

2.3. OBSIDIAN OUTCROPS IN UKRAINIAN TRANSCARPATHIANS AND THEIR USE DURING THE PALEOLITHIC TIME

Résumé

Nous connaissons encore mal les artefacts d'obsidienne trouvés à l'Age de la pierre en Ukraine et leur origine est mal comprise. Les principales sources d'obsidiennes se trouvent dans les montagnes volcaniques des Carpates, en Crimée et dans le Caucase. En l'état actuel de nos connaissances, il n'existe d'affleurements d'obsidiennes que dans la région volcanique de Transcarpathie, en Ukraine.

Les affleurements d'obsidiennes de la région de Transcarpathie sont uniquement connus à proximité de Velykyi Sholes (à côté des villages de Rokosovo et Marij Rakovets). Les recherches, en collaboration récente, ont mis en évidence la présence d'obsidienne locale. Les données obtenues par les méthodes XRF et NAA indiquent que l'obsidienne ukrainienne peut être chimiquement distinguée d'obsidiennes provenant d'autres régions des Carpates et suggèrent que le matériau ukrainien est caractérisé par une homogénéité dans la composition chimique et appartient à la catégorie 3 du type des sources d'obsidienne des Carpates (Rosania et al., 2008). Le site de Marij Rakovets IV est situé dans une région de volcans éteints de l'ère Néogène. Les habitants paléolithiques de ce site avaient intensivement employé des roches en obsidienne formées à la surface lors de l'éruption. Les couches archéologiques peuvent être séparées en 3 ensembles dans le contexte stratigraphique : le Paléolithique ancien (VII, VI, V), moyen (IV, III, II), et supérieur (I). Il n'existe pratiquement pas d'obsidienne d'origine locale à proximité du site de Marij Rakovets IV. Les affleurements les plus proches sont situés à une distance de 2 kilomètres et peuvent aujourd'hui même être localisés sur les pentes érodées. Les hommes paléolithiques de cette région, à différentes périodes et en particulier au Paléolithique supérieur, n'ont pas employé d'obsidienne, mais d'autres matières premières disponibles. Il n'est pas encore possible de trouver des preuves du transport de l'obsidienne d'un site à un autre site (excepté l'exemple du site de Korolevo).

Abstract

In Ukraine, obsidian artifacts found in the Stone Age, and their origin is poorly understood. Soon as possible sources of supply of obsidian artifacts are volcanic mountain in the Carpathians, the Crimea and the Caucasus.

At the current stage of research only volcanic region of Transcarpathia is the source outputs obsidian in Ukraine. Obsidian outcrops in the territory of Transcarpathia are known only in the vicinity of the ridge of Velykyj Sholes (next to villages Rokosovo and Malyj Rakovets). Recent collaborative studies have confirmed the presence of local obsidian. XRF and NAA data indicate that Ukrainian obsidian is chemically different from other Carpathian obsidians, and suggest that the Ukrainian material is internally homogenous and belongs to so called Carpathian 3 source (Rosania et al., 2008). The site of Malyj Rakovets IV is located in area of the extinct volcanoes of the Neogene period. Paleolithic inhabitants intensively used the obsidian rocks that were formed on the surface during eruptions. Artifacts of the Lower (VII, VI, V), Middle (IV, III, II), and Upper Paleolithic (I) cultural horizons of the site were discovered in stratigraphical context. On the site Malyj Rakovets IV natural obsidian blocks are virtually absent. The nearest outcrops are known at the distance of two kilometers of where and still can be found on eroded slopes. The local Paleolithic inhabitants in different times used other available raw materials. This is particularly clearly visible in the Upper Palaeolithic time.

Keywords: Ukraine, Transcarpathia, Velykiy Sholes Ridge, obsidian, outcrops, Malyj Rakovets IV, Paleolithic site, raw materials

1 – Introduction

Obsidian artifacts were reported as collected in different contexts from the very beginning of studies on the Paleolithic of Transcarpathia (Lehoczky 1910; Janšák 1935; Skutil 1935). In the second half of the XX century, the discovery of new Paleolithic sites which presented obsidian artifacts essentially add to these data (Sova 1964; Petrougne 1960, 1972; Kulakovskaja 1989; Gladilin and Sitlivij 1990; Sitlivij 1989; Sitlivij and Ryzov 1992; Ryzhov 1998, 2003, 2009; Tkachenko 2003).

In 1970-80s of XX century during the works of the archaeological expedition led by V. Gladilin the Paleolithic site in the vicinity of villages Rokosovo and Malyj Rakovets were discovered (Irshava and Khust district). Obsidian was the main raw material used at these Paleolithic sites. Unfortunately, most of the items were collected on the surface and only the site of Malyj Rakovets IV provides artifacts recovered in stratigraphic position (Sitlivij 1989).

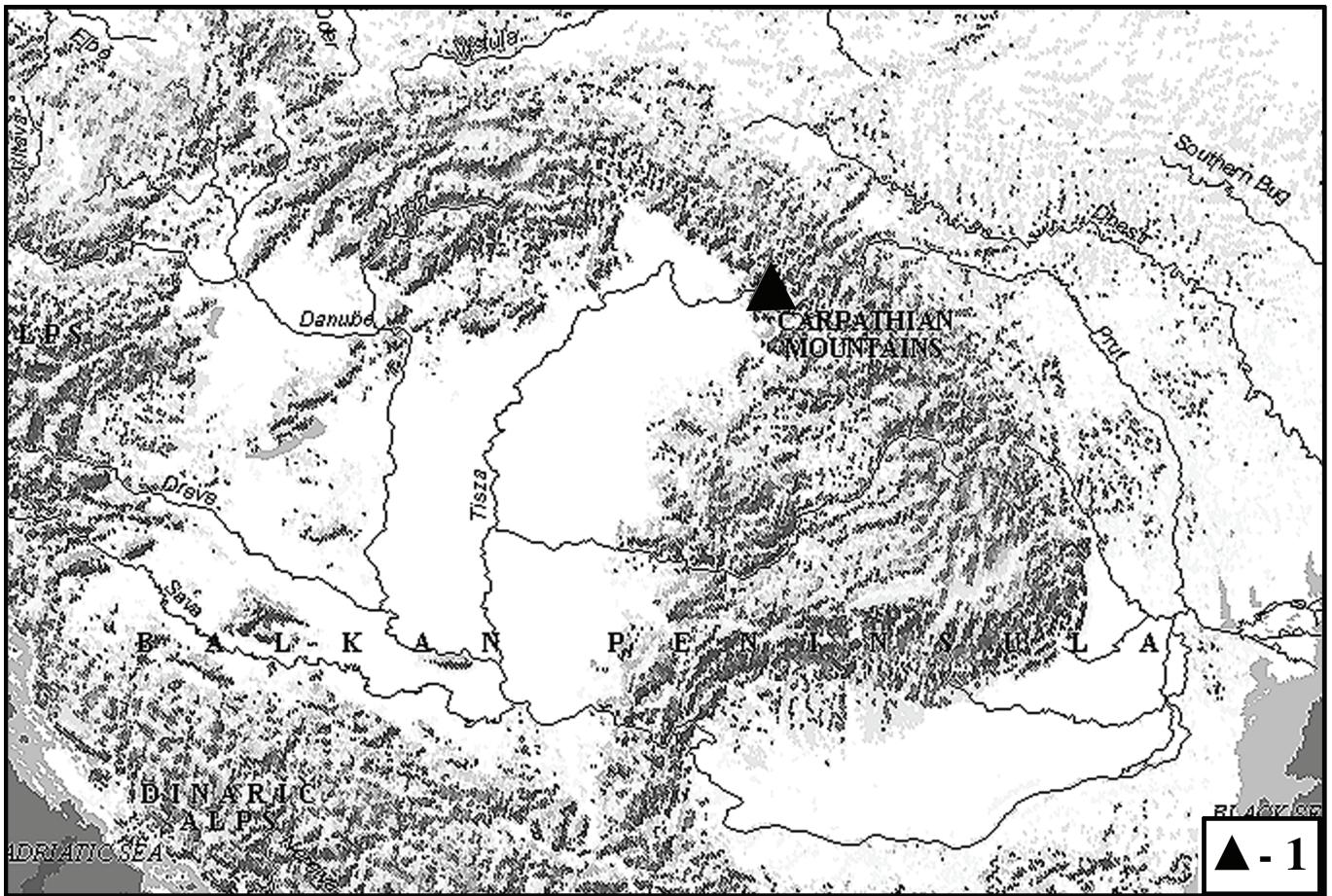


Figure 1 – Map Carpathians: 1 - Obsidian outcrops in the Ukrainian Carpathians

The result of the investigation was the discovery of several cultural stratigraphic horizons in the Malyj Rakovets IV, yielding Lower (VII, VI, V), and Middle (IV, III, II) and Upper Paleolithic (I) artifacts (Gladilin, Sitlivyj 1990; Sitlivyj, Ryzov 1992; Ryzhov 1998, 1999, 2003, 2009).

2 – Geological background of obsidian studies in Transcarpathia

Obsidian occurs in the southeast area of the volcanic Vihorlat-Gutinian mountain range in Ukrainian Transcarpathia (Zakarpattya). This volcanic mountain range starts on the territory of Slovakia and passes in the southeast direction across the territory of Ukrainian Transcarpathia to Romania (Fig. 1 & 2).

During 1948 and 1967-1968 geologist V.F. Petrougne (Petrougne 1960, 1972) collect obsidian of the Velykyj Sholes Ridge on the eastern slopes of Vihorlat-Hutyn volcanic mountain range, localized in the Ukrainian Carpathians.

Volcanic bombs ejected from explosive eruptions during the last (IVth) orogenic phase of regional volcanic activity roughly 8 to 15 Ma (Fig.3) (Nasedkin 1963; Maleev 1964; Shevkopljias *et al.*, 1986; Pécskay *et al.*, 2000).

In central part of Velykyj Sholes Ridge geologists found six sites liparites outcrops (upper lava flows). In the western part of the spine occur liparites tuffs with a small spread. On the north hillside thick top closer to the center of the region are liparites outcrops, which are confined to hydrothermal rocks that cover an area about 0.5 km² (Fig.4, 5).

Accordingly to geological data, the Velykyj Sholes Ridge represents the destroyed polygenic stratovolcano of Strombolian and Plinian type. Volcanic material delayed in an aqueous medium in the lower parts of the relief, after which the material was transported by temporary water and mud flows.

The diameter of the main part of the volcano was about 10 km and its height reaches approximately 2 km. Eruption of lava flows liparites held on the last stages of life of the volcano, when the building it was already largely destroyed (Fig. 5) (Maleev 1964).

Geologist Nasedkin V.V. has investigated obsidian outcrops nearby Rokosovo in Bykchachiy Jar (Fig.6) (Nasedkin 1963: 44).

3 – Petrographic study of obsidians from the Ridge of Velykyj Sholes

The first petrographic studies of obsidian in the area showed that obsidian occurs in two forms: 1 – clear translucent, banded obsidian, 2 - dark, almost opacus, banded (Petrougne 1972: 86).

Obsidian has a black color and frosted glass glitter. Obsidian surface deprived shine, rough and “hole”. Crystalline phase (40-50% by weight of the rock) and represented phenocrysts kristallito-microlitic formations. Phenocryst content is typically less than 5-10% of the total weight of the rock.

Phenocrysts are represented by the following minerals: andezin-labrador, rhombic pirokosen, glandular basaltic hornblende, hypersthene and plagioclase. Microliths are needles of amphibole and plagioclase tablets.

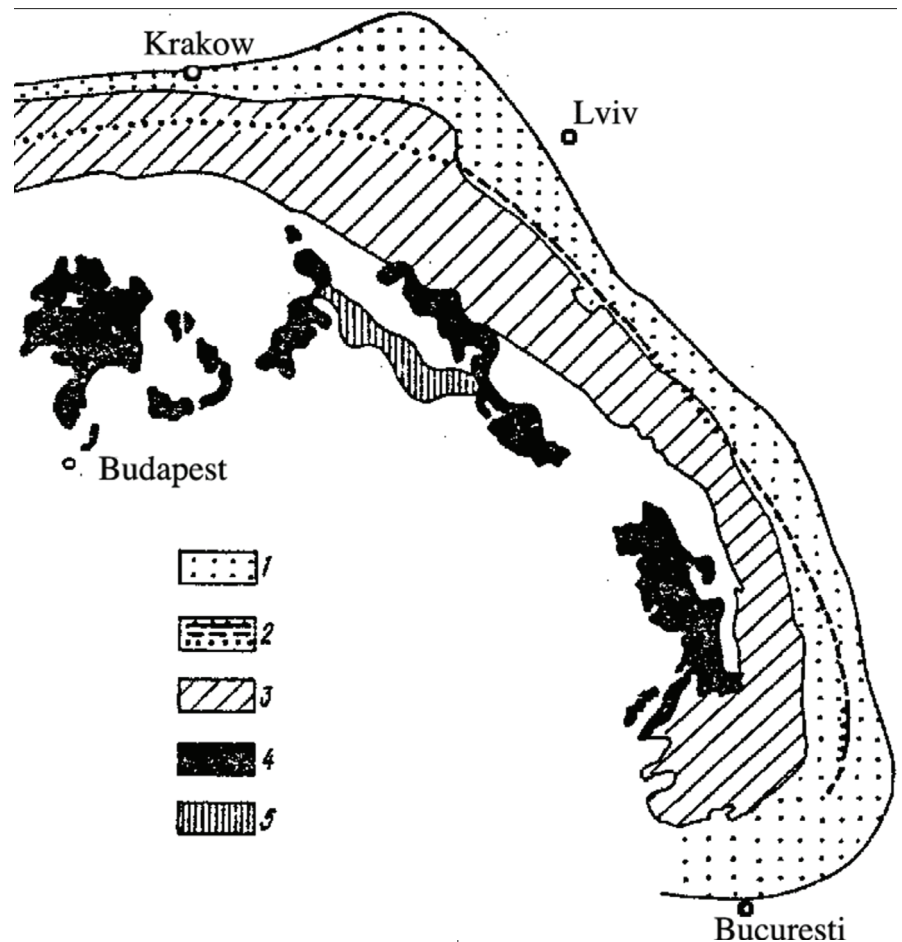
In the crystallization of glass around phenocrysts occur spherulites potassium-sodium consisting of feldspar and cristobalite or tridymite. The initial stage of the devitrification leads to the formation of voids around phenocrysts and brown with a faint halo polarization. Spherulites not violate primary fluidal rocks, as it were riddled with fluidal flows microliths.

Obsidian has a low water content, amount of it varies from 0.01 to 0.05%. Refraction coefficient: $1,482 \pm 0,001$; $1,487 \pm 0,002$; $1,498 \pm 0,001$. Ultimate uniaxial compression this obsidian equal 2500-4450 kg/cm². The chemical composition of obsidian following: SiO₂ - 70,00%; TiO₂ - 0.20% Al₂O₃ - 15.49% Fe₂O₃ - 1.10% FeO - 0.24% CaO - 2.33% MgO - traces, MnO - traces, K₂O - 3,37%; N₂O - 3,82%; SO₃ - tracks; R₂O₅ - traces, loss on ignition - 0.24% total - 100.79% (Nasedkin 1963, Petrougne 1972).

In 2006, we selected 4 samples of obsidian from different topographical points south-western slope of the Velykyj Sholes Ridge. In 2011, Dr. Manichev V.Y. (Institute of Geochemistry, Mineralogy and Ore named Semenenko Academy of science Ukraine) were held petrographic study of samples of obsidian (Fig.7).

Sample № 1 (Fig.7: 1) *Malyj Rakovets III* ($48^{\circ}14'17.99''N$; $23^{\circ}10'56.78''E$). On the surface (200 m to south from Malyj Rakovets IV).

Figure 2 – Carpathian arc in the Neogene: 1 - piedmont depressions; 2 - seismic zone; 3 - system flysch Carpathians; 4 - volcanic mountains; 5 - buried volcanoes ridge. 6 - Transcarpathian obsidian outcrops (after Gofshcheyn 1995)



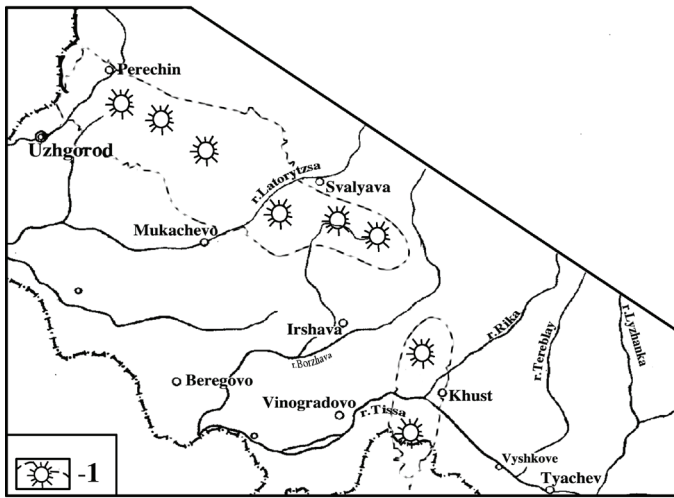


Figure 3 (Above) – Volcanic activity in the late Neogene in Transcarpathia: volcanoes and scope of products of the volcanic activity (after Maleev

Figure 4 (Right) – Computer model of the Velykiy Sholles Ridge: 1 – obsidian outcrops between villages Malyj Rakovets and Rokosovo

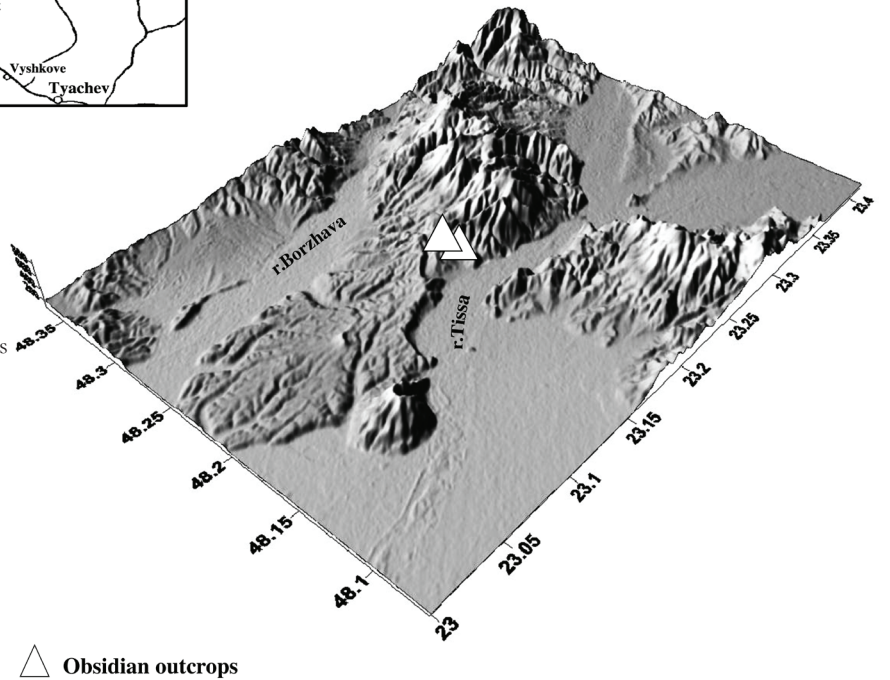


Figure 5 (Below) – Location scheme the volcanoes eruption center in Velykiy Scholes Ridge: 1 - stratovolcanoes; 2 - monovolcanoes; 3 - deposits of dacitic; 4 - deposits of andesite-dacite composition; 5 - domes, stocks, dikes, eruption center I, III, IV phases; 6 - district acidic magma intrusions; 7 - tuffaceous sedimentary deposits; 8 - deposits of liparite composition; 9 - palaeolithic sites with obsidian artefacts (after Maleev 1964)

△ Obsidian outcrops

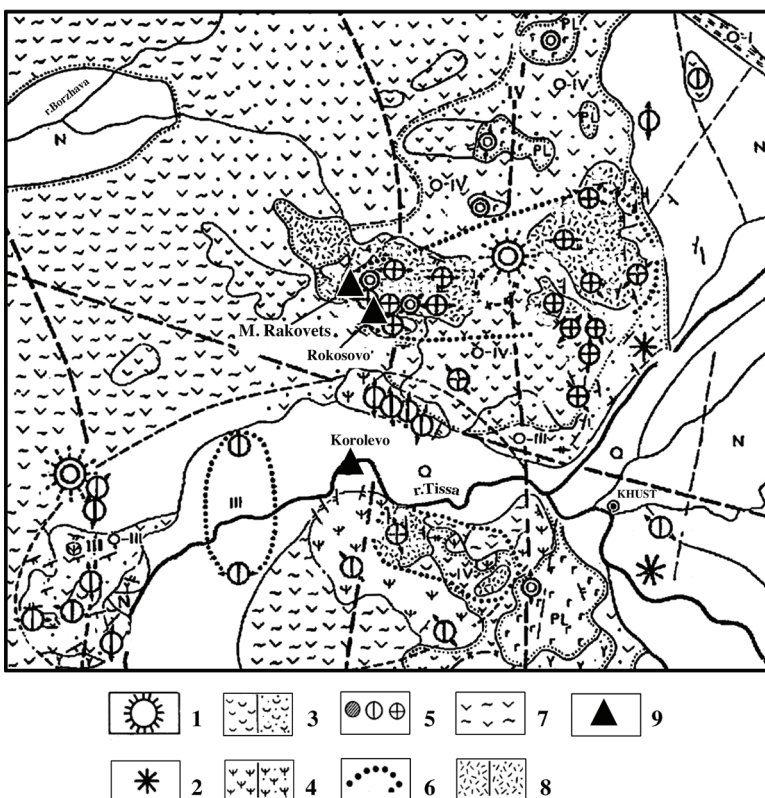
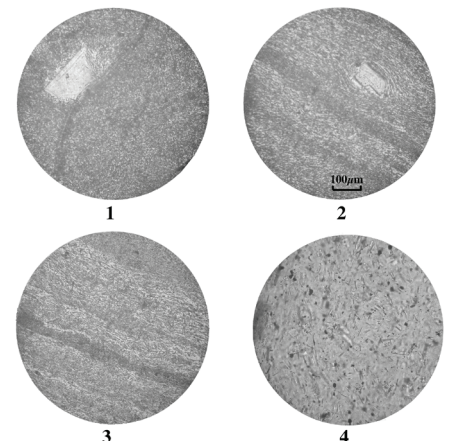


Figure 7 (Below) – Petrographic thin sections of obsidian of the Velykiy Scholes Ridge area: 1 - obsidian from surface Rokosovo IV; 2 - from cultural layer II of Malyj Rakovets IV; 3 - Malyj Rakovets III, on the surface (200 m to south from Malyj Rakovets IV); 4 - Malyj Rakovets IV, from cultural layer I



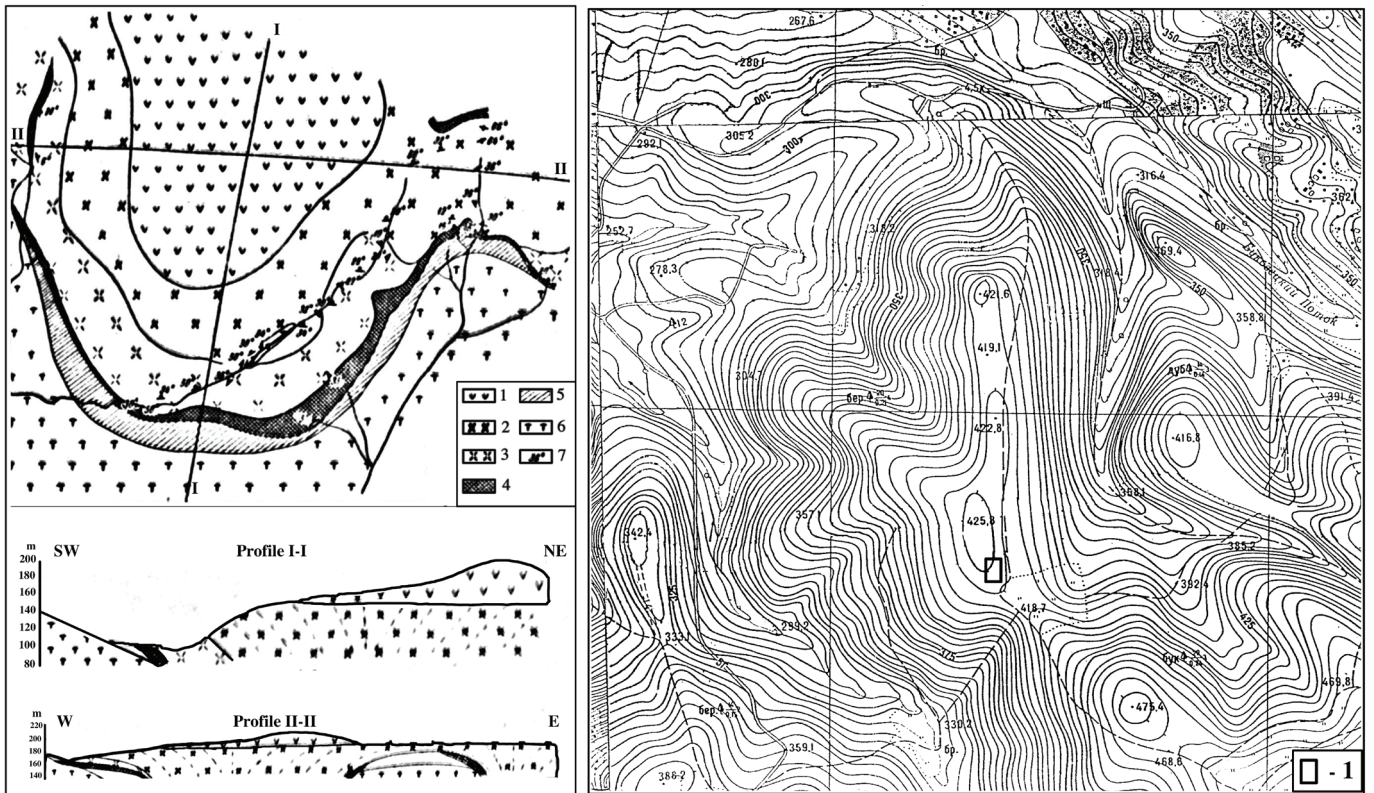
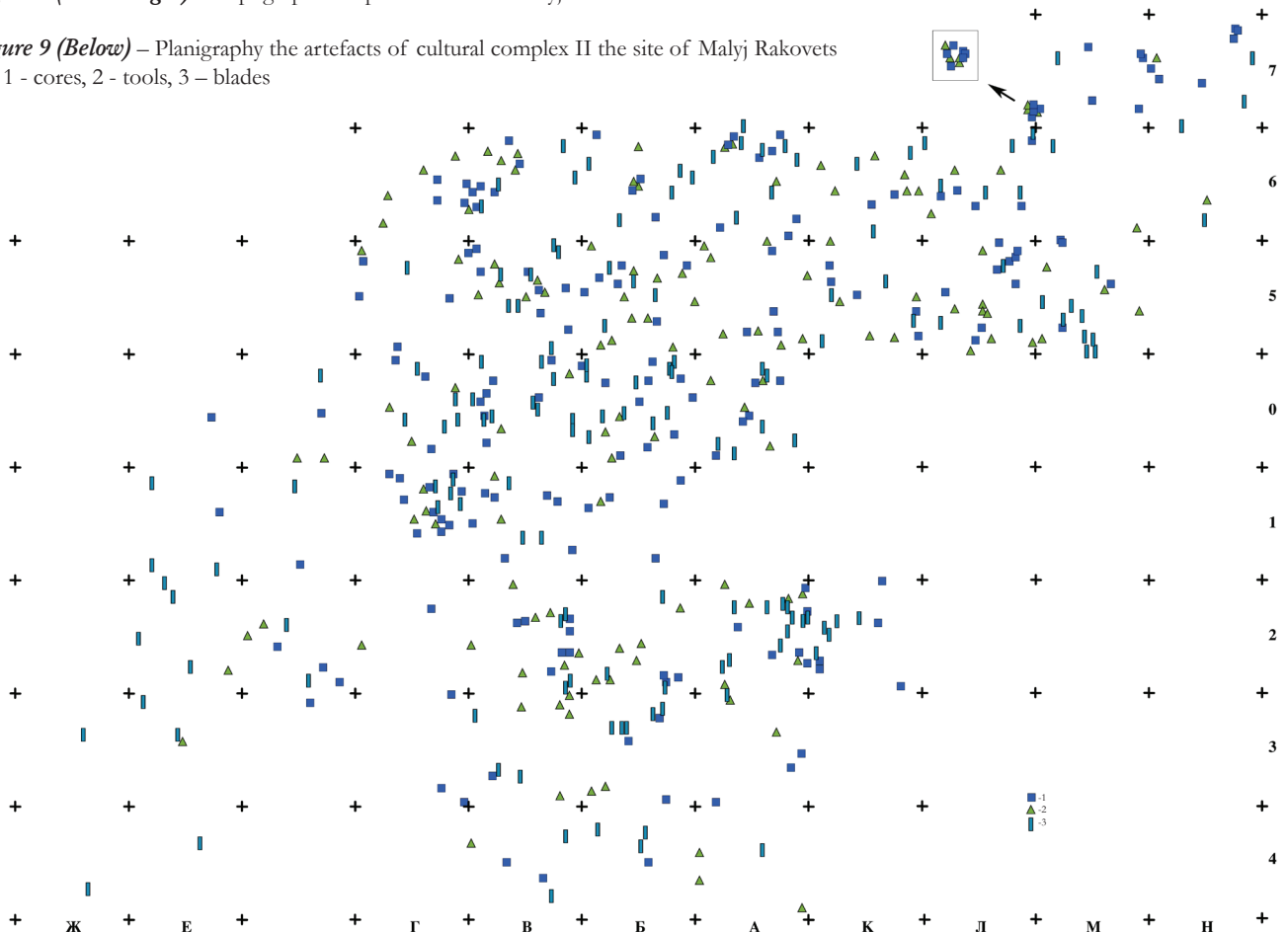


Figure 6 (Above left) – Schematic geological map of the extrusive dome Bykchachy Yar (Rokosovo): 1 - andesite; 2 - liparite with tridymite; 3 - kristabolito-liparite; 4 - obsidian-perlite glass; 5 - dome agglomerate; 6 - tuff of liparites composition; 7 - elements abundance and orientation of lines in the current range (after Nasedkin 1963)

Figure 6 (Above right) – Topographic map of the site of Malyj Rakovets IV

Figure 9 (Below) – Planigraphy the artefacts of cultural complex II the site of Malyj Rakovets IV: 1 - cores, 2 - tools, 3 – blades



Volcanic glass. Obsidian. The color black, shiny, conchoidal fracture. Microscopically breed is a glass with a characteristic striped texture, defined brownish and gray color. In the bulk glass isolated microliths of feldspar, hornblende and ore minerals are black, correct and tablet form.

Sample № 2 (Fig.7: 2). *Rokosovo IV* (48°13'50.04"N; 23°11'7.43"E). On the surface (2 km south from *Malyj Rakovets IV*).

Volcanic glass. Obsidian. The color-striped black. Breaking mostly poorly conchoidal fracture, brilliant. Microscopically striped texture (fluidal) for which there is a horizontal whitish brownish and light gray areas. Evenly throughout the volume of volcanic glasses indicated the presence of a small amount tablet feldspar, rarely hornblende (0.02 mm).

Sample № 3 (Fig.7: 3). *Malyj Rakovets IV* (48°14'18.71"N; 23°10'45.65"E). From cultural layer II (Middle Palaelithic).

Volcanic glass. Obsidian. The color-striped black. Analog sample №2.

Sample № 4 (Fig.7: 4). *Malyj Rakovets IV*. From cultural layer I (Upper Palaelithic).

Volcanic glass. Obsidian. Rock black. Tekstura of black uniform, chaotic. In the bulk, glass high content of microcrystals. In a small number indicated the presence of different sized light spheroid.

In the preliminary results of the petrographic analysis of samples number 2 and number 3 are identical. As a result, we find confirmation of transportation or distribution of obsidian in a radius of 1,5-2,5 km in the south-western part of the Velykiy Scholes range.

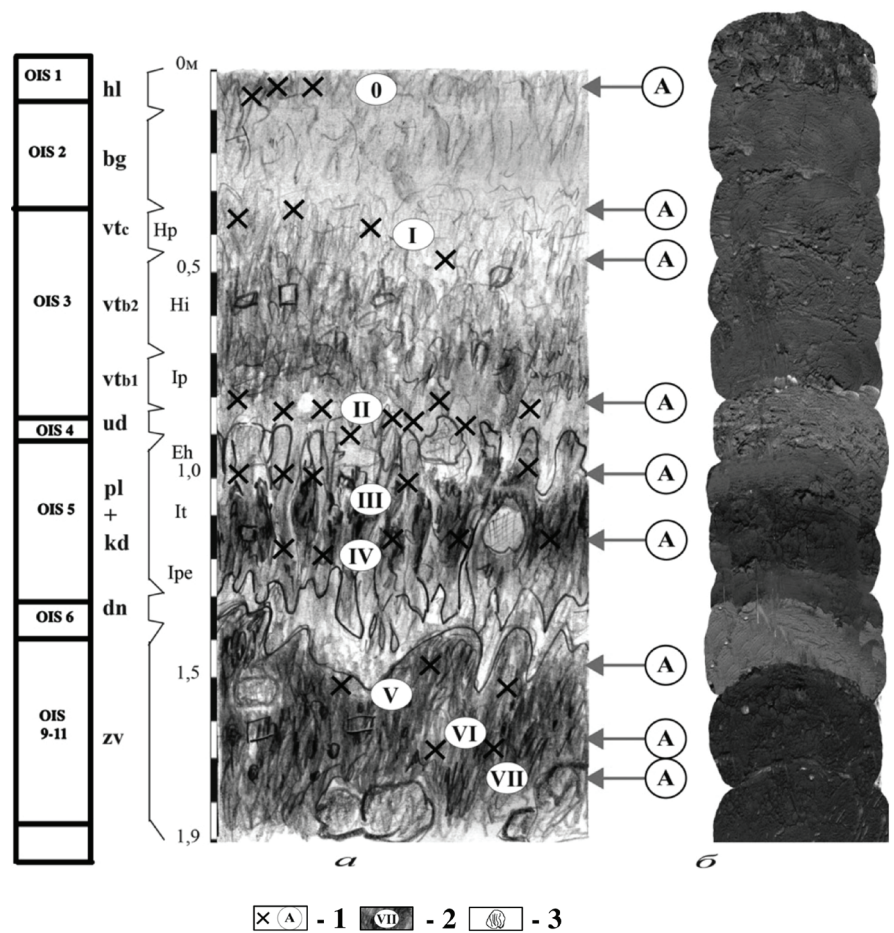


Figure 10 – Malyj Rakovets IV. Stratigraphical sequence of SE wall of square H-5. 1, artefacts; 2, culture-chronological assemblage; 3, tufa concretion

Sample № 1, was selected at 200 m south of the site Malyj Rakovets IV is somewhat different from the two foresaid. Sample № 4 was selected from cultural-chronological complex I (Upper Paleolithic) completely different from all other samples this series. It is quite possible we have result of transportation from other obsidian sources of the Carpathian Basin.

4 – Archaeological research

Local obsidian is the most common raw material for Malyj Rakovets IV, the rest consists of quartzite, flint, slate, sandstone, quartz and andesite. Non-volcanic material is represented by pebbles.

The raw material is not found naturally on the site and was transported (0,5-3 км) by numerous streams in the vicinity of the settlement. It is important that the artifacts made of volcanic materials and coming from different chronological complexes at this site and have differently preserved surfaces due to various degrees of patination and cellular leaching (corrosion) (Fig.11).

The most ancient artefacts have the most destroyed surface and vice versa the youngest implements have a better state of preservation.

5 – The palaeolithic site of Malyj Rakovets IV

(48°14'18.71"N; 23°10'45.65"E)

The palaeolithic site of Malyj Rakovets IV is located on the volcanic Vihorlat-Gutinian Ridge (Velykyj Scholes Ridge), southeast of the Malyj Rakovets village between the towns Khust and Irsava in Transcarpathia, West Ukraine (Fig.3, 5). Malyj Rakovets IV is the highest of the Lower and Middle Palaeolithic sites in this region (Fig.8).

The first stone artifacts were collected between the villages Malyj Rakovets and Rokosovo (another area with numerous sites) by V. Petrougne and then by V.Gladilin at the end of 1960's. In 1978, in course of a survey along the trench for the gas pipeline "Sojuz" V. Sitlivyj and Y. Kucharchuk discovered a number of stone artifacts of Lower and Middle Palaeolithic types at the site MR IV and, following the planed direction of the pipeline towards the town of Vinogradovo, in a few additional places: MR V, VI, VII (Sitlivyj 1989).

Archaeological researches were conducted by the archaeological museum of the Institute of Zoology of Ukraine at this location in 1990-1991 (Sitlivyj and Ryzov 1992). These works were followed by 1995-2006 excavations conducted by the archaeological expeditions of the Department of Archaeology and Museology of Kyiv National Taras Shevchenko University (Ryzhov 1998, 2003, 2009).

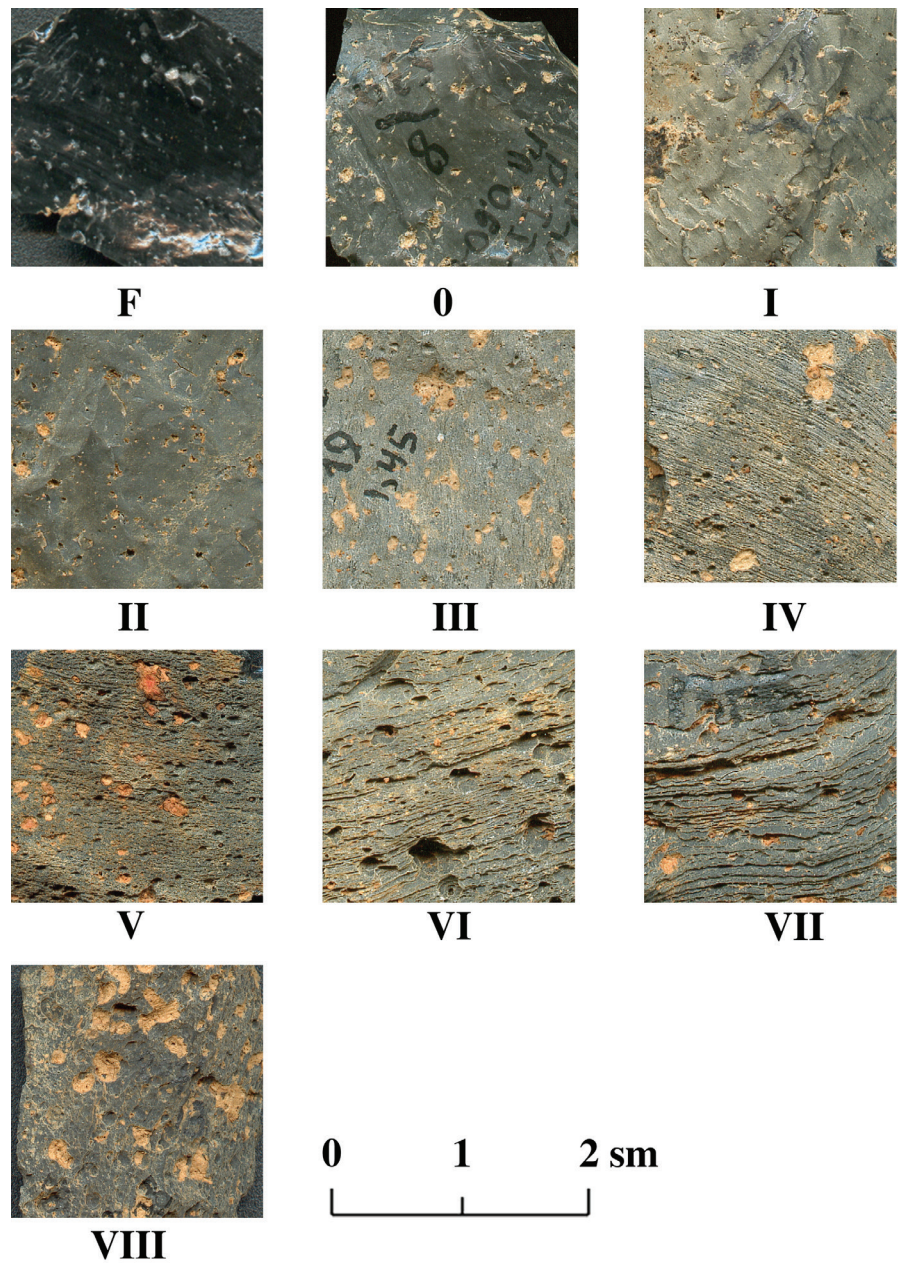


Figure 11 – Obsidian chronological systems of the site of Malyj Rakovets IV on the degree of leaching; 0-VII - cultural-chronological complex; F - fresh chip

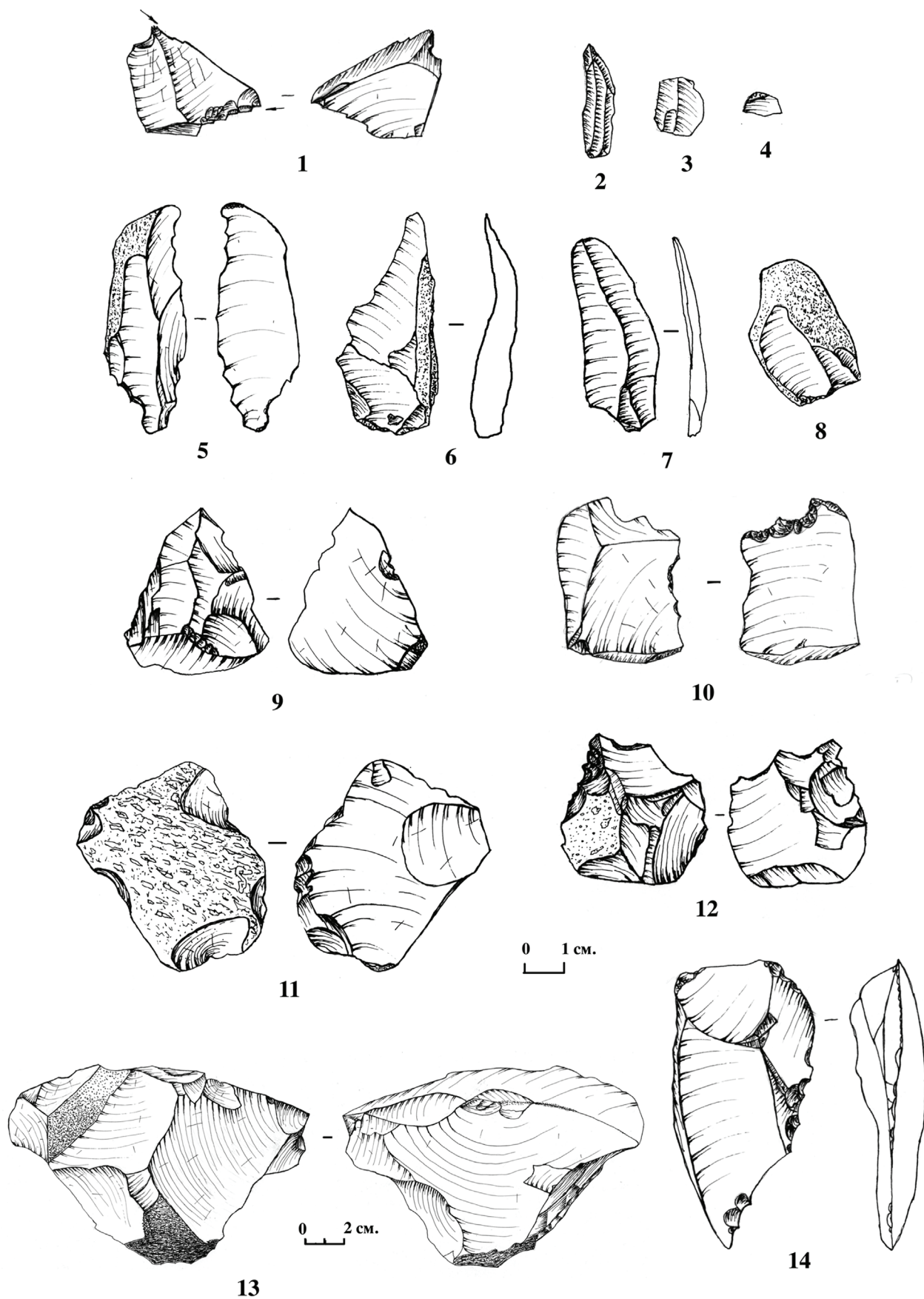
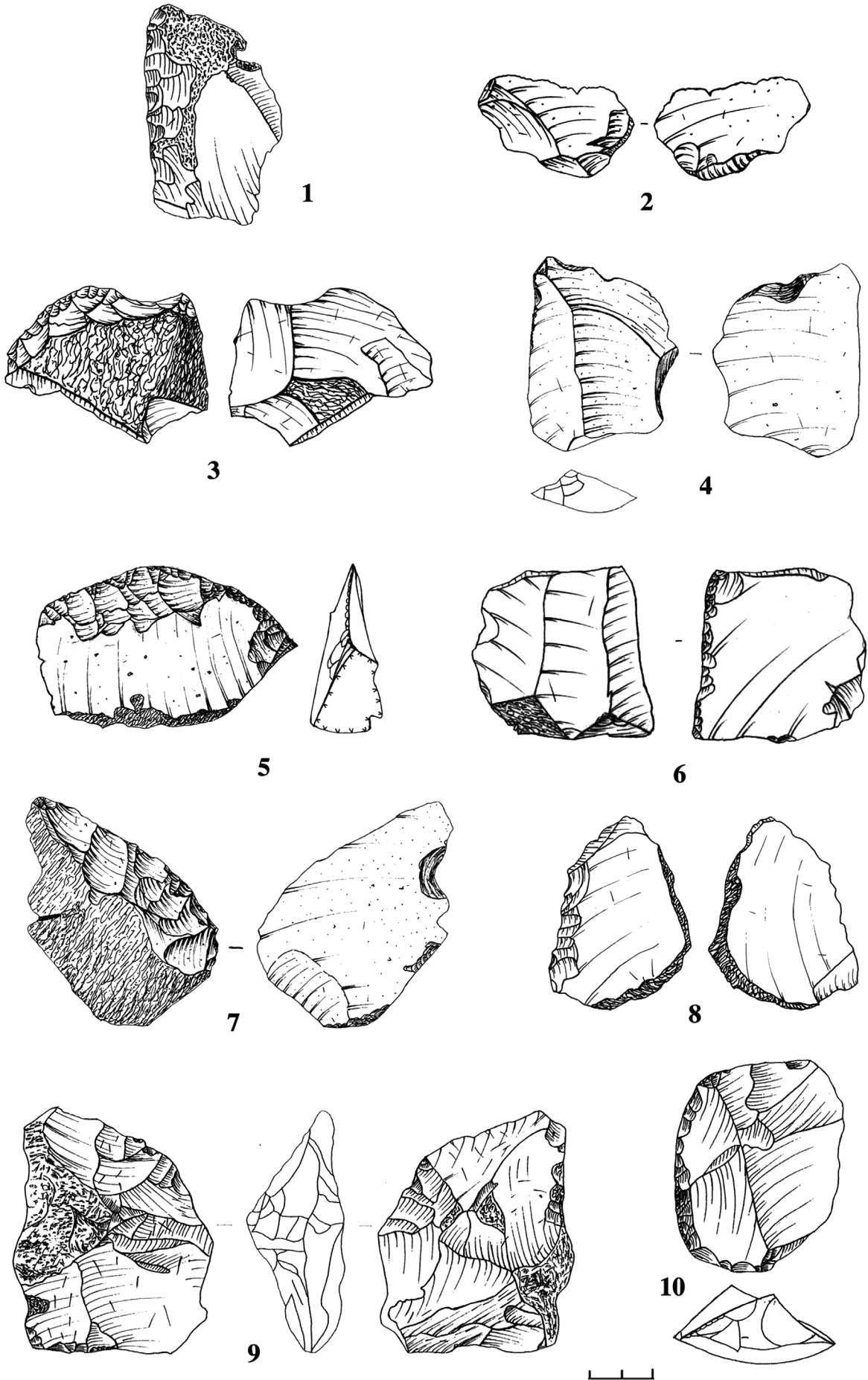
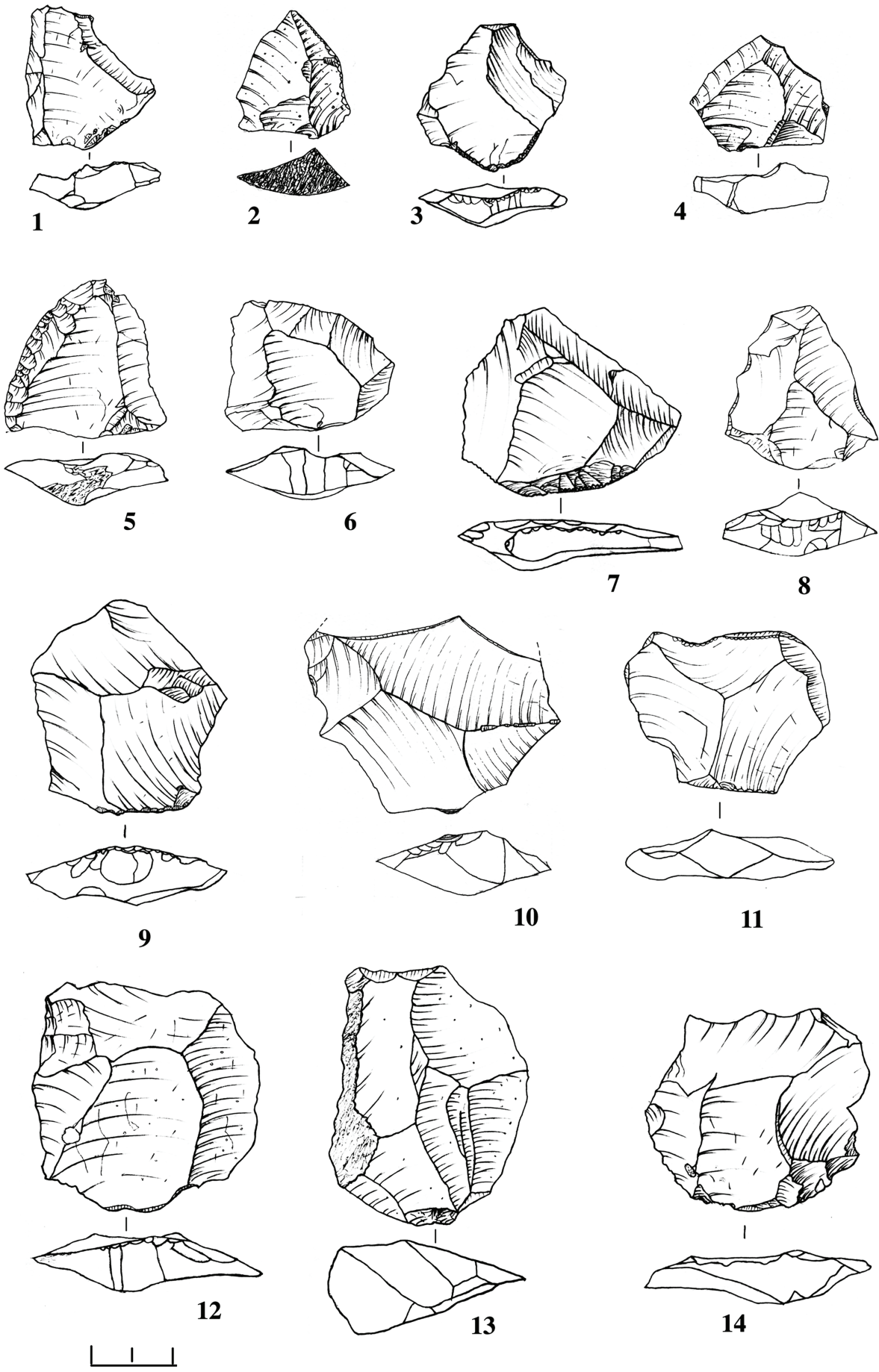


Figure 12 (Above) – The site of Malyj Rakovets IV. Lithic artefacts of culture–chronological complex I. 2, 6, 7 – from not local obsidian; 3, 4, 8 – flint; 1, 5, 9, 10 – 14 - local obsidian (Carpathian III)

Figure 13 (Right) – The site of Malyj Rakovets IV, Lithic artefacts of culture–chronological complex II. Stone tools from local obsidian





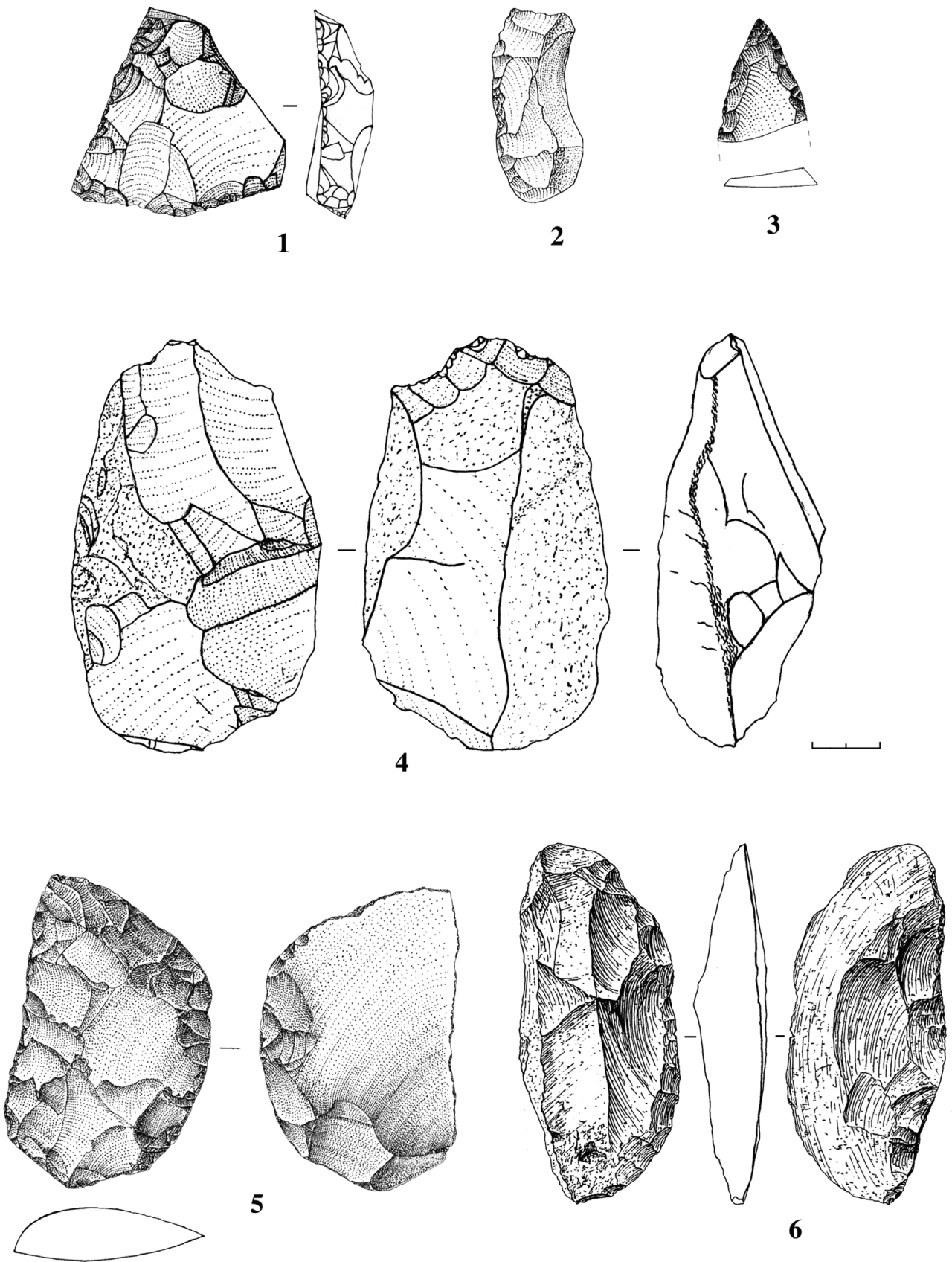


Figure 14 (Left) – The site of Malyj Rakovets IV. Lithic artefacts of culture–chronological complex II. Levallois flakes from local obsidian

Figure 15 (Above) – The site of Malyj Rakovets IV. Lithic artefacts of culture–chronological complex II: core from quartzite – 4; quartzite tools – 1, 2, 3, 5; andezite side-screper – 6

In the process of dating the geostratigraphical and technic-typological study were used and dissection technique finds the degree of preservation (leaching) products from volcanic materials (Fig.11, planche 23) (Gladilin, Sitlivy 1991). Thus, over the years of research in the site was allocated eight cultural horizon: 0 – Neolithic and Bronze age; I - Upper Paleolithic; II, III, IV - Middle Paleolithic; V, VI, VII - Lower Paleolithic (Ryzhov 2009).

The total area of the excavation was 208 m² (Fig. 9). There was found about 6 thousand artifacts. The bulk (75%) of these findings belong to the II-th cultural horizon (Middle Paleolithic). Faunal and paleoanthropological findings were not found.

In 2006 studies were conducted stratigraphic research (paleopedological, macro and micromorphological) by the Institute of Geography of the Academy of Sciences of Ukraine. The result was a more detailed stratigraphic column (Fig. 10). Here were tracked for the following deposits: hl, bg, vt, ud, pl, kd, dn, zv (Ryzhov et al 2008).

Eight cultural complexes were recognized at the site on the base of geostratigraphical data and technical-typological studies, these are: Neolithic-Bronze age (0), Upper Paleolithic (I), Middle Paleolithic (II-IV), Lower Paleolithic (V-VII).

A – Cultural-chronological complex of Malyj Rakovets IV (Upper Paleolithic)

Most of the remains occur at depths of 0,30-0,50 m at the top of Vitachev horizont (vt). Obsidian findings (83%) differ from the previous by the presence of complex (0 complex) and opaque crust leaching with a blue tint patina. There are in total 177 found: debitage – 150, tools - 27.

By its technical and typological characteristics, this complex is different from all the other complexes *Malyj Rakovets IV*. Complex I comprise blades (17%) and burin (1.7%). Assemblage includes backed bladelet made on not local obsidian raw material (2).

Variety of raw materials used at the site increases during the Upper Paleolithic period. Tools from non-local obsidian, radiolarites, hydroquartzites, and various flints are represented. Retouched obsidian blades and end-scrapers are dominating, but burin made on non-obsidian material (Fig. 12) is also represented in the assemblage.

B – Cultural-chronological complex of Malyj Rakovets IV (Middle Paleolithic)

Findings of this complex occur at depths of 1,40-1,20 m in the south-eastern part of the excavation while in the north-western part of the excavation area the majority of artifacts were recovered at a depth of 1,00-1,20 m. The major portion of artifacts was reported for the lower section of forest soil of vitachev age (vt_{b1}).

Assemblage of complex II comprises 4210 finds: debitage products - 3765/89, 4%, tools - 236/5, 6%, undefinable - 209/4, 9% (Fig. 13, 15). Following groups of tools are recognized among artifacts, namely: side-scrapers and knives - 67/28, 3%, notches - 17/7, 2%, retouched flakes - 34/14, 4%, and denticulates - 16/6, 8%, Levallois points - 4/1, 7%, blades retouched - 2/0, 8%, end-scrapers - 8/3, 9%, burin - 1/0, 4%, blank of tools - 4/1, 7%, hammerstones - 28 / 11.8% and anvil - 2/0, 8%.

Tools were made of obsidian (85,5%), quartzite (6%), slate (3%), flint (1,5%). Hammerstones are made of sandstone, quartzite and quartz pebbles. Usually, the tools were prepared on flakes and blades. Their length varies between 3-10,8cm, the width is between 2,7-7,8 cm, thickness 0,7-4 cm. The average proportions are 6 x 4,4 xl, 8 cm. Generally retouch on tools is unifacial scalariform, occurs pearllike, step, sub-parallel. The tools with retouch on dorsal side dominate (79,3%), ventral retouching occurs (18,9%)

From the typological point of view, available side-scrapers, knives and denticulates are

simple: convex, concave, straight, sinuous (Fig. 13, 15). The tools with more than one retouched edge (double, convergent) are rare. Points are not numerous but typical. They are represented by retouched Levallois points and points on blades. Upper Palaeolithic tools are rare and atypical.

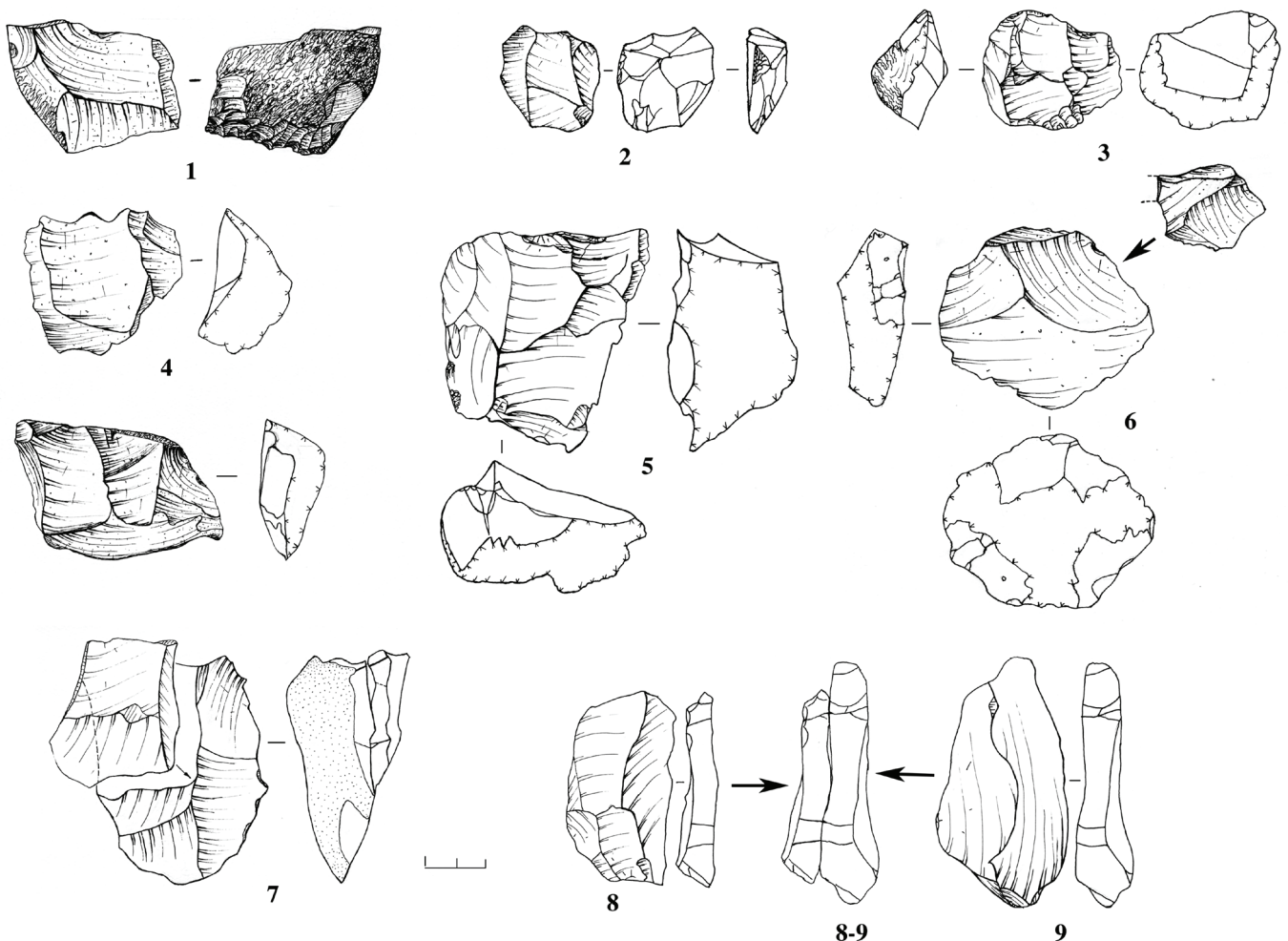
Malyj Rakovets IV, complex II is characterized by Mousterian forms with prevailing simple side-scrapers and knives, modest level of denticulate and notches. The specific character of the complex is given by Levallois points with broad base, some partly bifacial and stepped retouched knives and side-scrapers. This assemblage was attributed to the typical Mousterian characterized by domination of simple scrapers and backed knives made on flakes.

C – Cultural-chronological complex of Malyj Rakovets IV (Middle Paleolithic)

Artefacts of this complex were unearthed directly in the upper part of Priluky soil (pl). Obsidian artifacts are characterized by more intensive weathering and rough patina. One of the surfaces of artifacts usually demonstrates cells leach residues Priluky soil hydroxides of iron and manganese.

The assemblage of this complex includes debitage products - 115, tools - 15. Debitage is typical for the Middle Palaeolithic time in this region (including Levallois forms) and comprises flakes – 62, cores – 15, pieces – 25, small flakes or chips up to 2 cm - 13. The tools included: denticulates - 3, side-scrapers – 2, retouched flakes - 4, retouched flakes - 1, broken tools - 4, retoucher – 1 (Fig. 17).

Figure 16 – The site of Malyj Rakovets IV. Lithic artefacts of culture–chronological complex II: cores from local obsidian (1, 3, 4, 5, 6, 7), cores from radiolarite (2), conjoining flakes. (8-9)



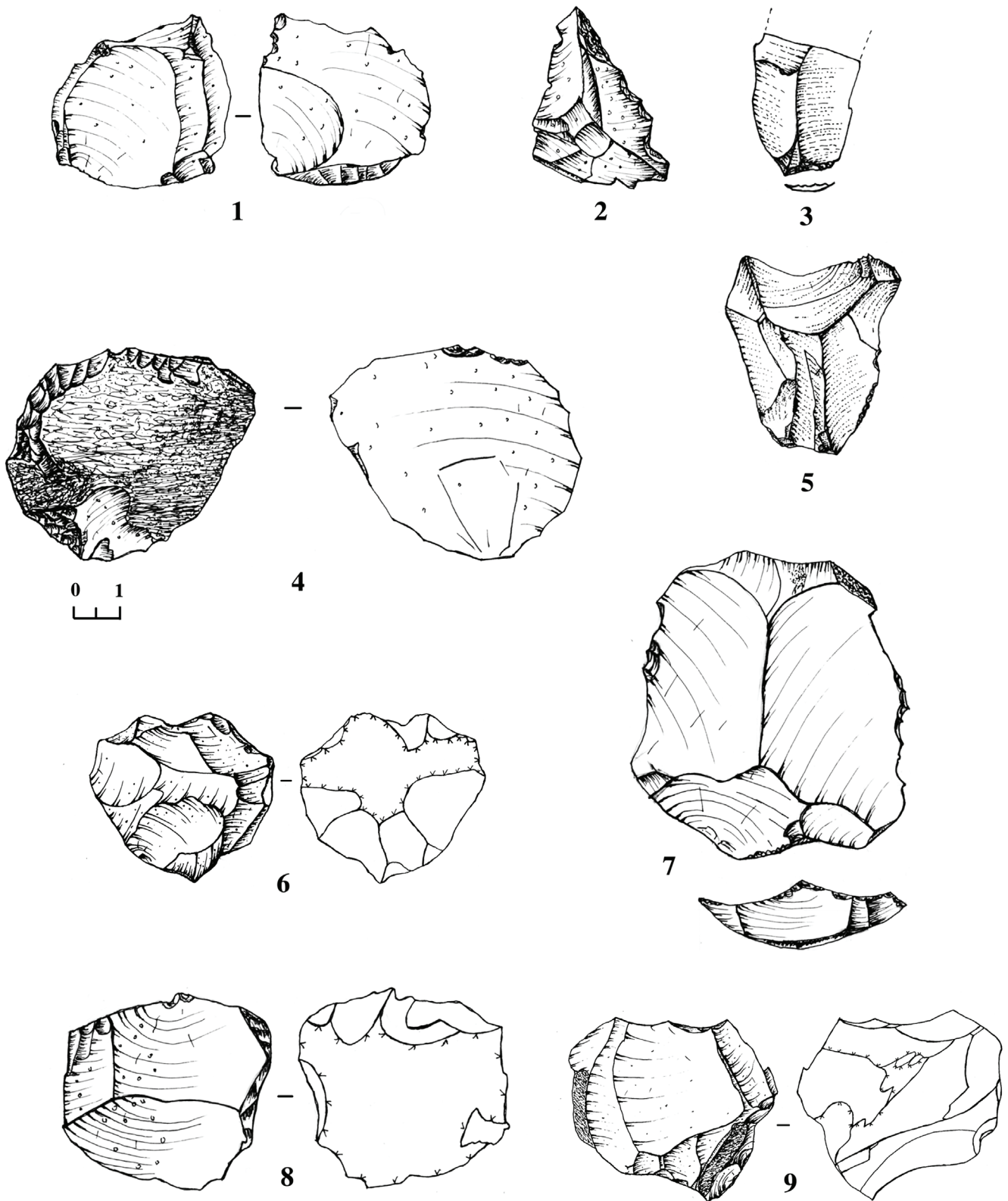
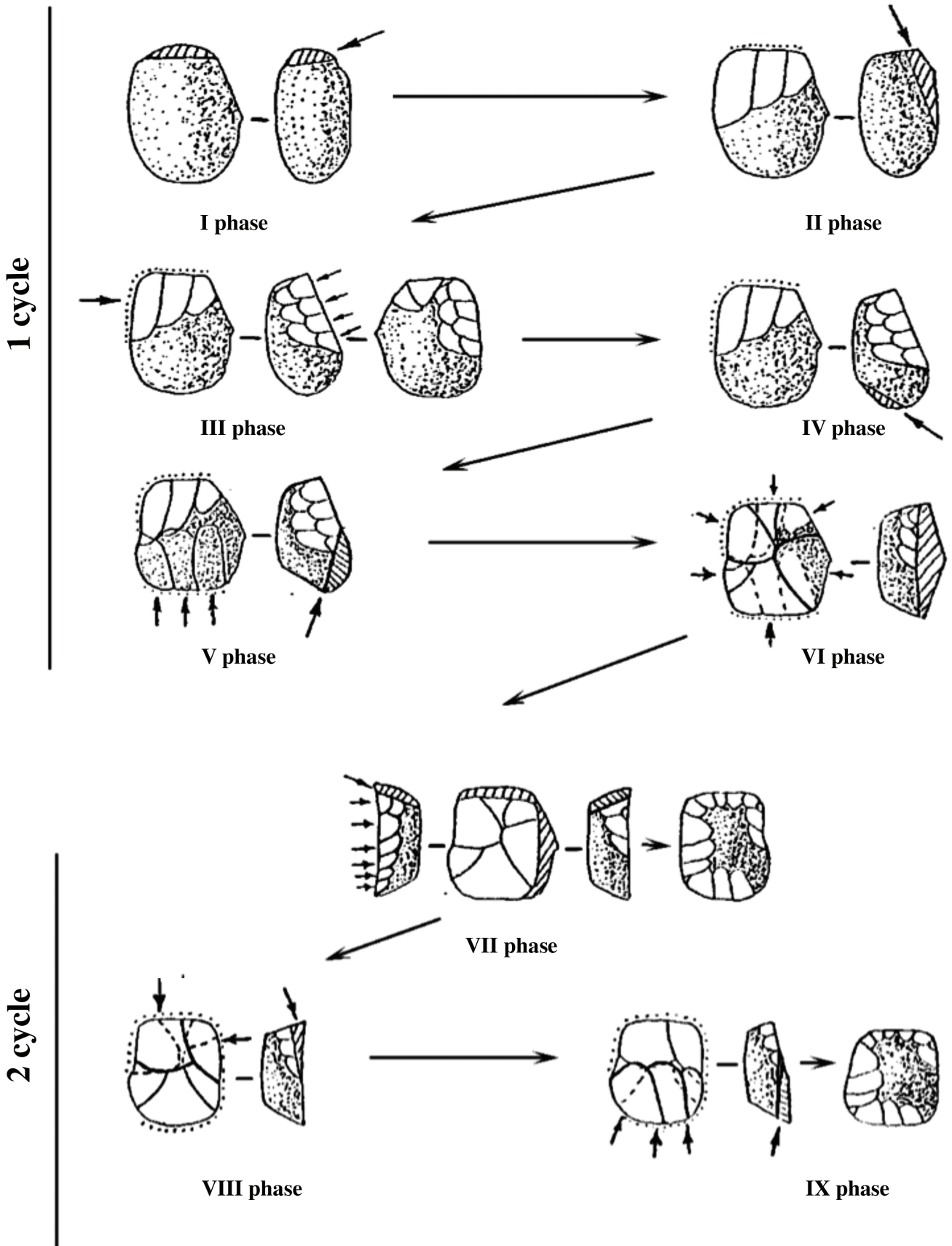


Figure 17 (Above) – The site of Malyj Rakovets IV. Lithic artefacts of culture–chronological complex III: obsidian tools (1, 2, 4), Levallois flakes with retouch (5 – quartzite, 7 – obsidian), discoide core (6), rokosovo cores (8, 9)

Figure 18 (Right) – Strategic model of obsidian knapping cores. Cultural-chronological complex II



A relatively small collection of this complex was attributed to the Middle Palaeolithic assemblages with Levallois technique.

D – Cultural-chronological complex of Malyj Rakovets IV (Middle Palaeolithic)

Findings occur in the middle part of the Priluky soil and have stronger leaching than the cultural complex III. Collection includes 72 finds: debitage – 67, tools - 5. Among the tools allocated andesity back knife and quartzite Levallois flake with retouch.

E – Cultural-chronological complex of Malyj Rakovets IV (Acheulian period)

Artifacts were recorded in Zavdovka soil at different levels. Obsidian artefacts differ by the degree of preservation of surfaces. These assemblages are not numerous (V - 16 pcs, VI - 6 pcs., VII - 9 pcs.) and do not represent a homogeneous typological groups.

Lower Palaeolithic assemblages are characterized by presence of tools on massive natural flakes with irregular retouch. This time mostly black obsidian bombs of larger dimensions were used. Some obsidian finds with intensively corroded surfaces at the same time represents the morphologically more primitive artifact types, like proto-Levallois and cubic cores were discovered. These are assigned to the Acheulian time.

Natural obsidian blocks are virtually absent at the site of Malyj Rakovets IV. The nearest surface outcrop is localized at a distance of two kilometers and obsidians till now can be found in this area on eroded slopes. Local Paleolithic occupants used another available raw material, as well. This feature becomes especially clearly visible during the Upper Paleolithic. Evidence of local transportation of obsidian to other sites of the area (save for the Korolevo site) is not traced yet.

6 – Conclusion

Obsidian outcrops in the Ukrainian Transcarpathians were localized as a result of special geological and archaeological research

XRF data, NAA and petro-geologic data indicate that Ukrainian obsidian is chemically different from other Carpathian obsidians, and suggest that the Ukrainian material is internally homogenous and belongs to so called Carpathian 3 source (Rosania *et al.*, 2008)

The study of Paleolithic sites in Velykiy Scholes Ridge witnesses for rather long period of exploitation of obsidian by Prehistoric man, as there are obsidian artifacts dates to the Lower, Middle and Upper Paleolithic. Unfortunately the major part of Paleolithic sites was destroyed by erosion processes very intensive in this area of Carpathians.

Due to its stratigraphic context, the multilayered site of Malyj Rakovets IV is of great importance for the study of Prehistory of Carpathian Basin. The same obsidian raw material outcrop was exploited by the inhabitants of the site at different stages of its occupation. At the same time, non-volcanic rocks and imported obsidian were also used at the site

However, at the moment, there are no facts of transportation of obsidian finished tools or blocks of raw material for long distances (over 10 km).

Technological and typological indications of obsidian products do not show sharp differences to the general principles of knapped isotropic rocks in the Paleolithic time.

The study was developed by obsidian artifacts chronological scale for degree of preservation surface that matches the stratigraphic bedding artifacts. Further research in this area can improve the dating obsidian material which is found on the surface or present as an import in other sites.

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References Cited

- GLADILIN, V.N. & SITLIVYJ, V.I. (1990) – *Achel Tzentralnoy Evropu* [Acheul of the Central Europe]. Naukova dumka, Kiev.
- GOFSHTEIN, I.D. (1995) – *Geomorfologicheskij ocherk Ukraïnskib Karpat* [Geomorphological essay of the Ukrainian Carpathia] Naukova dumka, Kien.
- JANŠÁK, S. (1935) – *Praveké sídliska s obsidianovou industriou na Východnom Slovensku*, Bratislava, 193p.
- KOULAKOVSKAYA, L.V. (1989) – *Moust'erskie kul'tury Karpatskogo bassejna* [Mousterian culture of the Carpathian Basin]. Naukova dumka, Kiev.
- LEHOCZKY, T. (1910) – Kokorszaki letek Beregmegeyében. In *Archaeologiai értesítő*, XXX (1), Budapest, pp. 154-164
- MALEEY, E.F. (1964) – *Neogenovny vulkanizm Zakarpatya* [The neogen volcanizm in the Transcarpathia], Science, Moscow.
- NASEDKIN, V.V. (1963) – Vodosoderzhashie vulkanicheskie stekla kislogo sostava, i genezis ih izmeneniy [The water-contain volcanic glasses of sour structure, and genesis of their change], *Trudu Instituta Geologii, vypusk 98*, Moscow.
- PÉCSKAY, Z., SEGHEDI, I., DOWNES, H., PRYCHODKO, M. & MACKIV, B. (2000) – K/ar dating of neogene calc-alkaline volcanic rocks from Transcarpathian Ukraine. In *Geologica Carpathica*, 51 (2), Bratislava, April, pp. 83-89
- PETROUGNE, V.F. (1960) – Iz istorii primeneniya vulkanicheskogo stekla (obsidiana) v pervobytnoj tehnikе [From history of using the volcanic glass (obsidian) in primitive technics]. In *Sbornik nauchnub trudov, Vyypysk VIII*, pp. 104-115. Krivorozhskiy gornorudnyy institut.
- PETROUGNE, V.F. (1972) – Levalluazskie masterskie obsidianovyh orudij Zakarpat'ja i problemy syr'ja [The obsidian levallois workshops tools in Transcarpathia and the problem of raw material]. In *Materialy 13-oj konferencii*, pp. 86-92. Institut Arheologii AN USSR, Kiev.
- PETROUGNE, V.F. (1986) – About Some Species of Lithic Raw Materials in Archaeological Complexes of the Carpathians and Adjoining Territories of the USSR. In *Papers for the 1-st Internaional Conference on Prehistoric Flint Mining and Lithic Raw Material Identification in the Carpatian Basin*, pp. 229-231, Magyar Nemzetimuseum, Budapest.
- ROSANIA, C.N., BOULANGER, M.T., BIRÖ, K.T., RYZOV, S., TMKA, G. & GLASCOCK, M.D. (2008) – Revisiting Carpathian obsidian, *Antiquity*, vol 82, Issue 318, December, p. 318.
- RYZHOV, S.M. (1998) – Must'ers'ka obsidianova stojanka M. Rakovec' IV na Zakarpatti [The Mousterian site of Malyj Rakovets IV in Transcarpathia]. *Arheologija* 4, pp. 91-107.
- RYZHOV, S.M. (1999) – Nekotorye aspekty obrabotki kamnja na must'erskoj stojanke M. Rakovec IV na Zakarpat'e [The some aspects of knapping stone on the mousterian site of Malyj Rakovets IV in Transcarpathia]. *Vita Antiqua* 1, pp. 3-17.
- RYZHOV, S.M. (2003) – Stojanka Malyj Rakovets IV v Zakarpt'e [The site of Malyj Rakovets IV in Transcarpathia]. In *The Middle Paleolithic variability on the territory of Ukraine, The proceedings as round table discussion, «Shliakb»*, Kiev, pp. 35-44.
- RYZHOV, S.M., MATVIISHINA, J.N., PUDOVKINA, A. S. & LEVCHUK, P. A. (2009) – Stratigraficheskie i planigraficheskie issledovanija paleolicheskoy stojanki Malyj Rakovec IV v Zakarpat'e [Stratigraphic and planigrafic study Paleolithic site of Malyj Rakovets IV in Transcarpathia]. *Vita Antiqua*, 7-8, Kien, pp. 60-71.
- SHEVKOPLJAS, V.N., GOZHIK, P.F. & HRISTOFOROVA, T.F. (1986) – *Antropogenovye otlogenija Ukrainy* [Antropogenetic depozite of Ukraine]. Naukova Dumka, Kiev.
- SITLIVYJ, V.I. (1989) – Rannepaleolicheskije kompleksy Malogo Rakovca v Zakarpat'e. In *Cbetvertichnyy period: paleontologija i arheologija*, Kishinev, pp. 146-154.
- SITLIVYJ, V. & RYZOV, S. (1992) – The late middle palaeolithic of Malyj Rakovets IV in Transcarpathia, *Archaeologisches Korrespondenzblatt* 22, Mainz, Verlag des Römisch - Germanischen Zentralmuseums, pp. 301-314.
- SKUTIL, J. (1935) – Paleoliticum Slovenska a Podkarpatskej Rusi. In *Matica Slovenska*, Bratislava, pp. 126-135.
- SOVA, P.P. (1964) – Paleolitychni mictzernahodzhennja v Uzhgorodi. In *Arheologija* [Palaeolithic sites in Uzhgorod] 17, pp. 180-187.
- STEPANCHUK, V., RYZHOV, S., REKOVETS, L. & MATVIISHINA, Zh. (2009) – The Lower Palaeolithic of Ukraine: Current Evidence, *Quaternary International*, 23 December 2009, pp. 131-142. <http://dx.doi.org/10.1016/j.quaint.2009.12.006>
- TKACHENKO, V. (2003) – *Piznij paleolit Zakarpattja* [Upper Palaelithic of Transcarpathia], Kyiv.