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Obsidian Procurement at Pecica Şanţul Mare, Romania*

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Introduction

Since its founding the Museum of Art and Archaeology has actively pursued archaeological field research projects and reported the results in *Muse.*[1] Here we present the initial results of characterization studies on obsidian recovered during the course of the 2008 field campaign at Pecica Şanțul Mare, a major Middle Bronze Age tell settlement in western Romania, sponsored by the Museum of Art and Archaeology as an international collaborative project. This research reflects collaborations both in the field (among multiple museums in Romania and the United States) and in the laboratory (between the Museum of Art and Archaeology and the University of Missouri Research Reactor [MURR] Archaeometry Laboratory).

The characterization of archaeologically utilized lithic resources in the Great Hungarian Plain is of particular value as the region is marked by a paucity of lithic materials suitable for most kinds of chipped-stone tools. Obsidian, a silicic glass formed by rapid cooling of magma from volcanic eruptions, possesses the conchoidal fracture characteristics necessary for manufacturing chipped-stone tools and represented the highest quality lithic material available. Within the larger region, obsidian is found only in the Zemplén Mountains of the Carpathian Range in Slovakia, Hungary, Romania, and Ukraine and appears to have been formed during Miocene eruptions.[2] For the most part, these eruptions produced varying forms of perlite, pumice, and scoria, but some eruptions, probably on the immediate shoreline of the Paratethys Sea, produced vitreous obsidian.[3] In contrast to the lava flows found in Slovakia, Hungary, and Romania, which produced rich primary deposits, obsidian-producing volcanic eruptions in Ukraine produced primary deposits of obsidian by ejecting magma “bombs” (strombolites) away from the source. Regardless of the volcanic origin, obsidian today is found beyond areas of primary geological deposit due to fragmentation and dispersal of primary flows into secondary geological deposits.[4]

Carpathian Obsidian

Several chemically unique sources have been identified in the Carpathians. Williams Thorpe et al.[5] and Bíro et al.[6] identified two compositional groups of Carpathian obsidian: Carpathian 1 (C1), in southeast Slovakia, and Carpathian 2 (C2), in northeast Hungary. Two subgroups (C2a and C2b) were further distinguished within C2.[7] Additionally, Rosania et al. identified two subgroups within C1 (C1a and C1b) and chemically characterized three additional Carpathian obsidian sources: Carpathian 3, in west Ukraine, Carpathian 4,

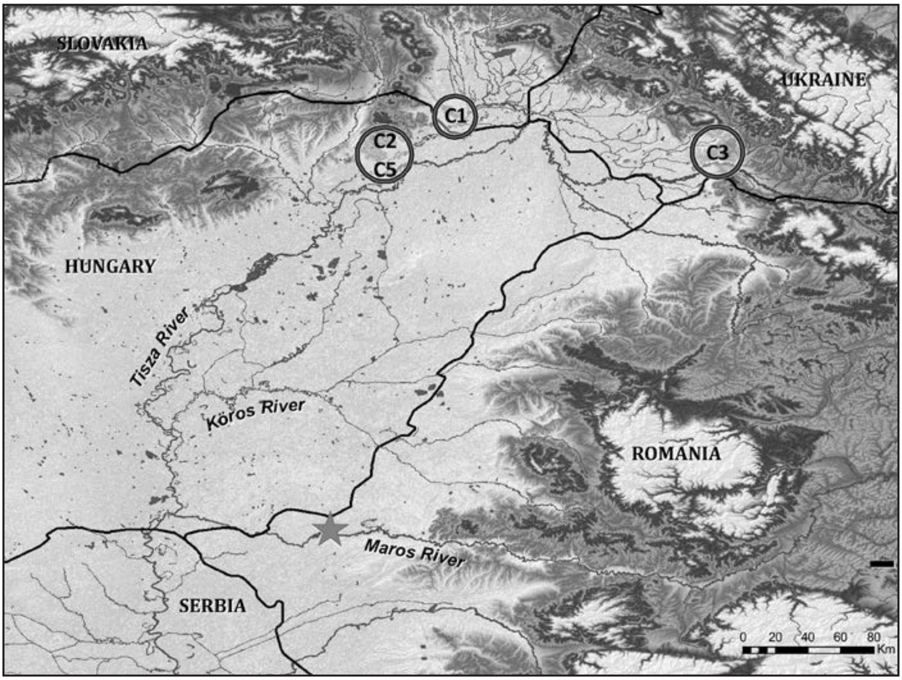

Fig. 1. Location of previously characterized Carpathian obsidian sources (C1, C2, C3, and C5) and Pecica Şanţul Mare (indicated by the star). Note that C4 in northwest Slovakia is not shown here.

in west Slovakia, and Carpathian 5, in northeast Hungary (Fig. 1).[8] The five main source groups (C1 through C5) can be reliably differentiated using non-destructive X-ray fluorescence (XRF) methods based on concentrations of large-ion lithophile elements including thorium (Th), rubidium (Rb), and strontium (Sr), as well as iron (Fe), zinc (Zn), and zirconium (Zr).[9] Neutron activation analysis (NAA) identifies up to twenty-seven elements that further separate all Carpathian obsidian source groups and subgroups.

Archaeological Context

Excavations at the great tell of Pecica Șanțul Mare (Arad County, western Romania) by the University of Missouri Museum of Art and Archaeology and the University of Michigan Museum of Anthropology from 2006 through 2009 document changing socioeconomic emphases and patterns of exchange during the later part of the Middle Bronze Age.[10] Pecica Șanțul Mare was a large fortified tell settlement roughly one hundred kilometers east of the confluence of the Maros and the Tisza Rivers (Fig. 1).[11] Dömötör[12] conducted the earliest documented excavations at the site in 1898 and 1900, with larger and more thorough excavations conducted by Martin Roska in 1910 and 1911 and, again, in 1923 and 1924.[13] Roska's systematic excavations provided a key stratigraphic sequence for both the site and the region and were influential in the development of larger temporocultural frameworks and syntheses, including V. Gordon Childe's classic book, *The Danube in Prehistory*.[14] Roska's stratigraphic sequence and associated ceramic and metal types, mediated by the work of Childe and others, remain the basis for most relative dating throughout the Bronze Age of the Carpathian Basin.[15] I. H. Crişan opened a series of large excavation units in the north-central portion of Pecica Șanțul Mare during campaigns from 1960 to 1962 and in 1964,[16] but these campaigns focused on later Dacian components.

In 2005 a joint Romanian American project returned to Pecica Șanțul Mare and opened two three-meter deep stratigraphic trenches to recover chronometric samples (including both radiocarbon and archaeomagnetic samples) and to document the relative density of Bronze Age occupations in different portions of the summit. Based on these tests, in 2006 a 10 x 10 m excavation block was opened just east of Trench I, in an area where Dacian occupation layers were previously removed during Crişan's earlier campaigns.

Sample	Archaeological Context	Associated Lot Material	Total Station Reference
PSM001	N12E10 Layer C5	Lot 8-151	Ref No. 14367
PSM002	Structure 2 Post 39	Flot 8-213 HF	From flotation
PSM003	N14E14 PP No. 13	Lot 8-320	Ref No. 15670
PSM004	Feature 36	Lot 8-414	Pit Feature Fill (F36)
PSM005	N12E12 Layer C5	Special Sample 542	Ref No. 14971

Table 1. Contextual information regarding obsidian samples from the 2008 campaign. Samples PSM001, PSM003, and PSM005 are from occupation layer excavations with precise provenience recorded by total station reference point; samples PSM002 and PSM004 are from defined architectural features.

Sample	Site Context	Age BP	Calibrated Intercept	Calibrated Range
415	N18E16 C3	3540±40	1890 B.C.E.	1941–1777 B.C.E.
420	N10E18 C3	3350±40	1630 B.C.E.	1727–1538 B.C.E.
424	N10E8 C4	4010±60	2490–2560 B.C.E.	2621–2466 B.C.E.
429	N12E10 C4	3430±40	1740 B.C.E.	1870–1683 B.C.E.
611	N18E18 C3a	3370±40	1670 B.C.E.	1736–1616 B.C.E.
600	Structure 2 IL-6	3440±40	1740 B.C.E.	1871–1689 B.C.E.
583	F141 IL-1	3310±40	1610 B.C.E.	1630–1526 B.C.E.

Table 2. Radiocarbon dates associated with lower portions of C layer complex and Structure 2. Age BP reflects conventional radiocarbon age, corrected for 13C/12C ratio; Calibrated Range is a one-sigma calibrated result (68.2 percent probability).

Preliminary reports on the results of these ongoing excavations have been published elsewhere.[17]

The three flakes and two blades analyzed here (Table 1) comprise all of the obsidian recovered during the 2008 season. All are from Middle Bronze Age tell construction/deposition layers or from specific, bounded cultural features; based on a suite of radiocarbon dates, these layers date to between 1800 and 1600 B.C.E. (Table 2). For the most part they are associated with either the Layer C complex or Structure 2, both Late Middle Bronze Age deposits from the western side of the 10 x 10 m block, although one (PSM004) is from Feature 36, a large irregular pit feature along the western margin of the block.

Under terms of the established contract of collaboration, certain categories of analytical samples could be exported for technical analysis, and the obsidian artifacts analyzed are now in the care of the University of Michigan Museum of Anthropology. In order to preserve the potential of these materials for future analyses, we chose to employ non-destructive XRF analytical procedures to determine their chemical characterizations and geological source(s).

Methodology

We employed energy-dispersive X-ray fluorescence (EDXRF) spectroscopy at the University of Missouri Research Reactor (MURR) to provide a chemical "fingerprint" of the obsidian artifacts from Pecica Șanțul Mare. Non-destructive EDXRF was employed to identify the concentrations of eleven elements. The resulting chemical data were used to assess the most likely source of the Romanian artifacts by comparison with previously characterized Carpathian obsidian (i.e., C1, C2, C3, C4, and C5).

Methods employed followed standard MURR obsidian sampling and characterization procedures. Samples were analyzed using the MURR Elva-X spectrometer. The Elva-X spectrometer is equipped with an air-cooled X-ray tube with tungsten target. The spectrometer has a 140 micron Be window and a thermoelectrically cooled Si-PIN diode detector. The beam dimensions are 3 x 4 mm. The detector has a resolution of 180 eV at 5.9 keV. The X-ray tube was operated at 40 kV, and the tube current was automatically adjusted between 20 to 45 μA to maintain a counting rate of 6,000 counts per second on each sample.

Measurable elements in obsidian using a three-minute counting time include K, Ti, Mn, Fe, Zn, Ga, Rb, Sr, Y, Zr, and Nb. Peak deconvolution and element concentrations were accomplished using the ElvaX spectral analysis package.

The instrument was calibrated to report absolute concentrations using the data for obsidian source samples analyzed by neutron activation analysis (NAA) and in a round-robin exercise with other XRF laboratories. The calibration samples came from the MURR reference collection and include eleven Mesoamerican obsidian sources, El Chayal, Ixtepeque, San Martin Jilotepeque, Guadalupe Victoria, Pico de Orizaba, Otumba, Paredon, Sierra de Pachuca, Ucareo, Zaragoza, and Zacualtipan; and three Peruvian obsidian sources, Alca, Chivay, and Quispisisa.

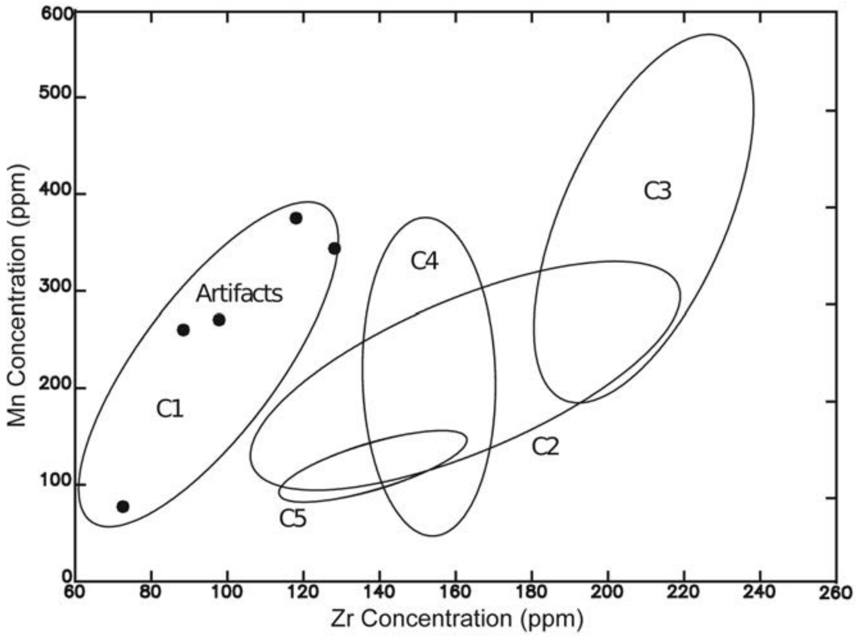

Fig. 2. Bivariate plot of zirconium and manganese values for Pecica obsidian artifacts projected against previously characterized Carpathian obsidian source groups. Ellipses represent a 90 percent confidence interval for group membership.

Results and Discussion

All five Pecica artifacts are chemically similar to the previously characterized obsidian source group Carpathian 1 (C1) found in southeast Slovakia (Figs. 2 and 3). Additionally, when compared to the two C1 subgroups, all five artifacts are more chemically similar to C1a found near Vinicky, Slovakia (Figs. 3 and 4). Carpathian 1a and the Romanian artifacts can be distinguished from other Carpathian source groups by concentrations of several elements: rubidium (Rb), strontium (Sr), iron (Fe), zirconium (Zr), zinc (Zn), and manganese (Mn). For the most part these results are consistent and point clearly to a C1 geological source for the obsidian from Pecica Șanțul Mare (Fig. 2). When the focus is narrowed to elements that discriminate sub sources, the data generally suggest

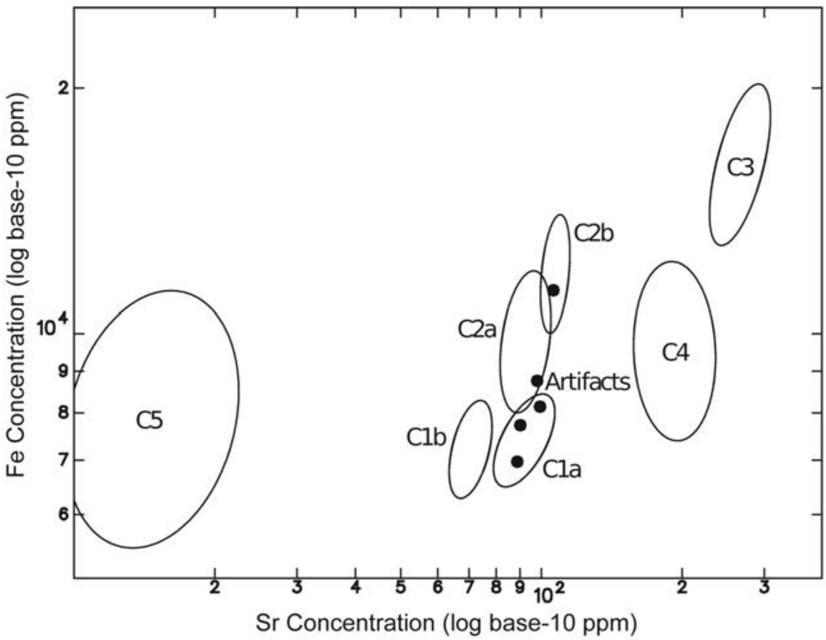

Fig. 3. Bivariate plot of strontium and iron values for Pecica obsidian artifacts projected against previously characterized Carpathian obsidian source groups. Ellipses represent a 90 percent confidence interval for group membership.

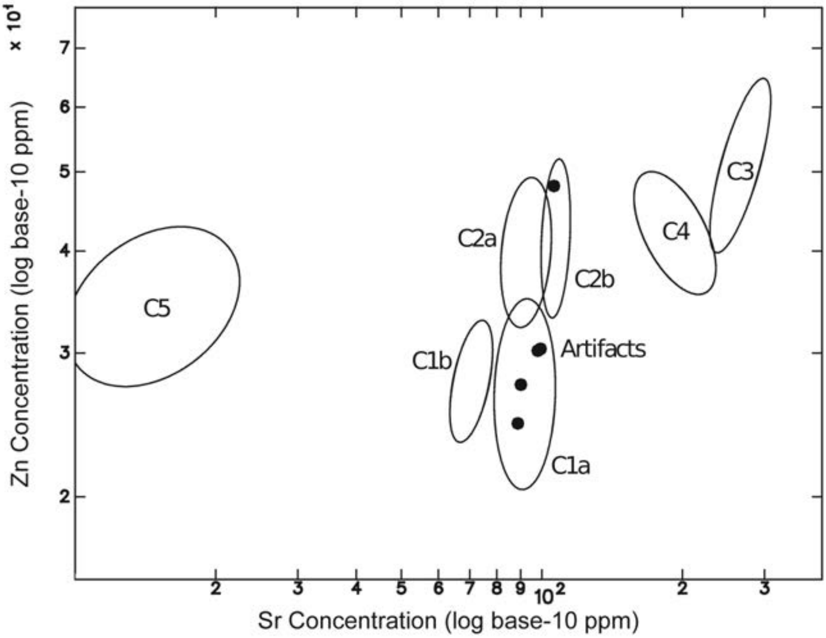

Fig. 4. Bivariate plot of strontium and zinc values for Pecica obsidian artifacts projected against previously characterized Carpathian obsidian source groups. Ellipses represent a 90 percent confidence interval for group membership.

a C1a (Vinicky) source (Figs. 3 and 4). It is evident, however, that one sample (PSM002) consistently plots outside the 90 percent confidence interval for membership in C1a. Despite this apparent discrepancy, there is reason to believe that the sample is indeed from C1a. Elemental concentrations measured for the higher atomic number elements such as Rb, Sr, and Zr (i.e., higher-Z and higher X-ray energy) in PSM002 fall within the expected distribution for C1a, but concentrations for the lower-Z elements such as Mn, Fe, and Zn appear skewed. This effect is probably due to sample geometry; PSM002 is much thinner than the other four Pecica artifacts.

In contrast to thick obsidian flakes or blades, thin obsidian samples are easily penetrated by X-rays. Thickness differentially affects the measurement of low-Z versus high-Z elements. Thus, the concentrations for the low-Z elements in thin samples will falsely appear enriched relative to the high-Z elements (Figs. 3 and 4). Therefore, despite some observed variability in chemical characterizations, there is a strong likelihood that all Pecica artifacts analyzed here are from the C1a obsidian-source. Variation in chemical characterizations of these artifacts is likely the result of variation in sample thickness, but alternatively, there could be an additional source in the region that has yet to be chemically characterized. Current knowledge, though, places all five Pecica artifacts within the chemical distribution of the Vinicky source.

Based on these data it appears that the Middle Bronze Age communities at Pecica used or acquired obsidian from the southeastern portion of what is now Vinicky, Slovakia, during the period between approximately 1800 and 1600 B.C.E. This is significant given that two Hungarian sources of obsidian (i.e., C2 and C5) are geographically closer to Pecica, and earlier studies have emphasized the close cultural connections between Middle Bronze Age occupations in western Romania and Eastern/Southeastern Hungary.[18] Carpathian 1 obsidian, in comparison to other known local obsidians (i.e., C2, C3, C4, and C5), has larger nodules with higher silicon content and is thus of better quality, evidenced by its resiliency and predictable fracture patterns. These features likely contributed to its long-term favored use in tool production, despite the closer proximity of other sources. Future studies will be required to test this prediction by analyzing more obsidian artifacts from the region, including artifacts from the same stratigraphic level (to measure synchronic variation) and from other stratigraphic levels (to measure diachronic changes).

Conclusions

Previous archaeological and geological investigations in the Carpathian Basin have identified and chemically characterized five obsidian sources, representing five distinct Miocene-aged volcanic eruptions in the regions known today as Slovakia, Hungary, and Ukraine.[19] As yet, however, no primary obsidian sources of archaeological utility have been identified in Romania. Despite the lack of primary geological sources, secondary geological and archaeological samples of obsidian have been recovered from several regions in Romania, including the archaeological site of Pecica Şanțul Mare.

Chemical and formal analyses of Middle Bronze Age artifacts from known sites associated with the Periam-Pecica group and the Maros Culture reveal "extensive movement of exotic goods."[20] Raw materials such as gold, copper, and tin were acquired from sources in north and west Slovakia, east Romania, and central Europe.[21] Likewise, obsidian procurement indicates "extensive movement" of materials, and perhaps people. Archaeologists working in Romania have often assumed that Romanian artifacts were made from geographically close obsidian sources located in the Tokaj Mountains in northeast Hungary. To the contrary, chemical analysis from this study indicates that the Middle Bronze Age communities of the Maros Culture (Periam-Pecica group) utilized obsidian from beyond the Tokaj Mountains, in southeast Slovakia. Characterization by non-destructive EDXRF of museum-curated artifacts from Pecica Șanțul Mare indicates that long-distance trade, down-the-line exchange, or travel was used to obtain high-quality Slovakian obsidian. Future studies will investigate whether this procurement pattern represents only a small window (ca. 1800 to 1600 B.C.E.) at a particular site or whether this pattern persisted both synchronically at contemporary Middle Bronze Age sites throughout the region and diachronically during the entirety of Bronze Age occupations at Pecica Șanțul Mare, Romania.

NOTES

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1. *Muse* 14 (1980), for example, contained three separate articles detailing field excavations, including David Soren and Diana Buitron's report on continuing excavations at Kourion, Cyprus; Albert Leonard's report on the Bronze Age settlement at Monte Castellazzo, Sicily; and Sharon Herbert's report on the 1980 season at Tel Anafa, Israel, which, like the work at Pecica Șanțul Mare, was a collaborative project with the University of Michigan.
2. K. T. Bíro, "Carpathian Obsidians: Myth and Reality," *Proceedings of the 34th International Symposium on Archaeometry, 3–7 May, 2004* (Saragossa, 2004).
3. M. Oddone, P. Márton, G. Bigazzi, and K. T. Bíro, "Chemical Characterisations of Carpathian Obsidian Sources by Instrumental and Epithermal Neutron Activation Analysis," *Journal of Radioanalytical and Nuclear Chemistry* 240 (1999) pp. 147–153; Bíro, "Carpathian Obsidians"; C. N. Rosania, M. T. Boulanger, K. T. Bíro, S. Ryzhov, G. Trnka, and M. D. Glascock, "Revisiting Carpathian Obsidian," *Antiquity* 82/318 (2008), available at http://antiquity.ac.uk/ProjGall/rosania/index.html (accessed July 2010).

4. Rosania et al., "Revisiting Carpathian Obsidian."
5. O. Williams Thorpe, S. E. Warren, and J. G. Nandris, "The Distribution and Provenance of Archaeological Obsidian in Central and Eastern Europe," *Journal of Archaeological Science* 11 (1984) pp. 183–212.
6. K. T. Bíro, I. Poszgai, and A. Valdar, "Electron Beam Microanalysis of Obsidian Samples from Geological and Archaeological Sites," *Acta Archaeologica Academiae Scientarum Hungaricae* 38 (1986) pp. 257–278; ibid., "Central European Obsidian Studies," *Archaeometrical Studies in Hungary (Budapest)* 1 (1988) pp. 119–130.
7. Williams Thorpe et al., "Distribution and Provenance of Archaeological Obsidian."
8. Rosania et al., "Revisiting Carpathian Obsidian."
9. Ibid.
10. J. O'Shea and A. Barker, "Report on Archaeological Investigations at Pecica 'Şanţul Mare': 2008 Campaign," *Raport de Cercetare Arheologică, Institutul de Memorie Culturală/Ministerul Culturii şi Patrimoniului Naţional* (2008); J. O'Shea, A. Barker, S. Sherwood, and A. Nicodemus, "New Archaeological Investigations at Pecica Şanţul Mare," *Analele Banatului, S.N. Arheologie-Istorie* 12–13 (2005) pp. 81–109; J. O'Shea, A. Barker, A. Nicodemus, S. Sherwood, and A. Szentmiklosi, "Archaeological Investigations at Pecica Şanţul Mare: The 2006 Campaign," *Analele Banatului, S.N. Arheologie-Istorie* 14 (2006) pp. 211–228. The 2005 season represented a collaboration among the University of Michigan, the Milwaukee Public Museum, and the Romanian museums of the Banat and Arad. The Museum of Art and Archaeology became a collaborator, replacing the Milwaukee Public Museum, in 2006.
11. Whether the fortifications are contemporary with the extensive Middle Bronze Age occupation, however, or are associated with later, more focused Dacian Iron Age occupations remains unclear. Some scholars such as I. H. Crişan, *Ziridava. Săpăturile de la "Şanţul Mare" din anii 1960, 1961, 1962, 1964* (Arad, 1978), have identified Pecica Şanţul Mare as the Dacian fortress of Ziridava mentioned by Ptolemy.
12. L. Dömötör, "A pécskai östelepröl származó öntömintákról," *Archeologiai Értesítö* 22 (1902) pp. 271–274.
13. M. Roska, "Ásatás a pécska-szemláki határban levö Nagy Sánczon," *Dolgozatok Cluj* 3 (1912) pp. 1–73; M. Roska "Erdély régészeti repertóriuma, I. Öskor," *Thesaurus antiquitatum transsilvanicarum* vol. I. *Praehistorica. Kolozsvar* (Cluj, 1942).
14. V. G. Childe, *The Danube in Prehistory* (Oxford, 1929).
15. Cf. I. Bóna, *Die Mittlere Bronzezeit Ungarns und Ihre Südöstlichen Beziehungen* (Budapest, 1975); T. Soroçeanu, "Studien zur Mures-Kultur," *Internationale Archäologie* 7 (1991).
16. Crişan, *Ziridava*. See also D. Popescu, "Raport asupra săpăturiilor arheologice de la Pecica-Rovine şi Semlac (jud. Arad*), Raport asupra activităii ştiinţifice a Muzeului Naţional de Antichităţi în anii 1942 şi 1943* (1944) pp. 71–73; F. Draşovean, "Repertoriul Arheologic al Mureşului Inferior: Judeţul Arad," *Bibliotheca Historica et Archaeologica Banatica* 24 (1999) pp. 95–96.
17. O'Shea et al., "Archaeological Investigations"; O'Shea et al., "New Archaeological Investigations"; O'Shea and Barker, "Report on Archaeological Investigations."
18. Bóna, *Mittlere Bronzezeit Ungarns*.
19. Oddone et al., "Chemical Characterizations"; Bíro "Carpathian Obsidians."

20. J. O'Shea, *Villagers of the Maros: A Portrait of an Early Bronze Age Society* (New York, 1996) p. 376; see also M. Girić, "Die Maros (Moriš, Mures) Kultur," in N. Tasi, ed., *Kulturen der Frühbronzezeit das Karpatenbeckens und Nordbalkans* (Belgrade, 1984) pp. 33–58.
21. E. Sangmeister, "Spectralanalysen von Metallfunden des Graberfeldes Mokrin," in N. Tasić, ed., *Mokrin, The Early Bronze Age Necropolis II, Dissertationes et Monografiae* 12 (1972) pp. 97–106.

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