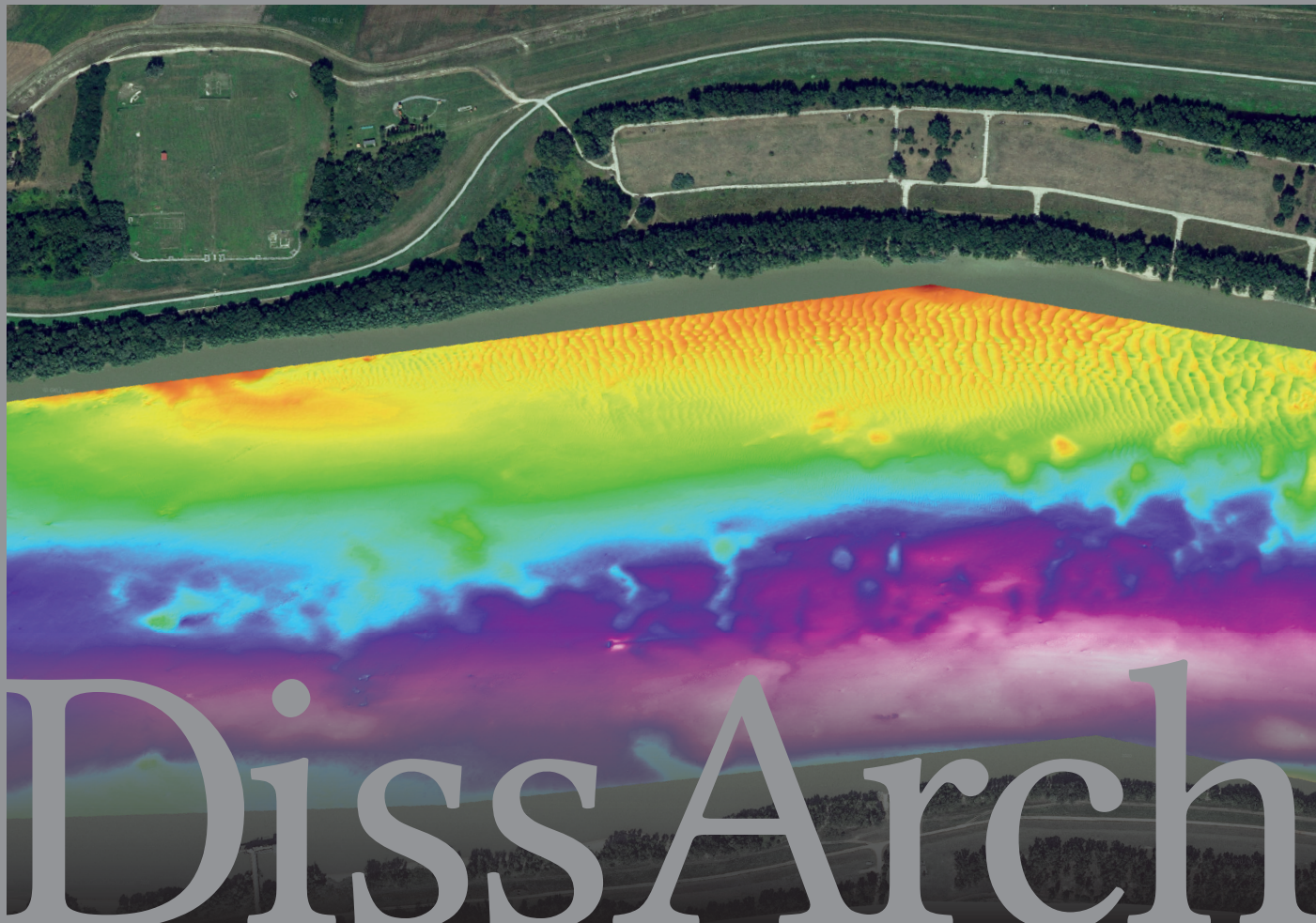


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ex Instituto Archaeologico

Universitatis de Rolando Eötvös nominatae



Ser. 3. No. 13. | 2025

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ex Instituto Archaeologico
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Szekszárd-Palánk and the postglacial recolonization of the Pannonian Basin

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Abstract: Szekszárd-Palánk, located in South Transdanubia (Hungary), was discovered in the late 1950s and has yielded several hundred archaeological finds, including lithics and faunal remains. Initially, the site was regarded as ‘the latest Palaeolithic’ site in Hungary; later, it was reclassified as an Early Mesolithic industry bridging the Palaeolithic–Mesolithic transition. More recently, the site was proposed to be evidence for the continuity of Epigravettian hunter-gatherers from the Late Glacial to the Early Holocene. However, recent findings regarding the Late Epigravettian in the Pannonian Basin suggest that these populations vanished with the onset of Greenland Interstadial 1. To address this discrepancy, the authors reassessed the lithic assemblage and archaeozoological remains, obtained new radiocarbon dates, and conducted

a new excavation to re-evaluate the stratigraphy and geomorphological processes of the site. Our new absolute dates place the site firmly between 11.6–10.4 ka cal BP, and techno-typological analysis attributes it to the Early Holocene Final Epigravettian. These results indicate that hunter-gatherers largely abandoned the Pannonian Basin during Greenland Interstadial 1 and Greenland Stadial 1. This population vacuum ended at the onset of the Preboreal with the arrival of hunter-gatherers from the Balkans or Adriatic coastlines. The repopulation process appears to have been influenced by palaeoecological factors, with the establishment of the pioneering Early Holocene Final Epigravettian settlement in South Transdanubia coinciding with global sea-level rise Meltwater Pulse Event 1B.

Keywords: Early Holocene, Final Epigravettian, mobility, pioneer settlement

Introduction

The Late Glacial period in Eastern Central Europe is marked by diverse cultural units and technological adaptations.¹ On the North European Lowland, the Late Magdalenian,² the Arched-Backed Point, Shouldered Point, and Tanged Point Technocomplexes developed,³ whereas in Southern Europe the Late Upper Palaeolithic Epigravettian persisted.⁴ In Eastern Central Europe, the archaeological record of Late Glacial and the Early Holocene transition however has long been a subject of debate.⁵

In Hungary, two approaches have emerged regarding the continuity between Late Glacial and Early Holocene industries: one posits a discontinuity,⁶ while the other supports a model of cultural and populational continuation, suggesting that the Mesolithic in the Pannonian Basin originated in the local Late Upper Palaeolithic Epigravettian, which had been adapted to the Holocene environmental conditions.⁷ Recent reassessments have revised the classification of several Palaeolithic sites in the inner Pannonian Basin that previously were designated as ‘Epipalaeolithic’ or as Late Glacial occupations.⁸ The revision also pointed out the unreliable nature of previous lithic or chronological evidence from the Pannonian Basin in the Late Glacial period. Thus, the validity of the ‘Epipalaeolithic’ period was challenged, and its elimination from the regional chronological system was proposed.⁹ The onset of the Late Glacial hence was interpreted as a period with population hiatus, which lasted until the emergence of the Mesolithic.¹⁰ Therefore, the occupational hiatus in Late Glacial affected the understanding of the Pleistocene–Holocene transition and the onset of the Mesolithic cultures in Hungary.

To clarify the potential cultural and population continuity between the Late Glacial and Early Holocene, we reassessed the foundation of the ‘continuity theory’; the lithic assemblage of Szekszárd-Palánk open-air site in South Transdanubia, Hungary, incorporating data from newly conducted excavations and absolute dating. The results refine the absolute chronology of the site and provide a new interpretation of the emergence of Holocene hunter-gatherer societies in the Pannonian Basin.

1 KOZŁOWSKI – KOZŁOWSKI 1979.

2 POŁTOWICZ-BOBAK – BOBAK 2022.

3 BURDUKIEWICZ 2011; SOBKOWIAK-TABAKA 2017.

4 FASSER *et al.* 2024; KACZANOWSKA – KOZŁOWSKI 2018; VUKOSAVLJEVIĆ 2023.

5 PŁONKA *et al.* 2020; KERTÉSZ 2002.

6 T. DOBOSI 1999; T. DOBOSI 2001.

7 KERTÉSZ 2002; KIRÁLY – KERTÉSZ 2023.

8 SZEGEDI *et al.* 2023; SZEGEDI *et al.* 2024a; SZEGEDI *et al.* 2024b.

9 SZEGEDI *et al.* 2023.

10 LENGYEL *et al.* 2021; SZEGEDI *et al.* 2023.

Materials and methods

Szekszárd-Palánk site and its location

Szekszárd-Palánk is located in South Transdanubia, Hungary, at the foot of the Szekszárd Hills, on the high floodplain of the Danube, northeast of the town of Szekszárd (Fig. 1). The site is situated on a bank of a former oxbow meander at an elevation of approximately 90.5 meters.

The site was discovered in 1957 during construction works of the embankment. At first, primarily Avar Period graves (7th–9th century AD) were uncovered, but the presence of lithics beneath these graves was perceived. Following this discovery, László Vértés led rescue excavations over several seasons. During his investigations of an area of 60 square meters, a consistent stratigraphy was reported in all parts of the site,¹¹ as follows: Layer 1: the uppermost humic grey sediment, rich in carbonates (ca. 0–50 centimetres), Layer 2: accumulation horizon (ca. 20 centimetres), Layer 3: light yellow, loess-like mud layer, Layer 4: loess-like sediment, embedding the archaeological layer, Layer 5: sandy layer with an abundant amount of mollusc shells.

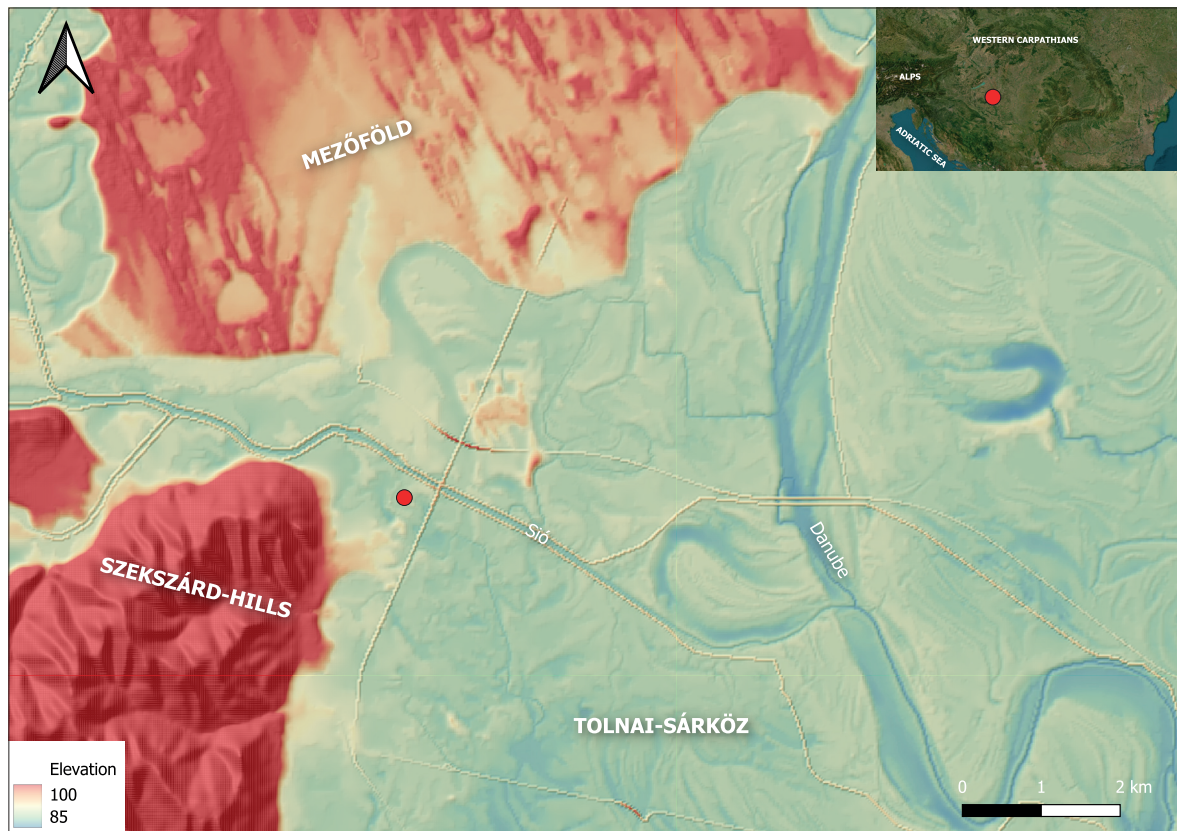


Fig. 1. The environs of Szekszárd-Palánk site (red dot) on a digital elevation model.

Field work in 2023 and the description of stratigraphy

A one-week fieldwork was conducted in 2023, preceded by meticulous preparation involving data acquisition limited by a documented disturbance that had occurred during the 1950s and 1960s. To ensure that the trenches did not compromise these previously affected areas or intersect with modern utility lines, we utilized field maps created by the original excavators,¹² a 1966 aerial photograph,

¹¹ VÉRTES 1958; VÉRTES 1962.

¹² VÉRTES 1962; SALAMON 1968.

satellite images from Google Earth and photos taken during the excavation based on landmarks that are still visible today. By integrating and georeferencing this data, we successfully delineated the boundaries of the original excavations (Fig. 2). In preparation for the fieldwork, we also conducted geomagnetic prospection and coring to determine the location of the trenches.

Three trenches (Trench 1, Trench 2, and Trench 3), covering a total area of 12 square meters, were subsequently opened adjacent to these boundaries to uncover stratigraphic layers undisturbed by modern human activity.



Fig. 2. Excavation trenches at Szekszárd-Palánk on an aerial photograph from 1966 (source: www.fentrol.hu).

The soil horizons and layers in the excavated trenches were described following the Hungarian¹³ and international¹⁴ standards. Colours of soil horizons and geological layers were identified using the Munsell Soil Colour Chart. Calcium carbonate content in the field was identified using 1 M hydrochloric acid (HCl) solution.

Soil samples were obtained from each soil genetic horizon or layer for further investigations at the laboratory of the National Food Chain Safety Office. The soil samples selected for laboratory analysis were characterized based on fundamental soil chemical and physical parameters to gain a more accurate understanding of the development of the individual soil layers. The pH value [pH(H₂O)] and the mass percentage of total soluble salts (salt%) were determined using potentiometric measurements according to the MSZ 08-0206-2 standard.¹⁵ The carbonate content (CaCO₃%)

13 MICHÉLI *et al.* 2024.

14 IUSS WORKING GROUP WRB 2022.

15 MSZ 08-0206/2-78 (1978): A talaj egyes kémiai tulajdonságainak vizsgálata. Laboratóriumi vizsgálatok (pH érték, szódában kifejezett fenoftealin lúgosság, vízben oldható összes só, hidrolitos (y1 érték) és kicserélődési aciditás (y2 érték). Magyar Szabványügyi Hivatal, Budapest.

was measured with a Scheibler calcimeter, also in accordance with the MSZ 08-0206-2 standard. The physical properties of the samples were characterized using the Arany plasticity index (KA), with measurements conducted as described in the MSZ 08-0205 standard.¹⁶ The humus content (H%) was measured according to the MSZ 21470-52 standard.¹⁷

Particle size analysis

A total of six sediment samples collected from each stratigraphic layer, were analysed at the Szentágotthai Research Centre, University of Pécs. Grain size measurements were conducted using a Malvern Instruments Mastersizer 3000 laser diffractometer equipped with a Hydro LV wet dispersion unit. Prior to granulometric analysis, the samples underwent chemical pretreatment following the established protocol.¹⁸

The particle size statistics and volume percentage values of different fractions within the bulk sediments were calculated using output data from the Mastersizer 3000 software and processed with version 9.1 of GRADISTAT.¹⁹ Particle size classification and sediment type comparisons were based on the published data.²⁰

Lithics

Lithic raw materials were identified macroscopically using the Lithotheca Comparative Raw Material Collection of the Hungarian National Museum.²¹ Radiolarites from the Transdanubian Mountains were not subdivided into categories but were collectively classified as Bakony radiolarites.²² The raw material procurement zones follow the classification used in Hungarian archaeological literature, which distinguishes four categories: local (0–10 km), regional (10–100 km), distant (over 100 km), and Transcarpathian sources.²³

The lithic assemblage was divided into eight technological categories:²⁴ blades, blade cores, crested blades, debris, flakes, flake cores, neo-crested blades, and platform rejuvenating flakes. Debitage methods were classified into three categories: unidirectional, bidirectional, and multidirectional, based on the configuration of striking platforms. A single striking platform, opposed striking platforms, or multiple striking platforms, respectively. The identification of percussion techniques was based on the following parameters: presence of overhang and impact point, butt and lip formation.²⁵ Lithic artifacts were measured along the technological axis to record their length, width, and thickness.

The typological evaluation adhered to the classification system established for the Middle and Late Upper Palaeolithic of Hungary.²⁶ This system categorizes retouched tools into two primary groups:

- 16 MSZ 08-0205 (1978): A talaj fizikai és vízgazdálkodási tulajdonságainak vizsgálata (Arany-féle kötöttségi szám, a leiszapolható rész, a higroszkóposság és a térfogattömeg meghatározásával). Magyar Szabványügyi Hivatal, Budapest.
- 17 MSZ 21470-52 (1983): Környezetvédelmi talajvizsgálatok. Talajok szervesanyag-tartalmának meghatározása. Magyar Szabványügyi Hivatal, Budapest.
- 18 KOVÁCS 2008.
- 19 BLOTT – PYE 2001.
- 20 BLOTT – PYE 2012.
- 21 T. BIRÓ – T. DOBOSI 1991.
- 22 SZILASI 2017.
- 23 LENGYEL 2018.
- 24 INIZAN *et al.* 1999.
- 25 INIZAN *et al.* 1999.
- 26 LENGYEL 2016.

domestic tool types, which include endscrapers, burins, retouched flakes and blades, truncated flakes and blades, borers, and splintered pieces; and armatures, comprising backed blades, truncated-backed blades, and backed points. Geometric microliths were classified as armatures, as these implements are widely regarded as components of composite tools and hunting weapons.²⁷

Archaeozoology

The identification of bone remains was based on the comparative Archaeozoological Collection of the Hungarian National Museum. The examined remains (n=16) are found under the inventory numbers 62.46.1–62.46.8.

Radiocarbon dating

The newly obtained AMS radiocarbon dates were measured at the Ede Hertelendi Laboratory of Environmental Studies (Debrecen, Hungary). The chemical pre-treatment methods for the samples are detailed in previous publications.²⁸ All the mentioned absolute dates were calibrated using OxCal 4.4, with a 95.4% probability.²⁹ All the animal bone samples were sourced from the Archaeozoological Collection of the Hungarian National Museum. In all cremated bone samples, cremation changed the bone's chemical structure, making the inorganic apatite the primary source for dating rather than the original collagen. Since cremated bones are not a typical sample type for radiocarbon measurement, the measurement error for these samples was doubled.

Chronology

The Late Glacial corresponds to the GI-1 (14.7–12.9 ka cal BP) and GS-1 (12.9–11.7 ka cal BP) phases in the Greenland ice-core records, dated to 14.7–11.7 ka cal BP.³⁰ The beginning of this period is characterized by a gradual shift in the Pleistocene herbivore megafauna, along with the rapid spread of coniferous forests in the Pannonian Basin.³¹ The Early Holocene marks the start of the Holocene epoch and includes the Preboreal (11.7–10.2 ka cal BP) and Boreal (10.2–8.2 ka cal BP) phases, spanning 11.7–8.2 ka cal BP.³² The division between the Late Glacial and Early Holocene is set at 11.7 ka cal BP, which defines the base of the Holocene epoch.³³

Cultural taxonomy

The archaeological record of the Late Glacial in the Pannonian Basin, following the Late Epigravettian, is defined as the Final Palaeolithic.³⁴ This period is also sometimes referred to as the Late Palaeolithic.³⁵ However, we consider the term Late Palaeolithic potentially confusing, as the final stage of the Upper Palaeolithic in Eastern Central Europe is traditionally termed the Late Upper Palaeolithic.³⁶ For this reason, we adhere to the definition of Final Palaeolithic.

27 BURDUKIEWICZ 2005.

28 MOLNÁR *et al.* 2013; MAJOR *et al.* 2018; MAJOR *et al.* 2019.

29 BRONK RAMSEY 2009; REIMER *et al.* 2020.

30 RASMUSSEN *et al.* 2014.

31 MAGYARI *et al.* 2019; MAGYARI *et al.* 2022.

32 BABINSZKI *et al.* 2023.

33 WALKER *et al.* 2009.

34 SZEGEDI *et al.* 2023.

35 KIRÁLY – KERTÉSZ 2023.

36 LENGYEL 2016; LENGYEL 2018.

The Early Holocene corresponds to the Mesolithic archaeological period in the Pannonian Basin.³⁷ Initially, the label of ‘Early Mesolithic’ was applied to sites dated to the Boreal period, as no earlier sites were recognized.³⁸ The exception was Szekszárd-Palánk, which has been variously classified as the ‘latest Palaeolithic’,³⁹ Early Mesolithic,⁴⁰ or as a Pleistocene–Holocene transitional industry.⁴¹

Results

Stratigraphy

Different successions of layers were observed in all the three trenches. In Trench 1, the layers were primarily of recent anthropogenic origin. In Trench 2, the complete loss of soil horizon B was observed due to agricultural activity. Both Trench 1 and Trench 2 can be identified as Terric Anthrosol (Calcic, Loamic).

In Trench 3 (Fig. 3), we found lesser anthropogenic soil disturbance. This trench was the closest to the original excavation areas in 1957–1960.

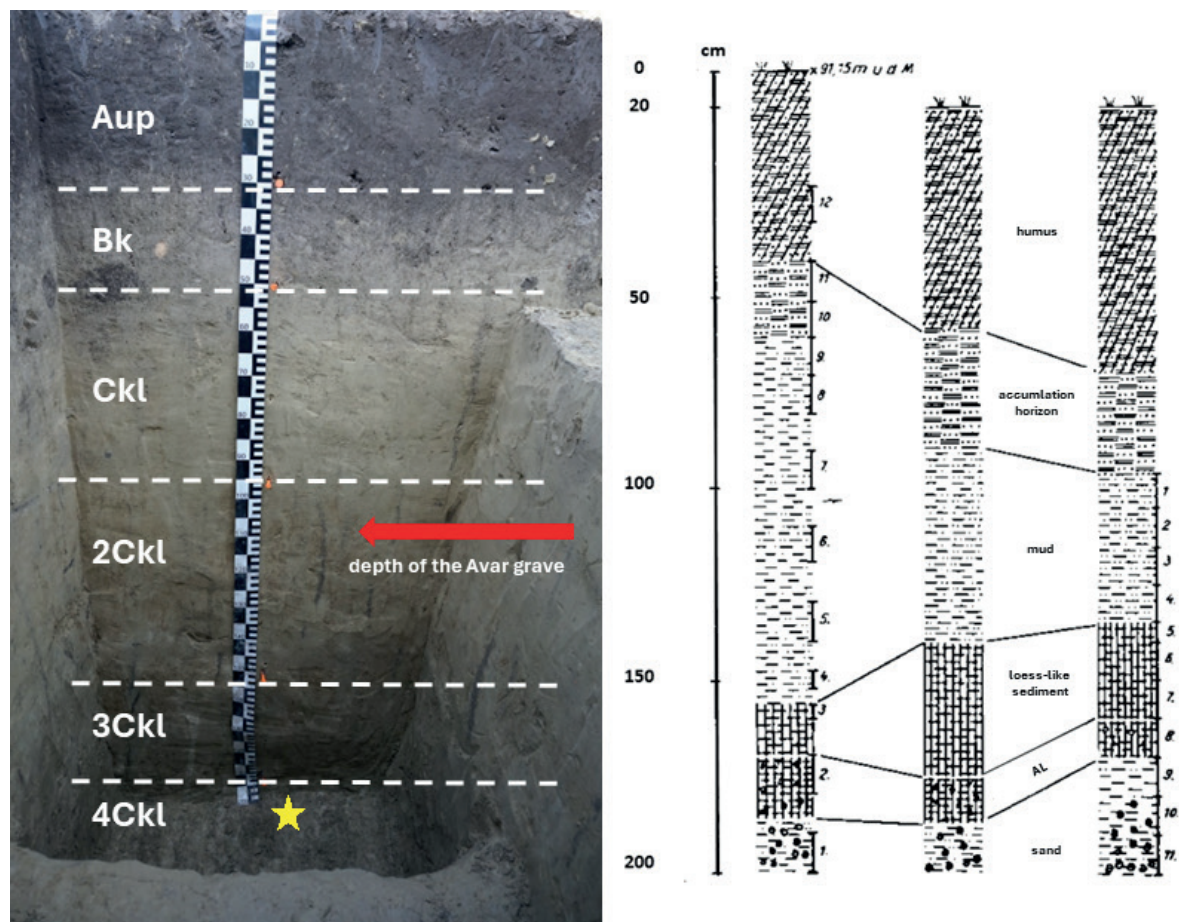


Fig. 3. Stratigraphy of the site compared to the stratigraphy described by Vértés (VÉRTES 1962). Yellow star: mollusc sample (DeA-1377).

37 SZEGEDI *et al.* 2023.

38 KERTÉSZ *et al.* 1995.

39 VÉRTES 1962.

40 KERTÉSZ – DEMETER 2020.

41 KIRÁLY – KERTÉSZ 2023.

Trench 3 was located at an elevation of 90.5 meters. The surface sloped moderately, facing south. When compared to the original elevation of approximately 91.153 meters described by László Vértés, a significant soil degradation due to agricultural activity can be inferred in the form of an abrupt lower boundary at the ploughing depth in the eastern wall of the trench. Overall, the humus content is low in the Aup horizon, and it further decreases in the Bk horizon and is negligible in the parent material and lower sediment layers (Tab. 1). Due to the thickness, organic carbon content and colour, the Aup horizon meets the criteria of a mollic diagnostic horizon. Although base saturation was not measured, the alkaline pH indicates that it likely meets the criteria.

Tab. 1. Soil sample results.

Depth (cm)	Soil horizon/ layer	Color ⁴²		KA	humus (m/m %)	CaCO ₃ (m/m %)	total soluble salts (m/m %)	pH
		dry	wet					
0–30	Aup	10YR 4/2	10YR 4/3	38	1.43	14	< 0.02	8.12
30–50	Bk	10YR 6/4	10YR 5/2	36	0.647	24	< 0.02	8.37
50–95	Ckl	2.5Y 6/4	2.5Y 5/3	31	0.212	21	< 0.02	8.54
95–150	2Ckl	2.5Y 7/4	2.5Y 6/4	<25	0.12	17	< 0.02	8.62
150–190	3Ckl	2.5Y 8/4	2.5Y 6/4	37	0.108	23	< 0.02	8.52
190–	4Ckl	2.5Y 7/4	2.5Y 6/4	37	0.243	21	< 0.02	8.45

The high carbonate content, alkaline pH (>8), and low levels of water-soluble salts are consistent throughout the profile. KA is very similar in the horizons and layers, indicating loam and sandy loam texture classes, except for layer 2Ckl, which is sand with >25 KA. Leaching is not prominent, although the particularly high carbonate content in the Bk horizon and the presence of discontinuous concentrations, such as coatings and larger nodules in deeper layers, indicate the accumulation of secondary calcium carbonates. Consequently, the Bk and lower horizons and layers can be classified as calcic horizons. Reducing properties caused by groundwater saturation are evident through the accumulation of Fe[III] and Mn[IV] on soil aggregate surfaces below 50 centimetres, as well as higher Munsell values, meeting the diagnostic criteria for gleyic horizons. Reductive conditions are particularly pronounced in layer 4Ckl, which exhibits a high concentration of Mn[IV] (Fig. 4). This layer also contains a significant quantity of freshwater mollusc shells, albeit in a fragmentary state. To sum up, the soil profile can be described as a Calcic, Endogleyic Kastanozem (Mollic, Loamic).



Fig. 4. Gleyic properties on soil aggregate surfaces, layer 4Ckl.

42 Munsell Soil Colour Charts (1990). Soil Survey Manual. Vol. 18. U.S. Dept. Agriculture Handbook.

From a sedimentological perspective, the layers are uniform, mostly poorly sorted, with kurtosis predominantly mesokurtic. The curves are generally unimodal, and the skewness is slightly negative. A notable difference, also highlighted by the KA concerning the texture class of layer 2Ckl, stands out. According to measurements, this layer is classified as very slightly clayey silty sand, in contrast to the other layers (Fig. 5). The amount of clay particles is small, indicating a low degree of weathering processes. This observation aligns with the pedological interpretation, which suggests that the primary soil formation processes are humus formation, reducing conditions, and slight clay illuviation.

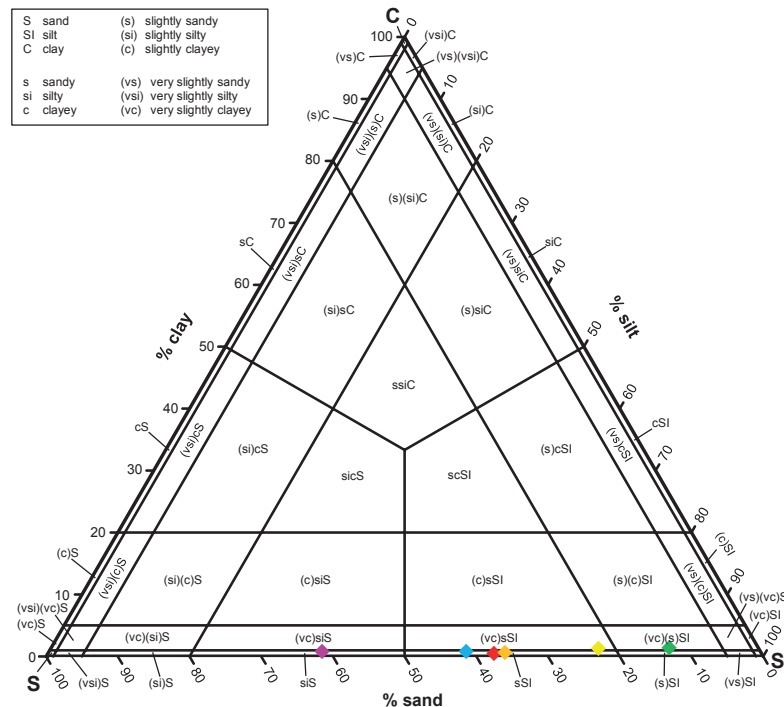


Fig. 5. Soil texture triangle. Red dot: A horizon; orange dot: Bk horizon; blue dot: Ckl horizon; pink dot: 2Ckl layer; yellow dot: 3Ckl layer; green dot: 4Ckl layer.

Lithics

Lithic raw materials at the site derived from various sources. We divided them into six categories. The outcome indicates that the lithic assemblage is dominated by radiolarites or radiolarian cherts from Transdanubia (Tab. 2). These raw materials are provenanced from both the Bakony and the Mecsek Mountains. The former category can be regarded as representing a regional raw material source, whereas the Bakony radiolarites can be classified as distant sources. Bakony radiolarites are recognized due to their distinctive reddish hue. The second most common raw-material category is a grey to bluish-brown chert, which in some cases displays multiple colour variants within a single piece, occasionally including blackish banding. Limnic silicites are likewise present in significant quantities; the majority of these specimens display characteristic white patination. A small subset of the artefacts, characterized by a deeper red tone not known among Bakony radiolarites were identified as Bosnian radiolarites.⁴³ A proportion of the raw materials could not be identified due to their fragmentary or heavily burnt condition.

The assemblage consists of debris as the most numerous category, followed by flakes, blades, flake cores, platform rejuvenation flakes, neocrested blades, burin spalls and blade cores (Tab. 3). The abundance of lithic debris, combined with the absence of original raw material nodules and cor-

43 T. BIRÓ *et al.* 2009.

tical pieces, indicates that knapping took place on site, while most likely the initial shaping of raw materials was carried out elsewhere. Most of the flake cores have multiple striking platforms (n=13) proving a constant reorientation of the flaking surfaces, with some evidences of bipolar anvil technique (Fig. 8.13–15).⁴⁴ Splintered pieces (n=7) are probably cores and products of the bipolar anvil technique.⁴⁵ The blade cores are unidirectional, although one plunging blade suggests bidirectional blade core exploitation (Fig. 8.12). The predominance of flake production is reflected in the flake-to-blade core ratio, with flake cores occurring eight times more frequently than blade cores.

In the case of complete flakes and proximal fragments (n=74) the lip formation on the ventral side is frequent (n=43) accompanied by the abrasion of the overhangs (n=68). These suggest the use of soft hammer percussion technique.⁴⁶ Overhangs of the laminar blanks were abraded, impact points are absent, and lip formation is frequent (n=17), which also suggests the use of soft hammer percussion. The production of longer blades (Fig. 6.22,24,31), seems to have been part of the operational sequence; however, during the knapping process, this tendency shifted toward flake production. The blades do not display inferior regularity characteristics of pressure flaking or indirect percussion (Fig. 6.17–31).

The metric data of the blades suggest that blade production at the site was relatively standardized, as indicated by the moderate standard deviation, reflecting a general target size with some degree of flexibility in production. In contrast, the standard deviation of flake lengths is high, indicating substantial variability. This pattern corresponds with the multidirectional core reduction strategy, suggesting an opportunistic flake production characterized by lower degrees of standardization (Tab. 4).

Tab. 4. Statistical measures of flakes and blades.

	No.	Mean	Median	Standard deviation	Minimum	Maximum
blades	18	30.35778	31.285	6.104356	20.01	46.14
flakes	63	22.72381	21.37	7.827996	12.26	39.38

Tab. 2. Lithic raw materials of Szekszárd-Palánk.

Lithic raw material	Weight (grams)	%
Bakony radiolarite	586.4	55.32%
Mecsek radiolarite	97.2	9.17%
grey, blueish chert	205.6	19.40%
Bosnian radiolarite	25.4	2.40%
limninc silicite	62.25	5.87%
unknown	83.1	7.84%
Sum	1059.95	100.00%

Tab. 3. Technological categories of Szekszárd-Palánk.

Technological category	No.	%
blade core	2	0.37%
blade	75	14.04%
burin spall	2	0.37%
debris	313	58.61%
flake core	17	3.18%
flake	116	21.72%
neocrest	4	0.75%
platform rejuvenating flake	5	0.94%
Sum	534	100.00%

⁴⁴ KIRÁLY – KERTÉSZ 2023.

⁴⁵ SHOTT 1999.

⁴⁶ PELEGRIN 2000.

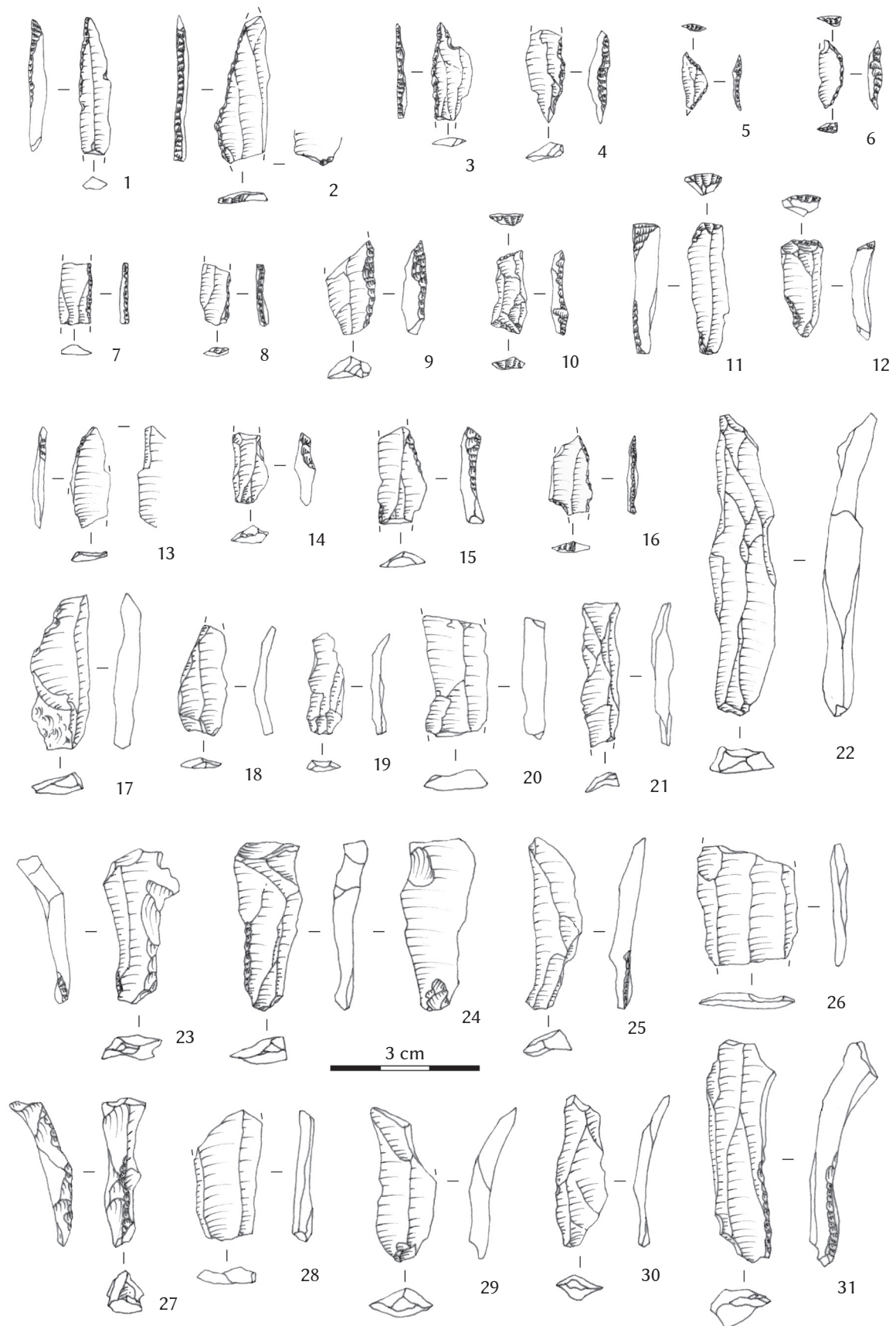


Fig. 6. Lithics from Szekszárd-Palánk. 1–2 – backed points, 3–4, 8, 14–15 – backed blades, 5–6 – geometric microliths, 7, 9, 23–25, 31 – retouched blades, 10–11 – truncated backed blades, 12 – truncated retouched blade, 13, 16 – retouched point, 27 – neocrest blade, 17–31 – blade fragments and blades.

Tab. 5. Lithic typological composition of Szekszárd-Palánk.

Tool category	Tool type	Blank			%
		flake	debris	blade	
Domestic	borer		1		0.97%
	burin	2	2	1	4.85%
	combined	3			2.91%
	endscraper	47	1		46.60%
	retouched blade			9	8.74%
	retouched flake	13			12.62%
	splintered pieces	5	1	1	6.80%
	truncated flake	3			2.91%
	truncated retouched blade			1	0.97%
Armature	backed point			2	1.94%
	backed blade			5	4.85%
	bitruncated backed blade			1	0.97%
	crescent			1	0.97%
	triangle			1	0.97%
	truncated backed blade			1	0.97%
	retouched point			2	1.94%
Sum		103			100.00%

Retouched tools were predominantly manufactured from Bakony radiolarite ($n=63$; 61.17%). This is followed by grey bluish-brown chert ($n=16$; 15.53%), limnic silicites ($n=15$; 14.56%), and Mecsek radiolarite ($n=5$; 4.85%). Additionally, four tools (3.88%) were produced from raw materials that could not be identified. Most of the tools were produced on flake blanks and debris ($n=77$), while blade tools are less numerous ($n=26$). Domestic tools dominate the assemblage ($n=90$), whereas armatures are rare ($n=13$). The most frequent tool type is the thumbnail endscraper ($n=48$) manufactured on short, broad, moderately thin flake blanks, typically rounded or circular in shape, with an average length around 17 mm (Fig. 7.1–25, Fig. 8.1–5). Their morphological data (Tab. 6) indicate a limited variation in length, width and thickness, implying standardized manufacture what likely reflects shared functional use.

Edge-retouched tools were made on flakes ($n=13$) (e.g. Fig. 8.3,5,9) and blades ($n=9$) (e.g. Fig. 6.7,9,31). Less frequent tool types are truncated blades ($n=2$) (Fig. 6.11–12), a borer (Fig. 8.7), and burins ($n=5$) (Fig. 8.6,8). Combined tools also occur like borers on a retouched flakes and a burin on an endscraper.

Armatures are represented by geometric and non-geometric microliths, and backed blades mostly made of, Bakony radiolarites. The assemblage includes two retouched points (Fig. 6.13,16), one of which probably shows burinization likely caused by impact. The backed points are slender

and only partially backed. (Fig. 6.1–2). A distally truncated blade with partial backing along the left edge is also part of the armatures (Fig. 6.11). One of the backed blades is a bitruncated backed one (Fig. 6.10). The two geometric microliths are an isosceles triangle and a segment (Fig. 6.5–6).

Tab. 6. Metric data of endscrapers.

	Length	Width	Thickness
Mean	16.933	18.366	6.522
Median	16.83	17.875	6.335
Standard deviation	4.200	3.873	1.792

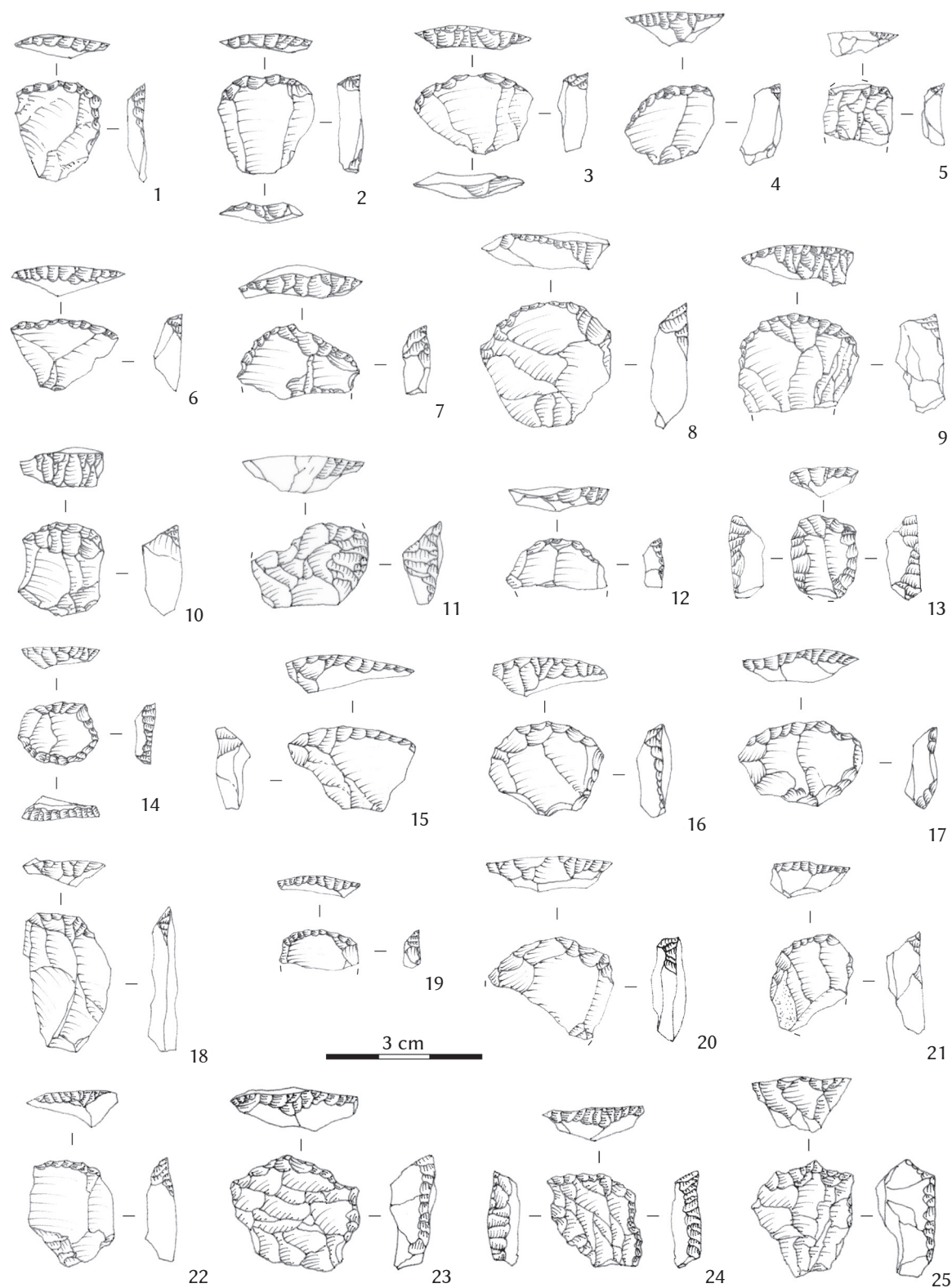


Fig. 7. Lithics from Szekszárd-Palánk. 1–25 – endscrapers.

A single curved backed point was published from the site;⁴⁷ however, we consider that it does not conform to the formal definition of this tool type.⁴⁸

⁴⁷ KIRÁLY – KERTÉSZ 2023, Fig. 13.3.

⁴⁸ LENGYEL 2016.

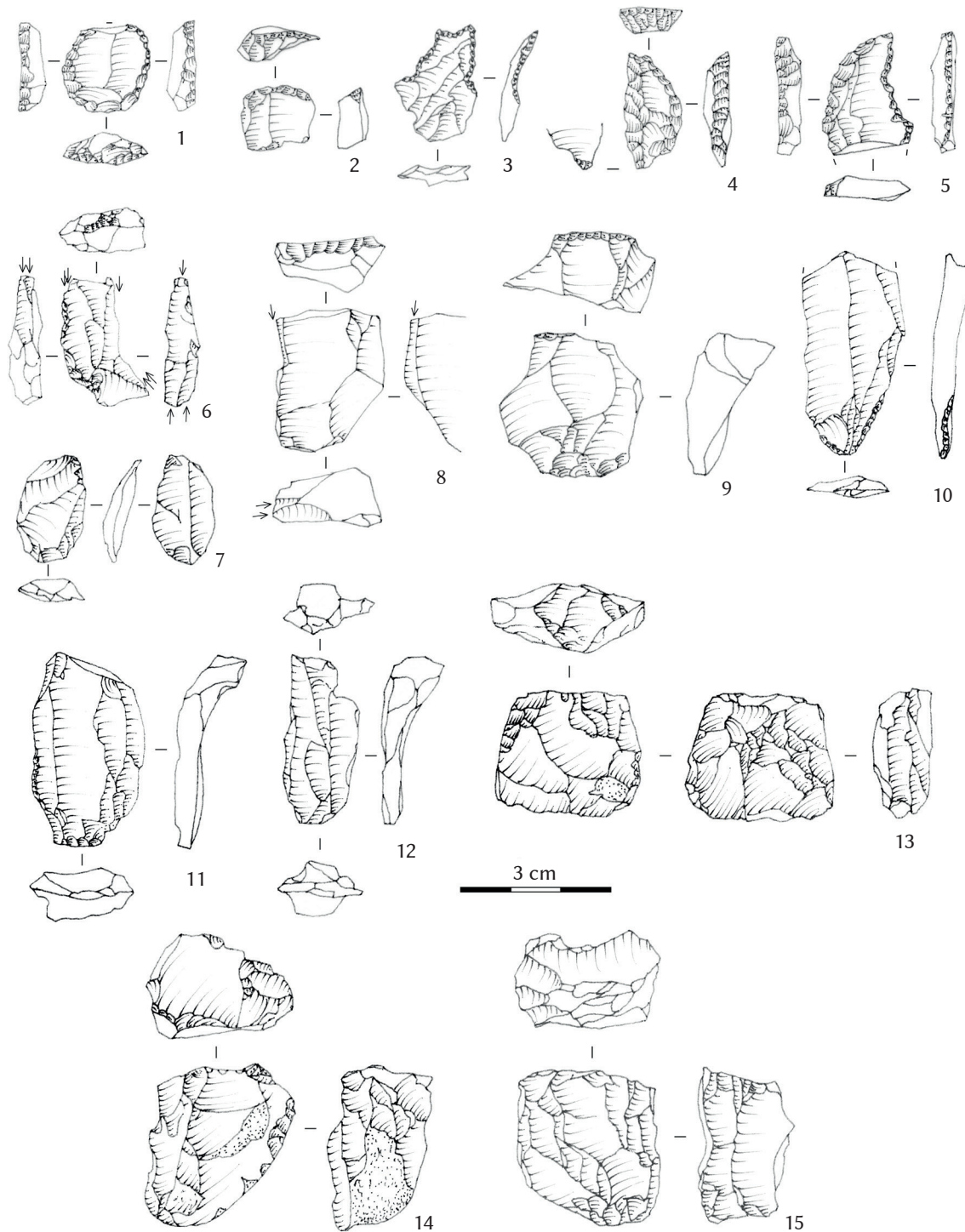


Fig. 8. Lithics from Szekszárd-Palánk. 1–6 – endscrapers, 7 – endscraper/borer, 8, 10–11 – retouched flake, 9 – burin, 12 – plunging blade, 13–15 – flake cores.

Archaeozoology

Animal remains (n=27) were originally described by Sándor Bökönyi.⁴⁹ A small variability of species was identified, including auroch or bison scapula (n=3), humerus (n=1), radius (n=1), phalange (n=2), *Cervus* scapula (n=1), humerus (n=2), patella (n=1), and *Castor fiber* molar (n=11) and incisor (n=5) fragments. At that time, this assemblage was considered to represent the Late Glacial period

⁴⁹ VÉRTES 1962.

Tab. 7. Faunal remains from Szekszád-Palánk.

Inventory number	Species	
62.46.1	<i>Bos primigenius</i> (Bojanus, 1827)	left scapula, distal part
62.46.2	<i>Bos primigenius</i> (Bojanus, 1827)	right scapula, distal part
62.46.3	<i>Bos primigenius</i> (Bojanus, 1827)	left radius, proximal part
62.46.4	<i>Bos primigenius</i> (Bojanus, 1827)	first (proximal) phalanx
62.46.5	<i>Bos primigenius</i> (Bojanus, 1827)	first (proximal) phalanx
62.46.6	<i>Cervus elaphus</i> (Linnaeus, 1758)	left humerus, distal part
62.46.7	<i>Castor fiber</i> (Linnaeus, 1758)	molar tooth fragment
62.46.8	<i>Castor fiber</i> (Linnaeus, 1758)	incisor tooth fragment

in Quaternary palaeontology⁵⁰ or the early Holocene.⁵¹ The review of the fauna found no differences in the spectrum of species, which consisted of *Bos primigenius* (Bojanus, 1827), *Cervus elaphus* (Linnaeus, 1758), and *Castor fiber* (Linnaeus, 1758) (Tab. 7). No human activity was observed on the bones; however, due to the poor preservation, this determination remains inconclusive. Our revision underlines the Holocene dating of the site.

Radiocarbon dating

We attempted to obtain AMS dates from animal bones: a fragment of a *Bos primigenius* left scapula distal end, a left radius proximal end, and a fragment of a *Castor fiber* molar. All samples yielded less than 1% collagen, unsuitable for radiocarbon dating.

In addition, cremated bones were also subjected to AMS dating (Fig. 9). The samples most likely from hearths which were associated with the archaeological layer described by László Vértes.⁵² These bones, as being heavily fragmented, could not have been identified taxonomically.

In total, six cremated bones were analysed, of which five yielded absolute dates (Tab. 8). The dates 9834 ± 72 (DeA-41146) and 9745 ± 54 (DeA-46491) overlap after calibration, followed by a slightly younger date of 9349 ± 50 (DeA-46493). Two other cremated bones yielded older and younger dates: 10810 ± 60 (DeA-46494) and 8881 ± 50 (DeA-46492). To verify the older 10810 ± 60 (DeA-46494) date, we measured a *Valvata macrostoma* (Mörch, 1864) shell from the 4Ckl layer of the 2023 excavation, which corresponds to the archaeologically sterile layer described by László Vértes beneath the archaeological layer. The freshwater Mollusc shell yielded 10536 ± 46 (DeA-1377) date. Considering the potential influence of the freshwater reservoir effect on the mollusc sample, it is likely younger than the $10,810 \pm 60$ BP (DeA-46494) date obtained from the archaeological layer. Consequently, we treat the oldest cremated bone as an outlier.

The dates fit the Preboreal period, between 11.6 and 10.4 ka cal BP, while the youngest date corresponds to the Boreal period, between 10.2 and 9.8 ka cal BP. The younger date might represent a contamination or a sign of a later ‘palimpsest’ like hunter-gatherer occupation of the site.

The first radiocarbon date of the site 10350 ± 500 (H. 408 C + B 371), was measured by the Heidelberg Laboratory.⁵³ Based on the laboratory archives, the weight of the carbon sample, prepared

50 JÁNOSSY 1979.

51 VÖRÖS 1987.

52 VÉRTES 1962.

53 VÉRTES 1962.

chemically with sodium hydroxide and hydrochloric acid, was only 50% of the required amount, and was boosted with ^{14}C -free carbon dioxide. The latter might explain the higher uncertainty of the conventional radiocarbon data. Another issue with this date is the uncertainty regarding the material of the sample. László Vértés refers to the sample as ‘burnt bones’,⁵⁴ while the laboratory’s report identifies it as charcoal. Due to its high uncertainty, we deem this date unreliable.

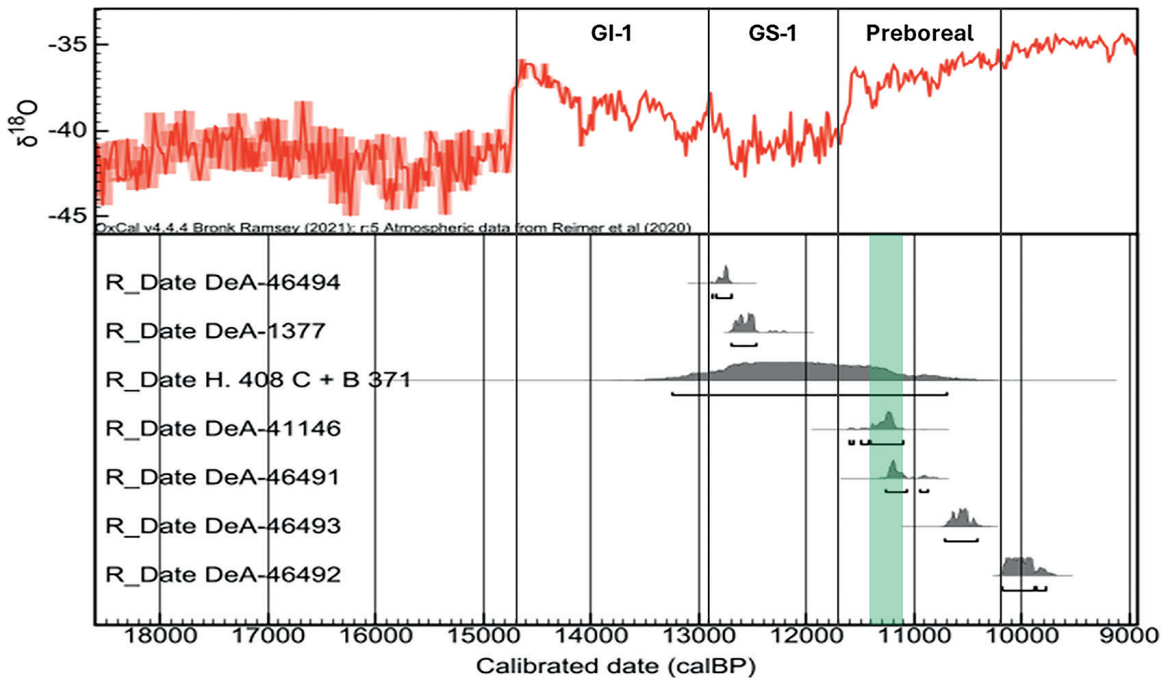


Fig. 9. Results of radiocarbon dating from Szekszárd-Palánk. Green bar: duration of Meltwater Pulse Event 1B.

Discussion

Geomorphological processes and site formation

Overall, the analysed layer sequence, combined with its proximity to the modern-day Danube, suggests a dynamic floodplain as geomorphological setting. This environment is characterized by moderate to high-energy events, as evidenced by the deposition of layer 2Ckl, which contains coarser sediments compared to the others. The fluctuation in energy conditions is further reflected by the slightly negative skewness, poorly sorted sediments, and bimodal curves, indicating variations in the flow regime. These changes likely involved periodic high-energy events depositing coarser sediments and lower-energy conditions contributing to the deposition of finer sediments.⁵⁵ Due to the foothill location of the site, it is likely that the Danube sediment was partly mixed with finer materials eroded and transported from the hill side. The absence of very coarse sediments, such as gravel, coarse sand, and medium sand, suggests that the profile represents a downstream section of the river system.⁵⁶

In the site’s vicinity, a borehole uncovered driftwood at a depth of 23.3 meters, which was radiocarbon-dated to $10,880 \pm 150$ years BP (Deb-953), with a calibrated age range of 13.1–12.6 ka cal BP.⁵⁷ The driftwood was found in the lower portion of a sandy gravel layer, directly overlying Tertiary

⁵⁴ VÉRTES 1962, 162.

⁵⁵ AWASTHI 1970; FOLK – WARD 1957; McLAREN – BOWLES 1985.

⁵⁶ BRIDGE – DEMICCO 2008, 400.

⁵⁷ HERTELENDI *et al.* 1989.

sediments. Although a geological unconformity is presumed between these two layers, the presence of sandy gravel sediment suggests high-velocity fluvial activity, likely associated with the Danube. This interpretation proves that the Danube entered the Tolnai-Sárköz region during the transition from the GI-1 to the GS-1, due to tectonic subsidence.⁵⁸ This interpretation is further supported by evidence of fluvial erosion observed west of the Szekszárd-Palánk site on the eastern fringes of the Transdanubian Hills (Fig. 1). Additionally, the presence of oxbow lakes, such as Lake Kapszeg in the vicinity, corroborates the dynamic fluvial activity in the region.⁵⁹ These geomorphological features highlight the active role of the Danube in shaping the landscape during the Late Glacial. The age and depth of the driftwood in the sandy gravel layer indicate that during the GI-1 period the rate of fluvial sedimentation in the area was very rapid, which continued to the Holocene, effectively burying the remnants of the Preboreal hunter-gatherer settlement.⁶⁰ According to the newly obtained radiocarbon dates presented in this study, this rapid sedimentation process persisted into the Holocene. By the time of the Avar cemetery (7th–9th century AD), environmental conditions had become sufficiently dry and continental to support ephemeral grassland vegetation, which facilitated the development of a Kastanozem soil.

The stratigraphy described can be reliably correlated with the stratigraphy documented by László Vértés (Fig. 3). This correlation is supported by Vértés's field descriptions, which mention a layer beneath the archaeological one containing an abundant amount of Mollusc shells and Mn(IV) concentrations.⁶¹ Although Vértés initially described this layer as 'wet loess' in his journal, he later revised its description to 'sand' in his subsequent publication.⁶² The sand identification was based on the particle size measurements conducted by Pál Kriván, where this layer was described as sand according to the particle size curves.⁶³ This classification was likely influenced by Kriván's use of the Atterberg particle size classes. However, when comparing Kriván's data with the particle size classification system of Blott and Pye,⁶⁴ it appears that the originally analysed lower layer consists of approximately 50–60% silt, which closely aligns with our findings (Fig. 5). This further strengthens the correlation between the stratigraphy documented during the 2023 excavation and that described by László Vértés. Nonetheless, the presence of abundant mollusc shells and the high amount of translocated Mn[IV] on soil aggregate surfaces remains consistent and is clearly depicted in his stratigraphy.⁶⁵ Based on these observations, layer 4Ckl identified in this study is considered identical to the layer 5 described by László Vértés. This conclusion is further corroborated by the matching depth of approximately 2 meters from the surface. The cultural layer was most likely above layer 4Ckl and beneath the bottom level of the Avar grave.

The cultural layer was originally described as embedded in aeolian loess.⁶⁶ However, our findings do not support this interpretation. Aeolian loess is not typical for floodplain environments, as it is more commonly associated with drier, less disturbed areas, whereas floodplains are more exposed to fluvial activity. Besides, aeolian loesses are typically well-sorted sediments with a 45–55% particle size range between 20–60 µm.⁶⁷ Layer 3Ckl which corresponds with the layer embedding the

58 JASKÓ – KROLOPP 1991.

59 PÉCSI 1959, 163.

60 BALLA *et al.* 1993.

61 VÉRTES 1958.

62 VÉRTES 1962, Abb. 4.

63 KRIVÁN 1960.

64 BLOTT – PYE 2012.

65 VÉRTES 1962, Abb. 4.

66 KRIVÁN 1960; VÉRTES 1962; KIRÁLY – KERTÉSZ 2023.

67 BALOGH 2017.

archaeological horizon, yielded a high amount of very coarse and coarse silt and the sediment is poorly sorted. This particle size distribution aligns with the range found in aeolian loesses, but due to its sorting more consistent with the characteristics of glacio-fluvial loesses.⁶⁸ This reinterpretation is further supported by the absolute chronology of the youngest loess sequences in the Pannonian Basin, which suggests that loess accumulation ceased around 15.3 ± 1.5 ka BP.⁶⁹ Given these observations and the geographic situation, we suggest that the 3Ckl layer should be identified as an alluvial (infusional) loess-like sediment rather than aeolian loess.

These observations are further supported by the absolute dates obtained from the 4Ckl layer and the associated archaeological material, suggesting that the high floodplain of the Danube in this region developed from the late GI-1 through the Early Holocene, providing a suitable habitat for hunter-gatherers. Thus, Szekszárd-Palánk represents a Preboreal archaeological site.

Lithic analysis

Earlier lithic provenience studies on the assemblage claimed, the most frequently used raw materials were Bakony and Mecsek radiolarites, then limnic silicites from the Börzsöny and Cserhát Mountains while flints from north of the Pannonian Basin were also part of the assemblage.⁷⁰ Our revision did not identify Transcarpathian flints. Even so, the substantial proportion of distant raw materials, particularly Bakony radiolarites, still implies a high degree of mobility among the Szekszárd-Palánk hunter-gatherer groups.

In the case of Transdanubian radiolarites the macroscopically observed colour and textural similarities often overlap significantly, making the precise provenance of the raw material difficult to establish.⁷¹ Furthermore, the presence of multiple colour variants of radiolarites or radiolarian cherts, along with white-patinated limnic silicites and the grey bluish–brownish chert group, complicates the reconstruction of raw-material procurement zones. Since we found no reliable parallels for these materials, and there is no compelling evidence linking them to flint or limnic silicite sources north of the Pannonian Basin or the Cserhát Mountains.⁷² Thus, we suggest that Triassic and Jurassic radiolarites and radiolarian cherts from present-day Bosnia and Croatia may represent plausible source areas, as these regions contain a wide range of lithic raw materials with diverse diagenetic origins.⁷³

In conclusion, we consider it premature to determine the provenance of the assemblage with precision, as a substantial proportion may plausibly derive from southern sources. This interpretation is further supported by the fact that grey bluish radiolarites are documented from raw-material sources located south of the Pannonian Basin. If our argument is correct regarding these southern origins, approximately 20% of the raw materials used at the site can be classified as southern ones, implying the involvement of the Szekszárd-Palánk community in a broad interregional communication network.

The predominance of flake cores and the abundance of flake blanks indicates that Szekszárd-Palánk is a flake-debitage-based industry. The scarcity of platform rejuvenation flakes and neocrested blades suggests a low level of investment in laminar core maintenance. Flake cores are non-hierarchical, polyhedral, primarily aimed at producing thin, but robust flakes. Tools made on blades were manufactured on slender blanks. The assemblage shows no evidence of the use of the microburin tech-

68 BLOTT – PYE 2012.

69 NOVOTHNY *et al.* 2009.

70 KERTÉSZ – DEMETER 2020.

71 CHEBEN – CHEBEN 2010.

72 KIRÁLY – KERTÉSZ 2023.

73 HALAMIĆ – KLINDŽIĆ 2009; VUJEVIĆ *et al.* 2017.

nique, as neither distal nor proximal microburins were identified. Overall, the archaeological assemblage and lithic technological features indicate that primary shaping of raw materials occurred off-site, while on-site activities were dominated by a short core reduction sequence producing irregular flakes and blades/bladelets as blanks. Backed tools are consistently manufactured on elongated slender blanks, and the assemblage exhibits a low degree of microlithization. Despite the representative character of the lithic assemblage, the identification of sites within the Pannonian Basin yielding lithic materials of comparable technological and typological composition remains challenging.

Szekszárd-Palánk in the context of Eastern Central Europe and Southern Europe

Current evidence suggests that the last Palaeolithic culture, the Late Epigravettian, disappeared from the Pannonian Basin after 15.0 ka cal BP, coinciding with the onset of GI-1.⁷⁴ Evidence for sparse hunter-gatherer habitation during the GI-1 in the inner part of the Pannonian Basin is limited to a few isolated finds, including elk antler artifacts from the Lovas ochre mine,⁷⁵ a harpoon from Mezőlak,⁷⁶ and a human skull from Moča (Slovakia).⁷⁷ Furthermore, no archaeological sites are documented from the GS-1 in the Pannonian Basin, and apart from the stray harpoon find from Nádasdladány,⁷⁸ the Szekszárd-Palánk assemblage has no chronological counterparts in the region during the Preboreal either. Based on the present evidence, the Szekszárd-Palánk population cannot be rooted in the Late Upper Palaeolithic of the Pannonian Basin, compelling us to look towards other possible regions of origin (Fig. 10, Tab. 8).

In the Western Carpathians, the sites of Spišská Teplica-Suchá diera⁷⁹ and Nowa Biała⁸⁰ indicate occasional visits by the Federmesser groups during the Late Glacial, while a Magdalenian occupation was attested at Hučivá Cave.⁸¹ However, no sites characterized by curved backed points are known in the Pannonian Basin during the Late Glacial, and Magdalenian sites are likewise absent.⁸² In Moravia (Czech Republic), Kůlna Cave is the only Epimagdalenian site associated with Late Glacial populations, dated to between 14.1–12.7 ka cal BP.⁸³ This assemblage, which yielded backed armatures and geometric microliths, precedes Szekszárd-Palánk by over a thousand years. The closest site in the northeastern direction with comparable Preboreal absolute dates is Městec/Ostrov (Czech Republic). While it shares certain features with Szekszárd-Palánk, the typological composition of its assemblage clearly situates it within the Final Palaeolithic–Early Mesolithic of Central Europe.⁸⁴ In the GS-1 we face the issue of even fewer sites. Only single tanged points in Slovakia, lacking stratigraphic context, suggest additional sporadic visits from the core area of the Tanged Point Technocomplex.⁸⁵

In Lower Austria and Styria, the Final Palaeolithic is represented solely by undated sites, often characterized by curved backed points, such as Horn-Galgenberg, Zigeunerhöhle bei Gratkorn, and

74 BÉRES *et al.* 2021; LENGYEL *et al.* 2021; MAGYARI *et al.* 2022.

75 SAJÓ *et al.* 2015.

76 HORVÁTH – ILON 2017.

77 ŠEFČÁKOVÁ *et al.* 2011.

78 KACZANOWSKA – KOZŁOWSKI 2014.

79 SOJÁK – HUNKA 2003.

80 VALDE-NOWAK – KRASZEWSKA 2014.

81 VALDE-NOVAK *et al.* 2022.

82 LENGYEL *et al.* 2021.

83 READE *et al.* 2021.

84 MLEJNEK *et al.* 2023.

85 KAMINSKÁ 2014, 297–317.

Limberg-Mühlberg.⁸⁶ However, except for Gratkorn, these sites provided surface collections and therefore lack both reliable absolute chronology and stratigraphic contexts. Similarly, sites dated to the Preboreal are unknown in Lower Austria.

At the fringes of the Pannonian Basin, in the Iron Gates region (Romania), Epigravettian sites such as Climente II, Cuina Turcului Level I, and Peștera Hoților have yielded dates within the GI-1 period. Although radiocarbon dates corresponding to the GS-1 are currently lacking likely due to taphonomic processes or sampling strategy, the upper Epigravettian layer at Cuina Turcului is still considered to represent a GS-1 human occupation.⁸⁷ Cuina Turcului Level II yielded Preboreal radiocarbon dates and produced an assemblage characterized by thumbnail endscrapers, retouched flakes, geometric microliths (segments, scalene and isosceles triangles, bitruncated blades), and a curved backed point, alongside technological features such as the frequent use of the bipolar technique and a predominance of flakes in the reduction process.⁸⁸

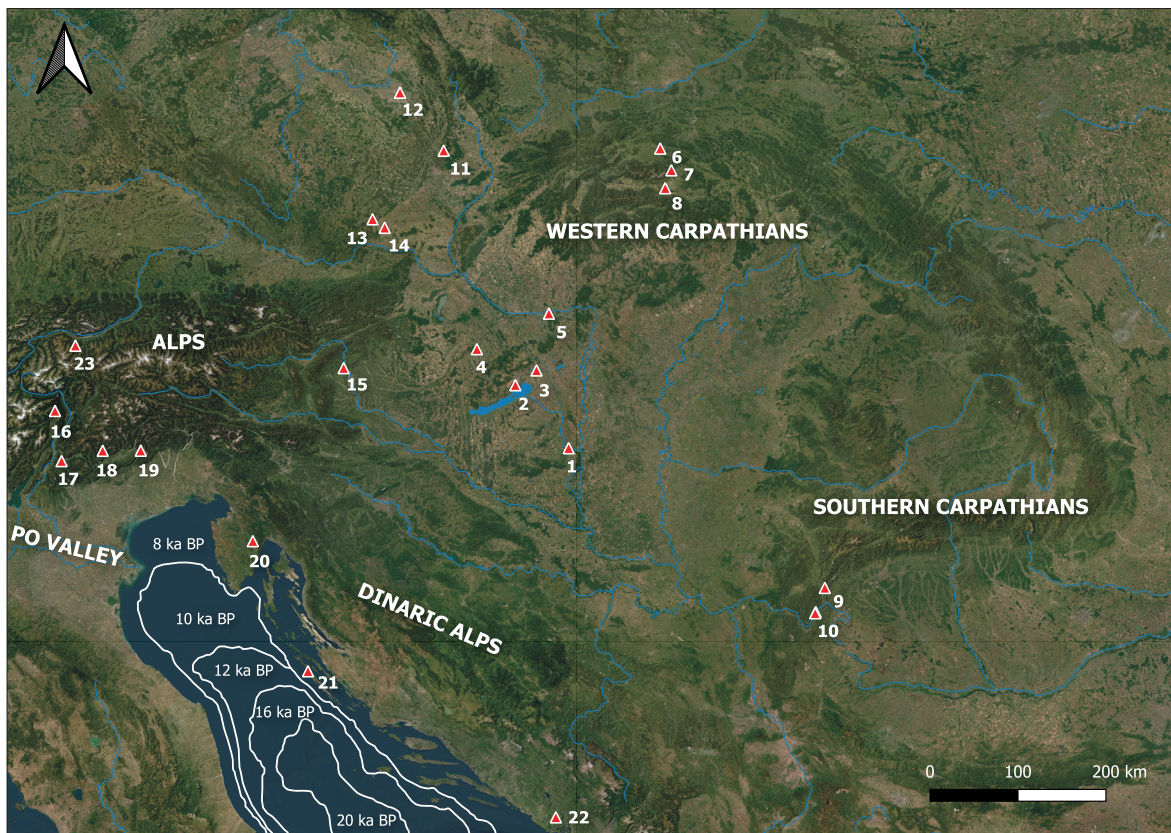


Fig. 10. Sites mentioned in the text. 1 – Szekszárd-Palánk, 2 – Lovas, 3 – Nádasdladány, 4 – Mezőlak, 5 – Moča, 6 – Nowa Biała, 7 – Hučivá Cave, 8 – Spišská Teplica-Suchá diera, 9 – Peștera Hoților, 10 – Climente II and Cuina Turcului II, 11 – Kůlna Cave, 12 – Městec/Ostrov, 13 – Horn-Galgenberg, 14 – Limberg-Mühlberg, 15 – Zigeunerhöhle bei Gratkorn, 16 – Laghetto della Regola di Castefondo, 17 – Riparo Cogola, 18 – Pian dei Laghetti, 19 – Palughetto, 20 – Pupičina Cave, 21 – Vlakno Cave, 22 – Crvena stijena, 23 – Ullafelsen (the sea level rise of the Adriatic after [BIRCH – MIRACLE 2017](#)).

At Vlakno Cave (Croatia), the Preboreal Stratum 3 is contemporary with Szekszárd-Palánk. The assemblage is dominated by flake debitage, with amorphous cores with multiple striking platforms, with evidence of the bipolar-anvil technique. Thumbnail endscraper is the most common tool

⁸⁶ [GULDER 1953](#); [PITTONI 1955](#).

⁸⁷ [BONSALL – BORONEANȚ 2016](#).

⁸⁸ [RADOVANOVIĆ 1996](#); [BORONEANȚ 2000](#).

type, while geometric microliths are absent, as well as the traces of the microburin technique.⁸⁹ A comparable situation is observed at Pupićina Cave (Croatia), where layers dated to the GS-1 and Preboreal yielded an assemblage dominated by flake debitage and thumbnail endscrapers, with a low frequency of backed armatures and the appearance of geometric microliths produced by the microburin technique.⁹⁰

In Northern Italy, the terminal phase of the Epigravettian spans 12.3–11.1 ka cal BP.⁹¹ Assemblages such as Riparo Cogola Layer 18⁹², Palughetto MN and MO⁹³, Pian dei Laghetti⁹⁴, and Laghetto della Regola di Castefondo⁹⁵ demonstrate clear trends toward microlithization, with an increase in geometric microliths (triangles, segments, bitruncated backed blades) manufactured by the microburin technique.⁹⁶

At present, the Late Glacial population hiatus undermines any model of cultural continuity or convergence in the Pannonian Basin. Thus, the origins of the earliest Preboreal settlement in southern Transdanubia can only be examined through techno-typological comparisons with other contemporary archaeological cultures. Since the Szekszárd-Palánk lithic sequence does not exhibit characteristics typical of the ‘western’ Early Mesolithic (e.g., the Beuronian),⁹⁷ these lines of evidence compel us to suggest a southern origin for the Szekszárd-Palánk population.

The Szekszárd-Palánk lithic assemblage attests techno-typological and chronological affinities with the aforementioned Late Glacial and Early Holocene Epigravettian industries of the Balkans and Northern Italy. This association is evidenced by the abundance of thumbnail endscrapers, retouched irregular flakes, backed implements, geometric microliths and a bitruncated backed blade, the latter closely paralleling Northern Italian Terminal Epigravettian assemblages.⁹⁸ The reduction of technological variability and the impoverishment of lithic industries also link the Szekszárd-Palánk site to the Epigravettian of southern Europe.⁹⁹ However, in terms of microburin production, Szekszárd-Palánk appears closer to its Eastern Adriatic and Balkan counterparts, as no microburins are present in the assemblage. This absence corresponds with a broader trend in the region: none are reported from Cuina Turcului Level II, only a single specimen was recovered from Vlakno Cave’s Pleistocene Stratum while none from the Preboreal one.¹⁰⁰ By contrast, the production of geometric microliths by the microburin technique is far more prominent in the Northern Italian Final Epigravettian, which is continuous with the Early Mesolithic Sauveterrian.¹⁰¹ While the Szekszárd-Palánk assemblage is also contemporary with the Ancient Sauveterrian, dated between 11.7 and 10.5 ka cal BP, and shares certain techno-typological features with it, it differs in several key aspects: the widespread use of the microburin technique, the presence of double-backed points, and the high frequency of geometric microliths typical of the Sauveterrian.¹⁰² Therefore, we cannot

89 CVITKUŠIĆ *et al.* 2018; VUKOSAVLJEVIĆ *et al.* 2014.

90 KOMŠO – PELLEGATTI 2007.

91 FASSER *et al.* 2024.

92 CUSINATO *et al.* 2004.

93 PERESANI *et al.* 2011.

94 BAGOLINI *et al.* 1984.

95 DALMERI *et al.* 2002.

96 FASSER *et al.* 2024.

97 TAUTE 1974.

98 BAGOLINI *et al.* 1984; CUSINATO *et al.* 2004; FASSER *et al.* 2024; PERESANI *et al.* 2011.

99 BERTOLA *et al.* 2007; CVITKUŠIĆ *et al.* 2018; KOMŠO – PELLEGATTI 2007; MIHAILOVIĆ *et al.* 2017.

100 CVITKUŠIĆ *et al.* 2018; VUKOSAVLJEVIĆ *et al.* 2014.

101 BASSETTI *et al.* 2009; CUSINATO *et al.* 2004.

102 FONTANA *et al.* 2023.

classify it as Sauveterrian. Consequently, Szekszárd-Palánk most likely fits into the Mid-Adriatic Early Holocene Epigravettian tradition, as represented for instance at Crvena Stijena, given the absence of the microburin technique, appearance of geometric microliths, flake debitage, bipolar-anvil technique, and the lack of Sauveterrian tool types.¹⁰³ In conclusion, we define the Szekszárd-Palánk lithic assemblage as belonging to the Early Holocene Epigravettian.

Szekszárd-Palánk lies at a considerable distance from the core area of the ‘Mediterranean’ Early Holocene Epigravettian, and no inland Early Holocene sites contemporaneous with it are currently known in the Balkans.¹⁰⁴ The lack of contemporary inland sites between these regions suggests that the movement of hunter-gatherers was rapid. This mode of expansion can be accounted for by the leapfrogging movement of populations.¹⁰⁵ Such mobility presupposes at least a basic knowledge of the regions targeted for settlement. The Pannonian Basin was certainly not unfamiliar to the ‘southern’ Epigravettian hunter-gatherers, as evidenced by the presence of obsidian sourced from the Tokaj-Prešov Mountains in the Palaeolithic layers of Cuina Turcului.¹⁰⁶ The dispersal into the Pannonian Basin may have been facilitated by similar paleoenvironmental conditions as well, since both regions were undergoing afforestation with mixed deciduous woodlands during the Preboreal, offering familiar habitats to incoming groups.¹⁰⁷

The absolute dates of Szekszárd-Palánk coincide with Meltwater Pulse 1B dated between 11.5–11.2 ka cal BP, a major eustatic fluctuation that caused rapid sea-level rise continuing into the Holocene.¹⁰⁸ This transgression of the Adriatic Sea resulted in the submergence of the Adriatic Plain, long considered a crucial hub and communication corridor for Epigravettian hunter-gatherers. The absence of Preboreal sites between the Eastern Adriatic and Balkanic sites and the southern Pannonian Basin may suggest that environmental stress resulting from shrinking foraging territories prompted a rapid movement of populations, potentially leading to the reorganization of long-standing east–west interaction networks. Such a rapid dispersal could also explain the pronounced techno-typological similarities between the Szekszárd-Palánk assemblage and contemporary Epigravettian industries of the Balkans, and, together with indications of southern raw materials, suggests that these hunter-gatherers participated in a wider communication network extending across the Adriatic region. The northward expansion of Epigravettian groups into the Alpine regions is well documented,¹⁰⁹ while the spread of Sauveterrian further north is demonstrated by the Preboreal site of Ullafelsen (Austria).¹¹⁰

Conclusions

Our study confirmed that the high floodplain of the Danube in the Tolnai-Sárköz area developed during the GI-1 and Early Holocene periods, providing a stable habitat for Early Holocene hunter-gatherer populations. The archaeological assemblage from Szekszárd-Palánk can be attributed to the Early Holocene Epigravettian of the Balkans and Northern Italy and is dated to the Preboreal. During the Final Palaeolithic, the hunter-gatherer population of the Pannonian Basin was sparse, as archaeological evidence primarily consists of stray finds from the GI-1, while a complete

103 MIHAILOVIĆ 2017.

104 KACZANOWSKA – KOZŁOWSKI 2018.

105 ANTHONY 1990.

106 BORONEANȚ – BONSALL 2021.

107 BIRCH – LINDEN 2018; MAGYARI *et al.* 2019.

108 VELAY-VITOW *et al.* 2024.

109 CUSINATO – BASSETTI 2005.

110 BERTOLA *et al.* 2020.

population hiatus is evident during the GS-1. Consequently, the origins of the Szekszárd-Palánk population cannot be traced to the local Late Epigravettian of the Pannonian Basin, as there is a chronological gap of approximately 3000 years between this earlier industry and the absolute dates of Szekszárd-Palánk, rendering the ‘continuity theory’ unlikely. We propose that this pioneer hunter-gatherer population originated from the ‘Mediterranean’ type Epigravettian, and its appearance at the southern fringes of the Pannonian Basin was facilitated by global climatic events during the Early Holocene, enabling participation in the postglacial recolonization of Eastern Central Europe.

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Tab. 8. Radiocarbon dates mentioned in the text.

Site	Lab. Code	Date	±	Cal BP 95.4%	Sample	Method	Reference
Szekszárd-Palánk	DeA-41146	9834	72	11 610–11 100	cremated bone	AMS	this paper
	DeA-46491	9745	54	11 261–10 874	cremated bone	AMS	
	DeA-46492	8881	50	10 188–9770	cremated bone	AMS	
	DeA-46493	9349	50	10 709–10 405	cremated bone	AMS	
	DeA-46494	10810	60	12 880–12 701	cremated bone	AMS	
	DeA-1377	10536	46	12 692–12 470	mollusc	AMS	
	H. 408 C + B 371	10350	500	13 240–10 692	unknown	decay counting	VÉRTES 1962
Szekszárd 2/1	Deb-953	10880	150	13 110–12 617	charcoal	decay counting	HERTELENDI <i>et al.</i> 1989
Lovas	ETH-15119	11740	100	13 799–13 361	bone	decay counting	T. DOBOSI – SZÁNTÓ 2003
	MAMS-21718	11941	44	14 022–13 610	bone	AMS	Sajó <i>et al.</i> 2015
	MAMS-21719	11918	41	14 009–13 606	bone	AMS	
	MAMS-21720	11825	41	13 785–13 530	bone	AMS	
	MAMS-21721	11469	40	13 454–13 242	bone	AMS	
	MAMS-21722	11728	46	13 747–13 484	bone	AMS	

► Site	Lab Code	Date	±	Cal BP 95.4%	Sample	Method	Reference
Mezőlak	DeA-4878	11745	60	13 758–13 490	harpoon	AMS	HORVÁTH – ILON 2017
Moča	OxA-7068	11255	80	13 320–13 028	human skull	AMS	ŠEFČÁKOVÁ <i>et al.</i> 2011
Nádasdladány	Poz-25427	9520	60	11 000–10 590	harpoon	AMS	KACZANOWSKA – KOZŁOWSKI 2014
Spišská Teplica-Suchá diera	Gd-30012	11620	390	14 834–12 756	bone	decay counting	SOJÁK – HUNKA 2003
	Gd-18146	11230	280	13 747–12 705	bone	decay counting	
Nowa Biała	Poz-53553	11270	60	13 298–13 092	charcoal	AMS	VALDE-NOWAK – KRASZEWSKA 2014
Hucivá Cave	Poz-114742	12190	60	14 765–13 860	charcoal	AMS	VALDE-NOWAK <i>et al.</i> 2022
	Poz-114743	12160	60	14 297–13 809	charcoal	AMS	
Kúlna Cave	OxA-25284	11820	50	13 520–13 790	bone	AMS	READE <i>et al.</i> 2021
	OxA-25285	11770	55	13 501–13 765	bone	AMS	
	OxA-25286	11070	50	12 846–13 096	bone	AMS	
	OxA-25287	11010	50	13 298–13 490	bone	AMS	
Městec/Ostrov	DeA-25068	9856	38	11 391–11 200	charcoal	AMS	MLEJNEK <i>et al.</i> 2023
	DeA-25069	9744	43	11 247–10 897	charcoal	AMS	
	DeA-25070	9672	39	11 203–10 802	charcoal	AMS	
	DeA-25071	9852	41	11 392–11 196	charcoal	AMS	
Climente II	OxA-26310	11970	55	14 025–13 625	bone	AMS	BONSALL – BORONEANȚ 2016
	OxA-26199	11880	55	13 805–13 555	bone	AMS	
	OxA-25735	10900	50	12 875–12 690	bone	AMS	
	OxA-26198	10840	50	12 805–12 680	bone	AMS	
	OxA-22042/24990	12565	37	14 375–13 925	human bone	AMS	
Cuina Turcului Level 1	Bln-803	12600	120	15 290–14 280	charcoal	decay counting	PĂUNESCU 2002
	Bln-804	12050	120	14 205–13 575	charcoal	decay counting	
	GrN-12665	11960	60	14 005–13 595	charcoal	decay counting	
Cuina Turcului Level 2	Bln-802	10125	200	12 520–11 210	charcoal, burnt bones	decay counting	PĂUNESCU 2002
	OxA-19203	10003	71	11 795–11 245	human bone	AMS	BONSALL – BORONEANȚ 2016
	OxA-19202	9918	71	11 695–11 200	human bone	AMS	
Peștera Hoților	GrN-16987	11490	75	13 425–13 160	burnt bones	decay counting	PĂUNESCU 2002
Vlakno Cave Layer 10	Z-3383	10160	100	12 370–11 320	unknown	decay counting	BRUSIĆ 2005

► Site	Lab Code	Date	±	Cal BP 95.4%	Sample	Method	Reference
Vlakno Cave Stratum 3	Beta 327417	9860	40	11 393–11 200	bone	AMS	CVITKUŠIĆ <i>et al.</i> 2018
	Beta 302762	10060	50	11 815–11 346	bone	AMS	
Vlakno Cave Stratum 4	Beta 423618	10270	40	12 440–11 820	bone	AMS	
	Beta 416303	10380	40	12 477–12 004	bone	AMS	
	Beta 363142	10970	50	13 063–12 761	bone	AMS	
Pupićina Cave	Z-2613	10020	180	12 463–11 112	charcoal	decay counting	KOMŠO – PELLEGATTI 2007
	Beta 131626	10150	60	11 969–11 403	charcoal	decay counting	
	Beta 188919	10280	50	12 455–11 823	charcoal	decay counting	
	Z-2574	10610	200	12 965–11 832	charcoal	decay counting	
Riparo Cogola US19	Lacogola-RC4	10640	60	12 737–12 492	unknown	AMS	BASSETTI <i>et al.</i> 2009
	Lacogola-RC3	10380	70	12 590–11 945	unknown	AMS	
Riparo Cogola US18	Lacogola-RC2	9820	60	11 397–11 115	unknown	AMS	
Riparo Cogola US16	Lacogola-RC1	9430	60	11 068–10 500	unknown	AMS	
Crvena Stijena Layer 8	OxA-23314	9665	45	11 201–10 793	bone	AMS	MERCIER <i>et al.</i> 2017
	OxA-23313	11755	55	13 756–13 500	bone	AMS	
Crvena Stijena Layer 6	OxA-23311	9775	45	11 263–11 113	bone	AMS	
	OxA-23312	9785	45	11 269–11 115	bone	AMS	
Romagnano Loc 3 AF	R-1147	9830	90	11 689–10 875	charcoal	decay counting	ALESSIO <i>et al.</i> 1984
Romagnano Loc 3 AE	R-1146B	9490	80	11 135–10 518	charcoal	decay counting	
Romagnano Loc 3 AE1-5	R-1146α	9420	60	11 066–10 439	charcoal	decay counting	
Romagnano Loc 3 AE1-4	R-1146Aα	9580	250	11 700–10 241	charcoal	decay counting	
Ullafelsen	BE 9781.1.1	9120	235	11 069–9555	charcoal	AMS	ZECH <i>et al.</i> 2021
	BE 9779.1.1	9020	235	10 760–9535	charcoal	AMS	
	BE 9780.1.1	8556	227	10 190–9026	charcoal	AMS	

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