Raw material provenance of artefacts from non-clastic siliceous sediments (Korobchyne-kurhan, central Ukraine)

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Abstract:

The Korobchyne-kurhan Palaeolithic site in the Velyka Vys river basin in central Ukraine is investigated for raw material of non-clastic siliceous sediments and human contact networks. The surrounding geography, the site and its investigation history are presented. The extensive search for outcrops around the monument resulted in the discovery of nearer than previously expected outcrops. Scientific investigations of 15 artefacts from Korobchyne-kurhan using non-destructive microfacies analysis allows us to have a first insight into the raw materials used by the prehistoric people of the region and to provide a detailed description of the siliceous raw material varieties that were encountered. The microfacies analyses investigates the deposition biotope of the non-clastic siliceous sediment and its mother rock. By comparison with geologic maps and knowledge, the geographical origin of the rock can be found. Interestingly, artefacts composed of two different materials were found. But only one of the material types is present in the investigated outcrops. Our work confirms the use of local materials as well as of some other material of yet unknown origin. Comparison to materials of younger sites shows that the exogenous material is as well testified in the Southern Buh river valley further to the west, whereas material of local origin is missing. First hypotheses about the origin of the material of unknown provenience are formulated.

Keywords: Ukraine; Korobchyne-kurhan; siliceous sedimentary artefacts (flint and chert); geology; Palaeolithic; raw material sourcing; Kamyane-Zavallia; Mohylna III; Stone Age

1. Introduction

In this article, we present the method applied for the raw material determination of flint and chert artefacts. As both terms have problems due to geological attribution to certain ages and to ambiguous definitions in different countries, the term ‘non-clastic siliceous sediments’ is used (Hallsworth & Knox 1999: 22, Přichystal 2010, 178-179). For better readability, we use the abbreviations ‘siliceous sediments’ or ‘siliceous rocks’.

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In Ukraine, the study of the sourcing of the raw material varieties used by prehistoric people has still to be advanced. Besides V. F. Petrun (Petrougne), who has published mostly in Ukrainian on this topic, there is not much to be found. The localisation of natural siliceous deposits and their cartography is still in the initial stages (*e.g.*, Ryzhov *et al.* 2005). Conducting our own fieldwork is the securest way of obtaining geological reference samples. To give an impulse to the sourcing of raw materials in Ukraine, we demonstrate a non-destructive method of determination that can be used to orient the search for raw material deposits. By linking deposits with the artefacts found at archaeological sites, economic relationships can be sketched out.

Fifteen samples from Korobchyne-kurhan were investigated in reference to local raw material, from which we could compare the archaeological material to a nearby outcrop bearing siliceous nodules. This report gives an overview of the archaeological situation and shows the methods used for the investigation and the results gained thereby. To complete the picture, the raw materials are compared to those of artefacts from archaeological sites in another region. 476 artefacts from siliceous sediments at sites in the Southern Buh river valley were investigated using the same methods (Wehren 2019; Wehren *et al.* 2019).

1.1. General information about the Korobchyne-kurhan site

The Korobchyne-kurhan Palaeolithic site belongs to the group of Stone Age sites that are located in the Velyka Vys river basin, in central Ukraine. The site is located near the eastern part of Korobchyne village, around 10 km west of Novomyrhorod (Figure 1).

Figure 1. Location of the Korobchyne-kurhan site in Ukraine (according to Nezdolii 2017b). The red dot indicates the location of the site on the map of Ukraine.

The Korobchyne-kurhan site occupies the highest part of the plateau on the left bank of the Velyka Vys river. The height of the monument above the water level in the floodplain is 60 m; the absolute height is 190-192 m. The site is located halfway along the dirt road connecting

Korobchyne village with the Novomyrhorod-Novoarkhanhelsk highway. Near the dirt road there are two burial mounds (4.2 m high and 1.8 m high), which mark the central part of the site (Figure 2). To the north and east of the monument is the start of a slope towards the floodplain of the Velyka Vys river. The topography of the slope is enhanced by the ramified system of gullies and draws (Nezdolii 2016; 2017b).

Figure 2. Location of the Korobchyne-kurhan site near the Korobchyne village. The red arrow marks the location of the site.

The draws are box-shaped, less often trough-shaped and U-shaped, fluvial relief forms (Beliaev 2004: 23), dry or with temporary watercourse valleys with flat or slightly concave bottoms and gentle slopes, covered with grass. The draws are of a considerable length (longer than the gullies) and are the final stage of gulley development. Gullies are V-shaped valleys with deep and wide steep slopes, usually without vegetation. Like draws, they are the result of erosion by temporary linear watercourses.

Local historian P.I. Ozerov discovered the Palaeolithic monument in 1983. The archaeologists O. V. Tsvek, L. V. Kulakovska, V. I. Tkachenko, V. M. Stepanchuk and S. M. Ryzhov visited the monument at different times up until 2010. They gathered surface artefacts; in addition, V. M. Stepanchuk and S. M. Ryzhov made one trial pit in the northern part of the monument (Stepanchuk *et al.* 2008). During 2010-2016, scientific investigations of the Korobchyne-kurhan site were conducted by the archaeological expedition of the National University "Kyiv-Mohyla Academy", led by L. L. Zalizniak. The expedition excavated 99 m^2 in the main excavation, 21 m^2 in the northern excavation and made 10 pits in different parts of the monument. The leader of the excavation campaign was O. I. Nezdolii (2017a).

Stratigraphical and palaeopedological investigations of the Korobchyne-kurhan site were carried out in cooperation with the palaeogeographers Zh. M. Matviishyna and S. P.

Doroshkevych. In 2010-2011, they investigated a 7 m long and 2.2 m deep profile and discovered the Holocene soil and the Upper Pleistocene deposits of the Vytachiv and Udai horizons (Matviishyna & Doroshkevych 2011).

The researchers define the Holocene soil as a typical chernozem (black earth) formed in the forest-steppe zone within the steppe areas; it reflects the present physical and geographical conditions of the monument. The Holocene soil overlays the suite of buried Vytachiv soils. There are no loess deposits between them, which is typical for most of the raised areas in the region's relief (Doroshkevych 2009). In the Vytachiv horizon, there is the main archaic complex of the site's siliceous sediments. The suite was defined as the brown soil of the late climatic optimum (vt_{b2}) and the dark brown soil of the early optimum (vt_{b1}) of the Middle Valdai, which was formed on the loess loams of the Udai time.

N. P. Herasymenko (2010) correlates the chronological positioning of the Vytachiv sub-stages in the Middle Pleniglacial and the third oxygen isotope stage (OIS 3 or MIS 3). She correlates the first Vytachiv interstadial (vt_{b1}) with the Eastern European first interstadial of the Middle Valdai and the West European interstadial of Moershoft (60-41 millennia BP); its optimum is determined separately in the range of 51-47 millennia BP. The second Vytachiv interstadial (vt_{b2}) is compared to the Molodove (second Middle Valdai) interstadial and Hengelo interstadial (38-36 millennia BP).

The chronological positions of the first two climatic optima of the Middle Pleniglacial generally correspond to the previous dating of the Korobchyne-kurhan archaic complex, carried out based on the artefact inventory specifics and the radiocarbon dating of sites with similar industries (Zalizniak & Nezdolii 2011; 2013).

The finds from the Korobchyne-kurhan site amount to more than 20 thousand pieces. Artefacts from the site show that the primary knapping technology is the usage of cores with longitudinal flattened and weakly convex flaking surfaces. Both single- and double-platform flat and high-backed cores of longitudinal and bipolar reduction were found. Single- and bifacial discoidal cores are represented in smaller numbers. Separate cores with a somewhat convex flaking surface and some bulk core variants have been observed too, as the core preforms used were mainly fragments of nodules and massive flakes.

The typological set of tools at the Korobchyne-kurhan site (Figures 3 and 4) includes different types of scrapers and backed knives with natural and artificial backs. Among the artefacts were Mousterian points and elongated Mousterian points, which were produced from flakes and blade-like flakes. The convergent form of the tools was given mainly by dorsal steep, semi-steep, scaly and stepped scaly retouching. There are quantitatively presented series of bi-truncated-faceted tools and notched drawknives with bilateral longitudinal flaking on the ventral surface. The toolset includes notches and denticulate pieces.

In the siliceous artefacts complex of the Korobchyne-kurhan collection, along with the Middle Palaeolithic types of products, there are artefacts that are traditionally identified with the Upper Palaeolithic types of tools. Among them, there are series of different end-scrapers, carinated end-scrapers, nosed scrapers and burins.

The artefact collection from the Korobchyne-kurhan site has no direct analogies among the Stone Age sites in the south of Eastern Europe. Together with the peculiarities of the siliceous artefacts complex, it became the basis for its classification as a separate type of Palaeolithic monument in the transition from the Middle to Upper Palaeolithic (Zalizniak & Nezdolii 2013).

Considering the lithic technology and typology of siliceous tools, some parallels to the Korobchyne-kurhan complex can be found among the monuments of the Late Middle Palaeolithic and the Early Upper Palaeolithic in the south of the East European Plain. These are some layers of the Donbas (Bilokuzmynivka, Kurdiumivka), the Middle Don (Shliakh), the

Lower Don (Byriuchia Balka 2) and the Mountain Crimea (Kabazi II) sites (Chabai 2006; Kolesnik 2002: 110-146, 168-213; Matiukhin 2012: 31-49; Nekhoroshev 2006: 27-61).

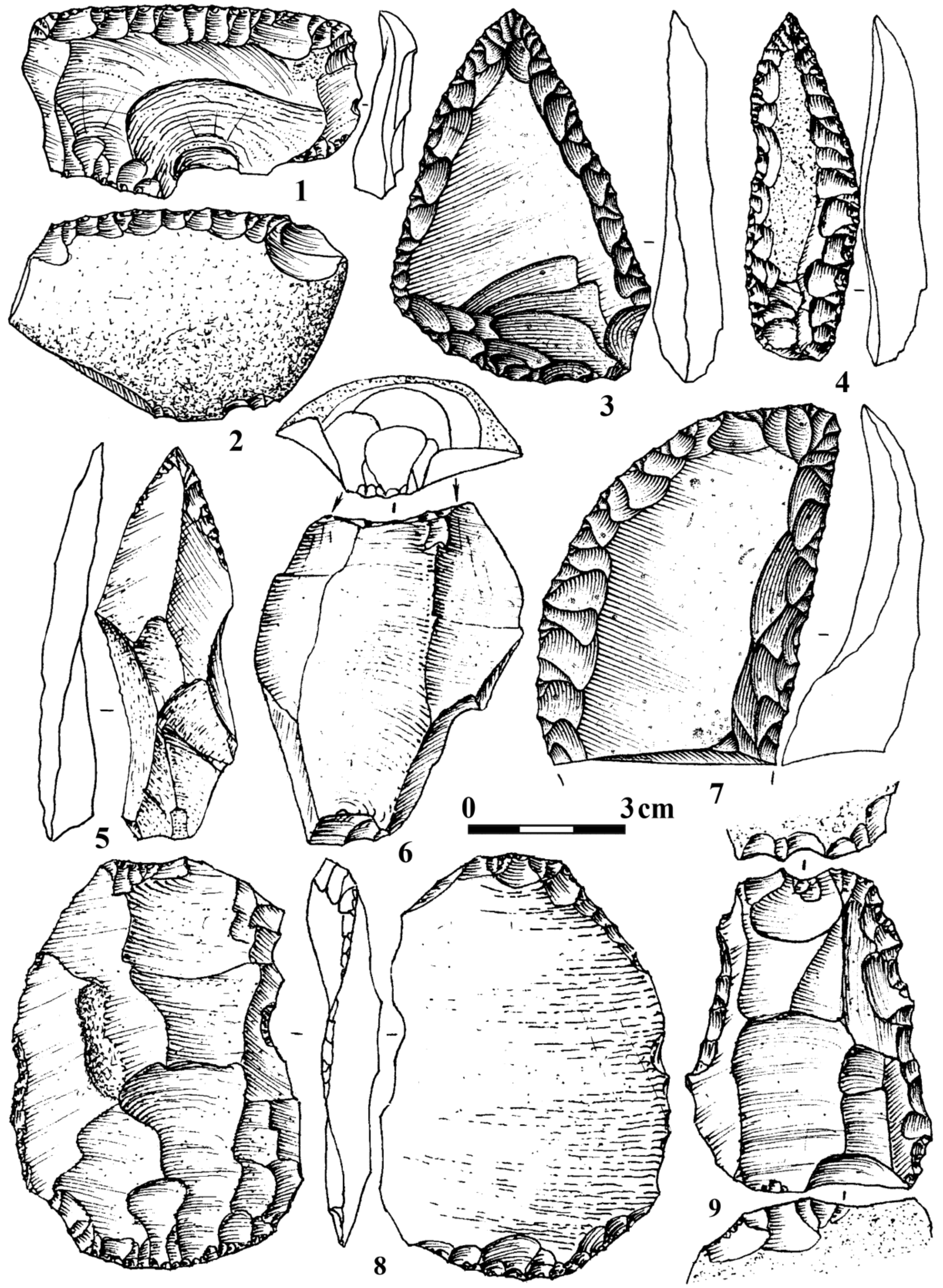


Figure 3. Korobchyne-kurhan: siliceous rock artefacts. (Drawings by L.L. Zalizniak & O.I. Nezdolii.)

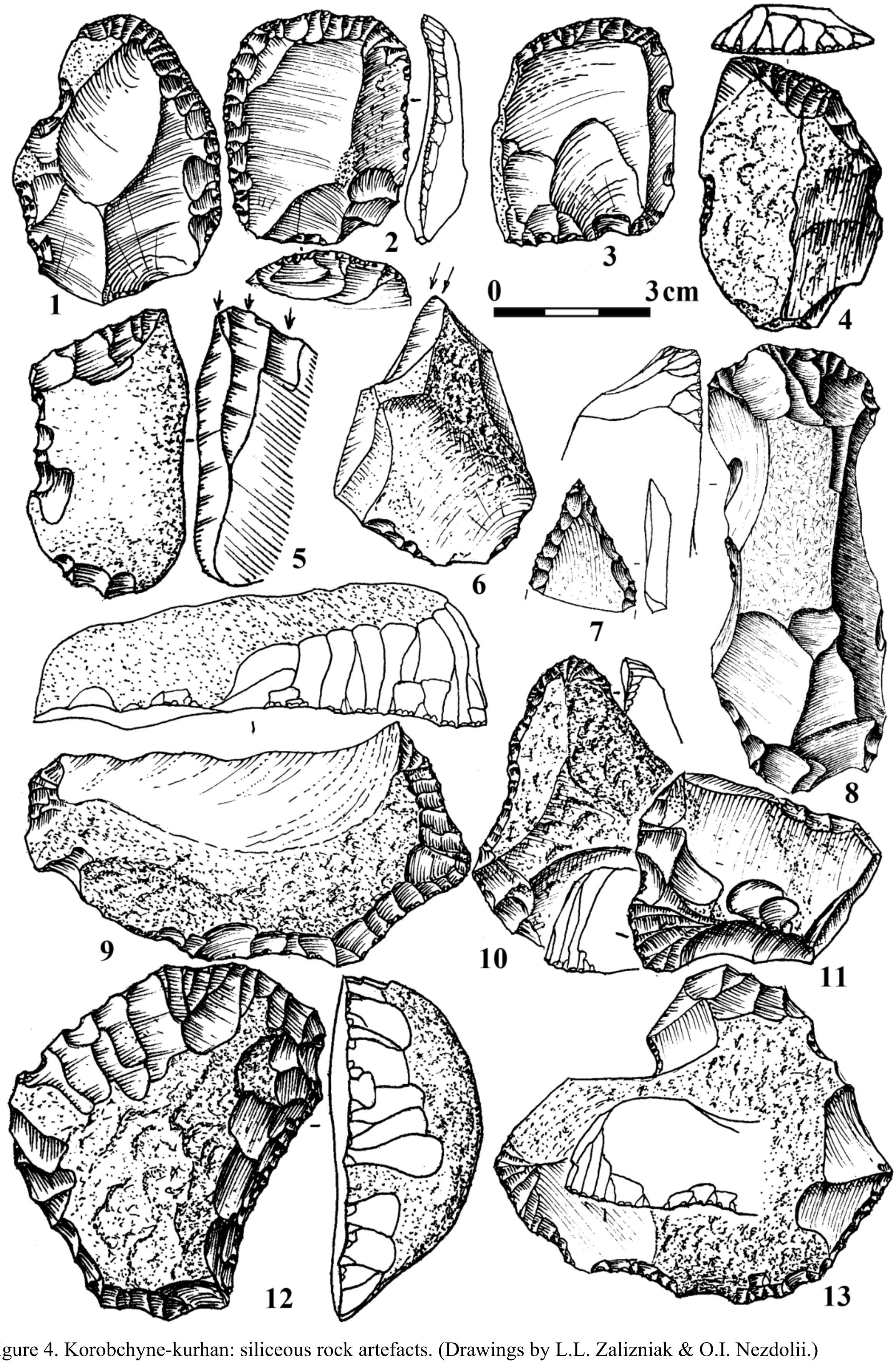


Figure 4. Korobchyne-kurhan: siliceous rock artefacts. (Drawings by L.L. Zalizniak & O.I. Nezdolii.)

However, the above monuments do not include quantitative series of Upper Palaeolithic-type end-scrapers, Aurignacian-type scrapers, and notched drawknives with bilateral longitudinal flaking on the ventral surface, which are typical for the Korobchyne-kurhan collection. These absences additionally testify to the peculiarities of the Korobchyne-kurhan collection. The complex of siliceous sedimentary rocks was classified as the Korobchyne type of Palaeolithic site.

1.2. Question: Where are the outcrops of siliceous raw materials?

The inhabitants of the Korobchyne-kurhan site mainly used various shades of grey fine-grained siliceous sedimentary raw material, with and without inclusions. The surface of patinated artefacts is mainly milky white and dark yellow with a purple tint. Stratified siliceous finds are covered with a carbonate crust. Below it, artefacts are weakly patinated and, in some cases, there are no traces of patina. The surface of many patinated finds shows various traces of alveolar weathering, meaning the formation of small cup-shaped recesses on the surface of siliceous rocks caused by frost or other temperature influences. Most likely, the Korobchyne-kurhan inhabitants used local deposits of siliceous raw material from the Velyka Vys river basin (Nezdolii 2018).

In 2004, and 2006-2007, V. M. Stepanchuk and S. M. Ryzhov explored the deposits of sedimentary siliceous raw material in the quarries of Korobchyne village (Ryzhov *et al.* 2005; Stepanchuk *et al.* 2006; Stepanchuk *et al.* 2009).

In the wall of a grus-granite quarry, they distinguished three levels of sedimentary siliceous raw material deposits (Figure 5). The siliceous raw material of the lower layer had the appearance of platy forms with visual layers from light brown to red shades, from which they infer that the lower layer corresponded to the primary geological position; it was located on slightly shifted Upper Cretaceous bedrock. The raw material of the middle layer in the form of light gray, bluish nodules and pebbles was visibly displaced by neotectonic and water processes. Root-like and amorphous siliceous rocks of infiltration origin represented the upper level. The level located under the Quaternary sediments was redeposited in the Paleogene and Neogene.

V. M. Stepanchuk and S. M. Ryzhov found siliceous raw material deposits in the secondary position in the wall of an ilmenite quarry as well (Figure 6: 4). The siliceous material was located on the surface and at the contact between the Quaternary and the Paleogene-Neogene layers.

In a grus-granite quarry near the village of Troianove, they found a raw material deposit that corresponded to the geological position (Figure 6: 6). The siliceous raw material was located at the level of the modern floodplain of the Velyka Vys river.

The peculiarities of the Velyka Vys river basin location on the crystalline surface of the Ukrainian Shield, covered with a layer of Quaternary deposits represented by eolian-deluvial sandy-clayed and loess-like rocks, led to the active development of a weakly voluminous plain surface of a fairly dense and deep dissected network of draws and gullies in the region (Yakovliev *et al.* 1991: 8).

The nearest known natural outcrop of sedimentary siliceous raw material is located about 3 km west of the site. In the gully of the left slope of the Velyka Vys river valley near Korobchyne village, Cretaceous outcrops containing numerous siliceous nodules, embedded in clayey layers, are located. According to the petrographer V. F. Petrun (2004), the location of similar deposits within the Velyka Vys river basin belongs to the outcrops of sedimentary-diagenetic rocks of the Upper Cretaceous (approximately the Upper-Cenomanian time), which covered the Ukrainian Crystalline Massif (Petrun 2004: 207).

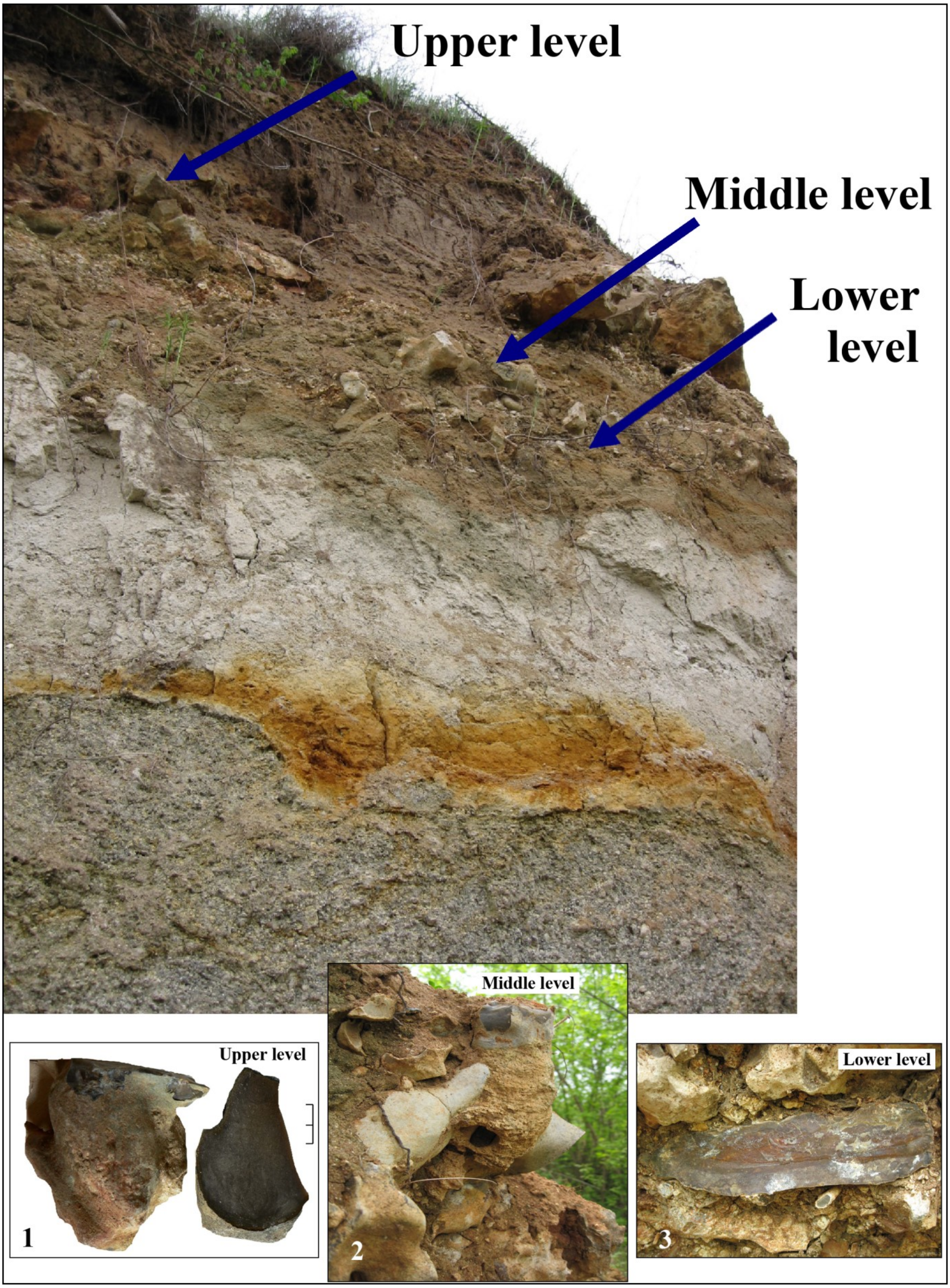


Figure 5. Three levels of the siliceous raw material deposits in the grus-granite quarry of Korobchyne village: 1 - upper level; 2 - middle level; 3 - lower level. (Photos by S. M. Ryzhov.)

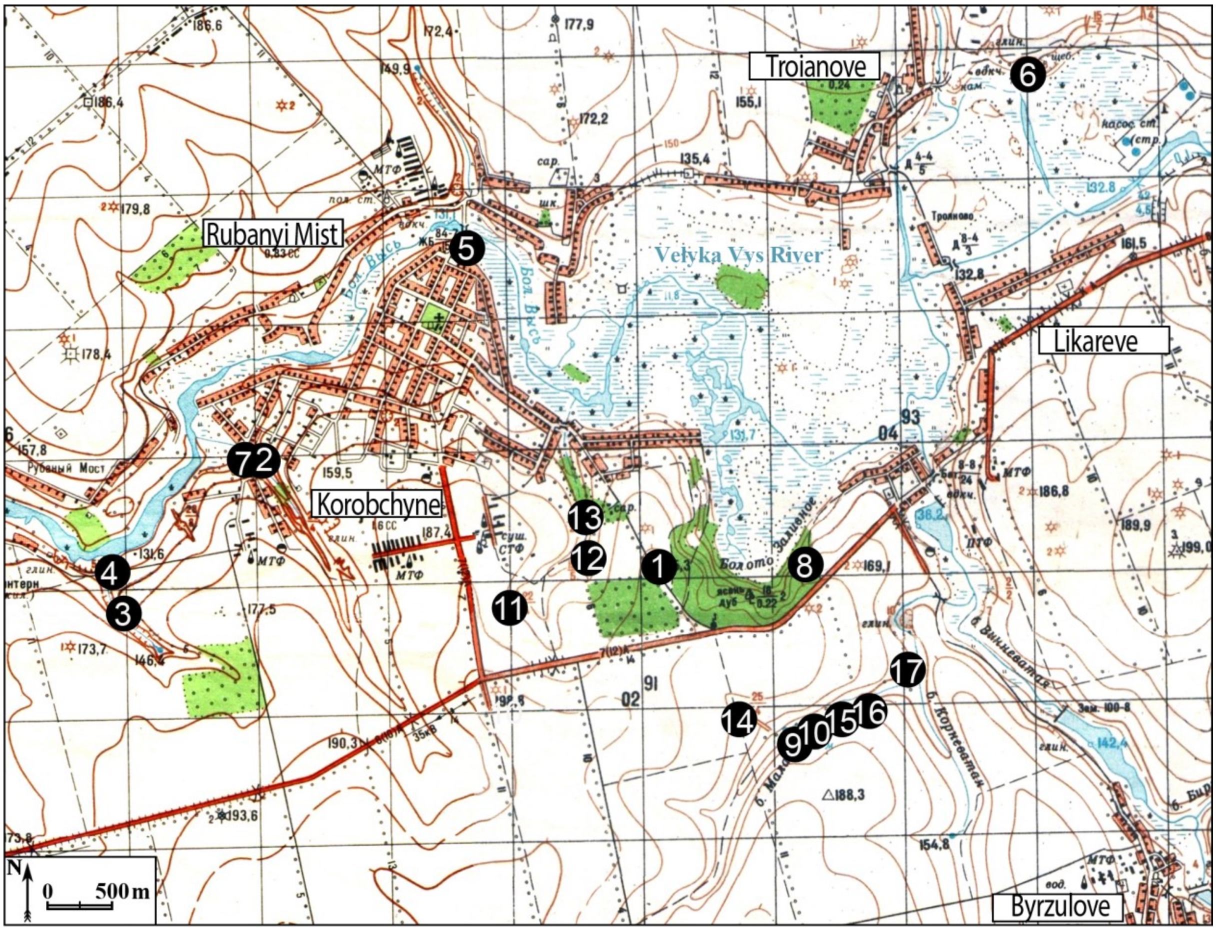


Figure 6. Map of the siliceous sedimentary raw material deposits near the Korobchyne-kurhan site: 1 - Korobchyne-kurhan site; 2 - gully with available outcrops of siliceous nodules; 3 - location of raw material outcrops in the former draw (according to Tsvek & Ozerov 1989; Zalizniak et al. 2007b: 86-105); 4 - location of the siliceous raw material deposits in the ilmenite quarry (according to Ryzhov et al. 2005; Stepanchuk et al. 2009); 5 - grus-granite quarry with siliceous raw material deposits (according to Ryzhov et al. 2005; Stepanchuk et al. 2009); 6 - grus-granite quarry with siliceous raw material deposit (according to Ryzhov et al. 2005; Stepanchuk et al. 2009); 7 - location of the Chalcolithic mines (according to Tsvek 2012; Tsvek & Ozerov 1989); 8-10 - locations with available outcrops of small siliceous pebbles, chalk and marl nodules; 13-17 - surveyed gullies.

About 70 m west of the natural outcrop of raw material in Korobchyne there were Chalcolithic mines. P. I. Ozerov discovered the mines in the wall of the grus quarry in 1985. In 1988-1990, the mines were investigated by the archaeological expedition of the Institute of Archeology of the NASU, led by O. V. Tsvek (Tsvek & Movchan 2005; Tsvek & Ozerov 1989). In total, five mines were identified, which had been dug into greenish-yellow loams, alternating with white-red clays (Figure 7). The mines, up to 6 m deep from the modern surface, went down to the layer of siliceous nodules. The thickness of the layer was 50 cm. High-quality dark gray siliceous nodules represented the siliceous raw material deposits. According to O. V. Tsvek, the flint mines in Korobchyne and in the Trypillian settlement near the village of Rubanyi Mist constituted a single industrial complex for the extraction and processing of siliceous rocks, which existed in the 30th to 29th centuries BCE (Tsvek 2012; Tsvek & Movchan 1997).

Many archaeologists attribute the presence of numerous Stone Age sites in the region to the outcrops of sedimentary siliceous raw material near Korobchyne village, (Zalizniak *et al.* 2007a). At the Korobchyne-kurhan site and other sites in the Velyka Vys river basin, the wasteful knapping and many massive siliceous concretions and nodules are striking. The dissected heterogeneous terrain relief suggests that there were closer and more accessible raw material deposits for the Palaeolithic inhabitants.

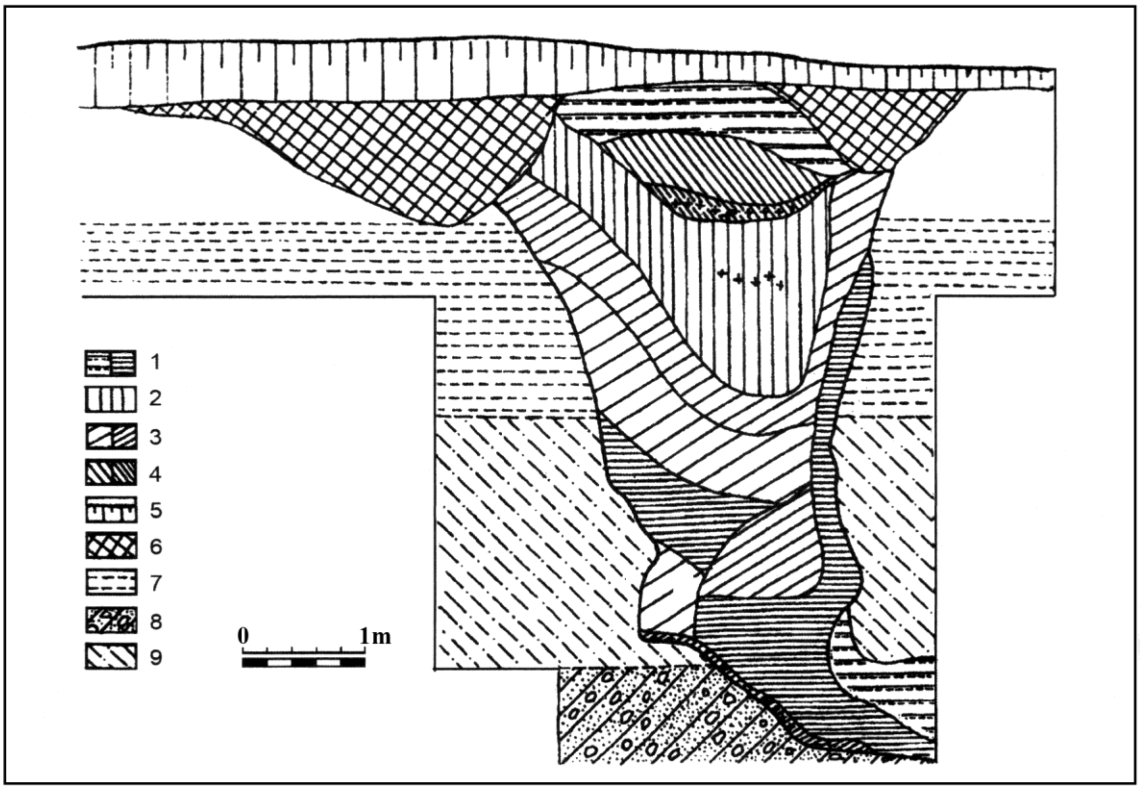


Figure 7. Section of the Chalcolithic mine in the village of Korobchyne (Tsvek 2012: fig. 3): 1 - red-reddish brown filling; 2 - dark-brown humus clay filling; 3 - reddish brown clay filling; 4 - reddish brown-yellow argil filling; 5 - layer of soil; 6 - hollow; 7 - subsoil reddish clay; 8 - layer with inclusions of sedimentary siliceous nodules; 9 - greenish-yellow subsoil.

1.2.1. The search for deposits of siliceous sedimentary raw material near Korobchyne-kurhan

The left slope of the Velyka Vys river is located to the north and east of Korobchyne-kurhan. It is dissected by a dense network of gullies and draws. To the south and west of the Palaeolithic site there are two wide and deep draws with several gullies on their slopes. In 2017, in the search for available deposits of sedimentary siliceous raw material, O. I. Nezdolii (2018) conducted a survey of these gullies and draws near the site (Figure 6).

Currently available natural outcrops of sedimentary siliceous raw material near Korobchyne village were investigated. The outcrops are in the upper part of the very steep, almost vertical, right slope of the gully (Figure 8).

The revealed sequence of the gully slope, which includes flint nodules, is interesting for comparison to the stratigraphy of the nearby ilmenite quarry (Figure 9). Zh. M. Matviishyna and S. P. Doroshkevych carried out a study of stratigraphic sections in the career in 2011 (Matviishyna & Doroshkevych 2013). The ilmenite quarry was built on the site of a former draw, where flint raw material crops out (Tsvek & Ozerov 1989: 18). According to L. L. Zalizniak and Yu. V. Kukharchuk, the natural outcrops of high-quality flint raw materials at the bottom of the former draw were in a primary position, and the development of this deposit by prehistoric people could have begun as early as the Middle Palaeolithic (Zalizniak *et al*. 2007b: 90).

As a result of the survey for siliceous raw materials in the remaining draws and gullies around the Korobchyne-kurhan site, several outcrops of small siliceous pebbles, chalk and marl nodules, often imbedded in clayey layers, were found in the very steep, almost vertical parts of the gulley's slopes (Figure 10).

Figure 8. Outcrop with siliceous nodules on the slope of the gully near Korobchyne village. (Photo by O.I. Nezdolii.)

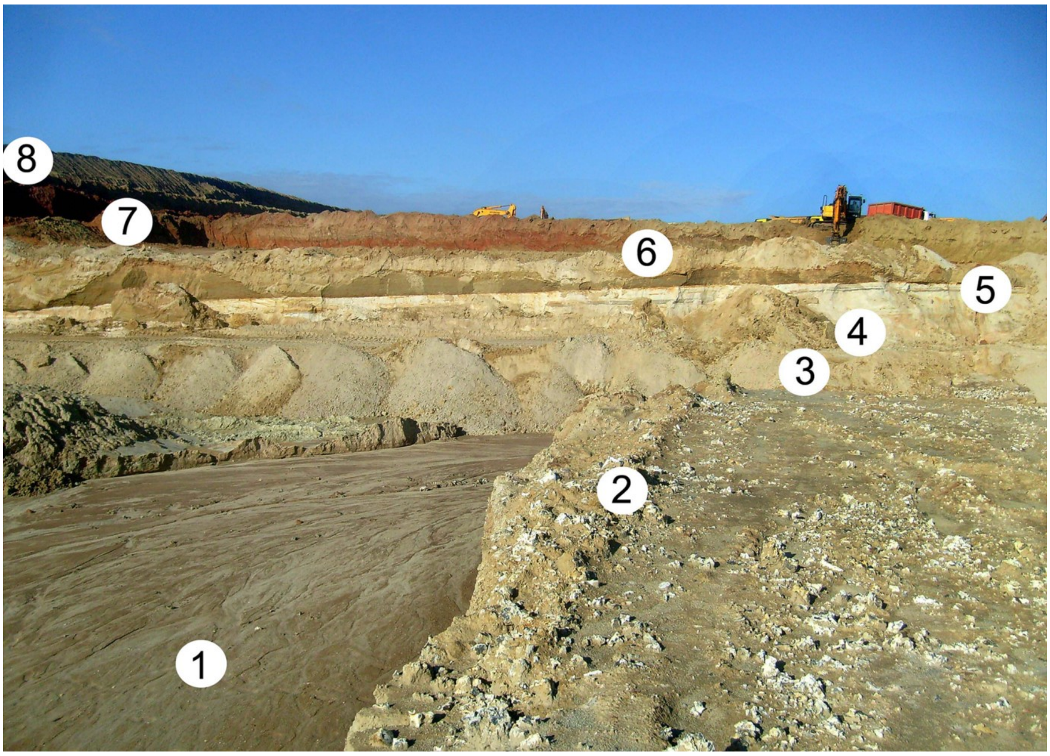


Figure 9. General stratigraphy of deposits in the ilmenite quarry (Matviishyna & Doroshkevych 2013: Fig. 1): 1 - sands with industrial content of ilmenite; 2 - siliceous raw material stratum; 3 - sands of the Kyiv strata (Upper Eocene); 4 - greenish-grey sands of the Kharkiv strata (Lower-Middle Oligocene); 5 - whitish sands of the Poltava strata (Upper Oligocene - Lower-Middle Miocene); 6 - brown clays of the Miocene; 7 - deposits of the Pliocene; 8 - deposits of the Pleistocene and the Holocene. The siliceous raw material stratum (nr 2) described by Matviishyna and Doroshkevych is probably the redeposited and weathered remains of Cretaceous layers.

Figure 10. Outcrop with chalk and marl nodules on the slope of the gully near the Korobchyne-kurhan site (Figure 7: 8). (Photo by O. I. Nezdolii.)

During fieldwork in 2017, the topographic map of 1971 was used (Nezdolii 2018: fig. 2). Most of the surveyed gullies, marked on the map, have gentle and moderately steep slopes. The slopes and bottoms of these gullies are densely covered with grass, and often with shrubs and trees. The gullies mostly have flat and sometimes relatively wide bottoms. No signs of active erosion were found in these gullies. Such a lack of dynamic conditions and the stabilization of erosion processes indicate a further transformation of the gullies into young draw erosion forms (Beliaev 2004: 22; Zorina 2003: 7-31).

A comparison of the 1971 topographic data with the information obtained during 2017 shows that, at present, most of the gullies marked on the map have lost their erosion activity, being essentially young draw forms. Conversely, during the surveys of the region, active, mostly deep, gullies with steep slopes without grass, absent on the topographic map, were found. The gully with outcrops of nodules of siliceous sediments is absent on the topographic map of 1971. Such changes, which have taken place over almost half a century, indicate the permanent active dynamics of gully-draw dissection in the region’s relief.

Thus, due to the conducted surveys of the gully-draw network around the Korobchyne-kurhan site, the topographic evolution could be studied. The regional geomorphological features of the Velyka Vys river basin, the developed hydrographic system of the river valley, the climatic conditions and the peculiarities of the soils led to the development of a deep and dense system of gullies and draws during the Quaternary. The irregularities and raising of the Ukrainian Crystalline Massif’s foundation had led to the development of raw material-bearing deposits on its surface, which have contributed to the provision of Stone Age collectives with local raw materials of siliceous rocks.

The significant speed and active dynamics of erosive changes in the morphology of the region suggest the availability and accessibility of siliceous raw material outcrops in the immediate proximity to the Palaeolithic site in different periods.

2. Method: How the sedimentary microfacies is determined

Various determination methods exist to identify the source of siliceous materials used during prehistory.

The most basic and common method is to estimate the geographic origin of the raw materials by the macroscopic appearance of the artefact. This method requires an abundant experience of analysis of siliceous sedimentary rocks and the results are unreliable (Affolter 2002: 19-20; Turq 1999: 8). Artefacts with a similar macroscopic appearance as well as soil processes altering the surface of artefacts can be misleading. For a solid linking of artefact and outcrop, the application of scientific methods is needed.

A completely non-destructive investigation method used for raw material analysis is the sedimentary microfacies method. The large majority of the silicifications used for artefact production were formed contemporaneously with the deposition, or later during the diagenesis, of the surrounding sediments. Sediments reflect the biotopes in which they formed, and each biotope differs from the others. Reconstituting the environment of formation allows us to find out more about the sediment's geographical origin (Altorfer & Affolter 2011: 31-52; Fisher *et al.* 2013; Flügel 2010: 7-10).

We wet the surface and make the determinations under a stereomicroscope. For the investigations, a Leica MZ 6, M80 and an Ulab SZM-45T were used. As water lowers the difference in the refraction of light on the surface, we can look just below the surface of the artefact. This allows us to determine sedimentary features and fossils. With fossils, texture and sedimentary indices we can deduce the age and the deposition environment of the sedimentary siliceous material. This corresponds to the sedimentary microfacies, which gives the geological attribution of the mother rock. The definite attribution of an artefact's origin is only possible if it can be compared to geological samples, *e.g.*, fragments of the outcrop or its surrounding mother rock. However, the sedimentary microfacies provides clues as to where to search for outcrops in an area of known geology (Altorfer & Affolter 2011: 40). For all methods, access to good lithotheques that comprise geological reference samples from the research area is essential. The alternative is to collect geological samples on field surveys and to compose a lithotheque according to the microfacies identified on the archaeological artefacts. A more detailed description of the method is given in Affolter (2002: 16-42), Altorfer & Affolter (2011: 31-52), Affolter *et al.* (2020) and Wehren (2017: 3-18).

Geochemical methods, such as ICP-MS, need a solid database for a region and only give good results for specific questions. Geochemical investigations are very costly and, depending on the applied methods, damage to the artefact is necessary. Geochemical methods that are virtually non-destructive can only achieve a shallow penetration of the beam and are only applicable to samples without patina (Brandl 2015: 40; Moreau *et al.* 2018). The application of geochemical methods only proves useful after an investigation by means of sedimentary methods. For very specific questions, *e.g.*, in the case of too similar facies, we can try if a geochemical fingerprint allows their differentiation. For these methods, access to reference samples, a lithotheque, is necessary as well.

So far, the method used here is the only truly non-destructive investigation method for archaeological objects. Its costs are moderate, as a stereomicroscope is the only instrument required.

Besides the artefacts themselves, the cortex provides important clues. A fresh cortex indicates that the material was gathered from a primary deposit. Dissolution signs point to dissolved mother rock and the deposition of the harder siliceous fragments in a sub-primary position. A rolled cortex is due to river transportation. Iron impregnation indicates the deposition of the siliceous sediment in iron rich soil (Fernandes 2012: 3; Luedke 1979; Rottländer 1975).

For the present work there was no lithotheque available, therefore we can only make preliminary statements how non-local raw material was acquired.

3. Data results

Fifteen artefacts from Korobchyne-kurhan were analysed as a possible raw material reference for another project (Figure 11a). The artefacts are fine grained and have different colours: white and grey to brownish-red. The cortex is mostly sub-primary but not rolled; two artefacts show signs of frost weathering. Most show strong and irregular coloration. The macroscopic appearance of the artefacts is quite similar. However, the sedimentary microfacies analyses showed that they consist of two different raw materials. We could arrange a sampling of the above-described outcrop in the Velyka Vys river valley (Nezdolii 2017b, Figure 11b). The sedimentary microfacies of the outcrop fit to only one of the archaeological types.

3.1. Description of the identified sedimentary microfacies

In Table 1, the most important sedimentary features for the description and differentiation of the sedimentary microfacies of Types 3422 and 3421 as well as their respective subtypes are given.

Type 3421 is the sedimentary microfacies of the local outcrop and the archaeological site. The numbering follows the system of the “Affolter” lithotheque (Biró 2008: 40). The facies shows the biotope of an estuary with saline-brackish water. A rather quiet environment where only few species thrive is shown by massive domination of *Incertae sedis* and *Tintinnina cf.* together with algae. The trochospiral foraminifers with globular cells and sponge spicules point towards saline water. In subtype 3421A are rock pieces, large black, angular minerals and translucid minerals, which were brought in by a river at the time of the rock’s formation. The habitus of the black minerals resembles ilmenite and the translucid titanite. The nearby ilmenite mine (see section 1.2.1.) supports this hypothesis. Possibly, the large minerals show a volcanic influence. Subtype 3421B shows far more algae, no rock pieces, smaller and fewer black minerals and nearly no translucid minerals. This material was deposited further away from the river discharge. Groundmass and certain fossils such as *Incertae sedis* are typical for the Cretaceous. This and the rare occurrence of sponge spicula make a much younger formation of the siliceous sediments, due to massive SiO_2 inflow in the Middle Eocene paleobasin (Stefanskyi *et al*. 2018), unlikely.

The second facies, 3422, points to a much deeper environment beyond the influence of waves in the forefront of a sponge reef. The facies 3422A shows abundant sponge larvae and curved sponge spicules but no other species. The subtype 3422B is within the sponge with a different silicification and foraminifera. There are some pieces in which both facies occur, which confirms that both are very different but belong to the same type (Figure 12). The small globular foraminifera point to the open ocean. According to their shape and the coiling of the cells, it is possible that these foraminifera correspond to the species *Anomalina ammonoides* (Reuss) or *Anomalina cenomanica* (Brotz), which are the marker species indicated on the geologic maps of the area (state geological map of Ukraine, sheet m-36-XXVI, scale 1:200,000) (Poddubnyi 1970).

It must be kept in mind that the Cretaceous corresponds to the formation time of the silicification. The cortex of most samples shows signs of sub-primary alteration, indicating that the host rock, in which the siliceous sediment formed, has become dissolved. There is no reaction to 5% HCl, showing the absence of a carbonaceous cortex. This is easily explained by the weaker mineral structure of carbonaceous sediments. Therefore, the layers in which the siliceous nodules are presently deposited could be of a younger age.

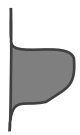
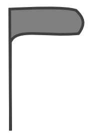
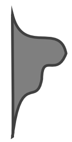
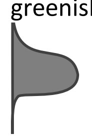
Figure 11A

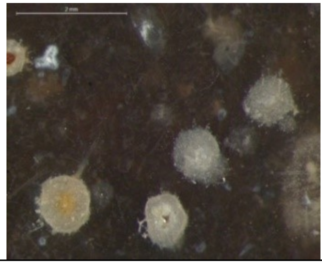
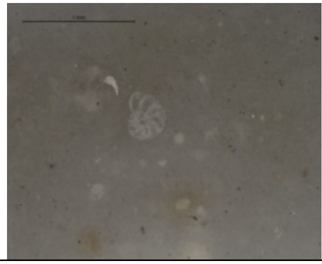
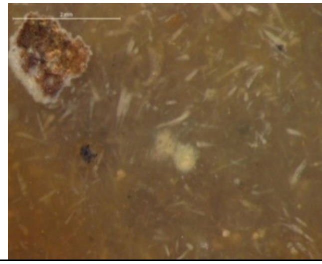
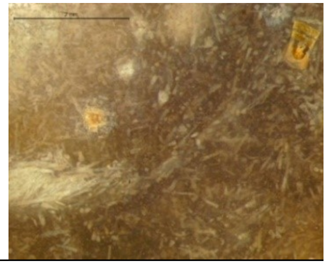
Figure 11B

Figure 11C

Figure 11a: The artefacts of Korobchyne-kurhan investigated for the sedimentary microfacies analyses. (Photo by H. Wehren.) 11b and 11c: Samples of the outcrop used as reference for determination. The length of the black plate is 5 cm (Photos by H. Wehren).

Table 1. Comparison of the raw material of artefacts from Korobchyne-kurhan and the outcrop in the Velyka Vys river valley. Amount is coded with – absent, (+) can be present, + little, ++often, +++dominant. Subc. Stands for subcortical, min. for mineral, part. For particle (< 50µm) and comp. for components (>50µm). See details in supplementary file 1

	name		**3422A**	**3422B**	**3421A**	**3421B**
	kind of sample		archaeological	archaeological	geological	geological
	form		nodule	probable nodule	nodules	nodules
	size		>4cm	>4cm	10cm-1m	10cm-1m
	colour		5Y 2.5/1-8/1	2,5Y 6/0 (subc. 2,5Y 3/2)	10YR 3/2-4/1	10YR 7/1-2/1 / 7.5YR 5/6-3/1
macroscopic	**appearance**		dark light spots, very heterogeneous	homogenous grey thick subcortical brownish zone)	dark, strongly irregular very heterogeneous	heterogeneous, dark with light areas, different coloured subc.
	Cortex		thin, greenish, sinter, neocortex	up to 6mm	very irregular, whitish	sub-primary, silicatic, (few greenish)
	texture	mudstone wackestone packstone grainstone boundstone				
	matrix	shiny dust	--	--	+	(+)
		chalk components	--	--	++	+
		translucide				
	wet long enough for components to become visible		++	--	--	--
	components	roundness (Pilkey)	1-(2)	2	2 or 3	2
		size µm	600-1600 (<4mm)	50-400 (<2mm)	50-1500 <big	50-1200 <8mm
		glittering possible cavity)	--	--	+	+
microscopic		micritisation	--	++	--	--
		heterogenous distribution	--	--	+++	++
		sorted	--	+	--	+

	components: category or species	bioclasts	--	(+)	+ frag	+ frag
		Incertae sedis	--	--	+	+
		cones (*Tintinnina cf.*)	--	--	+++	++
		algae filaments	--	--	(+)	++
		Echinoderm spine	--	--	+	+ frag
		sponge spicules	+++most curved	+	+	(+)
		sponge larvae	++	--	--	--
		foraminifers	(+)	+	(+)	(+)
		clasts rock-pcs	--	--	++	--
		quartz grains	--	--	++	(+) small
		transl. min. (possibly titanite)	--	--	+ big	(+)
		black min. (possibly ilmenite)	--	--	++ big	-
		organic preservation	(+) part	+ part	+ comp	(+)
microscopic	**structure**	brecciation	+	(+)	+	--
		swirling	--	--	--	++
		alignment	--	--	chaotic	+
	picture					

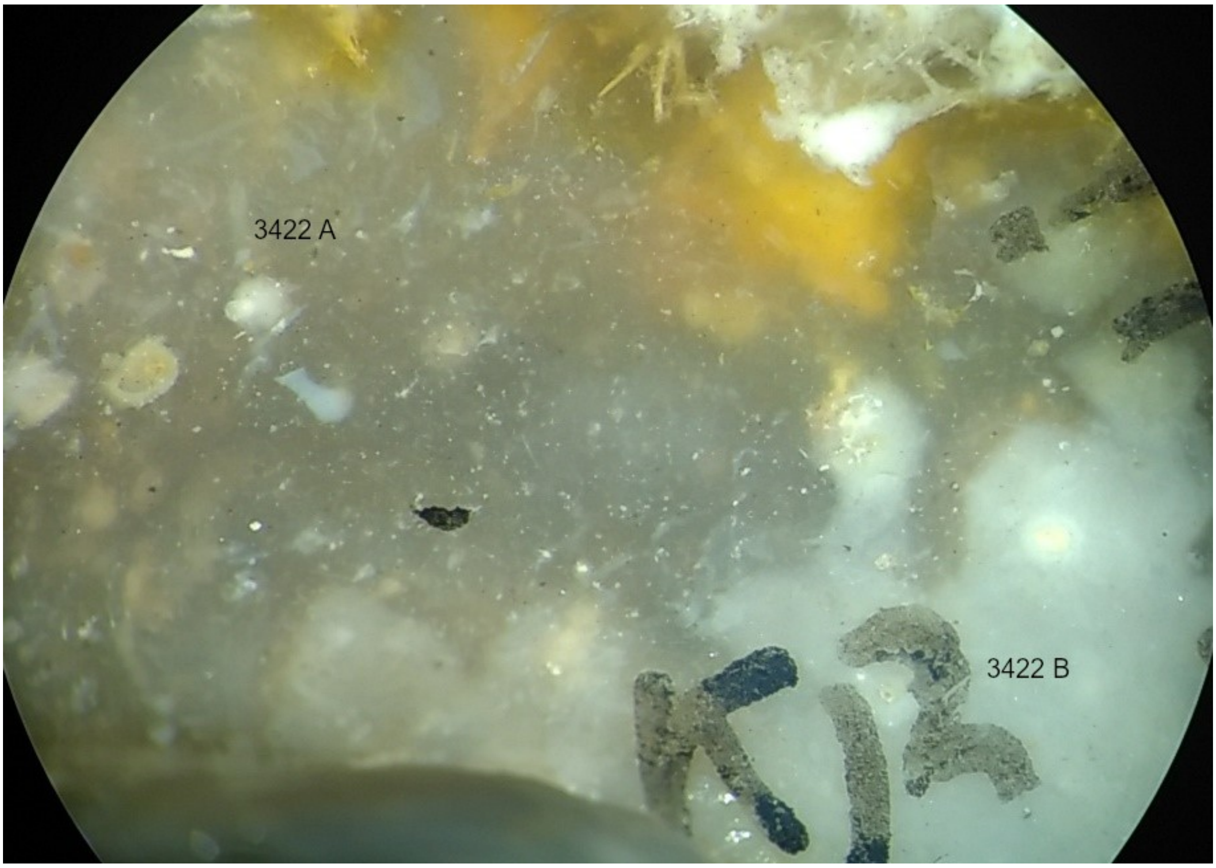


Figure 12 An archaeological artefact including both subtypes 3422A and 3422B of the facies.

3.2. Comparison with material from Melnychna Krucha, Kamyane-Zavallia, Mohylna III

For comparison, material from the Southern Buh river valley, north Odesa region, Ukraine was considered. The artefacts originate from three different archaeological sites, located about 120 km as the crow flies from Korobchyne-kurhan (Figure 13). Archaeological material from the LBK settlement of Kamyane-Zavallia was found in an elongated pit (Kiosak 2017: 256-263; Kiosak & Salavert 2018: 122). Mohylna III is a Trypillia A settlement. Only surface finds are known from this site (Kiosak 2018: 41). Melnychna Krucha consists of small-scale workshops on the river ravines. From around 4000 BCE to the middle 8.th century BCE, the site shows several activity periods (Kiosak & Salavert 2018: 123). The determinations lists are provided in Table 2.

The raw material type 3422 is found in minor amounts in the archaeological material of Melnychna Krucha, Mohylna III and Korobchyne-kurhan, but is absent in Kamyane-Zavallia. The type 3421 is the dominant material in Korobchyne-kurhan but absent in the other three sites (Wehren *et al*. 2019).

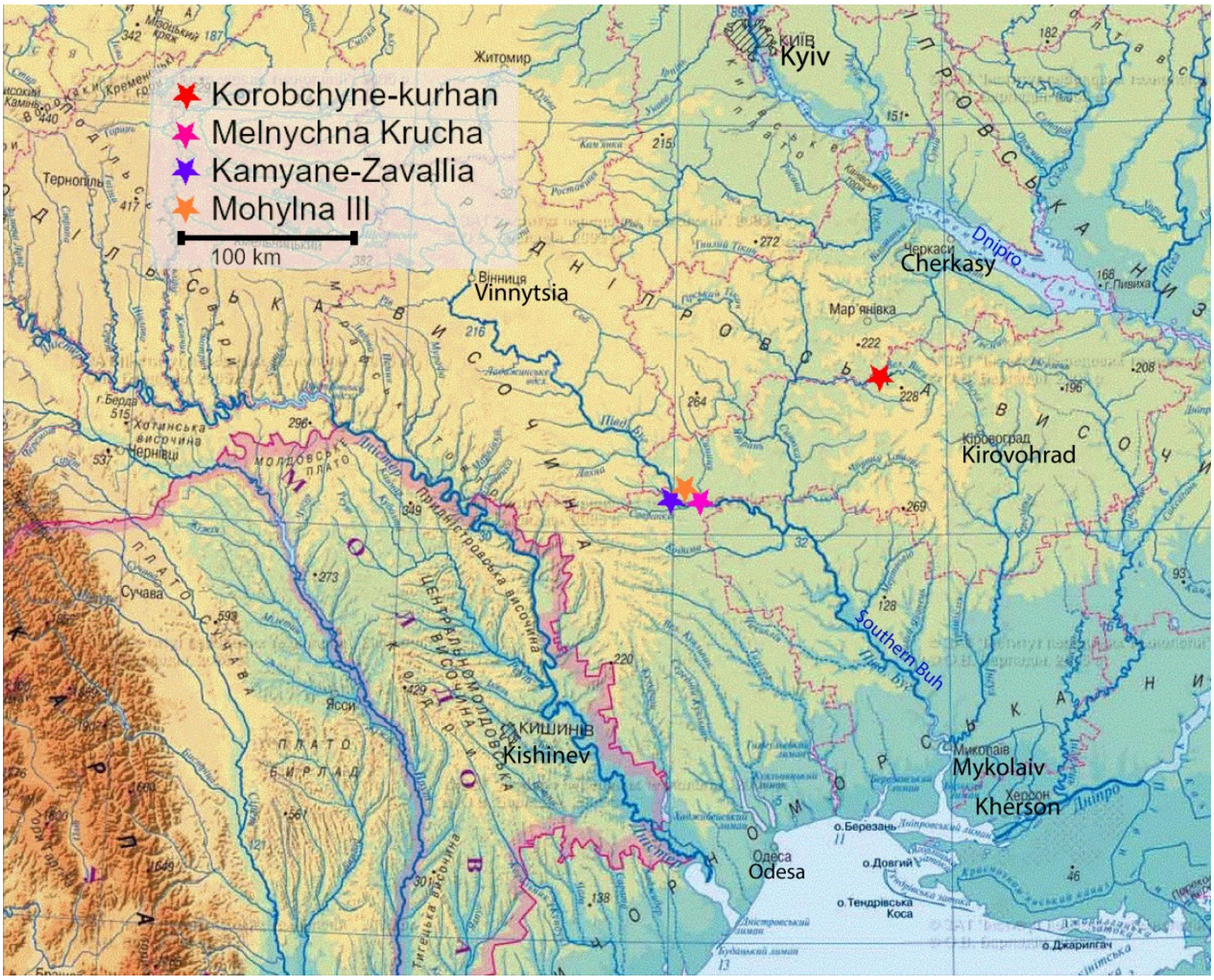


Figure 13 Location of Korobchyne-kurhan (red star) in central Ukraine and the sites in the Southern Buh river valley. Melnychna Krucha, Kamyane-Zavallia and Mohylna III (purple, pink and orange stars) lie in the same region but date to different periods.

Table 2 Artefacts from Korobchyne-kurhan (KK), Mohylna III (MogIII) and Melnychna Krucha (MK). 'yes' in the column 'present' marks the presence of cortex. 'sp' means sub-primary, 'sp?' means possibly sub-primary, as the host rock silicifications were eroded and the more erosion resistant silicifications remained. 'R' stands for rolled (river transport), 'P1a' is a strong air patination and 'P1b' is a light air patination. 'New-formation' is noted when there is calcite or other new formations on the artefact's surface.

Artefact	Type	Cortex			oxid	patina
		present	state	remarks		
KK c1	3421B	yes	sp?	neocortex, frost cracking	red	P1a
KK c2	3421B	-	sp	frost cracking, cleavage slightly oxidised, neocortex on knapped faces	(+)	P1b
KK c4	3422A	yes	r, sp	neocortex, secondary deposit	+	P1b
KK c3	3422B	yes	f	sec oxidised	+	-
KK c5	3421	yes	sp	neocortex	+	P1a
KK c6	3421A	yes	sp?	new-formation covers surface	+	-
KK c7	3421A	yes	sp?	new-formation covers surface	+	-
KK c8	3421A	yes	sp?	-	+	-
KK c9, c10	3421A	yes	-	neocortex, new-formation covers surface	+	P1a
KK c11	3421B	yes	sp	-	+	-
KK c12	3421A	-	sp?	too small to determine if cortex or another surface		-
KK c13	3421A	yes	sp	new-formation covers surface	+	-
KK c14	3421	yes	sp	strong patination	+	P1b
KK c15	3421	yes	sp	neocortex is oxidised, neocortex on knapped faces	+	P1b
MogIII	3422A + 3422B	-				
MK-17 SU1	3422A	-				
MK-16 SU2	3422A	-				
MK-17 SU3	3422A + 3422B	yes	sp			
MK-17 SU3	3422/U7	yes	r			
MK-17 SU3	3422A	-				
MK-17 SU3	3422A	-				
MK-17 SU3	3422A	yes	sp			
MK SU4	3422A	-				
MK-16 SU4	3422A	yes	r, sp	neocortex, secondary deposit		

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The number of artefacts investigated are given in Table 3 to show the results in relation to each other. About 60% of the siliceous artefacts found in Melnychna Krucha have been analysed. In Kamyane-Zavallia, around 10% of the artefacts were found in a pit excavated in 2016. Korobchyne and Mohylna have only a very small sample of all the artefacts excavated or found on the surface.

Table 3. Comparison of the material from different sites in view to the portion of type 3422.

Site	Total number artefacts	Number investigated	Type 3422 pcs	Type 3422 %
Melnychna Krucha	523	321	8	3
Mohylna III	many	40	1	3
Kamyane-Zavallia	>500 (in pit nr. 1)	73	0	0
Korobchyne-kurhan	>20,000	15	2	13

4. Interpretations of the data and hypothesis about the possible outcrops

The local material type 3421 was only used in the region where it crops out. It is very heterogeneous and it is highly unlikely that people would transport this material over great distances. If the siliceous rock-bearing layer is the same as described in the Ilmenite quarry by Matviishyna & Doroshkevych (2013), it should be under the Eocene Kyiv strata. There we have the Eocene Buchak strata and the upper and lower Palaeocene (Raihorod). The profile on the stratigraphic map 1:200,000 (state geological map of Ukraine, sheet m-36-XXVI) (Poddubnyi 1970) seems to be quite representative for the area, as there are boreholes at about 2 km distance from Korobchyne. On the profile, the Kyiv strata only appears further north. However, there are the Upper Cretaceous of Cenomanian and Turonian age and the Smila stratum of lower Cretaceous age that are promising for siliceous sediments. On the geological map, the foraminifer *Anomalina ammonoides* (Reuss) and *Anomalina cenomanica* (Brotz) are given as marker species of the Upper Cretaceous. The foraminifera in the siliceous artefacts are convolute and have globular cells. Therefore, it seems uncertain that the rocks originate from the Upper Cretaceous (Cenomanian or Turonian). The description of the Smila stratum (lower Cretaceous) mostly names pollens, which are not determinable by stereomicroscope and would point to a shallow environment. Without further investigations it is difficult to say from which layer the raw material derives. In fact, the outcrop described by O. Nezdolii (Figure 8) and the cortex of the investigated samples point to a secondary deposit due to strong erosive processes in a dry and hot climate. During long and intense erosion, siliceous nodules were transported towards the deepest areas of the current topography. There, they were deposited in iron-rich sediments and are now characterised by varying degrees of iron oxide impregnation (Affolter & Altorfer 2011: 47). This would fit well to the Eocene strata, as proposed by V. Petrun. In the Ilmenite mine described above, the siliceous rock-bearing layer is described as lying below the Kyiv strata (Figure 9); this points to Eocene redeposition as well (Matviishyna & Doroshkevych 2013; Petrun 2004: 203).

Out of the investigated samples, two of the fifteen artefacts belong to the raw material type 3422. The artefact KK c3 shows no dissolution of the cortex, which shows that prehistoric people gathered their raw material in a primary position. The cortex of the artefact KKc4 on the other hand shows dissolution on the cortex, pointing to a secondary raw material source. Therefore, the inhabitants of the Korobchyne-kurhan site gathered the raw material during the first two climatic optima of the Middle Pleniglacial in primary as well as in secondary position.

For the secondary deposit, it should be kept in mind that the type 3422 was used in the Velyka Vys river basin as well as in the Southern Buh river valley more to the west. The few artefacts with the cortex investigated from the Southern Buh river valley show no fresh cortex.

Therefore, people living in later times in the Southern Buh river valley seem to have extracted this raw material from the secondary position, which suggests different outcrops of primary and secondary origin.

The sampling of Upper Cretaceous deposits between Korobchyne and Novomyrhorod (state geological map of Ukraine, sheet m-36-XXVI, scale 1:200,000) (Poddubnyi 1970) would be interesting as a primary source of raw material. The artefacts of type 3422 with an altered cortex show signs of dissolution and iron impregnation but do not show typical signs of river transport. Transport in moraines or by strong erosion in the Eocene or Miocene period is possible. Secondary outcrops could probably be located in between the two sites.

The absence of type 3422 in Kamyane-Zavallia can be explained in the orientation of the LBK people towards the north west, as is shown by the raw material that is heavily oriented towards the "Volhynian" materials cropping out in this area (Petrougne 1995: 193, figure. 1). Kamyane-Zavallia is the easternmost LBK settlement and the contact networks seem to be oriented towards this area (Wehren 2019; Wehren *et al*. 2019; Saile *et al*. 2016: 1).

5. Conclusions, significance, opinions, possible continuation

A larger scale investigation to search for more materials would be very interesting; the origin of 3422 is especially intriguing. The sample of 15 artefacts from Korobchyne-kurhan that were investigated is very small and not representative. For the continuation of this work, it would be obligatory to compare raw material found in the region to more artefacts from the Korobchyne-kurhan site. Such analysis would allow statements about the change of contact webs over time.

If we suppose that the material 3422 from secondary outcrops is really a minor occurrence at the Korobchyne-kurhan site, then it would be an exogenous material for both regions. The later use of only one eastern material by the habitants of the Southern Buh river valley could be due to a preference for better material and the location of nearer outcrops. The common occurrence of material in minor amounts at sites about 120 km apart is not much in such a flat relief as is seen in Ukraine. The river valleys, however, create a steep and exhausting crossing. Possibly, people followed the river valleys in their movement pattern. Possibly, the outcrops must be searched for somewhere in the region downstream of the rivers. Nevertheless, this is just preliminary thinking as the few artefacts investigated are not enough to build a solid hypothesis.

An enlargement of and accessibility to the work of V. Petrun, *e.g.*, his lithotheque could greatly enhance the understanding of sociocultural contact webs. Building up a dependable and easily accessible lithotheque or lithotheques in different regions seems to be the priority.

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Data accessibility statement

All data used for the article are included in the article.

List of supplementary files

Supplementary file 1
"Wehren *et al*. - supplementary file 1 – Description of raw material types.doc"
Description of raw material types.

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Силіцитові артефакти: сировина та її походження (стоянка Коробчине-курган, Центральна Україна)

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Анотація:

Статтю присвячено результатам дослідження сировини та пошуку джерел її походження, отриманим на основі проведеного мікрофаціального аналізу вибірки силіцитових артефактів із колекції знахідок палеолітичної стоянки Коробчине-курган (Коробчине 7), яка знаходиться в долині річки Велика Вись (ареал рівня середньої течії басейну Південного Побужжя), у центральній частині України.

Розглянуто природно-географічні умови розташування палеолітичної стоянки, її топографічні особливості, історію відкриття та дослідження пам'ятки. Наведено опис стратиграфічних нашарувань стоянки, при цьому основну увагу зосереджено на геологічних горизонтах, що містять археологічні артефакти основного комплексу археологічної пам'ятки. Розглянуто хронологічні позиції та питання геологічного датування культуровмісних стратиграфічних відкладів стоянки Коробчине-курган. Подано коротку типологічну характеристику виявлених крем'яних артефактів основного культурного горизонту палеолітичної пам'ятки та їхню культурно-хронологічну атрибуцію, із залученням широкого кола найближчих можливих аналогій.

Охарактеризовано наявну інформацію, і дані про відомі відслонення крем'яної сировини, їхні рівні залягання та стратиграфічну позицію в розрізах найближчих кар'єрів, у стінках та схилах ярів і балок, які розташовані на незначних відстанях, довкола стоянки Коробчине-курган. Наведено стратиграфічний опис розрізу відомих та археологічно досліджених енеолітичних штолень з видобутку жовен якісної крем'яної сировини, що разом з поселенням трипільської культури, яке розташоване неподалік, становили єдиний комплекс з видобутку та обробки крем'яної сировини. Зазначені шахти та поселення локалізовані на відстані кількох кілометрів від палеолітичної стоянки.

Здійснено пошук відслонень крем'яної сировини в матеріалах бортів і схилів розгалуженої та розчленованої густої мережі ярів і балок басейну Великої Висі, навколо пам'ятки Коробчине-курган. У результаті було отримано нові дані про наявність у матеріалах еродованих схилів довколишніх ярів кількох місць із відслоненнями, що містять знахідки крем'яної сировини. На основі проведених пошуків і здобутої інформації, зроблено висновок про відносно швидку та досить активну динаміку ерозійних змін у морфології досліджуваного регіону, що дозволяє припускати можливість наявності та доступності джерел крем'яної сировини в безпосередній близькості до стоянки в період її існування.

З метою вивчення використаної сировини, та пошуку її можливих джерел походження, було проведено наукові дослідження кількісно невеликої вибірки силіцитових артефактів (15 екземплярів) з культурних нашарувань палеолітичної пам'ятки Коробчине-курган. Вивчення археологічних знахідок здійснено із застосуванням неруйнівного методу мікрофаціального аналізу, що в результаті дало змогу сформувати попереднє уявлення про використану при виготовленні артефактів сировину, та отримати детальний опис проаналізованих силіцитів.

Метод мікрофаціального аналізу в своїй основі досліджує відклади біотопу в силіцитах та їхній материнській породі. За допомогою співставлення отриманої інформації з наявними геологічними картами, цей метод дає змогу окреслити просторову географію найімовірнішого походження цієї породи.

У ході дослідження силіцитових знахідок стоянки Коробчине-курган виявлено артефакти, що містять два різні типи включень у своїй структурі. Разом з тим, лише один тип з цих двох різновидів було зафіксовано серед досліджених силіцитових матеріалів, відібраних у доступних природніх відслоненнях крем'яної сировини, що наявні у стінці борту яру, який розташований на незначній відстані від палеолітичної пам'ятки. Результати проведеного мікрофаціального дослідження засвідчують використання мешканцями стоянки Коробчине-курган як місцевої крем'яної сировини, так й іншого її різновиду на даний час невстановленого походження.

Було здійснене порівняння результатів дослідження артефактів Коробчине-кургану з даними мікрофаціального аналізу виконаного для комплексів кількох інших, суттєво молодшого віку, археологічних пам'яток (Мельнична Круча, Кам'яне-Завалля та Могильна III), які знаходяться в долині річки Південний Буг, та розташовані на значній відстані в західному напрямку від стоянки Коробчине-курган. Проведене співставлення отриманих результатів, також вказує на наявність джерел сировини екзогенного характеру на прикладі досліджених артефактів цих пам'яток. Сформульовано попередню гіпотезу про ймовірне походження невідомого різновиду сировини.

Ключові слова: Україна; Коробчине-курган; крем’яні артефакти; геологія; палеоліт; джерела сировини; Кам’яне-Завалля; Могильна III; кам'яна доба