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Szerkesztők • Edited by

Zsolt Mester

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RESEARCH ARTICLE

Gyöngyöspata-Felső-Eresztvény, a Middle Palaeolithic open-air site complex (western Mátra Mountains, Northern Hungary) – preliminary results

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Abstract. The Felső-Eresztvény site complex was identified in January 2025 on a ridge north of Gyöngyöspata in the Western Mátra Mountains. Systematic field surveys documented a 13.9-hectare open-air Middle Palaeolithic locality with a predominantly limnosilicite assemblage. The lithics are technologically homogeneous and characterised mainly by Mousterian notched tools and side-scrapers with a non-significant sub-laminar component. Elements of the Upper Palaeolithic and Later Prehistoric periods are very scarce or absent. An exhausted recurrent centripetal core indicates the limited presence of the Levallois concept within a flake-based Mousterian industry. Variation in patination and rolling suggests multiple occupation episodes. These results position Felső-Eresztvény as one of the most extensive and informative Middle Palaeolithic surface assemblages in the Gyöngyöspata Basin.

Keywords: western Mátra Mountains, Gyöngyöspata Basin, Middle Palaeolithic, Mousterian industry, Levallois concept, limnosilicite

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1 Introduction

The Gyöngyöspata Basin represents one of the most significant, yet still insufficiently documented, Middle Palaeolithic micro-regional units of the Western Mátra Mountains. From the 1980s onwards, several sites became known in the area, and in the 2000s, further lithic concentrations and low-density open-air localities were identified. Nevertheless, the structure, technological variability and spatial patterning of Middle Palaeolithic activity in the basin remain only fragmentarily understood.

Beginning in January 2025, a large Palaeolithic site complex was identified on a ridge currently under viticulture in the northern part of Gyöngyöspata (Felső-Eresztvény). The surface assemblage of the approximately 13.9-hectare area showed a technologically homogeneous,

predominantly limnosilicite-based Middle Palaeolithic, Mousterian character already during the initial field surveys. A few elements suggesting the application of the Levallois concept are also present in the assemblage. Given its extent and the typological variability of the assemblage, the site complex represents a significant new data source for Middle Palaeolithic research along the southern margin of the Mátra Mountains.

The present paper aims to provide the first comprehensive presentation of the Felső-Eresztvény site complex and to contextualise its assemblage within the framework of the Gyöngyöspata Basin and the Middle Palaeolithic industries of northern Hungary. The study briefly reviews the research history of the site's surroundings, as well as its geographical and geological setting. It then describes the knapped stone assemblage. On the basis of taphonomic



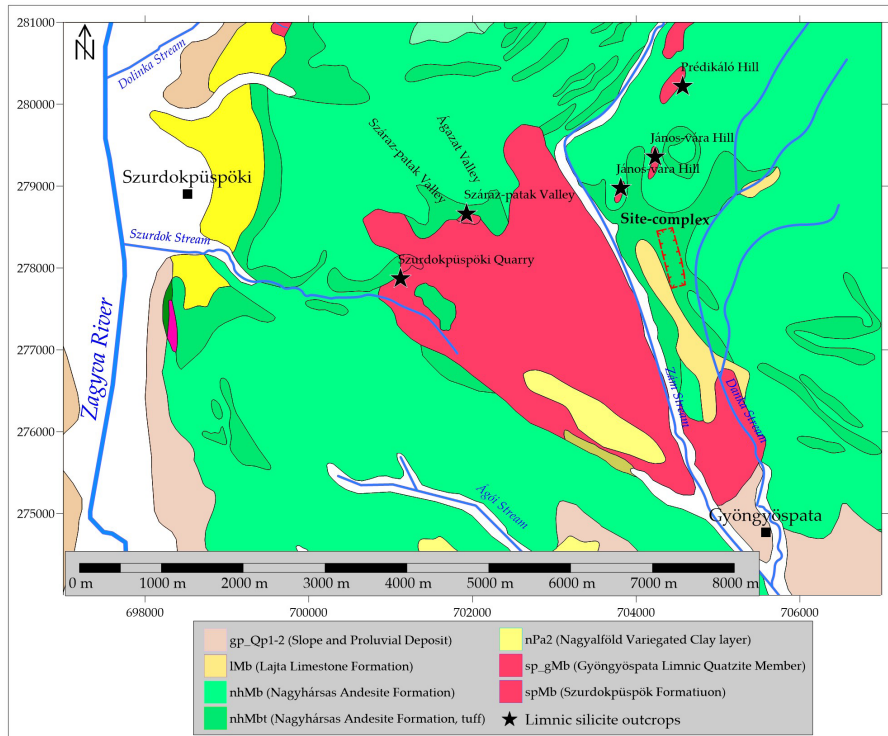


Fig. 1. Geological map of the Gyöngyöspata Basin. Basemap: SZTFH (Szabályozott Tevékenységek Felügyeleti Hatósága) térképek - Magyarország földtani alapszelvényei 1: 100 000

variation, reduction strategies and regional parallels, an assessment of the assemblage is attempted. GIS-based spatial analyses were also conducted to evaluate the possible secondary displacement of finds and to characterise the function and nature of the site complex.

2 The site complex

2.1 The research history of the surroundings

The first significant phase of Palaeolithic research in the Gyöngyöspata Basin dates to the mid-1980s, when László Tóth, an agronomist from Pásztó, identified several surface sites in the area. The collected knapped stone material proved to be clearly of Middle Palaeolithic character in several cases, indicating that the basin preserves not merely scattered finds but potentially the traces of more extensive open-air activity (Péntek *et al.*, 2025).

Further surveys in 2005 by Mónika Gutay and Gyula Kerékgyártó in the southern part of the basin documented additional occurrences of limnosilicite artefacts around the Gyöngyöspata-Úrrá-tesz area. Gutay's (2007) thesis noted that although the artefacts were widely dispersed, surface processes and erosion had likely modified

the original spatial patterning of prehistoric activity.

Subsequent field observations by archaeology student Ferenc Benus in 2012 led to the identification of another Middle Palaeolithic locality in the Gyöngyöspata-Mész-oldal area, further supporting the interpretation that the geomorphological conditions and raw material sources of the basin were favourable for Palaeolithic settlement. Repeated field surveys conducted by the authors since spring 2025 indicate that the site originally identified by Benus is considerably more extensive than initially recognised.

In November 2024, the author and colleagues identified the Közép-bérc site complex, a large locality of approximately 17 ha situated west of the Felső-Eresztvény site complex, on the southwestern side of the Zám (Ám) Stream.

The identification of the Felső-Eresztvény site complex in 2025 represents a significant new result in this research sequence. The extensive, technologically homogeneous assemblage, traceable over several hundred metres, is among the first localities in the Gyöngyöspata Basin where the spatial patterning of Middle Palaeolithic activity, raw material use and knapping can be examined in detail.

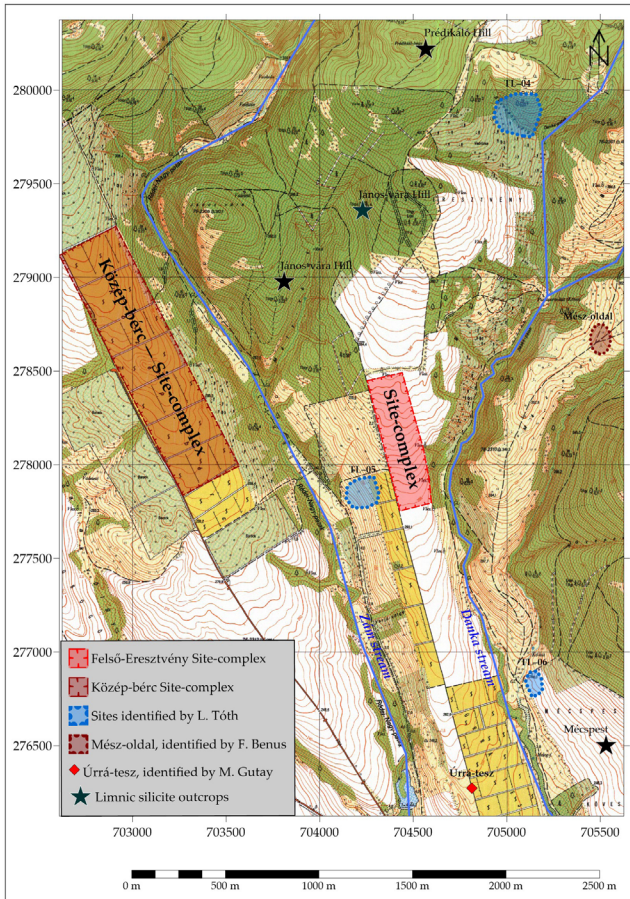


Fig. 2. Archaeological sites and raw material outcrops in the vicinity of the site complex. Map: Attila Péntek

2.2 Geographical and geological environment

The site complex is situated in the northwestern part of the Gyöngyöspata Basin, on a north-northwest–south-southeast oriented ridge running between the Zám and Danka streams. The area can be regarded as the northwestern continuation of the Gyöngyöspata-Úrrá-tesz field boundary area. The ridge is flanked both to the west and to the east – beyond the Danka Stream – by pyroxene andesite tuff, agglomerate and breccia belonging to the Nagyhársas Andesite Formation; andesite also occurs as surface outcrops at several locations (Fig. 1).

At some locations along the ridge, particularly on the right bank of the Zám Stream, limnosilicite-bearing diatomite, limestone and occasionally a post-volcanic, silica-rich raw material outcrop. Following Přichystal (2010) and Mester & Faragó (2016), we refer to the latter as limnosilicite. The silica-rich hydrothermal springs associated with the region's post-volcanic hydrothermal activity produced geysirite and limnosilicite precipitates

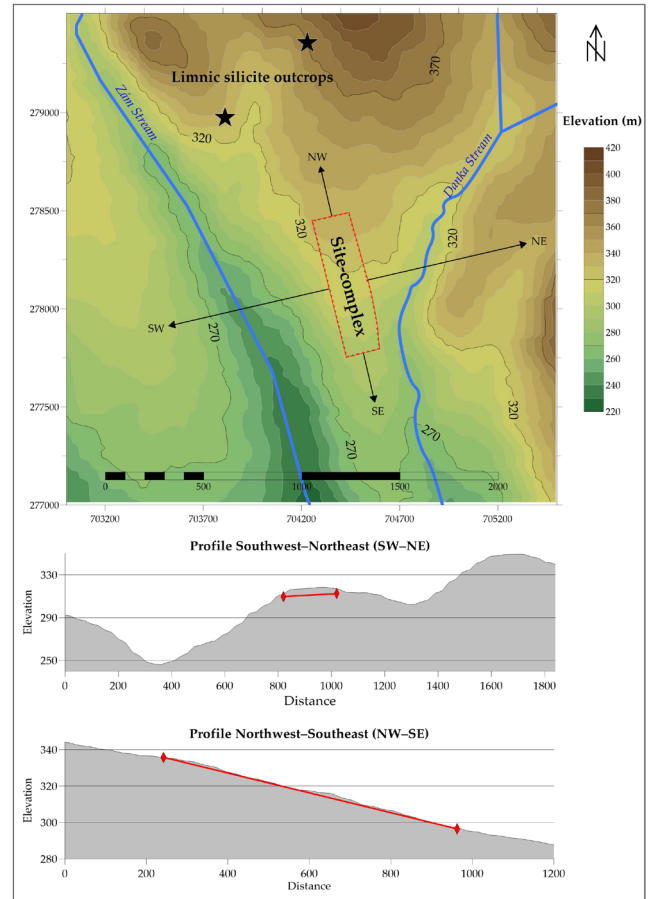


Fig. 3. The position of the site complex on the hillcrest. Map: Attila Péntek

in the surrounding basins. These formations form part of the Gyöngyöspata Limnic Quartzite Member, with characteristic outcrops known from the János-vára and Predikáló-tető localities (Schréter, 1950; Varga *et al.*, 1975; Dövényi, 2010; Mester & Faragó, 2022).

The local limnosilicite is fine-grained and homogeneous in structure, contains few inclusions, and possesses excellent knapping properties. These characteristics likely played a determining role in the development of the Middle Palaeolithic knapping activities documented in the Gyöngyöspata Basin.

2.3 Topographic data

Fig. 2 shows the previously known archaeological sites in the vicinity of the site complex. At the Gyöngyöspata 05 site, located on the southwestern slope of the ridge, Tóth collected a small quantity of prehistoric material containing Late Bronze Age (Kyjatice culture) pottery. The find circumstances suggest a secondary,

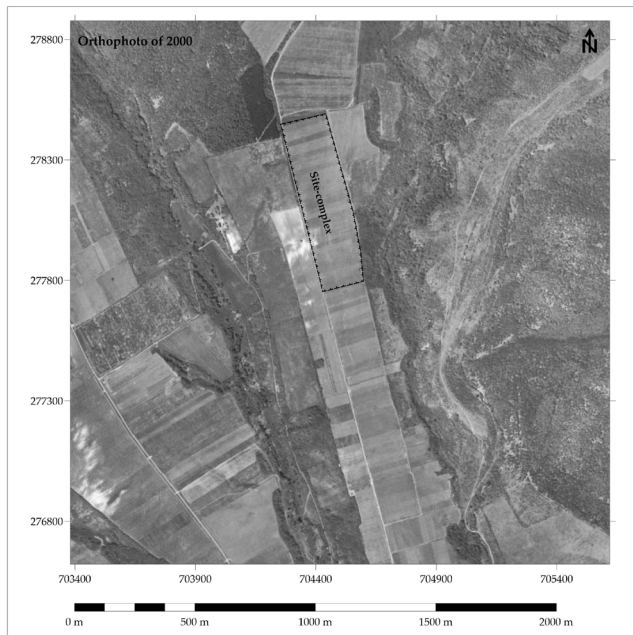


Fig. 4. Orthophoto of the surroundings taken in 2000. “Orthophoto of Hungary – 2000.” Digital Orthophoto Database. Source: Lechner Tudásközpont / FÖMI, Budapest.

downslope-displaced position. The figure also indicates the Gyöngyöspata-Mész-oldal Middle Palaeolithic site discovered by Benus in 2012, as well as the principal limnosilicite raw material outcrops in the Gyöngyöspata Basin.

The currently known length of the site complex is 715–720 m, its width is typically 190–200 m, narrowing to 170 m at the south-southeastern end. Its total area is 13.94 ha. The elevation of the ridge ranges between 298.0 and 334.7 m above sea level; the longitudinal slope is relatively pronounced at 5.14% (“Sloping”, Reinhold *et al.*, 2006, p. 12, Table 7). The surface is relatively even in the transverse direction, with an elevation difference of only 4 m between the western and eastern margins. The relative height towards the Zám Stream valley to the west is 60–80 m, while towards the Danka Stream to the east it is only 15–25 m (Fig. 3).

2.4 The lithic material

The total assemblage comprises 601 lithic artefacts, documented by the author through systematic surface collections. The spatial position of the finds was recorded using a handheld GPS device. Of these, 326 finds were recovered from Collection Zone 1 (CZ1) and 110 from Collection Zone 2 (CZ2). A further 31 finds were recorded in the 1.72-hectare poorly collectable area adjoining

the southeastern margin of CZ1. These stray finds, which cannot be confidently assigned to the concentration, are not discussed in detail. Similarly, the 44 documented finds from the 5.73-hectare area at the southeastern end of the site complex are not described individually, as their asymmetric, non-concentrated scatter would introduce distortion into the analysis. Since they are, however, technologically and typologically as homogeneous as the assemblage from the two main concentrations, they are included in the overall description.

The surface distribution of finds is closely related to the intensive agricultural use of the area. Archive data and an orthophotography from 2000 (Fig. 4) allow the transition from crop cultivation to viticulture to be identified. The Palaeolithic contexts were most likely disturbed most significantly by deep ploughing before vineyard establishment, which brought large quantities of finds to the surface. The northern-northwestern section of the current find concentration – approximately 420 m long and 202 m wide (ca. 8.18 ha) – presents an uneven picture, partly due to parcels withdrawn from cultivation and overgrown with vegetation, and partly due to the natural limnosilicite surface cover. The upper CZ1 covers 2.23 ha, and the lower CZ2 covers 3.52 ha. The area between the two collection zones is partly poorly collectable and partly uncollectable. Despite the factors hampering collection, the assemblage from the entire area of the site complex forms a technologically coherent unit.

The artefact distribution across the entire site complex is shown in Fig. 5, and a heatmap of the artefact-rich northwestern area is presented in Fig. 6. Both figures indicate the poorly collectable (light grey) and uncollectable (medium grey) zones of the site complex.

3 Methods

3.1 Classification of lithic implements

The composition of the total 601-piece assemblage is presented in Table 1, and that of the individual collection zones in Table 2.

Finds were assigned to five categories based on their role within the reduction sequence (*chaîne opératoire*):

Tools: Typologically identifiable retouched implements. This category also includes diverse

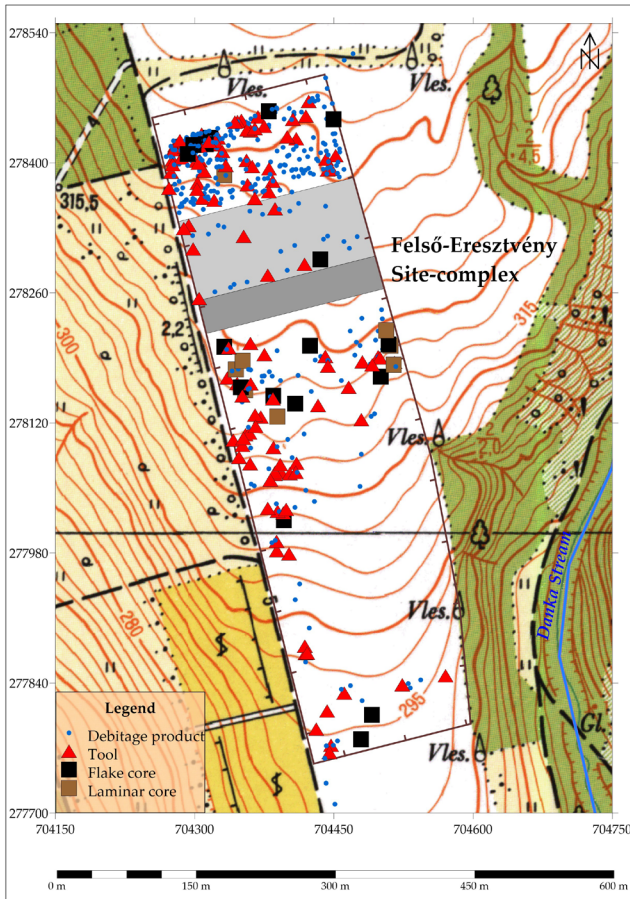


Fig. 5. The artefact distribution across the entire site complex. Map: Attila Péntek

(indeterminate) tools which, due to heavy weathering or rolling, cannot be assigned to a typological category but bear traces of anthropogenic modification (114 pieces, 18.97% of the assemblage).

Debitage products: Following Inizan *et al.* (1999, p. 138), this term refers to all removals resulting from the knapping of a core. In the present study, however, debitage products are distinguished from waste products on morphological grounds: only flakes retaining a clearly identifiable butt and bulb of percussion are assigned to this category (245 pieces, 40.77% of the assemblage). The boundary between debitage products and waste products is inherently uncertain in surface assemblages, where platform attributes may be obscured by weathering or rolling; pieces in which platform preservation was ambiguous were therefore assigned to the waste product category.

Waste products: A functional rather than technological category, comprising all by-products— including cortical flakes, shatter

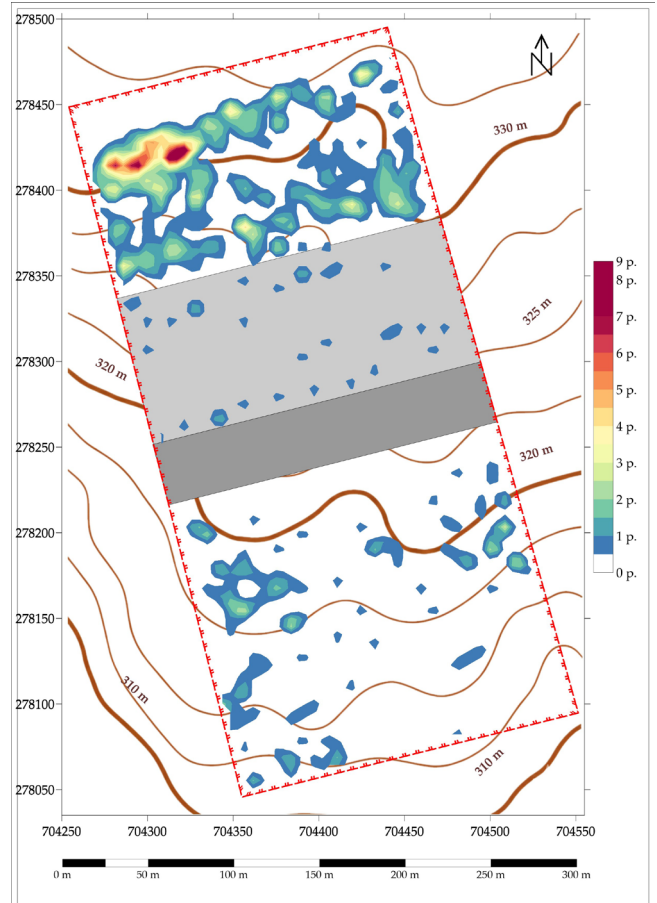


Fig. 6. Heatmap of the artefact-rich northwestern area of the site complex. Map: Attila Péntek

and fragments lacking diagnostic platform attributes—that did not become tools or preforms (cf. Andrefsky, 2005) (210 pieces, 34.94% of the assemblage).

Cores: Blocks used for the production of knapped products, on which the negative scars from removal are clearly identifiable (26 pieces). Within this category, flake cores (18 pieces, 3.00% of the assemblage) and sub-laminar cores (8 pieces, 1.33% of the assemblage) were distinguished. The products detached from the latter include elongated pieces, flakes, and blade-like flakes that meet the length-to-width ratio criterion for blades but do not satisfy the strict blade criteria of regularity, parallel edges, and consistent dorsal ridges.

Pebbles: Six quartzite pieces belong to this category (1.24%), one of which was probably used as a hammerstone during knapping, based on the damage visible at its ends.

3.2 Spatial analyses

Table 1. Gyöngyöspata-Felső-Eresztvény, lithic implement counts and ratios.

	Limnosilicite	Andesite	Quartzite	Total	% of tools	% of total
End-scraper	4	-	-	4	3.51	-
Side scraper	14	-	1	15	13.16	-
Borer	1	-	-	1	0.88	-
Burin	2	-	-	2	1.75	-
Combined tool	1	-	-	1	0.88	-
Denticulated tool	4	-	-	4	3.51	-
Notched tool	15	-	1	16	14.04	-
Retouched flake	20	-	-	20	17.54	-
Retouched RMF	35	-	1	36	31.58	-
Diverse	14	-	1	15	13.16	-
Tools total	110	-	4	114	-	18.97
	-	-	-	-	-	-
Debitage	234	6	5	245	-	40.77
Waste product	198	-	12	210	-	34.94
Flake core	15	2	1	18	-	3.00
Laminar core	8	-	-	8	-	1.33
Pebble	-	-	6	6	-	1.00
Total	565	8	28	601	-	100.00
%	94.01	1.33	4.66	100.00	-	-

The geomorphological and spatial-statistical analysis aimed to determine whether the observed artefact distribution reflects post-depositional displacement caused by natural processes or primarily preserves the spatial patterning of human activity. The Standard Deviation Ellipse method, used as the primary statistical tool, characterises the shape, orientation and central tendency of the artefact distribution.

The analyses were performed in QGIS v3.40 LTR using Python 3.1.2 scripting. The database comprises GPS coordinates recorded during field surveys and a high-resolution digital elevation model of the study area (Copernicus DEM, 10 m resolution). Figures were produced using Surfer 22.1.

3.2.1 Geomorphological and spatial-statistical assessment of post-depositional risk

To evaluate the potential effect of post-depositional slope processes on the distribution of artefacts, a multi-criteria geomorphological analysis was conducted, combining terrain indicators with spatial-statistical analysis of archaeological point data.

As the study area is located on a sloping surface, we assessed whether the observed spatial patterns largely preserve the primary spatial

patterning of prehistoric activity (*sensu* Rick 1976) or whether they reflect secondary displacement caused by slope-related geomorphological processes. Solifluction represents a cryogenic denudational process in which water-saturated soil slowly moves downslope under gravity, potentially producing elongated patterns parallel to the slope. Solifluction transport can be initiated at slope angles as low as 2.0°–3.0°.

Surface assemblages are also affected by additional biases, including ploughing disturbance, preservation factors and collection bias. These processes typically result in the underrepresentation of smaller flakes and technological by-products and the overrepresentation of larger, visually conspicuous pieces. Furthermore, the surface context does not allow precise chronological separation of individual reduction episodes.

To evaluate these potential effects, terrain gradient and slope aspect were calculated from the digital elevation model, and their relationship to the geometry of the artefact distribution was examined. This procedure allows the identification of spatial patterns compatible with primary spatial patterning as opposed to those likely influenced by post-depositional slope processes. The detailed methodology of the spatial analysis is provided in Appendix B.

Table 2a. Gyöngyöspata-Felső-Eresztvény, collection zone 1, lithic implement counts and ratios.

	Limnosilicite	Andesite	Quartzite	Total	% of tools	% of total
End-scraper	1			1	1,96	
Side scraper	7		1	8	15,69	
Borer	1			1	1,96	
Burin						
Combined tool	1			1	1,96	
Denticulated tool	2			2	3,92	
Notched tool	5		1	6	11,76	
Retouched flake	10			10	19,61	
Retouched RMF	13			13	25,49	
Diverse	8		1	9	17,65	
Tools total	48		3	51		15,64
Debitage	161	3	3	167		51,23
Waste product	91	1	7	99		30,37
Flake core	6	1		7		2,15
Laminar core	1			1		0,31
Pebble			1	1		0,31
Total	307	5	14	326		100,00
%	94,17	1,53	4,29	100,00		

Table 2b. Gyöngyöspata-Felső-Eresztvény, collection zone 2, lithic implement counts and ratios.

	Limnosilicite	Andesite	Quartzite	Total	% of tools	% of total
End-scraper	1			1	1,96	
Side scraper	5			5	13,51	
Borer						
Burin	1			1	2,70	
Combined tool						
Denticulated tool	1			1	2,70	
Notched tool	3			3	8,11	
Retouched flake	6			6	16,22	
Retouched RMF	16			16	43,24	
Diverse	4			4	10,81	
Tools total	37			37		33,64
Debitage	37	1		38		34,55
Waste product	19			19		17,27
Flake core	5	1	1	7		6,36
Laminar core	7			7		6,36
Pebble			2	2		1,82
Total	105	2	3	110		100,00
%	95,45	1,82	2,73	100,00		

3.2.2 Assessment of the functional character of the site complex

Concerning Middle Palaeolithic hunting strategies, the use of long-range projectile weapons (spearthrowers, bow) generally cannot be demonstrated for Neanderthal groups, although close-range spear use and possibly hand-thrown spears are well-attested (cf. Shea, 2006; Villa & Lenoir, 2009; Rots & Plisson, 2014). In open-air contexts, however, the exploitation of topographic affordances and solutions based on driving, encircling or topographic trapping may have played a significant role. Visibility would have been particularly important for the inter-group communication required for cooperative hunting.

To explore this aspect, we applied a GIS-based viewshed analysis performed using a digital elevation model (DEM) to interpret the spatial position of the site complex and to draw inferences regarding its possible function. The analysis focuses on a single factor: the extent to which the surroundings of the site complex may have been suitable, from the perspective of hunting and primary subsistence activities, for longer-term occupation.

The viewshed analysis identifies all terrain cells visible from the observer point under standard line-of-sight conditions. In addition, cross-sectional profiles were constructed at three topographically characteristic points across the Zám Stream valley in order to quantify slope gradients relevant to large game movement and hunting feasibility. The detailed methodology of the spatial analysis is provided in Appendix C.

4 Results

4.1 Lithic implements

4.1.1 Raw material use

The raw material composition of the assemblage is relatively homogeneous: the overwhelming majority of the lithics were made from local limnosilicite (565 pieces, 94.01%). Andesite (8 pcs, 1.33%) and quartzite (28 pcs, 4.66%) are present in much smaller quantities. All quartzite pieces were considered to be of

anthropogenic origin based on the presence of detachment negatives. As no significant gravel beds are known in the Gyöngyöspata Basin, the most probable source of this raw material is the valley of the Zagyva River. Except for a single flake, the andesite artefacts were made from a fine-grained raw material, with a homogeneous texture. This texture reflects rapid cooling at or near the surface, resulting in the formation of a fine-grained matrix (Haldar, 2020). Andesite with such favourable knapping properties occurs at several locations within the Gyöngyöspata Basin, although in varying quantities. In the descriptions that follow, the raw material is specified only for artefacts made from non-limnosilicite material.

4.1.2 The tool assemblage

The tool assemblage is relatively large (114 pieces) and displays a high tool ratio (18.97%). Considerable variation, however, exists between the two collection zones. In CZ1, 51 tools represent 17.65% of the 326 finds, whereas in CZ2, 37 tools account for 33.64% of the 110 finds. The remaining 26 tools represent 4.3% of the total assemblage.

The high tool ratio is partly a consequence of collection conditions. Due to the dense natural raw material cover of the area, not all debitage and waste products were recovered, and the selection was inevitably biased toward more diagnostically informative pieces. Furthermore, most tools were made on naturally fragmented raw material nodules and are typically atypical, *ad hoc*, or opportunistic. Consequently, the classical Middle Palaeolithic typology of François Bordes (1981) applies only with limitations. Percentage values given in parentheses for individual tool types refer to the tool assemblage as a whole.

Notched tools are the most common type within the assemblage (16 pieces; 14.04% of tools: Fig. 8, 5; Fig. 9, 4–5; Fig. 10, 1–3). Side-scrapers number 14 pieces (13.16%), the majority being simple straight (7 pieces: Fig. 7, 1–2; Fig. 8, 1) or convex (4 pieces: Fig. 8, 3) forms. Among the double side-scrapers, one is straight-straight (Fig. 8, 4), one convex-concave (Fig. 7, 3), and one concave-straight (Fig. 8, 2). A single Quina-type convex side-scrapers is present (Fig. 7, 4). End-scrapers and denticulated tools are each represented by four pieces (3.51% each; Fig. 9, 1), while a borer and a combined tool are represented by single specimens (0.88% each), along with two

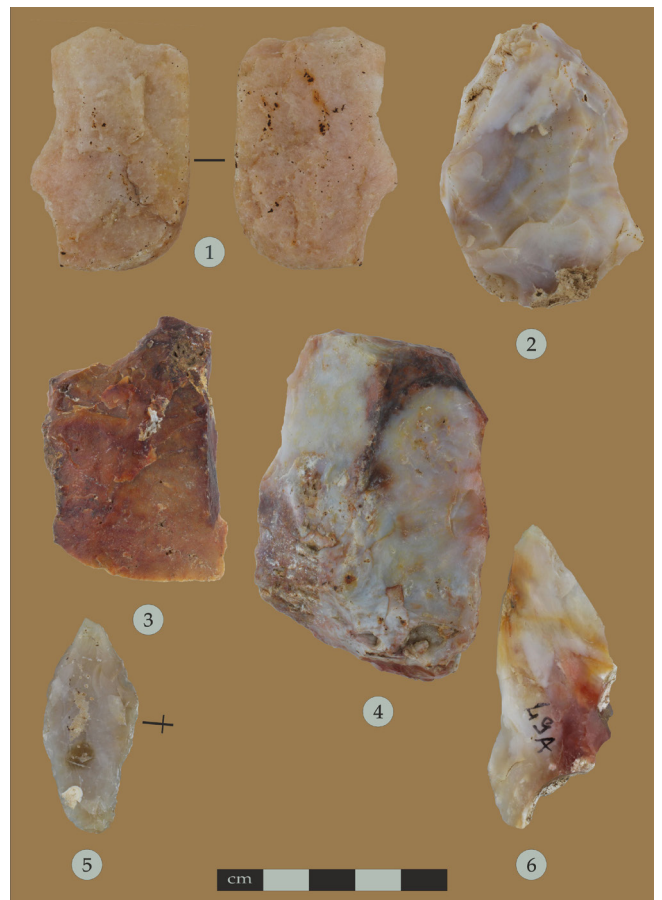
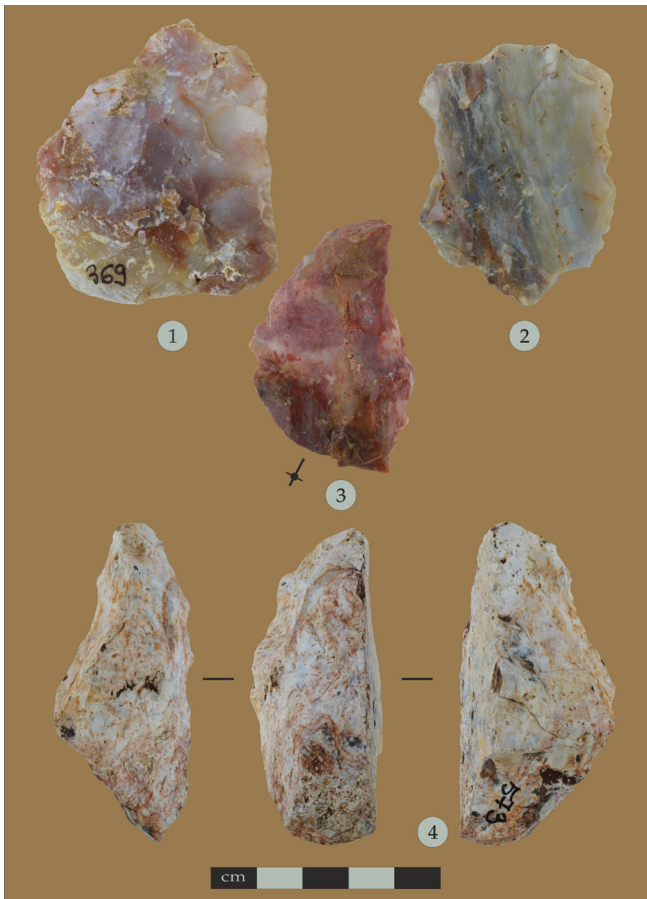


Fig. 7–10. Selected tools from the site complex. Photos: Attila Péntek

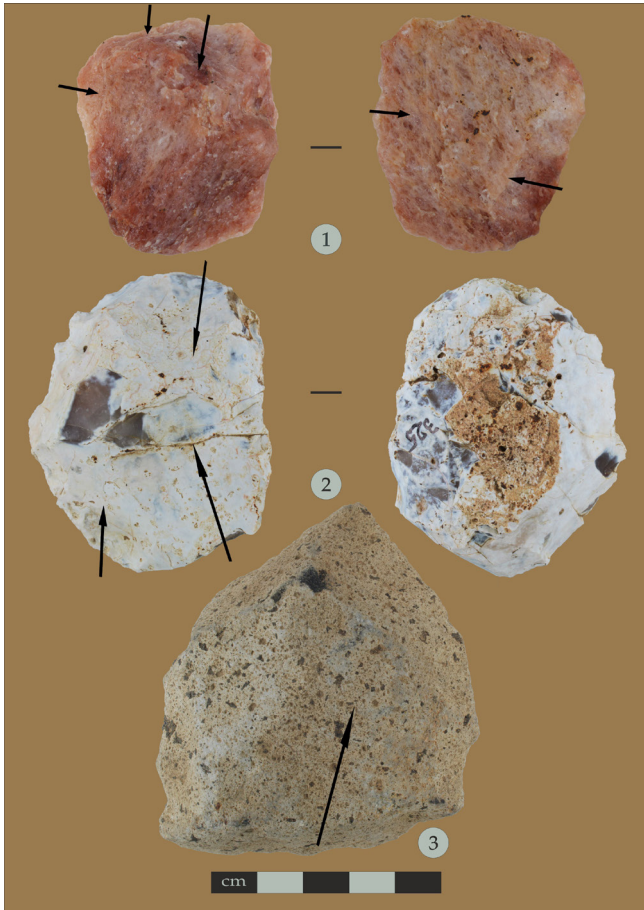


Fig. 11. Selected cores from the site complex. Photos: Attila Péntek.

burins (1.75%). The combined tool consists of a simple convex side-scraper and an unretouched notch (Fig. 8, 7).

Edge-retouched pieces are numerous: retouched flakes number 20 pieces (17.54%) and retouched raw material fragments 36 pieces (31.58%). The distinction between some of these pieces and side-scrapers was based on the retouched edge length and the quality of retouch. Detailed descriptions of the tools illustrated in Figs. 7–10 are provided in Appendix A.

4.1.3 Cores

The assemblage contains 26 cores, the majority of which are made of limnosilicite (23 pieces), with two andesite and one quartzite specimen also present. Flake production was the primary objective: except for eight sub-laminar cores intended for the production of elongated flakes, the remaining 18 cores are standard flake cores.

Several pieces are particularly noteworthy. A small, likely exhausted quartzite flake core

measures 58.9×48.2×23.8 mm (Fig. 11, 1). An exhausted recurrent centripetal Levallois core measures 61.4×52.4×26.0 mm (Fig. 11, 2). A large, thick-sectioned andesite core has the dimensions 75.7×68.6×27.9 mm (Fig. 11, 3).

4.2 Results of the spatial analysis

4.2.1 Collection Zone 1

In all categories, the major axis of the Standard Deviation Ellipse is oriented perpendicular to the slope direction, which strongly suggests that the artefacts were not displaced downslope (Fig. 12–15). If the assemblage had undergone post-depositional downslope movement, the ellipses would be expected to elongate parallel to the slope direction; this pattern is not observed in any category. The slope angle measured along the major axis is extremely low in all cases, confirming that the orientation of the distribution does not follow the terrain gradient.

Rick's selection analysis revealed a moderate difference in the areal ratio of debitage and cores, suggesting functional differences in activity areas rather than a clear size-selective displacement process. In the case of cores, the ellipse parameters are statistically uncertain given the sample of only seven pieces, and this partial result should therefore be treated with caution.

Overall, the results indicate that the material from this collection zone is situated on a surface where the influence of natural redistribution processes appears to have been minimal, and the find distribution most probably reflects the spatial patterning of past human activity. The finds were most likely brought to the surface as a result of deep ploughing before vineyard establishment.

4.2.2 Collection Zone 2

In all categories, the slope angle measured along the major axis is low, and none of the Standard Deviation Ellipses shows an orientation parallel to the slope direction – debitage and cores display a transverse orientation, while the total finds and tools show an oblique arrangement (Fig. 12–15). The latter presents a slightly less favourable picture compared to CZ1, where all categories were clearly transverse; however, an oblique orientation alone does not indicate post-depositional movement. In all cases, the

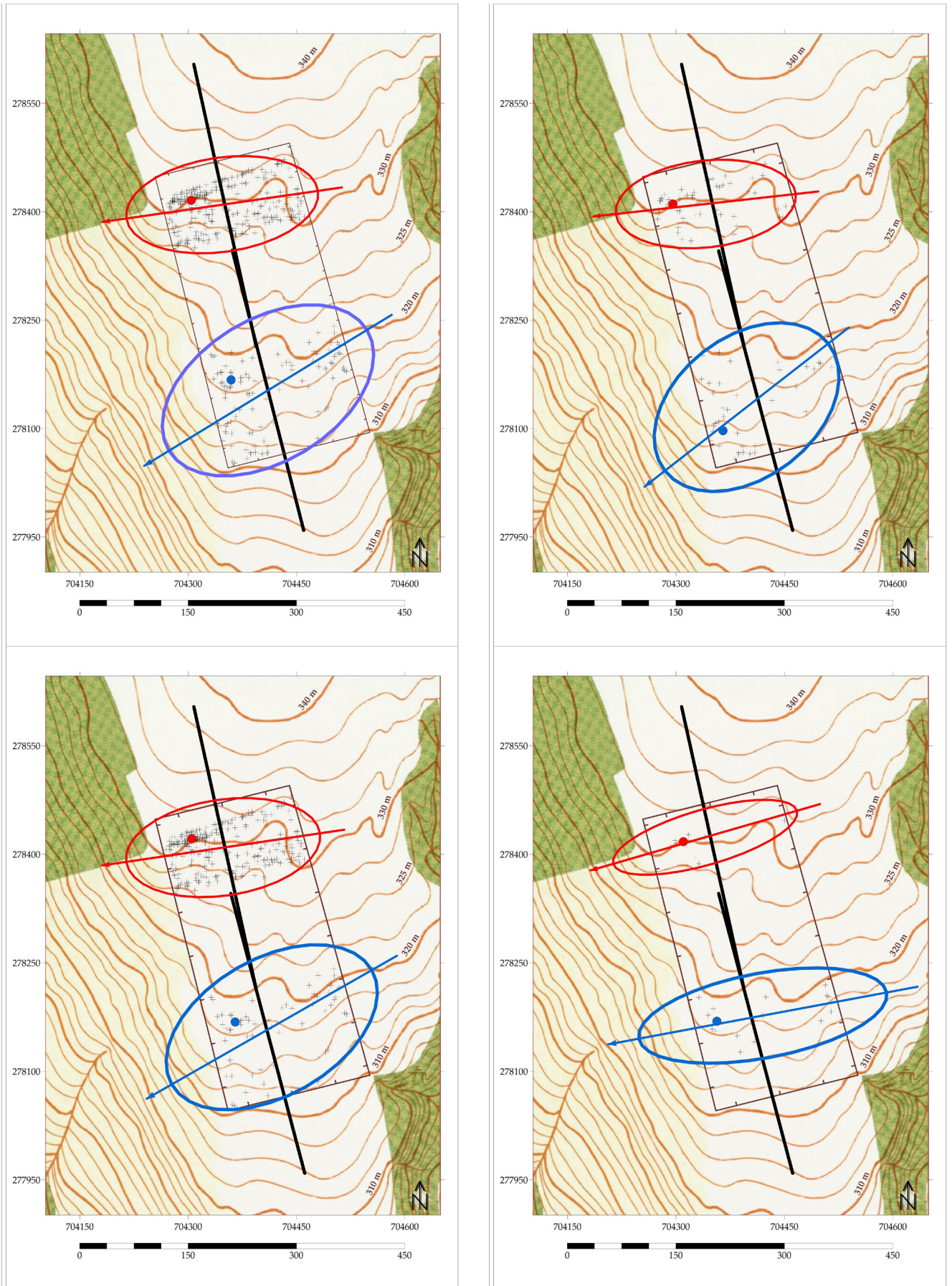


Fig. 12–15. Standard Deviational Ellipses: top left (fig. 12) - of the total assemblages of the two collection zones; top right (fig. 13) - of the tools of the two collection zones; bottom left (fig. 14) - of the knapping by-products (debitage) of the two collection zones; bottom right (fig. 15) - of the cores of the two collection zones. Maps: Attila Péntek.

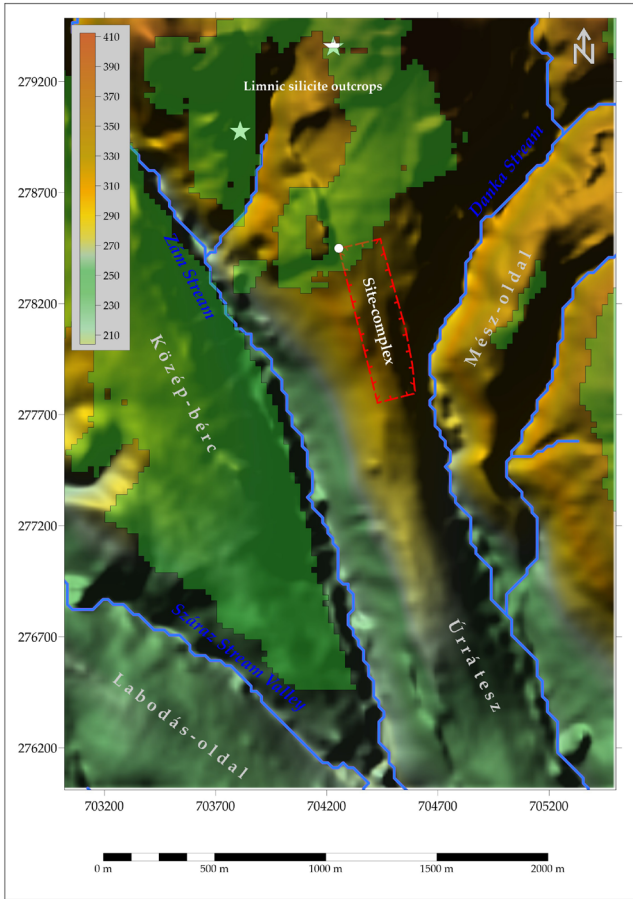


Fig. 16. Viewshed constructed with a 2.5 km radius from the northwestern corner of the site complex. Map: Attila Péntek

Slope Anisotropy values indicate that the terrain is steeper along the minor axis than the major axis. Within the logic of the analysis, this is not necessarily a risk indicator; rather, it confirms that the elongation does not follow the slope gradient. The dispersion of finds along the minor axis may reflect either multiple occupation episodes or functional differentiation within the activity area. Rick’s selection analysis revealed a moderate difference in the areal ratio of debitage and cores, suggesting natural functional differences rather than a clear size-based selection process. The results for the core category should nevertheless be treated with caution, as the sample of 14 pieces, while somewhat more favourable than the seven pieces from CZ1, still lies at the lower boundary of the method’s reliability.

Overall, the results suggest that the CZ2 assemblage is also situated within a relatively stable depositional context, where the effect of natural redistribution processes was minimal, and the find distribution most probably reflects the spatial patterning of past human activity. As

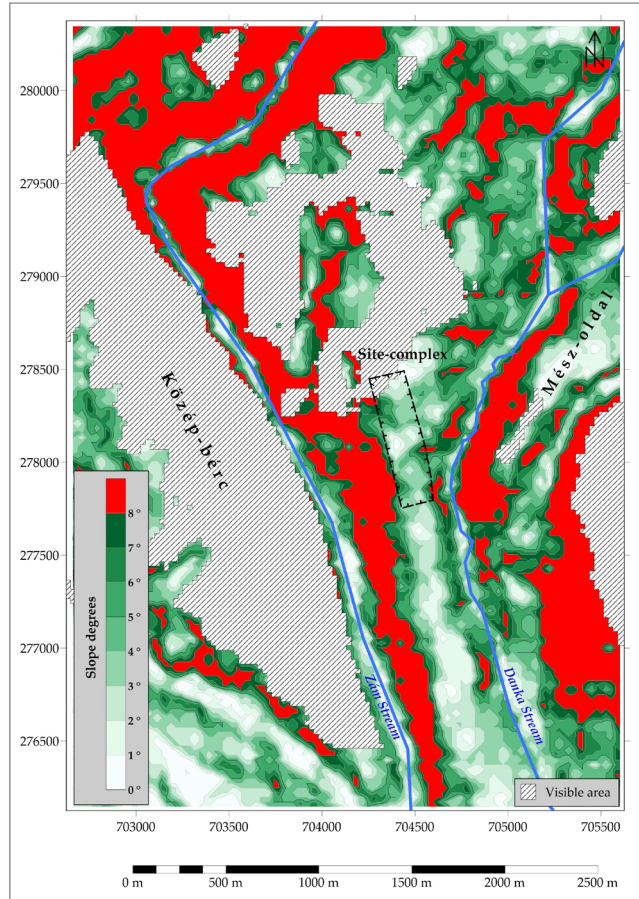


Fig. 17. Slope conditions of the site complex’s surroundings, the viewshed is also indicated. Map: Attila Péntek

in the case of CZ1, the finds from CZ2 were most likely brought to the surface as a result of deep ploughing before vineyard establishment.

4.2.3 Results of the viewshed analysis

Fig. 16 shows a detailed extract of the viewshed constructed with a 2.5 km radius from the artefact-rich northwestern corner of the site complex, indicated in spring green on the digital elevation model (DEM). The area to the north of the site complex is unfavourable for hunting, as it consists of open, gently sloping hillside. Part of the area to the east – the Mész-oldal zone between the Danka Stream and the unnamed dry valley below Havashegy – was accessible to Pleistocene megafauna. Slope angles either do not exceed the 8° (14%) threshold considered critical for ungulates (Krist & Brown, 1994), or steeper sections could be negotiated by diagonal traversal. Steep slopes would, of course, also significantly reduce the effectiveness of human hunting strategies such as encirclement or exhaustion drives. Rather than

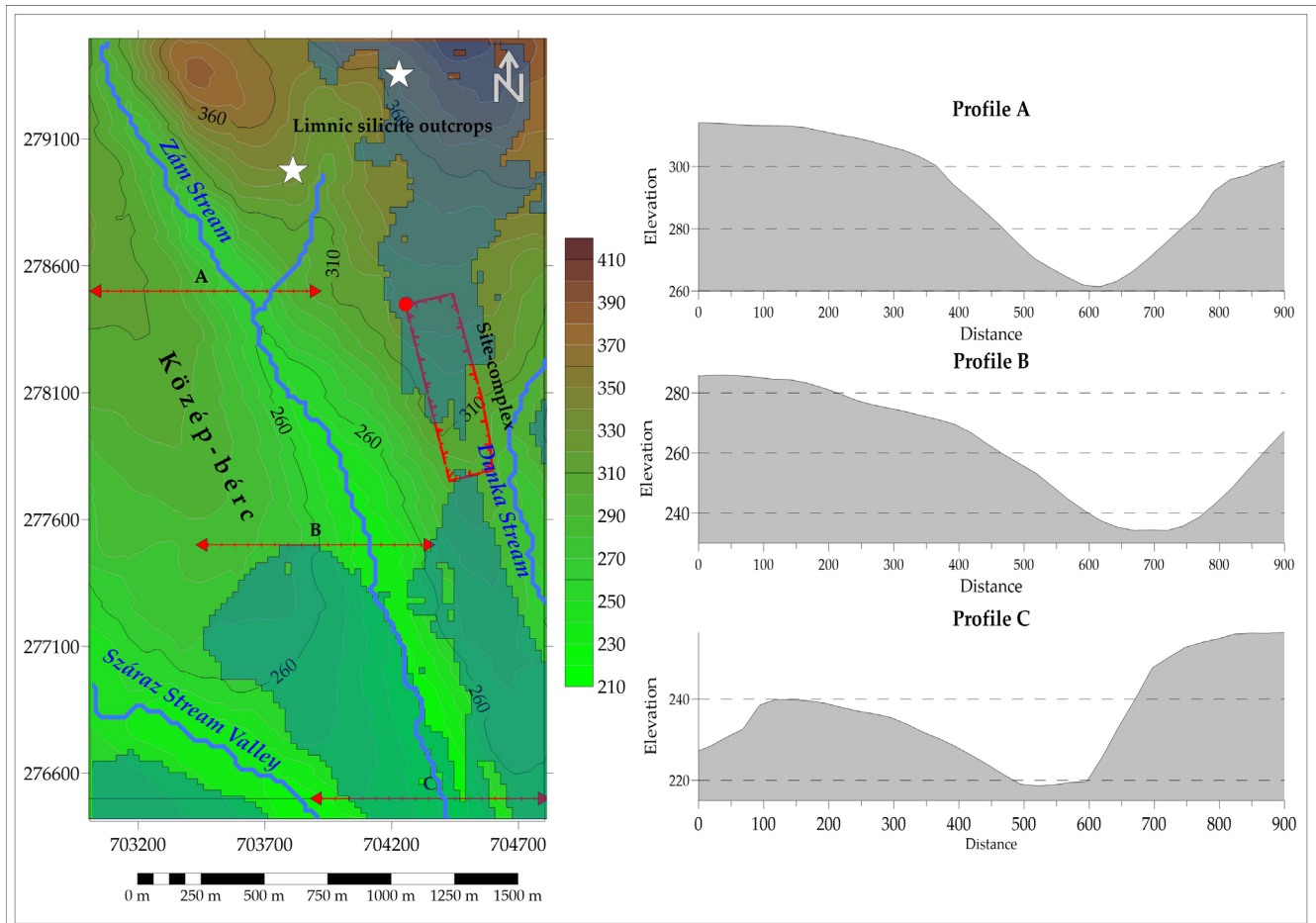


Fig. 18. Three cross-section profiles across the Zám Stream valley. Map: Attila Péntek.

the open Gyöngyöspata Basin to the south and southwest, the focus of hunting strategy most probably lay to the west, towards the Közép-bérc plateau and the Zám Stream valley. The slope conditions of the site complex's surroundings, with the viewshed indicated, are shown in Fig. 17.

From a hunting perspective, the Mész-oldal area mentioned above was likely unsuitable because of its open character. The narrow valley of the Danka Stream below it may appear more favourable due to its topographic bottleneck; however, an important limitation must be considered. Most herd animals – potential prey species of the Pleistocene megafauna – rely strongly on group cohesion, which provides protection against predators and facilitates orientation and foraging. As a result, solitary individuals are relatively uncommon, typically occurring only in specific situations such as illness or injury, displacement from dominance hierarchies, or during the reproductive season when males may temporarily move independently.

For a more detailed analysis, three cross-sections, each 900 m in length and spaced 1 km apart, were constructed across the Zám Stream valley, which appeared more promising from a hunting perspective (Fig. 18). The cross-sections are designated A, B and C from northwest to southeast, respectively. Slope angles were calculated based on the last visible point on the western and eastern slopes when viewed from the lowest point of the valley. For profile A, these values are 15.3% and 17.20%; for profile B, 12.86% and 14.37% (“Strongly sloping/Moderately steep”, Reinhold *et al.*, 2006, p. 12, Table 7). For profile C, the values decrease to 5.81% and 12.25% (“Sloping” and “Strongly sloping/Moderately steep” respectively, Reinhold *et al.*, 2006, p. 12, Table 7). The side of the stream valley facing Közép-bérc is therefore not critical for animal movement as viewed from the basin, particularly when the possibility of diagonal traversal along the slope is taken into account. On the southwestern side of the Zám Stream valley, in the Közép-bérc area, a previously identified large-scale site complex is located, the assemblage of which has not yet

been published. As contemporaneity cannot be demonstrated for open-air sites, the relationship between the two site complexes remains an open question for the time being.

These results collectively suggest that the spatial structure of the assemblage largely preserves the original patterning of prehistoric activity rather than being the product of slope-related post-depositional processes.

5 Discussion

The functional interpretation of the site complex remains uncertain. Its character as a base camp, a temporary hunting camp, or a knapping workshop cannot be unambiguously established. This uncertainty results partly from the relatively small quantity of surface-collectable material, despite the high tool ratio within the assemblage, and partly from the fact that a considerable proportion of the area is currently occupied by patches that are inaccessible or only poorly suited to archaeological investigation.

5.1 Taphonomic variability and multi-phase occupation

One of the most striking characteristics of the collected assemblage is the considerable variability in the surface condition and patina of the artefacts. This variability may reflect differences in raw material properties, chronological variation, or post-depositional taphonomic processes. While some pieces show little or no patina, others display varying degrees of surface alteration.

Several artefacts are covered by a patina resembling desert varnish, a dark, manganese-rich coating typically forming on exposed rock surfaces in arid and semi-arid regions (Perry *et al.*, 2005). Another common form of surface alteration is so-called gloss patina, which is primarily a result of soil solution-related chemical processes. The adsorption of amorphous silica from the surrounding depositional environment may lead to the formation of such glossy surfaces (Howard, 2002).

The surfaces of strongly patinated pieces – particularly along their edges – often appear heavily worn and rounded. Taken together, these observations strongly suggest that the assemblage

accumulated over multiple periods and reflects more than one occupation episode.

5.2 The dichotomy observed in the tool assemblage

Alongside finely worked, typologically identifiable tools, the assemblage also contains numerous ad hoc, opportunistically produced pieces from naturally fragmented raw material nodules. Many of these represent expedient implements rather than tools intended for long-term use (non-curved tools *sensu* Binford, 1979). Such non-economic use of raw material is commonly observed in knapping workshops where suitable raw material is readily available.

Distinguishing pseudo-artefacts – geofacts produced entirely by natural processes – and pseudo-tools with accidental, tool-like modifications from genuine artefacts often presents serious interpretive challenges. Some ambiguous pieces may even have been used as expedient tools. Evan Peacock's (1991) scoring method introduced a simple, systematic way to reduce subjective judgement by standardising the assessment of key lithic attributes. Its main limitation is a substantial grey zone, where natural and human-made flakes receive similar scores, and its reliability varies with raw material and context. Consequently, it functions best as a preliminary screening tool that must be complemented by other analytical approaches.

Recent studies have attempted to refine or replace such scoring systems (Wiśniewski *et al.*, 2023). In the case of limnosilicite, natural processes such as frost fragmentation or slope-related mass movements may produce fractures that can be misleading in this respect.

5.3 Regional parallels

The exhausted recurrent Levallois or Proto-Levallois (“simple prepared-core” technology *sensu* White & Ashton, 2003) core present in the technological profile of the Felső-Eresztvény site complex, and the application of the Levallois method, are relatively rare in the domestic open-air context. This is probably partly the result of a research gap and partly a consequence of the neglect of surface assemblages. On the basis of the typologically dominant standard Mousterian tools, part of the assemblage can unquestionably

be assigned to Mousterian industries with partial application of the Levallois concept (Levallois-Mousterian *sensu* Kozłowski, 2016). The sporadic presence of Levallois elements at Gyöngyöspata raises the question of whether this technological choice appears marginal due to a deliberate reduction strategy conditioned by raw material quality, or as a result of the selective nature of surface collection.

The recently identified sites of Szurdokpüspöki-Lapos-tanya (SzP-21) and Tilalmas-tető (SzP-16) in the immediate vicinity of the Gyöngyöspata Basin (Péntek *et al.*, 2025), together with sites identified in the southern and southwestern sectors of the basin, provide direct analogies, indicating an extensive, technologically homogeneous presence in the western Mátra Mountains. Based on the typological spectrum – particularly the high proportion of side-scrapers – strong parallels may be identified with the classic Mousterian sites of the Bükk Mountains (Bartucz *et al.*, 1940; Gábori, 1976; Mester, 1989; 1995; 2004; 2006; 2022; Mester & Patou-Mathis, 2016; Mester *et al.*, 2023).

It is important to highlight, however, the differences in raw material procurement strategies. For understandable geological reasons, while the industry at Felső-Eresztvény is characterised by the near-exclusive dominance of local limnosilicite, Subalyuk Cave presents a considerably more diverse spectrum that includes non-local raw material types. The assemblage from layer 4 of Búdöspeszt Cave is characterised by the dominance of metarhyolite (89.3%). The greater part of the Felső-Eresztvény industry is more closely reminiscent of the side-scrapers-rich Typical Mousterian, but certain scraper types, the high proportion of transverse side-scrapers, and the notched tools suggest affinities with the Quina-type Mousterian (Mester, 1995). Given the differing properties of the raw materials used, the Bükk assemblages are difficult to compare directly with the Mátra limnosilicite industry on technological grounds.

5.4 Central European analogies

While the few Levallois elements present in the assemblage of the site complex would not in themselves call for such a discussion, the sporadic application of the Levallois method is attested in the assemblages of numerous sites within the

Gyöngyöspata Basin, and a brief overview limited to Central Europe is therefore warranted.

Numerous Mousterian sites are known from the core countries of Central Europe (Austria, Czech Republic, Poland, Slovakia) and the adjacent transitional zones (Croatia, Romanian Transylvania, Serbia, Ukrainian Transcarpathia), where the application of the Levallois concept is attested. The majority of these sites date to the last interglacial (Eemian) and the first half of the Würm glacial (ca. 130,000–60,000 BP). The most important parallels are summarised below, without claiming exhaustiveness, to illustrate the wide distribution of this technology across the region.

In Austria, several significant cave sites along the Danube valley and the margins of the Eastern Alps exhibit a Mousterian character. Unlike several open-air sites, the well-known Middle Palaeolithic cave sites of Austria (Gudenus Cave, Repolust Cave) have not yielded unequivocal evidence for the application of the Levallois concept (Obermaier & Breuil, 1908; Mottl, 1951; Modl *et al.*, 2014; Schmid & Nigst, 2014). The Levallois concept is attested in the assemblage of Ramesch-Knochenhöhle (Rabeder, 1985). Its intensive application is known from the sites of Großweikersdorf-Kogel (Neugebauer-Maresch & Thomas, 2012; 2013) and Csaterberg (Schmid *et al.*, 2021).

In Poland, the presence of the Levallois technique in cave assemblages is often linked to specific facies. The oldest (that is, pre-OIS 3) Middle Palaeolithic record in the Kraków region, based only on geological interpretations, comprises a Levallois-Mousterian predominantly. Biśnik Cave is a cave site with a long stratigraphic sequence, where Micoquian and Levallois elements occur in parallel or alternating succession (Cyrek *et al.*, 2014). At the open-air site of Kraków-Zwierzyniec I, a Shaitan Koba-type Levallois-Mousterian industry was identified in Area P alongside the Micoquo-Pradnikian assemblage (Chmielewski, 1975; Chmielewski *et al.*, 1977; Kozłowski, 2006). The Piekary complex of Palaeolithic sites (IIa and III) has yielded Micoquian and Levallois-Mousterian industries (Sitlivy *et al.*, 2008).

In Slovakia, the Levallois technique is particularly prominent at the travertine sites of the Szepes region and in the Upper Nitra valley. Artefacts typical of a younger phase of the Levalloisian technique were found at

Hôrka-Ondrej (Kaminská *et al.*, 1993) and Vyšne Ružbachy, and those of Mousterian with Levalloisian technique at Beharovce-Sobotisko. At the sites of Bojnice I (Bajmóc-Prepoštská Cave) and Prievidza-Mariánsky vršok (Privigyte), the Levallois technique was adapted to local raw materials (andesite, quartzite, limnosilicite) (Neruda & Kaminská, 2013; Kaminská, 2014).

Northern Bosnia and Herzegovina, Croatia and Serbia. Both cave and open-air sites in the western Balkan region demonstrate the technological diversity of the Levallois concept.

In northern Bosnia, Mousterian layers have been documented at numerous sites (e.g. Kadar, Kamen, Londza, Ratusa Cave, Visoko Brdo and Zobište), whose assemblages are characterised by a notable importance of Levallois debitage (Montet-White, 1994; Rajkovaca, n.d.).

In the older layers (unit K) of Vindija Cave (Croatia), typical Mousterian tools predominate, and there is clear evidence for the use of Levallois technology (Ahern *et al.*, 2004; Janković *et al.*, 2006). At Krapina Cave (Croatia), the application of the Levallois concept was observable in the earlier layers. Despite the small sample, Levallois flakes appear to be particularly frequent as blanks for tools made on exotic raw materials (Simek & Smith, 1997).

In Serbia, the Levallois concept and even proto-Levallois (simple core technology; White & Ashton, 2003) are well documented in the assemblages from the Morava valley (Samaila-Vlaška Glava near Kraljevo; Ježevica-Vojnovića in the vicinity of Zabláče) and the surrounding uplands (Pešturina Cave) (Mihailović, 2014).

In Romania, numerous Typical Mousterian sites applying the Levallois concept are known, including the lower layers (I–III) of Ripiceni-Izvor, Cheia-La Izvor, Gornea, Boinești and Remetea-Somoș (Pop, 2013; Doboș, 2017). In Dobrudja, the site of Mamaia Sat represents one of the most important open-air occurrences of the Levallois technique (Balescu *et al.*, 2015).

In Ukraine (Transcarpathia and western Ukraine), Korolevo (Királyháza) I (layers III and 2b) is one of the most significant stratified sites in Europe, where the development of the Levallois technique has been traced over a long chronological span (Demidenko & Usik, 1993; 1995; Usik, 2013). Near Korolevo, at the foot of Sorgeidy Hill, the partial application of the Levallois concept in the assemblage of Sorgeidy

Complex I is documented by cores and flakes (Sitlivy, 1989). At the site of Velykyi Glybochok, the flint finds of the early Mousterian were produced using the Levallois method (Łanczont *et al.*, 2014).

On the basis of the Central European analogies, the industry of Felső-Eresztvény, and probably that of numerous further sites in the Gyöngyöspata Basin, fits well within the broader series of open-air sites in the region where the technological character was determined primarily by adaptation to local raw materials. The Levallois concept – as in the parallels examined – appears only sporadically. The emphasis throughout remains on stable, flake-oriented reduction strategies and the Mousterian tool repertoire. The parallels suggest that this industry of the Western Mátra represents a technological tradition widespread across a broader geographical unit, well adapted to the prevailing environmental conditions of the Middle Pleistocene.

6 Conclusion

The Felső-Eresztvény site complex, identified on the northern margin of Gyöngyöspata, constitutes one of the most extensive and complex Middle Palaeolithic surface assemblages in the Gyöngyöspata Basin. Within a smaller, relatively well-defined part of the area, elongated flakes and several sub-laminar cores were recorded. Among the tools, a few atypical end-scrapers were identified. It remains unclear how this small quantity of material relates to the dominant flake industry of the site complex. On the basis of find distribution, raw material composition and typological characteristics, the site complex, covering more than 13.9 hectares and situated on a ridge, most probably preserves the traces of repeated occupations based on the exploitation of local limnosilicite. Alongside the probable workshop character of the site complex, the possibility of short-term, functionally complex occupations cannot be entirely excluded. The latter possibility, however, does not appear likely given the absence of favourable hunting opportunities in the surrounding area.

The differences in taphonomic conditions and patina, together with the co-occurrence of finely worked tools and ad hoc pieces, suggest that the site complex represents multiple occupation periods and is by no means the product of a

single functional event or knapping episode. The technological and typological characteristics – the dominance of notched tools, the presence of numerous varied side-scrapers and denticulated tools, and the complete absence of Upper Palaeolithic elements – show close affinities with the Mousterian sites of the Bükk Mountains. The partial, non-systematic application of the Levallois concept is indicated by the Levallois core and several Levallois-like flakes.

The Felső-Eresztvény site complex represents an important new regional data source. It has the potential to advance our understanding of Middle Palaeolithic technological variability, raw material use and open-air settlement patterns. At the same time, the limitations of surface collection – disturbance, artefact-free patches and taphonomic distortions – require considerable caution in interpretation.

The significance of the site complex lies primarily in its capacity to add a new dimension to Middle Palaeolithic research in the Gyöngyöspata Basin. In the future, targeted surface collections and, above all, small-scale test excavations could contribute to a more precise chronological, stratigraphic and functional interpretation of the assemblage. The site complex also offers an opportunity to examine the role of Mousterian and Levallois elements within the technological diversity of Central European Neanderthal communities.

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Appendix

Appendix A – Artefact descriptions

A.1 Side-scrapers

Thick, simple side-scraper on a raw material fragment. The cross-section is approximately triangular in shape, with a thick, approximately straight base. The straight right edge is semi-abruptly retouched (58.9×48.2×23.8 mm; Fig. 7, 1).

Thick, simple side-scraper on a raw material fragment. The cross-section is irregularly triangular; the irregularly shaped edge on the left side is thick. The right edge is approximately straight and semi-abruptly retouched. At the midpoint of the edge, two removals resembling denticulation or shallow notching are present (54.2×40.3×18.8 mm; Fig. 7, 2).

Simple side-scraper on a raw material fragment. The straight left edge is semi-abruptly retouched. The right edge is thick, forming a natural back (48.5×38.3×15.8 mm; Fig. 8, 1).

Simple side-scraper or retouched raw material fragment. The left side of the obtuse-angled, irregularly shaped distal end is slightly concave, the right side straight. Both sections are semi-abruptly retouched (35.0×33.4×14.1 mm; Fig. 8, 2).

Side-scraper on a raw material fragment. The slightly convex section of the distal end of the right edge bears fine retouch above and two shallow notches or denticulations below (76.3×44.4×15.9 mm; Fig. 8, 3).

Straight-edged side-scraper on a raw material fragment. A retouched section approximately 25 mm in length is present at the proximal end of the left edge. The thicker right edge forms a natural back (60.6×31.8×14.6 mm; Fig. 8, 6).

Simple side-scraper on an elongated, thick-sectioned pseudo-Levallois flake with a dihedral platform. The straight distal end of the right edge is inversely retouched (64.7×39.2×17.0 mm; Fig. 9, 2).

Simple straight-edged side-scraper on a quartzite flake. The distal end of the left edge is abruptly retouched. The right edge forms a natural back (66.8×33.3×18.0 mm; Fig. 9, 3).

Convex-concave double side-scraper on an off-axis (*déjeté*) flake. Both edges are semi-abruptly retouched in a scalar-stepped pattern (50.9×41.6×14.8 mm; Fig. 7, 3).

Double side-scraper on a flake. The proximal end of the left edge and the right edge are semi-abruptly retouched (43.1×34.8×11.4 mm; Fig. 8, 4).

Thick Quina-type side-scraper on a raw material fragment. The edge on the right side is convex with steep scalar-stepped retouch (67.8×29.5×28.8 mm; Fig. 7, 4).

Large, thick alternate side-scraper on a raw material fragment. The distal end of the left edge bears straight semi-abrupt direct retouch, while the proximal end bears straight inverse retouch. The distal end features a steeply, coarsely retouched section with use-damage (81.7×55.6×24.7 mm; Fig. 10, 4).

Side-scraper with an irregularly convex transverse edge on a raw material fragment (20.6×46.1×7.9 mm; Fig. 10, 5).

Straight-edged inversely retouched side-scraper on a raw material fragment (63.4×25.1×14.2 mm; Fig. 10, 6).

A.2 Notched tools

Small notched tool on a raw material fragment. There is a shallow, retouched notch at the distal end. A short retouched section is visible at the distal end of the left edge, below which a possibly unretouched small notch may be present (38.5×31.9×11.2 mm; Fig. 8, 5).

Large tool on a raw material fragment. On the left edge, there is an unretouched notch with use-wear traces (67.6×53.6×16.1 mm; Fig. 9, 4).

Large, thick-sectioned tool on a raw material fragment. Two coarse, retouched notches are visible on the left edge in the orientation shown (62.8×59.5×23.5 mm; Fig. 9, 5).

Notched tool on a thick raw material fragment or flake. A semi-abruptly retouched notch is present on the right edge (60.9×43.3×21.8 mm; Fig. 10, 2).

Notched tool on a raw material fragment. A shallow, retouched notch is present on the left side of the distal end; thinning retouch is visible on the upper face. Minor use damage is present within the notch (57.8×37.9×18.4 mm; Fig. 10, 3).

Atypical tool on a cortical quartzite pebble slice produced by the bifacial anvil technique. On the thinner edge opposite the natural back, two longer retouched notches are present in opposing directions – one direct and one inverse – placed one above the other (57.8×37.9×18.4 mm; Fig. 10, 1).

A.3 Combined tool

Combined tool on a raw material fragment. The distal end of the right edge forms a simple convex side-scraper; a small notch is present on the concave middle section of the left edge (53.5×31.3×16.4 mm; Fig. 8, 7).

A.4 Other tools

End-scraper on a raw material fragment. The slightly arched, semi-abrupt working edge is resharpened, with partial use-wear traces (44.4×34.3×20.8 mm; Fig. 9, 1).

Appendix B – Geomorphological and spatial-statistical assessment of post-depositional risk

B.1 Spatial summary of find distribution – Standard Deviational Ellipse

The spatial configuration of each find category was characterised using the Standard Deviational Ellipse (SDE), which simultaneously determines the location of the centroid, the lengths of the major and minor axes, the elongation, and the principal orientation (azimuth) (Fig. 12–15). The ellipse covers the 95%, i.e. 2-sigma (2σ), spatial extent of the finds. These parameters served as the geometric basis for evaluating the directional patterning of the distributions.

Elongation (expressed as the ratio of the major to the minor axis) characterises the shape of the distribution, ranging from a circular distribution with a value of 1.0 to a strongly elongated, linear pattern. High elongation does not in itself indicate post-depositional disturbance – orientation is the determining factor: a transverse arrangement relative to the slope is a typical indicator of primary spatial patterning conditions, whereas elongation parallel to the slope suggests the influence of slope processes.

The find concentration index, calculated from the area of the SDE, expresses the number of finds per unit area (1000 m²). This allows the distinction between diluted, dispersed (probably redistributed) and intensive, clustered, potentially primary spatial patterning zones.

The analysis was run in parallel for four find categories: all finds (total), retouched tools (tool), knapping by-products (debitage), and cores (core).

B.2 Terrain correlation

B.2.1 Determination of general slope conditions. The general slope angle and slope aspect at the centroid of the SDE were estimated using a multi-directional finite difference sampling scheme. The sampling radius was determined adaptively, calibrated to the length of the major axis and the resolution of the DEM, in order to minimise error arising from DEM noise while ensuring sufficient spatial coverage for the representation of regional slope conditions.

B.2.2 Directional slope measurement along the major and minor axes. In addition to the general slope angle, directional slope components were calculated along the major and minor axes of the SDE by linear regression of elevation samples taken at regular intervals along the axes. This enabled the quantification of slope anisotropy: the analysis examined whether the terrain is steeper in the direction of the major axis or in the transverse direction. If the slope along the major axis is substantially greater than along the minor axis, and the SDE is oriented parallel to the slope direction, this is considered a strong indicator of directional slope processes.

B.3 Density asymmetry – Kernel Density Estimation and hotspot analysis

Internal clustering within individual assemblages was characterised using Kernel Density Estimation (KDE). The spatial offset between the centroid of the SDE and the density maximum of the KDE (hotspot) was measured, and the magnitude and direction of this displacement were evaluated relative to the slope aspect.

The relative hotspot displacement compares the hotspot-centroid distance to the length of the major axis. When this value approaches 1.0, the density core is located at the margin of the ellipse, indicating strong density asymmetry. Hotspot displacement in the slope direction is interpreted as an indicator of gravity-induced reworking, whereas transverse displacement is considered compatible with functionally or behaviourally structured spatial organisation.

B.4 Angular deviation and orientation analysis

The angular deviation between the slope aspect and the major axis of the SDE was calculated and classified as parallel ($<22.5^\circ$), oblique (22.5° – 67.5°) or transverse ($>67.5^\circ$). A parallel arrangement under moderate or steep slope conditions – particularly when combined with high slope anisotropy – is interpreted as an indication of slope process-induced redistribution, whereas a transverse arrangement under low and isotropic slope conditions is treated as evidence of primary spatial patterning.

B.5 Rick's selection index

Following Rick (1976), the ratio of the dispersal areas of debitage and heavier pieces (cores) was calculated. A ratio exceeding 2.0 indicates strong natural size-based selection: smaller, lighter flakes have been dispersed across a considerably larger area on the slope than the more stable, heavier cores. This size class-specific dispersal is one of the most characteristic field indicators of gravitational transport.

B.6 Stability Coefficient

In addition to the risk classification, a normalised Stability Coefficient (SC) was calculated on a 0–1 scale, relating the direction of hotspot displacement to the slope aspect. $SC = 0$ denotes complete geomorphological control (downslope migration), while $SC=1$

denotes dominant anthropogenic control (primary spatial patterning). On flat terrain, the coefficient assumes a higher baseline value, as limited topographic relief inherently constrains gravitational movement.

B.7 Composite post-depositional risk assessment

The geomorphological and spatial-statistical indicators were integrated into a composite post-depositional risk assessment, which assigns each assemblage to one of three categories. The classification is built on four principal criteria, whose weighting is based on models in the literature concerning the destructive effect of slope processes on archaeological contexts (Rick, 1976; Lenoble & Bertran, 2004; Bertran *et al.*, 2012): the slope angle along the major axis; the combination of slope anisotropy and orientation; parallelism relative to the slope direction; and the degree of elongation of the distribution. The three defined categories are as follows: Low risk – the distribution is probably primary spatial patterning; the direction of elongation is perpendicular to the slope, or the terrain is near-flat; Moderate risk – moderate distortion cannot be excluded; the context requires cautious interpretation; High risk – strong post-depositional redistribution is probable; the spatial arrangement of finds is determined primarily by gravity and erosion. This framework provides a reproducible basis for distinguishing geomorphological forcing effects from anthropogenic spatial patterning on sloping terrain. The results should always be interpreted in conjunction with field observations and archaeological contextual data.

Appendix C – Viewshed analysis

Viewshed analysis is a fundamental function of geographic information systems, determining which areas are visible from a given point. In archaeological contexts, the method is used primarily to investigate the location of sites and settlement complexes (Jones, 2006; Čucković, 2015). It is assumed that the visibility relationships between base camps, temporary hunting camps and nearby satellite points may have played an important role in communication and cooperative hunting strategies.

Based on analogies from open-air sites in the Cserhát Mountains, Middle Palaeolithic

occupations are frequently associated with topographic bottlenecks. These typically take the form of blind valleys or natural passages – gorges, steep valleys, river crossings – where animal herds are forced to converge and move in a single direction. Hunters would wait at such locations, knowing that the terrain prevented the animals from dispersing or detouring. Such a location serves as the point of passive waiting and herd encirclement. A closely related concept is the topographic neuralgic point, which designates the terrain feature where prey becomes most vulnerable or where the hunter has the greatest opportunity for intervention. Such points may include the crest of a steep ascent, where animals become fatigued and slow down; the edge of a marshy area, where animal movement becomes uncertain; or a blind bend or ridgeline from which the hunter can appear unexpectedly, concealed by the terrain until the moment of approach (Péntek, 2014–2015). The distinction between the two concepts is not arbitrary. While the bottleneck regulates channelling and mass movement, the neuralgic point is the locus of tactical advantage – the place where the outcome of the hunt is decided, where the actual kill takes place or where the herd is directed towards a natural hazard such as a cliff edge.

If we assume that the site complex was not exclusively used as a knapping workshop, the topographic conditions for hunting opportunities must be examined. To investigate this assumption, a viewshed analysis was performed with the following parameters. The analysis was centred on the artefact-rich northwestern corner of the site complex with a radius of 2.5 km. Observer height was set to 1.65 m above ground level, representing the eye level of a standing adult. Target height was set to 1.65 m above ground level, approximating the lower boundary of the shoulder or back height of large Pleistocene megafauna present in the region during the Middle Palaeolithic, including mammoth (*Mammuthus primigenius*), woolly rhinoceros (*Coelodonta antiquitatis*) and giant deer (*Megaloceros giganteus*). The analysis identifies all terrain cells visible from the observer point under standard line-of-sight conditions, without atmospheric correction. Three cross-sections were constructed across the Zám Stream valley at 1 km intervals to quantify slope gradients relevant to large game movement and hunting feasibility.