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The Upper Palaeolithic at Trenčianske Bohuslavice, Western Carpathians, Slovakia

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ABSTRACT
Trenčianske Bohuslavice Gravettian site has been known since the early 1980s, with possibly the longest sequence of Upper Palaeolithic human occupation in the region, including a peculiar assemblage of lithic tools composed of bifacial leaf points. This paper presents the results of the 2017 excavation season that produced new data on the absolute chronology, stratigraphy, paleobotany, archaeology, and archaeozoology of the site. We found that the earliest occupation most probably belongs to the Aurignacian. This is followed by two Late Gravettian layers and the layer that yielded the bifacial leaf points. An Early Epigravettian layer dated to 26 kya seals the sequence. The succession of biological remains and geological evidence enabled the reconstruction of a cooling climate and disappearing boreal forest, which corresponded well with the development of the Last Glacial Maximum.

KEYWORDS
Late Gravettian; Epigravettian; Last Glacial Maximum; lithic armature; bifacial leaf point

Introduction

Long Upper Palaeolithic (UP) archaeological sequences are rare for the Weichselian glacial period in eastern central Europe (ECE). The longest sequence of UP human occupation is from Willendorf II, Lower Austria, which consists of Early Aurignacian, Early Gravettian, Pavlovian, and Late Gravettian occupations between 43.5 and 27 kya (Otte 1981; Haesaerts et al. 1996; Moreau 2009; Nigst 2012; Nigst et al. 2014). In southern Moravia, the Dolní Věstonice brickyard also provides a long Weichselian stratigraphic sequence, but the number of multi-layered archaeological sites in the Pavlov Hills is small. The Pavlovian layers are sometimes underlain by uncharacteristic UP lithic assemblages contemporaneous with the Early Gravettian of Willendorf II, dated to 34 kya (Novák 2016; Svoboda 2016), without any traces of the Early Upper Palaeolithic (EUP) Aurignacian, and the human occupations at the Pavlovian sites halted before the Late Upper Palaeolithic (LUP) Epigravettian of the Last Glacial Maximum (LGM) (Klíma 1963, 1990; Svoboda 1997, 2005, 2007, 2016; Oliva 2009, 2016). Indeed, it is exceptional when a LUP layer seals a Middle Upper Palaeolithic (MUP) series of human occupation in ECE, and when it does so, then the EUP layer is missing, such as the case with the Gravettian–Epigravettian succession at Pilisszántó I rockshelter in Hungary (Dobosi and Vörös 1987; Lengyel 2016) or at Kašov I in eastern Slovakia (Novák 2004; Kaminská 2014). According to the available archaeological record (Bárta 1988; Vlačiky et al. 2013), the only site in ECE which may have contained occupations from each UP subperiod was found at the village Trenčianske Bohuslavice (hereafter abbreviated as TrB) in western Slovakia.

Several excavation seasons were carried out at TrB in the 1980s (Bárta 1988), and a test pit was made in 2008 to retrieve controlled samples to clarify the stratigraphy of the site (Vlačiky et al. 2013). The archaeological sequences recovered in the 1980s, which retrieved the majority of the finds known from the site, remained unclear due to the lack of published details necessary to understand the relation between assemblages excavated in different areas of the site. All human occupations were dated to the Gravettian period, including a bifacial leaf point (BLP) tool assemblage, which eventually resulted in a major inconsistency in the archaeological record of ECE, because BLPs had primarily been associated with the Szeletian culture prior to the discovery of the TrB site (Mester 2018). The Gravettian and the BLP assemblages were found 75 m apart from each other, and no stratigraphic correlation was made between the two areas, although the radiocarbon dates suggested contemporaneity between the two types of lithic industries. In spite of the ambiguous correlation, the TrB and other archaeological records suggested that BLPs are an integral part of the Gravettian technology (Simán 1990; Lengyel, Mester, and Szolyák 2016; Lengyel and Wilczyński 2018).

The fieldwork in 2008 was too limited to clarify the stratigraphic correlations between the excavation areas located 75 m apart; however, it achieved important results concerning archaeological, faunal, and botanical remains. The most interesting result was the discovery of an archaeological layer on the top of the Gravettian sequence (Vlačiky et al. 2013), which highlighted the possibility of finding an UP sequence at TrB almost as long as that at Willendorf II. This stratigraphy has the potential to illuminate cultural changes of hunter-gatherers in relation to the dynamic climate and environment of the last glacial period. In this paper, therefore, we present new data that clarifies the number of human occupations and the relevant archaeological cultures recovered at TrB, which contribute to our knowledge

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about the Upper Pleniglacial human occupation of eastern central Europe.

Trenčianske Bohuslavice Site

Location

Trenčianske Bohuslavice is a village situated in western Slovakia, in the Slovak-Moravian Carpathians, a part of the Outer Western Carpathians (Figure 1A–B). It is 14 km southwest of Trenčín, in the valley of the Bošáčka Stream, which is a western tributary of the Váh, the main river of this region. The opening of the Bošáčka valley from the Váh valley is narrow. The archaeological area is located outside of the center of the village and is called Pod Tureckom (Figure 1). Pod Tureckom was the local brickyard of the village until the late 1970s. Earthmoving at the brickyard uncovered mammoth remains in the early 20th century, and artifacts have been found since World War II (Bárta 1967, 1988). The archaeological site is found on the northern lower slopes of Turecký Vrch (Turkish Hill) (346 masl), directly behind the narrow pass of Bošáčka. The elevation of the site is 207.5–211 masl, 10–15 m above the bottom of the Bošáčka Stream bed.

Previous research

The first set of excavations at the site were carried out between 1981 and 1986 (Bárta 1988). J. Bárta opened three areas to excavate, A, B, and C (Figure 2). Area A contained two sets of trenches placed 25 m apart from each other. In the first location of this area (A1), a large part of the sediment covering the archaeological layer was removed by bulldozer. In 1981, about 75 m westwards from area A, a 7 m deep section was exposed in a deep gully running west–east, exposing the stratigraphy of the Pod Tureckom area. Area B was opened up from the stratigraphic section of the gully wall in 1982, oriented to the north. In 1983, a second set of trenches was excavated in A (area A2) west of the bulldozed area A1 (Bárta 1986). The third location, area C, was tested about 50 m north of area A, but after yielding only a few archaeological finds, the excavation was not continued. Altogether, Bárta found four archaeological levels in the site's different excavation areas.

The uppermost archaeological level found in the 1980s, 70–90 cm under the surface in area A2, was classified as Gravettian. Animal bones, such as those from reindeer and horses, marked this layer in the stratum, and lithic artifacts were fewer than in other layers, but this layer contained a stone-paved hearth (Bárta 1988, fig. 9). Bárta marked this stratigraphic unit layer III (Figure 3A). The main Gravettian occupation (layer II) lay beneath layer III. According to Bárta (1988), these two layers were embedded within a calcareous loess formed during the Würm 3 stadial. Layer II yielded an abundant collection of knapped lithic artifacts. The third and lowermost archaeological layer (layer I) was below layer II. This layer was associated with the Würm 2–3 interstadial soil. Compared to layer II, layer I yielded fewer lithic artifacts, and animal bones were almost absent.

In area B, the human occupation was found 260–290 cm under the surface in a single layer. Area B was excavated through two trenches: 1B/82 in 1982 and 2B/83 in 1983 (Figure 2). The findings included lithic artifacts, animal bones, pierced quartzite pebbles, and hearths. The hearths in area B had been disturbed by solifluction (Figure 3B). The area B lithic tools' compositions differed from the compositions of areas A1 and A2 by containing bifacial leaf points (BLPs). However, no correlation was made between the layers of areas A1, A2, and B.

In 2008, Vlačiky and colleagues (2013) reopened 2 m^2 in area A2 to collect samples for stable isotope analysis ($^{87}Sr/^{86}Sr$, $^{13}C/^{12}C$, and $^{15}N/^{14}N$) of the paleontological remains and also to collect samples for radiocarbon dating

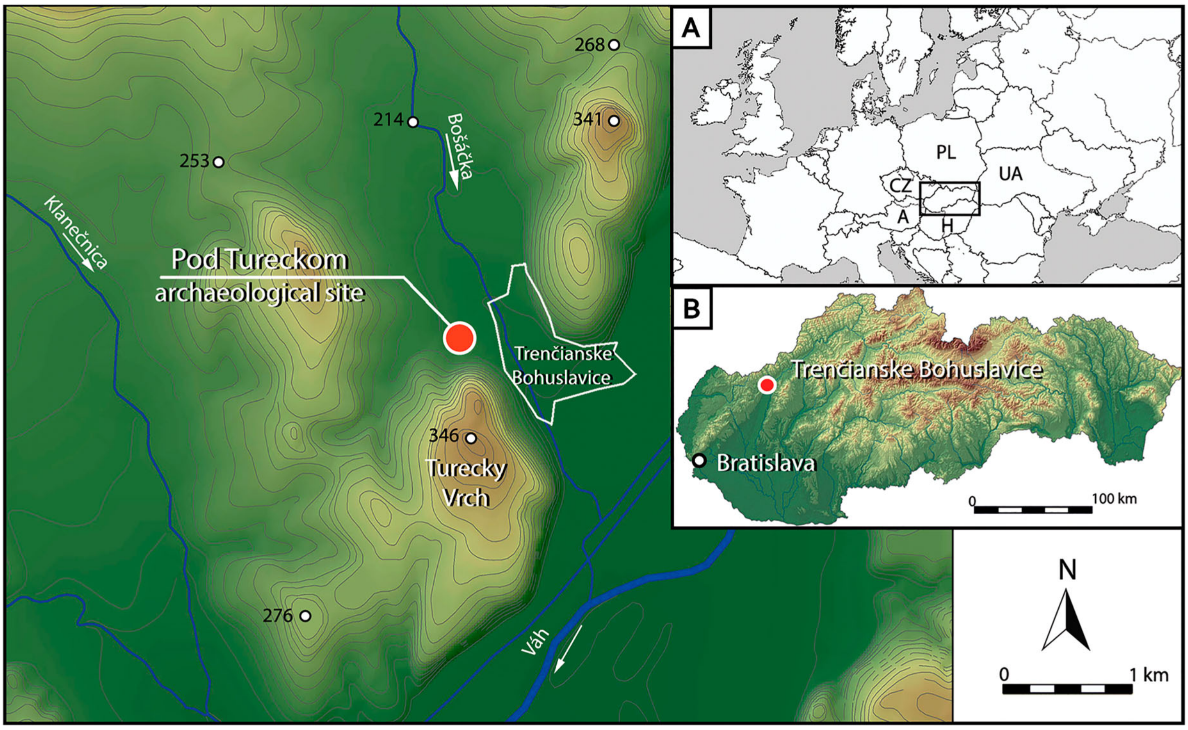

Figure 1. Location of the archaeological site (Pod Tureckom) at Trenčianske Bohuslavice on a hypsometric map: A) Location of Slovakia (framed) in central Europe; marked are the countries bordering Slovakia; B) Enlarged area of Slovakia.

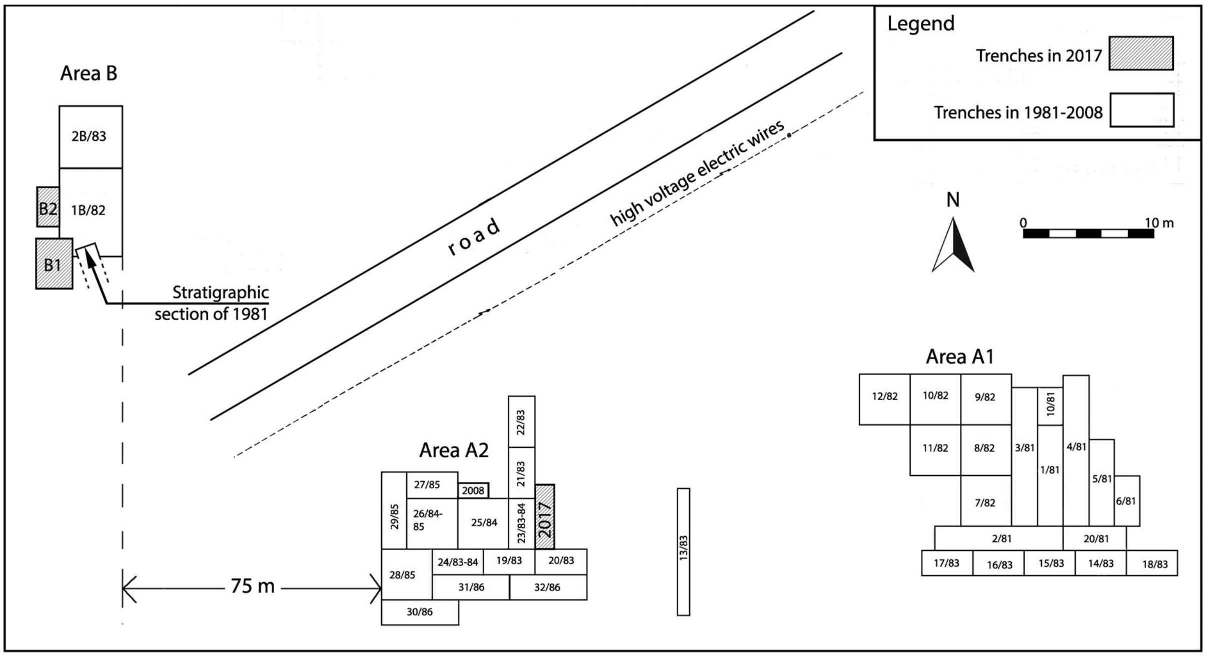

Figure 2. Excavation trenches at Trenčianske Bohuslavice.

and for sedimentological, malacozoological, palynological, and lithic studies. Vlačiky and colleagues (2013) found three archaeological layers in area A2 (Figure 3C). The uppermost layer (layer I) was between 25 and 35 cm below the recent surface, the second (layer II) between 55 and 65 cm, and the third (layer III) between 85 and 110 cm. The uppermost layer cannot be correlated with any layers in Bárta's stratigraphy. The second layer was equal to Bárta's layer III, due to the similar depth in area A2, the presence of animal bones, and the scarcity of lithics. The lowermost layer can be identified as Bárta's layer II, which yielded the greatest number of lithic artifacts.

Radiocarbon dating results from previous research

Radiocarbon dates were obtained from both former excavations (Table 1). Dates of the 1980s were obtained at the Gliwice Radiocarbon Laboratory, Poland, with the decay counting method. The first date that Bárta (1988) mentions in the publication of the site is 22,000 ± 600 B.P. (Ge-4009) from the archaeological layer of area B, which was obtained from charcoals of the distorted hearths (Figure 3B). The laboratory code "Ge" was given in error for Gliwice laboratory, correctly identified by Gd. A slightly different date with the same laboratory number is also given in the same paper, 22,500 ± 600 B.P., but this time with the correct laboratory code (Gd-4009). Bárta assigned this date to a stone structured hearth in area A2, trench 29/85, found in layer III of Bárta's division. However, the date Gd-4009 was obtained from a sample taken off the combustion features of area B (Figure 3B), according to the original submission sheets stored in the archives of the Gliwice Radiocarbon Laboratory. A few pages later in the same publication (Bárta 1988, 181), the date Gd-4009 was correctly assigned to the BLP assemblage in area B.

The next date mentioned by Bárta (1988) is 20,300 ± 500 B.P. (Gd-4011), obtained from trench 26–27/84–85 (area A2) on charcoals of a hearth situated 70 cm under the surface of Bárta's layer III (Figure 3A). The charcoals of this hearth were identified as *Picea abies* and other *Pinopsida* species (Bárta 1988).

Bárta's layer II was dated to 23,000 ± 1300 B.P. (Gd-4010) in trench 23/83 of area A2 via charcoals from a hearth. The charcoals were also of *Picea abies* and other *Pinopsida* species. No dates were eventually obtained for the lowest layer (layer I) embedded in the interstadial soil.

Verpoorte (2002) also obtained dates on charcoal collected by Bárta in the 1980s. A total of five dates were published (Table 1), along with a hitherto unmentioned date without trench number and depth data: 23,700 ± 500 B.P. (Gd-2490). According to the Gliwice Radiocarbon Laboratory Archives, the sample of this date derived from trench 28/85 in area A2, 1.80 m below the surface. One of the dates was significantly older than the others: 29,910 ± 260 B.P. (GrA-16139). This date was assigned to trench IB/18 and obtained from a sample taken at 1.20 m under the modern surface. Such a trench number, however, did not exist, and there was no archaeological layer mentioned from this elevation in area B. This date, however, could be associated with area 1B and the digits "18" marking the year could have been inadvertently transposed instead of "81", the year when the stratigraphic section in the gully wall was made in 1981.

Vlačiky and colleagues (2013) published the third set of dates from area A2. The uppermost layer was dated to 22,330 ± 110 B.P. (GrA-42311), the second layer that equals Bárta's layer III was dated to 23,210 ± 130 B.P. (GrA-44244), and the lowermost layer that corresponds to Bárta's layer II was dated to 24,540 ± 130 B.P. (GrA-42312). Vlačiky and colleagues (2013) published two further dates yet unmentioned, making a reference to Žaár's (2007) unpublished dissertation, which were obtained from area B at a depth of 1.80 m (22,800 ± 600 B.P. [Gd-4016]) and from area A2, trench 29/85, a hearth at a depth of 0.90 m (23,400 ± 700 B.P. [Gd-4014]) (Figure 3A).

Materials and Methods

Field methods

Two areas of the site were excavated in 2017: A2 and B. In area A2, we opened a trench of 10 m^2 in the unexcavated corner of

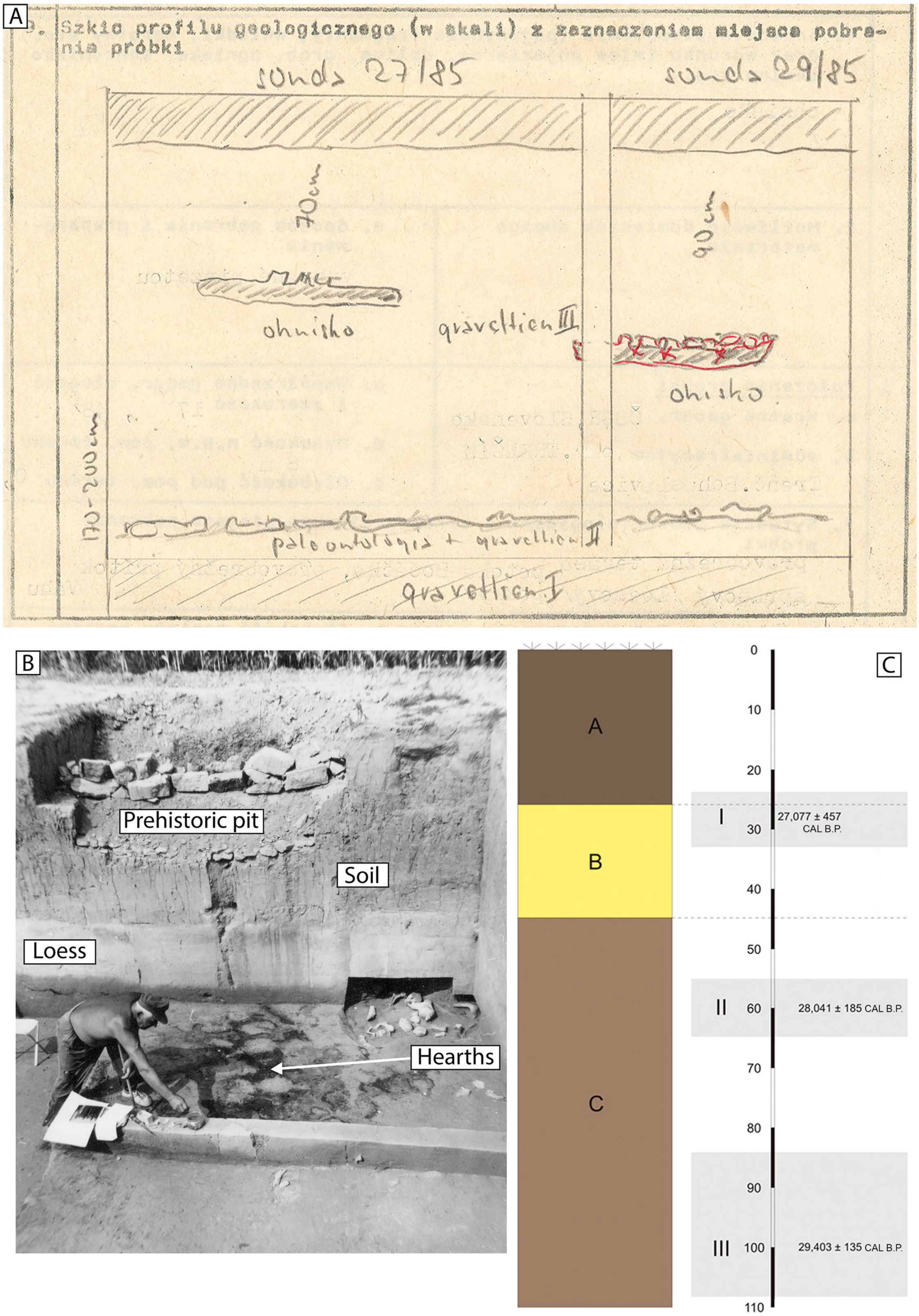

Figure 3. Previous stratigraphic sections at Trenčianske Bohuslavice: A) Sketch of archaeological layers in area A2. Marked are the hearths in the uppermost archaeological layer of the excavations in 1980 (archives of the Institute of Archaeology, SAS); B) Hearths of area 1B/82 in the stratigraphy (modified after Bárta 1988, fig. 6); C) The stratigraphy of the trench in 2008. Roman numerals mark the archaeological layers and capital letters are the geological units (modified after Vlačiky et al. 2013, fig. 4).

Bárta's trenches from 1983 (Figure 2). In area B, 18 m^2 were exposed on the western edge of Bárta's trench 1B/82 (Figure 2), and our trench B2 recovered the area under the prehistoric pit found by J. Bárta (Figure 3B). Recovery methods included hand-collection and wet-sieving using a mesh size of 1 mm. The positions of archaeological finds and animal remains were recorded by total station (Geomax Zoom 30Pro2).

Geology

Descriptions of archaeological exposures were made on the basis of geological and paleopedological criteria. The subjects of the analysis were sediment-soil sequences available for direct studies in key sections. Their basic units were geological layers (loess) separated by soil and/or archaeological horizons. In

Table 1. Radiocarbon dates of the site.

Lab Code	Layer	Date	Std	Trench	CAL B.P. 95.4%	Sample	Origin	Reference
GrA-42311	A2–1	22330	110	2008/B1	27,025–26,230	Charcoal	Arch. Layer	Vlačiky et al. 2013
Poz-97252	A2–1	22370	150	2017/A2	27,110–26,220	Charcoal	Hearth	This paper
Gd-4011	A2–2	20300	500	27/85	25,695–23,367	Charcoal	Hearth	Bárta 1988
GrA-16126	A2–2	23100	150	27/85	27,662–27,126	Charcoal	Arch. Layer	Verpoorte 2002
GrA-44244	A2–2	23210	100	2008/B3	27,684–27,283	Charcoal	Arch. Layer	Vlačiky et al. 2013
Gd-4014	A2–2	23400	700	29/85	29,036–26,191	Charcoal	Hearth	Bárta 1988
Gd-2490	A2–2	23700	500	28/85	28,894–27,055	Charcoal	Arch. Layer	Bárta 1988
Poz-101182	A2–2	23850	230	2017/A2	28,447–27,574	Bone	Arch. Layer	This paper
Poz-101178	A2–2	25130	270	2017/A2	29,886–28,593	Bone	Arch. Layer	This paper
Gd-4010	A2–3	23100	1200	23/83-84	30,395–25,280	Charcoal	Hearth	Bárta 1988
GrA-42312	A2–3	24540	130	2008/A3	28,871–28,261	Charcoal	Arch. Layer	Vlačiky et al. 2013
GrA-16163	A2–3	25130	170	20/83	29,584–28,764	Charcoal	Arch. Layer	Verpoorte 2002
Poz-101180	A2–3	25560	290	2017/A2	30,544–29,007	Bone	Arch. Layer	This paper
GrA-16162	A2–3	25650	160	24/1983-84	30,365–29,365	Charcoal	Arch. Layer	Verpoorte 2002
Poz-101181	A2–3	25910	300	2017/A2	30,810–29,435	Bone	Arch. Layer	This paper
Poz-97362	B–1	22180	220	2017/B2	27,042–25,984	Charcoal	Arch. Layer	This paper
Gd-4009	B–1	22500	600	B/83	27,836–25,720	Charcoal	Arch. Layer	Bárta 1988
Gd-4016	B–1	22800	600	1B/1982	28,136–25,917	Charcoal	Arch. Layer	Bárta 1988
GrA-16161	B–1	23280	140	2B/1983	27,753–27,296	Charcoal	Arch. Layer	Verpoorte 2002
Poz-97254	B–1	24560	180	2017/B2	28,994–28,158	Charcoal	Arch. Layer	This paper
Poz-97253	B–1	24600	180	2017/B2	29,046–28,203	Charcoal	Arch. Layer	This paper
GrA-16139	?	29910	260	1B/18	34510-33605	Charcoal	?	Verpoorte 2002
Poz-101822	B–2	32790	460	2017/B1	38315-35887	Charcoal	Arch. Layer	This paper

addition, drilling has been carried out in each section to reach primary loess. For each part of the archaeological trenches, descriptions of key sequences were constructed. The following criteria were taken into account: lithology, structure, color, carbonate content, and the presence of Mn and Fe concentrations. In addition, three sections were sampled for particle size analysis at intervals of 10 cm (recent soil) and 5 cm (loess and archaeological layers). The grain size measurements were made based on the laser diffraction method (instrument Malvern Mastersizer 2000) according to the methodology described by Újvári and colleagues (2016).

Dating

Samples for radiocarbon dating were taken from each archaeological layer. Bones and charcoal were selected for dating. Charcoal was both hand-collected and floated from archaeological sediments through 0.5 and 1.0 mm mesh. Wood charcoal was identified taxonomically prior to radiocarbon dating. When possible, branch wood or twigs were selected, since this kind of wood might be an optimal material to avoid the old wood effect (Moskal–del Hoyo and Kozłowski 2009; Nowak et al. 2017).

The AMS radiocarbon dating was performed at Poznan Radiocarbon Laboratory. Methods of chemical pre-treatment at Poznan Laboratory are available online (Goslar 2015), according to which the lab follows the protocol of the Oxford Radiocarbon Accelerator Unit (Brock et al. 2010). Extraction of bone collagen was performed according to Piotrowska and Goslar (2002). Bone samples were regarded as suitable for collagen dating if nitrogen content was not lower than 0.6% and the C/N ratio was within the interval of 2.7–3.5. The AMS dating procedure followed Czernik and Goslar (2001). Content of ^{14}C was measured using a 0.5 MV NEC machine (Goslar, Czernik, and Goslar 2004). Radiocarbon dates were calibrated with OxCal (Reimer et al. 2013), indicating 95.4% probability.

Paleobotany

The present study analyzed floated samples of a total volume of 126 liters of sediment, using meshes of 0.5 and 1.0 mm, and manually collected samples. Charred wood anatomy was studied applying a reflected light microscope with magnifications of 100, 200, and 500 to observe three anatomical sections of the wood: transverse section, longitudinal radial section, and longitudinal tangential section in freshly broken charcoal fragments. Taxonomical identifications were made by comparing the specimens with the modern wood collections of the Department of Paleobotany of the W. Szafer Institute of Botany PAS and atlases of wood anatomy (Greguss 1955; Schweingruber 1990). The charcoal of *Pinus* type *sylvestris-mugo* was identified based on the presence of large fenestriform pits and ray tracheids with dentated walls in cross-fields, while the identification of *Pinus cembra* was based on the presence of large fenestriform pits and ray tracheids with smooth walls in cross-fields. Badly preserved charcoals with large fenestriform pits were recognized as *Pinus* sp. Based on wood anatomy, it was not possible to distinguish between two genera, *Picea* and *Larix*, and thus both genera are identified to one taxon. Coniferous wood, without specifying the species, was indicated when details of cross-fields could not have been observed due to the poor state of preservation.

Additional dendrological analysis focused on ring curvature observations was performed (Marguerie and Hunot 2007), and the presence of decayed wood was noted (Moskal–del Hoyo, Wachowiak, and Blanchette 2010). Charcoal fragments were also investigated using a scanning electron microscope (SEM Hitachi S-4700) at the Laboratory of Field Emission Scanning Electron Microscopy and Microanalysis at the Institute of Geological Sciences of the Jagiellonian University (Kraków, Poland).

Malacology

Snail shells were identified to species level whenever possible. Nomenclature followed Welter-Schultes (2012). *Pupilla pratensis* (Clessin, 1871) was not distinguished from *Pupilla muscorum* (Linnaeus, 1758) until recently (von Proschwitz et al. 2009). Due to their close conchological similarity, we treated all *P. muscorum*-like shells as *P. muscorum*. Ecological information on each species followed Ložek (1964), Kerney, Cameron, and Jungbluth (1983), Meng and Hoffmann (2009), Welter-Schultes (2012), and Horsák, Juřičková, and Picka (2013).

Table 2. Litho- and pedological characteristics of trenches A2, B1, and B2.

Depth (m)	Description	Interpretation (soils/ archaeological layers)	
Trench A2 section (north wall)			
0.0–0.17	Clayey loam, grey-yellow, HCl ++, sharp limit in color	Soil horizon Ap	
0.17–0.80	Calcareous loess with numerous pseudomycelium and molluscs, HCl+++, clear boundary, includes layer A2–1 and A2–2	Soil horizon Ck	
0.80–0.95	Calcareous loam, light pale yellow, numerous bones and charcoals, HCl +, sharp undulated boundary	Archaeological layer A2–3	
0.95–1.40	Calcareous loam, olive yellow, HCl+, diffuse boundary	Poorly developed soil (interstadial rank)	
1.40–2.45 (drilling)	Massive calcareous loam, yellow-grey, fine iron hydroxide bands, HCl++	Aeolian-solifluction loess layer	
Trench B1 section (north wall)			
0.0–0.30	Clayey loam, brown-grey, overgrown with roots of modern plants, HCl-, clear boundary	Soil horizon Ap	Recent soil
0.30–0.57	Silt loam, grey, numerous roots, tubules with coprolites, HCl-, clear border	Soil horizon Et	
0.57–1.10	Clayey loam, numerous roots and coprolites, compacted, cracks from drying, HCl-, boundary visible in color	Soil horizon Bt	
1.10–1.60	Clayey loam, mosaic of brown and dark grey colors—marble with bioglifs, clay coatings—clear traces of illuviation, lower boundary visible in color and presence of carbonates	Soil horizon BC	
1.60–2.10	Non-calcareous clayey loam, grey-yellow, numerous pseudomycelia (vertical) and nodule (2–3 mm), numerous concretions of Fe and MN-Fe (1–2 mm in diameter), numerous biochannels with coprolites, HCl+, sharp border in color, manganese horizon at a depth of 1.80–1.82 m	Soil horizon C	
2.10–2.70	Silt loam, grey-dark yellow, pseudomycelia and nodule as above, in the lower part numerous and large molluscs filled with soil-repellent material (average 15–20 cm), although no artifacts were found here, this layer corresponds with the upper cultural layer of area B found in trench B2, HCl+, clear boundary	Soil horizon Ab	Buried soil
2.70–2.90	Silt loam, grey-brown, HCl +, diffuse boundary	Soil horizon Btb	
2.90–6.25	Calcareous loam, brown-grey, numerous channels with coprolites, the top includes archaeological layer B–2 of area B	Aeolian-solifluction loess layer	
Trench B2 section (west wall)			
0.0–0.30	Clayey loam, brown-grey, HCl+, clear boundary	Soil horizon Ap	Heap
0.30–0.35	Calcareous loam HCl+++, clear boundary	Soil horizon Ck	
0.35–1.15	Clayey loam, brownish-red, intersected with vertical slits, overgrown, numerous channels, visible illuvial clay coatings, HCl-	Soil horizon Bt	Recent soil
1.15–1.55	Clayey loam, light brownish-red, numerous bioglyphs, HCl-, boundary visible in carbonates	Soil horizon BC	
1.55–2.10	Calcareous clayey loam, at a depth of 1.90–1.95 m there is a manganese layer detected also in Trench B1 at a depth of 1.80–1.82 m, HCl +, clear boundary	Soil horizon C, loess	
2.10–2.60	Numerous artifacts, animal bones, charcoals, bioturbations, HCl+	Archaeological layer B–1	

Table 3. Trenčianske Bohuslavice lithic tool kit raw material composition.

	A2–1	A2–2	A2–3	B–1	B–2	Total
Radiolarite	8	43	303	77	1	432
	100.0%	35.2%	35.7%	88.5%	100.0%	40.5%
Erratic flint	0	67	462	9	0	538
	0.0%	54.9%	54.5%	10.3%	0.0%	50.5%
Jurassic flint	0	2	47	0	0	49
	0.0%	1.6%	5.5%	0.0%	0.0%	4.6%
Obsidian	0	4	22	0	0	26
	0.0%	3.3%	2.6%	0.0%	0.0%	2.4%
Chert	0	6	14	1	0	21
	0.0%	4.9%	1.7%	1.1%	0.0%	2.0%
Total	8	122	848	87	1	1066
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Archaeozoology

The bone remains were identified applying a comparative collection of the Institute of Systematics and Evolution of Animals (Polish Academy of Sciences, Kraków) and published data (Gramova 1950; Pales and Garcia 1981a, 1981b). Two quantified calculations were made: NISP (Number of Identified Specimens) and MNI (Minimal Number of Individuals) (Klein and Cruz–Uribe 1984; Lyman 1994). All bone remains were subjected to detailed observations in order to identify impacts of humans, carnivores, rodents, and plant root activity (Sutcliffe 1970; Haynes 1980, 1983; Binford 1981; Shipman and Rose 1983; Shipman, Foster, and Schoeninger 1984; Olsen and Shipman 1988; Lyman 1994; Stiner et al. 1995; Bennet 1999; Théry-Parisot 2002; Villa, Bon, and Castel 2002). Each mark was examined under low-power magnification.

Lithic tools

We studied 686 lithic tools discovered in areas A2 and B in the 1980s and 2017. The materials from area A1 were excluded because the bulldozer work truncated the sequence, and the lithics cannot be securely paired with archaeological layers. Lithic raw materials were identified macroscopically following Přichystal (2013) and the Lithic Reference Collection of the Eötvös Loránd University of Budapest (Mester 2013).

A lithic tool is defined here as a knapped stone product whose edges were modified by retouching or burin spall removals. The tools were analyzed in terms of lithic raw material, blanks of the tools, typology, and use-wear. We differentiated raw materials by their type, which also provides information about their geographic origin. The blanks of the tools were classified as either blade, flake, or debris. The category blade includes the small specimens (bladelets).

The tools were divided into major type classes: end-scraper, burin, edge retouched tool, perforator, truncation, splintered tool, combined tool, knife, and armature. We included notched and denticulated artifacts within the group of edge retouched tools. The category of armatures was subdivided into points, backed, and backed-truncated artifacts. The points were further divided into the categories of Gravette/microgravette point, fléchette, Vachons point, retouched point, and BLPs. BLPs included unfinished bifacial tools as well. The Gravette/microgravette definition here was restricted to those specimens having inverse flat basal or, rarely, distal retouch opposed to the backed edge (Lengyel 2016, 2018).

The use-wear analysis aimed at determining the function of the lithic tool. The microscopic analysis was carried out at the Laboratory of Archaeometry and Archaeological Conservation, Institute of Archaeology, University of Wrocław. An experimental collection of the laboratory and published results of the use-wear analyses were the references to identify wear traces. Scars were analyzed with the use of an Olympus SZX9 stereomicroscope (up to ×114 magnification). Polish, edge rounding, and striations were identified under a Nikon ECLIPSE LV100 metallographic microscope (×50–500 magnification). Prior to microscopic observations, the artifacts were cleaned in an ultrasonic tank.

Results

Geology and stratigraphy

In area A2, aeolian sediments lay directly under the thin, ploughed modern surface. The archaeological layers were embedded in loess and loess-like sediments, which, according to the grain size analyses, are typical aeolian periglacial formations. The content of the loess fraction (20–50 μm) is variable and falls within the range of 25–40%. The diversity of these sediments underlines the distinct variability of average grain size (Md), which suggests these are stratified sediments composed mainly of silt and sand and are interpreted as redeposited aeolian-slope loess-like sediments.

The uppermost archaeological layer (A2–1) (Figure 4) was situated near the top of the calcaric loess (Figures 5, 6), marked by charcoal and Mn-Fe and Fe oxide concretions, knapped lithics, and a hearth. The thickness of the layer was ca. 5 cm. This layer was correlated with layer I of Vlačiky and colleagues (2013).

The second archaeological layer in area A2 (A2–2) lay 25 cm beneath layer A2–1, still in calcaric loess. This layer was correlated with Bárta's uppermost archaeological layer (layer III) and layer II of the excavation in 2008; similarly, the findings were mostly animal bones and a few knapped lithics. However, the level of layer A2–2 compared to the surface is 0.20 m higher than Bárta's layer III, which we explain with a reorganization of the terrain at Pod Tureckom that resulted in lowering the surface of the topsoil above sea level. Charcoal was sporadic, and the small concretions of iron oxide found in layer A2–1 were missing. This archaeological layer cannot be distinguished by geological data.

The third archaeological layer of area A2 (layer A2–3) was situated 25 cm beneath A2–2 in loess. Compared to A2–1, A2–3 was extremely abundant in charcoal, iron oxide concretions, hard-burnt loess fragments, animal bones, and knapped lithics. This layer can be correlated with the main Gravettian occupation of Bárta's excavation (layer II) and layer III of 2008.

Our analysis of the geological section in area A2 obtained converging results with the 2008 fieldwork (Vlačiky et al. 2013). Our 5 cm interval sampling, however, provided more details on the sediment features.

We did not find Bárta's lowermost layer (layer I) in area A2.

In area B, two trenches were opened, B1 and B2, separated by a 1 m thick unexcavated area. B1 was situated south of B2. In both trenches, the stratigraphy started with a well-developed zonal Luvisol type soil of Late Glacial-Holocene origin ca. 1.60 m thick, which preserved only the B and lower horizons, due to being truncated on the top (Figure 5). The border between the Luvisol and the underlying loess was very pronounced in the content of carbonates. The upper archaeological layer was found only in B2 (layer B–1) and correlated with Bárta's only archaeological layer in area B, which lay 2.60–2.90 m beneath the surface (Figure 3B). This layer was found 2.10–2.60 m below the surface in 2017; therefore, we suspect that a reorganization of the surface might have occurred since the 1980s. Layer B–1 was embedded in loess and marked by irregular charcoal bands, patches of burnt loess surfaces, scattered charcoal and iron oxide concretions, animal bones, and knapped lithics. The morphology of the archaeological layer basically indicates its development in the form of poorly developed soil with traces of local redeposition and allows the traces to be recognized as typical weakly developed soil units formed as gley cryosols in a periglacial environment. This layer is decalcified or weakly calcified. Its main features are root pseudomorphs, coprolites, and artifacts. Its color was sharply darker than the embedding sedimentary environment, showing the characteristics of gley (redoximorphic) processes. The activity of soil processes and slope deformations in this layer are confirmed by the analysis of grain size. The average grain size is clearly drifting within the archaeological layer, and it increases by leaps and bounds towards the uppermost horizon (Figure 7). The

Figure 4. The eastern wall of A2 trench in 2017; marked are the positions of the archaeological layers. Black dots mark lithic finds, grey dots mark bones in the stratigraphy. Grey lines with grey dots mark bones of multiple measurements.

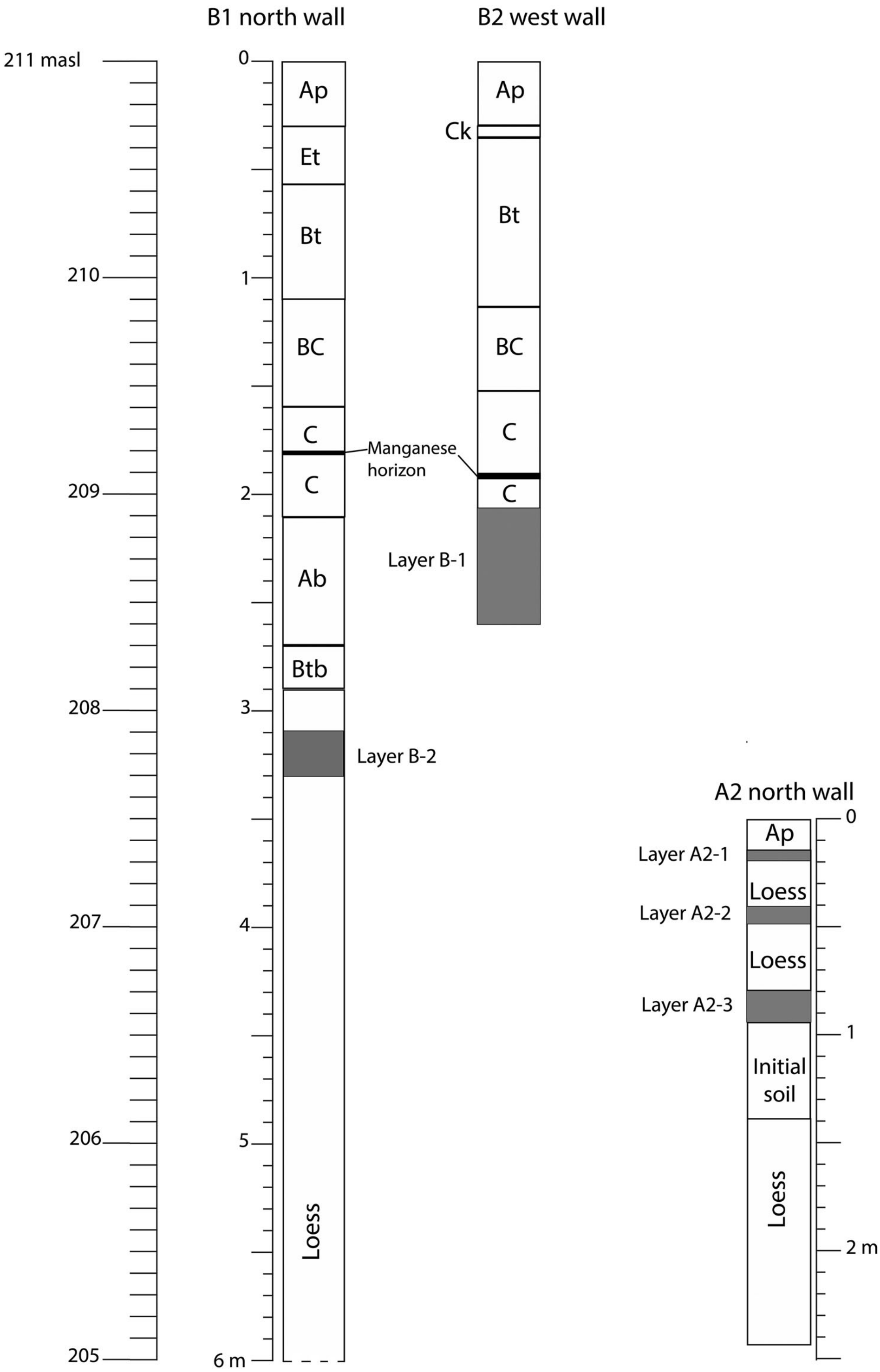

Figure 5. The correlation of the archaeological layers in areas A2, B1, and B2. Grey shades mark the archaeological layers.

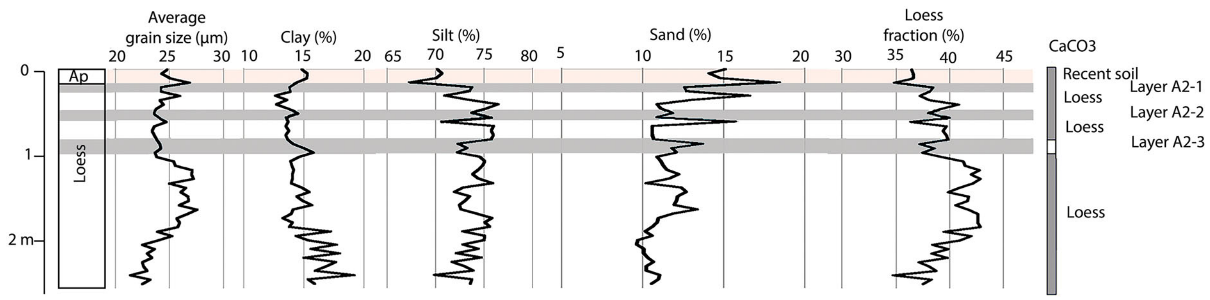

Figure 6. Results of the sedimentological analyses in trench A2.

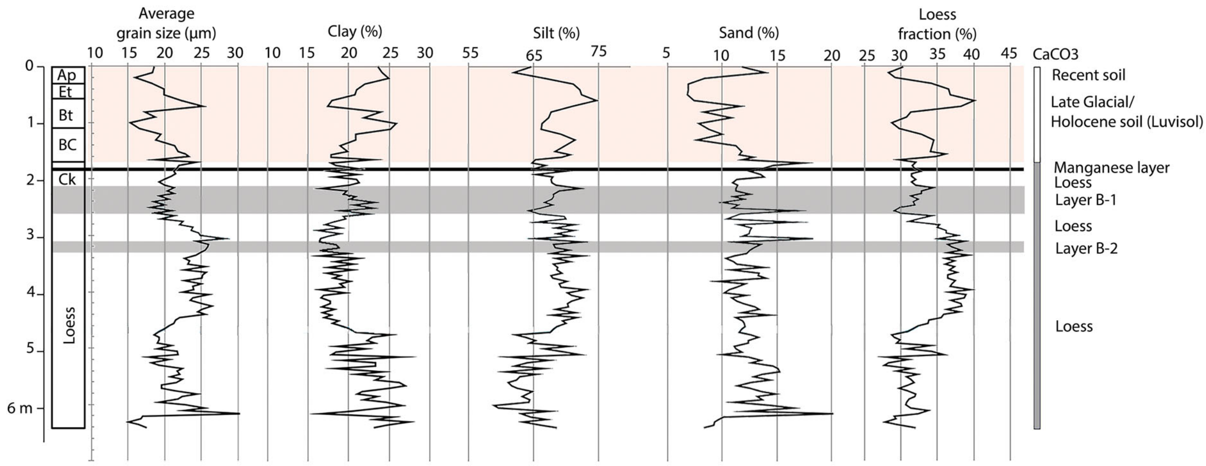

Figure 7. Results of the sedimentological analyses in trench B1.

activity of aeolian processes is reflected by the peaks of increased sand accumulation.

The lower layer of area B, layer B–2, was found in trench B1 (Figure 5), 1 m south of the excavation limit of B2, about 0.50 m beneath layer B–1. Layer B–2 (Figure 8) was a weakly developed soil marked with a few archaeological remains, including charcoal and knapped lithics. This layer was not mentioned in reports from work in the 1980s. Based on the similar geological positions, this could tentatively be correlated with the lowermost archaeological layer of the 1980s (layer I) situated in area A1 under the main Gravettian occupation (layer II) in an interstadial soil.

The correlation of the stratigraphic sequences between area A2 and area B is not straightforward, because the top of the section in area A2 was truncated down to the aeolian sediment. A fixed stratigraphic marker can be the interstadial soil under A2–3, which corresponds with the soil in B that contained the lower archaeological layer (B–2). According to this position, A2–3 is younger than B–2. Further correlations can be achieved relying on other data.

Chronology

Nine new dating samples were obtained from the 2017 excavation (Table 1). Layer A2–1 was dated to 22,370 ± 150 B.P. (Poz-97252) on the basis of a charcoal of *Pinus sylvestris-mugo* taken from a hearth. Layer A2–2 was dated to 23,850 ± 230 B.P. (Poz-101182), as derived from a *Mammuthus primigenius* rib fragment, and 25,130 ± 270 B.P. (Poz-101178), as derived from a piece of mammoth vertebra. Layer A2–3 dates were also made on bones: 25,560 ± 290 B.P. (Poz-101180) was measured on a *Rangifer* metacarpal bone, and a date of 25,910 ± 300 B.P. (Poz-101181) was from a *Rangifer* radius bone.

Concerning layer B–1, all bone samples failed to yield a sufficient amount of collagen. However, charcoal samples taken from three charcoal bands (Figure 9), each separated by a ca. 10 cm thick loess layer, yielded three dates. The charcoals were of *Pinus* sp. (Poz-97362), *Picea* sp./*Larix* sp. (Poz-97254), and a coniferous tree (Poz-97253). From within the second band (middle), remains of twigs were dated. The stratigraphic order of the dates is reversed. The lowest date, 22,180 ± 220 B.P. (Poz-97362), is significantly younger than the two others above this: 24,560 ± 180 B.P. (Poz-97254) and 24,600 ± 180 B.P. (Poz-97253). Layer B–2 was dated on a *Picea* sp. or *Larix* sp. charcoal to 32,790 ± 460 B.P. (Poz-101822).

All radiocarbon dates obtained from the two areas of the site are divided among five layers. The first three are located in area A2, and they have a direct superposition. The fourth and fifth layers are in area B. Plotting the dates with 95.4% probability after calibration with OxCal (Reimer et al. 2013) in B.P. years shows a tendency for aging towards lower stratigraphic positions in area A2 (Figure 10).

The age 22,370 ± 150 B.P. (Poz-97252) of *Pinus* sp. of layer A2–1 is identical to the 22,330 ± 110 B.P. (GrA-42311) obtained by Vlačiky and colleagues (2013) for the same layer. Below, in layer A2–2, however, there is one outlier date of 20,300 ± 500 B.P. (Gd-4011). In layer A2–3, there is one insecure date, Gd-4010, that has a large standard deviation of 1300 radiocarbon years. Removing these dates from the list, we see that the most probable age of the uppermost occupation (layer A2–1) after calibration is 26–27 kya. Layer A2–2 is dated to 27–28 kya, and layer A2–3 dates to 28–30 kya.

In area B, two of the new dates are significantly older than the rest of the dates. If we disregard these two outliers, the age of the B–1 human occupation is most likely dated to 26–27 kya. The uppermost charcoal sample dated among the three (Poz-97253) was situated about 7 cm higher in the stratigraphy than the uppermost BLP specimen, and no BLP was found below the lowermost date. Therefore, we find an association between BLPs and the charcoal bands which eventually seem to be related with the periphery of the distorted hearth features of Bárta (Figure 3B). The reverse order of dates from the microstratigraphy of the 2017 excavation might have been caused by the redeposition of an older sediment over a later one, which may occur frequently in a slope position in a periglacial environment (Händel 2017), such as the case of layer B–1. Taking into account the movement of sediment, we estimate layer B–1 to postdate layer A2–2 and predate layer A2–1.

Charcoal analysis

Layer A2–1 contained a very small number of charcoal fragments associated with a hearth. Only remains of *Pinus* t. *sylvestris–mugo* were identified (n = 8). In layer A2–2, *Picea* sp. or *Larix* sp. were found (n = 13) dispersed within the layer. Layer A2–3 yielded *Pinus cembra* (n = 41), *Pinus*

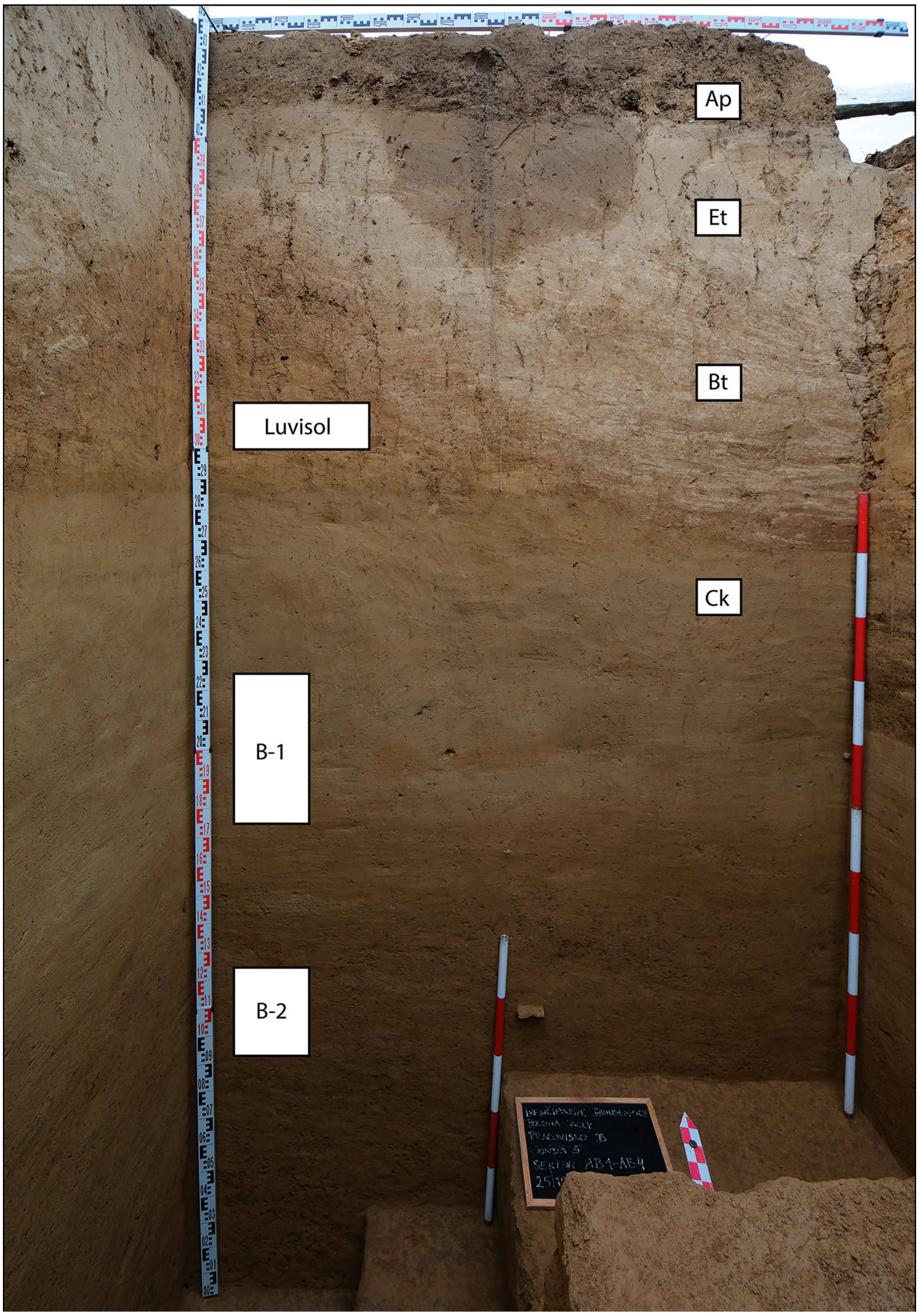

Figure 8. The development of loess-soil sequence and the position of archaeological layers B–1 and B–2 in trench B2 in 2017.

sp. (n = 39), *Picea* sp. or *Larix* sp. (n = 141), and coniferous wood (n = 47). The most abundant samples came from a hearth of layer A2–3 (n = 207), and in this context, the remains of *Picea* sp. or *Larix* sp. were dominant (n = 117). With the exception of hearth remains, all other charcoal assemblages contained very small charcoal fragments that usually did not exceed 2–3 mm in transverse section. Charcoal of layer A2–3 was infected by fungi and xylophagous insects. Some of them had originated from branchwood, as they were characterized by the presence of compression wood; some twigs were documented, as well. The majority of *Picea* sp. or *Larix* sp. fragments had narrow rings. Fragments of bark were also found.

The layer B–1 charcoal assemblage included *Pinus cembra* (n = 21), *Pinus* sp. (n = 27), *Picea* sp. or *Larix* sp. (n = 98), and coniferous wood (n = 34). These samples were also frequently infected by fungi. Layer B–2 yielded only *Picea* sp. or *Larix* sp. (n = 5). They were characterized by the presence of fungi.

Malacology

Of the 7058 shells, 6987 specimens were identified to species level, divided among 17 species (Ložek 1964; Welter-Schultes 2012). The most dominant species were *Pupilla muscorum* (Linnaeus, 1758) (n = 4116) and *Succinella oblonga* (Draparnaud, 1801) (n = 1732) (Figure 11); both taxa inhabit relatively dry, open areas, although they have a wide ecological tolerance. Therefore, their role in reconstructing habitat and climate is moderate.

The layer B–1 snail faunal assemblage (n = 1476) is divided among twelve species, and its spectrum of species is most similar to that of layer A2–1 (n = 3734) (Figure 11), with the occurrence of *Pupilla loessica* (Ložek, 1954), *Clausilia dubia* Draparnaud, 1805, *Vallonia tenuilabris* (Braun, 1843), *Trochulus hispidus* (Linnaeus, 1758), and *Columella columella* (G. von Martens, 1830) in both layers. These

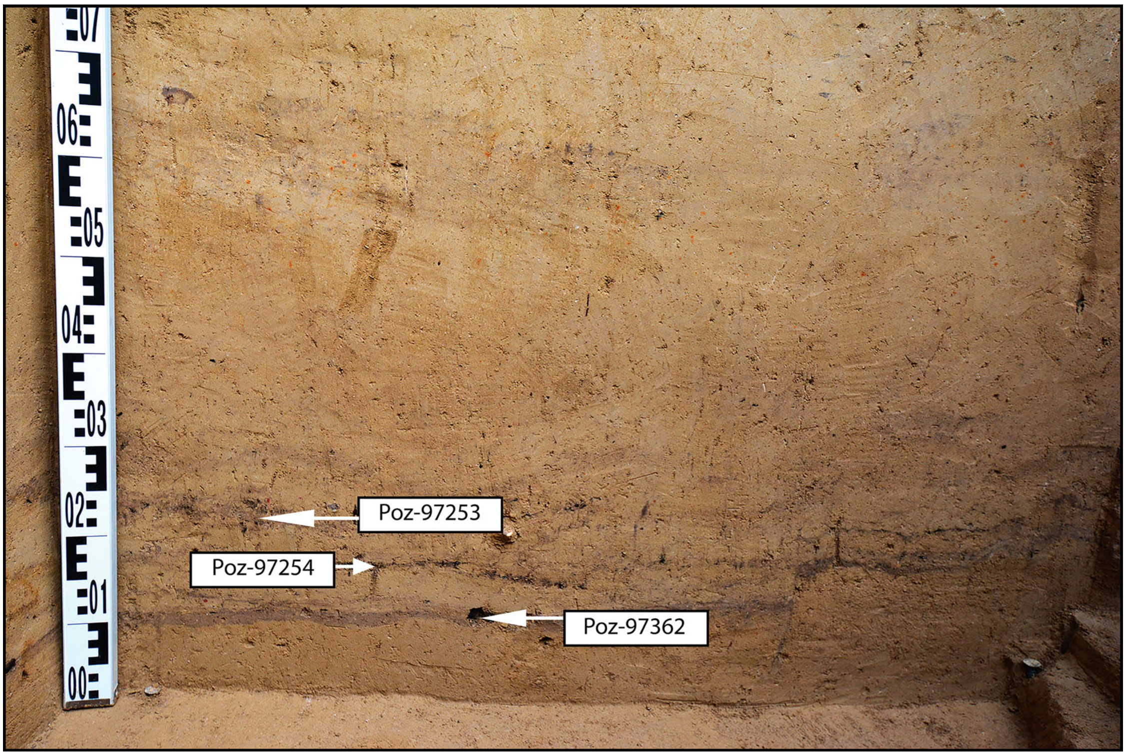

Figure 9. The three charcoal bands in the western wall, trench B2. Indicated are the origins of the radiocarbon samples.

species are absent or relatively rare in other layers. The most conspicuous difference between layers B–1 and A2–1 is the frequency of *Pupilla sterrii* (Forster, 1840) in the former (n = 40) and *Columella columella* in the latter (n = 39). Both species prefer cold climates, and therefore the two species have minor importance in terms of differentiating climate reconstructions for the two layers. A single shell of *Orcula dolium* (Draparnaud, 1801), which is primarily a forest species, was found in layer A2–1, too.

The layer A2–2 snail faunal collection (n = 1587) consists of ten species whose presence indicates the driest climate among all the snail taxa, as indicated by the frequent occurrence of *Pupilla triplicata* (n = 80), the absence/low frequency of hygrophilous species such as *Clausilia dubia*, *Trochulus hispidus*, *Cochlicopa lubrica* (O. F. Müller, 1774), and *Pseudotrichia rubiginosa* (Rossmässler, 1838), and the relatively low number of species.

The layer A2–3 snail faunal assemblage (n = 264) is made up of thirteen species which indicate relatively humid environmental conditions, as signaled by the occurrence of hygrophilous species, such as *Clausilia dubia* and *Cochlicopa lubrica*. *Vestia turgida* (Rossmässler, 1836), which typically inhabits wet marshes and stream banks, was found most frequently in layer A2–3, although it was also found in one sample in layer B–1. A single shell of the hygrophilous *Vitrea crystallina* was found in layer A2–3, further emphasizing the wet climate. The absence of *Columella columella* and *Pupilla loessica* and the decreased number of *Vallonia tenuilabris* in layer A2–3 indicates that the layer's sedimentation occurred in a warmer climate than that of layers A2–1 and B–1.

The ratios of mollusc species we observed largely match with the data of Vlačiky and colleagues (2013, table 7) in the cases of layers A2–1 and A2–2. The mollusc samples of Vlačiky and colleagues (2013) at 85 cm and 105 cm depth derived from the upper and the lower boundaries of their layer III (Vlačiky et al. 2013, fig. 4) that is equivalent to our layer A2–3. Therefore, our snail sample from layer A2–3 was situated between the 85 cm and the 105 cm samples of 2008. This stratigraphic difference might have resulted in finding a slightly higher number of *Pupilla loessica* (n = 10) and *Pupilla sterri* (n = 12) in the sample at 85 cm (Vlačiky et al. 2013, table 7), compared to the frequency of these species we found in layer A2–3 (n = 0 and n = 1, respectively). The sample at 105 cm from 2008 contained fewer *Pupilla loessica* (n = 2) and *Pupilla sterri* (n = 7). These species indicate a colder climate than what we estimate for layer A2–3, and thus their presence suggests that the 85 cm and 105 cm samples of 2008 could have been related with the sediments laying above and below archaeological layer A2–3.

Vertebrate animals

Animal remains were discovered in layers A2–2, A2–3 and B–1. Layers A2–1 and B–2 did not contain animal remains.

In layer A2–2, single bones were found of mammoth (mainly vertebrae), wolf, and Arctic/red fox. Layer A2–3 contained the most abundant animal remains, including mammoth (NISP = 29, MNI = 1), reindeer (NISP = 41, MNI = 2), wolf (NISP = 21, MNI = 1), Arctic/red fox (NISP = 2, MNI = 1), and hare (NISP = 7, MNI = 1). Additionally, in this layer, single bones of unidentified birds and rodents were also noted. Layer B–1 is similar to layers A2–2 and A2–3 in containing remains of mammoth (NISP = 25, MNI = 2), reindeer (NISP = 7, MNI = 1), wolf (NISP = 13, MNI = 1), and Arctic/red fox (NISP = 12, MNI = 1). In layers A2–3 and B–1, some skeletal elements of carnivores were preserved in anatomical order. Generally, material identified to species/genus are known from earlier studies of this site (Vlačiky et al. 2013). A new discovery is of rodents (*Microtus agrestis*, *Microtus gregalis*, and *Microtus oeconomus*) from layer A2–3.

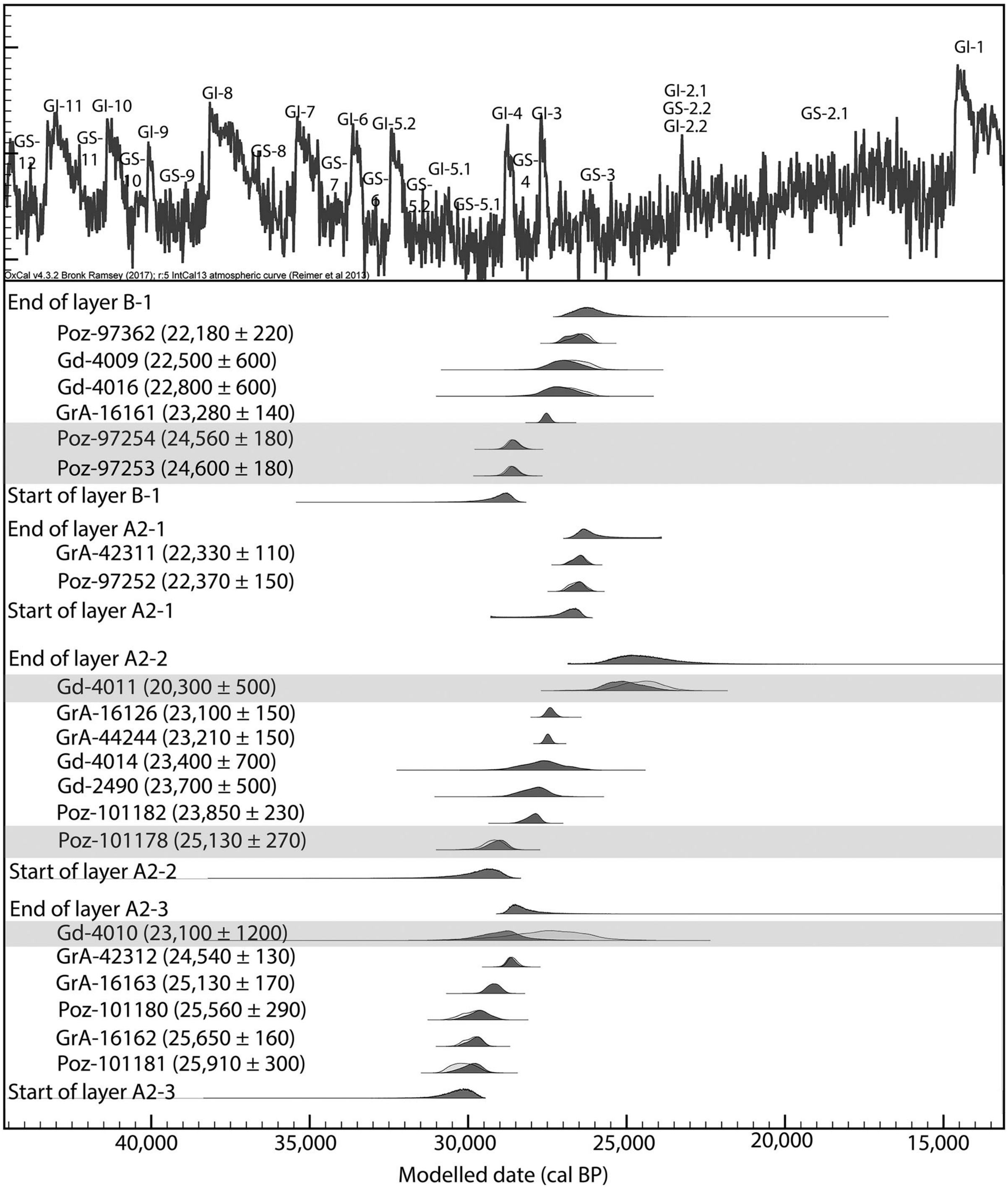

Figure 10. Modelled age of the human occupations using OxCal 4.3.2 (Reimer et al. 2013). Grey shades mark outlier dates.

Direct traces of human activity, such as cut- or punch marks, are few, which can be explained by the poor state of bone preservation. However, the context of their discovery —a human settlement discovered together with numerous artifacts and artificial structures—indicates that animal remains at the site are the results of human activity. The bones are heavily fragmented, which makes identification of element and taxon very difficult. The fragmentation was due to both post-depositional processes and, most likely, human activity. Bones were relatively often covered by root etching.

Our findings match the results of the fieldwork in 2008 (Vlačiky et al. 2013), except the case of layer A2–2 that contained mammoth bones, compared to the lack of this species in layer II of 2008.

Knapped lithics

The distribution of the raw materials used in the formal tool kits was different between the archaeological layers. What is especially important is that the proportions of the lithic raw materials in the tool assemblages accurately represent the complete collections.

Identified were five types of lithic raw materials in the formal toolkits of the layers. First is the erratic flint originating closest from glacial deposits of the Moravian gate (Přichystal 2013). This flint is of Cretaceous origin. Another type of flint is of Jurassic origin, which is found at the Kraków-Częstochowa Upland in Poland (Kaczanowska and Kozłowski 1976), but a coarser variant of this flint can be found in southern Moravia (Přichystal 2013). Polish Jurassic flint in

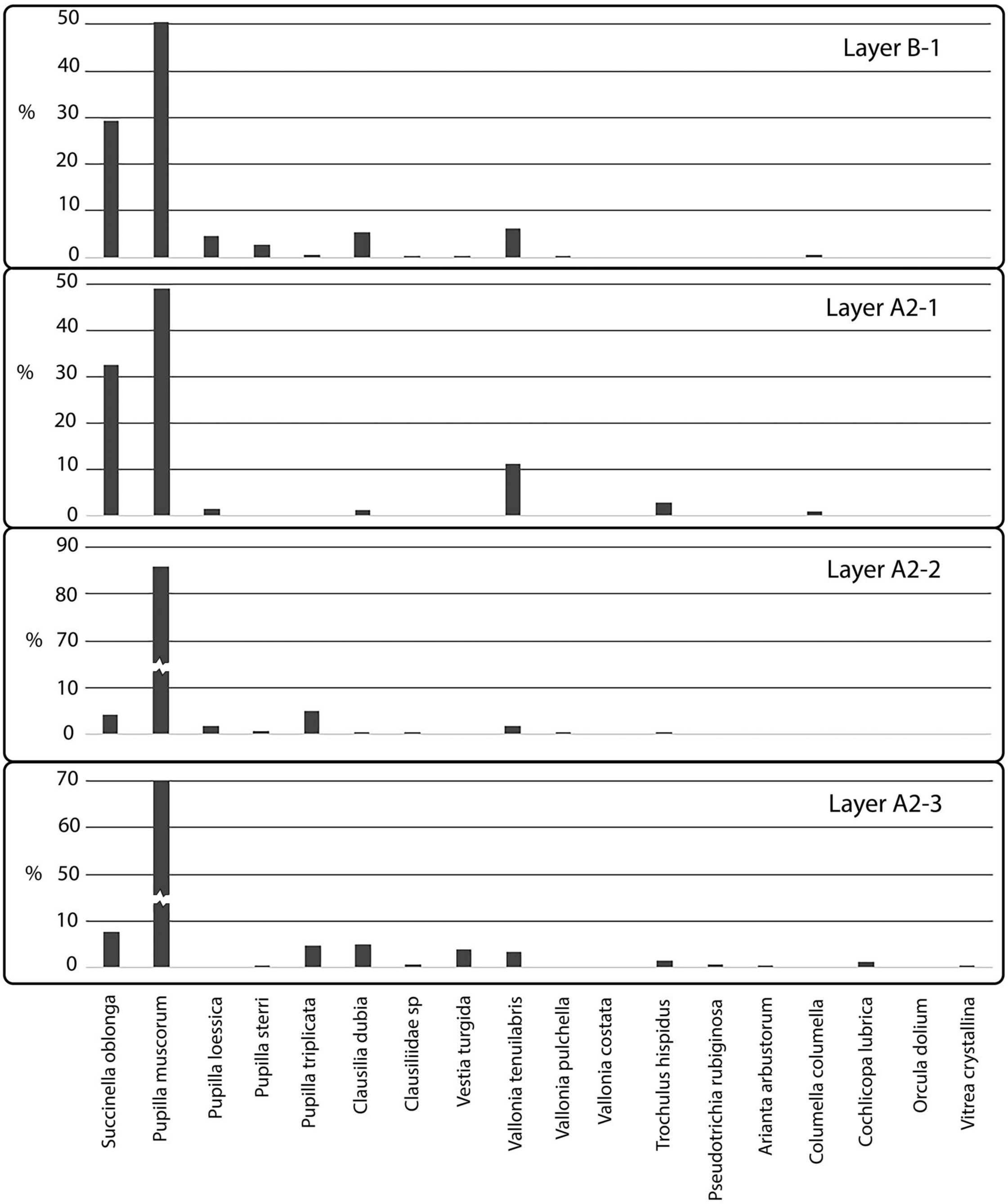

Figure 11. The distribution of mollusc fauna in the archaeological layers.

most cases has a brownish hue and finer texture. The Moravian type is predominantly of greyish hue. Locally available raw material at TrB was the radiolarite originating in the Klippen Belt of the White Carpathians (Přichystal 2013). The obsidian in the assemblages derived from the Tokaj Mountains of northeastern Hungary, type Carpathian 2 (Kasztovszky and Přichystal 2018). The fifth raw material category includes various siliceous rocks called limnic silicite. These were formed by post-volcanic activity of Miocene age in a lacustrine sedimentary environment (Přichystal 2013). The closest sources are in central Slovakia, but they might have originated from the volcanic ranges in northern Hungary, as well.

The layer A2–1 tool assemblage is made of radiolarite (n = 8), while formal tool assemblages from layers A2–2 (n = 122) and A2–3 (n = 848) have very similar proportions of raw materials, consisting of radiolarite, erratic flint, Jurassic flint, obsidian, and unidentified chert. In both assemblages, the erratic flint is dominant (54.9% and 54.5%); radiolarite is the next most abundant (35.2% and 35.7%), while all the other materials make up less than 5.5%. The sole, but slight, difference between them is the greater percentage of Jurassic flint in A2–3 (5.5% versus 1.6%). In layer B–1, radiolarite dominates (88.5%), supplemented by erratic flint (10.3%) and chert (1.1%). Only one specimen of a radiolarite retouched tool was found in layer B–2.

Layer A2–1 has no lithic armatures and is dominated by domestic tools such as the edge retouched tools, end-scrapers, and burins (Figure 12, Table 4). Tools made on blades make up 62.5% of the assemblage, and tools made from flakes are in the minority. All edge retouched tools are blades, except the splintered tool made from a flake; the other types were made of both blades and flakes.

Layer A2–2 yielded a wider spectrum of tool types, including the armatures. The assemblage consists of mostly blade

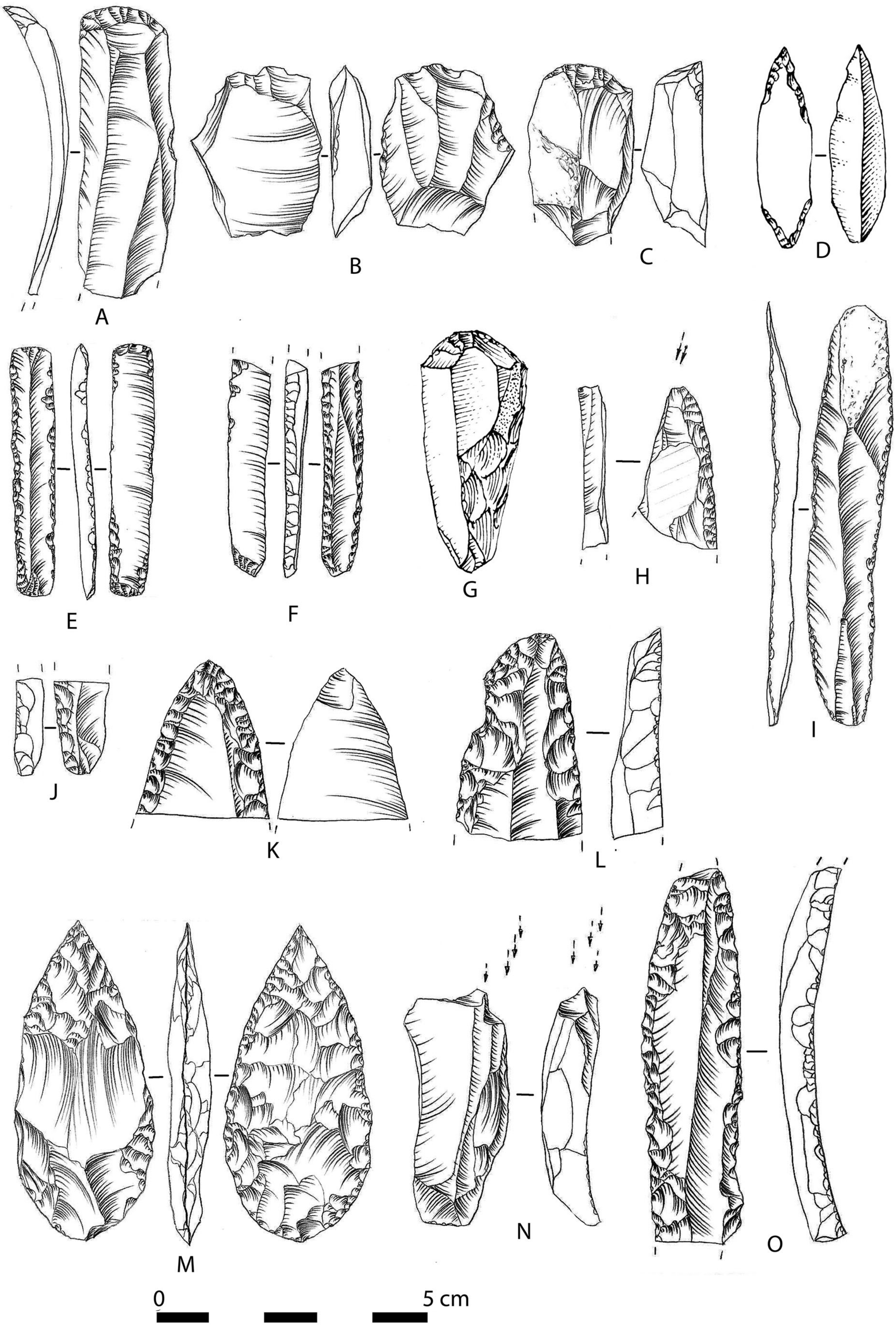

Figure 12. Tools of layer A2–1 (A–C), layer A2–3 (D–J), and layer B–1 (K–O). A, C, G, L) end-scrapers; B) splintered tool; D) fléchette; E) backed and ventrally truncated bladelets (Late Gravettian rectangle); F) microgravette; H, N) burins; I, O) retouched blades; J) backed bladelet; K) retouched blade point; M) bifacial leaf point. (D and G are from Bárta 1988, figs. 3 and 2, respectively. All other artifacts were found in 2017, drawn by J Wilczyński).

tools (84.4%). Edge retouched tools, burins, and end-scrapers dominate the domestic tool assemblage. The largest number of flake tools are burins (n = 10), and there are a few end-scrapers (n = 3) and edge retouched tools (n = 5); a single borer is made from a flake. The armatures make up 23% of the tool assemblage. Within the armatures, backed bladelets

Table 4. Trenčianske Bohuslavice retouched tool inventories of areas A2, B1, and B2.

	A2–1	A2–2	A2–3	B–1	B–2	Total
Domestic tools						
End-scraper	2	12	85	7	0	106
	25.0%	9.8%	10.0%	8.0%	0.0%	9.9%
Burin	2	32	214	7	0	255
	25.0%	26.2%	25.2%	8.0%	0.0%	23.9%
Edge-retouched	3	41	304	44	1	393
	37.5%	33.6%	35.8%	50.6%	100.0%	36.9%
Splintered	1	3	33	1	0	38
	12.5%	2.5%	3.9%	1.1%	0.0%	3.6%
Perforator/borer	0	1	7	0	0	8
	0.0%	0.8%	0.8%	0.0%	0.0%	0.8%
Truncated	0	3	18	5	0	26
	0.0%	2.5%	2.1%	5.7%	0.0%	2.4%
Combined	0	2	13	0	0	15
	0.0%	1.6%	1.5%	0.0%	0.0%	1.4%
Knife	0	0	0	1	0	1
	0.0%	0.0%	0.0%	1.1%	0.0%	0.1%
Armature						
Backed blade/let	0	14	50	0	0	64
	0.0%	11.5%	5.9%	0.0%	0.0%	6.0%
Backed-truncated blade/let	0	0	1	0	0	1
	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%
Rectangle	0	0	3	0	0	3
	0.0%	0.0%	0.4%	0.0%	0.0%	0.3%
LG rectangle	0	5	67	1	0	73
	0.0%	4.1%	7.9%	1.1%	0.0%	6.8%
Gravette/microgravette	0	0	16	0	0	16
	0.0%	0.0%	1.9%	0.0%	0.0%	1.5%
Retouched blade point	0	8	30	3	0	41
	0.0%	6.6%	3.5%	3.4%	0.0%	3.8%
Fléchette	0	1	3	0	0	4
	0.0%	0.8%	0.4%	0.0%	0.0%	0.4%
Vachons point	0	0	3	0	0	3
	0.0%	0.0%	0.4%	0.0%	0.0%	0.3%
Bifacial leaf point	0	0	1	18	0	19
	0.0%	0.0%	0.1%	20.7%	0.0%	1.8%
Total	8	122	848	87	1	1066
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

and retouched blade points are the most numerous. The layer A2–3 tool assemblage is also strongly dominated by blade tools (92.1%). Flake tools are most often burins (n = 27), splintered tools (n = 18), edge retouched tools (n = 10), or end-scrapers (n = 5). The domestic tool spectrum is almost identical to what is found in the layer A2–2 assemblage. The armatures make up 20.5%, within which the Gravette/microgravette group, absent in layer A2–2, is represented several times.

The 2008 lithic tool collection's (Vlačiky et al. 2013) typological spectrum correlates with our results from area A2 concerning all the three layers.

The layer B–1 tool kit is also dominated by blades (63.2%), and most of the flakes are edge-retouched tools (n = 9). The blanks of the BLPs are classified as unknown, because the retouching removed all diagnostic features needed to identify blank types. There are two BLPs on which unretouched removal scar surfaces were preserved: thus we suppose the blanks of the unknown BLPs were also flakes. Armatures make up 25.3% of the assemblage, with BLPs being dominant. The single tool of layer B–2 is a retouched flake.

Use-wear analysis

We studied 192 artifacts, including retouched tools (n = 71), unretouched blades (n = 96), and bifacial thinning flakes (n = 25). Use-wear traces appeared on a significant portion of the studied assemblage (30%, n = 56). Items showing no use-wear (n = 136) are mainly blank blades (n = 85), all the bifacial thinning flakes, and a small portion of the retouched tools (n = 26).

Layers A2–1 and A2–2 yielded a small number of tools with traces of use. This includes two burins of layer A2–1, which preserved use scars on their burin tips, and a mesial fragment of a retouched blade of layer A2–2, used for sawing bone/antler.

Layer A2–3 produced tools used for various domestic activities. Retouched (n = 3) and unretouched blades (n = 1) were used for cutting soft animal tissue and scraping hides. Retouched blades, a burin, and an end-scraper were used for processing bone/antler. The retouched blades (n = 4) were used for sawing and scraping (n = 1), while the burin was used to carve bone/antler, and the end-scraper was a tool for adzing. A possible ochre stain was detected on the passive part of the end-scraper. One of the other retouched blades was probably used for whittling wood. A further 23 tools were used in undetermined activities. Most of them are incomplete specimens, nevertheless there are four retouched blades and an end-scraper bearing hafting polish. Hunting activity is not reflected in traces of use, excluding one retouched blade with an impact scar.

In layer B–1, a hunting practice was noticed through the presence of two artifacts with impact traces. One artifact is a retouched pointed blade that bears the impact scar on its tip's ventral face (Figure 12K). The other tool is a BLP (Figure 13) with bifacial step and hinged bending fractures at its tip (Figure 13A). The lateral edges near the BLP's tip are partially rounded and polished, and the polished area is cut through by short and narrow striations, parallel to the cutting edge (Figure 13B). A bright haft polish also was noticed on the ridges bordering the flake scars in the middle part of one of the surfaces of the BLP (Figure

Table 5. Lithic artifacts use-wear analyses results.

Layer	Type	Impact traces	Soft material	Hard material	Undetermined material, other	No traces	Total
A2–1	End-scraper	-	-	-	-	1	1
	Burin	-	-	-	2	-	2
	Edge-retouched	-	-	-	-	1	1
	Blade	-	-	-	-	12	12
	Sub-total	-	-	-	2	14	16
A2–2	Edge-retouched	-	-	1	-	-	1
	Blade	-	-	-	-	1	1
	Sub-total	-	-	1	-	1	2
A2–3	End-scraper	-	-	1	1	1	3
	Burin	-	-	1	2	1	4
	Edge-retouched	1	3	6	8	6	24
	Splintered	-	-	-	2	4	6
	Borer	-	-	-	-	1	1
	Truncated	-	-	-	-	1	1
	Backed	-	-	-	2	2	4
	LG rectangle	-	-	-	2	1	3
	Gravette/Microgravette	-	-	-	-	1	1
	Retouched point	-	-	-	1	-	1
	Blade	-	1	-	5	36	42
	Sub-total	1	4	8	23	54	90
B–1	End-scraper	-	-	-	1	1	2
	Burin	-	1	-	-	-	1
	Edge-retouched	1	-	-	4	2	7
	Splintered	-	-	-	-	1	1
	Truncated	-	2	-	-	1	3
	Retouched point	-	-	-	1		1
	Bifacial leaf point	1	1	-	-	1	3
	Blade	-	-	2	3	36	41
	Bifacial thinning flake	-	-	-	-	25	25
	Sub-total	2	4	2	9	67	84
Total		3	8	11	34	136	192

13C). Further traces of working on soft animal tissue, hides, and meat were recorded on truncated pieces (n = 2) (Figure 14A), a burin (n = 1), and a bifacial knife (n = 1) (Figure 14B). The truncated blade and the bifacial knife (Figure 14) were used for cutting. The right lateral edge of the knife remained roughly shaped, and the opposite edge was retouched to a sharp tip. The left edge adjoining the tip is rounded and covered by greasy polish, and tiny scratches parallel to the edge are visible (Figure 14B). Blank blades (n = 2) were used for sawing bone/antler. The determination of the use failed for nine artifacts. Blades (n = 3) and retouched flakes (n = 2) having a weak polish indicate a short usage time. Retouched blades (n = 2), an end-scraper, and a retouched point bear intense traces of wear and hafting, which suggest storage and reutilization of the same tool. The lack of use-wear traces on the bifacial thinning flakes (n = 25) proves no re-sharpening of used bifacial tools at the site.

Adornments

Bárta (1988) reported pendants made of flat limestone pebbles, without specifying their manufacturing technology and the number of finds. All pebble pendants were found in area B in association with the BLP lithic industry (layer B–1).

The collection consists of 14 modified pebbles, of which 13 are drilled and one shows the mark of drilling, although a penetrating hole was not achieved (Figure 15A). Except for one, all the drilled specimens were made of white quartzite pebbles. The exception is a greyish-brown sandstone pebble. A total of eight specimens of the drilled pebbles are complete, and five are broken. The breakage always occurred at the eye of the pendant. The pendant eye was made in each case by perforating both faces of the pebble. The eyes are therefore biconical in section. The outline of the quartzite pebbles are naturally tear-drop or oval, while the one sandstone item is circular in shape. The original outline of the pebble always remained intact.

Two items were further decorated with paired parallel incised lines on the edges of the pebbles (Figure 15A: 1–2). One pendant has five pairs of lines on one edge and six pairs of lines on the other edge (Figure 15B: 1). The second incised pebble has three pairs of lines (Figure 15B: 2).

By length, the pendants can be divided into two groups: greater than 35 mm and shorter than 25 mm. By thickness, most items are thinner than 8 mm. By width, most are narrower than 25 mm. The sandstone item is always an outlier. The incised items belong to the larger kind of pendant. Most broken items and the unfinished specimen belong to the smaller kind. It is unclear whether the broken items were damaged during production or while in use.

Apart from the pierced pendants, blanks for making pendants were also found solely in area B. A total of 42 small, flat pebbles were found by Bárta in the 1980s, and 41 items were found in 2017. The majority of these pebbles are quartzite (n = 71), two pebbles are fossils, one is granite, and the rest are limestone or sandstone. The origin of the pebbles is still unclear, since Bošáčka gravel is entirely composed of limestone pebbles, and the Váh valley gravel contains mostly limestone and sandstone pebbles, rarely radiolarite pebbles, and hardly any quartzite.

The only personal ornament of layer A2–3 in area A2 is a pierced canine tooth from a red deer (*Cervus elaphus*) recovered in the 1980s but which remained unpublished (Figure 15C). The eye of the pendant is broken and was made at the root of the tooth by perforating from opposites faces, similarly to the drilling of the pebble pendants in area B. Therefore, the shape of the hole is also biconical, and the pendant's shape again resembles a tear-drop.

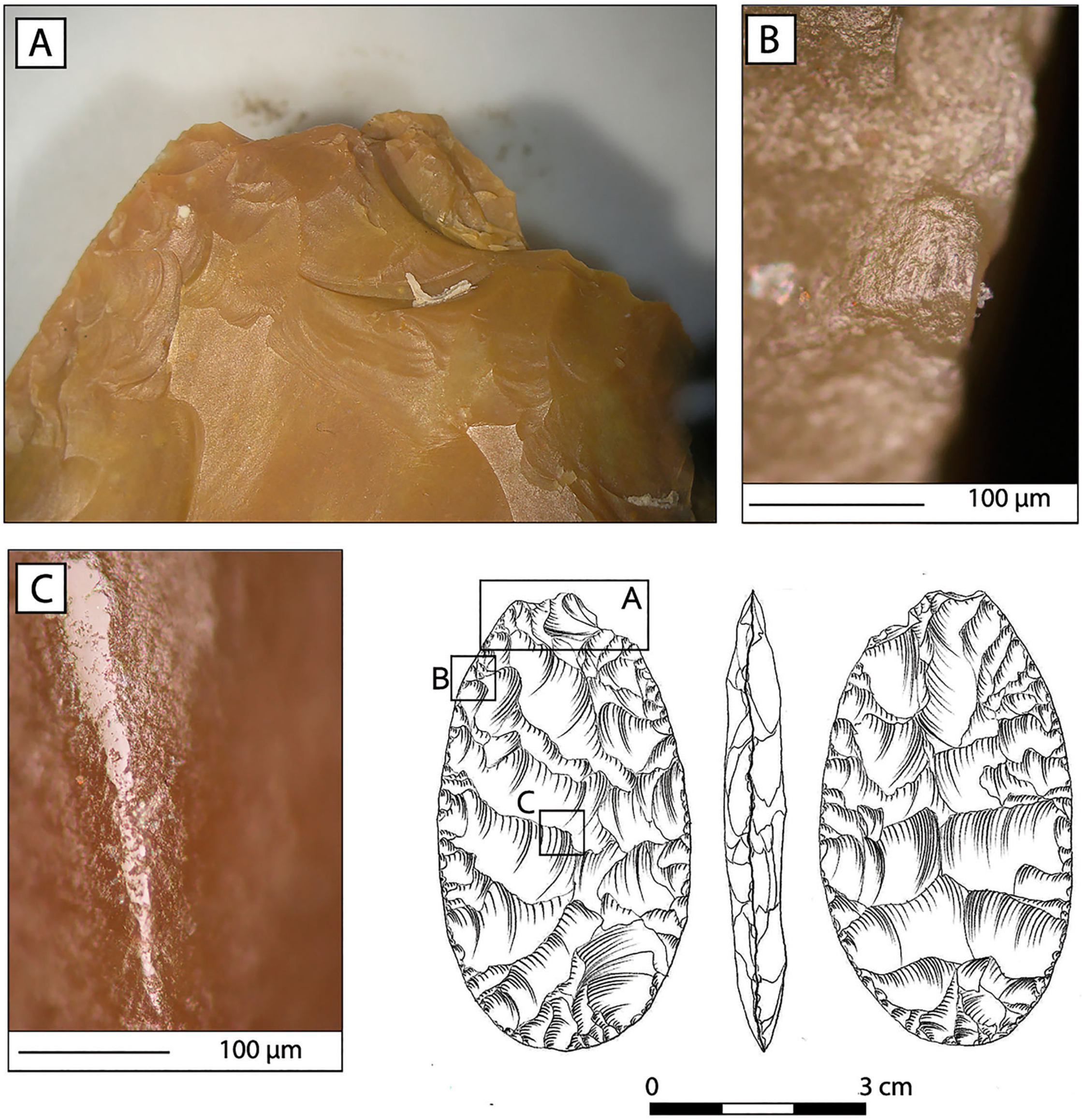

Figure 13. A bifacial leaf point from excavation area B, layer B–1, with impact fracture (A), use-wear on the edge (B), and hafting polish on the surface (C).

Discussion and Conclusions

The most awaited question to answer in regard to the archaeological record of TrB human occupation is the stratigraphic correlation between areas A and B. Former attempts (Verpoorte 2002; Vlačiky et al. 2013) were unsuccessful in accomplishing this task, mainly due to the fact that stratigraphic depth data of the 1980s was insufficient to reconstruct the order of the radiocarbon samples because of the steep slope of the Pod Tureckom area behind the Turecký Vrch. This situation was responsible for covering the archaeological layers with significantly varying thicknesses of sediments between areas A2 and B. Therefore, the method of Verpoorte (2002) that sorted the radiocarbon dates and the archaeological layers according to depth data resulted in a mixed order of the human occupation. Another issue that caused inaccuracy in the chronology of the site arose from Bárta's layer numbering. Verpoorte (2002) and Vlačiky and colleagues (2013) provided layer numbers for the dates of the 1980s arranged ascending from top to bottom. However, the archives of the 1980s excavations and the Gliwice Radiocarbon Laboratory include a radiocarbon date submission sheet on which Bárta numbered the layers descending from bottom to top (Figure 3A).

As best we can establish, the earliest human occupation at TrB is found in layer B–2, dated to 38.3–35.8 kya. This period is largely coeval with the GI-8 interstadial (Rasmussen et al. 2014), which explains the soil formation found related with layer B–2. This layer can be correlated with the lowest archaeological layer that Bárta found in an Interpleniglacial soil in area A1. Besides the same stratigraphic position, the low number of artifacts and the lack of Gravettian character also coincide with the features presented by Bárta (1988) for the lowest layer. The thin list of tool types does not allow specification of the cultural affiliation of this lithic industry. In western Slovakia, Dzeravá skála Cave occupation yielded Aurignacian osseous points dated to 38.3–33.2 kya (Davies and Hedges 2005); in Moravia, modern human teeth at Mladeč Cave date to 36.2–34.3 kya (Wild et al. 2005); and, at Stránská Skála, Aurignacian dates fall between 38.7 and 31.8 kya (Svoboda 2003). Based on the chronological overlap of these sites, we suspect that layer B–2 belongs to the Aurignacian occupation of the western Carpathians.

The next occupation is in layer A2–3. This layer yielded the densest archaeological remains, being the main Gravettian occupation by the definition of Bárta (1988). The lithic toolkit contains all the armatures of the Late Gravettian of central Europe (Lengyel 2016, 2018; Lengyel and Wilczyński

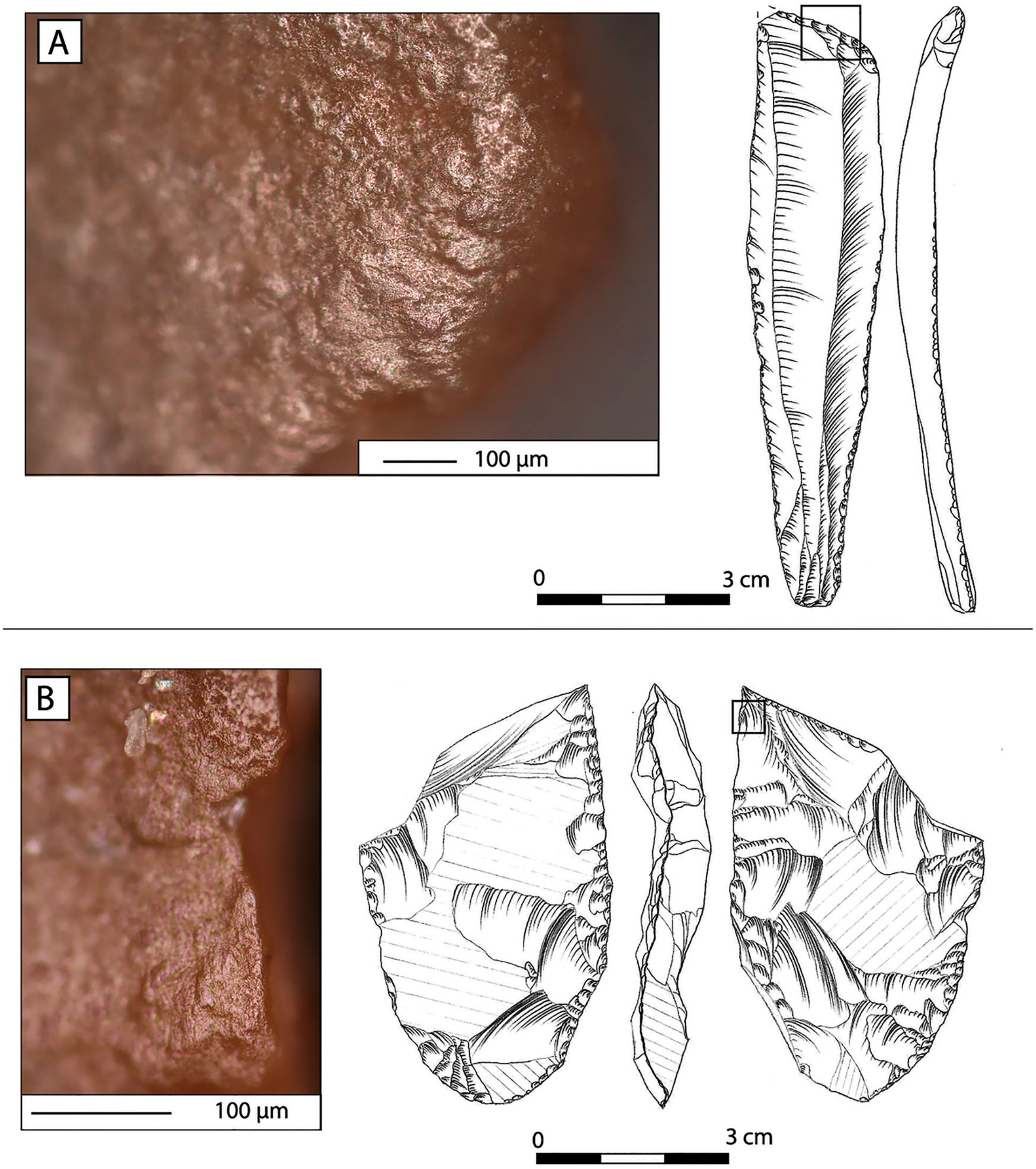

Figure 14. Use-wear traces on a truncated blade (A) and a bifacial knife (B) of excavation area B, layer B–1.

2018). The age 30.5–29.0 kya also falls into the span of the Late Gravettian chronology (Lengyel and Wilczyński 2018; Wilczyński et al. 2020) and correlates with the GS-5.1 stadial phase (Rasmussen et al. 2014). Besides the radiocarbon ages, the geological data showed this layer was embedded within a windblown sediment, partially redeposited in slope position, which is typical for stadial events. The sole artistic object is a pendant made of a deer canine tooth. This raw material is absent in the Pavlovian of southern Moravia, where personal ornaments were most often made of fox and wolf incisors and canines (Lázničková-Galetová 2011; Wojtal et al. 2012, 2018), and rarely from reindeer teeth (Wojtal et al. 2012). A single exemplar of a pendant made of red deer canine was found at Lubná II Late Gravettian site, of a similar age, which is decorated by incisions (Šída et al. 2015, figs. 154, 155).

Superposing layer A2–3, layer A2–2 also belongs to the Late Gravettian occupation of the area on the basis of the backed bladelets, the rectangle of Late Gravettian type, the fléchette, and the Vachons point (Lengyel 2015, 2016, 2018; Wilczyński 2016). The sole difference between A2–3 and A2–2 is the lack of Gravette/microgravette points in A2–2. The calibrated radiocarbon age 29.0–27.1 kya falls into the chronological position of this type of lithic industry of central Europe (Lengyel and Wilczyński 2018; Wilczyński et al. 2020), which is coeval mostly with the GS-4 stadial and overlaps GI-4, GI-3, and GS-3 (Rasmussen et al. 2014).

On the basis of the radiocarbon measurements, the next human occupation is the BLP assemblage of area B in layer B–1, dated to between 27.7 and 25.9 kya. The period between 27.7 and 25.9 kya corresponds with the GS–3 stadial leading to the Last Glacial Maximum (Rasmussen et al. 2014). The mollusc faunal spectra support the radiometric age correlation and showed identity between layers B–1 and A2–1. The molluscan fauna of layers B–1 and A2–1 include species with cold preferences, indicating the coldest period in the stratigraphic sequence at TrB, which corresponds with the development of the LGM in the region. Also, the gley soil formation in layer B–1, which is the only periglacial phenomenon in the strata, further supports the estimated early LGM chronological position of layer B–1.

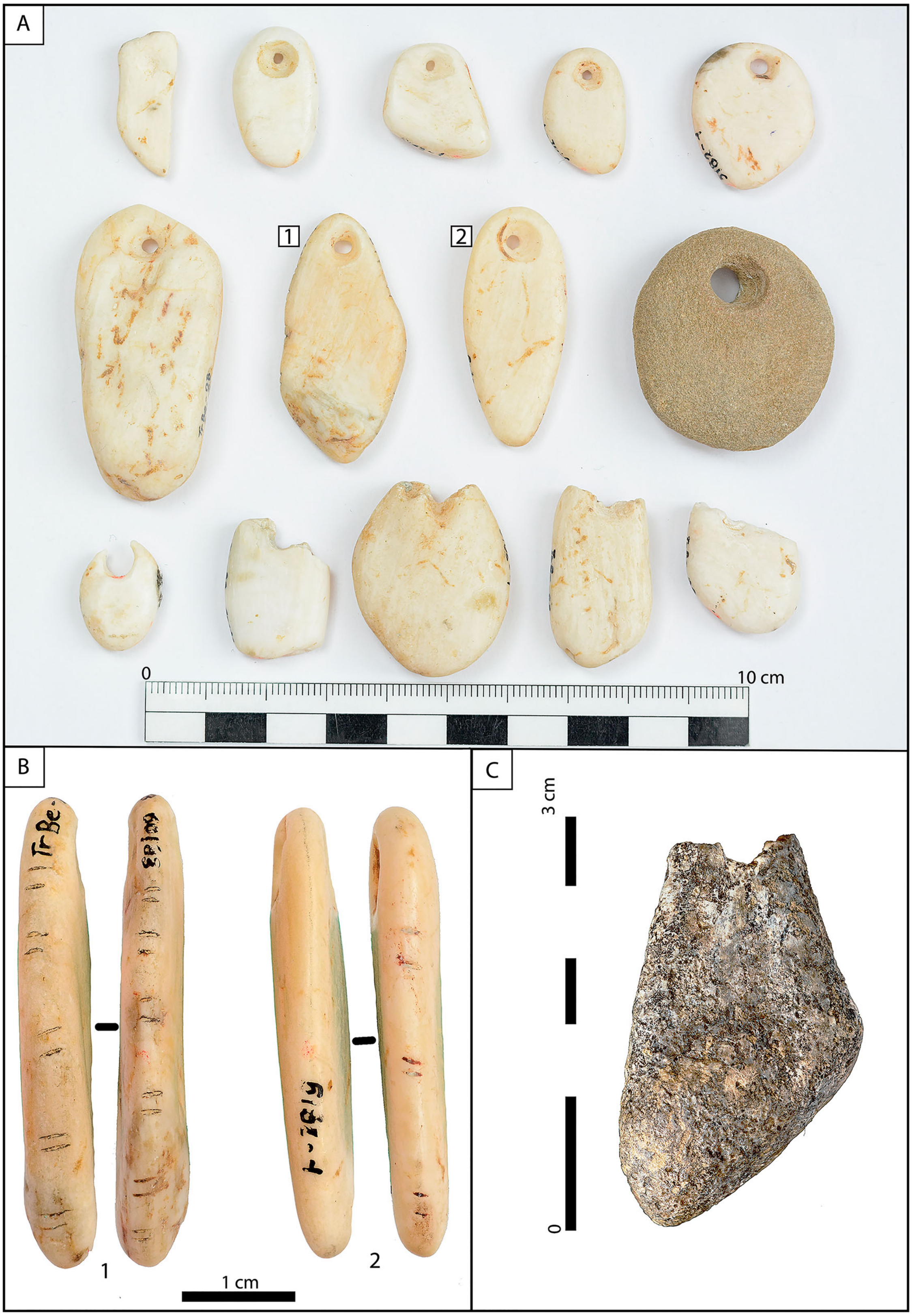

Figure 15. A) Pierced pebble pendants of layer B–1; B) two of which have incisions on their edges; and, C) the tooth pendant of layer A2–3.

However, the results of charcoal analysis support this only partially.

The charcoal remains mainly derived from the human gathering of firewood, and it is likely that all available wood was chosen for fuel. In the Weichselian glacial conditions of central Europe, *Pinus* and *Picea* or *Larix* are the most frequent taxa of trees found in the charcoal assemblages from archaeological sites before and during the LGM (Willis and van Andel 2004). The stratigraphic record at TrB shows a change in the distribution of tree species in area A2 from the bottom to the top. The widest spectrum of trees was found in layers A2–3 and B–1, in similar proportions. Layer A2–2 yielded only *Picea* or *Larix*, and layer A2–1 is the only one to include *Pinus sylvestris-mugo*. This distribution shows that during occupations A2–3 and B–1, a possibly similar vegetal environment characterized the Váh valley. There is a dominance of *Picea* or *Larix* charcoal in layers A2–2 and B–2, but it is also probable that the unspecified coniferous charcoal fragments belong to *Pinus*. However, we suspect that a change in charcoal assemblages from *Picea* or *Larix*-dominated layers in A2–3, A2–2, and B–1 to the presence of *Pinus sylvestris-mugo* in A2–1 might be significant in the vegetation at the beginning of the LGM. Based on recent ecological conditions, both trees *Picea* or *Larix*, most likely *Picea abies* and *Larix decidua* in central European sites, can be regarded as growing on semi-permanently frozen soils, although *Larix decidua* is better adapted to colder conditions and nowadays grows in the mountains, together with *Pinus cembra* above *Picea abies*-dominated forests. *Pinus cembra* and *Pinus sylvestris*, together with *P. mugo*, can also grow under conditions of a full-glacial environment (Willis, Rudner, and Sümegi 2000). The slight decrease in coniferous wood charcoal abundance in layer A2–1 may also indicate a cooling climate. Out of the 18 snail species identified, four have woodland preferences and another four prefer intermediate environments between open habitat and woodland. Except the 89.1% in layer A2–3, the proportion of snails preferring open habitat makes up 94.4–99.8% of all species in each layer. Thus, compared to layers A2–2, B–1, and A2–1, during the formation of layer A2–3, a slightly more expanded forest cover can be reconstructed, similarly to what has been recovered from Pavlovian sites dated to 31 kya in nearby Moravia (Beresford-Jones et al. 2010; Cichocki, Knibbe, and Tillich 2014; Svoboda et al. 2015), while the coniferous trees may have formed only patches of trees near the site at the onset of the LGM. These results indicate that LGM environmental conditions might have been fully formed already during the formation of layer A2–1 in the Váh valley.

The archaeological, radiometric, paleobotanical, stratigraphic, and snail faunal evidence straightforwardly generates an argument for the cultural classification of layer B–1 in the UP in ECE. BLP-maker hunter-gatherers were primarily associated with the Middle to Upper Palaeolithic transitional period, the EUP (Škrdla et al. 2014), and the Late Gravettian (Simán 1990; Lengyel, Mester, and Szolyák 2016), but never occurred postdating the Late Gravettian. The dating results argue against a MP–UP transitional Szeletian occupation at the TrB site; this phase is dated to 37–44 kya in the region (Kaminská, Kozłowski, and Škrdla 2011; Škrdla et al. 2014; Hauck et al. 2016). The lack of Gravettian armatures in TrB Layer B–1 does not allow identifying this assemblage as Late Gravettian with bifacial leaf points, because each Late Gravettian assemblage with leaf points has at least three further types of the Gravettian armature, besides the bifacial tools and the retouched points (Novák 2008; Lengyel, Mester, and Szolyák 2016), which are missing in the layer B–1 assemblage. The lack of diagnostic Gravettian tool types in the latest human occupations at TrB actually corresponds with the gradual disappearance of Gravettian type armatures in the archaeological record of ECE during the transition from the Late Gravettian to the Epigravettian as the LGM developed to its apex (Lengyel 2016, 2018; Lengyel and Wilczyński 2018). The pendants made of small pebbles in layer B–1 occasionally appear in both the Late Gravettian (Kazior, Kozłowski, and Sobczyk 1998, fig. 36) and Early Epigravettian assemblages (Montet–White 1990, fig. IX–14). The layer B–1 lithic assemblage also presents a shift in the raw material economy compared to layers A2–3 and A2–2, having been made mostly from the local radiolarite. This fits a general tendency found in the archaeological record of the Carpathian Basin, in which the lithic raw material procurement strategy changes from distant to local as the Late Gravettian fades out and the Early Epigravettian emerges at the onset of the LGM (Svoboda and Novák 2004; Kozłowski 2013; Lengyel 2014, 2018). Therefore, the chronological position of layer B–1's BLP industry is unique in ECE. A similar archaeological record is found in western Europe, where the formation of the BLP-producing Middle Solutrean was linked with the global cooling by the LGM (Banks et al. 2009; Renard 2011). Currently, it is unwise to interpret the TrB BLP assemblage as Solutrean. Most likely, we need to regard the BLP as a tool type that emerged in the Late Middle Palaeolithic in Neanderthal technology (Richter 2016) but kept recurring with uneven frequency throughout the Bohunician (Škrdla 2017), Jankovichian (Mester 2017), Szeletian (Mester 2018), Aurignacian (Oliva 1990), and Gravettian (Lengyel, Mester, and Szolyák 2016) up to the LGM, and it is not a distinctive archaeological index fossil.

In the sequence of human occupation at TrB, it is only layer A2–1 that fully represents Early Epigravettian features of ECE (Lengyel 2018) by lacking any piece of distant lithic raw material and Gravettian armature. The dating of layer A2–1 places the occurrence of the Early Epigravettian type lithic industry to ca. 26.0 kya, which is two millennia earlier than expected. The occurrence of the Epigravettian was generally found to have been coeval with the onset of the LGM (Lengyel and Wilczyński 2018), based on chronologies that roughly date this event to 25–23 kya (Hughes and Gibbard 2015; Hughes et al. 2016; Stroeven et al. 2016; Patton et al. 2017). The archaeological results of the research at TrB, however, provide the first radiocarbon ages of the Epigravettian, fitting the onset of the LGM defined by Clark and colleagues (2009), which showed that the terrestrial ice sheets reached their maximum extent by 26.5 kya at the earliest on a global scale, based on the Greenland ice core GS-3 stadial record (Hughes and Gibbard 2015). Therefore, there is a chance that archaeological records linked with the onset of the LGM in ECE might produce earlier radiometric ages than usually expected.

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Disclosure Statement

No potential conflict of interest was reported by the author(s).

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