

ARCHAEOLOGICAL AND GEOLOGICAL STUDIES OF OBSIDIANS IN UKRAINIAN TRANSCARPATHIA*

RÉGÉSZETI ÉS GEOLÓGIAI VIZSGÁLATOK A KÁRPÁTALJAI OBSZIDIÁNOKON

RYZHOV, Sergii¹

¹Department of Archaeology and Museum Study, Taras Shevchenko National University of Kyiv, 64/13
Volodymyrska Street, Kyiv 01601, Ukraine

E-mail: seryzh@knu.ua

Abstract

The geological and archaeological results of the study of obsidians in the territory of Ukrainian Transcarpathia are presented. As a result of many years of research, the primary outcrops of obsidians in the area of the Velykyj Sholes Ridge (Rokosovo and Malyj Rakovets villages) of the Vihorlat-Gutin volcanic range were localized and described.

Petrographic and geochemical analyzes of obsidians in this region allowed to identify a new group of primary outcrops - Carpathian 3. Archaeological studies indicate the existence of a multi-layered site Malyj Rakovets IV in the area of outcrops of obsidian sources during the Palaeolithic. In the process of cultural adaptation, the Palaeolithic groups used local obsidian. Stratigraphic and palaeopedological studies indicate that ancient people many times have visited these places in prehistory.

Kivonat

A tanulmány a kárpátaljai (Ukrajna) területén végzett földtani és régészeti obszidián vizsgálatokkal foglalkozik. Több éves kutatás eredményeképpen felderítették és leírták a Nagyszőlősi Hegység (Velykyj Sholes Ridge) elsődleges obszidián előfordulásait, Rakasz és Kistrákóc falvak határában (Rokosovo és Malyj Rakovets). A lelőhelyek a Vihorlát-Gutin vulkáni hegység-vonulathoz tartoznak.

A területen található obszidiánok közettani és geokémiai vizsgálata lehetővé tette egy újabb nyersanyag-csoport elkülönítését, amelyet kárpáti 3. néven írtak le. A régészeti kutatások szerint a nyersanyagforrásokat az őskor során kiaknázták, például Kistrákóc (Malyj Rakovets) IV. sz. lelőhelyen, amely több rétegű paleolit lelőhely. A kulturális adaptáció folyamatában, a területen élő csoportok ismerték és használták a helyi obszidiánt. A rétegtani és talajtani vizsgálatok szerint a területet sokszor felkeresték az őskori és őskori emberek.

KEYWORDS: OBSIDIAN, TRANSCARPATHIA, PALAEOLITHIC, ROKOSOVO, MALYJ RAKOVETS

KULCSSZAVAK: OBSZIDIÁN, KÁRPÁTALJA, ŐSKÖR, RAKASZ, KISTRÁKÓC

Introduction

The territory of the Ukrainian Transcarpathia is part of the Central Europe and the Carpathian Basin. The study of the use and transportation by ancient people of the natural resources of this region is an integral part of the reconstruction of historical events of the past.

Identifying the primary sources of obsidian is one of the main tasks in studying raw material procurement in the prehistoric past of the Carpathian Basin (Nandris 1975; Williams & Nandris 1977; Williams-Thorpe et al. 1984; Kozłowski, 1973, 2013; Biró 1984, 2009; Biró, Dobosi 1991; Féblot-Augustins 1993; Markó 2008, 2009; Dobosi 2011; Moutsiou 2011; Mester 2013; Kaminska 2013; Lengyel 2015; Hughes & Ryzhov 2018; Hughes et al. 2018; Dobrescu et al. 2018).

* How to cite this paper: RYZHOV, Sergii, (2018): Archaeological and geological studies of obsidians in Ukrainian Transcarpathia, *Archeometriai Műhely* XV/3 225-230.

The studies of the obsidians of Transcarpathia are closely related to geological and archaeological research. Tivadar Lehoczky were collected the first collections of obsidian artifacts on the territory of Transcarpathia in the second half of the 19th century. Obsidian artifacts were collected in the area of Mukachevo, Uzhgorod, Serednye, Nelipeno, Dragobratovo, Ardanovo, Ardovets, Beregove, Irshava (Lehoczky 1910; Janšak 1935).

The first obsidian artifacts in the area of the villages of Rokosovo and Malyj Rakovets geologist V. Petrougne were collected in 1948. He will divide obsidian artifacts into two groups: transparent and banded, dark (almost opaque) and banded. V. Petrougne for the first time raises the question of the local origin of obsidian sources (Petrougne 1960).

V. Petrougne performed geological reconnaissance in the area of the villages Rokosovo and Malyj Rakovets in 1967 and for the first time gives a geological and petrographic description of the obsidians of this region. On the south-western outskirts of the Velykyj Sholes Ridge (the mountain watershed between the Tisza, Borzhava and Rika rivers) V. Petrougne discovered two locality of obsidian artifacts (Rokosovo I, II). On based of comparative petrographic characteristics he argues about the local origin of the obsidian raw materials (Petrougne, 1960, 1972).

Geological studies of volcanic formations of Transcarpathia

In the second half of the 20th century, geological studies of volcanic formations take place on the territory of Ukrainian Transcarpathia and geological maps are compiled, works on chronology and stages of volcanic activity are published (Sobolev et al. 1955; Kostyuk, 1960, 1961; Danilovich 1963; Maleev, 1964; Vyalov, 1965; Merlich, Spitkovskaya 1965; Gofshtein, 1964; Mykyta 2014).

Separate studies were devoted to the volcanic glasses of this part of the Carpathians, among which researchers identified obsidians. Comparative petrographic analyzes of the obsidians of Transcarpathia, the Caucasus, and the Far East were conducted (Nasedkin 1963, 1975; Petrougne 1972).

One of the key points regarding the geological structure and stratigraphy of the Transcarpathian region is disagreement about the age of formation or completion of the Vihorlat-Gutyn Range volcanic activity (Gofshtein, 1964; Pécskay et al, 2000; Seghedi et al, 2001; Prikhodko, 2004; Matviishyna & Karmazinenko 2014; Veklich 1999, 2016).

In recent years, dating of the absolute age (K-Ar) of the effusive and subvolcanic formations of the Ukrainian part of the Vihorlat-Gutin Range has been obtained. For the latter, they range from 13.08 ± 0.61 million years to 9.50 ± 0.81 million years. For the region of the Velykyj Sholes Ridge (one of the parts of the Vihorlat-Gutin volcanic range), explorer data determine the time of the last eruption 11.4–9.8 million years ago (Pécskay et al, 2000; Seghedi et al, 2001; Shevchuk, Vasilenko 2014).

Georchaological research of obsidians from Ukrainian Transcarpathia

In 1974, the Korolevo multi-layer Palaeolithic site was discovered. As a result of many years of archaeological and geological research conducted under the direction of Vladislav Gladilin, new Palaeolithic sites were discovered in Transcarpathia (Kulakovskaya 1989; Gladilin, Sitlivyj 1990; Tkachenko 2003). For the Palaeolithic sites of Korolevo, andesite served as the main raw material and only occasionally obsidian artifacts were determined in the cultural layers.

In the 70s-80s of the 20th century, in the area of the villages of Rokosovo and Malyj Rakovets, numerous obsidian artifact localizations on the surface were discovered, the cultural identity of which was determined from the Lower to the Upper Palaeolithic. Most of the archaeological finds were made from local obsidian (Sitlivyj 1989; Gladilin, Sitlivyj 1990).

A distinctive feature of stone artifacts from andesite (hyalodacite) and obsidian at the Palaeolithic sites of Korolevo, Malyj Rakovets and Rokosovo was a different degree of surface preservation. Based on the stratigraphic occurrence, technical and typological characteristics, cell depth, leaching and the degree of surface roughness, the artifacts from andesite and obsidian were divided into cultural and chronological complexes. Thus, most of the obsidian finds collected on the surface in the area of the Velykyj Sholes Ridge (villages Rokosovo and Malyj Rakovets) were correlated with the cultural horizons of the Korolevo Palaeolithic site (Sitlivyj 1989; Gladilin, Sitlivyj 1991; Usik et al. 2014).

In 1989, the stratified multilayered Palaeolithic site of Malyj Rakovets IV was discovered in this area. The most of obsidian artifacts were made from local resources (Petrougne 1972; Sitlivyj 1989). Since 1990, periodic archaeological and geological research has been conducted in the area of the site of Malyj Rakovets IV and the Velykyj Sholes Ridge (Sitlivyj and Ryjov 1992; Ryzhov 2009, 2014a, 2014b).

As a result of perennial archaeological excavations, 8 cultural layers were identified: 0 - Neolithic, Bronze Age; I — Upper Palaeolithic; II, III, IV - Middle Palaeolithic; V, VI, VII - the Lower

Palaeolithic (Ryzhov 2009, 2014a; Stepanchuk et al. 2010; Stepanchuk et al. 2013, Matviyishyna & Karmazinenko 2015).

From 2006 to 2014, palaeopedological surveys of soil and forest deposits were carried out on the territory of the Velykyj Sholes Ridge. In the trench and excavations profile of the Malyj Rakovets IV, the stratigraphic horizons of the Pleistocene and Holocene were traced: Martonosha, Lubny, Zavadovka, Dnipro, Kaidaky, Tyasmin, Priluky, Udayi, Vitachiv, Bug and Holocene. The findings of artifacts from obsidian are mainly confined to deposits of the Martonosha, Lubny, Zavadovka, Kaydaky, Priluky, Vitachiv and Holocene horizons of the Ukrainian stratigraphic scheme (Gozhyk et al. 2012; Matviyishyna and Karmazinenko 2015).

Thus, palaeogeographic and stratigraphic studies of the distribution of artifacts in the cultural layers of the Malyj Rakovets IV confirm the regular use of the local obsidian outcrops throughout the Pleistocene by ancient man (Ryzhov 2014a; Stepanchuk et al. 2010; Matviyishyna & Karmazinenko 2015).

Palaeopedological studies of the multilayered Palaeolithic site of Malyj Rakovets IV indicate the characteristic dependence of the depth of leaching cells and the surface roughness of obsidians on the time of burial in the lithological layer. During of time, the depth of the cells increases and the surface roughness of obsidian increases (hydration). So, for the release of obsidians in the area of the Velykyj Sholes Ridge, a hydration geochronological scheme was developed (Stepanchuk et al. 2013; Ryzhov 2014a, 2014b).

The degree of hydration shows a clear dependence on being in the geological layer. During the excavations of the cultural layers of the Palaeolithic site Malyj Rakovets IV it was recorded the artifacts that were exposed to the sun had a more destroyed surface than the part that was facing the earth. However, the older the artifacts were, the less noticeable was the difference in the surface integrity of the same cultural horizon.

It should be noted that V. Nasedkin conducted experimental studies on the effect of temperature and acid-base composition on the degree of destruction of obsidians. As a result of experimental studies of Armenian obsidians with a refractive index of 1.487–1.492, he was able to establish that a hydrated layer with a thickness of 1.3 mm can be formed within 1 million years (Nasedkin 1975: 62).

In the south-western part of the Velykyj Sholes Ridge, numerous obsidian outcrops were revealed. In the process of geoarchaeological research of this area, it was noted that larger blocks (mostly bombs) are more often found on the southern vicinity of the v. Malyj Rakovets, along small local streams.

The average size of the blocks was 10–20 cm. The maximum sizes of the blocks found were up to 65x45x40 cm. The surface of such a block was littered with a large number of weathering cells with a depth of 6–10 mm and a diameter of 10–15 mm. Weight was 26 kg. On the southern part of the village of Malyj Rakovets, obsidian boulders were found at the one of the sources of the Bukovetskyj stream, deeply falling into the ground. Most likely they exceeded 100 kg.

It should be noted that behind its form all-natural obsidian blocks in the south-western part of the Velykyj Sholes Ridge can be divided into two main types: bomb-shaped and flat-shaped (only in the area of the village Rokosovo).

Bomb-like obsidian forms are often found on southern eroded slopes or sub-horizontal surfaces (villages Maly Rakovets and Rokosovo). Often, obsidian bombs include the remains of red clays. According to some Ukrainian geologists, the remains of red clay in leaching cells may indicate the time of volcanic activity in the area of the Velykyj Sholes Ridge and other areas of Transcarpathia (Veklich 1999, 2016).

Flat-shaped (naturally flattened and no inclusions of red clay) forms of obsidian blocks are more often found along the ravines of fast streams with a large amount of pebble material of tuffaceous origin (village Rokosovo). Very often, these forms of obsidian have a pronounced banded (fluid) structure.

Petrographic and geochemical studies

The first studies of the petrography of obsidians of the Velykyj Sholes Ridge were conducted by V. Petrougne. On the basis of petrographic analysis and preliminary geochemical analysis, V. Petrougne identified obsidians of local origin (Petrougne 1960, 1972).

In 1999, a geochemical analysis of 20 artifacts from the site of Maly Rakovets IV was carried out in the laboratory of X-ray research methods of the Taras Shevchenko National University of Kyiv. Among the artifacts, obsidians were identified, which, by their characteristics and origin, were associated with the volcanic regions of Transcarpathia (Kisilevich et al. 2000; Ryzhov et al. 2005, 2009).

In 2007–2008, thanks to the assistance and cooperation of scientists who dealt with the problems of the origin and transportation of raw materials in archaeology, three geochemical groups of obsidian outputs were identified in Central Europe. Since that time, the obsidian outcrops of the Velykyj Sholes Ridge (villages Rokosovo and Malyj Rakovets) in Ukrainian Transcarpathia belong to the Carpathian 3 geochemical group (Rosania et al. 2008).

In recent years, petrographic, micro, and macroscopic descriptions of obsidians and other volcanic rocks have been carried out in Transcarpathia, which confirm and clarify previous studies (Rácz 2009; Suda et al. 2014; Ryzhov 2014a; Usik et al. 2014; Rácz et al. 2016).

Recently, obsidian artifacts from the Malyj Rakovets IV site and geological obsidian references samples from the territory of the Ukrainian Transcarpathia by non-destructive energy dispersive X-ray fluorescence (EDXRF) analysis was conducted (Hughes & Ryzhov 2018).

As a result, the conclusion was confirmed that the local obsidian raw materials are mainly used by the Upper Palaeolithic communities. However, in the same time the inhabitants of cultural layer I of Malyj Rakovets IV used the exotic obsidian - Carpathian 1. Most likely, during this period, transportation of this material from the eastern regions of modern Slovakia took place (over 80 km).

Conclusions

Archaeological and geological studies of the obsidians of Ukrainian Transcarpathia continue for more than a hundred years. Scientists from different countries took part in the research.

As a result:

- an area of primary obsidian exits was established;
- based on the petrographic and geochemical characteristics a new group of obsidian sources in the Carpathian Basin was identified - Carpathian 3;
- the Palaeolithic site of Malyj Rakovets IV was discovered and provides evidence of use and transportation obsidian throughout the prehistoric times.

References

BIRÓ, K.T. (1984): Distribution of obsidian from the Carpathian Sources on Central European Palaeolithic and Mesolithic sites. *Acta Archaeologica Carpathica* Kraków **23** 5–42.

BIRÓ, K.T., DOBOSI, V.T. (1991): *Lithotheca. Comparative Raw Material Collection of the Hungarian National Museum*, Budapest, Magyar Nemzeti Múzeum, 268 p.

BIRÓ, K. T. (2009): Sourcing Raw Materials for Chipped Stone Artifacts: The State-of-the-Art in Hungary and the Carpathian Basin. In: ADAMS, B. & BLADES, B.S. eds., *Lithic Materials and Palaeolithic Societies*. Oxford, UK: Wiley-Blackwell, 47–53.

DANILOVICH, L.G. (1963): Геолого-петрографічна характеристика вулканічного

комплексу хр. Оаш (Закарпаття). Київ, АН УРСР. 94 pp.

DOBOSI, V. (2011): Obsidian use in the Palaeolithic in Hungary and adjoining areas. *Natural Resource Environment and Humans*, 83–95.

DOBRESCU, R., TUFFREAU, A., & BONSALE C. (2018): The use of obsidian during the Upper Palaeolithic in Northwest Romania. *Anthropologie* (France), **122** 111–128.

FÉBLLOT-AUGUSTINS, J. (1993): Mobility strategies in the late Middle Palaeolithic of central Europe and western Europe: elements of stability and variability. *Journal of Anthropological Archaeology* **12** 211–265.

GOFSHTEYN, I. D. (1964): Неотектоника Карпат. Киев: Изд-во АН УССР. 257 pp.

GOZHYK, P.F., SEMENENKO, V.N., POLETAEV, V.I., IVANIK, M.M., VELIKANOV, V.YA., MASLUN, N.V., SEMENENKO, V.M., KONSTANTINENKO, L.I., ANDREYEVA-GRIGOROVITCH, A.S., ZOSIMOVITCH, V.YU., SHOVKOPLIAS, V.M. (2012): Стратиграфічний кодекс України. Київ, Національний стратиграфічний комітет України. 66 pp.

HUGHES, R. E. & RYZHOV, S. (2018): Trace element characterization of obsidian from the Transcarpathian Ukraine. *Journal of Archaeological Science: Reports* **19** 618–624.

HUGHES, R. E., WERRA, D. H., SULGOSTOWSKA, Z. (2018): On the sources and uses of obsidian during the Palaeolithic and Mesolithic in Poland. *Quaternary International* **468** 84–100.

JANŠÁK, S. (1935): *Praveké sídliska s obsidiánovou industriou na Východnom Slovensku*. Bratislava, 1–193.

KAMINSKA, L. (2013): Sources of raw materials and their use in the Palaeolithic of Slovakia. In: MESTER, Zs. ed., *The Lithic Raw Materials Sources and Interregional Human Contacts in the Northern Carpathian Regions*. Polish Academy of Arts and Sciences, Krakow and Institute of Archaeology Sciences, Kraków-Budapest, 99–109.

KISILEVICH, L.S., KISILEVICH, P.L., (2000) Геолого-геохімічні особливості артефактів палеоантропів стоянки Малий Раковець IV (Закарпаття). *Вісник Київського національного університету імені Тараса Шевченка*, 791(22), 97–99.

KOSTYUK, V.P. (1961): Геолого-петрографічний нарис магматизму Карпат. Видавництво УН УРСР, 157 pp.

KOZŁOWSKI, J. (1973): The origin of lithic raw material used in the Carpathian countries. *Acta Archaeologica Carpathica* **13** 5–19.

KOZŁOWSKI, J.K. 2013: Raw materials procurement in the Late Gravettian of the Carpathian Basin. In: MESTER, Zs. ed.,: *The Lithic Raw Material Sources and Interregional Human Contacts in the Northern Carpathian Regions*. Polish Academy of Arts and Sciences, Kraków-Budapest, 63–85.

KULAKOVSKAJA, L. (1989): Мустьерские культуры Карпатского бассейна. Киев: Наукова думка. 126 pp.

LEHOCZKY, T. (1910): Kőkorszaki leletek Bereg megyében. *Archaeológiai Értesítő* **XXX/2** 154–164.

LENGYEL, Gy. (2015): Lithic raw material procurement at Bodrogkeresztúr-Henye Gravettian site, northeast Hungary. *Quaternary International* 292–303, 359–360.

MALEEV, E.F. (1958): О новейших неотектонических движениях в Выгорлат-Гутинской зоне. Геологический сборник 2-3. Львов: Изд-во Львовского ун-та, 125–127.

MALEEV, E.F. (1964): *Неогеновый вулканизм Закарпаття*. Москва: Наука. 254 pp.

MARKÓ, A. (2008): Raw Material Use at the Middle Palaeolithic Site of Vanyarc (Northern Hungary). *Praehistoria* **9** 183–194.

MARKÓ, A. (2009): Raw material circulation during the Middle Palaeolithic period in Northern Hungary. In: GANCARSKI, J., MUZYCZUK, A. eds., *Surowce naturalne w Karpatach oraz ich wykorzystanie w pradziejach i wczesnym średniowieczu*. Krosno, 107–119.

MATVIYISHYNA, Zh., KARMAZINENKO, S. (2015): The paleogeography of the Palaeolithic site at the Velykyj Sholes Ridge area, Transcarpathia. In: YAMADA, M., RYZHOV, S. eds.,: *Archaeology and Geology of Ukraine in Regional Context/Археология и геология Украины в региональном контексте*. Center for Obsidian and Lithic Studies, Meiji University, Tokyo, 91–159.

MERLICH, B.V., SPITKOVSKAYA, S.M. (1965): Особенности верхнеогенового магматизма глубинных разломов Закарпаття. Геологический сборник Львовского геологического общества 9. Львов: Изд-во Львовского ун-та, 54–68.

MESTER, Zs. (2013): The lithic raw material sources and interregional human contacts in the northern Carpathian regions: aims and methodology. In: Mester, Zs. ed., *The Lithic Raw Material Sources and Interregional Human Contacts in the Northern Carpathian Regions*.

Polish Academy of Arts and Sciences, Kraków-Budapest, 9–21.

MOUTSIU, T. (2011): The obsidian evidence for the scale of social life during the Palaeolithic. Unpublished *PhD thesis*, Royal Holloway University of London. 378 pp.

МЫКТА, М.М. (2014): Характеристика вулканічних комплексів Закарпаття. *Фізична географія та геоморфологія* **4** 29–37.

NANDRIS, J. (1975): A Re-consideration of the South-East European sources of archaeological obsidian. *Institute of Archaeology (University of London) Bulletin* **12** 71–101.

NASEDKIN, V.V. (1975) *Петрогенезис кислых вулканитов*. Москва: Наука. 208 pp.

PÉCSKAY, Z., SEGHEI, I., DOWNES, H., PRYCHODKO, M., MACKIV, B. (2000): K/Ar Dating of calcalkaline volcanic rocks from Transcarpathian Ukraine. *Geologica Carpathica Bratislava*, **52/2** 83–89.

PETROUGNE, V.F. (1960): Из истории применения вулканического стекла (обсидиана) в первобытной технике. *Сборник научных трудов: Криворожский горнорудный институт*, **VIII** 104–115.

PETROUGNE, V.F. (1972): Леваллуазские мастерские обсидиановых орудий Закарпаття и проблемы сырья. *Матеріали XIII конференції Інституту археології АН УРСР, присвяченої 50-річчю Академії Наук Української РСР*. Киев: Наукова думка, 86–92.

PRYCHODKO, M. (2004): Цикличность эволюции неогенового вулканизма и связанного с ним оруденения южной части Мукачевской депрессии (Украинское Закарпатье). *Геолог України* **4** 50–54.

RÁCZ, B. (2009): Закарпатські обсидіани: міфи та реальність. *Acta Beregsasiensis* **VIII/2** 273–278.

RÁCZ, B., SZAKMÁNY, Gy. & BIRÓ, K. T. (2016): Contribution to the cognizance of raw materials and raw material regions of the Transcarpathian Palaeolithic. *Acta Archaeologica Academiae Scientiarum Hungaricae*, **67/2** 209–229.

ROSANIA, C., BOULANGER, M., BIRÓ, K., RYZHOV, S., TRNKA, G., GLASCOCK, M. (2008): Revisiting Carpathian obsidian, *Antiquity*, 82(318), 1986–1988.

RYZHOV, S., STEPANCHUK, V., SAPOZHNIKOV, I. (2005): Raw material provenance the Palaeolithic of Ukraine: state of problem. Current approaches and first results. *Archeometriai Műhely* **II/4** 17–25.

RYZHOV, S.N., MATVIYISHYNA, Zh.N., PUDOVKINA, A.S., LEVCHUK, P.A. (2009): Стратиграфические и планиграфические исследования палеолитической стоянки Малый Раковец IV на Закарпатье. *Vita Antiqua* **7-8** 60–72.

RYZHOV, S. (2014a): Obsidian outcrops in Ukrainian Transcarpathians and their use during the paleolithic time. *ERAUL: Etudes et recherches archeologiques de l'Universite de Liege* **138** 117–133.

RYZHOV, S. (2014b): The Palaeolithic Site of Malyj Rakovets IV in Transcarpathia of Ukraine. In: M. Yamada ed.: *International joint research project, Fieldwork report 2013. Archaeological and Geological Researches in Ukraine*. Nagano, Japan: Center for Obsidian and Lithic Studies, Meiji University, 19–25.

SEGHEDI, I., DOWNES, H., PÉCSKAY, Z., THIRLWALL, M., SZAKÁCS, A., PRYCHODKO, M., MATTEY, D. (2001): Magmagenesis in a subduction related post-collisional volcanic arc segment: the Ukrainian Carpathians. *Lithos* **57** 237–262.

SHEVCHUK, V., VASILENKO, A. (2014): Взаємозв'язок тектонічного розвитку та проявів неогенового магматизму Закарпаття. *Вісник Київського національного університету імені Тараса Шевченка*, 3(66), 15–20.

SITLIVYJ, V.I. (1989) Раннепалеолитические комплексы Малого Раковца в Закарпатье. Четвертичный период, *Палеонтология и археология*. Кишинев, 146–153.

SITLIVYJ, V., RYJOV, S. (1992): The late middle palaeolithic of Malyj Rakovets IV in Transcarpathia. *Archaeologisches Korrespondenzblatt* **22** Mainz, Verlag des Romisch-Germanischen Zentralmuseums, 301–314.

SKUTIL, J. (1935): *Paleolitikum Slovenska a Podkarpatskej Rusi*. Matica Slovenska. Bratislava, 126–135.

SOBOLEV, V.S. et al. (1955): Петрография неогеновых вулканических и гипабиссальных пород Советских Карпат. Киев: Издательство АН УССР. 248 pp.

SOBOLEV, V.S., KOSTIUK, V.P. (1958): К геологии неогеновых вулканических пород Закарпатья. *Труды лаборатории вулканологии АН СССР* **13** 243–254.

SUDA, Y., YAMADA, M., RYZHOV, S., STEPANCHUK, V. (2014): Preliminary report on obsidian petrography from the Transcarpathian region in Ukraine. *Natural Resource Environment and Humans* **4** 21–37.

STEPANCHUK, V., RYZHOV, S., REKOVETS, L., MATVIYISHYNA, Z. (2010): The Lower Palaeolithic of Ukraine: Current evidence. *Quaternary International*, 223–224, 131–142.

STEPANCHUK, V.M., MATVIYISHYNA, Zh.M., RYZHOV, S.M., KARMAZINENKO, S.P. (2013): Давня людина. Палеогеографія та археологія. Київ: Наукова думка. 208 pp.

TKACHENKO, V. (2003) Пізній палеоліт Закарпаття. Шлях, Київ. 166 pp.

USIK, V., RÁCZ, B., KULAKOVSKAJA, L. (2014): Вулканическое сырьё в палеолите Закарпатья: относительная хронология индустрий. Будапешт, 197–206.

VEKLICH, Y.M. (1999): Вік найпізнішої вулканічної діяльності в Україні. Геоморфологія в Україні: новітні напрямки і завдання. Тези доп. Київ: Київський державний університет, 82–84.

VEKLICH, Y.M. (2016): Час завершення вулканічної діяльності в Закарпатті. *Збірник наукових праць УкрДГПІ* **4** 9–23.

VJALOV, O.S. (1965): Глубинные разломы и тектоника Карпат. Геологический сборник 9. Москва: Недра, 21–54.

WILLIAMS-THORPE, O., WARREN, S. E. AND NANDRIS, J. G. (1984): The distribution and provenance of archaeological obsidian in Central and Eastern Europe. *Journal of Archaeological Science* **11** 183–212.

WILLIAMS, O. & NANDRIS, J. (1977): The Hungarian and Slovak sources of archaeological obsidian: an interim report on further fieldwork, with a note on tektites. *Journal of Archaeological Science Quaternary International* 207–219.