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SOURCING OBSIDIAN FROM EARLY PREHISTORIC SITES ON THE ARAD PLAIN, WESTERN ROMANIA

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Abstract: *Portable X-ray Fluorescence Spectroscopy (pXRF) was used to obtain source determinations for 109 obsidian artefacts from seven sites on the Arad Plain in western Romania, belonging to the Neolithic and Eneolithic periods. All the pieces analysed were made of obsidian that originated from the Carpathian 1 source area in eastern Slovakia. The results are consistent with the pattern observed at sites in the Banat and western Transylvania, which indicates a clear preference for Carpathian 1 obsidian throughout the period from the later stages of the Early Neolithic to the Bronze Age.*

Cuvinte cheie*: pXRF, surse de obsidian, neolitic, eneolitic, vestul României*

Rezumat: *Metoda pXRF a fost utilizată pentru a obține determinări sursă pentru 109 artefacte din obsidian, provenind din șapte situri din Câmpia Aradului, din vestul României, și aparținând perioadelor neolitic și eneolitic. Obsidianul din care au fost realizate piesele analizate, provine din zona sursă a Carpaților 1 din estul Slovaciei. Rezultatele sunt în concordanță cu modelul observat la siturile din Banat și vestul Transilvaniei, ceea ce indică o preferință clară pentru obsidianul Carpatic 1 pe parcursul perioadei de la etapele ulterioare ale neoliticului timpuriu până la epoca bronzului.*

INTRODUCTION

In this paper we report on the geochemical characterization of 109 obsidian artefacts from seven sites in the Arad region of western Romania belonging to the Neolithic and Eneolithic periods. This research forms part of a much broader study of obsidian distribution patterns in Romanian prehistory being undertaken by two of us (AB and CB) with the aim of establishing the patterns of movement, modes of acquisition and use of obsidian during different archaeological periods. The locations of the sites are shown in Figure 1. Accounts of the excavations and principal archaeological finds can be found in various works (Crișan 1978; Nicodemus *et alii* 2015; O'Shea *et alii* 2005; 2006; 2011; Sava 2009; 2015; 2019; Sava *et alii* 2017; Székely 2014; Soroceanu 1991). The list of sites, number of measured samples and their cultural attributions are summarized in Table 1.

THE SITES

Ghioroc – *Balastiera Vest*

The Early Neolithic site is located ca. 2.5 km NNW of the centre of Ghioroc commune (Arad County), stretching along the foothills of the Zărand Mountains on the Arad Plain (Fig. 1). Rescue excavations over and area of ca. 2023

Site	Geographical coordinates		No. of pcs.	Context	Chronology
Ghioroc – *Balastiera Vest*	46°09'30.80" N	21°33'31.87" E	1	settlement	EN
Ghioroc – *CFR Site 1*	46°09'50.47" N	21°32'42.77" E	3	settlement	LE
Pecica – *Est/Smart Diesel*	46°10'52.75" N	21°07'12.24" E	1+14	settlement/ cemetery	EN/ E
Pecica – *Est/Duvenbec*k	46°10'52.75" N	21°07'48.27" E	19	settlement	E
Pecica – *Șanțul Mare*	46°09'09.34" N	20°59'09.40" E	68	settlement	ME
Pecica – *Arsat*	46°10'14.65" N	21°06'12.82" E	2	settlement	LE
Macea – *Topila*	46°22'37.49" N	21°21'16.06" E	1	settlement	LN

Table 1. *Locational and chronological information for sites with obsidian artefacts on the Arad Plain, western Romania (EN-Early Neolithic, LE-Late Eneolithic, E-Eneolithic, ME-Middle Eneolithic, LN-Late Neolithic).*

m² took place during the summer of 2011, uncovering 20 archaeological features: 17 pits of various sizes and shapes as well as three agglomerations/concentrations of archaeological material (Sava *et alii* 2015). The relatively small number of pottery fragments recovered from the above-mentioned features date them to the Starčevo-Criș-Körös III phase. The small lithic assemblage comprised both flaked and ground stone tools (Savu 2015). The only obsidian artefact (a corticated) sidescraper (Table 2) came from the Early Neolithic cultural layer.

Ghioroc – *CFR Sit 1*

The site is located on a small sand dune where the Mureș River Valley opens onto the Arad Plain, adjacent to the foothills of the Zărand Mountains (Fig. 1). The investigation of 2250 m² uncovered nine archaeological features. Most of them were small agglomerations of archaeological material observed at ca. 0.40 m depth, at the boundary between the topsoil and the underlying yellow clay (which was archaeologically sterile). The finds were dominated by pottery sherds, represented by small, atypical fragments and two decorated fragments. The closest analogies for the sherds decorated with successive prick-like impressions are to be found in the so-called Sălcuța IV – Herculane II–III cultural horizon (Sava 2019). Features Cx. 7 and Cx. 8 (Table 2) also yielded obsidian artefacts – two (a core and a flake/blade fragment) from Cx.7 and one (a flake) from Cx.8.

Macea – *Topila*

This Late Neolithic tell is located on the Arad Plain, midway between the Mureș and Crișul Alb rivers (Fig. 1). Very few systematic archaeological investigations have taken place, most excavations being undertaken by amateurs; consequently, many finds have ended up in private or school collections. A small assemblage is curated at the Arad County Museum and was recovered in a sondage excavated in 1955 (Sava 2009; Szekely 2014). Alongside abundant Late Neolithic (Tisza culture) pottery, there were a few Bronze Age and medieval potsherds. A single piece of obsidian piece (a mesial fragment of a blade – Table 2), attributed to the Late Neolithic, was also recovered.

Pecica – *Arsat*

Rescue excavations in the autumn of 2018 uncovered 102 features stretching over an area of 10,341 m². They were dated to the Early Eneolithic (a Tiszapolgár culture settlement and a small group of burials dated to the same period) and the Late Eneolithic (a Baden culture settlement).

The 32 Baden culture pit features represent the northern part of a large Late Eneolithic settlement that extended over ca. 3.5 ha. Most of the pits yielded significant amounts of pottery, osteological remains and lithics, among which were two obsidian artefacts (Table 2). One piece (a bladelet) came from the infill of feature Cx. 25 along with a large number of Baden decorated pottery

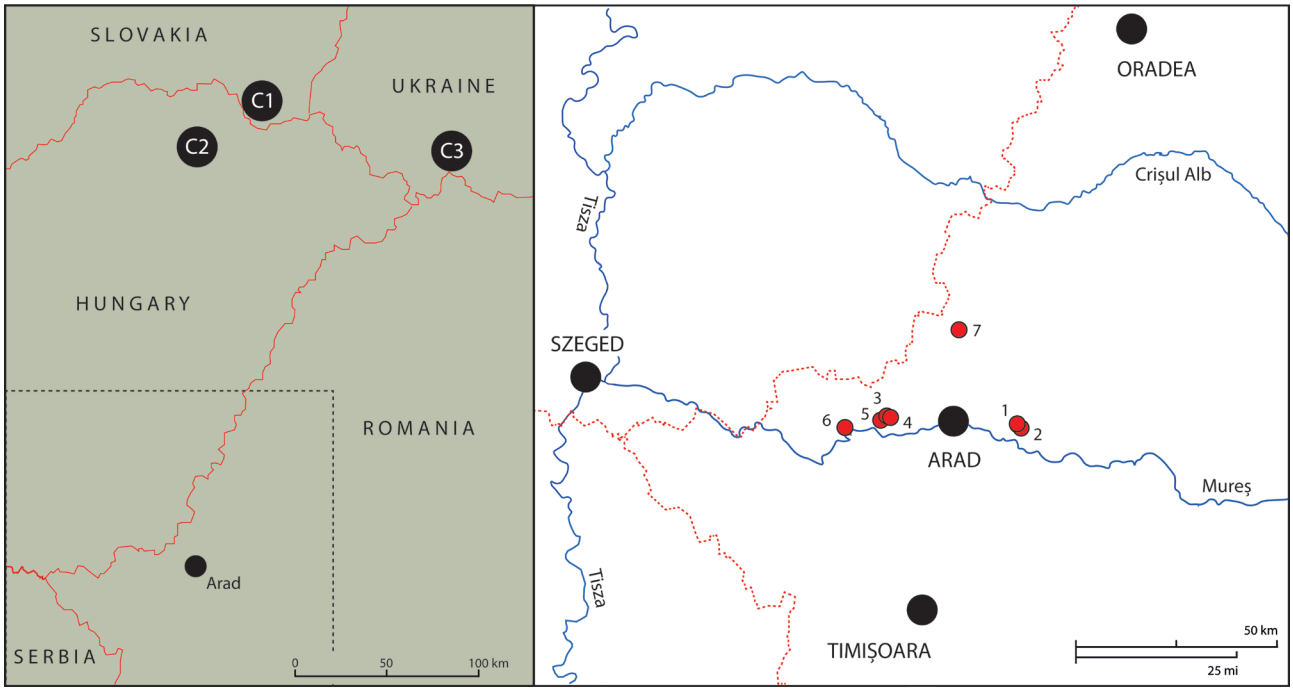

Figure 1. *Locations of archaeological sites with obsidian artefacts discussed in the text, and the approximate locations of obsidian source areas in the Western Carpathians. Key: 1. Ghioroc* – Balastiera Vest*; 2. Ghioroc* – CFR Site 1*; 3. Pecica* – Est/Smart Diesel*; 4. Pecica* – Est/Duvenbeck*; 5. Pecica* – Arsat*; 6. Pecica* – Șanțul Mare*; 7. Macea* – Topila*; C1, C2, C3 – Carpathian 1, 2 and 3 obsidian source areas.*

sherds, animal bones, daub fragments, two fragments of miniature cartwheels and a clay figurine.

The second piece (a mesial fragment of a blade) was found in the infill of pit Cx.47. The pottery from the infill was dated to the 2nd–4th centuries AD, which suggests the obsidian was probably derived from the Eneolithic cultural layer. However, it is not possible to establish a more secure chronological position for it (Early or Late Eneolithic).

Pecica – *Est/Duvenbeck*

The eastern part of Pecica town has been the object of extensive rescue excavations during the past few years. The 2018 excavations uncovered 582 features scattered over an area of 43,600 m^2. The seven prehistoric features excavated were well separated from one other. The pottery indicated that five of them were Middle Eneolithic (Bodrogkeresztúr culture), while two yielded non-diagnostic materials. Given that they were located at a relatively short distance from contemporaneous sites such as Pecica – *Forgaci* (approx. 300–400 m away, Luca 1993), Pecica – *Site 15* (approx. 800 m away, Virag 2013) and the Pecica – *Est/Smart Diesel* necropolis (approx. 700 m away, Sava *et alii* 2017), it is quite likely they belonged to one of them.

Nine of the obsidian pieces analysed for this paper (Table 2) came from the infill of pit features dated to the 2nd–4th centuries AD (one piece each from Cx. 479 and Cx. 548, and 7 pieces from Cx. 671). They were considered to be of Eneolithic origin based on the fact that the Eneolithic cultural layer was the only recognisable cultural layer represented at the sites (Mihail, Sava 2019).

Twelve obsidian artefacts (Table 2) were recovered from Cx. 160, identified as an agglomeration of archaeological material represented by pottery fragments, numerous lithic pieces, small fragments of daub and occasional charcoal fragments.

Pecica – *Șanțul Mare*

The earliest (amateur) research at this important site was undertaken by László Dömötör during several seasons of excavation: 1898, 1900, 1901 and 1902 (Dömötör 1901, 1902). Márton Roska was the first to undertake professional research in 1910–1911 and 1923–1924. The latter excavations played a major role in establishing the chronology of this tell (Roska 1912). Roska reported that in the southern part of the tell he had reached the earliest chronological layer, nowadays identified as a Middle Eneolithic (*Scheibenhenkel)* cultural horizon (Roska 1912; Roman 1971). The overlying layers were dated to the Middle Bronze Age and the Dacian period. Subsequent research was coordinated by Ioan Horațiu Crișan and Egon Dörner (1960–1962 and 1964) and a joint Romanian-American team (2005–2015), leading to a better understanding of the tell's development (Crișan 1978; Soroceanu 1991; O'Shea *et alii* 2005; 2006; 2011; Nicodemus 2011; Nicodemus *et alii* 2015. Most of the above-mentioned research focused on the study of the Bronze and Dacian occupations, and less on the Eneolithic occupation. Nevertheless, a small area of the Middle Eneolithic occupation was investigated and radiocarbon dates obtained (Nicodemus *et alii* 2015).

The 68 obsidian pieces analysed for this paper (Table 2) came from Márton Roska's excavations in 1923 and 1924, as no obsidian was recovered from the later investigations. They are part of the archaeological collection of the Arad Museum Complex and they originated from the 'Lower Layer' (Middle Eneolithic) of the tell, associated with pottery of *Scheibenhenkel* type.

MATERIALS AND METHODS

Non-destructive ED-XRF analysis was performed on 109 obsidian artefacts using a Thermo-Scientific *Niton XL3t Ultra* portable X-ray fluorescence (pXRF) spectrometer. The *Niton XL3t Ultra* pXRF analyser is equipped with an Ag anode X-ray source (capable of a maximum voltage of 50 keV, current of 200 µA and power of 2W) and a 45 mm^2 Silicon Drift Detector (SDD). The analyser uses beam filters to improve the detection of particular elements and is capable of measuring up to 38 elements simultaneously from Mg to U, although the number of elements varies according to the 'mode' (calibration model) selected. The instrument is supplied with several factory-installed 'calibrations' optimised for analysis of specific materials. The factory-set calibrations that are most suitable for the analysis of obsidian (and other bulk samples) are the Fundamental Parameter (FP) 'Mining' and Compton Normalization 'Soil' calibration models.

The results reported here were obtained using the FP mining mode calibration for 98 samples (from Ghioroc –

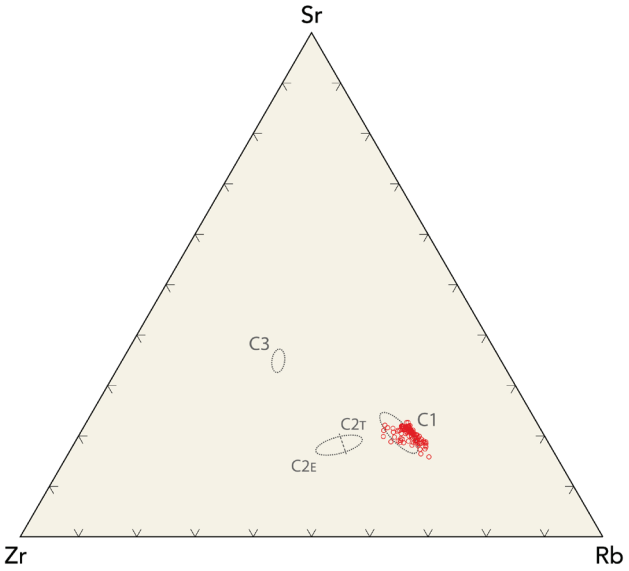

Figure 2. *Ternary graph of Rb-Sr-Zr data for obsidian artefacts from sites on the Arad Plain, plotted against the compositional ranges (ellipses) of obsidian reference samples from the three known source areas (C1, C2 and C3) in the Western Carpathians.*

Balastiera Vest, Macea – *Topila*, Pecica – *Arsat*, Pecica – *Șanțul Mare* and Pecica – *Duvenbeck*, plus one sample from Pecica – *Smart Diesel*) and the 'Soil' mode calibration for the remaining 15 samples (from Pecica – *Smart Diesel* and Pecica – *Est SD2*). Each obsidian sample was measured for a total of 180s, using 60s analysis times per filter. To improve accuracy, the elemental concentrations reported by the instrument for Rb, Sr, Y, Zr, and Nb, which are particularly useful for obsidian characterization by XRF, were adjusted by empirical calibration factors obtained through the analysis of 27 obsidian reference samples of known elemental composition.

RESULTS AND DISCUSSION

Of the seven archaeological sites included in this study, six are situated in the valley of the River Mureș to the east and west of Arad, while one (Macea – *Topila*) lies further north on the interfluve between the Mureș and Crișul Alb rivers. Obsidian artefacts were recovered from contexts which, based on the associated pottery, range in age from the later part of the Early Neolithic to the late Eneolithic.

A total of 113 knapped lithic artefacts were examined on two separate visits to Arad Museum, in June and August 2019. The techno-typological attributes of the artefacts were recorded during the first visit, and pXRF measurements made on the second visit. A summary of the data is provided in Table 2. pXRF measurements were not taken for two pieces that were identified as obsidian by visual inspection, while two other pieces proved to be chert. Of the 111 pieces identified as obsidian, the majority were various forms of debitage suggesting the obsidian had been knapped on site. The formal tools comprised three scrapers, six bifacial arrowheads from Eneolithic contexts at Pecica – *Smart Diesel* (n=2) and Pecica – *Est SD2* (n=4), and six microliths (all trapezes) from Eneolithic contexts at Pecica – *Șanțul Mare*.

The nearest geological sources of knappable obsidian to the Arad Plain sites are in the Western Carpathian Mountains (Fig. 1), between 200 and 250 km to the north. Chemically, the Carpathian obsidians can be divided into three main groups (Thorpe 1978; Rosania *et alii* 2008): Carpathian 1 (C1) in southeast Slovakia, Carpathian 2 (C2) in the Tokaj Hills of northeast Hungary and Carpathian 3 (C3) in southwest Ukraine. The C2 group has been subdivided into two subgroups termed C2E and C2T. Differentiation of the main Carpathian groups using pXRF can usually be made on the basis of three elements: Rb, Sr and Zr.

The concentrations in parts per million (ppm) of zirconium (Zr), strontium (Sr) and rubidium (Rb) in the obsidian artefacts from the Arad Plain sites are listed in Table 2 and these data are plotted against the compositional ranges of the various Carpathian obsidian sources in Figure 2. The source ellipses were established from pXRF measurements on geological samples using identical instrument settings and timings.

The results suggest that the Carpathian 1 (C1) source area in eastern Slovakia supplied all the obsidian used at the sites included in the present study. Some of our samples plot outside the C1 source ellipse. This likely reflects two factors. Unlike the geological reference samples, some of the archaeological samples are quite thin (<3mm maximum thickness) and did not cover the measurement window of the analyser. Hence, they are not 'infinitely thick' in reference to XRF, which can lead to measurement inaccuracies. Secondly, each of the source ellipses derives from measurements on just a small number (<15) of geological reference samples and may underestimate the range of variation within each chemical group.

Previous obsidian characterisation studies in northwest Romania have focused on the Banat (Biagi *et alii* 2007; Glascock *et alii* 2015; 2016; 2017) and northwestern Transylvania (Boroneanț *et alii* 2018; 2019; Dobrescu *et alii* 2018). Our results are the first to be obtained for the intervening area, and specifically the Arad Plain between the Mureș and Crișul Alb rivers. They add to a growing body of obsidian provenance data for the Neolithic and Eneolithic of the region and confirm the pattern noted by previous authors that from the late Early Neolithic onwards prehistoric obsidian procurement focused predominantly, if not exclusively, on the C1 source in southeast Slovakia.

CONCLUSIONS

One hundred and nine obsidian artefacts from seven sites on the Arad Plain in western Romania were analysed by pXRF. Every piece was successfully characterised geochemically and matched to its geological source, even though many pieces were of less than 'infinite thickness' for X-ray fluorescence spectrometry.

The results show that the Carpathian 1 source area in eastern Slovakia supplied all the obsidian used at the sites included in the present study. This is consistent with the pattern observed at sites in other areas of western Romania, that lie to the north (western Transylvania) and south (the Banat) of the Arad Plain, which shows a clear preference for Carpathian 1 obsidian throughout the period from the later stages of the Early Neolithic to the Bronze Age.

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Site	Period	Inventory no.	Sample No.	Type	Length (mm)	Breadth (mm)	Thichness (mm)	Weight (g)	Source	Zr	Sr	Rb
Ghioroc – *Balastiera Vest*	Starčevo-Criș III		**1**	F	-22.61	-33.07	7.89	4.97	C1	82	70	207
Pecica – *Smart Diesel*	Eneolithic		**2**	S	26.46	46.04	12.08	14.67	C1	Not measured		
Macea – *Topila*	Late Neolithic, Tisza culture	**13012**	**3**	Bb	-16.21	16.74	3.41	1.16	C1	78	66	203
Pecica *Arsat*	Eneolithic		**4**	Bb	-23.21	8.74	2.50	0.55	C1	87	82	214
Pecica *Arsat*	Eneolithic		**5**	Bmf	10.97	8.21	4.45	0.36	C1	83	81	205
Pecica – *Șanțul Mare*	Middle Eneolithic	**5542**	**6**	F	22.99	19.65	4.26	1.83	C1	87	80	204
Pecica – *Șanțul Mare*	Middle Eneolithic	**5510**	**7**	Cb	-20.78	26.26	10.50	4.43	C1?	78	65	200
Pecica – *Șanțul Mare*	Middle Eneolithic	**5660**	**8**	Bb	-24.73	12.53	29.50	0.86	C1	82	77	208
Pecica-Șanțul Mare	Middle Eneolithic	**5669**	**9**	F	26.81	18.71	6.69	2.31	C1	79	70	190
Pecica – *Șanțul Mare*	Middle Eneolithic	**5931**	**10**	ER	18.94	23.41	7.31	2.66		Chert?		
Pecica – *Șanțul Mare*	Middle Eneolithic	**6000**	**11**	F	22.21	14.70	4.53	1.25	C1	90	78	202
Pecica – *Șanțul Mare*	Middle Eneolithic	**5830**	**12**	B	-19.90	-13.56	3.83	1.17	C1	81	77	196
Pecica – *Șanțul Mare*	Middle Eneolithic	**5823**	**13**	Bb	-44.73	16.16	10.23	5.63	C1	78	67	205
Pecica – *Șanțul Mare*	Middle Eneolithic	**5831**	**14**	Bpf	-21.61	16.32	4.27	1.61	C1	79	74	197
Pecica – *Șanțul Mare*	Middle Eneolithic	**5489**	**15**	F	26.16	20.58	3.09	1.53	C1	87	81	202
Pecica – *Șanțul Mare*	Middle Eneolithic	**5509**	**16**	Cb	-41.45	30.43	10.71	11.64	C1	84	76	195
Pecica – *Șanțul Mare*	Middle Eneolithic	**5554**	**17**	F	-17.71	12.50	3.08	0.59	C1	88	76	220
Pecica – *Șanțul Mare*	Middle Eneolithic	**5524**	**18**	M	-21.77	15.99	3.90	1.05	C1	81	73	223
Pecica – *Șanțul Mare*	Middle Eneolithic	**5525**	**19**	F	18.21	10.65	2.71	0.48	C1	85	80	217
Pecica – *Șanțul Mare*	Middle Eneolithic	**5522**	**20**	Bmf	-22.92	7.99	2.38	0.48	C1	89	74	252
Pecica – *Șanțul Mare*	Middle Eneolithic	**5567**	**21**	F	-10.73	13.92	2.23	0.30	C1	85	78	210
Pecica – *Șanțul Mare*	Middle Eneolithic	**5514**	**22**	F	19.42	19.78	4.26	1.56	C1	77	65	209
Pecica – *Șanțul Mare*	Middle Eneolithic	**5552**	**23**	M	-18.18	22.23	4.55	1.58	C1	82	75	194
Pecica – *Șanțul Mare*	Middle Eneolithic	**5520**	**24**	Bpf	-20.29	1.36	4.35	1.20	C1	85	80	201
Pecica – *Șanțul Mare*	Middle Eneolithic	**5526**	**25**	F	-17.86	18.17	3.74	0.84	C1	81	78	203
Pecica – *Șanțul Mare*	Middle Eneolithic	**5568**	**26**	F	-8.12	-11.80	3.41	0.33	C1	81	74	210
Pecica – *Șanțul Mare*	Middle Eneolithic	**5597**	**27**	Bpf	-15.81	19.06	4.61	1.09	C1	79	72	202
Pecica – *Șanțul Mare*	Middle Eneolithic	**5555**	**28**	ER	-19.69	16.40	4.41	0.81	C1	90	82	220

Pecica – *Șanțul Mare*	Middle Eneolithic	**5521**	**29**	Bmf	-21.82	16.72	6.64	2.43	C1	82	66	206
Pecica – *Șanțul Mare*	Middle Eneolithic	**5535**	**30**	F	22.15	13.93	2.18	0.73	C1	82	76	223
Pecica – *Șanțul Mare*	Middle Eneolithic	**5527**	**31**	M	14.74	9.29	2.92	0.39	C1	76	68	214
Pecica – *Șanțul Mare*	Middle Eneolithic	**5561**	**32**	F	-35.30	20.59	3.30	2.04	C1	82	67	214
Pecica – *Șanțul Mare*	Middle Eneolithic	**5533**	**33**	Bmf	-22.02	15.79	3.74	1.47	C1	78	70	209
Pecica – *Șanțul Mare*	Middle Eneolithic	**5565**	**34**	Cb	-18.99	8.82	5.69	0.67	C1	77	71	204
Pecica – *Șanțul Mare*	Middle Eneolithic	**5569**	**35**	F	-13.72	-13.22	3.72	0.44	C1	83	84	204
Pecica – *Șanțul Mare*	Middle Eneolithic	**5570**	**36**	Bmf	-22.76	10.72	4.09	0.98	C1	78	70	224
Pecica – *Șanțul Mare*	Middle Eneolithic	**5539**	**37**	Bb	-13.52	12.63	1.70	0.33	C1	98	91	254
Pecica – *Șanțul Mare*	Middle Eneolithic	**5550**	**38**	F	-16.35	11.38	3.08	0.40	C1	87	84	214
Pecica – *Șanțul Mare*	Middle Eneolithic	**5517**	**39**	F	15.58	12.26	3.93	0.56	C1	89	75	195
Pecica – *Șanțul Mare*	Middle Eneolithic	**5538**	**40**	Bpf	-16.90	13.58	2.79	0.63	C1	88	70	230
Pecica – *Șanțul Mare*	Middle Eneolithic	**5544**	**41**	F	-14.47	12.38	1.92	0.39	C1	90	69	221
Pecica – *Șanțul Mare*	Middle Eneolithic	**5563**	**42**	F	-14.99	-13.18	1.75	0.37	C1	91	77	258
Pecica – *Șanțul Mare*	Middle Eneolithic	**5540**	**43**	Bpf	-15.24	18.28	4.78	1.26	C1	84	72	205
Pecica – *Șanțul Mare*	Middle Eneolithic	**5553**	**44**	M	17.37	14.63	3.18	0.66	C1?	84	80	211
Pecica – *Șanțul Mare*	Middle Eneolithic	**5551**	**45**	F	-18.34	13.73	3.37	0.80	C1	83	76	197
Pecica – *Șanțul Mare*	Middle Eneolithic	**5552**	**46**	Bdf	-22.91	14.40	2.46	0.78	C1	83	73	235
Pecica – *Șanțul Mare*	Middle Eneolithic	**5513**	**47**	F	-21.44	-18.32	5.34	1.87	C1	80	78	199
Pecica – *Șanțul Mare*	Middle Eneolithic	**5566**	**48**	F	19.45	5.93	4.84	0.37	C1	90	78	213
Pecica – *Șanțul Mare*	Middle Eneolithic	**5543**	**49**	Bpf	-15.20	10.99	3.25	0.61	C1	85	86	209
Pecica – *Șanțul Mare*	Middle Eneolithic	**5558**	**50**	Cb	14.29	8.30	5.41	0.55	C1	83	77	193
Pecica – *Șanțul Mare*	Middle Eneolithic	**5548**	**51**	F	-15.36	15.37	3.35	0.62	C1	87	80	204
Pecica – *Șanțul Mare*	Middle Eneolithic	**5833**	**52**	Bpf	-22.37	15.65	7.15	2.62	C1	84	60	221
Pecica – *Șanțul Mare*	Middle Eneolithic	**5508**	**53**	Cp	22.42	18.94	11.73	6.34	C1	76	68	203
Pecica – *Duvenbeck*	Middle Eneolithic		**54**	F	13.13	15.14	3.89	0.67	C1	82	69	212
Pecica – *Duvenbeck*	Middle Eneolithic		**55**	Bb	-38.50	20.32	6.08	4.95	C1	77	65	202
Pecica – *Duvenbeck*	Middle Eneolithic		**56**	Bdf	-14.25	7.26	4.00	0.36	C1	84	77	201

Site	Period		CB No.	Type	L	B	Th	Wgt	Source	Zr	Sr	Rb
Pecica – *Duvenbeck*	Middle Eneolithic		**57**	F	21.68	14.74	5.53	1.46	C1	83	78	200
Pecica – *Duvenbeck*	Middle Eneolithic		**58**	Bmf	-23.26	10.61	27.00	0.75	C1	87	78	210
Pecica – *Duvenbeck*	Middle Eneolithic		**59**	Bmf	-22.42	8.10	2.15	0.37	C1	93	86	236
Pecica – *Duvenbeck*	Middle Eneolithic		**60**	Bdf	12.48	5.08	1.24	0.07	C1	Not measured - too small and thin		
Pecica – *Duvenbeck*	Middle Eneolithic		**61**	S	-20.93	19.94	6.32	2.55		Chert?		
Pecica – *Duvenbeck*	Middle Eneolithic		**62**	Bmf	-18.85	9.28	1.59	0.38	C1	88	77	245
Pecica – *Duvenbeck*	Middle Eneolithic - Bodrogkeresztúr	**Viktor 8**	**63**	F	30.54	17.45	6.17	3.16	C1	79	63	220
Pecica – *Duvenbeck*	Middle Eneolithic - Bodrogkeresztúr	**Viktor 12**	**64**	Cp	23.62	14.25	10.52	3.70	C1	81	76	188
Pecica – *Duvenbeck*	Middle Eneolithic - Bodrogkeresztúr	**Viktor 25**	**65**	Bb	-24.17	9.72	2.82	0.46	C1	89	68	235
Pecica – *Duvenbeck*	Middle Eneolithic - Bodrogkeresztúr	**Viktor 21**	**66**	F	-10.19	11.60	6.20	0.63	C1	82	75	192
Pecica – *Duvenbeck*	Middle Eneolithic - Bodrogkeresztúr	**Viktor 30**	**67**	Bb	-15.35	6.18	1.90	0.20	C1	94	68	267
Pecica – *Duvenbeck*	Middle Eneolithic - Bodrogkeresztúr	**Viktor 34**	**68**	F	19.76	16.98	4.72	1.72	C1	78	80	195
Pecica – *Duvenbeck*	Middle Eneolithic - Bodrogkeresztúr	**Viktor 38**	**69**	Bmf	-12.67	9.14	3.24	0.35	C1	83	77	221
Pecica – *Duvenbeck*	Middle Eneolithic - Bodrogkeresztúr	**Viktor 31**	**70**	Bmf	-17.97	13.85	2.78	0.79	C1	83	78	208
Pecica – *Duvenbeck*	Middle Eneolithic - Bodrogkeresztúr	**Viktor 39**	**71**	Bmf	-13.35	5.53	1.41	0.14	C1	99	90	249
Pecica – *Duvenbeck*	Middle Eneolithic - Bodrogkeresztúr	**Viktor 40**	**72**	Bb	-18.03	9.41	3.72	0.55	C1	85	75	213
Pecica – *Duvenbeck*	Middle Eneolithic - Bodrogkeresztúr	**Viktor 6**	**73**	Fr	26.30	23.88	7.35	3.89	C1	78	69	204
Pecica – *Șanțul Mare*	Eneolithic - Lower layer	**5532**	**74**	Bb	-23.58	14.59	3.38	1.09	C1	83	76	209
Pecica – *Șanțul Mare*	Eneolithic - Lower layer		**75**	Cb	29.38	18.74	12.44	5.26	C1	79	79	200
Pecica – *Șanțul Mare*	Eneolithic - Lower layer	**5541**	**76**	F	-20.36	19.23	4.27	1.37	C1	79	76	204
Pecica – *Șanțul Mare*	Eneolithic - Lower layer	**5510**	**76.1**	F	-14.43	21.17	5.00	1.01	C1	78	77	195
Pecica – *Șanțul Mare*	Eneolithic - Lower layer	**5?70**	**77**	F	-13.50	14.80	3.67	0.48	C1	84	77	197
Pecica – *Șanțul Mare*	Eneolithic - Lower layer		**78**	F	-17.57	16.78	3.52	0.85	C1	82	77	193
Pecica – *Șanțul Mare*	Eneolithic - Lower layer		**79**	M	19.28	12.36	2.90	0.68	C1	83	73	223
Pecica – *Șanțul Mare*	Eneolithic - Lower layer	**5556**	**80**	M	17.51	13.20	2.64	0.48	C1	82	69	218
Pecica – *Șanțul Mare*	Eneolithic - Lower layer	**5559**	**81**	ER	-19.21	8.19	2.09	0.24	C1	85	78	214

Pecica – *Șanțul Mare*	Eneolithic - Lower layer		**82**	F	-26.13	29.30	6.70	5.45	C1	76	70	200
Pecica – *Șanțul Mare*	Eneolithic - Lower layer		**83**	F	-16.92	23.07	6.60	2.46	C1	79	69	203
Pecica – *Șanțul Mare*	Eneolithic - Lower layer	**55??**	**84**	S	-16.12	14.54	4.96	1.33	C1	78	75	193
Pecica – *Șanțul Mare*	Eneolithic - Lower layer		**85**	Bb	-28.17	12.51	4.36	1.23	C1	78	67	205
Pecica – *Șanțul Mare*	Eneolithic - Lower layer		**86**	B	-18.57	7.27	2.12	0.23	C1	94	79	213
Pecica – *Șanțul Mare*	Eneolithic - Lower layer		**87**	Bb	-39.20	12.72	7.12	3.21	C1	73	64	209
Pecica – *Șanțul Mare*	Eneolithic - Lower layer		**88**	F	-13.31	-19.05	4.48	0.82	C1	81	67	216
Pecica – *Șanțul Mare*	Eneolithic - Lower layer	**59??**	**89**	Bb	-42.27	17.36	7.53	5.18	C1	82	79	202
Pecica – *Șanțul Mare*	Eneolithic - Lower layer	**55?6**	**90**	F	-16.37	20.24	4.20	1.52	C1	84	78	207
Pecica – *Șanțul Mare*	Eneolithic - Lower layer		**91**	F	14.69	18.98	6.37	1.29	C1	77	72	188
Pecica – *Șanțul Mare*	Eneolithic - Lower layer		**92**	F	12.52	22.18	7.84	1.19	C1	82	76	189
Pecica – *Șanțul Mare*	Eneolithic - Lower layer	**5557**	**93**	F	-14.32	-16.50	3.03	0.53	C1	88	82	206
Pecica – *Duvenbeck*	Middle Eneolithic - Bodrogkeresztúr	**Viktor 20**	**94**	B	26.67	9.77	4.00	0.93	C1	85	81	215
Ghioroc – *sit 1*	Middle Eneolithic		**95**	F	-35.57	21.31	5.23	3.45	C1	92	69	209
Ghioroc – *sit 1*	Middle Eneolithic		**96**	Ca	37.27	37.74	16.45	17.84	C1	85	77	200
Ghioroc – *sit 1*	Middle Eneolithic		**97**	Bb	-11.97	-15.16	3.49	0.51	C1	83	76	207
Pecica – *Smart Diesel*	Eneolithic	**BD55**	**98**	BA	33.05	16.02	3.70	1.49	C1	90	73	189
Pecica – *Smart Diesel*	Eneolithic	**BD56**	**99**	ER	-21.94	7.64	2.42	0.38	C1	92	73	220
Pecica – *Smart Diesel*	Eneolithic	**BD57**	**100**	BA	23.90	18.07	4.10	1.36	C1	94	79	184
Pecica – *Smart Diesel*	Eneolithic	**BD58**	**101**	F	25.08	32.41	11.02	7.12	C1	99	71	187
Pecica – *Est SD2*	Eneolithic	**BD59**	**102**	BA	22.95	23.33	2.97	1.02	C1	93	69	201
Pecica – *Est SD2*	Eneolithic	**BD60**	**103**	BA	26.41	19.55	4.16	1.25	C1	91	67	200
Pecica – *Est SD2*	Eneolithic	**BD61**	**104**	BA	21.49	15.82	4.04	1.07	C1	87	68	194
Pecica – *Est SD2*	Eneolithic	**BD62**	**105**	BA	-13.16	-15.16	-2.90	0.37	C1	94	80	198
Pecica – *Est SD2*	Eneolithic	**BD63**	**106**	Bb	-29.41	8.27	3.11	0.70	C1	92	72	208
Pecica – *Est SD2*	Eneolithic	**BD64**	**107**	Bb	-20.45	-8.57	-2.07	0.30	C1	100	86	221
Pecica – *Est SD2*	Eneolithic	**BD65**	**108**	F	34.75	23.73	5.59	5.13	C1	87	66	192

Pecica – *Est SD2*	Eneolithic	**BD67**	**109**	S	35.84	23.30	4.60	3.99	C1	93	65	187
Pecica – *Est SD2*	Eneolithic	**BD68**	**110**	Cp	26.89	15.06	11.58	5.62	C1	95	74	182
Pecica – *Est SD2*	Eneolithic	**BD69**	**111**	Cp	21.96	13.19	12.42	4.81	C1	89	68	187
Pecica – *Est SD2*	Eneolithic	**BD70**	**112**	Cp	49.45	36.69	36.37	86.34	C1	93	77	186

***Table 2**. Summary of typological, metrical and elemental concentration data (in ppm) for obsidian artefacts from Neolithic and Eneolithic sites on the Arad Plain, in western Romania. A minus-sign before a measurement indicates that the piece is broken in that dimension. Abbreviations: B – blade; BA – bifacial arrowhead; Bb – broken blade; Bdf – blade, distal fragment; Bmf – blade, mesial fragment; Bpf – blade, proximal fragment; Ca – amorphous core; Cb – bipolar core; Cp – platform core; ER – edge retouched piece; F – flake; M – microlith; S – scraper.*

ABREVIERI / ABRÉVIATIONS / ABBREVIATIONS

ActaMN – Acta Musei Napocensis, Cluj
ActaMP – Acta Musei Porolissensis, Zalău
ActaTS – Acta Terrae Septemcastrensis, Universitatea Lucian Blaga, Sibiu
AÉ – Archaeológiai Értesítő, Budapest
American Antiquity – American Antiquity. Society for American Archaeology, Washington
AnB – Analele Banatului, Muzeul Banatului, Timișoara
l'Anthropologie (Paris) – l'Anthropologie, Paris
Antiquity – Antiquity. A Quarterly Review of Archaeology, University of York
AnUVT – Annales d'Université «Valahia» Târgoviște, Section d'Archéologie et d'Histoire
Apulum – Acta Musei Apulensis. Muzeul Național al Unirii, Alba Iulia
Archaeol Anthropol Sci – Archaeological and Anthropological Sciences
Archaeometry – Archaeometry, Research Laboratory for Archaeology and the History of Art, Oxford University
ArchBulg – Archaeologia Bulgarica, Sofia
Argesis – Argesis. Muzeul Județean Argeș, Pitești
Arheovest – Arheovest – Asociația Arheo Vest, Timișoara
BAHC – Bibliotheca Archaeologica et Historica Corvinensis, Hunedoara
BAI – Bibliotheca Archaeologica Iassiensis, Iași
Banatica – Banatica, Muzeul Banatului Montan, Reșița
BARBrSer – British Archaeological Reports. British Series, Oxford
BARIntSer – British Archaeological Reports. International Series, Oxford
BeJA – Bulgarian e-Journal of Archaeology
BerRGK – Bericht der Römisch-Germanischen Kommission des Deutschen Archäologischen Instituts, Frankfurt am Main
BHAUT – Bibliotheca Historica et Archaeologica Universitatis Timisiensis, Timișoara
BMJT – Buletinul Muzeului Județean Teleorman, Alexandria
BSPF – Bulletin de la Societé Préhistorique Française, Paris
CA – Cercetări Arheologice, București
CAB – Cercetări arheologice în București
CCA – Cronica Cercetărilor Arheologice din România, București
CCDJ – Cultură și Civilizație la Dunărea de Jos, Călărași
Crisia – Crisia. Muzeul Țării Crișurilor, Oradea
Dacia – Dacia (Nouvelle Série). Revue d'archéologie et d'histoire ancienne. Académie Roumaine. Institut d'archéologie « V. Pârvan », Bucarest
EJA – European Journal of Archaeology
EphemNap – Ephemeris Napocensis. Academia Română, Institutul de Arheologie și Istoria Artei, Cluj-Napoca
Germania – Germania. Anzeiger der Römisch-Germanischen Kommission des Deutschen Archäologischen Instituts, Frankfurt
JAS – Journal of Archaeological Science
JRGZM – Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz, Mainz
MCA – Materiale și Cercetări Arheologice, București
MEFRA – Mélanges de l'École Française de Rome. Antiquité, Rome
MemAnt – Memoria Antiquitatis, Piatra Neamț
MIM – Materiale de Istorie și Muzeografie, București
Mousaios – Mousaios. Buletinul Științific al Muzeului Județean Buzău
Paléo – Paléo. Revue d'Archéologie Préhistorique. Musée National de Préhistoire, Les Eyzies, France
Paléorient – Paléorient: revue interdisciplinaire de préhistoire et de protohistoire du sud-ouest et de l'Asie centrale, Paris
Pallas – Pallas. Revue d'Etudes Antiques, Toulouse
Pontica – Pontica. Studii și materiale de istorie, arheologie și muzeografie. Muzeul de Istorie Națională și Arheologie Constanța
RACF – Revue Archéologique du Centre de la France, Lyon-Tours
Radiocarbon – An International Journal of Cosmogenic Isotope Research, Cambridge
RCAN – Revista de Cercetări Arheologice și Numismatice, Muzeul Municipiului București
RÉL – Revue des Études Latines, Paris
RevMuz – Revista Muzeelor, București

RN – Revue Numismatique, Paris
RMI – Revista Monumentelor Istorice, București
RMM.MIA – Revista Muzeelor și Monumentelor, seria Monumente Istorice și de Artă, București
Sargetia – Sargetia. Acta Musei Devensis, Buletinul Muzeului județean Hunedoara, Deva
SCIV(A) – Studii și Cercetări de Istorie Veche (și Arheologie), București
SP – Studii de Preistorie, București
SUCSH – Studia Universitatis Cibiniensis. Series Historica, Sibiu
Tibiscum – Muzeul Județean de Etnografie și al Regimentului de Graniță Caransebeș
Th-D – Thraco-Dacica, București
Tyche – Tyche. Beiträge zur Alten Geschichte, Papyrologie und Epigraphik
Tyragetia – Tyragetia. Anuarul Muzeului Național de Istorie a Moldovei, Chișinău
VAH – Varia Archaeologica Hungarica V. Redigit Csanád Bálint. Publicationes Instituti Archaeologici Academiae Scientiarum Hungaricae, Budapest
Ziridava – Ziridava. Studia Archaeologica, Arad