GEOLOGICAL BACKGROUND OF THE OCCURRENCES OF CARPATHIAN VOLCANIC GLASS, MAINLY OBSIDIAN, IN EASTERN SLOVAKIA •

A VULKÁNI ÜVEGEK, FŐKÉNT AZ OBSZIDIÁN FÖLDTANI VISZONYAI KELET-SZLOVÁKIÁBAN

BAČO, Pavel.[1], LEXA. Jaroslav[2], BAČOVÁ, Zuzana[1], KONEČNÝ, Patrik[3]
& PÉCSKAY, Zoltán.[4]

[1]State Geological Institute of D. Štúr, Jesenského 8, 040 01 Košice, Slovakia; pavel.baco@geology.sk;
zuzana.bacova@geology.sk

[2]Geological Institute, Slovak Academy of Sciences, Dúbravská cesta 9, 840 05 Bratislava, Slovakia;
geoljalx@savba.sk

[3]State Geological Institute of D. Štúr, Mlynská dol. 1, 817 04 Bratislava, Slovakia; patrik.konecny@geology.sk;

[4]Institute of Nuclear Research, Hungarian Academy of Sciences, Debrecen, Hungary;
pecskay@namafia.atomki.hu

Abstract

Primary natural occurrences of volcanic glass in the region of Eastern Slovakia are associated with other products of silicic (rhyolite, rhyodacite) volcanism. This Upper Badenian to Lower Pannonian volcanism was a part of the bimodal andesite/rhyolite volcanic activity. Products of the silicic volcanism occur as tuffs and pumice tuffs, reworked epiclastic volcanic rocks, rare intrusions and dominantly as extrusive domes that sometimes pass into short and thick lava flows. The volcanic glass associates with intrusive and extrusive forms of silicic volcanism and occurs in massive as well as brecciated forms (e.g. in the type locality of Merník), or as perlite (Brezina, Byšta) and perlite with obsidian (Malá Bara, Viničky). Rarely the volcanic glass can occur in explosive forms of silicic volcanism (obsidian – Hermanovce, Veľká Bara). Fragments of perlite with obsidian and rare obsidian, occurring alone, are a part of reworked rhyolite/rhyodacite tuffs, epiclastic volcanic sandstones and gravels, as well as epiclastic volcanic breccias, all occurring near the municipality of Streda nad Bodrogom. In Quaternary deposits, obsidian occurs around the Cejkov and Brehov villages.

Kivonat

A vulkáni üvegek természetes előfordulása Kelet-Szlovákiában a magas SiO_2 tartalmú (savanyú) vulkanizmussal kapcsolható össze, ami a riolitos, riodácitos vulkanizmussal függ össze. A Felső Badeni időszaktól az Alsó Pannon időszakig terjedő időszakot bimodális, andezites/riolitos vulkánosság jellemezte. A savanyú vulkanizmus termékei a riolittufák és horzsaköves tufák, áthalmozott epiklasztos vulkáni kőzetek, ritkábban intrúziók formájában és uralkodóan mint extrużív kőzettestek, amelyek időnként rövid és vaskos lávakőzetekbe mennek át. Az intruzív és extruzív savanyú vulkanitokhoz kapcsolódó vulkáni üveg tömeges és breccsás formában is előfordul (pl. Merník típus-lelőhelyen),vagy mint perlit (Brezina, Byšta) és perlites obszidián (Malá Bara, Viničky). Ritkábban a vulkáni üveg a savanyú vulkanizmus explozív formájában jelenik meg (obszidián – Hermanovce, Veľká Bara). Az obszidián darabokat tartalmazó perlit és ritkábban a magában előforduló obszidián részét képezi az áthalmozott riolit és riodácit tufáknak, együtt fordul elő az epiklasztos vulkáni törmelékes kőzeteknek és breccsáknak, amelyek Bodrogszerdahely környékén fordulnak elő. A negyedkori üledékekben, másodlagos helyzetben, obszidiánt találhatunk Cejkov és Brehov falvak környezetében is.

KEYWORDS: EASTERN SLOVAKIA, SOURCES OF OBSIDIAN, FACIES POSITION, EVOLUTION OF OBSIDIAN SURFACE

KULCSSZAVAK: KELET-SZLOVÁKIA, OBSZIDIÁN FORRÁSOK, FÁCIES POZÍCIÓ, OBSZIDIÁN FELSZÍN ÉRTÉKELÉSE

• How to cite this paper: BAČO, P.[1], LEXA. J.[2], BAČOVÁ, Z[1], KONEČNÝ, P.[3] & PÉCSKAY, Z.[4], (2018): Geological background of the occurrences of Carpathian volcanic glass, mainly obsidian, in Eastern Slovakia, *Archeometriai Műhely* **XV/3** 157-166.

HU ISSN 1786-271X; urn: nbn: hu-4106

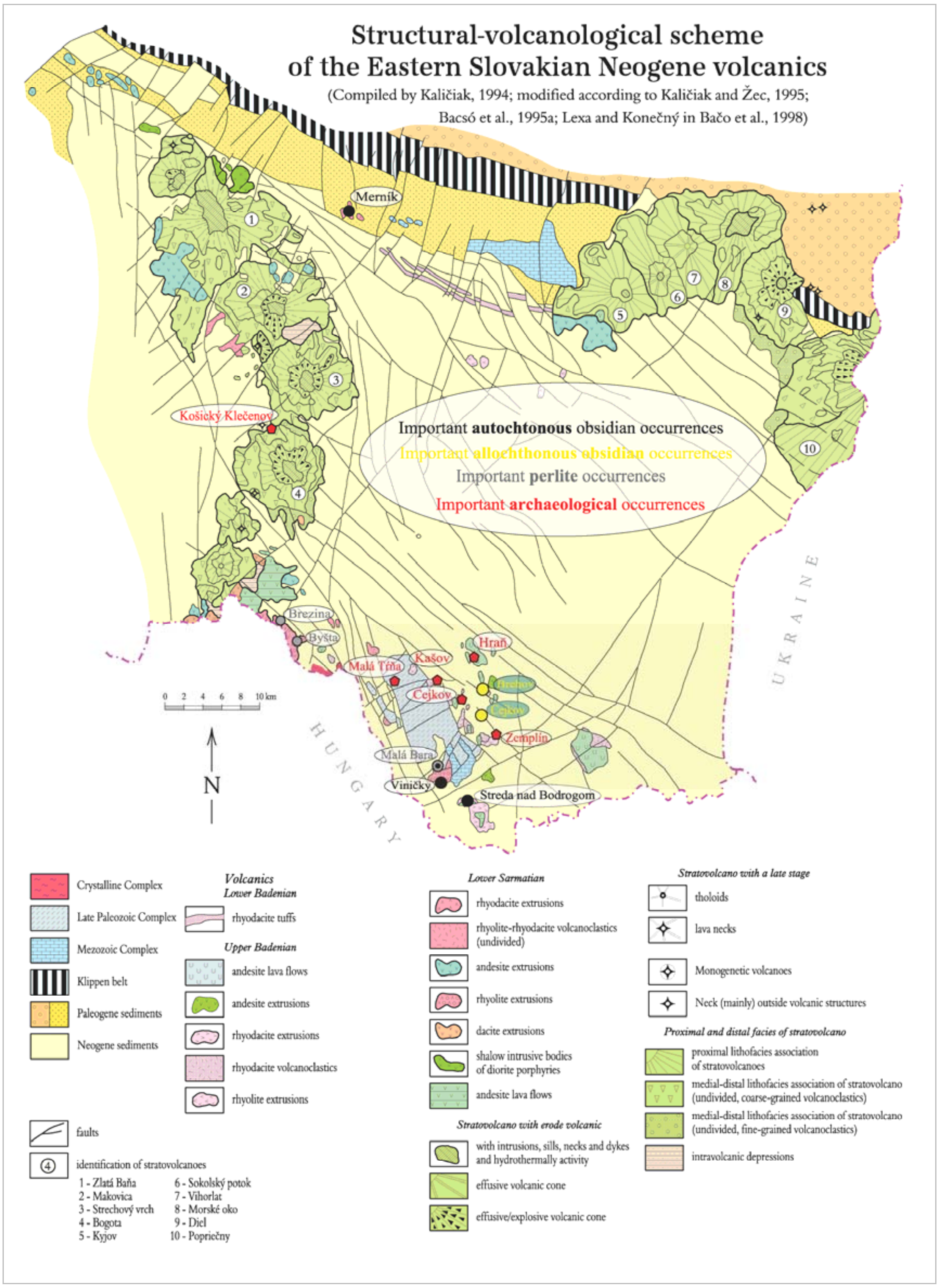


Fig. 1.: Natural obsidian and perlite occurrences in Eastern Slovakia, including the most important archeological sites with obsidian industry. According Bačo et al., 2017, Fig. 4, p. 212. (structural-volcanological scheme compiled by Kaličiak (1994), modified by Kaličiak & Žec (1995), Bacsó et al. (1995), Lexa & Konečný in Bačo et al. (1998).

1. ábra: Természetes obszidián és perlit előfordulások Kelet-Szlovákiában, a legfontosabb obszidián-kőiparral rendelkező régészeti lelőhelyek feltüntetésével. Bačo et al., 2017, Fig. 4, p. 212. nyomán (a szerkezeti vázlatot Kaličiak (1994), állította össze, majd a következő tanulmányok alapján módosítottuk: Kaličiak & Žec (1995), Bacsó et al. (1995), Lexa & Konečný in Bačo et al. (1998).

Introduction

Occurrences of the volcanic glass in the Eastern Slovakia are mainly associated with products of acidic volcanism. It is a part of bimodal andesite-rhyolite volcanism of the Late Badenian to Early Pannonian age (Lexa & Kaličiak, 2000; Pécskay et al., 2006). Rhyolite and rhyodacite volcanism is characterized by pyroclastic rocks in the form of tuffs and pumice tuffs, in minor extent with juvenile and lithic lapilli. Volcanic complex contains also various forms of intrusive, but mainly extrusive bodies with rare transition to lava flows. Previous works about geological position of the obsidian in the area of Eastern Slovakia provided only general information. More detail work, but focused on perlite, is by Šalát & Ončáková (1964). Later works (Kaminská & Ďuďa, 1995; Baňacký et al., 1989) did not describe a detail geological position of the obsidians. The description of obsidian allochthonous occurrences near Cejkov was published only recently (Přichystal & Škrdla, 2014). Various facies positions of obsidians, either primary or secondary, was reported in work by Bačo et al. (2017).

Geological settings

The Middle Miocene Tokaj-Zemplín-Beregovo-Oas field of monogenetic rhyolite volcanoes is an integral part of the Middle/Late Miocene bimodal andesite-rhyolite volcanics associated with a system of horsts and grabens south of the Transcarpathian Basin – a segment in the Carpathian volcanic arc (Lexa et al., 2010). Episodes of rhyolite volcanic activity alternated with activity of andesites and dacites that have given rise to mostly solitary small stratovolcanoes, effusive complexes and extrusive domes. K/Ar ages of andesites, dacites and rhyolites overlap in the interval 13.8 – 9.5 Ma (Pécskay et al., 2006).

The formation of the horst and grabens as well as the volcanism were related to the interplay of subduction, delamination and back-arc extension (Seghedi & Downes 2011). The bimodal andesite-rhyolite volcanic association is interpreted as contemporaneous partial melting of metasomatized lithospheric mantle and crustal source materials as a result of the related tectono-thermal reactivation. Peraluminous rhyolites are of anatectic origin, later affected to various extent by mixing with mafic mantle source magmas and lower pressure AFC *(Assimilation and Fractional Crystallization)* processes (Konečný et al., 2010, Kohút et al., 2017).

Primary natural occurrences of obsidian in the region of Eastern Slovakia associate with other products of silicic (rhyolite, rhyodacite) volcanism that was a part of the bimodal andesite/rhyolite volcanic activity during the Upper Badenian to Lower Pannonian time (Lexa & Kaličiak 2000, Pécskay et al., 2006). Products of the silicic volcanism occur as tuffs and pumice tuffs, reworked epiclastic volcanic rocks, rare intrusions and dominantly as extrusive domes that sometimes pass into short and thick lava flows (dome flows, coulées). Massive as well as brecciated forms of volcanic glass, perlite and obsidian, associate especially with intrusive and extrusive forms of silicic volcanism (Bačo et al. 2017, Fig. 1).

Main sources of volcanic glass

At the Merník locality (**Fig. 1.**) volcanic glass forms marginal parts of various small rhyolite intrusions and dykes at a cinnabar deposit. Directly at the surface it crops out at the northwestern side of the hill Lipová hora, where it forms margin of a rhyolite intrusion as well as several purely glassy dykes. It is of a dark gray color with variable tints, contains xenoliths of surrounding rocks (mostly claystone and sandstones) and is highly fractured. That prevents utilization of the glass for a production of chipped artifacts, though rare massive parts have been identified.

Hydrated volcanic glass – perlite occurs at marginal parts of the extrusive dome Harsas next to the village Byšta and it forms also separate dykes in surroundings of Byšta and Brezina (**Fig. 1.**). However, in this case perlite does not include obsidian cores that could be used for a production of obsidian industry.

Marginal parts of the extrusive dome/flow Borsuk close to the village Malá Bara, but especially in surroundings of the village Viničky host the most important primary occurrences of obsidian in Slovakia. First of all they crop out at the southeastern side of the dome/flow at localities marked as 1, 2 and 3 in the **Fig. 2.** Obsidians always occur along with perlite, usually as obsidian cores in perlite environment.

Lithological setting of the autochthonous obsidian occurrences

The form of obsidian occurrence in the perlite environment could be observed in newly driven (years 2006 – 2007) underground galleries of the Tokaj Viničky ltd. (PROMACO SA) wine cellars. Clearly, obsidian occurs in two types of geological/lithological setting.

The first type of setting is represented by perlitized parts of small rhyolite intrusions and/or dykes (**Fig. 3.**), including a direct continuation of the intrusion with all attributes of obsidian occurrence. The same type of setting could occur elsewhere in surroundings, especially eastward and southeastward at localities 2 and 3 (**Fig. 2.**).

Fig. 2.: Panorama of the SW side of the Borsuk rhyolite dome/flow (rhyolite volcano) next to the village Viničky with obsidian and perlite occurrences, including the Tokaj Viničky ltd.(PROMACO AS) Winecellars, 1,2,3 – obsidian occurrences. View from the southeast. Photo by P. Bačo. According Bačo et al. (2017), Fig. 7, p. 214.

2. ábra: A Borsuk riolit kőzettest (riolit vulkán) DNY oldaláról nyíló kilátás Szőlőske (Viničky) határában, a perlit és obszidián előfordulási helyekkel, a Tokaj Viničky Ltd. (PROMACO AS) 1,2,3 borospincékkel, DK felől. P. Bačo felvétele. Bačo et al. (2017), Fig. 7, p. 214. nyomán.

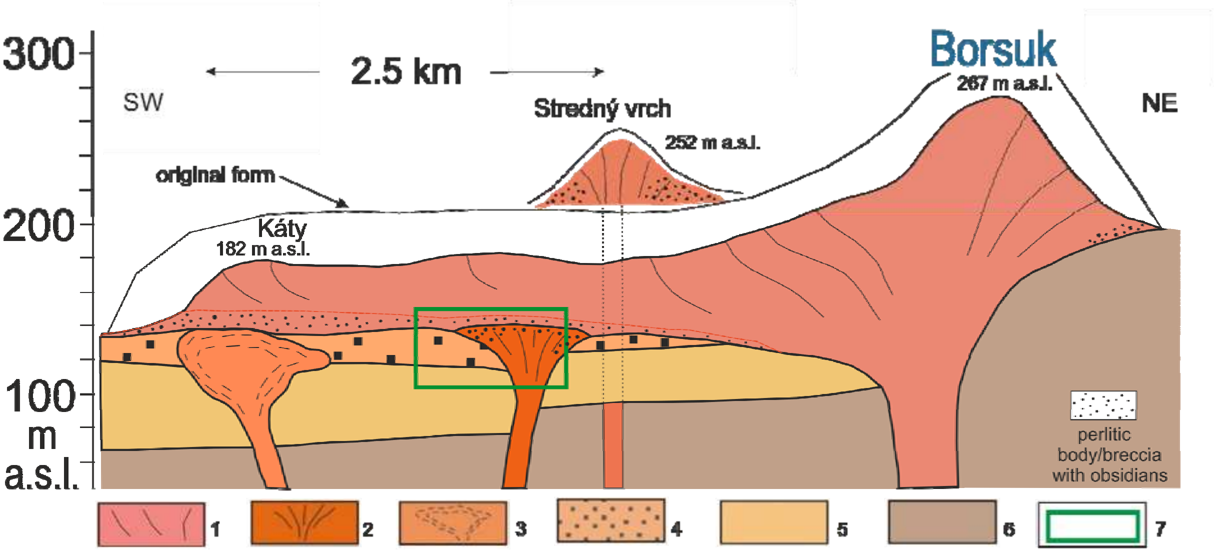


Fig. 3.: Structural cross section of the Viničky rhyolite volcanoes. (modified after Lexa et al. (2014); Fig. 1B, p. 237). 1-Late rhyolite dome and couleé (dome flow), 2-Early rhyolite extrusive dome, 3-Dacite/rhyodacite cryptodome, 4-Coarse proximal facies dacite/rhyodacite phreatic/phreatomagmatic pyroclastic rocks, 5-Distal facies rhyolite tuffs and pumice tuffs, 6-Permian and Triassic basement rocks, 7-Area well documented in walls of the wine-cellar

3. ábra: A szőlőskei (Viničky) riolit vulkánok szerkezeti metszete (Lexa et al. (2014); Fig. 1B, p. 237 nyomán, módosítva). 1 – késői riolit kőzettest és láva, 2 – korai riolit extruzív kőzettest, 3 – dácit / riodácit kőzettest, 4 – durva proximális fáciesű dácit / riodácit freatikus / freato magmatikus piroklasztikus kőzet, 5 – távoli fácieshez tartozó riolit tufák és horzsaköves tufák, 6 – perm és triász korú alapkőzet, 7 – a borpince falában jól dokumentált terület

Fig. 4a, b, c.: Locality Viničky, obsidian nodules showing a progressive evolution of their surface as a function of their position (compare the fig. 6): a – obsidian nodule from the weathered top of perlitized intrusion; b – obsidian nodule from eluvial deposits; c – obsidian nodule with initial surface sculpturing from eluvial/deluvial deposits. Photo by P. Bačo.

4a, b, c. ábra: Szőlőske (Viničky) lelőhely, obszidián gumók felszíne a környezet hatásainak függvényében (v.ö., 6. ábra): a – obszidián gumó a perlitesedett intrúzió felső, mállott részéből; b – obszidián gumó eluviális környezetből; c – obszidián gumó a felszín barázdálódásának kezdeti szakaszából, eluviális / deluviális környezetből. P. Bačo felvétele.

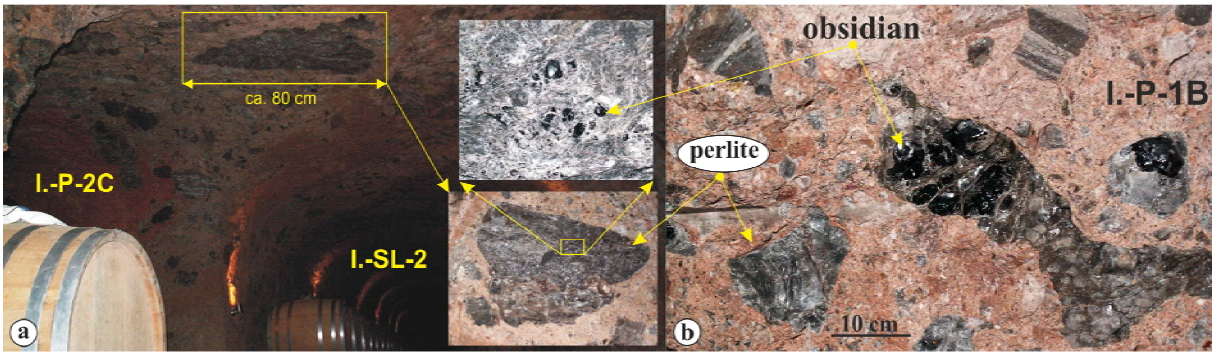


Fig. 5a, b,. Locality Viničky, Tokaj Viničky ltd. winecellars: a, b – autochtonous occurrence of obsidian nodules in perlitic breccias at the base of the Borsuk dome/flow. Photo by P. Bačo.

5a, b. ábra: Szőlőske (Viničky), Tokaj Viničky Ltd. borpincéje lelőhely: a, b – obszidián gumók autochton előfordulása perlit-breccsában a Borsuk kőzettest / lávaár találkozásánál. P. Bačo felvétele.

Intrusions with perlite and obsidian are covered by a thin veneer of eluvial deposits. Gradual weathering of perlite frees enclosed obsidian cores into these eluvial/deluvial deposits. Size of individual obsidian pieces varies in the range 2 mm – 14 cm, with the average size 3 – 5 cm. Not often, however, more frequently as generally assumed, there are present cores 10 cm or more in diameter. Form of obsidian pieces is irregular. Their surface is mostly smooth, patinated, sometimes with rare remnants of perlite. Sculpture of the type, as it is known from the surface of obsidians at archeological sites, is absent (has not been observed). Apparently, the residence time of obsidians in eluvial/deluvial deposits is too short to develop full scale sculpturing. Obsidian in the figure 4a from the top of weathered perlite shows the same type of surface attributes as obsidian cores in fresh perlite. Obsidian nodule in the figure 4b from a higher position shows patinated surface with a minimal rounding of edges and planes that are characteristic of bigger obsidians in perlite. Obsidian nodule in the figure **4c** from the highest position in the section (and the longest expected residence time) shows an initial stage of sculpturing in the form of roughness and small pits.

The second type of setting is represented by perlitic breccias at the base of the Borsuk dome/flow. This type of setting applies also to the locality Malá Bara (**Fig. 1, 2**). Most of the obsidian cores observed in the Tokaj Viničky Ltd. (PROMACO SA) wine cellars occurs in perlitic breccias (**Fig. 5a, b**) that represent base of a thick and extensive rhyolite lava flow with a source at the extrusive dome of Borsuk hill NE of the village Viničky (Bačo e*t al.* 2012). Perlitic breccias are formed of angular blocks of dark to pale perlites up to 3 m in diameter, often with pronounced flow banding, in pinkish matrix of grounded perlitic material. Rarely they include fragments of underlying pyroclastic rocks. In these breccias obsidian occurs as fragments up to 10 – 15 cm in diameter, much smaller on the average.

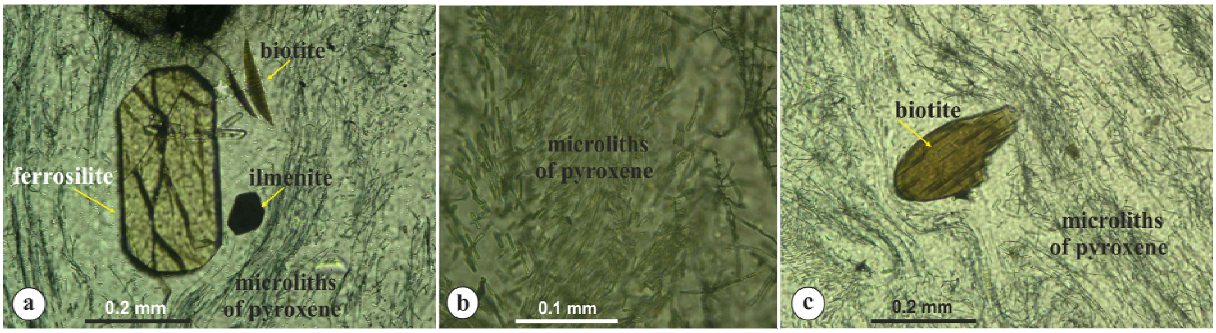


Fig. 6a, b, c.: Locality Viničky: microphotographs of obsidian thin-section (transmitted light, one nicol). Photo by P. Bačo.

6a, b, c. ábra: Szőlőske (Viničky) lelőhely: obszidián vékonycsiszolata (áteső fényben, 1 Nikol). P. Bačo felvétele.

Planes of obsidian fragments are variably convex or concave, smooth and glossy. At freshly broken surface they are black or pitch black with a pronounced conchoidal fracture.

Using a microscope one can observe in obsidian rare microphenocrysts of biotite, plagioclase, rare Fe-orthopyroxene (ferosilite) and ilmenite (**Fig. 6a, c**). Frequently observed banded texture or alternation of dark and pale streaks is caused by flow oriented minute crystals – microlites and trichytes (**Fig. 6b**), mostly of pyroxene composition. This internal fabric of obsidian glass is a probable cause of sculpturing if the glass is exposed to weathering.

Lithological setting of the allochthonous obsidian occurrences

Rare and generally small cores of obsidian enclosed in perlite fragments (marekanites) of breccias at the base of the same rhyolite lava flow occur also on its northern side, south of the village Malá Bara. However, in this case the small size of obsidian cores prevented its utilization for a production of obsidian industry.

Perlite with cores of obsidian, known also under the name "marekanite" (**Fig. 7a, b**) occurs in an abandoned quarry north of the city Streda nad Bodrogom. Fragments of perlite with obsidian as well as obsidian alone are a part of reworked rhyolite/rhyodacite tuffs, epiclastic volcanic sandstones and gravels and epiclastic volcanic breccias laid down as a submarine landslide. So the perlite and obsidian fragments are not at the place of their origin. Size of obsidian cores varies in the range 0.5 – 5 cm with the average size around 2.5 cm. Obsidian cores at this locality show many attributes that are characteristic of obsidians at the locality Viničky, as there are occurrence in the form of cores in perlite, color, luster and conchoidal fracture. The Viničky locality was generally accepted as probable source. However, results of K/Ar dating point to a different age and yet unknow primary source (Bačo et al., 2017).

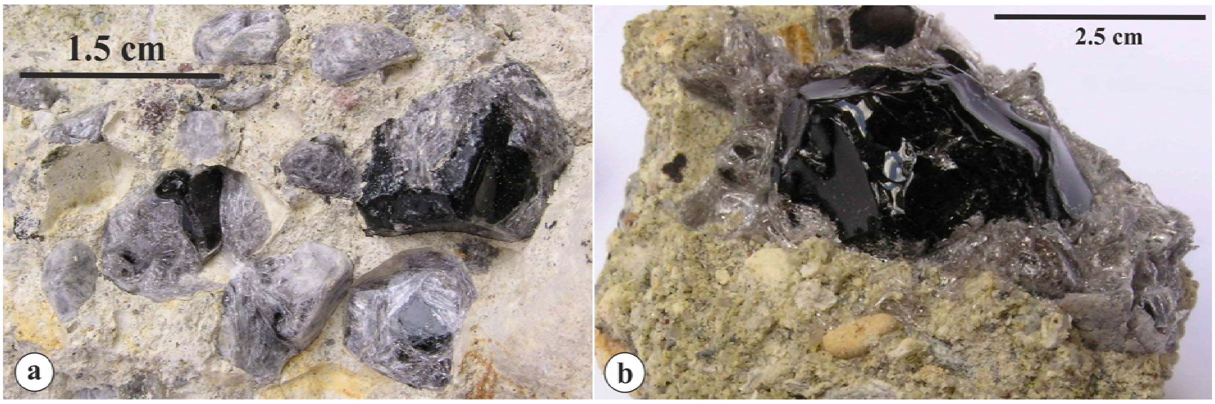


Fig. 7a,b.: Locality Streda nad Bodrogom, abandoned quarry: a, b – obsidian in perlite shell (marekanite) occurring as fragments in reworked polimict rhyolite volcanoclastic rocks. Photo by P. Bačo.

7a, b ábra: Bodrogszerdahely (Streda nad Bodrogom), felhagyott bánya: a, b – perlitben előforduló obszidián szemek (marekanit) törmelékként az áthalmozott polimikt rioltos vulkanoklaszt kőzetben. P. Bačo felvétele.

Fig. 8a,b.: Locality Cejkov – Malé lúky-Žihľavník: a – finding position of obsidian nodule; b – surface sculpturing reflecting its fluidal texture. Dimensions: 5.1 x 4.6 x 4.0 cm. Photo by P. Bačo.

8a, b ábra: Céke (Cejkov) – Malé lúky-Žihľavník lelőhely: a – obszidián gumó lelőkörülmények; b – felszíni barázdáltság a fluidális szövet nyomaival. Méretek: 5.1 x 4.6 x 4.0 cm. P. Bačo felvétele.

Fig. 9.: Locality Brehov – Za alejou: isometric, moderately sculptured obsidian nodules. Mass/dimensions: 128 g / 3.9 x 5.2 x 5.4 cm; 68 g / 3.3 x 3.9 x 4.0 cm; 76 g / 3.9 x 4.3 x 4.6 cm . Photo by P. Bačo.

9. ábra: Imreg (Brehov) – Za alejou lelőhely: izometrikus, kevéssé barázdált felszínű obszidián gumók. Tömeg / méretek: 128 g / 3.9 x 5.2 x 5.4 cm; 68 g / 3.3 x 3.9 x 4.0 cm; 76 g / 3.9 x 4.3 x 4.6 cm . P. Bačo felvétele.

Obsidian at secondary natural occurrences

The area with obsidian fragments and nodules at secondary naturally position extends SW of the village Brehov, nowadays in cadaster of the village Cejkov. Š. Janšák (1935) recognized the locality „as one of the richest finding places in Eastern Slovakia“. Raw, unworked obsidian occurs as grains/nodules of variable size from tiny gains 0.5 – 1 mm in diameter to nodules 8 cm in diameter, rarely with mass over 1 kg. Their surface shows a variety of sculpturing (**Fig. 8.**), often identical with remnants of sculpturing on worked obsidian nodules at archeological localities. That lead A. Přichystal & P. Škrdla (2014), who have studied this locality in a great detail, to consider this locality as a possible principal source of obsidian for the obsidian industry at the Palaeolithic/Neolithic archeological sites of Central Europe (C1a subgroup of Biró & Kasztovszky (2013) and Kasztovszky et al. (2014).

Obsidians in Quaternary deposits northwest of the village Brehov – area „Za alejou“ represents a second concentrated occurrence of obsidian in surroundings of Brehov. It was discovered during exploration for base metal ores (Bacsó et al. 1995) that included trenching. In this case obsidian fragments and nodules (**Fig. 9.**) occur in loamy weathered and argillized rhyodacites and their breccias. These are covered by eolian sands in thickness up to 2 m. Size of obsidian fragments and nodules varies in the range 5 mm to 10 cm, around 5 cm on the average. Their surface shows usually sculpturing. Obsidians with less developed sculpturing (**Fig. 9**., middle piece) are present too. Form of obsidian fragments and nodules is irregular, dominantly isometric (**Fig. 9.**). Sculpturing is less pronounced than on obsidians at archeological sites. Important there is an absence of flakes in the horizon with obsidian, though at the surface they are present. Areal extend of the occurrence is several hectares and we can't exclude other ones in close surroundings. Obsidian in the form of sculptured fragments/nodules is quite frequent, often of relatively large size. Brehov is the locality with the largest fragments/nodules of sculptured obsidians. Geological setting, amount and size distribution of obsidian fragments/nodules at the Brehov locality points to an analogical (not similar) allochthonous occurrence as in the case of the Cejkov locality.

Discussion

Surroundings of Viničky, respectively southern slopes of the hills Borsuk and Katy, is the most important autochthonous occurrence of obsidian in the Zemplinske vrchy Mts. area.

Based on observations in the Tokaj Viničky Ltd. wine cellars obsidian nodules occur in two geological/lithological settings. Those related to perlite breccias at the base of the rhyolite lava flow could be more widespread. Their possible exposures are nowadays obscured by vineyards.

The problem, whether the Viničky locality was or could be a sole source of obsidian in the Zemplinske vrchy Mts. area for obsidian industry at archaeological sites remains open (Bačo et al. 2003, Přichystal 2009, Bačo et al., 2017).

However, owing to a short residence time of obsidian nodules in eluvial/delluvial deposits above the primary source there was not enough time to develop sculpturing that is characteristic for majority of obsidian raw material pieces with the Zemplinske vrchy Mts. provenance at archaeological sites. Sculpturing originated in the secondary environment where obsidian is exposed to long lasting weathering. In Viničky we can't exclude entirely a possibility of repeated reworking of the weathered out obsidian nodules during the Late Sarmatian and Pannonian time and in that case also evolution of sculpturing. These deposits have not been observed. Also, reworking could not bring obsidians to the area of Cejkov and Brehov where the two most extensive secondary occurrences of obsidian are present (Janšák 1935, Bacso et al. 1995a, b, Bačo et al. 2003, Přichystal & Škrdla 2014). Primary source of obsidians at both allochthonous localities remains unknown.

Conclusions

Careful description of primary and secondary natural occurrences of volcanic glasses allows for following conclusions:

There are two primary sources of obsidian nodules at the Viničky locality related to two phases of rhyolite volcanic activity. Perlitic breccias with obsidian nodules at the base of the Borsuk dome/flow represent the older source. Perlitized margins of small intrusions with obsidian nodules represent the younger source. Absence or rudimentary development of sculpturing on the surface of obsidian nodules is characteristic for both sources.

Allochthonous obsidians and associated perlite (marekanites) at the locality Streda nad Bodrogom are older than obsidians and perlites at other natural and archeological localities. They do not have equivalents among obsidians at archeological sites and we do not know their source.

There are two known allochthonous occurrences of obsidian nodules in Quaternary deposits around Cejkov and Brehov: Cejkov – Malé lúky-Žihľavník and Brehov – Za alejou. Theirs, at the moment hypothetical, primary source was in the Brehov area.

Evolution of rhyolite volcanic activity in the region of Zemplín Hills is more complex as previously assumed. Owing to changing paleogeography it could create secondary obsidian accumulations in an unexpected way. We can't exclude surprise findings in future, including new, yet unknown sources of volcanic glasses.

References

BACSÓ Z., KALIČIAKOVÁ E., KOŠARKOVÁ M., SELIGA J., KOMOŇ J., STAŇA Š., ZEMAN I., VELICH R., ZLINSKÁ A., (1995a): Subvulkanické telesá východného Slovenska, polymetalické, drahokovové, vzácnokovové a ortuťové rudy. [Sub-volcanic bodies of Eastern Slovakia, polymetallic, precious and mercury ores. Open file report, in Slovak] Záverečná správa. Geologický ústav Dionýza Štúra. Bratislava. 239s.

BACSÓ, Z., MALACHOVSKÝ, P., HRINKOS. V., REPČIAK M., KALIČIAKOVÁ E., KOŠARKOVÁ M., SELIGA J., KOMOŇ J., STAŇA Š. & ZLINSKÁ A. (1995b): Brehov – západ. [Brehov - west - polymetalic ores, a search survey as of 15.4.1995. Open file report, in Slovak] Záverečná správa. Geologický ústav Dionýza Štúra. Bratislava. 206s.

BAČO, P., BAČOVÁ, Z., KONEČNÝ, P. & KONEČNÝ, V. (2012): Extruzívne teleso ryolitu Borsuk pri Viničkách, Banské diela. [Rhyolite extrusive body Borsuk close to village Viničky, mining works. Open file report, in Slovak] *Čiastková záverečná práca,* Geofond, ŠGÚDŠ, Bratislava, 1–82.

BAČO, P., KAMINSKÁ, Ľ., LEXA, J., PÉCSKAY, Z., BAČOVÁ, Z. & KONEČNÝ, V. (2017): Occurrences of Neogene Volcanic Glass in the Eastern Slovakia – Raw Material source for the Stone Industry. *Anthropologie* **LV/1-2** 207–230.

BAŇACKÝ, V., ELEČKO, M., KALIČIAK, M., STRAKA, P., ŠKVARKA, L., ŠUCHA, P., VASS, D., VOZÁROVÁ, A. & VOZÁR, J. (1989): *Vysvetlivky ku geologickej mape južnej časti Východoslovenskej nížiny a Zemplínskych vrchov* 1:50 000. Vydavateľstvo GÚDŠ, Bratislava, 143s.

BIRÓ, K. T. & KASZTOVSZKY, Zs. (2013): Obsidian Studies Using Nuclear Techniques in Hungary. *Science for Heritage. Newsletter* No.**1** December. Zagreb 2013: 6–9.

JANŠÁK Š. (1935): *Praveké sídliská s obsidiánovou industriou na východnom Slovensku.* [Prehistoric settlements with obsidian industry in Eastern Slovakia, in Slovak] Bratislava 1935. Jan Pociska et al., Bratislava, 330s.

KASZTOVSZKY. Zs., BIRÓ, K. T. & KIS Z. (2014): Prompt Gamma Activation Analysis of the Nyírlugos obsidian core depot find. *Journal of Lithic Studies* **1/1** 151–163.

KOHÚT, M., MIKUŠ, T., MILOVSKÁ, S., ŠURKA, J., KONEČNÝ, P., HOLICKÝ, I., KOLLÁROVÁ, V., JESENÁK, K., DRÁBIK, M. & BAČO, P. (2017): Geochémia obsidiánov Východného Slovenska - časť 2.: Odlišnosti v zložení skla a horniny, [Geochemistry of the obsidians from the Eastern Slovakia - Part 2: Differences in composition of glass and rock, in Slovak] *Konferencia Geochémia* ŠGÚDŠ 79–82.

KONEČNÝ, P., BAČO, P. & KONEČNÝ, V. (2010): Acid Miocene volcanism in the Eastern Slovakia, variable sources and magma forming processes: constraints from petrology and geochemistry. In CHATZIPEROS, A. et al. (eds.), XIX CBGA congress abstract volume, *Geologica Balcanica* **39** 199–200.

LEXA, J. & KALIČIAK, M. (2000): Geotectonic aspects of the Neogene volcanism in Eastern Slovakia, *Mineralia Slovaca* **32/3** 205–210.

LEXA, J., SEGHEDI, I., NÉMETH, K., SZAKÁCS, A., KONEČNÝ, V., PÉCSKAY, Z., FÜLÖP, A. & KOVACS, M. (2010): Neogene-Quaternary Volcanic forms in the Carpathian-Pannonian Region: a review. Central European *Journal of Geosciences* **2** 207–270.

PÉCSKAY, Z., LEXA, J., SZAKÁCS, A., SEGHEDI, I., BALOGH, K., KONEČNÝ, V., ZELENKA, T., KOVACS, M., PÓKA, T., FÜLÖP, A., MÁRTON, E., PANAIOTU, C. & CVETKOVIC, V. (2006): Geochronology of Neogene magmatism in the Carpathian arc and intra-Carpathian area. *Geol. Carpathica* **57/6** 511–530.

PŘICHYSTAL, A. & ŠKRDLA, P. (2014): Kde ležel hlavní zdroj obsidiánu v pravěku střední Evropy?, (Where was situated the principal source of obsidian in prehistory of Central Europe?) *Slovenská archeológia* **62** 215–226.

SEGHEDI, I. & DOWNES, H. (2011): Geochemistry and tectonic development of Cenozoic magmatism in the Carpathian-Pannonian region. *Gondwana Research* **20** 655–672.

ŠALÁT, J. & ONČÁKOVÁ P. (1964): *Perlity, ich výskyt, petrochémia a praktické využitie.* GÚ SAV, Bratislava. 147s.

GEOLOGY OF TOKAJ MOUNTAINS OBSIDIANS•

A TOKAJI-HEGYSÉGI OBSZIDIÁNOK GEOLÓGIÁJA

SZEPESI, J.[1,2], LUKÁCS, R.[1], T. BIRÓ, K.[3], MARKÓ A.[3], PÉCSKAY, Z.[2]
& HARANGI, Sz. [1,4]

[1]MTA-ELTE Volcanology Research Group, 1117 Pázmány Péter sétány 1/c Budapest, Hungary;
szepeja@gmail.com; reka.harangi@gmail.com

[2]Institute of Nuclear Research, Hungarian Academy of Sciences, Debrecen, Hungary; pecskay@mta.atomki.hu

[3]Hungarian National Museum 1088 Budapest, Múzeum krt. 14-18, Hungary, tbk@hnm.hu,
marko.andras@hnm.hu

[4]Department of Petrology and Geochemistry, Eötvös University, Budapest, Hungary,
szabolcsharangi@gmail.com

Abstract

Tokaj Mountains (TM) is well known for the occurrence of the Carpathian Obsidian. This paper presents a general stratigraphy, geochronology and lithology framework for Miocene volcanic successions associated with obsidian formation in the area. Specific localities were chosen to show an accurate description of the geological settings. The primary occurrences are related to deposits of the Sarmatian – Lower Pannonian silicic effusive and explosive volcanism in the area of Szerencs and Erdőbénye - Erdőhorváti Caldera. The lava bodies are flow or dome like in morphology and were built-up during the several phases between 12.8±0.5 and 10.6±0.5 Ma. The Lebuj and Rókabérc localities contain obsidian marekanite (0,5-3 cm) nested in banded perlite that developed in the medial and basal, glassy part of the flow sequences. The pumice rich volcanoclastic deposits also contains fresh, angular obsidian lapilli (<cm, Meszes Hill). These clasts were incorporated from lava domes by pyroclastic flows during the caldera-related explosive eruptions. The allochthonous localities have a widespread areal distribution around the lava dome sequences with larger obsidian nodules (up to dm, Tolcsva, Erdőbénye, Olaszliszka, Mád). Due to the size range of the allochthonous obsidian fragments, the described primary occurrences cannot be considered as obsidian sources. Instead, currently unrevealed glassy parts of the latest rhyolite effusions are assumed to be the major suppliers of secondary sites.

Kivonat

A Tokaji-hegység a kárpáti obszidián jól ismert, régóta vizsgált lelőhelye. Jelen tanulmányunk átfogó összefoglalást ad a miocén vulkáni sorozat általános vulkano-sztratigráfiai, geokronológiai és a kőzettani viszonyairól. A kiválasztott előfordulások jól szemléltetik az obszidián lelőhelyek földtani jellemzőit. Az elsődleges előfordulások a szarmata-alsó pannon effuzív és explozív jellegű riolit vulkanizmus kőzetsorozataihoz kapcsolódnak a Szerencs, valamint az Erdőbénye-Erdőhorváti kaldera területén. A lávaár és lávadóm vulkáni formák több egymást követő fázisban képződtek 12.8±0.5 és 10.6±0.5 millió év között. A Lebuj és Rókabérc előfordulások fluidális perlitben megjelenő ún. marekanitokat tartalmaznak (0.5-3cm), amelyek a savanyú lávaárak belső üveges, illetve a fekü közelében kifejlődött ún. bázis övéhez kapcsolódnak. A horzsakőben gazdag vulkáni tufák szintén tartalmaznak üde, szögletes obszidián lapilliket (<cm, Meszes). Ezek a litoklasztok közeli üveges lávadómokból származtathatók, amelyeket a kaldera beszakadásokat kísérő piroklaszt árak szállítottak tovább. A másodlagos (allochton) előfordulásokat nagyobb méretű obszidián darabok jellemzik (akár dm) és ezeket jelentősebb távolságban is megtaláljuk a láva dóm sorozatok környezetében (Tolcsva, Erdőbénye, Olaszliszka, Mád). A különböző másodlagos lelőhelyekről leírt obszidiánok méretét vizsgálva megállapítható, hogy a jellemzett elsődleges előfordulások nem lehettek ezek forrásrégiói. Feltételezhető azonban, hogy az effuzív riolitos vulkanizmus jelenleg feltárásban nem vizsgálható üveges lávatestei a másodlagos előfordulások legfontosabb forrásai.

KEYWORDS: OBSIDIAN, PERLITE, RHYOLITE, CALDERA, LAVA DOME

KULCSSZAVAK: OBSZIDIÁN, PERLIT, RIOLIT, KALDERA, LÁVADÓM

• How to cite this paper: SZEPESI, J., LUKÁCS, R., T. BIRÓ, K., MARKÓ, A, PÉCSKAY, Z.& HARANGI, Sz., (2018): Geology of Tokaj Mountains obsidians, *Archeometriai Műhely* **XV/3** 167-180

Introduction

Obsidian is primary, non-hydrated volcanic glass, its formation is related to fast quenching of lavas with elevated silica content (>70%). Perlite is the hydrated variety of the silicic glass that can develop during and after solidification via water diffusion into the glass (up to 5 % H_2O). Tokaj Mountains (or Tokaj-Zemplén Mountains, Lóczy 2015) is a well-known occurrence of the Carpathian obsidians which are usually associated with perlite. The classic localities are in the famous wine region of Tokaj-Hegyalja. Its geological recognition is dated back to 18th century (Townson 1798, Esmark 1797, Beudant 1822). Szabó (1866, 1867, 1876) and Szádeczky (1886) reported the first detailed geological studies summarizing the knowledge about the geological settings and major occurrences of the obsidians. After these works, the geological and raw material research mainly focused on the volcanoclastics and hydrated, perlitic glass deposits (I. Perlaki 1972). The obsidians have received more attention in recent years due to its archaeological importance. Beside the comprehensive analytical research of them (Biró et al. 2005, Kasztovszky et al. 2008, 2014, 2018), their geological-volcanological context remain unstudied. The ongoing volcanological field survey of the MTA-ELTE Volcanology Research Group in the Tokaj Mountains (Szepesi et al. 2016 a, b 2017) also identified and described volcanic glass bearing outcrops in the southern part of TM. The mapping work recognized the primary outcrops and reworked, allochthonous materials. As a first result, the present paper gives a brief review of obsidian occurrences with their geological settings and interpretation of formation in the distinct volcanological environments. On the ground of our fieldwork-based experience we attempt to explain the processes related to the origin of secondary sources. Furthermore, we give a basic data for the further source correlation studies.

Geological settings

TM is located in north-eastern part of the Carpathian Pannonian Region and is the southern part of the Tokaj-Slanske Mts. which is roughly perpendicular to the orogenic belt of the Carpathians. The TM extends until the Hungarian-Slovakian border. It is a composite volcanic area that is bounded by the Hernád, Bodrog and Ronyva tectonic lines (**Fig. 1.**) that created its 15-25 km wide, faults aligned graben-like structure (Gyarmati, 1977, Kaličiak and Žec 1995, Gyarmati and Szepesi 2007, Zelenka et al. 2012). The volcanic formations continue towards western and eastern direction under the sedimentary cover of Bodrogköz and Hernád valley. The region evolved at the eastern part ALCAPA microplate (Horváth 1995) as part of the Central Parathetys realm and is connected to the Eastern Slovakian Basin of the Transcarpathian Depression (Vass et al. 1988, Kováč et al. 2007).

The calc-alkaline volcanic activity occurred between the Late Badenian and Early Pannonian period in the TM (15-9.4 Ma Pécskay et al. 1987, 2006, Pécskay & Molnár 2002; Lexa et al. 2010). While the Slanskè Mountains is dominated by andesitic volcanism, the TM and the neighbouring Zemplín Hills (Bačo et al. 2017, 2019 in this volume) represent coeval intermediate to silicic volcanic activity. The latest palaeovolcanic reconstruction (Zelenka et al. 2012) is based on detailed volcanological, petrological geochemical and geophysical investigations and defined the major evolutionary stages and eruptive centres of the succession. The volcanism involved explosive and effusive activity and the palaeovolcanic environment gradually changed from submarine to subaerial.

The first Badenian explosive eruptions were phreatomagmatic, they produced extensive rhyo-dacitic and rhyolitic ignimbrite sheets that covered large areas (Lexa et al. 2010, Zelenka et al. 2012). The following, widespread Sarmatian ignimbrites and related lava dome edifices are the most frequent obsidian sources. The associated large eruptive centres are at the northern (Hegyköz, Perlaky 1972), middle (Erdőbénye - Erdőhorváti) and the southern part (Szerencs Caldera, Zelenka et al. 2012) of the mountains. The accompanying lava dome building extrusions (blue coloured, **Fig. 1.**) occurred at the early and late stage of the eruptive cycles (Telkibánya, Kishuta, Erdőhorváti, Mád, Bodrogkeresztúr).

Coeval andesitic composite volcanoes with eroded/collapsed calderas occur in the northern (Hollóháza), central (Regéc-Baskó) and southern (Mád) segments of the TM. Several subvolcanic bodies (andesite-dacite) intruded into the volcanoclastic succession (Tállya-Kopasz Hill, Gönc-Hársas). The youngest ignimbrite horizon (Vizsoly Tuff) is bounded to a N-S striking fracture zone along the Hernád Through (Zelenka et al. 2012). The volcanic activity terminated by pyroxene-dacite cones (Tokaj, Szegi), olivine bearing andesite domes (Erdőbénye) and a basaltic dike (Sárospatak).

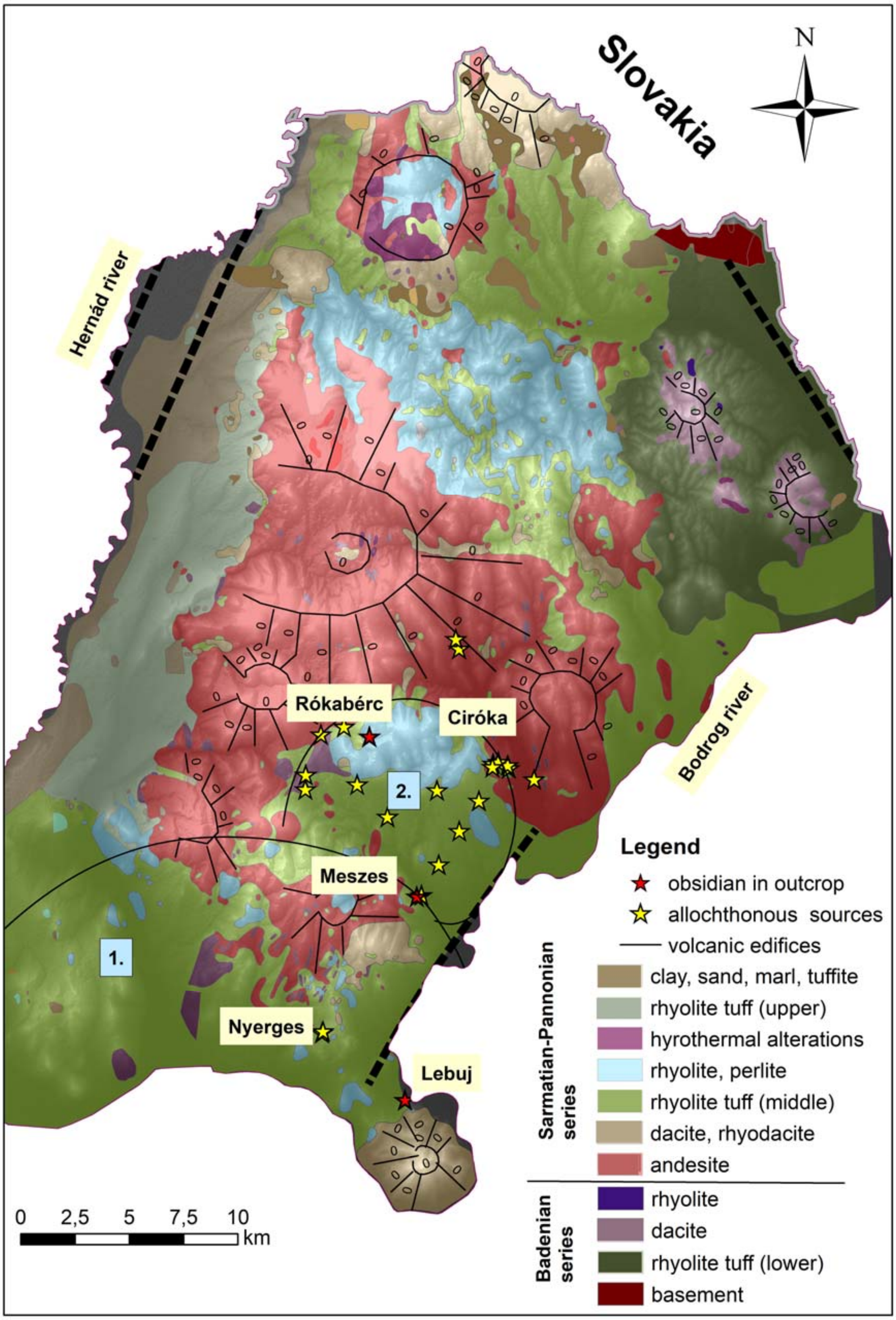


Fig. 1.: Geological scheme of the Tokaj Mountains with the major volcanic centres, Based on Gyarmati 1977, Lexa et al. 2010, Zelenka et al. 2012, 1. Szerencs Caldera, 2. Erdőbénye-Erdőhorváti Caldera

1. ábra: A Tokaji-hegység földtani térképe a legfontosabb vulkáni központokkal, Gyarmati 1977, Lexa et al. 2010, Zelenka et al. 2012 alapján módosítva, 1. Szerencs kaldera, 2. Erdőbénye-Erdőhorváti kaldera

Methods

The current investigation involved detailed fieldwork sampling and compilation of geochronology database to establish a general stratigraphic framework for the obsidian occurrences. Fieldwork was carried out using 1:10 000 scale topographic and the 1:25 000 geologic maps (Erhardt et al. 1964, Gyarmati 1971, Gyarmati et al. 1968, Gyarmati & Zelenka 1968, 1970, Pentelényi 1968). The lithologic (e.g. glassy/microcrystalline texture) and volcano-sedimentology (e.g., massive/bedded lapilli tuff) features were used to distinguish lithofacies units. The obsidian bearing lithofacies zones investigated in detail (**Fig. 1.**). Collected samples were cut to document macroscopic scale features and then thin sections were made from their particular parts. Petrographic descriptions were made using combined optical microscopy observations and back scattered electron imaging (AMRAY 1830, EDAX PV9800 spectrometer) at the Dept. Petrology and Geochemistry, Eötvös University using 20 kV voltage. The K-Ar geochronology data were compiled from literature (Pécskay et al. 1987, 2006, Pécskay and Molnár 2002) and linked to previously described volcanic forms (Zelenka et al. 2012).

Results

The former TM fieldworks (I. Perlaki 1972, Szepesi et al. 2016, 2017) predicted and identified obsidian sources only in the southern part of the mountains. The current research identified 22 obsidian sites (**Fig. 1.**) from the southern TM, in the area of the Szerencs and Erdőbénye-Erdőhorváti Caldera. Based on previous works (Zelenka 1964, Gyarmati and Zelenka 1968) the general stratigraphic profile was compiled for both successions (**Fig. 2.**). The registered elevations of the outcrops varied between 90-400 m above sea level and are related to different stratigraphic segments of the caldera successions (**Fig. 2.**). The previous radiometric dating sampled the rhyolites from the surroundings of the obsidian localities (**Table 1., Fig. 2.**). The Szerencs Caldera rhyolites formed between 12.8-11.6±0.5 Ma, while the slightly younger and smaller volcanic centre of Erdőhorváti-Erdőbénye Caldera evolved between 11.8-10.6±0,5 million years.

According to Szádeczky (1886) two types of occurrences can be distinguished in the area: primary outcrops containing obsidians and secondary, allochthonous sources where the obsidian was found in the deluvial sediments or soil. The localities from northern part of TM were reported as primary sources by Szádeczky (1886) and recognized to variably hydrated perlite deposits. The following part describes five localities which are representative for the TM obsidians.

Table 1.: Geochronology data of Szerencs Caldera and Erdőbénye lava domes/flows, for lithostratigraphy correlation see **Fig. 2.**

1. táblázat: A Szerencs és Erdőbénye-Erdőhorváti kaldera lávadóm/lávaár előfordulásainak geokronológiai adatai, rétegtani korreláció a **2. ábra** alapján

Volcanological unit	**Locality**	**rock type**	**Age**	**±1σ**	**Reference**
Erdőbénye-Erdőhorváti Caldera lava domes	Szokolya	rhyolite	10.6	0.5	unpublished
	Nagy-Páca	rhyolite	11.2	0.5	Pécskay et al. 1987
	Bh. Eh-13 106-114.8	rhyolite	11.0	0.4	Pécskay et al. 1987
	Fenyves road	rhyolite	11.5	0.5	Pécskay et al. 1987
	Vörös peak	rhyolite	11.8	0.4	Kiss et al. 2010
Szerencs Caldera lava domes	Harcsa Hill	rhyolite	10.8	0.8	Pécskay & Molnár 2002
	Király Hill	rhyolite	11.6	0.6	unpublished
	Lebuj, Tokaj Hill	rhyolite	11.6	0.6	Pécskay et al. 1987
	Terézia Hill	rhyolite	12.1	0.5	Pécskay et al. 1987
	Kakas Hill	rhyolite	12.8	0.5	Pécskay & Molnár 2002
	Tállya 15 borehole 518-556 m	rhyolite	12.0	0.8	Pécskay et al. 1987

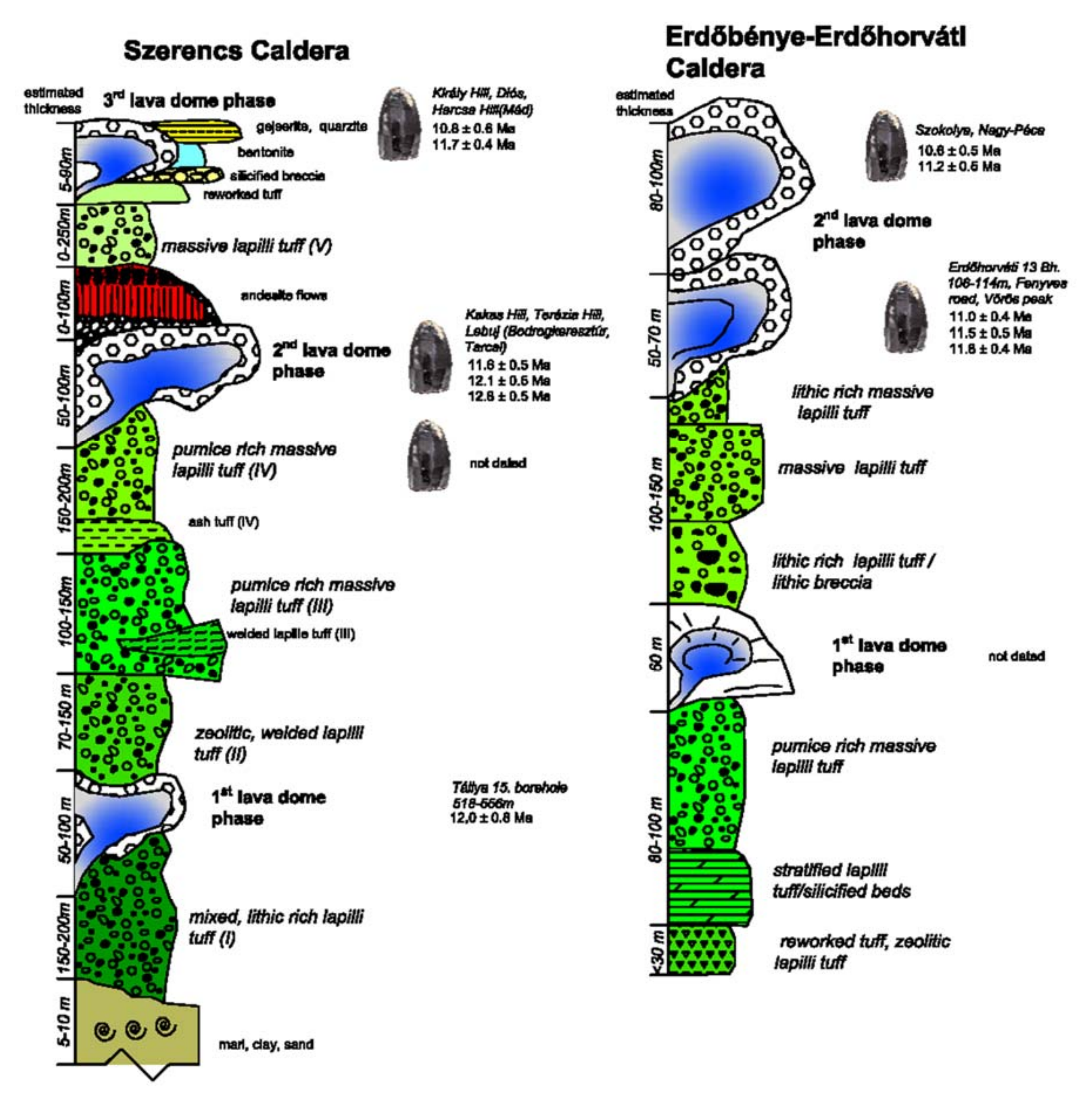


Fig. 2.: Schematic sketch of Szerencs and Erdőbénye-Erdőhorváti Caldera succession based on Zelenka (1964) and borehole documentary (Eh.13, Gyarmati 1981). Obsidian symbols indicate primary localities in the stratigraphy.

2. ábra: A Szerencs és Erdőbénye-Erdőhorváti kaldera vulkáni kőzetsorozatának vázlata Zelenka (1964) és az Erdőhorváti 13. fúrás rétegsora alapján (Gyarmati 1981. Az obszidián szimbólumok az elsődleges előfordulások rétegtani helyzetét rögzítik.

Lebuj locality (Bodrogkeresztúr)

The outcrop is located at eastern edge of Tokaj-Nagy Hill (**Fig. 1.**), its name is connected to the famous, centuries-old Lebuj pub in Bodrogkeresztúr. The outcrop wall (**Fig. 3.**) was created during a road construction in the 18th century. The significance of this outcrop is demonstrated by historical perspectives (Townson 1793, Beudant 1822, Ricthofen 1860). Esmark (1798) applied the perlite geological term at the first time in Hungary referring the Lebuj locality. Szabó (1866) recognized the genetic relationship between obsidian and perlite. The 100 meter long, 15 meter high wall (**Fig. 3.**) contains obsidian grains nested in perlite which is called traditionally as “marekanite”. The name came from Pallas, who described almost the same formation from Okhotsk, Russia (Pallas 1771).

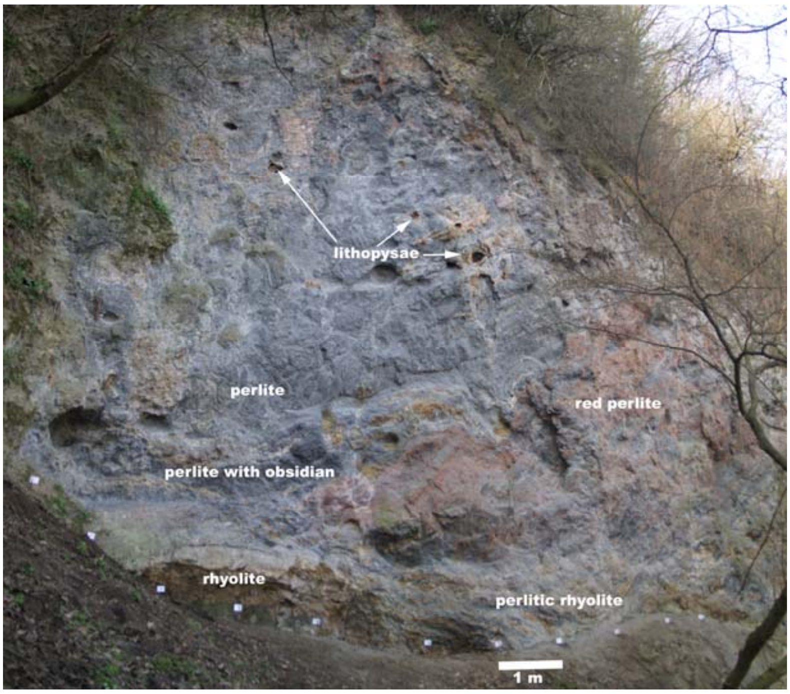


Fig. 3.: Lithofacies zonation of western wall of Lebuj outcrop (Photo by J. Szepesi, 2009)

3. ábra: A Lebuj-feltárás nyugati falának litofáciesei (Fotó: Szepesi J., 2009)

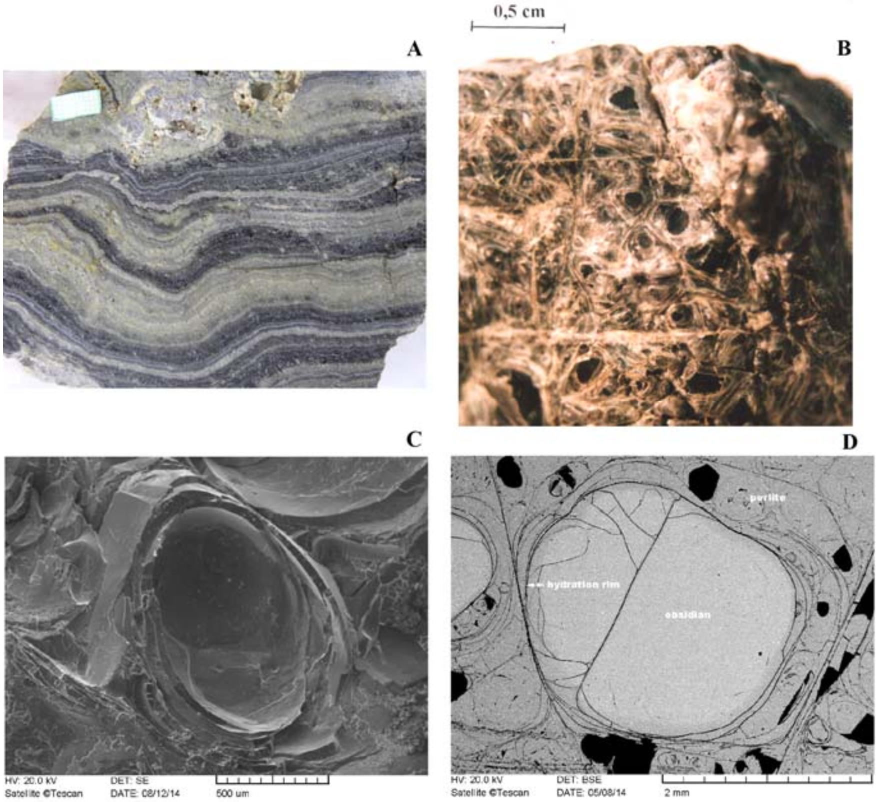


Fig. 4.: Close-up and SEM imaging of the Lebuj samples, a, banded perlite with obsidians (scale=1cm), b, close up view of the textures with rounded to subangular obsidian grains, c, rounded surface of the obsidian grain bounded by dense perlitic cracking (SEM image), d, Backscattered image of an obsidian grain in thin section, a darker hydration rim can be clearly identified at the grain boundary

4 ábra: A Lebuj-feltárás mintáinak makro- és pásztázó elektronmikroszkópos felvételei. a, fluidális perlit obszidián szemcsékkel (lépték=1 cm), b, makroszkópos szöveti felvétel, az obszidián szemcsék alakja a gömbölyded és szögletes között változhat, c, kerekded obszidián szemcse körül kialakult sűrű perlites repedés rendszer (pásztázó elektronmikroszkópos felvétel) d, Obszidián szemcse vékonycsiszolatban (visszaszórt elektron kép): a sötétebb hidratációs szegély jól azonosítható a szemcse határfelületén.

Fig. 5.: Rókabérc locality, a, brownish perlite with small obsidian grains in the Zsivány-valley road cut (400 m a.s.l.) b Larger obsidian grains in rhyolite debris (375 m a.s.l.)

5 ábra: Rókabérc lelőhely, barna perlit kisméretű obszidián szemcsékkel, Zsivány-völgy út bevágás (400 m t.sz.f.) b nagyobb méretű obszidián szemcsék vörös riolit törmelékben (375 t.sz.f.)

From a volcanological point of view the Lebuj represents an older lava dome occurrence (**Fig. 2.**) at the eastern margin of the Szerencs Caldera (**Fig. 1.**). The field survey identified 6 major lithofacies zones (**Fig. 3.**) which follow each other upwards: rhyolite, welded lapilli tuff, red and black perlite breccia, obsidian rich perlite, reddish perlite, lithophysae-rich perlite.

The obsidian-rich zone is identified only at the central-lower perlitic part of the outcrop (**Fig. 3.**) in a thickness of 2-4 meters. The small (<1cm), rounded to subangular grains are nested in gray perlite. The perlitic lava texture is generally flow banded, which is defined by strong fluidal alignment of white-gray bands (**Fig. 4a, b**).

Two feldspars (sanidine and plagioclase), quartz, biotite and rare ilmenite are observed as phenocrysts. The perlitic texture is defined by an onion skin-like foliation around the obsidian cores (**Fig. 4c**). The density of perlitic fracturing is varied between 50-250 µm, rare fractures cut through the obsidian cores (**Fig. 4d**). The macroscopically black obsidian shows light-gray colour on backscattered images, while the perlitic matrix is dark gray. A hydration rim can be seen at the margin of obsidian cores (**Fig. 4d**). The surrounding glass is variably felsitic in certain bands and sometimes contains small spherulites. Under the glassy zone a devitrified rhyolite lithofacies is identified with a thickness of 1-2 m (**Fig. 3.**) which disappear from the central part of the outcrop wall and occurs in the eastern edge. Common hollow cavities (lithopysae, 1-10 cm) developed with concentric crystallized rims most frequently in the upper part of central wall (**Fig. 3.**). Occasionally, a reddish coloured perlite breccia zone crops out at the partly soil covered western part. A welded lapilli tuff and the lowermost rhyolite at the base of the succession make the volcanological interpretation even more complicated.

Rókabérc

The Rókabérc (530 m a.s.l.) is situated at the centre of the Erdőbénye-Erdőhorváti Caldera and expose obsidians in two different outcrops (**Fig. 1.**). The Zsivány-valley section (400 m a.s.l.) is a 250 m long road cut which reveals rhyolite, perlitic rhyolite-perlite lithofacies zonation in upward direction. The prominent obsidian grains (3-5 mm, **Fig. 5a**) are embedded in perlite in comprising a 2-5 meter thick layer. The colour of perlitic matrix is brownish and cut through by vertical, shiny shrinkage joints. The other outcrop is located behind the Rókabérc hunting lodge. The dense debris of the reddish rhyolite mixed with fresh, black coloured obsidians. Here, the grain size of the obsidian clasts is slightly larger (0,5-2 cm, **Fig. 5b**).Their shape is varied from angular to rounded. The surface of the obsidians are very irregular and are dissected by cracks and conchoidal fractures. As phenocryst, beside the most frequent plagioclase, sanidine, quartz and biotite small grains of magnetite and pyroxenes were also identified (Rózsa et al. 2003).

Meszes section

The Meszes Hill (254 m a.s.l.) is located at north-eastern part of the Szerencs Caldera. A 200 meter deep borehole (Eb-163) revealed the complete lithostratigraphic section of the hill. This is consistent with the upper part of caldera succession (**Fig. 2.**). The unaltered, pumice enriched massive lapilli tuff (80 m) at the bottom represents the 4th major, explosive event of the caldera (**Fig. 2.**). In the middle part, a 40 meter thick andesite flow sequence is embedded in layers of mixed (andesitic-rhyolitic) lapilli tuff (50m).

Fig. 6.: Meszes locality, a, Pumice rich, obsidian bearing lapilli tuff (147 m a.s.l.) b, Larger obsidian grains around the tuff locality from the ditch (150-135 m a.s.l.)

6. ábra: Meszes előfordulás, a horzsakőben gazdag obszidiánt tartalmazó lapilli tufa (147 m t.sz.f.) b, Nagyobb obszidián szemcse a lapilli tufa előfordulás környezetében kialakult árokból 150-135 m t.sz.f)

At the top, the sequence terminates with rhyolitic lavas (10 metre) in which a perlitic layer developed at the base. The obsidian was identified in two primary sources. First one was revealed by drilling and found at basal part of the rhyolite flow (5-9 m), where the obsidian forms marekanite in perlitic rhyolite and pumiceous perlite. Unfortunately, the borehole documentary did not provide data on its grain size. The other primary source is the pumice rich lapilli tuff (**Fig. 6a**) which is available in outcrops, too. The logged outcrops were in a small quarry around the vineyards, 2 large gorges and smaller ditches. The lithofacies lacks internal stratification and comprises high amount of rounded pumice (<cm) and subordinate angular obsidian and rhyolite lapilli (~cm, **Fig. 6a**) in a fine ash size matrix (Fig. 6a). The matrix (30-45%) consists of glass shards and crystal fragments (5-10%), mainly feldspars (sanidine and plagioclase), quartz and biotite.

Allochthonous sources

There are localities where obsidian is found in the deluvial sediments and soil (brown forest soil, Raman forest soil) and therefore they are termed as secondary allochthonous sources (**Fig. 1.**). Generally, the common black coloured type (**Fig. 6d, 7a, c, d**) can be collected from the vineyards of the foothill regions with moderately steep slopes between 250-110 m elevations. The grain size is highly variable and range between 1-10 cm (Mád, Olaszliszka, Erdőbénye, Tolcsva). The largest obsidians (up to 5 kg) were reported in historical studies (Olaszliszka, Szádeczky 1886). A broad number of collected obsidian nodules are available in museums (**Fig. 7.**) or private collections (e.g. Encsy György, Tállya) but currently the source areas are hidden in the field.

Accumulations of rounded obsidian grains are observed at Meszes on the gentle slopes (150 m a.s.l) and foots of the Meszes hill (110 m a.s.l.). Here, the largest size was about 5-8 cm in diameter, and the average around 3 cm (**Fig. 6b.**). The obsidian surface is smooth and curvy and has brown-gray crust while the fresh fracture surface is black.

A more dense debris of the black angular fragments (1-3 cm) was found in Nyerges (**Fig. 1.**, 229 m. a.s.l) between Mád and Bodrogkeresztúr. The obsidian mixed with slightly larger fragments of hydrothermally altered rhyolite and lapilli tuff (**Fig. 7a**). The unusual abundance of the obsidian is nearly equal with other clast types. The larger individual grains collected from Erdőbénye, Tolcsva region where well defined flow banding texture can be observed (**Fig. 7c**). Another, rare, reddish coloured type (**Fig. 7b**) obsidian was collected from a very small area around Tolcsva (Gyopáros-Ciróka, 205 m a.s.l. **Fig. 1.**).

Fig. 7.: Secondary obsidian sources, a, Nyerges (229 m a.s.l.) Dense obsidian debris (black)with rhyolite tuff (white) and rhyolite (light brown-pink) fragments in forest soil. b, Tolcsva, Mahogany obsidian (Ciróka, 200 m a.s.l.) Note the irregular reddish surface of glass (Hungarian National Museum collection, photo by J. Antoni), c, Flow-banded obsidian from Erdőbénye (Hungarian National Museum collection photo by J. Antoni), d, One of the largest obsidian nodule from Mád, Kakas Hill (photo by J. Antoni)

7 ábra: Másodlagos obszidián lelőhelyek a, Nyerges (229 m t.sz.f) Sűrű obszidián törmelék (fekete), riolittufával (fehér) és riolittal barna erdőtalajban. b, Tolcsva, mahagóni obszidián (200 m t.sz.f.) jellegzetes szabálytalan bemélyedésekkel a felszínén (Magyar Nemzeti Múzeum gyűjteménye Fotó: Antoni J.). c, fluidális szövetű obszidián Erdőbényéről (Magyar Nemzeti Múzeum gyűjteménye, Fotó: Antoni J.), d, a legnagyobb obszidián példányok egyike (Mád, Kakas-hegy, Magyar Nemzeti Múzeum gyűjteménye. Fotó: Antoni J.)

This variety occurs together with the black variant, but its frequency is much lower. This special TM obsidian is referred as “mahogany” subtype (Biró et al. 2005, Kasztovszky et al. 2018) using the terminology from the historical descriptions (Szabó, 1867, 1876). The grains size is usually smaller (1-5 cm) and flow banding is also typical. The surface is highly irregular showing gas bubble originated cavities.

Discussion

The Tokaj Mountains is recognized as a classic locality of the Carpathian obsidian (Biró 1984, Williams-Thorpe et al. 1984, Kasztovszky et al. 2018). Generally, this is a non-transparent, black silicic glass variety (Carpathian 2 type) but macroscopically different types were distinguished by archaeological and geochemical studies (Biró et al. 1984, 1986, Williams-Thorpe et al. 1984.). The early workers have classified the sources using their primary (in outcrop) or secondary (reworked) occurrence (Szabó 1867, 1876, Szádeczky 1886). We found that the reported northern primary localities contain variably hydrated perlite and cannot be taken as obsidian sources. The fieldwork confirmed that obsidian of TM is related to two major rhyolitic volcanic centres, the Szerencs and Erdőbénye - Erdőhorváti Caldera (**Fig. 1.**) at the southern part of the mountains. Only three primary natural sources are identified in specific outcrops. Some boreholes also drilled obsidian rich layers but usually they are not revealed in the surface. All the other occurrence localities could be interpreted as allochthonous sources and are in reworked deluvial deposits or soils. The size range of TM obsidians is considerably smaller than the Zemplín Hills samples. The size in the primary sources range between 0.5-3 cm in the TM while the fragments from the perlitic breccias of Viničky can reach dimensions up to 10-15cm (Bačo et al. 2017, 2019 in this volume).

The K-Ar radiometric ages of the volcanic deposits related to the obsidian clasts scatter between 12.8±0.5 and 10.6±0.5 million years. The ages suggest that the activity of Erdőbénye - Erdőhorváti Caldera succession is s slightly younger than the Szerencs Caldera. Comparing the TM volcanism with those of Zemplin Hills (Bačo et al. 2017, 2019 in this volume) the activity is older in the area of Streda and Bodrogom (from 15.0±0.7 to 14.3±0.6, Bačo et al. 2017) but the other localities (Viničky, Brehov) developed in the same time span (from 12.1±0.5 to 11.0±0.4).

Primary obsidian localities

The primary outcrops are located at various altitude levels (100-400 a.s.l.) and the obsidian is dominantly associated with rhyolite lavas and hydrated perlite deposits. This relationship was first described by Pallas (1771) and indicates that formation of obsidian is connected to the basal or upper glassy layers around the microcrystalline rhyolitic core of the rhyolitic lava dome sequences (Manley & Fink 1987, McPhie et al. 1993, Szepesi et al. 2016a). The primary volcanic glass suffered partial syn and /or post-emplacement hydration, so the unaffected obsidian grains vary in size and are nested in perlitic matrix. These lava dome edifices are associated with both caldera successions in different stratigraphic level (**Fig. 2.**).

The Lebuj obsidian developed at the lowest stratigraphic position and is related to 2nd lava dome phase of the Szerencs Caldera (**Fig. 2.**). The obsidian rich perlite lithofacies characterizes the basal section of a rhyolite lava flow (Szepesi and Kozák 2014, Szepesi et al. 2016b). The Rókabérc outcrops (400 m a.s.l.) reveal the topmost section of the Erdőbénye Caldera related volcanic deposits (**Fig. 2.**). The obsidian is identified in perlite which represents the upper and basal glassy layers of a rhyolite flow, where the size of marekanite is slightly larger at the basal settings (**Fig. 5.**). Fresh angular lapilli sized obsidian grains are also identified in volcanoclastic layers (**Fig. 2., 6.**) of the caldera-forming explosive eruptions. The Meszes site reveals the pumice rich lapilli tuff which probably represents the 4th major rhyolite tuff layer (**Fig. 2.**) of the Szerencs Caldera eruptions. The angular lapilli can be interpreted as juvenile clasts of the massive lapilli tuff (ignimbrite) that deposited from pyroclastic density currents during large explosive eruptions. They show no signs of successive reworking as reported from Streda and Bodrogom (Zemplín Hills, Bačo et al. 2017, 2018 in this volume).

Allochthonous sources

The allochthonous sources are the most widespread localities in Tokaj Mountains (**Fig. 1.**) and represent reworked occurrences of primary obsidian formations. The altitude conditions are highly variable but are usually lower than 300 meter in elevation. Large obsidian nodules (3-8 cm, **Fig. 6b**) can be found in the foothill of Meszes, and we have only indirect evidences about their origin. The obsidian bearing pumice rich lapilli tuff outcrops directly above on the slopes, but its obsidian lapilli size (cm, **Fig. 6a**) is below the range of those from the reworked deposit. The Eb-163 borehole drilled a marekanite bearing layer below Meszes top that represents the topmost rhyolite flow units of the Szerencs Caldera (**Fig. 1., 2.**) succession. This layer is assumed as the potential source for the slope material (**Fig. 6b**). In this case, the altitude difference is about 180 meter and suggest long (~km) erosional transport on the slope. This scenario could also be applicable in the Nyerges case where obsidian debris mixed with lapilli tuff and hydrothermally affected rhyolite deposits (**Fig. 7a**). The angular shape of glass fragments indicates nearby source with shorter deluvial transport distance.

The thickest rhyolitic lava dome sequence developed in the Erdőbénye-Erdőhorváti Caldera succession (over 100 m, **Fig. 2.**), where obsidians were reported from also the basal and medial sections. Accordingly, the largest number of allochthonous sources is identified around this lava dome field (**Fig. 1.**) including the special mahogany (red) type (**Fig. 7b**). The primary lava dome localities suggest that they were formed during the last evolutional stage of the silicic volcanism. The following long-continuous (10 million years) denudation exposed and partly eroded the glassy parts of the rhyolite flows. The obsidians clasts detached from the easily disintegrable perlite and were carried by slope transport processes and were distributed widespread around the lava dome field in deluvial deposits.

Conclusions

This study summarizes our present knowledge on the geological setting of the Carpathian C2 obsidian. We demonstrated that the primary origin of the obsidian is related to the quenched glassy (mainly basal) carapace part of the silicic lava domes or flows in the TM. We also showed that beside the primary lava dome originated obsidian fragments, obsidian clast can be found as lithic clasts in primary pyroclastic flow deposits. Our results provide compelling evidence for the connection between rhyolitic lava dome sequences and the allochthonous obsidian occurrences. Although, the Zemplín Hills obsidian fragments developed at similar settings, their grain size is usually in larger order. However, historical obsidian studies of the TM reported quite large grains, but unfortunately we could not find these occurrences so far. Therefore, future work should include more detailed field studies of rhyolite lavas and tuffs where we would expect new occurrences. Detailed volcanological and geochemical studies are also important ways to better understand the formation and archaeological correlation of the Carpathian obsidian.

References

BAČO, P., KAMINSKÁ, Ľ., LEXA, J., PÉCSKAY, Z., BAČOVÁ, Z. & KONEČNÝ, V. (2017): Occurrences of NeogeneVolcanic Glass in the Eastern Slovakia – Raw Material source for the Stone Industry. *Anthropologie* **LV/1-2** 207–230.

BAČO, P., LEXA, J., BAČOVÁ, Z. KONEČNÝ, P. & PÉCSKAY, Z. (2018): Geological background of the occurrences of Carpathian volcanic glass, mainly obsidians, in Eastern Slovakia. *Archeometriai Műhely* **XV/3** page

BEUDANT, F. S. (1822): *Voyage minéralogique et géologique en Hongrie pendant l'année 1818.* Chez Verdiére Libraire Quai Des Audustines 25, Paris 1–659.

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

BIRÓ, K.T., POZSGAI, I., VLADÁR, A. (1986): Electron beam microanalyses of obsidian samples from geological and archaeological sites. *Acta Archaeologica Academiae Scientiarum Hungaricae* Budapest, **38** 257–278.

BIRÓ, K.T., MARKÓ, A., KASZTOVSZKY, Zs. (2005): Red obsidian in the Hungarian Palaeolithic: Characterisation studies by PGAA. *Praehistoria* **6**. 91–101.

ERHARDT GY., GYARMATI P., ILKEY-PERLAKI E. & PANTÓ G. (1964): Tolcsva. *Magyarázó a Tokaji-hegység földtani térképéhez, 25000-es sorozat*. MÁFI, Budapest, 1–35.

ESMARK, I. (1798): *Kurze Beschreibungen einer mineralogische Reise durch Ungarn, Siebenbürgen und das Bahnat*. Freiberg, Im Verlage der Grazischen Buchhandlung, 1–191.

GYARMATI P. (1971): Tarcal – Tokaj. *Magyarázó a Tokaji-hegység földtani térképéhez. 25000-es sorozat*. MÁFI, Budapest, 1–67.

GYARMATI P. (1977): *A Tokaji-hegység intermedier vulkanizmusa*. MÁFI Évkönyv **58** 1–195.

GYARMATI P. (1981): *Tokaji-hegységi perlit prognózis. Összefoglaló jelentés az 1978-80 között elvégzett munkáról*. Manuscript, MÁFI Archives, 9476. pp.

GYARMATI P., SZEPESI J. (2007): Fejlődéstörténet, földtani felépítés, földtani értékek. In: BARÁZ CS., KISS G. eds., *A Zempléni tájvédelmi körzet, Abaúj és Zemplén határán.* Bükki Nemzeti Park Igazgatóság, Eger, 15–44.

GYARMATI P., ZELENKA T., MÁTYÁS E. & VETŐ I. (1968): Mád. *Magyarázó a Tokaji-hegység földtani térképéhez. 25000-es sorozat.* MÁFI, Budapest, 1–70.

GYARMATI P., ZELENKA T. (1968): Tállya. *Magyarázó a Tokaj-hegység földtani térképéhez. 25000-es sorozat.* MÁFI, Budapest, 1–50.

GYARMATI P., ZELENKA T. (1970): Olaszliszka. *Magyarázó a Tokaj-hegység földtani térképéhez. 25000-es sorozat.* MÁFI, Budapest, 1–39.

HORVÁTH F. (1995): Phases of compression during the evolution of the Pannonian Basin and its bearing on hydrocarbon exploration *Marine and Petroleum Geology* **12** 837–844.

ILKEYNÉ PERLAKI E. (1972): *A Tokaji-hegység harmadkori savanyú vulkanizmusa.* Manuscript, MÁFI Archives, Budapest, 1–256.

KALIČIAK, M.I., ŽEC, B. (1995): Review of Neogene volcanism of Eastern Slovakia *Acta Volcanologica* **7** 87–95.

KASZTOVSZKY, Zs., BIRÓ, K.T., MARKÓ, A. & DOBOSI, V. (2008): Cold neutron prompt gamma activation analysis - A non-destructive method for characterization of high silica content chipped stone tools and raw materials. *Archaeometry* **50/1** 12–29.

KASZTOVSZKY, ZS., BIRÓ, K. T., KIS, Z. (2014): Prompt Gamma Activation Analysis of the Nyírlugos obsidian core depot find. *Journal of Lithic Studies* **1** 151–163.

KASZTOVSZKY, Zs., LÁZÁR, K., KOVÁCS KIS, V., LEN, A., FÜZI, J., MARKÓ, A. & BIRÓ, K.T. (2018): A novel approach in the mineralogy of Carpathian mahogany obsidian using complementary methods. *Quaternary International* **467** 332–341.

KISS, P., GMÉLING, K., MOLNÁR, F. & PÉCSKAY, Z. (2010): Geochemistry of Sarmatian volcanic rocks in the Tokaj Mts. (NE Hungary) and their relationship to hydrothermal mineralization. *Central European Geology* **53** 377–403.

KOVÁČ, M., ANDREYEVA-GRIGOROVICH, A., BAJRAKTAREVIĆ, Z., BRZOBOHATÝ, R., FILIPESCU, S., FODOR, L., HARZHAUSER, M., NAGYMAROSY, A., OSZCZYPKO, N., PAVELIĆ, D., RÖGL, F., SAFTIĆ, B., SLIVA, U. & STUDENCKA, B. (2007): Badenian evolution of the Central Paratethys Sea: paleogeography, climate and eustatic sea-level changes. *Geologia Carpathica* **58** 579–606.

LEXA, J., SEGHEDI, I., NÉMETH, K., SZAKÁCS, A., KONEČNÝ, V., PÉCSKAY, Z., FÜLÖP, A. & KOVACS, M., (2010): Neogene-Quaternary Volcanic forms in the Carpathian-Pannonian Region: a review. *Central European Journal of Geosciences* **2** 207–270.

LÓCZY, D. (2015): Geomorphological Regions in LÓCZY, D. (ed.) *Landscapes and Landforms of Hungary,* Springer International Publishing. Cham, Switzerland 39–47.

MANLEY, C.R., FINK, J.H., (1987): Internal textures of rhyolite flows as revealed by research drilling. *Geology* **15** 549–555.

McPHIE, J., DOYLE, M., ALLEN, R. (1993): *Volcanic Textures; A Guide to the Interpretation of Textures in Volcanic Rocks.* University of Tasmania, Launceston., 1–196.

PALLAS, P. S. (1771): *Reise durch verschiedene Provinzen des Rußischen Reichs*. Kaiserlich Academie der Wissenschaften, St. Petersburg, 1–368.

PENTELÉNYI L. (1968): *Erdőbénye. Magyarázó a Tokaji-hegység földtani térképéhez, 25000-es sorozat.* MÁFI, Budapest, 1–52.

PÉCSKAY Z., BALOGH K., SZÉKYNÉ F.V. & GYARMATI P. (1987): A Tokaji-hegység miocén vulkánosságának K/Ar geokronológiája (K/Ar geochronology of the Miocene volcanism in the Tokaj Mts., *Földtani Közlöny* **117** 237–253.

PÉCSKAY, Z., LEXA, J., SZAKÁCS, A., SEGHEDI, I., BALOGH, K., KONEČNÝ, V., ZELENKA, T., KOVACS, M., PÓKA, T., FÜLÖP, A., MÁRTON, E., PANAIOTU, C. & CVETKOVIC, V. (2006): Geochronology of Neogene magmatism in the Carpathian arc and intra-Carpathian area. *Geologia Carpathica* **57/6** 511–530.

PÉCSKAY, Z., MOLNÁR, F. (2002): Relationships between volcanism and hydrothermal activity in the Tokaj Mountains, Northeast Hungary *Geologia Carpathica* **53** 303–314.

RICHTHOFEN, F. (1860): Studie aus dem ungarisch-siebenbürgischen Trachytgebirgen. *Jahrbuch des Kaiserliches und königliches Geologisches Reichsanstalt,* Wien. **11** 153–278.

RÓZSA, P., ELEKES, Z., SZÖÖR, Gy., SIMON, A., SIMULÁK, J., UZONYI, I. & KISS, Á.Z. (2003): Phenocrysts in obsidian glasses. *Journal of Radioanalytical and Nuclear Chemistry* **256** 329–337.

SZABÓ J (1866): Tokaj-Hegyalja és környékének földtani viszonyai. *Mathematikai és Természettudományi Közlemények* **4** 226–303.

SZABÓ J., (1867): A Tokaj-Hegyalja obsidiánjai (Obsidians of the Tokaj Mts.) *A Magyarhoni Földtani Társulat Munkálatai* **3** 147–172.

SZABÓ, J., (1876): L'obsidienne prehistorique en Hongrie et en Grece. *Congres international d'anthropologie et d'archeologie prehistoriques Compte-rendu de la huitieme session a Budapest* **2** 96–100.

SZÁDECZKY Gy. (1887): A magyarországi Obsidianok, különös tekintettel geológiai viszonyaikra. *Értekezések a Természettudományok Köréből* **16** 1–64.

SZEPESI, J., KOZAK, M. (2014): Reheating, welding and hydration at an acidic lava flow base - a case study of Lebuj outcrop, Tokaj Mts., Hungary. *Schriftenreihe der Deutschen Gesellschaft für Geowissenschaften* **85** 418.

SZEPESI, J., HARANGI, Sz., LUKÁCS, R., & PÁL-MOLNÁR, E. (2016a): Facies analysis of a Late Miocene lava dome field in the Tokaj Mts. (Carpathian-Pannonian Region): Implication for a silicic caldera structure? In: BRANCA, S., GROPPELLI, G., LUCCHI, F., & SULPIZIO, R. (eds.), *Geological fieldwork in volcanic areas: mapping techiques and applications* III. Workshop on Volcano Geology July 3-10, 2016, Sicily, Italy Abstract book 60–63.

SZEPESI, J., PÁL-MOLNÁR, E., FINTOR, K., KOVÁCS, I. J., PAPP, I., KOZÁK, M., SÁNDORNÉ K.J. & HARANGI, Sz. (2016b): Hidratáció, devitrifikáció és összesülés szöveti vizsgálata (SEM, RAMAN, FTIR, TG) egy riolitos lávaár kontakt zónájában, Esettanulmány, Lebuj Perlitfal, Tokaji-Hg. Itt az idő! Kőzettani-geokémiai folyamatok és azok geokronológiai vonatkozásai. *7. Kőzettani és Geokémiai Vándorgyűlés,* Debrecen, 103–109.

SZEPESI, J., SOÓS, I., LUKÁCS, R., SULPIZIO, R., GROPPELLI, G. & HARANGI, Sz. (2017): Reconstructing the facies architecture and depositional settings of Miocene pyroclastic sequence, Tokaj - Slanske Mountains, Carpathian-Pannonian region. *Romanian Journal of Earth Sciences* **91** 84–85.

TOWNSON, R. (1797): Travels in Hungary with a short account of Vienna in the year 1793. London XI. 261–303.

VASS, D., KOVÁČ, M., KONEČNÝ, V. & LEXA, J., (1988): Molasse basinsand volcanic activity in West Carpathian Neogeneits evolutionand geodynamic character. *Geologica Carpathica* **39/5** 539–562.

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

ZELENKA T. (1964): A Szerencsi-öböl tufaszintjei és fáciesei. *Földtani Közlöny* **94** 33–52.

ZELENKA, T., GYARMATI, P., KISS, J. (2012): Paleovolcanic reconstruction in the Tokaj Mountains. *Central European Geology* 55, 49–84.

THE CARPATHIAN 3 OBSIDIAN[•]

A KÁRPÁTI 3 OBSZIDIÁN

RÁCZ, Béla[1]

[1] Department of History and Social Sciences, Ferenc Rákóczi II. Transcarpathian Hungarian Institute, 6 Kossuth Square, Beregove 90202, Ukraine

E-mail: raczb@kmf.uz.ua

Abstract

The territory of the westernmost part of present-day Ukraine (Transcarpathia) has been a densely inhabited area in almost all periods of human history. In the region of Transcarpathia, currently more than 100 Palaeolithic sites are known, most of them known from surface collections. Early petroarchaeological studies commenced in Transcarpathia with the activity of V. Petrun' and by the discovery of Middle Palaeolithic settlements and workshops around Rokosovo and Maliy Rakovets and the description of the local obsidian sources. Obsidian was one of the most important raw material for prehistoric stone tools. In the Carpathian Basin we know three separete sources of Carpathian obsidian (C1 – from Slovakia, C2 - from Hungary and C3 – from Ukraine), the aim of the present work is to introduce the Carpathian 3 obsidian from Transcarpathia.

Palaeolithic communities in the recent territory of Transcarpathia were primarily using local raw materials for the production of their tools. In the volcanic raw material regions of the Transcarpathian Palaeolithic two raw material types of volcanic origin played a dominant part in the production of stone artefacts: glassy dacite from Korolevo and Carpathian 3 type obsidian from Rokosovo.

Kivonat

Az emberiség története folyamán a mai Kárpátalja területe, Ukrajna legnyugatibb régiója, mindig is lakott vidék volt. Jelenleg több mint 100 paleolit régészeti lelőhelyet ismerünk a megye területén, ezeknek a legnagyobb része felszíni jellegű. A legkorábbi petroarcheológiai vizsgálatok Kárpátalján V. Petruny nevéhez fűződnek, aki számos középső paleolit telepet és műhelyt fedezett fel Rakasz (Rokosovo) és Kisrákóc (Maliy Rakovets) környékén, továbbá leírta a helyi obszidián-forrásokat. Az obszidián az őskori kőeszközök egyik legfontosabb nyersanyaga. A Kárpát-medencében összesen három különálló forrását ismerjük a kárpáti obszidiánoknak (C1 – Szlovákiában, C2 – Magyarországon és C3 – Ukrajnában), jelen munka célja abban rejlik, hogy bemutassa a Kárpátalján előforduló kárpáti 3 obszidiánt.

A mai Kárpátalja területén élő paleolit közösségek elsősorban a helyi nyersanyagokat használták az eszközeik elkészítéséhez. Kárpátalja paleolitikumában a vulkáni nyersanyagrégióban két magmas eredetű kőzet szolgált elsődleges nyersanyagként a pattintott kőeszközök előállításához: a királyházi üveges dácit és a rakaszi kárpáti 3 obszidián.

KEYWORDS: OBSIDIAN, TRANSCARPATHIA, PALAEOLITHIC, RAW MATERIALS

KULCSSZAVAK: OBSZIDIÁN, KÁRPÁTALJA, PALEOLITIKUM, NYERSANYAGOK

Introduction

The territory of the westernmost part of present-day Ukraine (Transcarpathia) has been a densely inhabited area in almost all periods of human history (**Fig. 1.**). In the region of Transcarpathia, currently more than 100 Palaeolithic sites are known, most of them known from surface collections.

Early petroarchaeological studies commenced in Transcarpathia with the activity of V. Petrun' and by the discovery of Middle Palaeolithic settlements and workshops around Rokosovo and Maliy Rakovets and the description of the local obsidian sources (Petrun' 1972). Obsidian was one of the most important raw materials for prehistoric stone tools. In the Carpathian Basin we know three separate sources of Carpathian obsidian (C1 – from Slovakia, C2 - from Hungary and C3 – from Ukraine), the aim of the present work is to introduce the Carpathian 3 obsidian from Transcarpathia (**Fig. 2.**).

[•] How to cite this paper: RÁCZ, B., (2018): The Carpathian 3 obsidian, *Archeometriai Műhely* **XV/3** 181-186.

Fig. 1.: The current territory of the Trancarpathian region

1. ábra: Kárpátalja mai területe

Fig. 2.: The Carpathian 3 obsidian from Rokosovo village, geological sample

2. ábra: Kárpáti 3 obszidián Rakasz település környékéről, geológiai minta

Methods

Systematical field surveys have been conducted to Transcarpathian regions since 2006. The primary macroscopic analysis of the samples was followed by petrographic thin section analysis. Chemical analysis of samples was performed using ICP-OES and ICP-MS, PGAA and SEM-EDX methods (Kasztovszky et al. 2008).

Results

International petroarchaeological research has integrated Transcarpathian obsidian, occurring in the region around Rokosovo and Maliy Rakovets, under the name Carpathian 3 (C3) obsidian in 2008 (Rosania et al. 2008).

Occurrence: At the upper reaches of Silskiy stream, to the North of the village Rokosovo and to the South of Maliy Rakovets, the Upper Tertiary Sin'ak Formation comprises obsidian blocks and bombs in an agglomerate type tuff of acidic composition (**Fig. 3.**) (Matskiv & Kuzovenko 2003). The area forms the central part of the Vinohradiv Mountains (Velikiy Sholes) in the Vihorlat-Gutin volcanic range. The size of the blocks currently available varies between a few cms to several dozens of cms. It can be collected in substantial quantities on the eroded surface and the stream valleys even today.

Macroscopic description: The blocks are typically encrusted in their natural form with light or dark cortex, resulting from interaction with the environment. The surface is often porous, weathered (**Fig. 4.**). The fresh fractures are black, glassy, with macroscopically observable mineral grains. The fracture is conchoidal. It is non-transparent, even in thin flakes.

On the basis of recent field surveys we can say that the Carpathian 3 obsidian has two sub-types. The difference can be observed both in macro- and microscopic level. In the first case, the fresh broken surface is black, with glassy lustre, occasionally with oriented grey stripes. The other version is grey on fresh broken surface, with dull lustre and a subordinate amount of darker stripes. In the matrix we can observe spherolitic forms with naked eye, emerging as brown entities in microscopic thin section surrounding some crystallites. This feature is very rarely observed for the black version of C3 obsidian.

Fig. 3.: The Carpathian 3 obsidian in an agglomerate type tuff

3. ábra: Kárpáti 3 obszidián agglomerátumos tufában

Microscopic description

In thin section the texture of the rock is vitroporphyric with clear fluidal character formed by the unidirectional movement of the lava flow. In the matrix, alternating stripes of light and less frequently dark phases can be observed. The texture of the rock abounds in microlithes (crystallites), surrounding spectacularly the phenocrysts grouped frequently in aggregates (**Figs. 5-6.**). Torn inclusions of plagioclase, monocline pyroxene, amphibole and biotite comprise maximally 5-10 volume% (**Fig. 7.**). Accessory minerals observed include magnetite and zircon. The plagioclase crystals are often twinning and zoned, their size may reach 2 mm. At some places they contain glass inclusions and certain resorption can be observed in the crystals (**Figs. 8-9.**).

Fig. 4.: The Carpathian 3 obsidian from Rokosovo village, archaeological sample

4. ábra: Kárpáti 3 obszidián Rakasz település környékéről, régészeti minta

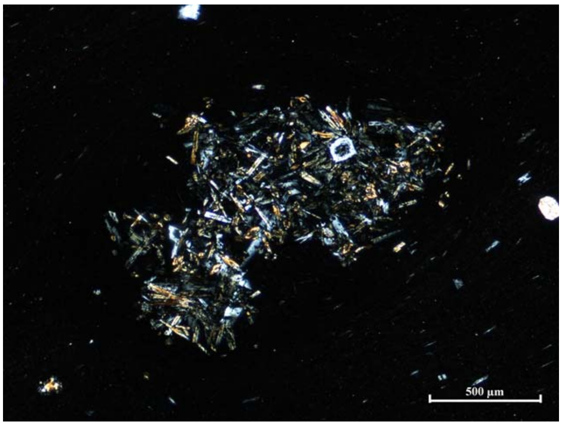


Fig. 5.: Thin section microscopic photos (XN) of C3 type obsidian – aggregate

5. ábra: A kárpáti 3 obszidián mikroszkópi képe vékonycsiszolatban (XN) - aggregátum

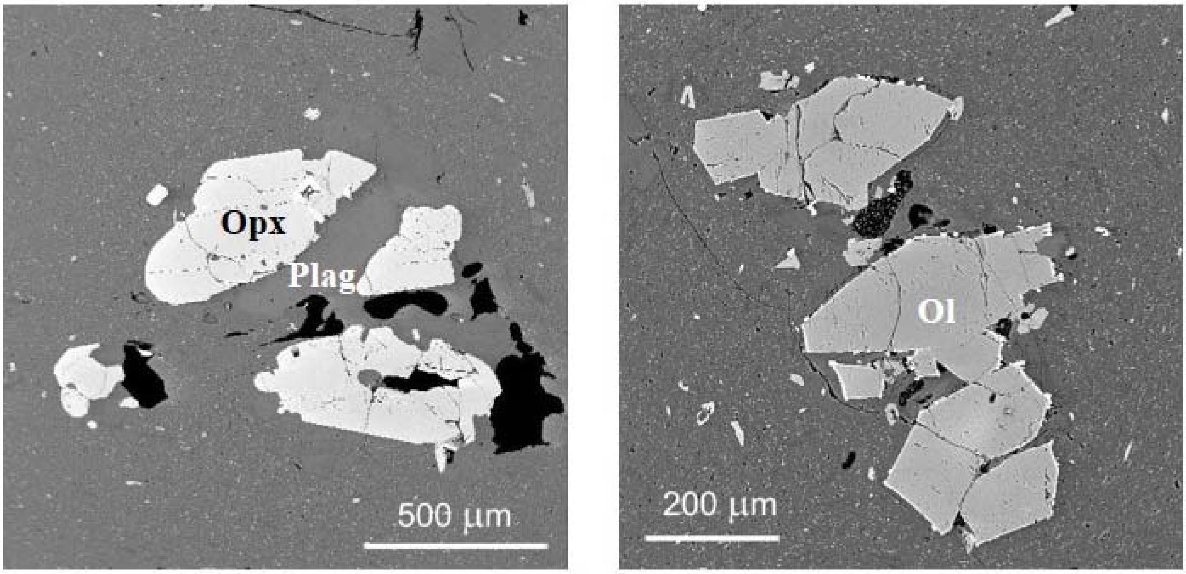


Fig. 6.: Back-acattered elektron image photos of C3 type obsidian – aggregates

6. ábra: Aggregátumok a kárpáti 3 obszidiánban (visszaszórt elektronkép)

Fig. 7.: Thin section microscopic photos (1N) of C3 type obsidian – aggregate in the fluidal type of matrix

7. ábra: A kárpáti 3 obszidián mikroszkópi képe vékonycsiszolatban (1N) – aggregátumok a fluidális alapanyagban

At some places in the thin section we can observe the mineral grains and inclusions disintegrating parallel to the orientation of the fluidal movement and the grains floating apart. The inclusions were probably formed in the deeper regions of the magma chamber.

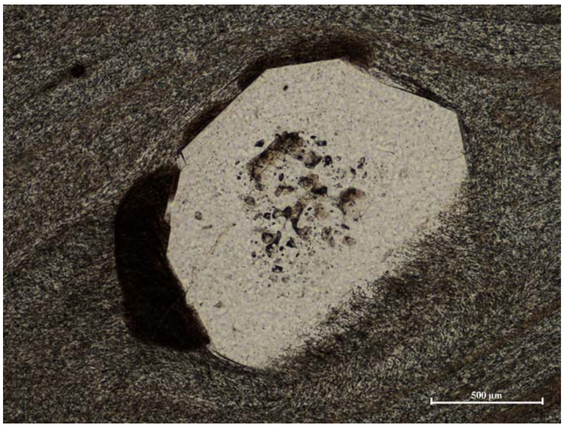


Fig. 8.: Thin section microscopic photos (1N) of C3 type obsidian – plagioclase phenocryst with glass inclusions and certain resorption

8. ábra: A kárpáti 3 obszidián mikroszkópi képe vékonycsiszolatban (1N) – üvegzárványos plagioklász fenokristály rezorpciós szélekkel

Chemical composition

The analysis of two representative samples yielded 70.40% and 70.94% weight% SiO_2 (with LOI 0.4% and 0.3%, respectively). Consequently, the raw material was assigned to rhyolitic obsidians.

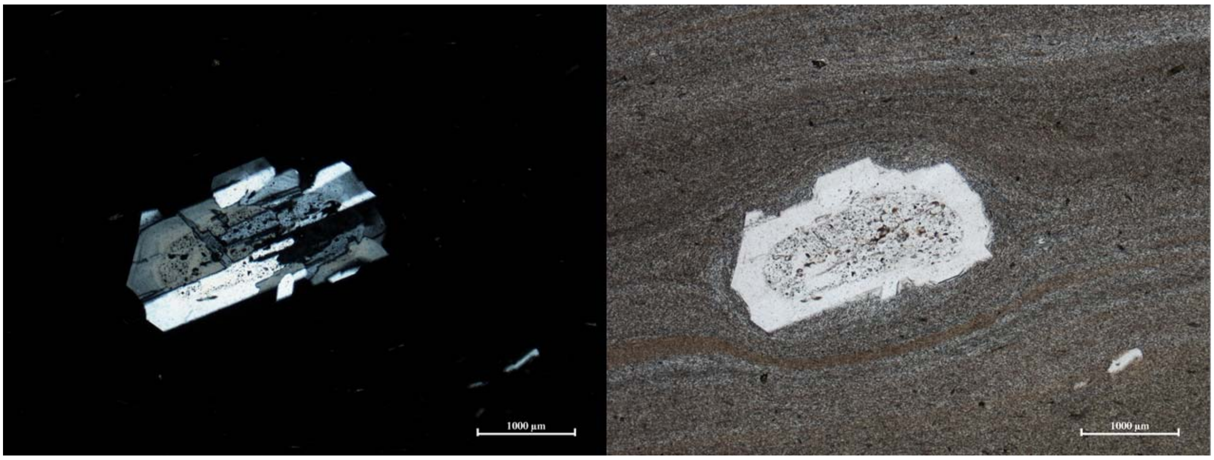


Fig. 9.: Thin section microscopic photos (1N and XN) of C3 type obsidian – zoned plagioclase phenocryst with glass inclusions

9. ábra: A kárpáti 3 obszidián mikroszkópi képe vékonycsiszolatban (1N és XN) – zónás plagioklász fenokristály üvegzárványokkal

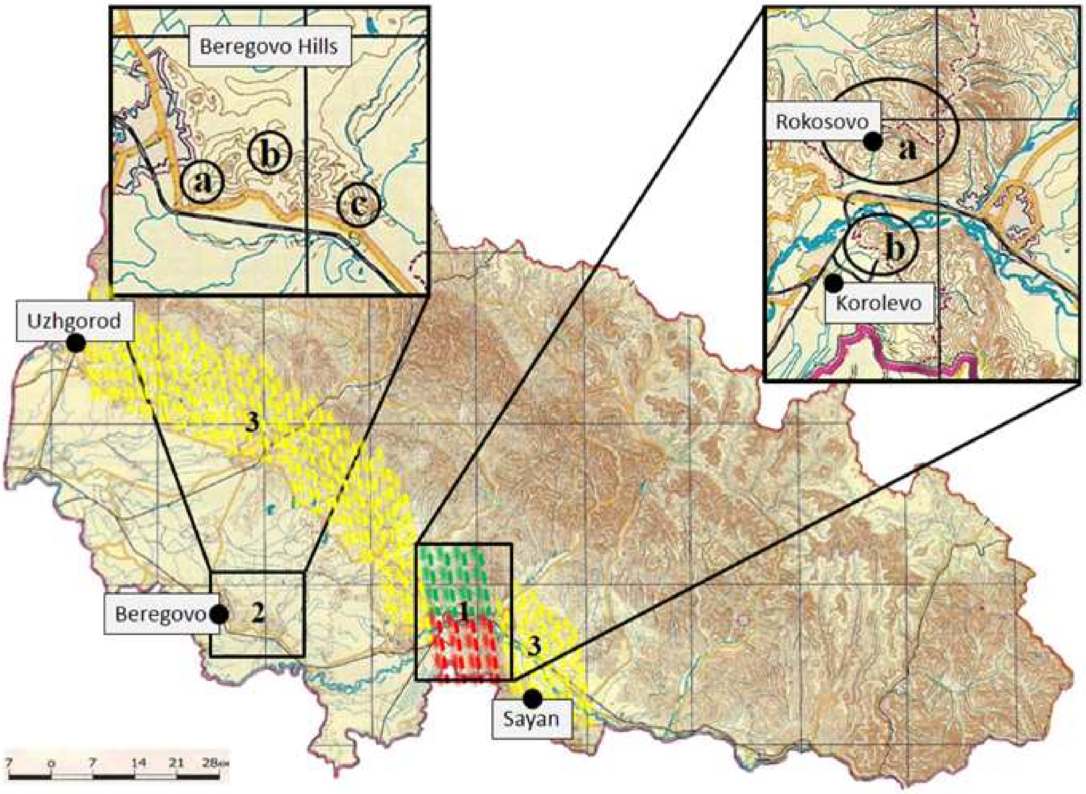


Fig. 10.: Palaeolithic raw material regions in Transcarpathia. 1: volcanic; 2: metasomatical / silicified; 3: sedimentary

10. ábra: Kárpátalja paleolit nyersanyag-régiói: 1: vulkáni; 2: metaszomatikus; 3: üledékes

Conclusion

Palaeolithic communities in the recent territory of Transcarpathia were primarily using local raw materials for the production of their tools (**Fig. 10.**). In the volcanic raw material regions of the Transcarpathian Palaeolithic two raw material types of volcanic origin played a dominant part in the production of stone artefacts: glassy dacite from Korolevo and Carpathian 3 type obsidian from Rokosovo (Usik et al. 2014).

The Rokosovo-Maliy Rakovets sub-region

On the settlements around Rokosovo and Maliy Rakovets, stone knappers used mainly another local, glassy and volcanic material, i.e., local obsidian (Ryzhov 1999, 2003). Obsidian is a volcanic glass formed by quenching (very fast cooling) of the lava. The Transcarpathian obsidian source is unique as there are no more geological sources known in the whole territory of the Ukraine. On the source region (Vinohradiv Mountains – Velikiy Sholes) we can still find it in primary position in the form of smaller and larger blocks.

Obsidian as lithic raw material played an important role in the Palaeolithic and Neolithic periods in Transcarpathia. On the Palaeolithic settlements we can find all the three Carpathian obsidian types. So far we could not locate obsidian from more distant sources as yet. On the basis of field surveys made so far, we can support the existence of only one obsidian source in Transcarpathia, i.e., that of the Vinohradiv Mountains (Rats 2009, Rácz 2012).

In the Neolithic period, seemingly the Carpathian 1 obsidian type was preferentially used in the Transcarpathian region, as much as we can judge from present data (Potushniak 2011). The Carpathian 1 (and, to a lesser extent, Carpathian 2) obsidian was distributed over much larger area than the Carpathian 3 type, already in the Palaeolithic period. Carpathian 3 obsidian was mainly used locally in the Palaeolithic period; it is possible, though, that it was also used by the local Neolithic cultures. As C3 obsidian got established and fingerprinted (geochemically) only recently, this issue was not examined as yet (Mester & Rácz 2010). It is important to note that the Carpathian 3 obsidian have been detected in the territory of today's Romania, in the upper Palaeolithic sites, so the known spreading area of this raw material became larger (Dobrescu et al. 2018).

References

DOBRESCU, R., ŞTEFAN, C.E. & BONSALL, C. (2018): L'utilisation de l'obsidienne au Paléolithique supérieur dans le nord-ouest de la Roumanie. *L'Anthropologie* **122/2** 111–128.

KASZTOVSZKY, Zs., BIRÓ, K.T., MARKÓ, A. & DOBOSI, V. (2008): Cold Neutron Prompt Gamma Activation Analysis – a Non-Destructive Method for Characterization of High Silica Content Chipped Stone Tools and Raw Materials. *Archaeometry* **50/1** 12–29. Published online DOI: 10.1111/j.1475-4754.2007.00348.x

MATSKIV, B.V. & KUZOVENKO, V.V. (2003): *Геологічна карта дочетвертинних утворень. Карпатська серія.* 1:200000, M-34-XXXV. [Geological map. Carpathian series. 1:200000, M-34-XXXV] (in Ukrainian). – Uzhgorod.

MESTER, Zs. & RÁCZ, B. (2010): The spread of the Körös Culture and the raw material sources in the northeastern part of the Carpathian basin: a research project. In: KOZŁOWSKI, J.& RACZKY, P. (Eds.) : *Neolithization of the Carpathian basin: Northernmost distribution of the Starčevo/Körös Culture*, Kraków-Budapest, 23 –35.

PETRUN`, V.F. (1972): Леваллуазские мастерские обсидиановых орудий Закарпатья и проблема сырья. [Levalloisian workshops and raw material procurement of Transcarpathian obsidian artefacts] (in Russian). Kiyiv, Naukova Dumka, 86–92.

POTUSHNIAK, M. (2011): *Middle Neolithic settlement at Drisino-Balocza, Transcarpathian Ukraine.* Kraków, Polish Academy of Science, p. 87.

RÁCZ, B. (2012): Kárpátaljai obszidiánok: szakirodalmi adatok és terepi tapasztalatok. [Transcarpathian obsidians: literature data and field experience] (in Hungarian). In: KREITER, A., PETŐ Á & TUGYA B. eds., *Környezet – Ember – Kultúra: Az alkalmazott természettudományok és a régészet párbeszéde.* [Environment – Human – Culture, Dialogue between applied sciences and archaeology]. Budapest, MNM NÖK, 353– 362.

RATS, A.YO. (2009): Закарпатські обсидіани: міфи та реальність. 1 частина: дані спеціальної літератури. [Transcarpathian obsidian: myths and reality]. Part 1: literature (in Ukrainian). *Acta Beregsasiensis* **VIII/2** 273–278.

RYZHOV, S.M. (1999): Некоторые аспекты обработки камня на мустьерской стоянке Малый Раковец IV в Закарпатье.[Some aspects of lithic technology of the Mousterian site Maliy Rakovets IV] (in Russian). *Vita Antiqua* **1** 3–17.

RYZHOV, S.M. (2003): Стоянка Малий Раковець IV на Закарпатті. [The site site Maliy Rakovets IV in Transcarpathian Ukraine] (in Ukrainian). In: KULAKOVSKA L.V. ed., *Варіабельність середнього палеоліту України.* [The variability of the Middle Palaeolithic of the Ukraine]. Kiyiv, Slyach, 191–206.

ROSANIA, C.N., BOULANGER, M.T., BIRÓ, K.T., RYZHOV, S., TRNKA, G. & GLASCOCK, M.D. (2008): Revisiting Carpathian obsidian. *Antiquity*, **82** Issue: 318.

USIK, V., RÁCZ, B., KULAKOVSKAYA, L. (2014): Вулканическое сырье в палеолите Закарпатья: относительная хронология индустрий. [Volcanic raw materials in the Paleolithic of Transcarpathia: relative chronology of the industries.] In: T. BIRÓ,K., MARKÓ, A., P. BAJNOK, K. eds., Aeolian scripts new ideas on the lithic world studies in honour of Viola T. Dobosi. Budapest, Inventaria Praehistorica Hungariae **XIII** 197–206.

AN OVERVIEW OF THE ANALYTICAL TECHNIQUES APPLIED TO STUDY THE CARPATHIAN OBSIDIANS•

A KÁRPÁTI OBSZIDIÁNOK VIZSGÁLATÁRA ALKALMAZOTT ANALITIKAI MÓDSZEREK ÁTTEKINTÉSE

Zsolt KASZTOVSZKY[1], Antonín PŘICHYSTAL[2]

[1]Centre for Energy Research, Hungarian Academy of Sciences
H-1121, Konkoly Thege Str. 29-33., Budapest, HUNGARY

[2]Department of Geological Sciences, Faculty of Science, Masaryk University
CZ-611 37 Kotlářská 2, Brno, CZECH REPUBLIC

E-mail: kasztovszky.zsolt@energia.mta.hu, prichy@sci.muni.cz

Abstract

In this paper, we give a brief overview of the analytical techniques applied on Carpathian obsidians, from the mid-sixties until present. Besides modern analytical techniques that are focussed especially on the determination of obsidian artefact provenance, microscopic methods are also applied: investigation in thin section under polarising microscope (flow fabric, inclusions, phenocrysts), characterization of individual microlites and trichites embedded in a glassy groundmass using microprobe, measurement of glass refractive index. Already in 1886, Gyula Szádeczky used the determination of specific gravity on Hungarian obsidians to describe black, translucent, green and red varieties. Magnetic susceptibility was used to distinguish obsidian tools from pieces of artificial glassy slag resembling to artefacts and found during field prospection.

The presented methods are discussed according to their physical features, i.e. how the information obtained, elemental-, isotopic- or structural analysis, bulk or surface methods, what elements can be measured, are they sensitive enough for trace element analysis, what are the advantages and limitations. Question of the non-destructivity, as well as economic aspects, i.e. the speed and costs of the analysis are also discussed. Some examples of the provenance research of Carpathian obsidians are shown.

Kivonat

Ebben a cikkben áttekintést kívánunk adni a kárpáti obszidiánok vizsgálatára alkalmazott analitikai módszerekről, az 1960-as évek közepétől napjainkig. Az obszidián nyersanyag lelőhelyek azonosítását célzó modern vizsgálati módszerek mellett hagyományos petrográfiai módszerek is alkalmazhatók az obszidiánok kutatására. Ilyen például a vékonycsiszolatok vizsgálata polarizációs mikroszkóppal, amely alkalmas a szöveti kép és irányítottság, zárványok, fenokristályok elemzésére. Mikroszondával vizsgálhatjuk az üveges mátrixba beágyazódó különálló mikrolitokat, trichiteket, és a hagyományos kőzettani vizsgálatok körébe tartozik az üveg törésmutatójának mérése is. Szádeczky Gyula már 1886-ban a fajsúlyuk alapján jellemezte a különböző – fekete, áttetsző, zöldesvörös – obszidián változatokat. A mágneses szuszceptibilitás mérésével az obszidiánok megkülönböztethetők a velük összetéveszthető modern salaküvegektől, amelyek terepbejárásokon gyakran kerülnek elő.

A bemutatott kísérleti módszereket a fizikai jellemzőik szerint tárgyaljuk, azaz, hogy milyen típusú információ nyerhető a vizsgálat segítségével. Elemi- vagy izotópösszetétel, felszíni vagy tömbi összetétel adatot kapunk? Mely kémiai elemek mérhetőek, elég érzékenyek az említett technikák nyomelemek kimutatására? Melyek az egyes módszerek előnyei és hátrányai? A minták roncsolásának kérdését, továbbá a vizsgálatok gazdaságosságát (gyorsaság, költség) is tárgyaljuk. Néhány irodalmi példán mutatjuk be az egyes módszerek alkalmazását a kárpáti obszidiánok provenancia kutatásában.

KEYWORDS: OBSIDIAN, PETROGRAPHY, NAA/PGAA, XRF, ICP-AES/MS, DATING

KULCSSZAVAK: OBSZIDIÁN, KŐZETTAN, NAA/PGAA, XRF, ICP-AES/MS, KELTEZÉS

• How to cite this paper: KASZTOVSZKY, Zs. & PŘICHYSTAL, A. (2018): An overview of the analytical techniques applied to study the Carpathian obsidians, *Archeometriai Műhely* **XV/3** 187-196.

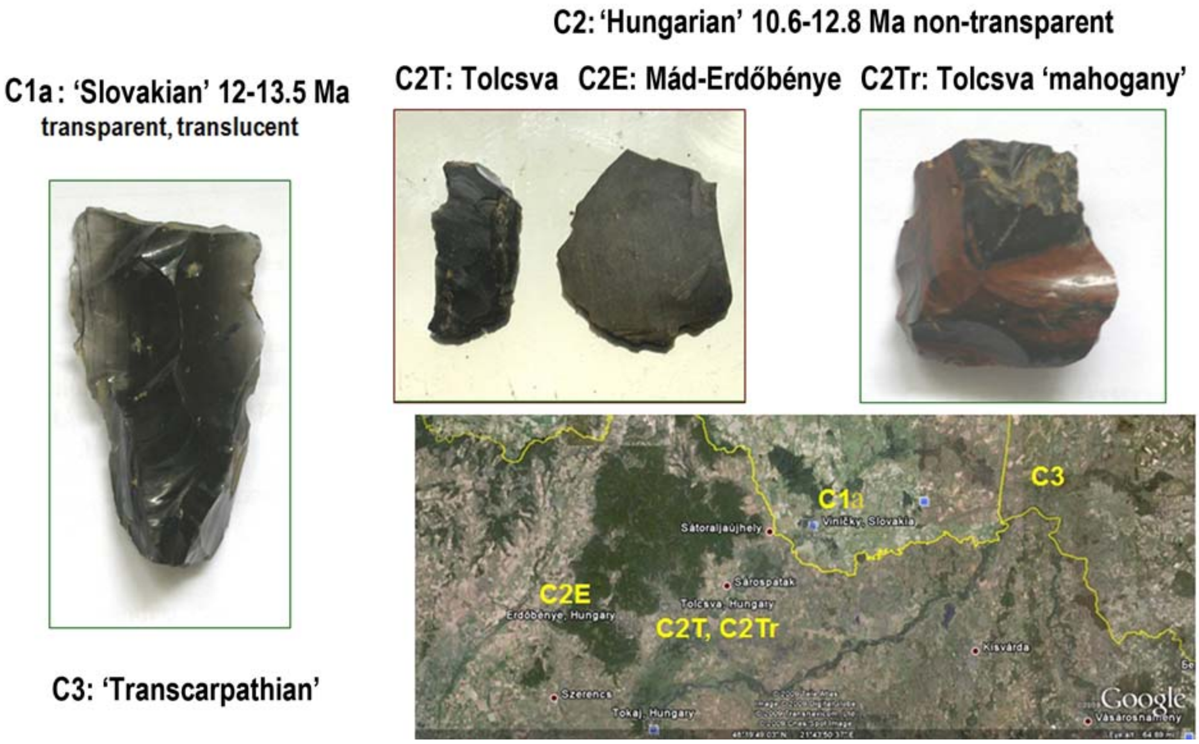


Fig. 1.: The geographical occurrence of the Carpathian 1a, 2 and 3 types obsidian
1. ábra: A kárpáti 1a, 2 és 3. típusú obszidiánok földrajzi előfordulásai

Introduction

Obsidian is one of the most popular raw materials used for chipped stone production in the prehistoric times. It is a volcanic glass formed from rhyolitic lava during quenching process (Taylor 1976). One of the important questions in the archaeological research is to determine the possible geographical locations of the raw material sources that have been used for production of tools. Fortunately, because of the specific conditions of its formation, the geochemical composition of the obsidian can be associated with the provenance with high confidence, as it has shown as early as in the 1960's and 1970's (Cann & Renfrew 1964, Gordus et al., 1968, Bowman et al., 1973).

In addition, the number of geological obsidian sources over the world is limited (Pollmann 1999), which makes the assignation of historical outcrops easier.

In this study, we focus on the Carpathian obsidian, as the main obsidian raw material type used in the prehistory of the Carpathian basin and in its surroundings. The utilization of Carpathian obsidian has been studied already in the 19th century (Rómer 1867, 1878, Szabó 1867, 1878, Szádeczky 1886) and later, in the early 20th century (Janšák 1935, Roska 1934, 1936, Gábori 1950, Vértes 1953).

By now, it is agreed between the scientists (Williams Thorpe et al. 1984, Rosania et al. 2008, Biró 2014) that basically three major types of Carpathian obsidian exist. The C1 (Slovakian) types are 11–15 Ma old (K-Ar dating and fission tracks ages are summarized by Bačo et al. 2017) and they can be found in the Zemplín Hills (south-eastern Slovakia). Comparing the Tokaj – Zemplén Mountains in Hungary, it is another geological and geomorphological unit with Palaeozoic central part and Tertiary volcanic rocks only on its margins. In the south we can distinguish an area of primary obsidian sources around a rhyolite body of Borsuk (267.3 m) with localities Viničky, Malá Bara, Velká Bara and with two different groups from the standpoint of K-Ar ages (older group approximately in the range 13.5 – 11.6 Ma and the younger one with the age a little bit above 11 Ma). Macroscopically similar obsidians probably only shortly transported at Streda nad Bodrogom yielded the third different group of ages between 14.32 – 14.95 Ma (see Bačo et al. 2017).Obsidian from the southern part of Zemplín Hills can be characterized as black, non-translucent, with polyedric shape and smooth surface without sculpture (source Carpathians 1b). Its utilisation in prehistoric times is still a matter of question.

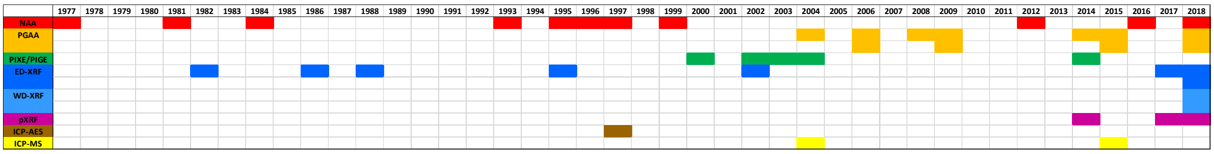
In the north-eastern part of Zemplín Hills there exists a large secondary source of obsidian (fluvial and deluviofluvial deposits, about 6 km^2) near the

Ošva River. The obsidian is usually translucent, partly in the form of pebbles or rounded pieces up to 20 cm with expressively sculptured surface (source Carpathians 1a) and its K-Ar dating varies between 12 – 13.5 Ma. Because of the best quality it was the most popular prehistoric obsidian raw material in the Carpathian region (Přichystal & Škrdla 2014, Bačo et al. 2017).

Radiometric ages for silicic volcanism in the southern part of Tokaj – Zemplén Mountains, it means Hungarian continuation of the Slanec (Slanské) Mountains in Slovakia, are between 12.8±0.5 and 10.6±0.5 Ma (Pécskay et al. 1987, Szepesi & Kozak 2014), so the C2 (Hungarian) type obsidian has the same age. It can be divided in two sub-types, the C2E is from Mád-Erdőbénye, the C2T is from Tolcsva. Its colour is typically grey or brownish, but there exists a unique mahogany coloured variant of the Tolcsva type, which is labelled as C2Tr. Hungarian obsidians from the primary sources have smooth surface without sculpture.

Finally, there is a C3 type Carpathian obsidian, which can be found in the Vinohradiv Mountains, the Tolstoi-Tupoi volcano in Transcarpathian Ukraine (**Fig. 1.**). The Carpathian 3 obsidian is black with pitch lustre, non translucent, its surface can be sculptured by sharp grooves filled with red clay. C3 is considered the poorest type local material of the three, rarely used as raw material for tools. Plagioclase phenocrysts up to 2 mm are visible by naked eye. The whole-rock K-Ar age of surrounding pyroxene dacite is 10.6±0.5 Ma (Pécskay et al. 2000).

In our paper, we discuss the modern analytical methods applied on the Carpathian obsidian samples for provenance research purposes, starting from the 1960s. Certainly, besides of the archaeometry, pure geochemistry might also be interested in the investigation of obsidian composition. These studies aim to answer questions regarding the geological age, formation mechanism, genetics, coloured variants, etc., but this research is out of our scope. We classify the methods according to their physical features, i.e. how the information obtained, elemental-, isotopic- or structural analysis, bulk or surface methods. We examine what elements can be measured, are they sensitive enough for trace element analysis, what are the advantages and limitations. Question of the non-destructivity, as well as economic aspects, i.e. the speed and costs of the analysis are also considered. Some examples of the provenance research of Carpathian obsidians are shown. Further detailed annotated bibliography of the Carpathian obsidian research can be found in this volume. The dates of significant publications about a novel application of a new analytical method on obsidian research are shown in **Table 1.**



	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NAA	🟥				🟥			🟥									🟥		🟥	🟥	🟥		🟥													🟥				🟥		🟥
PGAA																												🟧		🟧		🟧	🟧					🟧	🟧			🟧
																														🟧			🟧						🟧			🟧
PIXE/PIGE																								🟩		🟩	🟩	🟩										🟩				
ED-XRF						🟦				🟦		🟦							🟦							🟦															🟦	🟦
																																										🟦
WD-XRF																																										🟦
																																										🟦
pXRF																																						🟪			🟪	🟪
ICP-AES																					🟫																					
ICP-MS																												🟨											🟨			

Table 1.: Appearance of various analytical techniques in the studied literature about Carpathian obsidian. The total number of the papers studied is about 50. Each coloured cell represents one publication.

1. táblázat: A különböző analitikai módszerek alkalmazásainak első publikáció a kárpáti obszidiánok irodalmában - Kb. 50 cikk alapján. Minden színes téglalap egy publikációt jelöl.

Overview and discussion

Petrographic studies and investigation of physical properties

Before using modern geochemistry on a large scale, the determination of physical properties (specific gravity, refractive index) represented important non-destructive and cheep methods to characterise individual sources of the Carpathian obsidian and to distinguish archaeological obsidian from pseudoartefacts made of artificial glassy slag. That is why a chapter using these methods for mineralogical investigation of the Carpathian obsidian appeared in the classical comprehensive book of Š. Janšák (1935). The chapter has been written by F. Ulrich, professor of mineralogy at Charles University in Prague. The same methods and determination of the main oxides by wet analysis were used by J. Štelcl (1973) when looking for provenance of Neolithic obsidians in Moravia (eastern part of the Czech Republic). He measured specific gravity and refractive index on 29 obsidians from three Neolithic localities in Moravia. He concluded to be a homogenous group belonging to rhyolite obsidian and because of different refractive index on obsidian from Viničky (at that time believed the only one natural occurrence of obsidian in Slovakia), he supposed origin of Moravian archaeological obsidians in Hungary.

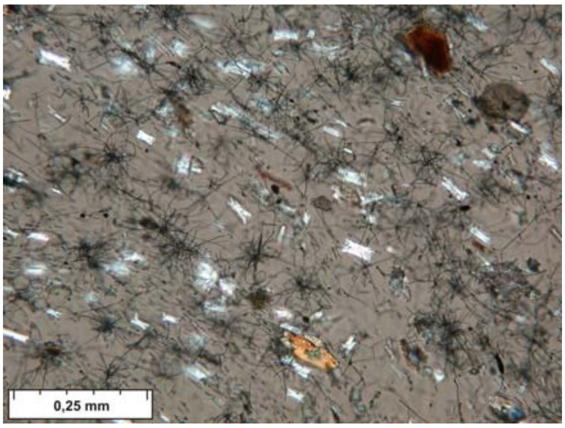


Fig. 2.: Characteristic mineral inclusions (biotite microphenocrysts, plagioclase microliths, clusters of hair-like trichites) in thin section of obsidian from Malá Bara, Slovakia. Photo by A. Přichystal.

2. ábra: Jellegzetes zárványok (biotit mikro-fenokristályok, plagioklász mikrolitok, hajszálszerű trichit-csomók) obszidián vékonycsiszolatában (Kisbár, Szlovákia). A. Přichystal felvétele.

Classic petrographic studies of thin sections under polarising microscope revealed usually hyaline fluidal texture with various proportions of microphenocrysts (plagioclase, biotite), microlites (plagioclase, magnetite, ilmenite, zircon, monazite, pyroxene, olivine, garnet, apatite) and hair-like blackish trichites (**Fig. 2.**). Such clusters or fluffs of microlites seem to be typical for dark obsidians from the Borsuk rhyolite body in Slovakia while in the Hungarian non-translucent obsidian sources the microlites form many simple individual small bars arranged in almost parallel orientation. R. Ďuďa (in Kaminská & Ďuďa 1985) estimated the contents of microlites in Slovakian obsidians from the Borsuk rhyolite body between 10–25% of the rock volume. Substantial progress in petrography of the Carpathian obsidians is connected to the application of microprobe. E. Švecová (2009) or M. Kohút et al. (2018) studied Slovakian obsidians (Carpathians 1 type). Plagioclases are usually zoned with Ca-rich cores (bytownite) and a higher content of Na in their rims (oligoclase). Biotites correspond to Fe-annites. As pyroxenes are concerned, orthopyroxenes of enstatite composition substantially prevail.

Y. Suda et al. (2014) and B. Rácz et al. (2016) investigated Transcarpathian obsidians (Carpathians 3) from the area of Rokosovo. The first group of authors studied in detail plagioclases (with and without zonal structure), orthopyroxenes, olivine and amphibole. Presence of three types of glomeroporphyritic aggregates (the olivine and the orthopyroxene bearing varieties, the third one is composed of only plagioclase) seems to be a characteristic sign for the Transcarpathian obsidians as well.

Petrographic description of Hungarian volcanic glasses was partly a subject of two PhD theses at University of Debrecen. Z. Elekes (2001) studied phenocrysts in obsidian glasses from Armenia, Greece, Slovakia and Hungary as well. He mentioned in detail zircon, pyroxene a biotite from two Hungarian samples (Erdőbénye, Sima). J. Szepesi (2009) focussed his attention on acid lava sequences in NE Hungary including their K/Ar dating and volcano-facies investigation.

At Masaryk University in Brno E. Švecová (2011) studied Carpathian obsidians from all three main sources (Slovakia, Hungary, Transcarpathian Ukraine). Using microprobe, she investigated also obsidians from Olaszliszka, Erdőbénye and Mád and she found plagioclases, orthopyroxenes, biotites, zircons, apatites, magnetites, ilmenites, rarely chalcopyrite (Olaszliszka) or olivine (Mád) among mineral inclusions.

	What is measured?	Bulk / Surface?	Sensitivity?	Accuracy	Sampling?	Speed?	Price?
NAA	Some major, more trace elements (Rb, Sr, Zr, REE); isotopes	Bulk; average for the sample	Sensitive	Good	10-100 mg	Slow (cooling)	Expensive (Reactor)
PGAA	Most major, some trace (B, Cl, H)	Bulk; average for a few cm3	Medium for traces 1-10 ppm	Good	No (large objects!)	Slow (spectrum evaluation)	Expensive (Reactor)
PIXE/PIGE	Major and traces, >Al	Near surface 10-100 um	Sensitive	Good	No	Fast	Less expensive (accelerator)
ED-XRF	Major and traces, >Mg	Near surface some 10 um	Sensitive 0.1-1 ppm	Good	Yes or No	Fast	Less expensive
WD-XRF							
pXRF				Moderate	No		Cheap
ICP-AES	Traces	Bulk for the sample	Very sensitive: <<ppm	Very good	Yes	Slow (Calibration)	Expensive
ICP-MS							

Table 2.: The major characteristics of the analytical methods most frequently applied in obsidian research

2. táblázat: Az obszidián kutatására általánosan használt módszerek összehasonlítása

Determination of finger-printing chemical elements

As it was mentioned earlier, the geochemical composition, i.e. the concentrations of the major, minor and trace elements is characteristic for the location of the obsidian source. This means that sources of two different geographical locations are significantly different in chemical composition. Furthermore, samples within one geographical source can be considered homogeneous, at least within the uncertainty of the given analytical method. It implies that an analytical technique, which is capable to measure the "finger-printing" chemical element with high precision will be useful in provenance studies. Since many times valuable archaeological objects are studied, non-destructive methods are preferred. The various chemical methods are summarized according to their basic features (i.e. the size of the analysed sample, sensitivities, accuracy, speed and costs), in **Table 2.**

Neutron activation methods

In general, the various neutron activation analytical methods are based on the physical phenomenon, that an atomic nucleus emits characteristic gamma radiation, following the capture of a neutron.

From the 1960s, in parallel with the development of spectroscopic instrumentation, neutron activation analysis (NAA) has become a routine analytical tool to determine a few major and a series of trace elements in obsidian, and also in other geological samples. The chemical elements that can be easily measured by NAA are: Na, K, Sc, Cr, Fe, Co, Ni, Zn, As, Se, Br, Rb, Sr, Zr, Ag, Cd, Sb, La, Hf, Ta, W, Ir, Au, Th, U and the rare-earth elements. From these elements, mostly Na, K, Fe, Rb, Sr and Zr are used in the obsidian provenance research. Kilikoglou et al. was able to differentiate between the Mediterranean (Antiparos, Adamas, Demenegaki, Giali) and the Carpathian 1 – mentioned as "Slovakian" obsidian, based on INAA measurements (Kilikoglou et al., 1996). Williams-Thorpe et al. have applied Principal Component Analysis on the concentration data measured by NAA and were able to distinguish even between the various Carpathian sources (Williams-Thorpe et al., 1984).

The NAA method was the most popular technique applied in the obsidian archaeometry in the 1970's and 1980's, at the heyday of the research reactors. When NAA chosen, it must be considered that it requires samples of 10-100 mg to analyse. Furthermore, due to the high neutron flux in the reactor core, the sample will stay radioactive for several days, and cannot be returned to the owner.

Another, less known neutron activation method is called Prompt Gamma Activation Analysis (PGAA). The physical phenomenon is the same as in the case of NAA, but the object is irradiated in an external beam of thermal or cold neutrons, and the characteristic photons are detected at the same time. The use of external beam allows the scientist to omit the sampling. On the other hand, since the so-called prompt photons are detected, the method is sensitive for different chemical elements. Typically, the major geochemical components, i.e. H, Na, K, Ca, Mg, Al, Si, Ti, Mn, Fe and some minor and trace elements, i.e. B, Cl, Sc, V, Nd, Sm, Gd and Eu can be detected with PGAA. Since neutrons can travel deep into the irradiated object, the result is representative for the whole irradiated volume, i.e. the method is a "*bulk*" analytical method.

Until now, only the Budapest PGAA laboratory at the Budapest Neutron Centre applied the method for systematic provenance research of obsidians (Kasztovszky et al., 2008). They have successfully determined the provenance of archaeological obsidian from Hungary (Kasztovszky et al., 2014), from Croatia (Kasztovszky et al., 2009) from Poland (Kabacinski et al., 2015) and from Romania (Kasztovszky et al., 2018a). They have compared the applicability of PGAA, the handheld XRF and the INAA methods for obsidian provenance research and have shown that the B, Cl and Ti concentrations measured by PGAA are perfectly applicable finger-prints (Kasztovszky et al., 2018b).

X-ray fluorescence methods

In another large group of the methods, the analytical information is obtained by detection of characteristic X-ray photons emitted by the electrons of the atoms. The electrons of the atoms in a sample can be excited with various kinds of incident radiation that can be produced by an X-ray (XRF)-, electron (SEM-EDS)- or proton (PIXE) source. The characteristic radiation is detected in energy dispersive (ED) or wavelength dispersive (WD) modes. For all these mentioned methods, the sensitivity is proportional to the atomic number of a given element, and the lightest detectable element is Mg. We must mention that with some portable XRF instrument using He-flush, the detection of Na is also possible. When evaluating the analytical results provided by any of the X-ray fluorescence methods, we must remember that the penetration depth of the exiting radiation is in the order of 10–100 μm, thus the result is representative for the bulk composition, if the sample is homogeneous and the surface is free of any layer of different composition. Furthermore, the result is reliable only if the analyse surface is flat and smooth. In case of laboratory based XRF instruments, homogenized samples are produced by melting the original geological pieces. R. E. Hughes and D. Werra (2014) applied the XRF method to find the provenance of Late Mesolithic obsidians from central Poland. Similarly, this method together with LA–ICP–MS determination of Rb and Zr was used to analyse Late Palaeolithic/Mesolithic and Neolithic obsidians from Bohemia, western part of the Czech Republic (Burgert et al. 2016). Rózsa et al. (2006) have applied comparative fluorescence spectroscopic methods (i.e. PIGE and LA-ICP-MS) for geochemical studies of obsidian samples from various localities (Carpathian Mts., Mexico, Armenia, Iceland and Turkey).

Despite the above disadvantages, the XRF methods, especially the portable ones are widespread, because they are cheap, fast and easy to handle. Marina Milić has shown that the analytical data provided by handheld XRF are as precise as those provided by laboratory-based ED-XRF, PIXE or ICP-MS instruments. Furthermore, based on the well detectable Rb, Sr and Zr concentrations, obsidians from various sources are well separable (Milić 2014).

Although Proton Induced X-ray Emission (PIXE) Spectroscopy in principle does not differ from the XRF methods, in practice it is considered as a “large scale facility” since it requires a Van de Graaf accelerator to generate a proton beam, and therefore associated with significantly higher operational costs, compared to the portable XRF. Using PIXE and PIGE, however, it is possible to measure fingerprinting chemical elements, such as Ti, Mn, Rb and Sr, based on which discrimination of obsidian sources can be done (Elekes et al., 2000; Bugoi et al., 2004; Constantinescu et al, 2002, 2014.). It can be seen from **Table 1**, that PIXE and PIGE are mostly used in the archaeometry of the Carpathian obsidian from the 2000’s and performed by the laboratories of Debrecen, Hungary and Bucarest, Romania. Rózsa et al (2003) have applied micro-PIXE method to map the distribution of phenocrysts in obsidian, mainly in Carpathian ones for provenance purposes.

Plasma spectroscopy methods

In case of the third large group of analytical methods, the elemental or isotopic composition of the samples is determined by the means of plasma spectroscopy. A tiny amount of the sample is combusted in a high frequency plasma torch, and the atomized components are analysed by the detection of characteristic electromagnetic radiation (AAS, AES, ICP-AES) or by mass spectrometry (ICP-MS). When the analysed material is vaporized by a laser beam (LA-ICP-MS), the smallest, practically invisible destruction is done on the object. The method was used to analyse a large collection of 46 obsidians from three basic geological sources in the Carpathians, from natural occurrences in Turkey or Greece and archaeological artefacts from Moravia, Slovakia, Italy, Nicaragua, Mexico, Iraq and Syria (Prokeš et al. 2015).

On the other hand, the Inductively Coupled Plasma Spectroscopic (ICP) methods represent the most sensitive and most accurate techniques applicable in geochemistry, specifically in the obsidian provenance research. Almost every chemical element – except hydrogen, the halogens and noble gases – can be measured in a concentration as low as ppb (ng/g) level. These methods are also applicable to determine isotopic composition of the samples that is even more effective tool to identify the geological origin of obsidian (Orange et al., 2016).

Structural studies (Electron Microscopy, Mössbauer Spectroscopy, Small Angle Neutron Scattering)

Although only a few studies dealt with the topic, it is believed that – as a consequence of the formation process – not only the elemental composition, but also some structural information might refer to the location of a given obsidian source. In a recent study (Kasztovszky et al., 2018c), geochemical reasons of the formation of the rare mahogany obsidian, and the possibilities of source identification was discussed. Black and mahogany obsidians from Tolcsva, as well as mahogany obsidian from Bogazköy have been analysed by Electron Microscopy, Mössbauer Spectroscopy and Small Angle Neutron Scattering (SANS). With the help of SANS, anisotropy, porosity, etc. can be investigated on a 10-100 nm scale by detecting the elastic scattering pattern by cold or thermal neutrons.

SANS measurements at the Budapest Neutron Centre have determined that the so-called fractal exponents (3.28 for Tolcsva black and 3.60 for Tolcsva mahogany) are the “measure” of the surface roughness. Smoother or rougher surface features could be linked to the different genetic conditions of the samples (such as composition, temperature, pressure, cooling rate etc.) With the help of Transmission Electron Microscopy (TEM), agglomerated iron-oxide nanocrystallites were identified as scattering objects. The isotropic scattering of the Tolcsva sample originated from randomly oriented nanocrystallites, while anisotropic scattering originated from nanocrystallites with a preferred orientation, aligned during their formation. Finally, Mössbauer Spectroscopy has identified disordered hematite in the mahogany samples.

Dating methods (Fission Track Dating & Hydration Dating)

Two different kinds of dating are applied to study the provenance of archaeological obsidian. Fission Track Dating (FTD) is based on the counting of microscopic tracks caused by the fission of natural uranium content of obsidian. This method aims to determine the geological age, i.e. the date of formation of obsidian. With the help of FTD, Bigazzi et al. was able to distinguish between the younger "Tokaj" (i.e. C2 type) and the older "Zemplin" (i.e. C1 type) obsidians (Bigazzi et al., 1990). In a later study (Bigazzi et al., 1993) it is shown that with combination of FTD and NAA, Anatolian and Carpathian obsidians were possible to distinguish with high efficiency.

The Hydration Dating (HD) is based on the phenomenon that on a fresh surface of obsidian, a thin hydration layer starts to grow. The thickness of the layer is typically in the order of 10 μm, and it grows proportionally with the ½ exponent of time. With the help of HD, one can determine the approximate time of the elaboration of the archaeological obsidian (Biró & Pozsgai 1982).

Conclusions

In this study, we aimed to give a brief overview of the modern analytical methods that can be used in the archaeometrical studies of obsidian. We have demonstrated, that not only the elemental composition, but also some structural information as well as the dating of obsidian samples might help to determine the provenance of the object, i.e. to localise the geographical source of its raw material.

Apparently, when one must choose one or more analytical techniques, more arguments has to be considered. Every analytical method has advantages and disadvantages, too. Speaking of objects of the Cultural Heritage, non-destructive and non-invasive methods are absolutely preferred. Optimisation of costs vs. benefit (i.e. the abundance and usefulness of the provided information), as well as of speed and accuracy of the investigations are natural demands.

In many cases, combination of complementary methods may lead to more successful research. But we have to draw the attention to the adequate interpretation of the analytical results that are obtained with inherently different methods.

To help the analyst to choose the best combination of method, we summarize the most important features of the techniques discussed here.

References

BAČO, P., KAMINSKÁ, Ľ., LEXA, J., PÉCSKAY, Z., BAČOVÁ, Z. & KONEČNÝ, V. (2017): Occurrences of Neogene volcanic glass in the eastern Slovakia – raw material source for the stone industry. *Anthropologie* **LV/1-2** 207–230.

BIGAZZI, G., MÁRTON, P., NORELLI, P.& ROZLOŽNÍK, L. (1990): Fission track dating of Carpathian obsidians and provenance identification. *Nucl. Tracks Radiat. Meas*. **17** 3 391–396.

BIGAZZI G., ERCAN, T., . ODDONE, M. ÖZDOĞAN, M. & YEĞINGIL, Z. (1993): Application of fission track dating to archaeometry: provenance studies of prehistoric obsidian artifacts. *Nucl. Tracks Radiat. Meas*. **22/1-4** 752–762.

BIRÓ, K. T. (2014): Carpathian obsidians: state of art. In: Yamada, M., Ono, A. (Eds.), Lithic Raw Material Exploitation and Circulation in Prehistory. ERAUL **138** 47–69.

BIRÓ, K. T. & POZSGAI, I. (1982): Obszidián hidrációs kérgének vizsgálata kormeghatározás céljából (Obsidian hydration rind measurement for archaeological dating). *Archaeologiai Értesítő* **109/1** 124–132.

BOWMAN, H. R., ASARO, F.& PERLMAN, I. (1973): Composition variations in obsidian sources and the archaeological implications. *Archaeometry* **15** 123–127.

BUGOI, R., CONSTANTINESCU, B., NEELMEIJER,C. & CONSTANTIN, F.(2004): The potential of external IBA and LA-ICP-MS for obsidian elemental characterization. *Nuclear Instruments and Methods in Physics Research B* **226** 136–146.

BURGERT, P., PŘICHYSTAL, A., PROKEŠ, L., PETŘÍK, J. & HUŠKOVÁ, S. (2016): Původ obsidiánové suroviny v pravěku Čech (The origin of obsidian in prehistoric Bohemia). *Archeologické rozhledy* **68** 224–234.

CANN, J. R. & RENFREW, C. (1964): The characterization of obsidian and its application to the Mediterranean Region. *Proceedings of the Prehistoric Society* **30** 111–133.

CONSTANTINESCU, B., BUGOI, R. & SZIKI, G. (2002) Obsidian provenance studies of Transylvanian's Neolithic tools using PIXE, micro-PIXE and XRF. *Nuclear Instruments and Methods in Physics Research B* **189** 373–377.

CONSTANTINESCU, B., CRISTEA-STAN, D., KOVÁCS, I. & SZŐKEFALVI-NAGY Z. (2014): Provenance studies of Central European Neolithic obsidians using external beam milli-PIXE spectroscopy. *Nuclear Instruments and Methods in Physics Research B* **318** 145–148.

ELEKES, Z. (2001): Ion Beam Based Nuclear Microanalysis of Geological and Archaeological Objects. PhD theses. University of Debrecen.

ELEKES, Z., UZONYI, I., GRATUZE, B., RÓZSA, P., KISS, Á.Z. & SZÖŐR, GY. (2000): Contribution of PIGE technique to the study of obsidian glasses. *Nuclear Instruments and Methods in Physics Research B* **161-163** 836–841.

GÁBORI, M. (1950): Az őskori obszidián-kereskedelem néhány problémája (Some problems of prehistoric mobsidian trade). *Archaeológiai Értesítő* **77** 50–53.

GORDUS, A. A., WRIGHT, G. A. & GRIFFIN, J. B. (1968): Obsidian Sources Characterized by Neutron-Activation Analysis. *Science* **161** 3839 382–384.

HUGHES, R. E. & WERRA, D. (2014): The source of Late Mesolithic obsidian recovered from Rydno XIII/1959, central Poland. *Archeologia Polski* **59** 31–46.

JANŠÁK, S. (1935): Praveké sídliská s obsidiánovou industriou na východnom Slovensku (Prehistoric settlements with obsidian industry in eastern Slovakia). Bratislava 1935, 1–193.

KABACIŃSKI, J., SOBKOWIAK-TABAKA, I., KASZTOVSZKY, ZS., PIETRZAK, S., LANGER, J.J., BIRÓ, K.T. & MARÓTI, B. (2015): Transcarpatian influences in the early neolithic Poland. A case study of Kowalewko and Rudna Wielka sites. *Acta Archaeologica Carpathica* **50** 5–32.

KAMINSKÁ, Ľ. & ĎUĎA, R. (1985): K otázce významu obsidiánovej suroviny v paleolite Slovenska (To the question of obsidian raw material importance in the Paleolithic of Slovakia). *Archeologické rozhledy* **37** 121–129.

KASZTOVSZKY, ZS., BIRÓ, K.T., MARKÓ, A. & DOBOSI, V. (2008) Cold neutron prompt gamma activation analysis - a non-destructive method for characterization of high silica content chipped stone tools and raw materials. *Archaeometry* **50** 112–19.

KASZTOVSZKY, ZS., BIRÓ, K.T., KIS, Z. (2014): Prompt gamma activation analysis of the Nyírlugos obsidian core depot find. *Journal of Lithic Studies* **1** 151–163.

KASZTOVSZKY ZS., BIRÓ, K. T., NAGY-KORODI, I., SZTÁNCSUJ, S. J., HÁGÓ, A., SZILÁGYI, V., MARÓTI, B., CONSTANTINESCU, B., BERECKI, S. & MIREA, P. 2019: Provenance study on prehistoric obsidian objects found in Romania (Eastern Carpathian Basin and its neighbouring regions) using Prompt Gamma Activation Analysis. *Quaternary International* **510** 76–87

KASZTOVSZKY, ZS., LÁZÁR, K., KOVÁCS KIS,V., LEN, A., FÜZI, J., MARKÓ, A., BIRÓ, K. T.(2018c): A novel approach in the mineralogy of Carpathian mahogany obsidian using complementary methods. *Quaternary International* **467** 332–341.

KASZTOVSZKY, ZS., MARÓTI, B., HARSÁNYI, I., PÁRKÁNYI, D., SZILÁGYI V. (2018): A comparative study of PGAA and portable XRF used for non-destructive provenancing archaeological obsidian. *Quaternary International* **468** 179–189.

KASZTOVSZKY, ZS., SZILÁGYI, V., BIRÓ, K.T., TEŽAK-GREGL, T., BURIČ, M., ŠOŠIČ, R. & SZAKMÁNY, GY.(2009): Horvát és bosnyák régészeti lelőhelyekről származó obszidián eszközök eredetvizsgálata PGAA-val (Provenance study of Croatian and Bosnian archaeological obsidian artefacts by PGAA). *Archeometriai Műhely* **6/3** 5–14.

KILIKOGLOU, V., BASSIAKOS, Y., GRIMANIS, A.P., SOUVATZIS, K. (1996): Carpathian obsidian in Macedonia, Greece. *Journal of Archaeological Science* **23** 343–349.

KOHÚT, M., KOLLÁROVÁ, V., MIKUŠ, T., KONEČNÝ, P., ŠURKA, J., MILOVSKÁ, S., HOLICKÝ, I. & BAČO, P. 2018: The mineralogy and petrology of the Carpathian obsidians. *Joint 5th Central-European Mineralogical Conference and 7th Mineral Sciences in the Carpathians Conference, Banská Štiavnica.* Book of abstracts, , Comenius University in Bratislava, 50–52.

MILIĆ, M. (2014): PXRF characterisation of obsidian from central Anatolia, the Aegeanand central Europe. *Journal of Archaeological Science* **41** 285–296.

ORANGE, M., LE BOURDONNEC, F-X., SCHEFFERS, A., JOANNES-BOYAU, R. (2016): Sourcing obsidian: a new optimized LA-ICP-MS protocol, *STAR: Science & Technology of Archaeological Research*, **2/2** 192–202

PÉCSKAY Z., BALOGH K., SZÉKYNÉ F.V. & GYARMATI P. (1987): A Tokaji-hegység miocén vulkánosságának K/Ar geokronológiája (K/Ar geochronology of the Miocene volcanism in the Tokaj Mts.). *Földtani Közlöny* **117** 237–253.

PÉCSKAY, Z., SEGHEDI, I., DOWNES, H., PRYCHODKO, M. & MACKIV, B. (2000): K/Ar dating of Neogene calc-alkaline volcanic rocks from Transcarpathian Ukraine. *Geologica Carpathica* **51** 83–89.

POLLMANN, H.O. (1999): *Obsidian-Bibliographie. Artefakt und Provenienz.* Bochum Verlag des Deutschen Bergbau-Museums, pp. 1–151.

PROKEŠ, L., VAŠINOVÁ GALIOVÁ, M., HUŠKOVÁ, S., VACULOVIČ, T., HRDLIČKA, A., MASON, A. Z., NEFF, H., PŘICHYSTAL, A. & KANICKÝ, V. (2015): Laser microsampling and multivariate methods in provenance studies of obsidian artefacts. *Chemical Papers* **69/6** 761–778.

PŘICHYSTAL, A. & ŠKRDLA, P. (2014): Kde ležel hlavní zdroj obsidiánu v pravěku střední Evropy? / Where was situated the principal source of obsidian in prehistory of Central Europe? *Slovenská Archeológia* **62** 215–226.

RÁCZ, B., SZAKMÁNY, G. & 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** 209–230.

ROSKA, M. (1934): Adatok Erdély őskori kereskedelmi, művelődési és népvándorlási útjaihoz (Data on the trade, cultural and migrational routes of prehistoric Transsylvania). *Archaeológiai Értesítő* **47** 149–158.

ROSKA, M. (1936): Adatok Erdély őskori kereskedelmi, művelődési és népvándorlási útjaihoz II. (Data on the trade, cultural and migrational routes of prehistoric Transsylvania II.). *Archaeológiai Értesítő* **49** 72–83.

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

RÓMER, F. (1867): Első obsidian-eszközök Magyarországon (First obsidian implements in Hungary). *Archaeológiai Közlemények* **7** 161–166.

RÓMER, F. (1878): Les silex taillé set les obsidiennes en Hongrie. Congr. Int. d'Anthr. et d'Arch. Prehist. VIII. 1876 *Compte-Rendu* **2,** Budapest, 6–17.

RÓZSA, P., ELEKES, Z., SZÖŐR, GY., SIMON, A., SIMULÁK, J., UZONYI, I. & KISS, Á. Z. (2003): Phenocrysts in obsidian glasses. *Journal of Radioanalytical and Nuclear Chemistry* **256/2** 329–337.

RÓZSA, P., SZÖŐR, GY., ELEKES, Z., GRATUZE, B., UZONYI, I. & KISS, Á. Z. (2006): Comparative geochemical studies of obsidian samples from various localities. *Acta Geologica Hungarica* **49/1** 73–87.

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* **1** 21–37.

SZABÓ, J. (1867): A Tokaj-Hegyalja obsidiánjai (Obsidians of the Tokaj Mts). *A Magyarhoni Földtani Társulat Munkálatai* **3** 147–172.

SZABÓ, J. (1878): L'obsidienne prehistorique en Hongrie et en Grece. Congr.Int. d´Anthr. et d´Arch. Prehist. VIII. 1876 *Compte-Rendu* **2** Budapest, 96–100.

SZÁDECZKY, Gy. (1886): A magyarországi obsidiánok, különös tekintettel geológiai viszonyaikra. (Hungarian obsidians, with special regard to their geological relations). *Értekezések a természettudományokköréből*, Budapest, **16** 1–64.

SZEPESI, J. (2009): A savanyú vulkanizmus fáciestani vizsgálata ÉK–Magyarországon (Volcano-facies investigation on acid lava sequences, north-eastern Hungary). *PhD thesis*. University of Debrecen.

SZEPESI, J., & KOZAK, M. (2014): Reheating, welding and hydration at an acidic lava flow base - a case study of Lebuj outcrop, Tokaj Mts., Hungary. *Schriftenreihe der Deutschen Gesellschaft für Geowissenschaften* **85** 418.

SZEPESI, J., LUKÁCS, R.., T. BIRÓ, K., MARKÓ A., PÉCSKAY, Z. & HARANGI, Sz. (2018): Geology of Tokaj Mountains obsidians. *Archeometriai Műhely* **15/3** 167–180.

ŠTELCL, J. (1973): Contribution to the knowledge of obsidians occurring in the Moravian Neolithic. *Scripta Fac. Sci. UJEP Brunensis, Geologia* **3** 89–101.

ŠVECOVÁ, E. (2011): Charakteristika vulkanických skel z Karpat a jejich využívání v pravěku (Characterization of volcanic glasses from the Carpathians and their utilization in the prehistory). Manuscript of MSc thesis, Faculty of Science, Masaryk University in Brno.

TAYLOR, R. E. (ed.) (1976): Advances in Obsidian Glass Studies: *Archaeological and Geochemical Perspectives*. Park Ridge: Noyes Press.

ULRICH, F. (1935): Mineralogický výzkum obsidiánu (Mineralogical investigation of obsidian). In: JANŠÁK, Š. (1935): Praveké sídliská s obsidiánovou industriou na východnom Slovensku , 11–16. Bratislava.

VÉRTES, L. (1953): Az őskőkor társadalmának néhány kérdéséről (On some questions concerning

Palaeolithic society). *Archaeológiai Értesítő* **80** 89–103

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

USE OF OBSIDIAN FROM THE PALEOLITHIC TO THE BRONZE AGE IN SLOVAKIA•

OBSZIDIÁN FELHASZNÁLÁS SZLOVÁKIA TERÜLETÉN AZ ŐSKŐKORTÓL A BRONZKORIG

Ľubomíra KAMINSKÁ[1]

[1]Institute of Archeology, Slovak Academy of Science, Hrnčiarska 13, 040 01 Košice, Slovak Republic

E-mail: kaminska@saske.sk

Abstract

Near the Zemplínske vrchy hills, there are autochthonous sources of obsidians in Viničky and secondary ones between Cejkov and Brehov. Most artifacts at archaeological sites were made of obsidians with sculpturing from secondary sources. In the culture of Aurignacian, obsidian was only marginally used, however, it dominated in the Gravettian and Epigravettian. It sporadically occurred in western Slovakia as well. It is documented in the Świderian in Spiš in the Late Paleolithic and at other Epipaleolithic to Mesolithic sites in Spiš, Orava and in southern Slovakia. The Mesolithic industry from Košice-Barca I was exclusively made of obsidian.

Obsidian prevailed in all stages of the Eastern Linear Pottery culture at sites in the Východoslovenská nížina lowland. On the other hand, it was less frequent in the Košická kotlina basin. In the Bükk culture, it prevailed at the sites situated closer to its sources; in the rest of the territory, it was a minor raw material. In the west of Slovakia, obsidian first appears as early as the later stage of the Linear Pottery Culture. There is higher frequency of occurrence at sites of the Želiezovce group – Lengyel I culture, when it arrives in Moravia and Austria. The occurrence of obsidian decreases in the subsequent periods.

By the end of the Neolithic (Csőszhalom-Čičarovce group) and in the Early Eneolithic (Tiszapolgár culture), obsidian artifacts are more frequent at settlements than burial grounds. Use of obsidian survives until the Early Bronze Age (the Košťany and Otomani cultures).

Kivonat

A Zempléni dombvidék mellett Szőlőskén (Viničky) elsődleges helyzetben levő obszidián nyersanyag előfordulást ismerünk. További, másodlagos nyersanyagforrások ismertek Céke (Cejkov) és Imreg (Brehov) között. A jellegzetes kortex alapján a legtöbb régészeti lelőhelyen előkerült obszidián másodlagos nyersanyagforrásból származik. Az aurignaci kultúra idején az obszidiánt csak kisebb mennyiségben használták, de a gravetti és epigravetti lelőhelyeken Kelet-Szlovákiában domináns nyersanyag. Kisebb mennyiségben eljutott Nyugat-Szlovákia trületére is. Ismerjük előfordulását a Szepesség świderi kultúrájából (késő paleolitikum) és további lelőhelyekről az epipaleolit és mezolit időszakban, a Szepesség, Árva (Orava) vidék, és Dél-Szlovákia területéről. Košice-Barca I lelőhely mezolit ipar kizárólag obszidián nyersanyagot használt fel.

Az obszdián domináns a Keleti Vonaldíszes Kerámia kultúrájának minden fázisában a Kelet-Szlovákiai Síkságon. Másrészt kevésbé gyakran fordult elő a Kassai medencében. A Bükki kultúra idején a nyersanyagforrásokhoz közelebb eső lelőhelyeken az obszidián dominál, a távolabbi lelőhelyeken csak kisebb mennyiségben van jelen ez a nyersanyag. Nyugat-Szlovákiában az újkőkor során az obszidián először a Vonaldíszes Kerámia Kultúrájának késői fázisában jelenik meg. nagyobb mennyiségben van jelen a zselizi és a lengyeli kultúra I. fázisának anyagában, amikor is eléri a morva és osztrák területeket is. A továbbiakban az obszidián jelentősége, előfordulása fokozatosan csökken.

A késői neolitikum idejére (Csőszhalom-Čičarovce csoport) és a korarézkorban (tiszapolgári kultúra), az obszidián eszközök gyakrabban fordulnak elő telepanyagokban mint temetőkben, sírmellékletként. Az obszidián felhasználás a korai bronzkorig dokumentált (Košťany és ottományi kultúra leletanyagában).

KEYWORDS: OBSIDIAN, USE, ARCHAEOLOGICAL CULTURES, SLOVAKIA

KULCSSZAVAK: OBSZIDIÁN, FELHASZNÁLÁS, RÉGÉSZETI KULTÚRÁK, SZLOVÁKIA

• How to cite this paper: KAMINSKÁ, Ľ., (2018): Use of obsidian from the Paleolithic to the Bronze Age in Slovakia, *Archeometriai Műhely /Archaeometry Workshop* **XV/3** 197-212.

HU ISSN 1786-271X; urn: nbn: hu-4106 © by the author(s)

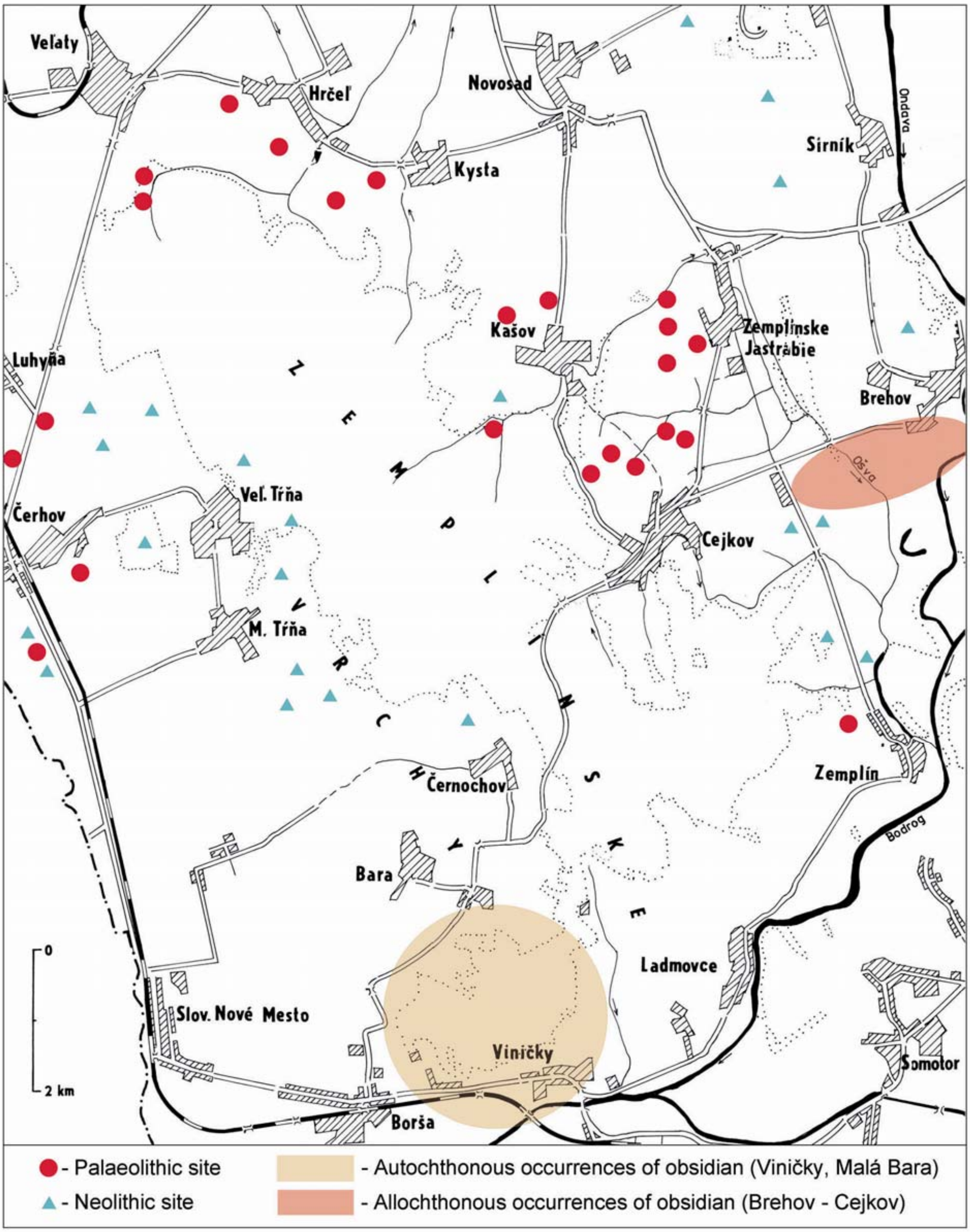


Fig. 1.: Map of the area of the Zemplínske vrchy hills with autochthonous and allochthonous source of obsidian, with sites from the Paleolithic and Neolithic.

1. ábra: A Zempléni dombvidék térképe, elsődleges és másodlagos helyzetű obszidián nyersanyagforrásokkal és az őskőkori és újkőkori lelőhelyekkel

Introduction

The rich occurrence of obsidians in fields and vineyards near the Zemplínske vrchy hills has attracted attention of collectors for decades. It is still possible to collect other artifacts at new Paleolithic and Neolithic/Eneolithic sites (**Fig. 1**.). Our knowledge of primary and secondary sources of obsidian near the Zemplínske vrchy hills is rather complex. The name of Carpathian group 1 or C1 is used for the Slovak sources, Carpathian group 2 or C2 includes Hungarian sources in the Tokaj-Prešov Mountains north of Miskolc (Williams-Thorpe et al. 1984; Biró & Kasztovszky 2013). Sources of obsidians in Transcarpathian Ukraine near Rokosovo are considered Carpathian group 3 or C3 (Rácz 2013).

Primary sources of obsidian in Slovakia are concentrated near Viničky (Kaminská 1991; 2013; Kaminská & Ďuďa 1985), secondary ones are found in the area of Brehov – Cejkov (Bascó et al. 1995; Přichystal & Škrdla 2014). On the basis of comparisons between obsidians from the sources and artifacts from archaeological sites, the secondary occurrences of obsidians with sculpturing from the area of Brehov - Cejkov are currently considered the main source for prehistoric industry (Bačo & Bačová 2014; Přichystal & Škrdla 2014). However, dating of the obsidians from the archaeological sites shows accordance with obsidians from the early phase of rhyolite volcanism from Viničky and does not exclude existence of another, so far unknown natural source (Bačo et al. 2017, 224, Table I).

Paleolithic

Š. Janšák (1935) was the first scientist to point to the occurrence of the high number of obsidian industry near the Zemplínske vrchy hills. In the archaeological cultures of the Stone Ages, the share of obsidian varied – its use declined with the distance from the sources.

Individual prehistoric communities used also other local minerals, although their quality was lower (limnosilicites, hornstones, andesite). We detected presence of raw materials from distant sources (flints from Poland, Volhynian flint, limnosilicites and quartz porpfyry from the northeastern Hungary, etc.) at the sites.

Middle Paleolithic settlement has not been reliably confirmed near the Zemplínske vrchy hills, thus, use of obsidian in the above stated period (Přichystal & Škrdla 2014, 223) is not considered undoubtedly proved. Artifacts made of obsidian have not been found at other old Paleolithic sites either (Hôrka-Ondrej, Gánovce-Hrádok, Bojnice I and III, etc.).

The Early Paleolithic Aurignacian culture in the Košická kotlina basin prefered limnosilicite for production of artifacts (Kaminská 1991; 2001; 2013). A small number of obsidians occurred also among the finds from Košice-Barca I, Košice-Barca II, Kechnec I (Bánesz 1968), from Čečejovce (Kaminská 1990), where end-scrapers were made from it (**Fig. 2.**).

Fig. 2.: Čečejovce. End-scrapers made of obsidian. Aurignacian (photo A. Marková).

2. ábra: Čečejovce (Csécs). Obszidián vakarók. Aurignaci kultúra (felvételt készítette: A. Marková).

Fig. 3.: Tibava (Tiba). Carinated end-scrapers made of patinated obsidian. Aurignacian (photo A. Marková).

3. ábra: Tibava (Tiba). Obszidián vakarók patinás felülettel. Aurignaci kultúra (felvételt készítette: A. Marková).

Higher percentage of obsidian (19%) is found only in Tibava in the Východoslovenská nížina lowland (Bánesz 1960). According to geochemical analyses, it came from Hungarian – not Slovak – sources identified as Carpathian group 2 (Williams-Thorpe et al. 1984, 195). Considerable patinated obsidian occurring in Tibava was used mainly in production of carinated end-scrapers (**Fig. 3.**), blades and bladelike flakes. The Aurignacian of the Košická kotlina basin is roughly dated to 35-28 ka BP (Chu et al. in press; Verpoorte 2002, 316, tab. 9).

The highest concentration of the younger paleolithic culture of Gravettian and Epigravettian is situated in the Východoslovenská nížina lowland and near the Zemplínske vrchy hills. This fact was reflected also in the considerably more frequent use of obsidian from local sources (Carpathian group 1) for production of chipped stone industry. Cejkov and Kašov are the most important sites. In Cejkov, Gravettian and Epigravettian settlement is concentrated on the top and slopes of Tokajský vrch hill (Cejkov I-V). During multiple-year investigations and collections of L. Bánesz (1960; 1969; 1996) and other investigators (Kaminská & Tomášková 2004), numerous chipped industry was obtained from several sites. Obsidian prevailed on most of them, but limnosilicites of various provenances and patinated erratic silicite from remote sources were also frequent. Accumulation of smaller obsidian nodules with sculpturing was uncovered during investigation of the site of Cejkov I in 1969, in trench II over area of 50 x 35 cm (Bánesz 1974, Fig. 4.). Some of them bore traces of primary processing. They were an imported raw material for artifacts chipped in the area of the camp. The chronological span of the Late Gravettian settlement in Cejkov I is determined by several datings to 24 – 21 ka calBP (Verpoorte 2002; Kaminská & Tomášková 2004).

At the neighbouring site of Kašov I in the bottom layer, obsidian artifacts made 33.26% of finds (Bánesz 1969; Novák 2002). Considerable amount of artifacts (49.32%) was chipped off patinated flints (erratic flint from Silesia, Kraków-Jurassic and Volhynian flints). Dating of the bottom layer by ^{14}C is 20 700 ± 350 BP (Bánesz 1993).

We know a smaller number of Gravettian sites from the Košická kotlina basin. Košice-Barca-Svetlá III is the most distinct one; there, obsidian occurred, however, patinated flint prevailed (Bánesz 1967).

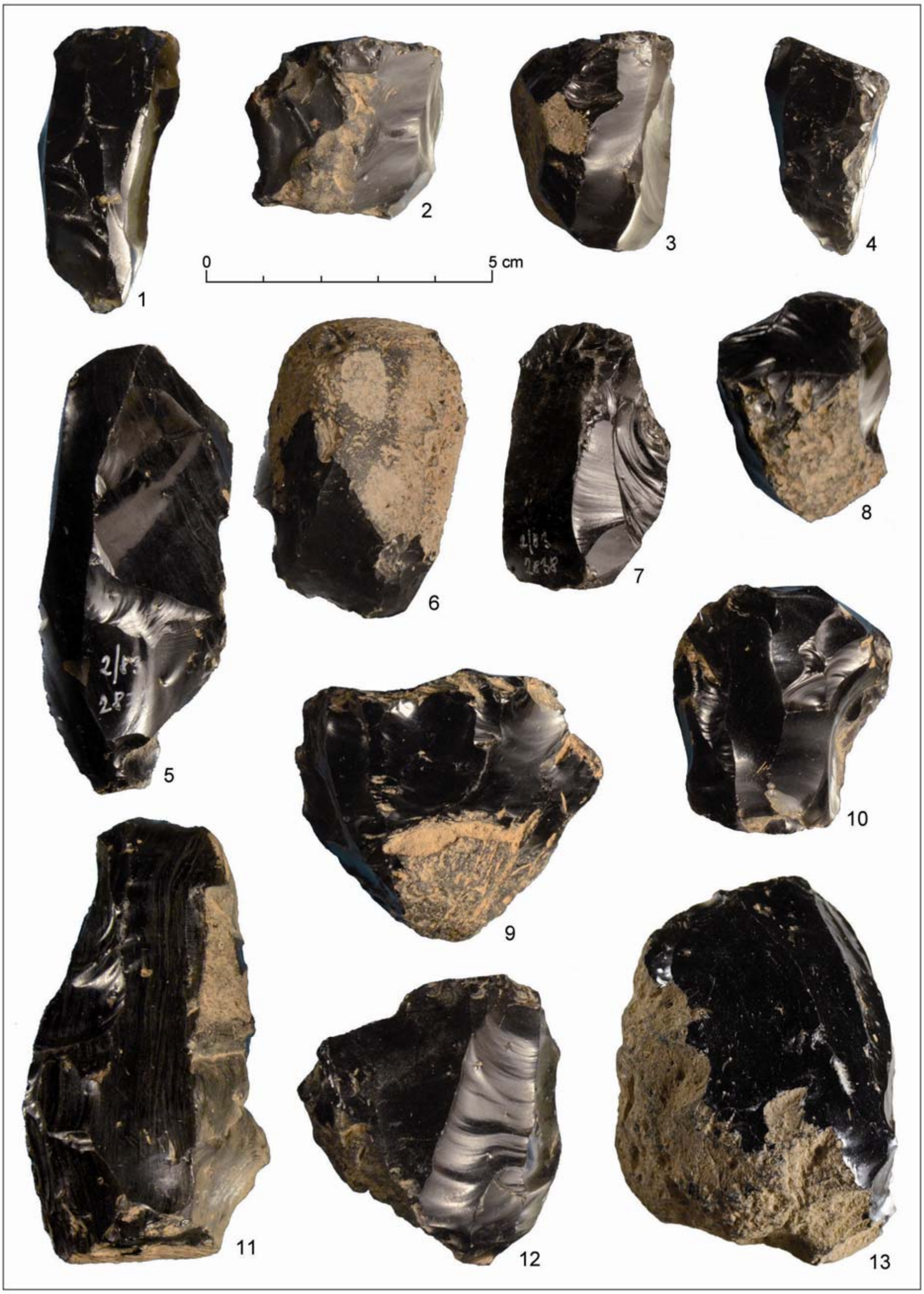


Fig. 4.: Hrčeľ-Pivničky. Various obsidian cores. Epigravettian (photo A. Marková).
4. ábra: Hrčeľ (Gercsely)-Pivničky. Obszidián magkövek. Epigravetti kultúra (felvételt készítette: A. Marková).

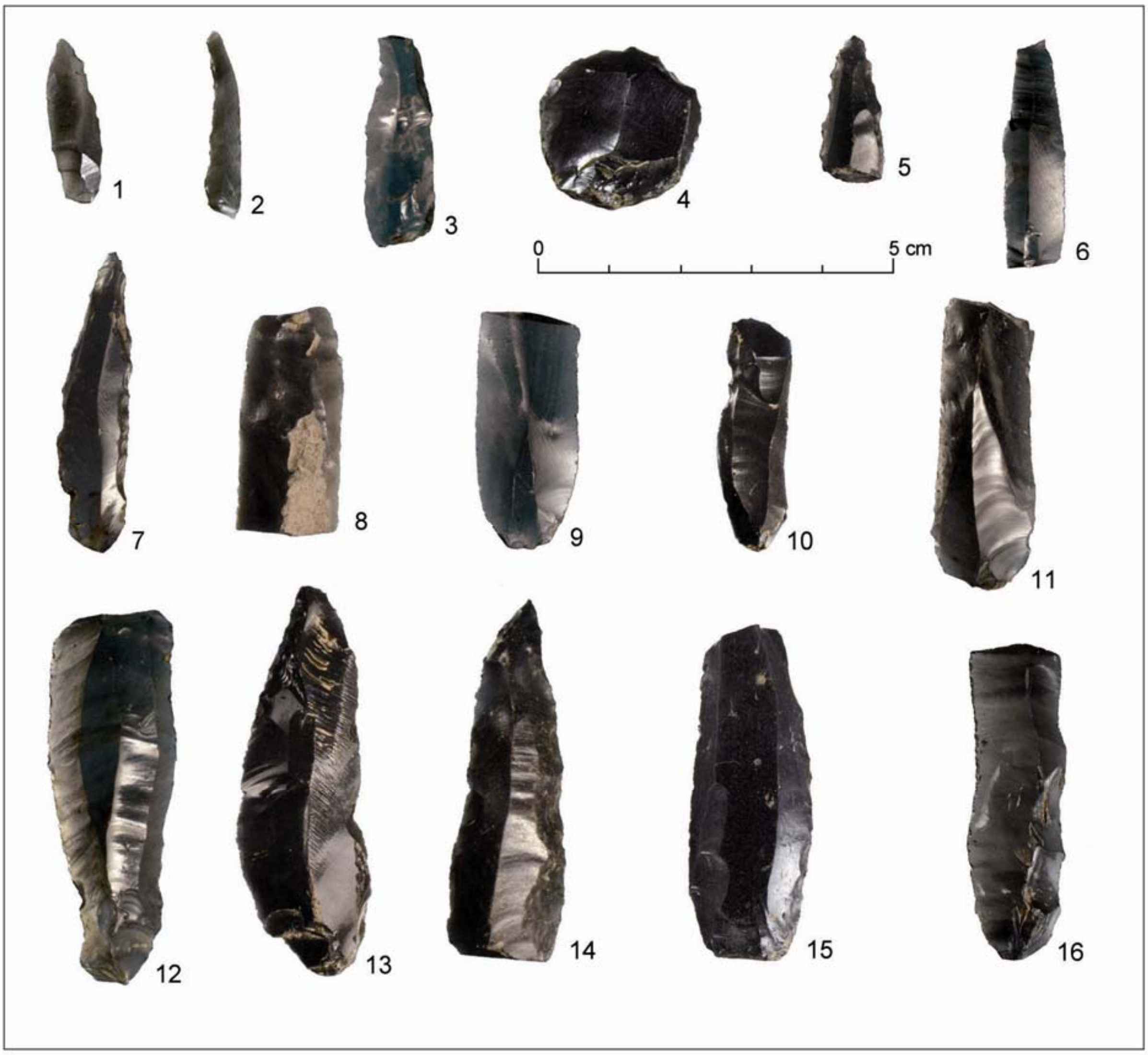


Fig. 5.: Hrčeľ-Pivničky. Chipped industry made of obsidian. Epigravettian. 1, 5, 7, 13, 14 – retouched pointed blades; 2 – backed bladelet; 4 – end-scraper; 3, 6, 8, 9 – blades; 10 – notched blade; 11, 12, 15, 16 – retouched blades (photo A. Marková).

5. ábra: Hrčeľ (Gercsely)-Pivničky. Kőeszközök obszidiánból. Epigravetti kultúra. 1, 5, 7, 13, 14 – retusált pengehegyek; 2 – tompított hátú penge; 4 – vakaró; 3, 6, 8, 9 – pengék; 10 – hornyolt penge; 11, 12, 15, 16 – retusált pengék (felvételt készítette: A. Marková).

Obsidian was the dominant raw material at all Epigravettian sites near the Zemplínske vrchy hills. In Kašov I in the upper layer, it made 81.73% (Bánesz 1969; Bánesz et al. 1992), in Hrčeľ-Nad baňou it was 47.29%, in Hrčeľ-Pivničky (**Fig. 4., 5.**) up to 69.95%, like in Veľaty I, where 66.45% of artifacts were made of obsidian (Kaminská 1995). The upper layer from Kašov I dated by ^{14}C analysis to 18 600 ± 390 BP (Bánesz 1992) is one of the richest Epigravettian sites in Central Europe. Thus, term *kašovian* was suggested to define the Epigravettian in the eastern part of Central Europe after the last glacial maximum (Bánesz 1990; Svoboda & Novák 2004). The problem is that from 43,500 artifacts, only a small part has been processed (Bánesz et al. 1992).

Finished single- and double-platform cores were made from the obsidian raw material, mostly with sculpturing, at Gravettian and Epigravettian sites. Various types of retouched tools were chipped from them, such as end-scrapers, burins, perforators, blades, points, backed bladelets and others (Kaminská 2016).

Obsidian sporadically occurred at sites of the Late Gravettian in western Slovakia, particularly in Trenčianske Bohuslavice (Bárta 1998) and Nitra I-Čermáň (Kaminská & Kozłowski 2011). It is also documented in the Epigravettian in Nitra III (Bárta 1980a; Kaminská & Nemergut 2014) and in the Ipeľ region (Veľká Ves nad Ipľom) in southern Slovakia (Bárta & Petrovský-Šichman 1962).

In the late Paleolithic, use of obsidian is known from sites with the Świderian culture in Spiš, although radiolarite prevails among finds, like e. g. at the site of Veľký Slavkov-Burich (Bárta 1980b) or Lučivná/Svit (Soják 2002). In the territory of Spiš, there is a higher number of sites from Epipaleolithic to Mesolithic without more exact association of industries to individual cultures. Chipped stone industry from older collections which includes artifacts made of obsidian (Spišská Belá, Kežmarok, Podhorany, Podolínec, Stará Ľubovňa) was roughly processed by L. Bánesz (1962). As for newer collections and researches, obsidian occurred at the sites of Smižany-Hradisko I (Kaminská & Javorský 1996), Bušovce, Krížova Ves, Spišská Teplica-Brehy (Soják 2002). Several obsidian artifacts come from Epipaleolithic – Mesolithic sites in Orava (Bobrov – Bárta 1984). In the end of the Paleolithic, obsidian reached north to sites in southern Poland (Ginter 1986; Sobkowiak-Tabaka et al. 2015).

Mesolithic

The Mesolithic settlement of Slovakia creates several territorial concentrations. The best documented one is situated in southwestern Slovakia, on sand dunes near Sereď, where, however, obsidian was not used (Bárta 1972). In the north of Slovakia, mainly in Spiš, obsidian occurred very sporadically on two locations at the studied site of Spišská Belá (Soják 2002; Valde-Nowak & Soják 2010). Obsidian prevailed in the non-numerous industry in Čičarovce in the Východoslovenská nížina lowland (Kaminská 2014, 319). A similar situation is found in the Košická kotlina basin, where chipped industry in Košice-Barca I (**Fig. 6.**) was made exclusively of obsidian (Prošek 1959). Obsidian was present also among finds from Medvedia jaskyňa cave near Ružín (Bárta 1990).

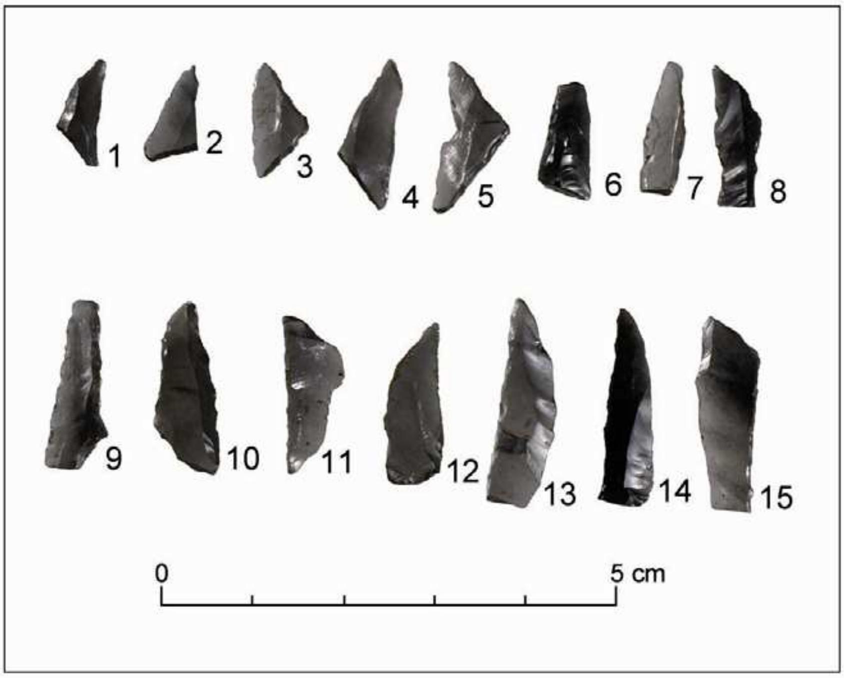


Fig. 6.: Košice-Barca I. Mesolithic chipped industry made of obsidian (photo A. Marková).

6. ábra: Košice (Kassa) -Barca I. Mezolit kőeszközök obszidiánból (felvételt készítette: A. Marková).

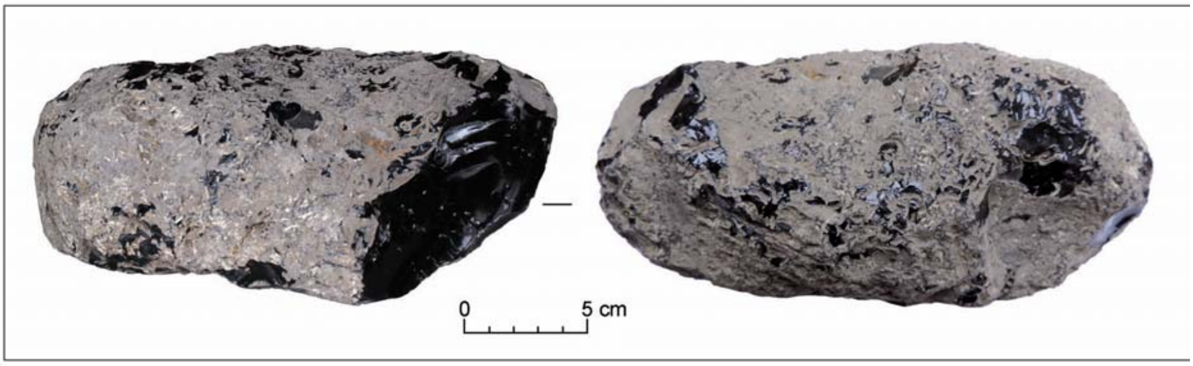


Fig. 7.: Slavkovce. Obsidian nodule, feature E/88. Eastern Linear Pottery culture. Proto-Kopčany phase (photo by Z. Bačová).

7. ábra: Slavkovce (Szalók). Obsidian nyersanyag gumó az E/88. objektumból. Keleti Vonaldíszes Kerámia kultúrája. Proto-Kopčany fázis (felvételt készítette: Z. Bačová).

Neolithic and Eneolithic

Neolithic cultures used obsidian very frequently. The Eastern Linear Pottery culture settled the Východoslovenská nížina lowland and the Košická kotlina basin. According to current datings, older sites are located in the Východoslovenská nížina lowland. One of them is the site of Moravany in the Ondava river basin. The site's settlement covers all three stages of the Eastern Linear Pottery Culture (proto-Kopčany, Kopčany and Raškovce) in the period between 5500 and 5150 BC (Nowak 2015, 226). Obsidian was the main raw material used in all phases of settlement for up to 90% (Kaczanowska et al. 2015, 172). Artifacts came from various stages of processing of obisdian – from imported nodules through obsidian cores, flakes, fragments and chips, to blades and tools.

Obsidian dominated from the oldest stages of the Eastern Linear Pottery culture also at other sites in the Východoslovenská nížina lowland – it made 90.7% in Zbudza, 96.2% in Slavkovce, 67%-91% in Zalužice, 97.6% in Zemplínske Kopčany (Kaczanowska & Kozłowski 1997, 220-221; Šiška 1989). 110 obsidians come from Slavkovce, feature E/88 (proto-Kopčany phase). They included 34 nodules, one of which, with one scar (**Fig. 7.**), weighed 2.9 kg (Kaczanowska & Kozłowski 1997, 177, Table VI-3, Fig. VI-1-3). Popularity of obsidian survived during the whole Eastern Linear Pottery culture. In the raw material composition of the chipped stone industry from the settlement in Veľké Raškovce (Raškovce group), obsidian made 91.7% of finds (Vizdal 1973, 102).

Obsidian was less frequent in the Eastern Linear Pottery culture in the Košická kotlina basin. Compared to limnosilicite, obsidian was less used (29.3%) in the protolinear phase in Košice-Červený rak (Kaminská et al. 2008, 90, Tab. 1). In the following group Barca III at the site of Košice-Barca III, obsidian made 36.5% of finds and in Čečejovce, it was 32.7% (Kozłowski 1989). Use of obsidian in the following Tiszadob group at the site of Košice-Galgovec (**Fig. 8.**) increased and made almost half of all finds (Kaminská et al. 2016).

Prevalence of obsidians at the sites situated near the sources of raw material continues in the succeeding Bükk culture. In Zemplínske Kopčany, 96% of artifacts were made of obsidian, but in Šarišské Michaľany, it was only 25.2% (Kaczanowska, Kozłowski & Šiška 1993, 42, 43, Table 9). 13 pyramidal cores from obsidian found above the studied feature (**Fig. 9-11.**) come from Kašov, Čepegov I site.

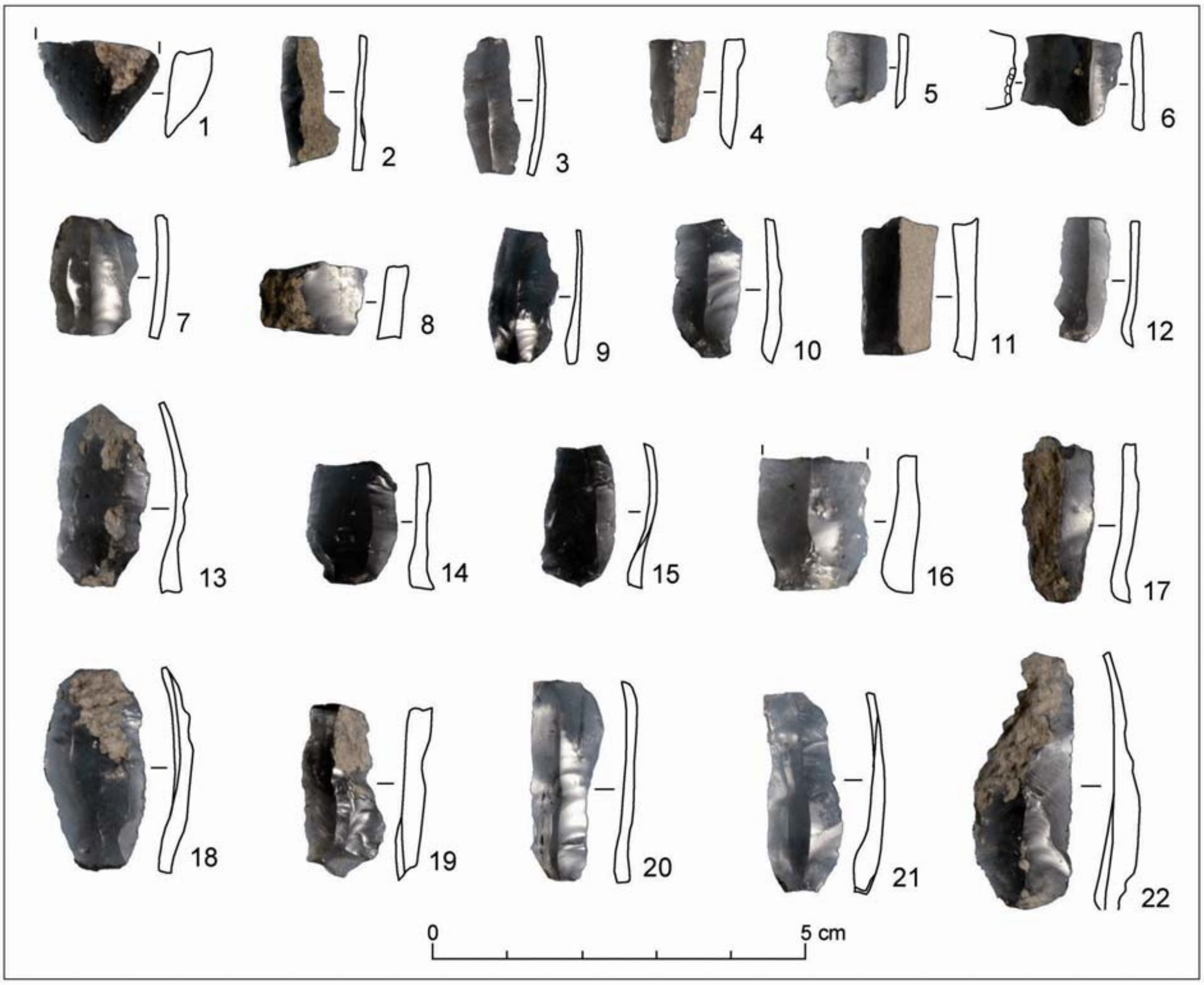


Fig. 8.: Košice-Galgovec III, feature 9/97. Eastern Linear Pottery culture, Tiszadob group (photo A. Marková).

8. ábra: Košice (Kassa)-Galgovec III, 9/97. objektum. Keleti Vonaldíszes Kerámia kultúrája, Tiszadob csoport (felvételt készítette: A. Marková).

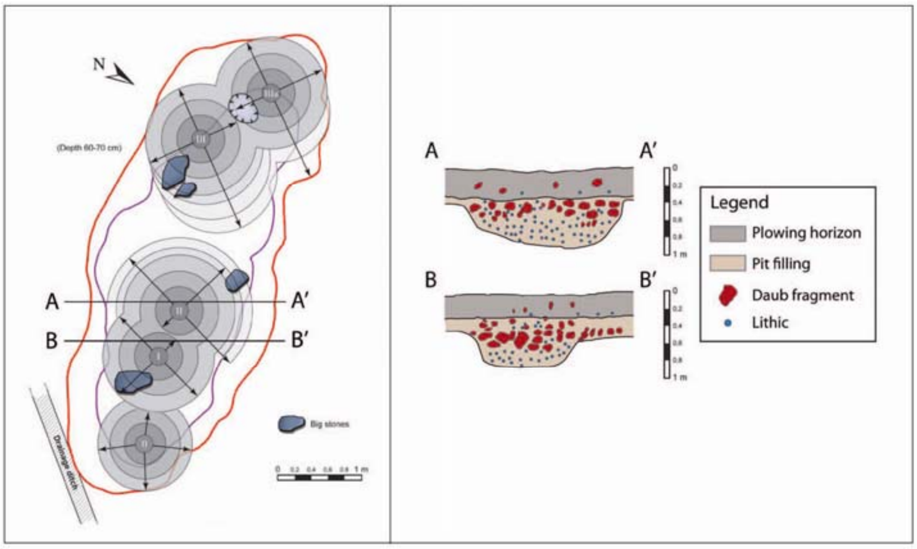


Fig. 9.: Kašov-Čepegov I. Plan and stratigraphy. Bükk culture (after Allard et al. 2017 and Bánesz 1991, modified).

9. ábra: Kašov (Kásó)-Čepegov I. alaprajz és rétegsor. Bükki kultúra (Allard et al. 2017 és Bánesz 1991 nyomán).

Fig. 10.: Kašov-Čepegov I. Blade core made of obsidian. Bükk culture (after Allard et al. 2017, modified).

10. ábra: Kašov (Kásó)-Čepegov I. Obszidián pengemagkő, Bükki kultúra (Allard et al. 2017 nyomán).

In the feature, there were tools, blades and flakes of obsidian as well as sherds of the Bükk culture (Šiška 1991). L. Bánesz (1991) interpreted the finds as specialized on-site workshop for production of cores which could become an exchange article. According to the new processing of finds, it was not a workshop. It could be a feature for production of household industry (Allard, Klaric & Hromadová 2017, Fig. 2; 6: 1). A similar core (**Fig. 12.**) was discovered also in Košice, Táborisko site (Béreš & Novák 2002).

Obsidian raw material or finished cores got outside the territory of Eastern Slovakia, as documented by numerous finds. Obsidian cores from the depot at the Hungarian site of Nyírlugos classified in the Middle Neolithic are of Slovak origin (Kasztovszky, Biró & Kis 2014). In Slovakia, we have recorded occurrence of obsidian in western Slovakia and southern Poland in the environment of the Želiezovce group (contemporary with the Bükk culture in eastern Slovakia). The number of sites with obsidian artifacts in western and central Slovakia increases in the beginning of the Lengyel culture (**Fig. 13.**), when obsidians reach the central Danube region (Šiška 1998). Further, in subsequent phases of the Lengyel culture, the share of obsidian among the finds from western Slovakia decreases.

In the cultures of the Late Neolithic and in the Early Eneolithic, there were differences in use of obsidian between settlements and burial grounds in the Východoslovenská nížina lowland. In Čičarovce, in the Csőszhalom-Čičarovce group, artifacts made of Volhynian flint prevailed over obsidian in burials, but obsidian share in settlement features was almost 50% (Vizdal 1980).

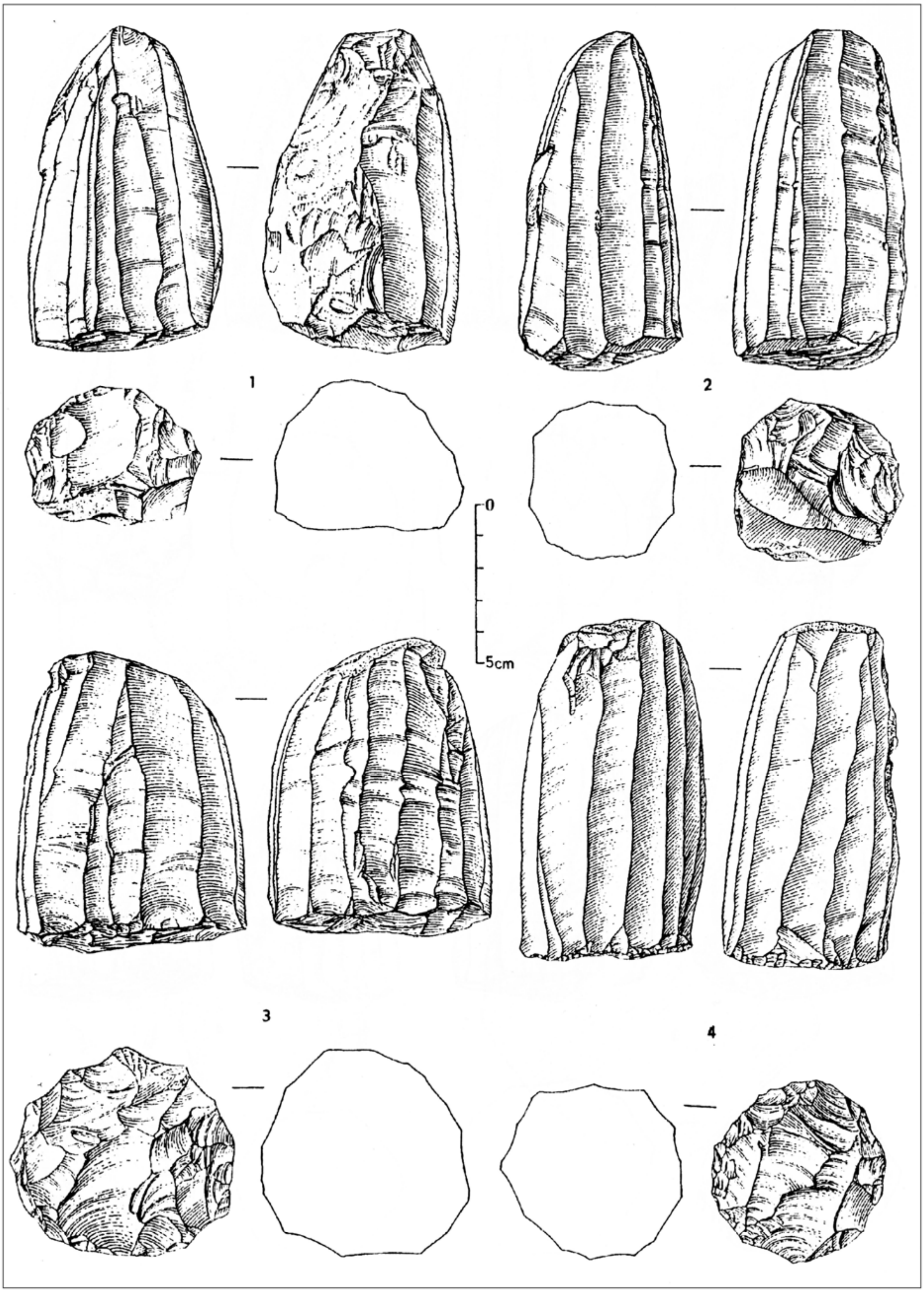


Fig. 11.: Kašov-Čepegov I. Blade cores. Bükk culture (after Bánesz 1991, modified).

11. ábra: Kašov (Kásó)-Čepegov I. Obszidián pengemagkövek (Bánesz 1991 nyomán).

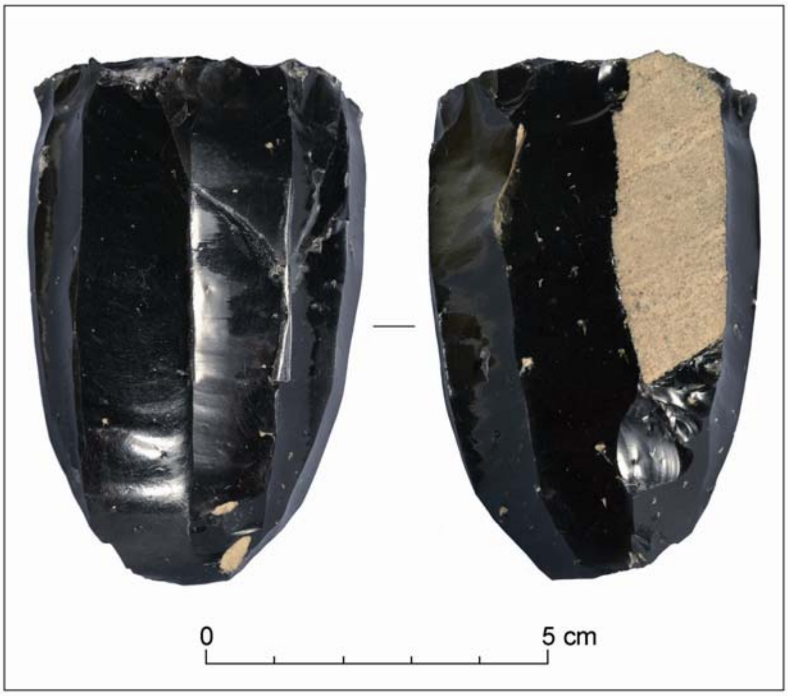


Fig. 12.:

Košice-Táborisko. Blade core. Bükk culture (photo A. Marková).

12. ábra:

Košice (Kassa)-Táborisko. Obszidián magkő, Bükki kultúra (felvételt készítette: A. Marková).

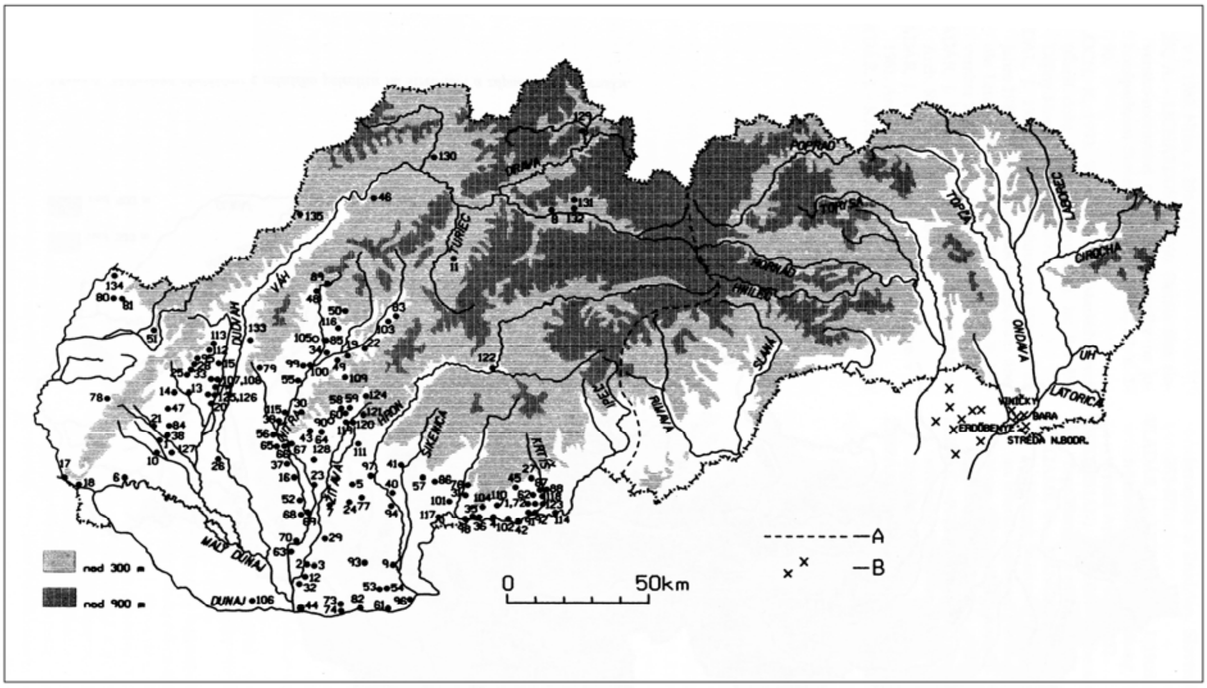


Fig. 13.: Map of Neolithic and Eneolithic sites with obsidian in central and western Slovakia. A – watershed of water streams and border between the settlements of the Tisza and the Danube regions. B – primary sources of obsidian (after Šiška 1998, modified).

13. ábra: Újkőkori és rézkori lelőhelyek régészeti obszidián előfordulással Közép- és Nyugat-Szlovákiában. A – vízválasztó a Tisza illetve a Duna irányába folyó vízfolyások között. B – obszidián nyersanyag források (Šiška 1998 nyomán).

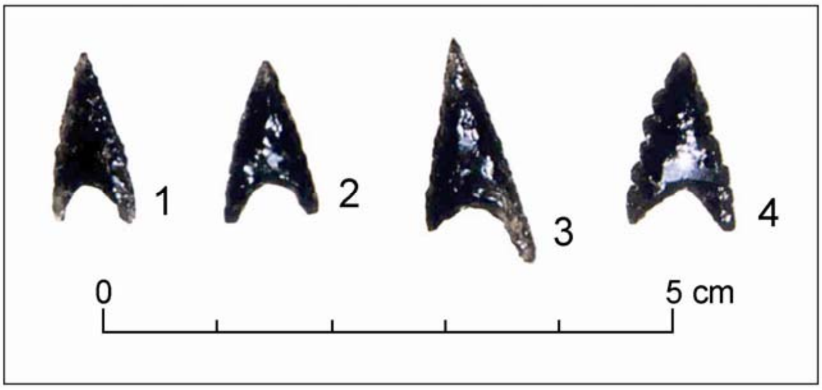


Fig. 14.: Nižná Myšľa. Arrowheads made of obsidian. Otomani-Füzesabony culture (after Gancarski 2002, modified).

14. ábra: Nižná Myšľa (Alsómislye). Obszidián nyílhegyek. Füzesabony-Ottományi kultúra (Gancarski 2002. nyomán).

Obsidian prevailed (74.81%) over other minerals at the settlement of the Csőszhalom-Oborín group in Hrčeľ (Kaminská & Pelisiak 1991).

Eneolithic – Early Bronze Age

We observe even more considerable difference in representation of obsidian at settlements and burial grounds in the Eneolithic. It is particularly visible in the Tiszapolgár culture. At the burial ground in Tibava (Šiška 1964) and in Veľké Raškovce (Vizdal 1978), Volhynian flint was the dominant raw material. Nevertheless, at the settlement at the site of Konopianky in Zemplínske Hradište artifacts were made only from obsidian. The chipped industry discovered in the settlement of the Baden culture was also made of obsidian (Chovanec 1988).

At the end of Eneolithics, various types of flints of foreign provenance (banded Krzemionki flint from Poland, Volhynian flint from Ukraine) were used in the cultures of the Corded ware cultural complex (group of „East Slovakian Barrow Group“ in the northern part of eastern Slovakia) and they were more frequent than the local obsidian (Budinský-Krička 1991).

In the southern part of eastern Slovakia, the Nyírség-Zatín culture is common in the end of the Eneolithic and in the beginning of the Bronze Age. From the few partially researched sites, chipped industry is known from Čičarovce, where obsidian blades and flakes prevail (Kaminská 2010, 64).

Early Bronze Age

Some types of tools (fully retouched arrowheads) occur also in the cultures of the Early Bronze Age. They were uncovered in burials of the Košťany culture in Valaliky-Všechsvätých (Pastor 1962, 44, tab. VI: 11-13), in Valaliky-Košťany (Pastor 1962, 40, tab. VI: 8-10) and in Košice (Pástor 1969). Occurrence of arrowheads made of obsidian (and other minerals) continued at the settlement and burial ground of the Otomani-Füzesabony culture (Gancarski 2002) in Nižná Myšľa (**Fig. 14.**). In the succeeding cultures, lithic industry was only sporadically used because it was effectively replaced by metal artifacts. That is why obsidian artifacts occur rarely.

Acknowledgement

This study was done as a part of the project 2/0084/18 of the scientific grant agency VEGA.

Translated by Mgr. Viera Tejbusová

References

ALLARD, P., KLARIC, L. & HROMADOVÁ, B. (2017): Obsidian blade debitage at Kašov-Čepegov I (Bükk culture), Slovakia. *Bulgarian e-Journal of Archaeology* **7** 17–35.

BAČO, P. & BAČOVÁ, Z. (2014): Autochtónne výskyty vulkanických skiel spojené s neogénnym vulkanizmom na východnom Slovensku. In: ŽAÁR, O. & GREGOR, M. (eds.): 3. Geologicko-Paleontologicko-Archeologická Diskusia (GEPAARD). *Zborník abstraktov*. Bratislava. 8.

BACSÓ, Z., MALACHOVSKÝ, P., HRINKO, V., REPČIAK, M., KALIČIAKOVÁ, E., KOŠARKOVÁ, M., SELIGA, J., KOMOŇ, J., STAŇA, Š. & ZLINSKÁ A. (1995): Brehov – západ. Záverečná správa. Geologický ústav Dionýza Štúra. Bratislava 1995.

BAČO, P., KAMINSKÁ, Ľ., LEXA, J., PÉCSKAY, Z., BAČOVÁ, Z. & KONEČNÝ, V. (2017): Occurences of neogene volcanic glass in the Eastern Slovakia – raw material source for the stone industry. *Anthropologie* **LV/2** 207–230.

BÁNESZ, L. (1959): Cejkov II-III, nové paleolitické stanice s obsidiánovou industriou. *Archeologické rozhledy* **11** 769–780.

BÁNESZ, L. (1960): Die Problematik der paläolithischen Besiedlung in Tibava. *Slovenská archeológia* **8** 7–58.

BÁNESZ, L. (1962): Nálezy drobnotvarej štiepanej industrie pod Vysokými Tatrami. *Študijné Zvesti Arch. Ústavu SAV* **10** 5–20.

BÁNESZ, L. (1967):Paleolitické sídliskové objekty z Barce-Svetlej III. *Archeologické rozhledy* **19** 285–295.

BÁNESZ, L. (1968): *Barca bei Košice Paläolithische Fundstelle*, Slovenská akadémia vied, Bratislava. 232 pp.

BÁNESZ, L. (1969): Gravettské súvrstvia s obsidiánovou industriou v Kašove a Cejkove. *Archeologické rozhledy* **21** 281–290.

BÁNESZ, L. (1974) : Hromadný nález obsidiánovej suroviny na gravettskom sídlisku v Cejkove, okr. Trebišov. *Archeologické rozhledy* **26** 51–54.

BÁNESZ, L. (1990): Súčasná problematika paleolitu východného Slovenska a severovýchodnej časti Karpatskej kotliny. *Historica Carpatica* **21** 9–19.

BÁNESZ, L. (1991): Neolitická dielňa na výrobu obsidiánovej industrie v Kašove. *Východoslovenský pravek* **3** 39–68.

BÁNESZ, L. (1992): Prvé absolútne datovanie nálezov z paleolitickej stanice Kašov I metódou C_{14}. *Archeologický výskumy a nálezy v roku 1991.* 16.

BÁNESZ, L. (1993): K absolútnemu datovaniu paleolitických staníc s obsidiánovou a pazúrikovou industriou v Kašove a Cejkove. *Archeologické výskumy a nálezy v roku 1992.* 22.

BÁNESZ, L. (1996): Predmety umeleckého prejavu z paleolitickej stanice pri Cejkove a Kašove. *Slovenská archeológia* **44** 7–24.

BÁNESZ, L., HROMADA, J., DESBROSSE, R., MARGERAND, I., KOZŁOWSKI, J. K., SOBCZYK, K. & PAWLIKOWSKI, M. (1992): Le site de plein air du Paléolithique supérieur de Kašov I en Slovaquie orientale. *Slovenská archeológia* **40** 5–28.

BÁRTA, J. (1972): Die mittlere Steinzeit in der Slowakei. *Acta Praehistorica et Archaeologica* **3** 57–76.

BÁRTA, J. (1980a): Významné paleolitické lokality na západnom Slovensku. Archeologický ústav SAV, Nitra. 59. pp.

BÁRTA, J. (1980b): Wielki Sławków - pierwsza osada świderskiej kultury na Słowacji. *Acta Archaeologica Carpathica* **20** 5–17.

BÁRTA, J. (1984): Prvé nálezy zo staršej doby kamennej na Orave. *Krásy Slovenska* **11** 10–15.

BÁRTA, J. (1988): Trenčianske Bohuslavice. Un habitat gravettien en Slovaquie occidentale. *L´Anthropologie (Paris)* **92** 173–182.

BÁRTA, J. (1990): Mezolitickí lovci v Medvedej jaskyni pri Ružíne. *Slovenská archeológia* **38** 5–30.

BÁRTA, J. & PETROVSKÝ-ŠICHMAN, A. (1962): Paleolitické nálezy z Ipeľskej kotliny. *Archeologické rozhledy* **14** 297–308.

KASZTOVSZKY, Zs., BIRÓ, K. T. & KIS, Z. (2014): Prompt Gamma Activation Analysis of the Nyírlugos obsidian core depot find. *Journal of Lithic Studies* **1** 151–163.

BÉREŠ, J. & NOVÁK, M. (2002): Nález obsidiánového jadra z Košíc. *Archeologické výskumy a nálezy v roku 2001.* 34.

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

BIRÓ, K. T. & KASZTOVSZKY, Z. (2013): Obsidian Studies Using Nuclear Techniques in Hungary. *Science for Heritage*. Newsletter No. **1**. December. 6–9.

BUDINSKÝ-KRIČKA, V. (1991): K otázke skupiny východoslovenských mohýl. *Východoslovenský pravek* **3** 96–111.

CHU, W., KAMINSKÁ, Ľ., KLASEN, N., ZEEDEN, Ch. & LENGYEL, Gy. in press: The chronostratigraphy of the Aurignacian in the northern Carpathian Basen based on new chronometric/archeological data from Seňa I (eastern Slovakia).

GANCARSKI, J. (2002): Kultura Otomani-Füzesabony po północnej stronie Karpat. In: GANCARSKI, J. (ed.): *Między Mykenami a Bałtykiem. Kultura Otomani-Füzesabony.* Krosno-Warszawa. 103–126.

GINTER, B. (1986): Obsidianimporte im Spätpaläolithikum und Mesolithikum in Südpolen. In: *Urgeschichtliche Besiedlung der Ostslowakei in Bezug zu den Nachbargebieten*. Nitra. 71–76.

CHOVANEC, J. (1988): Sídlisko ľudu s bukovohorskou kultúrou v Zemplínskom Hradišti. *Archeologické výskumy a nálezy v roku 1987.* 57–58.

JANŠÁK, Š. (1935): Praveké sídliská s obsidiánovou industriou na východnom Slovensku. Bratislava. 268 pp.

KACZANOWSKA, M. & KOZŁOWSKI, J. K. (1997): Lithic industries. In: KOZŁOWSKI, J. K. (ed.): *The Early Linear Pottera Culture in Eastern Slovakia.* Kraków. 177–253.

KACZANOWSKA, M., KOZŁOWSKI, J. K. & ŠIŠKA, S. (1993): Neolithic and Eneolithic Chipped Stone Industry from Šarišské Michaľany, Eastern Slovakia. Institute of Archaeology, Kraków. 180 pp.

KACZANOWSKA, M., KOZŁOWSKI, J. K. & NOWAK, M. (2013): Raw materials of chipped industries at the Eastern Linear Pottery Culture site at Moravany, eastern Slovakia. In: MESTER, Zs. (ed.): *The lithic raw material sources and interregional human contacts in the Northern Carpathian region.* Kraków – Budapest. 111–130.

KACZANOWSKA, M., KOZŁOWSKI, J. K., WASILEWSKI, M. (2015): Chipped, ground and polished stone industries at the early neolithic settlement of Moravany. In: KOZŁOWSKI, J. K., NOWAK, M. & VIZDAL, M. (eds.): *Early farmers of the Eastern Slovak Lowland: the settlement of the Eastern linear pottery culture at Moravany.* Kraków. 163–196.

KAMINSKÁ, Ľ. (1990): Aurignacké stanice v Čečejovciach. *Archeologické rozhledy* **42** 3–12.

KAMINSKÁ, Ľ. (1991): Význam surovinovej základne pre mladopaleolitickú spoločnosť vo východokarpatskej oblasti. *Slovenská archeológia* **39** 7–58.

KAMINSKÁ, Ľ., (1995): Katalóg štiepanej kamennej industrie z Hrčeľa-Pivničiek a Veliat. Informátor SAS pri SAV, Suplement 4 Nitra Nitra. 98 pp.

KAMINSKÁ, Ľ.: Die Nutzung von Steinrohmaterialien im Paläolithikum der Slowakei. *Quartär* **51/52** 81–106.

KAMINSKÁ, Ľ. (2010): Čičarovce-Veľká Moľva. Výskum polykultúrneho sídliska. Archeologický ústav SAV, Nitra. 152 pp.

KAMINSKÁ, Ľ. (2013): Sources of raw materials and their use in the Palaeolithic of Slovakia. In: MESTER, Zs. (ed.): *The lithic raw material sources and interregional human contacts in the Northern Carpathian region*. Kraków – Budapest. 99–110.

KAMINSKÁ, Ľ., (2016): Gravettian and epigravettian lithics in Slovakia. *Quaternary International* **406** 144–165.

KAMINSKÁ, Ľ. & ĎUĎA, R. (1985): K otázke významu obsidiánovej suroviny v paleolite Slovenska. *Archeologické rozhledy* **37** 121–129, 233–235.

KAMINSKÁ, Ľ. & JAVORSKÝ, F. (1996): Drobnotvará štiepaná kamenná industria zo Smižian. *Študijné zvesti AÚ SAV* **32** 5–14.

KAMINSKÁ, Ľ. & PELISIAK, A. (1991): Štiepaná kamenná industria skupiny Tiszapolgár-Csöszhalom-Oborín z Hrčeľa. *Východoslovenský pravek* **3** 26–38.

KAMINSKÁ, Ľ. & TOMÁŠKOVÁ, S. (2004): Time space systematics of Gravettian finds from Cejkov I. In: SVOBODA, J. A. & SEDLÁČKOVÁ, L. (eds.): *The Gravettian along the Danube.* Archeologický ústav AV ČR, Brno. 198–216.

KAMINSKÁ, Ľ., KACZANOWSKA, M. & KOZŁOWSKI, J. K. (2008): Košice-Červený rak and the Körös/Eastern Linear transition in the Hornád Basin (Eastern Slovakia). *Přehled výzkumů* **49** 83–91.

KAMINSKÁ, Ľ. & KOZŁOWSKI, J. K. (2011): Nitra I-Čermáň v rámci štruktúry osídlenia gravettienskej kultúry na Slovensku. *Slovenská archeológia* **59** 1–85.

KAMINSKÁ, Ľ. & NEMERGUT, A. (2014): The Epigravettian chipped stone industrie from Nitra III site (Slovakia). In: BIRÓ, K. T., MARKÓ, A. & BAJNOK, K. P. (eds.): *Eolian scripts new ideas on the lithic world studies in honour of Viola T. Dobosi*. Hungarian National Museum, Budapest. 93–119.

KAMINSKÁ, Ľ. (2014): Mezolit. In: KAMINSKÁ, Ľ., MORAVCOVÁ, M. & ŠEFČÁKOVÁ, A.: *Staré Slovensko 2: Paleolit a mezolit.* Archeologický ústav SAV, Nitra. 318–330.

KAMINSKÁ, Ľ., KACZANOWSKA, M. & KOZŁOWSKI, J. K. (2016): Stone Industry from Košice-Galgovec and its place in the evolution and differentiation of the Eastern Linear Pottery Culture. *Študijné zvesti AÚ SAV* **60** 5–29.

KOZŁOWSKI, J. K. (1989): The lithic industry of the Eastern Linear Pottery Culture in Slovakia. *Slovenská archeológia* **37** 377–410.

NOVÁK, M. (2002): Gravettienske osídlenie spodnej vrstvy z Kašova I. *Slovenská archeológia* **50** 1–52.

NOWAK, M. (2015): Absolute chronology of the settlement of the Eastern Linear Pottery culture at Moravany. In: KOZŁOWSKI, J. K., NOWAK, M. & VIZDAL, M. (eds.): *Early farmers of the Eastern Slovak Lowland: the settlement of the Eastern linear pottery culture at Moravany.* Kraków. 215–234.

PASTOR, J. (1962): Pohrebiská z počiatkov doby bronzovej na východnom Slovensku. *Nové obzory* **4** 37–51.

PÁSTOR, J. (1969): Košické pohrebisko. Východoslovenské vydavateľstvo Košice. 104 pp.

PROŠEK, F. (1959): Mesolitická obsidiánová industrie ze stanice Barca I. *Archeologické rozhledy* **9** 145–148, 193.

PŘICHYSTAL, A. & ŠKRDLA, P. (2014: Kde ležel hlavní zdroj obsidiánu v pravěku střední Evropy. *Slovenská archeológia* **62** 215–226.

RÁCZ, B. (2013): Main raw materials of the Palaeolithic in Transcarpathian Ukraine: geological and petrographical overview. In: MESTER, Zs. (Ed.): *The lithic raw material sources and interregional human contacts in the Northern Carpathian region.* Kraków – Budapest. 131–146.

SOBKOWIAK-TABAKA, I., KASZTOVSZKY, Zs., KABAĆINSKI, J., BIRÓ, K. T., MARÓTI, B. & GMÉLING, K. (2015): Transcarpathian contacts of the Late Glacial societes of the Polish Lowlands. *Przegląd Archeologiczny* **63** 5–28.

SOJÁK, M. (2002): Osídlenie horného Spiša na sklonku staršej doby kamennej. In: GANCARSKI, J. (ed.): *Starsza i środkowa epoka kamienia w Karpatach polskich*. Krosno. 255–278.

SVOBODA, J. A. & NOVÁK, M. (2014): Eastern Central Euroe after the Upper pleniglacial: changing points of obsarvation. *Archäologisches Korrespondenzblatt* **34** 463–477.

ŠIŠKA, S. (1964): Pohrebisko tiszapolgárskej kultúry v Tibave. *Slovenská archeológia* **12** 293–356.

ŠIŠKA, S. (1989): *Kultúra s východnou lineárnou keramikou na Slovensku.* VEDA Vydavateľstvo SAV, Bratislava. 1989. 262 pp.

ŠIŠKA, S. (1991): Keramika a datovanie neolitickej dielne v Kašove. *Východoslovenský pravek* **3** 69–74.

ŠIŠKA, S. (1998): Obsidián v prostredí spoločenstiev doby kamennej na strednom a západnom Slovensku (Súpis nálezísk). *Východoslovenský pravek* **5** 63–90.

VALDE-NOWAK, P. & SOJÁK, M. (2009): Výskum mezolitických lokalít v Spišskej Belej. *Archeologické výskumy a nálezy na Slovensku v roku 2007*. 188–190.

VALDE-NOWAK, P. & SOJÁK, M. (2010): Contribution to the mesolithic in the Slovak Carpathians. *Slovenská archeológia* **58** 1–12.

VERPOORTE, A. (2002): Radiocarbon dating the Upper Palaeolithic of Slovakia: results, problems and prospects. *Archäologisches Korrespondenzblatt* **32** 311–325.

VIZDAL, J. (1973): Zemplín v mladšej dobe kamennej. Košice. 204 pp.

VIZDAL, J. (1977): Tiszapolgárske pohrebisko vo Veľkých Raškovciach. Košice. 236 pp.

VIZDAL, J. (1980): Potiská kultúra na Slovensku. Košice. 240 pp.

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

MORE ON THE STATE OF ART OF HUNGARIAN OBSIDIANS•

TOVÁBBI ADATOK A MAGYARORSZÁGI OBSZIDIÁNOK KUTATÁSÁRÓL

Katalin T. BIRÓ[1]

[1]Hungarian National Museum, H-1088 Múzeum krt. 14-16, Budapest, Hungary

E-mail: tbk@ace.hu

Abstract

Obsidian was known and used on the territory of present-day Hungary since the Middle Palaeolithic period. The raw material sources are located on the territory of the Tokaj-Prešov Mountains. They are known in international archaeometrical literature as Carpathian 1 (Slovakian) and Carpathian 2 (Hungarian) types. All of the obsidian artefacts found on archaeological sites can be assigned, macroscopically, to these categories; this is also corroborated by the analytical studies performed so far (see in details in the study of Kasztovszky & Přichystal in the same volume.). Carpathian 3 (Transcarpathian) obsidian and the other obsidian types from the Mediterranean region has not been spotted on Hungarian archaeological sites as yet. The paper briefly summarizes archaeological data on the distribution and use of obsidian in Hungary, with an extensive list of technical literature.

Kivonat

Hazánk területén az őskőkortól ismerték és használták az obszidiánt. A nyersanyagforrások a Tokaj-Eperjesi hegység területén találhatók, ezeket a nemzetközi kutatás kárpáti 1 (szlovákiai), illetve kárpáti 2 (magyarországi) obszidiánok néven különíti el. A mai Magyarország területéről származó valamennyi obszidián makroszkóposan ezekhez a forrásokhoz köthető, amit az eddigi analitikai eredmények (részletesen ld. Kasztovszky & Přichystal tanulmányát, jelen kötetben) is megerősítenek. A kárpáti 3 (kárpátaljai) obszidián Magyarország területéről eddig még nem került elő, ahogy a mediterrán régió többi obszidián változata sem.

A tanulmány röviden összefoglalja az obszidián használatára vonatkozó régészeti adatokat és a legfontosabb szakirodalmat.

KEYWORDS: OBSIDIAN, PREHISTORY, HUNGARY, "CARPATHIAN" OBSIDIAN

KULCSSZAVAK: OBSZIDIÁN, ŐSKOR, MAGYARORSZÁG, "KÁRPÁTI" OBSZIDIÁN

Introduction

Hungarian obsidian has been in the focus of both archaeological and geological attention for a long time. The 'pioneering fathers' of Hungarian archaeology and geology (notably, Flóris Rómer and József Szabó) dedicated special attention to the problem. It is of symbolic significance, that the leading periodical of Hungarian archaeology, founded by Rómer and active till our times (i.e. Archaeológiai Értesítő), consecrated space and attention for the subject in the very first volume of the periodical (Rómer 1868a, 1868b) as well as other early communications on Hungarian chipped stone industry (Rómer 1867).

Obsidian played a central role on the first and so far, only World archaeological conference and related exhibition held in Hungary (VIII-ième Congrès International d'Anthropologie et d'Archéologie Préhistoriques, Budapest 1876., Rómer ed.1878); for this occasion, Rómer constructed the first distribution map on what we call today Carpathian obsidian (Rómer 1878; accessible as Appendix 1. for Biró 2005).

The archaeological interest was fortunately coupled by regional geological studies. Exploration of the Tokaj obsidian sources and related volcanic events were described by J. Szabó (1867, 1878) and one generation of researchers later, by Gy. Szádeczky (1887).

• How to cite this paper: BIRÓ, K.T. (2018): More on the state of art of Hungarian obsidians, *Archeometriai Műhely* **XV/3** 213-224.

All these studies took place in the framework of the Austro-Hungarian monarchy, where all the sources we call today Carpathian obsidians, and most of the distribution area were under the umbrella of the same political entity.

State of art - efforts and difficulties

Theoretically, changes in the World politics should not influence the objectivity of scientific research. Practically, however, the new states emerging after the closing of the World War I. started to develop their own research strategies, backed up by disciplines on their native languages (summaries produced time-to-time in some of the scientific '*lingua franca*' of their age). Thus the information we have become segmented and uneven. Valuable regional summaries and details have been published (Kostrewski 1930, Roska 1934, Janšák 1935, Kulczycka & Kozłowski 1960, Comşa 1969. Paunescu 1970) but the unity of information that characterised the research of Rómer's times was lost.

Personally, I had the occasion of compiling several distribution maps; overall distribution by technical literature mainly (Biró 1981), Palaeolithic distribution on the basis of museum material (the Hungarian National Museum and the Herman Ottó Museum, Miskolc; Biró 1984) later incorporating analytical studies (Biró 2004, 2006).

In the most recent summary, written on the occasion of the Japanese workshop initiated by Akira Ono (Yamada & Ono eds. 2014, Biró 2014a), I was trying to include all information at hand. This effort comprised, apart from former resources, HNM inventory data, my personal lithic reference database and an admittedly deficient selection of the lithic study papers.

The first effort to interpret the dataset was on the UISPP 4th commission meeting in Budapest, 2009 when I tried to plot coordinates of sites in relation to sources by archaeological periods and calculate distances and directions for the archaeological spreading of obsidians (Biró 2009, unpublished). As a result of the analysis, I could see the weaknesses of my approach.

1, there is a strong bias towards 'home data',

2, data quality is very uneven due to several reasons - collection strategy, lithic analysis coverage, chronological precision etc.

I tried to solve the problem by mapping only a fraction of the information. I hope that the current efforts, published in the actual volume of AM and hopefully presented by researchers on the IOC-2019 conference will essentially contribute to a more complete image on the use of Carpathian obsidians, in general.

State of art - as it seems today from Hungary

Carpathian obsidian is a rather awkward name for the obsidians in the Carpathian Basin - none of them in the Carpathian Mts., none of them of Carpathian geological age (Biró et al. 2000, Szepesi et al. 2018). As international obsidian research adopted the name since Renfrew et al. (1965), it is better to use because people know the term and what it implies.

Palaeolithic period (Fig. 1.)

The use of Carpathian obsidians started latest in the Middle Palaeolithic. Around the Carpathian 3 sources, we can suppose even more ancient use (Ryzhov 2014, 2018). Carpathian 3 obsidian, however, is not known so far from Hungarian sites, either Palaeolithic or Prehistoric context.

In Hungary, the earliest known pieces of archaeological obsidian came forth from the Subalyuk cave (near Cserépfalu), already described in the site monograph (Bartucz et al. 1939, Kadić 1939, Vendl 1939). The site is approximately 100 km from the obsidian source region. Recent finds from Legénd 200 km from the sources, Markó & Péntek (2003-2004, Biró et al. 2005) justified not only the extended regional use of the material, but yielded all important Carpathian 1 and 2 obsidian phenotypes (even mahogany obsidian!).

This proves the excellent regional knowledge of the source areas, even at a distance of 200 km from source to site. The mechanism for obsidian transfer can only be hypothetically studied in this period.

The Early Upper Palaeolithic Szeletian and Aurignacian cultures had both used obsidian, though in subordinate quantities (**Fig. 2.**). Both of these cultures inhabited the North-Eastern hilly regions.

In Hungary, a major geographical boundary is represented by the river Danube. This barrier was crossed probably by the beginning of the Würm 1 period as reflected by the retouched obsidian flake from the Pilisszántó II rock shelter.

In the more recent part of the Upper Palaeolithic, several phyla of the Gravettian Entity used obsidian in significant, but not dominant quantities (Biró 1984, Dobosi 2011, Markó 2017). The most important from this respect is probably Bodrogkeresztúr, in the hearth of the obsidian region (Dobosi ed. 2000). The percentage of obsidian use is impressive in itself but it is even more important for us that the Southern Tokaj sources (Carpathian 2) were used as local raw material together with a variety of hydrothermal and limnosilicites.

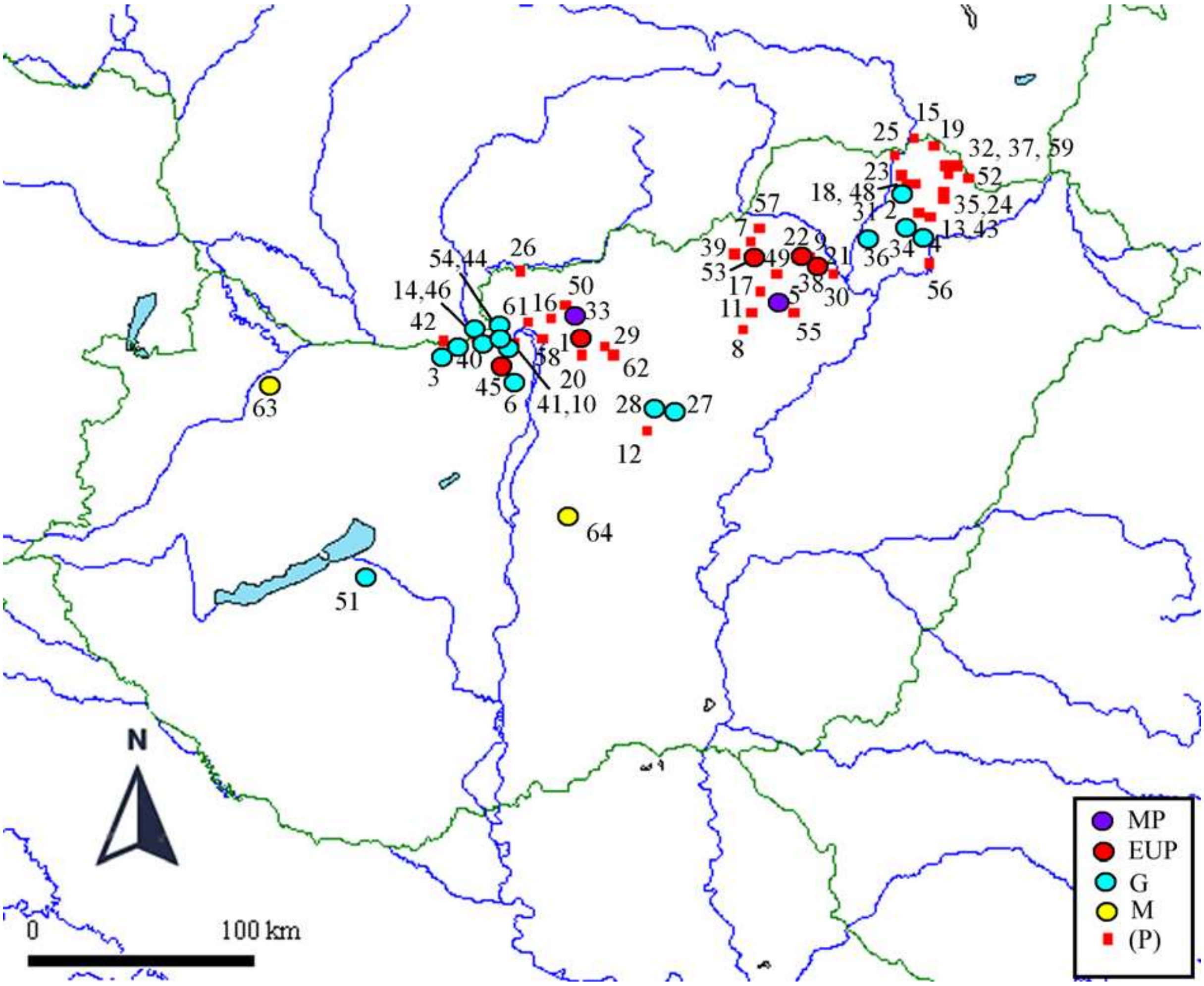


Fig. 1.: Palaeolithic and Mesolithic obsidian use in Hungary.

Key of symbols: MP: Middle Palaeolithic; EUP: Early Upper Palaeolithic; G: Gravettian; M: Mesolithic; (P): unspecified Palaeolithic

Site numbers: 1. Acsa; 2. Arka; 3. Bajót; 4. Bodrogkeresztúr; 5. Cserépfalu; 6. Csobánka; 7. Csokvaomány; 8. Demjén; 9. Diósgyőrtapolca; 10. Dömös; 11. Eger; 12. Egreskáta; 13. Erdőbénye; 14. Esztergom; 15. Felsőkéked; 16. Felsőpetény; 17. Felsőtárkány; 18. Fony; 19. Füzér; 20. Galgagyörk; 21. Miskolc-Görömbölytapolca; 22. Hámor; 23. Hejce; 24. Hercegkút; 25. Hidasnémeti; 26. Hont; 27. Jászberény; 28. Jászfelsőszentgyörgy; 29. Kálló; 30. Kistokaj; 31. Korlát; 32. Kovácsvágás; 33. Legénd; 34. Mád; 35. Makkoshotyka; 36. Megyaszó; 37. Mikóháza; 38. Miskolc; 39. Mocsolyástelep; 40. Mogyorósbánya; 41. Nagymaros; 42. Nyergesújfalu; 43. Olaszliszka; 44. Pilismarót; 45. Pilisszántó; 46. Pilisszentlélek; 47. Püspökhatvan; 48. Regéc; 49. Répáshuta; 50. Romhány; 51. Ságvár; 52. Sátoraljaújhely; 53. Szilvásvárad; 54. Szob; 55. Tarcal; 56. Tiszaladány; 57. Uppony; 58. Vác-Csipkés; 59. Vágáshuta; 60. Verőce; 61. Verőcemaros; 62. Verseg; 63. Koroncó; 64. Kunpeszér

1. ábra: Őskőkori és középső kőkori lelőhelyek régészeti obszidián leletekkel.

Jelkulcs: MP: középső paleolitikum; EUP: korai felső paleolitikum; G: gravetti; M: mezolitikum; (P): pontosabban nem meghatározott paleolitikus lelőhely

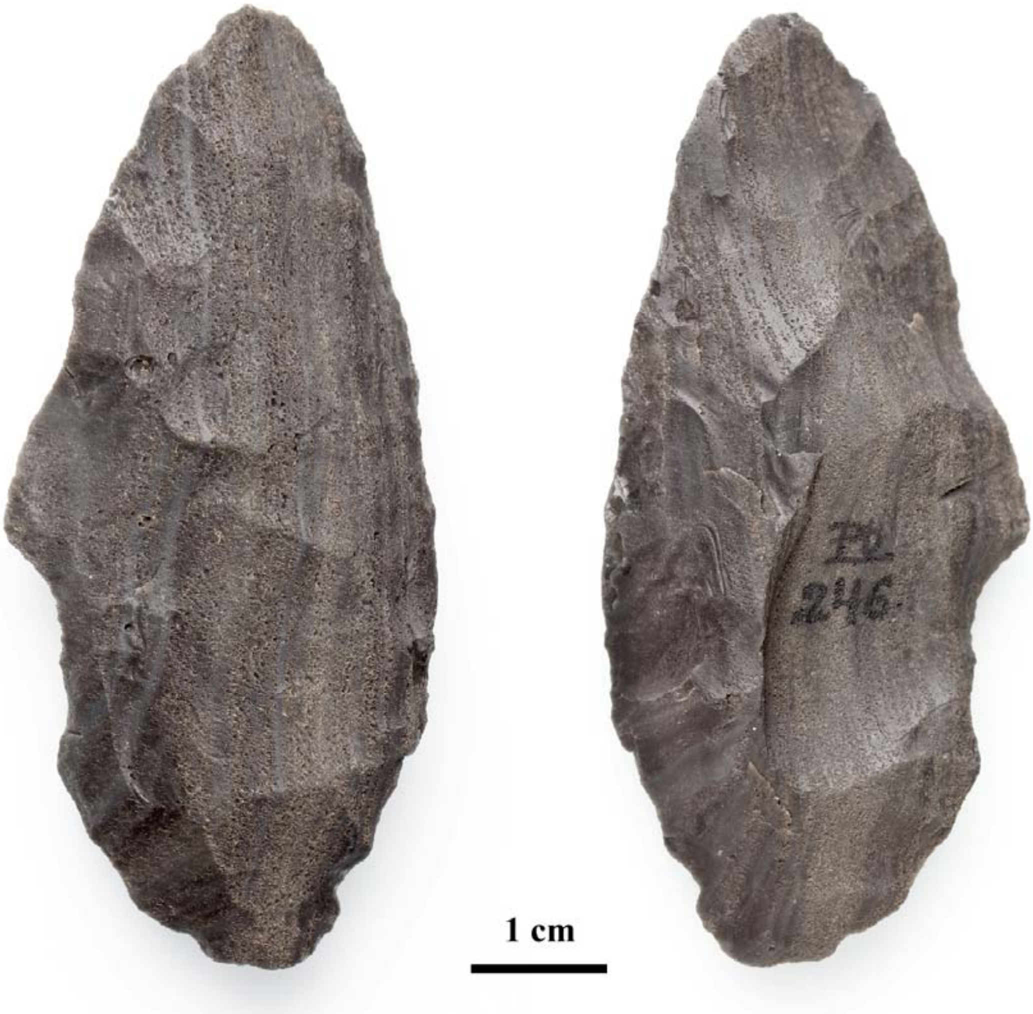


Fig. 2.: Early Upper Palaeolithic leafpoint from the Puskaporos rock shelter, Miskolc environs. Szeletian culture. (Photo by J. Kardos)

2. ábra: Korai felső paleolit levélhegy a Puskaporosi kőfülkéből, Szeleta kultúra. (Kardos J. felvétele)

Practically all the Gravettian localities to the East of the Danube had obsidian and most of the Transdanubian sites as well (Pilismarót, Mogyorósbánya, Ságvár).

At Megyaszó and Arka-Herzsarét, the rare mahogany obsidian was also spotted (Biró et al. 2005, Kasztovszky at al. 2018).

The Mesolithic period is very poorly represented in Hungary; obsidian use was documented on some of the few sites, even in Transdanubia (e.g. Koroncó, Biró 1984, 2002).

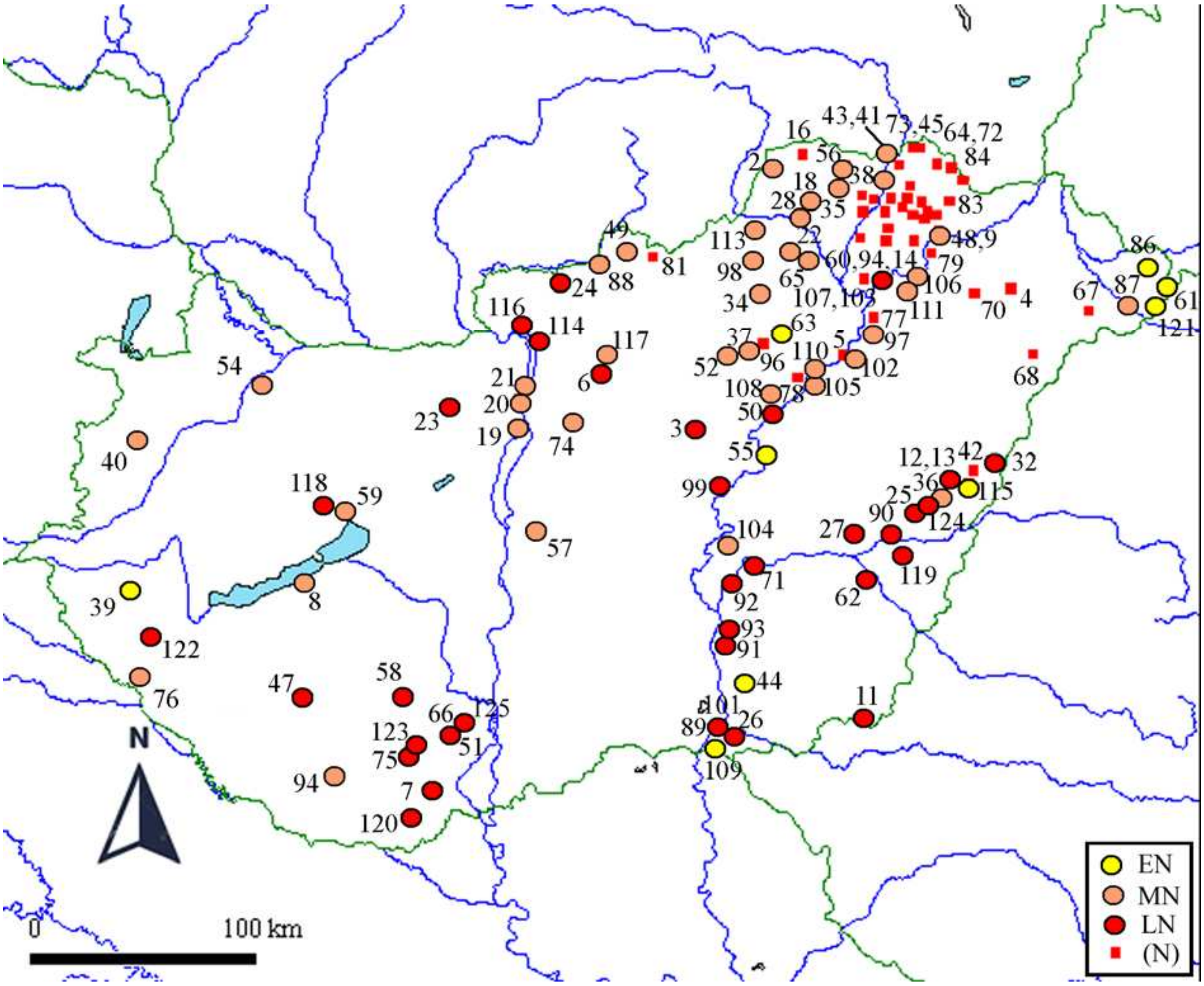


Fig. 3.: Neolithic obsidian use in Hungary.

Key of symbols: EN: Early Neolithic; MN: Middle Neolithic; LN: Late Neolithic; (N): unspecified Neolithic

Site numbers: 1. Abaújszántó; 2. Aggtelek; 3. Alattyán; 4. Apagy; 5. Ároktő; 6. Aszód; 7. Babarc; 8. Balatonszemes; 9. Balsa-Fecskepart; 10. Baskó; 11. Battonya; 12. Berettyószentmárton; 13. Berettyóújfalu; 14. Bodrogkeresztúr; 15. Bodrogzsadány; 16. Bódvaszilas; 17. Boldogkőváralja; 18. Borsod; 19. Budapest-Albertfalva; 20. Budapest-Aranyhegyi út; 21. Budapest-Nánási út 69; 22. Büdöspest barlang; 23. Csabdi; 24. Csesztve; 25. Darvas; 26. Deszk; 27. Dévaványa; 28. Edelény; 29. Encs; 30. Erdőbénye; 31. Erdőhorváti; 32. Esztár; 33. Fancsal; 34. Felsőtárkány; 35. Felsővadász; 36. Furta; 37. Füzesabony; 38. Garadna; 39. Gellénháza; 40. Gór; 41. Gönc; 42. Hencida; 43. Hidasnémeti; 44. Hódmezővásárhely; 45. Hollóháza; 46. Ináncs; 47. Kaposvár; 48. Kenézlő; 49. Karancsság; 50. Kisköre; 51. Kismórágy; 52. Kompolt; 53. Korlát; 54. Koroncó; 55. Kőtelek; 56. Krasznokvajda; 57. Kunszentmiklós; 58. Lengyel; 59. Litér; 60. Megyaszó; 61. Méhtelek; 62. Mezőberény; 63. Mezőkövesd; 64. Mikóháza; 65. Miskolc; 66. Mórágy; 67. Nagyecsed; 68. Nyírlugos; 69. Olaszliszka; 70. Oros; 71. Öcsöd; 72. Pálháza; 73. Pányok; 74. Pécel; 75. Pécsvárad; 76. Petrivente; 77. Polgár; 78. Poroszló; 79. Rakamaz; 80. Regéc; 81. Salgótarján; 82. Sárazsadány; 83. Sárospatak; 84. Sátoraljaújhely; 85. Sima; 86. Sonkád; 87. Szamossályi; 88. Szécsény; 89. Szeged; 90. Szeghalom; 91. Szegvár; 92. Szelevény; 93. Szentes; 94. Szentlőrinc; 95. Szerencs; 96. Szihalom; 97. Szilmeg; 98. Szilvásvárad; 99. Szolnok; 100. Tállya; 101. Tápé; 102. Tiszacsege; 103. Tiszadob; 104. Tiszaföldvár; 105. Tiszafüred; 106. Tiszalök; 107. Tiszalúc; 108. Tiszanána; 109. Tiszasziget; 110. Tiszavalk; 111. Tiszavasvári; 112. Tolcsva; 113. Uppony; 114. Vác; 115. Váncsod; 116. Verőcemaros; 117. Verseg; 118. Veszprém; 119. Vésztő; 120. Villánykövesd; 121. Zajta; 122. Zalaszentbalázs; 123. Zengővárkony; 124. Zsáka 125. Szálka.

3. ábra: Újkőkori lelőhelyek régészeti obszidián leletekkel.

Jelkulcs: EN: kora neolitikum; MN: középső neolitikum; LN: késő neolitikum; (N): pontosabban nem meghatározott neolitikus lelőhely

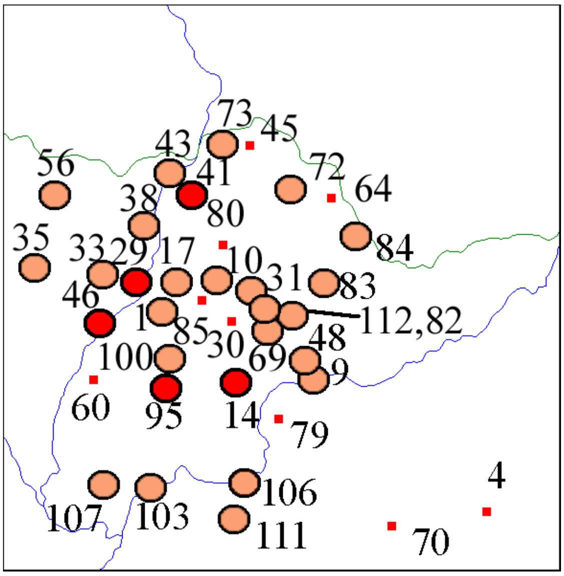


Fig. 3a: Neolithic obsidian use in Hungary.

(Top right corner of Fig. 3.)

3a ábra: Újkőkori lelőhelyek régészeti obszidián leletekkel.

(a 3. ábra jobb felső sarkának részlete)

Neolithic period (Fig. 3.)

The utilisation of obsidian in the Early Neolithic period show important new directions. Sites of the Körös culture and its late variants, so-called Szatmár-group used obsidian in very large quantities and also large percentages (Méhtelek & Starnini 1993, Bácskay & Simán 1987). Among the most recent finds we can mention the fabulous obsidian raw material depot find from Váncsod (excavation by A. Priskin, poster presented on the conference Carpathian Obsidians: State of Art (http://www.ace.hu/ametry/Varnyukova.pdf) and to be presented on IOC-2019), also from Early Neolithic context.

The tendency of using large quantities of obsidian continued on the foothill regions of the Alföld in the earliest phases of the LBC culture, notably at Mezőkövesd-Mocsolyás (Biró 2002, 2014b) and Füzesabony-Gubakút (Biró 2002).

In the LBC industries of the Alföld, the Middle Neolithic period brought about a characteristic ’home-based’ lithic industry comprising obsidian and limnic silicites of the North Hungarian Mid-Mountain range, mainly from the Tokaj Mts. (e.g. Hidasnémeti: Biró et al. in press). These raw materials appeared in Transdanubia in the same period mainly along the Danube, notably in Budapest environs. (e.g. Budapest-Aranyhegyi út, Biró 1987, Biró 1998a). The role of the northern communication road (Ipoly valley) is seemingly getting stronger as reflected by the important site Szécsény-Ültetés and related industries like Karancsság (Biró 1987, Szilágyi 2009).

By the Late Neolithic, important changes can be observed both on the lowlands and Transdanubia as well. The central parts of the Alföld became relatively poor in obsidian and the local limnosilicites of the Mátra and possibly Cserhát Mts. became more popular (Biró 1998a).

Centres for distribution of obsidian can be hypothesed, especially in Lengyel Culture context (Aszód, Csabdi, Biró 1998a, Szálka (unpublished surface collection, Fig. 4.) and probably also in coeval Vinča context (Chapman 1981).

Fig. 4.:

Obsidian micro-blades and micro-cores from Szálka-Pincehely, Lengyel Culture. (Photo by the author)

4. ábra:

Obszidián mikropengék és mikromagkövek. Szálka-Pincehely, lengyeli kultúra. (a szerző felvétele)

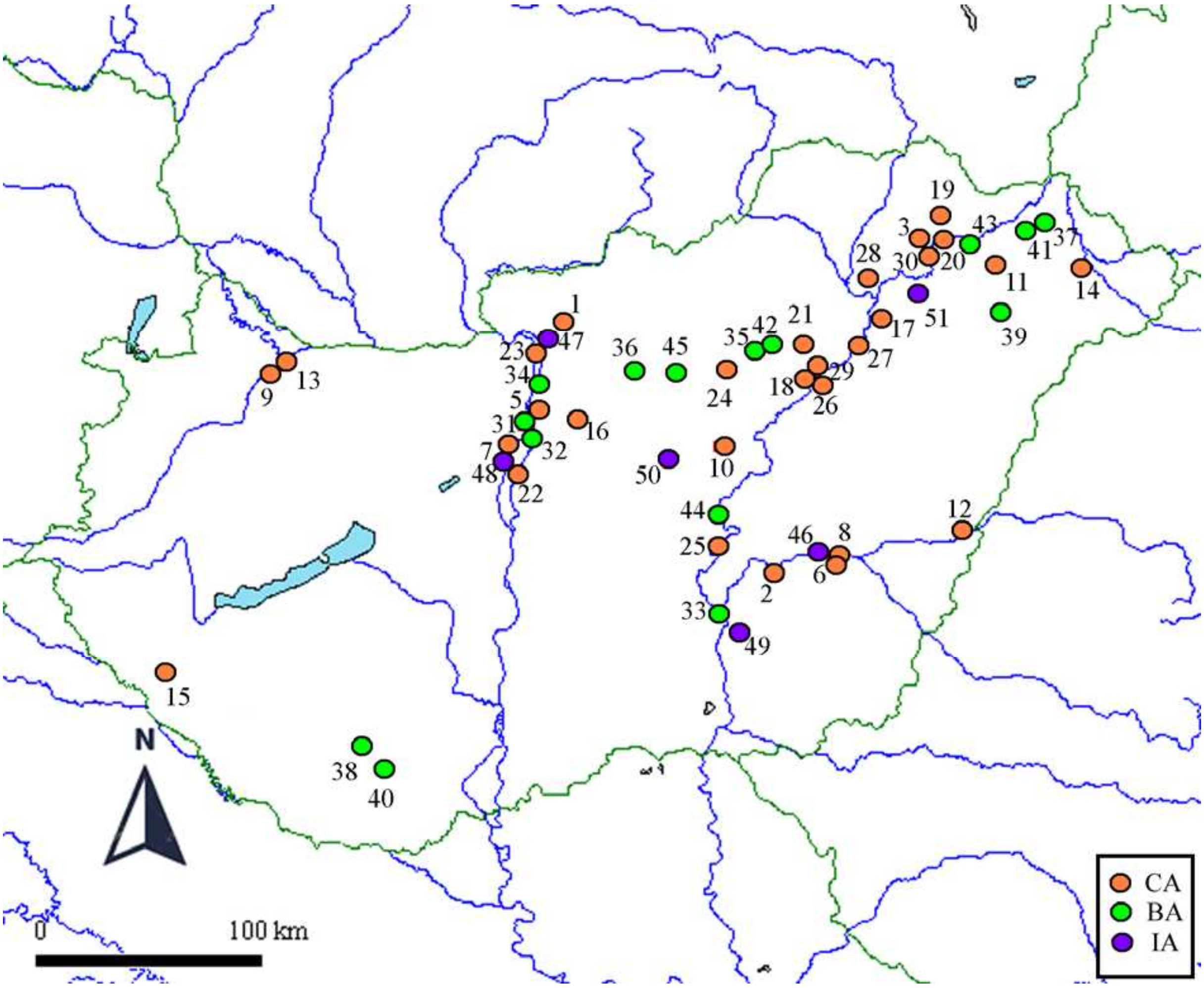


Fig. 5.: Obsidian use in Hungary after the Neolithic period.

Key of symbols: CA: Copper Age; BA: Bronze Age; IA: Iron Age

Site numbers: 1. Alsópetény; 2. Békésszentandrás; 3. Bodrogkeresztúr; 4. Bodrogzsadány; 5. Budapest; 6. Endrőd; 7. Érd; 8. Gyoma; 9. Ikrény; 10. Jászladány; 11. Kemecse; 12. Magyarhomorog; 13. Ménfőcsanak; 14. Nagydobos; 15. Nagykanizsa; 16. Pécel; 17. Polgár; 18. Poroszló; 19. Sárazsadány; 20. Szabolcs; 21. Szentistván; 22. Szigetcsép; 23. Tahitótfalu; 24. Tarnabod; 25. Tiszabög; 26. Tiszafüred; 27. Tiszakeszi; 28. Tiszalúc; 29. Tiszavalk; 30. Tokaj; 31. Budapest-Albertfalva; 32. Budapest-Csepel, Hollandi u.; 33. Csongrád; 34. Dunakeszi; 35. Füzesabony; 36. Hatvan; 37. Kisvárda; 38. Kovácsszénája; 39. Nagykálló; 40. Pécs; 41. Rétközberencs; 42. Szihalom; 43. Tiszabercel; 44. Tószeg; 45. Vámosgyörk; 46. Gyomaendrőd; 47. Kosd; 48. Százhalombatta; 49. Szentes; 50. Tápiószele; 51. Tiszavasvári

5. ábra: Újkőkornál fiatalabb lelőhelyek régészeti obszidián leletekkel.

Jelkulcs: CA: rézkor; BA: bronzkor; IA: vaskor

This period is probably the most favourable for long distance contacts. The Carpathian obsidian travels in Late Neolithic context as far as Istria (Williams et al. 1984), giving one of the rare instances of interaction with the areas basically supplied from Lipari (Kasztovszky & Težak-Gregl 2009). The extreme long-distance trade network of the period is also documented by special raw materials like jade (Biró et al. 2017).

More recent prehistoric obsidian use (Fig. 5.)

Obsidian distribution in the recent periods of prehistory, especially in Bronze and Iron Age has not been systematically studied. As part of the evaluation of Late Neolithic obsidian distribution, mainly Early and Middle Copper Age obsidian use was evaluated by Biró (1998a). This period (the first half of the Copper Age) has also been surveyed by I. Bognár-Kutzián (Kutzián 1972).

Fig. 6.: Copper Age obsidian arrowheads from Magyarhomorog. (Photo by J. Kardos)

6. ábra: Rézkori nyílhegyek Magyarhomorogról. (Kardos J. felvétele)

Fig. 7.: Large obsidian retouched blade from the Kurgan Csongrád-Felgyő. (Photo by the author)

7. ábra: Csongrád-Felgyő, nagy méretű obszidián retusált penge a kurgánból. (a szerző felvétele)

In his classical study on Copper Age lithic implements, P. Patay (Patay 1976a) has mentioned Copper Age obsidian use. He has also contributed to the knowledge on authentic, well dated and „personal" obsidian use by his excavations of Copper Age cemeteries, e.g. Magyarhomorog (Patay 1976b) (**Fig. 6.**). More Copper Age obsidian finds were studied from the Tiszalúc settlement (Patay 2005, Kövecses-Varga 2005). Late Copper Age obsidian finds tend to centre, apart from the Alföld, again in the Danube-band region and along the Danube (Zandler & Horváth 2010).

Early Bronze Age sites give ample evidence of obsidian use in traditional stone tool functions (Csongrád-Felgyő, Ecsedy 1979, Albertfalva Biró 2016) (**Fig. 7.**). In the Middle Bronze Age, scattered obsidian finds are still known (Horváth 2009).

Fig. 8.: Obsidian finds from Scythian graves. Prehistoric collection of HNM. (Photo by J. Antoni)

1: Tápiószele 55.11.43; 2: Tiszavasvári 62.50.112; 3: Szentes-Vekerzug 55.14.138.

8. ábra: Obszidián leletek szkíta sírokból. MNM őskori gyűjteménye. (Antoni J. felvétele)

The prehistoric collection of the Hungarian National Museum contains obsidian finds from classical Bronze Age localities like Füzesabony, Hatvan and Nagykálló. More surprisingly, we have quite a few obsidian from Iron Age (Celtic and Scythian) context. In these cases, the question of the secondary use and non-traditional stone tool functions like fire-flint emerge (**Fig. 8.**).

Concluding remarks

Obsidian is a characteristic element of the lithic industries in Hungary from the (Middle) Palaeolithic till the terminal periods of prehistory. So far, only Carpathian obsidians (C1 and C2E, C2T) types have been identified. There is a characteristic temporal and spatial pattern observable in the archaeological distribution of obsidian, along main river valleys and foothill regions of the Northern Mid-Mountain range. The most intensive use of obsidian is observed on the Hungarian Lowlands (Alföld) at the beginning and first half of the Neolithic period (early Neolithic, Körös culture and Szatmár group as well as early LBC). By the Late Neolithic, obsidian access is clearly a political issue – the longest distances of distribution, local distribution centres relatively far from the source areas (Lengyel culture) and scarcity of obsidian on traditionally well supplied Alföld region (Biró 1998a, 1998b).

There is still much work to do. It is important to check – especially long distance – items of obsidian by strictly non-destructive analytical methods. Also, more attention should be paid to relatively recent, i.e., recent prehistoric obsidian distribution. It is important to know more on border zones of the distribution area, regions probably supplied from several obsidian sources. Probably the most important is the study of the complete distribution area of Carpathian obsidians, over the current political boundaries and the collection of representative data on the lithic composition of sites.

References

BARTUCZ L., DANCZA J., HOLLENDONNER F., KADIĆ O., MOTTL M., PATAKI V., PÁLOSI E,, SZABÓ J & VENDL A. (1939): A cserépfalui Mussolini barlang (Subalyuk) *Geologia Hungarica Series Palaeonthologica* **14** 381 p.

BÁCSKAY, E. & SIMÁN, K. (1987): Some remarks on chipped stone industries of the earliest Neolithic populations in present Hungary. *Archaeologia Interregionalis* **240** 107–130.

BIRÓ, K.T. (1981): A Kárpát medencei obszidiánok vizsgálata (Investigation of obsidian from the Carpathian Basin). *Archaeologiai Értesítő* (Budapest) **108** 196–205.

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

BIRÓ, K.T. (1987): Chipped stone industry of the Linearband Pottery Culture in Hungary. *Archaeologia Interregionalis* **240** 131–167.

BIRÓ, K.T. (1998a): *Lithic implements and the circulation of raw materials in the Great Hungarian Plain during the Late Neolithic Period.* Hungarian National Museum, Budapest, 1–350.

BIRÓ, K.T. (1998b): Stones, Numbers- History? The utilization of lithic raw materials in the middle and neolithic of Hungary. *Journal of Antropological Archaeology* **17** 1-18.

BIRÓ, K.T. (2002): Advances in the study of Early Neolithic lithic materials in Hungary. *Antaeus* **25** 119–168**.**

BIRÓ, K.T. (2004): A kárpáti obszidiánok: legenda és valóság. *Archeometriai Műhely / Archaeometry Workshop* **I/1** 3–8**.**

BIRÓ, K.T. (2005): Gyűjtemény és adatbázis: eszközök a pattintott kőeszköz nyersanyag azonosítás szolgálatában / Collection-and-Database Approach in the Study of Lithic Raw Material Provenance. *Archeometriai Műhely / Archaeometry Workshop* **II/4** 46–51., http://www.ace.hu/am/2005_4/AM-2005-4-TBK-melleklet.pdf

BIRÓ, K.T. (2006): Carpathian Obsidians: Myth and reality. In: *Proceedings of the 34th International Symposium on Archaeometry*, 3-7 May 2004. Institution Fernando el Catolico Zaragoza. E-book, 267–278**.** http://www.dpz.es/ifc/libros/ebook2621.pdf

BIRÓ, K.T. (2009): The Obsidian Road. unpublished lecture for Annual Meeting of the UISPP 4th Commission 2009 in Budapest, *Data Management and Mathematical Methods in Archaeology.* http://www.ace.hu/UISPP_4/preliminary_program.html

BIRÓ, K.T. (2014a): Carpathian Obsidians: State of Art. In: YAMADA, M. & ONO, A. eds., Lithic raw material exploitation and circulation in Préhistory *ERAUL* **138** 47–69.

BIRÓ, K.T. (2014b): Mezőkövesd-Mocsolyás: A kőanyag értékelése. / Mezőkövesd-Mocsolyás: Evaluation of the lithic material. *Borsod-Abaúj-Zemplén Megye Régészeti Emlékei,* Miskolc, **9** 205–280.

BIRÓ, K.T. (2016): Ch. 9.3. Lithic material of the Budapest, Albertfalva Bell Beaker site In: ENDRŐDI, A. & REMÉNYI, L. eds. *A Bell-Beaker settlement in Albertfalva, Hungary (2470-*

1950 BC). Budapest Historical Museum, Budapest 153–164.

BIRÓ, K.T., BIGAZZI, G. & ODDONE, M. (2000): Instrumental analysis I. The Carpathian sources of raw material for obsidian tool-making. In: DOBOSI, V. ed., *Bodrogkeresztúr-Henye. (NE-Hungary) Upper Palaeolithic site.* Magyar Nemzeti Múzeum, Budapest, 221–240.

BIRÓ, K.T., MARKÓ, A., KASZTOVSZKY, Zs. (2005): Red obsidian in the Hungarian Palaeolithic: Characterisation studies by PGAA. *Praehistoria* **6**. 91–101.

BIRÓ, K.T., PÉTREQUIN, P., ERRERA, M., PRĬCHYSTAL, A., TRNKA, G., ZALAI-GAÁL, I. & OSZTÁS, A. (2017): Ch.18. Des Alpes à l'Europe centrale (Autriche, République tchèque, Slovaquie et Hongrie) In: Pétrequin et al. eds.,JADE. Presses universitaires de Franche-ComtéCentre de Recherche Archéologique de la Vallée de l'Ain, Tome 3. 431–466.

BIRÓ, K.T., KOÓS, J., CSENGERI, P. in press: Obszidián és limnokvarcit feldolgozó műhely a Hernád völgyében / Obsidian and limnoquartzite processing workshop in the Hernád valley. In press for *Mómosz* **X**.

CHAPMAN, J. (1981): The Vinča Culture of South-East Europe I-II.. *BAR* **117** 512 p.

COMŞA, E. (1969): Comşa, Eugen L'usage de l'obsidienne a l'epoque neolithique dans le territoire de la Roumanie. *Acta Archaeologica Carpathica* **11** 5–15.

DOBOSI, V. (2011): Obsidian use in the Palaeolithic in Hungary and adjoining areas. Natural Resource Environment and Humans, Meiji University, Tokyo, **1** 83–95.

DOBOSI, V. ed. (2000): *Bodrogkeresztúr-Henye (NE-Hungary) Upper Palaeolithic site*. Hungarian National Museum Budapest 1-245**.**

ECSEDY, I. (1979): The people of the pit-grave kurgans in Eastern Hungary. *Fontes Archaeologici Hungariae* Budapest, 1–147.

HORVÁTH T. (2009): Pattintással készült eszközök kronológiai szerepe a kora- es középső bronzkor folyamán / The Chronological Role of Chipped Stone Implements in the Early and Middle Bronze Ages. *Tisicum* **XIX** 413–440.

JANŠÁK, S. (1935): *Praveké sidliska s obsidianovou industriou na Vychodnom Slovensku.* Bratislava 1–193.

KADIĆ, O. (1939): Ősrégészeti eredmények (Subalyuk) *Geologia Hungarica Series Palaeonthologica* **14** 105–154.

KASZTOVSZKY, Zs. & TEŽAK-GREGL, T. (2009): Kora-neolitikus radiolarit és obszidián kőeszközök vizsgálata Prompt Gamma Aktivációs analízissel / Prompt Gamma Activation Analysis of Early Neolithic radiolarite and obsidian stone tools *Mómósz* **6** 189–195.

KASZTOVSZKY, Zs., LÁZÁR, K., KOVÁCS KIS, V., LEN, A., FÜZI, J., MARKÓ, A. & BIRÓ, K.T. (2018): A novel approach in the mineralogy of Carpathian mahogany obsidian using complementary methods. *Quaternary International* **467** 332–341.

KASZTOVSZKY, Zs. & PŘICHYSTAL, A. (2018): An overview of the analytical techniques applied to study the Carpathian obsidians. *Archeometriai Műhely / Archaeometry Workshop* **XV/3** 187–196.

KOSTRZEWSKI, J. (1930): Obsidian implements found in Poland. *Man* **30** 95–98.

KÖVECSES-VARGA, E. (2005): Ch. 4.3.1. Gespaltenes Steinwerkzeug. In: PATAY P. ed, 2005 Kupferzeitliche Siedlung von Tiszalúc. *Inventaria Praehistorica Hungariae* Budapest, Magyar Nemzeti Múzeum, **11** 66-70.

KULCZYCKA, A. & KOZŁOWSKI, J.K. (1960): Pierwsze materialny kultury Bukowogorskiej na Polnoc od Karpat. *Acta Archaeologica Carpathica* **2** 41–54.

BOGNÁR-KUTZIÁN, I. (1972): The Early Copper Age Tiszapolgár-Culture. *Archaeologia Hungarica*. Ser. **48** 253 p.

MARKÓ, A. (2017): Use of obsidian during the LGM: case studies from the Pebble Gravettian sites in Hungary / Az obszidián felhasználása a kavicsgravetti leletegyüttesekben: esettanulmányok az utolsó hideg maximum idejéből. *Archeometriai Műhely / Archaeometry Workshop* **XIV/3** 131–142.

MARKÓ, A. & PÉNTEK, A. (2003-2004): Raw material procurement strategy on the Palaeolithic site of Legénd-Káldy tanya (Cserhát Mountains, Northern Hungary) *Praehistoria* **3-4** 165–177.

ONO, A. ed. (2012): *Lithic Raw Material exploitation and circulation in prehistory. Conference 2012.10.27-28,* Meiji University, Tokyo 1–51.

PAUNESCU, Al. (1970): *Evolutia uneltelor si armelor de piatra cioplita descoperite pe teritoriul Romanei.* Editura Academiei Republicii Socialiste Romania, Bucharest, 358 p.

PATAY, P. (1976a): Les matières premières lithiques de l'âge du cuivre en Hongrie. *Acta Archaeologica Carpathica* **16** 229–238.

PATAY, P. (1976b): A magyarhomorogi rézkori temető. (Das Kupferzeitliche Gräberfeld von Magyarhomorog.). *Déri Múzeum Évkönyve* 1975-1976, 173–254.

PATAY, P. (2005): Kupferzeitliche Siedlung von Tiszalúc. *Inventaria Praehistorica Hungariae* **11** 1–207.

RENFREW, C., CANN, J. R., DIXON, E. (1965): Obsidian in the Aegean. *The Annual of the British School at Athens* **60** 225–247.

RÓMER, F. (1867): Első obsidian-eszközök Magyarországon (First obsidian implements in Hungary). *Archaeológiai Közlemények* **7** 161–166.

RÓMER, F. (1868a): Ó-kőkori eszközök Magyarországon. *Archaeológiai Értesítő* **1** 3–8.

RÓMER, F. (1868b): Ismét néhány szó az obsidián eszközökről. *Archaeológiai Értesítő* **1** 56–59.

RÓMER, F. (1878): Les silex taillés et les obsidiennes en Hongrie. *Congr. Int. d'Anthr. et d'Arch. Prehist. VIII. Compte-Rendu* **2** Budapest 6–17.

RÓMER, F. ed. (1878): Congrès International d'Anthropologie et d'Archéologie Préhistoriques 1876. VIII. Compte-Rendu de la huitième session à Budapest, Vol. 1-2. Musée National Hongrois, Budapest.

ROSKA M. (1934): Adatok Erdély őskori kereskedelmi, művelődési és népvándorlási útjaihoz (Data on the trade, cultural and migrational routes of prehistoric Transsylvania). *Archaeológiai Értesítő* **47** 149–158.

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

RYZHOV, Sergii, (2018): Archaeological and geological studies of obsidians in Ukrainian Transcarpathia, *Archeometriai Műhely / Archaeometry Workshop* **XV/3** 225–230.

STARNINI, E. (1993): Typological and technological analyses of the Körös culture chipped, polished and ground stone assemblages of Méhtelek-Nádasd (North-Eastern Hungary). *Atti della Societa per la Preistoria e Protostoria della Regione Friuli-Venezia Giulia* 29–96.

SZABÓ, J. (1867): A Tokaj-Hegyalja obsidiánjai (Obsidians of the Tokaj Mts). *A Magyarhoni Földtani Társulat Munkálatai* (Pest) **3** 147–172.

SZABÓ, J. (1878): L'obsidienne prehistorique en Hongrie et en Grece. - *Congr.Int. d. Anthr. et d. Arch. Prehist., Compte-Rendu II* Budapest 96–100.

SZÁDECZKY Gy. (1887): A magyarországi Obsidianok, különös tekintettel geológiai viszonyaikra. *Értekezések a Természettudományok Köréből* **16** 1–64.

SZEPESI, J., LUKÁCS, R., T. BIRÓ, K., MARKÓ, A, PÉCSKAY, Z.& HARANGI, Sz., (2018): Geology of Tokaj Mountains obsidians, *Archeometriai Műhely / Archaeometry Workshop* **XV/3** 167–180.

SZILÁGYI K. (2009): Karancsság - Alsó Rétek középső és késő neolit pattintott kőeszközei *Diplomamunka*, kézirat Szeged 1–140.

VENDL, A. (1939): A paleolitok kőanyaga [Subalyuk lithic raw materials, in Hungarian] *Geologia Hungarica Series Palaeonthologica* **14** 155–181.

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

YAMADA, M. & ONO A. eds. (2014): Lithic raw material exploitation and circulation in Préhistory. A comparative perspective in diverse palaeoenvironments ERAUL **138** 230 p.

ZANDLER, K. & HORVÁTH, T. (2010): Balatonőszöd–Temetői dűlő őskori, több periódusú település pattintott kőeszközeinek vizsgálata / The investigation of the Chipped Stone Industry of the Prehistorical Multi-Period Settlement of Balatonőszöd–Temetői dűlő. *Archeometriai Műhely / Archaeometry Workshop* **VII/4** 259–296.

ARCHAEOLOGICAL AND GEOLOGICAL STUDIES OF OBSIDIANS IN UKRAINIAN TRANSCARPATHIA•

RÉGÉSZETI ÉS GEOLÓGIAI VIZSGÁLATOK A KÁRPÁTALJAI OBSZIDIÁNOKON

RYZHOV, Sergii [1]

[1]Department 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 Kisrákóc falvak határában (Rokosovo és Malyj Rakovets). A lelőhelyek a Vihorlát-Gutin vulkáni hegység-vonulathoz tartoznak.

A területen található obszidiánok kőzettani és geokémiai vizsgálata lehetővé tette egy újabb nyersanyag-csoport elkülönítését, amelyet kárpáti 3. néven írtak le. A régészeti kutatások szerint a nyersanyagforrásokat az őskőkor során kiaknázták, például Kisrákóc (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 őskőkori és őskori emberek.

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

KULCSSZAVAK: OBSZIDIÁN, KÁRPÁTALJA, ŐSKŐKOR, RAKASZ, KISRÁKÓC

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 row 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.

HU ISSN 1786-271X; urn: nbn: hu-4106

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).

Georchaeological 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 Velikyj 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., & BONSALL C. (2018): The use of obsidian during the Upper Palaeolithic in Northwest Romania. *Anthropologie* (France), **122** 111–128.

FÉBLOT-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 sidliska s obsidianovou industriou na Vychodnom 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 Закарпатья*. 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 Закарпатья. 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.

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

MYKYTA, M.M. (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., SEGHEDI, 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. научых трудов: Криворожский горнорудный институт,* **VIII** 104–115.

PETROUGNE, V.F. (1972): Леваллуазские мастерские обсидиановых орудий Закарпатья 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 paleolitidc time. *ERAUL: Etudes et recherches archeogiques 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 are 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. *Archaologisches Korrespondenz-blatt* **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 сырье 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 УкрДГРІ* **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.

STATE OF ARTS: THE CARPATHIAN OBSIDIANS IN THE CZECH REPUBLIC•

ADATOK A KÁRPÁTI OBSZIDIÁN RÉGÉSZETI ELTERJEDÉSÉRŐL A CSEH KÖZTÁRSASÁG TERÜLETÉN

Antonín PŘICHYSTAL[1]

[1]Department of Geological Sciences, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic

E-mail: prichy@sci.muni.cz

Abstract

In spite of no natural obsidian occurrences in the Czech Republic, its first sporadic artefacts have been described already at some Szeletian and Aurignacian sites in Moravia (eastern part of the Czech Republic). Small but systematic presence of obsidian seems to be characteristic for big Gravettian settlements in eastern and southern Moravia and we suppose its transport in the "northern road", it means along the Carpathian flysch belt. Obsidian tools in the Moravian Magdalenian, Late Palaeolithic and Mesolithic represent probably only accidental contacts with the area of SE Slovakia or NE Hungary.

The "northern road" for transport of obsidian was used again in the period of Linear Pottery culture when obsidian tools very often occur at settlements (in Czech Silesia) rich also in the silicites from Cracow-Częstochowa Jurassic. The most extensive import of obsidian to Moravia is connected with the older stage of Lengyel culture (Moravian Painted Ware I). It was transported very probably via northern Hungary or southern and western Slovakia ("southern road") to south-western Moravia, later to the area of Brno and Eastern Bohemia.

Occurrences of archaeological obsidian in Bohemia (western part of the Czech Republic) were evaluated in detail by P. Burgert (2015). Comparing Moravia, obsidian artefacts appeared there later (Late Palaeolithic/Mesolithic) and its presence in the Neolithic culminated in the late phase of Stroked Pottery culture.

Kivonat

Annak ellenére, hogy a Cseh Köztársaság területén nem találunk természetes obszidián előfordulást, már a korai felső paleolitikum idején (Szeleta és Aurignaci kultúrák idején) találkozunk szórványosan obszidiánból készült eszközökkel a morva területeken (a Cseh Köztársaság keleti részén). Az obszidián kis mennyiségben, de folyamatosan jelen van a keleti és déli morva területeken a Gravetti kultúra nagyobb településein. Feltételezzük, hogy elterjedése az „északi útvonalon" történt, azaz a Kárpátok flis öve mentén. A morva magdaléni, késő paleolit és mezolit lelőhelyeken valószínűleg csak a mai DK-szlovákiai és ÉK-magyarországi területekkel való alkalmi kapcsolatok révén jelennek meg obszidián eszközök.

Az „északi útvonal" ismét használatba került a Vonaldíszes Kerámia Kultúrája idején, amikor is gyakran találkozunk obszidián eszközökkel a Cseh Szilézia területén levő településeken, amelyeken gyakran kerülnek elő krakkói jura tűzkő leletek is. A legintenzívebb obszidián felhasználást morva területen a Lengyeli kultúra idősebb szakaszában figyelhetjük meg (más néven, Morva Festett Kerámia Kultúrája I. fázis). Valószínűleg Észak-Magyarország vagy Dél- és Nyugat-Szlovákia felől érkezett (az ú.n. „déli úton"), a délnyugat morva területekre, majd később Brno környékére és a keleti cseh területekre.

A cseh területeken (a Cseh Köztársaság nyugati részén) előforduló obszidiánokat P. Burgert (2015) tanulmánya részletesen bemutatta. A morva területtel szemben az obszidián eszközök itt később jelentek meg (késő paleolitikum és mezolitikum idején). A felhasználás csúcspontja a Tűzdelt Szalagdíszes Kerámia Kultúra késői fázisának idejére keltezhető.

KEYWORDS: CARPATHIAN OBSIDIAN, CZECH REPUBLIC, PREHISTORIC DISTRIBUTION

KULCSSZAVAK: KÁRPÁTI OBSZIDIÁN, CSEH KÖZTÁRSASÁG, ŐSKORI RÉGÉSZETI ELTERJEDÉS

• How to cite this paper: PŘICHYSTAL, A., (2018): State of arts: the Carpathian obsidians in the Czech Republic. *Archeometriai Műhely /Archaeometry Workshop* **XV/3** 231-240.

Introduction

In the second half of the 19th century the geological knowledge of recent Czech Republic allowed to form conclusion about the absence of natural occurrences of volcanic glass obsidian. It is true that after discovery of moldavites (natural glasses from the group of tektites) in Bohemia 1787 some mineralogists originally believed to be a special type of obsidian ("edlen Obsidian von Moldauthein, böhmische chrysolithartigen Obsidian"). Also the founder of Bohemian geology, professor J. Krejčí (1846) has written under the pseudonym Š. Hanuš in his article focussed on Bohemian precious stones: "The Bohemian obsidian is called Moldawit". He mentioned natural sources of obsidian in Mexico, Peru, Lipari but he did not know the Carpathian obsidian. After the investigation of physical and chemical properties of moldavites and especially after a detailed geological mapping (no occurrences of Cenozoic acid volcanism in the Czech Republic) this classification to the group of volcanic glasses was rejected. Systematic study of obsidian as a raw material for prehistoric chipped stone tools appeared in Central Europe after the International congress of anthropology and prehistoric archaeology in Budapest 1876 when the Hungarian occurrences of natural obsidian around Tokaj started to be generally known.

Knowledge of archaeological obsidian in Moravia and Czech Silesia (eastern part of the Czech Republic)

It was evident the finds of obsidian in Moravia, Bohemia and Czech Silesia (Lands of the Czech Crown; the Czech Republic in recent time) had to be considered as archaeological artefacts. The first written information on Moravian archaeological obsidian was published by J. Knies (1891). He described six Neolithic finding places with obsidian prevalently from southern Moravia and he supposed its provenance around Tokaj (Hungary) and Prešov (Slovakia). Moravian archaeologist I. L. Červinka (1902) already knew ten Neolithic localities with occurrences of obsidian. A very important obsidian find was described from the famous Gravettian settlement at Přerov-Předmostí, at that time classified as the Aurignacian. It represented probably the first stratified Palaeolithic obsidian in Central Europe (Maška 1889, Absolon 1918, Knies 1925), unfortunately without more detailed description. J. Skutil (1928) mentioned two Palaeolithic obsidians in Moravia, one from Přerov-Předmostí and another important obsidian from a unique rock crystal Magdalenian collection in the Žitný Cave near Křtiny, the Moravian Karst north of Brno. Nobody confirmed the obsidian artefact from the Žitný Cave later. That is why K. Absolon (1938, 18) had doubts about both Skutil´s obsidians and he supposed to be smoky quartz (see also Klíma 1957).

Based on published reports, Slovakian researcher Š. Janšák (1935, 191) summarized available data on archaeological finds of obsidian in Central Europe in his monograph and he registered Neolithic obsidian in the cadastral areas of 70 Moravian villages and towns. These finds have been connected especially with the older stage of the Moravian Painted Ware culture (Lengyel culture). In Janšák´s book participated also a mineralogist F. Ulrich from Charles University in Prague who determined physical properties (refractive index, specific gravity) for nine obsidian tools from seven Neolithic sites in Moravia and one from Bohemia (Ulrich 1935, 15).

The definition of petroarchaeology around 1970 in Brno represented a new impulse in investigations of the Neolithic obsidian in Moravia. J. Štelcl (1973) studied specific gravity, and refractive index of 29 artefacts from the Neolithic sites of Kyjovice and Střelice (Znojmo district) and Brno-Holásky. Chemical analyses of main oxides for three obsidian artefacts from Kyjovice were also carried out. From the viewpoint of physical properties and their chemism, the studied Moravian Neolithic obsidians formed a homogenous collection. In that time there was mentioned only one source of obsidian in Slovakia (Viničky) with polyedric, smooth appearance of obsidian pieces and without sculpture. Comparative obsidian samples from Viničky had different refractive index and specific refractivity. That is why J. Štelcl was looking for the provenance of Moravian Neolithic obsidians in Hungary. He was influenced by opinions of K. Žebera (in Rost 1971) that the sculpture is typical for obsidians from Hungary. In recent time we know that it is exactly the opposite because the sculpture is a typical sign for natural obsidians from a secondary natural source in the northern part of Zemplínské vrchy Hills in Slovakia (Přichystal and Škrdla 2014).

Using the instrumental neutron activation analysis (INAA), Williams Thorpe et al. (1984) studied 264 pieces of archaeological obsidian from central and eastern Europe and for comparison 48 samples from natural sources in northeast Hungary and southeast Slovakia. The authors included in their analyses also 8 Moravian Palaeolithic – Mesolithic obsidian artefacts (cultural affiliation done by K. Valoch from Moravian Museum in Brno) with the following results:

1. Nová Dědina near Kroměříž, Aurignacian, source Carpathian 2a;
2. Bořitov, Szeletian, unknown source;
3. Dolní Věstonice, Gravettian, source Carpathian 1;
4. Kůlna Cave, Epimagdalenian, source Carpathian 1;
5. Uherské Hradiště – Sady, Late Palaeolithic, source Carpathian 1;

6. Přibice near Pohořelice, Mesolithic, source Carpathian 1;
7. Smolín A near Pohořelice, Mesolithic, source Carpathian 1;
8. Smolín C near Pohořelice, Mesolithic, source Carpathian 1.

In cooperation with A. Zeman (Geological Survey Prague) O. Williams Thorpe studied also 5 obsidian tools from the Neolithic site at Těšetice-Kyjovice near Znojmo (Lengyel Ia or Moravian Painted Ware Ia) and she found for them again the source Carpathian 1.

Excluding Nová Dědina and Bořitov, all Moravian Palaeolithic – Mesolithic samples had geochemical signs corresponding to the Slovakian source Carpathian 1 that represented the totally prevalent natural occurrence for the whole central and eastern Europe.

The Aurignacian obsidian from Nová Dědina was the only one with the Hungarian provenance. The surface find from a Szeletian site Bořitov had a very strange composition different from all the others to be analysed, so Williams Thorpe et al. (1984, Fig. 8) classified it as “source unknown”. Later investigation of the “obsidian” from Bořitov by A. Přichystal proved the sample as a natural glassy slag.

As is the provenance of Neolithic obsidian artefacts from Moravia, Zeman and Navrátil (1987) summarised results of J. Štelcl (1973) and Williams Thorpe et al. (1984) on obsidian artefacts from Těšetice-Kyjovice. In addition they added 28 analyses of main oxides from marginal and central artefact parts using microprobe JEOL JXA – 50A. The authors concluded the source area for the obsidians from Těšetice-Kyjovice was the Viničky – Kašov area in Eastern Slovakia but they also mentioned differences in the refractive index of obsidian artefacts and natural obsidian from Viničky. Their comparison of chemical composition of the weathered marginal part of artefacts and fresh central part showed only a slight decrease in Na content in the hydration rim.

During a few last years we applied modern analytical methods (LA – ICP – MS) to characterize both archaeological and natural obsidians from various parts of the world - Central Europe, Nicaragua, Syria, Turkey, Greece (Prokeš et al. 2015). The investigated collection contained also 11 obsidians from various Moravian Neolithic sites and one obsidian of the Aurignacian age (Nová Dědina near Kroměříž). The Moravian Neolithic obsidians have been in agreement with the Carpathian 1 source (south-eastern Slovakia), for the Aurignacian obsidian from Nová Dědina it was confirmed the Carpathian 2a source (north-eastern Hungary).

Chronostratigraphic occurrences of archaeological obsidian in Moravia and Czech Silesia

There are no finds of obsidian tools at the Moravian Middle Palaeolithic localities and at sites of the oldest Upper Palaeolithic culture – the Bohunician. There were described two obsidian surface finds from Szeletian sites Bořitov and Neslovice (Valoch 1975, Oliva 2005) but later investigation of the Bořitov “obsidian” classified it as an artificial glassy slag. So the obsidian side scraper weighting 45.5 g from Neslovice (Brno-venkov district) would be the oldest obsidian tool found in the Czech Republic (**Fig. 1/1**). Obsidian burin (3.94 g; **Fig. 1/2**) has been described from Míškovice I – Křemenná, an Aurignacian site influenced by the Szeletian in the Holešov area, central Moravia (Oliva 2016, 62). Surprisingly rich in obsidian artefacts is an Aurignacian locality Nová Dědina I near Kroměříž, also in central Moravia. The site is famous by prevalent utilisation of rock crystal (more than 500 pieces). Five pieces of patinated obsidians have surface without preserved sculpture (**Fig. 1/3**), their glassy mass is non-translucent and black with greasy lustre. The geochemical signature testifies for the Hungarian provenance (source Carpathian 2a – see above).

Individual pieces of obsidian artefacts have been ascertained at almost all important Moravian Gravettian settlements. For the first time in Central Europe, a Palaeolithic obsidian was mentioned at Přerov-Předmostí (Maška 1889), M. Oliva (2007) later added an obsidian scraper from this famous site (**Fig. 1/4**). Also Gravettian localities under the Pavlov Hills yielded a few obsidian artefacts – 6 cm long blade with marginal retouch on both sides and preserved sculpture of the original pebble from Pavlov 1 (Klíma 1957), later another piece was found again at Pavlov 1 (Klíma 1957), one flake at Dolní Věstonice 1 and 1 chip from Milovice (Oliva 2007: 19, 43, 59). The translucent obsidian chip with an evident fluidal structure from Dolní Věstonice was involved in the collection analysed by O. Williams Thorpe et al. (1984) and it corresponded to the Slovakian source Carpathian 1. Gravettian sites with obsidian in eastern Moravia are represented by Napajedla I (4 pieces, Oliva 2007: 105) and Jarošov II (6 obsidians from about 31000 pieces, Škrdla 2005). At a very interesting Epigravettian locality Brno-Stránská skála IV where the shape of Stránská skála Hill was used for hunting of horses, surprisingly a wide spectrum of raw materials including 1 piece of obsidian was found (Přichystal 1991). At another Epigravettian site Mohelno-Plevovce in Western Moravia P. Škrdla et al. (2015) ascertained 4 pieces of obsidian (personal communication of P. Škrdla 2019).

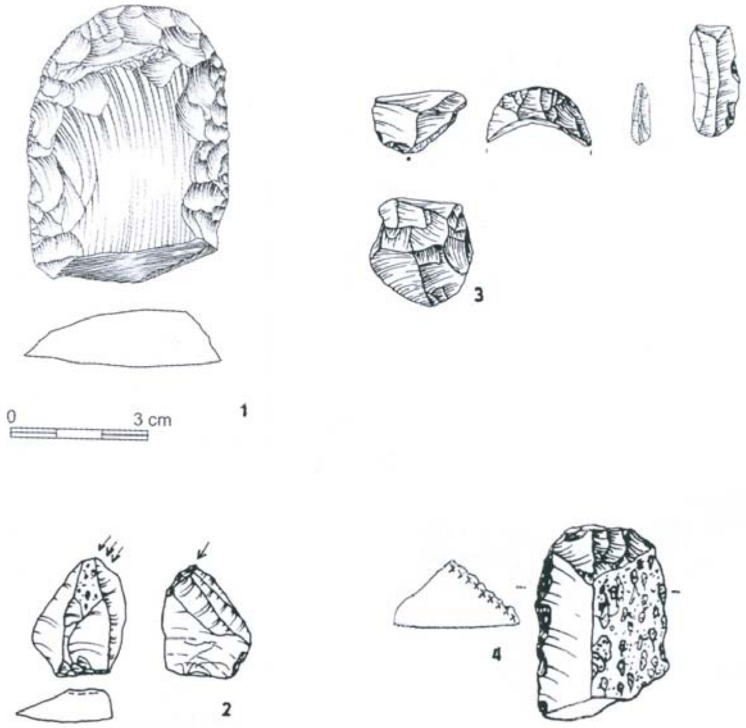


Fig. 1.: Examples of Palaeolithic obsidian tools from Moravia (adapted after Oliva 1987, 2007, 2016).
1. side scraper, Neslovice, Szeletian;
2. burin, Míškovice, Aurignacian influenced by Szeletian;
3. five obsidian artefacts, Nová Dědina, Aurignacian;
4. end scraper, Přerov-Předmostí, Gravettian.

1. ábra: Őskőkori obszidián eszközök morva területekről (Oliva 1987, 2007, 2016 nyomán).
1. kaparó, Neslovice, Szeleta kultúra; 2. árvéső, Míškovice, Aurignaci kultúra, Szeleta hatásokkal; 3. öt obszidián eszköz, Nová Dědina, Aurignaci kultúra; 4. vakaró, Přerov-Předmostí, Gravetti kultúra

Occurrences of obsidian at Magdalenian sites situated especially in caves of the Moravian Karst are rare comparing the previous Gravettian – Epigravettian. With no doubt it was found in the Magdalenian - Epimagdalenian layers no. 5 and 4 in the Kůlna Cave during excavations of K. Valoch (1988). The problematic find of obsidian or more probably smoky quartz from the Žitný Cave was already mentioned. The third locality is represented by another famous Magdalenian site in the Pekárna Cave where it is not evident the archaeological age of 2 obsidian artefacts uncovered before the cave, according to B. Klíma (1974) connected rather with the Neolithic.

Rare obsidian chipped artefacts have been found at localities classified as the Late Palaeolithic. Such a site is represented for example by Uherské Hradiště – Sady, southern Moravia (obsidian coming from the Slovakian source Carpathians 1) or Kněžice south Jihlava, Western Moravia with a small obsidian core (Diviš 1990).

Individual pieces of obsidian are connected also with the Mesolithic in Southern Moravia. At a Mesolithic station Smolín (the biggest one in the Czech Republic with about 34 000 chipped pieces) there were found 2 obsidian artefacts. According to the INAA analyses by O. Williams Thorpe et al. (1984) they correspond to the Slovakian source Carpathians 1. Another close site Přibice III gave also 2 pieces. Famous early medieval fortification Mikulčice near Hodonín had been settled also earlier in the Mesolithic. Archaeological excavation uncovered 1617 Mesolithic artefacts with 1 piece of obsidian (Škrdla et al. 1997).

Occurrences of archaeological obsidian in the period of the oldest Neolithic culture with Linear Pottery (LBK) were evaluated by I. Mateiciucová (2008). Since the early phase of the LBK, obsidian artefacts appeared only at a few settlements of northern Moravia (Mohelnice, Šišma), later in central Moravia (Količín), Mezice (Upper Moravian Basin), Pustějov – Dolní Role in Czech Silesia (4 pieces including two blades, Janák et al. 2016). Isolated imports of obsidian were ascertained even in south Moravia (Buchlovice). As is the distribution of LBK obsidian concerned, it was transported almost surely in the "northern road", i.e. along the Carpathian flysch belt via the Cracow area because the obsidian artefacts appeared in chipped assemblages with dominance of silicites from the Cracow-Częstochowa Jurassic.

Fig. 2.: Neolithic obsidian blades and cores from Brno-Žebětín, Moravian Painted Ware culture, phase Ib. Photo by A. Přichystal.

2. ábra: Újkőkori obszidián pengék és magkövek Brno-Žebětín lelőhelyről, Morva Festett Kerámia Kultúrája Ib fázis. A. Přichystal. felvétele.

The most important presence of obsidian in Moravia is connected with the early stage I of the Lengyel cultural complex, it means with the Moravian Painted Ware culture I (6850 – 6010 cal BP; data for the MPWC according to Kuča et al. 2016). Finds of obsidian are typical for prevalent part of settlements of this stage (phases Ia and Ib) and their number can be estimate about 100 localities. The last list published by E. Kazdová (1984) contains 94 sites. As an example it is possible to mention Těšetice-Kyjovice near Znojmo where the collection of 1629 chipped artefacts of Ia phase contained 225 small chips of obsidian (i.e. 14 %; Přichystal 1984), similarly in Brno-Žebětín (phase Ib) it was ascertained 154 small pieces of obsidian – see Fig. 2. (7.3 % of the whole collection; Kuča et al. 2005). Raw material had to be transported as small pieces along the "southern road", it means probably across Northern Hungary and south-western Slovakia. For the younger stage II of the Moravian Painted Ware culture (6600 – 5660 cal BP) it was typical that obsidian was replaced by local rock crystal or moldavites from Western Moravia. In Upper Silesia obsidian exceptionally appeared in connection with the Upper Silesian Lengyel group I (Early Eneolithic) at the locality Bohuslavice "U dubu" – 3 pieces of obsidian in a collection of 55 chipped artefacts (Janák 2007, 157).

Obsidian can be rarely found also in lithic materials of the Early Eneolithic Jordanów culture (4000 – 3700 BC; data for the Moravian Eneolithic according to Kopacz et al. 2014). Six pieces of well translucent grey obsidian with fluidal structure (probably of the Carpathian 1 origin) have been described from Drnovice near Vyškov (Koštuřík et al. 1998). They represent 3 % in the collection of 195 chipped artefacts. Chipped assemblages connected with the Old and Middle Eneolithic cultures in Moravia (Funnel Beakers, Baden culture; 3700 – 2900 BC) are usually without obsidian tools excluding the important hillfort Hlinsko near Lipník (Boleráz stage of the Baden culture) where 3 obsidian artefacts (two microcores, one blade) are presented (Šebela a kol. 2007, Obr. 151) and one obsidian is mentioned from Služovice/Hněvošice in Czech Silesia (Funnel

Beakers I?, Janák 2007, 160). The Globular Amphorae, Bošáca and Jevišovice cultures (2900 – 2700 BC) are classified as the Young Eneolithic and only three pieces of obsidian were ascertained in the collection of 2155 artefacts from the whole Moravia (Kopacz et al. 2014). Two flakes with marginal retouch have been described from Hlinsko near Lipník (Bošáca culture) and 1 cortical flake with wide butt from Vysočany (Jevišovice culture). No obsidian was found in the Late Eneolithic (2700 – 2200 BC) chipped assemblages of the Corded Ware culture and it appeared very rarely among chipped raw materials of the Moravian Bell Beaker culture (MBBC). An arrowhead from Dětkovice (Prostějov district) and a blade with marginal retouch from Žadovice (Hodonín district) are only two items in the assemblages of 1110 chipped artefacts connected with the MBBC from whole Moravia and Czech Silesia (Kopacz et al. 2009). These obsidians represent very probably pieces picked up at older Neolithic/Eneolithic sites. Evaluation of chipped assemblages from the Early Bronze Age (the Únětice culture and Věteřov group) in Moravia included 1463 artefacts from 86 finding places but no obsidian has been found.

Archaeological obsidian in Bohemia (western part of the Czech Republic)

Bohemia is substantially poorer in finds of archaeological obsidian and comparing Moravia, it appeared there later. P. Burgert (2015) summarised data on its occurrences in this part of the Czech Republic including drawings of tools from various finding places. With no doubt, 24 localities are concentrated in Eastern Bohemia (especially around Hradec Králové and Kolín) and in the border part between Eastern Bohemia and Western Moravia (the Svitavy district). Only 7 localities have been found in Southern, Western and Central Bohemia. The oldest obsidian artefacts appeared as individual pieces at Late Palaeolithic /Mesolithic sites. At two localities obsidian artefacts are connected with the Linear Pottery culture but in addition such classification cannot be excluded for a few surface finds in Eastern Bohemia (they are ranked as only the Neolithic). The maximal imports of obsidian to Bohemia culminated in the late phase of Stroked Pottery culture (4900 – 4500/4400 cal BC) when for example at Smiřice (Hradec Králové district) 18 pieces of obsidian represent 15 % of the whole collection or at Plotiště nad Labem (Hradec Králové district) 77 obsidian artefacts form 4.1 % of the chipped assemblage. Only one obsidian tool (flake with retouch) was ascertained in younger prehistoric periods - in a grave of the Bell Beaker culture at Lochenice near Hradec Králové but it is supposed to be reutilised Neolithic artefact (Popelka 1990).

Geochemical study of 11 obsidian artefacts from 8 archaeological sites was carried out by P. Burgert et al. (2016) using X-ray fluorescence spectroscopy (pXRF) and laser ablation together with inductively coupled plasma and mass spectrometry (LA – ICP – MS). Almost all studied artefacts covering probably Late Palaeolithic, Linear Pottery culture and Stroked Pottery culture have Rb and Zr contents comparable with the Slovakian source Carpathian 1, only two obsidians from Kolín (younger stage of the Stroked Pottery culture) correspond to the Hungarian source Carpathians 2b.

3. ábra:

Őskőkori és középső kőkori lelőhelyek kárpáti obszidián előfordulással a Cseh Köztársaság területén

Fig. 3.: Palaeolithic and Mesolithic sites in the Czech Republic with occurrences of the Carpathian obsidian

Moravia: 1 – Nová Dědina, Aurignacian; 2 – Neslovice, Szeletian; 3 – Míškovice, Aurignacian/Szeletian; 4 – Přerov-Předmostí, Gravettian; 5 – Pavlov, Gravettian; 6 – Dolní Věstonice, Gravettian; 7 – Napajedla, Gravettian; 8 - Jarošov, Gravettian; 9 – Brno-Stránská skála, Epigravettian; 10 Mohelno-Plevovce, Epigravettian; 11 – Sloup-Kůlna Cave, Magdalenian and Epimagdalenian; 12 - Mokrá-Pekárna Cave, Magdalenian; 13 – Uherské Hradiště-Sady, Late Palaeolithic; 14 - Kněžice, Late Palaeolithic; 15 – Smolín, Mesolithic; 16 - Přibice, Mesolithic; 17 – Mikulčice, Mesolithic

Bohemia: 18 – Stradouň, Late Palaeolithic/Mesolithic; 19 – Putim, Late Palaeolithic/Mesolithic; 20 – Ražice, Late Palaeolithic/Mesolithic; 21 – Dolní Poříčí, Late Palaeolithic/Mesolithic; 22 – Koldín, Mesolithic; 23 - Čistá, Mesolithic

Conclusions

There are no occurrences of natural obsidian in the Czech Republic. In spite of it, rare pieces of archaeological obsidian appeared already at a few Upper Palaeolithic (Szeletian, Aurignacian) sites in Moravia (eastern part of the Czech Republic). Aurignacian site of Nová Dědina I near Kroměříž with prevalent rock crystal and 5 pieces of black non-translucent obsidian of the Hungarian provenance is standing out of them.

Individual pieces of obsidian artefacts have been ascertained at almost all important Moravian Gravettian (maybe also Epigravettian) settlements. They correspond to the Slovakian source "Carpathians 1". Collections of chipped artefacts connected with the Magdalenian, Late Palaeolithic and Mesolithic contain obsidian artefacts only occasionally. Geochemical analyses testify again for the Slovakian provenance (**Fig. 3.**).

Since the early phase of the LBK, obsidian artefacts appeared at a few settlements of northern Moravia and Czech Silesia, later in central Moravia and rarely in south Moravia. As is the distribution of LBK obsidian concerned, it was transported almost surely in the "northern road", i.e. along the Carpathian flysch belt via the Cracow area because the obsidian artefacts appeared in chipped assemblages with dominance of silicites from the Cracow-Częstochowa Jurassic.

The most important presence of archaeological obsidian in Moravia is connected with the early stage I of the Lengyel cultural complex, it means with the Moravian/Austrian Painted Ware culture I. Finds of obsidian are typical for prevalent part of settlements of this stage (phases Ia, Ib, possibly even Ic) and their number can be estimated about 100 localities.

Raw material had to be transported as small pieces along the "southern road", it means probably across Northern Hungary and south-western Slovakia. According to a few INAA analyses of the Lengyel obsidian, its chemical composition corresponds again to the Slovakian source. During the younger stage II of the Moravian/Austrian Painted Ware this attractive raw material was not accessible and it was replaced by local rock crystal or moldavites from Western Moravia. Obsidian is only occasional or missing in collections of chipped artefacts connected with the Eneolithic cultures in Moravia.

In Bohemia (western part of the Czech Republic), the oldest obsidian artefacts appeared as individual pieces later - at Late Palaeolithic /Mesolithic sites. At two localities obsidian artefacts are connected with the Linear Pottery culture but next few surface finds in Eastern Bohemia could be ranked only as the Neolithic. The maximal imports of obsidian to Bohemia culminated in the late phase of Stroked Pottery culture (4900 – 4500/4400 cal BC) but its quantity is substantially less comparing simultaneous distribution to the Moravian Painted Ware I stage settlements. Bohemian archaeological obsidian comes prevalently from the Slovakian source. In the period of maximal import in the Neolithic some artefacts have the Hungarian origin as well.

Bibliography

ABSOLON, K. (1918): Předmostí. *Zlatá Praha* **35** 298–299.

ABSOLON, K. (1938): Die Erforschung der diluvialen Mammut-jäger-Station von Unter-Wisternitz an der Pollauer Bergen in Mähren. Arbeitsbericht über das zweite Jahr 1925. *Studien aus dem Gebiete der allgemeinen Karstforschung, der wissenschaftlichen Höhlenkunde, die Eiszeitforschung und der Nachbargebieten*, Brünn, Palaeoethnologische Serie Nr. **6 (9)** 1–101.

BURGERT, P. (2015): Štípaná industrie z obsidiánu v Čechách (Chipped industry from obsidian in Bohemia). *Archeologické rozhledy* **67** 239–266.

BURGERT, P., PŘICHYSTAL, A., PROKEŠ, L., PETŘÍK, J. & HUŠKOVÁ, S. (2016): Původ obsidiánové suroviny v pravěku Čech (The origin of obsidian in prehistoric Bohemia). *Archeologické rozhledy* **68** 224–234.

ČERVINKA, I. L. (1902): *Morava za pravěku (Moravia in prehistory).* Vlastivěda moravská I. Brno. 368 pp.

DIVIŠ, J. (1990): Zpráva o nálezech štípané kamenné industrie z Kněžic, okr. Třebíč (Der Bericht über die Funde des gespalten Steinartikels aus Kněžice, Bezirk Třebíč). *Vlastivědný sborník Vysočiny,* odd. věd společenských, Jihlava **VII** 195–204.

JANÁK, V. (2007): Příspěvek neolitické a eneolitické štípané kamenné industrie k poznání sociálních a hospodářských poměrů své doby na příkladu horního Poodří (Beitrag der neo- und äneolithischen steinernen Spaltindustrie zum Erkenntnis der sozialen und wirtschaftlichen Verhältnisse seiner Zeit auf dem Beispiel des Oberen Odergebiets). In: KAZDOVÁ, E. & PODBORSKÝ, V. (eds.), *Studium sociálních a duchovních struktur pravěku*, ÚAM FF MU Brno, 137–179.

JANÁK, V., PAPÁKOVÁ, K., PŘICHYSTAL, A., KOVÁČIK, P., RATAJ, P. & HOŘÍNKOVÁ, A. (2016): Neolitické osídlení v okolí Studénky a úloha zdejšího mikroregionu kutury s lineární keramikou v distribuci silicitů krakovsko-čenstochovské jury (Neolithische Besiedlung in der

Umgebung von Studénka und die Rolle der hiesigen Mikroregion der Kultur mit der Linearbandkeramik in der Distribution der Silizite der Krakau-Tschenstochauer Jura). *Slovenská Archeológia* **LXIV-1** 1–63.

JANŠÁK, Š (1935): Praveké sídliská s obsidiánovou industriou na východnom Slovensku (Stations préhistoriques à industrie de l´obsidienne dans la Slovaquie orientale). *Práce učené společnosti Šafaříkovy v Bratislavě* **17** Bratislava. 193 pp.

KAZDOVÁ, E. (1984) Těšetice-Kyjovice 1. Starší stupeň kultury s moravskou malovanou keramikou (Těšetice-Kyjovice. Ältere Stufe der Kultur mit mährischer bemalter Keramik), UJEP Brno, 299 pp.

KLÍMA, B. (1957): Příspěvek k rozšíření obsidiánu v paleolitických kamenných industriích (Beitrag.zur Obsidianverbreitung in der Paläolithischen Steinindustrie). *Študijné zvesti AU-SAV Nitra* **2** 25–27.

KLÍMA, B. (1974): Archeologický výzkum plošiny před jeskyní Pekárnou (Die archäologische Erforschung des Plateau von der Pekárna-Höhle). *Studie Archeologického ústavu Československé akademie věd v Brně* **II (1973)**, 1 1–78.

KNIES, J. (1891): Pravěké nálezy obsidianu na Moravě (Prehistoric finds of obsidian in Moravia). *Časopis Vlasteneckého musejniho spolku v Olomouci* **8** 161.

KNIES, J. (1925): Přehled moravského palaeolithu (Overview of the Moravian Palaeolithic). *Obzor praehistorický* **4** 89–116.

KOPACZ, J., PŘICHYSTAL, A. & ŠEBELA, L. (2009): Lithic chipped industry of the Bell Beaker culture in Moravia and its East-Central European context. Kraków – Brno, 364 pp.

KOPACZ, J., PŘICHYSTAL, A. & ŠEBELA, L. (2014): Lithic chipped industry of the young Eneolithic in Moravia and Czech Silesia. Brno, 184 pp.

KOŠTUŘÍK, P., RUMIANOVÁ, A. & PŘICHYSTAL, A. (1998): Nálezy jordanovské keramiky z Drnovic a Radslavic (okr. Vyškov) [Funde der Jordanov-Keramik aus Drnovice und Radslavice (Bez. Vyškov)]. *Pravěk NŘ* **7** 129–147.

KREJČÍ, J. (HANUŠ, K.) (1846): O českých drahých kamenech (On Bohemian precious stones). *Pautnik* **I** 100–110.

KUČA, M., KAZDOVÁ, E. & PŘICHYSTAL, A. (2005): Sídliště kultury s moravskou malovanou keramikou staršího stupně v Brně-Žebětíně (Siedlung der Kultur mit mährischer bemalter Keramik der älteren Stufe in Brno-Žebětín). *Pravěk NŘ* **13** 37–89.

KUČA, M., PROKEŠ, L., ESKAROUSOVÁ, L., KOVÁŘ, J. J. & NÝVLTOVÁ FIŠÁKOVÁ, M. (2016): Testing the proposed relative chronology model for the Moravian Late Neolithic using radiometric dating. In: KOVÁRNÍK, J. et al.: *Centenary of J. Palliardi´s Neolithic and Aeneolithic Relative Chronology (1914-2014)*, University Hradec Králové, 117–125.

MAŠKA, K. J. (1889): Über die Gleichzeitigkeit des Mammuths mit dem diluvialen Menschen in Mähren. *Mitteilungen der Anthropologischen Gesellschaft in Wien* **19** 82–87.

MATEICIUCOVÁ, I. (2008): Talking Stones: The Chipped Stone Industry in Lower Austria and Moravia and the Beginnings of the Neolithic in Central Europe (LBK), 5700-4900 BC. *Dissertationes Archaeologicae Brunenses/ Pragensesque* **4**, 357 pp. Masarykova univerzita Brno.

OLIVA, M. (1987): Aurignacien na Moravě (Ľ Aurignacien en Moravie). *Studie Muzea Kroměřížska ´***87** 1–128.

OLIVA, M. (2005): *Civilizace moravského paleolitu a mezolitu (Civilizations of the Moravian Palaeolithic and Mesolithic).* Moravské zemské muzeum Brno. 120 pp.

OLIVA, M. (2007): Gravettien na Moravě (Gravettien en Moravie). *Dissertationes Archaeologicae Brunenses/ Pragensesque* **1.** Brno – Praha, 257 pp.

OLIVA, M. (2016): *Encyklopedie paleolitu a mezolitu českých zemí (Encyclopedia of the Palaeolithic and Mesolithic of the Czech Lands).* Moravské zemské museum Brno, 341 pp.

POPELKA, M. (1990): Štípaná industrie z Lochenic (Spaltindustrie aus Lochenice). *Praehistorica* **XVI** 135–144.

PROKEŠ, L., VAŠINOVÁ GALIOVÁ, M., HUŠKOVÁ, S., VACULOVIČ, T., HRDLIČKA, A., MASON A. Z., NEFF H., PŘICHYSTAL, A. & KANICKÝ, V. (2015): Laser microsampling and multivariate methods in provenance studies of obsidian artefacts. *Chemical Papers* **69** 761–778.

PŘICHYSTAL, A. 1984: Petrografické stadium štípané industrie (Die petrographische Auswertung der Spaltindustrie). In: KAZDOVÁ, E., Těšetice-Kyjovice 1. Starší stupeň kultury s moravskou malovanou keramikou, UJEP Brno, 205–212.

PŘICHYSTAL, A. (1991): Soubor SS – IV (epigravettien). Suroviny. In: SVOBODA, J.: Stránská skála. Výsledky výzkumu v letech 1985-1987. *Památky archeologické* **82** 32–34.

PŘICHYSTAL, A. & ŠKRDLA, P. (2014): Kde ležel hlavní zdroj obsidánu v pravěku střední Evropy? / Where was situated the principal source of obsidian in prehistory of Central Europe? *Slovenská archeológia* **62** 215–226.

ROST, R. (1971): Vývoj a dnešní stav vltavínové otázky (The evolution and the up to date state of the moldavite question). *Folia Fac. Sci. Nat. Univ. Purk. Brun. Geologia* **XII** 55–61.

SKUTIL, J. (1928): Les trouvailles d´obsidienne et d´ambre dans les stations paléolithiques. *L´Homme Prehistorique* **15** 100–105.

ŠKRDLA, P. (2005): The Upper Palaeolithic on the Middle Course of the Morava River. *Dolnověstonické studie* **13**. Brno. 229 pp.

ŠEBELA, L. A KOL. (2007): Hlinsko. Výšinná osada lidu badenské kultury (Höhensiedlung der Badener Kultur in Hlinsko). *Spisy Archeologického ústavuAV ČR Brno* **32** 1–498.

ŠKRDLA, P., MATEICIUCOVÁ, I. & PŘICHYSTAL, A. (1997): Mesolithikum (gespaltene Steinindustrie). In: POLÁČEK, L. (ed.), *Studien zum Burgwall von Mikulčice* **2** 45–91.

ŠKRDLA, P., BARTÍK, J. & RYCHTAŘÍKOVÁ, T. (2015): Dvě koncentrace epigravettských artefaktů v Mohelně-Plevovcích (Two Epigravettian artifact clusters in Mohelno-Plevovce). *Přehled výzkumů* **56-1** 9–29.

ŠTELCL, J. (1973): Contribution to the knowledge of obsidians occurring in the Moravian Neolithic period. *Scripta Facultatis Sci. Natur. Univ. Purkynianae Brunensis,* Geology **2-3** 80–101.

ULRICH, F. (1935): Mineralogický výzkum obsidiánu (Mineralogical investigation of obsidian). In: JANŠÁK, Š., Praveké sídliská s obsidiánovou industriou na východnom Slovensku, *Práce učené společnosti Šafaříkovy v Bratislavě* **17** Bratislava. 11–16.

VALOCH, K. (1975): Příspěvek k otázce provenience surovin v moravském paleolitu (Contribution to the question of raw material provenance in the Moravian Palaeolithic). *Folia Fac. Sci. Natur. Univ. Purkynianae Brunensis,* Geologia 27, **XVI** 83–87.

VALOCH, K. (1988): Die Erforschung der Kůlna Höhle 1961-1976. Moravské muzeum – Anthropos Institut. Brno.

WILLIAMS THORPE, O., WARREN, S., E. & NANDRIS, J.G. (1984): The Distribution and Provenance of Archaeological Obsidian in Central and Eastern Europe. *Journal of Archaeological Science* **11** 183–212.

ZEMAN, A. & NAVRÁTIL, O. 1987: Obsidian artifacts from the Neolithic locality Těšetice in Southern Moravia. – *Second International. Conference on Natural Glasses*, Charles University Prague. 177–181.

THE DISTRIBUTION OF CARPATHIAN OBSIDIAN IN POLAND DURING THE STONE AGE•

A KÁRPÁTI OBSZIDIÁN ELTERJEDÉSE A KŐKORBAN LENGYELORSZÁG TERÜLETÉN

Iwona SOBKOWIAK-TABAKA[1]

[1]Institute of Archaeology and Ethnology, Polish Academy of Sciences, Rubież 46, 61-612 Poznań, Poland

E-mail: iwona.sobkowiak@iaepan.poznan.pl

Abstract

Obsidian, as a natural volcanic glass, was one of the best siliceous rocks available for prehistoric societies for manufacturing various tools. Due to distinctive trace and rare earth element composition, both its geological sources and chemical types can be precisely determined. This feature made obsidian an excellent record for reconstructing its distributions routes, exchange, mobility, communication network and contacts between human groups. In recent years studies devoted to recognition of obsidian provenance and variant by means of instrumental, non-destructive methods (i.e. prompt gamma activation analysis – PGAA, energy dispersive x-ray fluorescence – EDXRF) have been distinctively developed. The strong increase of application this kind of analyses has been observed also in reference to obsidian archaeological collections from present-day Poland.

The paper aims primarily to give a comprehensive overview of Carpathian obsidian distribution within the assemblages from Palaeolithic, Mesolithic and Neolithic, registered in Poland. Furthermore, we will focus on the changeable obsidian flow intensiveness – rather small in the Palaeolithic and Mesolithic to significant increase in the Neolithic, especially over the time of Malice development.

Kivonat

Az obszidián, azaz természetes vulkáni üveg az egyik legkiválóbb nyersanyag volt amiből az őskori közösségek eszközeiket készíthették. Jellemző nyomelem és ritkaföldfém összetételének alapján a geológiai források és a kémiai típusok is pontosan azonosíthatók. Ezen tulajdonságai alapján az obszidián kiválóan alkalmas elterjedési útvonalak, cserekereskedelem, mobilitás, kapcsolati hálózatok és embercsoportok közötti kapcsolatok rekonstruálására. Az elmúlt néhány évben jelentősen fejlődtek az obszidián származási helyének megállapítására alkalmas roncsolásmentes vizsgálatok (pl. prompt gamma aktivációs analízis – PGAA, energia-diszperzív röntgen fluoreszcencia vizsgálat – EDXRF). Ezeknek a vizsgálatoknak az elérhetővé válásával lehetőség nyílt a lengyelországi régészeti gyűjtemények obszidián leleteinek vizsgálatára is.

A jelen tanulmány elsődleges célja, hogy bemutassa a kárpáti obszidián elterjedését a lengyelországi őskőkori, középső kőkori és újkőkori lelőhelyeken. Továbbá, megvizsgáljuk az obszidián beáramlásának dinamizmusát, amely meglehetősen szerény az őskőkor és a középső kőkor idején és jelentősen növekszik az újkőkorban, különösen a Malice kultúra idején.

KEYWORDS: OBSIDIAN, STONE AGE, POLAND, NON-DESTRUCTIVE METHODS

KULCSSZAVAK: OBSZIDIÁN, KŐKOR, LENGYELORSZÁG, RONCSOLÁSMENTES VIZSGÁLATI MÓDSZEREK

Introduction

Obsidian is a rock of volcanic origin. The colour of obsidian divers from black, dark grey and sometimes brown-yellow to dark green, olive, orange, red, blue, purple and even gold. Distribution of the colour can be uniform, striped, ribbon or mottled (Żaba 2003).

Due to both physical (good knappability, giving sharp and hard edges of artefacts) and aesthetic properties (mostly transparent or translucent with strong glassy lustre) obsidian was eagerly used by different prehistoric societies, in various region of the world. Specific chemical composition of obsidian makes possible to trace the origin of particular artefacts, essential in studies of distributions routes, exchange, mobility, communication network and contacts between human groups.

• How to cite this paper: SOBKOWIAK-TABAKA, I., (2018): The distribution of Carpathian obsidian in Poland during the Stone Age, *Archeometriai Műhely* **XV/3** 241-252.

HU ISSN 1786-271X; urn: nbn: hu-4106

From the present-day Poland perspective, the nearest European territories with obsidian outcrops are central and south-eastern Slovakia, north-eastern Hungary and western Ukraine (Rosania et al. 2008). In the late 1970s, instrumental analytical methods were developed to characterise the outcrops of Carpathian obsidians. They were divided into two major groups – *Carpathian 1* (C1) related to outcrops in the vicinity of Viničky and Cejkov (Slovakia) and *Carpathian 2* (C2) from the Tokaj Mts. in Hungary (Williams & Nandris 1977; Williams-Thorpe et al. 1984). Apart from C1 and C2 type, a Transcarpathian variant of obsidian was also distinguished – *C3* from the vicinity of Rokosovo, today's Ukraine (Petrougne 1972; Williams-Thorpe et al. 1984; Rosania et al. 2008).

Obsidian artefacts were found in the 2nd half of 19th century by Z. Gloger and S. Przyborowski (1876) in the south and south-eastern part of Poland. Almost at the same time obsidian items were recorded in Racibórz-Ocice, site 1[1] (southern Poland nowadays) as a result of excavations, carried out by German officer, Oberleutnant Rudolf Stöckel (1881)[2].

However, we have to admit here that obsidian was mentioned for the first time in Polish archaeological literature in the early 1920s (Krukowski 1920, 1922; Kozłowski 1923). Since that time many of obsidian assemblages, related to the entire Stone Age, have been found in different regions of present-day Poland.

The aim of the paper is firstly to discuss the intensity of occurrence of Carpathian obsidian finds within various periods of time. Secondly, it will examine the recent results of obsidian provenance determination by means of both destructive and non-destructive methods.

Palaeolithic

Probably the oldest obsidian artefact found in Poland is a side-scraper from Rusko, site 31 (Świdinica district), dated to the Lower Palaeolithic (Pawlikowski 1994) – **Fig. 1.; Table 1**. Next items, single tools or debitage pieces, attributed to the Middle Palaeolithic, were found in caves (Obłazowa – Nowy Targ, district and Ciemna; Kraków district) and at the site Rybnik-Kamień A, loco district (Foltyn & Foltyn, 2002; Valde-Nowak et al. 2003; Ginter 1986). The utilization of obsidian increased in the Upper Palaeolithic. From that period several assemblages, related to different traditions, are known.

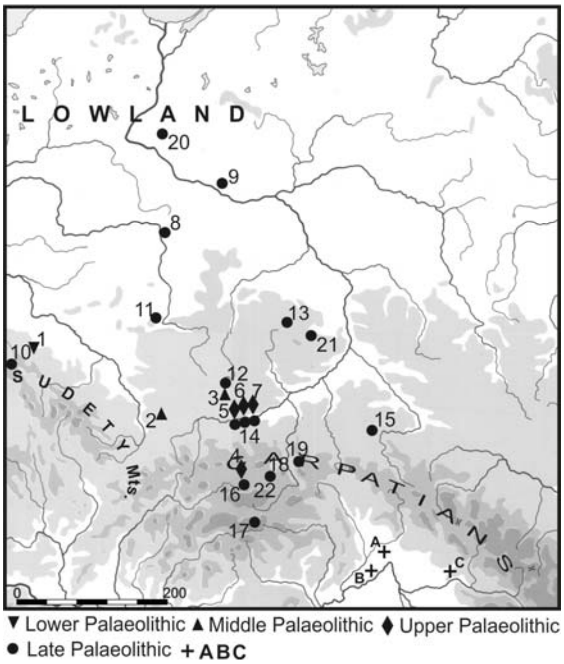


Fig. 1.: Location of main Palaeolithic sites discussed in the paper: 1 – Rusko, site 31; 2 – Rybnik-Kamień, site A; 3 – Ojców, Ciemna Cave; 4 – Nowa Biała, site 1; 5 – Kraków-Zwierzyniec, site I; 6 – Kraków, Spadzista Street B; 7 – Targowisko, site 10 and 11; 8 – Cichmiana, site 2; 9 – Płock; 10 – Mieroszów, site 9; 11 – Mokrsko; 12 – Glanów, site 3; 13 – Rydno; 14 – sites from the vicinity of Kraków; 15 – Wołodź, site 7; 16 – Obłazowa cave (Middle and Upper Palaeolithic layers); 17 – Sromowce Niżne, site 1; 18 – Skwirtne, site 1; 19 – Tylicz, site A; 20 – Nowogród, site 17; 21 – Ćmielów 'Mały Gawroniec'. A – Carpathian 1 geological obsidian outcrops; B – Carpathian 2 geological obsidian outcrops; C – Carpathian 3 geological obsidian outcrops.

1. ábra: A cikkben említett legfontosabb őskőkori lelőhelyek (számozva). A, B, C: a kárpáti 1, 2, 3 nyersanyagforrások elhelyezkedése

Szeletian inventories consisting obsidian artefacts were registered in Obłazowa cave (layer XI), Aurignacian in Kraków-Zwierzyniec, and Gravettian in Kraków-Spadzista and Targowisko, site 10 – Wieliczka district (Sawicki 1949; Sobczyk 1995; Valde-Nowak et al. 2003; Wilczyński 2010a).

---

[1] The site is known nowadays as Racibórz 113. At this paper the old name will be used.

[2] In 1793, as a result of the Second Partition of Poland, this area became a part of Prussia.

Table 1.: Chronological subdivision within Palaeolithic, Mesolithic and Neolithic in Poland (according to Hughes et al. 2018 with additions)

1. táblázat: A lengyel őskőkor, középső kőkor és újkőkor kronológiai tagolása, Hughes et al. (2018) nyomán, kiegészítésekkel

Time Period	**Age (BP)**	**Sites with obsidian artefacts**	**References for sites chronology**
Lower Palaeolithic		Rusko, site 31	Pawlikowski 1994
Upper Palaeolithic	Late Gravettian 24,000-25,000	Kraków-Spadzista	Wilczyński 2015
	Epigravettian 19,000-14,000	Targowisko, site 10	Wilczyński 2010a; 2014b
Late Palaeolithic	Magdalenian culture 15,000-11,000 BP	Ćmielów 'Mały Gawroniec'	Przeździecki et al. 2012; Sulgostowska 2015
	Arched Backed Piece Technocomplex 11,700-10,750 BP	Nowa Biała, site 1; Sromowce-Niżne, site 1; Skwirtne, site 1; Tylicz, site A; Rydno	Tunia 1978; Schild & Królik 1981; Tomaszewski et al. 2008
	Tanged Point Technocomplex (Swiderian culture) 10,800-9,700 BP	Cichmiana, site 2; Wołodź, site 7; Glanów, site 3; Nowogród, site 17; Rydno, site XI/59	Osipowicz & Szeliga 2004; Sulgostowska 2005; Winiarska-Kabacińska & Kabaciński 2009; Osipowicz et al. 2018
Mesolithic	9,700-4,000 BP	Chwalibogowice; RydnoXIII/59; Brzozówka	Schild et al. 1975; Sulgostowska 2005; Hughes & Werra 2014
Neolithic	Early Neolithic (LBK) 7,500-6,800	Rudna Wielka, site 5; Rzeszów, site 16 (os. Piastów); Tominy, site 6; Brzezie, site 17; Olszanica	Kulczycka-Leciejewiczowa 1979; Kadrow 1990; Wilczyński 2014a; Kabaciński et al. 2015;
	Middle Neolithic/Late Neolithic Younger Danubian cultures (Stroked Band Pottery and Lengyel-Polgár complex) 6,800-6,200 BP	Kraków-Nowa Huta-Wyciąże; Racibórz-Ocice, site 1	Kurtz 1931; Furmanek 2010; Brzeska-Pasek 2016
	Middle Neolithic Malice culture 6,800-6,400 BP	Ćmielów; Rzeszów, site 16 (os. Piastów); Targowisko, site 11	Kadrow 1990; Ścibor 1992; Wilczyński 2010b, 2014b

Fig. 2.: Selection of Upper Palaeolithic obsidian artefacts from Targowisko, site 11 (photo by J. Wilczyński).

2. ábra: Válogatás Targowisko 11. felső paleolit lelőhely obszidián leleteiből (Fotó: J. Wilczyński).

The last one is especially noteworthy because of the quantity of items. Nearly 300 artefacts, including 3 tools, 29 flakes, 14 blades and ca. 250 chips, were discovered as the concentration in the western part of the site (**Fig. 2.**). Taking into account the structure of the assemblage and the presence of cortex, mostly on the surface of the flakes, it is very likely that only one nodule of obsidian was brought at the site (Wilczyński 2010a).

From that long period of time, from the Lower to the Upper Palaeolithic, very few assemblages containing obsidian items were recorded. Moreover, they occurred at the sites located only in the southern part of Poland. Only in the Late Palaeolithic, assemblages became more numerous, and obsidian items reached even the territory of Polish Lowland.

Magdalenian obsidian items are known only from one site – Ćmielów - 'Mały Gawroniec', Ostrowiec Świętokrzyski district (Sulgostowska 2005; Przeździecki et al. 2012). No obsidian artefacts have been found so far within Hamburgian assemblages, while numerous items made of this raw material were registered at the sites related to the Arched Backed Piece Technocomplex.

Fig. 3.: Selection of Late Palaeolithic obsidian artefacts from Cichmiana, site 2 (photo by P. Szejnoga).

3. ábra: Válogatás Cichmiana 2. késő paleolit lelőhely obszidián leleteiből (Fotó: P. Szejnoga).

One of the most important site, due to quantity of items and their variety is Rydno, Starachowice district (Schild & Królik 1981; Tomaszewski et al. 2008). Other sites, where obsidian was present, are located in southern Poland (Podhale region), namely Nowa Biała 1 in Nowy Targ district; Sromowce-Niżne, site 1, Nowy Targ district (Valde-Nowak 1987); Skwirtne, site 1, Gorlice district (Valde-Nowak 1991) and Tylicz, site A, Nowy Sącz district (Tunia 1978). However, we have to admit here that technological structure of obsidian collections is quite homogenous, including mostly flakes, occasional blades, cores and eight tools (2 end-scrapers, 3 backed pieces, a core-like burin, dihedral burin, and an undefined tool).

Obsidian was used also by Swiderian societies related to Tanged Point Technocomplex. Recently discovered in Nowogród, site 17 (Golub-Dobrzyń district) with a fragment of a blade is the most northerly of obsidian finds, in present-day Poland (Osipowicz et al. 2018) – **Fig. 1.** The most numerous obsidian collection was found on the Polish Lowland in Cichmiana (Koło district) where 49 items, including 6 tools (1 burin, 2 truncations, 2 retouched blades and 1 retouched chip) and a few dozens of small chips were found (**Fig. 3.**). Micro-wear analysis of the assemblage showed that only seven of them were used for scraping or cutting wood or other unidentified soft material (truncations, retouched blade, blades, flakes) (Winiarska-Kabacińska & Kabaciński 2009).

In southern Poland only single obsidian finds have been recorded so far (i.e. Kraków-Bagno, Glanów, Kraków-Bieżanów 15, Wołodź, Mokrsko and Mieroszów; Krukowski 1920; Sulgostowska 2005; Osipowicz & Szeliga 2004). Similarly, single pieces may also be attributed to the Swiderian settlement complex in Rydno XI/59 (as in the case of radiolarite – Schild et al. 2011). Finally, two obsidian artefacts with problematic data should be mentioned. In the first case, its location is uncertain, defined as „somewhere near Płock" (Sulgostowska 2005), while in the case of item from Czerniejów (Lublin district; Przyborowski 1876) it is likely that raw material definition is incorrect (Hughes et al. 2018).

Mesolithic

In comparison to Palaeolithic sites in Poland, obsidian items occurred very rarely at Mesolithic localities and only in the late phase of Mesolithic settlement development (**Fig. 4.**).

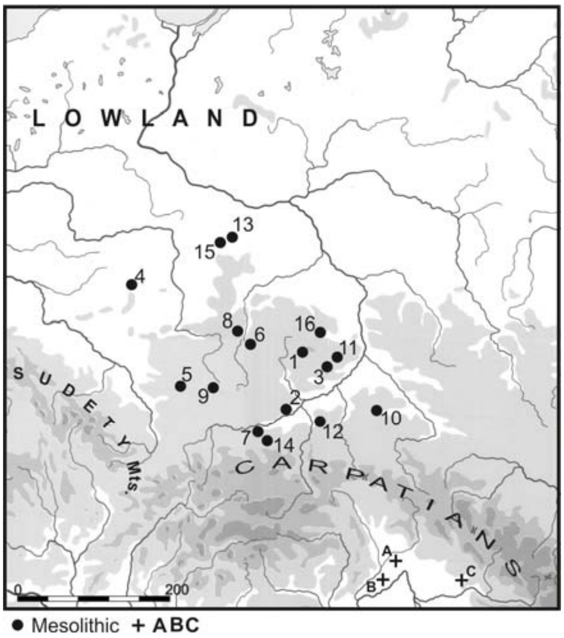


Fig. 4.: Location of main Late Mesolithic sites discussed in the paper: 1 – Brzozówka; 2 – Chwalibogowice; 3 – Czyżów, 4 – Długawieś, 5 – Dzierżno, 6 – Kamień; 7 – Kraków-Zakrzów; 8 – Przedbórz;9 – Pustynia Błędowska; 10 – Raniżów; 11 – Rytwiany; 12 – Tarnów-Rzędzin; 13 – Wrzask-Zagłoba; 14 – Zakrzów; 15 – Zgierz, site III; 16 – Rydno, site XIII/1958. A – Carpathian 1 geological obsidian outcrops; B – Carpathian 2 geological obsidian outcrops; C – Carpathian 3 geological obsidian outcrops.

4. ábra: A cikkben említett legfontosabb középső kőkori lelőhelyek (számozva). A, B, C: a kárpáti 1, 2, 3 nyersanyagforrások elhelyezkedése

Fig. 5.: Selection of Mesolithic obsidian artefacts. 1 – Brzozówka, 2 – Chwalibogowice (according to Hughes et al. 2018, Fig. 4).

5. ábra: Középső kőkori obszidián eszközök. 1 – Brzozówka, 2 – Chwalibogowice (Hughes et al. 2018, Fig. 4 nyomán).

Assemblages, including specimens from this raw material, usually one, rarely 2 or more, were recovered at Brzozówka (Busko district) – a retouched blade and blade (**Fig. 5/1**); Chwalibogowice (Kazimierz district) – a trapeze (**Fig. 5/2**); Czyżów (Busko district) – a blade; Długawieś (Turek district) – a trapeze; Dzierżno (Gliwice district) – 2 flakes; Kamień (Kamień district) – a retouched blade; Kraków-Zakrzów (Kraków district) – a blade; Przedbórz (Radomsko district) – a blade; Pustynia Błędowska (Biały Piach, "Siedziba" III and VII) – 3 blades; Raniżów, site 1 (Kolbuszowa district) – 2 blades; Rytwiany (Staszów district) – a blade; Tarnów-Rzędzin (Tarnów district) – a blade; Wrzask-Zagłoba (Zgierz, district) – a triangle (inset); Zakrzów (Wieliczka district) – a few small blades and Zgierz, site III (Zgierz district) – a blade (Kozłowski 1923; Kozłowski 1972; Jażdżewski 1929; Cyrek 1981; Ginter 1972, 1986; Sulgostowska 2005). However, we must highlight here that most of the mentioned artefacts were found during surface prospection of the sites at the end of 19th or in the beginning of 20th century. Only few of them were documented during regular archaeological excavations. We should mentioned here the 10 obsidian artefacts (including a multiplatform core for flakes and blades (refitted with 3 flakes, a blade and 5 chips), 2 flakes, 3 microflake and 2 blades) found at the Rydno XIII/1958 site (Skarżysko-Kamienna district – Schild et al. 1975).

Neolithic

In Palaeolithic and Mesolithic the number of sites, where obsidian items were unearthed, is rather small. This situation has changed significantly in the Neolithic. Up to now, more than 120 sites with obsidian assemblages were recorded.

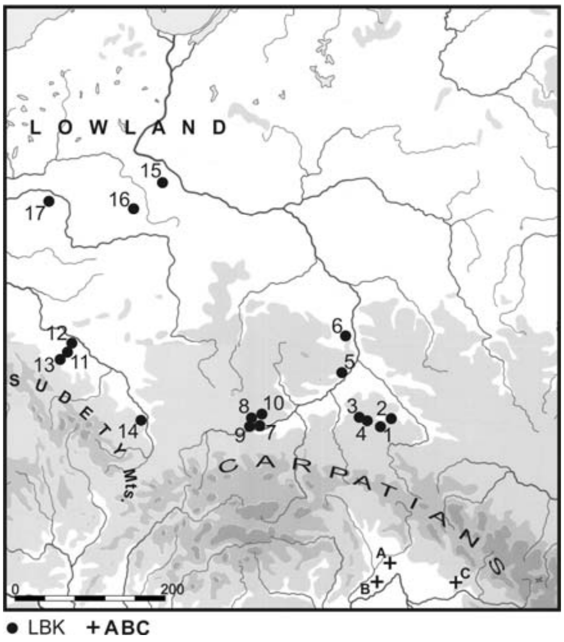


Fig. 6.: Location of main Early Neolithic (LBK) sites discussed in the paper: 1 – Kormanice, site 1; 2 – Łańcut, site 3; 3 – Rudna Wielka, site 5; 4 – Rzeszów, site 16 (os. Piastów); 5 – Samborzec; 6 – Tominy, site 6; 7 – Kraków-Nowa Huta-Mogiła; 8 – Modlnica, site 5, 9 – Olszanica; 10 – Zabrzezie, site 17; 11 – Skoroszowice, site 1; 12 – Strachów, site 2; 13 – Strzelin, site 19, 14 – Dzielnica, site 17; 15 – Zagajewice, site 1; 16 – Chabsko, site 40; 17 – Kowalewko, site 14. A – Carpathian 1 geological obsidian outcrops; B – Carpathian 2 geological obsidian outcrops; C – Carpathian 3 geological obsidian outcrops.

6. ábra: A cikkben említett legfontosabb korai újkőkori (LBK) lelőhelyek (számozva). A, B, C: a kárpáti 1, 2, 3 nyersanyagforrások elhelyezkedése

Most of them are related to Linear Band Pottery Culture (LBK) settlement (**Fig. 6.**), when artefacts made of this raw material occurred from the beginning of its development, through the ‘music note phase’ (*Notenkopf* phase) and in the late (Želiezovce) phase. However, we must highlight here that the intensiveness and range of obsidian inflow was very diversified. In the beginning obsidian artefacts were distributed only in the southern part of Poland. In classic phase of LBK development obsidian items occurred much further to the north from the Carpathian region. The last phase is characterized by the occurrence obsidians together with imports of the Eastern Linear Pottery Culture or the Bükk Culture (Kaczanowska 1971, 2003; Kozłowski et al. 2014; Szeliga 2018; Szeliga et al. 2018).

Generally speaking, most of obsidian artefacts concentrated in the south-eastern part of Poland, e.g. in the vicinity of Rzeszów, i.e. Kormanice, site 1 (Przemyśl district), Łańcut, site 3; Rudna Wielka, site 5; Rzeszów, site 16 (os. Piastów); around Sandomierz, i.e. Samborzec, Tominy, site 6 (with118 pieces) – middle Wisłok and San river; the Lubelska Upland and the area of Kraków-Miechów Loess, i.e. Kraków-Nowa Huta-Mogiła, site 62 (ca. 200 items), Modlnica, site 5, Olszanica (with more than 200 items, including cores, flakes, blades, tools – mainly retouched flakes and blades, truncation), Brzezie, site 17 – 39 items (Kadrow 1990; Kulczycka-Leciejewiczowa 1979; Szeliga 2009; Wilczyński 2014a; Kabaciński et al. 2015; Szeliga et al. 2018). In limited number obsidian artefacts are known from Silesia, i.e. Skoroszowice, site 1; Strachów, site 2; Strzelin, site 19; Dzielnica, site 17 (Furmanek 2010), Kujavia – Zagajewice, site 1; Chabsko, site 40 and extremely rare from Greater Poland – Kowalewko, site 14 (Kabaciński 2010) and Pyrzyce Land (Kulczycka-Leciejewiczowa 1980).

At the sites located in the vicinity of the Carpathians the complete process of obsidian elaboration has been observed (Szeliga 2009). On the area located further to the north and west, namely the Lower Silesia, Kujavia, Greater Poland and Pyrzyce Land only flake or blade blanks and sporadically tools have been recorded (Kabaciński 2010; Szeliga 2009).

Obsidian related to Younger Danubian Culture ("Stichband" or Stroke Band Pottery Culture and Lengyel-Polgár complex – Nowak 2013) are known from several sites located in Lesser Poland and Silesia (**Fig. 7.**). These specimens occurred usually in small number within the inventory, e.g. Kraków-Nowa Huta-Wyciąże an arrowhead of triangular shape, a perforator and a blade (Brzeska-Pasek 2016); Kraków-Nowa Huta-Mogiła, site 48 – 2 pieces (Kaczanowska & Kozłowski 1971), Złota-Grodzisko I (Sandomierz district) – an arrowhead (triangular in shape (Kaczanowska 1980). To the Silesian sites belong Racibórz-Ocice, site 1 where 95 obsidian artefacts were found (Kurtz 1931) – **Fig. 8.**; Dzielnica, site 17 (Kędzierzyn-Koźle district), where several dozen obsidian items were recorded, and Mierczyce, site 42 (Jawor district) – 2 items (Furmanek 2010).

The most intensive increase in obsidian distribution occurred during the period of the Malice Culture, especially in its classical phase and the gradual decline of its intensiveness, contemporaneous with the Lengyel Complex and the late phase of culture. In the beginning of Malice Culture development inventories including obsidian artefacts concentrated in the south, south-eastern part of Poland near Kraków, Sandomierz, Rzeszów and Przemyśl (Szeliga 2007) – **Fig. 7**.

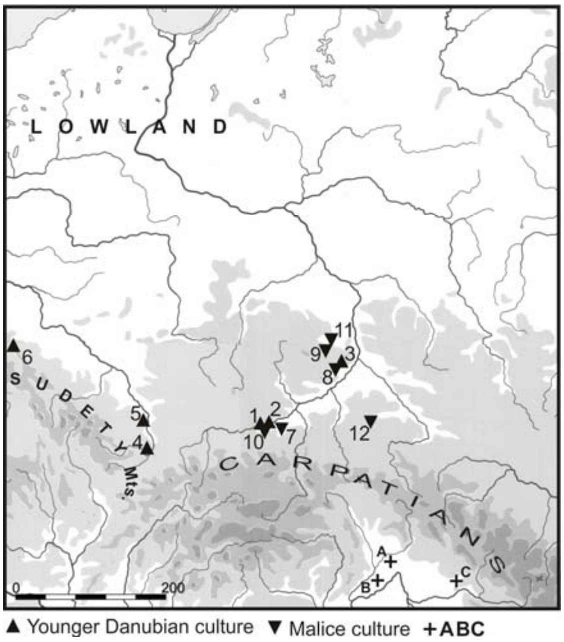


Fig. 7.: Location of main Middle and Late Neolithic sites discussed in the paper: 1- Kraków-Nowa Huta-Wyciąże; 2 – Kraków-Nowa Huta-Mogiła, site 48; 3 – Złota-Grodzisko I; 4 – Racibórz-Ocice, site 1; 5 – Dzielnica, site 17; 6 – Mierczyce, site 42; 7 – Targowisko, site 11; 8 – Samborzec; 9 – Opatów; 10 – Kraków-Nowa Huta-Pleszów; 11 – Ćmielów; 12 – Rzeszów, site 16. A – Carpathian 1 geological obsidian outcrops; B – Carpathian 2 geological obsidian outcrops; C – Carpathian 3 geological obsidian outcrops.

7. ábra: A cikkben említett legfontosabb középső és késő újkőkori lelőhelyek (számozva). A, B, C: a kárpáti 1, 2, 3 nyersanyagforrások elhelyezkedése

The most numerous assemblage related to the Malice Culture was found during rescue excavations in Targowisko, site 11 (Wieliczka district), on the planned route of A-4 motorway linking Kraków and Tarnów. The inventory consists of 585 obsidian items, including 69 cores, 209 flakes, 263 blades, 42 chips and chunks, and 2 tools – a retouched flake and a retouched blade. Artefacts were made of small nodules of obsidian, not exceeding 5 cm in size, mostly spherical, sometimes of cubic in shape. The cortex covering the surface of specimens is rough, often forming a porous outer layer of the concretion, which indicates that raw material was extracted directly from the outcrops (Wilczyński 2010b, 2014b).

Fig. 8.: Selection of obsidian artefacts from Racibórz-Ocice, site 1 (photo T. Gąsior). The photo by courtesy of Muzeum Miejskie Wrocławia.

8. ábra: Válogatás Racibórz-Ocice, 1. lelőhely obszidián eszközéből. (Fotó: T. Gąsior, Muzeum Miejskie, Wroclaw).

The other large in numbers collections are known from Samborzec (Sandomierz district) – over 300 items: 15 cores, ca. 200 blades, ca. 100 flakes and 5 nodules (Kamieńska 1964); Opatów (Sandomierz district) – 295 items: mostly blades and flakes, a few cores and tools (mainly retouched blades and notches (Więckowska 1971); Kraków-Nowa Huta-Pleszów (214 items, namely 7 cores, 133 flakes, 25 chunks and 49 mainly microlithic tools) – Cabalska 1964; Ćmielów (140 items: 4 cores, and 2 fragments of cores, 38 flakes, 84 blades, 7 tools, 5 nodules (Ścibor 1992) and Rzeszów, site 16 – more than 50 items: 6 cores, 12 flakes, 33 blades and 2 nodules (Kadrow 1990).

At many sites in south and south-eastern Poland assemblages including a few or only one item made of obsidian were registered, e.g. Fredropol (Przemyśl district; Wojciechowski 1989), Dwikozy, site 2, Góry Wysokie, site 9, Kamień Łukawski, site 1, Kichary Nowe, site 2, Linów, site 30/38, Polanów, site 11/79; Sandomierz-Żmigród (Sandomierz district; Ścibor 1992) and Rzeszów, site 20 (Kadrow 1990).

Instrumental analysis

Until 1990s obsidian collections from present-day Poland have been intuitively linked to outcrops based on macroscopic analyses. In order to proper identification outcrops of this raw material, a detailed recognition of its geochemical characteristics was needed. The very first attempt was undertaken by M. Pawlikowski (1994) in refers to the item from Rusko site. He applied several destructive, physical and chemical methods, such as: polarising microscopy, scanning electron microscopy, electron microprobe and X-ray diffraction phase analysis. The qualitative identification of Al, Si, Fe, Sn, Ag, Mn and Cl allowed only rough comparison of the examined piece with Slovakian and Hungarian obsidians. Taking into account the occurrence of iron and the grey colour of the artefact and opacity, the author suggested its provenance from Tokaj Mts. in Hungary.

Only twenty years later non-destructive methods for the provenance of obsidian artefacts were conducted by R. E Hughes and D. H. Werra (2014) in Geochemical Research Laboratory, Portola Valley. The energy dispersive x-ray fluorescence analysis (EDXRF) was applied to obsidian type identification for Late Mesolithic specimens from Rydno site. On the basis of quantitative composition of trace elements such as Rb, Sr, Y, Zr, Nb, Fe and Mn the geological source – Carpathian 1a and 1 b (Rosania et al. 2008) was documented. The very similar results brought next non-destructive analysis carried out for Late Palaeolithic items from Cichmiana and Mokrsko and Neolithic ones from Rudna and Kowalewko. Prompt gamma activation analysis (PGGA) was conducted in Budapest Research Reactor. Based on the data obtained by this method, quantifying most major components (oxides of Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K and H) and a few significant trace elements (mostly B, Cl, Gd and in some cases also Sc, V, Cr, Co, Ni, Cd, Nd, Sm and Eu) a similarity between Polish archaeological objects and the Carpathian 1 (C1, i.e. Slovakian, northern part of the Tokaj Mts.) was established (Sobkowiak-Tabaka et al. 2015; Kabaciński et al. 2015). Recently the same method was applied for analysing the artefacts from the Late Palaeolithic localities of Nowogród (Osipowicz et al. 2018) and the Neolithic site of Tominy (Opatów district – Szeliga et al. 2018).

The latest research were conducted by E. Hughes, D. H. Werra and Z. Sulgostowska (2018, Table 5) and examined 86 obsidian artefacts from twenty Palaeolithic and Mesolithic sites in Poland. The obtained results showed that majority of the specimens were made of Carpathian 1 chemical type of obsidian from Slovakia, while only three item from Kraków-Spadzista (Upper Palaeolithic) were made of the Carpathian 2 obsidian variant, from Hungary.

The most recent project concerning the provenance of Neolithic obsidian of assemblages from present-day Poland, financed by National Science Centre, has been started in 2019 by D. H. Werra.

Conclusions

Except Gravettian site at Targowisko and Swiderian at Cichmiana, obsidian was used sporadically by Palaeolithic societies. Taking into account long-distance provenance (even more than 600 km from Slovakian outcrops in case of Nowogród site) and lack of well-organized system of exchange (rather occasional occurrence within assemblages), a number of non-exclusive explanations of obsidian presence might have been proposed. On the one hand, it may manifest a personal inheritance, a gift or bringing to the site together with other "southern" raw materials, e.g. Jurassic and Świeciechów flint or radiolarite (Hughes et al. 2018). On the other hand, it may express contacts and relations between more southern and northern bands – being presumably at the same time part of much wider network of ideas, social knowledge and prestige exchange (Sobkowiak-Tabaka et al. 2015).

Late Mesolithic societies used obsidian extremely rarely. The only exception is an assemblage from Rydno. However, regarding the refitting of artefacts it is very likely that only one or two nodules were utilized. It is very likely that obsidian was obtained from Neolithic communities or was just picked up from the surface at Palaeolithic sites (Cyrek 1981).

Very intensive influx of Carpathian obsidian was recorded only within Neolithic communities, especially in southern and south-eastern part of Poland. Interregional contacts between Danubian societies from southern Poland and the East Linear Pottery communities from eastern Slovakia and north-eastern Hungary are confirmed not only by presence of obsidian items, but also by the imports of vessels. These containers were registered at many sites in the southern Poland (Czekaj-Zastawny 2016; Furmanek 2010; Kamieńska 1964) and Polish Lowland (Grygiel 2001; Werra & Sobkowiak-Tabaka 2017).

At the LBK sites in the upper and middle Odra River basin in Poland and in somewhat larger numbers at sites linked with later groups, including those of the Lengyel Culture, obsidian artefacts occur rarely —usually as single finds (with the exception of the site 1 at Racibórz-Ocice). In that period interregional connections between Silesia and area of upper Tisa River basin (Hungary) are well attested in ceramic inventories (Furmanek 2010).

The raise of obsidian usage in Neolithic is related to Younger Danubian cultures, especially to Malice Culture. Both the number of sites with obsidian assemblage and, what is more important, the number of inventories increased. In that period the most intensive contacts between communities settled the southern part of Poland and Transcarpathian ones were recorded (Kulczycka-Leciejewiczowa 1979).

The disappearance of the obsidian usage tradition is probably the result of loosening the cultural contacts between Polish Late Neolithic and Transcarpathian communities. The other reason, we should take into consideration, is different technological requirements of flint-processing, namely enlargement of the metric aspect ratio of blades (Ścibor 1992).

References

BRZESKA-PASEK, A. (2016): Materiały krzemienne z neolitu i epoki brązu ze stanowiska 5, 5a, 5b w Krakowie Nowej Hucie-Wyciążu (badania w latach 1988-1997). *Materiały Archeologiczne* **41** 115–159.

CABALSKA, M. (1964): Materiały kamienne z przydomowej pracowni krzemieniarskiej z jamy 2 na stanowisku II w Nowej Hucie-Pleszowie. *Przegląd Archeologiczny* **16** 110–131.

CYREK, K. (1981): Uzyskiwanie i użytkowanie surowców krzemiennych w mezolicie. *Prace i Materiały Muzeum Archeologicznego i Etnograficznego w Łodzi. Seria Archeologiczna* **28** 5–108.

CZEKAJ-ZASTAWNY, A. (2016): The first farmers from the south – Linear Pottery Culture. In: WŁODARCZAK, P (ed.): *The Past Societies. vol. II., 5500 – 2000BC* [URBAŃCZYK, P. (ed.), The Past Societies. Polish lands from the first evidence of human presence to the Early Middle Ages vol. I-V]. Institute of Archaeology and Ethnology PAS, Warszawa, 51–62.

FOLTYN, E.M. & FOLTYN, E. (2002): Wstępne wyniki badań sondażowych na stanowisku A w Rybniku-Kamieniu, województwo śląskie. In: TOMCZAK, E. (ed.), *Badania archeologiczne na Górnym Śląsku i ziemiach pogranicznych w latach 1999-2000*, Śląskie Centrum Dziedzictwa Kulturowego w Katowicach, Katowice, 46–53.

FURMANEK, M. (2010): Wczesnorolnicze społeczności dorzecza górnej i środkowej Odry i ich związki kulturowe z obszarami zakarpackimi (ok. 5500/5300-4600/4500 BC). In: GARNCARSKI, J. (ed.), *Transkarpackie kontakty kulturowe w epoce kamienia, brązu i wczesnej epoce żelaza*, Muzeum Podkarpackie w Krośnie, Krosno, 177–204.

GINTER, B. (1972): Dwa stanowiska mezolityczne z miejscowości Dzierżno, pow. Gliwice. *Rocznik Muzeum Górnośląskiego w Bytomiu* **10** 7–76.

GINTER, B. (1986): Obsidianimporte im Spätpaläolithikum und Mesolithikum im Südpolen, In: CHROPOVSKÝ, B. (ed.), *Urzeitliche und frühhistorische Besiedlung der Ostslowakei in Bezug zu den Nachbargebieten*, Archeologický Ústav, Nitra; 71–76.

GRYGIEL, R. (2001): Wpływ wschodnio-lineranego kręgu kulturowego w kulturze ceramiki wstęgowej rytej na Kujawach. In: GINTER, B., DROBNIEWICZ, B., NOWAK, M., KAZIOR, B. & POŁTOWICZ, M. (eds.), *Problemy epoki kamienia na obszarze starego świata. Księga jubileuszowa dedykowana Profesorowi Januszowi K. Kozłowskiemu w czterdziestolecie pracy naukowej w Uniwersytecie Jagiellońskim*, Instytut Archeologii UJ, Kraków, 297–310.

HUGHES, R.E. & WERRA, D.H. (2014): The source of late Mesolithic obsidian recovered from Rydno XIII/1959, Central Poland. *Archeologia Polski* **59** 31–46.

HUGHES, R., 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.

JAŻDŻEWSKI, K. (1929): Osadnictwo prehistoryczne nad górną Prosną. *Z Otchłani Wieków* **4** 85–94.

KABACIŃSKI, J. 2010. *Przemiany wytwórczości krzemieniarskiej społeczności kultur wstęgowych strefy wielkodolinnej Niżu Polskiego*, Instytut Archeologii i Etnologii Polskiej Akademii Nauk, Oddział w Poznaniu, Poznań. p. 543.

KABACIŃSKI, J., SOBKOWIAK-TABAKA, I., KASZTOVSZKY, Z., PIETRZAK, S., LANGER, J.J., BIRÓ, K.T. & MARÓTI, B. (2015): Transcarpathian influences in the Early Neolithic of Poland. A case study of Kowalewko and Rudna Wielka sites. *Acta Archaeologica Carpathica* **50** 5–32.

KACZANOWSKA, M. (1971): Krzemienne materiały kultur neolitycznych pochodzenia południowego z terenu Nowej Huty. In: KOZŁOWSKI, J.K (ed.), *Z badań nad krzemieniarstwem neolitycznym i eneolitycznym, Muzeum Archeologiczne w Krakowie,* Polskie Towarzystwo Archeologiczne Oddział w Nowej Hucie, Kraków, 10–24.

KACZANOWSKA, M. (1980): Uwagi o surowcach, technice i typologii przemysłu krzemiennego kultury bodrogkereszturskiej i grupy Lažňany. *Acta Archaeologica Carpathica* **20** 19–56.

KACZANOWSKA, M. (2003). Distribution of raw materials used in chipped stone industry of the western Linear Band Pottery Culture and the eastern Linear Band Pottery Culture in the Circum-Carpathian area. In: BRUNEZ-LANOTTE, L. (ed.), *Production and Management of Lithic Materials in the European Linearbandkeramik,* BAR International Series **1200**, Ofxord, 5–10.

KACZANOWSKA, M., & KOZŁOWSKI, J.K. (1971): Materiały kamienne z osady neolitycznej i eneolitycznej w Nowej Hucie-Mogile (stan. 48). *Materiały Archeologiczne Nowej Huty* **4** 67–110.

KADROW, S. (1990): The Rzeszów settlement microregion in Neolithic. *Acta Archaeologica Carpathica* **29** 33–70.

KAMIEŃSKA, J. (1964): Osady kultur wstęgowych w Samborcu, pow. Sandomierz. In: NOSEK, S. (ed.), *Studia i materiały do badań nad neolitem Małopolski*. Zakład Narodowy im. Ossolińskich, Wrocław, 77–189.

KOZŁOWSKI, J.K., KACZANOWSKA, M., CZEKAJ-ZASTAWNY, A., RAUBA-BUKOWSKA, A., BUKOWSKI, K. (2014): Early/Middle Neolithic Western (LBK) vs Eastern (ALPC) Linear Pottery Cultures: ceramics and lithic raw materials circulation*, Acta Archaeologica Carpathica* **49** 37–76.

KOZŁOWSKI, L. (1923): *Epoka kamienia na wydmach wschodniej części Wyżyny Małopolskiej*. Książnica Polska, Warszawa-Lwów. p. 274.

KOZŁOWSKI, S.K. (1972): *Pradzieje ziem polskich od IX do V tysiąclecia p.n.e.* Państwowe Wydawnictwo Naukowe, Warszawa. p. 321.

KRUKOWSKI, S. (1920): Pierwociny krzemieniarskie górnictwa, transport i handlu w holocenie Polski. Wnioski z właściwości surowców i wyrobów. *Wiadomości Archeologiczne* **5** 185–206.

KRUKOWSKI, S. (1922): Pierwociny krzemieniarskie górnictwa, transport i handlu w holocenie Polski. Wnioski z właściwości surowców i wyrobów. Cz. II. *Wiadomości Archeologiczne* **7** 34–57.

KULCZYCKA-LECIEJEWICZOWA, A. (1979): Pierwsze społeczeństwa rolnicze na ziemiach polskich. Kultury kręgu naddunajskiego. In. HENSEL, W. & WIŚLAŃSKI, T (ed.), *Prahistoria ziem polskich 2. Neolit.* Ossolineum, Wrocław-Warszawa-Kraków-Gdańsk, 19–164.

KULCZYCKA-LECIEJEWICZOWA, A. (1980): Rev. of N. Kalicz, J. Makkay*, Die Linienbandkeramik in der Grossen Ungarischen Tiefbene,* Budapest 1977, *Acta Archaeologica Carpathica* **20** 255–260.

KURTZ, H. (1931): Funde von Obsidiangeräten in Oberschlesien. *Aus Oberschlesiens Urzeit* **11** 3–10.

NOWAK, M. (2013): Neolithisation in Polish Territories: Different Patterns, Different Perspectives, and Marek Zvelebil's Ideas. *Interdisciplinaria archaeologica. Natural Sciences in Archaeology* **4/1** 11–22.

OSIPOWICZ, G., CHACHLIKOWSKI, P., ORŁOWSKA, J., KASZTOVSZKY, Zs., SIUDA, R. & WECKWERTH, P. (2018): Late Palaeolithic and Mesolithic Treatment and Use of Non-flint Stone Raw Materials: Material Collection From Site 17 at Nowogród, Golub-Dobrzyń District, Poland. *Archaeologia Polona* **56** 99 – 121.

OSIPOWICZ, G. & SZELIGA, M. (2004): Analiza funkcjonalna obsydianowego liściaka schyłkowopaleolitycznego z Wołodzi, powiat Brzozów, województwo podkarpackie*. Acta Archaeologica Carpathica* **39** 153–160.

PAWLIKOWSKI, M. (1994): Artefakt z obsydianu z osadów środkowoplejstoceńskich w Rusku, gm. Strzegom. *Śląskie Sprawozdania Archeologiczne* **35** 79–84.

PETROUGNE, V.F. (1972): Levalluazskie masterskie obsidianovykh orudij Zakarpat'ya i problema syr'ya. In: *Mareriali XII konferencii Institutu Arheologii AN URSR, 1968*, Kiev, 86–92 (In Russian).

PRZEŹDZIECKI, M., MIGAL, W., KRAJCARZ, M. & PYŻEWICZ, K. (2012): Obozowisko kultury magdaleńskiej na stanowisku 95 "Mały Gawroniec" w Ćmielowie, pow. ostrowiecki, woj. świętokrzyskie. *Światowit* **7(48)** Fascykuł B, 225–234.

PRZYBOROWSKI, J. (1876): Wycieczki archeologiczne nad Tyśmienicę i Wieprz. *Wiadomości Archeologiczne* **3** 1–48.

ROSANIA, C.N., BOULANGER, M.T., BIRÓ, K.T., RYZHOV, S., TRNKA, G. & GLASCOCK, M.D. (2008): Revisiting Carpathian obsidian. *Antiquity* **82** (318), online: www.antiquity.ac.uk.

SAWICKI, L. (1949): Wyniki badań obozowiska myśliwców z epoki lodowcowej na Zwierzyńcu w Krakowie. *Archeologicke Rozhledy* **1** 74–76.

SCHILD, R. & KRÓLIK, H. (1981): Rydno a Final Palaeolithic Ochre Mining Complex. *Przegląd Archeologiczny* **29** 53–100.

SCHILD, R., KRÓLIK, H., TOMASZEWSKI, A. J. & CIEPIELEWSKA, E. (2011): *Rydno. A Stone Age Red Ochre Quarry and Socioecnomic Center. A Century of Research*. Institute of Archaeology and Ethnology PAS, Warszawa. p. 467.

SCHILD, R., MARCZAK, M. & KRÓLIK, H. (1975): Poźny mezolit. Próba wieloaspektowej analizy otwartych stanowisk piaskowych. Ossolineum, Wrocław-Warszawa-Kraków. p. 262.

SOBCZYK, K. (1995): *Osadnictwo wschodniograweckie w dolinie Wisły pod Krakowem*. Wydawnictwo Uniwersytetu Jagiellońskiego, Kraków. p. 149.

SOBKOWIAK-TABAKA, I., KASZTOVSZKY, ZS., KABACIŃSKI, J., T. BIRÓ, K., MARÓTI, B. & GMÉLING, K. (2015): Transcarpathian contacts of the Late Glacial Societies of the Polish Lowlands. *Przegląd Archeologiczny* **63** 5–28.

STÖCKEL, R. (1881): Die prähistorische Funde in Oberschlesiens im Jahr 1879. *Schlesiens Vorzeit in Bild und Schrift* **3** 472–477.

SULGOSTOWSKA, Z. (2005): *Kontakty społeczności późnopaleolitycznych i mezolitycznych między Odrą a Dźwiną i górnym Dniestrem*. Instytut Archeologii i Etnologii PAN, Warszawa. p. 344.

SZELIGA, M. (2007): Der Zufluss und die Bedeutung des Karpatenobsidians in der Rohstoffwirtschaft der Postlinearen Donaugemeinschaften auf den polnischen Gebieten. In: KOZŁOWSKI J.K., & RACZKY, P. (eds.), *The Lengyel, Polgar and related cultures in the Middle/Late Neolithic in Central Europe*. The Polish Academy of Arts and Sciences, Kraków, Eötvös Loránd University. Institute of Archaeological Sciences, Budapest. Kraków, 231–248.

SZELIGA, M. (2009): Znaczenie obsydianu karpackiego w gospodarce surowcowej najstarszych społeczności rolniczych na ziemiach polskich. In: GANCARSKI, J. (ed.), *Surowce naturalne w Karpatach oraz ich wykorzystanie w pradziejach i wczesnym średniowieczu. Matetriały z konferencji, Krosno 25-26 listopada 2008.* Muzeum Podkarpackie w Krośnie, Krosno, 287–342.

SZELIGA M. (2018): Transcarpathian distribution and exchange system of the flint raw materials and obsidian during the Linear Pottery Culture development. In. C. Preoteasa, M. Cârciumaru, A. Pelisiak, C.-D. Nicola (eds.), Patra-Neamț: Editura „Constatin Matasă", 84–85.

SZELIGA, M., KASZTOVSZKY, ZS., OSIPOWICZ, G. (2018): Obsidian in the Early Neolithic of the Upper Vistula basin: origin, processing and use. In: *24th EAA Annual Meeting 5-8 September 2018. Reflecting futures. Abstract Book II*. Universitat de Barcelona, Barcelona, 731.

ŚCIBOR, J.M. 1992. Nowe znaleziska obsydianu na Wyżynie Sandomierskiej. *Acta Archaeologica Carpathica* **31** 35–53.

TOMASZEWSKI, A.J., KRÓLIK, H., CIEPIELEWSKA, E., LAPRUS-MADEJ, B. & MAŃKA, D. (2008): Rydno's obsidians: almost all of them. In: SULGOSTOWSKA, Z. & TOMASZEWSKI, A.J. (eds.), *Man–Millenium–Environment: Studies in Honor of Romuald Schild*. Institute of Archaeology and Ethnology, Polish Academy of Sciences, Warsaw, 293–300.

TUNIA, K. (1978): Sprawozdanie z badań stanowiska z epoki kamienia w Tyliczu, woj. Nowy Sącz. *Acta Archaeologica Carpathica* **18** 227–233.

VALDE-NOWAK, P. (1987): Entdeckung der Paläolithischen Fundstellen im Tal des Białka Tatrzańska-Flusses. *Acta Archaeologica Carpathica* **26** 5–35.

VALDE-NOWAK, P. (1991): Studies in Pleistocene Settlement in The Polish Carpathians. *Antiquity* **65** 593–606.

VALDE-NOWAK, P., NADACHOWSKI, A. & MADEYSKA T. (eds.) 2003. *Obłazowa Cave: Human Activity, Stratigraphy and Palaeoenvironment*. Institute of Archaeology and Ethnology, Polish Academy of Sciences, Kraków. p. 176.

WERRA, D.H. & SOBKOWIAK-TABAKA, I. (2017): Elementy kultury bukowo-górskiej na Nizinie Polskiej – aspekt teoretyczny. In: MARCINIAK-KAJZER, A., ANDRZEJEWSKI, A., GOLAŃSKI, A., RZEPECKI, S. & WĄS, M. (eds.), *Nie tylko krzemienie. Non only flints. Studia ofiarowane prof. Lucynie Domańskiej w 45-lecie pracy naukowo-dydaktycznej i w 70. rocznicę urodzin.* Uniwersytet Łódzki Instytut Archeologii, Łódź, 237–248.

WIĘCKOWSKA, H. (1971): Materiały krzemienne i kamienne z osady kultury ceramiki wstęgowej i trzcinieckiej w Opatowie. In: CHMIELEWSKI, W. (ed.), *Z polskich badań nad epoką kamienia*. Zakład Narodowy im. Ossolińskich, Wydawnictwo Polskiej Akademii Nauk, Wrocław, 103–183.

WILCZYŃSKI, J. (2010a): Obsydian products from Targowisko 10 site (Wieliczka distr.) In. GANCARSKI, J. (ed.), *Transkarpackie kontakty kulturowe w epoce kamienia, brązu i wczesnej epoce żelaza.* Muzeum Podkarpackie w Krośnie, Krosno, 115–137.

WILCZYŃSKI, J. (2010b): The techniques of obsidian treatment on the Malice Culture. Settlement of Targowisko 11, Lesser Poland. *Przegląd Archeologiczny* **58** 23–37.

WILCZYŃSKI, J. (2014a): Krzemienny oraz obsydianowy inwentarz kultury ceramiki wstęgowej rytej ze stanowiska Brzezie 17, gm. Kłaj. In: CZEKAJ-ZASTAWNY, A. (ed.), *Brzezie 17. Osada kultury ceramiki wstęgowej rytej.* Via Archaeologica. Źródła z badań wykopaliskowych na trasie autostrady A4 w Małopolsce. Krakowski Zespół do Badań Autostrad, Kraków, 499–546.

WILCZYŃSKI, J. (2014b): Neolityczne materiały kamienne z wielokulturowego stanowiska 10, 11 w targowisku, pow. wielicki. In: ZASTAWNY, A. (ed.), *Targowisko, stan. 10, 11. Osadnictwo z epoki kamienia.* Via Archaeologica. Źródła z badań wykopaliskowych na trasie autostrady A4 w Małopolsce. Krakowski Zespół do Badań Autostrad, Kraków, 59–534.

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* **4** 207–219.

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

WINIARSKA-KABACIŃSKA, M. & KABACIŃSKI, J. (2009): The first obsidian workshop at the Polish Lowland – a technological and microwear study. In: STERNKE, F., EIGELAND, L. & COSTA, L.-J. (eds.), *Non-flint Raw Material Use in Prehistory. Old prejudices and new directions*, *BAR International Series* **1939** Oxford, 187–190.

WOJCIECHOWSKI, W. (1981): Wczesno-neolityczna osada w Skoroszowicach. *Studia Archeologiczne* **12** Wrocław. p. 125.

WOJCIECHOWSKI, W. (1989): Młodsze kultury kręgu naddunajskiego. In: KMIECIŃSKI, J. (ed.), *Pradzieje ziem polskich* 1. Państwowe Wydawnictwo Naukowe, Warszawa-Łódź, 1561. ábra180.

ŻABA, J. 2003. *Ilustrowany słownik minerałów i skał.* Videograf II, Katowice. p. 504.

EXTRA-EUROPEAN OBSIDIAN TOOL ASSEMBLAGES IN HUNGARIAN MUSEUMS[•]

EURÓPÁN KÍVÜLI OBSZIDIÁN ESZKÖZ-EGYÜTTESEK MAGYAR MÚZEUMOKBAN

Judit ANTONI[1]

[1]independent researcher, Budapest

E-mail: falchettoalf@gmail.com

Abstract

There are over 1500 obsidian objects registered in four Hungarian museums, acquired mainly by donations, purchase and exchange, from Africa, North and Middle America and Oceania (Melanesia and Polynesia). The assemblages serve first of all to demonstrate the technological skill of different cultures. Some of them were the subject of scientific studies, some others are currently prepared for working up.

Kivonat

Magyarországi múzeumaink több mint 1500 obszidián tárgyat őriznek, melyek főleg adományozás, vétel és csere útján kerültek az intézményekbe Afrika, Észak- és Közép-Amerika és Óceánia (Melanézia és Polinézia) területéről. Az együttesek elsődlegesen a különböző kultúrák technikai felkészültségét szemléltetik. A tárgyak egy része szerepel tudományos közleményekben, némelyek pedig feldolgozás alatt állnak.

KEYWORDS: OBSIDIAN, WORLD COLLECTION, HUNGARIAN MUSEUMS

KULCSSZAVAK: OBSZIDIÁN, VILÁG-GYŰJTEMÉNYEK, MAGYARORSZÁGI MÚZEUMOK

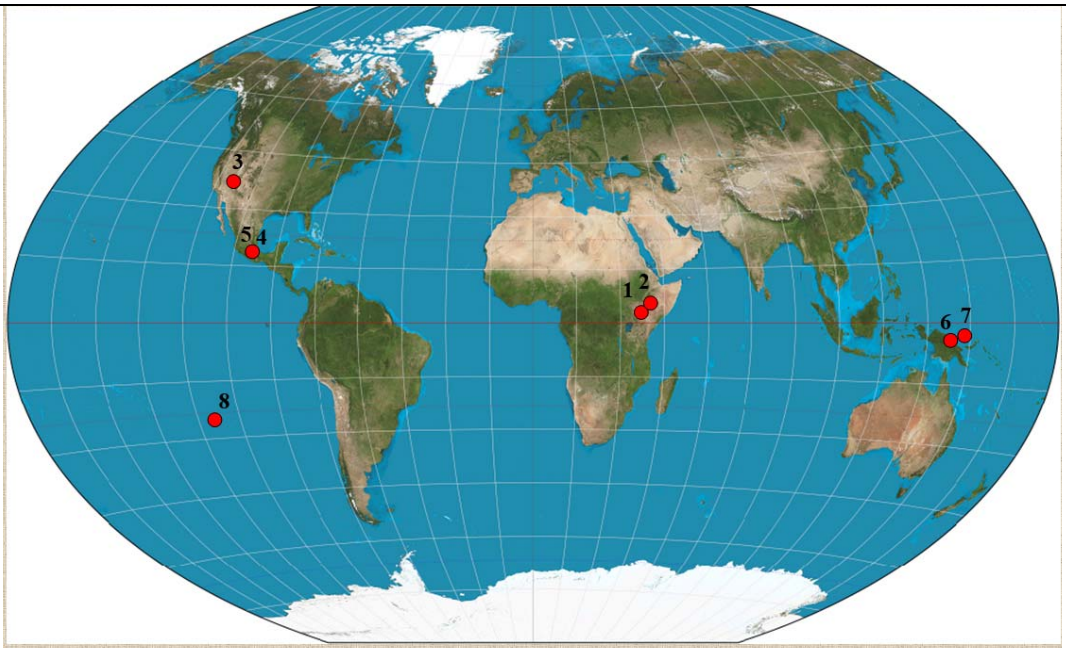


Fig. 1.: Location of the sites mentioned

Key: 1. Prospect farm, Kenya; 2. Naivasha Railway, Kenya; 3. Oregon, Coffeepot Plateau; 4. Mexico; 5. Puebla, Mexico; 6. Huon-Gulf area, Admiralty Islands; 7. Manus, Admiralty Islands; 8. Easter Island

1. kép: Az említett lelőhelyek térképe

[•] How to cite this paper: ANTONI, J. (2018): Extra-European obsidian tool assemblages in Hungarian museums, *Archeometriai Műhely / Archaeometry Workshop* **XV/3** 253-258.

HU ISSN 1786-271X; urn: nbn: hu-4106

Because of the raw material's beauty, obsidian attracted every time general attention among collectors. The collectors and donators who contributed to the wealth of World Collections in Hungary were, with few exceptions, Hungarians living abroad, who considered very important to send their objects to their homeland: we are very grateful for their efforts.

Their aim was that these objects, by transforming them into public property, should give the same experience to their compatriots as for himself discovering them, and to learn something about the culture of other peoples in the past and in our present. The multicoloured aspect of human cultures - what is one of the primary conditions of the sustainability of human existence - are brightfully represented by these elegant, well-worked tools.

By the turn of the 19/20th century Hungarians joined in the wide-spread collecting activity of other European people who sent scientific expeditions everywhere, to document the knowledge of extra-European cultures and to „save" the material of these peoples.

The representatives of this activity were ethnologists, archaeologists, doctors, geologists, entomologists, lawyers and other scientists, but voyagers, missionaries, officers, merchants and private collectors participated in similar projects too.

In the middle of the 20th century there were thousands of objects in our museums, selected by the people who collected them, sometimes with only very poor information about the circumstances of the findings and even poorer about the objects themselves.

By gifts from Hungarians living in foreign countries, by exchange with other museums or by purchase we have many collections from other continents and among these we can find some obsidian assemblages.(**Fig. 1.**)

Due to the specific conditions of origin of the obsidian, the geological occurrence and consequently the use of this material are fairly uneven.

The oldest pieces in the Palaeolithic Collection of the Hungarian National Museum from Africa, Kenya came from the Prospect Farm, Middle Palaeolithic Stillbay culture: five obsidian tools (**Fig. 2.**). More African obsidians are stored in the collection from Naivasha Railway-shelter, Upper Palaeolithic „Upper Kenya-Capsian" tools (8 pieces) made of a local obsidian, (**Fig. 3.,** Dobosi, 1982)

Fig. 2.: Tools from Prospect Farm, Kenya

2. kép: Eszközök, Prospect Farm, Kenya

Fig. 3.: Tools from Naivasha Railway-shelter, Kenya

3. kép: Eszközök, Naivasha Railway shelter, Kenya

From North America there is a large amount of Paleo-Indian obsidian tools (1282 pieces) collected in the U.S.A., Oregon State (Coffeepot Plateau) by N. Salgó dated between 8000 B.C. and 1850 A.D. This assemblage, now in the Ethnographical Museum, Budapest, contains projectile points, arrow-heads and spear-points without information on exact provenance. A selection of specific types (60 items) was transferred to the Palaeolithic Collection of the Hungarian National Museum (**Fig. 4.,** T. Biró 1992) More Paleo-Indian obsidian tools got into the HNM from the collection of geologist Gy. Varga (**Fig. 5.,** T. Biró 1992).

Middle America is represented by 5 pieces from Mexico in the Hungarian National Museum (**Fig. 6.**) and 15 pieces (mainly spear-points) in the Ethnographical Museum collected at the very end of the 19th century. In this latter museum we can find more objects from the Mexico Valley (6 lip-decoration) and a greater assemblage (77 pieces) of spear-points, flakes, arrow-points and some nuclei (cores) from Mexico, Puebla, deposited in the museum in 1903.

Fig. 4.: Pieces from the Salgó-collection, North America, Coffeepot Plateau

4. kép: Néhány darab a Salgó-gyűjteményből: Észak-Amerika, Coffeepot Plateau

Fig. 5.: Tools from the former Varga collection, North America

5. kép: Eszközök az egykori Varga-gyűjteményből, Észak-Amerika

After the 50-ies of the 20th century two new donations of some 17 pieces arrived, including two copies of obsidian statues and more arrowheads or flakes.

Fig. 6.: Tools from Mexico, Middle America in the Hungarian National Museum

6. kép: Mexikói eszközök a MNM-ban, Közép-Amerika

The most interesting part of obsidian objects are from Melanesia: New Guinea and the Admiralty Islands. They are ethnographical material, from the turn of the 19/20th century and they are deposited in the Ethnographical Museum.

In the Huon-Gulf area, from Tami Islands (New Guinea), there is a well-documented little collection of razor blades of obsidian (21 pieces): they were used by the local people between 1896-1899. As the collector (Bíró L.) mentions, the obsidian splinters were also used for medical purposes, like a scalpel in a surgical intervention, too. He collected even a „modern” variant of the obsidian splinters, which came in usage at the time of his visit: a knife, made from a beer-bottle.

Fig. 7.: Admiralty Islands: young man with obsidian-headed spear (after Antoni, 2002, photo by R. Festetics)

7. kép: Admiralitás-szigetek: fiatal férfi obszidián-hegyű dárdával. (Festetics R. fotója)

The Admiralty Islands were famous for their obsidian-headed spears, and everyone who visited the islands collected them as many as they could find. (**Fig. 7., Fig. 8.**)

So, the museum has 56 complete spears and many spear-shafts without obsidian: they are lost in the course of time. The spears come from four different collections, each was made between cca. 1890 and 1902.

There are six spears with obsidian head, made around 1930, collected by a missionary and deposited in the Protestant Church Museum at Sárospatak (**Fig. 9.**) and two daggers from Manus, made in the last 20 years, deposited at the Town Museum of Gödöllő (**Fig.10.**).

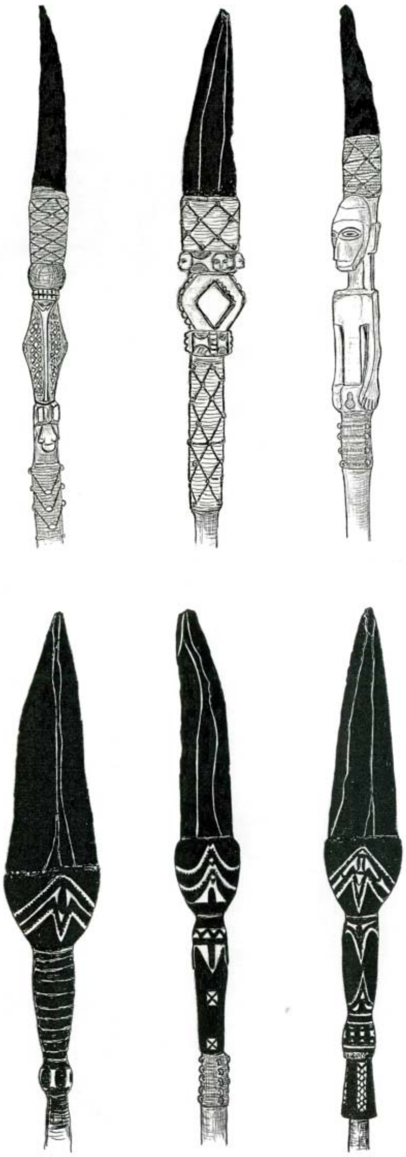


Fig. 8.: Admiralty Islands: spears in the collection of the Ethnographical Museum (after Antoni, 2002, drawings by J. Antoni)

8. kép: Admiralitás-szigetek: a Néprajzi Múzeum dárdái (Antoni J. rajzai, Antoni, 2002)

All these objects, spears and daggers, after their appearance and their usefulness (as weapons) were made specially for visitors as trade goods or for dancing: the paintings and other decorations (carving, fixation) and the weakness of the connecting parts of the spear suggest that they are not intended for use in combat.

Fig. 9.: Spears from the Admiralty Islands at Sárospatak, Protestant Church District Museum
9. kép: Admiralitás-szigetek: obszidián-hegyű dárdák, Sárospatak, Református Kollégium Múzeumának gyűjteménye

Fig. 10.: Dagger from the Admiralty Islands in the Gödöllő Town Museum Collection
10.kép: Obszidián pengéjű tőr, Admiralitás-szigetek, Gödöllői Városi Múzeum gyűjteménye

On the Admiralty Islands the people had probably similar razor-blades that in New Guinea: the razed head was the sign of mourning (**Fig. 11.**). Obsidian splinters were used by tattooing, by surgery, by the initiation (circumcision) and eventually by fine works of wood, but – because of their tiny dimensions – apparently they were not interesting enough for the collectors.

Fig. 11.: Admiralty Islands: women in mourning dress, with razed head (after Nevermann, 1934, photo by Fr. Fülleborn)

11. kép: Borotvált fejű asszonyok (a gyász jele), Admiralitás-szigetek Nevermann 1934, Fr. Fülleborn fotója)

Finally, by donation in 1966, the Ethnographical Museum acquired 9 lance-heads from Polynesia, Easter Island (**Fig. 12.**). They are the typical crescent-shape little mata'a used in combat by throwing the lance against the enemy.

There is a question which needs a special study, if they are archaeological or ethnographic material, including the possibility that they were produced for tourist only about 60 years ago.

Fig. 12.: Lance-head from the Easter Island (private collection)

12. kép: Lándzsahegy a Húsvét-szigetről. (magángyűjtemény)

Our Extra-European collections illustrates very well the collectors ideas (and the ideas of the time period of the collecting) about „interesting", „useful", „exotic", „valuable" objects: We find, however, only rarely the objects which were really useful or important in the life of the local people.

References:

ANTONI, J. (2002): *A kaland nyomában. Tolnai Festetics Rudolf gróf óceániai utazásai.* [In search of adventure. Oceanian travels of Count Rudolf Festetics of Tolna]. Helikon Kastélymúzeum, Keszthely: 1–83.

ANTONI, J. (2019, in press): „Vidd el a te faludba…" Molnár Mária misszionárius melanéziai gyűjteménye. [Take it to your homeland... The Melanesian collection of Maria Molnár, missionary]. Sárospataki Református Kollégium kiadványa.

BÍRÓ, L.: (1987): *Hat év Új-Guineában*. Válogatott írások. (Six years in New Guinea. Selected studies) Gondolat kiadó, Budapest, 1–356.

DOBOSI, V. (1982): Foreign finds in the Palaeolithic collection of the Hungarian National Museum. *Folia Archaeologica* **33** 7–42.

OHNEMUS, S. (1998): *An Ethnology of the Admiralty Islanders.* The Alfred Bühler Collection, Museum der Kulturen, Basel. Crawford House Publishing, Bathurst, 1–430.

NEVERMANN, H. (1934): Admiralitäts-Inseln. Ergebnisse der Südsee-Expedition 1908-1910. Hamburg, Friederichsen, De Gruyter + Co.,m.b.H.: 1–399.

T. BIRÓ, K. (1992): Prehistoric American stone tools in the collection of the Hungarian Ethnographic Museum. *Néprajzi Értesítő* **74** 151–187.

USE OF OBSIDIAN IN THE EPIGRAVETTIAN PERIOD•

OBSZIDIÁN FELHASZNÁLÁS AZ EPIGRAVETTI IDŐSZAKBAN

András MARKÓ[1]

[1]Hungarian National Museum, H-1088 Múzeum krt. 14-16, Budapest, Hungary

E-mail: markoa@hnm.hu

Abstract

Obsidian sources in the continental Europe are known exclusively from the Carpathian basin, where the occurrences of this volcanic rock were reported from several outcrops in the north-eastern part of Hungary, Eastern Slovakia and the westernmost part of Ukraine. The three or four distinct variants of the so-called Carpathian obsidian are easy to identify by macroscopic methods: the transparent - translucent type are found in the Slovakian sources, the homogenous black and grey (and exceptionally reddish) variants are known from Hungary. The poor quality pieces from the Transcarpathian Ukraine were rarely used on the territories lying far from the source area, so in the following the occurrences of the Slovakian and Hungarian variants will be discussed.

In this paper we review the available evidences on the use of the obsidian in the Central European assemblages dated to the Epigravettian period, dated to the second half of the LGM and to the Late Glacial. The distance of the raw material transport and the intensity of the obsidian manufacture will be emphasised.

Kivonat

A szárazföldi Európában csak a Kárpát-medencéből, északkelet-Magyarország, kelet-Szlovákia és Ukrajna legnyugatibb, kárpátaljai területéről ismerünk obszidián előfordulásokat. Az úgynevezett kárpáti obszidián három vagy négy változatát szabad szemmel is könnyen el lehet különíteni: az átlátszó-áttetsző típus a szlovákiai forrásokból, az átlátszatlan fekete, szürke, vagy nagyon ritkán mahagóni színű változatok a magyarországi előfordulásokhoz köthetőek. A kárpátaljai, gyenge minőségű kőzetet eddigi adataink szerint csak elvétve használták fel a forrásterülettől távolabbi lelőhelyeken, ezért csak a szlovákiai és magyarországi típusokat tárgyaljuk.

A tanulmányban áttekintjük a közép-európai epigravetti korú régészeti lelőhelyekről ismert, az obszidián felhasználásra vonatkozó adatokat. Különös tekintettel a nyersanyagszállítás távolságára és a helyi megmunkálás intenzitására.

KEYWORDS: EPIGRAVETTIAN PERIOD, OBSIDIAN, REFITTING, RAW MATERIAL TRANSPORT

KULCSSZAVAK: EPIGRAVETTI IDŐSZAK, OBSZIDIÁN, REFITTING, NYERSANYAG SZÁLLÍTÁS

Obsidian sources in the Carpathian basin

In the continental Europe obsidian sources are found exclusively in the Carpathian basin, where occurrences of this volcanic glass were reported from several outcrops in the north-eastern part of Hungary, Eastern Slovakia and the westernmost part of Ukraine.

As very few data are available on the Palaeolithic use of the low quality obsidian from the Transcarpathian Ukraine as extralocal raw material (Dobrescu et al 2018, 124), in the following the artefacts of the Slovakian and Hungarian variants will be discussed.

We agree with the observations by Biró and her colleagues (1986, note 1) and Biró (2006, 268; 2014) the widely used term 'Carpathian obsidian' is inaccurate or even inappropriate from geographical, geological and geochronological point of view.

• How to cite this paper: MARKÓ, A. (2018): Use of obsidian in the Epigravettian period, *Archeometriai Műhely* **XV/3** 259-276.

In earlier paper (Markó 2014; 2017) we used the terms Slovakian, Tolcsva and Mád type for these variants easy to distinguish even after macroscopic inspections. The first variant (Carpathian I or C1) was originally reported from Viničky, Streda nad Bodrogom, Vel'ka and Malá Bara (all in Slovakia: Kaminská 1991) in pyroclastic or slope deposits. The most probable source of the transparent or translucent archaeological artefacts from the vast region of Central Europe was recently identified at Cejkov and Brehov in the Zemplínske vrchy (Janšák 1935; Přichystal & Škrdla 2015, Bačo et al. 2017), where large pieces of the same macroscopic type are found in alluvial deposit.

In the southern part of the 'obsidian region' two main macroscopic groups are distinguished (Hungarian, Carpathian II or C2 variants). The rock of grey coloured, sometimes with grey and black laminated structure (Mád type, C2E) are collected from Mád and Olaszliszka, from the eastern part of the Szerencs caldera, while the homogenous black coloured or the exceptionally rare 'mahogany', non-transparent variant is from the southern slopes of the nearby Szokolya hill at Tolcsva and Erdőbénye (Tolcsva type, C2T). The pieces, generally not larger than a fist are typically found in slope deposits.

For a more detailed petrographic and geochemical description of the different variants and their outcrops the papers by Szepesi, J. and Bačo, P. and Bačova, Z. are recommended in the same volume.

Epigravettian period

In the following we shortly review the available data (**Table 1., Fig. 1.**) on the occurrence of raw material on archaeological assemblages dated to the second half of the LGM and to the Late Glacial. In the seventies the ‘Epigravettian’ was used e.g. in Slovakia for the localities dated the older Dryas and postdating the W3 Kašov and Cejkov sites (Bárta 1970, 213), however, the according to our present understanding this term was introduced for the Late Upper Palaeolithic industries of Italy (Bartolomei et al 1979). In our view, in Central Europe the 'Epigravettian' is not a cultural entity but a chronological period, following the latest Gravettian industries, represented by the lower layer of Kašov I in Eastern Slovakia (Novák 2002).

In lithostratigraphic point of view the artefacts of this period were excavated in the uppermost loess layer, sometimes in embryonic soils, marked as h2 and h1 levels in Hungary (Pécsi 1975). The formation of these humic horizons was compared to the Laugerie and Lascaux climatic oscillations by Gábori-Csánk (1978); the former one is most probably identical with the Grubgraben oscillation described from Lower Austria and Cossautsi VI-4 and VI-2 in the Dniester valley (Haesaerts et al 2007, 36, 43).

In biostratigraphic point of view, the artefacts were associated with faunal assemblages dated to the Pilisszántó faunal phase following the division used in Hungary (Jánossy 1986) clearly dominated by reindeer and horse remains. Finally, the radiocarbon dates from the discussed sites are listed on **Table 2**. In our view, there are a number of problems with these dates:

1. The site of Moravány – Žakovska, Slovakia (Pazdur 1995) and level II excavated in layer 6a of the site of Kraków - Spadzista C2, Poland (Kozłowski & Sobczyk 1987, 12, 68) yielded single C-14 dates of the Epigravettian period. The recent measurements of the same assemblages, however, yielded much older dates, suggesting the Gravettian classification for these assemblages (Verpoorte 2002, 314; Wilczyński et al. 2015). In fact, the majority of the sites discussed in this paper is dated by a single radiocarbon age too, which can be erroneous by a number of reasons.

2. Not necessarily the rich sites are dated, which are interesting in archaeological point of view. E.g. no radiocarbon ages are published from the localities of Pilismarót - Diós and Bitóc (Dobosi 2006) which yielded more important assemblages than the dated upper yellowish layer of the Bivak cave in the northern Transdanubia, Hungary (Jánossy et al. 1957).

3. In the vicinity of the obsidian sources few palaeontological remains and clear hearths were preserved due to the intense viticulture and the Vertisol ('nyirok'). Moreover, the dated charcoal of the upper artefact bearing layer of the Kašov I site was collected from a fireplace, lying at the depth of 35 cm below the present-day surface in a forested area. At the same time, the Late Gravettian lower layer of the same site, excavated only 10-20 cm beneath the upper one (Bánesz 1969; Bánesz et al. 1991) yielded a 2000 years older age (20.700 ± 350 BP: Bánesz 1993), which may raise certain questions about the authenticity of these absolute dates. These doubts underline the opinion by L. Bánesz (1990, 10), who emphasised, that although the upper layer of this site yielded the richest collection in the Carpathian basin with unique typological composition, the geochronological background is very problematic, and therefore, the use of a 'Kašovian' term as a cultural entity would be less well-based (c.f. Svoboda & Novák 2004).

The variability of the archaeological assemblages of the Epigravettian period is best illustrated by the upper culture bearing layer of the same locality. Here a characteristic industry with numerous backed bladelets were documented during the 1960 and 1967 excavations on the northern part of the site (Bánesz 1961, 778; 1961a, 220; 1969: 287; 1990, 16).

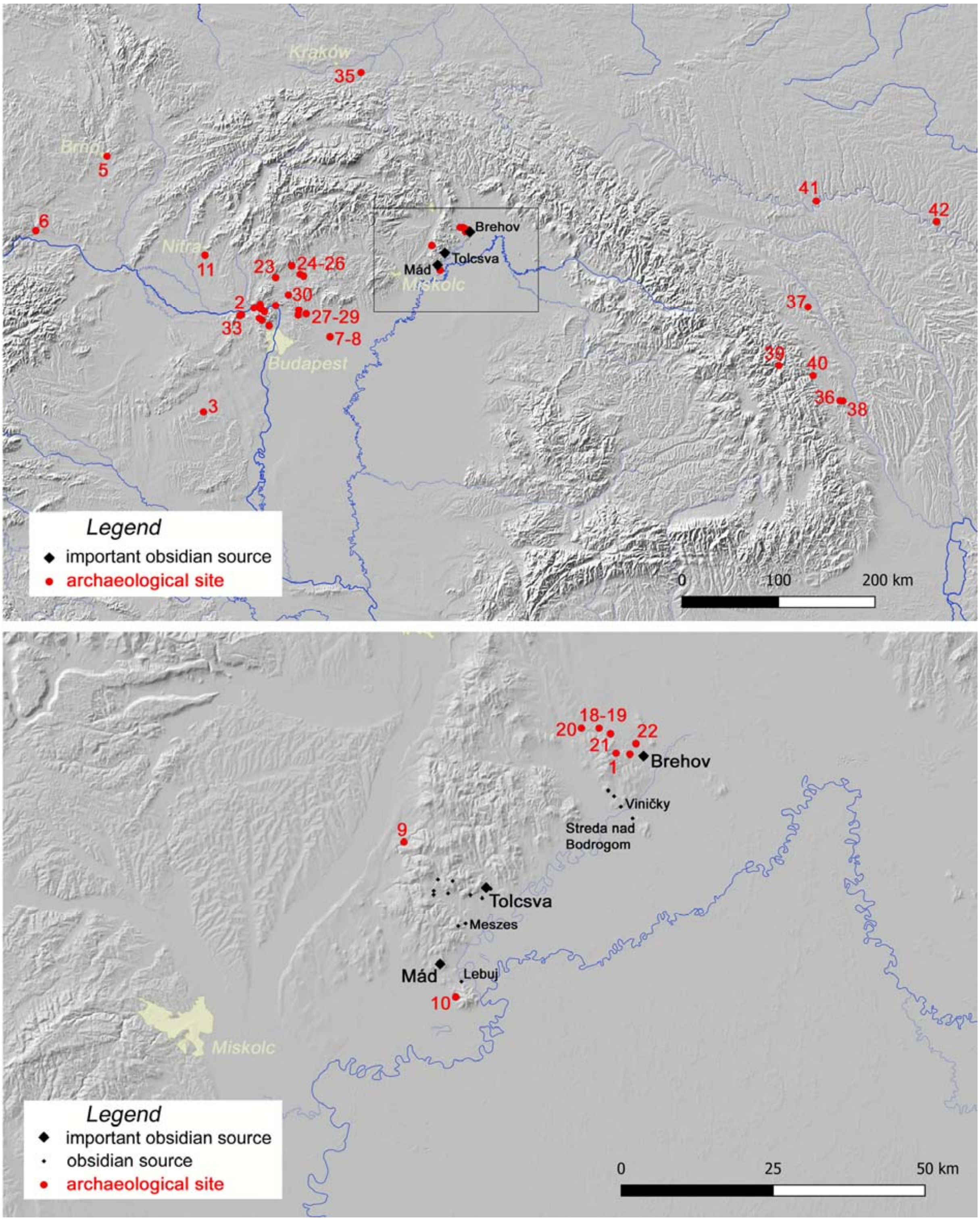


Fig. 1.: The sites mentioned in the text (Map by B. Holl, for the numbering see: **Table 1**.).

1. ábra: A szövegben említett lelőhelyek (Térkép: Holl Balázs, a számozás feloldása az **1. táblázat**ban)

Table 1.: The distance of the archaeological sites from the obsidian sources

1. táblázat: A lelőhelyek távolsága az obszidián nyersanyag forrásoktól

	Site name	**Slovakian type (C1)**	**Tolcsva type (C2T)**	**Mád type (C2M)**
1	Kašov I	4 km	31 km	45 km
2	Mogyorósbánya	251 km	220 km	210 km
3	Ságvár	335 km		
4	Szob	229 km	198 km	188 km
5	Stránska skála IV	360-385 km		
6	Grubgraben	450 km		
7-8	Jászfelsőszentgyörgy	181 km	148 km	135 km
9	Arka - Herzsa-rét	42 km	15 km	20 km
10	Tarcal	50 km	19 km	6 km
11	Nitra III	240-275 km		
12	Pilismarót - Öregek-dűlő	230 km	200 km	188 km
13	Dömös	228 km	197 km	186 km
14	Verőce	215 km		
15	Esztergom - Gyurgyalag	236 km		
16-17	Pilismarót - Diós, Bitóc	231 km	200 km	189 km
18-19	Hrčeľ – Pivničky, Nad baňou	9 km	32 km	47 km
20	Vel'aty	11 km	31 km	46 km
21	Kysta	7 km	33 km	47 km
22	Zemplínske Jastrabie	3 km	35 km	49 km
23	Vel'ka Ves nad Iplom	205-167 km		
24	Kiarov	181-143 km		
25	Kováčovce	178-139 km		
26	Slovenské Ďarmoty	190-151 km		
27	Acsa - Viszoki hill		163 km	
28	Kálló - Puszta hill	190 km	157 km	145 km
29	Galgagyörk - Kelemen föld	198-153 km		
30	Romhány	199-157 km		

Table 1. cnt.

1. táblázat folytatás

<table>
<tr><th></th><th>Site name</th><th>Slovakian type (C1)</th><th>Tolcsva type (C2T)</th><th>Mád type (C2M)</th></tr>
<tr><td>31</td><td>Pilisszántó rockshelter</td><td></td><td></td><td>190 km</td></tr>
<tr><td>32</td><td>Bivak cave</td><td>235 km</td><td></td><td></td></tr>
<tr><td>33</td><td>Jankovich cave</td><td>253 km</td><td></td><td></td></tr>
<tr><td>34</td><td>Kiskevély cave</td><td>230 km</td><td>198 km</td><td>186 km</td></tr>
<tr><td>35</td><td>Targowisko</td><td>200 km</td><td></td><td></td></tr>
<tr><td>36</td><td>Buda</td><td></td><td></td><td>438 km</td></tr>
<tr><td>37</td><td>Udeşti</td><td>358 km</td><td></td><td></td></tr>
<tr><td>38</td><td>Lespezi-Lutărie</td><td colspan="3">422-440 km</td></tr>
<tr><td>39</td><td>Bistricioara-Lutărie III</td><td colspan="3">349-368 km</td></tr>
<tr><td>40</td><td>Piatra Neamț - Pietricica</td><td colspan="3">386-405 km</td></tr>
<tr><td>41</td><td>Voronovitsa I</td><td colspan="3">360-398 km</td></tr>
<tr><td>42</td><td>Cossauti</td><td colspan="3">481-516 km</td></tr>
</table>

At the same time, these elements are practically absent from the central and southern part of the excavated territory (Bánesz 1980, 30); e.g. in the published assemblage, excavated during the 1979 and probably 1972 seasons there is a single backed blade and two bladelets with micro-retouch (Bánesz et al. 1992, 15).

Similarly, the different ratio of backed elements in the assemblages of Pilismarót and Esztergom led Gy. Lengyel (2018, 9) to place the sites into the Early and the Late Epigravettian industries, respectively. However, the artefact-bearing layers of Pilismarót - Pálrét and Esztergom - Gyurgyalag were documented in the same embryonic soil and both the malaco-biostratigraphic evaluation and the radiocarbon dates of these sites perfectly agree (Ringer & Schweitzer 1983; Krolopp, E. 1983; 1991; Hertelendi 1991; Sümegi & Krolopp 2000, Table 1). In fact, the boundary between the Early and Recent Epigravettian in Italy is postdated to 16 ka cal B.P. (based on the data from Riparo Tagliente, NE Italy, Veneto: Tomasso 2017, 17, 18), showing that each dated assemblage discussed in this paper is contemporaneous with the Early Epigravettian of Italy.

In the following we will use the chronological and archaeological framework developed by V. Dobosi (1996; Dobosi & Szántó 2003) based on the lithostratigraphic and radiocarbon dates from Hungary. According to this schema the Pebble Gravettian industry is associated with the h2 embryonic soil 20-19 ky radiocarbon dates. Another, more heterogeneous group of assemblages (younger blade industries) were basically excavated in the younger h1 level and are dated to around16 ka. These periods seemingly fit well to the Stránská skála and Plevovce phases, which, together with the third Vídeňska phase were recently suggested for the chronological division of the sites in Moravia (Škrdla et al. 2014).

Table 2.: Radiocarbon dates from the assemblages discussed in the paper
2. táblázat: A dolgozatban tárgyalt lelőhelyek radiokarbon koradatai

site	lab.code	material	age	ref.
Esztergom - Gyurgyalag	Deb–1160	charcoal	16,160 ± 200 BP	Hertelendi 1991
Kašov I, upper layer	Gd – 6569	charcoal	18.600 ± 390 BP(?)	Bánesz 1992
Stránská skála IV	GrN-13945	bone	18.220 ± 120 BP	Svoboda 1991
Stránská skála IV	GrN-14351	bone	17.740 ± 90 BP	Svoboda 1991
Ságvár, upper layer	GrN-1959	charcoal	17.760±150	Vogel & Waterbolk 1964
Ságvár, lower layer	GrN-1783	charcoal	18.900±100	Vogel & Waterbolk 1964
Ságvár, ‘cultural layer’	Deb–8821	charcoal	19.770±150	Krolopp & Sümegi 2002
Ságvár, ‘cultural layer’	Deb–8822	mollusc shell	18.510±160	Krolopp & Sümegi 2002
Mogyorósbánya	Deb-1169	charcoal	19.930±300	Dobosi 1992
Mogyorósbánya	Deb-9673	charcoal	19.000±250	Dobosi & Szántó 2003
Bivak cave, upper yellowish layer	Gd-15614	bone	15.970±207 B.P	Pazonyi 2006
Targowisko	Poz-14691	charcoal	14.790±80 BP	Wilczyński 2009
Targowisko	Poz-14693	charcoal	13.720±70 BP	Wilczyński 2009
Targowisko	Poz-14692	charcoal	14.790±70 BP	Wilczyński 2009
Targowisko	Poz-14694	charcoal	14.520±70 BP	Wilczyński 2009
Targowisko	Poz-14695	charcoal	14.820±70 BP	Wilczyński 2009
Jászfelsőszentgyörgy - Szúnyogos, lower layer	DEB-1674	bone	18.500±400 BP	Hertenedi 1993
Arka – Herzsa-rét, lower layer	GrN-4038	charcoal?	17.050±350 BP	Vogel - Waterbolk 1964
Arka – Herzsa-rét, upper layer	GrN-4218	charcoal from a hearth	13.230±85 BP	Vogel - Waterbolk 1967
Arka – Herzsa-rét, lower layer?	A-518	charcoal	18.600±1900 BP	Haynes et al 1966
Grubgraben KS 1	GrN-21902		18.380±130 BP	Zöller 2000
Grubgraben KS 2	GrN-21529		18.890±140 BP	Zöller 2000
Grubgraben KS 3	GrN-21530		18.920±180 BP	Zöller 2000
Grubgraben KS 3+4	LV-1660		18.170±300 BP	Zöller 2000
Grubgraben KS 4	AA-1746		18.960±290 BP	Zöller 2000
Grubgraben KS 4	LV-1680		18.400±330 BP	Zöller 2000
Grubgraben KS 4	GrN-21531		19.380±90 BP	Zöller 2000

Table 2., cont.

2. táblázat folytatás

site	lab.code	material	age	ref.
Buda, lower layer	GrN-23072		23.810±190 BP	Tuffreau et al. 2018
Buda, level C	OxA-29525	bone	23.300±160 BP	Tuffreau et al. 2018
Buda, level C	OxA-29526	bone	23.440±160 BP	Tuffreau et al. 2018
Lespezi - Lutărie layer II	Bln-805	charcoal	17.620±320 BP	Tuffreau et al. 2018
Lespezi - Lutărie layer II	OxA-31557	bone	18.500±110 BP	Tuffreau et al. 2018
Bistricioara - Lutărie	DeA-7465		16.949±57 BP	Anghelinu et al. 2018

The use of obsidian in the archaeological assemblages

The upper artefact-bearing layer of Kašov I yielded more than 43 thousand lithic artefacts, dominantly made of obsidian. Although the site is lying in the immediate vicinity of the Brehov and Cejkov obsidian occurrences, in the time of the publication only the outcrops of Viničky and Streda nad Bodrogom were known, which led the authors to suppose a non-local source (Bánesz et al 1992, 9). For the time being, only 5.2% of the lithics collected from 4.8% of the excavated surface was published in details (Bánesz et al 1992) and the ratio of the different obsidian variants is not known; probably a comprehensive evaluation of this large assemblage in the future will give new data on the raw material, typological and intra-site variation of the locality.

The Pebble Gravettian sites (Ságvár and Mogyorósbánya in the Transdanubia, Szob in the Danube bend and Madaras in the southern part of the Great Hungarian Plain) form a fairly homogenous group of assemblages both in stratigraphic and archaeological point of view. The obsidian artefacts (Markó 2017), dominantly made of the Slovakian (C-I) variant, introduced to the site as tools (end scrapers, retouched blades), cores in the advanced stage of exploitation and possibly, very rarely as nodules. The intense on-site bladelet production from typical cores and burin-cores, moreover, the rejuvenation of transversal burins or burins on end scrapers is evidenced from the assemblage of Mogyorósbánya, lying at a distance of 250 km from the source area. According to our data in the lower layer of Ságvár only single atypical pieces were found of the same variant. Finally, the Hungarian (Tolcsva and Mád type) obsidian are represented by tools in Mogyorósbánya and Szob.

In the Brno basin, Moravia, the site of Stránska skála IV is the single locality dated to this period (Stránska skála IV phase by Škrdla et al. 2014). In the rather uncharacteristic assemblage a single atypical retouched tool of obsidian is also found (Svoboda 1991, 34, Obr. 20, 17).

From the site of Grubgraben, Lower Austria a unique end-scraper of transparent obsidian was reported, probably from the main artefact bearing layer 3 (Brandtner 1996, 129, Taf. VI, 13; Neugebauer-Maresch et al. 2008, 113). Based on the lithostratigraphic observations (Grubgraben oscillation: Haesaerts et al 2007) and the radiocarbon ages (**Table 2.**) the artefact-bearing layer could be contemporaneous with the Mogyorósbánya site.

The lower artefact-bearing layers of the sites at Jászfelsőszentgyörgy in the northern part of the Great Hungarian Plain (Dobosi 1993, 2001) were excavated in a loess layer, associated by a 'cold' malacofauna, underlying the sediment deposited under milder conditions (Sümegi 2005, 225-232.). Contrary to the objection by Lengyel (2008-2009, 253, 258-259) the single radiocarbon date from the Szúnyogos site perfectly agrees with the lithostratigraphic dates of the artefact-bearing layer.

Although the assemblages of the localities are contemporaneous in stratigraphic point of view, certain differences are observed in the use of the obsidian raw material. In the Székes-dűlő assemblage the four artefacts of Mád-type obsidian (**Fig. 2.**) document the local core reduction. In the lower layer of the neighbouring Szúnyogos site fifty pieces (including two burins and an end-scraper) were made of the Slovakian obsidian, which is represented by a single flake fragment at Székes-dűlő. Additionally, four pieces are made of the Tolcsva and two of the Mád-type obsidian.

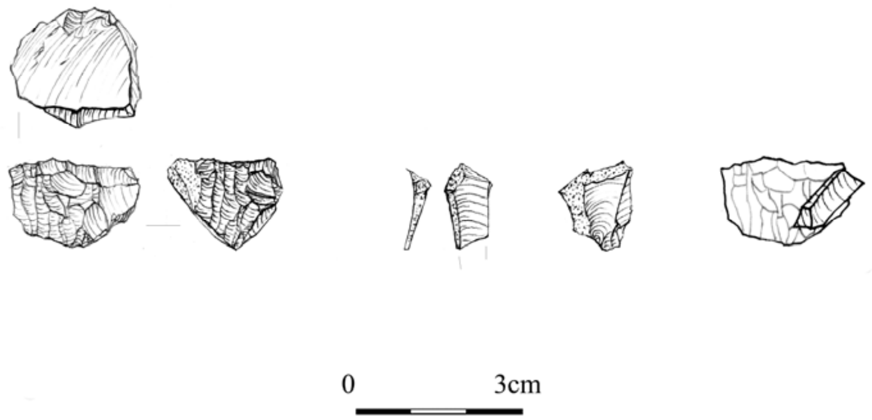


Fig 2.: Jászfelsőszentgyörgy – Székes-dűlő: refitted obsidian artefacts from the lower layer (drawing: Katalin Nagy)

2. ábra: Jászfelsőszentgyörgy – Székes-dűlő: összeilleszthető obszidián eszközök az alsó rétegből (rajz: Nagy Katalin)

The lithic assemblages from the important Upper Palaeolithic site of Arka, lying in the Hernád / Hornád valley, Northern Hungary belong probably to the same period. The artefacts of this locality were collected partly from two artefact bearing layers underlying a fossil soil horizon of unknown age, partly during the surface collections. The list of the characteristic forms (Vértes 1965, 348; 1964-65, 102-103) reflects important differences in the ratio of the backed elements or the carenoid pieces of each assemblage. From the surface collection a 'Willendorf type' shouldered point as well as a leaf shaped scraper, similar to the pieces from the lower layer of the Szeleta cave were reported. No information is published about the place of recovery of the rather atypical *fléchette* and the backed points with flat ventral retouch, published by Gy. Lengyel (2016) as diagnostic pieces for the Late Gravettian. Regrettably, the interpretation of the radiocarbon dates from the site (**Table 2.**) is rather problematic (Lengyel 2008-2009, 251-253), however, it seems to be clear, that if sample A-518 was collected from a charcoal concentration lying 25 cm above the lithics belonging to the lower layer and 75 cm beneath the charcoal layer from where the 13 ka old sample (GrN-4218) was collected (Lengyel 2008-2009, 253), this later one is reasonably linked to the upper archaeological layer. Moreover, although the field observations published by the excavator (Vértes 1962, 143; 1964-1965, 82) raised certain questions on the nature of the site formation processes, the radical conclusions by Lengyel (2018, 15) claiming that the "Pleistocene layers were severely reworked by cryoturbation down to the andesite bedrock" are unrealistic. In fact, the upper level of the slope loess and the upper artefact-bearing layer was most probably disturbed by the frost, however, in the lower part of the same layer instead of polygonal pattern root-channels with carbonate infill were found. Furthermore, the documented pits from both layers (Vértes 1962, Plate IX, 2) and the circular feature of the upper level (Vértes 1962, 145-147, Abb. 2, Plate IX, 4; Bild 1a) does not support the hypothesis of intense and deep cryoturbation.

Unfortunately, the assemblages have not been published yet, and the recent cultural classification, based exclusively on the analysis of the armatures, more precisely on the points (Lengyel 2016) is not convincing. In the future the detailed study of the whole assemblages, including the domestic tools (reaching 78.7% of the typical pieces from Arka: Lengyel 2016, Table 1) and the pieces of 'Aurignacian character', the raw material types used on this locality, as well as the documented features will certainly shed new light on this important locality.

Following the data given by K. Biró (1984, 36, Table 3) 351 specimens from a total of 8543 lithics (i.e. 4.11% of the lithic assemblage) were made of Slovakian and Hungarian obsidian, including the very rare mahogany coloured type (Biró et al. 2005). We have to keep in our mind, however, that only a sample was collected from the workshop material of the local hydrothermal rocks, so this ratio could have been even lower.

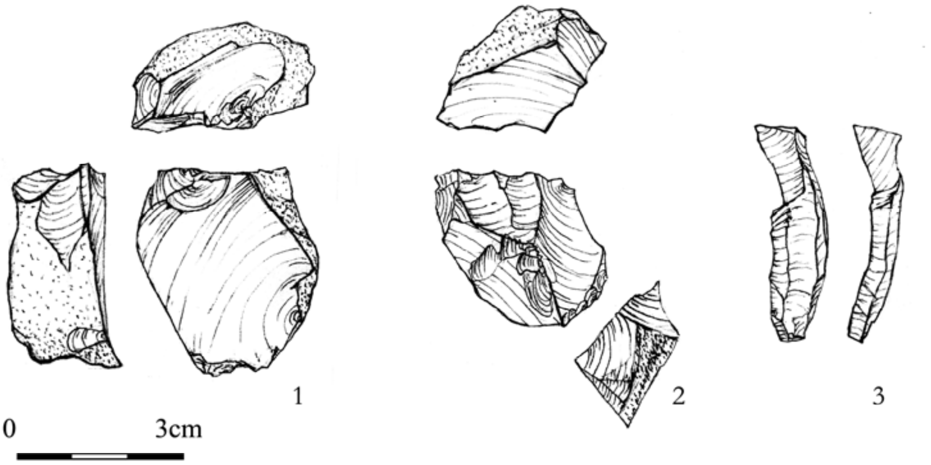


Fig. 3.: Obsidian artefacts from the Danube bend: 1-2: Verőce, former brickyard, 3: Esztergom – Gyurgyalag (drawing: Katalin Nagy)

3. ábra: Obszidián eszközök a Dunakanyarból: 1-2: Verőce, régi téglagyár; 3. Esztergem-Gyurgyalag (rajz: Nagy Katalin)

The little assemblage excavated from Tarcal (Dobosi 1974; Markó 2014), excavated in a humic layer imbedded to the uppermost loess layer. Among the obsidian artefacts of this little collection the Mád-type is the most abundant (8.29%), while the Tolcsva-type (5.80%) and the Slovakian variant (2.20%) are represented by a smaller number of artefacts, suggesting that the ratio of each variant depends on the distance of the raw material source from the locality. Unusually, 22 lithics (5.38% of the assemblage) are made of perlite, with a possible source lying at a distance of 2-3 km from the site (Lebuj kanyar at Bodrogkeresztúr). As a total, the ratio of the volcanic glasses among the chipped stone artefacts is 21,72%, which is clearly higher than it was observed in the Arka assemblage.

Finally, during the excavations of the Nitra III site in western Slovakia four flakes, a blade and a burin made of obsidian were found (Bárta 1971, 213; Kaminská & Nemergut 2014, Table 1, Fig. 8:8). The artefacts were found in the upper loess layer and the general character of the assemblage supports the Epigravettian classification.

The use of obsidian in the Danube bend - transport of raw material pieces

The Danube bend, lying north of Budapest in Hungary belongs to one of the classical regions of the Palaeolithic research in Hungary. In the 1980s and 1990s a number artefact bearing layers were excavated in the vicinity of Pilismarót and Esztergom, partly in the younger embryonic soil h1, partly in a younger sediment, on the top of the loess layer, immediately underlying the Holocene humic soil (Dobosi et al 1991; Dobosi 1996; 2006). The former assemblages, excavated in the h1 embryonic soil are stratigraphically contemporaneous with the layer excavated at Szeged - Öthalom in the 1930s and can be compared to the Plevovce phase described recently from Moravia (Škrdla et al. 2014).

In spite of the topographic proximity and the contemporaneity of the assemblages, they are very different both in the raw material and typological composition. The common points are the intense use of extralocal raw material types imported from eastern direction, including the limnic quartzite variant from Magyarkút or the metarhyolite / felsitic porphyry from the eastern part of the Bükk mountains. In the exceptional assemblage of Esztergom - Gyurgyalag the majority of the artefacts were made of Prut flint, imported to the site from the source region lying more than 600 km (Dobosi et al 1991). Obsidian artefacts were excavated at Esztergom (a single blade: **Fig. 3/3**) as well as at the localities of Diós and Bitóc I and II at Pilismarót (Dobosi 2006).

The first evidences of the transport of obsidian nodules were published by K. Biró (1984, 20) from Pilismarót - Öregek-dűlő and Dömös. However, the field documentations of the excavations carried out after the World War II are not available, and the artefacts of the former locality were collected from secondary position and later mixed during the publication (Gábori & Gábori 1957).

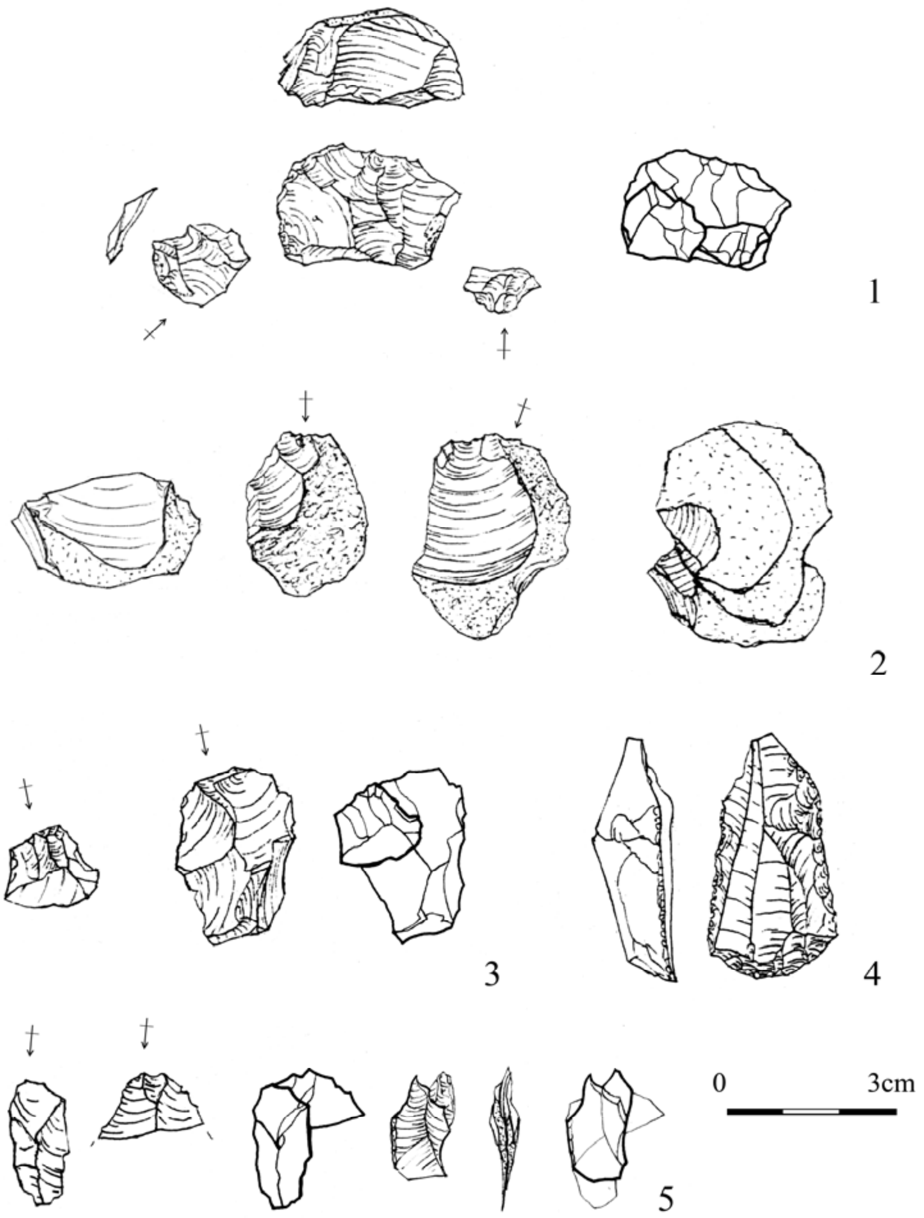


Fig. 4.: Pilismarót – Diós: 1-3, 5: refitted artefacts of Tolcsva-type (C2T) obsidian; 4: end-scraper of Slovakian (C1) type (drawing: Katalin Nagy)

4. ábra: Pilismarót – Diós: 1-3, 5: összeillesztett eszközök, Tolcsva-típusú (C2T) obszidiánbóé; 4: Szlovákiai (C1) obszidiánból készült vakaró (rajz: Nagy Katalin)

The artefact-bearing layer found in the uppermost loess layer in the former brickyard at Verőce yielded five pieces of obsidian (of the best quality, Slovakian variant), including a nearly half nodule and a totally exhausted core (**Fig. 3/1-2**) suggesting the complete on-site exploitation of a raw material piece, imported from more than 200 km to the site. Even if the stratigraphic data are absent in this case too, the character of the lithic industry places the site to the Epigravettian period (Markó 2002).

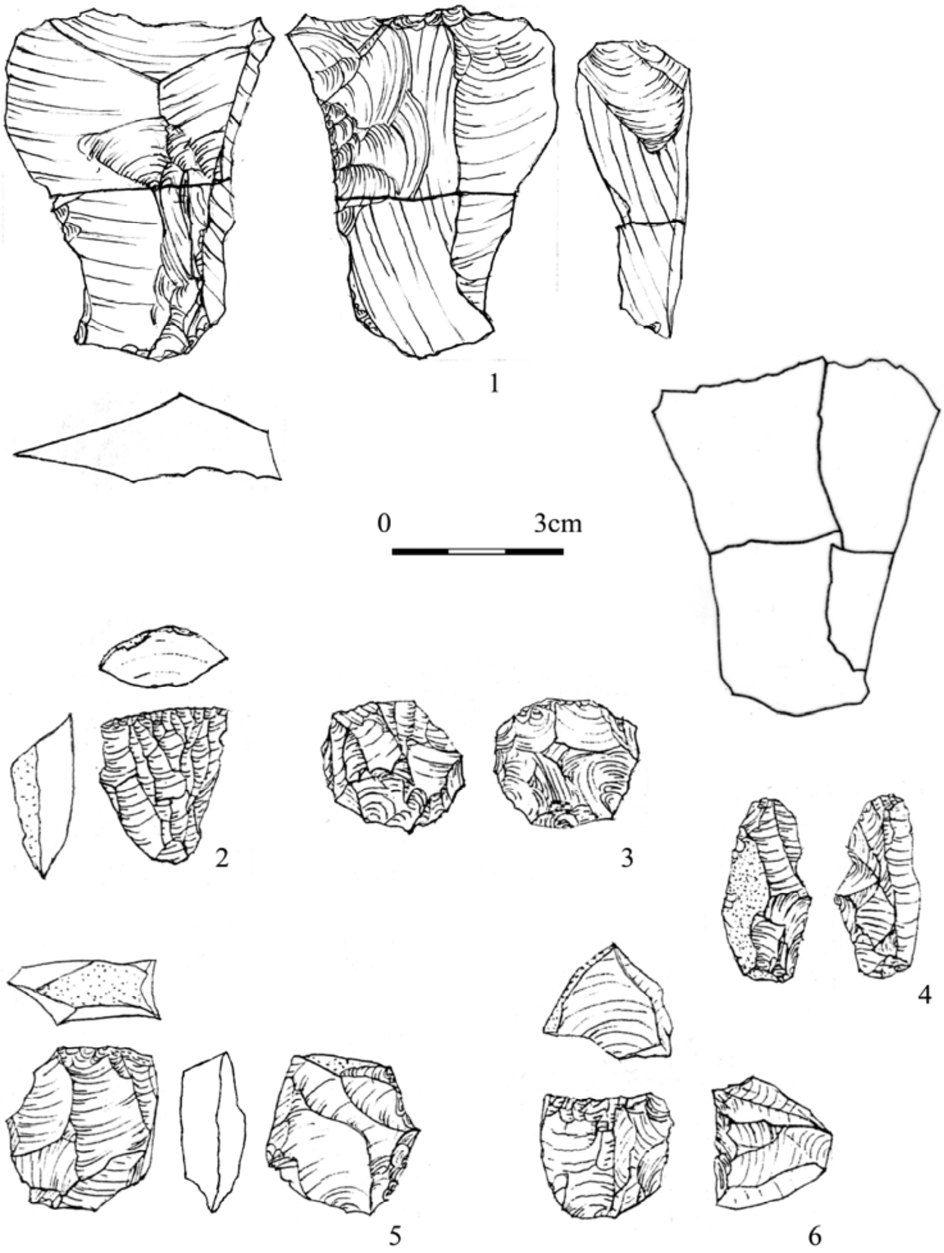


Fig. 5.: Pilismarót – Bitóc: 1: refitted artefacts; 2-6: bladelet cores and residual core of Slovakian and Tolcsva-type obsidian (drawing: Katalin Nagy)

5. ábra: Pilismarót – Bitóc: 1: összeillesztett eszközök; 2-6: mikropenge-magkövek és magkőmaradék szlovákiai és tolcsvai típusú obszidiánból (rajz: Nagy Katalin)

Around 2 per cent of the artefacts from Pilismarót - Diós are made of obsidian, but only five pieces (including an end-scraper: **Fig. 4/4**) belong to the Slovakian variant. The majority of the artefacts (16 pieces) most probably belong to a single nodule of the homogenous black Hungarian (Tolcsva) variant. According to the refit studies, the preparation of the striking platform of a core was carried out on this site (**Fig. 4/2**). Partly cortical and refitted blanks (**Fig. 4/3, 5**) removed from the same core are also present in the assemblage, however, only the last removals: two tiny chips could have been refitted to the exhausted core (**Fig. 4/1**).

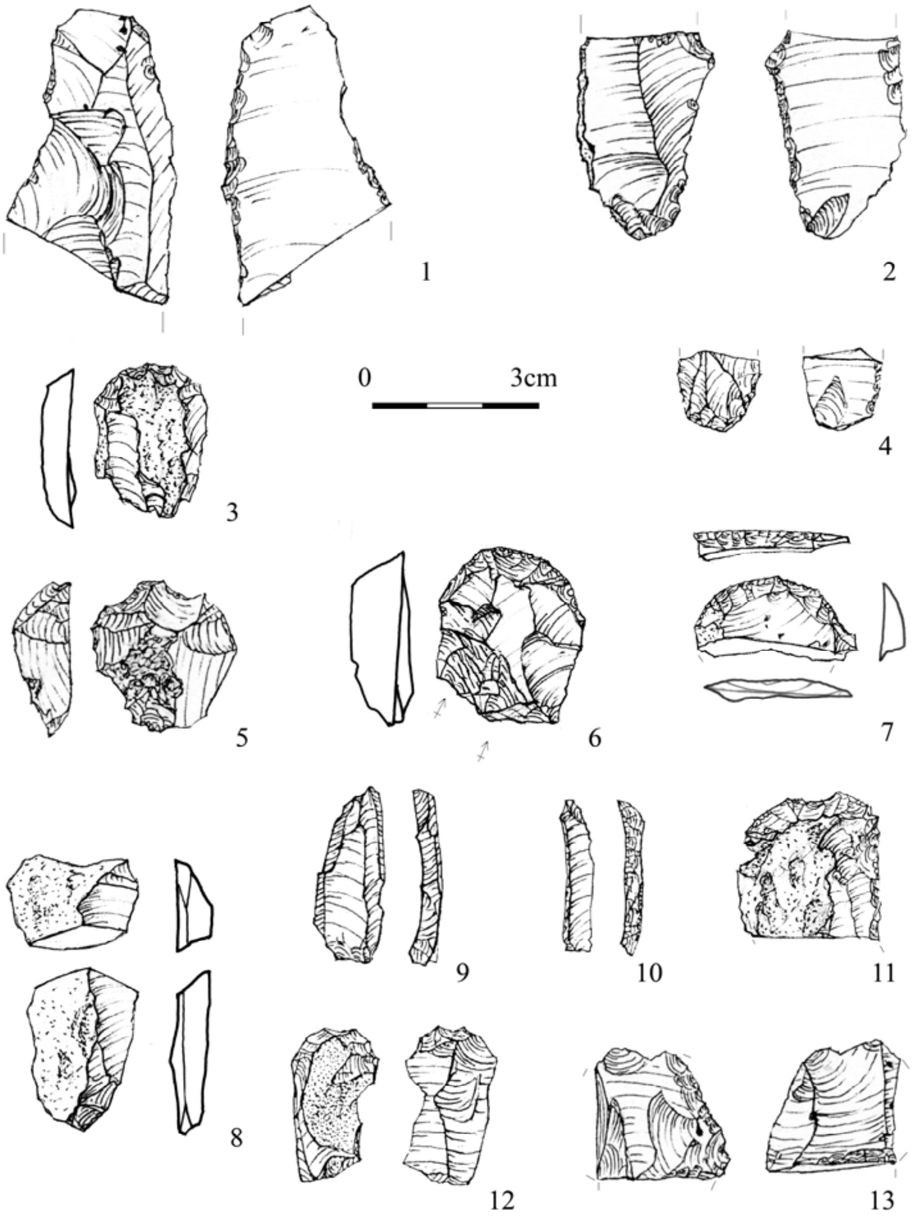


Fig. 6.: Pilismarót – Bitóc: tools and refitted cortical blade of obsidian (drawing: Katalin Nagy)

6. ábra: Pilismarót – Bitóc: eszközök és összeillesztett kortexes szilánk obszidiánból (rajz: Nagy Katalin)

Importantly, the majority of the blanks are not found in the excavated assemblage, suggesting that only the waste material was found on the site.

Finally, 21.02% of the assemblages (230 pieces) from the neighbouring Bitóc site were made of obsidian, dominantly the Slovakian (best quality, transparent) type. Refit studies proved that intact raw material pieces, flakes of natural origin were introduced to the locality. However, in some cases unsuccessful removals led to breaks and the abandonment of the pieces (**Fig. 5/1**). Besides, bladelet cores (**Fig. 5/2-6**) and formal tools like end scrapers and burins (**Fig. 6.**), as well as a large amount of waste material are also found in these assemblages.

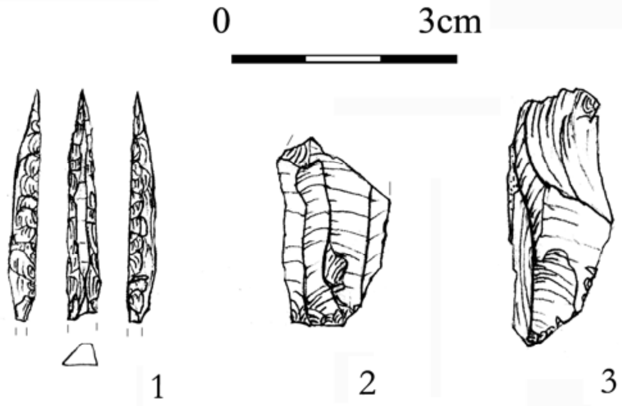


Fig. 7.: Pilisszántó I rockshelter, Bivak cave and Jankovich cave: artefacts of obsidian (drawing: Katalin Nagy)

7. ábra: Obszidián eszközök a Pilisszántó I kőfülkéből, a Bivak és a Jankovich barlangból (rajz: Nagy Katalin)

As a summary, from the assemblages of the Danube bend each obsidian variant is known, however, their importance changed from site to site. Moreover, the pieces were partly imported to the sites as not modified nodules or natural flakes, partly as ready made tools. Finally, the regular bladelet production of this raw material is evidenced in each locality.

Occurrence of obsidian in the assemblages without stratigraphic control

In the surface collected assemblages of Hrčeľ - Nad baňou and Hrčeľ - Pivničky, lying in the vicinity of the obsidian occurrences in Eastern Slovakia the relatively high ratio of obsidian (50-70% of the assemblages), including not modified nodules and pre-cores is evidenced. Regrettably, during the excavations no Palaeolithic artefact-bearing layer was observed, but at the locality Nad baňou Copper Age features were documented. Based on the presence of the 'Aurignacian type' lithics and the moderate ratio of the 'northern flint' types the assemblage from Hrčeľ-Pivničky as well as the little collections from Vel'aty, Kysta and Zemplinske Jastrabie were compared to the published assemblage of upper layer of Kašov I. The site of Hrčeľ - Nad baňou where the 'Aurignacian types' are absent and the flint types are better represented were placed into an earlier period, approximately between the two layers of Kašov (Kaminská 2004, 212; 2014, 283-285).

From the Cserhát region and the Ipoly / Ipel' valley a number of surface collected were dated to the Gravettian or Epigravettian period (Bárta & Petrovský-Šichman 1962; Dobosi 2010, Péntek-Zandler 2016), even if from Kiarov II, Kováčovce I. and Slovenské Ďarmoty in the Ipel' valley only less typical, Gravettian or Epigravettian artefacts are known (Bárta & Petrovský-Šichman 1962, 298-300, 305-306) and the results of the excavations at Vel'ka Ves nad Iplom (Bárta 1970, 213) are not published. From the Cserhát localities in Northern Hungary (Acsa - Viszoki hill, Kálló - Puszta hill and Galgagyörk - Kelemen földek) the presence of mahogany obsidian from Kálló (Biró et al. 2005, 94-95, 94–95, Fig. 3: 4; Péntek-Zandler 2016, 133) is worth to mention. The obsidian artefacts collected also from the surface at Romhány most probably does not belong to the Palaeolithic period (Dobosi 2011-2013, 21).

Occurrence of obsidian in the Upper Palaeolithic assemblages in the cave sites

After the first excavations of the cave localities lying in the north-eastern part of the Transdanubia it became clear that two 'Magdalenian' artefact bearing levels could have been observed: an older layer containing cave bear bones and teeth and a more recent one without the remains of this species. Using the modern terminology, the assemblages are placed to the Gravettian and Epigravettian period, respectively.

During the excavations of the 'Lower diluvium' of the Pilisszántó I rock shelter, the eponymous site of the biostratigraphic stage dated to the late Würm, a single backed bladelet (Fig. 7: 1 – c.f. Kormos & Lambrecht 1915, 10. ábra) of grey Mád-type obsidian was collected. In the upper yellow layer of the nearby Bivak cave a blade fragment of Slovakian obsidian (**Fig. 7/2**) associated by another blade of low quality siliceous rock and a fossil shell fragment (Jánossy et al. 1957, 31, Taf. I, 9, 7, 2) was found. Based on the presence, or, in the case of the Bivak cave, the dominance of the cave bears (Jánossy 1986), these assemblages should be earlier than 24 ka, when this species is estimated to be disappeared from Central Europe (Pacher & Stuart 2008). The single radiocarbon date measured on a bone fragment of unknown species from the Bivak cave (Pazonyi 2006, see **Table 2.**) contradicts to the Gravettian age; further fieldworks or radiocarbon measurements are necessary to clear the age of the layers.

We have to mention the Jankovich cave, where a single flake of Slovakian obsidian was found in a not specified Upper Palaeolithic layer, and finally, from the Kiskevély cave a number of artefacts made of this rock was reported (Biró 1984, 25, Fig. 13, 7-18), however, the typological and technological observations suggest for a more recent Prehistoric period for these objects.

Obsidian artefacts excavated north and east of the Carpathians

In Poland, during the excavations at Targowisko the local exploitation of a Slovakian obsidian (Hughes et al 2018) nodule was documented in a restricted artefact concentration lying on the western part of the excavated trench; the 43 blades and flakes and the roughly 250 chips and fragments make up 5.3% of the assemblage (Wilczyński 2010, 114-115, 121). The site is well dated into a younger period than the localities discussed earlier (see **Table 2.**), and it is seemingly contemporaneous with the Vídeňska phase in Moravia (Škrdla et al. 2014).

In the Bistrița and Suceava valleys, eastern Romania, two assemblages, dated to the Herculane II period, i.e. to the Laugerie interstadial and the late glacial period by V. Chirica (1989, 146) yielded some obsidian artefacts. In layer I of the site at Buda, excavated in a pseudo-mycelian level, a few pieces of black or greyish, non-transparent obsidian were found (Căpitanu 1967, 270; Bitiri 1981, 339; Bitiri-Ciortescu et al 1989, 21; Chirica 1989, 108-110; Tuffreau et al, 2018, 138), not found in the collections today (Tuffreau et al, 2018, 140). The available excavation reports from the 1958 and 1959 seasons (Nicolăescu-Plopşor et al 1961; Căpitanu et al. 1962) do not mention these pieces, which were most probably collected during the last excavations in 1960.

Based on the presence of the shouldered points this assemblage was placed into the Late Gravettian period (Căpitanu et al 1962), even if the chronological importance of the atypical pieces was questioned (Chirica 1989, 146). The radiocarbon dates (**Table 2.**), however, clearly support the typological evaluation of the site. The presence of shouldered points suggests for the Late Gravettian classification of the assemblage collected at Udeşti too (Bitiri 1981, 333, 337, Fig. 3,3). At this locality a single translucent obsidian was found (Bitiri 1981, 332; Chirica 1989, 76-78), probably from the surface of the site.

Recently from the eastern part of Romania the presence of obsidian was reported from the Epigravettian layer II of Lespezi – Lutărie, from the 2015 excavations of layer II of Bistricioara - Lutărie III and from the Gravettian or Epigravettian site of Piatra Neamț - Pietricica (Anghelinu et al. 2017, 28; 2018, 311; Dobrescu et al 2018, 112). However, the field reports and the review of the museum collections from these sites did not mention obsidian artefacts (Anghelinu et al, 2016, 223; Bitiri-Ciortescu et al 1989, 18-19; Tuffreau et al 2018, 151-156.).

Finally we have to shortly mention two localities from the Dniester valley. From the assemblage excavated in the upper layer of Voronovitsa I two obsidian artefacts were published (Chernysh 1956; Noiret 2009, 244). The well dated layer 5 of Cossautsi, lying between the embryonic soil horizons COS VI and COS V seven pieces were found during the 1995 season (Borziac et al 2006, 326, fig. 226, 3-6, 11-12; Noiret 2009, 256, 257). In the future the publication of these lithic assemblages will certainly provide important data on the use of obsidian in Eastern Romania and Moldavia. Moreover, considering the large distance of the raw material transport in these cases, the archaeometrical analysis of the artefacts would be important to confirm the macroscopic raw material determination.

Discussion and conclusions

From the assemblages discussed above, Buda and Udeşti most probably belong to the Gravettian period. After typological and biostratigraphic considerations the site of Arka, the lower layer of the Pilisszántó rock shelter, the upper yellow layer of the Bivak cave may also be dated to the Middle Upper Palaeolithic period, similarly to the surface collected assemblages in Slovakia and in Hungary. On the other hand, the upper artefact bearing layers documented immediately beneath the present day humic soil at Pilismarót - Bitóc and Bánom, at Jászfelsőszentgyörgy and probably in Arka may belong to the Late Upper Palaeolithic. The radiocarbon dated bone from Jászfelsőszentgyörgy - Székes-dűlő (with an age of 11.600±137 BP: Sümegi 2005, 226, Fig. 138) was possibly collected from the upper layer of this site. In the future, the detailed publication of these archaeological assemblages would be very important.

The use of obsidian in the assemblages dated to the Epigravettian period followed some simple principles. The transport of obsidian nodules and prepared cores and their on-site reduction is evidenced from the northern part of the Great Hungarian Plain (Jászfelsőszentgyörgy), from the Danube bend (Dömös, several sites around Pilismarót, Verőce, probably in Mogyorósbánya, see: Markó 2017) in Hungary and from Little Poland (Targowisko). The maximum of these localities from the source region is not more than 250 km and seemingly the Carpathians did not form an important geographical barrier during the

Epigravettian period (see **Table 1. and Fig.1.**.). The scarcity of the data of the obsidian transport from Poland may be due to the rarity of Epigravettian settlements. In any cases, we have to keep in our mind that the Targowisko site is dated to a more recent period, than that ones, known from Hungary or Slovakia. On the other hand, in the close vicinity of the mentioned localities in the Danube bend, the well preserved site of Esztergom yielded a single blade of obsidian, and from the assemblages of Pilismarót - Pálrét (Dobosi 2006) and Budapest - Csillaghegy (Gáboriné 1984) this raw material is absent, suggesting that the occurrence of this raw material was not regular in each assemblages of the Epigravettian period.

On the sites of the Danube bend and the Jászság area certain differences are observed in the exploitation of the obsidian sources. In Pilismarót - Diós and Jászfelsőszentgyörgy - Székes-dűlő, where only a few obsidian pieces were excavated, mainly a single little nodule of the Tolcsva or Mád variant was found. In the obsidian-rich assemblages from the neighbouring Pilismarót - Bitóc and Jászfelsőszentgyörgy - Szúnyogos site the best quality Slovakian variant was dominating with a large number of waste material and flakes, similarly to the Targowisko assemblage from Poland.

Finally, from the sites lying at a larger distance from the sources like Ságvár, Stránska skála, Grubgraben or the localities in the Bistrița valley only single tools or blanks of obsidian are known. According to the present data the maximum distance of obsidian transport in the Epigravettian period is 450 km (in the case of Grubgraben) or more than 500 km (the sites along the Dniester valley).

References

ANGELINU, M., NIȚĂ, L. & MURĂTOREANU, G., HAMBACH, U., SCHMIDT, C., VERES, D. & DUMITRAŞCU, V. (2016): Raport de cercetare arheologică, com. Ceahlău, punct: Bistricioara, Cronica, campania 2015, http://patrimoniu.gov.ro, 222–224.

ANGHELINU, M., MĂRGĂRIT, M. & NIȚĂ, L. (2017): A Paleolithic eyed needle from Bistricioara-Lutărie III (Ceahlău Basin, Northeastern Romania). *Studii de Preistorie* **14** 27–35.

ANGHELINU, M., NIȚĂ, L. & MURĂTOREANU, G. (2018): Le Gravettien et l'Épigravettien de l'Est de la Roumanie: une réévaluation. *L'Anthropologie* (Paris) **122 (2)** 183–219.

BAČO, P., KAMINSKÁ, L'., LEXA, J., PÉCSKAY, Z., BAČOVA, Z. & KONEČNÝ, V. (2017) : Occurrences of Neogene volcanic glass in the Eastern Slovakia – raw material source for the stone industry. *Anthropologie* (Brno) **LV** 207–230.

BÁNESZ, L. (1961): Zlomok hlinenej plastiky z paleolitickej stanice v Kašove. *Archeologické rozhledy* **XIII** 774–780.

BÁNESZ, L. (1961a): Výskum paleolitickej stanice v Kašove v roku 1960. *Študijné Zvesti AÚ-SAV* **6** 215–224.

BÁNESZ, L. (1969): Gravettské súvrstvia s obsidiánovou a pazurikou industriou v Kašove a Cejkove. *Archeologické rozhledy* **XXI/3** 281–290.

BÁNESZ, L. (1980): Výskum mladopaleolitickej stanice v Kašove. *AVANS* 1979 28–30.

BÁNESZ, L. (1990): Súčasná problematika paleolitu východného Slovenska a severovýchodnej časti Karpatskej kotliny. *Historica carpatica* **21** 9–19.

BÁNESZ, L. (1992): Prvé absolutnie datovanie nálezov z paleolitickej stanice Kašov I metódu C14. *AVANS* 1991 16.

BÁNESZ, L. (1993): K absolútnemu datovaniu paleolitických staníc obsidianovou industriou v Kašove a Cejkove. *AVANS* 1992 22.

BÁNESZ, L., HROMADA, J., DESBROSSE, R., MARGERAND, I., KOZŁOWSKI, J. K., SOBCZYK, K. & PAWLIKOWSKI, M. (1992): Le site de plein air du Paléolithique supérieur de Kašov 1 en Slovaquie Orientale. *Slovenská Archeológia* **XL** 5–28.

BÁRTA, J. (1970): Zur Problematik der gravettezeitlicher Besiedlung der Slowakei. *Slovenská Archeológia* **XVIII-2** 207–215.

BÁRTA, J. & PETROVSKÝ-ŠICHMAN, A. (1962): Paleolitické nálezy z Ipel'skej kotliny. *Archaeologické rozhledy* **XIV** 297–308.

BARTOLOMEI, G., BROGLIO, A. & PALMA DI CESNOLA, A. (1977): Chronostratigraphie et écologie de l'Epigravettien en Italie. In: *La fin des temps glaciaires en Europe - Chronostratigraphie et écologie des cultures du Paléolithique final.* C.N.R.S. 271, p. 297–324.

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

BIRÓ, K. (2006): Carpathian obsidians: myth and reality. In: Proceedings of 34th International Symposium on Archaeometry, Zaragoza, 2004. E-book: http://www.dpz.es/ifc/libros/ebook2621.pdf, Insttitución „Fernando el Católico" (C.S.I.C.) Excma. Diputación de Zaragoza, 2006, 267–277.

BIRÓ, K. (2014): Carpathian obsidians: state of art. In: YAMADA, M. & ONO, A. (eds): Lithic raw material exploitation and circulation in Prehistory. A comparative perspective in diverse palaeoenvironments. *ERAUL* **138** 47–69.

BIRÓ, K., MARKÓ, A. & KASZTOVSZKY, ZS. (2005): 'Red' obsidian in the Hungarian Palaeolithic - characterisation studies by PGAA. *Praehistoria* **6** 91–101.

BIRÓ, K. T., POZSGAI, I. & VLADÁR, A. (1986): Electron beam microanalyses of obsidian samples from geological and archaeological sites. *Acta Archaeologia Hungarica* **38** 257–278.

BITIRI, M. (1981): Aşezarea paleolitică de la Udeşti şi specificul ei cultural. *SCIVA* **32/3** 331–345.

BITIRI-CIORTESCU, M., CĂPITANU, C. & CĂRCIUMARU, M. (1989): Paleoliticul din sectorul subcarpatic al Bistriței în lumina cercetărilor de la Lespezi-Băcău. *Carpica* **20** 7–52.

BORZIAC, I., CHIRICA, V. & VĂLEANU, M.-C. (2006): Cultures et sociétés pendant le Paléolithique Supérieur à travers l'espace Carpato-Dniestréen. *Bibliotheca Archaeologica Moldaviae* **VI** Académie Roumanie. Filiale de Iaşi, Institut d'archéologie. Iaşi.

BRANDTNER, F. (1996): Zur geostratigraphische und kulturellen Zuordnung der Paläolithstation Grubgraben bei Kammern, NÖ. In: SVOBODA, J. (ed): *Paleolithic in the Muiddle Danube region – Anniversary volume to Bohuslav Klíma*. Archeologický ústav AV ČR, Brno, 121–145.

CĂPITANU, C. (1967): Aşezarea paleolitică de la Buda-Blăgeşti, regiunea Bacău. *Revista Muzeelor* **IV/3** 267–271.

CĂPITANU, C., BUZDUGAN, C. & URSACHE, V. (1962): Săpăturile de la Buda (r. Buhuşi, reg. Bacău). *Materiale şi Cercetări Archeologice* **VIII** 141–144.

CHERNYSH, A. P. (1956): Paleoliticheskaya stoyanka Voronovica I (Po dannym raskopok 1951-1953 gg.). *Kratkie Soobscheniya Instituta Istorii material'noj Kultury* **63** 40–47.

CHIRICA, V. (1989): The Gravettian in the east of the Romanian Carpathians. *Bibliotheca Archaeologica Iassiensis* **III** Al. I. Cuza University of Jassy, Jassy.

DOBOSI, V. (1974): Adatok a Bodrog-völgy őskőkorához. *Folia Archaeologica* **XXV** 9–32.

DOBOSI, V. (1992): A new Upper Palaeolithic site at Mogyorósbánya. *Communicationes Archaeologicae Hungariae* 5–17.

DOBOSI, V. (1993): Jászfelsőszentgyörgy-Szunyogos, Upper Paleolithic locality. *Tisicum* **8** 41–60.

DOBOSI, V. (1996): Upper Palaeolithic in the Danube Bend - In: SVOBODA, J. (ed.): *Palaeolithic in the Middle Danube Region*. Spisy Archeologckého Ústav AV CR v Brné, Svazek 5. Archeologicky ústav AV CR, Brno. 25–37.

DOBOSI, V. (2001): Antecedents: Upper Palaeolithic in the Jászság region. In: KERTÉSZ, R. & MAKKAY, J. (eds): *From the Mesolithic to the Neolithic*. Proceedings of the International Archaeological Conference held in the Damjanich Museum of Szolnok, September 22–27. 1996, Budapest, 177–191.

DOBOSI, V. (2006): Gravetti lelőhelyek Pilismarót környékén / Gravettian sites around Pilismarót. *Folia Archaeologica* **52** (2005-2006) 21–48.

DOBOSI, V. (2010): „…akkoriban ugyanis még paleolit régésznek készültem" (Patay Pál). „… at that time I was supposed to be a Palaeolithic researcher" (Patay Pál). In: GUBA, SZ. & TANKÓ, K. (szerkesztők): „Régről kell kezdenünk…" Studia Archaeologica in honorem Pauli Patay. *Régészeti tanulmányok Nógrád megyéből* Patay Pál tiszteletére. Szécsény, 11–21.

DOBOSI, V. (2011-2013): Őskőkori lelőhelyek Romhány környékén (Gyombola Gábor gyűjtése) / Palaeolithic sites around Romhány (collected by Gábor Gyombola). *Folia Archaeologica* **LV** 9–23.

DOBOSI, V. & SZÁNTÓ, Zs. (2003): A gravetti időszak hagyományos és radiokarbon koradatai. Traditional and radiocarbon dates of the Gravettian period. *Archaeologiai Értesítő* **128** 5–16.

DOBOSI, V., KÖVECSES-VARGA, E., KROLOPP, E., VÖRÖS, I., MAGYAR, I. & VARGA, I., HERTELENDI, E. (1991): Upper Palaeolithic site at Esztergom-Gyurgyalag. *Acta Archaeologia Hungarica* **43** 233–271.

DOBRESCU, R., TUFFREAU, A. & BONSALL, C. (2018): L'utilisation de l'obsidienne au Paléolithique supérieur dans le nord-ouest de la Roumanie. *L'Anthropologie* (Paris) **122** 111–128.

GÁBORI, M. & GÁBORI, V. (1957): Études archéologiques et stratigraphiques dans les stations de loess paléolithiques de Hongrie. *Acta Archaeologia Hungarica* **8** 3–117.

GÁBORI-CSÁNK, V. (1978): Une oscillation climatique a la fin du Würm en Hongrie. *Acta Archaeologia Hungarica* **30** 3–11.

GÁBORI-CSÁNK, V. (1986): Spuren des Jungpaläolithikums in Budapest. *Acta Archaeologia Hungarica* **38** 3–12.

HAESAERTS, P., BORZIAC, I., CHIRICA, V., DAMBLON, F. & KOULAKOVSKA, L. (2007): Cadre stratigraphique et chronologique du Gravettien en Europe centrale. *Paleo* **19** 31–51.

HAYNES, V. C., DAMON, P. E. & GREY, D. C. (1966): Arizona radiocarbon dates. *Radiocarbon* **8** 1–21.

HERTELENDI, E. (1991): Radiocarbon dating of a wood sample from an excavation near Esztergom-Gyurgyalag. *Acta Archaeologia Hungarica* **43** 271.

HERTELENDI, E. (1993): Radiocarbon age of a bone sample from the Upper Paleolithic settlement near Jászfelsőszentgyörgy. *Tisicum* **VIII** 61.

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

JÁNOSSY, D. (1986): Pleistocene vertebrate faunas of Hungary. Budapest.

JÁNOSSY, D., KRETZOI-VARRÓK, S., HERRMANN, M. & VÉRTES, L. (1957): Forschungen in der Bivakhöle, Ungarn. *Eiszeitalter und Gegenwart* **8** 18–36.

JANŠÁK, Š. (1935): Praveké sídliská s obsidiánovou industriou na východnom Slovensku.

KAMINSKÁ, Ľ. (1991): Význam surovinej základne pre mladopaleolitickú spoločnost vo východokarpatskej oblasti. *Slovenská Archeológia* **39** 7–58.

KAMINSKÁ, L. (2004): Time space systematics of Gravettian finds from Cejkov I. In: SVOBODA, J. A. & SEDLÁČKOVÁ, L. (eds): *The Gravettian along the Danube - Proceedings of the Mikulov Conference* 20-21. November, 2002. Archeologický ústav AV ČR, Brno, 186–215.

KAMINSKÁ, L. (2014): *Staré Slovensko 2*. Paleolit a mezolit. Nitra.

KAMINSKÁ, L. & NEMERGUT, A. (2014): The Epigravettian chipped stone industry from Nitra III site (Slovakia). In: BIRÓ, K. T., MARKÓ, A. & BAJNOK, K. P. (eds): *Aeolian scripts - new ideas on the lithic word - Studies in Honour of Viola T. Dobosi.* Magyar Nemzeti Múzeum, Budapest, 93–119.

KORMOS, T. & LAMBRECHT, K. (1915): A Pilisszántói kőfülke. Tanulmányok a postglaciális kor geologiája, ősipara és faunája köréből. *A Magyar Kir. Földtani Intézet Évkönyve* **XXIII/6** 309–498.

KOZŁOWSKI, J. K. & SOBCZYK, K. (1987): The Upper Palaeolithic site Kraków-Spadzista Street C2 – excavations 1980. *Prace Archeologiczne* **42** Nakładem Uniwersytetu Jagiellońskiego, Kraków.

KROLOPP, E. (1983): Malacological analysis of the samples from the Pilismarót-Pálrét. *Acta Archaeologia Hungarica* **35** 304–306.

KROLOPP, E. (1991): Malacological analysis of the loess from the archaeological site at Esztergom-Gyurgyalag. *Acta Archaeologia Hungarica* **43** 257–259.

LENGYEL, GY. (2008-2009): Radiocarbon dates of the "Gravettian entity" in Hungary. *Praehistoria* **9-10** 241–263.

LENGYEL, GY. (2016): Reassessing the Middle and Late Upper Palaeolithic in Hungary. *Acta Archaeologica Carpathica* **LI** 47–66.

LENGYEL, GY. (2018): Lithic analysis of the Middle and Late Upper Palaeolithic in Hungary. *Folia Quaternaria* **86** 5–157.

MARKÓ, A. (2002): Palaeolithic sites on the left bank in the Danube Bend. Unpublished master thesis (in Hungarian).

MARKÓ, A. (2014): Recent studies on the Upper Palaeolithic assemblage of Tarcal (Tokaj hill, north-eastern Hungary). In: BIRÓ, K. T., MARKÓ, A. & BAJNOK, K. P. (eds): *Aeolian scripts - new ideas on the lithic word - Studies in Honour of Viola T. Dobosi.* Magyar Nemzeti Múzeum, Budapest, 131–148.

MARKÓ, A. (2017): Use of obsidian from the LGM: case studies from the Pebble Gravettian sites in Hungary / Az obszidián felhasználása a kavicsgravetti leletegyüttesekben: esettanulmányok az utolsó hideg maximum idejéből. *Archeometriai Műhely* **XIV/3** 131–142.

NEUGEBAUER-MARESCH, CH., BACHNER, M. & TUZAR, J. M. (2008): Kammern-Grubgraben. *Wissenschaftliche Mitt. Niederösterr. Landesmuseum* **19** 109–118.

NICOLĂESCU-PLOPŞOR, C. S., CĂPITANU, V., BUZDUGAN, C. & URSACHE, V. (1961) Cercetările şi săpăturile archeologice de la Buda. *Materiale şi Cercetări Archeologice* **VII** 1–25.

NOVÁK, M. (2002) Gravettienske osídlenie spodnej vrstvy Kašova I. *Slovenská Archeológia* **L-1** 1–52.

NOIRET, P. (2009) Le Paléolithique supérieur de Moldavie. Essai de synthèse d'une évolution multi-culturelle. *ERAUL* **121** Liège.

PACHER, M. & STUART, A. J. (2008): Extinction chronology and palaeobiology of the cave bear (Ursus spelaeus). *Boreas* 10.1111/j.1502-3885.2007.00071.x.

PAZDUR, A. (1995) Radiocarbon dating. In: HROMADA, J. & KOZŁOWSKI, J. K. (eds): *Complex of Upper Palaeolithic sites near Moravany, Western Slovakia,* Vol. I Moravany-Žakovska. Jagellonian University Press, Kraków, 74.

PAZONYI, P. (2006): A Kárpát-medence kvarter emlősfauna közösségeinek paleoökológiai és rétegtani vizsgálata [Palaeoecological and stratigraphic investigations of the Quaternary mammal faunas in the Carpathian Basin]. *Manusript,* Diss., Budapest 2006.

PÉCSI, M. (1975) A magyarországi löszszelvények litosztratigráfiai tagolása. *Földrajzi Közlemények* **3-4** 217–230.

PÉNTEK, A. & ZANDLER, K. A Cserhát-hegység és az Ipoly-völgy felső paleolitikus és epipaleolitikus lelőhelyeinek topográfiája. *Neograd - A Dornyay Béla Múzeum Évkönyve* **XXXIX** 122–171.

PŘICHYSTAL, A. & ŠKRDLA, P. (2014) Kde ležel hlavní zdroj obsidiánu v pravěku střední Evropy? / Where was situated the principal source of obsidian in prehistory of Central Europe? *Slovenská Archeológia* **62** 215–226.

RINGER, Á. & SCHWEITZER, F. 1983. Stratigraphy, palaeogeography and palaeopedochronology of the Pilismarót-Pálrét Upper Palaeolithic site. *Acta Archaeologia Hungarica* **35** 307-311.

SÜMEGI, P. (2005): Loess and Upper Palaeolithic environment in Hungary – An introduction to the environmental history of Hungary. Aurea, Nagykovácsi.

SÜMEGI, P. & KROLOPP, E. (2000): Palaeoecological reconstruction of the Ságvár-Lascaux interstadial (Upper Weichselian). In: RINGER, Á. & MESTER, Zs. (réd.) A la recherche de l'Homme préhistorique. *ERAUL* **95** 103–112.

SVOBODA, J. (1991): Stránská skála. Výsledky výzkumu v letech 1985-1987. *Památky Archeologické* **LXXXII** 5–47.

SVOBODA, J. & NOVÁK, M. (2004) Eastern Central Europe after the Upper Pleniglacial: Changing points of observation. *Archäologisches Korrespondenzblatt* **34** 463–477.

ŠKRDLA, P., RYCHTAŘÍKOVA, T., EIGNER, J., BARTÍK, J., NIKOLAEV, P., VOKÁČ, M., NÝVLTOVÁ FIŠÁKOVÁ, M., ČEREVKOVÁ, A. & KNOTKOVÁ, J. (2014): Mohelno-Plevovce: lokalita osídlená v průběhu posledního glaciálního maxima a pozdního glaciálu. Archeologické rozhledy LX**VI** 243–270.

TOMASSO, A. (2017) L'épigravettien: variabilité diachronique et géographique. In: OLIVE, M. (dir.): *Campo delle Piane - un habitat de plein air épigravettien dans la vallée du Gallero (Abruzzes, Italie centrale).* Collection de l'École Française de Rome 526. École Française de Rome.

TUFFREAU, A., DOBRESCU, R., CIORNEI, A., NIȚĂ, L. & KOSTEK, A. (2018) Le Paléolithique supérieur de la basse vallée de la Bistrița (Moldavie roumaine): Buda et Lespezi, nouvelles recherches. *L'Anthropologie* (Paris) **122/2** 129–165.

VERPOORTE, A. (2002) Radiocarbon dating the Upper Palaeolithic of Slovakia: results, problems and prospects. *Archäologisches Korrespondenzblatt* **32-3** 311–25.

VÉRTES, L. (1962): Ausgrabungen der altsteinzeitlichen Siedlung von Arka 1960-61. *Acta Archaeologica Hungarica* **14** 143–157.

VÉRTES, L. (1964-1965): Das Jungpaläolithikum von Arka in Nord-Ungarn. *Quartär* **15-16** 79–132.

VÉRTES, L. (1965): *Az őskőkor és átmeneti kőkor emlékei Magyarországon.* Akadémiai Kiadó, Budapest.

VOGEL, J. C. & WATERBOLK, H. T. 1964. Groningen radiocarbon dates V. *Radiocarbon* **6** 349–369.

VOGEL, J. C. & WATERBOLK, H. T. 1967. Groningen radiocarbon dates VII. *Radiocarbon* **9** 107–155.

WILCZYŃSKI, J. (2009): Targowisko - a new Late Glacial site in Southern Poland. *Eurasian Prehistory* **6/1-2)** 95–118.

WILCZYŃSKI, J. (2010): Obsidian products from Targowisko 10 site (Wieliczka distr.) In: GANCARSKI, J. (red.): *Transkarpackie kontakty kulturowe w epoce kamienia, brązu iwczesnej epoce żelaza.* Muzeum Podkarpackie w Krośnie 109–131.

WILCZYŃSKI, J., WOJTAL, P., SOBIERAJ, D. & SOBCZYK, K. (2015) Kraków Spadzista trench C2: New research and interpretations of Gravettian settlement. *Quaternary International* **359-360** 96–113.

ZÖLLER, L. (2000): - Chronologie mittel- und jungwürmzeitlicher “Interstadialböden” im Löss an paläolithischen Freilandfundstellen Nieder-österreichs. *Quartär* **51/52** 195–209.

ANNOTATED BIBLIOGRAPHY OF STUDIES ON CARPATHIAN OBSIDIAN[•]

A kárpáti obszidiánok vizsgálatának annotált bibliográfiája

KATA SZILÁGYI[1]

[1]Móra Ferenc Museum, Szeged

E-mail: szil.szvetlana@gmail.com

Abstract

This paper gives a short annotated bibliography of studies on Carpathian obsidians, created, when accessible, on the basis of authors' abstracts. If possible, the original papers in pdf will be available on the conference website for IOC-2019 (http://ioc-2019.ace.hu/).

Kivonat

Ez a cikk a kárpáti obszidiánokkal foglalkozó tanulmányok annotált bibliográfiája. Amennyiben lehetséges, az eredeti közleményt letölthető pdf formájában közzé tesszük az IOC-2019 konferencia weblapján (http://ioc-2019.ace.hu/).

KEYWORDS: CARPATHIAN OBSIDIAN, RAW MATERIAL ANALYSES, ARCHAEOMETRY, BIBLIOGRAPHY

KULCSSZAVAK: KÁRPÁTI OBSZIDIÁN, ANYAGVIZSGÁLAT, ARCHEOMETRIA, BIBLIOGRÁFIA

Allard, P., Klaric, L., Hromadová, B.: Obsidian blade debitage at Kašov-Čepegov I (Bükk culture), Slovakia. *Bulgarian e-Journal of Archaeology* 7/1 (2017), 17–35.

This paper presents the first results of a new lithic study of the site of Kašov-Čepegov I (KČ-I) in eastern Slovakia. Excavations at Kašov were conducted by Ladislav Bánesz during the mid-1980's after finds were made during the digging of a drainage ditch. Archaeological excavation exposed a pit that contained several concentrations of hundreds of obsidian artefacts associated with decorated pottery sherds belonging to the Bükk culture. Previous analyses of the chipped stone industries from various sites have shown that obsidian played a major role in distribution networks, especially given the existence of so-called 'specialized on-site workshops' where blocks of raw material were preliminarily worked and partially exploited to obtain blades. Technological study of two concentrations at KČ-I shows that the chaîne opératoire of debitage of obsidian blades is quite distinctive and made by 'punch technique' (indirect percussion).

Astalos, C., Kasztovszky, Zs.: Prompt gamma activation analysis of some prehistoric stone tools from North-Western Romania. In: Moreau, J. F., Auger, R., Chabot, J., Herzog, A. (eds.): *Proceedings of the 36th International Symposium on Archaeometry.* [Proceedings Actes ISA 2006] Quebec, 2006, 135–140.

In this paper we present the first application of Prompt Gamma Activation Analysis (PGAA) on chipped stone tools from Romania. PGAA experiments were previously made on different chipped stone raw materials from Hungary, such as obsidian, grey flint and Szeletian felsitic porphyry. The main objective of the project was to determine the chemical composition of the rocks (major and trace elements) as a significant step in the studies of the provenance of the raw materials. For this, 24 samples from Satu Mare and Baia Mare museum collections have been investigated by PGAA. The samples originate from prehistoric sites from North-Western Romania, a region that is part of the Upper Tisza Basin, in the North of the Carpathian Basin. The pieces were selected from representative sites that belong to the Middle and Upper Palaeolithic, the Early and the Middle Neolithic, and the Middle Copper Age.

[•] How to cite this paper: SZILÁGYI, K. (2018): Annotated bibliography of studies on Carpathian obsidian. *Archeometriai Műhely* **XV/3** 277-308.

HU ISSN 1786-271X; urn: nbn: hu-4106

Bačo, P.: Obsidiánová industria – prehistorické sídliska. In: *Štátny Geologický Ústav Dionýza Štúra Bratislava*. Regionalne centrum Košice. Prírodovedecká Fakulta Uk Bratislava. Slovenska Asociácia Ložiskových Geológov, Kerkorund a.s. Košice. Východné Slovensko, 2003.

The presence of obsidian on prehistoric settlements in various forms is evidence of the oldest use of this raw material around its primary occurrences. Archaeologically dated settlements belong to the younger Aurignacian and the Gravettian, which means that this area was inhabited more than 25,000 years ago. and obsidian tools are the dominant artifact of this settlement. It is amazing to imagine that we can touch such an industry. It is also astonishing how they were able to work on this material and certainly used it for decorative purposes.

Bačo, P., Bačová, Z.: Autochtónne výskyty vulkanických skiel spojené s neogénnym vulkanizmom na východnom Slovensku. In: Žaár, O., Gragor, M. (eds.): 3. *Geologicko-Paleontologicko-Archeologická Diskusia 2014*. Výpovedná hodnota, kompatibilita a porovnateľnosť údajov získaných povrchovým prieskumom a výskumom. Bratislava, 2014, 8.

Occurrences of volcanic glass in eastern Slovakia are mainly genetically associated with acidic volcanic products. It is part of the bimodal andesite of rhyolite volcanism of the Upper Baden to the Lower Pannon. Rhyolithic and rhyodacitic volcanism is characterized by pyroclastic rocks in the form of tuffs and pumice tuffs, to a lesser extent with the presence of juvenile and lithic plumes and various forms of intrusive, especially extrusion, bodies with a unique passage into lava flows. In the Brehova area, the technical work revealed the positions of the argilitised volcanoclastic rocks with obsidian fragments. Only the nuclei of obsidian are present in this position, without the presence of splinters. The glassy facies and the pure volcanic glass were verified by drilling work under the upper andesite extrusion body Big Hill north of Brehov. Based on these facts we assume a primary-autochthonous position of obsidians in altered volcanoclastics. Their occurrence is autochthonous also in relation to their collection and subsequent use for the production of obsidian industry. The radiometric dating of similar nuclei of obsidian from Hrane (here, however, from anthropogenic positions) advises the emergence of these glasses at the bottom of Upper Baden.

Bačo, P., Kaminská, Ľ., Lexa, J., Pécskay, Z., Bačová, Z., Konečný, V.: Occurrences of Neogene volcanic glass in the Eastern Slovakia – Raw material source for the stone industry. *Anthropologie* 55/1/2 (2017), 207–230.

In Eastern Slovakia obsidians were used most extensively during the Late Palaeolithic and Neolithic. Natural occurrences of obsidian are linked with products of rhyolite/rhyodacite volcanism, where they associate with perlite. Viničky, Malá Bara and Brehov are the known natural occurrences. Considering the present state of knowledge, the Brehov locality is a primary source of secondary obsidian accumulations in Quaternary diluvial/fluvial deposits, partially covered by eolian sands, in the area of Brehov and Cejkov. Some of the macroscopic attributes, especially surface sculpture, of the obsidian cores from archeological sites resemble more those from the secondary accumulations. Conventional K/Ar dating of obsidians from natural occurrences and archeological sites implies multiple ages of natural sources. However, dating of obsidians at archeological sites points rather to a single source, or yet unknown source in addition to the secondary accumulations. Obsidians from at least two phases of rhyolite volcanic activity have been utilized for production of obsidian industry. Obsidians from the secondary accumulations in the area of Brehov and Cejkov apparently dominate at archeological sites and probably are equivalent to the subgroup C1a of the Carpathian obsidians.

Bánesz, L.: Cejkov II-III, nové paleolitické stanice s obsidiánovou industrious/Cejkov II-III, a new paleolithic site with obsidian industry. *Archeologické rozhledy* 11 (1959), 769–780, 801–802.

Not far from the Tokaj Mountains located the Upper Palaeolithic site Cejkov I, which is well known since 1932 thanks to the care of Š. Janšák. The paper focused on the recently discovered two new paleolithic sites, where also found obsidian industry. Both sites were located on the northern slope of a mountain range called Zemplinski ostrov.

Bánesz, L.: Výskum paleolitickej stanice Cejkov I v roku 1961/The research at the Paleolithic site Cejkov I in 1961. *Archeologické rozhledy* 14/6 (1962), 753–761.

The research of the Palaeolithic site at Cejkov continued. In some probes obsidian and chert artefacts were found, most of them in the stratigraphical position. Finds were found in the fifth probe. On the basis of the finds it can be said that the main settlements were on the ridge, where a lot of artefacts and animal bones were found as early as 1960.

Bánesz, L.: D'alší výskum na paleolitickej stanici Cejkov I/The further exploration of the Paleolithic site Cejkov. *Archeologické rozhledy* 16/3 (1964), 317–323.

During excavations in 1962, finds from the Early Gravettian, Gravettian and Aurignacien–Szeletien periods were recovered in stratigraphic position on the southern slope of the hill. The paper summarized the new excavation features and the lithic materials.

Bánesz, L.: Gravettské súvrstvia s obsidiánovou a pazúrikovou industriou v Kašove a Cejkove. *Archeologické rozhledy* 21/3 (1969), 281–290.

This paper summarized the succession of gravel layers with obsidian and flint industries in Kašov and Cejkov. The Archaeology Institute of the Slovak Academy of Sciences excavated at Kašov I in 1967, where two independent layers containing paleolithic finds. The lower layer was limited to an area of 12 by 8 m and is characterized by a larger quantity of flint tools while obsidian objects predominate in the superimposed layer. Both strata produced a considerable number of composite tools and are dated, from the point of view of research carried out on the surface, which confirmed the serious nature of the lithic industry identified there.

Bánesz, L.: Hromadný nález obsidiánovej suroviny na gravettskom sídlisku v Cejkove, okr. Trebišov. *Archeologické rozhledy* 26/1 (1974), 51–54.

During the rescue excavations in 1969, we have discovered depot find in the loess of the Würm 3 horizon comprising 41 pieces of obsidian. For some obsidian nodules, the knapping surface for detaching flakes was already prepared. The obsidian depot is shedding light on how the habitation site in Cejkov was supplied with obsidian. The location of the depot is about 5 km from the site. The collected material was prepared for processing, already tested and show the first phase of elaboration. The depot indicates that the nodules collected were brought to the site in one batch. Though the obsidian hoard was probably an element of regular supply, we cannot exclude – especially in the case of more distant settlements – barter trade.

Bánesz, L. Hromada, J., Desbrosse, R., Margerand, I., Kozłowski, J. K., Sobczyk, K., Pawlikowski, M.: Le site de plein air du Paléolithique Supérieur de Kašov 1 en Slovaquie Orientale. *Slovenská Archeológia* 40/1 (1992), 5–28.

The Kašov excavation has demonstrated the existence of two Gravettian levels among six lithostratigraphic units. Excavation was carried on by L Bánesz during 20 years (between 1960 and 1984). In the lower strata, there was an important and characteristical production of artefacts – mainly from flint (imported from southern Poland) – from Gravettian culture (968 artefacts in which 171 tools). There are less typical Gravettian features in the upper one where 43450 artefacts in which 3963 tools (mainly from obsidian) were distinguished. Spatial and technological analysis show many clusters (Kchemenitsa): – small concentrations (<100 pieces) with majority of tools – large concentrations (>100 Pieces) with many flakes and fragments.

Biagi, P., De Francesco, A.M., Bocci, M.: New Data on the archaeological obsidian from the Middle-Late Neolithic and Chalcholitic sites of the Banat and Transylvania (Romania). In: Kozłowski, J. K., Raczky, P. (eds.): *The Lengyel, Polgár and related cultures in the Middle/Late Neolithic in Central Europe*. The Polish Academy of Arts and Sciences Kraków – Eötvös Loránd University Institute of Archaeological Sciences Budapest, Kraków, 2007, 309–326.

This paper presents preliminary results obtained from the analysis of archaeological obsidian specimens from seven Middle Neolithic-Chalcolithic sites from the Banat and Transylvania (Romania). The XRF characterisation has shown that the Slovak Carpathian 1 source was almost exclusively exploited during both these periods. The typological analysis of the assemblages has demonstrated that the excavation retrieving methods are of fundamental importance in the study of the way this raw material circulated and the understanding of the activities carried out within each single site during a period of some 1000 radiocarbon years, from the late seventh to the late sixth millennium uncal. BP. These preliminary results fill a gap in our knowledge of the obsidian movements across the Carpathian Basin, which was badly known until a few years ago.

Biagi, P., Gratuze, B., Boucetta, S.: New data on the archaeological obsidians from the Banat and Transylvania. In: Spataro, M., Biagi, P. (eds.): *A Short Walk through the Balkans: the First Farmers of the Carpathian Basin and Adjacent Regions*. Società Preistoria Protostoria Friuli-V.G., Trieste, Quaderno 12, 2007, 129–148

New data on the archaeological obsidians from the Banat and Transylvania (Romania). This paper deals with the study of a limited number of obsidian artefacts from the earliest FTN Criş sites of the Banat and Transylvania. The first impression is that the first FTN farmers, who settled in the region at the turn of the 8th millennium uncal BP, had a limited local supply of bad quality lithic raw

materials. The pioneer search for workable stones, north of the maximum spread of the FTN, led to the discovery of the Slovak (Cejkov, Kašov: Carpathian 1) and Hungarian (Mád: Carpathian 2E), Tokaj deposits, which both started to be exploited on a very small scale.

Biagi, P., Gratuze, B., Kiosak, D. V., Tubolze, O. V., Popandopulo, Z. H.: The Neolithic Obsidians from Southeastern Ukraine: First Characterization and Provenance Determination. *Anadolu/Anatolia* 40 (2014), 1–20.

This paper discusses the results obtained from the characterization of six obsidian samples from the Neolithic sites of Lysa Gora and one from Semenovka 1, in southeastern Ukraine. They show that obsidians of different sources were utilized by the inhabitants of Lysa Gora, among which are Baksan (Russian Federation), Sjunik (Armenia) and another undefined source, while the provenance of the bladelet fragment from Semenovka 1 is of particular interest since it comes from one of the Göllüdağ outcrops in Central Anatolia. The first characterization of Ukrainian specimens fills a gap in our knowledge in the distribution of the archaeological obsidians in a wide region delimited by the Carpathians, in the west, and the Caucasus, in the east. They contribute to the interpretation of the models of their procurement and circulation in the steppe region northwest of the Azov Sea during the Neolithic.

Bigazzi, G., Neto, J. C., Norelli, P., Osorio Araya, A. M., Paulino, R., Poupeau, G., Stella de Navia, L.: Dating of Glass: The Importance of Correctly Identifying Fission Tracks. *Nuclear Tracks and Radiation Measurements* 15/1–4 (1988), 711–714.

Comparing age determinations by persons with different degrees of experience in FT dating shows that induced track counts are in good agreement but spontaneous track densities determined by beginners disagree with those determined by experienced persons. Proper identification of fission tracks appears to be of prime importance in glass samples; reliable data are the result of experience and careful selection of samples.

Bigazzi, G., Márton, P., Norelli, P., Rozoznik, L.: Fission Track Dating of Carpathian Obsidians and Provenance Identification. *Nuclear Tracks and Radiation Measurements* 17/3 (1990), 391–396.

Rhyolitic obsidians were sampled from the Tokaj Mountains (Hungary) and the neighbouring Zemplin Hills (Slovakia) for dating by the fission track (FT) method. The FT ages are found to cluster around I0 and 15Ma, respectively. On this basis "Carpathian" obsidians can be deafly distinguished from their Mediterranean counterparts. Three types of artifacts have been identified: two with sources in the Zemplin Hills and the third with a source in the Tokaj Mountains.

Bigazzi, G., Biró, K. T., Oddone, M.: Instrumental analysis I. The Carpathian sources of raw material for obsidian tool-making. (Neutron activation and fission track analyses on the Bodrogkeresztúr-Henye Upper Palaeolithic artefacts). In: Dobosi, T., V. (ed.): *Bodrogkeresztúr-Henye (NE-Hungary) Upper Palaeolithic site*. Magyar Nemzeti Múzeum, Budapest, 2000, 221–240.

The characteristics of the Carpathian obsidians have been analysed by fission track dating method and by instrumental neutron activation analysis. Chemical analysis and geological dating techniques together discriminate the sources of the Tokaj Mountains (Carpathian I, II) from other sources located in the Mediterranean and in Anatolia. Although part of the original primary sources cannot be located today, the best quality glass preferentially used by prehistoric man for tool-making comes in all probability from Eastern Slovakia. Prehistoric exploitation of the Tokaj obsidian sources started in early times, and the Upper Paleolithic site Bodrogkeresztúr-Henye had a remarkable role in this process.

Biró, K. T.: A Kárpát medencei obszidiánok vizsgálata / Investigation of obsidian from the Carpathian Basin. *Archaeológiai Értesítő* 108 (1981), 194–205.

Archaeometrical study of the Carpathian obsidian source area has solved the problem of identification of obsidian found in the Tokaj-Eperjes Mountains, namely in South-Eastern Slovakia (Carpathian I. type) and in the surroundings of Erdőbénye (Carpathian II). The analyses were carried out by O. Williams, by means of neutron activation. Here some additional data given concerning the chemical analysis data, optical emission spectroscopic data and petrographical thin sections of the Carpathian I–II, source collected material. Chemical analysis data corroborate William's grouping, while, on the other hand, it provides a basis which to compare Carpathian I–II analysis data to other chemical analysis results obtained from archaeological obsidian finds published earlier in the literature.

Biró, K. T.: Hydration rates of the Carpathian Obsidians from Archaeological Lithic assemblages. In: Pécsi, M. (ed.): *INQUA XII Quaternary Studies in Hungary*. INQUA Hungarian National Committee – Magyar Tudományos Akadémia Földrajztudományi Kutató Intézet, Budapest, 1982, 135–144.

In the 1960's L. Vértes compiled a set of obsidian samples, from Middle Palaeolithic to Early Copper Age and transferred it the Geochemical Laboratory of the Hungarian Academy of Sciences for exploring potentials of obsidian hydration dating. The actual measurements were performed by K. Biró in the late seventies and published on the occasion of INQUA XII.

Biró, K. T.: Az obszidián archaeometriai vizsgálata / Archaeometrical investigation of obsidian. *Régészeti Továbbképző Füzetek* 1 (1982), 56–64.

Obsidian has special significance in both the material culture of prehistoric people and the subject of investigation for researchers of prehistoric cultures. The reason for this can be found in the specific qualities, formation and characteristics of the material. Namely obsidian is a quenched lava in which the constituting compounds freeze without crystallization. It is produced under specific conditions therefore it is relatively rare. Its chemical composition can vary widely but remains strictly homogeneous on the same source offering the possibility for provenancing, i.e. source characterisation, even for distant items. The special qualities made obsidian a desirable commodity for prehistoric people; its chemical and structural qualities make it very useful for archaeometrical investigation including archaeological and geological dating.

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

This paper summarizes results of systematical survey for obsidian in the most important Hungarian museum collections for Palaeolithic stone artefacts, i.e., the Hungarian National Museum and the Herman Ottó Museum, Miskolc. The role of obsidian in the Hungarian Palaeolithic is important but typically not dominant. Obsidian use is only one factor in a vast system of prehistoric economy.

Biró, K. T.: Prehistoric American stone tools in the collection of the Hungarian Ethnographic Museum. Néprajzi Értesítő. *A Néprajzi Múzeum Évkönyve* 74 (1992), 151–187.

A major collection of 'Palaeo-Indian' stone tools has been donated to the International Collection of the Hungarian Ethnographical Museum from Oregon, U.S.A. The assemblage was collected by a private collector at the locality Coffeepot Flat near the Chewaucan River, South-Central Oregon, at several sites and during a long period. A subsequent professional archaeological survey of the region indicated at least 50 settlements of various character from a wide temporal range (8000 B.C–1850 A.D.). Key finds of the region, chronologically significant projectile points, were unfortunately rare in the reach of the archaeological expedition, selected previously by the 'hobbyistic collecting activities' of private collectors. The assemblage presented to the Hungarian Ethnographical Museum contains, almost exclusively, choice pieces missed during the professional field surveys. This paper aims at presenting these beautiful and chronologically significant lithics, with an eye on the special circumstances resulting in one of the last effective hunter-gatherer economies of the World.

Biró, K. T.: A kárpáti obszidiánok: legenda és valóság. *Archeometriai Műhely/Archaeometry Workshop* 1/1 (2004), 3–8.

This paper is intended to give a review on the study of Carpathian Obsidian. The name implies the only source region in Central Europe, for long, the only source of archaeological obsidian in Continental Europe. Their archaeological, as well as geological research started in the sixties of the 19th century by the activity of pioneering personalities of Hungarian archaeology, geology and archaeometry. By the late 1970-ies, separation of Carpathian obsidian sources from other sources of European and other Mediterranean sources could be achieved (investigations of Warren and Williams), and intensive studies continued in the past decades. In spite of several publications devoted to the subject, there are still a lot of clearly erroneous views lingering in technical literature concerning the location of the sources and allocation of archaeological specimens. The first review of the author on the Carpathian obsidian was published in 1981: in the meantime, several research groups performed smaller or bigger research series on related finds, using various methods of analysis (NAA, EDS, XRF, FTD, PIXE-PIGE and recently, PGAA). Collection of obsidian distribution was completed using reference data as well as analysis of various assemblages dating from Middle Palaeolithic to Iron Age. Distribution maps were compiled for specific periods using percentage values. Access strategies, political implications could be claimed on the basis of changes in distribution areas.

Biró, K. T.: Carpathian Obsidians: Myth and reality. In: *Proceedings of the 34th International Symposium on Archaeometry*, 3–7 May 2004, Zaragoza, Spain. Institution Fernando el Catolico 2006, 267–278. (E-book, http://www.dpz.es/ifc/libros/ebook2621.pdf)

This paper is intended to give a review on the study of Carpathian obsidian. The name implies the only source region in Central Europe, for long, the only source of archaeological obsidian in Continental Europe. Their archaeological, as well as geological research started in the sixties of the 19th century by the activity of pioneering personalities of Hungarian archaeology, geology and archaeometry. By the late 70-ies, separation of Carpathian obsidian sources from other sources of European and other Mediterranean sources could be achieved (investigations of Warren and Williams), and intensive studies continued in the past decades. In spite of several publications devoted to the subject, there are still a lot of clearly erroneous views lingering in technical literature concerning the location of the sources and allocation of archaeological specimens. The first review of the author on the Carpathian obsidian was published in 1981: in the meantime, several research groups performed smaller or bigger research series on related finds, using various methods of analysis (NAA, EDS, XRF, FTD, PIXE-PIGE and recently, PGAA). Collection of obsidian distribution was completed using reference data as well as analysis of various assemblages dating from Middle Palaeolithic to Iron Age. Distribution maps were compiled for specific periods using percentage values. Access strategies, political implications could be claimed on the basis of changes in distribution areas.

Biró, K. T.: Az obszidián kultúrtörténete. In: Baráz, Cs., Kiss, G. (szerk.): *A Zempléni Tájvédelmi Körzet*. [A Bükki Nemzeti Park Igazgatóság Monográfiái 3] Bükki Nemzeti Park Igazgatóság, Eger, 2007, 279–282.

The paper summarizes formation, physical qualities, natural occurrences of obsidian for the general public. It deals specifically with sourcing and use of the Tokaj obsidians as important raw material of the Zemplén area. Highlight of archaeological and ethnographical obsidian use are presented.

Biró, K. T.: Carpathian Obsidians: State of Art of Central European Obsidian Research (in Japanese). In: Yamada, M., Ono, A. (eds.): *Lithic raw material exploitation and circulation in Prehistory. A comparative perspective in diverse paleoenvironments*. Series: Etudes et recherches archéologiques de l'Université de Liège No. 138., Université de Liège, Service de préhistoire & Centre de recherches archéologiques. 2014, 47–69.

This paper gives an actual summary of obsidian studies in Central Europe, related to the so-called Carpathian sources. History of research for the geological sources and the archaeological distribution data are presented together with summary information on instrumental analysis. The survey is necessarily biased and incomplete but storing information in a widely accessible interactive database, planned in the framework of the National Scientific Fund (OTKA-100385) may help to promote research. Collecting distribution data based on archaeological lithic research and instrumental characterisation of comparative material and archaeological obsidian artefacts allow us to delineate main distribution features and possible interacting supply zones. The historical importance of Carpathian obsidians is especially evident in the Palaeolithic period, when C1-C2-C3 obsidian sources were the only available mainland obsidian sources known and utilised by prehistoric people in Europe (apart from sources in Georgia and Armenia). It is to be remembered that data collection is far from completed, especially to the East of the obsidian sources. Source characterisation of Carpathian obsidians is feasible using several methods. Recently an essential advance was brought about using non-destructive methods that is imperative in the study of long distance trade connections.

Biró, K. T.: „Némi derű”. Rómer Flóris és a kőeszközök kutatása / “Some Gaiety”. Flóris Rómer and the study of the stone implements. *Arrabona* 51 (2013) [2015], 63–86.

An important element of the multifaceted activity of Flóris Rómer was the Prehistoric time, especially the investigation of the various lithic tools. In contrast to “antiquarian”, “value-oriented” and “cult of antiquities” approach, he recognized the historical significance of the lithic ground stones and tools and he described the possible and the most important research ways of these artefacts. These directions were: the morphology, the raw material, the technology of the tool making procedure and the approach of the ethnoarchaeology. He accompanied the first step of the lithic tools research from he recognized the lack, during the search and to the first integrated result which were significant in an international way also.

Biró K. T., Kasztovszky, Zs.: Obsidian Studies Using Nuclear Techniques in Hungary. *Science for Heritage Newsletter* 1/1 (2003), 6–9.

Obsidian is a success story in lithic provenance studies. The beauty, rarity and adaptability of the material for the purpose of making stone tools made it popular and widely known both in prehistory, folklore and studies. Obsidian is a special kind of rock and gemstone in many ways. Though it looks like a mineral on the strength of its homogeneity, it is a volcanic rock with generally *very high silica (SiO_2) content. Obsidian is formed from rhyolitic lava by quenching, i.e., the very fast, practically instantaneous cooling and solidification of the magma. These circumstances can be most easily met at volcanic islands surrounded by large water bodies like sea or ocean, occasionally lakes and ice sheet. The result is a solidified rock with no apparent mineral phases. The glass will, by the advance of geological times, crystallize starting from the surface and turn into felsitic volcanic rock with growing number of crystallites and, later, crystals of zeolite and feldspar.*

Biró K. T., Pozsgai, I.: Obszidián hidrációs kérgének vizsgálata kormeghatározás céljából / Obsidian hydration rind measurement for archaeological dating. *Archaeológiai Értesítő* 109 (1982), 124–132.

Obsidian hydration dating is a modern method of scientific dating in archaeology, independent of traditional historical and typological dating techniques. It. was developed in the early sixties, along with geochemical and glass structure studies in the U.S.A. In our paper we will describe the hydration phenomenon and summarize the experiences of hydration dating obtained during archaeological dating, measurement techniques, and sources of error and their possible elimination on the basis of the technical literature. For a long time, Hungarian adaptation of the method has been hindered by technical difficulties. In our efforts to measure the thickness of the hydration layer, we found that traditional thin-section technique failed to preserve the hydration rind. Furthermore, the rind embedded in an artificial resin, optical and abrasional distortion caused an error of 50% of the measured thickness, especially in the case of relatively thin (1–2 μm) hydration rinds characteristic of Neolithic, Carpathian I type obsidian implements deposited in caves. In order to achieve a high accuracy measurement technique, we elaborated a new method for hydration rind measurements, which is, at the same time, suitable for source characterization. We used a scanning electron microscope for this purpose, and, exploiting further potentials of the electron microscope, we performed electron microprobe analysis on the obsidian samples. We detected chemical differences between the hydrated glass and the inner intact structure, and we separated Carpathian I and Carpathian II type obsidian samples. Our results agree well with the known results of some previous methods for Carpathian obsidian source characterization and examinations concerning the hydration phenomenon.

Biró K. T., Pozsgai, I.: Obszidián lelőhely-azonosítás elektronsugaras mikroanalízis segítségével / Obsidian characterization by electron microprobe analysis. *Iparrégészet/Industrial Archaeology* 2 (1984), 25–37.

In the course of analysing obsidian preparata for hydration rind measurements, microprobe analyses were performed on archaeological material from several cave sites. The artefacts were identified on macroscopic inspection as belonging to Carpathian 1 (Slovakian) and Carpathian 2 (Hungarian) types. The EDS spectra corroborated the observed differences. The most distinctive elements were silicon and iron, respectively. More analytical studies are planned in near future.

Biró, K. T., Vladár, A.: Raw material analysis of the Oregon – Coffeepot flat lithic assemblage. Néprajzi Értesítő. *A Néprajzi Múzeum Évkönyve* 74 (1992), 189–202.

The lithic assemblage of the Coffeepot Plain, Oregon (USA) is deposited in the Hungarian Ethnographical Museum. The material was donated to the Museum by Nicholas Salgó, and comprises over 1300 items. The detailed typological presentation of the material is given by K. Biró, including macroscopical determination of the raw material. The overwhelming majority of the artifacts were made of obsidian. There were 13 macroscopical varieties separated among the obsidian artifacts according to colour, pattern and transparency. As it has been emphasized in connection with the typological study of the assemblage, it is obviously difficult to interpret achaeological problems of geographically remote and unfamiliar assemblages. This is even more true for an adequate provenance study of the material. Being aware of the limitations resulting from the lack of field information and improper amount of references we tried to apply our routine methods of analysis to the study of the raw material of the Salgó-Collection.

Biró K. T., Pozsgai, I., Vladár, A.: Electron beam microanalyses of obsidian samples from geological and archaeological sites. *Acta Archaeologica Academiae Scientiarum Hungaricae* 38 (1986), 257–278.

This paper summarizes the obsidian characterization studies performed conjointly by the Hungarian Geological Institute and the Institute for Applied Physics since 1981. The Central European obsidian occurrences are described and the associated geological and archaeological material is analysed in detail. These sources are referred to, after the terminology introduced by O. Williams, as "Carpathian obsidian sources", in spite of some misleading connotations of the term. Comparative material from the most important European obsidian sources were examined and a

number of archaeological obsidian finds, mainly from the territory of Hungary. The methods applied for the characterization of the samples were EDS (electron energy dispersive X-ray spectroscopy) and ED-XRF (energy dispersive X-ray fluorescence). The quantitative evaluation of the results were supported, as control method, by wet chemical analyses of the main components. The applied procedure seems sensitive enough for the examination of archaeological samples, requiring, at the same time, relatively short time and low cost.

Biró K. T., Pozsgai, I., Vladár, A.: Central European obsidian studies. State of affairs in 1987. *Archaeometrical Research in Hungary* 1 (1988), 119–130.

Continuation of obsidian studies by EDS (electron energy dispersive X-ray spectroscopy) and ED-XRF (energy dispersive X-ray fluorescence) in the collaboration of the Hungarian Geological Institute and the Institute for Applied Physics published in the first collective volume on archaeometrical research in Hungary.

Biró, K. T., Elekes, Z., Gratuze, B.: Instrumental analysis II. Ion beam analyses of artefacts from the Bodrogkeresztúr-Henye lithic assemblage. In: Dobosi, V. (ed.): *Bodrogkeresztur-Henye (NE-Hungary) Upper Palaeolithic Site*. Magyar Nemzeti Múzeum, Budapest, 2000, 241–245.

In frames of a collaboration project between the Hungarian National Museum and the Institute of Nuclear Research, Debrecen (ATOMKI), ion beam analytical techniques were used for provenancing geological and archaeological samples of a, obsidian b, radiolarite c, control samples of various other local materials (limnic quartzite, „stone marrow"). PIGE and PIXE methods were used for analysis in the ATOMKI; additionally, LA-ICP was used for the analysis of obsidian samples in Orléans, France. Identification of obsidian samples proved to be effective as known for several analytical techniques already; analysis of radiolarite samples represent preliminary state of research with a lot of open questions. Details of results on geological source areas and efficiency of characterisation are given elsewhere. In this paper, the data relevant to the Bodrogkeresztúr Upper Palaeolithic site are presented.

Biró, K. T., Markó, A., Kasztovszky, Zs.: 'Red' obsidian in the Hungarian Palaeolithic characterisation studies by PGAA. *Praehistoria* 6 (2005), 1–11.

Red obsidian is a rare commodity in the Carpathian Basin. It is known to occur among the outcrops only at C2T (Tolcsva environs) sources, and only in very small quantities. In the archaeological material, only sporadical occurrences were observed. As red obsidian is more common and better known from Eastern Mediterranean sources (notably Armenia and in subordinate quantity, Anatolia) the origin and characterisation of these pieces gave ground to a specific study. For the investigation of red obsidians, a non-destructive multielement nuclear analytical technique, prompt gamma activation analysis (PGAA) was used that has recently proved to be adequate for provenancing obsidian. The investigated red obsidians show similar chemical composition to the black obsidians found at the same source. Differences altogether are not very big and mainly observable in some diagnostic elements. Principal Component Analysis (PCA) and bivariate plots were used to distinguish between obsidian source regions and allocate newly analysed red obsidian to known source groups. As a result, we can establish that all archaeological pieces known so far come from the local sources.

Bonsall, C., Gurova, M., Elenski, N., Ivanov, G., Bakamska, A., Ganetsovski, G., Zlateva-Uzunova, R., Slavchev, V.: Tracing the source of obsidian from prehistoric sites in Bulgaria. *Bulgarian e-Journal of Archaeology* 7/1 (2017), 37–59.

Portable X-ray fluorescence (pXRF) spectrometry was used to obtain source determinations for 11 obsidian artefacts from five archaeological sites in Bulgaria. The results show that all the archaeological specimens can be linked to obsidian sources in the Carpathian Mountains in the border region between Hungary and Slovakia. Obsidian from the C2E source in Hungary occurred in very early Neolithic contexts at Dzhulyunitsa, while the majority of samples from later contexts at Ohoden, Dzherman and Varna came mainly from the Slovakian (C1) source. The data hint at a shift from the use of C2 obsidian in the Neolithic before 5900 cal BC, to a preference for C1 obsidian in later periods – however, more finds and better contextual and chronological data are required to verify this trend.

Bonsall, C., Elenski, N., Ganetsovski, G., Gurova, M., Ivanov, G., Slavchev, V., Zlateva-Uzunova, R.: Investigating the provenance of obsidian from Neolithic and Chalcolithic sites in Bulgaria. *Antiquity* 91/356 (2017), 1–6.

Portable energy-dispersive X-ray fluorescence (pXRF) has become a widely used tool for the chemical characterisation (source identification) of obsidian found in archaeological contexts. While laboratory techniques such as neutron activation analysis (NAA) and inductively coupled plasma mass spectrometry (ICP-MS) can analyse more elements and have lower detection limits, pXRF can

provide quantitative data of sufficient resolution to be able to match obsidian artefacts with their volcanic sources. At the same time, pXRF offers several advantages for obsidian research: (i) it can be deployed 'in the field' (i.e. on site or in a museum) without the need to bring samples back to a laboratory for analysis; (ii) information on elemental composition can be obtained relatively quickly; and (iii) measurements require no special preparation of samples and cause no visible damage to materials. The research outlined here forms part of a wider study of archaeological obsidian in south-eastern Europe involving archaeologists from Bulgaria, Romania and the UK, with the aim of reconstructing changes in patterns of procurement, production and use of obsidian between the Middle Palaeolithic and the Iron Age.

Bugoi, R., Constantinescu, B., Neelmeijer, C., Constantin, F.: The potential of external IBA and LA-ICP-MS for obsidian elemental characterization. *Nuclear Instruments and Methods in Physics Research Section* B 226 (2004), 136–146.

Combined external Ion Beam Analysis (IBA) measurements, consisting of Proton Induced X-ray Emission–Proton Induced Gamma-ray Emission–Rutherford Back-Scattering (PIXE-PIGE-RBS) have been performed on several obsidian fragments with archaeological significance at the Rossendorf tandem accelerator using a 3.85 MeV proton beam. A comparison was made between these external IBA results and the ones previously obtained on the same obsidian samples using Laser Ablation–Inductively Coupled Plasma–Mass Spectrometry (LA-ICP-MS). The purpose of the study was to assess the potentiality of external IBA for provenance studies on archaeological obsidian, especially as a non-destructive alternative to the LA-ICP-MS method. As an example, the source attribution of an archaeological obsidian fragment from Transylvania to Tokay Mountains/Slovakian range flow is discussed.

Burgert, P.: Štípaná industrie z obsidiánu v Čechách/Chipped industry from obsidian in Bohemia. *Archeologické Rozlhedy* 67 (2015), 239–266.

Chipped industry from obsidian in Bohemia. The work provides an overview of Bohemian finds of prehistoric chipped artefacts made from obsidian. Attention is also paid to the Late Neolithic period, when the share of this raw material in Bohemian assemblages culminates and, at the same time, the finds can be more accurately dated. Two of the richest assemblages, which come from Smiřice and Plotiště nad Labem near Hradec Králové, are analysed in detail. The work also expands its spatial framework to include the Svitavy region due to the close ties between this area and east Bohemia. Obsidian was processed at Stroked Pottery culture settlements in the form of nodules brought to the sites; based on the internal construction of artefacts, only a small number of pieces were extracted at the processing sites. The most probable source of raw material for Bohemian finds are Zemplínské vrchy (the Zemplín Highlands) in southeast Slovakia, while Tokajsko-Zemplínské vrchy (the Tokaj-Zemplín Highlands) in northeast Hungary are also possible, albeit less likely.

Burgert, P., Přichystal, A., Prokeš, L., Petřík, J., Hušková, S.: Původ obsidiánové suroviny v pravěku Čech / The origin of obsidian in prehistoric Bohemia. *Archeologické Rozhledy* 68 (2016), 224–234.

The paper presents the results of the first geochemical analysis conducted on prehistoric obsidian artefacts from Bohemia. Eleven samples from reliably dated contexts were chosen for the study. The vast majority of the analysed samples can be classified into the Neolithic period. The artefacts were analysed using two non-destructive geochemical methods: concentration values determined by portable X-ray fluorescence spectroscopy (pXRF) were calibrated using the results of laser ablation inductively coupled mass spectrometry (LA-ICP-MS). Based on the results, the origin of nine samples can, with the greatest degree of probability, be traced to Slovakia, the other two to Hungary.

Burgert, P., Přichystal, A., Prokeš, L., Petřík, J., Hušková, S.: The origin and distribution of obsidian in prehistoric Bohemia. *Bulgarian e-Journal of Archaeology* 7 (2017), 1–15.

This paper summarizes current knowledge of the distribution of obsidian in prehistoric Bohemia (Czech Republic). In terms of this raw material's distribution, Bohemia is a peripheral area, and it is also the westernmost part of its regular archaeological occurrence. Because of its rarity within the specified area, it is possible to identify this material quite easily even in earlier archaeological literature, and together with new discoveries, to create a coherent picture of its distribution. So far, only two locations in Bohemia have been described where the processing of raw obsidian material is documented. Both these sites are located in the eastern part of the study area; in terms of location these are the closest sites to the anticipated sources. The sites are dated to a later stage of the Stroked Pottery culture. Because no such processing sites are known from other periods, we believe it was mainly the distribution of entire

blanks and prepared cores that took place at that time. Furthermore, our study discusses the original sources of obsidian in terms of the region that is being monitored. In accordance with the aims of our investigation, the selected obsidian artefacts were subjected to geochemical analysis to identify their origins. The peak of the distribution is the period of the Stroked Pottery culture (4900–4500/4400 cal BC). The basic outcome of the geochemical analysis is the identification of at least two sources of raw material in the Carpathian source area.

Cann, J. R., Renfrew, C.: The Characterization of Obsidian and its application to the Mediterranean Region. *Proceedings of the Prehistoric Society* 30 (1964), 111–133.

Evidence of contact between cultural groups is of great importance to the study of prehistory. Although the development of absolute dating methods has decreased our dependence on the discovery of such contacts for chronology, they are essential material when the origin and spread of culture is being studied. In the past, cultural contacts have generally been demonstrated by typological similarities of artifacts, but unfortunately many typological comparisons are open to discussion, and it can be exceedingly difficult to be certain of direct contact by this means alone. The importance in this respect of the study of raw materials used in places far from their place of origin and presumably deliberately imported has long been realized. Recently more attention has been paid to the careful characterization of such materials; the detection, that is, of properties of the specimen under study which are characteristic of material from particular sources. By this means it is often possible to assign a source to a given specimen. The petrological identification of British neolithic stone axes is perhaps the most comprehensive archaeological characterization study yet undertaken. Demonstrations of trading links made by such methods, if based on a sure identification and a comprehensive survey of possible sources, are not open to the criticism and doubt which may be directed at typological similarities. The variety of techniques now available for the analysis and identification of materials makes this field a promising one for the archaeologist.

Carter, T.: The contribution of obsidian characterization studies to early prehistoric archaeology In: Yamada, M., Ono, A. (eds.): *Lithic raw material exploitation and circulation in Prehistory. A comparative perspective in diverse paleoenvironments*. Series: Etudes et recherches archéologiques de l'Université de Liège No. 138., Université de Liège, Service de préhistoire & Centre de recherches archéologiques. 2014, 23–33.

This paper details the interpretative role obsidian characterisation studies can play in earlier prehistoric archaeology. It reviews recent contributions to debates on early hominine cognitive development and social complexity, the question of Neanderthal mobility, and how obsidian sourcing is shedding light on colonisation processes globally. Methodologically it is suggested that by adopting a more holistic chaîne opératoire analytical framework, which integrates an artefacts' elemental data with its techno-typological attributes, we can maximise the interpretative potential of our data, and provide a more powerful means of reconstructing past networks of interaction, or 'communities of practice'.

Çetin-Draskovits, D.: *Obsidiane ausgewählter steinzeitlicher Fundstellen in Ostösterreich*. Diplomarbeit der Historisch-Kulturwissenschaftlichen Fakultät der Universität Wien, 2013.

Obsidians and their significance in prehistory have been an important field of research in archaeology since 1960's. They offer, like any other material of Prehistory, the possibility of adding a small piece of mosaic to the image of the study of human history. Their high esteem and wide distribution all over the world, even in areas where obsidian does not occur naturally, give an insight into prehistoric life. Very important is also the practical use of the obsidian for archaeology. After all, determinations of origin can trace the mobility and exchange paths of prehistoric human. Independent obsidian research, as it is known from the Mediterranean region or the Carpathian region, does not exist in Austria. This PhD dissertation attempts to take a first modest step in this direction.

Chirica, V., Kacsó, C., Văleanu, M.: Contribuții privind prezența obsidianului, ca materie primă pe teritoriul României / Contribution concernant la présence de l'obsidiane entant que matière première sur le territoire de la Roumanie). *Carpica* 27 (1998), 9–20.

Although obsidian tools have been discovered in the paleolithic deposits of Țara Oaşului (Aurignacian and Gravettian), it is considered possible that this raw material comes from natural deposits, located in Hungary, Slovakia and Ukraine. Recent research carried out on the territory of the municipality Maramureş of the department Maramureş has revealed the existence of kidneys, clouds, chips and primary products of debiting. In conclusion, there are also on the territory of Romania, more precisely in Țara â (the Country of Țara) deposits of obsidian used by the paleolithic communities at the size of the tools.

Comşa, E.: L'usage de l'obsidienne a l'epoque neolithique dans le territoire de la Roumanie. *Acta Archaeologica Carpathica* 11 (1969), 5–15.

Review of archaeological obsidian finds from the Neolithic period on the territory of Romania.

Constantinescu, B., Bugoi, R.: Obsidian provenance studies of Transylvania's Neolithic tools using PIXE, micro-PIXE, PIGE, RBS and XRF. *Studia Universitatis Babeş-Bolyai, Geologia* [Special Issue, MAEGS – 16 Univ. Babeş-Bolyai] (2009), 77–78.

Obsidian is a natural volcanic glass, which was widely used for prehistoric stone tools and traded over long distances. In the case of Transylvania (the North-Western part of Romania), the sources of the prehistoric tools are supposed to be Tokaj Mountains, Greek islands, Armenia and Turkish-Asia Minor. We used PIXE and XRF to analyse various obsidian tools from the above sources. The two-dimensional scatter plots of Ti/Mn versus Rb/Zr and Ba/Ce versus Y/Zr were considered as source indicators. On the basis of these classifications, the majority of the Transylvania's obsidian prehistoric tools were determined as coming from either Hungarian or Slovakian Tokaj Mountains.

Constantinescu, B., Bugoi, R., Sziki, G. Á.: Obsidian provenance studies of Transylvania's Neolithic tools using PIXE, micro-PIXE and XRF. *Nuclear Instruments and Methods in Physics Research Section* B 189 (2002), 373–377.

Obsidian is a natural volcanic glass, which was widely used for prehistoric stone tools and traded over long distances. In the case of Transylvania (the North-Western part of Romania), the sources of the prehistoric tools are supposed to be Tokaj Mountains, Greek islands, Armenia and Turkish-Asia Minor. We used PIXE and XRF to analyse various obsidian tools from the above sources. The two-dimensional scatter plots of Ti/Mn versus Rb/Zr and Ba/Ce versus Y/Zr were considered as source indicators. On the basis of these classifications, the majority of the Transylvania's obsidian prehistoric tools were determined as coming from either Hungarian or Slovakian Tokaj Mountains.

Constantinescu, B., Cristea-Stan, D., Kovács, I., Szőkefalvi-Nagy, Z.: Provenance studies of Central European Neolithic obsidians using external beam milli-PIXE spectroscopy. *Nuclear Instruments and Methods in Physics Research* B 318 (2014), 145–148.

External beam milli-PIXE technique was used for the determination of the elemental concentration ratios in some Prehistoric obsidian tools found in Transylvania, in the Iron Gates region near Danube, as well as on a few relevant geological obsidian samples from Slovak Tokaj Mountains, Lipari, Armenia. As provenance ''fingerprints'' the Ti to Mn and Rb to Zr ratios were used. The results confirm that the Transylvanian Neolithic samples have a Slovak Tokaj Mountains provenance. For Iron Gates samples, there are at least two different geological sources: for Late Neolithic tools, the origin is also the Slovak Tokaj Mountains but for Late Mesolithic–Early Neolithic samples, the sources are clearly different, possibly of the Hungarian Tokaj Mountains or the Balkan–Aegean origin.

Culicov, O. A., Frontasyeva, M. V., Daraban, L., Ghiurca, V.: I.N.A.A. at Dubna Nuclear Reactor Trace Element Characterization of Obsidian Found in Romania. *Studia Universitatis Babeş–Bolyai, Physica* 54/2 (2009), 41–50.

We measured the significant elements for provenance studies of obsidians by INAA at IBR-2 pulse reactor from, JINR, Dubna, Russia. The aims of this study are to identification an obsidian source in Oraşu Nou (Maramures country from Romania). Comparatively with geological studies, the results of correlation and dendrological diagrams of the analyzed elements from irradiated samples are presented in this paper. Until now the geologist assumed that the obsidian from Oaş area is of a new source. But this isn't confirmed by our experimental results. By this we can say that in Paleolithic these materials were extracted from Slovakia and they were brought by the river Tisa and exchanged for any kind of products.

Culicov, O. A., Frontasyeva, M. V., Daraban, L.: Characterization of obsidian found in Romania by neutron activation method. *Romanian Reports in Physics* 64/2 (2012), 609–618.

Significant elements for provenance studies on obsidians were measured by INAA at IBR-2 pulse reactor from JINR, Dubna, Russia. The aims of this study were to identify an obsidian source in Oraşu Nou (Maramures County, Romania). Comparatively with geological studies, new results of correlation and dendrological diagrams of the analyzed samples are presented. So far, the geologists assumed that the obsidian from Oas¸ area (from Romania) is a new source, but this was not confirmed by our experimental results. We can therefore conclude that in Paleolithic these materials were extracted from Slovakia and were brought by the river Tisa and exchanged for any kind of products.

De Francesco, A. M., Crisci, G. M., Bocci, M.: Non-destructive analytic method using XRF for determination of provenance of archaeological obsidians from the Mediterranean area: a comparison with traditional XRF methods. *Archaeometry* 50/2 (2008), 337–350.

A non-destructive analytical method using wavelength dispersive X-ray fluorescence (WDXRF) that allows the establishment of the provenance of archaeological obsidians was developed and a comparison with the classical XRF method on powders is discussed. Representative obsidian samples of all the geological outcrops of archaeological interest of the Mediterranean area, were analysed with the normal procedures used in rock analysis by XRF (crushing, powdering and pelletizing). The non-destructive XRF analysis was instead conducted on splinters taken from the original geological pieces, with the shape deliberately worked to be similar to the refuse usually found at archaeological sites. Since the analysis was conducted on the raw geological fragment, intensity ratios of the suitably selected chemical elements were used, instead of their absolute concentrations, to avoid surface effects due to the irregular shape. The comparison between concentration ratios and the intensity ratios of the selected trace elements show that the different domains of the chemical composition, corresponding to the geological obsidians of the source areas, are perfectly equivalent. In the same way, together with the geological splinters, complete archaeological obsidians, from Neolithic sites, may be analysed and their provenance may be determined.

De Francesco, A. M., Bocci, M., Crisci, G. M.: Application of non-destructive XRF method to the study of the provenance for archaeological obsidians from Italian, Central European and South American sites. *Quaternary International* 468 (2018), 101–108.

This paper presents the results of the attribution of approximately 1700 artifacts, from Italian, Central European and South American sites to the geological obsidian sources. The provenance was determined using the non-destructive X-ray Fluorescence (XRF) analytical method, based on the secondary X-ray intensity proposed by Crisci et al. (1994) and optimized by De Francesco et al. (2008). In the first phase of the research, to test the non-destructive XRF method, the analysis on entire obsidian fragments (similar to archaeological waste) was initially carried out on 60 samples representative of all the geological outcrops in the Mediterranean region. The secondary X-ray intensities obtained by non-destructive XRF on whole pieces were compared with the results using the XRF method on powders, carried out on the same samples (major elements, and selected trace elements, such as Nb, Y, Zr, Rb and Sr) as exhaustively described in De Francesco et al. (2008). These five trace elements were sufficient to characterize (by both methods) the different places of obsidian origin, because they are particularly indicative of the genetic processes that produced obsidian. The provenance of the obsidian artifacts was determined by comparing the X-rays intensity ratios of the selected elements with those obtained on the entire fragments of the obsidian sources in the Mediterranean.

Dobosi, V.: Obsidian use in the Palaeolithic in Hungary and adjoining areas. *Natural Resource Environment and Humans* 1 (2011), 83–95.

Summary of Palaeolithic obsidian use in Hungary with special regard to the Upper Palaeolithic period.

Dobrescu, R., Tuffreau, A.: L'Oaş et le Maramureş: la limite orientale de l'utilisation de l'obsidienne dans l'Europe centrale au paléolithique supérieur. In: Bodi, G., Danu, M., Pîrnău, R. (eds.): *De Hominum Primordiis. Studia in Honorem Professoris Vasile Chirica*. [Scripta archaeologica et historica Dacoromaniae 7] Editura Universității "Alexandru Ioan Cuza", Iaşi, 2013, 63–86.

The presence of obsidian is quite frequent in northwestern Romania where it represents an important part of the raw materials that have been chosen for the manufacture of tools. However, the question of its origin, local or exogenous, remains unresolved. It remains important to better appreciate the extent of cultural choices. The analysis of the lithic industries of Remetea Şomoş I and Buşag provides partial answers to these questions.

Dobrescu, R., Tuffreau, A., Bonsall, C.: L'utilisation de l'obsidienne au Paléolithique supérieur dans le nord-ouest de la Roumanie/The use of obsidian during the Upper Paleolithic in Northwest Romania. *L'Anthropologie* 122 (2018), 111–128.

Obsidian artefacts are numerous in the Upper Paleolithic sites of Northwest Romania. The use of obsidian begins during the Aurignacian and continues during the Gravettian, All the stages of the lithic reduction sequence are present. The obsidian tools are numerous in some sites. Non-destructive chemical analysis by X-ray fluorescence (XRF) was performed on 232 obsidian artefacts from five sites: Buşag, Remetea Şomoş I, Calineşti I, Boineşti and Turulung. The results show that Early/Middle Upper Paleolithic people in

northwest Romania acquired their obsidian, directly or indirectly, from sources on the western flank of the Carpathians, up to 170 km away.

Durrani, S. A., Khan, H. A., Taj, M., Renfrew, C.: Obsidian source identification by fission track analysis. *Nature* 233 (1971), 242–245.

Fission track analysis has been used to determine the age and uranium content of obsidians from sources in southeast Europe and Anatolia, and from archaeological deposits in mesolithic levels at the Franchthi Cave in southern Greece. It is confirmed that the Franchthi obsidian came from the Aegean island of Melos. This is the earliest positive indication available for maritime travel, and carries the history of seafaring back a thousand years.

Eder, F. M.: *OLDAPS – Obsidian Least Destructive Analytical Provenancing System: An application study*. Dissertation an der Technischen Universität Wien, Dissertation, Fakultät für Physik, Technischen Universität, Wien, 2013.

The natural volcanic glass obsidian is one of the classical objects of archaeometric analyses. Obsidian is generally described as a relatively homogeneous material and although the number of applicable geological sources is limited, numerous obsidian finds have been found all over the world far away from any natural outcrop. Reliable provenancing by means of the highly specific chemical composition, the "chemical fingerprint", can provide information about trading routes, extension of territory, long-distance contacts and the mobility of prehistoric people. Several museum collections contain large numbers of unidentified obsidian finds. Therefore, a novel scientific approach for provenancing obsidian artefacts found in archaeological contexts is demanded. The establishment of the OLDAPS contributes to both conservation and prehistoric research by ensuring a minimum of destruction to gain a maximum of information. Obsidian samples of seven archaeologically relevant geological obsidian sources in Central and Southern Europe were characterized by the application of three different methods: NAA, IBA, PIXE, PIGE and LA-ICP-MS. The reproducibility and accuracy of analytical data is demonstrated by the excellent agreement between determined analytical results and certified values of glassy reference material BAM-S005B. The combination of methods shows a maximum element spectrum composed of 42 elements and reveals the most characteristic – key elements –, in particular Ti, Co, As, Rb, Ba, Eu and U, by which all seven obsidian sources are clearly discriminable.

Elekes, Z., Uzonyi, I., Gratuze, B., Rózsa, P., Kiss, Á. Z., Szöőr, Gy.: Contribution of PIGE technique to the study of obsidian glasses. *Nuclear Instruments and Methods in Physics Research Section* B 161 (2000), 836–841.

An application of the particle induced gamma-ray emission (PIGE) method with the use of a CLOVER-Ge-BGO detector system for the analysis of source materials of obsidians of archaeological use is reported in this work. Grouping and association of samples resulted via various magmatic processes, with diverse provenances, is detailed based on the light element concentration data. A comparison of PIGE with the laser ablation ± inductively coupled plasma ± mass spectrometry (LA±ICP±MS) on heavier elements is presented.

Francaviglia, V. M.: Les gisements d'obsidienne hyperalcaline dans l'ancien monde: étude comparative. *Revue d'Archéométrie* 14 (1990), 43–64.

A comparative study of peralkaline obsidian sources of Pantelleria, Turkey, Yemen, Ethiopia and Tibesti have been carried out. Attempts have been made to establish the provenance of Neolithic and Bronze Age obsidian artifacts from The Yemen Arab Republic (Jabal Qufrân, Sirwâh, Miswah, Najid al-Abyadh, Wsdî Yanâ'im, Yalâ and the coastal plain of Tihâmah), from the Saudi Tihâmah, the Farasân Islands, the Koka Lake shore (Shoa, Ethiopia) and the Tibesti Massif. Finally, the origin of the obsidian of a statuette from a Tell al-'Amârnah tomb (18th dynasty) has been investigated. The hypothesis proposed by archaeologists, that might have been some obsidian trade across the Red Sea in Neolithic times, is supported: the majority of the obsidian artifacts found in coastal archaeological sites of the Yemeni and Saudi Tihimah, as well as on the Farasân islands and in the Yemeni highland does not originate from the well-known great Yemeni obsidian sources. The provenance of the raw material of the Tell al-'Amârnah statuette remains unknown. Overlap in chemistry of peralkaline volcanic provinces – even those distant from each other – is considerable and causes uncertainty in provenance studies.

Freund, K. P.: An assessment of the current applications and future directions of obsidian sourcing studies in archaeological research. *Archaeometry* 55/5 (2013), 779–793.

This paper thematically characterizes a large body of recent obsidian sourcing discourse as a means of highlighting the current place of obsidian provenance studies in larger archaeological discourse. It is shown that the field of obsidian *sourcing is flourishing, with a clear upward trend in the number of published studies in the past decade. This paper further argues that sourcing is a means to an end, a way to determine where artefacts originate, and thus a means of addressing broader archaeological problems. Through this contextual framework, obsidian sourcing studies – and indeed all provenance studies – are seen as relevant because they transcend the increasingly specialized world of archaeological discourse.*

Gábori, M.: Az őskori obszidián-kereskedelem néhány problémája / Quelques problèmes du commerce de l'obsidienne á l'age préhistorique / Some problems of the obsidian trade in prehistoric times. *Archaeologiai Értesítő* 80 (1950), 89–103.

Primitive forms of trade follow the evolution of economic life; in prehistoric times, as well as among today's primitive peoples, they follow a particular path of development. In the prehistoric age it is necessary to attach great importance to the trade of obsidian which, in all probability, was the first commodity of our country. In Central Europe it is only found in the Tokaj region; the remoteness of the other deposits therefore allows us to determine the starting point of this trade and also to determine the people who were in charge of it. In Hungary obsidian is demonstrable from the cultures of the Upper Aurignacian Palaeolithic and Magdalenian; its absence in the Solutrean period must be explained by the penetration of certain foreign ethnic groups. Neolithic man used obsidian more often. It is mainly used by the people representing the culture of Bükk; it is at this time that the transport of obsidian takes a certain expansion. Obsidian can be seen in Transylvania; to the west its traces can be seen as far as the Mura region, to the north as far as the territory of Poland and Bohemia. During the copper age, because of the new commercial possibilities, conditioned by the use of metal, the transport of obsidian took on proportions hitherto unknown.

Gale, N. H.: Mediterranean obsidian source characterisation by strontium isotope analysis. *Archaeometry* 23 (1981), 41–51.

Attempts by scientists to establish the geographical and geological sources of materials used by prehistoric man have a long history. In the eighteenth-century Halley and Stukeley used the microscope and simple petrological examination in an attempt to establish the origin of the rock used to build Stonehenge. Later the modern application of thin section petrography to finding the source of pottery was pioneered by Washington (1895). The volcanic glass obsidian was important to some Paleolithic, Neolithic and Early Bronze Age cultures principally for its use to make tools and weapons, though it was also used to make vessels and statuettes. As a material of value, it was widely traded, and so reliable methods of establishing its provenance are important in establishing ancient patterns of trade and have engaged the attention of archaeologists, prehistorians and scientists from at least 1892.

Glascock, M. D., Barker, A. W., Draşovean, F.: Sourcing Obsidian Artifacts from Archaeological Sites in Banat (Southwest Romania) by X-ray Fluorescence. *Analele Banatului* 23 (2015), 45–50.

This article concerns the chemical analysis by X-ray fluorescence and source determination for five obsidian artifacts from archaeological sites in Banat (Southwest Romania). The results show that all of the artifacts could be assigned to an obsidian source located in the Košice region of Slovakia. The specific source is known as Cejkov and it is a sub-source of the Viničky source.

Glascock, M. D., Barker, A. W., Bărbat, I. A., Bobînă, B., Draşovean, F., Virag, C.: Sourcing Obsidian Artifacts from Archaeological Sites in Central and Northwestern Romania by X-ray Fluorescence. *Ephemeris Napocensis* 27 (2017), 175–186.

The new data add to our previous knowledge regarding the sources of obsidian in Banat and Transylvania. If in Transylvania, with the exception of the initial period of the Neolithic, when obsidian comes only from the Mád Kakashegy source, all obsidian tools in the Neolithic, Eneolithic and Bronze Age cultures were made with obsidian from the Eastern Slovak source of Cejkov-Viničky. A somewhat similar situation was also observed in Banat where the Eastern Slovak source is predominant in all the investigated cultures.

Gratuze, B.: Obsidian characterization by laser ablation ICP-MS and its application to prehistoric trade in the Mediterranean and the Near East: sources and distribution of Obsidian within the Aegean and Anatolia. *Journal of Archaeological Science* 26/8 (1999), 869–881.

For geological studies, interest in mass spectrometry with an inductively coupled plasma as an ion source and its association with laser ablation as a sample introduction technique (LA-ICP-MS) has steadily increased during the past few years and is now being developed in other fields such as archaeology. After a description of the analytical procedure and the calculation method, we show the potential of this technique to characterize, almost non-destructively, archaeological artefacts. Among the 70 elements that could be routinely analysed by LA-ICP-MS *with detection limits below the ppm level, we choose to determine the more critical ones in order to evaluate the geochemical models of the magmatic process (major elements, rare earths and some transition elements).*

Grolig, D.: Mineraliensammeln in Nordost-Ungarn: Das Tokajer Gebirge. *Der Steirische Mineralog* 26 (2012), 13–26.

For a few years now, we have been happy to undertake holiday and group trips to Hungary, mainly to the northeast of the country. Hungary is home to numerous mineralogically interesting areas, but our favourite areas are the Mátra and especially the Zemplén (Tokaj) mountains. This preference is not only based on the mineral wealth of the region, but is also due to the charming surroundings and the knowledge of the historical background of the former mining region.

Hancock, R. G. V., Carter, T.: How reliable are our published archaeometric analyses? Effects of analytical techniques through time on the elemental analysis of obsidians. *Journal of Archaeological Science* 37 (2010), 243–250.

To assess the analytical accuracies and precisions of archaeometric elemental analyses by different techniques, a relatively homogeneous material such as obsidian must be studied. An assessment of published elemental concentration data from two Anatolian obsidian sources shows that while in most cases analytical accuracy is as high as is commonly expected, in some cases it is not. It also shows that the dispersions of elemental concentration data (indicators of analytical precisions) coming from modern analytical procedures are akin to the estimated homogeneity of the obsidian. Based on this latter observation, if one has element dispersion data from a single analytical technique, with a single source of obsidian as a control, data sets that contain multiple, but similar sources of obsidian may be differentiated.

Hillebrand, J.: A nyirlugosi obsidiannucleus depotleletről / On the Nyirlugos obsidian core depot find. *Archaeológiai Értesítő* 42 (1928), 39–42.

This paper focuses on the Nyírlugos obsidian depot find, which is deposited in the Prehistoric Collection of the Hungarian National Museum. The obsidian core depot found very close to Debrecen in 1923. The archaeological context was mostly unidentified, because this appeared by chance, however F. Tompa suggested this could be belong to the Late Neolithic and Early Copper Age periods. The 12 pieces of obsidian core mean a big value which is quite unique in Central Europe.

Hovorka, D.: Prehistoric transeuropean transport of stone tools. On examples of jadeitite and obsidian implements. *Acta Archaeologica Academiae Scientiarum Hungaricae* 61/1 (2010), 49–56.

In presented paper transcontinental transport of stone tools in the Neolithic/Aeneolithic is described. Attention is paid namely on the west–east transport of jadeitite axes from the Piedmont in the Western Alps to Central Europe, and east-west transport of the obsidian implements from Zemplin county (E-Slovakia and NE-Hungary) to the western part of Germany, as well. In both cases, transport, most probably of ready-made implements on a distance more than 1000 km, is discussed.

Hovorka, D., Illášová, L.: The Tokaj Mts. Obsidian – its use in Prehistory and Present Application. In: *Scientific Annals, School of Geology*. Aristotle University of Thessaloniki, Proceedings of the XIX CBGA Congress, Thessaloniki, [Greece Special volume 100] 2010, 385–390.

Homogeneous acid volcanic glass of low water content has been an object of human attention since the prehistory. There exist archaeological evidences dealing with the use of obsidian from the Tokaj Mts. (eastern Slovak Republic and the north-eastern part of Hungary, as well) Late Tertiary volcanic province in the Late Palaeolithic. There at present exist attempts to use it as a jewellery raw material. Obsidian namely in combination with silver, nickel alloys and gold can be effectively used as a modern jewellery material.

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

Non-destructive energy dispersive X-ray fluorescence (EDXRF) analysis was conducted on geological obsidian references samples from Carpathian 3 localities within the territory of the Ukrainian Transcarpathia. These data augment the trace element "signature" for this chemical variety of obsidian, which we applied to compare with trace element data determined on obsidian artifacts from nearby archaeological sites. The results: 1) document the local use and importance of Carpathian 3 obsidian, and 2) show use of non-local (Carpathian 1) volcanic glass at local geological outcrops of Carpathian 3 obsidian, suggesting prehistoric conveyance of Carpathian 1 volcanic glass in to Ukrainian Transcarpathian archaeological sites during the Upper Paleolithic period.

Hughes, R. E., Werra, D. H.: The source of Late Mesolithic obsidian recovered from Rydno XIII/1959, Central Poland. *Archaeologia Polski* 59/1–2 (2014), 31–46.

More than 40 years ago R. Schild reported the presence of obsidian and Vistulian lithics at Rydno XIII/1959 in central Poland, and speculated that the geological source for the obsidian lay in the Tokay region of Hungary. Non-destructive energy dispersive X-ray fluorescence analysis was conducted recently on the Rydno XIII obsidian artifacts, and the data generated support R. Schild, M. Marczak and H. Królik's suggestion (1975). The geological source of obsidian from a late Mesolithic site in Poland has been documented for the first time by instrumental data results.

Hughes, R. E., Werra, D. H., Sulgostowska, Z.: On the sources and uses of obsidian during the Paleolithic and Mesolithic in Poland. *Quaternary International* 468 (2018), 84–100.

Eighty-six obsidian artifacts from twenty Paleolithic and Mesolithic archaeological sites in Poland were analyzed using non-destructive energy dispersive X-ray fluorescence (EDXRF) analysis and assigned to parent geological obsidian source (chemical type). Results of the study the first country-wide survey of its kind support the conclusion that the geological source of obsidian remained largely unchanged for thousands of years, that obsidian use appears to have been minimal throughout the Paleolithic and Mesolithic regardless of distance to source, that obsidian artifacts were used to perform the same functions as their non-obsidian (flint and radiolarite) counterparts, and that the distinct visual properties of volcanic glass may have contributed to its recognition as unique and exotic in different social contexts.

Janšák, S.: *Praveké sidliska s obsidianovou industriou na Vychodnom Slovensku*. 1935, 1–193.

A basic monograph on sources and archaeological distribution of Slovakian obsidians.

Kabaciński, J., Sobkowiak-Tabaka, I., Kasztovszky, Zs., Pietrzak, S., Langer, J. J., Biró, K. T., Maróti, B.: Transcarpathian influences in the Early Neolithic of Poland. A case study of Kowalewko and Rudna Wielka sites. *Acta Archaeologica Carpathica* 50 (2015), 5–32.

The aim of the paper is to present and discuss traces of a long-distance contacts of the Early Neolithic Linear Band Pottery Culture registered at two sites, of which one is located in the Polish Lowland and second in the uplands of the southern Poland. They are manifested by the presence of obsidian finds and application the wood-tar substances, both of which being considered as a Transcarpathian phenomenon. The paper focuses on determination of characteristic chemical elements of obsidian artefacts from the two Polish Early Neolithic localities using non-invasive Prompt Gamma Activation Analysis (PGAA) as well as on a physicochemical analysis of composite organic-mineral substances found on pottery. The results of the analyses allow a discussion on the relationships between the Early Danubian societies inhabiting territories located on both sides of the Carpathians.

Kaminská, Ľ.: Význam surowinowej základne pre mladopaleolitickú spoločnost vo východokarpatskej oblasti. *Slovenská Archeológia* 39 (1991), 7–58.

This is an outline of the present state of Upper Palaeolithic studies with emphasis on the raw material composition of stone industries in eastern Slovakia and adjacent regions, i.e. in north-east Hungary, north-west Romania, Trans-Carpathian Ukraine, and southern Poland. The most significant kinds of stone raw materials and their deposits are considered as well as the employment of raw materials of Upper Palaeolithic cultures in the east Carpathian region.

Kaminská, Ľ., Duda, R.: K otázke vyznamu obsidiánovej suroviny v paleolite Slovenska. *Archeologické Rozlhedy* 37 (1985), 121–129.

Description of quasi-sources (large scale Palaeolithic workshops) and geological build-up of the Slovakian obsidian source area.

Kasztovszky, Zs.: Obszidián kőeszközök a Kárpátokon innen és túl – Tűz es víz talalkozasa. *Élet és Tudomány* 2 (2014), 38–40.

Popular scientific paper on the potentials of source characterisation and provenance studies. The author emphasizes the practical knowledge of prehistoric man on raw materials suitable for the production of tools, e.g. obsidian, and proofs of long distance trade.

Kasztovszky, Zs., Biró, K. T.: A kárpáti obszidiánok osztályozása prompt gamma aktivációs analízis segítségével: geológiai és régészeti mintákra vonatkozó első eredmények. *Archeometriai Műhely/Archaeometry Workshop* 1/1 (2004), 9–15.

Obsidian is one of the classical subjects of archaeometrical analyses. Most analytical methods however will require destruction or preparation of the sample equal to destruction. Therefore, most of

the choice pieces are not to be analysed by these methods. PGAA is suitable for analysing the pieces without destruction and without any residual radioactivity. The pieces were placed into the analytical equipment without any special preparation, intact and naturally, without any destruction or sampling. 2×2 cm2 of the sample surface was irradiated by a cold neutron beam of 5×107 cm-2s-1 flux. Since neutrons penetrate the whole sample, the information we get reflects the bulk composition of the material, which is very advantageous for the glassy, homogeneous volcanic glass (obsidian). The question is how distinctly we can separate different source regions according to the detected components, and how effectively we can allocate the archaeological pieces into the resulting data sets. Our results of two measurement series seem promising, however we are working on extending our database of PGAA measurements concerning archaeological, as well as geological obsidian samples. Geological samples from all the important known obsidian sources of the Mediterranean region were measured with special regard to Central European (Carpathian I, II) sources, as well as archaeological sources mainly from Hungary.

Kasztovszky, Zs., Biró, K. T.: Fingerprinting Carpathian Obsidians by PGAA: First results on geological and archaeological specimens. In: *Proceedings of the 34th International Symposium on Archaeometry*, 3–7 May 2004, Zaragoza, Spain. Institution Fernando el Catolico 2006, 301–308. (E-book, http://www.dpz.es/ifc/libros/ebook2621.pdf)

Obsidian is one of the classical subjects of archaeometrical analyses. Major and trace-element data can provide indispensable information on the provenance of valuable archaeological objects. Most analytical methods however will require destruction or preparation of the samples equal to destruction. Therefore, most of the choice pieces are not to be analysed by these methods. Prompt Gamma Activation Analysis (PGAA) is in principle suitable for analysing various kinds of pieces without destruction and without any residual radioactivity. The method is based on the detection of γ-photons originated in (n, γ) reaction. The question is how distinctly we can separate different source regions according to the detected components, and how effectively we can allocate the archaeological pieces into the resulting data sets. We had previous experience on provenancing various chipped stone raw materials, like Szeletian felsitic porphyry and various kinds of grey silex (radiolarite, flint, hornstone). PGAA proved to be effective for the former while with silex, we have to refine our method.

Kasztovszky, Zs., Težak-Gregl, T.: Kora-neolitikus radiolarit és obszidián kőeszközök vizsgálata prompt gamma aktivációs analízissel / Prompt gamma activation analysis of Early Neolithic radiolarite and obsidian stone tools. In: Ilon G. (szerk.): *ΜΩΜΩΣ VI. – Őskoros kutatók VI. Összejövetele. Nyersanyagok és kereskedelem.* Kulturális Örökségvédelmi Szakszolgálat – Vas megyei Múzeumok Igazgatósága, Kőszeg, 2009, 189–196.

In the earliest phase of the Neolithic, both obsidian and radiolarite are important markers of the movements of goods and people trading them. Obsidian is a favourite subject of archaeometrical studies. Radiolarite is of comparable significance, however, much less analyzed yet. There is no local obsidian on the territory of Croatia: import, however, may originate from both the Carpathian Basin and the Mediterranean region. The importance of radiolarites is adequately demonstrated in Hungary by now. It is apparent, however, that there used to be essential local supply of various radiolarites in Croatia, too. In addition, a considerable supposed import from the territory of today's Hungary is supposed. Thus, we wish to find objective discrimination features to define these supply zones and the border of these zones. The research is done in the frame of a 2008–2009 Croatian–Hungarian project and funded by Hungarian Science and Technology Foundation (TéT) and Croatian Ministry of Science, Education and Sport, with the aim of sampling and identification of potential obsidian and radiolarite sources in Croatia and in Hungary, as well as non-destructive investigation of archaeological stone tools. The basic analytical method is Prompt Gamma Activation Analysis.

Kasztovszky, Zs., Biró, K. T., Markó, A., Dobosi, V.: Cold Neutron Prompt Gamma Activation Analysis – a Non-Destructive Method for Characterization of High Silica Content Chipped Stone Tools and Raw Materials. *Archaeometry* 50/1 (2008), 12–29.

Recently, several archaeometrical projects have been started on the prehistoric collection of the Hungarian National Museum. Among the analytical methods applied, non-destructive prompt gamma activation analysis has a special importance. We have also tested the potential of this method on chipped stone tools, with the aim of determining their exact provenance. On the basis of major and trace element components, characterizations of stone tools and their raw materials – silicites (flint, chert, radiolarite and hornstone) as well as volcanites (felsitic porphyry and obsidian) – were performed. We discuss some important results concerning each group, as case studies. Compiling *the data set of different PGAA analysis series, compositions of 110 samples are reported, including 76 archaeological pieces. In the future, we plan to extend the number of investigated objects in each class.*

Kasztovszky, Zs., Biró, K. T., Markó, A., Dobosi, V.: Prompt gamma activation analysis for non-destructive characterization of chipped stone tools and raw materials. *Journal of Radioanalytical and Nuclear Chemistry* 278/2 (2008), 293–298.

Several archaeometrical projects were started on the prehistoric collection of the Hungarian National Museum. Among the analytical methods applied, non-destructive prompt gamma activation analysis (PGAA) has a special importance. Based on major- and trace components, characterization of stone tools and their raw materials were performed. Until now, 160 pieces from Carpathian Basin and from the surrounding area (Romania, Croatia, Ukraine, Poland and the Mediterranean region) have been analyzed, including both archaeological and geological pieces. Obsidian and Szeletian felsitic porphyry objects adequately separable with PGAA. Identification of high silica silex categories, however, is much more difficult.

Kasztovszky, Zs., Biró, K. T., Markó, A., Dobosi, V.: Pattintott kőeszközök nyersanyagainak roncsolásmentes vizsgálata prompt-gamma aktivációs analízissel. *Archeometriai Műhely/Archaeometry Workshop* 6/1 (2009), 31–38.

Since 2001, several archaeometrical projects were started on the prehistoric collection of the Hungarian National Museum. The aims of the investigations were to distinguish between macroscopically similar or inadequately identified types of rocks. Further aim is to associate the archaeological finds with potential raw material sources. Among the analytical methods applied, non-destructive Prompt-gamma Activation Analysis has a special importance. Based on major and trace elements, characterisation of stone tools and their raw materials were performed. Until now, more than 300 pieces of various materials (i.e. flint, radiolarite, Szeletian felsitic porphyry, obsidian, etc.) from the Carpathian Basin and from the surrounding areas (Romania, Croatia, Ukraine, Poland and the Mediterranean region) have been analysed, including both archaeological and geological pieces. The characterisation of obsidian and Szeletian felsitic porphyry objects by PGAA is seemingly effective while the identification of the high silica content siliceous rocks, however, is much more difficult.

Kasztovszky, Zs., Szilágyi, V., Biró, K. T., Težak-Gregl, T., Burić, M., Šošić, R., Szakmány, Gy.: Horvát és bosnyák régészeti lelőhelyekről származó obszidián eszközök eredetvizsgálata PGAA-val / Provenance study of Croatian and Bosnian archaeological obsidian artefacts by PGAA. *Archeometriai Műhely/Archaeometry Workshop* 6/3 (2009), 5–14.

In 2008–2009 we started to work on archaeological obsidians from Croatia and Bosnia-Herzegovina within the frame of a Croatian–Hungarian project. The main objective of our work was to perform a provenance study of these obsidian artefacts. The chemical compositions of the systematically collected samples have been determined non-destructively with Prompt Gamma Activation Analysis. Obsidian is among the important raw materials of prehistoric tool production in the Carpathian Basin, and a popular subject of archaeometric studies. According to previous studies, three main groups could be separated. The main categories are the transparent-translucent Carpathian 1 (C1 – Slovakian) type, the non-transparent Carpathian 2 (C2 – Hungarian) and the Carpathian 3 (C3) type from Ukraine. In order to determine the origin of obsidian raw materials, we have analysed Carpathian (C1 and C2) and Mediterranean (Melos, Lipari, Sardinia) geological samples as well as archaeological pieces from Hungary and Romania. Our PGAA database on obsidian is continuously expanding with the new analytical results. In our earlier studies, we concluded that PGAA is suitable for differentiating between various Carpathian and the Mediterranean obsidians. Adding Croatian and Bosnian archaeological obsidian data to our library, we found that some of them can be best identified as C1 (Slovakian) and some are chemically similar to the Lipari obsidians.

Kasztovszky, Zs., Biró, K. T., Kis, Z.: Prompt Gamma Activation Analysis of the Nyírlugos obsidian core depot find. *Journal of Lithic Studies* 1/1 (2014), 151–164.

The Nyírlugos obsidian core depot find is one of the most important lithic assemblages in the collection of the Hungarian National Museum. The original set comprised 12 giant obsidian cores, of which 11 are currently on the permanent archaeological exhibition of the HNM. One of the cores is known to be in Debrecen. The first publication attributed the hoard, on the strength of giant (flint) blades known from the Early and Middle Copper Age Tiszapolgár and Bodrogkeresztúr cultures, to the Copper Age. In the light of recent finds it is more likely to belong to the Middle Neolithic period. The source area was defined as Tokaj Mts., about 100 km to the NW from Nyírlugos. The size and beauty of the

exceptional pieces exclude any invasive analysis. Using Prompt Gamma Activation Analysis (PGAA), we can measure major chemical components and some key trace elements of stone artefacts with adequate accuracy to successfully determine provenance of obsidian. Recent methodological development also facilitated the study of relatively large objects like the Nyírlugos cores. The cores were individually measured by PGAA. The results show that the cores originate from the Carpathian 1 sources, most probably the Viničky variety (C1b). The study of the hoard as a batch is an important contribution to the assessment of prehistoric trade and allows us to reconsider the so-called Carpathian, especially Carpathian 1 (Slovakian) sources.

Kasztovszky, Zs., Biró, K. T., Szilágyi, V., Hajnal, A., Özvegy, K., Szekeres, Á.: Provenance study of archaeological obsidian using non-destructive Prompt Gamma Activation Analysis (poster presentation). In: *Synchrotron radiation and neutrons in art and archaeology.* (SR2A-2014), Paris, 9–12 September 2014.

Poster presented on the conference SR2A on results of PGAA measurements of lithic assemblages from Voivodina, environs of Szabadka (Subotica) with archaeological obsidian from the surface collection of K. Özvegy.

Kasztovszky, Zs., Lázár, K., Kovács Kis, V., Len, A., Füzi, J., Markó, A., Biró, K. T.: A novel approach in the mineralogy of Carpathian mahogany obsidian using complementary methods. *Quaternary International* 467 (2018), 332–341.

Carpathian obsidians can have various macroscopic features. They are typically black or grey and their transparency ranges from clear to opaque. The Tolcsva source, very rarely, can yield brown or red ('mahogany' type) obsidian. Archaeological, as well as geological pieces of mahogany obsidian were previously identified and characterised using PGAA. In 2007, the exact location of the red variant's outcrop was identified on the Szokolya hill (Tolcsva). The aim of this study was to better understand the possible reasons for the colouring of red obsidian. A novel approach was applied, using multiple methods for the analysis of the samples. For comparison, other Carpathian type, namely black obsidian from Tolcsva, and red obsidian from Bogazköy (Anatolia) were also studied. Besides the PGAA measurements of the bulk elemental composition, Mössbauer spectroscopy and TEM were used to study the samples in order to identify the presence of ferrous or ferric iron. With the help of SANS, the bulk nanostructures of the samples have been investigated and their surface or volume fractal dimensions have been determined. Black obsidians showed isotropy, while mahogany samples displayed a considerable anisotropy in the bulk pore orientation. According to our results, a large amount of the iron is dominantly located in different phases in the case of mahogany and black obsidians. Based on the summarised results, the differences between the red and black variants can be also explained by the different oxidation states of the Fe-ions, which may explain the colour difference.

Kasztovszky, Zs., Maróti, B., Harsányi, I., Párkányi, D., Szilágyi, V.: A comparative study of PGAA and portable XRF used for non-destructive provenancing archaeological obsidian. *Quaternary International* 468 (2018), 179–189.

Prompt Gamma Activation Analysis has successfully been applied to provenance research on Carpathian obsidians. The effectiveness of PGAA and a portable XRF device in discriminations of Carpathian, Lipari, Sardinia and Melos origin obsidians was compared on 75 representative geological samples obtained from the Lithotheca Collection of the Hungarian National Museum. Bivariate analyses and Principal Component Analysis have been made based on the individual PGAA and XRF data, as well as on the combination of both data types. Instrumental Neutron Activation Analysis was also applied on a group of 17 samples. The advantages and disadvantages of each method are discussed to determine the best possible way of investigations to fingerprint and characterize long-distance trade items with minimal damage to the samples.

Kilikoglou, V., Bassiakos, Y., Grimanis, A. P., Souvatzis, K., Pilali-Papasteriou, A., Papanthimou-Papaefthimious, A.: Carpathian Obsidian in Macedonia, Greece. *Journal of Archaeological Science* 23/3 (1996), 343–349.

The excavations at Mandalo in Macedonia, Greece, have produced a remarkably high number of obsidian objects, dated to the late Neolithic and early Bronze Age. Eleven of these samples were analysed by instrumental neutron activation for 19 minor and trace elements, in order to determine their provenance. It was found that all Neolithic and one Bronze Age samples came from the Carpathian 1 source, while another Early Bronze Age sample came from the Demenegaki source in Melos. The overlap between Carpathian and Melian obsidian distributions is evidence for interactions of ancient Macedonia with central Europe and the Aegean. Also, according to this finding, the Carpathian distribution pattern has now been extended for another 400 km to the south, from Vinča to Mandalo.

Kilikoglou, V., Bassiakos, Y., Doonan, R. C., Stratis, J.: NAA and ICP analysis of obsidian from Central Europe and the Aegean: Source characterisation and provenance determination. *Journal of Radioanalytical and Nuclear Chemistry* 216/1 (1997), 87–93.

INAA and ICPES are compared for their discriminative power in obsidian source characterisation. Geological samples from the Aegean and Carpathian sources were analysed for Na, Sc, Fe, Co, Rb, Sb, Cs, Ba, La, Ce, Sm, Eu, Tb, Yb, Lu, Hf, Ta, Th, U by INAA and for B, Na, Mg, Al, K, Ca, Sc, Ti, Mn, Fe, Zn, Y, Yr, Cs, Ba, La, Ce, Sm, Eu, Gd, Tb, Yb, Lu, Hf by two ICPES procedures. It is shown that all techniques work successfully, however, INAA is more efficient in the chemical discrimination of neighbouring sources.

Kobulský, J., Žecová, K., Gazdačko, Ľ., Bačo, P., Bačová, Z., Maglay, J., Petro, Ľ., Šesták, P.: *Guidebook to Geological-Educational Map of the Zemplínske vrchy Mts.* Bratislava, 2014.

In addition to the interpretation of geological structure of the region the map gives information about the natural beauties of the region, history of the Zemplín region and tourist attractions. The Zemplínske vrchy Mts. Is situated in the Southern part of Eastern Slovakia. On its territory the Protected Landscape Area Latorica, 4 National Nature Reserves: Botiansky luh, Kašvár, Latonický luh and Kašvár, 11 Nature Reserves: Biele jazero, Boľské rašelinisko, Dlhé Tice, Horešské lúky, Krátke Tice, Poniklecová lúčka, Raškovský luh, Tarbucka, Veľké jazero, Zatínsky luh a Zemplínska jelšina, 4 protected grounds: Bešiansky polder, Boršansky les, Oborínske jamy a Veľký kopec and 13 protected areas NATURA 2000: Bešiansky polder, Bodrog, Boršiansky lesík, Čičarovský les, Horešské lúky, Kováčské lúky, Ladmovské vápence, Latorica, Oborínske jamy, Oborínsky les, Raškovský luh, Tarbucka and Veľký kopec. They stretch over the Košice county and two districts: Trebišov and Michalovce.

Kohút, M., Westgate, J. A., Pearce, N. J. G., Bačo, P.: Obsidiány Východného Slovenska – nové výsledky FT datovania v kontexte geologického vývoja kenozoického vulkanizmu Západných Karpát. *Mente et Malleo* 1 (2017), 32.

Eastern Slovakia obsidians - new ft data results in the context of the geological development of the kenozoic vulcanism of the western Carpathians. Obsidian is a volcanic magmatic rock that was formed by the rapid solidification of the mainly rhyolite melt, often referred to as "volcanic glass." It is generally known that, in addition to flint and other SiO2 raw materials, obsidian has been used to produce the stone industry, thereby helping to develop humanity in its history. They were archaeologists who deserved to shift the knowledge of the obsidians of the Carpathian Zemplín – Tokaj region. In addition to using modern geochemistry, they also provided the first fission track (FT) dating from this area – the Borsod Neolithic Site, although the 3.8 –3 years presented by them 4 Ma point to local overheating over PAZ without magnesia-volcanic linkage.

Kostrzewski, J.: Obsidian implements found in Poland. *Man* 30 (1930), 95–98.

Though no sources of obsidian have yet been discovered in Poland, implements of this mineral are frequent enough there, and extend far to the north. This article summarized the appearance of the obsidian in Poland by different time periods.

Lehoczky, T.: Obsidian lelet Bereg megyéből. *Archaeológiai Értesítő* 1 (1868), 313–314.

Report on archaeological obsidian finds from Bereg county [in our times, part of Ukraine (ed.)].

Markó, A.: Obsidian in the Danube bend: Use of a long distance raw material in the Epigravettian period. In: Mangado, X., Crandell, O., Sánchez, M., Cubero, M. (eds.): *'On the rocks'* Abstracts volume – International Symposium on knappable materials. SERP - Universitat de Barcelona, 2015, 192.

Some of the few obsidian sources in continental Europe are found in the Carpathian Basin: in eastern Slovakia, in north-eastern Hungary and in Transcarpathian Ukraine. In an archaeological context, after the questionable data from the Lower Palaeolithic, the use of this raw material is clearly known from the last Interglacial period. In the millennia during and after the last Würmian Pleniglacial, a large part of Central Europe was more or less depopulated: from the areas north of the Carpathian chains and the Alps very few traces of the human occupation are known. In Hungary, however, a large number of hunting camps from this period have been excavated. The best-known cluster of sites is found in the Danube Bend, lying more than 200 km from the obsidian outcrops. The excavated assemblages from Pilismarót, Dömös, Szob and Verőce show various strategies of raw material use. The evidences of local reduction of the extra-local rocks together with the field observations and the analysis of the artefacts of other raw materials suggest short term occupations and increased mobility of Palaeolithic humans living in the period immediately following the coldest event of the last glacial period.

Markó, A.: Use of obsidian during the LGM: case studies from the pebble Gravettian sites in Hungary / Az obszidián felhasználása a kavicsgravetti leletegyüttesekben: esettanulmányok az utolsó hideg maximum idejéből. *Archeometriai Műhely/Archaeometry Workshop* 14/3 (2017), 131–142.

The few obsidian sources in continental Europe are found in the Carpathian basin: in eastern Slovakia, north-eastern Hungary and the Transcarpathian Ukraine. In archaeological context, after the questionable data from the Lower Palaeolithic, the use of this raw material is securely known from the last Interglacial period. During the last Würmian Pleniglacial and in a few millennia after it large part of Central Europe was more or less depopulated: very few traces of the human occupation were identified from the areas lying north of the Carpathians and the Alps. In Hungary, however, important sites of the Pebble Gravettian industry are known: at Ságvár, south of the lake Balaton two discrete artefact-bearing layers, at Mogyorósbánya in the NE part of the Transdanubia three relatively well-preserved settlement spots were excavated. The lithics from Szob, lying in the Ipoly valley in the Danube bend give supplementary data about this industry. The studied obsidian artefacts are mainly of the Slovakian variant, imported to the sites from more than 200 km; the Tolcsva and Mád types are represented only by single pieces. The majority of the artefacts are linked to the bladelet production, used as blanks for backed pieces. The bladelets were partly removed from cores, but burins of various forms are also considered as cores in technological point of view. Finally, some larger pieces were seemingly imported to the sites as ready-made tools (convergent scraper and end-scrapers).

Mateiciucová, I.: Worked stone: obsidian and flint. In: Whittle, A. (ed.): *The early Neolithic on the Great Hungarian Plain*. Investigation of the Körös culture site of Ecsegfalva 23, County Békés. [Varia Archaeologica Hungarica 21] Vol. II (2007), 677–720.

Over the course of the interdisciplinary archaeology project at Ecsegfalva (County Békés, Hungary), obsidian and flint artefacts were also recovered. This worked stone industry is important in the study of the Early Neolithic, since it is one of the few archaeological sources that were also produced and used in the preceding Mesolithic period. Its study can therefore not only reveal much about the customs, way of life and contacts of the Neolithic community, but by making comparisons with the worked stone artefacts of Mesolithic foragers, also permits statements about the origin of the traditions of Neolithic communities in specific regions. Until relatively recently, only small collections of worked or chipped stone artefacts from the Körös culture were known, and as a result it has been difficult to elaborate on their characteristics. Large scale archaeological research conducted in the 1970s, however, has enabled the collection of rich assemblages which have been the subject of numerous studies. A total of 485 chipped stone artefacts were recovered from the Körös culture settlement at Ecsegfalva 23. With the exception of Méhtelek–Nádas (Szatmár phase), this represents the largest assemblage recovered to date from the Körös culture.

McDougall, J. M., Tarling, D. H., Warren, S. E.: The Magnetic Sourcing of Obsidian Samples from Mediterranean and Near Eastern Sources. *Journal of Archaeological Science* 10 (1983), 441–452.

The magnetic properties of obsidians are examined for their potential in sourcing obsidian artifacts. The three simplest to determine magnetic parameters-initial intensity of magnetization, saturation magnetization and low field susceptibility- are found to be effective discriminants of many Mediterranean, Central European and near Eastern sources. Although the between-source precision is not as good as geochemical analyses of minor and rare-earth elements, the technique demonstrated the existence of new sources that were subsequently confirmed by minor element analyses. Unfortunately, some key sources do not appear to be readily distinguishable on these three simple magnetic parameters alone, although more sophisticated magnetic analyses may prove diagnostic. Despite this, it would appear that effective discrimination can be made in many cases, occasionally with more precision than minor element analyses. This technique therefore offers, as a minimum, a preliminary sourcing tool for use in many areas of the world, thus reducing the number of expensive geochemical analyses. Furthermore, its very low cost, non-destructive nature and speed open the possibility of quantitative evaluation of trade routes based on obsidian distributions, particularly as versions of the equipment are now suitable for use in the field.

Milic, M.: PXRF characterisation of obsidian from central Anatolia, the Aegean and central Europe. *Journal of Archaeological Science* 41 (2014), 285–296.

The obsidian sources of central Anatolia, the Aegean and central Europe have been studied in detail over the past 50 years. Various analytical techniques have been employed to discriminate artefacts from each of these and to reconstruct their zones of distribution. This paper presents a pXRF method that allows mass sampling of artefacts *focusing on three neighboring regions, particularly where these zones overlap. Successful discrimination of the obsidian source for products could be achieved using three-dimensional scatter plots of trace elements Rb/Sr/Zr. PXRF can thus be appreciated as a powerful tool in the region, enabling non-destructive on-site analyses in contexts where the export of artefacts is often difficult if not impossible. The ability to rapidly process large assemblages also has major implications for generating data-sets of sufficient resolution to transform archaeological interpretation.*

Moutsiou, T.: *The Obsidian Evidence for the Scale of Social Life during the Palaeolithic*. Thesis for the Degree of Doctor of Philosophy February 2011. Dissertation, University of London – Department of Geography, London, 2011.

The research demonstrated a strong correlation between obsidian use and long distances. The choice of obsidian makes sense within a system of exchange in which hominines chose to obtain their materials from elsewhere in order to maintain social links with other, more distant, groups. I argue that the scale of obsidian movement, although conditioned by a number of climatic, ecological and anatomical constraints, is actually rooted in social grounds. I thereby reject theories that see behavioural modernity as a recent advance inhuman history and argue for modern behaviour as gradual process that was initiated in East-Africa at least as early as the Middle Stone Age.

Moutsiou, T.: Changing Scales of Obsidian Movement and Social Networking. In: Ruebens, K., Bynoe, R., Romanowska, I. (eds.): *Unravelling the Palaeolithic: Ten years of research at the Centre for the Archaeology of Human Origins*. (CAHO, University of Southampton). BAR International Series 2400 (2012), 85–95.

In this paper I argue that modern social behaviour can be observed in the ability to create and maintain extended social networks where relatedness is successfully sustained in absentia. Archaeologically, modern social behaviour can be detected through the investigation of raw material movement. By concentrating on rare materials it is possible to reconstruct the dimensions of the exchange networks involved in their circulation. Using this information, the scale of social interactions can be inferred. The greater the distances of raw material movement the more complex the behavioural abilities of the individuals involved in the transfers. Information from obsidian-bearing sites spanning the temporal framework of the Palaeolithic and located in two different ecological niches, namely Africa and Europe, will be presented. Using latitude as an exploratory model, the movement of obsidian is investigated. A correlation between obsidian use and long distances is observed. More importantly, the analysis provides strong evidence that obsidian is chosen and transferred significant distances irrespectively of latitude. Subsequently, I argue that the scale of obsidian movement, although conditioned by a number of ecological constraints, is actually rooted in social grounds. It is due to advanced behavioural abilities that obsidian moves and hominines interact and feel related even in absentia.

Moutsiou, T.: *The Obsidian Evidence for the Scale of Social Life during the Palaeolithic*. BAR International Series 2613 (2014), Oxford, Archaeopress.

Obsidian-bearing sites spanning the temporal framework of the Palaeolithic and located in Africa and Europe are analysed in this volume with the aim of elucidating the evolution of modern social behaviour. Obsidian is a rock that forms only under very special conditions; its geological sources are infrequent and distinguished from each other on the basis of unique chemical properties. As such it is possible to reconstruct the distances of its movement and use these data to infer the scale of social life during the Palaeolithic. A strong correlation between obsidian use and long distances is observed implying that the hominines involved in the circulation of the specific material were behaving in a socially modern way.

Nandris, J.: A re-consideration of the South-East European Sources of archaeological obsidian. *University of London Bulletin of the Institute of Archaeology* 12 (1975), 71–94.

This article describes the results of fieldwork on the sources of obsidian in south-east Europe, carried out as part of a programme including other archaeological and environmental research during a short period in the summer of 1974. The object of the part of the work devoted to obsidian was to characterize the geological sources of archaeological obsidian in south-east Europe, by obtaining samples from them for neutron activation analysis, as a preliminary to the analysis of archaeological specimens. This was the first occasion on which fieldwork in this area has been carried out with the aim of verifying the geological sources of obsidian, and it yielded unexpected negative evidence about them.

Novák, M.: Gravettienske osídlenie spodnej vrstvy Kašova I / Gravettien-Besiedlung der unteren Schicht Kašov I. *Slovenská Archeológia* 50/1 (2002), 1–52.

Upper Palaeolithic settlement of eastern Slovakia was concentrated to the Zemplinske vrchy hills surroundings in the time of Gravettian and Epigravettian cultures. On the open-air site in Kašov 1-Spálenisko two layers were found with finds corresponding to two settlement phases. The bottom layer is dated to the late phase of shouldered-points horizon that closed the Gravettian evolution on the territory of central Europe and use to be interpreted as a transitional and short-stay basic camp. Its rise is probably connected with migration of Late Gravettian hunters' groups, moving seasonally between the territory north of the Carpathian are and inner space of the Carpathian basin.

Oddone, M., Márton, P., Bigazzi, G., Biró, K. T.: Chemical characterisation of Carpathian obsidian sources by instrumental and epithermal neutron activation analysis. *Journal of Radioanalytical and Nuclear Chemistry* 240/1 (1999), 147–153.

Obsidian samples from the Tokaj Mountains (Hungary) and from the neighbouring Zemplin Hills (Slovakia) were analysed by instrumental and epithermal neutron activation analysis for obtaining a "fingerprint" for discrimination of potential natural sources of raw material that would permit tracing the origin of archaeological obsidian artefacts. These techniques fully discriminate the Zemplin Hills sources (Carpathian I, Eastern-Slovakia) and the Tokaj Mountain sources (Carpathian II, Northeastern-Hungary) as well as these Central European sources from those already studied of the Mediterranean basin and adjacent regions.

Osipowicz, G., Szelinga, M.: Analiza funkcjonalna obsydianowego lisciaka schylkowopaleolitycznego z wolodzi / Functional analysis of a late-palaeolithic obsidian tanged point from Wolodz, district Brzozów, Podkarpacie Voivodship. *Acta Archaeologica Carpathica* 39 (2004), 153–160.

A microscopic and computer examination of a Late Palaeolithic tanged point recovered from the surface layer of Site 7 at Wolodz, showed the presence of numerous irregular scratches and abrasions resulting from its exposure on site. Nevertheless, it was possible to identify traces of original wear, and on that basis to determine the uses of the tool. The authors concluded that the tanged point was used to scrape hides and owing to continued use its edge gradually acquired a regular, rounded profile. The tanged point must have also served as the point of a missile, most probably an arrowhead. This is indicated by the tongue-shaped negatives disfiguring the pointed cone and its base. The use of the artifact seems to have passed through two phases. Originally employed as a hide scraper, it was later remade into an arrowhead and some technological processing was necessary to adapt the object to its new function.

Orange, M., Le Bourdonnec, F.-X., Scheffers, A., Joannes-Boyau, R.: Sourcing obsidian: a new optimized LA-ICP-MS protocol. *STAR: Science & Technology of Archaeological Research* 2/2 (2016), 192–202.

The LA-ICP-MS is one of the most successful analytical techniques used in archaeological sciences. Applied to the sourcing of lithic raw materials, it allows for fast and reliable analysis of large assemblages. However, the majority of published studies omit important analytical issues commonly encountered with laser ablation. This research presents a new advanced LA-ICP-MS protocol developed at Southern Cross GeoScience (SOLARIS laboratory, Southern Cross University, Australia), which optimizes the potential of this cutting-edge geochemical characterization technique for obsidian sourcing. This new protocol uses ablation lines with a reduced number of assayed elements (specific isotopes) to achieve higher sensitivity as well as increased precision and accuracy, in contrast to previous studies working with ablation points and an exhaustive list of measured isotopes. Applied to obsidian sources from the Western Mediterranean region, the Carpathian basin, and the Aegean, the results clearly differentiate between the main outcrops, thus demonstrating the efficiency of the new advanced LA-ICP-MS protocol in answering fundamental archaeological questions. The measured isotopes have been carefully selected amongst the most efficient to discriminate between the different obsidian sources. This shortened list of isotopes achieves precise and accurate measurements with a higher sensitivity, and with the use of ablation lines, contributes to enhancing the potential of this geochemical characterization technique for obsidian sourcing.

Pollmann, H.-O.: *Obsidian-Bibliographie. Artefakt und Provenienz*. [Der Anschnitt, Zeitschrift für Kunst und Kultur im Bergbau, Beiheft 10] Verlag des Deutschen Bergbau-Museums, Bochum, 1999, 1–151.

A comprehensive bibliography of obsidian research world-wide by geographical regions.

Prokeš, L., Galinová, M. V., Hušková, S., Vaculovič, T., Hrdlička, A., Mason, A. Z., Neff, H., Přichystal, A., Kanický, V.: Laser microsampling and multivariate methods in provenance studies of obsidian artefacts. *Chemical Papers* 69/6 (2015), 761–778.

The provenance of obsidian artefacts and raw materials was studied by the multivariate statistical analysis of forty-five samples using elemental composition data obtained by LA-ICP-MS. The influence of surface roughness (polished raw material vs. artefact) and micro-inhomogeneity on the LA-ICP-MS signal was studied under the optimised working conditions of the laser ablation device. Principal component analysis, correspondence analysis, independent component analysis, multi-dimensional scaling, Sammon mapping and fuzzy cluster analysis were applied and compared in order to reveal statistically significant compositional differences between particular geological sites and to disclose the provenance of the raw materials used in manufacture of the artefacts. Twenty-seven artefacts and eighteen raw material samples from natural resources in the Czech Republic, Slovakia, Italy, Greece, Syria, Iraq, Turkey, Mexico and Nicaragua were examined with special attention focused on samples from Moravia (Czech Republic) and some Near East sites (Tell Arbid, Tell Asmar). The Carpathian origin of the obsidian artefacts was investigated in the Moravian samples using the Pb, Rb and U contents. The Near East samples were classified according to their Sr, Ba, Zr and REE contents as per-alkaline obsidians (Bingöl A/Nemrut Dağ) originating from Southeast Anatolia.

Přichystal, A., Škrdla, P.: Searching for the principal source of obsidian used in prehistoric times of Slovakia and Central Europe. In: *19. Kvartér - Sborník abstract*. 29th November 2013.

Concerning the principal source of obsidian for Slovakia and Central Europe, all recent authors locate it to the primary occurrence at the village of Viničky (Szőllőske). This obsidian is evidently different comparing with this one used mostly for prehistoric artefacts. That is why we suppose the main source of prehistoric obsidian in fluvial sediments (secondary deposit) in the western surroundings of the Brehov village.

Přichystal, A., Škrdla, P.: Kde ležel hlavní zdroj obsidiánu v pravěku Střední Evropy? / Where was situated the principal source of obsidian in prehistory of Central Europe? *Slovenská Archeológia* 62/2 (2014), 215–226.

Carpathian obsidian represented one of the most important raw materials in prehistoric times of Central Europe. According to the distribution maps, the Slovakian source (Carpathian 1) played the decisive role not only in Slovakia but in the whole Central Europe as well. The provenance of this obsidian was supposed near the village Viničky at the southern margin of the Zemplínske vrchy Mts. But the natural obsidian from the surroundings of Viničky (no sculpture, polyhedral shape, almost non-translucent glassy mass, dimensions of pieces usually up to 3–4 cm) has absolutely different properties comparing the appearance of prevalent part of obsidian artefacts (conspicuous sculpture on relics of original surface, a good translucence, common dimensions of pieces above 6 cm and more). We found the occurrence of such shortly transported and sculptured natural obsidians in lenses of probably deluvio-fluvial gravels in air-borne sands situated in central to NE parts of the Zemplínske vrchy Mts., i.e. in the surroundings of Brehov. In recent time these deluvio-fluvial or fluvial rocks with obsidian are probably partly covered by younger flood loams or air-borne sands. Our finding shows the mentioned area with about 6 km^2 could be the principal source supporting by obsidian Central and SE Europe from the Middle Palaeolithic.

Rácz, B.: Закарпатські обсидіани: міфи та реальність. 1 частина: дані спеціальної літератури/Transcarpathian obsidians: myths and reality. Part 1: Data from special literature. *Acta Beregsasiensis* VIII/2 (2009), 273–278.

Trancarpathia is a populated region from the early periods of Palaeolithic. From each historical period we have got the archeological findings. The first tools have made from stone. Thanks to the variety of geological structures, Transcarpathia is very rich of raw materials. One of the most popular stone raw material for the prehistorical man was the obsidian. According to the geological and archaeological literature descriptions, the obsidian can be find in several places: Vihorlat-Gutin Mountain Range, the Oas (Avas) Mountains and Beregovo Hills. The obsidian is described in the form of bombs, seeds, debris and the block, their occurring mostly happened with perlite. The obsidians of the Rokosovo – Maliy Rakovets region are mentioned in the geological and in the archeological literature too. This is a Carpathian 3 type of the obsidians from the Carpathian Basin. The aim of the first part of the article was to collect the descriptions of the obsidians from the literature. In the future we would like to present the results of the field-work from the mentioned places.

Rácz B.: Kárpátaljai obszidiánok: szakirodalmi adatok és terepi tapasztalatok/Transcarpathian obsidians: literature data and field experience. In: Kreiter A. – Pető Á. – Tugya B. (szerk.): *Környezet-Ember-Kultúra. A természettudományok és a régészet párbeszéde*. Magyar Nemzeti Múzeum Örökségvédelmi Központ, Budapest, 2012, 353–362.

People of the Palaeolithic knew the environment and stone raw materials very well. In the territory of Transcarpathia people utilized stones, which proved to be suitable for the production of chipped stone tools. One of the most important raw materials was a high-quality obsidian, three types of which are already known in the Carpathian Basin. One of them is found in Transcarpathia, in primary geological conditions. In this study I present a literature review of geological and archaeological sites that are known in Transcarpathia, from which obsidians are described. The data are complemented by my own field experiences, analysis and evaluation of these resources. The majority of the obsidians that are described by the geological literature, cannot correlate with raw materials that would be suitable for preparing chipped stone tools. Moreover, the rocks in the geological literature are often incorrectly identified as obsidians. According to the literature and field research we can conclude that the Carpathian 3 obsidian was the only local obsidian raw material that was used by prehistoric people in the area of present-day Transcarpathia.

Rácz, B., Szakmány, Gy., Biró, K. T.: Contribution to the cognizance of raw materials and raw material regions of the Transcarpathian Palaeolithic. *Acta Archaeologica Academiae Scientiarum Hungaricae* 67/2 (2016), 209–230.

On the territory Transcarpathian Ukraine, about 100 Palaeolithic localities are known up to our days. Field survey for collecting geological samples localized 19 different raw material sources all of which yielded hard rocks with conchoidal fracture that are suitable for tool making with knapping. Out of the 19 raw material types 11 were actually found in archaeological assemblages of the studied area. The most popular raw materials of Transcarpathian Ukraine are the Korolevo hyaline dacite, Rokosovo obsidian, (Carpathian 3 type) and siliceous rhyolite tuff varieties (type I and II), siliceous tuffite (type I and II), siliceous and opalised rhyolite (type I and II) from the Beregovo Hills area, as well as silicified sandstone (type II) and the siliceous argillite. On the basis of the principal raw material circulation of the Palaeolithic three territorial groups have been formulated. These are named after the most abundant and used rock types of the given region. Three raw material regions are recognized in Transcarpathia: volcanic, metasomatic, and sedimentary. Furthermore, sub-regions were also established in the volcanic region (Rokosovo-Maliy Rakovets and Korolevo-Veryatsa sub-regions) and in the metasomatic region (Beregovo, Muzhiyevo and Bene–Kvasovo sub-regions).

Renfrew, C., Cann, J. R., Dixon, J. E.: Obsidian in the Aegean. *Annual of the British School at Athens* 60 (1965), 225–247.

Obsidian to the Greeks was no more than a semi-precious stone, black and shiny, suitable for mirrors or exotic ornaments. But to their predecessors in the Aegean through five millennia it was an important raw material for the manufacture of tools and weapons. Sharper and more abundant than flint, more easily worked and cheaper than copper, it was not displaced entirely even by the use of bronze, which was always an expensive material, there being no source of tin in the Aegean. Only when knowledge of iron-working was brought to the Aegean coasts did obsidian fall from its position as an important raw material to that of a curiosity. Huge quantities of obsidian are to be found lying about the surface of most prehistoric sites in south Greece—any farmer or shepherd will tell of the 'little razors' to be found on his land. But its occurrence in nature is very unusual since it is found exclusively in regions of recent volcanic activity, and then only when certain conditions exist, such as a high silica content in the lava of the volcano. Every single piece found in mainland Greece had to be imported from overseas, a process implying competent geological knowledge, skill in sailing and navigation, and perhaps social organization, to a considerable degree. It is the earliest trade in the world for which we have concrete evidence.

Repčok, I.: Stopy delenia uránu a možnosti ich využitia pre datovanie na príklade vulkanických skiel. *Západné Karpaty* [Séria mineralógia, petrografia, geochémia, ložiská 3] (1977), 175–196.

The paper deals with the methodology of dating natural materials on the basis of fission tracks originating from the splitting of uranium nuclei. Four types of volcanic glass were dated, from Viničky (11.1 ± 0.8 Ma), Merník (13.3 ± 1.2 Ma) Szabova skala (14.3 ± 1.4 Ma) and Rudno nad Hronom (12.3 ± 1.0 Ma).

Repčok, I., Kaličiak, M., Bacsó, Z.: Vek niektorych vulkanitov vychodneho Slovenska určeny metodou stop po štiepeni uranu. *Západné Karpaty* [Séria mineralógia, petrografia, geochémia, metalogenéza 11] (1988), 75–88.

Some volcanites of eastern Slovakia have been dated by the fission track method. The Slanské vrchy Mts.: rhyolites on the periphery – Upper Badenian, andesites and diorite porphyrites of the upper structure – Middle to Upper Sarmatian, dacites-rhyodacites of the upper structure – Upper Sarmatian. The Zemplínske vrsky Mts.: rhyolite –

Upper Badenian and rhyodacite – Middle Sarmatian.

Rómer, F.: Első obsidian-eszközök Magyarországon / First obsidian implements in Hungary. *Archaeologiai Közlemények* 7 (1868), 161–166.

Report on the first obsidian tools found in Hungary (1865) from the territory of Erdőbénye. Also presenting a large obsidian core from Marosvásárhely (Târgu Mureş, Romania) and Kolozsvár (Cluj-Napoca, Romania) as well as arrowheads made of silex from Transdanubia.

Rómer, F.: Ó-kőkori eszközök Magyarországon. *Archaeológiai Értesítő* 1 (1868), 3–8.

Flóris Rómer, pioneering figure of Hungarian archaeology and founder of the periodical Archaeológiai Értesítő was specifically interested in chipped stone artefacts. Just in 1866 in his monograph on Hungarian prehistory (first of its kind), he commented with regret on the lack of chipped stone tools from the territory of Hungary. In a few years time, he could report on stone tools from the beginnings of the lithic periods including several pieces made of obsidian. It is of symbolic significance for us that the leading archaeological periodical started with a communication on stone, more specifically, obsidian tools...

Rómer, F.: Ismét néhány szó az obsidián-eszközökről. *Archaeológiai Értesítő* 1 (186), 56–59.

Continuation of the report on obsidian tools recently found; mainly the same pieces as already published in Archaeologiai Közlemények 7. Rómer emphatically encouraged potential finders of stone artefacts on reporting the finds personally to him and the periodical Archaeológiai Értesítő, e.g., in form of letters to the Editor.

Rómer, F.: Hogyan készülnek az obszidián késpengék? *Archaeológiai Értesítő* 4 (1871), 250–252.

Technological observations by F. Rómer on the production of obsidian blades on the basis of anthropological analogies.

Rómer, F.: Les silex taillés et les obsidiennes en Hongrie. In: *Compte-Rendu*, Budapest 1876, 5–17.

On the occasion of the VIIIth International Congress on Anthropology and Prehistoric Archaeology, Flóris Rómer published the first catalogue and map of obsidian and silex artefacts collected in the previous decade from the territory of Hungary. The new acquisitions were presented on the exhibition organised in honour of the Congress.

Rosania, C. N., Boulanger, M. T., Glascock, M., Biró, K. T.: Geochemical Analysis of Central and Eastern European Obsidian. In: Gliozzo, (ed.): *37th International Symposium on Archaeometry*. Program and Abstracts. Siena, 12–16 May 2008, Universitá d. Studi de Siena, 2008, 245.

Poster presented on the 37th ISA conference in Siena based on analytical results of the University of Missouri, Research Reactor, using Neutron Activation Analysis.

Rosania, C. N., Boulanger, M. T., Biró, K. T., Ryzhov, S., Trnka, G., Glascock, M. D.: Revisiting Carpathian obsidian. *Antiquity: Project Gallery* 82/318 (2008).

Archaeological interest in sourcing obsidian artefacts has increased exponentially since Renfrew's ground-breaking work with Aegean obsidian. Although Mediterranean obsidian has received the lion's share of attention, sources in Central and Eastern Europe have recently become the focus of characterisation efforts. This is timely Carpathian obsidian was first exploited during the Middle Paleolithic, and was traded widely throughout Europe during later times. Identifying Carpathian sources of obsidian artefacts may therefore provide data on human cultural interactions ranging from social boundaries to resource-procurement patterns over a considerable period of time. Despite increased international collaboration aimed at characterising Carpathian obsidians, advances in understanding of the archaeological significance of Central and Eastern European obsidian sources have been hampered by difficulties of language and access.

Roska, M.: Adatok Erdély őskori kereskedelmi, művelődési és népvándorlási útjaihoz / Data on the trade, cultural and migrational routes of prehistoric Transylvania. *Archaeológiai Értesítő* 47 (1934), 149–158.

A systematical collection of archaeological obsidian finds from the territory of Transylvania, (Romania) by geographical location and chronological period. Possible routes of trade and communication were hypothesed. The author emphasised the role of the rock-salt deposits as possible counter value for barter.

Rózsa, P., Elekes, Z., Szöőr, Gy., Simon, A., Simulák, J., Uzonyi, I., Kiss, Á. Z.: Phenocrysts in obsidian glasses. *Journal of Radioanalytical and Nuclear Chemistry* 256/2 (2003), 329–337.

The aim of the current paper is to map minerals mainly of Carpathian obsidian glasses by nuclear microprobe based on the particle induced X-ray emission (PIXE) providing analytical data on them for the first time. Some samples from Armenia, Greece are also involved to make a comparison with the Carpathian specimens. The following minerals are identified and analyzed: pyrrhotine, chalcopyrite, pyrite, zircon, pyroxene, biotite, plagioclase feldspar, and anhydrite. On the basis of rock-forming silicate minerals, some petrologic processes are outlined. With the identification of accessory minerals (anhydrite, pyrrhotine, chalcopyrite, pyrite), some geological conclusions are also drawn.

Rózsa, P., Szöőr, Gy., Elekes, Z., Gratuze, B., Uzonyi, I., Kiss, Á. Z.: Comparative geochemical studies of obsidian samples from various localities. *Acta Geologica Hungarica* 49/1 (2006), 73–87.

Obsidian samples from different localities of various geologic settings (Armenia, Hungary, Iceland, Mexico, Slovakia and Turkey) were analyzed by particle induced Gamma-ray emission (PIGE) technique and laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS). Samples from Mexico and Iceland show higher alkali and REE content as well as higher Nb and Ta abundances than the other samples. Discrimination diagrams show samples from Mexico and Iceland to belong to WPG. The position of the samples from the Tokaj Mts. is also definite, and it corresponds to the expectation (VAG or VAG+syn-COLG fields). Using a Li-B diagram the obsidian samples can be distinguished according to their geographic distribution. By means of a Ce-Ti diagram, obsidian from the Tokaj Mts. can be divided into three groups that may correspond to the archeometrical C2E, C2T and C1 groups. Phenocrysts in the obsidian samples from the Tokaj Mts., and the Aragats Mts. (Armenia) were detected and analyzed by micro-PIXE (proton induced X-ray emission) method. In this way silicate minerals (zircon, pyroxene, biotite, plagioclase feldspars), ore minerals (chalcopyrite, pyrrhotine, pyrite), and other non-silicate mineral (anhydrite) were identified.

Ryzhov, S.: Obsidian outcrops in Transcarpathia and their use during the Palaeolithic Time. In: Yamada, M., Ono, A. (eds.): *Lithic raw material exploitation and circulation in Prehistory. A comparative perspective in diverse paleoenvironments*. Series: Etudes et recherches archéologiques de l'Université de Liège No. 138., Université de Liège, Service de préhistoire & Centre de recherches archéologiques. 2014, 113–129.

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. 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, Middle, and Upper Paleolithic 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.

Sobkowiak-Tabaka, I., Kasztovszky, Zs., Kabaciński, J., Biró, K. T., Maróti, B., Gméling, K.: Transcarpathian contacts of the Late Glacial Societies of the Polish Lowlands. *Przegląd Archeologiczny* 63 (2015), 5–28.

Identification of exotic raw materials discovered within the context of Late Glacial societies of the North European Plain is a crucial factor in discussion about far-reaching exchange systems of goods and ideas. The present paper considers the occurrence of obsidian finds on the Polish Lowlands, hundreds of kilometers away from its sources located south of the Carpathians. The focus is on chemical recognition and identification of a large and unique assemblage of obsidian artefacts from two Polish localities based on non-invasive Prompt Gamma Activation Analysis (PGAA). As a result, a clear connection of northern Polish obsidians with its outcrops located on the northern (Slovakian) fringe of the Tokaj Mountains was established that is the first detailed identification of obsidian finds from the territory of Poland ever. A review of Polish and Slovakian obsidian assemblages from the Late Glacial times and the importance of obsidian exchange and mobility for Late Palaeolithic societies of Central Europe are discussed supported by analytical results of PGAA.

Soják, M.: Analýza kamennej industrie zo Zemplínskych Kopčian a Brehova (Slovensko) / Analyse der Steinindustrie aus Zemplínske Kopčany und Brehov (Slowakei). *Přehled výzkumů* 54/1 (2013), 99–109.

Analysis of chipped stone industry from Kopčany and Brehov (Slovakia). The flake stone assemblages which were discovered during the excavation of two archaeological sites in Eastern Slovakia – Zemplínske Kopčany and Brehov were analysed. Obsidian stone, which is a local raw material, occurs at a higher frequency than imported raw materials – Jurassic flint "G" and basalt. Local raw materials were used at Brehov. The local obsidian dominates and other stone materials are present in small proportions. The typological character of the flake industries is also different. Flakes account for 68 % of the artefacts and blades 25 %. Specific artefacts are the „łuszcznie" ("Splitter" in German) though to have been used as chisels or cutting tools. The analyzed assemblages are compared with assemblages from other Baden culture sites in Slovakia and in particular to those from the Malopolskie Voivodship. The analyzed artefacts from Zemplinske Kopčany and Brehov correspond to two phases in the development of the Baden Culture. The older phase has stronger affinities to the Funnel Beaker culture, and in the case of the Brehov site, to a younger phase, which is parallel with the Pleszow-Zesławice group in the Malopolskie Voivodship.

Suda, Y., Yamada, M., Ryzhov, S., Stepanchuk, V.: Preliminary report on obsidian petrography from the Transcarpathian region in Ukraine. *Natural Resource Environment and Humans* 4 (2014), 21–37.

This paper reports the field occurrence, mineralogy, and whole-rock chemistry of the obsidian from the Neogene Carpathian volcanic arc area. The study area encompasses the Transcarpathian (Zakarpatia) region in Ukraine. A mafic xenolith comprising of a plagioclase, amphibole, and olivine mineral assemblage was found from the obsidian in this area. SEM-EDS analysis indicates that the olivine has high magnesium content. The forsterite (Mg_2SiO_4) content varies from 77% to 80%. The chemical composition of plagioclase remains constant, and is enriched in calcium. The anorthite ($CaAl_2Si_2O_8$) content varies from 89% to 94%. The amphibole is classified into the tschermakite following the nomenclature of Leake et al. (1997). Based on the compositions of the amphibole and the plagioclase, pressure and temperature conditions of the mafic xenolith were estimated to be 4.5–7.9kbar and 1185–1358°C respectively. These results indicate that this mineral aggregate is not genetically associated with the rhyolitic magma from which the obsidian was derived, but is considered to be of an exotic xenolith originated from the gabbroic rocks of the lower crustal level of the Carpathian volcanic arc. The finding of mafic xenolith will help in characterizing the obsidian from this area, and is a key in understanding the tectonic and evolutionary history of the Carpathian volcanic arc.

Suda, Y., Grebennikov, A. V., Kuzmin, Y. V., Glascock, M. D., Wada, K., Ferguson, J. R., Kim, J. C., Popov, V. K., Rasskazov, S. V., Yasnygina, T. A., Saito, N., Takehara, H., Carter, T., Kasztovszky, Zs., Biró, K. T., Ono, A.: Inter-laboratory validation of the WDXRF, EDXRF, ICP–MS, NAA and PGAA T analytical techniques and geochemical characterisation of obsidian sources in northeast Hokkaido Island, Japan. *Journal of Archaeological Science: Reports* 17 (2018), 379–392.

Obsidian provenance studies, based on geochemical signatures, are important for determining the source regions of obsidian artefacts. Such research depends on the availability of reproducible geochemical data. An inter-laboratory study was conducted to validate analytical methods applied to samples from four obsidian sources in northeast Hokkaido Island (Shirataki, Rubeshibe, and Oketo regions). The methods applied were WDXRF, EDXRF, ICP–MS, NAA and PGAA. Eight laboratories in Japan, the Russian Federation, Republic Korea, Hungary, Canada, and the USA took part in the trials. Results indicate discrepancies between laboratories, but compositional data for 53 elements were successfully compiled, and reference compositions for 16 elements in each sample defined. Based on these data, a new chemical discrimination scheme is proposed for obsidian sources in the Shirataki, Rubeshibe, and Oketo regions. This scheme is applicable to the discrimination of obsidian sources using semi-quantitative EDXRF analysis, with this being important in non-destructive provenance studies of artefacts. This study fosters the further establishment of reference materials for obsidian sources in the Hokkaido region, and the sharing of such materials.

Szabó, J.: A Tokaj-Hegyalja obsidiánjai (Obsidians of the Tokaj mts.). *A Magyarhoni Földtani Társulat Munkálatai* 3 (1867), 147–172.

Detailed geographical and geological description of the obsidian sources in the Tokaj region.

Szabó, J.: L'obsidienne prehistorique en Hongrie et en Grece. In: *Congr. Int. d'Anthr. et d'Arch. Prehist VIII.* Compte-Rendu 2 (1876), 96–100.

On the occasion of the VIIIth International Congress on Anthropology and Prehistoric Archaeology, József Szabó summarised geological information on obsidians of the Tokaj region and the Melian sources.

Szádeczky, Gy.: A magyarországi obsidiánok, különös tekintettel geológiai viszonyaikra [Hungarian obsidians, with special regard to their geological relations]. *Értekezések a természettudományok köréből* 16 (1886), 1–64.

Detailed geographical and geological description of the obsidian sources in the Tokaj region.

Szeliga, M.: Der Zufluss und die Bedeutung des Karpatenobsidians in der Rohstoffwirtschaft der Postlinearen Donaugemeinschaften auf den Polnischen Gebieten. In: Kozłowski, J. K., Raczky, P. (eds.): *The Lengyel, Polgár and related cultures in the Middle/Late Neolithic in Central Europe*. The Polish Academy of Arts and Sciences Kraków – Eötvös Loránd University Institute of Archaeological Sciences Budapest, Kraków, 2007, 295–307.

The inflow of Carpathian obsidian to the territory of Poland in the period of the development of post-linear communities constitutes a continuation of the phenomenon, which had been begun by the people of the Linear Pottery Culture. Archaeological data point to an undisrupted continuity of this process throughout the 5th and 4th millennia BC. The leading role in its distribution was played by the Rzeszów settlement concentration of the Malice culture. This is reflected in the local incidence of obsidian, which is decidedly higher in comparison to the more distant settlement enclaves of this culture, as well as of the Lengyel communities. This type of territorial differentiation does not point to a higher variability in time, retaining similar proportions throughout the entire 5th millennium BC. The conclusions following from a thorough analysis of the percentage-based shares of this raw material necessitate a search for justification of its inflow into the foothills of the Carpathians and the Sudets, which would be other than purely utilitarian. Obsidian is postulated to have the function of a symbol of prestige. It is not connected directly with the sphere of economic demand, but whose import resulted from the necessity to satisfy quite different needs and had other aims than obtaining good quality raw material.

Tripković, B.: Obsidian deposits in the Central Balkans? Tested against archaeological evidence. *Starinar* 53–54 (2003–2004), 163–179.

Finds of obsidian artefacts on sites distant from the presumed primary source have often received a romantic note in the history of archaeology, manifested in the idea about local exploitation as a form of procurement and archaeologists' search for as yet undetected deposits of this raw material. In due course, such concepts have found their way into Serbian archaeology as well. The main objective of this contribution, therefore, is to reconsider the current knowledge about obsidian in the central and north Balkans, to test how well founded the idea about the use of local sources is, as well as to indicate some possible directions for future research.

Tripković, B.: The quality and value in neolithic Europe: an alternative view on obsidian artifacts. In: Tsonev, T., Montagnari-Kokelj, E. (eds.): *The Humanized Mineral World: Towards social and symbolic evaluation of prehistoric technologies in South Eastern Europe.* Proceedings of the ESF Workshop, Sofia, 3–6 September 2003. ERAUL 103 (2004), 119–123.

In current studies, obsidian is considered both as a highly valuable commodity, of exotic origin, and in other cases as a raw material with practical use only. The answer to the problem is not an easy one, since the basic qualities of obsidian are also found in many other raw materials, often easily accessible from prehistoric settlements. In this assessment of the subject of distribution and the chronology of obsidian finds I have tried to view obsidian exclusively on the basis of its chronological and cultural context. Such methodological premise leads to a conclusion that the role, importance and value of obsidian in the life of prehistoric communities can be best understood during the period of neolithization of the European continent and later on, when obsidian becomes an integral part of the complex changes in the perception and the use of the environment.

Tripković, B., Milić, M.: The origin and exchange of obsidian from Vinča–Belo Brdo. *Starinar* 58 (2008), 71–86.

Since the time of the revolutionary characterisation of obsidian in the 1960's only a small number of artefacts from the Serbian sites have been analysed, of which at least seven samples come from the site of Vinča. These results showed that obsidian was coming from Carpathian sources, disproving old romantic ideas of the existence of local obsidian sources in the central Balkans. These results allowed for the development of ideas about exchange networks of interregional importance during the Late Neolithic in which obsidian was an integral component. In this paper we will be discussing the results of the characterisation of 60 obsidian samples, representing ca. 4% of the entire obsidian assemblage from the site. The samples

were taken from the whole Neolithic sequence at Vinča selecting macroscopically different obsidian types.

Tsonev, T., Montagnari-Kokelj, E. (eds.): *The Humanized Mineral World: towards social and symbolic interpretation of prehistoric technologies in South Eastern Europe*. Proceedings of ESF Exploratory Workshop, 3-6 September, Sofia, ERAUL 103 (2003), 71–76.

There are very few obsidian artefacts from prehistoric settlements in Bulgaria – sensu lato Neolithic till Bronze Age (Eneolithic). On the contrary, such artefacts are numerous in the countries surrounding (European Turkey, Romania, Greece, Hungary). we have tried explain this general absence of such artefacts in Bulgarian settlements. In seemed interesting to compare two generally divergent approaches, the geological and the archaeological. We decided to look for the existence of obsidian in the territory of Bulgaria, and organized a study trip to the main paleovolcanic regions located in the south and south-eastern parts of the country: the Dambalak (Eastern Rhodopes), as well as the Bulgarovo and Rossen paleovolcanoes (the latter actually under the Black Sea). According to geologists obsidian exists as nodules in these areas, as the paleovolcanoes produced acid conditions favourable for the production of obsidian or glassy rocks.

Tykot, R. H.: Obsidian procurement and distribution in the central and western mediterranean. *Journal of Mediterranean Archaeology* 9/1 (1996), 39–82.

Obsidian has long been recognized as an indicator of long-distance, maritime-based exchange networks in the Neolithic central and western Mediterranean. Earlier studies have identified and chemically characterized the major island sources, but few subsequent efforts have been directed at determining the provenance of significant numbers of artefacts from secure archaeological contexts. This paper presents new interpretations of obsidian procurement and distribution based on the chemical and visual sourcing of more than 2700 artefacts from island and mainland sites in France and Italy, and discusses the spatially and temporally dynamic economic and social role of obsidian. Finally, it is suggested that long-distance prestige exchange of obsidian and other materials was an important way of maintaining ethnic or kin connections in increasingly sedentary Neolithic societies.

Tykot, R. H., Ammerman, A. J.: New directions in central Mediterranean obsidian studies. *Antiquity* 71 (1997), 1000–1006.

Mediterranean obsidian-provenance studies are changing in direction and focus of modern research, with characterisation of the Sardinian sources, application of minimally destructive and inexpensive analytical techniques, analysis of complete or large parts of assemblages, and the integration of provenance data with reduction technology and use-wear traces.

Warren, S., Williams, O., Nandris, J.: The sources and distribution of obsidian in Central Europe. In: *International Symposium on Archaeometry and Archaeological Prospection*. 1977

Fieldwork and first source characterisation of the Carpathian obsidians by NAA, presented ob the ISA symposium, 1977

Wilczyński, J.: Obsidian products from Targowisko 10 site (Wieliczka distr.). In: Gancarski, J. (ed.): *Transkarpackie kontakty kulturowe w epoce kamienia, brązu i wczesnej epoce żelaza*. Wydawnictwo: Muzeum Podkarpackie w Krośnie, Krosno, 2010, 109–131.

The multicultural open-air site "Targowisko 10", located in the Kłaj commune, Małopolska province, Poland, was discovered during the surface research conducted on the planned route of the A-4 motorway between Krakówand Tarnów. The research was funded by the state, and the issues connected with the archaeological work were handled by the Institute of Archaeology and Ethnology of the Polish Academy of Sciences, the Archaeological Museum in Cracow and the Jagiellonian University: The Cracow Team for Motorway Survey, Registered Partnership. The systematic archaeological rescue research on the site started in 2000 under direction of W. Machowski. In 2001–2005 it was continued by B. Koniecznyand B. Grabowska. The result of the research was the discovery of a rich inventory consisting of the very interesting and diverse stone material (e.g. a group of obsidian items), hearth remains and, what is unusual for this part of Poland, some remains of fauna. This site, being one of the very few located east of the Vistula, is a perfect supplement to the image of Palaeolithic settlement of southern Poland.

Wilczyński, J.: The techniques of obsidian treatment on the Malice culture settlement of Targowisko 11, Lesser Poland. *Przegląd Archeologiczny* 58 (2010), 23–37.

This article is devoted to the obsidian inventory from Targowisko 11 site associated with the Malice settlement. The years of research on this site resulted in the discovery of a very rich complex of obsidian debitage, consisting of several dozen examples of cores and several hundred blade and flake fragments. Such a large number of artifacts made it possible to reconstruct the process of obsidian treatment carried out on this site.

Wilczyński, J., Czekaj-Zastawny, A., Zastawny, A.: Flint and Obsidian Malice Culture Artefacts from Brzezie, Site 17, Wieliczka District, Małopolska. *Fontes Archaeologici Posnanienses* 51 (2015), 245–262.

This article shall discuss the lithic inventory described at the Malice culture settlement discovered at the multicultural Brzezie 17 site. During rescue excavations at this site some 8,526 lithic artefacts were documented, diverse in terms of the raw material, technology of production, typology and chronology. The largest corpus of materials could be linked with settlements relating to the Linear Pottery culture (LPC; 4,123 specimens) and the remainder to the Malice culture (MLC; 677 specimens), the Neolithic (233 specimens) and general prehistory (3,503 specimens).

Williams, O., Nandris, J.: The Hungarian and Slovak sources of archaeological obsidian: an interim report on further fieldwork. *Journal of Archaeological Science* 4/3 (1977), 207–219.

This report describes the results of fieldwork carried out in the Zemplén Mountain area of north-eastern Hungary in 1975. The aim of this work was to locate and sample geological sources of obsidian which may have been used by prehistoric man. These sources are of increased importance since the work of Nandris (1975) showed that the Romanian "sources" do not produce workable obsidian. During the fieldwork three sources in Hungary were visited and sampled; one of these was the previously unlocated source of Csepegő Forrás. A number of other possible localities for geological obsidian are mentioned in 19th and 20th century geological and archaeological literature, and the present state of knowledge with regard to these is summarized. Further sources exist in central and in south-eastern Slovakia. These sources were not visited but material has been obtained from both areas. The central Slovak sources do not produce workable obsidian and are not therefore relevant to archaeological studies. Obsidian from three localities in south-eastern Slovakia is of good glassy quality and further fieldwork is now needed to check the validity of these localities as geological sources. Reference is made to obsidian sources in the western U.S.S.R., and the problem of the use of tektites in archaeological sites is discussed. The obsidian samples obtained during this work are currently being analyzed using neutron activation, in order to characterize the sources on the basis of their trace element analysis and thus to relate them to archaeological obsidian from central and eastern Europe.

Williams-Thorpe, O.: Obsidian in the Mediterranean and the Near East: A provenancing success story. *Archaeometry* 37/2 (1995), 217–248.

Obsidian provenancing studies comprise one of the most productive and successful research programmes of archaeological science. Obsidian characterization has been successful because workable obsidian is homogeneous on a small scale, analysable by a large number of methods, and is restricted to a small number of mainly readily distinguishable geological sources. Analytical, dating, source, and trade studies within the western Mediterranean, central and eastern Europe, the Aegean, and Anatolia and the Near East during the last 30 years or so are reviewed. Research has shown that distributions are mainly separate in the four regions examined, and that obsidian was traded up to 900km in the prehistoric period. Publications on obsidian in the areas under review reached a peak of frequency in the later 1970's and 1980's, but have now decreased in number. This may reflect changing fashions in archaeometric studies, and a current lack of routine application of the provenancing methods developed.

Williams-Thorpe, O., Warren, S. E., Nandris, J.: The Distribution and Provenance of Archaeological Obsidian in Central and Eastern Europe. *Journal of Archaeological Science* 11/3 (1984), 183–212.

The sources of archaeological obsidian in central and eastern Europe are briefly described and analyses in northeast Hungary and southeast Slovakia are reported. Instrumental Neutron Activation Analysis was used to determine 16 trace elements and two major elements. Principal Components Analysis supported by Discriminant Analysis showed seven analytical groups in these data. The archaeological obsidian were assigned by Discriminant Analysis to three of the Carpathian source groups defined, the remaining four source groups not being represented in the archaeological record. Carpathian obsidian was used most widely in Hungary, Slovakia and Romania, and also reached south to the Danube in Yugoslavia, west to Moravia, Austria and to the Adriatic near Trieste, and north to Poland. There is no evidence at present for any overlap between the Carpathian

obsidian distribution and the distributions of the Near Eastern or Aegean sources, but there is an overlap with Mediterranean obsidian at the Neolithic site of Grotta Tartaruga in northeast Italy where Liparian and Carpathian 1 material were identified. The distribution of obsidian from the Carpathian sources is considered in terms of linear supply routes. Based on limited available evidence the supply zone is significantly smaller and the rate of fall-off with distance slightly lower than that reported for Near Eastern obsidians.

Yamada, M., Ryzhov, S. (eds.): *Archaeology and Geology of Ukraine in Regional Context*. Center for Obsidian and Lithic Studies – Meiji University, Tokyo, 2015.

The Center for Obsidian and Lithic Studies (COLS), Meiji University, founded in April 2001, is unique because it is the only institute in Japan with research facilities for all fields of obsidian studies, both from the Natural and the Social Sciences. In 2010 the COLS was reorganized to further promote obsidian studies and to enhance international research collaborations networks, such as the Organization for the Strategic Coordination of Research and Intellectual Properties at Meiji University. In 2013 we embarked on an international joint research project with the Department of Archaeology and Museology of the Taras Shevchenko National University of Kiev, which led to archaeological and geological expeditions in Ukraine during August of the same year. In 2014 after the conclusion of the bilateral agreement on research, education, and cultural cooperation between Meiji University and Taras Shaevchenko National University of Kiev, we published the proceedings of our joint research projects titled "Archaeological and Geological Researches in Ukraine", edited by Masayoshi Yamada. The collected papers in this second volume present an update on the results of our ongoing research endeavors.