Obsidian Artifacts from Tell Hódmezővásárhely-Gorzsa (SE Hungary): Results of a Provenance Study Using pXRF

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CHAPTER 3

Obsidian Artifacts from Tell Hódmezővásárhely-Gorzsa (SE Hungary): Results of a Provenance Study Using pXRF

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Abstract

In total, 175 obsidian artifacts from Late Neolithic (Tisza culture) contexts at the tell site of Gorzsa in southeast Hungary were analyzed using a portable XRF device and the results were compared with the corresponding measurements made on geological samples from known European obsidian sources. The data support the conclusion that most of the obsidian used at Gorzsa originated in the Carpathian 1 (C1 – Cejkov-Viničky) source area in southern Slovakia, with just one piece traceable to the C2E (Mád-Erdőbénye) source area in northeast Hungary. However, four artifacts from Gorzsa that visually resemble C2E obsidian could not be matched with any known Carpathian, or indeed European, obsidian source and may derive from a previously undocumented source of obsidian or a very fine-grained obsidian-like rock.

Introduction

This chapter presents the results of portable X-ray fluorescence (pXRF) analysis of obsidian artifacts from the Late Neolithic tell settlement of Hódmezővásárhely-Gorzsa in southeast Hungary, which were recovered in excavations directed by Ferenc Horvath. The work is part of ongoing multidisciplinary research into the provenance of raw materials represented in the entire lithic assemblage from the tell excavation (Starnini et al. 2007, 2015). Considering the location of Gorzsa on the floodplain of the Tisza River and in the middle of the Alföld (the Great Hungarian Plain), the assumption is that virtually every piece of tool stone, including obsidian, was obtained from sources at least 60 km away and brought to the site either in the form of raw material or as a ready-made artifact. This presents a rare opportunity to infer the cultural connections, raw material procurement strategies, and social organization of a Late Neolithic community through geochemical identification of the sources used for the manufacture of stone tools (Szakmány et al. 2009, 2011). Choices, supply strategies, and changes in the exchange network of raw materials are the main historical issues of our scientific sourcing approach to the stone assemblage from Gorzsa.

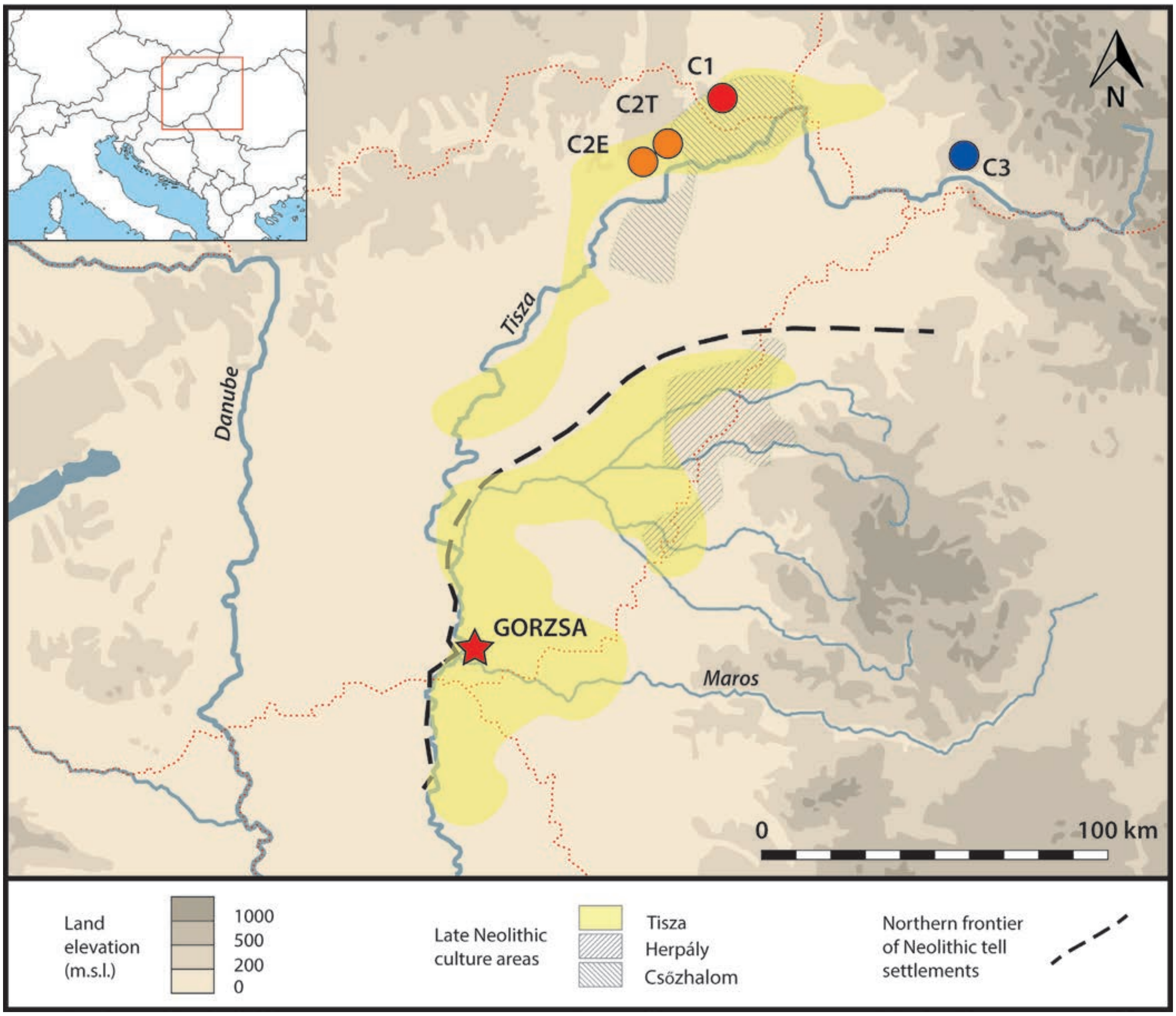

Figure 1. Map of the Alföld (Great Hungarian Plain) with the locations of Gorzsa, the Late Neolithic cultural groups (Tisza, Herpály, Csőszhalom), and the Carpathian obsidian sources (C1–C3) (drawn by C. Bonsall; cultural areas based on Raczky et al. 2020: Figure 1).

The site

The tell site of Hódmezővásárhely-Gorzsa, covering ca. five hectares, was explored during several excavation campaigns between 1978 and 1996, which investigated an area of ca. 1000 m^2 (Horváth 2005). The settlement was occupied during the greater part of the Late Neolithic corresponding to Phases II–V of the Tisza culture, dated to 4900–4500 cal BC, and continued to be occupied during the Bronze, Iron, and Sarmatian ages. The tell settlement is in the southern part of the Alföld (Figure 1), which during the Late Neolithic supported a dense settlement network (Tálas and Raczky 1987). The Alföld represents the northernmost frontier of the Neolithic tell settlements phenomenon that characterizes the southern Balkans. The plain is subdivided into several cultural areas: *Tisza*, located in the Tisza, Körös, and Lower Maros Valleys, *Herpály* in the Berettyó Valley, and *Csőszhalom* in the Upper Tisza Valley. The Herpály and Csőszhalom culture areas take the names of two eponymous tell sites, while Gorzsa belongs to the Tisza culture area, which takes the name of the river along which most of the sites have been found (Raczky 1992; Raczky et al. 2021). Each of these archaeological culture groups or areas corresponds traditionally to different ceramic styles, settlement types, and distribution patterns (Parkinson et al. 2018). The Alföld is delimited to the north and east by the Carpathian Mountains. In the foothills of the northeastern part of the mountain chain are located the Carpathian obsidian sources, the most important in continental Europe.

The Carpathian obsidian sources

Four chemically distinct types of obsidian are known in the region: Carpathian 1 (C1), Carpathian 2E, Carpathian 2T, and Carpathian 3. Usually, C1 and C2 can be distinguished visually: typically, C1 is highly translucent, with a glossy luster and (in some samples) darker stripes, while C2 obsidian is characteristically black or dark gray, with a duller luster, and only slightly translucent at the edges except in very thin pieces. Since the 1970s, compositional studies of the Carpathian obsidian sources have made it possible to differentiate those in northeast Hungary (C2E, C2T), eastern Slovakia (C1), and westernmost Ukraine (C3).

The C1 source area is in the Zemplín Hills of Slovakia, while the C2 source area, encompassing subgroups C2E and C2T (formerly C2b and C2a), lies in the Tokaj region of Hungary (Kaminská 2021; Furholt 2024). This division was confirmed by analyses (Biró 1984) leading to a subdivision of group C1 into subgroups C1a and C1b. Subgroup C1a comprises finds from a secondary source between Brehov and Cejkov, as well as archaeological sites ("quasi-sources") between Cejkov and Kašov, while subgroup C1b corresponds to a primary source in the Viničky-Malá Bara area (Biró and Kasztovszky 2013; Kasztovszky et al. 2014; Kaminská 2021). However, not all researchers accept the proposed subdivision of C1 obsidian (see Kohút et al. 2021). The obsidian from Transcarpathia in westernmost Ukraine was shown to be chemically distinct from the Slovakian and Hungarian sources (Rosania et al. 2008) and was designated as Carpathian 3 (C3) following the nomenclature of Williams-Thorpe and colleagues (1984). C3 obsidian is black and glassy, with macroscopic mineral grains, conchoidal to slightly hackly fracture, and is non-transparent even in thin flakes (Rácz 2018).

A general observation that emerges from studies of prehistoric sites in the Carpathian Basin is that obsidian was a lithic raw material used to produce a wide range of artifacts (endscrapers, burins, retouched blades, flakes, cores, etc.), and no close association between obsidian and a particular artifact type has been observed in any Neolithic site or culture (Kaminská 2021: 244; Starnini 1994: 57).

Figure 2. Hódmezővásárhely-Gorzsa, C1 obsidian artifacts: 1) short end scraper, used for scraping medium material (inv. MFM n. 99.3.2124./sample GOR#2124); 2) end scraper and truncation, used for scraping hard material (inv. MFM n. 99.3.2152./sample GOR#2152); 3) irregular, corticated bladelet, from the fill of Grave 4 (inv. MFM n. 99.3.2086./ sample GOR#2086); 4) end scraper, used to cut soft material (inv. MFM n. 99.3.2145./sample GOR#2145); 5) micro-bladelet (inv. MFM 99.3.1720./ sample GOR#1720); 6) microcore and refitting bladelet, inv. MFM 99.3.959-99.3.960./GOR#061); 7) core on a small, corticated volcanic bomb, from the ruins of House 2 (inv. MFM n. 99.3.1975./ sample GOR#1975); 8) retouched blade, used for cutting medium material (inv. MFM n. 99.3.1929./sample GOR#1929); 9) corticated flake, from House 3, room 3 (inv. MFM n. 99.3.1976./sample GOR#1976); 10) mesial fragment of an unretouched blade, possibly obtained by pressure technique, used for cutting medium material (inv. MFM n. 99.3.2212./ sample GOR#2122); 11) corticated and truncated bladelet, from the ruins of House 2 (inv. MFM n. 99.3.1944./sample GOR#1944) (photographs by E. Starnini).

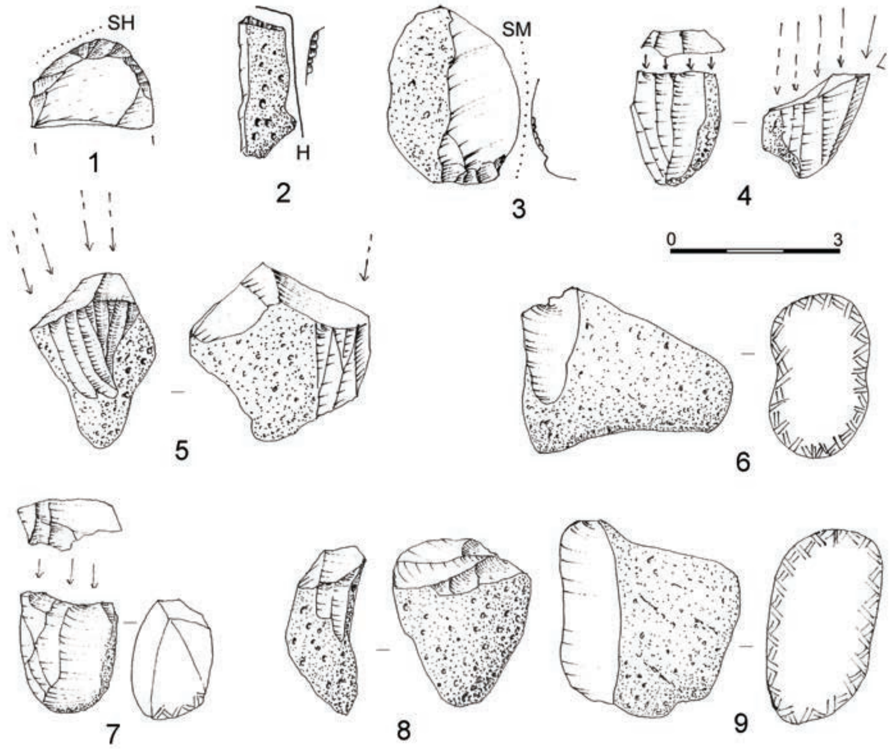

Figure 3. Hódmezővásárhely-Gorzsa, C1 obsidian artifacts: 1) short end scraper, used for scraping hard material (inv. MFM n. 99.3.431./analysis GOR#0431); 2) corticated bladelet with distal truncation, hafted (inv. MFM n. 99.3.404./analysis GOR#0404.); 3) corticated flake used for scraping soft material (inv. MFM n. 99.3.349./analysis GOR#349); 4) exhausted bladelet microcore, unidirectional, on small nodule (inv. MFM n. 99.3.341./analysis GOR#341); 5) small, exhausted bladelet core (inv. MFM n. 99.3.214.); 6) small, tested obsidian nodule (inv. MFM n. 99.3. 243.); 7) exhausted bladelet core on a small, corticated volcanic bomb (inv. MFM n. 99.3.587.); 8) pre-core on small, corticated nodule (inv. MFM n. 99.3.589.); 9) small, tested obsidian nodule (inv. MFM n. 99.3.242.) (drawings by E. Starnini).

Materials and methods

A total of 846 artifacts of obsidian were identified in excavations at Gorzsa from stratigraphic units of the Late Neolithic Tisza culture, representing ca. 20% of the knapped stone assemblages from those contexts. The obsidian assemblage comprises blanks, retouched and used artifacts, cores, and debitage waste (Figures 2 and 3). To investigate the provenance of the raw material, we carried out multielement X-ray fluorescence (XRF) analyses of a representative archaeological sample using portable/handheld instrumentation (pXRF), which is a rapid, non-destructive, and relatively inexpensive means of analyzing the chemical composition of a wide range of archaeological materials. Numerous provenance studies of obsidian have highlighted the advantages of pXRF—notably its reliability and the capability to analyze large numbers of specimens in a relatively short time (e.g., Frahm 2014; Speakman and Shackley 2013; Tykot 2018; Vazquez et al. 2012). More importantly, handheld instruments allow archaeological objects to be analyzed *in situ*, thus avoiding the problems inherent in transporting cultural heritage items from museums to laboratory facilities sometimes located abroad, as well as bypassing legal considerations and financial issues.

The XRF analyses reported here were conducted during two visits to the Móra Ferenc Múzeum in Szeged, Hungary. The first took place on August 26–28, 2019, when the measurements were taken using a *Niton XL3t Ultra He* handheld analyzer made by Thermo Fisher Scientific. Because of the COVID-19 pandemic, the second visit to Szeged had to be delayed until June 6–12, 2022. On that occasion, the instrument used was an Olympus *Vanta M* handheld XRF analyzer (Figure 4).

Figure 4. The pXRF analyzers used for chemical fingerprinting and source characterization of the Late Neolithic obsidian assemblage from Hódmezővásárhely-Gorzsa (photographs by C. Bonsall).

The Niton XL3t Ultra is equipped with a 2W Ag anode, 50 kV X-ray tube, and 45 mm^2 Silicon Drift Detector (SDD), while the Vanta M has a 4W Rh anode, 50 kV X-ray tube, and a 40 mm^2 SDD. Both instruments use beam filters to improve the detection of particular elements (Table 1).

Table 1. Niton XL3t Ultra and Olympus Vanta M: settings, filters, and element ranges.

Mode	kV	μA	Filter	Elements (optimized)
a) Niton XL3t Ultra: "Mining"	50	40	Main	Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Se, Rb, Sr, Zr, Nb, Mo, Pd, Ag, Cd, Sn, Sb, Hf, Ta, W, Re, Au, Pb, Bi
	50	40	High	Y, Pd, Ag, Cd, Sn, Sb, Ba
	20	100	Low	Ti, V, Cr
	8	200	Light	Mg, Al, Si, P, S, Cl
b) Olympus Vanta M: "Geochem-3-beam"	40	55	Beam 1	Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Rb, Sr, Y, Zr, Nb, Mo, Ag, Cd, Sn, Sb, Ba, W, Hg, Pb, Bi, Th, U
	10	66	Beam 2	Mg, Al, Si, P, S, K, Ca, Ti, Mn
	50	65	Beam 3	Ag, Cd, Sb, Ba, La, Ce, Pr, Nd

The XL3t was configured for measuring up to 42 elements simultaneously from Mg to U in the periodic table. The analyzer was controlled from a Windows 10 laptop and operated using the factory-set Fundamental Parameter (FP) Mining Mode Calibration, using 3 of the 4 filters available (Table 1a). Each obsidian sample was measured for a total of 180s (60s per filter). The light range filter was not used, partly because the low Z elements (Al, P, Si, Cl, S, Mg) usually are not critical for obsidian characterization, and partly to reduce the overall measurement time per sample. Deploying the light range filter would have added 120s to the measurement time per sample, and ultra-low light element detection with the XL3t Ultra requires helium purge.

Measurements with the Vanta M were taken using the GeoChem 3-beam (FP calibration) model (Table 1b). The main practical advantages of the more powerful Vanta M over the XL3t Ultra are shorter measurement times and lower limits of detection (LOD). The Vanta M is also equipped with a 0.9μm-thick graphene detector window, enabling better light element detection without helium or vacuum assistance (for an assessment of the capabilities of the Vanta M, see Frahm 2017).

XRF analysis of the Gorzsa material was preceded by visual sourcing of the obsidian artifacts by Barbara Voytek and Elisabetta Starnini. The overwhelming majority were identified provisionally as C1 obsidian, with just 5 pieces attributed to a different obsidian type, assumed to be C2. Altogether, pXRF measurements were taken on 175 (ca. 21%) of the obsidian artifacts recovered from Late Neolithic contexts at Gorzsa, including all 5 pieces that had been identified provisionally as "C2 obsidian."

Results and discussion

Knapped stone artifacts can pose challenges to obtaining reliable results with non-destructive XRF analysis. They vary in size, thickness, and surface irregularity, and surfaces may be contaminated by soil or calcareous residues—all of which can affect the accuracy of XRF measurements. In addition, museum specimens often have ink or paper labels. The ideal is to clean artifacts before XRF analysis, but very often this is not possible or practical, and none of the artifacts from Gorzsa in the Móra Ferenc Múzeum could be cleaned before XRF measurements were taken. The 130 obsidian artifacts measured in 2019 were relatively large, thick pieces. However, the 45 pieces measured in 2022 included some small, thin flakes and bladelets that were narrower than the detector window of the analyzer and/or may have been of less than infinite thickness, which can also affect the accuracy of the XRF measurements. Another potential source of error was the presence of museum inventory numbers written (usually) in white ink on the flatter, ventral surfaces of flakes and blades, such that XRF measurements had to be taken on the more irregular (sometimes partially corticated) dorsal surface.

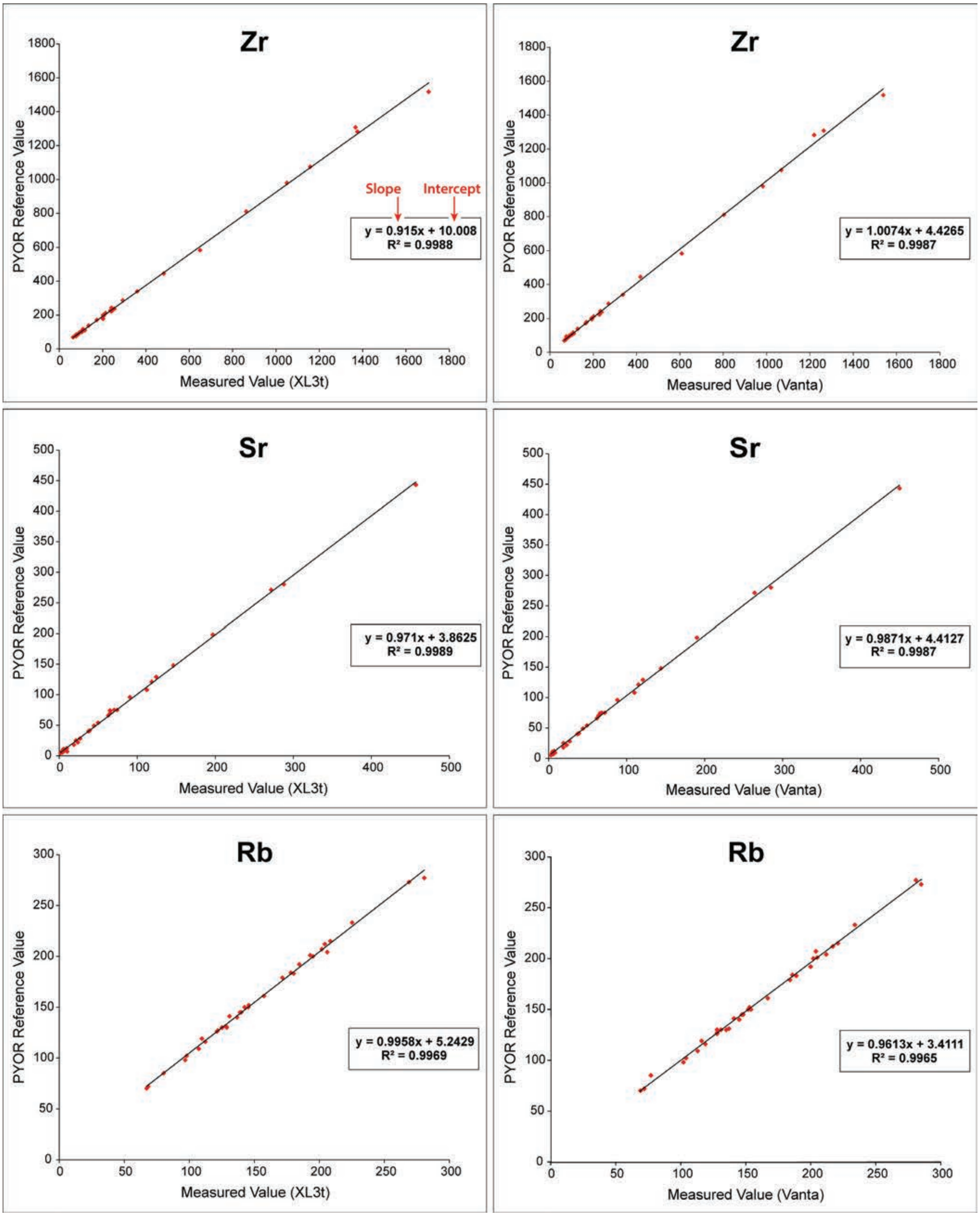

Figure 5. Calibration plots for Zr, Sr, and Rb using the Niton XL3t Ultra (left) and Olympus Vanta M (right) produced with the linear regression function (LINEST) in Excel. The equation shows the slope and intercept for the trend line. These are the calibration factors used to adjust for bias in each instrument's FP calibration model. R^2 is a measure of the strength of correlation between the measured and reference values, and ranges between 0 and 1. The closer R^2 is to 1, the stronger the relationship is (drawings by C. Bonsall).

The concentration data for Mn, Fe, Zn, Rb, Sr, Y, Zr, and Nb produced by the two pXRF analyzers were calibrated with measurements taken on the PYRO Calibration Set (Frahm 2019) using a simple linear regression model (Figure 5). Ternary plots of the Zr, Sr, and Rb values or ratios are a useful first step in assigning archaeological samples to obsidian sources. In Figure 6, the data for the Gorzsa samples are plotted against the range of variation recorded in geological specimens from the three known Carpathian source areas (C1, C2, and C3), represented by ellipsoid hulls.

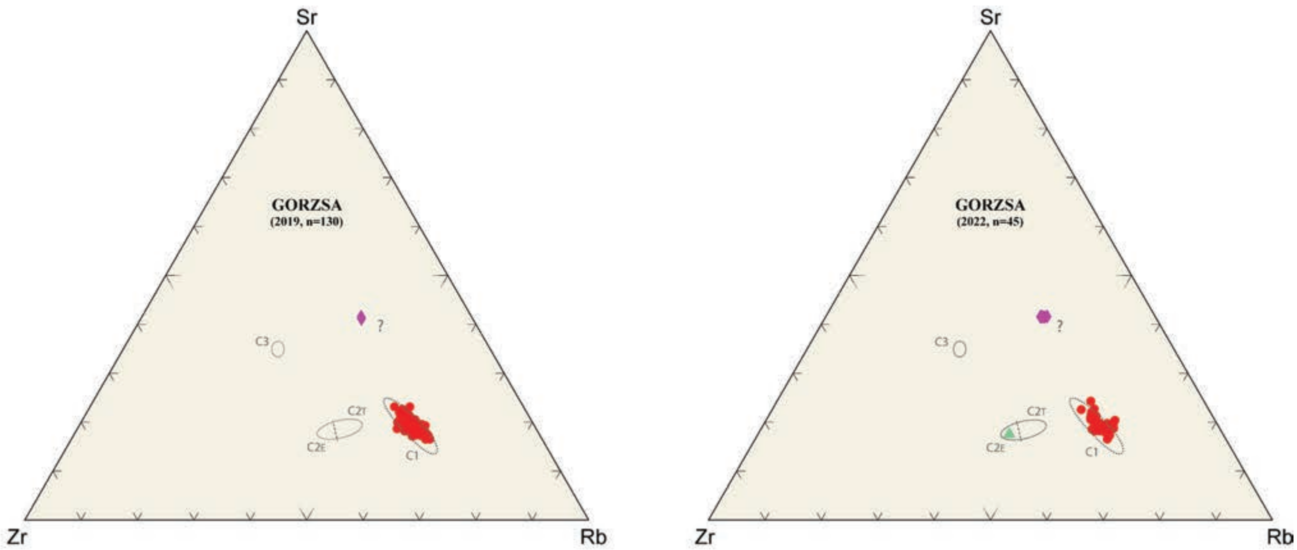

Figure 6. Ternary plots of the Zr/Sr/Rb composition of obsidian artifacts from Hódmezővásárhely-Gorzsa (symbols), and geological obsidian samples from Carpathian sources (shown as ellipsoid hulls). Red dots plot values for C1 obsidian, green triangle—C2E obsidian, and purple diamonds—unidentified "obsidian" (drawing by C. Bonsall).

Table 2. Element concentrations in parts per million in obsidian artifacts from Gorzsa (Hungary) measured by XRF using an Olympus Vanta M analyzer
(n.m. = no measurement recorded).

Sample ID	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Source
GOR #059	413	7172	31	195	64	32	70	10	C1
GOR #1560	404	6789	36	192	64	33	67	9	C1
GOR #1927	419	7127	31	200	62	32	70	7	C1
GOR #1928	424	7417	34	205	62	32	73	9	C1
GOR #1929	414	7218	30	189	69	31	72	7	C1
GOR #1944	401	9247	59	186	72	32	69	9	C1
GOR #1953	408	7233	43	189	61	29	61	10	C1
GOR #1958	385	7040	236	194	65	33	72	9	C1

Table 2. Continued.

Sample ID	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Source
GOR #1959	428	7570	33	208	67	33	69	9	C1
GOR #1961	439	8066	64	203	81	32	72	10	C1
GOR #1962	408	7060	30	202	64	32	69	9	C1
GOR #1963	438	7510	162	209	68	32	67	10	C1
GOR #1964	416	7367	47	199	63	31	77	7	C1
GOR #1965	413	6906	37	199	59	32	68	9	C1
GOR #1966	465	8735	60	206	68	28	59	n.m.	C1
GOR #1967	416	7328	61	184	59	26	57	7	C1
GOR #1968	416	7582	81	153	46	19	46	n.m.	C1
GOR #1970	385	7603	38	198	66	34	71	9	C1
GOR #1975	363	6941	43	186	68	30	66	10	C1
GOR #1976	385	6889	27	184	67	32	69	9	C1
GOR #2086	398	8375	36	189	78	32	78	10	C1
GOR #2095	417	8135	32	199	71	32	76	9	C1
GOR #2116	417	7099	31	194	63	32	70	9	C1
GOR #2124	400	6747	30	196	60	33	74	9	C1
GOR #2137	401	6630	28	189	60	32	67	9	C1
GOR #2145	430	7279	31	200	65	33	70	9	C1
GOR #2152	393	6839	31	196	62	33	75	10	C1
GOR #2162	447	7004	32	211	56	36	71	10	C1
GOR #2212	410	7007	28	193	62	32	70	10	C1
GOR #2235	401	7264	34	185	69	31	69	7	C1
GOR #99.3.14	400	6769	28	189	61	32	67	9	C1
GOR #99.3.14	428	7292	32	198	64	32	67	10	C1
GOR #x007	384	6716	30	190	61	32	67	9	C1
GOR #x007.1	388	7186	37	189	71	32	71	9	C1

Table 2. Continued.

Sample ID	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Source
GOR #x008	488	7571	35	200	67	34	71	10	C1
GOR #x008	488	7571	35	200	67	34	71	10	C1
GOR #x008.1	508	8521	70	199	63	28	59	n.m.	C1
GOR #x1011	396	6653	29	197	57	33	65	9	C1
GOR #x2324	402	6599	26	198	55	32	64	9	C1
GOR #2028	274	11979	41	206	81	32	175	11	C2E
GOR #x069	320	10622	76	130	139	7	66	19	?
GOR #x001	289	10986	79	131	139	6	64	17	?
GOR #337.g	302	11209	79	131	143	6	70	17	?
GOR #294.g	318	11066	80	132	143	6	69	19	?

Table 3. Element concentrations in parts per million (expressed as ranges) in geological samples of obsidian from sources in Slovakia, Hungary, and Ukraine measured by XRF using an Olympus Vanta M analyzer.

Sample locations	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Source
SK – Brehov-Cejkov-Kašov (n = 34)	362–466	6594–9475	27–43	180–203	56–69	31–34	62–75	7–10	C1a
SK – Viničky (n = 17)	332–408	7160–9772	27–32	166–188	69–85	29–34	70–78	9–11	C1b
HU – Mád-Erdőbénye (n = 33)	254–371	11525–17322	36–50	198–217	81–87	32–44	172–185	10–14	C2E
HU – Tolcsva (n = 11)	278–356	9712–11159	43–53	191–207	72–79	32–33	125–147	11–14	C2T
UKR – Rokosovo (n = 9)	502–594	18257–20614	55–60	148–157	181–202	23–25	209–218	11–13	C3

The Zr/Sr/Rb data for the overwhelming majority of the obsidian artifacts from Late Neolithic contexts at Gorzsa were within or close to the range determined for C1 obsidian from eastern Slovakia, confirming Voytek and Starnini's visual identifications (Tables 2–3). One piece (GOR #0028) came from the C2E source area in northeast Hungary (Figure 7, no. 5). The other four samples (GOR #x001, GOR #x069, GOR #294g, and GOR #337g; Figure 7, nos. 1–4) form a cluster that is chemically different from any known Carpathian obsidians (Figure 6).

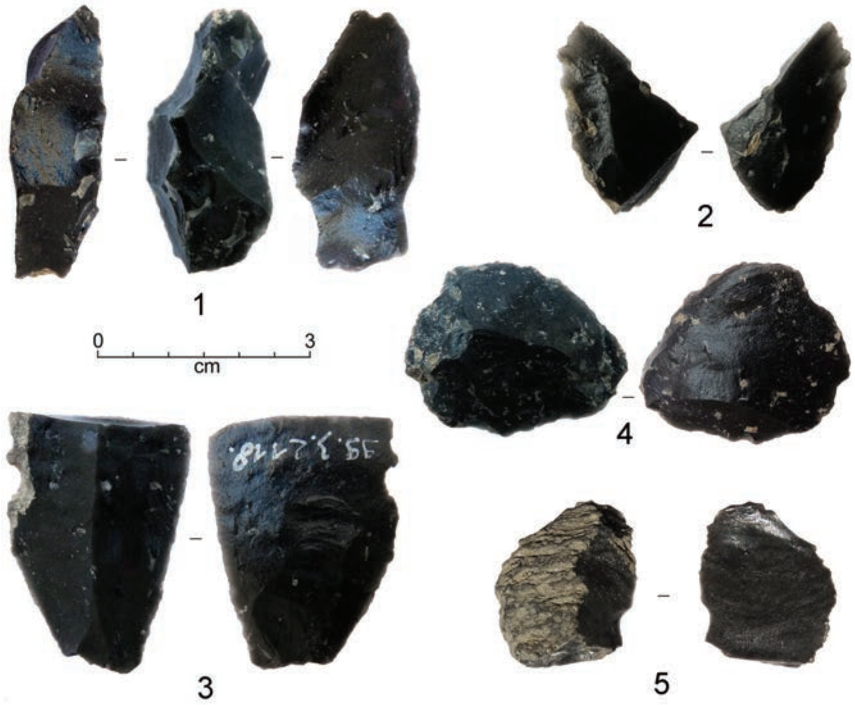

Figure 7. Hódmezővásárhely-Gorzsa, artifacts that were visually identified as non-C1 obsidian: 1) core platform rejuvenation corniche, from square XVIII, level 7–8 (analysis GOR#x001); 2) unretouched flake fragment, from square XVIII, Pit 337 (analysis GOR#337g); 3) proximal fragment of a blade, from square III/c, level 3–4 (inv. MFM n. 99.3.2118./analysis GOR#x069); 4) unretouched flake, from square XVIII Pit 294 (analysis GOR#294g); 5) fragment of a decortication flake, C2 obsidian, from Square XVIII, level 23–24 (analysis GOR#0028) (photographs by E. Starnini).

An earlier pXRF-based characterization study by Danielle Riebe presented the compositional analysis of 203 obsidian artifacts from 7 Late Neolithic sites on the Alföld, showing that obsidian from 3 geological source areas was utilized, namely C1, C2E, and C2T (Riebe 2019). Riebe noted that artifacts made of C2E obsidian were recovered only from Tisza culture sites and that the C2T artifacts were found only at Herpály culture sites. This led her to suggest that the exploitation of the secondary obsidian sources was linked to limited access and/or sociocultural preferences.

Therefore, the analysis of obsidian artifacts from Gorzsa, another Late Neolithic site, serves also to test the hypothesis of the possible sociocultural implications of obsidian source diversification in the Alföld. Of the 203 artifacts analyzed by Riebe (2019), there were only 4 pieces of C2 obsidian (<2%). Usually, C2 obsidian is scarce after the initial stages of the Early Neolithic. Carpathian obsidians (C1, C2T, and C2E) circulated widely among the earliest farming communities of Southeast Europe, and the archaeological distribution of Carpathian obsidian coincides more or less with the territorial range of the First Temperate Neolithic, or FTN (*sensu* Nandris 1970). Hence, it serves as an important marker of the FTN interaction sphere. After ca. 5800 cal BC, nearly all obsidian found at FTN sites originated from the C1 source area (e.g., Biagi et al. 2007a, 2007b; Bonsall et al. 2017; Boroneanț et al. 2018, 2019; Glascock et al. 2015)—a pattern that persisted into the Late Neolithic, Chalcolithic, and Early Bronze Age.

Our findings from Gorzsa are consistent with those of Riebe (2019) in documenting the presence of C2E obsidian in a Tisza culture context. However, Riebe did not consider the internal chronology of the sites she investigated. At Gorzsa, the single piece of C2E obsidian came from the earliest phase of the tell settlement, and no C2 obsidian was found in the later horizons.

The number of pieces of C2 obsidian from Late Neolithic sites on the Alföld (including its continuation into western Romania, northern Serbia, and eastern Croatia) is small, and it should not be excluded that occasional nodules of obsidian were collected from Pleistocene fluvial gravels on the plain itself. However, no pieces of obsidian in the Gorzsa collection show pebble cortex consistent with water rolling. Therefore, it is likely that all the (C1 and C2) obsidian found at Gorzsa originated from the volcanic sources on the northeastern margin of the plain. Here, it is worth emphasizing that the Late Neolithic inhabitants of Gorzsa also imported significant quantities of limnic silicite, the primary source of which occurs in the same Tokaj volcanic region containing the C2E and C2T obsidian outcrops (cf. Figure 1).

The four "obsidian" artifacts from Gorzsa that are chemically different from those made of C1 and C2E obsidian did not come from closed contexts, although at least three of them (GOR#001, GOR#294g, GOR#337g) are thought to be from the earlier (D2) and later (A–B) phases of the Late Neolithic settlement. Macroscopically, these pieces resemble obsidian: the material is black, translucent, with a glassy luster, signs of flow banding, and SiO^2 within the obsidian range (based on uncalibrated pXRF data). Chemically, this material is distinct from C1, C2E, C2T, and C3 obsidians (and the so-called C4 and C5 varieties of Rosania et al. 2008). A comparison with published compositional data for Central Mediterranean (Acquafredda et al. 2018), Aegean (Acquafredda et al. 2018; Carter et al. 2016), Central and Eastern Anatolian (Kobayashi and Mochizuki 2007), and Transcaucasian (Biagi and Gratuze 2016; Blackman et al. 1998) obsidians has so far failed to reveal a close match for the Gorzsa samples.

The "unknown" black volcanic rock from Gorzsa may be a previously undocumented variety of Carpathian obsidian or a very fine-grained volcanic rock with otherwise similar characteristics. Regardless, a Carpathian origin is supported by the fact that other lithic raw materials found at Gorzsa point to long-distance connections with the Alps, Bohemia, southern Poland, northwest Ukraine, and Bulgaria, rather than to regions with known obsidian occurrences (Starnini et al. 2015: Figure 18; Bendő et al. 2019: Figure 9).

Conclusions

Results from techno-typological analysis carried out on the obsidian assemblages from Gorzsa show a variety of products, with high percentages of categories linked to the early phases of the reduction sequence of the raw material (corticated nodules, decortication flakes, partially corticated blanks) and core exploitation and maintenance (debitage wastes, discarded irregular blanks, exhausted microcores), testifying to local reduction of the raw material and transformation of obsidian blanks.

Blades and bladelets are the most common artifact type produced with obsidian. The debitage technique employed is indirect percussion with an organic punch. Since the entire reduction sequence for obsidian seems to have occurred locally, Gorzsa most probably represents a site of reception of rough raw material pieces (i.e., nodules). Obsidian likely reached the tell in unprepared form, most probably through exchange/procurement networks connecting the southern part of the Alföld to the northern range of the Eastern Carpathians, crossing different cultural areas (Raczky et al. 2021: Figure 1).

Our pXRF analyses of the obsidian found at Gorzsa support the findings of previous researchers in showing that most obsidian consumed by Late Neolithic communities of the Alföld originated in the C1 source area in eastern Slovakia. Further, our analyses add weight to Riebe's (2019) hypothesis that the small amount of C2 obsidian that reached the Tisza culture settlements came from the C2E source in northeast Hungary.

Whether all the obsidian consumed at Gorzsa originated from Carpathian sources remains an open question. The next stage of our research will involve a more detailed study of the samples that cannot be assigned to the C1 or C2 source areas; this will allow us to determine if they are obsidian or some other black volcanic rock and will involve petrographic, SEM, and PGAA analyses. Our goal, upon completion of all analyses, will be the evaluation of patterns of change or continuity in obsidian procurement during the various phases in the lifespan of the Gorzsa tell.

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References

Acquafredda, Pasquale, Italo M. Muntoni, and Mauro Pallara
2018 Reassessment of WD-XRF Method for Obsidian Provenance Shareable Databases. *Quaternary International* 468: 169–178.

Bendő, Zsolt, György Szakmány, Zsolt Kasztovszky, Katalin T. Biró, István Oláh, Anett Osztás, Ildikó Harsányi, and Veronika Szilágyi
2019 High Pressure Metaophiolite Polished Stone Implements Found in Hungary. *Archaeological and Anthropological Sciences* 11: 1643–1667.

Biagi, Paolo, and Bernard Gratuze
2016 New Data on Source Characterization and Exploitation of Obsidian from the Chikiani Area (Georgia). *Eurasiatica* 6: 9–36.

Biagi, Paolo, Anna Maria De Francesco, and Marco Bocci
2007a New Data on the Archaeological Obsidian from the Middle-Late Neolithic and Chalcolithic Sites of the Banat and Transylvania. In *The Lengyel, Polgar and Related Cultures in the Middle/Late Neolithic in Central Europe*, edited by Janusz K. Kozłowski and Pál Raczky, pp. 309–326. Polish Academy of Arts and Sciences, Kraków.

Biagi, Paolo, Bernard Gratuze, and Sophie Bouchetta
2007b New Data on the Archaeological Obsidians from the Banat and Transylvania (Romania). In *A Short Walk through the Balkans: The First Farmers of the Carpathian Basin and Adjacent Regions*, edited by Michela Spataro and Paolo Biagi, pp. 129–148. Società per la Preistoria e Protostoria della Regione Friuli, Venezia Giulia, Trieste, Italy.

Biró, Katalin T.
1984 Distribution of Obsidian from the Carpathian Sources on Central European Palaeolithic and Mesolithic Sites. *Acta Archaeologica Carpathica* 23: 5–42.

Biró, Katalin T., and Zsolt Kasztovszky
2013 Obsidian Studies Using Nuclear Techniques in Hungary. *Science for Heritage* 1: 6–9.

Blackman, M. James, Ruben Badaljan, Zaal Kikodze, and Philip Kohl
1998 Chemical Characterization of Caucasian Obsidian Geological Sources. In *L'Obsidienne au Proche et Moyen Orient : Du Volcan à l'Outil*, edited by Marie-Claire Cauvin, Alain Gourgaud, Bernard Gratuze, Nicolas Arnaud, Gérard Poupeau, Jean-Louis Poidevin, and Christine Chataigner, pp. 205–231. BAR, Oxford.

Bonsall, Clive, Nedko Elenski, Georgi Ganecovski, Maria Gurova, Georgi Ivanov, Vladimir Slavchev, V., and Radka Zlateva-Uzanova
2017 Investigating the Provenance of Obsidian from Neolithic and Chalcolithic Sites in Bulgaria. *Antiquity* 91(356): e3, doi:10.15184/aqy.2017.

Boroneant, Adina, Cristian Virag, Ciprian Astaloş, and Clive Bonsall
2018 Sourcing Obsidian from Prehistoric Sites in Northwest Romania. *Materiale şi Cercetări Arheologice* 14: 13–23.

Boroneant, Adina, Pavel Mirea, Anna Ilie, and Clive Bonsall
2019 Sourcing Obsidian Artefacts from Early Neolithic Sites in South-Central Romania. *Materiale şi Cercetări Arheologice* 15: 27–40.

Carter, Tristan, Daniel A. Contreras, Kathryn Campeau, and Kyle Freund
2016 Spherulites and Aspiring Elites: The Identification, Distribution, and Consumption of Giali Obsidian (Dodecanese, Greece). *Journal of Mediterranean Archaeology* 29(1): 3–36.

Frahm, Ellery
2014 Characterizing Obsidian Sources with Portable XRF: Accuracy, Reproducibility, and Field Relationships in a Case Study from Armenia. *Journal of Archaeological Science* 49: 105–125.
2017 First Hands-On Tests of an Olympus Vanta Portable XRF Analyzer to Source Armenian Obsidian Artifacts. *IAOS Bulletin* 58: 8–23.
2019 Introducing the Peabody-Yale Reference Obsidians (PYRO) Sets: Open-source Calibration and Evaluation Standards for Quantitative X-ray Fluorescence Analysis. *Journal of Archaeological Science: Reports* 27: 101957.

Furholt, Kata
2024 Depositional Patterning of Obsidian Artifacts: Studying Diverse Value Concepts in the Neolithic Carpathian Basin. In *Reflections on Volcanic Glass: Proceedings of the 2021 International Obsidian Conference*, edited by Lucas R. M. Johnson, Kyle P. Freund, and Nicholas Tripcevich, pp. 15–47. ARF Monographs, Berkeley, California.

Glascock, Michael D., Alex W. Barker, and Florin Draşovean
2015 Sourcing Obsidian Artifacts from Archaeological Sites in Banat (Southwest Romania) by X-Ray Fluorescence. *Analele Banatului, S.N., Arheologie – Istorie* 23: 45–50.

Horváth, Ferenc
2005 Gorzsa. Előzetes eredmények az újkőkori tell 1978 és 1996 közötti feltárásából [Gorzsa. Preliminary Results of the Excavation of the Neolithic Tell between 1978 and 1996]. In *Hétköznapok Vénuszai*, edited by Livia Bende and Gábor Lőrinczy, pp. 51–83. Móra Ferenc Múzeum, Szeged, Hungary.

Kaminská, Ľubomíra
2021 Use of Obsidian in Slovak Prehistory. In *Fossile Directeur, Multiple Perspectives on Lithic Studies in Central and Eastern Europe*, Študijné *zvesti Archeologického* ústavu *SAV –Supplementum* 2: 231–250.

Kasztovszky Zsolt, Katalin T. Biró, and Zoltán Kis
2014 Prompt Gamma Activation Analysis of the Nyírlugos Obsidian Core Depot Find. *Journal of Lithic Studies* 1: 151–163.

Kobayashi, Katsuji, and Akihiko Mochizuki
2007 Source Identification of Obsidian Projectile Points from Kaman-Kalehöyük. *Anatolian Archaeological Studies* 16: 177–182.

Kohút, Milan, John A. Westgate, Nicholas J. G. Pearce, and Pavel Bačo
2021 The Carpathian Obsidians – Contribution to Their FT Dating and Provenance. *Journal of Archaeological Science: Reports* 37 (June): 102861.

Nandris, John
1970 The Development and Relationships of the Earlier Greek Neolithic. *Man* 5(2): 192–213.

Parkinson, William A., Attila Gyucha, Panagiotis Karkanas, Nikos Papadopoulos, Georgia Tsartsidou, Apostolos Sarris, Paul R. Duffy, and Richard W. Yerkes
2018 A Landscape of Tells: Geophysics and Microstratigraphy at Two Neolithic Tell Sites on the Great Hungarian Plain. *Journal of Archaeological Science: Reports* 19: 903–924.

Rácz, Béla
2018 The Carpathian 3 Obsidian. *Archeometriai Műhely* XV: 181–186.

Raczky, Pál
1992 The Tisza Culture of the Great Hungarian Plain. *Studia Praehistorica* 11–12: 162–176.

Raczky, Pál, András Füzesi, Katalin Sebők, Norbert Faragó, Péter Csippán, and Alexandra Anders
2020 A Special House from the Late Neolithic Tell Settlement of Berettyóújfalu-Herpály (Hungary). Reconstruction of a Two-Storey Building, Its Furnishings and Objects from the Earlier 5th Millennium BC. *Studia Troica* 11: 429–457.

Raczky, Pál, András Füzesi, Knut Rassmann, and Eszter Bánffy
2021 Újkőkori települési halmok Hódmezővásárhely környékén. In *Korok, kultúrák, lelőhelyek*, edited by Csányi Viktor, pp. 7–26. Tornyai János Múzeum, Hódmezővásárhely, Hungary.

Riebe, Daniela J.
2019 Sourcing Obsidian from Late Neolithic Sites on the Great Hungarian Plain: Preliminary p-XRF Compositional Results and the Socio-Cultural Implications. *Interdisciplinaria Archaeologica* 10(2): 113–120.

Rosania, Corinne N., Matthew T. Boulanger, Katalin T. Biró, Sergey Ryzhov, Gerhard Trnka, and Michael D. Glascock
2008 Revisiting Carpathian Obsidian. *Antiquity* 82(318), http://www.antiquity.ac.uk/projgall/rosania318/, accessed February 15, 2022.

Speakman, Robert J., and M. Steven Shackley
2013 Silo Science and Portable XRF in Archaeology: A Response to Frahm. *Journal of Archaeological Science* 40: 1435–1443.

Starnini, Elisabetta
1994 Typological and Technological Analysis of the Körös Culture Chipped, Polished and Ground Stone Assemblages of Mèhtelek-Nàdas (N-E Hungary). *Atti della Società per la Preistoria e Protostoria della regione Friuli Venezia-Giulia* 8: 29–96.

Starnini, Elisabetta, Barbara A. Voytek, and Ferenc Horváth
2007 Preliminary Results of the Multidisciplinary Study of the Chipped Stone Assemblage from the Tisza Culture Site of Tell Gorzsa (Hungary). In *The Lengyel, Polgár and Related Cultures in the Middle/Late Neolithic in Central Europe*, edited by Janusz K. Kozłowski and Pál Raczky, pp. 269–278. The Polish Academy of Arts and Sciences, Kraków.

Starnini, Elisabetta, György Szakmány, Sándor Józsa, Zsolt Kasztovszky, Veronika Szilágyi, Boglárka Maróti, Barbara Voytek, and Ferenc Horváth
2015 Lithics from the Tell Site Hódmezővásárhely-Gorzsa (S-E Hungary): Typology, Technology, Use and Raw Material Strategies During the Late Neolithic (Tisza Culture). In *Neolithic and Copper Age between the Carpathians and the Aegean Sea. Chronologies and Technologies from the 6th to 4th Millennium BC. International Workshop Budapest 2012*, edited by Svend Hansen, Pál Raczky, Alexandra Anders, and Agathe Reingruber, pp. 115–138. Habelt Verlag, Bonn, Germany.

Szakmány, György, Elisabetta Starnini, Ferenc Horváth, Veronika Szilágyi, and Zsolt Kasztovsky
2009 Investigating Trade and Exchange Patterns during the Late Neolithic: First Results of the Archaeometric Analyses of the Raw Materials for the Polished and Ground Stone Tools from Tell Gorzsa (Southeast Hungary). In *Proceedings of the 6th Meeting for the Researchers of Prehistory: Raw Materials and Trade, Kőszeg, March 19–21, 2009*, edited by Gábor Ilon, pp. 369–383. Vas County Museums Directorate, Szombathely, Hungary.

Szakmány, György, Elisabetta Starnini, Ferenc Horváth, and Balázs Bradák
2011 Investigating Trade and Exchange Patterns in Prehistory: Preliminary Results of the Archaeometric Analyses of the Stone Artifacts from Tell Gorzsa (Southeast Hungary). In *Proceedings of the 37th International Symposium on Archaeometry, Siena, May 12–16, 2008*, edited by Isabella Turbanti-Memmi, pp. 311–319. Springer, Berlin.

Tálas, László, and Pál Raczky (editors)
1987 *The Late Neolithic of the Tisza Region. A Survey of Recent Excavations and their Findings: Hódmezővásárhely-Gorzsa, Szegvár-Tűzköves,* Öcsöd-Kováshalom*, Vésztő-Mágor, Berettyóújfalu-Herpály*. Szolnok, Budapest.

Tykot, Robert H.
2018 Portable X-ray Fluorescence Spectrometry (pXRF). In *The Encyclopedia of Archaeological Sciences*, edited by Sandra L. López Varela, pp. 1–5. Wiley, Malden, Massachussetts.

Vazquez, Cristina, Oscar Palacios, Marcó Parra Lue-Meru, Graciela Custo, Martha Ortiz, and Martín Murillo
2012 Provenance Study of Obsidian Samples by Using Portable and Conventional X-ray Fluorescence Spectrometers. Performance Comparison of Both Instrumentations. *Journal of Radioanalytical and Nuclear Chemistry* 292: 367–373.

Williams-Thorpe, Olwen, Stanley E. Warren, and John G. Nandris
1984 The Distribution and Provenance of Archaeological Obsidian in Central and Eastern Europe. *Journal of Archaeological Science* 11: 183–21