Tracing the source of obsidian from prehistoric sites in Bulgaria

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ABSTRACT

Portable X-ray fluorescence (pXRF) spectrometry was used to obtain source determinations for 11 obsidian artefacts from five archaeological sites in Bulgaria. The results show that all the archaeological specimens can be linked to obsidian sources in the Carpathian Mountains in the border region between Hungary and Slovakia. Obsidian from the C2E source in Hungary occurred in very early Neolithic contexts at Dzhulyunitsa, while the majority of samples from later contexts at Ohoden, Dzherman and Varna came mainly from the Slovakian (C1) source. The data hint at a shift from the use of C2 obsidian in the Neolithic before 5900 cal BC, to a preference for C1 obsidian in later periods – however, more finds and better contextual and chronological data are required to verify this trend.

KEYWORDS

Obsidian, Bulgaria, source determination, pXRF, Early Neolithic, Late Chalcolithic

Introduction

Obsidian is a rare material with only a few known geological sources in Europe and neighbouring regions of Southwest Asia. Since most sources have a unique geochemical composition, the origin of the obsidian used for the manufacture of artefacts found in archaeological sites can usually be determined by comparing the elemental composition of individual artefacts with that of geological samples from known source locations.

Previously, we reported on the occurrence of small numbers of obsidian artefacts in prehistoric sites in Bulgaria, and summarized the results of portable X-ray fluorescence (pXRF) analysis to obtain source determinations for the artefacts (Bonsall et al. 2017). In this paper, we provide further information on the Bulgarian finds and their archaeological contexts, and describe in more detail the method and results of the pXRF analyses.

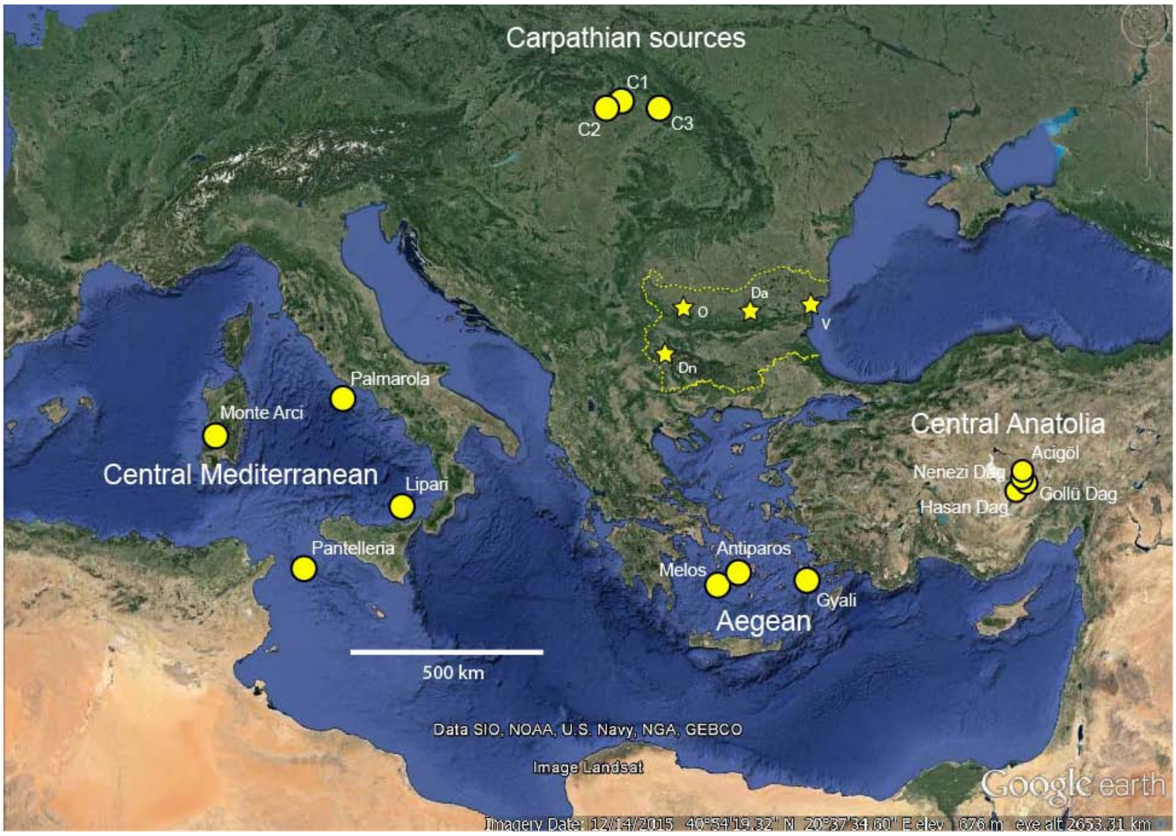

Fig. 1. Site locations in relation to major obsidian source areas (base map: Google Earth 7.0, viewed 8 June 2016): Da – Dzhulyunitsa; Dn – Dzherman; O –Ohoden; V – Varna
Обр. 1. Разположение на обектите от проучването в контекста на основните региони с обсидианови находища (карта – Google Earth 7.0, от 8.06.2016): Da – Джулюница; Dn – Джерман; O – Оходен; V – Варна

Archaeological context

The obsidian artefacts that are the focus of the present paper came from five archaeological sites – Ohoden-Valoga, Dzhulyunitsa-Smardesh and Varna cemeteries I and III in northern Bulgaria, and Dzherman in the southwest of the country (fig. 1).[1] At Ohoden, Dzhulyunitsa and Dzherman the obsidian pieces were recovered from Early Neolithic contexts, while the Varna finds have Late Chalcolithic associations.

Ohoden-Valoga

This Early Neolithic site, near the modern village of Ohoden in northwest Bulgaria, occupies an area of ca 12,000 m^2 on a terrace of the Skat river (fig. 2). Field research suggests the river has changed its course since the Neolithic, when it flowed ca 200 m closer to the settlement. Geomorphological investigations point to several episodes of flooding during the Neolithic occupation of Ohoden, which may have been responsible for the eventual abandonment of the settlement.

In archaeological excavations since 2002, remains of 15 semi-subterranean structures

1 In our earlier paper (Bonsall et al. 2017) we referred to only four sites with obsidian artefacts, since the Varna finds were treated as belonging to a single Late Chalcolithic cemetery complex. However, it is perhaps more realistic to consider the Varna I and III cemeteries as distinct sites.

Fig. 2. Ohoden-Valoga: a) Archeaological site of Ohoden-Valoga: view from the east, 2016 season (photo G. Ganetsovski); b) landscape setting (photo C. Bonsall)
Обр. 2. Оходен-Валога: общ вид на обекта от изток, сезон 2016 г. (снимка Г. Ганецовски); b) характеристика на ландшафта (снимка К. Бонсал)

(dwellings and intramural burial facilities) have been investigated. Two successive occupation phases have been identified based on pottery typology (Ганецовски 2009; 2014). The first phase (Ohoden I) is characterized by monochrome pottery, while the second phase (Ohoden II) is characterized by pottery with black painted ornamentation on a red background and vessels with pedestal bases (fig. 3)[2]. The obsidian artefacts in this study were all recovered from contexts assigned to the Ohoden II phase.

2 Based on ceramic typology, the excavator of Ohoden-Valoga (G.G.) equates Ohoden phase I to the final stage of the Proto-Starčevo culture (cf. Тодорова, Вайсов 1993, 59-63; Srejović 1995, 251-263), and Ohoden phase II to stage II of the Starčevo culture (cf. Garašanin 1979, 134-138).

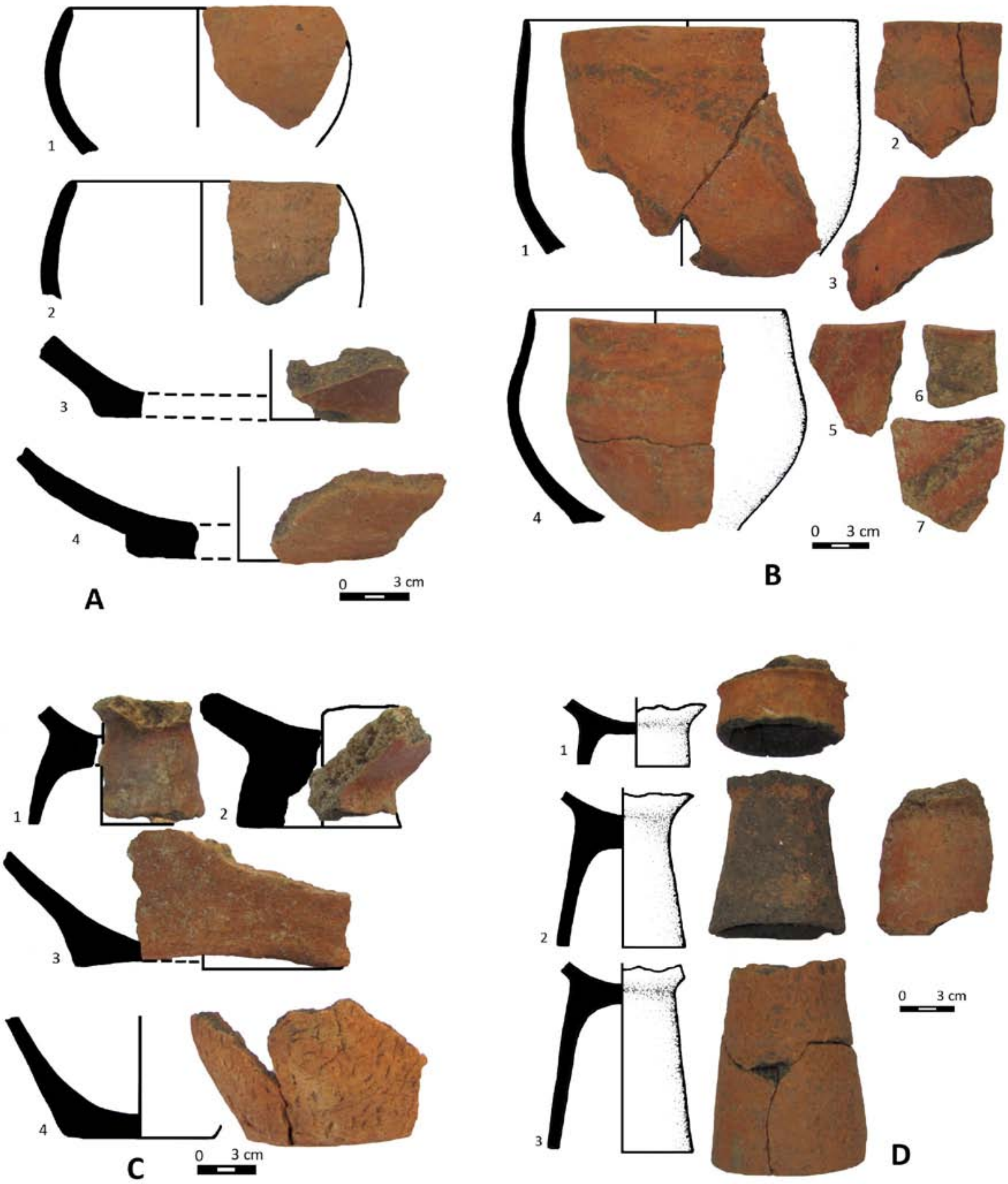

Fig. 3. Pottery from the site of Ohoden: A – from structure 13 (phase Ohoden I); B – from structure 12 (phase Ohoden II); C – from structure 7 (phase Ohoden II); D – from structure 12 (phase Ohoden II) (drawings G. Ganetsovski)

Обр. 3. Керамика от Оходен: A – от структура 13 (фаза I); B – от структура 12 (фаза II); C – от структура 7 (фаза II); D – от структура 12 (фаза II) (рисунки Г. Ганецовски)

Currently, there are only a small number of radiocarbon dates for the site. An AMS ^{14}C date of 7060±50 BP (Poz-81112: 6032-5837 cal BC) was obtained on bone collagen from an infant burial (grave 5) assigned to the Ohoden I phase (Mathieson et al. 2017). A series of radiometric dates on charcoal and carbonized plant remains from structures 1 and 13, which were assigned to the Ohoden II phase, fall around 5700/5650 cal BC (Ганецовски 2009; Krauß 2014).

Fig. 4. Dzhulyunitsa-Smardesh: viewed from the south, with the approximate locations of the Neolithic settlement (black arrow) and Copper Age tell (red arrow) indicated (photo N. Elenski).
Обр. 4. Джулюница-Смърдеш: поглед от юг с локализация на неолитното селище (черна стрелка) и халколитната селищна могила (червена стрелка) (снимка Н. Еленски)

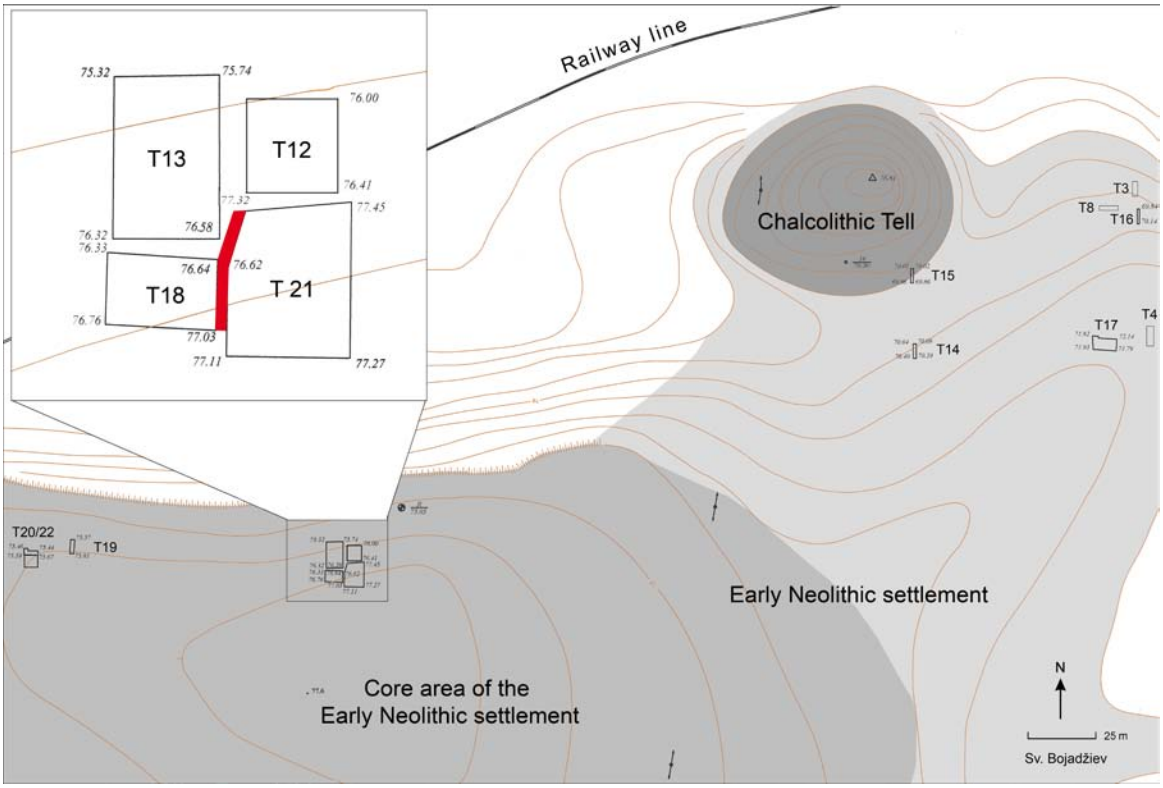

Fig. 5. Dzhulyunitsa-Smardesh: site plan showing the locations of trenches excavated between 2001-2011 (reproduced from Krauß et al. 2014, with permission)
Обр. 5. Джулюница-Смърдеш: план на селището с локализация на сондажите, разкопавани в периода 2001-2011 г. (по Krauß et al. 2014, с разрешение на авторите)

Dzhulyunitsa-Smardesh

Situated on the edge of the Danube Plain in the catchment of the Yantra river, a southern tributary of the Danube, Dzhulyunitsa (fig. 4) is a large open-air site with spatially overlapping occupations dating from the Early Neolithic to the Bronze Age, and sporadic evidence of settlement during the Iron Age and Medieval periods. The principal archaeological components of the site, however, are an Early Neolithic flat settlement and a Copper Age tell, which were centred on different parts of an old river terrace (fig. 5).

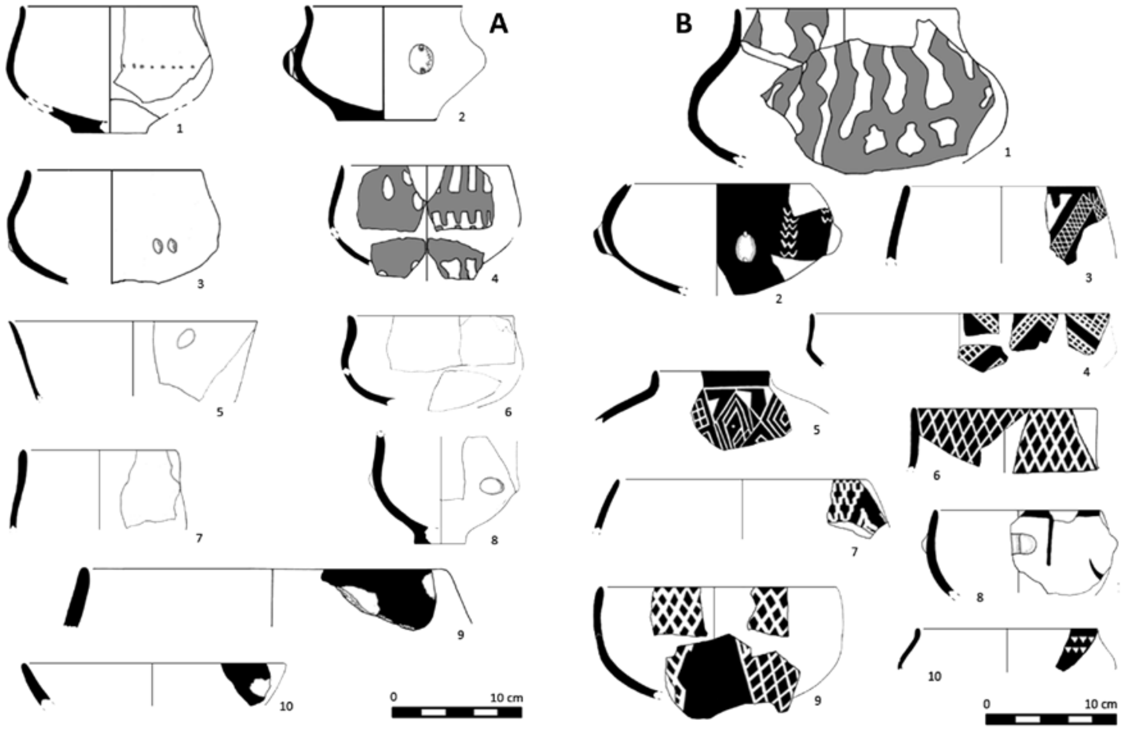

Fig. 6. Pottery from the site of Dzhulyunitsa: A – from phase Dzh-I (without decoration and with dark brown and black painting); B – from phase Dzh-II (decorated with white, dark brown and black painting) (drawings N. Elenski)

Обр. 6. Керамика от Джулюница: А – от фаза I (без рисунка, с тъмнокафява и черна рисунка); В – от фаза II (орнаментация с бяла, тъмнокафява и черна рисунка) (рисунки Н. Еленски)

Excavations between 2001-2011 (Еленски 2002; 2003; 2005; 2006; 2010; 2011; 2012; Krauß et al. 2014) identified four main phases of Early Neolithic occupation (Dzh I-IV) distinguished by means of stratigraphy and pottery typology (fig. 6). In phases I and II the settlement occupied an area of the terrace that was at least 4 ha (and possibly as much as 10 ha) in extent, decreasing in the final phase to ca 0.5 ha. Structural features belonging to the Early Neolithic include pits (some interpreted as pit houses), hearths and ovens. A number of human burials were also attributed to these early phases of the settlement.

Neither of the two obsidian artefacts from Dzhulyunitsa that were analyzed for this study was associated with a specific archaeological feature. One piece was recovered from the Dzh II horizon in test trench 21, in the 'core area' of the Early Neolithic settlement; the other came from the Dzh I horizon in test trench 3 located in a peripheral area of the settlement to the east of the Copper Age tell (fig. 5).

Krauß et al. (2014) reported 21 AMS ^{14}C dates on terrestrial animal bone and charcoal from the Early Neolithic at Dzhulyunitsa, all from test trench 21 in the 'core area' of the settlement. Eighteen dates for phases Dzh I-II suggest most activity was concentrated in the period between ca 6050–5900 cal BC. One date from phase I – OxA-24937: 7588±37 BP (6491–6396 cal BC) (Krauß et al. 2014, table 1) – on a bone from a wild pig, is a clear 'outlier' and should be treated with caution until supported by further dates on short-lived terrestrial samples. A new date of 7070±50 BP (Poz-81119) on the crouched inhumation burial of a child (grave 3) assigned to phase II (Mathieson et al. 2017) is similar to the dates reported by Krauß et al. (2014) for the Dzh II horizon.

Fig. 7. The site during the rescue excavations. In the background are the Rila Mountain footslopes, whence the debris flow originated (aerial photo I. Vajsov)

Обр. 7. Въздушна снимка на обекта по време на спасителните разкопки. В далечината – склоновете на Рила, откъдето са свличанията на земна маса (снимка И. Вайсов)

Fig. 8. Dzherman: find location of the single obsidian artefact (find no. 36) from the site (photo and annotation G. Ivanov)

Обр. 8. Джерман: местонамиране на обсодиановия артефакт (№ 36) (снимка и обозначение Г. Иванов)

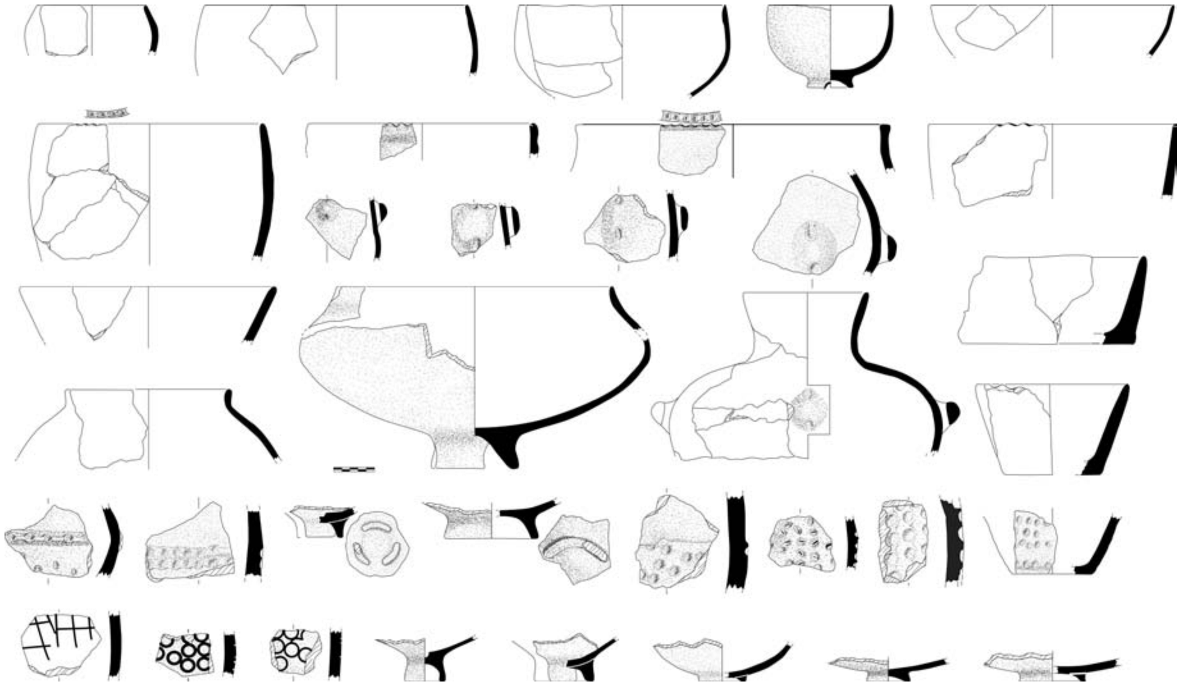

Fig. 9. Early Neolithic pottery from Dzherman (drawings I. Kulov)
Обр. 9. Раннонеолитната керамика от Джерман (рисунки И. Кулов)

Dzherman

This site on the northwestern edge of the Rila Mountains in southern Bulgaria occupies a structural terrace near the Dzherman River, a tributary of the Struma. Part of the site threatened by motorway construction was excavated in 2014-2015 (fig. 7), revealing evidence of occupation during the Early Neolithic and early Iron Age (Иванов и др. 2015, 2016)[3].

The remains of Early Neolithic occupation were buried under ancient stony debris flows. They consisted of concentrations of animal bones and artefacts (mainly pottery sherds, fragments of fired wall plaster, and stone tools), some of which infilled pit features dug into the virgin soil. The debris flows and later Iron Age occupation may have caused some translocation of Neolithic artefacts. The single obsidian artefact discussed in this paper was not part of a major artefact concentration, but was found at a level where the pottery sherds were exclusively of Early Neolithic type (fig. 8).

There are no radiocarbon dates from the Dzherman site. In terms of vessel form, surface treatment and decoration, the Early Neolithic pottery (fig. 9) is comparable to that from Gălăbnik (Pavúk, Čochadžiev 1984) and Krajnici (Tchochadjiev, Bakamska 1990), in the upper Struma Valley, southwest Bulgaria. Excluding potentially unreliable samples[4], radiocarbon dates for the earliest level (I.1) at Gălăbnik (Görsdorf, Boyadziev 1996; Thissen 2000) fall between ca 5900-5700 cal BC.

3 The excavation and scientific team consisted of Krastyu Chukalev, Veneta Genadieva, Małgorzata Grębska–Kulow, Martin Hristov, Maria Gurova, Angelina Pirovska.

4 Two ^{14}C dates for Gălăbnik phase I.1 are regarded as suspect – Bln-3579h: 7220±80 BP and Bln-3580: 7120±70 BP. Bln-3579h dates soil organics ('humic acids'), while Bln-3580 ('charcoal and sand') may also include soil organic matter. Such samples have been shown to produce unreliable results (cf. Boroneanţ, Bonsall 2016). The remaining dates for Gălăbnik I.1 range between 7030±70 and 6790±80 BP.

Site Registration No.	Period	Phase	Context	Type	Dimensions			Illustration (Fig. 14)
					L	B	Th	
Ohoden								
A3552/67	Early Neolithic	Ohoden II	Square G17,2; Structure 7/7a	Burin	2.1	1.0	0.30	A4
A 6911/86	Early Neolithic	Ohoden II	Square E18,2; Structure 12/12a	Endscraper	2.3	1.9	0.80	A6
A3522/20	Early Neolithic	Ohoden II	Square G17,2; Structure 7/7a	Flake	1.5	2.0	0.50	A3
A 3222/25	Early Neolithic	Ohoden II	Square L16,4; Structure 4	Combination tool	2.1	1.0	0.40	A5
A3757/95	Early Neolithic	Ohoden II	Square E18,2; Structure 10	Retouched flake	2.4	1.4	0.50	A2
A3753/87	Early Neolithic	Ohoden II	Square I21,3; Structure 8	Flake	3.6	2.1	0.60	A1
Dzhulyunitsa								
125/01	Early Neolithic	Dzh I	Trench 3	Flake	3.9	3.1	0.80	C1
660/09	Early Neolithic	Dzh II	Trench 21	Bladelet	2.1	1.0	0.30	C2
Dzherman								
36	Early Neolithic			Blade fragment	-2.0	1.4	0.30	B1
Varna								
I. 2717	Late Chalcolithic		Varna cemetery I, burial 41	Blade	-7.5	1.3	0.25	D1
I. 3472	Late Chalcolithic		Varna cemetery III	Blade fragment	-5.4	1.6	0.40	D2

Table 1. Details of the obsidian artefacts analyzed by pXRF.
Таблица 1. Информация за обсидиановите артефакти, анализирани с преносен рентгенов флуоресцентен сректрометър (pXRF)

Varna

Of the two obsidian artefacts from Varna described here, one comes from grave 41 in the famous Varna I cemetery on the western outskirts of the city, while the second is from a group of stray finds in the south part of the city where another Chalcolithic cemetery ('Varna III') is thought to exist (fig. 10).

The Varna I cemetery dates to the mid-5th millennium BC, corresponding to the Late Copper Age[5], and is the largest cemetery of that period from Southeast Europe. Archaeological excavations between 1972-1991 uncovered over 300 graves. The deceased were buried with heads pointing to the northeast – the men mainly in extended positions on their backs, and the women in crouched positions on the right side. A wide variety of burial goods were recovered from the graves, with some graves containing particularly 'rich' inventories numbering tens or hundreds of objects. Apart from ceramic vessels, which were found in all but 11 graves, the inventories are dominated by tools made of stone, bone and copper, and body ornaments of gold, minerals and marine shells. Over four-fifths of graves

5 AMS ^{14}C dates on human bone collagen (produced by three different laboratories: Mannheim, Oxford, and Poznan) are available for 8 burials from the Varna I cemetery (Higham et al. 2007; Krauß et al. 2016). From these data, Krauß et al. (2016, 282-286) suggested a time-range of 4650–4300 cal BC for the use of the Varna I cemetery.

Fig. 10. Locations of Varna cemeteries I and III
Обр. 10. Разположение на Варненските некрополи I и III

contained imported objects or objects made from imported materials – copper, gold, obsidian, and 'Dentalium'[6] (scaphopod) and *Spondylus* shell. Only five burials were unaccompanied by grave goods. (Slavchev 2010). Forty-seven graves in the Varna I cemetery contained 'burial goods' but no human remains, and were interpreted as cenotaphs – symbolic burials of members of the community who died elsewhere. Grave 41 – a roughly rectangular pit 2.70 m long, 1.20 m wide and 2.36-2.80 m deep – was a particularly 'rich' cenotaph (fig. 11). Within it were over a hundred gold objects, beads made of minerals (carnelian and serpentinite) and *Spondylus* shell, marble utensils, a flat bone figurine, an unusually large number (4573) of 'Dentalium' shells, and a single obsidian blade (fig. 12).

The 'Varna III' find comprised several objects made of copper (2 shaft-hole axes, a chisel, a flat axe and a spear-head), part of a long flint blade bearing traces of red ochre, and an obsidian blade (fig. 13; fig. 14.D1). They were discovered in 1997 during construction

6 In the archaeological literature, 'Dentalium' has tended to be used as a common name for all shells of scaphopod molluscs (tusk shells). However, not all (recent and sub-fossil) scaphopod shells from European archaeological sites necessarily belong to the genus, *Dentalium*. Many could belong to other genera of the Dentaliidae family, e.g. *Antalis*.

Fig. 11. Grave 41 (cenotaph) of Varna cemetery (photo I. Ivanov)
Обр. 11. Варненски некропол – гроб 41, кенотаф (снимка И. Иванов)

work in the south part of Varna, close to where a gold ring-amulet had been discovered fifty years earlier. A follow-up visit to the site by archaeologists failed to locate any traces of a burial pit or human remains, and no further artefacts were found. In number and character, the copper artefacts from Varna III resemble those from grave 43 of the Varna I cemetery, dated to ca 4500 cal BC[7].

Obsidian finds

Eleven obsidian artefacts from five sites were included in the present study (fig. 14). The six pieces from Ohoden-Valoga were examined macroscopically by Radka Zlateva-Uzunova. The artefacts from Dzhulyunitsa-Smardesh, Dzherman and Varna were examined by Maria Gurova – her analysis included microscopic observation of the pieces and microphotography of the artefact from Dzherman, undertaken using a Keyence VHX-100 digital microscope in the Conservation Laboratory of the National Archaeological Institute with Museum of the Bulgarian Academy of Sciences (NIAM-BAS). Basic information on the artefacts and their archaeological contexts is presented in Table 1. More detailed descriptions of the pieces are as follows:

Ohoden-Valoga

A 3222/25 Combination tool on a blade, comprising a break burin (on the distal end) and a proximal truncation (fig. 14.A5, fig. 15.2)

7 There are two published ^{14}C dates on the skeleton from grave 43 in the Varna I cemetery – 5720±29 BP [OxA-13685] and 5662±27 BP [MAMS-15095] (Krauß et al. 2016, table 2). The weighted mean of these two dates is: 5689±20 BP (4557-4458 cal BC).

A3552/67 Simple burin (fig. 14.A4; fig. 15.6)
A3522/20 Flake (fig. 14.A3; fig. 15.5)
A3757/95 Retouched flake (fig. 14.A2; fig. 15.1). Retouch is mainly ventral on the distal end.
A3753/87 Flake (fig. 14.A1; fig. 15.4).
A 6911/86 Endscraper on a flake (fig. 14.A6; fig. 15.3).

According to R.Z-U., A3522/20, A3753/87 show macro-traces of possible use, in the form of smoothing and rounding of the edges.

Dzhulyunitsa-Smardesh

125/01 Flake (atypical raclette) with a linear butt and two accidental scars on the distal transverse edge. No detectable use-wear traces (fig. 14.C1; fig. 16.2).
660/09 Bladelet with small plain butt and a curved profile, and with delicate breakage of the distal end. No detectable use-wear traces (fig. 14.C2; fig. 16.3).

Dzherman

36 Mesial fragment of a blade with sporadic scars on lateral edges and negatives of impact on the proximal part of the ventral surface (fig. 14.B1; fig. 16.1). Two chipping (negatives) on the right edge are not intentional retouch, but rather accidental or taphonomic damage. The left edge possesses micro retouch of utilization. Use-wear traces comprise matt lateral bands adjacent to the blade edges, fine striations, and microchipping. These micro-wear traces suggest cutting of relatively soft and not particularly abrasive material (i.e. plants, possibly cereals). Apart from wear traces related to the bilateral use of the blade, there are abundant chaotic striations and areas of smoothing on both the ventral and dorsal surfaces that probably resulted from secondary perturbation of the piece (fig. 17).

Varna

I. 2717 Blade in three fragments (found broken). Straight profile, triangular section, and narrow plain butt with no significant abrasion reduction. No retouch or traces of use (completely virgin edges apart from some slight taphonomic damage). Removal technique: skilfully applied pressure. Post-depositional/taphonomic damage: slight lateral chipping of the right edge, distal part (fig. 14.D1; fig. 16.4).
I. 3472 Proximal fragment of a blade in two parts (found broken), lighter in colour and more translucent than I. 2717, with numerous fine scars on the lateral edges, particularly on the proximal part of the right edge (partial, denticulate-like). No intentional retouch or traces of use. Narrow plain butt, straight profile, pressure technique (fig. 14.D2; fig. 16.5).

XRF analyses

Non-destructive XRF analysis of the archaeological obsidian was undertaken using a 'Niton XL3t ultra' handheld pXRF analyzer. The instrument was operated in the fundamental parameters 'mining mode' with the measurement window set to the 8-mm spot

Fig. 12. Varna cemetery: some grave-goods from Grave 41 (cenotaph): 1-3 – gold beads and appliqués; 4 – carnelian necklace; 5 – Spondylus necklace; 6, 8, 9 – bone artefacts; 7, 10 – marble objects (photo R. Kostadinova)

Обр. 12. Варненски некропол: някои гробни дарове от гроб 41 (кенотаф): 1-3 – златни мъниста и апликации; 4 – наниз от карнеол; 5 – наниз от Spondylus; 6, 8, 9 – костни артефакти; 7, 10 – мраморни предмети (снимки Р. Костадинова)

Fig. 13. Finds from the destroyed grave of the Varna III cemetery (photo K. Dimitrov)
Обр. 13. Находки от разрушения гроб на Варненския некропол III (снимка К. Димитров)

size. Each sample was analyzed for a total of 180 seconds – 60s using each of the 'Main', 'High' and 'Low' range filters that optimize the analyzer's sensitivity for various elements. Elemental concentrations were recorded for 35 minor and trace elements between potassium (K) and uranium (U) in the periodic table. The 'light range' filter was not selected, and so no measurements were recorded for elements 'lighter' than potassium (e.g. Mg, Al, Si, P, S or Cl).

Using the same instrument and settings, measurements were also taken on petrological samples from known source locations in the Carpathians, Aegean, central Anatolia and the Central Mediterranean, collected by the senior author (C.B.) or available in the reference collections of the Vienna-Lithotek (VLI) managed by Gerhard Trnka and the Lithoteca of the Hungarian National Museum in Budapest (Biró 2014).

To improve accuracy, the measurements obtained with the factory-set 'mining' calibration for both the archaeological and petrological samples were *recalibrated* (using linear regression analysis) against instrumental data for 23 pressed powder standard reference materials (SRMs).

Results and discussion

Regression analysis showed that the Niton XL3t ultra operated in 'mining mode' achieves high accuracy ($R^2 > 0.99$) for 10 elements that are particularly important in obsidian provenancing research: Ti, Fe, Zn, Rb, Sr, Zr, Nb, Pb, Th and U (see Bonsall et al. 2017:

Site	Dzhulyunitsa-Smardesh		Ohoden-Valoga						Dzherman	Varna	
Artefact No.	125/01	660/09	A3552/67	A6911/86	A3222/25	A3522/20	A3753/87	3757/95	36	I 3472	I 2717
Source	C2E	C2E	C2E	C2E	C1	C1	C1	C1	C1	C1	C1
Element											
Ti (ppm)	1150	1198	1213	1212	496	532	564	471	537	522	503
Fe (ppm)	12909	13235	12866	12442	6889	6875	7450	5905	7415	7610	7492
Zn (ppm)	36	32	52	40	27	30	29	23	22	25	22
Rb (ppm)	211	216	223	210	200	187	190	190	206	201	218
Sr (ppm)	84	86	89	85	72	63	71	51	66	73	63
Zr (ppm)	167	177	199	170	76	70	66	58	70	76	68
Nb (ppm)	11	12	11	10	10	6	7	7	9	9	11
Pb (ppm)	26	24	30	28	38	33	34	32	32	34	36
U (ppm)	3	5	8	12	-	16	9	7	5	5	6

Table 2. Elemental concentrations in parts per million (ppm) measured in obsidian artefacts from Bulgaria by pXRF. Source assignments: C1 – Cejkov-Viničky (Slovakia); C2E – Mád-Erdőbénye (Hungary)

Таблица 2. Концентрация на подбрани елементи (в части на милион) в обсидиановите артефакти от България, измерени с pXRF. Източници: C1 - Cejkov-Viničky (Словакия); C2E - Mád-Erdőbénye (Унгария).

fig. 3). Concentrations of nine of these elements measured in obsidian artefacts from Bulgaria are presented in Table 2. Results for thorium (Th) have been excluded from the table, since the instrument is not particularly sensitive to this element at low concentrations when operated in 'mining mode'.

The Bulgarian sites are between 600 and 1250 km straight-line distance from the known obsidian sources in the Carpathians, Central Mediterranean, Aegean and Central Anatolia, but roughly equidistant from the Carpathian and Aegean sources. Comparison of archaeological with source samples revealed the closest matches to be with the Carpathian sources. Three main obsidian source areas have been identified in the Carpathians: C1 in the Zemplín Hills of eastern Slovakia; C2 in the Tokaj Mountains of northeast Hungary; and C3 in the Transcarpathian region of southwest Ukraine (Biró 2006; 2014; Rosania et al. 2008). Within the C2 source area, two variants have been identified: C2E (from the vicinity of Mád and Erdőbénye) and C2T (from the vicinity of Tolcsva). The C1 source in Slovakia has also been divided into two subgroups, C1a known mainly from Late Palaeolithic and Neolithic 'workshop' sites (so-called 'quasi-sources') in the Kašov and Cejkov vicinity, and C1b from the Viničky-Malá Bara area.

Fig. 18 plots the Rb, Sr and Zr values for the archaeological samples against the ranges obtained for geological samples from the various Carpathian sources (C1, C2E, C2T, C3). No attempt has been made to distinguish between C1a and C1b, since they are difficult to separate using XRF and, in any case, the original sources have not been identified. Since

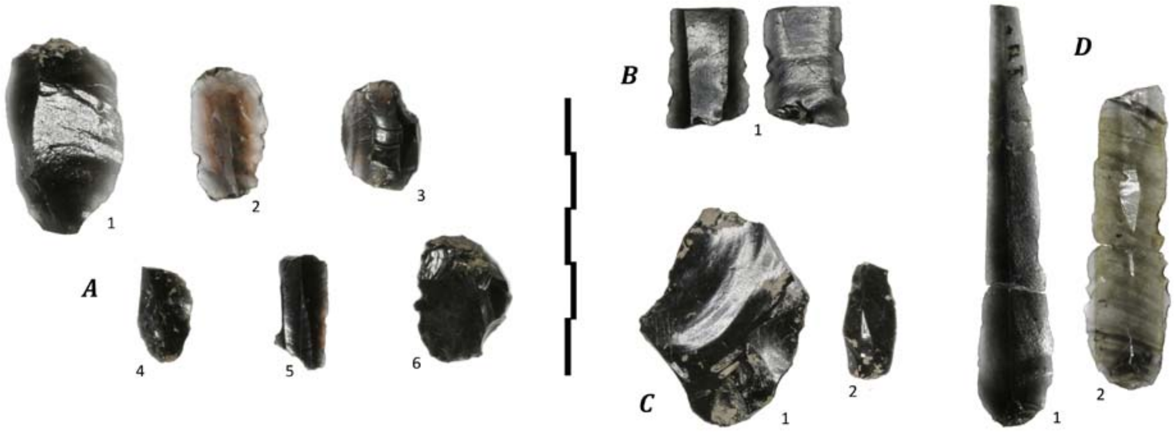

Fig. 14. Obsidian finds from: A – Ohoden: 1 – no. 3753, 2 – no. 3757, 3 – no. 3522, 4 – no.3552, 5 – no. 3222, 6 – no.3911; B – Dzherman: 1 – no. 36; C – Dzhulyunitsa: 1 – no. 125/01; 2 – no. 660/09; D: 1 – Varna I cemetery – no. I. 2717; 2. – Varna III cemetery – no. I. 3472 (photos C. Bonsall, figure by M. Gurova)

Обр. 14. Обсидианови артефакти от следните обекти: A – Оходен: 1 – № 3753, 2 – № 3757, 3 – № 3522, 4 – № 3552, 5 – № 3222, 6 – № 3911; B – Джерман: 1 – № 36; C – Джулюница: 1 – № 125/01; 2 – № 660/09; D: 1 – некропол Варна I – № I. 2717; 2. – некропол Варна III – №. I. 3472 (снимки К. Бонсал, колаж М. Гюрова)

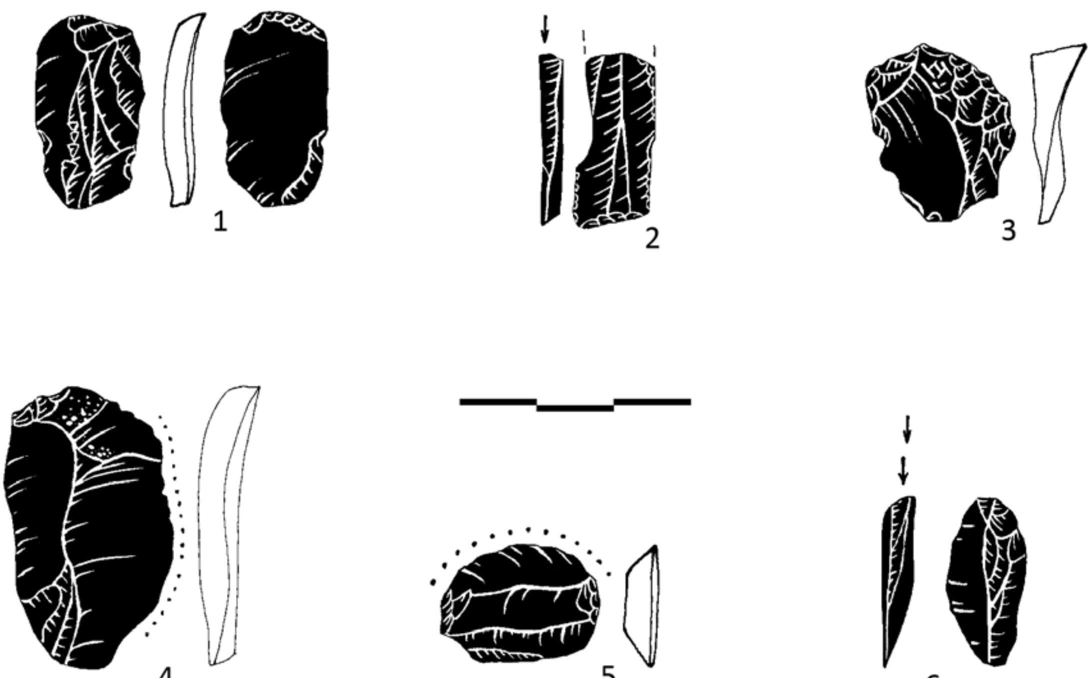

Fig. 15. Drawings of the obsidian artefacts from Ohoden: 1 – no. 3757; 2 – no. 3222; 3 – no. 3911; 4 – no. 3753; 5 – no. 3522; 6 – no.3552 (drawings R. Zlateva-Uzunova)

Обр. 15. Рисунки на обсидиановите артефакти от Оходен: 1 – № 3757; 2 – № 3222; 3 – № 3911; 4 – № 3753; 5 – № 3522; 6 – № 3552 (рисунки Р. Златева-Узунова)

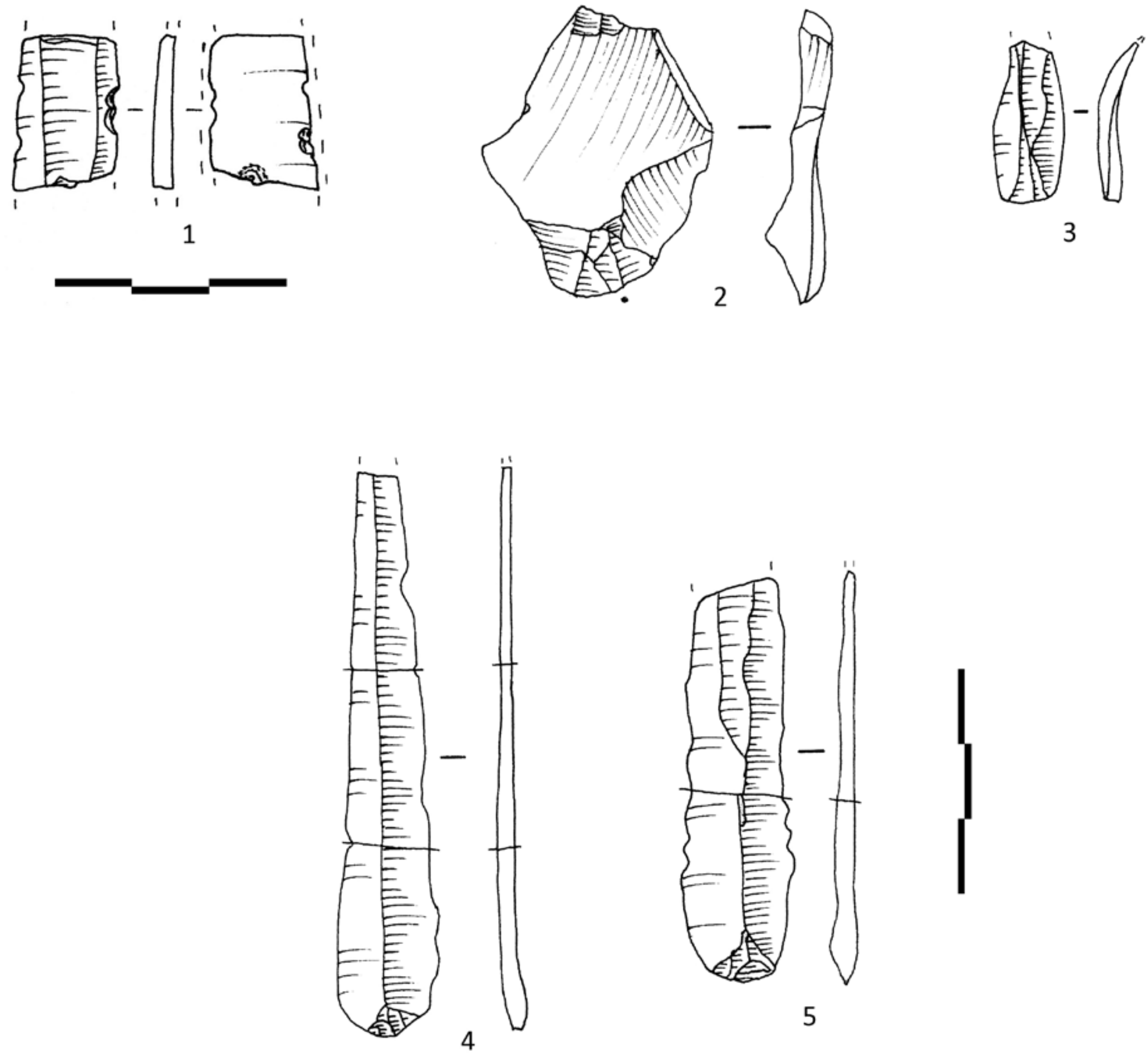

Fig. 16. Drawings of the obsidian artefacts from: 1. Dzherman – no. 36;
2. Dzhlyunitsa – no. 125/01; 3. Dzhulyunitsa – no. 660/09;
4. Varna I cemetery – no. I. 2717; 5. Varna III cemetery – no. I. 3472 (drawings M. Gurova)
Обр. 16. Рисунки на обсидиановите артефакти от: 1. Джерман – № 36;
2. Джулюница – № 125/01; 3. Джулюница – № 660/09; 4. Некропол Варна I – № I. 2717;
5. Некропол Варна III – № I. 3472 (рисунки М. Гюрова)

there have been occasional claims for the presence of obsidian from the Aegean on Neolithic sites in the central and northern Balkans (e.g. Vlassa 1965; Maxim 1995; Constantinescu et al. 2014), we also indicate in fig. 18 the Rb-Sr-Zr footprint of obsidians from Melos. The data are presented as ternary graphs (in which the three variables are normalized to sum to 100%) since this has the effect of 'reducing' measurement distortions that can result from archaeological samples being too thin, and/or not covering the entire measurement window of the instrument, and/or having irregular surface geometry[8].

8 Sample thickness, diameter and surface geometry are critical variables in XRF analysis. Among the 11 artefacts analyzed in this study, several were only just large enough to cover the measurement window of the pXRF analyzer, and these were less than 3.5 mm in maximum thickness becoming much thinner toward their edges. Moreover, two pieces (Fig. 14.A2, D2) had adhesive labels/tape on their ventral surfaces, so that XRF measurements had to be taken on the more irregular dorsal surfaces. Therefore, some distortion of element concentrations might be expected for these pieces.

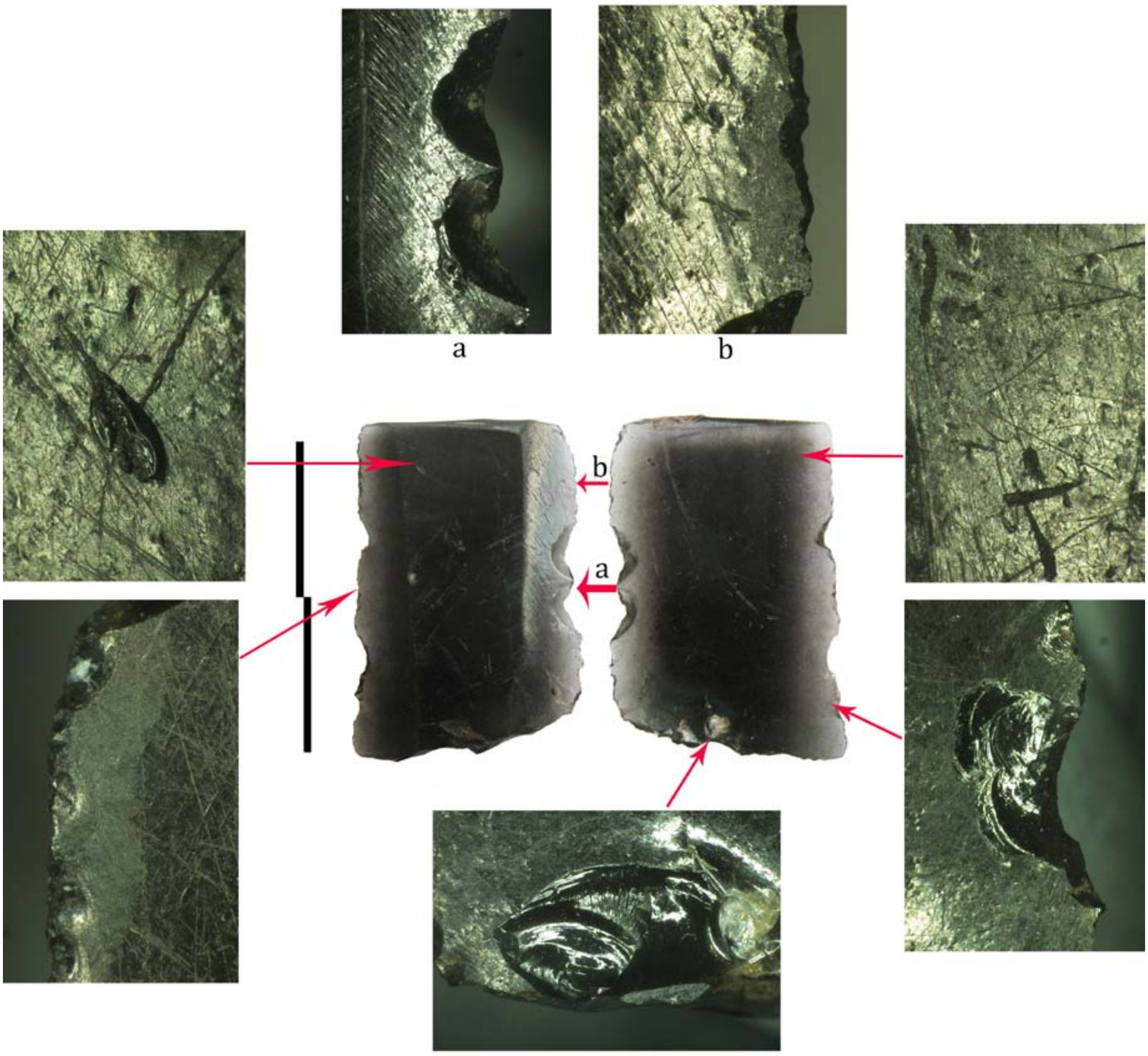

Fig. 17. Obsidian blade from Dzherman with microphotographs (x20 to x80) of the used edges and significant wear of the surfaces (photos M. Gurova)
Обр. 17. Обсидианова пластина от Джерман с микрофотографии (x20 до x80) на използваните ръбове и на характерни следи по повърхностите на артефакта (снимки М. Гюрова)

All of the archaeological samples from this study gave values for Rb-Sr-Zr that correspond closely with those obtained for petrological samples from sources in the Carpathians. C1 obsidian, from the Cejkov-Viničky area of eastern Slovakia, occurs at three of the five Bulgarian sites – Dzherman, Ohoden and Varna cemeteries; while obsidian from the C2E (Mád–Erdőbénye) source area in northeast Hungary was found at Dzhulyunitsa and also at Ohoden. Those contexts with C2E obsidian are all Early Neolithic in date but potentially belong to a relatively early phase of this period. At Dzhulyunitsa, C2E obsidian is restricted to phases Dzh I-II dated between ca 6050-5900 cal BC. At Ohoden, where the chronology is less secure, C2E obsidian appears to have been used during a later phase of the Early Neolithic, after 5900 cal BC, when C1 obsidian was also in use.

C1 obsidian is generally regarded as of superior quality to C2 obsidian (Tripković 2004; Biró 2006), and tends to dominate obsidian assemblages from later Neolithic and

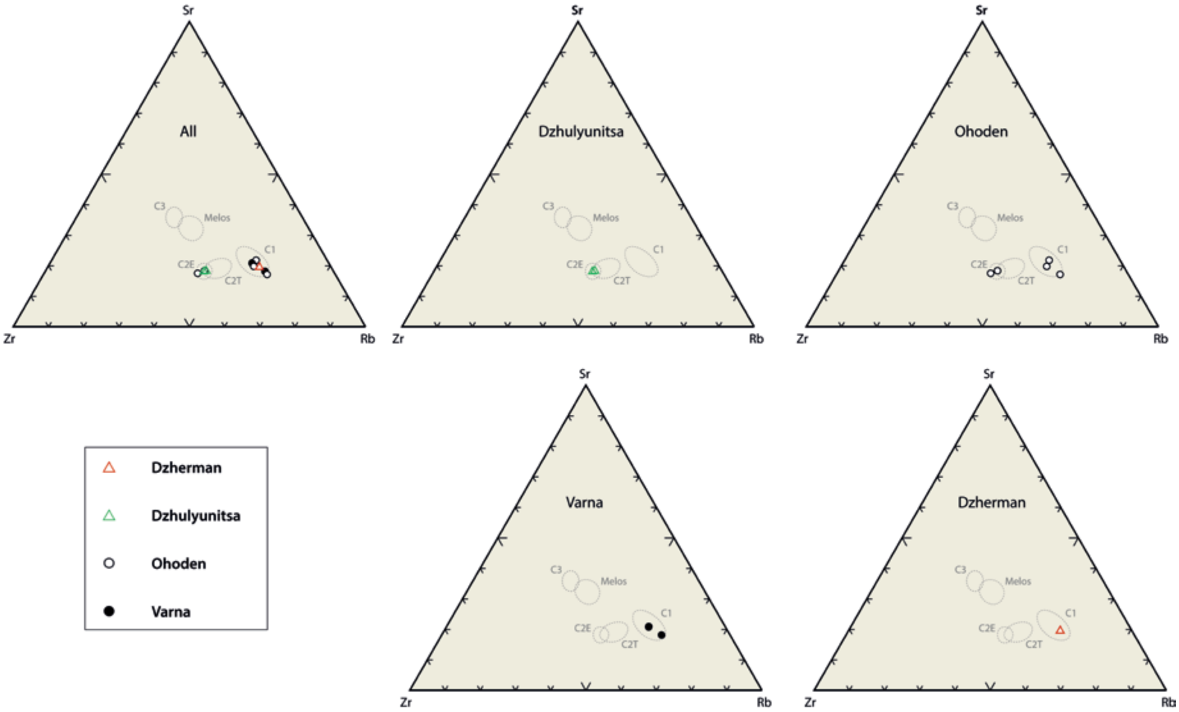

Fig. 18. Ternary plots of Rb, Sr and Zr ppm values for archaeological samples in this study. Grey ellipses represent the corresponding ranges of geological source materials from the Carpathians (C1, C2E, C2T, C3) and Melos

Обр. 18. Триизмерна графика на стойностите на Rb, Sr и Zr (в части на милион) в изследваните образци. Сивите елипси представляват съответните диапазони на суровини от Карпатите (C1, C2E, C2T, C3) и Мелос

Chalcolithic sites in the circum-Carpathian region (e.g. Tripković, Milić 2009; Dobrescu et al. 2016), which are often characterized by a high blade index (cf. Allard et al., this volume; Burgert et al., this volume). At Dzherman and Varna in Bulgaria the use of C1 obsidian was evidently linked to the production of blades; however, at Ohoden only one piece made from C1 obsidian was clearly removed from a blade core.

Conclusions

The research reported in this paper represents the first systematic obsidian provenancing study from Bulgaria. Measurements made on 11 artefacts from three Early Neolithic sites and two Late Chalcolithic sites show that all of the obsidian originated in the Carpathians, specifically from the C1 source area in Slovakia and the C2E source area in Hungary. In the Bulgarian sites C2E obsidian occurs in Early Neolithic contexts that are thought to be older than ca 5900 cal BC, while at least 6 of the 7 artefacts made from C1 obsidian come from later (Early Neolithic and Chalcolithic) contexts. However, given the very small sample of sites and artefacts, it may be premature to conclude that this reflects a general temporal trend in obsidian procurement patterns in the region? More finds from more sites, together with better contextual and chronological information, will be needed to satisfactorily address this issue.

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Установяване произхода на обсидиана от праисторически обекти в България

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(резюме)

Статията предлага резултатите от първото систематично химическо изследване на археологически обсидианови артефакти от България и представлява част от помащабно проучване на археологически обсидиан от Югоизточна Европа, включващо учени от България, Румъния и Великобритания. Целта на това надрегионално проучване е да се реконструират промените в системата на добиване, обработка и употреба на обсидиан в периода между средния палеолит и желязната епоха. Статията надгражда информацията, публикувана като кратко обобщаващо изложение в списание *Antiquity* (Bonsall et al. 2017).

Артефакти от обсидиан се срещат много рядко в археологически контекст в България. В статията са анализирани и представени 11 артефакта, произхождащи от пет праисторически обекта: Оходен, Джулюница и два от Варненските некрополи – I и III (в Северна България), и Джерман – в подножието на Рила, в Южна България. Хронологическият им обхват е от ранен неолит до късен халколит (около 6050–4300 cal BC), а пространствено са разположени на около 600-800 км от най-близките геологически находища на обсидиан в Егейския басейн, Карпатите и Централна Анатолия (обр. 1).

Преносим рентгенов флуоросцентен спектрометър (pXRF) е използван за идентифициране на източниците (геологическите местонаходища) на артефактите от представените археологически обекти. Статията съдържа кратко обобщаващо изложение на обектите и на археологическия контекст на обсидиановите находки (обр. 2-13), описание с фото- и графична документация на артефактите (обр. 14-17, таблица 1), както и резултатите от XRF анализите, представени в таблица 2.

Сред изследваните археологически образци са идентифицирани две разновидности на обсидиан. Сравнението с измервания на геологически образци от карпатски, егейски, централно средиземноморски и анатолийски обсидианови находища показва, че по своя химически профил, обсидиановите артефакти от България са най-близки до находищата в Карпатските планини (cf. Biró 2006; Rosania *et al*. 2008). Първата разновидност съвпада с образци от карпатското находище 1 (C1) в Словакия, докато втората произхожда най-вероятно от находищата, обозначавани като карпатски 2E (C2E), които са на територията на Унгария (обр. 18).

На базата на много ограничените хронологически данни, с които разполагаме, първата документирана употреба на обсидиан C2E е по-ранна от 5900 cal BC, докато артефактите, направени от обсидиан C1 произхождат от по-късни контексти. За да се установи дали ползването на различни карпатски находища на обсидиан отразява стабилни темпорални тенденции и характеристики в регионалната система за добиване и разпространение на тази суровина е необходимо системно проучване на повече находки от повече обекти, както и по-солидна контекстуална и хронологическа информация.