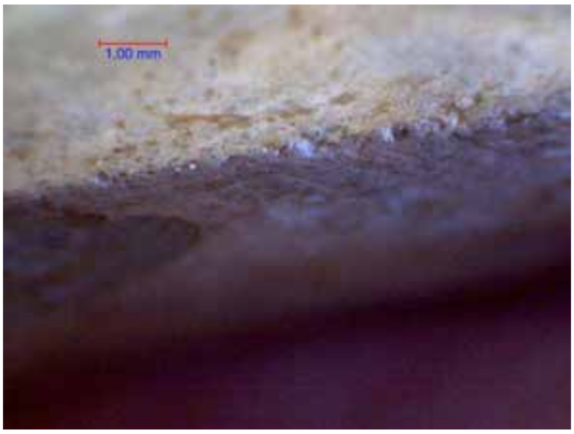


Fig.6.3.30.Celts:micro-flake negatives (MNO),Gumnište, L – P – 399, (meta)alevrolite.

The bottom parts of five instruments were narrowed by flaking, suggesting handling (fig. 6.3.31/12). These tools are between 61 to 87 mm long, 35 to 52 mm wide, 17 to 22 mm thick and their weight lays between 66,4 to 160 gr. Microscopically, handling can be associated with micro-pits, pits (GA), levelled surface (AL), flake negatives (NO) with edge rounding as on the tool L – MS - 1. A groove on the lateral side of the objects could also be linked to handling techniques (fig.6.3.31/8) (cf. Gimbutas 1974: 51; cf. Smoor 1976: Fig.110, 3; fig 115,3; 181). Their working edges display mainly flake negatives (NO), micro-flake negatives (MNO), while the working edge of one object shows no use traces (FL).

The use of schist in manufacturing celts (n=24) from the Middle Neolithic settlement of Tumba Madžari, Southern region presents the only one regional characteristic. Observations do not show any pattern in the relation between the size of tools from various Neolithic periods.

Relation width/thickness indicates that the tools from the Middle Neolithic are narrower than the Late Neolithic objects (fig. A 4.65-66).

Summary

The study of 145 Neolithic celts from the Central Balkans has allowed us to define their main characteristics. These items were mostly manufactured out of (meta)alevrolite. This rock was not found locally, in the surrounding of most settlements, thus, we assume that this raw material was part of a distant exchange. Easy manufacturing and maintenance might explain the use of raw material. Celts were shaped by flaking, retouching and polishing, while longitudinal grooves on the obverse and reverse sides of a small, schist tool L – TM – 69 might indicate sawing. The unworked, passive surface of a (meta)alevrolite object suggests that this raw material came from a primary source. Five artefacts display the presence of a handle.

These artefacts processed wood, bone, clay objects and material which contained oil or fat by cutting and scrapping. Wear of the active edges is not often, indicating their frequent re-sharpening.

The combined analysis of metrical, raw material, morphological, working part characteristics and use traces did not show any pattern. The results show that the use of schist was typical only for the Middle Neolithic settlement of Tumba Madžari. Observations also suggest that celts from this period were narrower than the Late Neolithic tools.

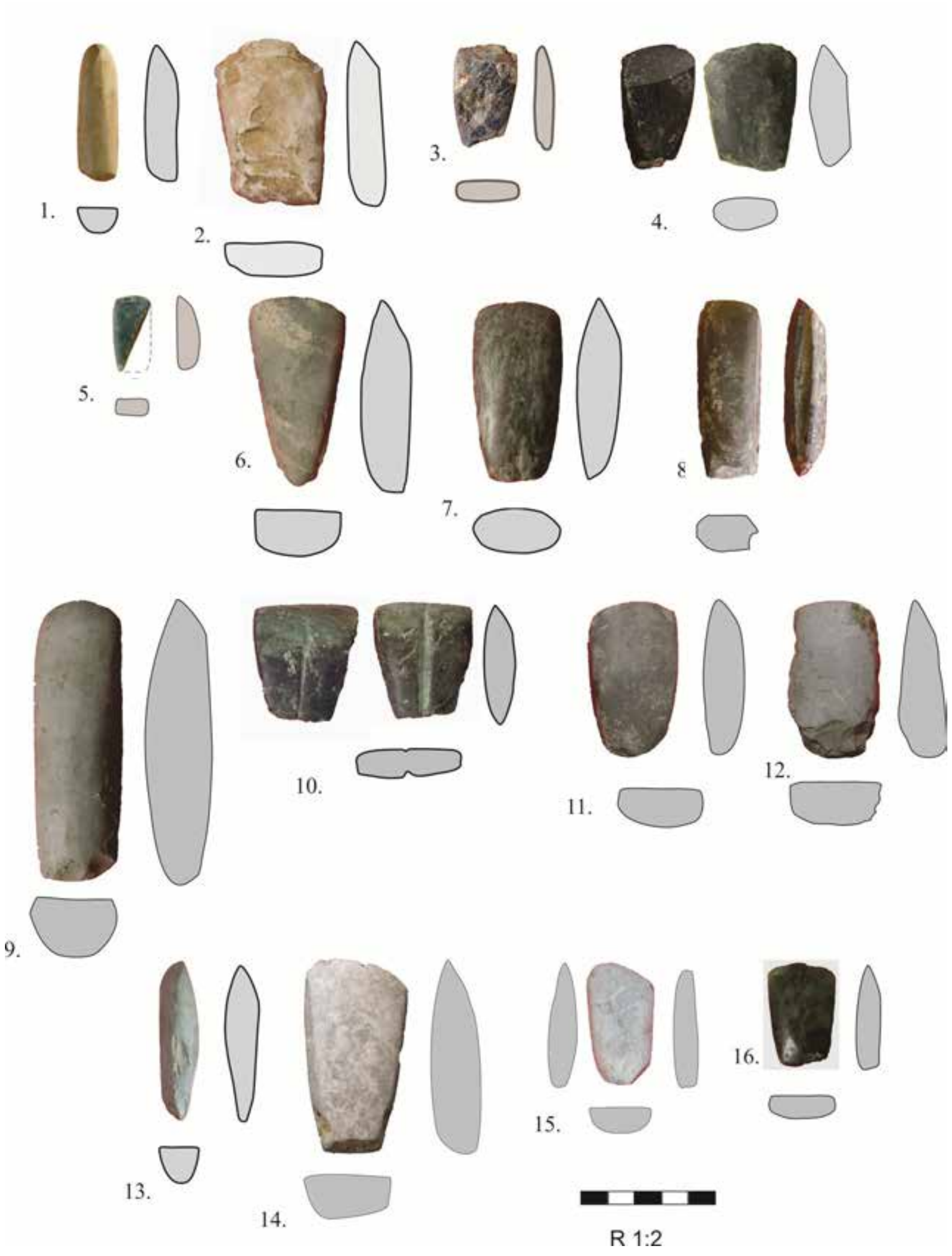


Fig. 6.3.31., Celts:1. L -MS-1, Motel Slatina; 2. L - KR - 80; 6. L – Kr – 28; Kremenilo; 3. L-Me-48;5.L- Me - 47; Međureč; 4. L-TM - 48; 7. L – TM- 54;8. L-TM- 33,; 10. L-TM-69, Tumba Madžari; 9. L-BB - 93; 11. L-BB - 114; 12. L - BB - 316; 16. L-BB-34, L-BB-34, Benska bara; 13. L - Dr - 122, Turska česma; 14. L - P - 399, Gumnište; 15. L - PO - 16,Potporanj.

6.3.3. Adzes

Adze is asymmetrical tool with cutting edge sets below the longitudinal axis of the lateral cross-section of artefact (fig. 6.3.38; fig. 6.3.49). The adze was used for shaping objects by scraping and trimming. Judging from previous ethnographic studies, it could be assumed that they were also employed as celts (subchapter: 6.3.2) or an axe (cf. Prinz 1988: 160). This suggests that celts, like axes were multifunctional tools.

Our study includes 34 adzes from the Late Neolithic settlements of Benska bara (n=10) (fig. 6.3.49/1-3), At (n=2) (fig. 6.3.49/9), Potporanj (n=2) (fig. 6.3.49/5), Kremenilo (n=10) (fig. 6.3.49/6,7), Koraća Han (n=2), Motel Slatina (n= 4), Turska česma, Slatina (n=1) (fig. 6.3.38) and Gumnište (n=3) (fig. 6.3.49/5).

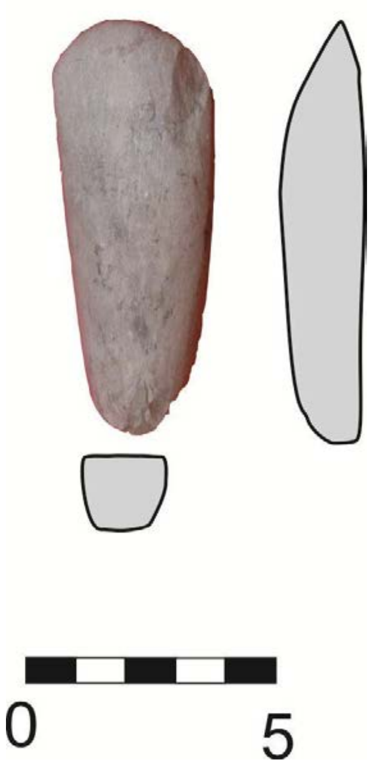


Fig. 6.3.38. Adzes: L – Kr – 68,(meta)alevrolite.

C. 67% of all studied tools are well preserved, while c. 32% of the objects are broken and fragmented (fig. 6.3.39). This suggests that the percentage of complete artefacts can provide enough data for the analysis.

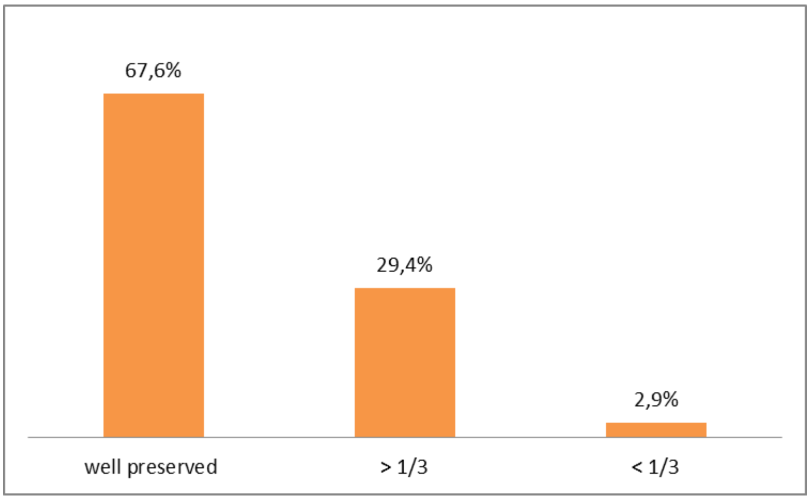


Fig. 6.3.39. Adzes: preservation; N= 34.

Like in the case of axes and celts, (meta)alevrolite is the most commonly used rock. Sedimentary rocks such as white light stone, claystone, and sandstone are implemented in smaller frequency. Only one object is made of peridotite (fig. 6.3.40).

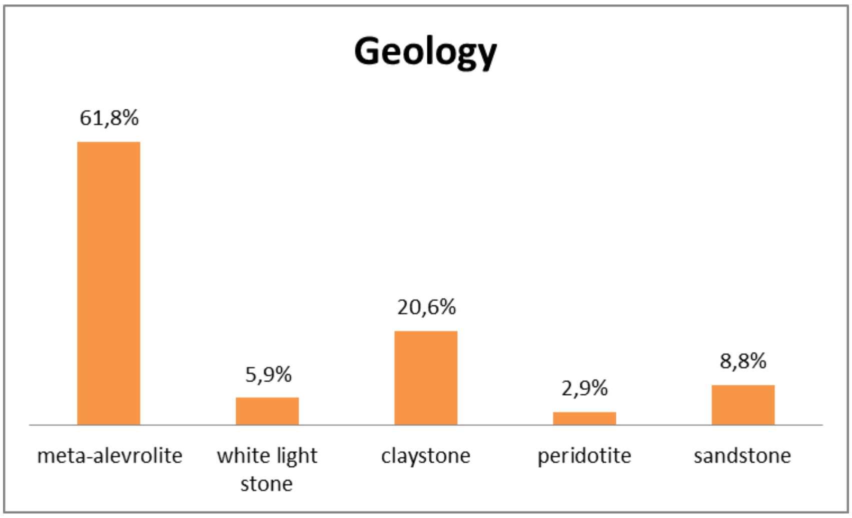


Fig. 6.3.40 Adzes: geology; N= 34.

46% of the passive sides show polished surfaces (PU). Flake negatives (FE-PU) are visible on some 29,5% of the analyzed passive surfaces while retouching (RT, RT-PU) has been detected on some 11,2% of passive sides. 5,2% of all passive sides show a combination of flaking and retouching (RE, RE-PU). Only 1,7% of all passive sides show natural surface (IR) of a selected light white stone and claystone pebbles. This means that these pieces came from a primary outcrop.

Geology and size

A correlation between the raw material and the size of tools do not display any pattern. The relations between length/weight, length/width, width/weight, and length/thickness and geology show a regular relationship, indicating that the increase in the length, width, thickness and weight are mutually dependent from each other (fig. 6.3.41).

Regardless of geology, the size of the objects is similar (table 4.3. 19-22.). It can be noted that white light stone objects are slightly longer, wider and thicker, while the (meta)alevrolite tools are the heaviest (table 6.3.19 - 22). Observations show that (meta)alevrolite tools are slightly more narrow and thicker (fig. A 4.67-68).

geology/N	$\bar{x}$	**σ**	**Max length (mm)**	**Min length (mm)**
(meta)alevrolite / 10	72	22	105	37
peridotite / 1	-	-	46	-
sandstone / 3	74	21	88	50
white light stone / 9	88	23	123	41

Table 6.3.19. Adzes: length according to geology; N= 23.

geology/N	$\bar{X}$	σ	Max width (mm)	Min width (mm)
(meta)alevrolite / 19	34	12	55	11
peidotite / 1	-	-	18	-
sandstone / 3	29	14	45	18
light white stone / 9	35	8	50	26

Table 6.3.20. Adzes: width according to geology; N= 32.

geology/N	$\bar{X}$	σ	Max thickness (mm)	Min thickness (mm)
(meta)alevrolite / 19	20	4	27	11
peidotite / 1	-	-	10	-
sandstone / 3	18	5	24	15
light white stone / 9	21	5	35	18

Table 6.3.21 Adzes: thickness according to geology; N= 32.

geology/N	$\bar{X}$	σ	Max weight (gr)	Min weight (gr)
(meta)alevrolite / 10	84	49	146	10,2
peridotite / 1	-	-	15,2	-
sandstone / 3	71,4	69	151,4	26
white light stone / 9	76,5	5	163,2	14

Table 6.3.22 Adzes: weight according to geology; N= 23.

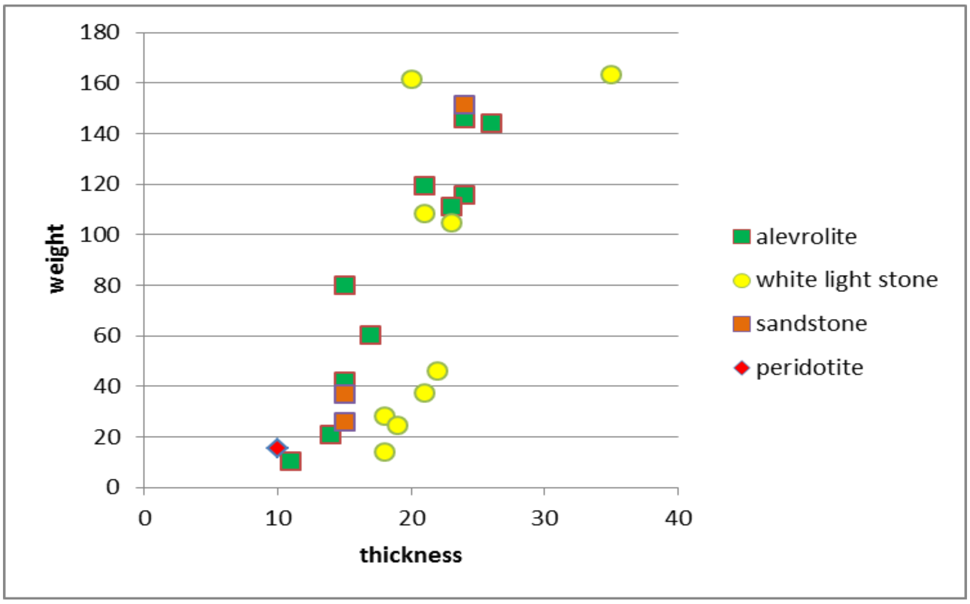


Fig. 6.3.41. Adzes: correlation between thickness, weight and geology; meta-alevrolite: R^2= 0,6289; light white stone R^2=0,0,3086; N=23.

Working edge

The working edges are mostly convex (CX/AG; n=20), although it can be irregular (CX/CX, n= 3; IR/AG, n= 1; and IR/CX, n=1), reviling an intensive activity.

Use traces

Working edges display mainly flake negatives (NO), which can be associated with micro-scratches (NO-MSC) and levelled surface (NO-AL). Active edges also display micro-scratches (MSC), micro-flake negatives (MNO), while micro-pits (MGA) and absence of use traces (FL) were detected rarely (fig. 6.3.42).

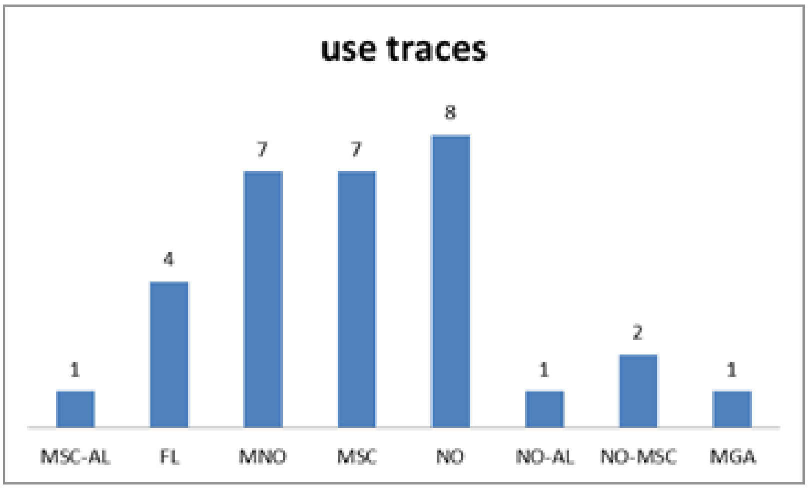


Fig. 6.3.42. Adzes: use traces; N= 30. MSC-AL: micro-scratches associated with smoothed surface; FL: no use traces; MNO: micro flake negatives; MSC: micro-scratches;NO:flake negatives; MNO: micro-flake negatives; NO-AL: flake negatives associated with levelled surface; NO-MSC: flake negatives associated with micro-scratche; MGA: micro-pits;

The record reveals that tools with micro-scratches (MSC) are the longest, widest, thickest and heaviest (table 6.3.23 – 26) A correlation between the width, thickness, weight of the tools and use traces suggests two functional patterns (fig. 6.3.43-45; fig. A 4.73). Pattern 1 includes the long, wide, thin and heavy objects with micro-scratches on the working edges. These artefacts are between 81 – 105 mm long, 33 – 45 mm wide, 20 – 24 mm thick and weight between 108,4 – 163, 2g. Pattern 2 consists of chiefly short, light, thin and narrow tools mainly with flake negatives (NO) on the working edges. These items are between 41 – 97 mm long, 11 – 32 mm wide, 11 - 22 mm thick and weight between 47 – 83 g.

These functional patterns are associated with different use of the instruments. Pattern 1 presents items from the Late Neolithic settlements of At, Kremenilo and Koraća Han. Pattern 2 involves artefacts with active edges, which were affected by the intensive implementation. These items have been identified at the Late Neolithic settlements of Kremenilo, Benska bara, Motel Slatina, Turska Česma and Gumnište. It has been also observed that the length/weight and length/thickness relations show a regular linear relationship for the tools with flake negatives (NO) and micro-scratches (MSC). This means that the increase in the length of the tools with this type of use traces is related to the increase in weight and thickness of these instruments (fig. 6.3.45-46).

The analysis of use wear traces shows that the most frequent working edges are with micro-scratches (MSC) (fig. 6.3.46), and micro-flake negatives (MNO) (fig. 6.3.47), while flake negatives (NO) can appear with edge rounding (fig. 6.3.48). The working edge with rounding can be associated with micro-scratches, which run in different direction (MSC) (fig. 6.3.49). Furthermore, micro-scratches (MSC) can be associated with micro-pits (MSC-MGA) (fig. 6.3.46).

geology/N	$\bar{X}$	σ	max length (mm)	min length (mm)
FL / 3	64	34	103	37
MNO / 3	64	22	90	46
MSC / 7	88	22	123	50
NO / 7	73	22	97	41

Table 6.3.23. Adzes: the length according to geology; N= 20.

geology/N	$\bar{X}$	σ	max width (mm)	min width (mm)
FL / 3	30	17	50	17
MNO / 7	33	12	53	18
MSC / 8	37	6	45	25
NO / 10	30	15	55	11

Table 6.3.24. Adzes: the width according to geology; N= 32.

geology/N	$\bar{X}$	σ	max thickness (mm)	min thickness (mm)
FL / 3	18	4	23	14
MNO / 7	17	4	21	10
MSC / 8	23	5	35	15
NO / 10	17	3	24	11

Table 6.3.25. Adzes: the thickness according to geology; N= 32.

geology/N	$\bar{x}$	σ	max weight (gr)	min weight (gr)
FL / 3	62	41	104,8	21
MNO / 3	53	45	119,6	15,2
MSC / 7	122,9	45	163,2	26
NO / 7	34	23	76,6	10,2

Table 6.3.26. Adzes: the weight according to geology; N= 20.

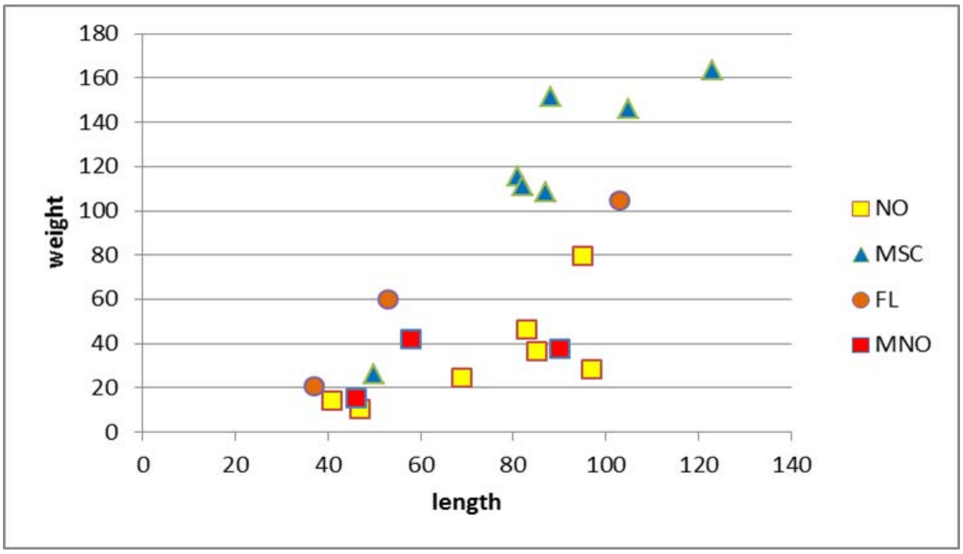


Fig. 6.3.43. Adzes: correlation between length, weight and use traces; flake negatives (NO): R^2= 0,4576; micro-scratches (MSC) R^2=0,7667; N=22.

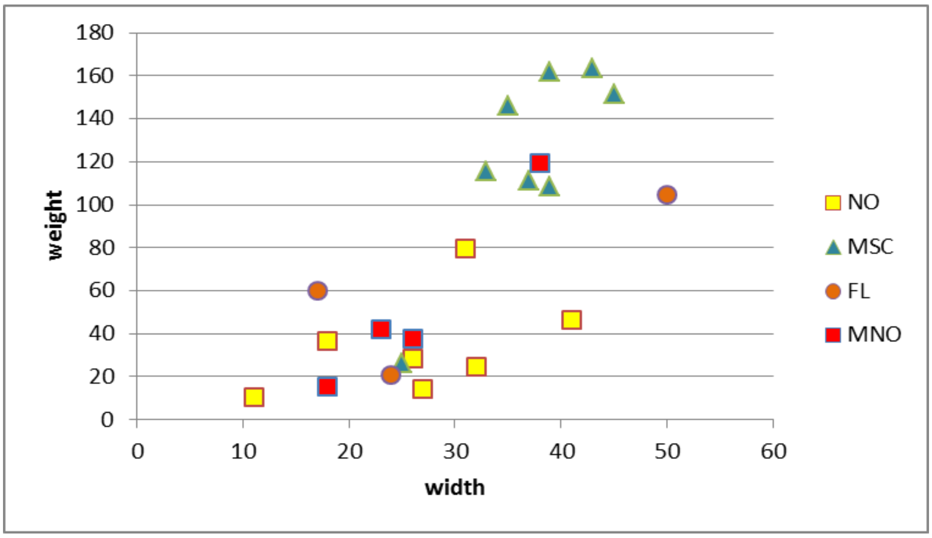


Fig. 6.3.44. Adzes: correlation between width, weight and use traces; N=22.

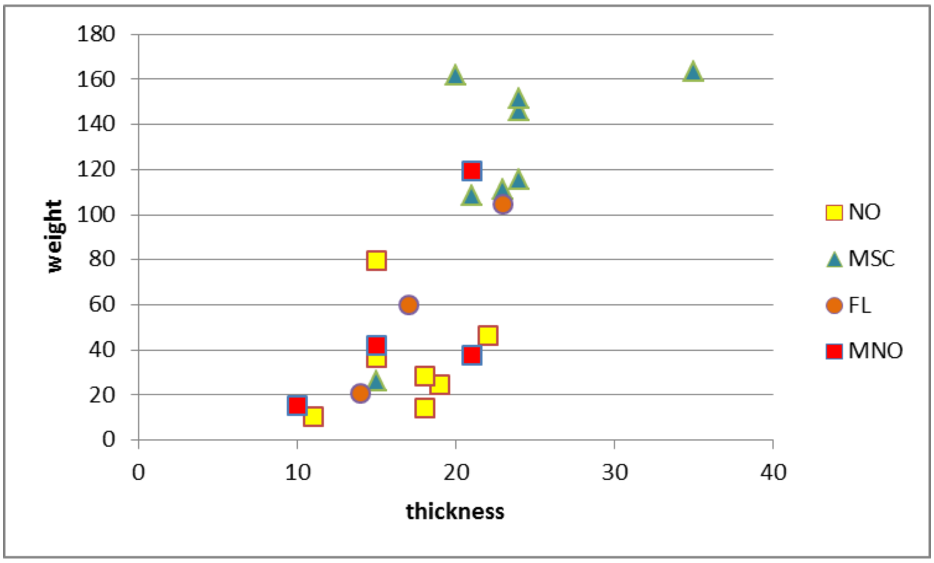


Fig. 6.3.45. Adzes: correlation between thickness, weight and use traces; N=22.

The combination of flake negatives (NO) with edge rounding might be related to the

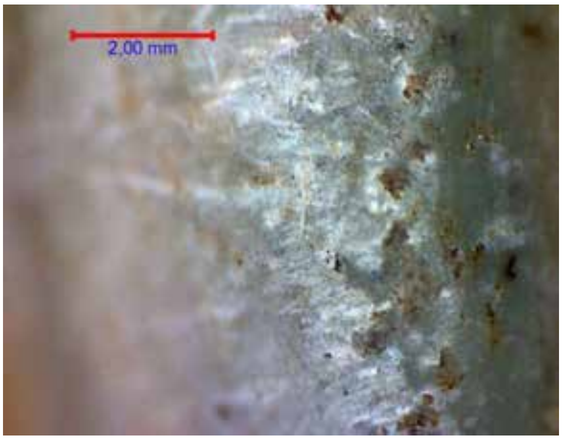


Fig. 6.3.46. Adzes: micro-pits and micro-scratches (MSC-MGA), L -KR – 67, (meta)alevrolite.

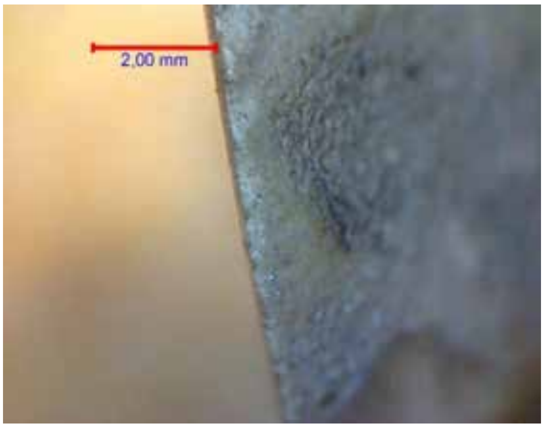


Fig.6.3.47.Adzes: micro-flake negatives (MNO), L -KR – 68, (meta)alevrolite

Fig. 6.3.48. Adzes: flake nagatives and edge rounding, L – KR – 36, (meta)alevrolite.

Fig. 6.3.49.Adzes: flake nagatives and edge rounding, L – KR – 50, (meta)alevrolite.

cutting of medium to hard materials, such as wood, bone or clay objects. Micro-flake negatives (MNO), micro-scratches (MSC) and micro-pits (MGA) suggest shaping medium to hard materials by incision and scraping, while the rounded working edge and disordered scratches indicate intensive scraping or perhaps smoothing a surface of a medium to hard materials.

Summary

The study of 34 Neolithic adzes from the Central Balkans has been conducted in order to reveal their characteristics. The adzes were used for shaping materials such as bone or wood by cutting and scraping. Raw materials such as (meta)alevrolite, light white stone, claystone and sandstone were used in this propose (subchapters 6.3.1, 6.3.2).

Techniques applied in manufacturing and shaping adzes are also the same as for the rest of the objects from the same group of tools. A very small number of artefacts show the natural surface of a selected light white stone and claystone, suggesting that these pebbles came from a primary outcrop.

The results display pattern based on a correlation between use traces and the size of the instruments revealed two patterns, which display their different use. The first pattern includes the long, wide, thin and heavy objects with micro-scratches, indicating that these objects were used for scarping. Pattern 2 consists of mainly short, light, thin and narrow objects with greater wear of the cutting edge, which is linked to percussion. Both patterns have been identified in the Late Neolithic settlements in different parts of the studied area.

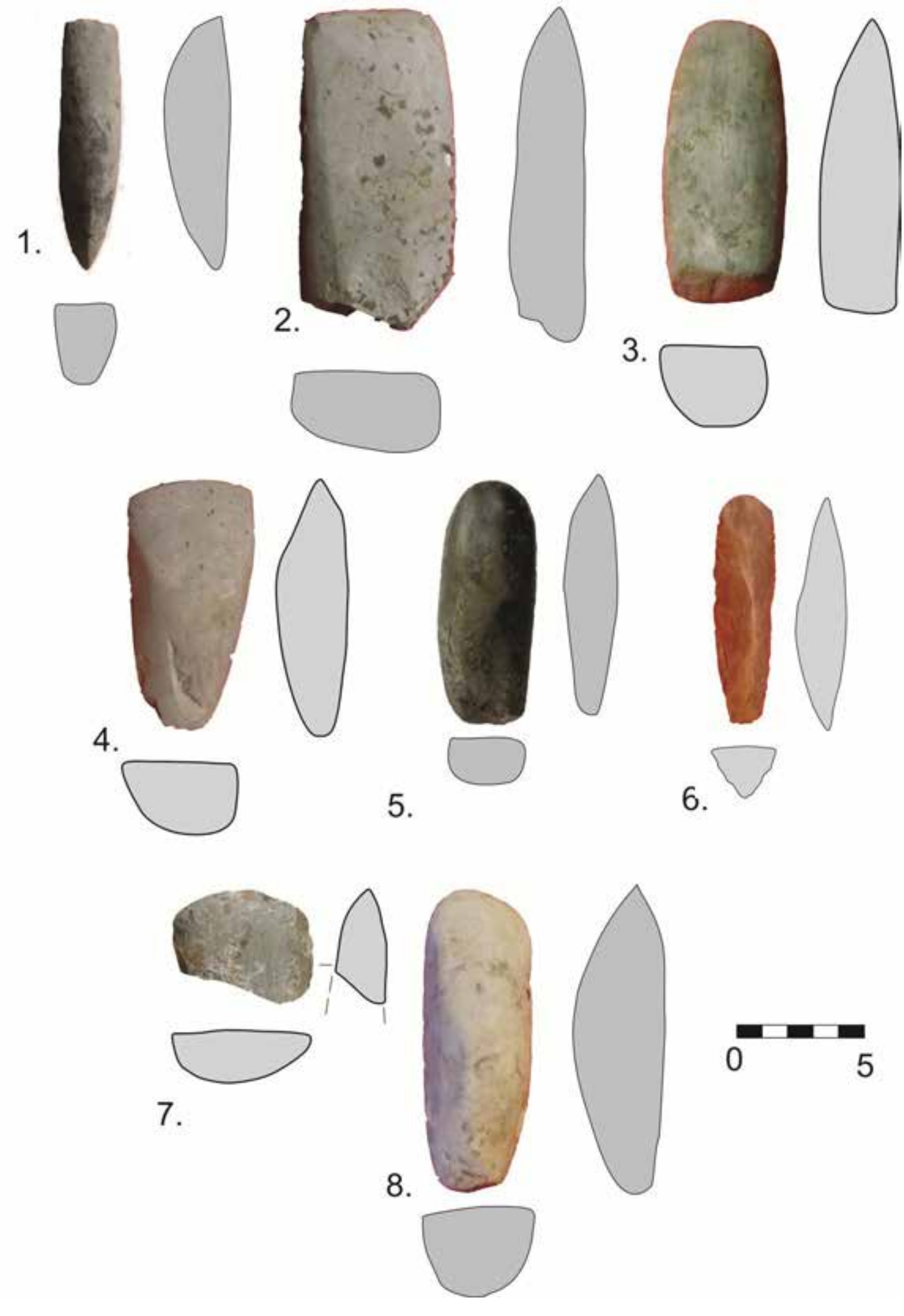


Fig. 6.3.49. Adzes: Pattern 1: 8. L-At-8,At. Pattern 2: 5. L-P-314, Gumnište; 3. L-BB-32 ,Benska bara; 6. L-Kr- 97, 7. L-MS-2, Motel Slatina; Non standardized artefacts:1. L-BB- 92; 2. L-BB- 124 ; 4. L-KR-36;

6.3.4. Chisels

6.3.50. *Chisels: L-PO-6, Potporanj, Northern region, meta-alevrolite.*

Chisel refers to an elongated polished edge tool with the parallel lateral sides, which was used for chiselling and gouging (fig. 6.3.50).

In total, we have been able to analyse 13 chisels. Most of the tools come from the Late Neolithic settlements of Benska bara (n=6), Potporanj (n= 3), Motel Slatina (n=2), Turska česma (n=1), Krementilo (n=1), while three objects are from the Middle Neolithic settlement of Tumba Madžari.

Five objects are complete, while the rest are broken or fragmented.

Meta-Alevrolite was again the main raw material used in manufacturing this type of tools (n=13). One tool is made of shale, while one object is made of unidentified rock. The chisels are between 87 and 151 mm long, 19 and 37 mm wide, 17 and 44 mm thick and weight between 54,6 and 417,8 gr. The length of the working edge varies between 12 and 25 mm.

Documented use traces are mainly related to percussion: flake negatives (NO) (n=7), dents (GO) (n=1), and associations of various use traces such as dents and micro-scratches (GO-MSC) (n=1), micro-flake negatives and micro-pits (MNO-GA) and friction (AL).

Microscopically, the working edges present micro-pits and grain rounding (fig. 6.3.51), flake negatives (NO) with no edge rounding (fig. 6.3.52) and flake negatives (NO) with edge rounding (fig. 6.3.53). The results suggest that these tools processed medium to hard materials by percussion of different intensity.

Fig. 6.3.51. Chisels: flake negatives (NO), L- Dr – 129, meta-alevrolite

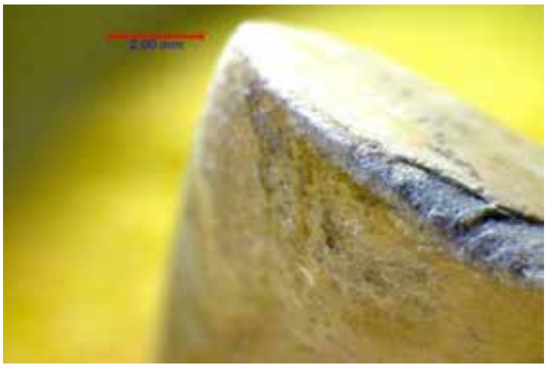


Fig. 6.3.52. Chisels: flake negatives (NO), L-BB – 166, meta-alevrolite.

Fig. 6.3.53. Chisels: flake negatives (NO), L- PO – 6, meta-alevrolite

In the following lines, we present general results of the analysis of polished edge tools. However, the chisels will be omitted, due to the small number and high fragmentation.

Technological and functional features/ (n)	Raw material	Manufacturing evidence	Artefact size length x width x thickness (mm) mean	Weight (g) mean	Size of cutting edg (mm) mean	Morphology of cutting edge	Use-wear traces mainly	Proposed tasks
Axes/132	Mainly (meta) alevrolite	Similar and include: flaking, retouching and polishing	76 x 40 x 18	70	37	CX/AG	flake negatives (NO)	cutting, chopping and scarping
Celts/145			70 x 38 x 17	70	34	CX/AG	flake negatives (NO)	cutting and scrapping
Adzes/34			78 x34 x 20	76	28	CX/AG	Pattern 1: micro-scratches Pattern 2: flake negatives (NO)	cutting and scraping

Tabela 6.3.27 Axes, celts and adzes: main qualitative and quantitative characteristics; N=311

The study of Neolithic axes (n= 132), celts (n= 145) and adzes (n= 34) from the Central Balkans has been allowed us to define their main characteristics. All objects were made mainly of (meta)alevrolite by flaking, retouching and polishing. Observations also show similarities in the size of the objects and morphology of the working edges. Although, the active edges of the adzes are slightly shorter than the working edges of the axes and celts. Flake negatives (NO) have been mainly identified on the working edges regardless of tool type. The analysis suggests that polished edge tools were involved in activities related to abrasion and percussion, which is related particularly to axes, while adzes were involved in different use related to scarping (pattern 1) and percussion (pattern 2) (table 6.3.27).

6.4. Percussion tools

6.4.1. Percussive tools

Percussive tools are handhold, unworked artefacts, made out of pebbles. They are a usual type macro-lithic finds at the Neolithic settlements of the Central Balkans. (fig.6.4.1). They were made of various rock types and show one or more active surfaces produced by percussion. In previous literature, these tools have also been defined as hammer-stones or retouching tools. They are related to various activities, such as shaping, and maintenance of various materials (stone, wood, minerals and bones) through percussion, as well as in mining. (Risch 2002: 158; Carozza 2005: 469 Delgaado-Rack 2008: 455 - 463 Antonović 1992: 25; 2006; Šarić 2006: 202, 204, 206, 210; Ţivanić 2010.). In some cases, percussive traces can be combined with other use-wear traces, resulted from friction, pounding or pressure retouching. Consequently, we are dealing mostly with multifunctional tools.

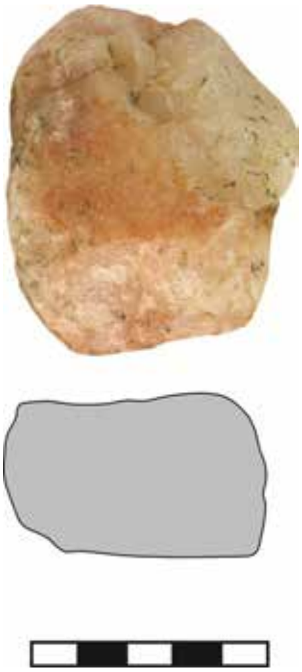


Fig. 6.4.1 Percussive tools: L - Dr - 50, quartzite.

Thus, we included them in the analysis of the same tool category. In order to define

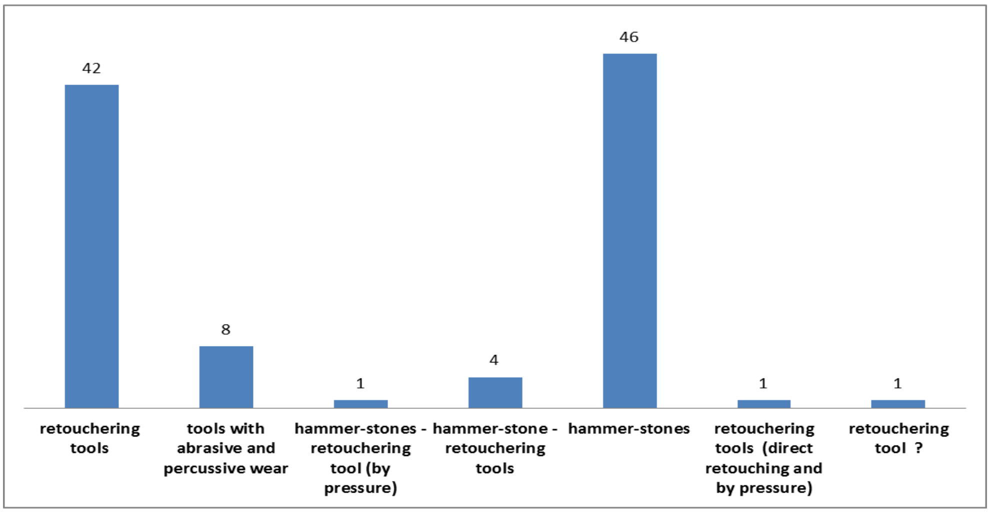


fig. 6.4.2. Type of percussive tools; N= 103.

their role in the technological process related to percussion activities we have analysed 103 tools and 237 working surfaces with percussive traces. They mainly come from the Late Neolithic settlements of Benska bara (n=4) and Potporanj (n= 12) (fig.6.4.16/9) in the Northern region, Turska česma (n= 34) (fig. 6.4.16/1,6), Motel Slatina (n= 15) (fig. 6.4.16/2-5) in the Central region, Čelina (n=6), Koraća Han (n=2) (fig. 6.4.16/10) and Kremenilo (n=1) (fig. 6.4.16/11) in the Western region as well as in Gumnište (n = 15) (fig. 6.4.16/7,12), in the Southern region. This type of tool is also present in the Early Neolithic settlement of MeĎureč (n = 14) (fig. 6.4.1), in the Central region.

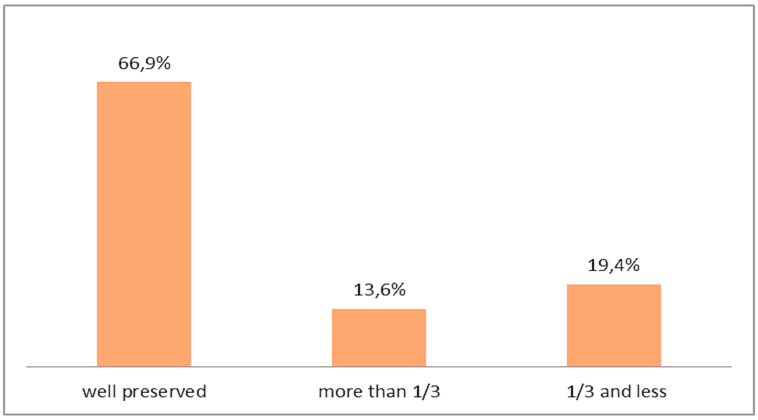


Fig. 6.4.3. Percussive tools: preservation level; N= 103.

66% of the tools are well preserved or complete (fig.6.4.3), which present a solid basis of quantitative and qualitative data for analysis and interpretation of the results.

Percussive tools were made commonly from quartzite, while flint, schist, igneous and sedimentary rocks had minor importance (fig. 6.4.4.). All passive surfaces display the natural surface of selected cobblestones. Only two objects L-MS-44 and L-MS-45 present smoothed, shiny areas on the surfaces, developed by the influence of water, suggesting that these items were collected from secondary sources such as a river bed.

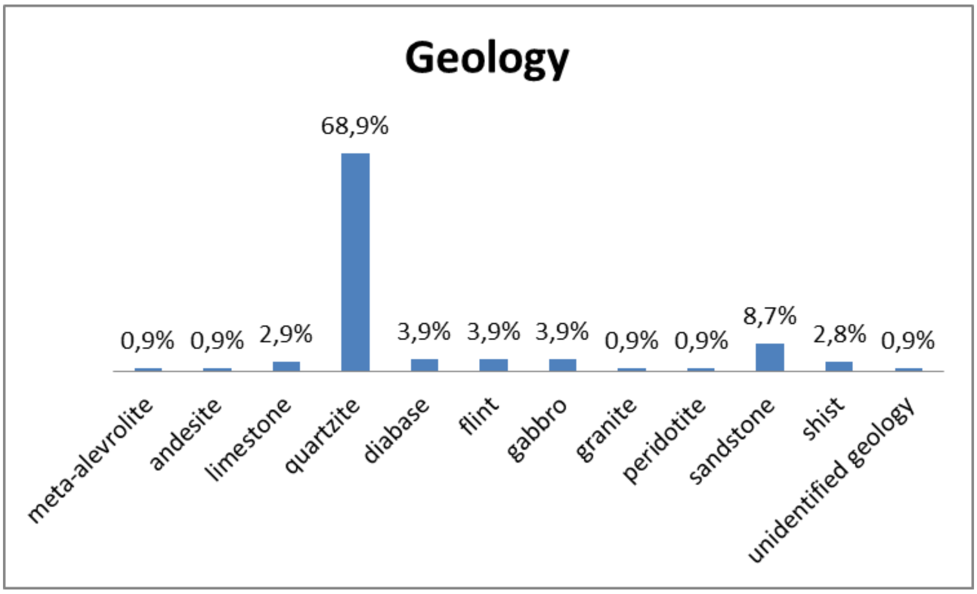


Fig. 6.4.4. percussive tools: geology; N= 103.

Analytic step 1

In this step association between geology and the size of the artefacts will be explored.

Based on the correlation between width and weight, four functional patterns can be identified (fig. A5.7- 12):

Functional pattern 1 includes narrow and light objects, which width varies between 45 – 59 mm and 96,6 to 324,8 g;

Pattern 2 consists of slightly wider and heavier tools than pattern 1 and they are 64 – 69 mm wide, while their weight varies between 431,4 – 480 g.

Geology/N	$\bar{X}$	σ	max length (mm)	min length (mm)
quartzite / 45	80	20	127	38
schist / 2	75	9	82	68
plutonic /6	75	30	131	47
flint / 4	60	10	66	44
volcanic / 1	-	-	65	-
sedimentary / 11	72	24	111	47

Table 6.4.1. Percussive tools: length according to geology; N= 69.

Geology/N	$\bar{X}$	σ	max width (mm)	min width (mm)
quartzite / 55	64	15	114	35
shist / 2	54	9	61	47
plutonic /6	54	10	69	31
flint / 4	56	7	63	46
sedimentary / 11	58	14	87	44
volcanic / 4	54	6	60	46

Table 6.4.2. Percussive tools: width according to geology; N= 82.

Geology/N	$\bar{X}$	σ	max thickness (mm)	min thickness (mm)
quartzite / 55	47	13	71	18
shist / 2	41	12	50	32
plutonic /6	39	7	49	26
flint / 4	51	9	60	41
sedimentary / 11	47	7	58	33
volcanic / 4	43	14	63	32

Table 6.4.3. Percussive tools: the thickness according to geology; N= 82.

Pattern 3 involves artefacts which are wider than the tools from pattern 2, and they are from 74 – 83 mm width and their weight is between 279 – 379 g.

Geology/N	$\bar{X}$	σ	max weight (g)	min weight (g)
quartzite / 46	395	235	1314,6	95,2
schist / 2	267,5	104	341,6	193,4
plutonic /6	283	179	511,6	98,4
flint / 4	300	197	511,6	98,4
sedimentary / 11	305	213	748,6	72,2
volcanic / 1	-	-	180,4	-

Table 6.4.4. Percussive tools: weight according to geology; N= 70.

Pattern 4 includes very wide and heavy objects which width varies between 82 – 91 mm and weight is between 485,8 – 748,6 g (fig. A5.9). Record show that quartzite items are mainly

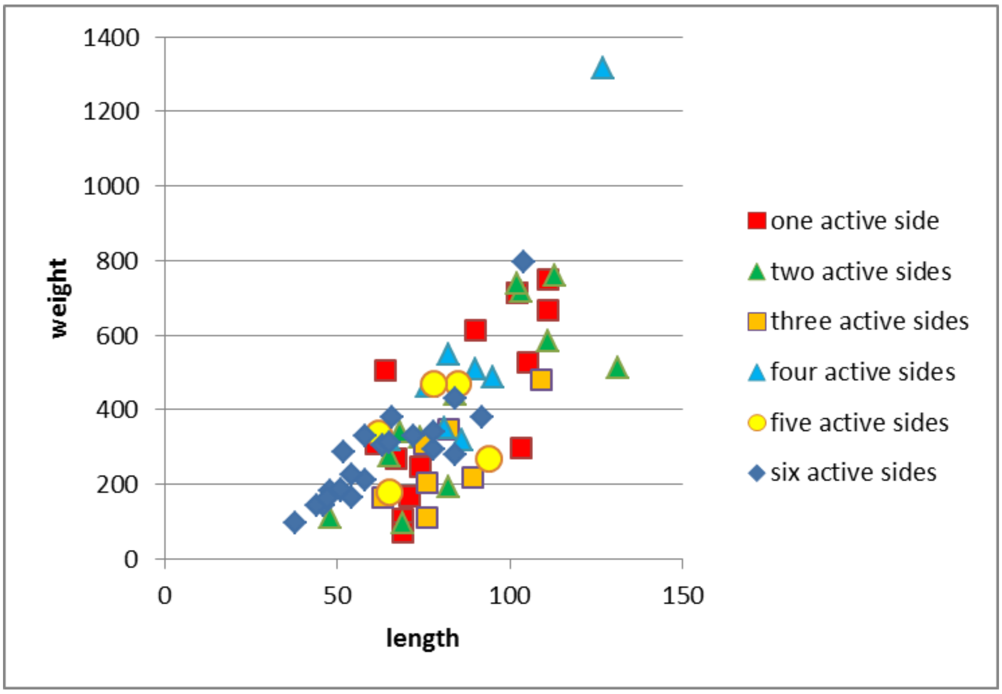
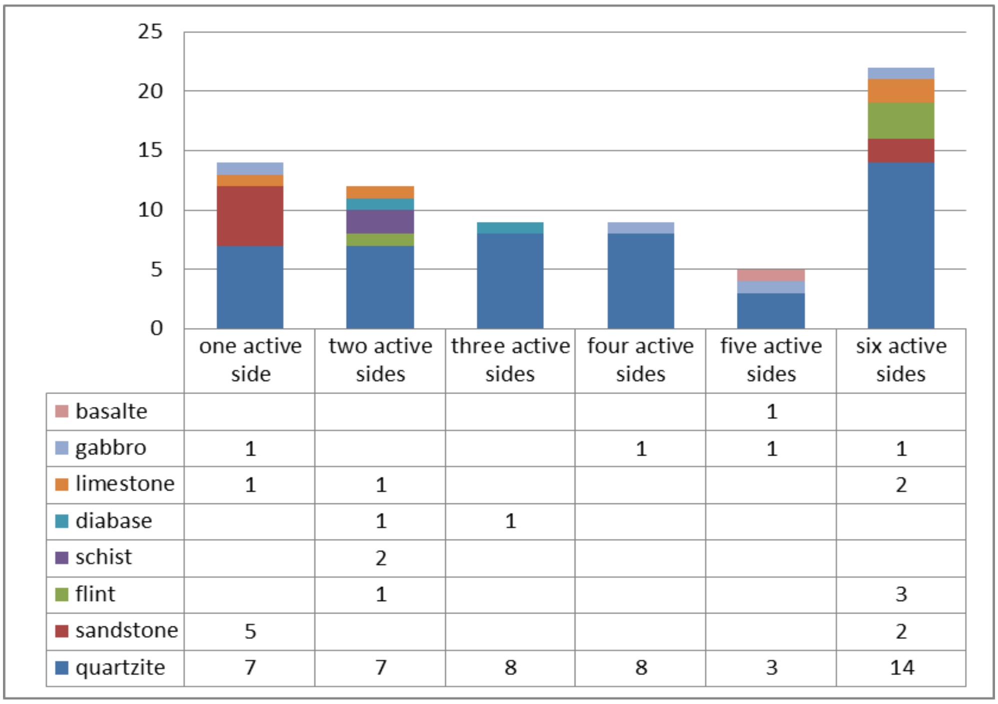


Fig.6.4.6. Percussive tools: correlation between the tools with one and more active sides, length and weight; one active side :one active sides: R²= 0,4379; two active sides: R²= 0, 55 01; three active sides: R²= 0,4379; six active sides: R²= 0,63; N=



	one active side	two active sides	three active sides	four active sides	five active sides	six active sides
basalte					1	
gabbro	1			1	1	1
limestone	1	1				2
diabase		1	1			
schist		2				
flint		1				3
sandstone	5					2
quartzite	7	7	8	8	3	14

Fig.6.4.7. Percussive tools: correlation between geology and number of the active sides; N= 70.

narrow, thin and light and tend to be round in longitudinal and transversal sections (fig.A. 5. 1-6) as well as the longest and heaviest in relation to the artefacts made of the rest of geology (table 6.4.1- 4.).

The analytical step 3: As a number of the active surfaces varies, we have examined a correlation between their number, the size of the tools and association with geology, which could also indicate specific use of an artefact.

Observations reveal associations between length/weight, length/width of the tools made of various rocks and the artefacts with three and six active surfaces (fig. A5. 20 – 24). This suggests that the increase of the length is related to the increase in the width and weight of these objects. The regression coefficients are on the average (fig. 6.4.9).

Pattern 5 includes quartzite and diabase tools with three active sides (fig. 6.4.6 - 7). These items are very light and the thin among all analysed percussive artefacts, and they are between 54 – 89 mm long and weight is 112,2 – 348,9 g (table A 4.1- 4). The active sides are mainly convex (CX/CX) and appear preferentially on the top and right sides of the artefacts.

Pattern 6 includes mainly quartzite artefacts, with six, frequently convex (CX/CX) active surfaces, while the rest are gabbro, sandstone and flint tools (fig. A5.25). These tools are between 38 – 84 mm long and weight between 95,2 – 381,2 g (fig. 6.4.6). These objects are the shortest and tend to be round in transversal and lateral sections (fig. A5.17- 18, 21).

The analytical step 4: Observations show that patterns 1 to 4 consists of tools with several numbers of the active sides. Thus, in this step, we have examined the relation between previously detected pattern 1 -4 and the relation between patterns 5 and 6. The record shows that the quartzite objects with three and six working sides have not been observed among wide and heavy artefacts from pattern 4 (fig. A5.20, 27).

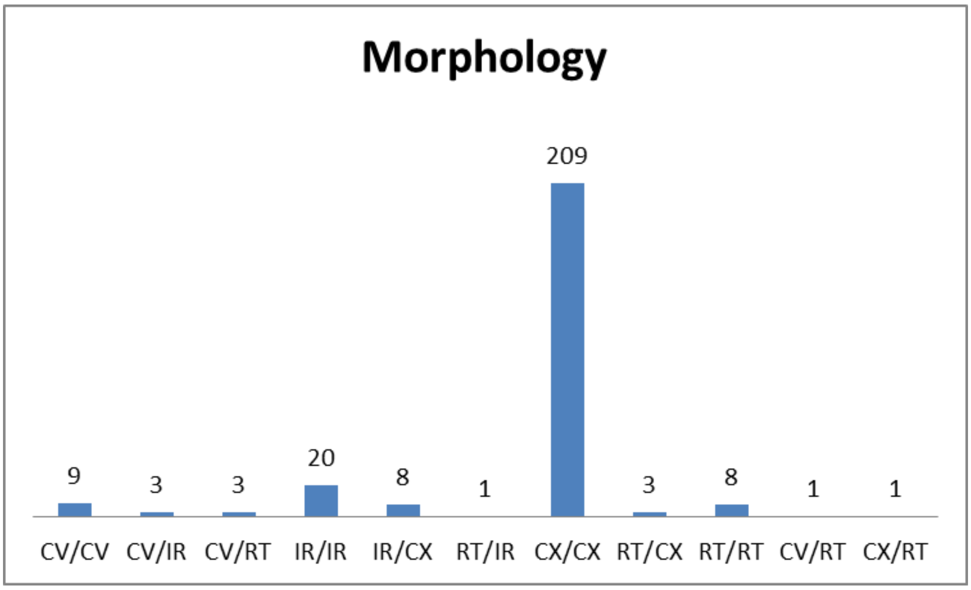


Fig. 6.4.8. Percussive tools: morphology of the active sides; N= 266.

Morphology of the active sides

Active surfaces of the percussive tools are usually convex (CX/CX) (fig.6.4.8). Variability of the shapes of the active sides could be explained by different operations, which have been already documented in detail on the forging and mining tools as well as their different wear level (Delgado, Risch 2005: 239, fig. 4; Delgado, Gomez-Gras 2017: 58.).

Geology/N	$\bar{X}$	σ	Max mm^2	Min mm^2
quartzite / 181	1167	871	5460	63
schist / 1	-	-		-
plutonic /23	1139	1041	3350	36
flint / 16	1788	882	2916	63
sedimentary / 33	1307	992	4757	95
volcanic /8	1569	860	2610	324

Table 6.4.5. Percussive tools: the surfaces of the active sides according to geology; N= 262.

The analytic step 5: A correlation between the size of the tools and morphology of the active side displays no pattern (fig. A 5.31- 34).

The analytic step 6: allows us to distinguish patterns 1A – 3A (active sides) which are associated with morphology and size of the active sides and geology.

Pattern 1A: flint tools with large convex (CX/CX) active surfaces (fig. 6.4.9; fig. A5.44, 46);

Pattern 2A: with middle-sized convex (CX/CX) active surfaces, mainly detected among quartzite tools (fig.6.4.9, fig. A5.31, 46);

Pattern 3A: the active surfaces with irregular active profiles (IR/IR, IR/CX and IR/RT) are mainly small, likely to be round and appears on the reverse side on quartzite and plutonic artefacts (fig. 6.4.9; A 5.35-36, 42;fig. A5.31,46). This pattern is also documented on fig. 6.4.10).

Morphology/N	$\bar{X}$	σ	mm^{2}max	mm^{2}min
CV/CV / 7	1117	1409	3894	162
CV/IR / 4	861	146	988	696
CV/RT / 1	-	-	440	-
CX/CX / 180	1346	896	5460	36
IR/CX / 13	1147	870	2700	117
IR/IR / 23	596	669	2310	81
IR/RT / 3	348	125	448	208
RT/CX / 5	803	777	2070	140
RT/RT / 4	815	791	1950	126

Table 6.4.6. Percussive tools: surfaces of the active sides according to morphology; N= 262.

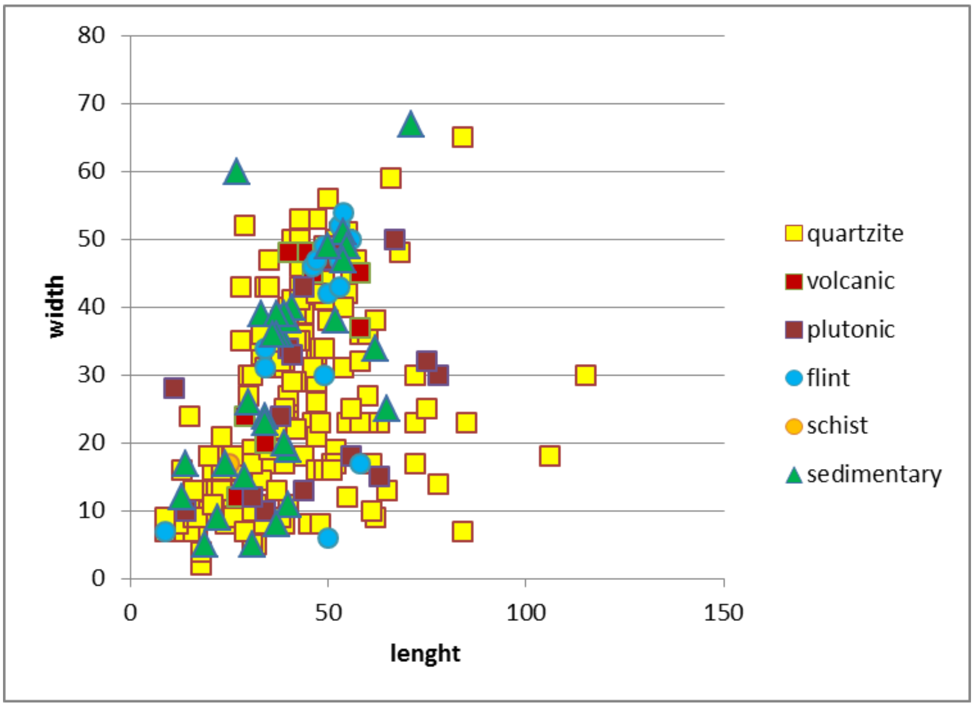


Fig.6.4.9. Percussive tools: correlation between the length, width of the active surfaces and geology (plutonic rocks R²= 0,4257; volcanic rocks R²=0,5009; flint R²= 0,2186; sedimentary R²= 0,3586; N= 262.

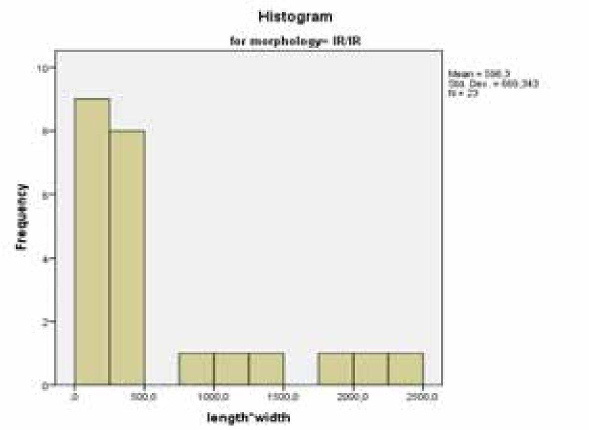


Fig. 6.4.10. Relative frequency of the active surfaces with IR/IR shape; N= 23.

Use wear traces

The analytical step 7: Macroscopical analysis indicates that the most frequent are the working surfaces with pits (GA), which are dominant on all tools regardless the number of active sides, while although dents (GO) and flake negatives (NO) appeared as well (fig. 6.4.11).

Pattern 1A consists of flint objects with the large working surfaces associated mainly with dents (GO). This type of use traces appears on all tools, regardless of a number of their active sides. Mesoscopically, the active surfaces show dents (GO) with sharp edges, which can be combined with pits (GA) (fig. 6.4.12 – 14). This indicates crushing and pulverizing hard materials such as stone.

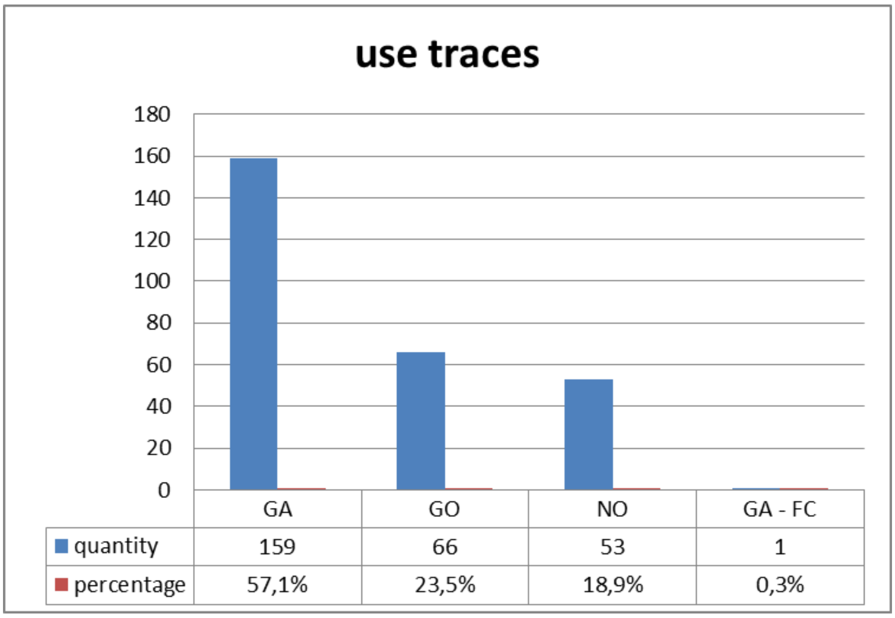


Fig. 6.4.11. Percussive tools: use traces; N= 266.

Pattern 2A involves mainly quartzite and some sedimentary tools with pits (GA) on the middle-sized active surfaces. Mesoscopical analysis indicates micro-pits (fig.6.4.14) and grain rounding (fig.6.4.15), suggesting that these artefacts were used for retouching and pounding soft and hard materials.

Use traces/N	$\bar{X}$	**σ**	**mm² max**	**mm² min**
GA/144	1112	771	5460	81
GA-FC/1	-	-	1089	-
GO/ 57	1834	910	3894	63
NO/ 36	666	649	2401	36

Table 6.4.7. Percussive tools: surfaces of the active sides according to use traces; N= 238.

Pattern 3A includes the small active sides, mainly with flake negatives (NO), developed on quartzite and igneous artefacts with three, five and six active sides (fig.A5.45). Our experimental test (subchapter 2.3.3) suggests that flake negatives (NO) can be formed by strong blows. Described characteristics suggest that these objects were used for splitting and crushing medium to hard materials such as bone or wood (subchapter 2.3.3).

The analytical step 8: In this step combination or dissociation of use traces on active surfaces of all identified patterns have been examined.

a. First, we present the results of analysis related to patterns 1 – 4, which have been identified based on the relation between geology and size of the tools (analytical step 1):

Patterns 1 – 4 include 36 artefacts among which 26 items show pits (GA) on 48,7%, active sides, flake negatives (NO) on 30,5% working surfaces and dents (GO) with 20,7% of all active sides. Pits and dents have been detected on 26 artefacts (GA: 13; 50%; GO: 7; 27%; NO: 6; 23%).

b. In following lines we present the results related combination or dissociation of use traces on active surfaces of patterns 5 – 6, which have been documented based on a correlation between the size of the tools and number of the active sides (analytical step 2):

50% of the active sides of the tools from pattern 5 display pits (GA), 33,3 % are with flake negatives (NO) and 16,7% are with dents (GO). The same type of use traces has been recorded on five of six objects (GA: 2; 40%; NO: 2; 40%; and GO: 1; 10%), which belong to this group.

Pattern 6 includes 19 tools and c. 44,7% of the active surfaces with pits (GA), 29% of the working surfaces reveal flake negatives (NO) and 26,3 % show dents (GO). Although the majority of the artefacts display only one activity, which can be associated with pulverizing and pounding (GA: 7; 36,8%) or can be linked to retouching (GO: 5; 26,3%).

c. Here, we focus on record obtained from analysis functional patterns 1A – 3A (table 6.4.8)

Pattern 1A includes 9 tools, which active surfaces produced mainly dents (GO) (table 6.4.8). This pattern has been recorded on 9 objects among which 7 items show dents (GO: 77,8%).

pattern	Number of active sides	Pits (GA) %	Dents (GO) %	Flake negatives (NO) %
1A	40	8,7	84,8	6,5
2A	43	68	26%	6%
3A	42	41,5	-	58,5

Table 6.4.8. Percussive tools: percentage of the type of use traces according to functional patterns

Pattern 2A displays mainly pits (GA) on the active surfaces (table 6.4.8).This pattern has been recorded on 14 objects among which 13 items show the same activity (GA: 9; 64,3%; GO: 3; 21,4%; NO:1; 7,7%).

Pattern 3A shows mainly flake negatives (NO) on the active sides (table 6.4.8). This pattern has been recorded on 9 objects, among which 5 items show the same activity (NO: 3; 55,56%; GA: 2; 22,2%).

The analytical step 9: A correlation between the size of the tools, use traces and geology do not reveal specific use (fig. A. 4.1.54 – 60). However, the percentile distribution of use traces according to relation width/thickness indicate specific use of the artefacts with pits (GA), flake negatives (NO) and dents (GO) (pattern 1B – 3B) (fig. A5.52). Specific use of these artefacts has been confirmed by a correlation with geology. fig. A5.53 shows that the active surfaces with pits (GA) are associated with limestone, gabbro and sandstone objects. This means that limestone, gabbro and sandstone tools with pits (GA) were mainly used pulverizing and pounding medium to hard raw materials such as wood and bone, and hard materials such as stone. Furthermore, flake negatives (NO), dents (GO) and pits (GA) are mainly linked to quartzite and flint objects. This indicates that that quartzite tools were mainly implemented in for retouching, pounding and pulverizing materials, but were also used to

Geology/N	$\bar{X}$	σ	max length (mm)	min length (mm)
GA / 146	73	22	131	44
GA-FC /1	-	-	84	-
GO/ 55	72	17	131	58
NO / 51	67	15	92	38

Table 6.4.9. Percussive tools: length according to use traces; N=253.

Geology/N	$\bar{X}$	σ	max width (mm)	min width (mm)
GA / 158	61	17	114	28
GO / 66	61	10	91	35
GA-FC /1	-	-	40	-
NO / 54	59	9	85	44

Table 6.4.10. Percussive tools: width according to use traces; N= 279

split and crush raw materials. Flint items were mainly implemented in crushing and retouching, and partly for splitting, crushing, pounding and pulverizing raw materials.

Geology/N	$\bar{X}$	σ	max thickness (mm)	min thickness (mm)
GA / 153	44	12	71	18
GA-FC /1	-	-	49	-
GO/ 66	53	10	71	22
NO / 54	49	11	65	32

Table 6.4.11. Percussive tools: thickness according to geology; N= 274.

The length, width and thickness of the tools do not vary with the different use-wear traces. It has been documented that the tools with dents (GO) are the heaviest. This type of use traces occurred mainly on the short, wide, thin and light objects. The tools with pits (GA) are the lightest (table 6.4.9 - 12) due to the loss of a big amount of material during activity. These artefacts are mainly long, narrow, thick and light. Flake negatives (NO) appeared mainly on the long, wide, thick and heavy items (fig. A.4.1.48 – 51).

Geology/N	$\bar{X}$	σ	Max weight (g)	Min weight (g)
GA / 148	244,2	245	1314,6	72,2
GA-FC /1	-	-	321,6	-
GO/ 55	352,2	128	761,2	112,2
NO / 52	286	116	613,4	95,2

Table 6.4.12. Percussive tools: weight according to geology; N= 256.

Records also reveal two atypical percussive tools. Two objects present re-used, fragmented perforated, tools made of shist and basalt They are from the Late Neolithic horizons of Potporanj in the Northern region (fig. 6.4.16/9) and Koraća Han in the Western region (fig.6.4.16/10). Their size is 68 x 61 x 50 mm and 65 x 46 x 32 mm and weight 341,6 and 180,4 gr. Percussive use traces have been documented along the fragmented perforation on the bottom side. The same type of re - used objects, more or less the same in the size, have been detected among the hammers (subchapter 6.4.3). Moreover, the analysis of the tools from the Neolithic settlement Divostin suggests that this type of tools was used for flaking as well as a pestle (Prinz 1988: 258).

Early Neolithic tools are mainly well preserved and occurred only in quartzite. The size of the tools does not vary in relation to the Late Neolithic quartzite tools (table 1.1-4, fig. A5.63-64).

Fig. 6.4.12. Percussive tools: dents (GO) L - P - 330, flint.

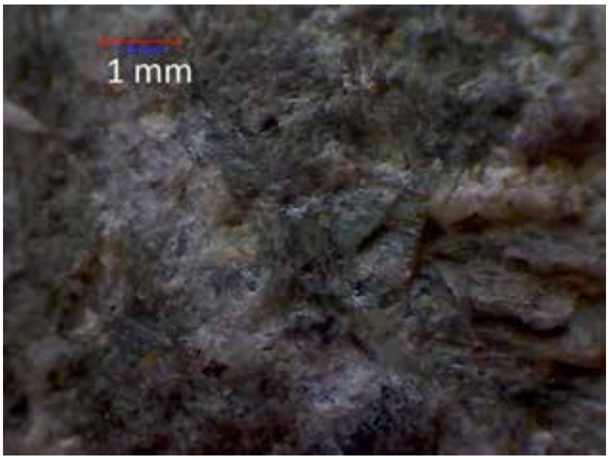


Fig. 6.4.13. Percussive tools: dents (GO), L - MS - 188, flint.

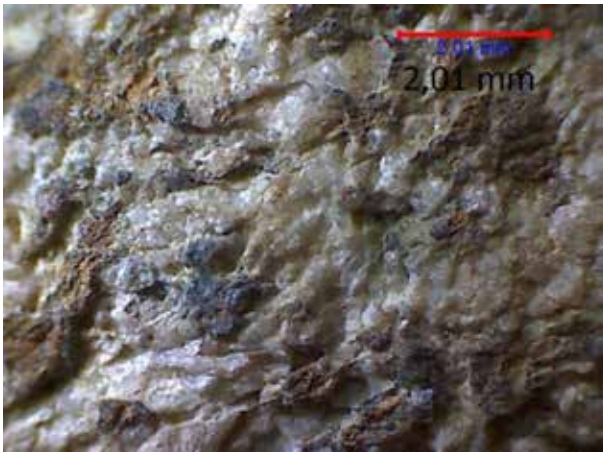


Fig. 6.4.14. Percussive tools: pits (GA), L – KR - 104, gabbro.

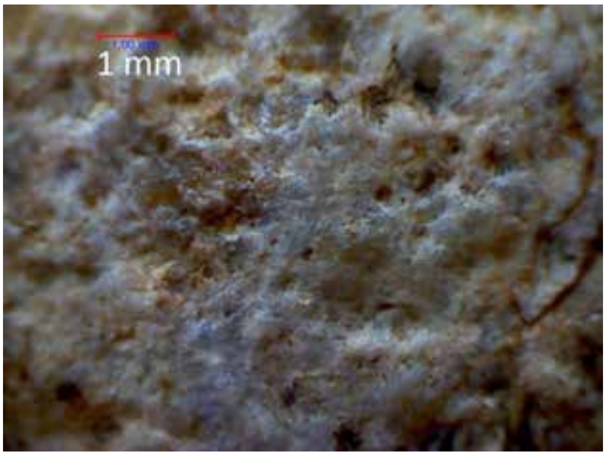


Fig. 6.4.15. Percussive tools: dents (GA), L - MS - 41, quartzite.

Summary

The percussive tools are a frequent type of macro-lithic artefacts at the Neolithic settlements of the Central Balkans. These objects were made mainly of hard rocks such as quartzite and other igneous rocks, which were collected from the river terraces. Various types of use traces on their active sides revealed different activities, according to which different tool types have been identified in previous literature. In order to define their specific role in the technological process associated with percussion activities, we have applied a set of analytical steps to this group of artefacts (chapter 2).

The analysis of geology, metrical characteristics and a number of the active sides of percussive tools suggest six patterns. Pattern 1-4 consists of four groups of quartzite artefacts distinguished according to their width and weight. Patterns 5 includes light and short tools, made of various rock types with three active sides, and pattern 6 includes also light and short items made of various geology and six active sides (table 6.4.13). Moreover, observations show that these patterns includes two groups of tools which are different function. Pulverizing and pounding produced pits (GA) on the active surfaces of the first group of tools, while the second group was implemented in retouching, which generated dents (GO) on the active surfaces (table 6.4.13).

The analysis of the active sides in terms of their material properties, morphometrical characteristics, and use traces revealed patterns 1A, 2A and 3A. The first pattern includes round flint objects, which were employed in crushing and pulverizing hard materials such as stone. A second group consists of long narrow and light artefacts, mainly made of quartzite and sedimentary rocks. These tools were employed in retouching and pounding soft and hard materials. A third group involves mainly long, narrow, thick, heavy and elongated artefacts, made from quartzite and igneous rocks. They show small active sides placed on three, five and six sides of objects. This group of tools was employed for splitting and crushing medium to hard materials such as bone or wood (table 6.4.13).

Furthermore, the percentile distribution of use traces according to relation width/thickness of the tools also suggested three groups of tools made of various geology. The first group of items was associated with pits (GA) on the active sides and was implemented to pound and pulverize raw materials. The second group includes artefacts with dents (GO) on the working surfaces and was linked to retouching. The third group of tools with flake negatives NO, which was used for splitting and crushing materials.

These patterns were produced mainly by one activity and distributed on the various sides of the artefacts.

pattern	geology/size of artefact	size of artefact/number of active sides	morphology, size of active surfaces and geology	use traces/size of artefact	combination or dissociation of use traces on active surfaces
pattern 1	lenght/weight lenght/width	-	-	-	-
pattern 2	lenght/weight lenght/width	-	-	-	-
pattern 3	lenght/weight lenght/width	-	-	-	-
pattern 4	lenght/weight lenght/width	-	-	-	-
pattern 5	-	lenght/weight	-	-	-
pattern 6	-	lenght/weight	-	-	pits (GA) dents (GO)
pattern 1A	-	-	convex (CX/CX) active side, flint	-	-
pattern 2A	-	-	convex (CX/CX) active side	-	-
pattern 3A	-	-	active surfaces with irregular active profiles (IR/IR, IR/CX and IR/RT)	-	-
pattern 1B	-	-	-	percentile distribution of use traces according to relation width/thickness	-
pattern 2B	-	-	-	percentile distribution of use traces according to relation width/thickness	-
pattern 3B	-	-	-	percentile distribution of use traces according to relation width/thickness	-

Table 6.4.13. Percussive tools: a list of functional patterns.

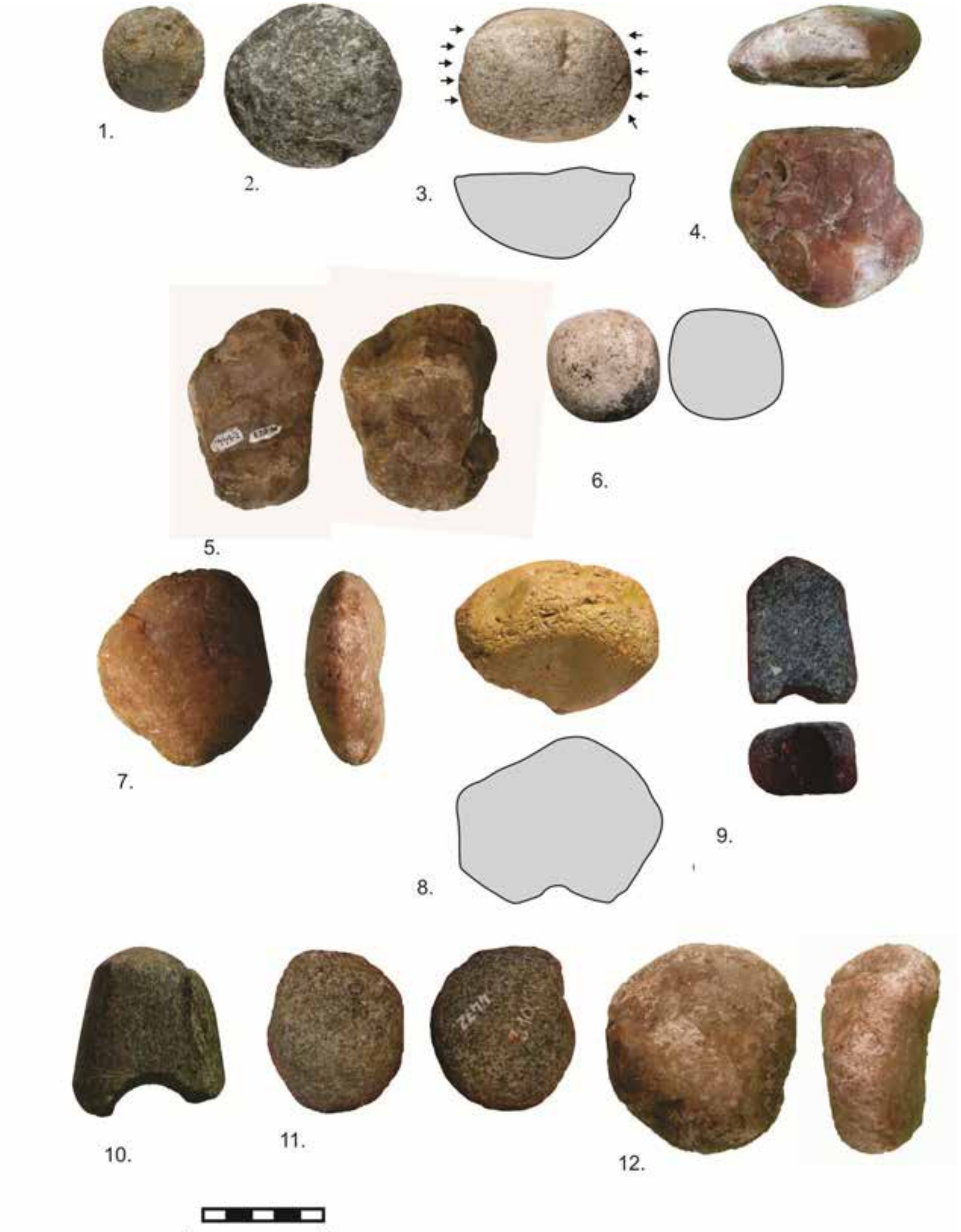


Fig. 6.4.16. Percussive tools: Pattern 1:12. L - P – 252, Gumnište; 4. L- DR -239, Turska česma; Pattern 2:7. L-P – 253, Gumnište; Pattern 3(2A and 3A): 8.L-MS-42; 2.(2A and 3A) L-MS- 189; Motel Slatina; Pattern 4 (1A): 5. L-MS- 41 Motel Slatina; Pattern 5: 6. L-MS- 63, Motel Slatina; Pattern 2A:3. L-MS-44 Motel Slatina; Pattern 3A: 1.L- MS – 160, Motel Slatina; Atypical and non standardized artefacts: 9. L – PO – 5, Potporanj ; 10. L – KR – 26, Koraća Han; 11. L – KR – 104, Kremenilo.

6.4.2. Re –used axes, celts, and adzes (RPE)

Fig. 6.4.17. RPE tool: L-BB-283, Bensak bara, Northern region, meta-alevrolite.

This category of artefacts defines an elongated artefact with square or elongated working surfaces on the top and often also on the bottom sides, formed by percussion. As these tools present the same manufacture traces on the passive surfaces as polished edge tools, it can be concluded that we are dealing here with mainly long, thick and heavy re-used axes, celts and adzes which were made to be used for heavy-duty tasks. Unfortunately, the results of the analysis did not suggest which specific type of polished edge tools were re-used. (fig.6.4.17; fig. 6.4.30; fig. A5.66- 68). Although different operations of the active sides of re-used polished edge tools have been distinguished based on the analysis of use traces. Thus, we have classified them into two groups. The first group or RPE tools 1 was recognized according to traces of percussion, resulting mainly in a levelled surface (AL) (fig.6.4.21-24/2) that could be combined with flake negatives (AL-NO) (fig. 6.4.30/1- 7). According to descriptions, we suppose that this type of tool was distinguished as a hammer in previous literature (Antonović 2003: 56;85, 89, 90,115 fig.74/9, 55/3). The second group of the tools or RPE tools 2 consists of objects identified as the re-used polished edge tools, which active sides show dents (GO) and pits (GA) (fig. 6.4.24–25, 30/8-10). In some cases, the active surface presents mainly more or less stepped flake

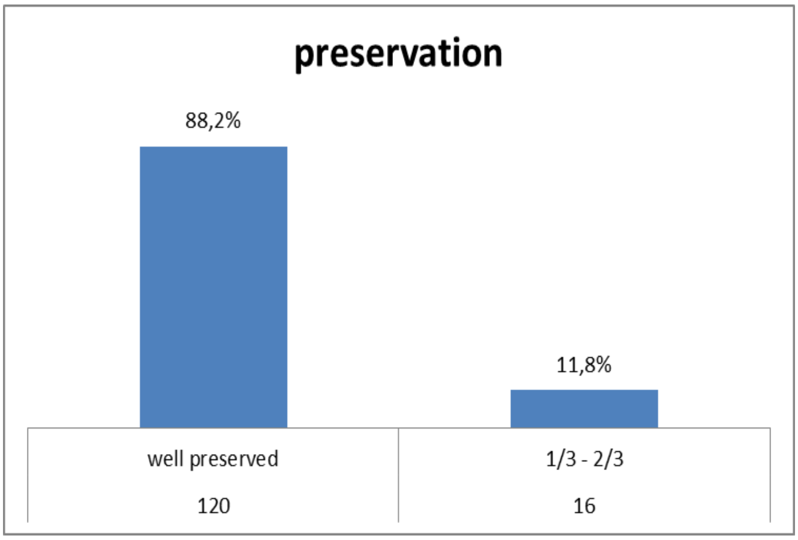


Fig. 6.4.18. RPE tool:preservation; N=136.

negatives which run perpendicular to the longitudinal axis of the tool (fig.6.4.24/3 – 6.4.26). This indicates that retouching and percussive tools shaped objects by percussive techniques, which has been already mentioned in previous literature. (Antonović 2003: 52). Previous studies also show that some of the chisels (elongated tools with the working edge, and parallel lateral sides, according to Wright 1992:73) with the same type of use traces were used in manufacturing stone figurines at Neolithic Çatalhöyük which has been confirmed experimentally[1].

We have analysed 136 objects, which have been identified in the Late Neolithic settlements of Potporanj (n=13) (fig. 6.4.30/1,2,4,5), Benska bara (n=87) (fig. 6.4.30/3,7), and At (n=3) (fig.6.4.30/6) in the Northern region, Kremanilo (n=22) (fig.6.4.30/8,9), Vranjani (n=2) (fig. 6.4.30/10) and Koraća Han (n=1) in the Western region as well as Motel Slatina (n=4) (fig. 6.4.25-26) and Turska Česma (n=1) in the Central region and Gumnište (n=1). The only one object comes from the Early Neolithic settlement of MeĎureč (fig. 6.4.27).

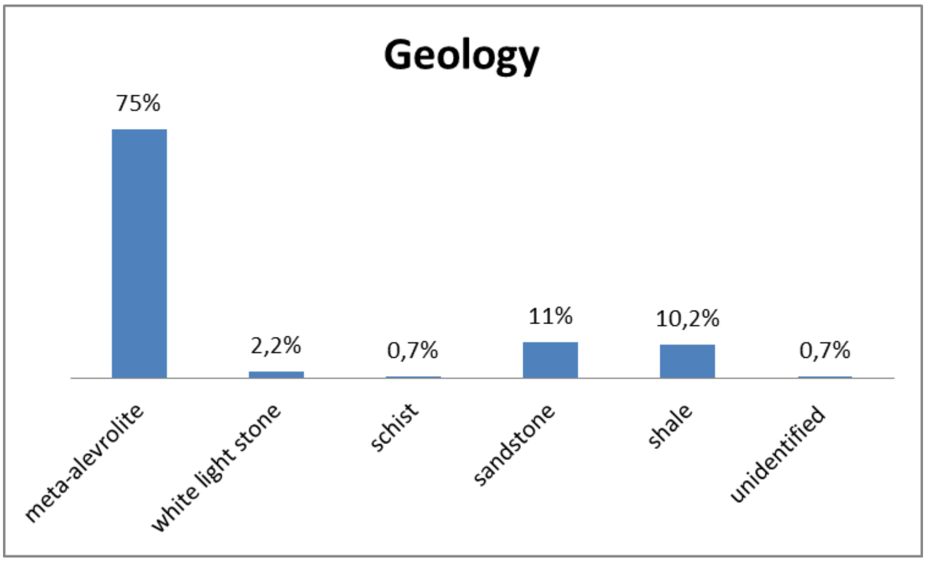


Fig. 6.4.19. RPE tool: geology; N=136.

88,2% of the items are in good preservation state. The rest (11,8%) is broken and fragmented (fig.6.4.18). This state of conservation provides a solid background for the analysis of this tool category. However, we believe this it is mainly a consequence of the sampling strategy applied during the excavation of the aforementioned settlements.

These re – used polished edge tools are commonly made of sedimentary rocks such as meta-alevrolite, sandstone, shale or light white stone. These proportions also coincide with raw materials used for axes and adzes (fig.6.4.19).

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[1] Personal comunication with dr K.Wright from UCL, at workshop ``Ground stone in Archaeology'' 2. – 3. 2. 2016, Lecture and meeting, Berlin, where this type of tools was presented.

In some cases, the morphology of lateral sections of a tool substantiates that these are indeed re-used axes, adzes and celts and allows us to clearly identify which of these tool types were transformed into RPE tool (fig.6.4.30/ 3,5).

Polishing traces (PU) have been detected on 48,1% of all passive sides (PU). 43,8% of the passive surfaces show unremoved flake scars (FE – PU and FE). Retouch (RT and RT-PU) has been determined occasionally as part of an object shaping (1,4%), and a combination of retouching and flaking (RE) can also be visible (1,5%). Only 3,9% of all the analyzed passive sides show the natural surface of the selected cobblestones (IR & LI).

Geology and the size of the active sides

No significant relation has been observed in relation between the size of re-used polished edge tools and geology (fig. A5.62 - 65). A correlations between (meta)alevrolite objects the length and weight, indicate regular linear relationship, while a correlation betweeen width, thickness and meta-alevrolite indicate regular negative relationship (fig.A5.62 and 65). Furthermore, regression coefficient of width/thickness is very strong in relation with the polished edge tools, which are mainly shorter, lighter and thicker (table 6.4.18). On the other hand, elongated, transversal sections of RPE tools are more uniform and likely to be square.

geology/N	**$\bar{X}$**	**σ**	**max length (mm)**	**min length (mm)**
meta-alevrolite / 92	86	14	147	58
light white stone /15	85	14	119	62
schist / 1	-	-	72	-
sandstone/ 12	94	16	127	68

Table 6.4.14. RPE tools: length according to geology; N= 120.

geology/N	**$\bar{X}$**	**σ**	**max width (mm)**	**min width (mm)**
meta-alevrolite / 102	42	9	83	25
light white stone /16	42	8	65	29
schist / 1	-	-	41	-
sandstone/ 8	43	8	62	32

Table 6.4.15. RPE tools: width according to geology; N= 127.

geology/N	**$\bar{X}$**	**σ**	**max thickness (mm)**	**min thickness (mm)**
meta-alevrolite / 102	26	6	52	7
light white stone /16	23	6	32	13
schist / 1	-	-	24	-
sandstone/ 8	23	5	34	15

Table 6.4.16. RPE tools: thickness according to geology; N=127.

geology/N	**$\bar{X}$**	**σ**	**max weight (gr)**	**min weight (gr)**
mata-alevrolite / 91	61,8	56	287,2	47,8
light white stone /15	04,5	51	202,	34,2
schist /1	-	-	123,2	-
sandstone/ 12	98.3	36	244	137.6

Table 6.4.17. RPE tools: weight according to geology; N= 120.

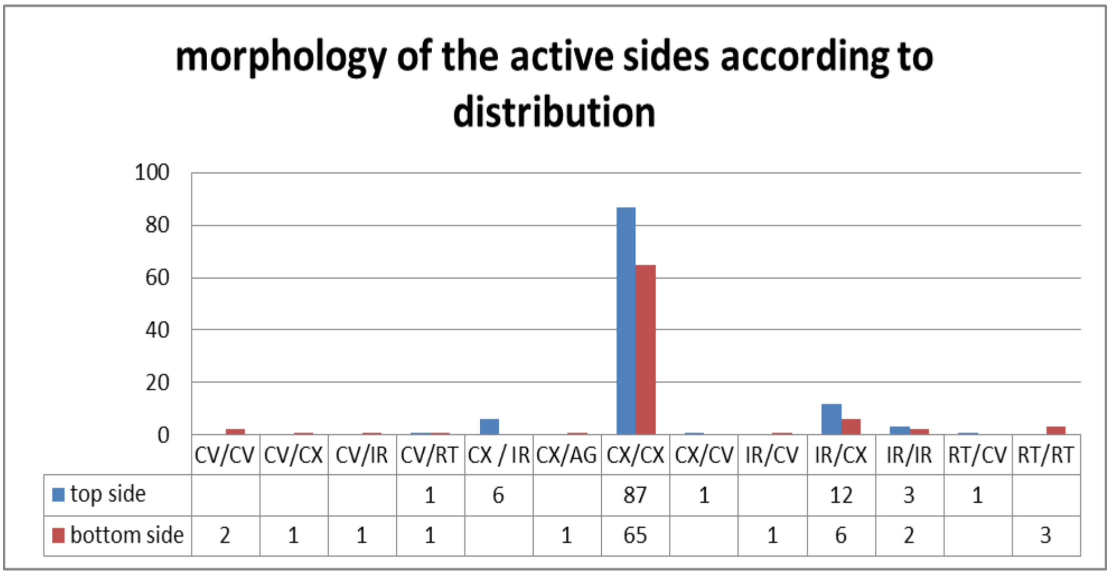
Type of **tool/N**	**length/weight R^2**	**width/thickness R^2**	**thickness/weight R^2**
RPE **tools / 120 / 127/120**	0,3084	0,608	0,409
axes /56/ 56 /56	0,317	0,1004	0,473
adzes / 20/ /20/ 20	0,4844	0,011	0,4799
celt /80 /106/80	0,505	0,144	0,5028

Table 6.4.18. RPE & TPE tools: Coefficient of determination of the correlations between length, width, thickness and weight.

The average width and thickness of the objects of different rocks are similar (table 6.4.12 - 13). The sandstone objects are the longest and heaviest. However, this could be a consequence of the small number of sandstone tools (n=12) (table 6.4.14-17).

The active surfaces

In terms of numbers, CX/CX morphology overwhelmingly dominates altogether. Unlike the top, bottom active surfaces show a variety of morphological forms. This points to the fact, that the bottom side is used more occasionally than the top and surfaces have not



	CV/CV	CV/CX	CV/IR	CV/RT	CX / IR	CX/AG	CX/CX	CX/CV	IR/CV	IR/CX	IR/IR	RT/CV	RT/RT
🟦 top side				1	6		87	1		12	3	1	
🟥 bottom side	2	1	1	1		1	65		1	6	2		3

Fig. 6.4.20. RPE tools: morphology of the active sides according to distribution in the artefact; N= 166.

become regularized. It should be noted that the top side is always the widest part of the artefact according to our classification system (fig.6.4.20).

The length, width and thickness of the tools are very similar according to the morphology of the active sides. The results only show that tools with the CX/CX shape of the active side are heavier (mean=169) than the tools with the CX/IR (mean=149) and IR/CX (mean=138) shapes of the active sides.

No pattern has been identified either in relation to the morphology of the active surfaces and measurements (fig. A5.69 – 74).

The active sides on the top and bottom appear levelled combined with percussion traces (AL-NO/AL-NO) (n=19; 43,2%) or only levelled (AL/AL) with 16% (n=7). No pattern has been identified in relation to the length or width of the bifacial active surfaces and use traces.

Patterns based on the relation of the measurements and use traces have not been identified (fig. A.5.75- 77). Although the relation between the width and thickness of the active sides and the levelling (AL1 and AL2) shows a regular linear relationship. This means that an increase in the length of the active surface is related to an increase of the width. The same correlation with the faceted, levelling (AL-FC) shows a negative linear relationship, suggesting that a decrease in the length is related to an increase in the width (fig. 6.4.21).

The surfaces of the sandstone items (n=19; mean= 698 mm^2) are the largest. However, this conclusion should be taken conditionally due to the small number of sandstone tools.

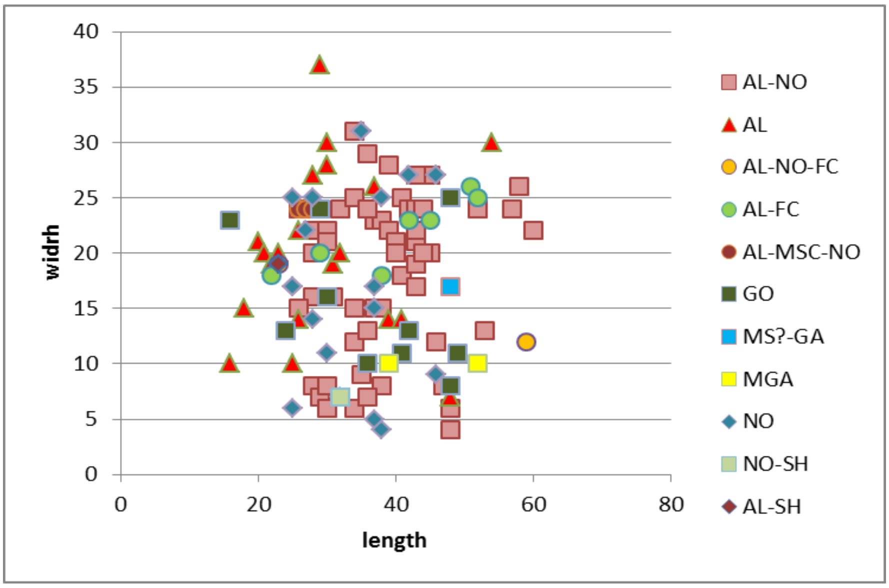
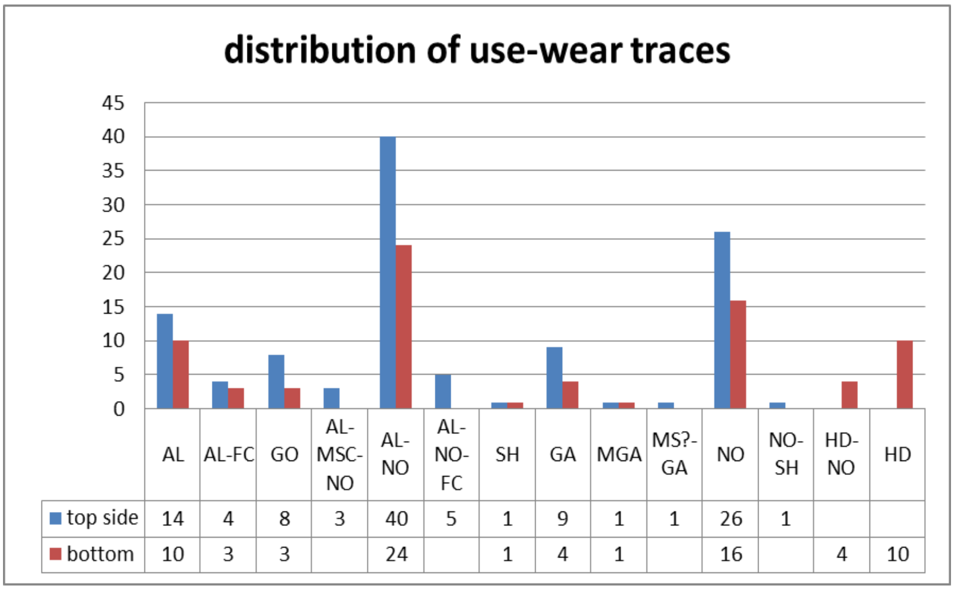


Fig. 6.4.21. RPE tools: correlation between surfaces and use traces of the active sides; AL 1: $R^2 = 0{,}747$; AL2: $R^2 = 0{,}7126$;AL-FC: $R^2 = -0{,}195$; N= 139.

Traces of handling (HD & HD-NO) and flake negatives (NO) occurred on the bottom active sides (fig.6.4.22).

The length, width and thickness of the tools does not vary with the different use traces. It could be said that the objects affected by levelling (AL) are slightly longer, narrower, thicker and heavier than the objects with the levelling combined with flake negatives (AL-NO) (table 6.4.19 – 22).

Observations under low power magnification (10-50X) indicate that levelling combined with flake negatives (AL-NO) and micro-pits can be intensive such on



	AL	AL-FC	GO	AL-MSC-NO	AL-NO	AL-NO-FC	SH	GA	MGA	MS?-GA	NO	NO-SH	HD-NO	HD
🟦 top side	14	4	8	3	40	5	1	9	1	1	26	1		
🟥 bottom	10	3	3		24		1	4	1		16		4	10

Fig. 6.4.22. RPE tools: use-wear traces according to distribution; N= 189.

the working surface of the tool L – BB - 260 (fig. 6.4.21-22.; fig.6.4.30/1; 2). Levelling (AL) show micro- topographic variations. The surfaces are uneven, intersected by micro – dents and micro-scratches, which run perpendicular to the working surfaces (fig. 6.4.23). Levelling, grains rounding and high topography with edge rounding are visible (fig. 6.4.23, 24). In some cases, abrasion eliminated previous traces of percussion (fig. 6.4.24/2.; fig.6.4.30/ 7).

An intensive appearance of pits (GA) and dents (GO) has been observed on the active surface of the tool L-KR- 65 (fig.6.4.24/3). A meta-alevrolite tool L -V-3 displays flake negatives with edge rounding (fig. 6.4.24/4).

Blunted edges of flake negatives are followed by shine on the active side of the object L-KR- 6 (fig. 6.4.24/5 - 6). An appearance of identical morphology of the working side on

use traces /N	**$\bar{X}$**	**σ**	**max length (mm)**	**min length (mm)**
AL / 23	93	8	111	80
AL-MSC-NO /2	98	12	107	90
AL-FC /7	75	7	89	68
AL-NO/ 60	87	11	109	58
AL-FC-NO/ 5	82	9	95	68
GA /13	91	17	119	62
GO/ 11	4	15	106	62
MGA / 2	82	3	85	80
NO/40	84	17	127	51

Table 6.4.19. RPE tools: length according to use traces; N= 163.

use traces /N	**$\bar{X}$**	**σ**	**max width (mm)**	**min width (mm)**
AL / 24	41	6	65	29
AL-MSC-NO /2	37	4	40	34
AL-FC /7	44	7	54	33
AL-NO/ 64	43	6	65	33
AL-FC-NO/ 5	36	6	42	26
GA /14	42	8	62	30
GO/ 11	42	7	51	27
MGA / 2	38	3	41	36
NO/40	42	1	83	25

Table 6.4.20. RPE tools: the width according to use traces; N= 169.

use traces /N	$\bar{X}$	**σ**	**max thickness (mm)**	**min thickness (mm)**
AL / 24	29	6	45	21
AL-MSC-NO /2	33	-	32	33
AL-FC /7	25	1	27	23
AL-NO/ 64	27	5	45	16
AL-FC-NO/ 5	22	3	28	19
GA /14	28	4	37	21
GO/ 11	26	6	35	16
MGA / 2	24	11	32	16
NO/40	24	7	52	14

Table 6.4.21. RPE tools: thickness according to use traces; N= 169.

use traces /N	$\bar{X}$	**σ**	**max weight (g)**	**min weight (g)**
AL / 23	96,9	46	252,2	114
AL-MSC-NO /2	10,5	44	242,2	178,8
AL-FC /7	47,9	24	173	105,2
AL-NO/ 60	85	47	271,6	74,6
AL-FC-NO/ 5	24,2	24	152	89
GA /13	53	55	236,8	78,2
GO/ 11	52,5	75	267,4	52,2
MGA / 2	1,4	80	148,6	34,2
NO/40	35,7	56	282	40,8

Table 6.4.22. RPE tools: weight according to use traces; N= 163.

tools L - MS – 33 (fig. 6.4.25) and L - MS – 35 (fig. 6.4.26) attracted our attention. More or less convex active sides have c. 3 mm thick blunted part. Micro-pits (fig.6.4.26/2) or micro-scratches (fig. 6.4.26/1) are visible on the surfaces of this part of the working surface.

The other part of the active side presents the edges rounding (fig. 6.4.25-26/1-2). We should mention another atypical Early Neolithic tool (fig. 6.4.27). It is the medial part of a tool with polished edges, whose top and bottom parts were removed, resulting in protruded edges suitable for work. Microscopically, active edges show high topography with rounding as well as grain rounding (fig.6.4.27/1). Fig.6.4.28. shows maintenance of the active side via flaking.

Former use traces are unremoved and still visible along the maintained surface. Results indicate handling of the RPE tools as well. Microscopically, direct contact with handle generated the uneven, pitted surface, intersected by dense, short and disordered

x

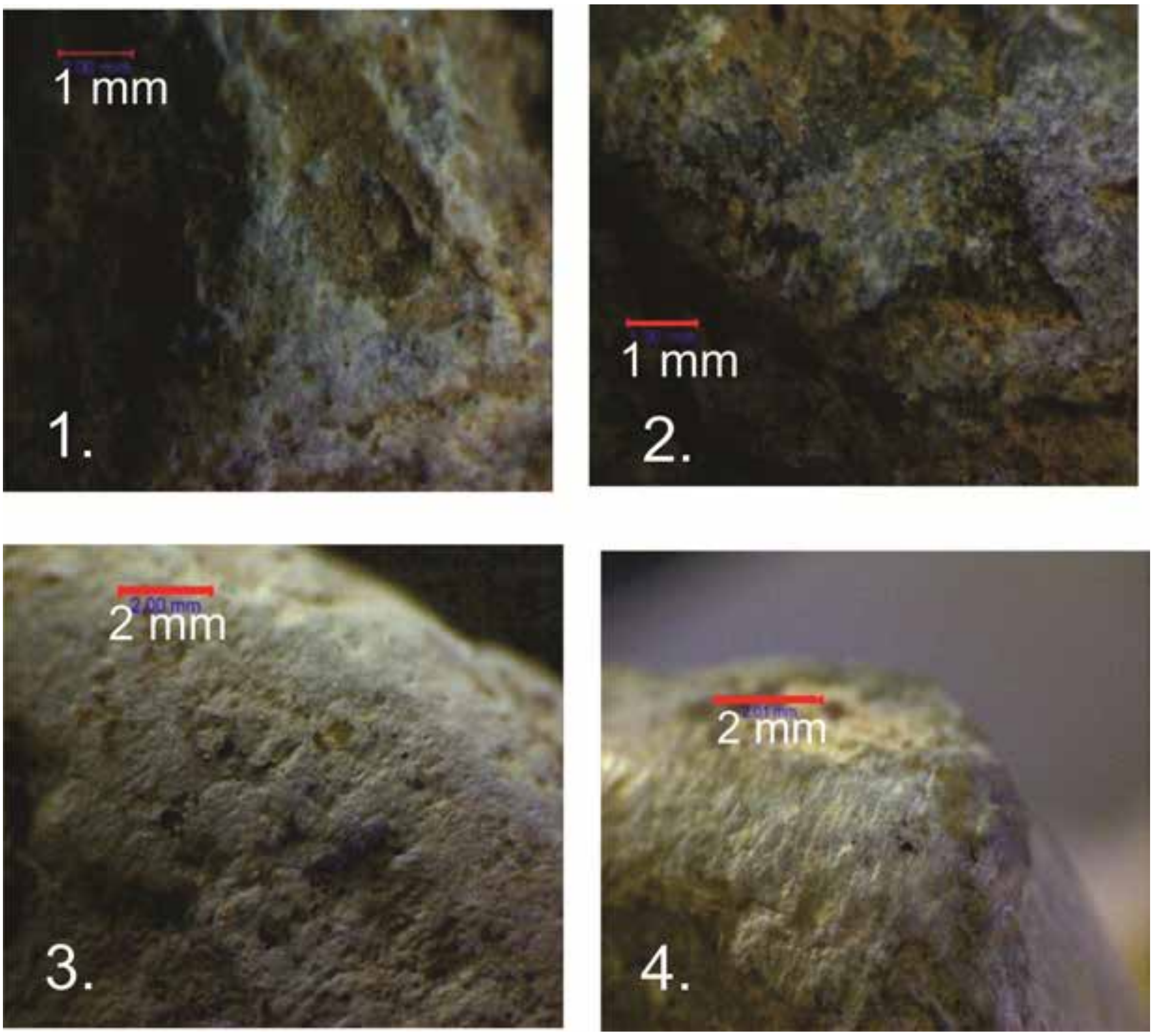


Fig.6.4.23. RPE: 1. levelling combined with flake negatives (AL-NO), L – BB – 260, meta-alevrolite; 2.flake negatives, L – BB – 269, meta-alevrolite;3. grain rounding and micro-scratches, L – BB – 227, meta-alevrolite. 4. Micro-scratches, L – BB – 173, meta-alevrolite.

micro-scratches (fig. 6.4.29).

Percussion traces are visible on the upper part of the maintained working surface of the tool L-PO-92, while the unremoved faceted surfaces is still present in the left lower part of the active side (fig. 6.4.30/1). This example confirms the idea of changing the purpose of the single

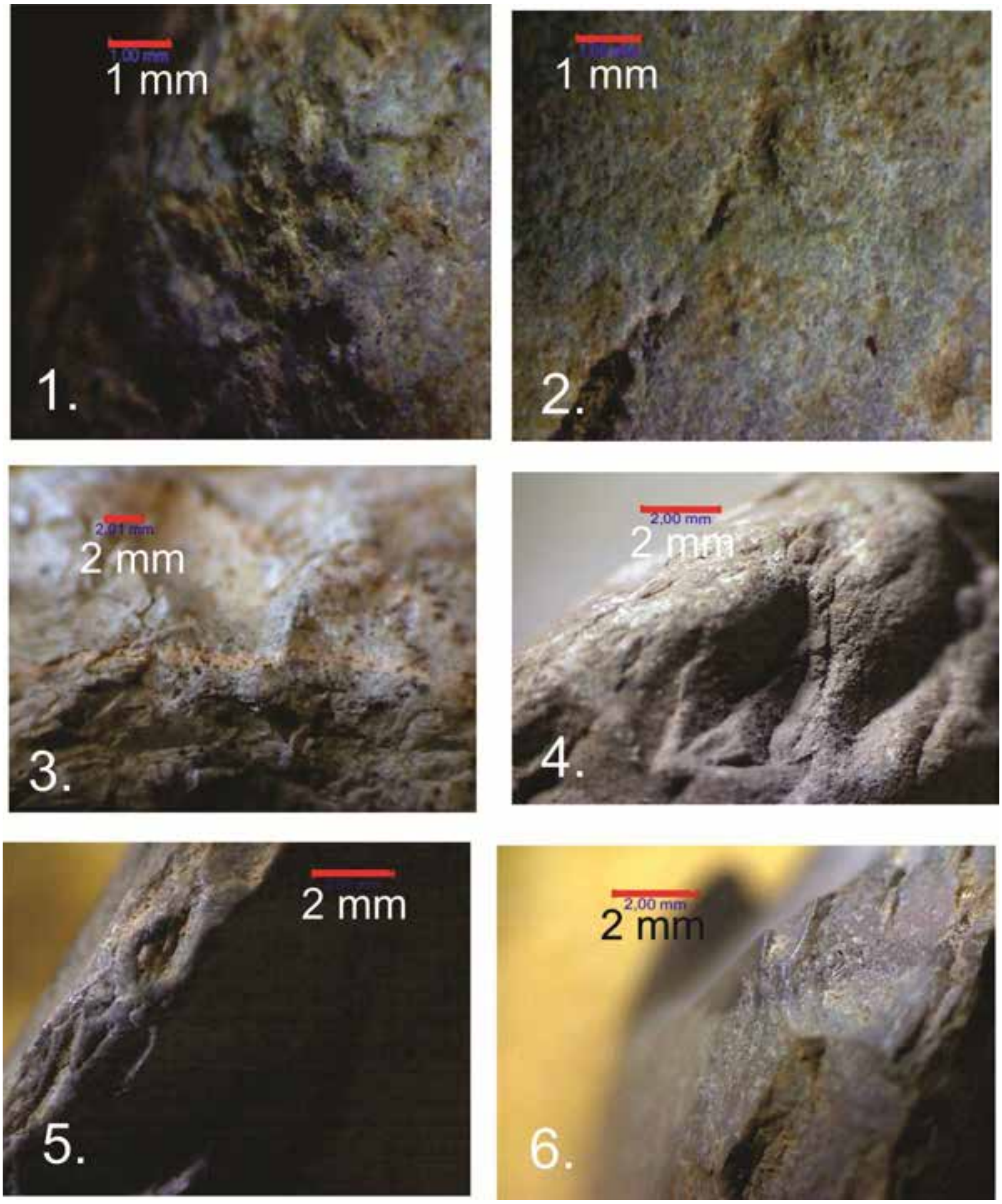


Fig. 6.4.24. RPE tools: 1. grain rounding, L – BB - 247, meta- alevrolite; 2. levelling (AL), L – BB - 337, meta- alevrolite; 3. pits (GA) and dents (GO), L-KR- 65, meta- alevrolite; 4. flake negatives (NO) with rounded edges , L – V – 3, meta- alevrolite; 5. flake negatives (NO) and dulled edges , L-KR- 6, meta- alevrolite; 6. flake negatives (NO) with sharp edges and shine , L-KR- 6, meta- alevrolite.

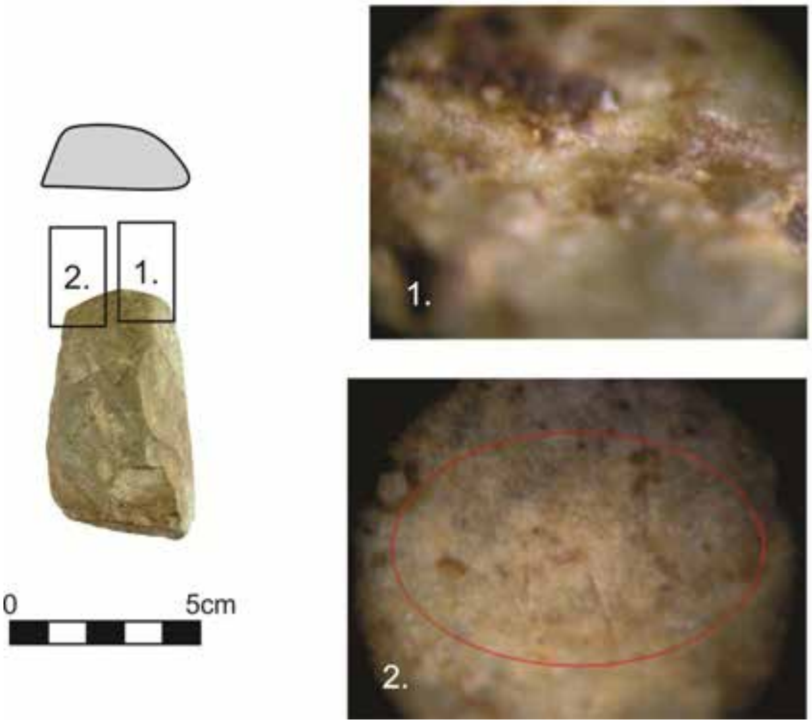


Fig. 6.4.25. RPE tools: blunted active sides with micropits (2.) combined with flake negatives (NO) (1.) , L – MS- 33 , meta-alevrolite.

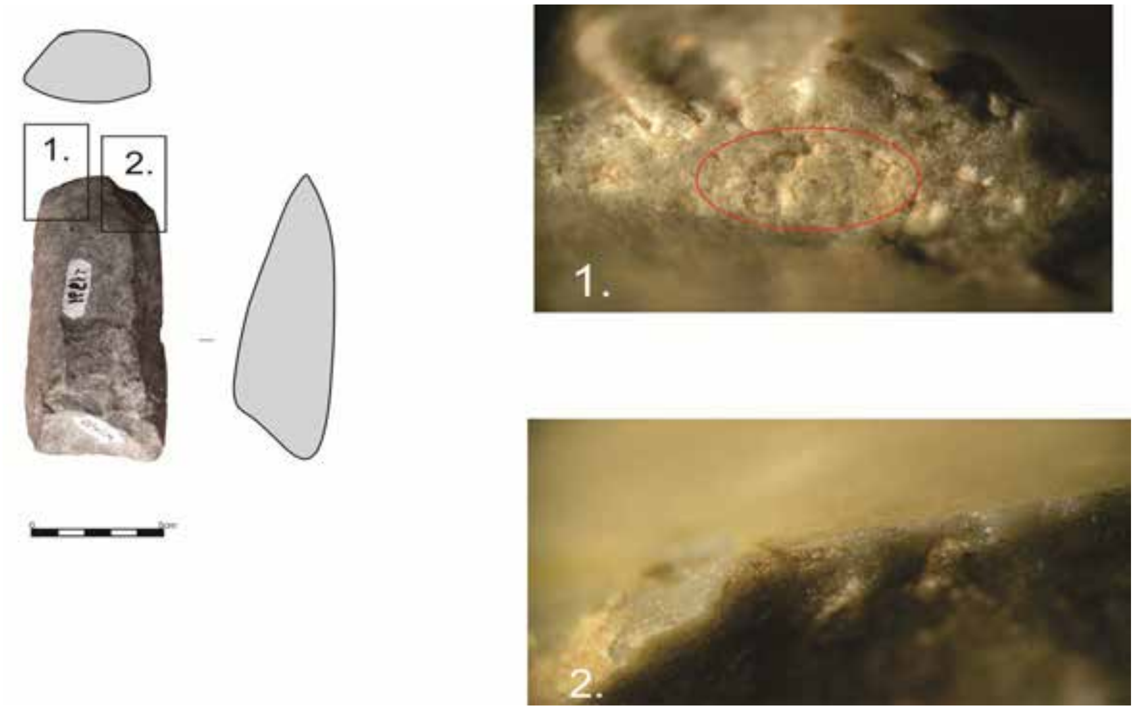


Fig. 6.4.26. RPE tools: blunted active sides with micropits (2.) combined with flake negatives (NO) (1.), L - MS – 35, meta-alevrolite.

tool and multi-functionality of RPE tools.

Taking into account morphology of use traces and the working part of the tool, which is narrowing, such is resemble to tools used for mining in prehistory, quality of raw material,
used to manufacture a re-used polished edge tool, and type of use traces, lead us to conclude that re-used polished edge tools 1 (REP1) might be employed for splitting, crashing hard material such as minerals. The same criteria suggest that re-used polished edge tools 2 (REP2) might be used for shaping objects made of hard material, such as stone by scarping and gouging.

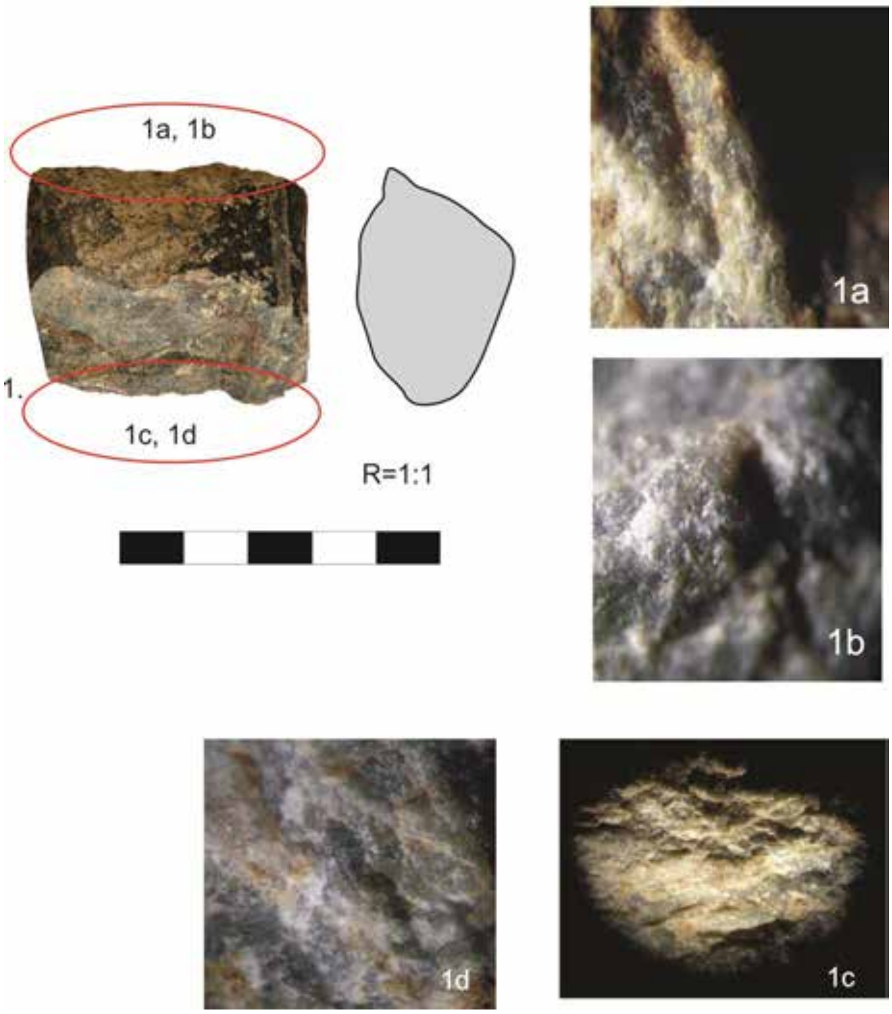


Fig. 6.4.27. RPE tools: grain rounding on the top (1a,b) and bottom side (1c.d.) L - Me – 40. meta-alevrolite.

Finally, it can be said that RPE 1 provides us with more information than RPE2 tools.

Fig. 6.4.28. RPE tools: traces of maintance of the top side of the object L –BB – 210, meta-alevrolite.

Fig. 6.4.29.RPE tools: wear traces developed in contact with handle (HD-NO), L - BB – 178, meta-alevrolite.

related to a different phases of the use life based on a different degree of wear. Mature phase has been identified based on flake negatives combined with levelling (AL-NO) (fig.6.4.21-22; 6.4.30/2) and levelling extended through pressure and abrasion with time. In this stage, levelling is combined with micro-scratches and grain rounding (fig. 6.4.23 – 27; fig.6.4.30/1,4). Prolonged use reflects that levelling covers almost completely flake negatives (NO), indicating worn-out working surface (fig.6.4.24/2; 6.4.30/7). An occurrence of faceted active side also confirms the intensive use of the tool (fig.6.4.30/1). Such interpretation has been supported by a previous study (Delgado, Gomez-Gras 2017) and our experimental program (subchapter 2.3.3)

Summary

The re-used polished edge tools present a large group of 136 Neolithic macro-lithic artefacts They have been detected mainly (75,7%) in the northern part of the Central Balkans. These objects present recycled robust polished edge tools. Geological context of the Northern region suggests a general lack of raw materials. This means that material used for manufacturing polished edge tools was not found locally, but was part of distant exchange networks (subchapter 5.3). Lack of raw material indicates high social value and might explain an appearance of the re-used polished edge tools on the Late Neolithic settlements at this area, as the quality of geology allowed percussion activity.

The analysis of geology, metrical values, morphology of the working surfaces and use-wear of re-used polished edge tools show no distinctive use. Use traces suggest that these tools were involved in work on hard materials such as minerals or maybe stone. We have distinguished two groups according to types of use traces. The first group, RPE1was employed for crushing or splitting hard material, such as stone (Risch 2002: 130, fig.5.1.1.). Although seldom appearance of levelled and glossy working surface confirms processing of a soft material containing oil or fat. Furthermore, this type of tool shows different degree of wear, revealing different stages of use-life, from operative to discarded one. The second group, RPE2 were used in shaping objects made of hard materials by scraping and gouging.

In summary, we can say that re-used polished edge tools suggest specific, intensive economic activity linked particularly to the Northern region. The quality of raw material used for manufacturing and re-using polished edge tools allowed processing of the material by percussion, causing loss of original morphology of polished edge tools. Once the re-used polished edge tool was worn out, its operative state was recovered by re-pecking of the active sides. This indicates the existence of technical knowledge related to the behaviour of the rocks, which also confirms that polished edge tools were manufactured within the settlements where they were found.

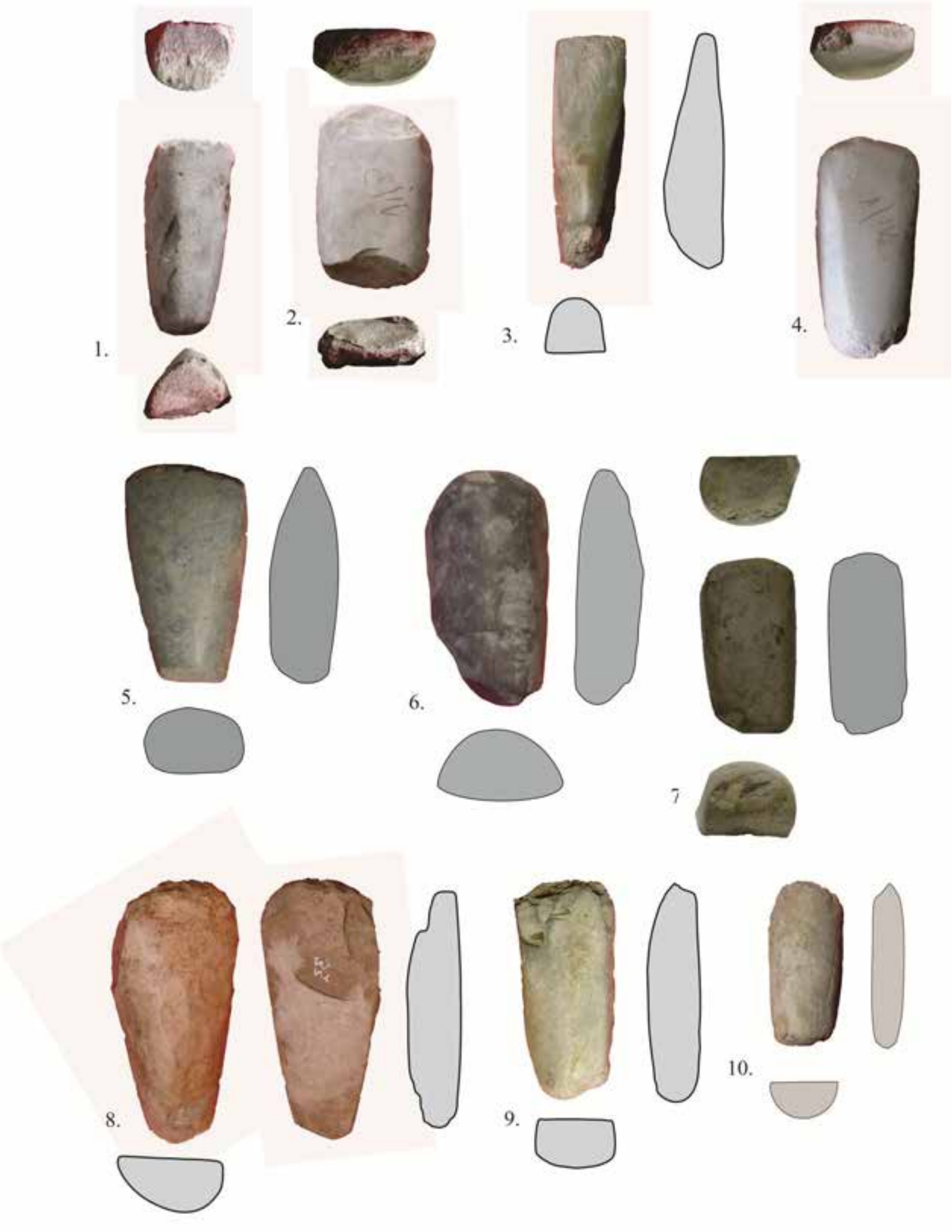


Fig. 6.4.30. RPE tools: 1. L-PO-92; 2. L-PO-108, 4. L-PO- 124; 5. L-PO- 112; Potporanj; 3. L-BB-312; 7. L-BB- 136, Benska bara; 6. L-AT-14, At; 8. L-KR- 65; 9. L – KR – 6, Kremenilo ; 10. L-V- 3, Vranjani;

6.4.3. Hammers

This artefact defines an elongated, massive, unworked, cobble tool. Characteristic of these tools are active sides, located on the top as well as on the bottom, formed during crashing and grinding raw material by strong blows. The previous studies mention this tool, made of various rocks as rare in the Neolithic settlements from the Central Balkans (Antonović 20003: 56, 81,86, 98, 113, 127).

Fig. 6.4.31 Hammer: L- Če – 84, Čelina, the Western region, sandstone.

In our study, we present results of analysis of 43 hammers, detected in the Late Neolithic settlements of Benska bara (n= 4) (fig.6.4.37/1-2) and Potporanj (n=2) (fig.6.4.37/5), Čelina (n=7) (fig.6.4.31) and Kremenilo (n= 4) (fig.6.4.37/3-4), Motel Slatine (n= 8) and Turska Česma (n= 10) and Gumnište (n= 5). A small number of the tools comes from the Middle Neolithic settlement of Tumba Madžari (n= 4).

C. 58% of all objects are broken or fragmented, while c. 44% are well preserved (fig.6.4.32). In spite of the function, a number of complete tools are good enough to provide a clear image of this type of percussion artefact. The fragmentation did not allow us to identify if two objects belong to this type of tools.

These were mostly manufactured out of sandstone and a high variability of igneous rocks. Metamorphic rocks and

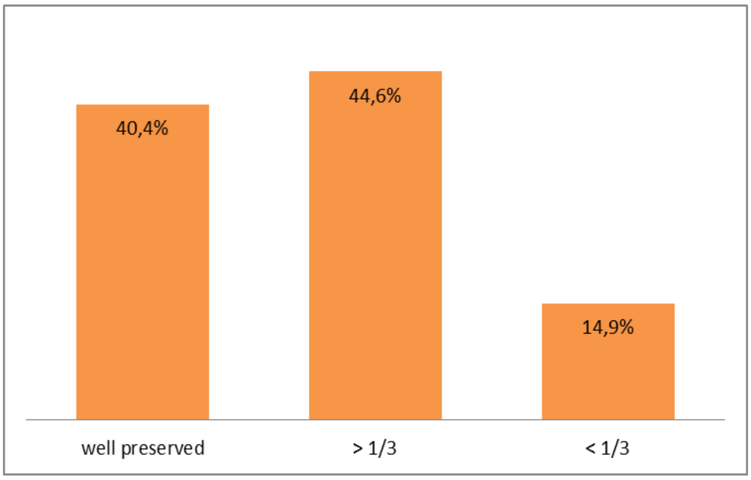


Fig.6.4.32. Hammers: preservation; N=45.

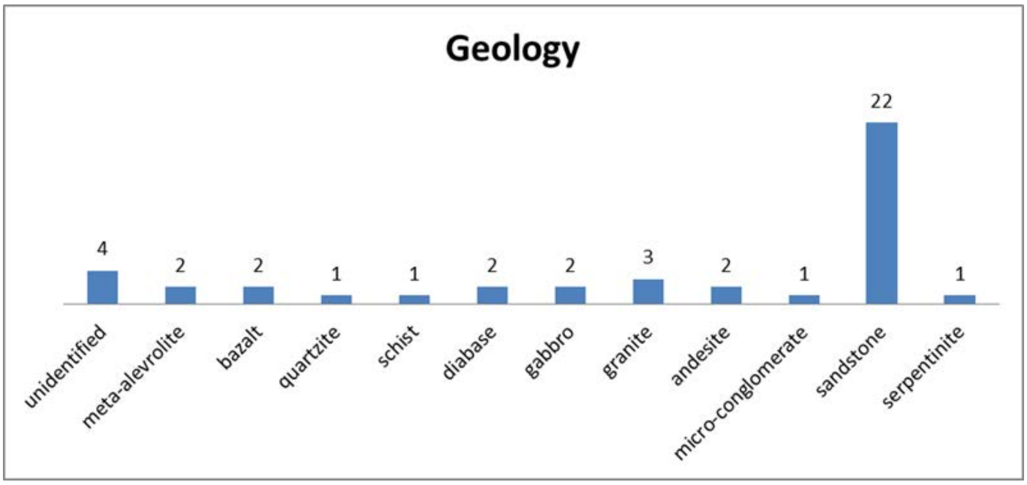


Fig.6.4.33. Hammers: geology; N=43.

micro-conglomerate objects were recorded as well (fig.6.4.33).

The obverse side of the tool L - TM – 104 presents smoothed surface and shine, suggesting that this pebble was collected from a river bed.

Geology and size of the tools

No pattern has been identified based on a correlation between the measurements and geology (fig.A5.78 – 80).

The record shows that sandstone artefacts are elongated in transversal section and likely to be square in longitudinal section. These artefacts are longer, narrower and lighter then igneous tools (Table 6.4.23 - 26).

geology/N	$\bar{X}$	**σ**	**max length (mm)**	**min length (mm)**
igneous rocks / 8	107	35	183	73
sandstone/ 6	124	37	167	76

Table 6.4.23. Hammers: length according to geology; N= 14.

geology/N	$\bar{X}$	**σ**	**max width (mm)**	**min width (mm)**
quartzite / 1	-	-	100	-
schist / 1	-	-	48	-
igneous rocks / 11	64	12	90	51
sandstone/ 18	55	16	95	29

Table 6.4.24. Pestles: width according to geology; N= 31.

geology/N	$\bar{X}$	**σ**	**max thickness (mm)**	**min thickness (mm)**
quartzite / 1	-	-	66	-
schist / 1	-	-	22	-
igneous rocks / 11	46	11	61	22
sandstone/ 18	41	10	61	21

Table 6.4.25. Hammers: thickness according to geology; N= 31.

geology/N	$\bar{X}$	**σ**	**max weight (g)**	**min weight (g)**
igneous rocks / 8	627,7	212	846	253,6
sandstone/ 6	451,5	702	754	85,4

Table 6.4.26. Hammers: weight according to geology; N= 14.

The active surfaces

Mainly the convex (CX/CX) active sides (n= 26; 76,8%) display mature or use phase of hammers (Delgado, Risch 2005: 239, fig. 4; Delgado, Gomez-Gras 2017: 58), while their irregular and convex (IR/CX, IR/IR & CX/IR) shapes of working sides indicate very intensive use of artefacts.

No pattern has been identified in relation to the size of the tools and the morphology of the active sides (fig. A 5.80 - 82). Different use has not been identified either based on a correlation between the size of the active sides and geology (fig. A 5.85) nor based on a correlation between the size of the active sides and morphology (fig.A 5.86).

Igneous items developed the large and elongated active sides (n=12; 336 – 2300 mm^2; mean= 1231 mm^2). Unlike them, the sedimentary objects show small active sides (55 to 1443 mm^2; mean= 1081 mm^2) (fig. A 5.83). This suggests that igneous objects were more used more frequently than sandstone objects.

Use tracess

The active surfaces on the top and the bottom sides show mainly pits (GA) and dents (GO). Flake negatives (NO), which suggest that these objects were used intensively are rare

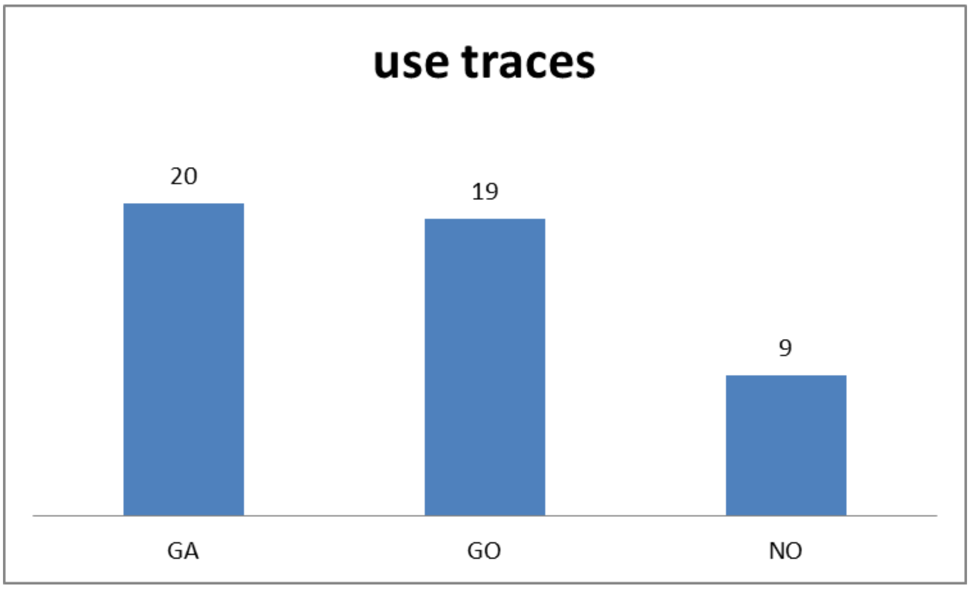


Fig. 6.4.34. Hammers: morphological forms of the actives sides; N= 48.

(fig.6.4.34).

No pattern has been identified in relation between the measurements of the tools and use traces and the size of the active sides and use traces (fig.A 1.87,91 - 93).

use traces/N	$\bar{X}$	σ	max length (mm)	min length (mm)
GA / 6	125	20	154	101
GO/ 10	98	28	167	73
NO/ 1	-	-	89	-

Table 6.4.27. Hammers: length according to geology; N= 14.

use traces /N	$\bar{X}$	σ	max width (mm)	min width (mm)
GA / 20	59	18	100	29
GO/ 19	63	15	90	37
NO/ 6	62	14	81	47

Table 6.4.28. Hammers: width according to use traces; N= 45.

Tools with dents (GO) are the longest, while tools with pits (GA) are the heaviest (table 6.4.27 - 30). Pits (GA) appeared on the wide tools, while dents (GO) are detected on the narrow and thin objects (fig.A5.84,88,89). This suggests that narrow and thin objects might be used for activities which were related to strong blows and crushing raw materials, while wide items were implemented for pulverizing. Regardless of use traces, the tools are elongated in transversal sections (fig. A5.90).

use traces/N	$\bar{X}$	σ	max thickness (mm)	min thickness (mm)
GA / 19	43	12	66	19
GO/ 19	43	10	61	28
NO/ 5	50	11	65	37

Tabe 6.4.29. Hammers: thickness according to use traces; N= 43.

use traces /N	$\bar{X}$	σ	max weight (g)	min weight (g)
GA / 6	624,6	160	832	413,4
GO/ 10	400,6	210	795,4	85,4
NO/ 1	-	-	364,8	-

Table 6.4.30. Hammers: weight according to use traces; N= 17.

The active surfaces with pits (GA) are mainly large (n=14; 55 - 3036 mm^2, mean=1221 mm^2), and are slightly smaller than the working surfaces with dents (GO) (n=11; 299 – 2300 mm^2; mean=1286 mm^2).

Microscopically, the surfaces of flake negatives (NO) present micro-dents and frosted like-appearance of the grains (fig. 6.4.35), suggesting work on hard materials such as stone.

We have also recognized four fragmented, perforated objects L - BB – 168, L - BB – 145, L – BB 338, and L - BB –100, which were re-used as hammers. They come from the Late Neolithic settlement of Benska bara in the Northern region and were made of sandstone, meta-alevrolite and serpentinite. Their average size is larger than the average size of the sandstone hammers, but the mean of weight is smaller than the mean of the weight of the sandstone objects (table 1.2 –5, 10). Use traces have been documented on the top and bottom sides, where the ancient breakage is located. The sandstone hammer L-BB-338 also shows an unsuccessful attempt of perforation on the obverse, which occurred probably before the object was re-used (fig. 6.4.36/2).

Fig. 6.4.35. Hammers: surface of flake negative (NO), L – KR – 40, 251, granite.

Observations also show notches on the left passive side of a granite object L - Dr – 86, which has weight is 543,8 g. This transformation was generated prior to the use of the artefact and present evidence of handling, aiming to facilitate the use of the instrument similar to what happens with the mining tools.

Summary

The hammers are a type of artefact, found rarely at settlements during Neolithic at the Central Balkans. This can be explained by their employment outside sites. They were made mainly of sandstone and used to crush hard raw materials such as stone. The result also shows that wide tools might be used for pulverizing, while narrow and thin objects were implemented for crushing raw material. This was also performed by a re-used perforated object. Notches on the passive sides of a granite object L - Dr – 86 suggest handling, and the idea of planned, long-term implementation of the instrument.

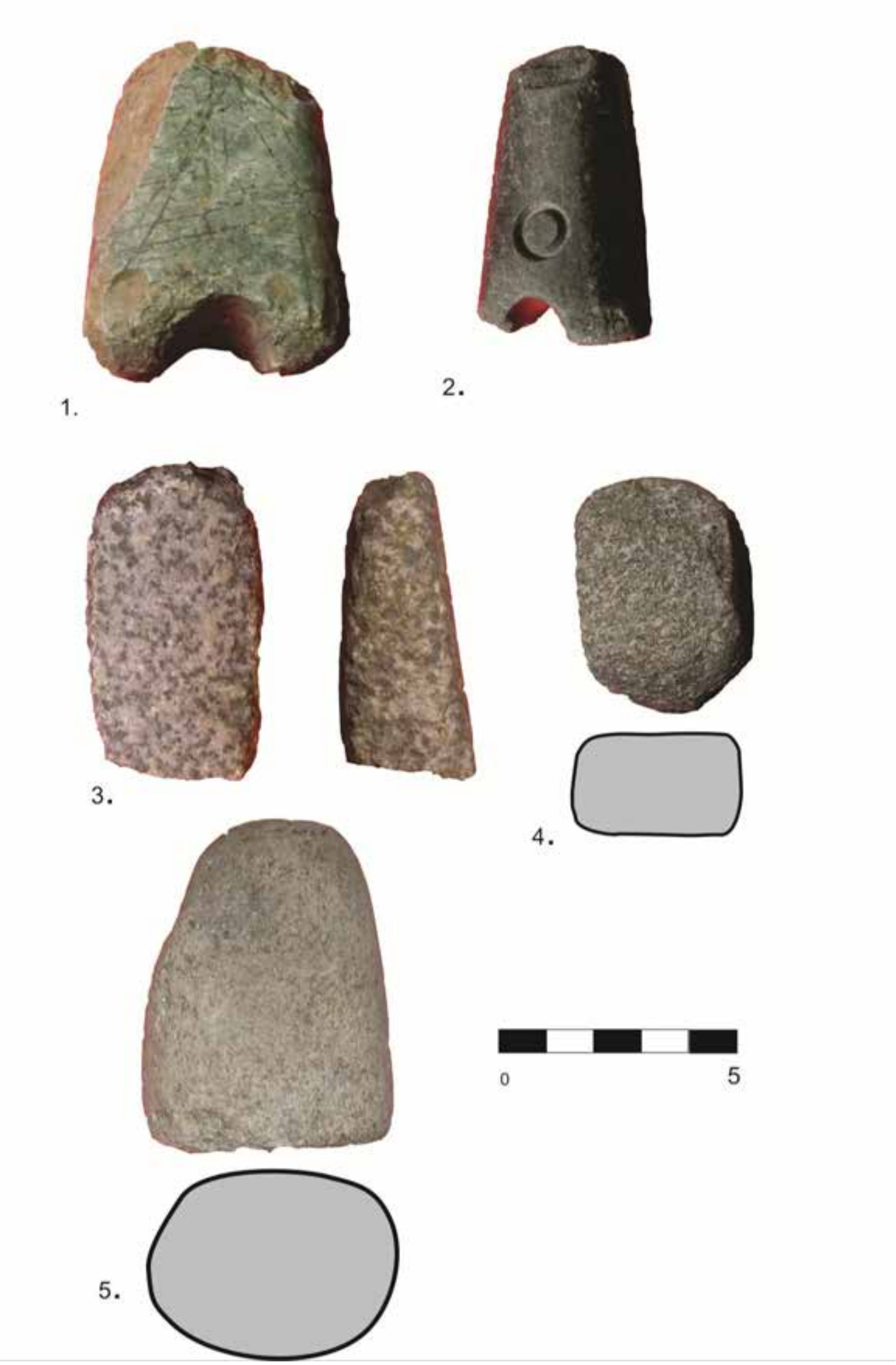


Fig. 6.4.36. Hammers:1. L-BB-100; 2. L-BB-338, Benska Bara; 3. L-KR-1; 4. L-KR-40 Kremenilo; 5. L-PO-20, Potporanj, Vršac.

6.4.4. Pestles

The pestle defines a cobble tool with active sides on the obverse and reverse sides generated in the process of pulverizing, crushing and grinding (fi. .6.4.46, 51, 53, 56). The studied collection come from the Late Neolithic settlements of Potporanj (n= 8) (fig. 6.4.56/6) in the Northern region, Motel Slatine (n= 8) (fig. 6.4.56/ 2,3) and Turska Česma (n= 10) (fig. 6.4.50, 53; fig. 6.4.56/ 5,7,8) in the Central region as well as at the settlement of Gumnište (n= 3) in the Southern region. The small number of the tools are from the Middle Neolithic settlement of Tumba Madžari (n= 3) (fig. 6.4.56/1,2; fig. 6.4.52) in the Southern region and the Early Neolithic settlement of MeĎureč (n= 2) in the Central region.

Fig. 6.4.46. Pestle: L – PO – 25, Potporanj, Northern region, sandstone.

C.57% of all studied tools are broken and fragmented, while the rest is well preserved or complete (fig. 6.4.47). This might suggest that these objects performed intensive operation, associated with strong blows. The percentage of well-conserved tools are enough to provide information on this type of percussion tools.

These tools occurred in the high variability of igneous rocks such as andesite, basalt, diabase, granite, gabbro and granodiorites. Quartzite and sandstone tools appeared as well (fig. 6.4.48). 90 % of passive surfaces of the pestles are the natural surface of selected cobblestones (IR and LI). Polishing (PU and IR-PU), traces of percussiona (TR)

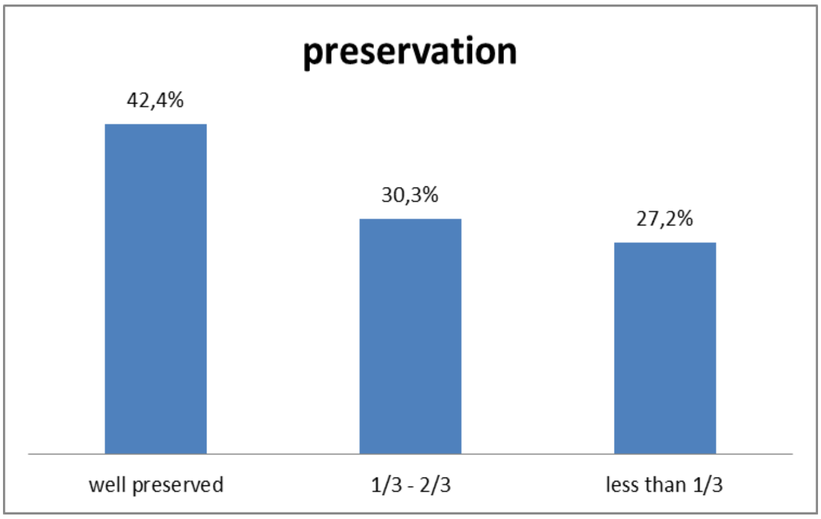


Fig. 6.4.47.Pestle: preservation; N= 33.

and pecking (PK) appeared on some 10% of all passive sides, suggesting that these raw materials were collected from river beds.

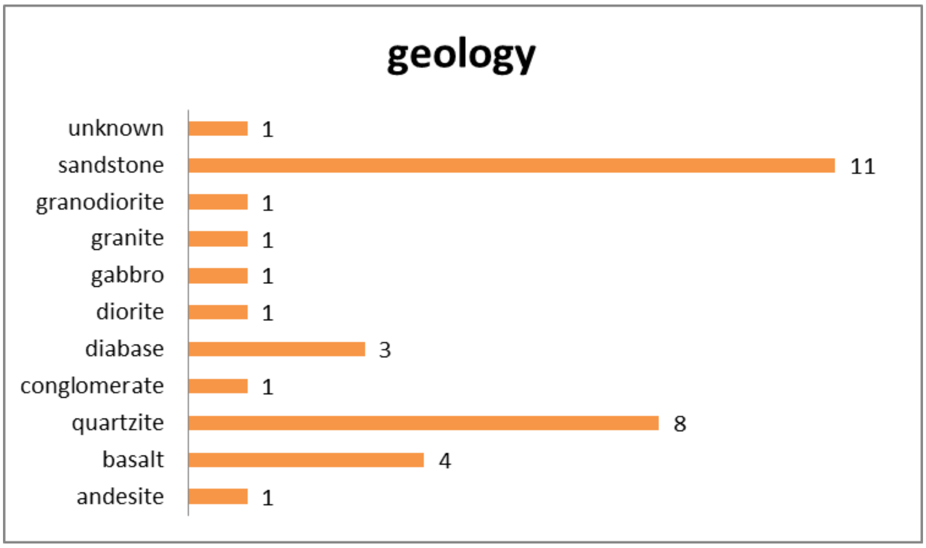


Fig. 6.4.48. Pestles: geology; N= 33.

Geology and the size of artefacts

The tools show similarities in the size, regardless of geology. Although it seems that the quartzite tools are the shortest, while the sandstone objects are the heaviest and very elongated in transversal section (table 6.4.31 - 34).

Certain patterns can be expected if we take into account only the length and weight, width and weight of the tools, made of various geology (fig. A5. 94-95). Pattern 1 includes

geology/N	$\bar{X}$	**σ**	**max length (mm)**	**min length (mm)**
quartzite / 3	73	9	81	63
igneous rocks /4	95	17	106	72
sandstone/ 5	99	44	175	67

Table 6.4.3. Pestles: length according to geology; N= 13.

geology/N	$\bar{X}$	**σ**	**max width (mm)**	**min width (mm)**
quartzite / 4	53	22	75	22
igneous rocks / 7	51	6	58	42
sandstone/ 9	60	11	82	48

Table 6.4.32. Pestles: width according to geology; N= 13.

geology/N	$\bar{X}$	σ	max thickness (mm)	min thickness (mm)
quartzite / 4	39	13	53	21
igneous rocks / 7	31	5	39	22
sandstone/ 9	34	10	50	20

Table 6.4.33. Pestles: thickness according to geology; N= 20.

geology/N	$\bar{X}$	σ	max weight (g)	min weight (g)
quartzite / 3	288,2	41	318,4	240,8
igneous rocks /5	359,7	225	644,4	167,6
sandstone/ 5	462,3	381	1100,6	173

Table 6.4.34. Pestles: weight according to geology; N= 20.

small group of long (85 – 116 mm), wide (67 – 81mm) and heavy (525,4 – 644,4 g) objects (n=3), while pattern 2 consists of short (45 – 106 mm), narrow (42-59 mm) and light (167, 6 – 318,4 g) (n=9). Altough the tools from pattern 2, which are associated with relation width/weight reach weight by 305,4g.

The active surfaces

The active sides of the pestles show different shapes, which are linked to their different operative stages. The result shows mainly the convex (CX/CX) shape of the active sides (n=35), which presents the mature or use phase. The irregular (IR/CX, IR/IR) (n=3), which indicate intensive use, and flat (RT/RT) working surfaces (n=1) shapes of the active

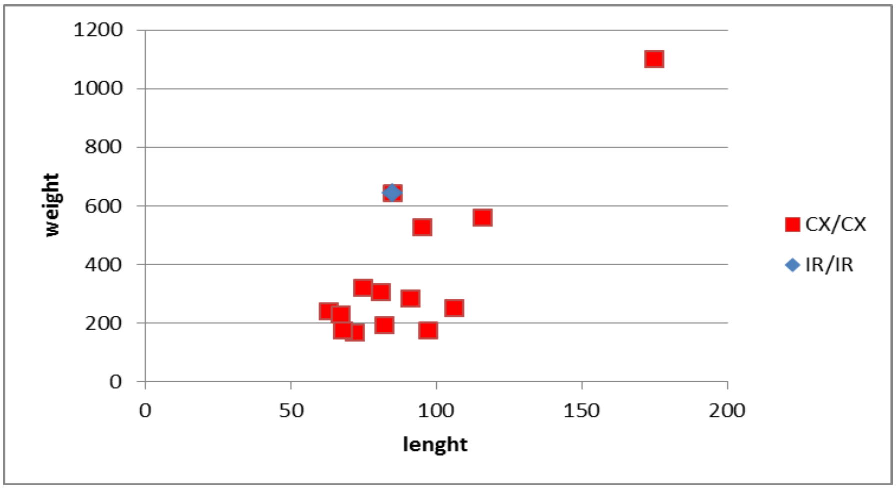


Fig.6.4.49 Pestle: correlation between the shape of the active sides and the size of the tools; N=27.

surfaces, suggesting maintenance phase.

A correlation between morphology and the size of artefacts might indicate functional groups. These groups correlate with pattern 1 and 2 and envolve the objects with convex (CX/CX) active (fig.6.4.49; A5.98).

Use traces

Most of the pestles show pits (GA) and levelled surfaces (AL), which could be also faceted (AL-FC) (fig. 6.4.51, 56 / 6) (fig. 6.4.50).

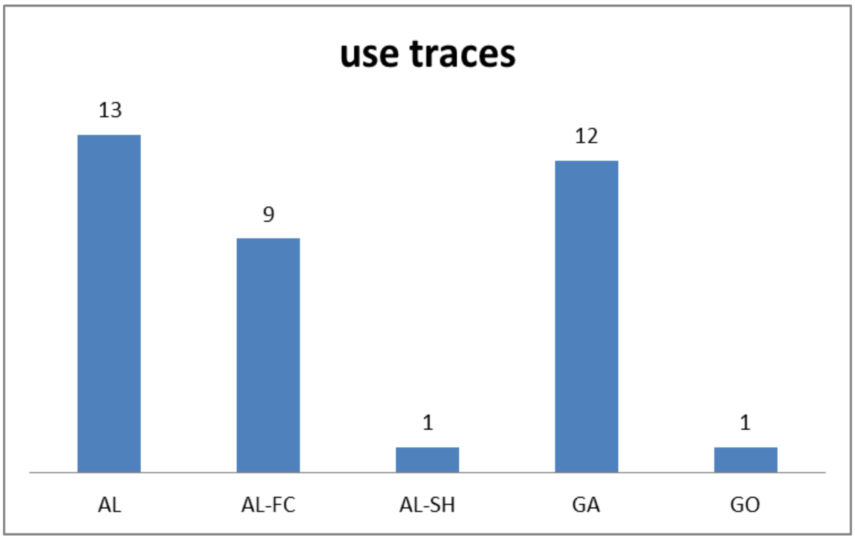


Fig. 6.4.50 Pestles: use trace; N= 36.

The levelled active sides (AL and AL-FC) appeared on the tools with elongated transversal sections, while pits (GA) occurred on the tools which transverse section likely to be square (fig. A 5.106). This menas that the first group of items were associated with grinding, while the second group of objects were used to pulverize.

The active sides are elongated, mainly convex in shape and their size varies between 1,2 – 20,2 cm^2. Certain patterns can be identified when geology is taken into account. Igneous rocks as very durable material developed the large, levelled (AL and AL-FC) working surfaces, which are mainly larger than 9 cm^2. Sedimentary and quartzite instruments produced mainly the medium to small active surfaces. Crushing produces pits (GA) and dents (GO) on their working sides (table 6.4.35-36, fig. A 1.7-8).

The active surfacaes of patterns 1 and 2 produced pits (GA), levelled surfaces (AL), and levelled, faceted surfaces (AL-FC), suggesting that they were employed in pulverizing

geology/N	$\bar{X}$	σ	max cm^2	min cm^2
volcanic / 4	12	6,7	20,2	6,1
quartzite / 4	3,3	2,2	6	1,2
plutonic/8	9,6	1,2	11	7,3
sedimentary/ 8	6,5	5	19	1,4

Table 6.4.35. Pestles: the size of active surfaces according to geology; N= 24.

Use traces/N	$\bar{X}$	σ	max cm^2	mincm^2
AL/ 9	6,5	4,7	14,9	1,2
AL-FC/ 9	10,3	4	20,2	6,1
AL-SH/ 1	-	-	1,4	-
GA/ 3	5,5	0,9	6,1	4,5
GO/ 1	-	-	4,1	-

Table 6.4.36. Pestles: the size of active surfaces according to use traces; N= 23.

Use traces/N	$\bar{X}$	σ	max length (mm)	min length (mm)
AL/ 6	87	7	95	75
AL-FC/ 8	73	9,3	95	67
AL-SH/ 1	-	-	97	-
GA/ 8	112	44,2	175	63

Table 6.4.37. Pestles: length according to use traces; N= 24.

Use traces/N	$\bar{X}$	σ	max width (mm)	min width (mm)
AL/ 12	62	16,2	82	22
AL-FC/ 9	53	11,6	72	42
AL-SH/ 1	-	-	49	-
GA/ 11	56,3	11,3	75	39
GO / 1	-	-	58	-

Table 6.4.38. Pestles: width according to use traces; N= 34.

Use traces/N	$\bar{X}$	σ	max thickness (mm)	max thickness (mm)
AL/ 11	43	14	62	21
AL-FC/ 8	33	7,9	46	25
GA/ 9	40,8	4,2	53	20
GO / 1	-	-	46	-

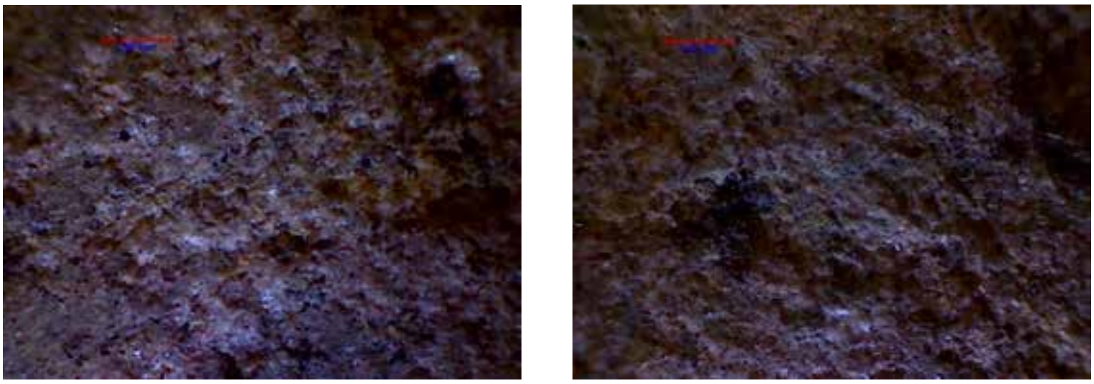
Table 6.4.39. Pestles: thickness according to use traces; N= 29.

Use traces/N	$\bar{X}$	σ	max weight (g)	max weight (g)
AL/ 11	450	175,4	644,4	283,8
AL-FC/ 8	247,8	123,5	525,4	167,6
GA/ 9	531	380	1100,6	193,4

Table 6.4.40. Pestles: weight according to use traces; N= 28.

and grinding (fig. A1.9-12). The record shows that the size of the tools does not vary significantly in relation to the type of use traces (table 6.4.37 - 40).

At the mesoscopical scale, the topography of the levelled surfaces (AL) can vary also according to the position of the active surface. This is the case of pestles L – Dr – 76 and L - Dr – 343 (fig. 6.4.52/1) with faceted levelled active surfaces (AL-FC). Their active surface on the top show grain rounding on high topography (fig. 6.4.52/a) and levelling with edge rounding (fig. 6.4.53/2), while the bottom sides display high amount micro-pits and grain extraction(fig.6.4.41, 52/3). Levelling with no rounding (AL) is associated with dents (GO) and micro-pits on the active surface of a basalt pestle L- TM – 11 (fig.6.4.53/2 -3). Reverse and left sides reflect thermal alternation, abrasive wear (AL) and dents (GO), suggesting contact with high temperature and an impact of an object made of hard material (fig. 6.4.53/a).



a. b.

Fig. 6.4.51. Pestles: a. levelled surfaces (AL) on top active side; b. Levelled surface (AL) on the bottom active side, L – Dr – 76, sandstone.

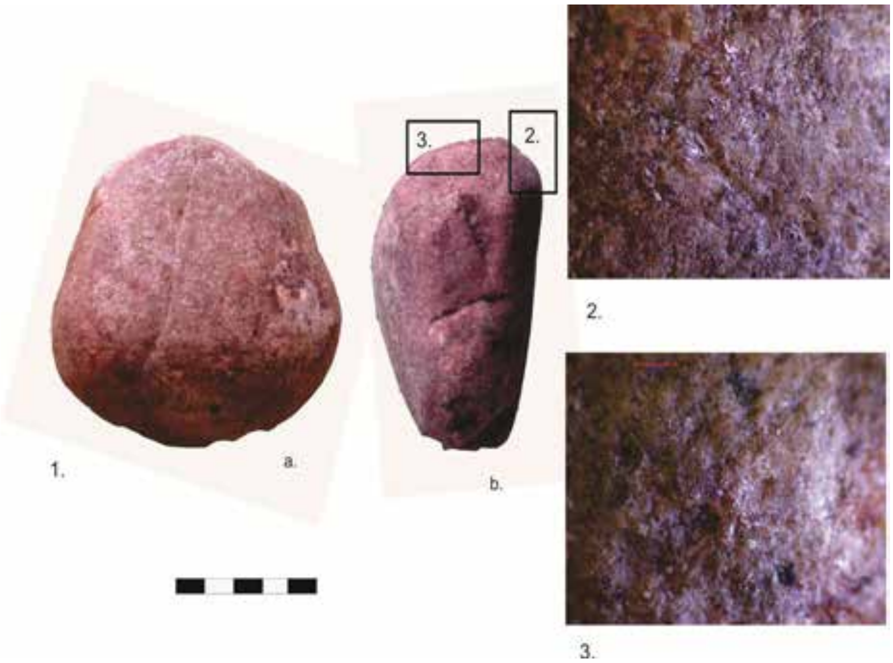


Fig. 6.4.53. Pestles: smoothed surfaces (AL) on faceted active sides, L - Dr – 343, quartzite.

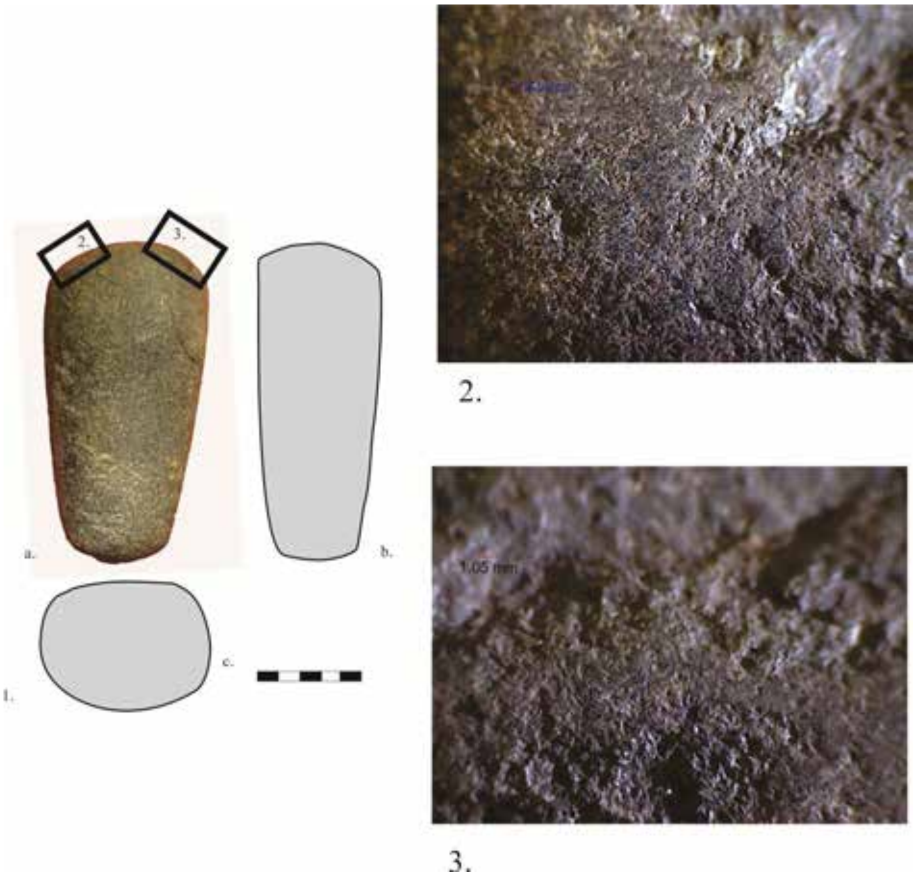


Fig. 6.4.54 Pestles: 2.- 3. levelled surfaces (AL) combined with dents (GO), L- TM – 11, basalt.

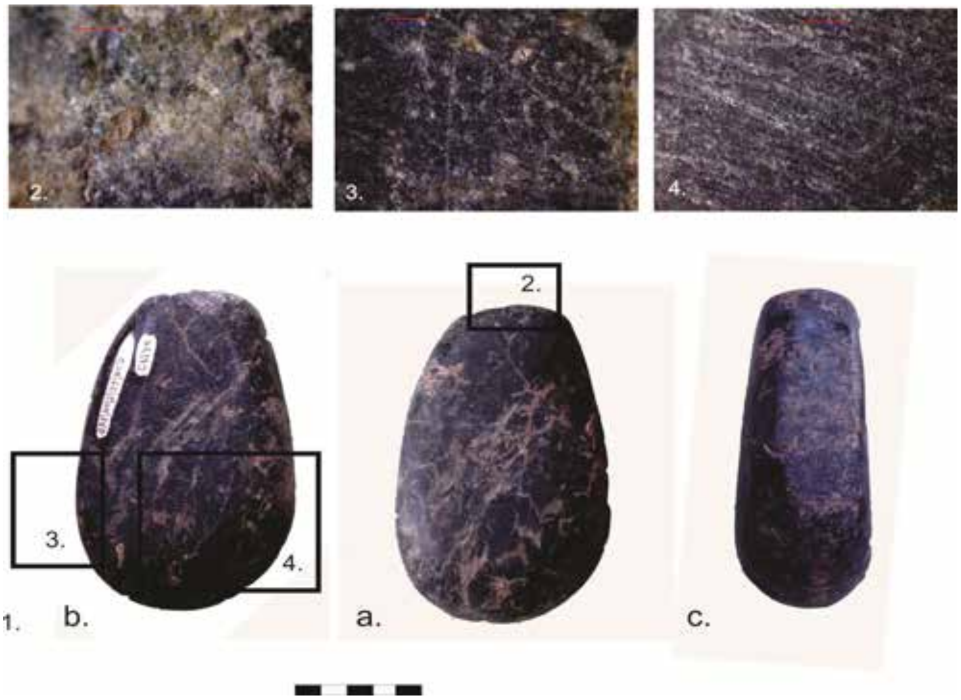


Fig. 6.4.55. Pestles: 2. Smoothed surfaces (AL), 3.-4. scratches on the obverse and reverse side, L – Dr – 46, basalt.

Percussion produced dents (GO) and crushed grains on the levelled surfaces (AL) on the top and bottom active sides of basaltic pestle L – Dr – 46 (fig. 6.4.55/ 2). The rims of the obverse and reverse sides display, micro-dents, long scratches and short, concentrated scratches, which run perpendicular to the longitudinal axis of the item, indicating an impact of a hard surface (fig. 6.4.55/3-4).

The active surfaces on the top and bottom have been developed on 14 (42,4%) artefacts and their analysis indicate that the same activity was performed by the same tool type.

Record also shows notches on the right and left passive sides of a sandstone object L - Dr – 76 (fig. 6.4.56/7). This transformation was generated prior to the use of the artefact and present evidence of handling.

The surface changes on passive sides indicate that pestles were used additionally as a hammer-stone (fig. 6.4.56/4), an anvil (fig. 6.4.56/1a.) and a passive tool probably for sharpening or blunting the edges of other stone objects (fig. 6.4.53/3-4).

Summary

Pestles are an infrequent type of artefact in the Neolithic settlements from the Central Balkans. They are characterized by unworked pebbles made of various geology, and different activities The record might indicate group of the long, wide and heavy items and a group of short, narrow and light tools associated with the convex (CV/CX) active sides grinding and pulverizing. The analysis of the active sides provides a clearer conclusion. Observations suggest that the main activity was grinding, pulverizing and crushing of raw material, which was performed by pestles made of igneous rocks, characterized by the large active surfaces. The second group includes mainly light and wide tools made commonly of quartzite and sedimentary rocks, used for pulverizing and crashing with. This activity produced small working surfaces. A small number of the objects did not allow us to notice economical, chronological changes or local characteristics linked with the employment of these type of artefact. Notches on the passive sides of a sandstone object L - Dr – 76 suggest handling, and planned, long-term implementation of the instrument.

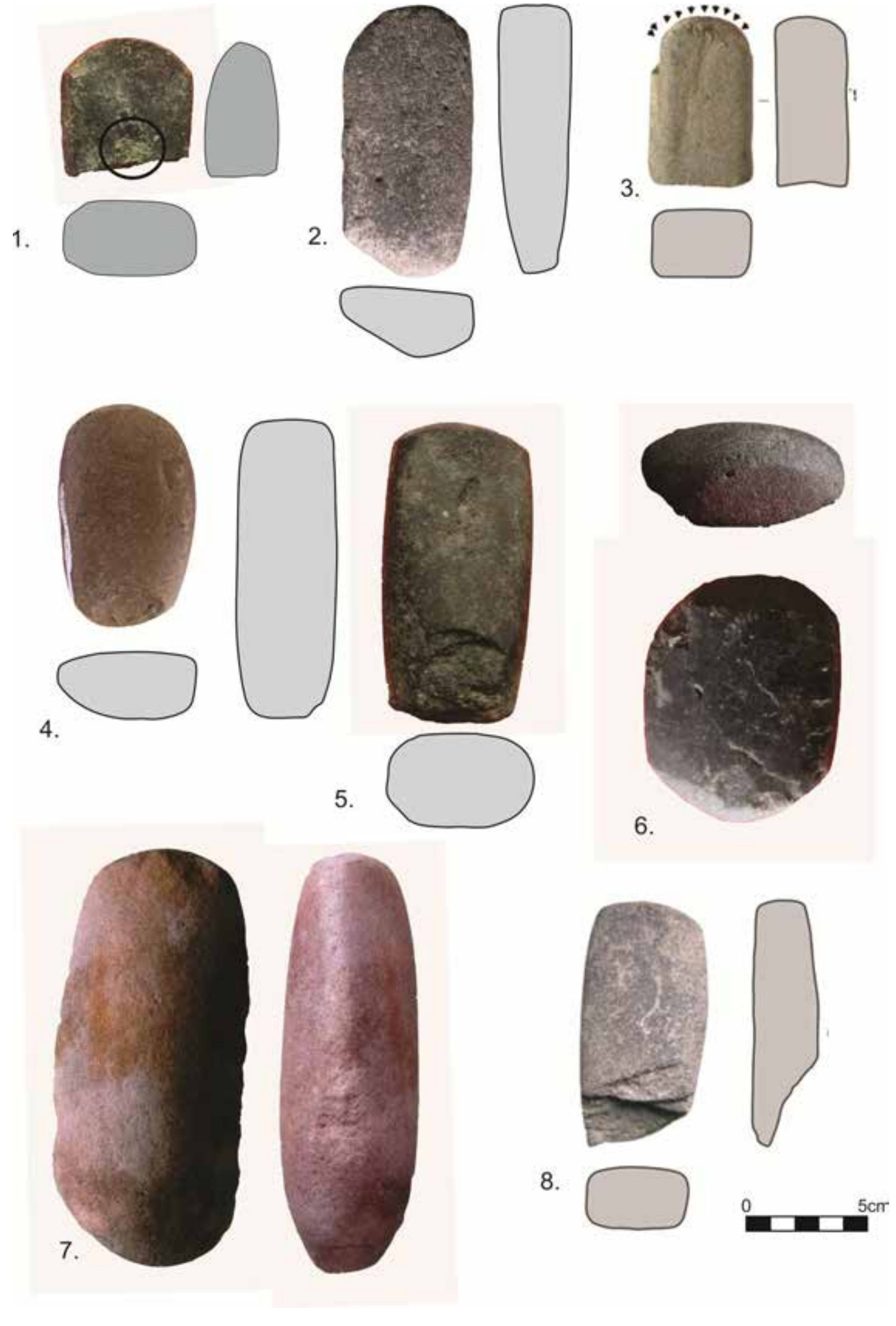


Fig. 6.4.56. Pestles: 1. L- TM- 84; 4. L- TM- 98, 463 Tumba Madžari; 2. L-MS- 164; 3. L – MS - 49, Motel Slatina; 6. L – PO – 112, Potporanj; 7. L – DR- 80; 5. L – DR - 76 ; 8. L – Dr -14, Turska česma.

6.4.5. Perforated percussion tools

These artefacts define elongated, vertically perforated tools with the active sides on the top and bottom. They include two tool types, regarding the the morphology of the top active side and its position according to the lateral axis of an item. The cutting edge, on the top side, perpendicular to the lateral axis of the object, determines a perforated axe (fig.6.4.57; fig. 6.4.60/1,2). A mattock is an artifact with the narrow, ponted active sides (fig. 6.4.60/3,4). These objects have been also identified under the same terms in previous studies (Antonović: 2003, 58; Живанић 2010).

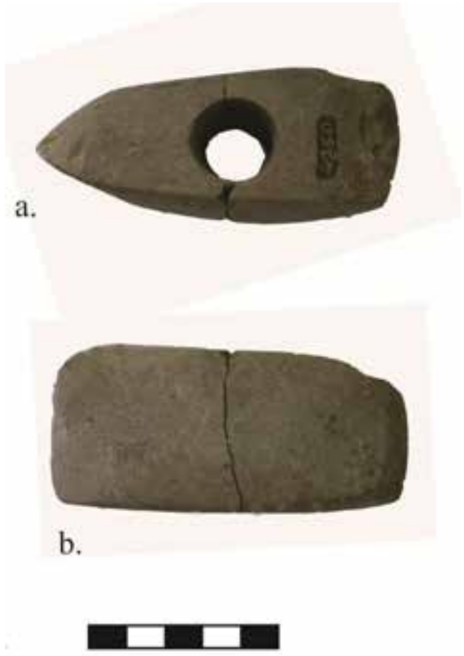


Fig.6.4.57. Perforated axe: L – KH- 28, Koraća Han, Western region, sandstone.

This type of items appeared during the middle and late development stages of Vinča culture (Antonović 2003: 132). Our studied collection includes seven perforated axes from the sites of Benska bara (n=1) in the Northern region, Kremenilo (n=1) (fig. 6.4.60/1) and Koraća Han (n= 1) (fig. 6.4.57) in the Western region and Motel Slatina (n= 4) (fig. 6.4.60/2). Eight perforated mattocks, which come from Benska bara (n=6) in the Northen region and Motel Slatina (n=2) (fig. 6.4.60/3,4).These objects are mainly fragmented and made commonly of sandstone,

Type of the tool	geology	Number of tools
perforated axes	meta-alevrolite	1
	sandstone	2
	granite	1
	peridotite	1
	gabbro	1
perforated mattocks	andesite	1
	meta-alevrolite	2
	sandstone	3
	diabase	1
	granite	2

Table 6.4.41. Perforated tools: geology; N= 13.

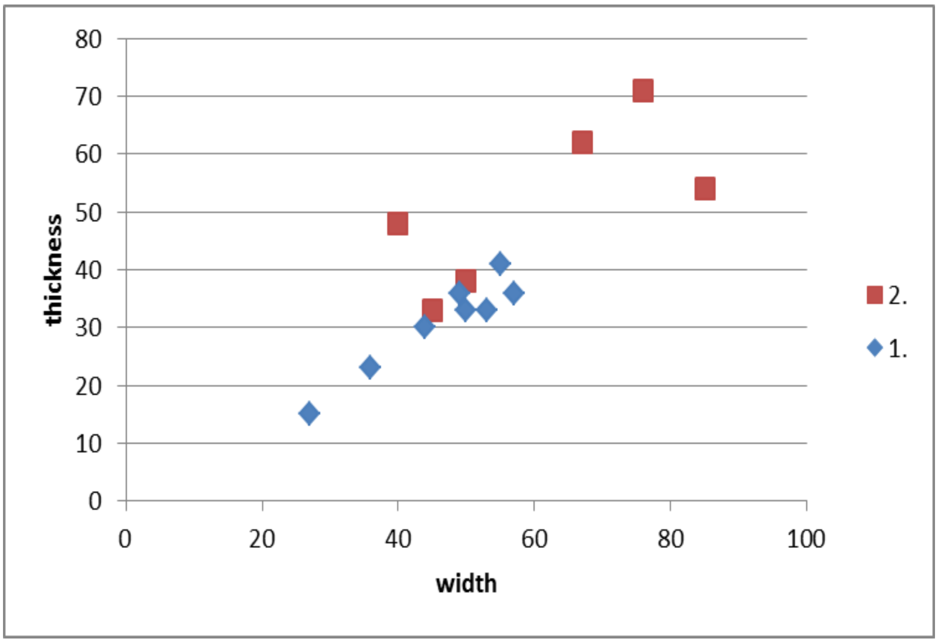


Fig. 6.4.58. Perforated tools: a correlation between width, length of the perforated axes (2.: R^2=0,3928) and perforated mattocks (1.: R^2=0,962). N= 14.

meta-alevrolite and plutonic rocks (table 6.4.41). The passive surfaces are polished (PU). Vertical perforations could be conical, with a wider opening of a hole on the averse side or conical, with more or less the same diameter of the opening of the holes on the passive sides. The natural surface was detected only in the case of a peridotite perforated axe, L - MS – 184, indicating that we are dealing with pebble.

Fig. 6.4.59. Perforated axe: grain rounding, L – MS – 176, andesite.

The length of the two perforated axes made of sandstone and meta-alevrolite is 99 and 112 mm, while their weight is 316 and 71,4 g. The average width and thickness of the perforated axes made of sedimentary (n=3; 40 to 85 mm; mean: 64mm) (n=3; 18 to 54 mm; mean: 40 mm) and plutonic rocks (n=3; 45 to 76 mm; mean: 57 mm) (n=3; 33 to 71 mm; mean: 47 mm) are similar.

The only one, well preserved meta-alevrolite mattock is 112 mm long and weight 71, 4 g (the heaviest is fragmented, diabase tool – 364,4 g). The average width and thickness of the perforated mattocks made of sedimentary rocks (n=5; 27 to 57 mm; mean: 45mm) (n=5; 15 to 36 mm; mean: 30 mm) and plutonic rocks (n=3; 36 to 55 mm; mean: 48 mm) (n=3; 21 to 43 mm; mean: 32 mm) are similar.

The results indicate that the sedimentary perforated axes are slightly wider than sedimentary mattocks. However, all conclusions should be taken with caution due to the small number of the studied objects.

No pattern has been observed in relation between the width, thickness of perforated axes and perforated mattocks. Although linear relationships of both types of tools shows that thickness and width are related. The regression coefficient is particularly strong for the perforated mattocks (fig. 6.4.58).

Use traces, detected on the cutting edge of the perforated axes, consist of dents (GO), pits (GA), flake negatives (NO) and levelled surface (AL). Microscopically, levelled surface (AL) shows rounded single grains and micro-scratches, suggesting the work on a medium to hard material such as wood (fig. 6.4.59). The active sides of the perforated mattocks show similar repertoire of use traces.

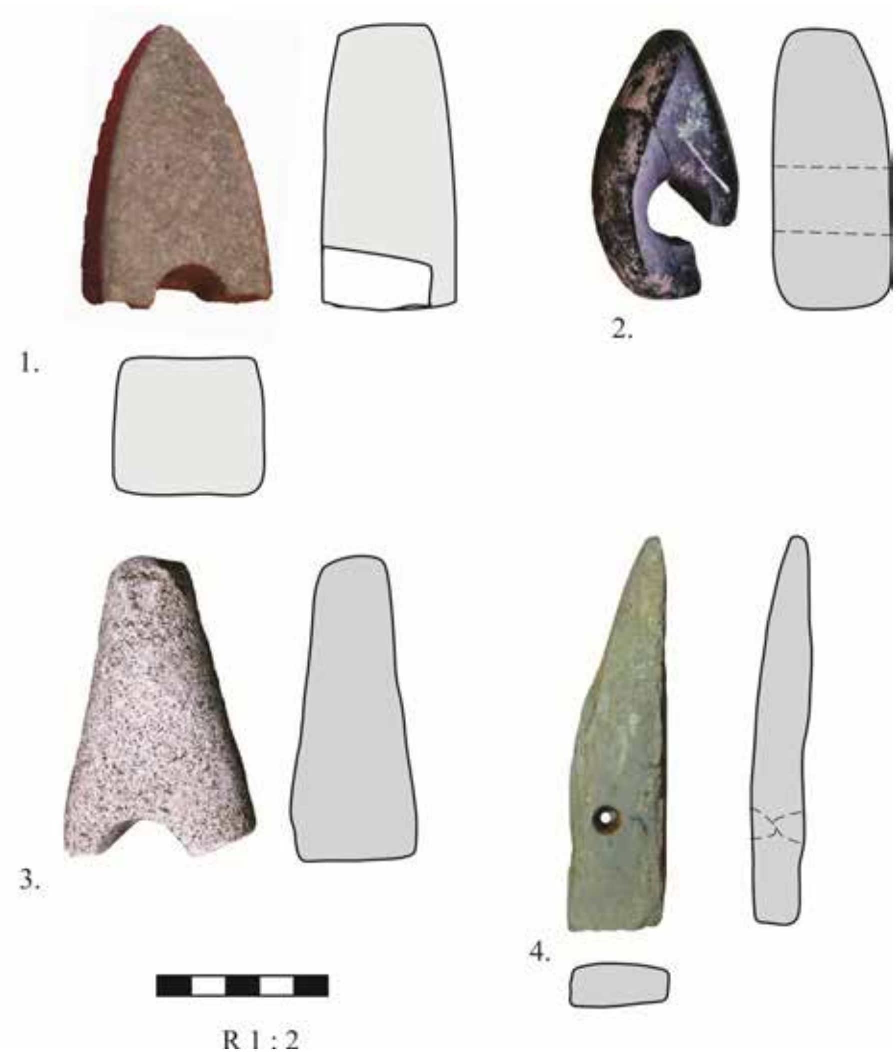


Fig. 6.4.60. Perforated tools: 1. L- KR – 72, Kremenilo; 2. L – MS -184; 3. L – MS – 183; 4 L – MS – 158, Motel Slatina;

6.5.1 Tools with the specific purpose

Grooved coarse-grained abraders

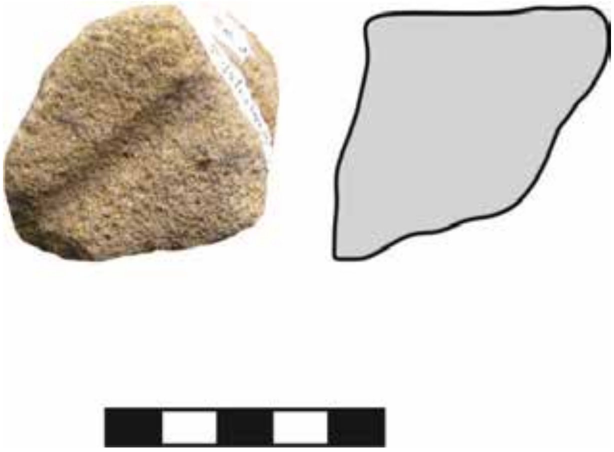


Fig. 6.5.1. Grooved coarse – grained abraders: L – DR – 137, Turska česma, sandstone.

This artefact defines a small tool, made of abrasive rocks, which was used to process wooden, bone or stone objects by abrasion (Adams 2002: 84 and other cited literature;Antonović 2003: 59; Живанић 2010). This activity produces U-shaped grooves on one or more active sides (fig. 1.1).

Grooved abraders have been identified mainly at the Late Neolithic settlement of Benska Bara (n=11), Turska česma, Slatina (n=4) and Gumnište (n=2). Two objects come from the Early Neolithic settlement of Medjureč.

Twelve objects are complete, while the rest are broken or fragmented. Twelve objects are manufactured out of coarse-grained rocks (>0,5 mm), such as sandstone, and the only one tool is made of schist. Mechanical properties of this geology allowed to shape objects by abrasion.

Traces of shaping are absent, while shape of some objects is naturally ergonomic and suitable for hand-holding, such in the case of a tool L - Dr – 137 (fig.6.5.1) Grooved coarse-grained abraders can be between 48 to 137 mm long, from 36 to 94 mm wide and from 21 to 72 mm thick. The weight lays between 36,6 to 620,2 gr.

Two morphological types of grooves have been identified. The first type includes the leaf-shaped groove, in some cases pointed at the end. One to four grooves could be formed on one or more active sides. The grooves are from to 57 to 130 mm long, 40 to 73 mm wide and from 6 to 12 mm deep.

The second morphological type is an elongated groove with parallel sides and open ends. These grooves are 14 to 129 mm long, 4 to 13 mm wide, and between 1 to 7 mm deep.

An appearance of abrasive surfaces has been also recorded such in the case of an item L - Dr - 143. Another active side shows a narrow groove with a pointed end. This confirms multi-functionality of the grooved abraders.

Fig. 6.5.2. Grooved abraders: L – DR – 137, sandstone.

At a microscopical scale, grooves present levelling on high topography and grain extraction (fig. 6.5.2) or shine.

Levelling and grain extractions suggest work in bone or wood (Semenov 1964; Bofill Martinez: 2:f. g.3.2, 9, e; Adams 1989: 268, 269.; Delgado 2008: 360, Figura 4.1.45, and other cited literature). An appearance of narrow groove with the pointed ends suggests sharpening the bone needle, awls or hard wooden objects such as arrow tips (Hampton 1999, 94, fig. 245, 247).

Fig. 6.5.3. Straighteners: surface of the grooves, Benska bara, Northern region, L – BB – 105, sandstone.

In following lines we focus on five sandstone objects L-BB – 105, L – BB – 322, L – BB – 326, L – BB – 324, and L – BB- 323, from the Late Neolithic settlement Benska Bara in the Northern

Fig. 6.5.4. Straighteners: surface of the grooves, L – BB – 241, P/1774, sandstone.

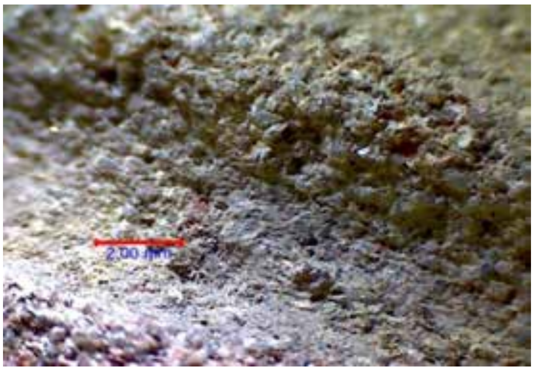


Fig. 6.5.5. Straighteners: surface of the grooves, L – BB – 322, P/1690, sandstone.

region (fig.6.5.3). Previous literature has distinguished them as tools used for shaping shafts. Experimental research shows that the same use-wear traces were generated by processing wood and antler objects (Adams 1989: 268, 269.; Delgado 2008: 360, Figura 4.1.45, and other cited literature).

Our objects are chiefly complete and grooved along the longitudinal section and they are between 78 to 137 mm long, 36 to 47 mm wide, 28 to 46 mm thick, and weight lays between 122,4 to 501,4 gr. The length of the grooves is between 75 to 129 mm, the width varies between 10 to 42 mm and their depth between 2 and 3 mm.

Microscopical observations display levelling associated with micro scratches, high topography with edge rounding grain extraction (fig. 6.5.2-3) Scratches are parallel to the lateral sides of the grooves (fig. 6.5.3). Geology, the size and shape of the grooves indicate processing of small, narrow and round objects made of wood or bone, thus we assume that they were used to manufacture shafts.

Schaft straighteners

This elongated artefact is characterised by a U morphology groove in a central part of the obverse side. Grooves can be positioned horizontally or vertically in relation to the longitudinal axes of an object (fig. 6.5.6). Previous literature suggests that they were made mostly of soft, non-abrasive, heat-resistant rocks (Adams 2002: 86; Usacheva 2016: 591, 594, figure 1).

Our study includes an object L – TM – 44 from the Middle Neolithic settlement of Tumba Madţari, and the Late Neolithic item L-P- 206 from Gumnište. Both tools are of schist. The size of these objects is 71 x 43 x 25 mm and 65 x 57 x 64 mm and weight 111,4 and 337,8 gr. Dimensions of the grooves are 40 x 14 mm and 36 x 12 mm, and cavities reached the depth of 7 mm in both cases. One short and shallow groove has been detected on the obverse side of the Middle Neolithic object,

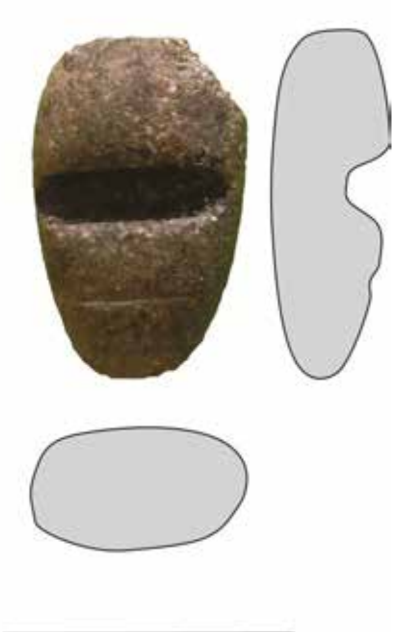


Fig. 6.5.6. Shaft straighteners:L-TM-44, Tumba Madžari, Southern region, schist.

suggesting intensive use of the artefact. The size of the groove is 26 x 3 mm and depth is 1 mm.

These objects were implemented for shafts made of wood and reed, or as bone polishers. The previous study indicates that such objects occurred mainly in the settlements located in open landscapes (steppes, forest-steppes, semi-deserts) where wood and reed is accessible. The process of straightening of wooden or shafts of reed was operated by heating the stone artefact (Usacheva 2016: 598, 599, 601). The implementation of this technique can explain the appearance of the dark layer on the reverse side of the objects L – TM – 44.

Grooved fine-grained abraders

This artefact presents a tool, made of fine-grained rocks (<0,5 mm), which were used to polishing the surface of wooden, bone, stone objects, or small objects such as beams. This activity produced U-shaped, smoothed grooves on one or more sides of the object (fig. 6.5.7).

The analysed objects are from the Late Neolithic settlements of Motel Slatina (n=6) and Turska česma (n=6) region, and Gumnište (n=1). Ten objects are complete, while the rest or four cases are broken and fragmented. These tools are made of soft and fine-grained (> 0,5 mm) sandstone, with little or no quartz, schist and alevrolite.

Fig. 6.5.7. Grooved smoother: L – MS – 11, Motel Slatina, sandstone.

49,1% (n=29) of the passive sides were obtained ergonomic shape and shaped by pecking. 33,8% (n= 20) of the sides remained unmarked.

These tools are between 49 to194 mm long, 49 to130 mm wide and 18 to 36 mm thick and weight between 52,2 to 800,8 gr. The abrasive traces have been documented on the concave and convex active sides of three objects.

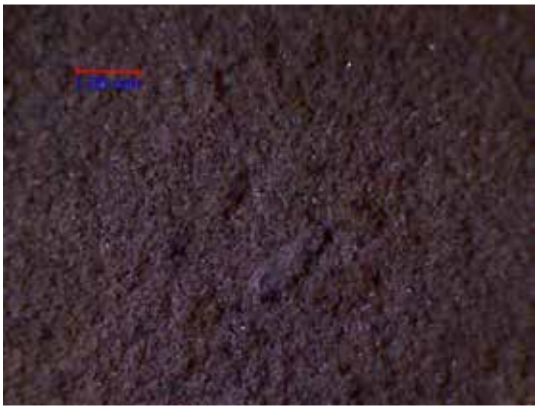


Fig. 6.5.8. Grooved fine-grained abrader: L – DR – 347, sandstone.

All the grooves are pointed on one end, and they are 14 to 101 mm in length and 5 to 88 mm in width on the obverse side, and between 44 to 101 mm long and from 8 to 67 mm wide on the reverse side. Their depth reaches 9 mm on the obverse side and 5 mm on reverse side. The abrasive surface of the grooves of objects L - Dr – 372 and L - Dr – 380 present shine. Microscopically the surface of the grooves reveals a grain rounding on the high topography and grain extractions, suggesting work on bone or wood (fig. 6.5.8).

Anvils

An anvil defines a passive tool whose surface was used as a platform for manufacturing other macro-lithic and chipped stone artefacts (fig. 6.5.9). Series of concentrated grains extractions or parts of the surface created a depression, which presents the characteristic of the working surface. The therm anvils have been also used in previous studies (Шарић 2006; Живанић 2010). Anvils can also present abrasion and percussion traces. This indicates their multi-functionality, and thus, they have been recognized as an anvil – abrader, an anvil – abrasive slab, and anvil retouching tool (table 1.1). The other parts of a tool can show the same activities.

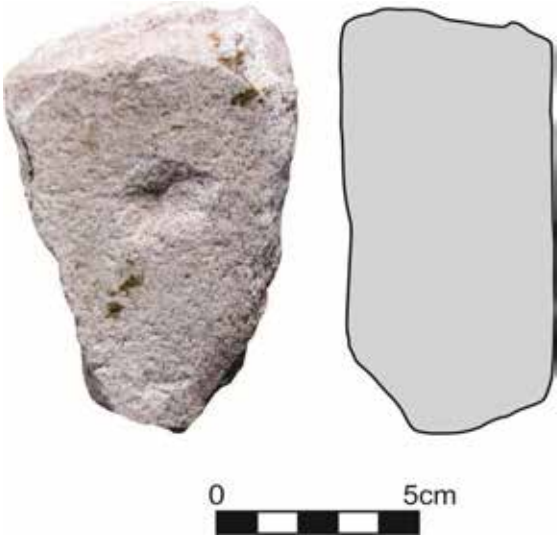


Fig. 6.5.9. Anvil: L – Dr – 169, Slatina, Turska česma, sandstone.

Ten anvils are included in our study. They are from the Late Neolithic settlements of Potporanj (n=2), Benska bara (n=1), Slatina, Turska česma (n=6), Motel Slatina (n=1), Kremenilo (n=1) and Gumnište (n=3) in the Southern region. Only one artefact is from the Middle Neolithic settlement of Tumba Madţari in the Southern region.

Twelve objects are complete, while the rest is broken or fragmented (n=3). The majority was made of sandstone (n=9), while the other types of rock had minor importance (table 6.5.1). We assume that sandstone was used preferentially due to ability to absorb the blows and prevent damage of processed material.

tool/N	geology	dimensions(mm)	Weight (g)
anvil, anvil? /5	sandstone,limestone unidentified rock,	56 x 41 x 14 -114x88 x 44	114 – 457,4
anvil-coarse grained abrader /5	sandstone, schist	80 x 84 x36 - >130 x >141x > 68	215,6– >1455,6
anvil-abrasive slabs/1	sandstone	>93x >41x >48	>1157,2
anvil-retouching tool/3	quartzite, sandstone	49 x 46x33 - 88x90x48	98 – 575,6
anvil-coarse grained abrader - retouching tool/1	sandstone	90 x 88 x 48	575,6
anvil-coarse grained abrader - retouching tool-pestle/1	quartzite	111 x 79 x 53	793

Table 6.5.1. Anvils: type of tools, qualitative and quantitative features. N=15.

Retouching tools (by pressure) or pottery polishers

Retouching tools (by pressure) or pottery polishers are small, pebble artefacts, which are characterized by disorientated scratches (fig. 6.5.10). Retouching tools were implemented in blunting the edges of the chipped stone artefacts, generating uniform thickness and preventing uneven wear, which can appear during prolonged use (Šarić 2006: 207).

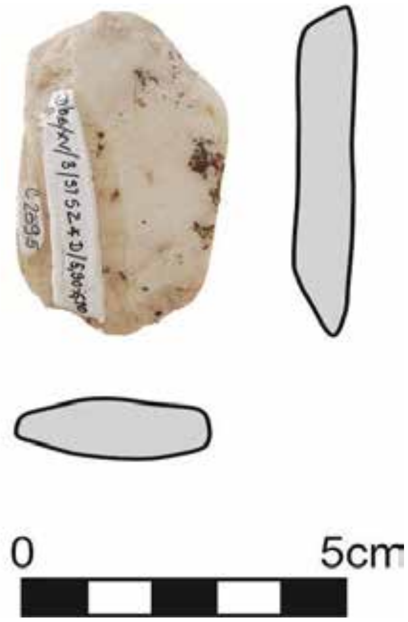


Fig. 6.5.10. Retouching tool (by pressure): L – Dr – 186, Slatina, Turska česma, limestone.

Fig. 6.5.11. Pottery polisher ?: L – Me – 51, c Medjureč, granite.

Our study includes nine artefacts, which were made mainly of limestone, as well as basalt, peridotite, granite, sandstone and serpentinite. These items have been detected in the Late Neolithic settlements of Slatina, Turska česma (n=1), Motel Slatina (n=1), Kremenilo Kremenilo (n=1), the Middle Neolithic settlement of Tumba Madţ ari (n=3). Three tools have been identified in the Early Neolithic settlement of Medjureč. Four artefacts are complete, while the rest is broken or fragmented. The size of the tools varies between 54 to 103 mm in length, 32 to 94 mm in width, 9 to 33 mm in thickness and weight varies between 23,2 to 299 gr.

However, we are not completely sure about the function of the four objects found in the Late and Early Neolithic settlements. The rounded shape and small size can also suggest that they could be used as pottery polishers, while the surface presents the same type of use traces (subchapter 2.3.1) (fig. 6.5.11). Unfortunately, archaeological context does not provide enough data to identify precisely their function.

Maces

Maces are round, polished, perforated objects, which accurate propose is not clear (fi. .6.5.12). In previous literature, they have been identified as well under the same term (Antonović 2003: 57; Живанић 2010).

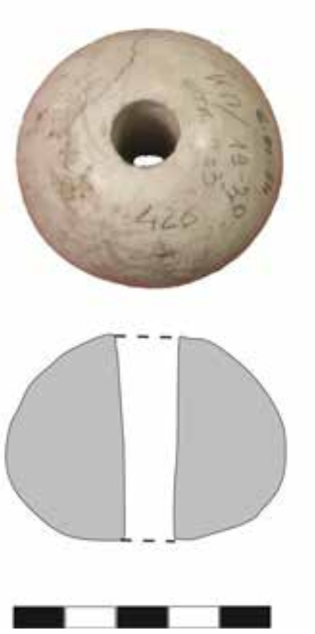


Fig. 6.5.12. Mace: L – TM – 81, Tumba Madžari, marble.

Two fragmented diorite objects are from the Late Neolithic settlement of Motel Slatina. The third item is made of shale and comes from the Late Neolithic settlement of Turska česma, Slatina. The fourth, marble item is from the Middle Neolithic settlement of Tumba Madţ ari (fig. 6.5.1). Previous literature shows that these objects are made of various geology such as limestone, gneiss-granite and marble. (Antonović 2003: 58, 81, 126).

The examinations did not show any use-wear traces on the polished surface, as it has been observed before (ibid: 58). Although, this type of findings from Çatalhöyük display stress fractures at the base of the perforations, indicating that they were used for striking (Wright 2008: 389).

Spindle weight

Fig. 6.5.13. Spindle weight: L – TM – 80, Tumba Madžari, limestone.

This is a perforated discoidal item, which was positioned on the lower third of a hand spindle (drop spindle), aiming to keep the speed and uniform rotation of the spindle. (Grömer 2016: 75, 81, 815 and other cited literature) (fig. 6.5.13). Our study consists of five (meta)alevrolite, limestone, schist and shale objects from the Middle Neolithic settlement of Tumba Madţari (n=4) and from the Early Neolithic settlement of Medjureč. Three objects are complete and they are 52 to 89 mm long, 32 to 89 mm wide, 14 to 27 mm thick and weight between 69 to 235,4 gr.

Weight for digging stick

We assume that gabbro object L - KR-103 T.I.292, from The Late Neolithic settlement Kremenilo present weight for digging stick, which propose was digging out the corms and roots, necessary in the human diet (fig.6.5.14). The size of this oval object is 110 x 88 x 36 mm and the weight is 482 gr. A bifacial perforation in the central part of the tool has identical diameters of the holes on both sides of 41 mm. The length of the opening is 36 mm and diameter of the perforation in the middle is 16 mm. Polishing and pecking are visible on the obverse and reverse side, while the lateral and transversal sides present dents, indicating intensive use and contact with soil.

Fig. 6.5.14. Weight for digging stick: L – Kr – 103, Kremenilo, gabbro.

Metrical values and weight of our sample fit to average metrical values and the weight of the samples from in California (Sutton 2014: 20,21; and other cited literature).

Hoe

This is an elongated, massive pebble object with the narrow active side on the top. The the surface of the item shows the natural surface of selected cobblestones. (fig.6. 5.15). This artefact was used for digging soil. We have identified six granite objects in the multi-layer Neolithic settlement of Kremenilo. Only one belongs to the Late Neolithic horizon, and the rest is from disturbed Neolithic layers. Two objects are complete and they are 118 and 125 mm long, 44 and 48 mm wide, 42 and 44 mm thick. Their weight is 383,6 and 414,4 gr. The objects were shaped additionally by pecking. Fractures and dents have been documented on the active side of the heaviest tool L – Kr – 73. Levelling, micro – pits (fig. 6.5.15/1) and frosted like appearance (fig. 6.5.15/2) were observed passive sides tools, suggesting contact with not so hard material, probably soil.

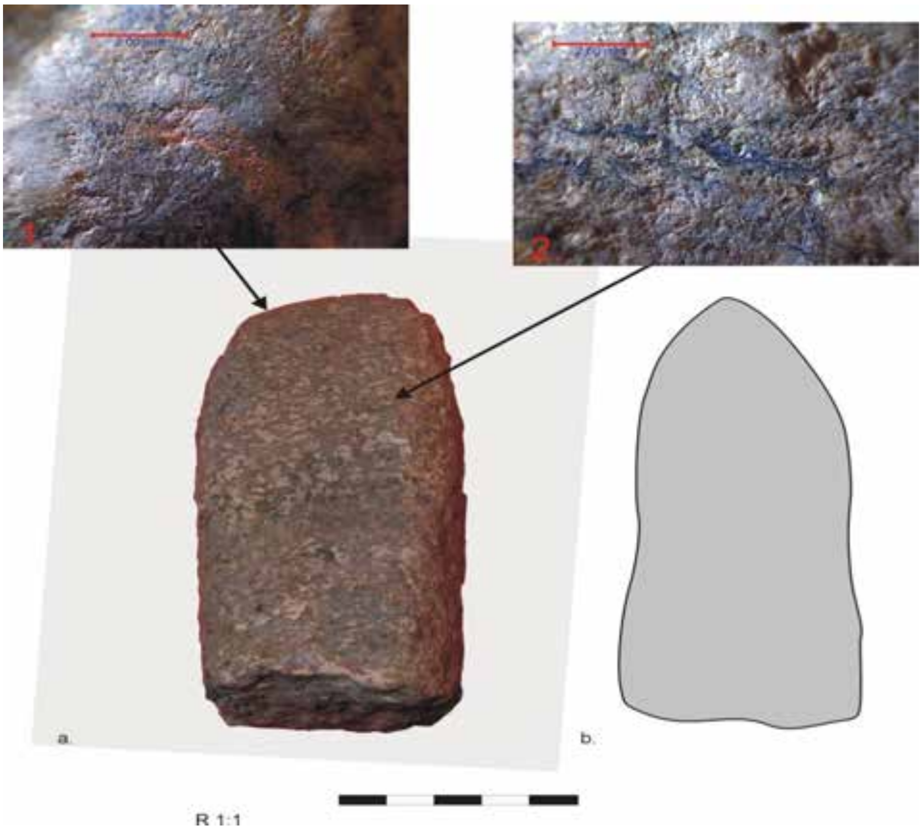


Fig.6.5.15. Hoe: L – Kr – 73, Kremenilo, Western region granite.

Fig.6.5.16. *Door post: L –PO- 46, Potporanj, schist.*

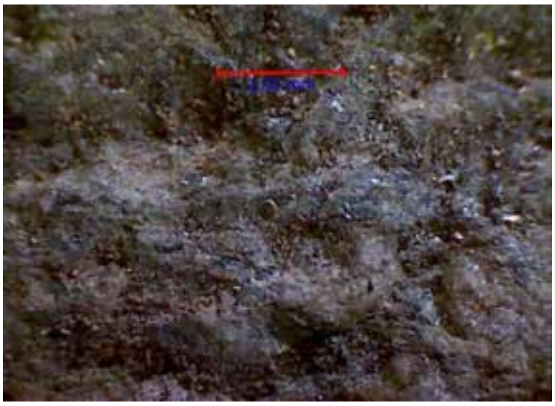


Fig.6.5.17. *Door post: surface of the wall of the cavity : L –PO- 46, schist.*

Doorpost

This artefact defines an object with a concavity on the obverse side. It was used as a base for door construction and facilitate the door function. The only one, schist object L –PO-46 is from the Late Neolithic settlement of Potporanj (fig. 6.5.16). Its shape was achieved by percussion. Dimensions of the artefact are 177 x 123 x 38 mm, the weight is1599, 6 gr, and concavity reaches a depth of 80 mm. The circular scratches are visible on the wall of the recipient concavity indicating intensive circular movements.

At a microscopical scale, the wall of a recipient displays grain rounding, grain rounding on the high topography and grain extractions (fig. 6.5.17). This suggests contact with medium to hard material such as wood.

Lid

A lid related to an object used for covering an opening of a vessel and to protect its content from pollution or evaporation. We assume that discoidal, flat schist item L - P – 127, from the Late Neolithic settlement of Gumnište was used in this purpose. This item is 73 mm long, 70 mm wide and 9 mm thick. The surfaces display no production.

Weights for fishing net

This object is related to a flat, pebble artefact with notches on lateral sides. Although pebbles have natural concave lateral sides. It was made of various geology. and used to give weight to a fishing net in order to sink below the water surface (fig. 6.5.18). The previous literature has also mentioned these objects under the same term (Antonović 2003: 63, sl. 42; Живанић 2010).

Our study includes 102 items from the Late Neolithic settlement of Čelina (n=54,) and Turska česma, Slatina (n=21), the Middle Neolithic settlement of Tumba Madţari (n= 21) and the Early Neolithic settlement of Turska česma, Slatina (n=6). 78,2% are complete, while the rest is broken.

Fig. 6.5.18. Weight for fishing nets: L-Dr- 204, Turska česma, Slatina, slate.

Weights for fishing nets occur mainly in sandstone, while the other types of rocks such as limestone, diabase and schist have been also identified. Schist, tracite, slate, gneiss-gabbro, gabbro and andesite had minor importance (fig. 6.5.19).

No pattern has been identified based on a correlation between the size of the tools and geology The results show a regular linear relationship between length/weight of the objects made of sandstone, limestone and igneous rocks. This means that an increase in the length is related to an increase of the weight of these items. The regression coefficients are chiefly on average (fig. 6.5.20; fig. A 1.5 - 7). Observations show that tools which weight is more than 150 gr were mainly implemented (fig. 6.5.20).

The results show that the length, width and thickness vary slightly according to geology. Sandstone was used for long tools, limestone for wide, while igneous rocks were implemented for thick and heavy artefacts (table 6.5.2 - 5).

Mainly long and heavy igneous and sandstone objects were used. It has been also observed that mainly narrow and thick sandstone objects were implemented. The igneous weights for fishing nets are mainly wide (fig. A1.1-4).

Notches allowed binding of weight to a net. They were manufactured by flaking. The notches are between up to 15 mm long, while their depth varies between 1 to 7 mm on the right side and between 1 to 14 mm on the left side.

geology/N	**$\bar{X}$**	**σ**	**max length (mm)**	**min length (mm)**
limestone/17	90	11	111	72
igneous rocks/14	98	26	147	36
metamorphic /4	80	17	98	57
sandstone / 34	99	24	151	40

Table 6.5.2. Weights for fishing nets: length according to geology; N= 69.

geology/N	**$\bar{X}$**	**σ**	**max width (mm)**	**min width (mm)**
limestone/18	66	12	94	50
igneous rocks/18	55	12	32	81
metamorphic /8	50	11	74	39
sandstone / 49	59	11	93	36

Table 6.5.3. Weights for fishing nets: width according to geology; N= 93.

geology/N	**$\bar{X}$**	**σ**	**max thickness (mm)**	**min thickness (mm)**
limestone/18	16	3	26	10
igneous rocks/18	20	5	32	8
metamorphic /8	12	3	19	7
sandstone / 49	18	7	46	7

Table 6.5.4. Weights for fishing nets: thickness according to geology; N= 93.

geology/N	**$\bar{X}$**	**σ**	**max weight (mm)**	**min weight (mm)**
limestone/17	144,4	59	210,6	65,2
igneous rocks/14	194,5	101	398,8	15,8
metamorphic /4	94,2	30	132,6	65,8
sandstone / 34	183,9	90	344,6	14,8

Table 6.5.6. Weights for fishing nets: weight according to geology; N= 69.

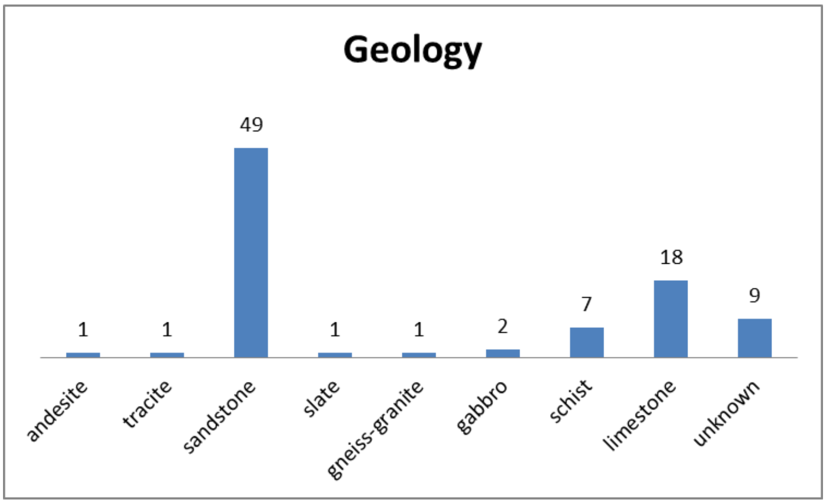


Fig. 6.5.19. Weight for fishing nets: geology; N= 102.

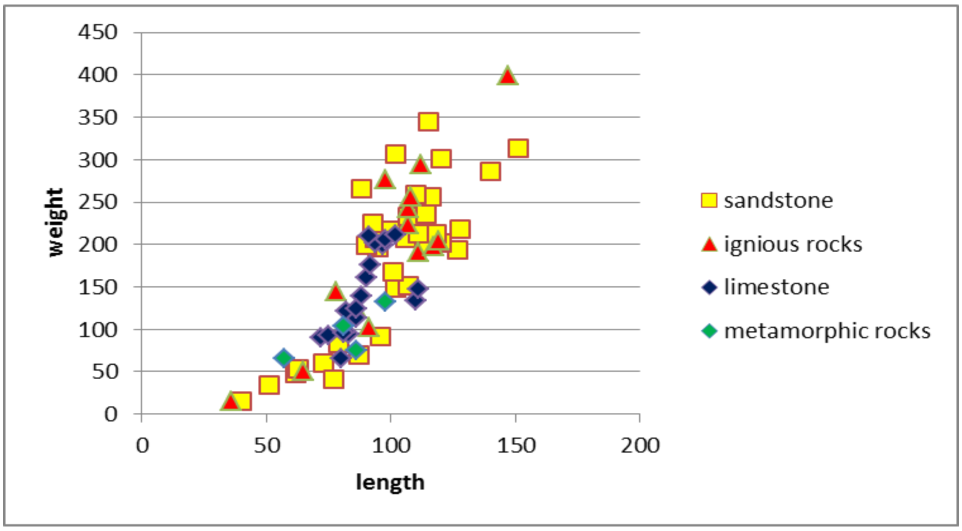


Fig. 6.5.20. Weight for fishing nets: correlation between the length, weight and geology; sandstone:R^2= 0,5528; limestone R^2= 0,332; igneous rocks: R^2= 0,6565;

It should be mentioned that the longest, widest and heaviest tools come from the late Neolithic settlement Čelina. It is assumed that they gave the weight to roof construction[1].

Observations also suggest that the Middle Neolithic weights for the fishing net are shorter, thinner and lighter than the Late Neolithic artefacts (fig.A.1.6-7). We suppose that the amount and size of catch caused the size of the weights.

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[1] Personal communication with S. Derikonjić, explorer of the settlement.

Summery

The study of the role of the macro-lithic tools in the Neolithic economy of the Central Balkans involved 102 weights for fishing net. These tools were mainly made of sandstone and weight more than 150 gr. Notches on the lateral sides allowed binding a tool for a net.

A correlation between the size of tools and geology did not suggest any link. We assume that their size might depend on the size and an amount of hunted fish. This could be explained by the large size of the Late Neolithic settlements and a number of inhabitants. They occupied a vicinity of large river courses, which represented one of food sources and the use of fishing net allowed them to obtain a large amount of food. Besides this, it has been also supposed that they could give weight to a roof construction as in the case of the Late Neolithic settlement of Čelina.

6. 5. 2. The cult objects and objects with the aesthetic purpose

These types of findings include figurines, a pedant, discoid perforated objects, beams, bracelets and different types of amulets. They have been detected in the settlements, different in chronology and cultural provenance.

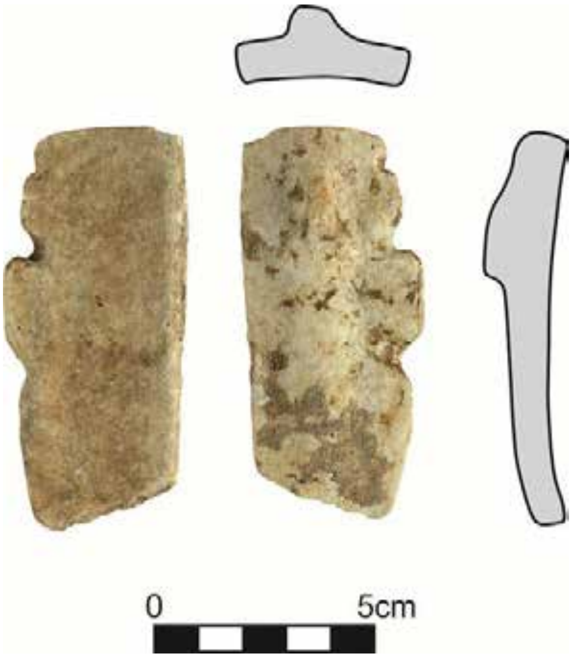

Fig. 6.5.21. Figurine, L – MS- 18, Motel Slatina, , marble.

A marble, *anthropomorphic figurine* L - MS – 18, from the Late Neolithic settlement Motel Slatina (fig.6.5.21) present one unusual finding. A head shows a plastic nose. A thin body is flat on the obverse and convex on the reverse side. The right part of the body was removed by sawing, and bottom is missing. The left hand is perforated. The surface of the figurine was polished. Described details make this object similar to the clay figurine.

It can be said that we are dealing with a masterpiece of a skilled craftsman. Chapman J., (Chapman 1981: 120) mentioned another marble anthropomorphic figurine from the settlement of Turska česma, Slatina which is 10 km to south from the Late Neolithic settlement of Motel Slatina. The rest of Late Neolithic anthropomorphic figurines from the Central Balkans from are made of marble. Unlike our sample, they are represented by schematic body or by mushroom-like heads placed on a pedestal (Antonović 2003: 65, Fig.44/7 – 10).

Fig. 6.5.22. Pedant:, L – Kr- 102, Kremenilo, , shale.

Fragmented, elongated, claystone *pedant* L - KR-102, from the Late Neolithic settlement of Kremenilo (fig. 6.5.22) is perforated unficially. The diameter of the opening is 6 mm. Previous studies suggest that this type of artefacts appeared during the Early and Late Neolithic in Central Balkans. They were usually made of galena, marble, alevrolite, sandstone and fine-grained limy sandstone (Mc Pherron – Rasson – Galdikas 1988: 330 Table 11.10/ 11.5j; Antonović 1992: 17 – 19; 2003: 67, 68 Fig. 46: 1 – 3, 6 and other cited literature).

Fig. 6.5.23. Discoidal amulets: L – TM- 5, Tumba Maržari, limestone.

Two flat, bifacial perforated discoidal *amulets* L- TM – 5, 825 and L- TM – 6, 854 derived from the Middle Neolithic settlement of Tumba Marţari (fig. 6.5.23). They are made of limestone and the size of the first, complete artefact is: 75 x 79 x 12 mm. Diameter of openings on both sides is equal and it amounts 9 mm. The diameter of the opening in the middle part is 4 mm, and the thickness of the perforation is 5 mm. This type of marble objects was also detected in the Late Neolithic settlements of Vinča, Ţarkovo and Predionica (Antonović 2003: 67, Fig. 46/ 4 – 6 and other cited literature).

Fig. 6.5.24. Amulet: L – P- 303, Gumnište, Southern region, gabbro?.

Another type of an *amulet* L - P – 303, has been identified in the Late Neolithic settlement of Gumnište. It was made of gabbro and the surface is polished. Its size is: 25 x 26 x 10 mm (fig.6.5.24). The rounded body of amulet extends into two convex horns. Scratches have been observed on the junction of the horns and body, probably resulted in intensive polishing.

Fig. 6.5.26. Beam, L – TM- 36, Tumba Maržari, unknown geology.

The previous studies indicate that these objects appear in the Balkan Peninsula during the Early Neolithic (ibid, 2005: 37; Perić 2008: 40). They are frequently made of clay and show no use traces. Their purpose is related mainly to the cult. However, an examination at Near East suggests that an appearance of this item could linked in to economic activities such counting and storing the goods in the transitional period to the agriculture economy (Mc Pherron – Rasson – Galdikas 1988: 325, Table , 11.1/ 11.3b, 11.3c; Antonović 2003: 67 – 68,fig; 46/14, 15; cf. Vuković 2005: 28, 36)

Fig. 6.5.27. Bracelet: L – Dr- 22, Turska česma,

13 *beams* were also detected in the Middle Neolithic settlement of Tumba Marţari (fig.6.5.26). They are of gabbro, limestone, and unidentified geology. The surfaces were carefully polished. Ten beams are oval or globular, the rest is elongated. This type of finds has been identified only in two Neolithic settlements of Divostin and Vinča (Mc Pherron – Rasson – Galdikas 1988: 329 - 330, Table 11.10/ 11.5j; Antonović 1992: 17).

We have detected two fragmented, claystone *bracelets*. The first one, L - P – 398, was found in the Late Neolithic settlement of Gumnište, while the second one, L - Dr – 22, comes from the settlement of Turska česma, Slatina (fig.6.5.27). Their outer sides are polished. Unremoved flake scars on the surface of the inner sides show bifacial flaking, and which shaped the transversal section of the objects. This kind of findings is also known from the other Neolithic sites from Central Balkans, and are manufactured out of limestone, fine-grained limy sandstone and rarely marble (Antonović 1992: 17; 2003: 67, Fig. 46: 16 and other cited literature).

Chapter 7:
Regional economic differences in the Central Balkans during the Neolithic

7. The economy of the Neolithic communities of the Central Balkans according to the macro-lithic artefacts

This chapter will deal with the temporal and regional economic differences and similarities according to the results of the typological, geological and use-wear analysis of macro-lithic tools. Moreover, these results will be compared with the four regional variants distinguished in the Vinča culture (Garašanin 1979: 163, 181 - 194; Tasić 2000: map 3.1). Fig.7.1 shows that most of the sites belong to the territory of classical Vinča culture. The resulting pattern of raw material distribution allows us to trace the possible political borders between economic territories with different lithic resources, eventually dominated by individual central settlements (Risch 1995; 2002).

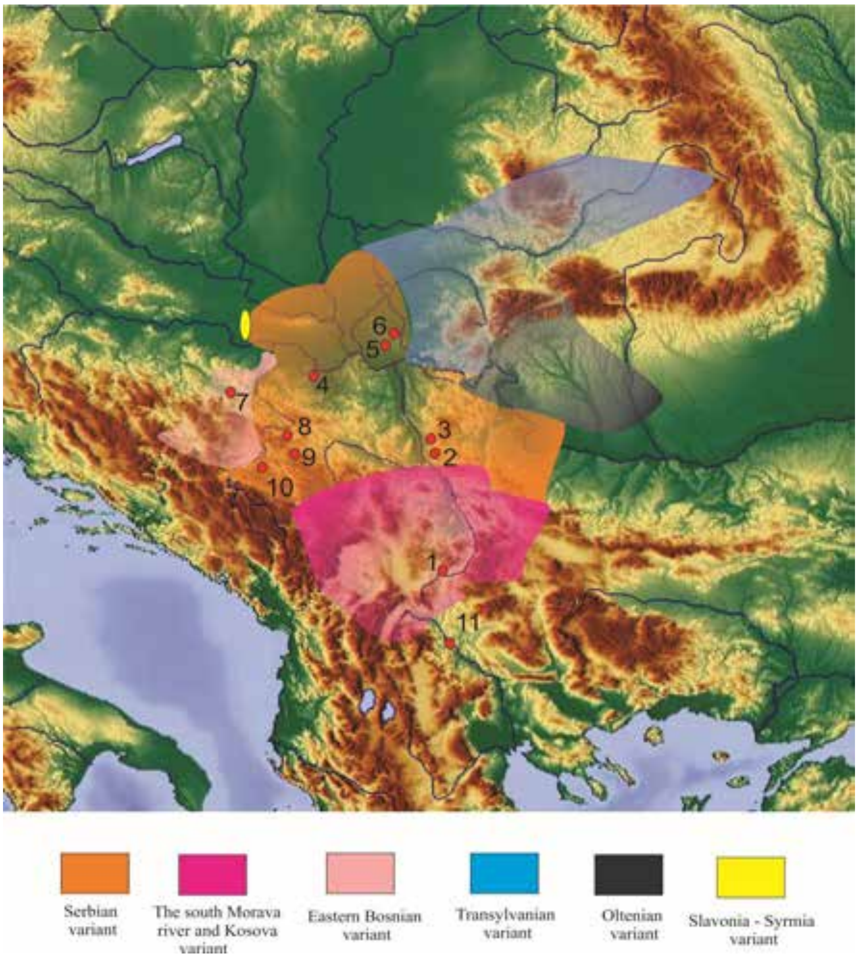

Fig.7.1. Variants of the Vinča culture and positon of the settlement from our study.

7.1. The development of macro-lithic technologies during the Early and Late Neolithic

The objective of this subchapter is to explore the technological changes between the Early and Late Neolithic period in the Central Balkans. This information should reveal the importance of particular economic activities, based on the different artefact types, gathered in systematic recovery processes at the Early Neolithic settlements of Medjureč (n=71), while 807 macro-lithic artefacts from the sites of Turska česma and Gumnište represent the Late Neolithic contexts. Unfortunately, excavations where artefacts have not been recorded thoroughly cannot be used for this comparison (see subchapter 3.5, table 3.4).

Grinding tools and abrasive slabs have been identified in the whole of the studied territory during both Neolithic periods. However, their proportion was much higher among the Late Neolithic macro-lithic tools than in the early period. Fishing has also been recognized as an important activity of the Late Neolithic communities (fig. 7.2). Both changes imply an increase in subsistence goods and seem to be the result of the development of sedentary life and of a large number of inhabitants in the Late Neolithic settlements.

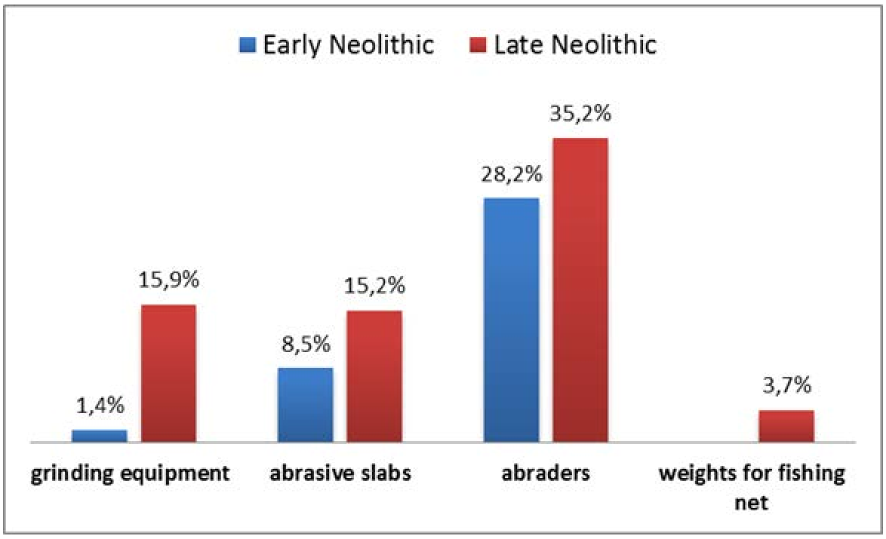

Fig.7.2.Early and Late Neolithic economy: macro-lithic objects and funcional groups, graph 1; Early Neolithic, n=71 ; Late Neolithic, N= 807,

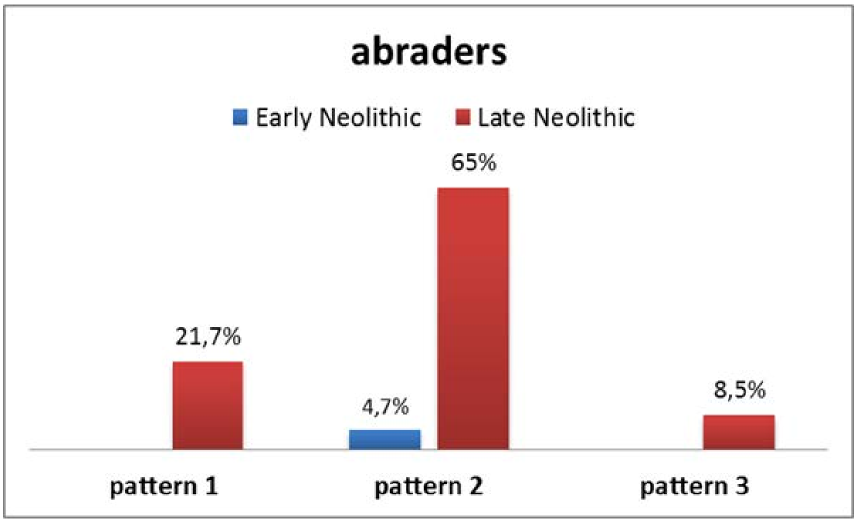

Fig.7.3.Early and Late Neolithic economy: abraders and patterns; N= 106.

Abraders played a significant role in the economy of the Early and Late Neolithic communities (fig. 7.2). A specialised type of schist abraders, are characteristic of the Early Neolithic. These items were employed in heavy abrasive work processes related to grinding and crushing subsistence goods, such as seeds and nuts (functional pattern 2) (subchapter 6.2.2; fig.7.3). The proportion and the variety of abrasive slabs and abraders is much higher among the Late Neolithic artefacts (fig. 7.2). Crafts, based on abrasive processes, were more developed and involved in various work.

Percussion tools were more important during the Early Neolithic (fig. 7.4). However, the variety of functional patterns is again larger in the later period (fig. 7.5) Specialised activities, such as the working of quartzite objects (pattern 1-4), were carried out in both moments. Tools with six active sides are also present in both periods (pattern 6). Craftmen and women also used percussion tools for splitting and crushing stone or for regularly roughening the active surfaces of the large abrasive tools (pattern A1). Specialised tools related to retouching and pounding soft and hard materials (pattern A2), as well as patterns 1-4 and 6, were, relatively speaking, more frequent during the Late Neolithic (fig. 7.4-5). The increase in diversity is also confirmed by the presence of percussion tools specialized in splitting and crushing medium to hard materials such as bone or wood (pattern 3A) and by the presence of large hammers, used for working stone, including the manufacture of grinding slabs (fig. 7.4-5).

The manufactur large macro-lithic tools is signalized by raw material and semi-finished products. These remains are more important during the Early Neolithic (fig.7.5). These remains are more important during the Early Neolithic (fig.7.5). This could be the result of seasonal occupations in the early period as opposed to the increasing sedentism in the later one. Raw materials and tool blanks are not likely to have been transported to the new settlements.

Furthermore, In the Early Neolithic, the proportion of clay polisher is much higher among the macro-lithic tools, than in later phases (fig. 7.4). This would imply either, that the pottery technology changed and pottery burnishers were made of other materials, or that pottery workshops have not been recorded in the settlements included in this chapter. In excavation with a non-systematic recording of lithic artefacts few stone burnishers have been identified.

Anvils, probably used for a technologically more complex fraked stone industry, have also been found only in Late Neolithic contexts (fig. 7.4).

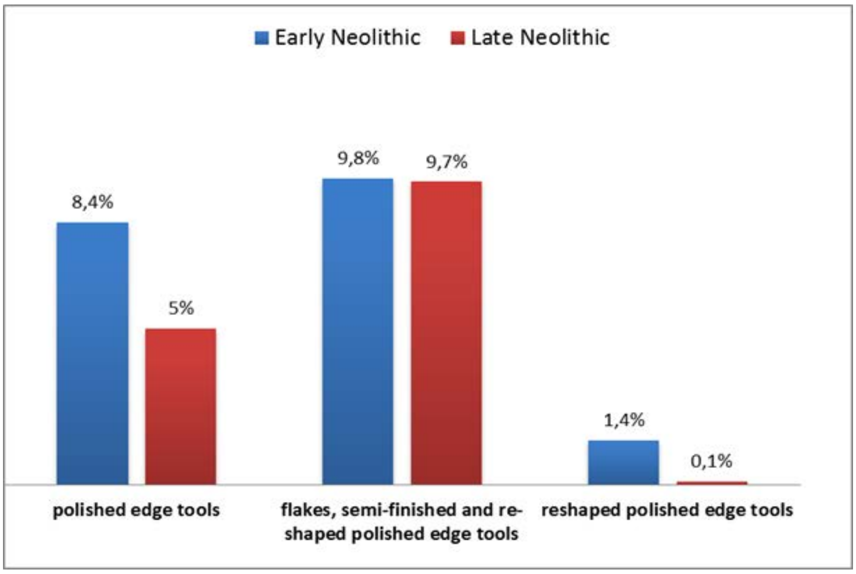

Fig.7.6.Early and Late Neolithic economy: macro-lithic objects and funcional group, graph 2; Early Neolithic, n=71 ; Late Neolithic, N= 807,

The distribution of polished edge tools indicates that their proportion was slightly higher during the Early Neolithic (fig. 7.6). However, in the later period a larger variaty of edge tools appears, such as adzes and chiesels. Adzes are related to scarping and cutting wood and bone (pattern 1 -2) while chisels would be more related to carpentry (fig. 7.7).

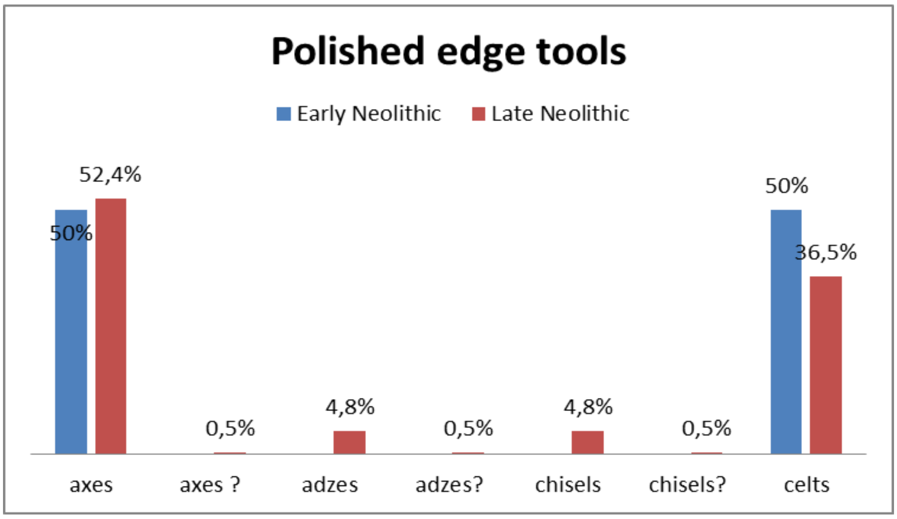

Fig.7.7. Early and Late Neolithic economy: polished edge tools; N=214.

The proportion of objects associated to manufacturing polished edge tools, such as flakes negatives, semi-finished products and re-shaped polished edge tools[1] is almost the same during both periods, while re-use of worn-out polished edge tools characterised the economy of the Early Neolithic (fig. 7.3-4). In conclusion, wood working and carpentry seems to have been more important during in the Vinça settlements, as is also suggested by the exceptional architecture and the furniture represented in clay models, characteristic of this period.

In general, the Late Neolithic economy saw a notable increase in the amount of artefacts, particularly of grinding tools and abraders, and in the variety of instruments, such as abraders, percussion and polished edge tools. Taken together, both changes imply a substantial development of the forces of production and of productive diversity and, hence, also of specialisation. Communities used a larger variety of tools for specific tasks, suggesting a specialisation of economic activities and, hence, the emergence of social division of work. This conclusion is not questioned by the materials from other Early and Late Neolithic sites, where artefacts were not recorded systematically. The smaller sample size of the Early Neolithic macro-lithic artefacts does seem representative, although the pattern observed in Medjureč needs to be confirmed in the future by examining the materials from other Early Neolithic settlements and regions.

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[1] LAS, SMF and UNK

7.2. The economic differences between settlements and regions during the Late Neolithic

This subchapter reveals economic differences between the settlements within Northern, Central and Western region. The Southern region has been omitted as the studied material come only from one site.

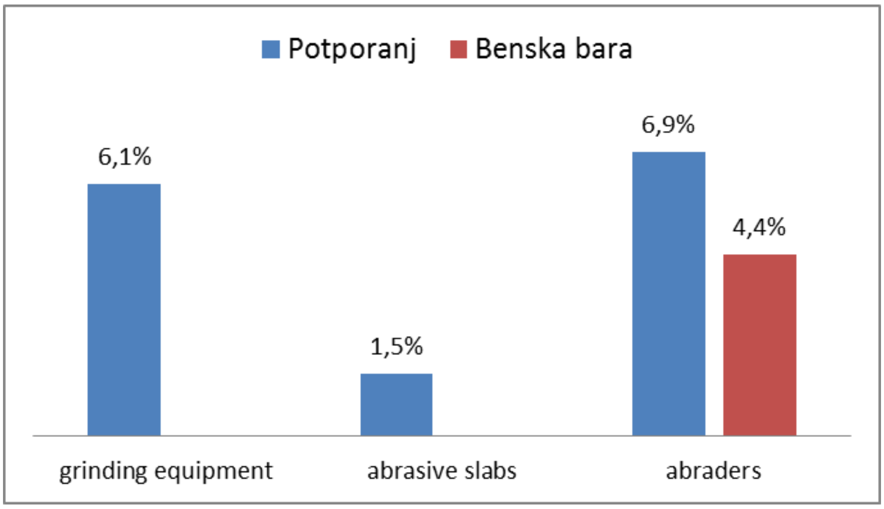

Fig. 7.2.1.Economy of the Late Neolithic: types of artefacts from settlements of Potporanj and Benska bara, Northern region, graph 1; Potporanj ,N=130; Benska bara, N= 338.

7.2.1. Northern region

In following lines we focus on a correlation between economies of the settlements of Benska Bara (n= 338) and Potporanj (n=130). The settlement of At has been omitted from these observations due to a small number of tools (n= 16).

The sites were located on slightly elevated areas on a fluvial terrace or probably, on some kind of peninsulas. They were surrounded by plain, rich in fertile soil, large and small river courses and poor in rocks (fig. 7.2). The sudden increase of the underground water level c. 5000 B.C. degraded the fertile soil – chernozem into forest soil. Sandy areas replaced marsh soil and meadow black soil on the loess plateaus. Erosion, lakes, marshes and ponds occurred in previously dry regions. (Benac, Garašanin, Srejović, 1979:17; Janković 1984: 68, 72, fig. 9).

Despite similarities, the economy of these two settlements reflects some differences. C. 6% of all studied tools from this region represent grinding[2], which has been documented only at the settlement of Potporanj. Low implementation of this activity in this region, might be explained by already described environmental conditions and selective recover strategy (fig. 7.2.1).

The economy of the Late Neolithic communities from Potporanj was characterised by the use of abrasive slabs and abraders[3]. The proportion of these objects is higher at Potporanj than in Benska (fig. 7.2.1). Although the specific use of abraders has been revealed at both sites. Activities associated with polishing and maintenance of polished edge tools (pattern 1) grinding and crushing subsistence goods, such as seeds and nuts (pattern 2) were identified at Benska bara, while pulverising of small soft organic materials in small quantities on hard, slightly concave surface (pattern 3) has been identified at Potporanj. The results show that 45,4% of all pestles, which were involved in work in soft materials at the Central Balkans, were part of organized production at this site.

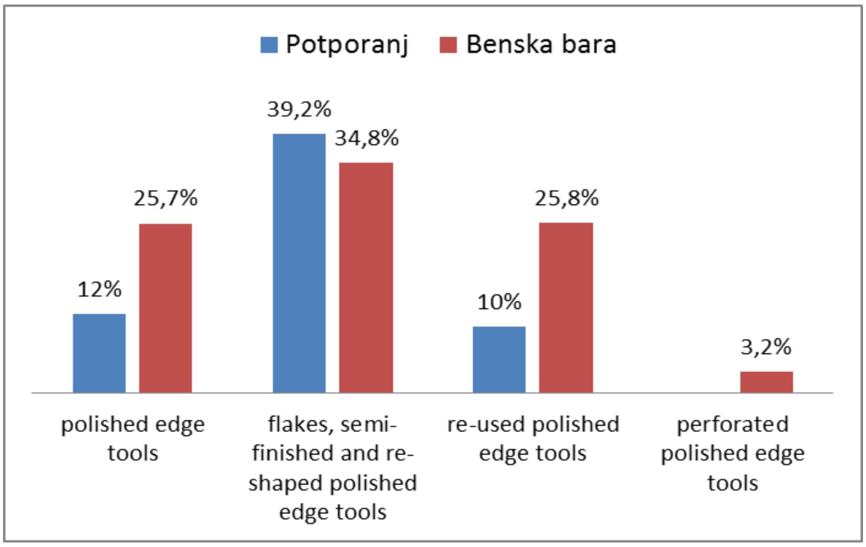

Fig. 7.2.2.Economy of the Late Neolithic: types of artefacts from settlements of Potporanj and Benska bara, Northern region, graph 2; Potporanj ,N=130; Benska bara, N= 338.

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[2] MOL – grinding slabs, MOR – mortars.

[3] LOS, ALS and ALS-PIA

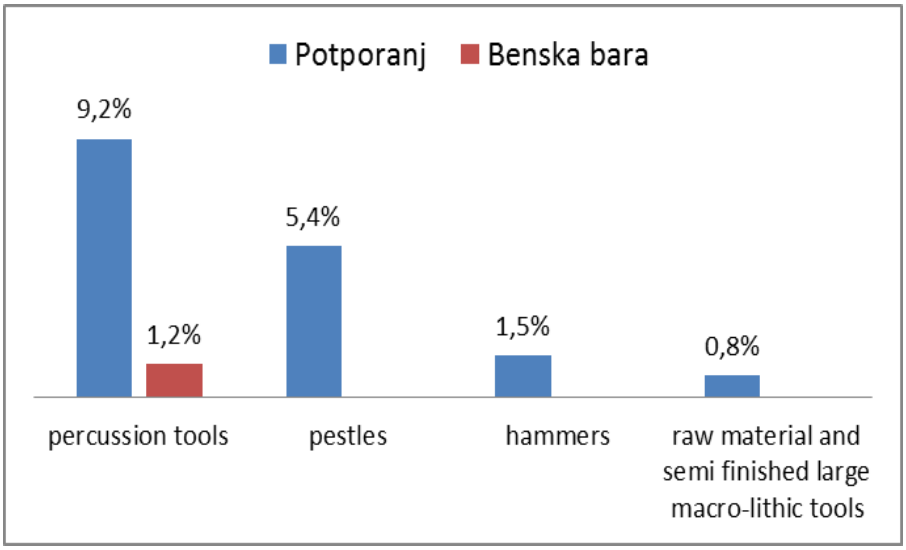

Fig. 7.2.3.Economy of the Late Neolithic: types of artefacts from settlements of Potporanj and Benska bara, Northern region, graph 3; Potporanj ,N=130; Benska bara, N= 338.

The proportion of the objects related to manufacturing polished edge tools is similar at both settlements [4]. Observations also show that the implementation of polished edge tools and their re-use is more intensive at Benska bara[5]. The organised use of adzes has been documented only at Potporanj and it included 16,6% of all adzes associated with craft production (pattern 2) (fig. 7.2.2). The economy of the Late Neolithic community from this site was also characterised by the implementation of percussive tools (percussion tools, pestles and hammers) and manufacturing large macro-lithic objects such as grinding tools or abrasive tools (fig. 7.2.3). Moreover, the analysis of percussion tools suggests organized production associated with several technological processes. They involved quartzite objects (pattern 1-4), artefacts with three and six active sides (patterns 5 and 6), artefacts involved in retouching and pounding soft and hard materials (pattern 2A) and splitting and crushing medium to hard materials such as bone or wood (pattern 3A). The last activity has been also recognized at Benska bara.

Insufficient data on other finds do not allow to delve deeper into the economy of the region (see subchapter 3.1.2 and 3.1.3). Although it can be said that lack of suitable rocks implied in this area the development of a long distance exchange network. C.68% of the raw material used at the settlement of Potporanj came from the distance larger

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[4] tool with secondary modifications (UNK), flakes knocked off polished edge tools (LAS), semi-finshed produscts (SFP).

[5] re-used polish edge tools (RPE 1 and 2).

than 50 km, while this proportion at the settlement of Benska bara is higher and represent c. 86% of all studied objects (subchapter 3.2.1, fig. 5.3.6 and fig. 5.3.8).

An appearance of light white stones with c. 7,5% of all studied tools and re-use of polished edge tools might indicate an economic connection or similarities with the Western region (chapter 3, fig. 3.2, 3.8b, 14a; subchapter 5.3.; fig. 5.3.3, 5, 8, 44).

7.2.2. Central region

Grassy areas, steppe fields, mixed forests and fertile lands, formed primarily along the Velika Morava river characterised the Central region during the Neolithic. The inhabitants of the Late Neolithic settlements Motel Slatina and Turska česma occupied the undulating terrains along alluvial zones covered mainly by vertisol (Benac, Garašanin, Srejović, 1979:17; Janković, 1984: 68, 72, fig. 9)(fig. 7.3). The Velika Morava and South Morava rivers linked this area to the Pannonian Basin in the north and to the southern part of the Balkan Peninsula.

The study of macro-lithic tools from the sites of Motel Slatina (n= 187) and Turska Česma, Slatina (n= 414) suggests similar activities, which appear in different proportions (fig. 7.2.4 - 6).

The Late Neolithic economy of the Central region was based mainly on the use

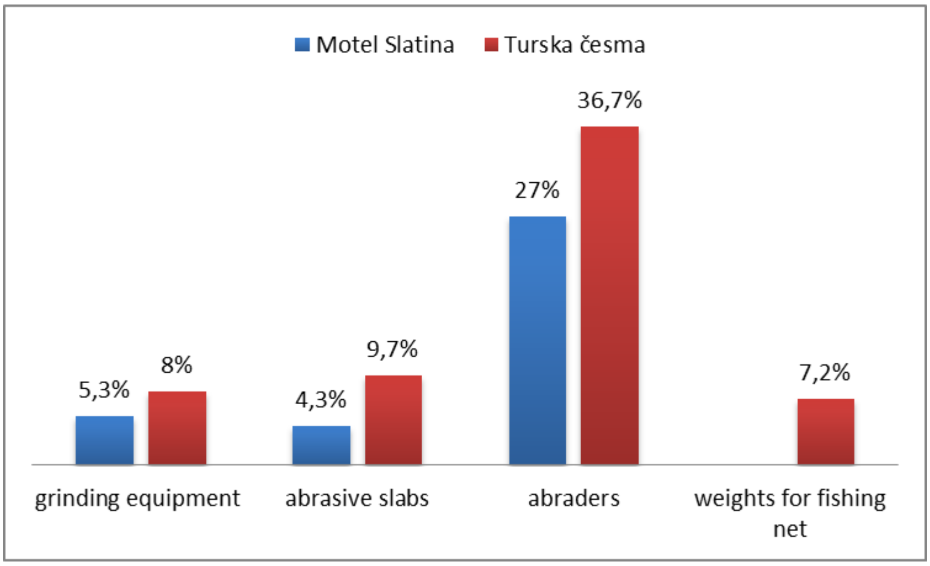

Fig. 7.2.4.Economy of the Late Neolithic: types of artefacts from settlements of Motel Slatina and Turska Česma, Slatina, Central region, graph 1; Motel Slatina , N=187, Turska Česma, Slatina N= 414.

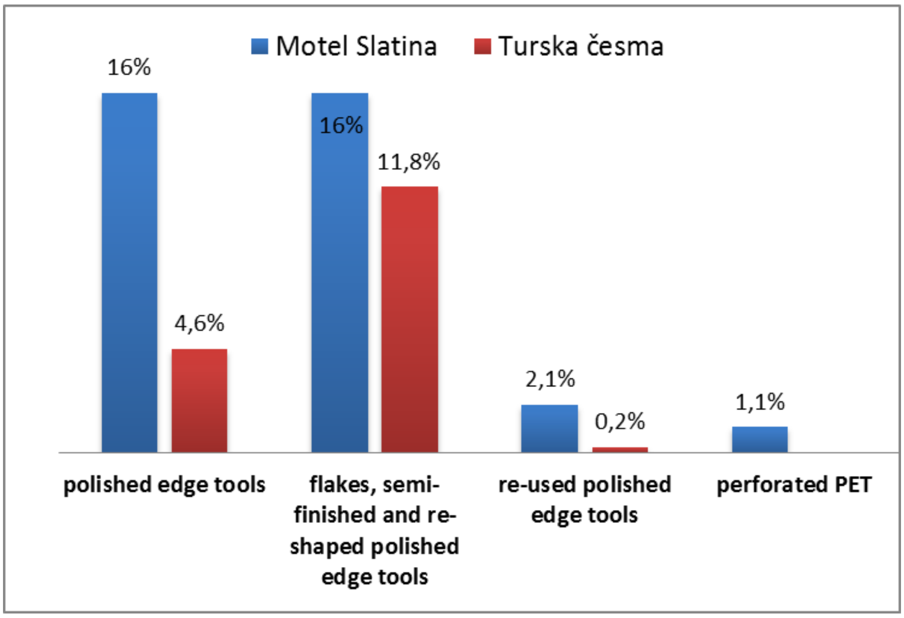

Fig. 7.2.5.Economy of the Late Neolithic: types of artefacts from settlements of Motel Slatina and Turska Česma, Slatina, Central region, graph 2; Motel Slatina , N=187, Turska Česma, Slatina N= 414.

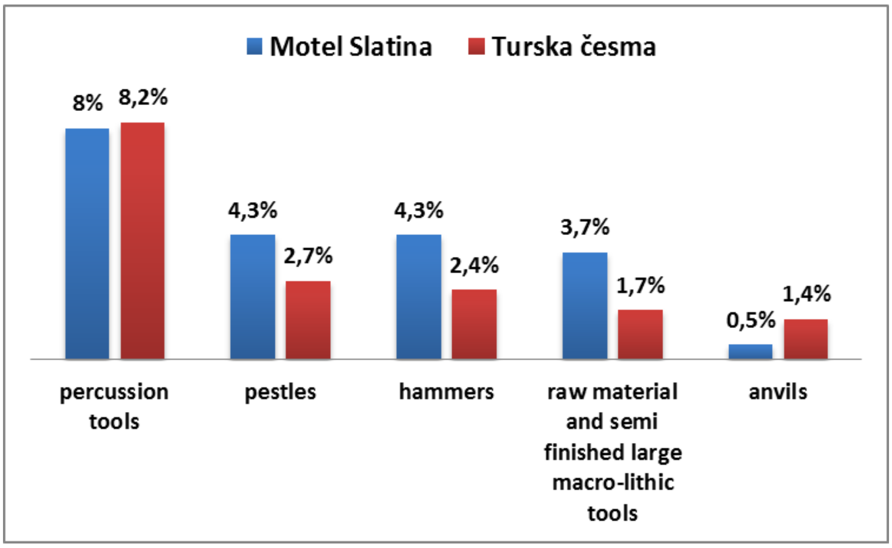

Fig. 7.2.6.Economy of the Late Neolithic: types of artefacts from settlements of Motel Slatina and Turska Česma, Slatina, Central region, graph 3; Motel Slatina , N=187, Turska Česma, Slatina N= 414.

of abrasive tools[6]. They appeared more often at Turska Česma, Slatina (c.46%) then at site Motel Slatina, where they represent c. 31% of all study artefacts. The analysis suggests that the use of abraders were organized in several technological processes at both settlements. 36 % of active surfaces in Turska Česma, Slatina were implemented in shaping, polishing, or sharpening stone tools (pattern 1), Their role in

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[6] Abrasive slabs – LOS and abraders.

the economy of the settlement of Motel Slatina, had larger importance (56%). 55% of the working surfaces of abraders from Turska Česma, Slatina was involved in the processing of certain plants, wood, or bone (pattern 2), while 33% of the active surfaces from the site of Motel Slatina were involved in the same activity[7]. C. 2% of all studied abraders were used to crush, pound, or pulverise small soft organic materials on hard and concave surfaces at both settlements (pattern 3) (subchapter 3; subchapter 6.2.1).

The use of polished edge tools was more intensive at Motel Slatina than at Turska česma, Slatina (fig. 7.2.5). Organized use of adzes in cutting processed materials (pattern 2) has been detected with 5,5% of all adzes used in crafted production at each of the sites. An appearance of flakes knocked of polished edge tools, semi-finished products and reshaped of polished edge tools at Motel Slatina is slightly stressed in relation to Turska česma, Slatina. The proportion of raw material, semi-finished products[8] and anvils[9], which suggest manufacturing of the rest of macro-lithic tools and chipped stone tools, is more or less similar in both settlements. The perforated polished edge tools were detected only at Motel Slatina (fig. 7.2.6)

Percussion tools present c. 8% of all studied artefacts at each of the studied sites in this region. These artefacts were involved in different organised activities. Crafters used quartzite objects (patterns 1 – 4) to performed various activities. The record shows that the use of these artefacts was more intensive at Turska Česma with 36,1% of all studied percussion tools than at Motel Slatina, where it has been observed based on 8,3% of all studied percussion tools (fig. .7.2.6). The implementation of the artefacts with six working surfaces (pattern 6) were more intensive at Motel Slatina than at Turska česma, Slatina. Observations indicate that specific use of the artefacts with three active sides (pattern 5) and artefacts

pattern	Motel Slatina (n)	Turska česma, Slatina (n)
1-4	3	13
5	3	3
6	7	2
1A	3	2
3A	1	-
In total	12	25

Table 7.1. Distribution of patterns of percussion tools during the Late Neolithic, the Central region. N=37

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[7] The results of analysis has been presented at“ The Neolithic tools with abrasive wear traces “ - International conference AWRANA, Beyond use-wear traces: Tools and people held between 29th may – 1st June 2018 at the University of Nice Côte d'Azur - Saint Jean d'Angely Campus (Nice, France), and in paperwork “A functional analysis of abrading stones: a case study from the Central Balkans” by R. Risch and V. Vučković, in press.

[8] IND – raw material and semi-finshed produscts –SFP (LOS)

[9] anvil- ANV

involved in splitting and crushing stone or maintenance the active surfaces of the abrasive tools (pattern 1A) have been also detected in both settlements. Processing medium to hard materials such as bone or wood by splitting and crushing (pattern 3A) has been documented only at Motel Slatina (table 7.1) (subchapter 6.4.1, fig. 6.4.16/1).

Record also shows that 45,4% of all pestles, which were involved in organized work at the Central Balkans were detected in Turska česma, Slatina, while only 9% come from Motel Slatina. The proportion of this type of tool in Turska česma, Slatina is similar to the result from the settlement of Potporanj, Northern region.

The rest of the tools such as grinding equipment, re-used polished edge tools, and hammers appeared in more or less similar proportion at the settlements (fig. 7.2. 4 – 6).

Previous study indicate practice of agriculture based on paleobotanic data such as cereal and pulses at Turska česma, Slatina which was associated with the implementation of grinding, sickle elements and bone tools related to soil cultivation (Vitozović 2007, Gurova 2016: 54, Figs. 12–16; Table 4 and 7; Stojanovic, Obradovic 2016: 92). A vicinity of the Velika Morava river explains an occurrence of weights for fishing net. Bone as raw material was highly accessible due to husbandry, which was part of the economy of both Late Neolithic settlement and hunting wild animals (Cvetković 2004: 77, 80)[10].

The economy of this area was established mainly on the exploitation of local raw materials, that is stressed at Turska česma, where c. 71% of all rocks were collected at the distance not larger than 10 km. This proportion is lower at the settlement of Motel Slatina, where c. 49% of all used raw material came from the same distance. This indicates different social organisation at these two settlements. Although some rocks such as (meta)alevrolite had a particular social value, as it demanded an organisation of distant exchange network.

7.2.3 Western region

The Neolithic settlements occupied the mountain area and the narrow plain zone in the Western region (fig. 7.2). We present economical differences between the

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[10] Stojanović, I.: Economic and Social Importance of Animals in Vinča Settlements in the Middle Morava Valley, Ph.D thesis, Archaeology department, Faculty of Philosophy, University of Belgrade. writing in progress.

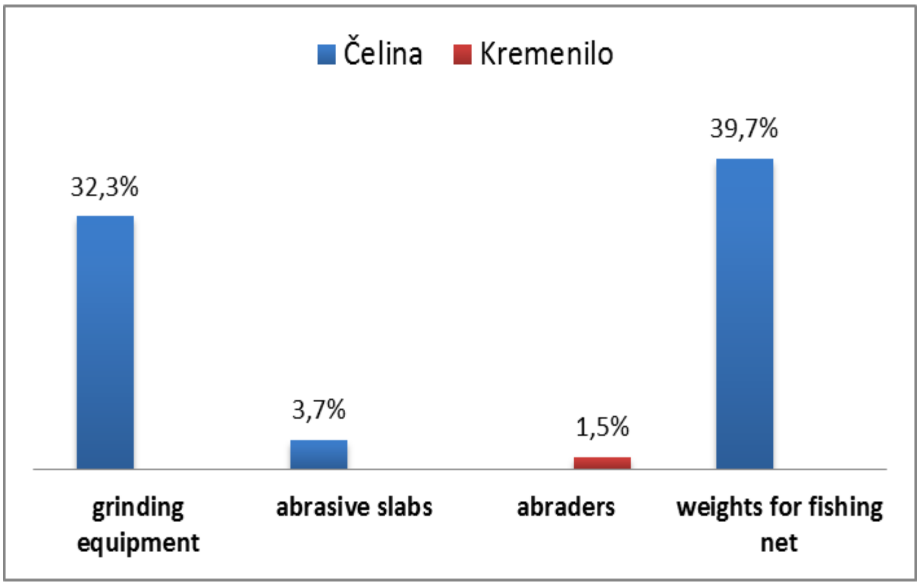

Fig. 7.2.7.Economy of the Late Neolithic: types of artefacts from settlements of Čelina and Kremenilo,Western region, graph 1; Čelina, N=136, Kremenilo, N= 67.

settlements of Čelina (n= 136) and Kremenilo (n= 67), as the Late Neolithic horizons of Koraća Han (n= 35) and Vranjani (n= 15) produced an insufficient number of artefacts.

The analysis indicates economical differences between these two settlements. Grinding equipment, abrasive slabs, weights for fishing net, percussion tools and pestles have been detected only at Čelina in the southern part of the area (fig.7.2.7). The analysis indicates specific use of long and heavy quartzite tool (pattern 1), and the implementation of one artefact in retouching and pounding soft and hard materials (pattern 2A). Observations show that manufacturing of macro-lithic tools, which has been identified based on raw material from an archaeological context was more intensive at this settlement than at Kremenilo.

The economy of the settlement of Kremenilo, in the northern part of the Western region, is characterised by objects such as flakes knocked of polished edge tools, re-shaped polished edge tools and its semi-finished products (c.44%) [11]. They suggest intensive manufacturing and maintenance of polished edge tools, while 29,9% of all studied tools are polished edge tools[12] (fig. 7.2.8). 44,4% of all adzes which were used in organised production at the Central Balkans came from Kremenilo which confirms importance of this type of tool. 17,9% of all analysed objects are re-used polished edge

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[11] LAS, UNK, SMF

[12] Adzes-ADZ, axes – HAC and celts – REN

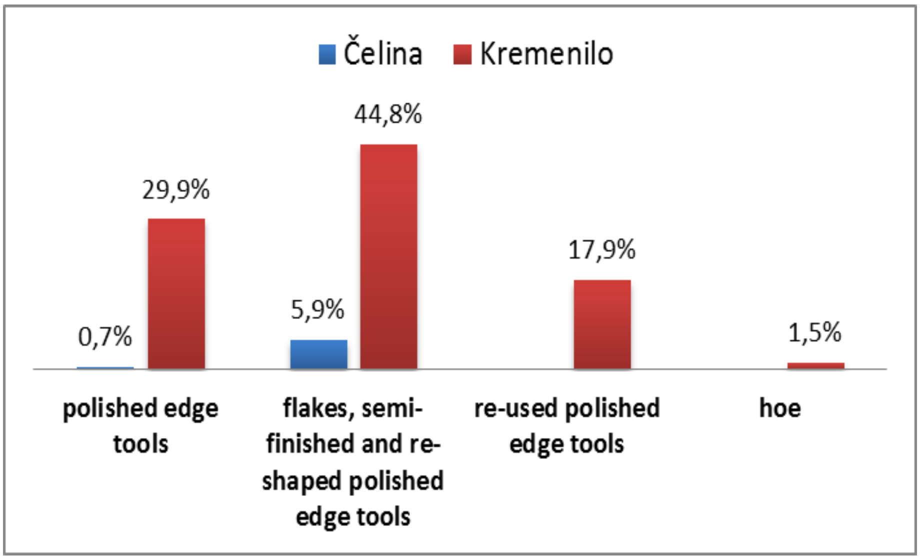

Fig. 7.2.8.Economy of the Late Neolithic: types of artefacts from settlements of Čelina and Kremenilo,Western region, graph 2; Čelina, N=136, Kremenilo, N= 67.

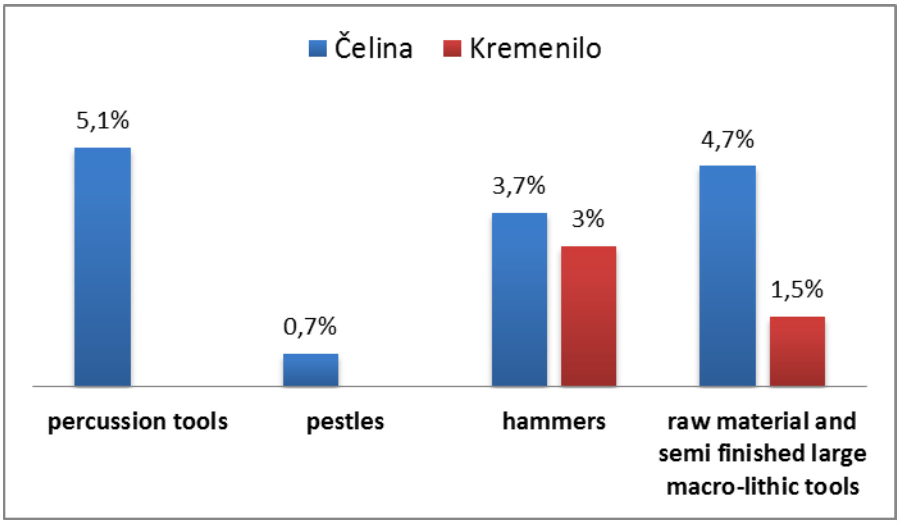

Fig. 7.2.9.Economy of the Late Neolithic: types of artefacts from settlements of Čelina and Kremenilo,Western region, graph 3; Čelina, N=136, Kremenilo, N= 67.

tools, which have been observed only in this settlement. The Late Neolithic horizon produced a hoe, which is associated with the exploitation of clay (fig. 7.2.8).

The geoarchaeological study show that macro-lithic tool technology in the Western region relayed on the exploitation of local raw material sources. C. 93% of all studied rocks from Kremenilo were locally found, while in the Late Neolithic settlement of Čelina this proportion presents 83% of all examined raw materials (subchapter 5.3.3).

region	Northern %	Central %	Western %	Southern %
grindig equipment	1,7	7,4	19,8	23,9
abrasive slabs	2,8	5,2	3	20,9
abraders	1,5	29,3	3	34
weight for fishing net	-	6,7	14,2	-
polished edge tools	27,6	8,5	21,6	5,3
flakes, semi-finished and re-shaped polished edge tools	37,3	15,4	21,6	7,3
re-used polished edge tools	21,4	0,9	5,2	-
perforated polished edge tools	0,9	0,9	-	-
percussion tools	3,4	10,7	6,5	3,8
pestles	1,1	3	5,2	0,5
hammers	1,5	3,9	3,4	1,3
raw material and semi finished large macro-lithic tools	0,2	5	0,4	2,3
hoe			0,4	-
anvils	0,6	1,5	0,4	0,8
pottery polishers?		0,2	0,4	-
specialised prodution	X	X	X	X
exchange network	X	X		X

Table 7.2. Main economical characteristics of the Late Neolithic according to region.

7.2.4 The regional economic differences of the Late Neolithic

This subchapter presents the general picture of the economy and regional differences based on the proportion of tool types and intensity of their employment in the most represented technological process during the Late Neolithic in the Central Balkans.

a. Grinding technology

Grinding has been observed in the whole studied area. This technology show low standardisation, the uneven intensity at the studied area and suggests regional differences (fig. 7.2.10).

C. 23% of all studied objects from the **Southern region**[13] were involved in this activity. Observations also suggest that grinding was employed most intensively in this part of Central Balkans (table 7.2, fig. 7.2.10). In spite of low working efficiency, inhabitants used mainly andesite grinding slabs, while grinding technique required chiefly handstones with the narrow active surface which produced the concave (CV/CV) active sides of andesite grinding slabs (subchapter 6.1; subchapter 6.1.1).

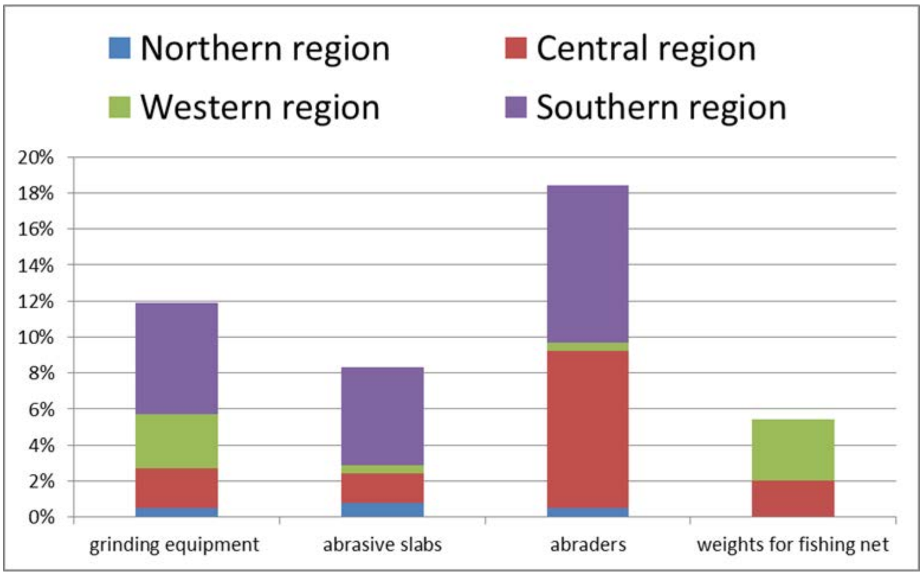

Fig.7.2.10. The Late Neolithic economy of the Central Balkans: types of artefacts; N= 1544;

C. 19 % of all studied objects from the Western region were involved in grinding, which was more intensive than in the Central and Northern region [14] (table 7.1, fig. 7.2.10). Grinding technology from this area is characterized by handstones, which length is equal to the width of the active surface of the grinding slab, wide gabbro grinding slabs with high working efficiency, which produce good quality product, surplus gain, and were also capable to grind hard materials (see subchapter 2.2, table 1.1). A vicinity of gabbro source presents another economic convenience. Thus, the

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[13] grinding slabs-MOL, MOL?, handstone-MUE, MUE? and mortars-MOR.

[14] grinding slabs-MOL, handstones – MUE and mortars –MOR.

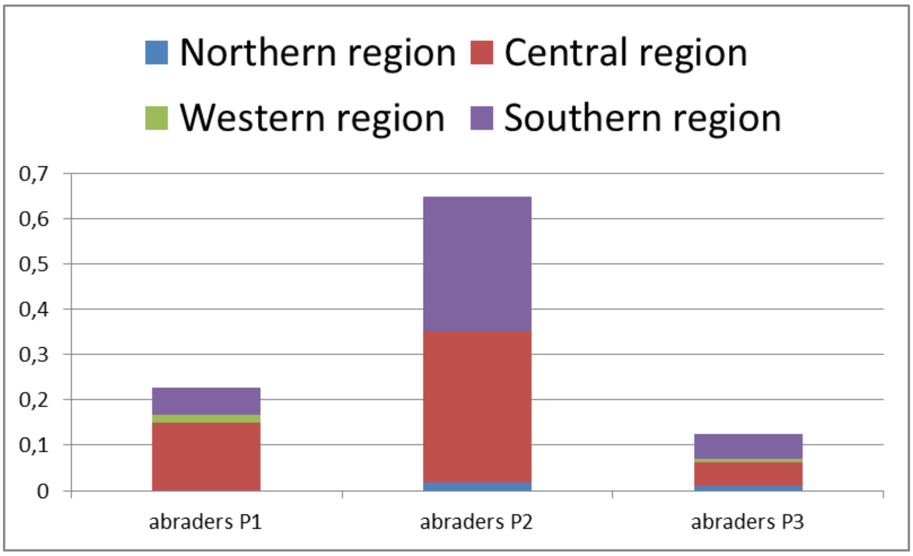

Fig.7.2.11. The Late Neolithic economy of the Central Balkans: abraders and patterns; N=114.

grinding technology in this area did not request an amount of the energy, time and organization, and was less demanding than technology in the settlement of Gumnište in the Southern region (subchapter 5.3; subchapter 6.1.1)

Grinding was recognized in **the Central region** based on c. 7% of all studied tools from this area (table 7.2, fig. 7.2.10). This technology displayed differences in relation to the rest of the studied area as grinding tools were manufactured out of various rocks with different working efficiency. Metrical and morphological characteristics of handstones are another characteristic. The length of these tools was mainly equal to the width of the grinding slab, producing the flat (RT/RT, RT/CX, CX/RT and CV/RT) active sides.

The proportion of grinding in the **Northern region** is low, and data are insufficient to provide its characteristic (table 7.2, fig. 7.2.10).

It has been also documented that dietary of the Late Neolithic communities in the Western and Central region were supplied by fishing (table 7.2, fig. 7.2.10).

b. Working stones and processing minerals

Variety and intensity of these activities were uneven at the studied area and organized production was developed uniquely.

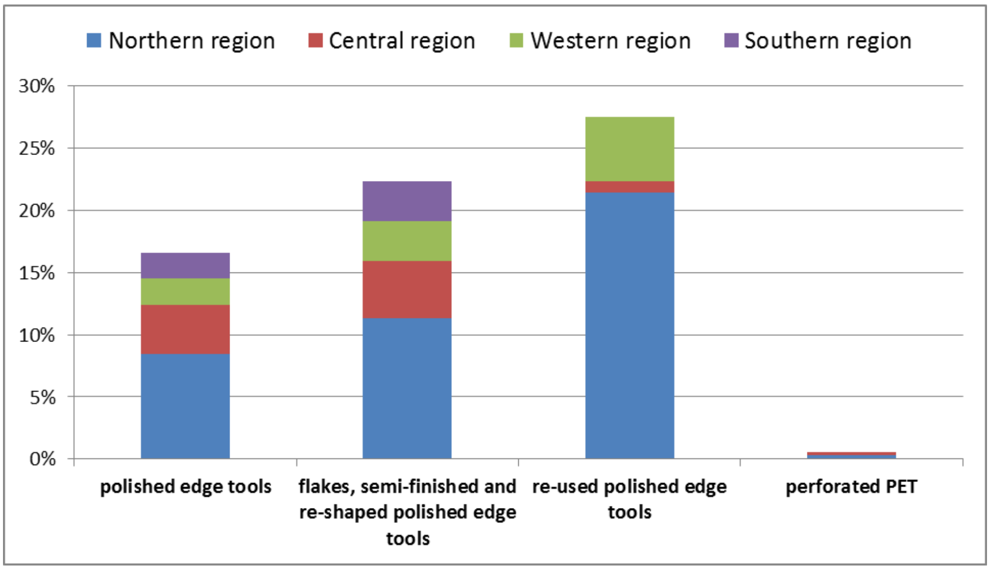

Fig.7.2.12. The Late Neolithic economy of the Central Balkans: types of artefacts; N= 1544.

Despite lack of raw materials, the economy of the **Northern region** during the Late Neolithic is characterised by manufacturing polished edge tools. It included c. 59% of the studied material, which were associated with tools with secondary modifications, flakes knocked off polished edge tools, semi-finished products, re-used polish edge tools[15] and percussive tools. The percussion tools were involved in craft production of low intensity. This economic activity regarded retouching, pounding, splitting and crushing and splitting and crushing stone or maintenance the active surfaces of the abrasive tools (table 7.2, fig. 7.2.12 - 7.2.14).

The result of the analysis indicates that the economy of the **Central region** during the Late Neolithic relayed mainly on stone processing, which was the most intensive in the Central Balkans (fig. 7.2.13). This activity involved c. 25% of all studied objects from this region such as semifinished products, flakes knocked of polished edge tools, reshaped polished edge tools and raw material[16], hammers and re-used polished edge tools confirm this observation (table 7.2) Moreover, stone processing displayed organized production and involved percussion tools (patterns 1- 6, 1A) and abraders.

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[15] tool with secondary modifications (UNK), flakes knocked off polished edge tools (LAS), semi-finshed produscts (SFP), re-used polish edge tools (RPE 1 and 2);

[16] tools with secondary modifications-UNK, flakes knocked off polished edge tools-LAS, semi-finshed produscts –SFP.

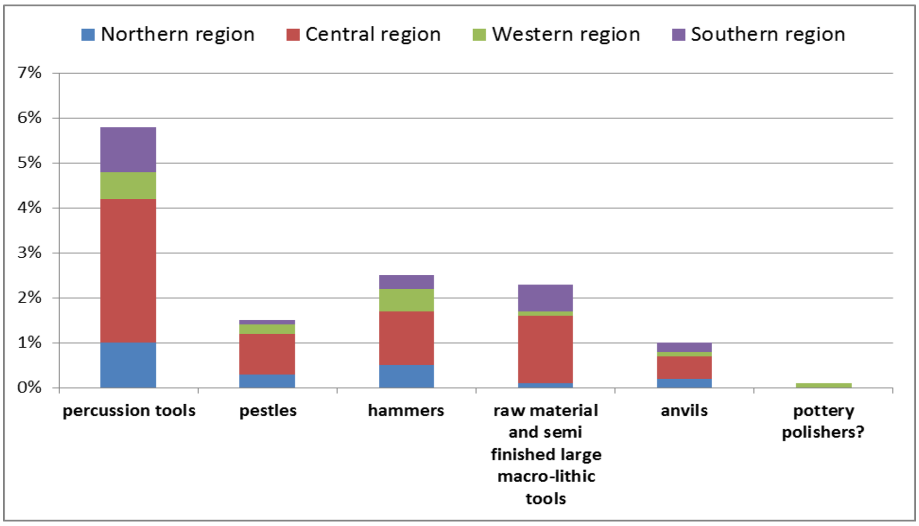

Fig.7.2.12. The Late Neolithic economy of the Central Balkans: types of artefacts; N= 1544.

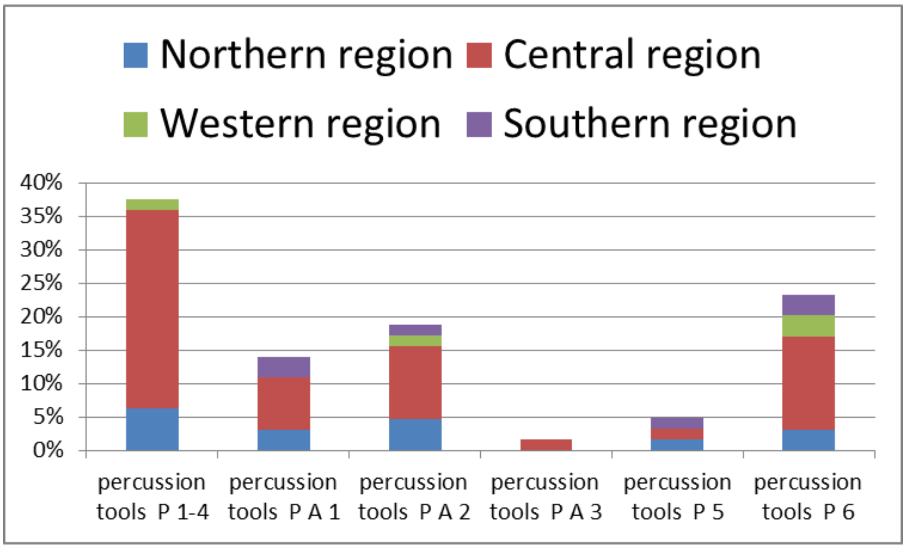

Fig.7.2.13. The Late Neolithic economy of the Central Balkans: percussion tools and patterns; N=64.

Fig. 7.2.11 and 7.2.17 suggest these crafts were the most intensive at the Central Balkans, during the Late Neolithic (table 7.1).

The economy of the Late Neolithic communities in the **Western region** was established mainly on manufacturing stone objects and chipped stone tools, processing other stones and minerals by percussion. The first activity has been recognized based on c. 20% of all studied artefacts,[17] while processing of stone was organized in specialised production of low intensity (fig. 7.2.12-13).

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[17] anvil-abrader (ANV-ALS), semifinshed products (SFP), flakes knocked off polished edge tools (LAS) and raw material (IND), Re-used polished edge tools (RPE) and hammers (HAM)

c. 22% of all analysed tools from the **Southern region** show activities related to processing stone (table 7.2). This a included manufacturing and re-shaping polished edge tools, abrasive tools[18] and percussion tools[19], while re-use of polished edge tools of was absent. The proportion of involved tools is similar to proportion detected in the Northern and Western region, and craft production was of low intensity (fig. 7.2.11-14). Furthermore, the results show that the active surfaces of abraders were involved in shaping and re-sharpening of polished edge tools (functional pattern 1) tend to be significantly larger than surfaces in Turska česma, Central region, suggesting that larger polished stone tools were prepared with this type of abrader.

c. *Processing of wood, bone and soft organic materials*

Processing of medium to hard materials such as wood and bone has been detected on the whole studied area, in different proportion and was associated partly with organized production.

Processing wooden and bone objects in the **Northern region** has been detected based on c. 26% of polished edge tools[20], and was the most intensive in the Central Balkans (fig. 7.2.12). Importance of this activity has been confirmed by organized use of adzes (fig. 7.2.15), and intensive production of polished edge tools (fig. 7.2.12), which organisation was of low intensity (table 7.2, fig. 7.2.11). Record also suggested a high level of organised use of pestles.

24% of all studied artefacts from the **Southern region** were involved in the technology of processing medium to hard materials (table 7.2). These activities were involved in organized production and included mainly abrasive tools (patterns 2 and 3)[21], whereby functional pattern 2 is represented by 60% of the identified abrasive surfaces in the Central Balkans[22]. This suggests that the processing of certain plants,

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[18] This activities have been recognized based on anvils (ANV, ANV-LOS, ANV-RET, ANV-RET?), flakes knocked from polished edge tools (LAS), tools with thraces of secondary modifications (UNK, UNK-HAC), raw materials (IND), a semi-finished product (SFP),

[19] percussion tools (percussive tools -PEC, retouching tools –RET, a retouching tools – percussion tools- RET-PEC) and hammers.

[20] axes -HAC, celts-REN, adzes -ADZ and chisels –CHI, CHI?.

[21] coarse-grained abraders-ALS, fine-grained abraders – ALS-PIA, abrasive slabs – LOS, LOS?, LOS-PIA.

[22] The results of this chapter has been presented at“ The Neolithic tools with abrasive wear traces “ - International conference AWRANA, Beyond use-wear traces: Tools and people held between 29th may – 1st June 2018 at the

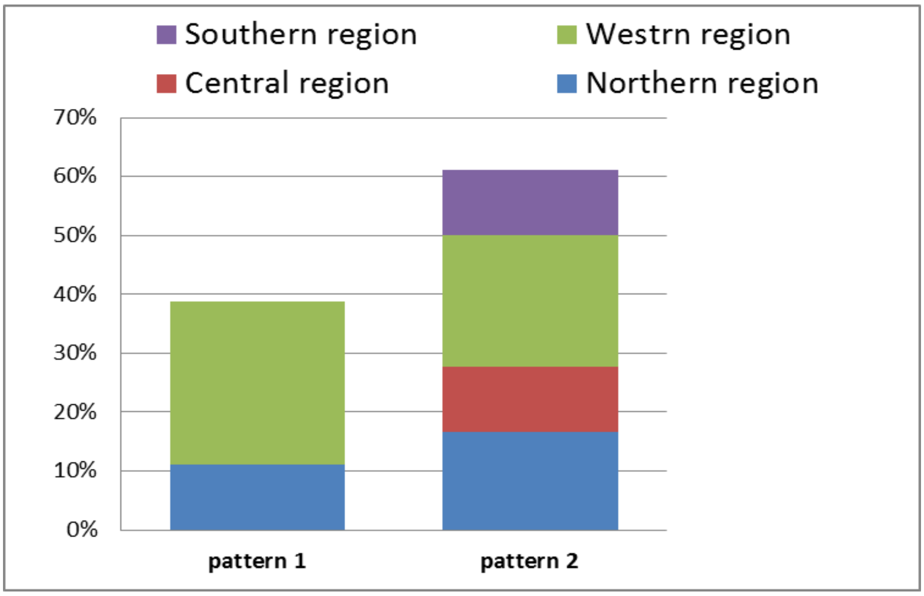

Fig.7.2.15. The Late Neolithic economy of the Central Balkans: adzes and patterns; N=18.

wood, or bone was more important than in the settlements in the Central region. C. 10% of all abraders tools from the settlement of Gumnište is related to crushing, pounding, or pulverising of small soft organic materials in small quantities and on hard, slightly concave surfaces (pattern3) (table 7.2, fig. 7.2.11 and 7.2.12). The proportion of these tools are similar to the proportion detected in the Central region. The low proportion of polished edge tools organized use of the adzes is characteristic of this region (fig. 7.2. 12 and 7.2.15; table 7.2).

Wood and bone processing are associated with polished edge tools, which present c.21% of all studied materials from the **Western region**[23]. It seems that their proportion is slightly higher than in the Southern region. Although the organised use of adzes is the most intensive in the Central Balkans (table 7.2, fig. 7.2.11, 7.2.12 and 7.2.15).

C. 13% of all studied objects from the **Central region** were used in work in wood and bone. These activities included mainly organized production related to the use of abraders (patterns 2 and 3) and percussion tools (pattern 3A), which was the most intensive in the Central Balkans (fig. fig. 7.2.11). This can explain intensive and crafted use of percussion tools typical only for this region (table 7.1, 7.2.12 - 13). Furthermore, the proportion of pestles from this region is the largest among this tool type at the

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University of Nice Côte d'Azur - Saint Jean d'Angely Campus (Nice, France), and in paperwork "A functional analysis of abrading stones: a case study from the Central Balkans" by R. Risch and V. Vučković, in press.

[23] axes -HAC, celts-REN, adzes -ADZ and chisels –CHI

Central Balkans. Moreover, c. 54% of all pestles, which were involved in a specific activity in the studied area, are from this region, which confirms their importance in the economy of the Central region.

Unlike this, the proportion of polished edge tools is not so high, and organized use of is associated with cutting processed materials (pattern 2) (table 7.1; fig. 7.2.12 and 7.2.15).

In following lines we present answers on questions which have been crystalized during our work:

The general conclusions derived from the analysis of the polished edge tools and re-used polished edge tools. Apart from a variety of rocks, (meta)alevrolite was a strategic raw material at the whole Central Balkans. It seems that deposits of this rock can be positioned in the area to the south from the Sava and Danube rivers. Importance of (meta)alevrolite in the Vinča society can be explained by the value theory established by R.Risch (Risch 2011). This concept includes production and use value of (meta)alevrolite. The first aspect is determined in terms of distant sources, as deposits of this rock were not always local, but remote more than 50 km from some of the settlements. This implicated different social organisation, procurement systems and distant exchange (subchapter 5.3) which resulted in circulation network extended throughout of Central Balkans. Moreover, organised production of polished edge tools has been detected by functional analysis of abraders. Use value is addressed to properties of tools and their ability to accomplish tasks, while their number confirms their importance and importance of their product. Although properties of (meta)alevrolite still needed to be examined. Thus, we believe that it is not far from the truth that production and use-value of polished edge tools caused their organised production at the Central Balkans during the Neolithic.

Although dependency only on (meta)alevrolite has not been observed. At the Western and Northern region, an occurrence of polished edge tools made of light white stone has been noted in much larger proportion than in the central and southern part of the studied area. This points to the difficulty of a regular supply of (meta)alevrolite over large distances.

8. Conclusions

The conclusion of this thesis can be grouped into several topics. Analysis of tool types from each settlement has suggested that important differences existed during the Neolithic of the Central Balkans in terms of economic activities and their intensity. The difference in accessibility and variability of rocks used as a raw material in the studied area affected the organisation of different, regional procurement systems. Observations show that a selection of geology within each region is mainly uniform regardless of the source distance.

The number of tools studied for each period allows us to define the socio-economic differences only during the Vinča period. Table 8.1 summarises the main economic traits of each of the four studied regions (North, Central, Western and Southern), in terms of raw material circulation, dominance and variability of tool types, intensity of production, economic specialisation and productive diversity. The percentage of fragmented material (preservation <1/3 of the original tool) in the macro-lithic assemblage is an indicator of the sample bias, which needs to be taken into account in any economic approach. Activities implying artefacts with a high breakage rate, such as grinding slabs and abraders, will be underrepresented in the Northern and Western region, while the results from the Central and Southern regions seem to be comparable as well as economically representative. The different fragmentation rates suggest that c. 25% of fragmented tools is missing in the Northern and Western regions. The conclusions offered in the following section have taken this bias into account.

Lack of raw material caused a good integration of **the Northern region** into inter-regional exchange networks with other parts of the Balkan Peninsula during the Late Neolithic. This can be also related by intensive manufacturing, use and re-use of polished edge tools. These objects are dominant among the studied artefacts and reveal that woodworking (bone processing) and carpentry as the most imprtant activity for inhabitants of three settlements in this area. Moreover, these results suggest intensive

Region	**Northern**	**Central**	**Western**	**Southern**
Nr. of sites	3 settlements	2 settlements	4 settlements	1 settlement
Lith. sampling	selective	1 systematic & 1 partial	selective	systematic
% of imported tools	87,4	32,4	6,2	28
% fragmentation	5,8	32,7	5,6	31,3
Dominant tool types	polished edge tools (28%), manufacturing and re-use of polished edge tools (58%)	abraders (29%) and percussion tools (15%)	**north**:polished edge tools (22%), manufacturing polished edge tools (22%); **south**: grinding (20%)	abraders (34%), grinding (24%) abrasive slabs (21%)
Dominant activity	**a.**woodworking (bone), carpentary **b.**mineral; processing	**a.**manufacturing polished edge tools, **b.**processing substance goods; **c.** work on stone	**a.**woodworking (bone), carpentary (in the northe); **b.**cearal processing (in the south)	**a.**processing substance goods; **b.**cearal processing c.work on stone
Variability of artefacts	0,8	0,9	0,7	0,6
Intesity of production	0,21	0,30	0,35	0,9
Density of edge tools	0,06	0,02	0,03	0,04
Economic specialisation	high	medium	variable (N/S)	high
Economic diversification	medium	high	medium	low

Table 8.1. Regional economic specialisation of the Vinča culture communities; ***Imported tools*** *is related to percentage of presence of raw materials comming from more than 10 km distance, and is based on the results from chapter 5.3;* ***Fragmentatin of tools*** *is obtained from the % of tool fragments (preservation <1/3) collected at each settlement (see chapter 3);* ***Dominant tool type*** *refers to the most represented tools in each region (chapter 3);* ***Dominant activity*** *correlates with dominant tool type;* ***Variability of artefacs*** *is related to presence of a certain tool type according to all defined functional types of tools (N=27);* ***Intesity of production is*** *obtained by considering the relation between total number of tools and the excavated area (see chapter 3);* ***Density of edge tools is*** *obtained by considering the relation between total number of polished edge tools and the excavated area;* ***Economic specialisation*** *is defined based on the relative importance of the dominant tool type(s);* ***Economic diversification*** *is established on values of productive variability.*

land clearances, which should be confirmed in the future by polen analysis. The results show that variability of artefacts was medium in comparison to the other regions, while economic specialisation reached high level, due to the intensive use of the whole vareity of edge tools (table 8.1). It could be objected that selective recovered strategy has generated this result. However, as polished edge tools will be the most carefully sampled lithic artefacts on any excavation, the density of polished edge tools per excavated m^2 provides an aditional value of the importance of these artefacts. In comparison to all other areas, tree felling and wood working continues to appear as the dominat economic activity of the Northern region (table 8.1). Deforestation and the opening of the landscape might also be related to a specialisation of these communities in husbandry. In sum, the Northern communities specialized in a specific economic realm (wood working), but reached a much lower productive intensity than the West, the Centre and especially the South. Taking these economic characteristics into account, we can observe the Northern region as a separate variant of classical Vinča culture, as it has been suggested previously based on other types of archaeological evidence (Perić 2006).

Examintaion of economic aspects presented in table 8.1. show different socio-economic organisation of the two Late Neolithic comunities in **the Central region** in a relation to the other regions**.** They obtained raw material mainly from local deposits, altought it should be mention that the exchange of rocks between settlements, and distant areas were not limited (chapter 5).

Abraders and percussive tools palyed the most imprtant role in the economy of the Central region. They were used to manufacture polished edge tool, process subsistance goods and mineral processing, which consequently would have represented dominant activities. Furthermore, tool variability was the highest in the Central Balkans. This suggests that various activities were performed in these settlements and correlate with a high economic diversity. A large variety of specialised percussion tools and abraders were employed mainly in working on stone, manufacturing polished edge tools and processing subsistence goods. Unlike this, the proportion of adzes in the processing of medium to hard materials was relatively low. Contrary what can be expected according to environmental context, bone processing and woodworking did not have large importance. This suggests the possibility that an area around these settlements was already deforested, which can be examined by pollen analysis in the future. Furthermore, the inhabitants of these settlements developed specific grinding technology based on the implementation of various raw materials and of grinding tools with flat surfaces (chapter 6.1). This enabled an increase in productivity and the production of a surplus gain. Low standardization of geology used for grinding tools could indicate the availability of sufficient labour force for grinding and/or low economic importance of cereal processing and specific dietary (Delagado-Rasck et al. 2009). Low economic importance of cereal grinding might explain the proportion of weights for fishing net among studied materials (table 7.2) and the role of wild sources in subsistence strategy. As the fragmentation index, used to reject clear sample biases, is high, it is not expected that the processing of cereals, fruits, nuts, etc. is underrepresented in this region.

In comparative terms, economic production reached a medium intensity but the highest diversity. Such a sustainable organisation of natural resources and means of production might explain the longer duration of the Vinča culture in the Central region. Evidence shows that this area resisted to Eneolithic Tiszapolgar culture and Bubanj-Salcuţa-Krivodol complex longer than the other parts of the Central Balkans, allowing (Garašanin 1973: 102; ibid. 1979: 189; Perić 2006).

Most of the raw material for macro-lithic tools were found locally in the **Western region,** suggesting low transport costs**.** Main activities of inhabitants of four studied settlements were manufacturing and use of polished edge tools in the northern part, while grinding tools were dominant in the south, despite of the low recovery of tool fragments. This suggests that in the first area tree felling and wood working was the most imporant activity, while grinding cereals plays a more significant role in the economy in the south, representred by the settlement of Člina. Variability of the studied tools was medium and correlates with the same level of economic diversity and intensity of production (table 8.1).

The economy of the north was also characterised by exploitation and use of light white stone in manufacturing polished edge tool, since the Early/Middle Neolithic. An appearance of polished edge tools made of light white stone might indicate a connection with the Northern region, during the Late Neolithic, while re-use of polished edge tools and intensive wood and bone processing confirm economic similarities.

Instead, Čelina in the south is characterized by efficient grinding equipment and fishing as a dietary supplement, which relates this settlement more to the economic sphere of the Central region.

Unlike low intensity of crafted production, which involved percussion tools and abraders, the specialised use of adzes, was the highest in the Central Balkans. It appears that these communities might be more or less autonomous and self-sufficient (subchapter 5. 3. table A1.4).

Thus, it seems that two specific areas might be distinguished within the western part of the Vinča culture.

The study of the economy of the **Southern region** suggests that raw materials were mainly found locally. Only c. 28% of the rocks were obtained through exchange networks. This concerns andesite in particular, which was used for manufacturing grinding tools (subchapter 5.3.4). Taking into account the limited mechanical properties of this variety of andesite, we assume that an exclusive choice of this rock might be caused by inaccessibility and controlled exploitation of other sources. Finally, it could be said, that the product of grinding requested an organization of this community, which required a larger amount of time invested in the work force, transport, and probably specific relations with other communities. Moreover, abrasive tools were dominat, while the results suggests that they were mainly applied in subsitance production, while grinding. was the most intensive in the Central Balkans during the Late Neolithic and reflected regional specificities related to raw materials and metrical characteristics. This might indicate a specialised cereal production. Varibility of the tools is the lowest among the studied sites, and correlates with high economic specialisation, low economic diversification, and the highest levels of productive force in the Central Balkans.

Variety of crafts were detected, but except activities concerning to grinding of subsistance goods and the crushing, pounding, or pulverising of small soft organic materials, the intensity of the rest of organized craft production was low.

Finally, it can be confirmed that the investigation of macro-lithic artefacts is crucial to the understanding the socio-economic organisation of the Neolithic communities of Sputheast Europe, particularly those whose belong to the Vinča culture. Social organization was conditioned by the environment and the development of economy, whose forms and intensity were unequal on the whole studied area during this period. This provides a better understanding of the previously suggested regional variants of this Late Neolithic "culture". The petrographic analysis has revealed the development of various procurement strategies. Although raw materials came mainly from local deposits, the exchange between settlements has also been recorded. Particularly, the economy of the north was linked intensively to long distance exchange networks. Low standardization of one part of the means of production suggested that some activities were performed in the household. Although organized production has been detected since the Early Neolithic, a larger variety of crafts has been identified in the whole of the studied area during the Late Neolithic, suggesting an appearance of surplus gains, and a well developed transport of goods and people. Such a diversified and intense production must have correlated with specialised human work force, particularly visible in the central part of the studied area, while the highes level of cereal production seems to have taken place in the South.

In summary, it can be said that in the area of the Central Balkans existed a powerful and regionally diversified Late Neolithic economy, which was based on very organised communities, planned use and circulation of resources, specialized means of production and specialized work force. This explains the innovative charater and the technological level visible in high quality products, such as pottery or figurines.

We would like to close with a comment regarding what needs to be done in the future studies of Neolithic macro-lithic tools in the Central Balkans. We hope that this thesis has provided enough data on the reconstruction of the economy and social organisation during the Neolithic, and offer guidance for future steps, which should include targeted geoarchaeological research and the study of the macro-lithic artefacts from a larger number of settlements. Hopefully, this study also helps to overcome the largely antiquarian flavour which still accompanies our discipline. The systematic recording of all lithic artefacts and fragments on prehistoric excavations, not only in the Central Balkans, is indispensable to understanding of the political economy of prehistoric societies.

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