

**Formation of Mesolithic hunting campsites:
Case studies of the Rydno and Wieliszew sites (Poland)**

Tomasz Boroń – Małgorzata Winiarska-Kabacińska – Karolina Płoska

**Digital spatial modelling for encampment localisation
related to the Battle of Mohi (1241), Hungary**

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**Medieval grain from Křivoklát Castle in Central Bohemia:
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EDITORIAL

This is the last year of *Archeologické Rozhledy*!

Now that I have shocked you and seized your attention, let me explain. This is the last year the journal will be published under its current title. After extensive discussion, the editorial board has decided, in cooperation with the publisher, to begin a new chapter in the journal's history. Starting in 2027, the journal will be published as *Archeologické rozhledy – Archaeology of Central Europe*. You may also come across the acronym *AR-ACE*.

As you can see, the title is not changing completely. We decided to retain the original name and complement it with an English subtitle. This decision reflects our deep respect for the journal's long tradition. Published continuously since 1949, *Archeologické Rozhledy* has been one of the pillars of Czechoslovak (later Czech) archaeology. Over the decades, it has built a strong reputation both at home and abroad. On the other hand, the journal has often been perceived as a primarily (if not only) Czech platform, partly because of its title.

Why move beyond this focus? I broadly addressed this question in my first editorial (issue 2023/1) when I took over as editor-in-chief, so I will only briefly repeat the main argument here. Archaeological phenomena cannot be studied sufficiently solely on a national basis, simply because the past world was not limited by strict borders, nor is our current world. No scholarly community can thrive in isolation without risking intellectual stagnation and self-replication. We want to avoid that risk and broaden our scope to a wider Central European perspective. In many ways, the title change just follows reality: over the past years, *AR* (or shall I say *AR-ACE*?) has published numerous studies on non-Czech material written by researchers from across Europe.

Change is never easy. Welcomed by many, it elicits apprehension in others. I must admit that the new title also brings many challenges for the editorial team, from designing a new logo to updating the website, journal layout, and many other things. Yet archaeologists know better than most that changes and transformations are inevitable and always present in human history. Nothing remains the same forever.

I believe this step is necessary if the journal is to navigate the changing landscape of contemporary archaeology. For the past two decades, academic publishing has transformed in many aspects: the ways authors decide where to publish, how readers consume the research, how research is released, and how scholarly communication has become increasingly international, especially in countries of the former Eastern Bloc. These are very different now from what they were in the 2000s. If our journal is to maintain and, most importantly, strengthen its relevance and impact, broadening its scope and updating its identity are essential. In this vein, the title change continues the course we set in 2023 toward building a Central European platform for archaeological research.

Despite the new title, the journal's core values remain unchanged. *AR-ACE* will remain an institution-based journal, ensuring that research dissemination remains in the hands of researchers themselves. In the current publishing environment, this is more important than ever. Even under the new title, *AR-ACE* will be committed to principles of open science and will continue to be published as a Diamond Open Access journal.

The announcement of the title change should not overshadow the interesting papers published in this issue.

It opens with a study by Tomasz Boroń and colleagues on the spatial organisation of Mesolithic campsites. They combine lithic refitting and use-wear analysis to reconstruct the processes behind the formation of the Rydno and Wieliszew sites in Poland. Their findings go well beyond these two case studies and are likely to inspire further research. They show that campsites with similar functions could differ considerably in their use of natural resources. By this, Boroń and colleagues demonstrated that even archival lithic collections still hold significant research potential.

The next papers take readers to the Middle Ages. András Dobai and colleagues contribute to a better understanding of the Battle of Mohi. Despite being one of the most consequential battles in Hungarian history, this clash is still shrouded in certain mysteries, including the location of the Hungarian camp before the battle. By integrating archaeological, military-historical, and environmental evidence within advanced GIS-based modelling, the authors identify the most likely locations. Beyond refining the understanding of the battle itself, the study provides a valuable methodological template for future investigations of historical battlefields and complex archaeological landscapes.

Josef Hložek and Petr Kočár also explore the theme of medieval conflict, albeit from a different perspective. Re-examining a remarkable assemblage of burnt grain and other crops from Křivoklát Castle dating to the beginning of the Hussite Wars, they arrive at a new interpretation by demonstrating that the grain was an emergency food store created in response to a period of instability. This finding challenges the earlier interpretation that linked the crops to brewery storage and highlights the risks of preliminary assessments becoming entrenched in the literature. The paper thus offers rare insight into the composition and organisation of emergency provisions in a medieval castle and helps us understand survival strategies in times of conflict.

Since war consumes wealth, abundance had to be created first; in the medieval Kingdom of Bohemia, wealth was born at the tip of a miner's chisel. Yet how much do we really know about these ordinary but essential tools? Filip Vološin and his colleagues addressed this question through metallographic analysis of mining chisels and a mallet from several 13th- and 14th-century silver-mining districts in the Bohemian-Moravian Highlands. Their study sheds new light on the technological expertise of smiths serving mining communities. The results reveal considerable variation in tool manufacture and show that individual chisels were adapted to specific tasks and geological conditions.

Readers should also not miss the report by Luboš Chroustovský on the 2025 conference of the International Study Group on Music Archaeology (ISGMA), held in Vienna. Finally, the book review section introduces *První Evropané* (*First Europeans*), a new book by Jan Turek, reviewed by Petr Pokorný.

Václav Vondrovský

RESEARCH ARTICLE – VÝZKUMNÝ ČLÁNEK

**Formation of Mesolithic hunting campsites:
Case studies of the Rydno and Wieliszew sites (Poland)**

Formování mezolitických loveckých tábořišť:
Případové studie lokalit Rydno a Wieliszew (Polsko)

Tomasz Boroń – Małgorzata Winiarska-Kabacińska –
Karolina Płoska

The organisation of hunter-gatherer campsites and whether repetitive behaviour patterns are reflected in the cultural and functional context of archaeological sites remains an important issue in Mesolithic archaeology. We analysed the material from the Rydno and Wieliszew sites in Poland, using the refitting of flint artefacts, the identification of use-wear on tools, and their spatial analysis to deliver the reconstruction of socio-technical processes that affected the formation of flint assemblages. The results indicate that despite the similar function of the campsites at Rydno and Wieliszew, they differed in the use of natural resources. These results are discussed in a broad European context and compared with findings obtained elsewhere. The article highlights new opportunities for reinterpreting many previously studied Mesolithic sites, some of which are already recognised as archival collections. Such lithic collections have the potential for developing new theories and comparing them with findings derived from materials obtained using modern excavation methods. The research results show that studies based on thorough and detailed analysis contribute to a deeper understanding of the processes involved in the formation of Mesolithic sites through the identification and description of settlement structures, which also allows us to determine the spatial and even temporal relationships between them.

Poland – Mesolithic campsites – site formation – archaeological record – behavioural activity

Uspořádání tábořišť lovců a sběračů a otázka, zda se opakující se vzorce chování odrážejí v kulturním a funkčním kontextu archeologických nálezů, zůstávají důležitými tématy mezolitické archeologie. Analyzovali jsme materiál z lokalit Rydno a Wieliszew v Polsku, přičemž jsme využili skládanky pazourkových artefaktů, identifikaci stop opotřebení na nástrojích a jejich prostorovou analýzu, abychom rekonstruovali sociálně-technické procesy, které ovlivnily vznik pazourkových souborů. Výsledky naznačují, že navzdory podobné funkci tábořišť v Rydnu a Wieliszewu se tyto lokality lišily ve způsobu využívání přírodních zdrojů. Tyto výsledky jsou diskutovány v širším evropském kontextu a porovnávány se zjištěními z jiných lokalit. Článek zdůrazňuje nové možnosti reinterpretace mnoha dříve zkoumaných mezolitických lokalit, z nichž některé jsou již považovány za archivní soubory. Takové soubory kamenné industrie mají potenciál pro vytváření nových teorií a jejich srovnání s poznatky vycházejícími z materiálů získaných moderními exkavačními metodami. Výsledky výzkumu ukazují, že studie založené na důkladné a detailní analýze přispívají k hlubšímu porozumění procesům formování mezolitických lokalit prostřednictvím identifikace a popisu sídelních struktur, což nám zároveň umožňuje určit prostorové a dokonce i časové vztahy mezi nimi.

Polsko – mezolitická tábořiště – formování lokalit – archeologický záznam – behaviorální aktivita

Introduction

Mesolithic communities of the Early Holocene differed significantly in their material culture and way of life from populations living in the Late Pleistocene. Their existence

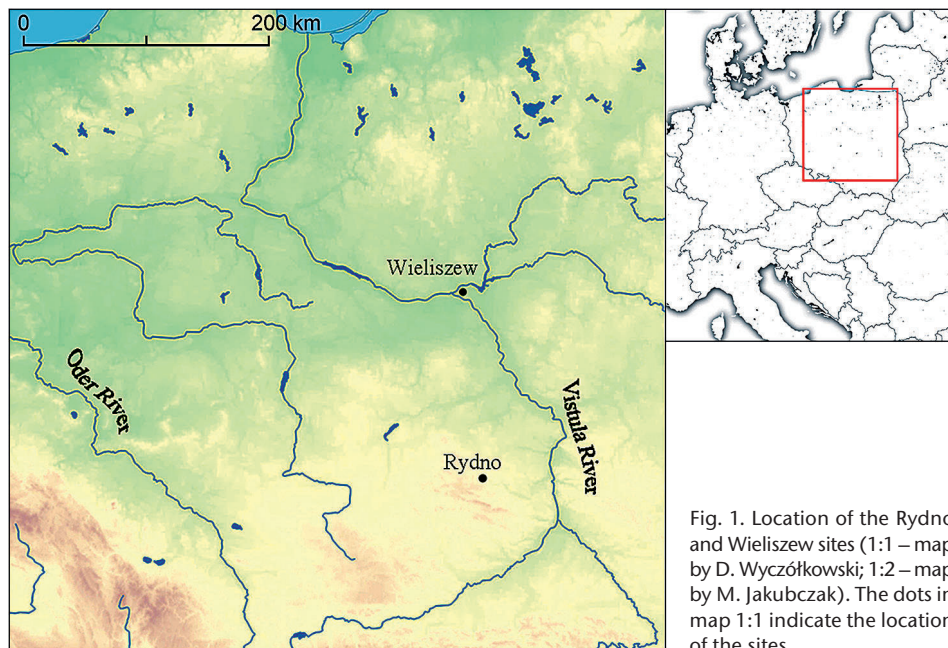


Fig. 1. Location of the Rydno and Wieliszew sites (1:1 – map by D. Wyczółkowski; 1:2 – map by M. Jakubczak). The dots in map 1:1 indicate the location of the sites.

and survival strategy depended on advanced methods of hunting, gathering, and fishing (Kabaciński 2016, 250). A characteristic feature of their lithic inventories was the microlithisation and geometrisation of the main tool types, such as triangles, rectangles, and trapezes, which required implementing a new concept of organisation for the processing of flint raw material (Sørensen – Sternke 2004, 105–106; Fisher 2006, 237).

These changes were dictated by adaptation to the conditions of the new ecosystem, which was characterised by a change in vegetation cover and the emergence of dense forest communities (Klerk 2004, 37) and, consequently, the emergence of forest fauna. This adaptation to the different environmental requirements is clearly visible in the stratigraphic sequence of archaeological sites, where, with the onset of the Holocene, the proportion of skeletal remains of forest animals increases in the northern parts of Central Europe (Kobusiewicz – Kabaciński 1993, 118; Benecke 2004, 45–46). According to Galiński (2019, 84), it is possible to distinguish five elementary complexes in the northern areas of Central Europe: Sauveterrian, Beuronian-Tardenosian, Duvensian, Maglemosian, and Janislavician. Their typology is based particularly on lithic and bone tools, as each complex possessed its own distinctive toolkit. There is also a change in the structure of social groups and their organisation, their way of life, and their working conditions, which is reflected in the structure of sites, whose context is extremely important in assessing human-environment relationships.

Flint artefacts are a concrete form of human categorisation understood as productive processes (Miller 1982, 17). They are the most numerous artefacts found at hunter-gatherer sites, especially when – as in the case of most sites in Poland – these are located on sandy dunes or on other geomorphological strata unfavourable for the preservation of organic materials. In these environments, lithic scatters thus constitute the primary archaeological

sources for research on the Mesolithic communities. It is thus crucial to understand formation processes that constitute the archaeological record of these sites and how past human agencies can be reconstructed within them (*Pecora 2001*, 188). This can be achieved on the basis of refittings and the detailed interpretation of the flint scatters.

The key issue addressed in this article is how Mesolithic hunter-gatherers organised their camp sites, and whether there are repetitive ‘behaviour patterns’ that are reflected in the cultural and functional context of the formation of archaeological sites. In order to learn more about the aspects of the life of Mesolithic groups and at the same time about the mechanisms that generated them, we may not only rely on the successive discoveries of new sites but should also attempt to reinterpret contexts of the already discovered sites, including archival excavations. We addressed this issue using the Rydno and Wieliszew sites as case studies. Both settlement sites represent distinct structures of artefact deposition, allowing us to study the formation of Mesolithic sites using the example of two qualitatively different flint scatters. Undoubtedly, these differences are not only the result of divergent processes creating the archaeological record but also of the distinct contexts in which the two sites were located. For this reason, the selected sites are perfectly suited to the aims, objectives, and issues discussed in this study.

Location and description of the sites

The case-study inventories were selected based on methodological and archaeological aspects. In methodological terms, appropriate procedural steps were taken to ensure the validity and reliability of the analysis of the material sources, whilst from the archaeological point of view, we should emphasise their homogeneity and the absence of any significant disturbance of the spatial distribution of flints, which can be caused by post-depositional human activity or ground erosion. Nevertheless, the selected sites represent two separate cultural-chronological horizons, allowing for broader comparisons in terms of cultural and chronological variability.

Rydno IV/47

The first site is located in the area of the large ‘Rydno’ settlement complex near Skarżysko-Kamienna (Świętokrzyskie Voivodeship) (*Fig. 1*). Over several decades of research, archaeologists discovered numerous Late Palaeolithic and Mesolithic sites in that area related mainly to a prehistoric haematite mine (*Schild et al. 2011*). The discovered sites have so far been the subject of many studies presented in numerous articles (e.g., *Ginter 1965*; *Schild – Królik 1981*; *Fiedorczuk 1992*). Detailed information on the study history, geomorphology, and taxonomy is provided by *Schild et al. (2011)*.

Trench IV/47, which is the focus of this study, is situated in the area called Pastwisko, one of the several large areas of archaeological excavations carried out at the Rydno settlement complex (*Fig. 3: a*). In this case, an area of 130 m² was excavated (*Fig. 3: b*). During the excavation, 576 flints (including chips and waste) were recovered.

The assemblages of artefacts from Rydno IV/47 are associated with the flint industry of the Janisławice culture. Its existence in the territory of Poland dates from the mid-7th millennium to almost the end of the 6th millennium BC (*Kozłowski 2009*, 451). At Rydno,

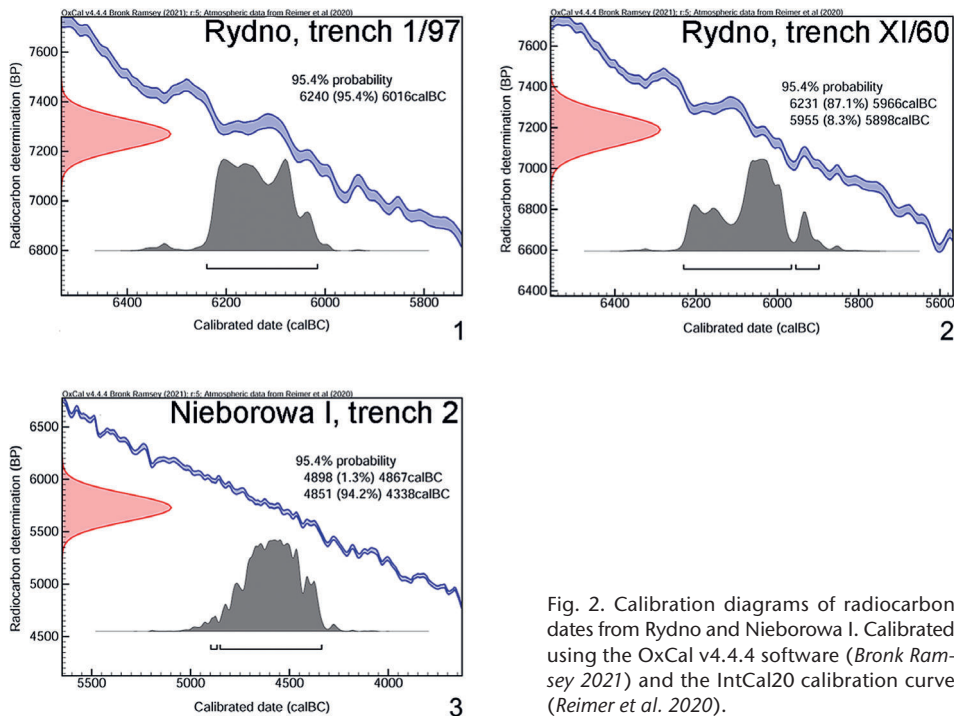


Fig. 2. Calibration diagrams of radiocarbon dates from Rydno and Nieborowa I. Calibrated using the OxCal v4.4.4 software (Bronk Ramsey 2021) and the IntCal20 calibration curve (Reimer et al. 2020).

this chronology has been confirmed by radiocarbon dating of charcoal samples taken from campfires from other trenches, i.e. XI/60 and I/97, where Janisławice culture lithics were located next to the hearths (Fig. 2: 1–2; Tab. 1).

The grouping of a number of Mesolithic sites of the Janisławice culture in a small area of the Rydno complex makes the scientific value of the materials excavated there exceptional and unique. The flint scatters are characterised by a highly diverse number of finds – from several dozen to several thousand artefacts. Also, the structure of the flint inventory is most often different. Assemblages containing mainly flake tools (Schild et al. 2011, 366; Boroń et al. 2018) were identified along with assemblages containing a fairly wide spectrum of tools (Ginter 1965, 7–10). Such typologically and technologically diverse collections of artefacts constitute an important contribution to the discussion on the nature and specificity of Mesolithic camps of the Janisławice culture in Poland.

Site	Context	Sample	Lab code	C ¹⁴ age BP	BC cal (95.4% probability)	References
Rydno	trench XI/60	charcoal	Gd-1765	7190±80	6231–5898	Schild et al. 2011
Rydno	trench I/97	charcoal	Poz-18065	7270±60	6240–6016	Schild et al. 2011
Nieborowa	trench 2	charcoal	Gd-144	5730±130	4898–4338	Boroń 2014, 26

Tab. 1. Overview of radiocarbon dates mentioned in the text. Calibrated using the OxCal v4.4.4 software (Bronk Ramsey 2021) and the IntCal20 calibration curve (Reimer et al. 2020).

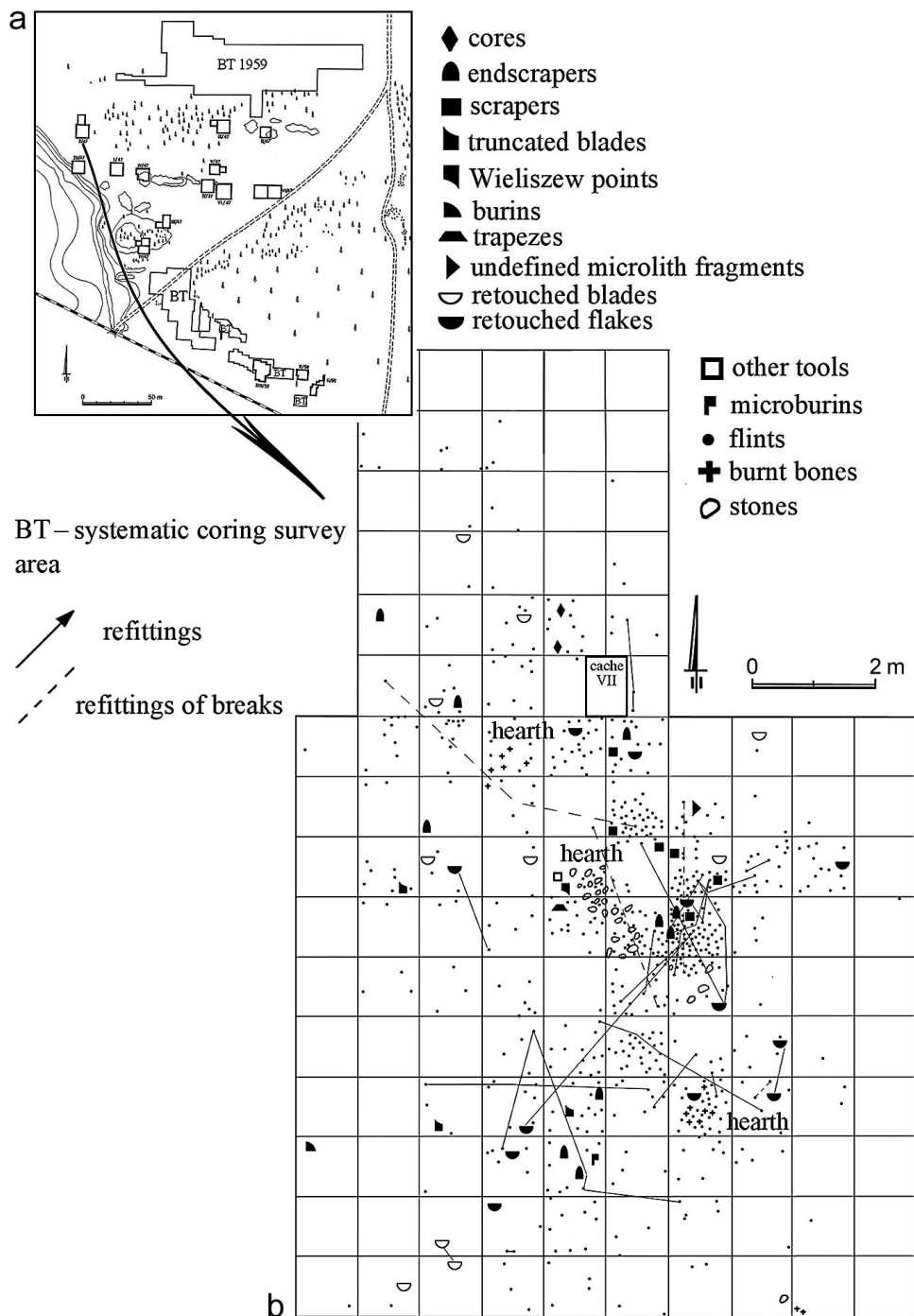


Fig. 3. Rydno site. a – location of trenches in the Pastwisko area; b – Planigraphy of the distribution of flint finds in trench IV/47.

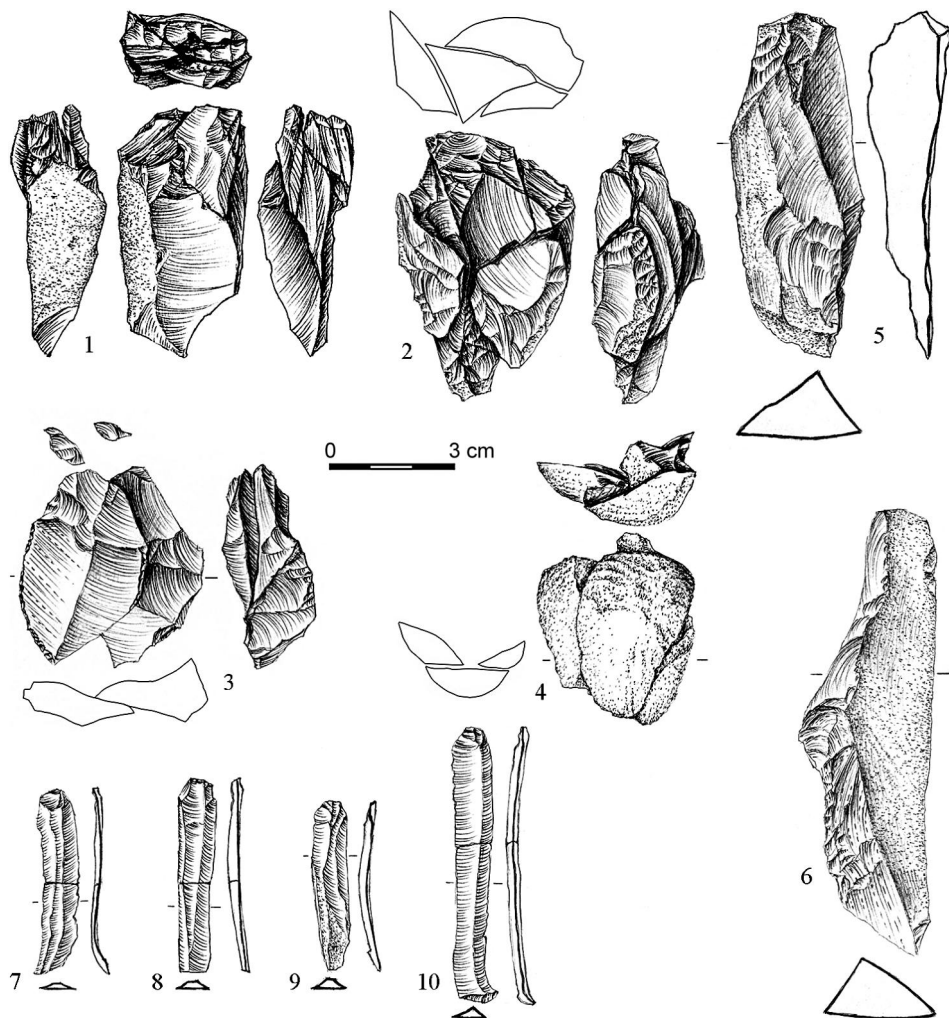


Fig. 4. Chipped stone artefacts from Rydno, trench IV/47. 1–4 – refittings (1–3 – from central concentration, 4 – from south concentration); 5–6 – crested blades; 7–10 – blades (drawing by E. Gumińska).

Wieliszew, trench XVII c

The site of Wieliszew is located in the Mazovian Voivodeship in Central Poland. It is situated on the left bank of the Narew River, next to its confluence with the Vistula River (Fig. 1). The material presented in this paper comes from excavations carried out in the late 1950s and early 1960s. To date, it has been the subject of several separate publications (Więckowska 1965; 1969, 94).

Trench XVII c with an area of 124 m² (Fig. 5: b) was opened on a small sandy hill (dune) defined as the Wieliszew site, where two other trenches – XVII a and XVII b – were also selected for exploration. This proves that the sandy hill was intensively settled by Mesolithic communities. Although there was concern that the site had been destroyed due to

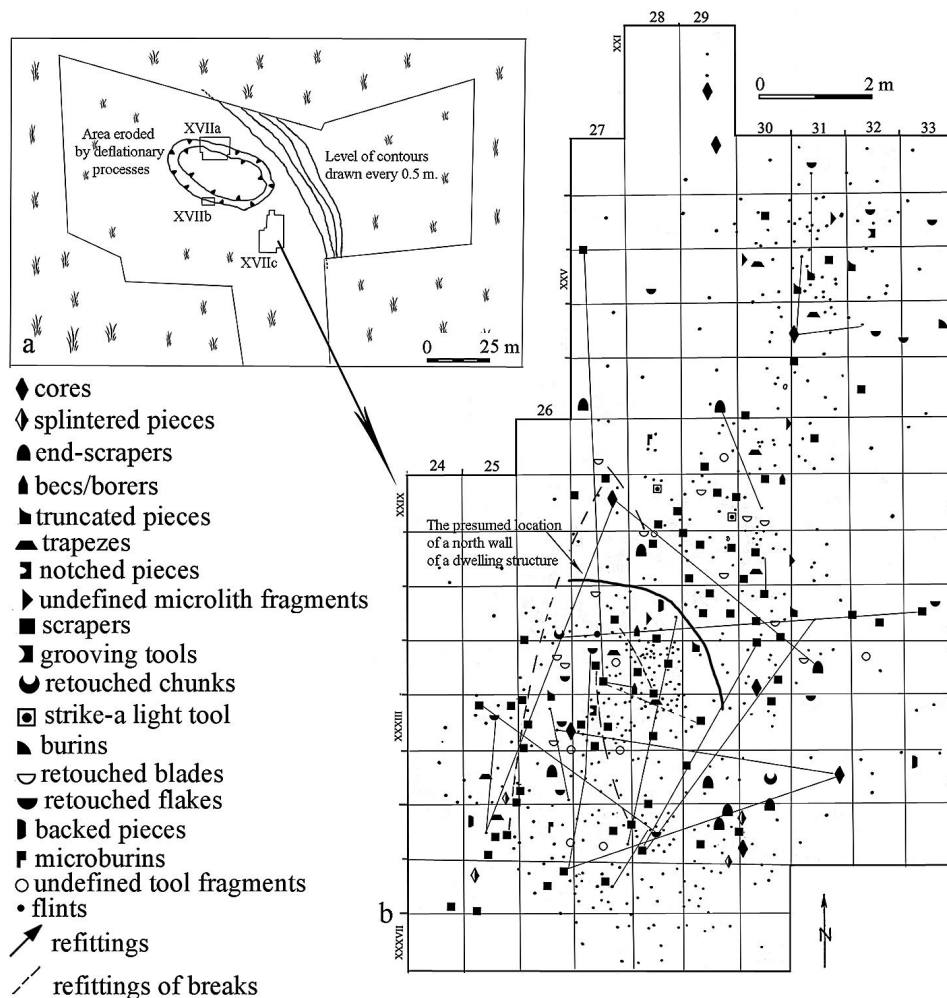


Fig. 5. Wieliszew site: a – location of trenches XVII a, XVII b, XVII c; b – planigraphy of the distribution of flint finds (according to Więckowska 1965, 3).

erosion, as is often recorded on exposed dunes, the trench section shows that the natural stratigraphy had been preserved (Fig. 5: a). A total of 736 flints were recovered from the trench, 483 of which were chips and small waste fragments. The artefacts were located at a depth of 40 to 60 cm.

In contrast to the Rydno site, the inventory from Wieliszew XVII c is associated with Mesolithic communities of the Late Atlantic period. Such a chronology can be inferred by analogy with the inventory from the Nieborowa I site located in central-eastern Poland, where a radiocarbon date from a charcoal sample obtained from a campfire within the concentration of flints sets the activities in 4898–4338 cal BC (see details in Fig. 2: 3; Tab. 1). The said inventory from Nieborowa I (Boroń 2014, 231–237) is typologically and technologically very similar to the collection of artefacts from Wieliszew. The termi-

nology describing these inventories in the Polish archaeological literature is quite abundant and varied, depending on the individual researcher's approach and interpretation. They are referred to as 'Kokry industry', 'post-Janisławice inventories', or 'assemblages with dominant trapezes' (Libera 2003, 26). Later in this article, I use the term 'post-Janisławice culture.'

The chronological range of the post-Janisławice assemblages covers the beginning of the 5th millennium BC, while the decline of these groups is associated with the arrival of the Neolithic Funnel Beaker culture or even the chronologically later Globular Amphora culture communities (Kozłowski – Nowak 2019). This took place at different times depending on the region of Poland.

The characteristic features of the post-Janisławice industry, which formed the basis for their separation, are the miniaturisation of tools. Depending on the region of Poland, the assemblages are characterised by the significant predominance of scrapers over end-scrapers (mostly flake forms), the presence of the splintering technique, and the small size of a set of microliths limited mainly to trapezes (Więckowska 1985, 102).

Methods

The complexity of the issues and research demands required the use of several analytical methods, including a) in-depth spatial-functional studies based on the analysis of the dispersion of archaeological sources to capture the logic of their distribution; b) the refitting of flint artefacts; and c) studies of use-wear transformations on the surfaces of flints. Combinations of these research procedures were developed within the analysis of the Meer II site in the Netherlands (Cahen *et al.* 1979; Cahen – Keeley 1980).

Spatial analysis of finds was – and still is – considered one of the objective methodological procedures in explaining the archaeological record at given archaeological sites (Binford 1977, 9). The horizontal distribution plan of archaeological finds is used in many methods of planigraphic analysis and is one of the fundamental aspects of spatial studies (Schild 1980, 79–80). Therefore, in the absence of features, studying their distribution is sometimes the only option for the spatial or settlement interpretation of a given site (Fiedorczuk 2006a, 11). In the case of the Rydno IV/47, where the planigraphy of finds indicated three possible concentrations of lithics, we decided to present the distribution of the flint material using a map depicting the frequency of points in each square metre made with the use of the Surfer software. At the same time, at the Wieliszew site, the map of finds was very clear and legible, showing a dense concentration with distinct boundaries.

The application of the technique of refitting flint artefacts was especially important. This simple research procedure, which in fact had already been used sporadically since the late 19th century (*e.g.* Spurrel 1880), has become a useful method and is now even an indispensable research activity, comprising a wide range of studies interpreting site formation processes (Kroll – Isaac 1984, 22; Morrow 1996, 355). The scientific aspects arising from the application of the flint refitting method were presented by Cahen *et al.* (1980). However, it is important to skilfully use the data we obtain from the refitting in conjunction with the structure and nature of the site (McCall 2010, 27–28). Several factors influenced the final outcome of the flint refitting. As in the case of Wieliszew, the work was hindered by small and minute finds, which constituted almost the entire flint inventory.

At Rydno, however, the work was made even more difficult by the selective and discriminating processing of cores and, in general, the relatively limited amount of flint material.

The research perspectives offered by the analysis of microwear on flint surfaces have provided scholars studying the Stone Age with an additional opportunity to interpret flint inventories, including archival ones, as in the case of the sites discussed here. It was introduced by Semenov and Keeley (*Semenov 1964; Tringham et al. 1974; Keeley – Newcomer 1977; Keeley 1980*) and further developed in line with research and technological and methodological advances (cf. *Marreiros et al 2015*). The method enables a more complete and accurate reconstruction of the economic activities of prehistoric communities (*Keeley 1974, 323*).

An Olympus SZX9 stereoscopic microscope and an Olympus BX53M metallographic microscope were used to record microwear on the flint specimens and determine the function they performed, which provided us with the ability to observe images at magnifications of several to several hundred times (from 6.3x to 500x). In order to make the results of the use-wear analysis reliable and provide possibilities for comparative studies, the assemblages selected for analysis included all tool categories as well as unworked blades. All traces of work discovered on flint surfaces were compared with a reference collection, which includes artefacts used in experiments involving the processing of organic and inorganic materials.

Results

Spatial analysis

Rydno

The lithic finds formed a rather dispersed horizontal distribution with a marked concentration of flints in the central part of the trench. The tools have a similar spatial distribution to other lithic finds (blades, flakes, and chips). However, taking into account individual types, microliths were found only in the central part of the excavation trench, and most of the retouched flakes were obtained from its southern part (*Tab. 2*). On the other hand, endscrapers were distributed fairly evenly. They were found in the southern, central, and northern parts of the trench.

Cache VII, containing cores and pre-cores, was discovered in the northern part of the trench (*Schild et al. 2011, 89, 91*). It represents a distinct, separate archaeological structure with spatially closed boundaries. This makes it difficult to determine the relationship with the other flint material from the site, and for this reason, it has been omitted from this analysis.

In the case of Mesolithic inventories, one of the most important categories of artefacts is blades. During archaeological excavations, nearly 100 of them were recovered (*Fig. 4: 7–10*), which is a relatively large number compared to the number of flakes (96). Their length varies greatly: from 22 to 64 mm (excluding crested blades, whose maximum length is 103 mm, *Fig. 4: 5–6*). The arithmetic mean length of the blades is 36 mm, which is basically consistent with the results obtained for selected, homogeneous inventories of the Janisławice culture (*Szymczak 1982, 134*). The two-blade cores left at the site are 60 mm long.

Cores and tools	Rydno IV/47			Total	Wieliszew XVII c		Total
	North camp	Central camp	South camp		North camp	South camp	
cores	2			2	3	9	12
end-scrapers	3	4	3	10		9	9
scrapers	1	5		6	4	68	72
burin			1	1	1		1
truncated pieces		1	2	3	3	3	6
Wieliszew point		1		1			
trapeze		1		1	2	6	8
backed pieces						3	3
borers						1	1
becs						2	2
notched pieces						1	1
undefined microlith fragments		1		1	2	3	5
retouched blades	3	4	3	10		12	12
retouched flakes	2	4	6	12	5	9	14
microburin			1	1		2	2
others		1		1	1	12	13

Tab. 2. Presence of artefact forms in individual camps at the Rydno and Wieliszew site.

Three campfires were identified. One, located in the central part, was probably surrounded by stones. The other two, in the northern and southern parts of the trench, were recorded at the site of occasional flint occurrence and were identified based on the presence of small, burned bones and flints (*Fig. 3: b*). This is important, as there are sometimes no other clear clues to indicate the location of a campfire. Similar methodological considerations occurred in the case of two sites from the Netherlands: Gramsbergen I (*Johansen – Stapert 1997/1998, 32*) and Zwolle (*Niekus et al. 2019, 53*).

Wieliszew

Based on the planigraphy of the artefacts, it is possible to distinguish one large concentration in the southern part of the excavated trench and another, a smaller one, in its northern part. In both concentrations, the spatial distribution of the tools is the same as that of the other lithics, i.e. they cover a similar area.

There are, however, some differences between the concentrations in terms of the occurrence of tools. In the northern concentration, there are no endscrapers, retouched blades, backed pieces, becs, which are present in the southern concentration (*Tab. 2*). The largest group of tools is scrapers, which significantly outnumber other tools. The next group consists of endscrapers, truncated blades, blades, and retouched flakes, whose numbers are very similar. The presence of microliths (trapezes, backed pieces, microlith fragments) is also clearly marked in the inventory.

Based on the analysis of archaeological sources, three techniques of core exploitation were distinguished: blade-making, flaking and splintering (*Fig. 6: 4–6*). Among the two-flake cores, one is a single platform core and the other is a double platform core, although the double platform core exploitation is probably the result of a change of the platform in

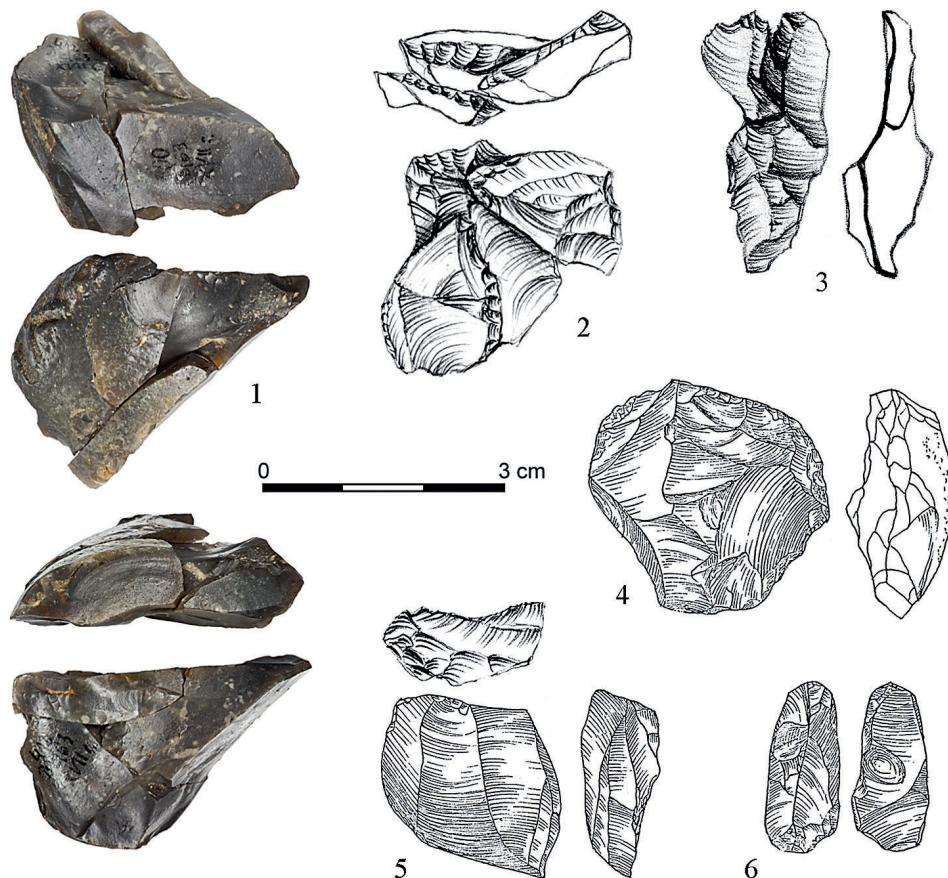


Fig. 6. Chipped stone artefacts from Wieliszew, trench XVIIc. 1–3 – refittings (1 and 2 from south concentration, 3 from north concentration); 4–5 – cores; 6 – splintered piece (drawing and photo by E. Gumińska and I. Niewiadowska).

the final phase. The remains of the flaking technique are single platform cores (4 pieces), with changed orientation (1), and semi-discoidal (1). The predominance of flake cores is reflected in the ratio of blades to flakes: 41 blades were recorded (including fragments), while there were 78 flakes and chips.

Unfortunately, no traces of dwelling structures have been found in Wieliszew, as is the case at the majority of sandy sites in Poland. Apart from the unfavourable preservation conditions, identification might also be hampered, as they may have been light and shallow structures (Vasilevich – Smolyak 1964, 638–639; Rogers 1967, 18–20; Grøn 2003, 688), which does not mean that dwelling structures did not exist. The refitting lines in the south cluster are arranged in a quadrangular pattern, which may represent the ‘barrier effect’ (Cahen *et al.* 1980; Tomaszewski 1986; Ciepielewska 2022, 51) marking the walls of a dwelling structure. Presumably, it would have had dimensions of 4 x 4 metres. The north wall of the feature is also perhaps outlined by the adjacent small concentration of artefacts (Fig. 5: b).

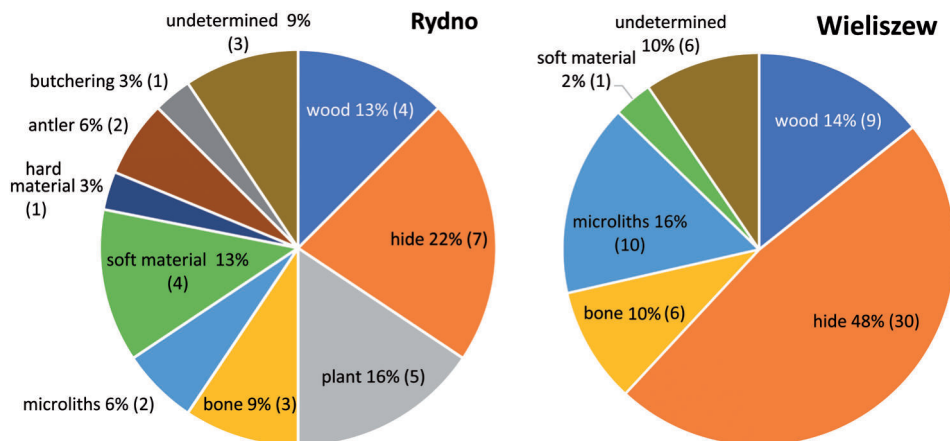


Fig. 7. Frequency of tools with traces of use-wear processing different raw materials at Rydno, trench IV/47 and Wieliszew, trench XVIIc (the number of artefacts is given in brackets).

Use-wear analysis

During the analysis, various traces were recorded on the edges and surfaces of the artefacts, such as damage, abrasion, rounding and polish associated with their use.

Rydno

Use-wear analysis was applied to the following tools: endscrapers, truncated blades, a burin, microliths, blades and retouched flakes, and a scraper (total 48 pieces). Unworked blades (32 pieces) were also analysed. The analysis took into account all excavated tools, while in the case of unworked blades, specimens were selected from each part of the excavation trench, i.e. its southern, central, and northern parts.

The activities performed at the site were mainly related to the processing of animal carcasses and the working of wood and plants (*Tab. 3; Fig. 7; Fig. 8*). It seems that the tools utilised in carrying out these tasks were generally not intensively used, and the nature of the transformations recorded on the endscraper fronts indicates the scraping of fresh hides. Also, tools with edge-marks resulting from bone working could be linked to butchering animal carcasses. Two of the analysed microliths were components of a projectile weapon. One was a trapeze with minor damage visible on one of the lateral edges, and the other was a Wieliszew point, which also had traces of use on the lateral edge.

Wieliszew

In total, 132 tools were subject to microscopic observations, of which 62 specimens had transformations associated with their use (*Tab. 3; Fig. 7*). Two main groups of tools can be identified: the first is related to the processing of hides, and the second is interpreted as elements of weapons.

With regard to the first activity, the tools show a high degree of wear. Apart from two endscrapers set in hafts, the tools were probably used without hafts (*Boroń – Winiarska-Kabacińska 2018, table 2*). Processing hides is a lengthy, multistage process that requires

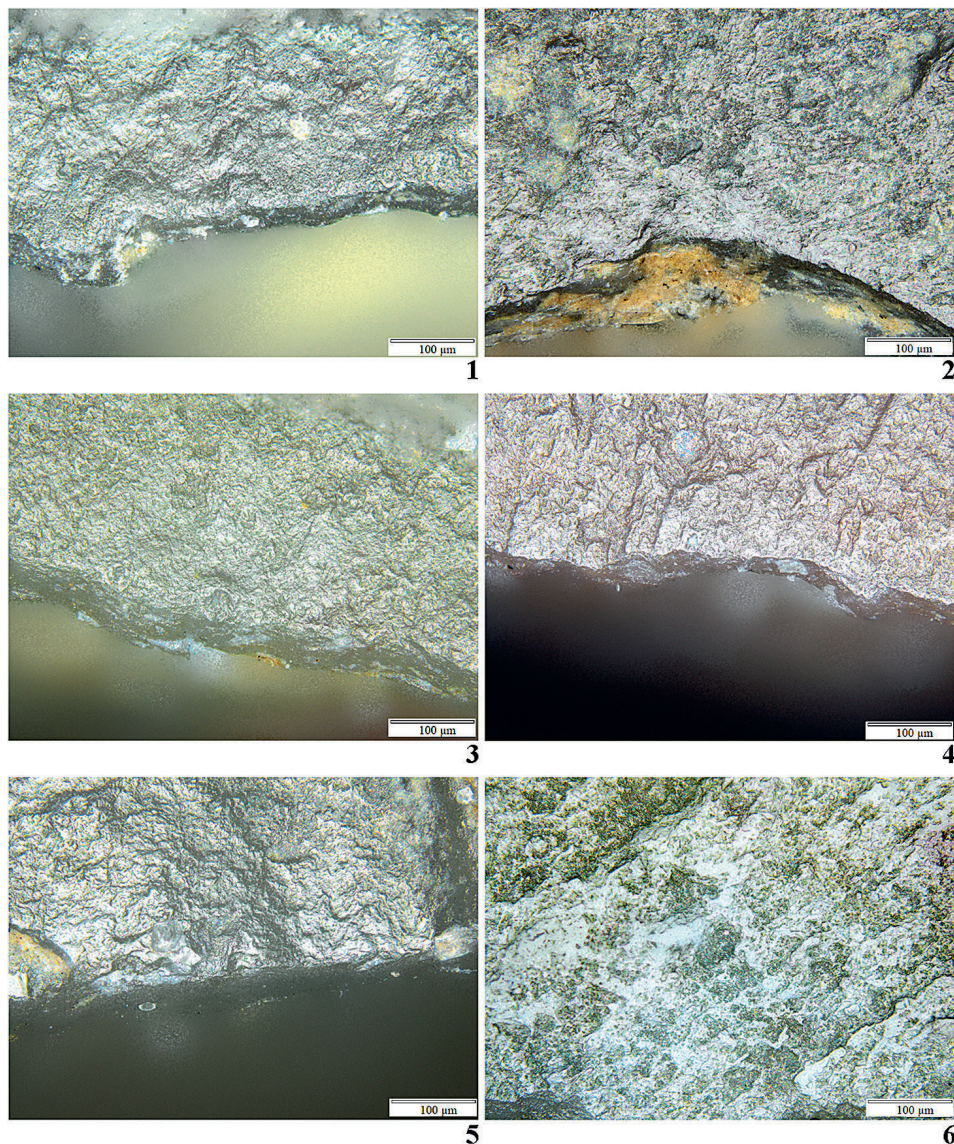


Fig. 8. Use-wear traces on the artefacts from Rydno, trench IV/47. 1 – endscraper, scraping hides; 2 – crested blade, scraping bones (northern concentration); 3 – endscraper, scraping hides; 4 – retouched flake, scraping bones (central concentration); 5 – burin, carving bones; 6 – retouched blade, cutting plants (southern concentration) (photo by M. Winiarska-Kabacińska).

the use of specialised tools made not only from stone raw materials but also bone or wood (among others, *Hayden 1990; Weedman 2006; Beyries 2008*). In part, this time-consuming process is also reflected in the diagnosed traces, indicating the use of tools at various stages of the hide dressing process. Ochre was often used to soften hides (*Beyries – Inizan 1982, 321*), and its presence was recorded on several artefacts in the assemblage from Wieliszew

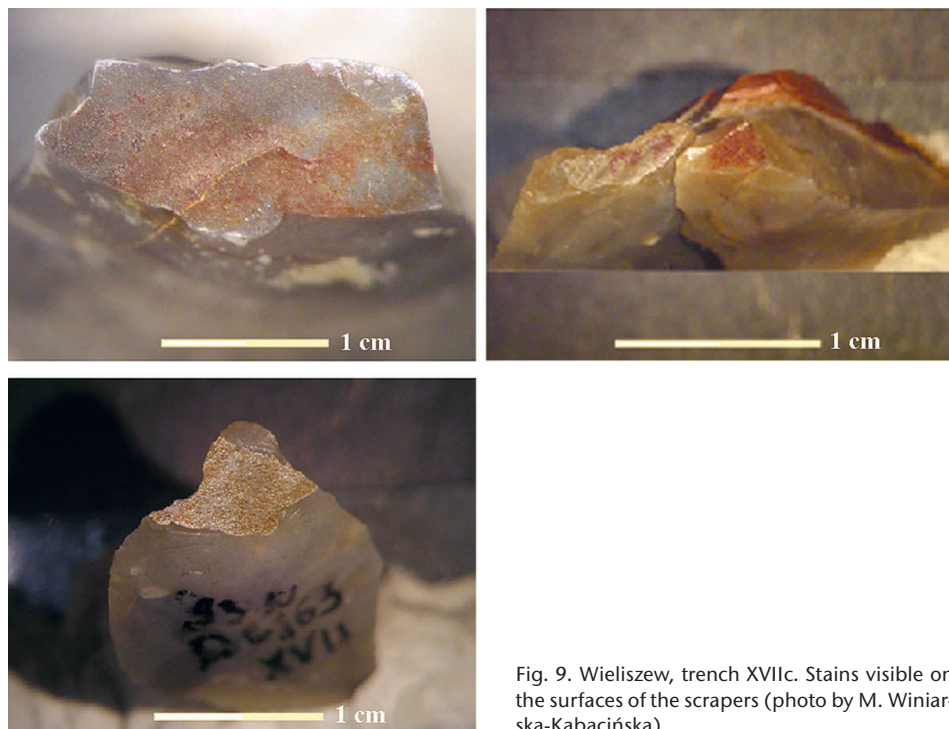


Fig. 9. Wieliszew, trench XVIIc. Stains visible on the surfaces of the scrapers (photo by M. Winiarska-Kabacińska).

(Fig. 9), although this may also be a secondary indication of contact between flints and ochre.

The second group, clearly identified in the Wieliszew inventory, are specimens functioning as weapon elements. The observations made and the macroscopic and microscopic traces found, including traces from the haft, would indicate that five trapezes and two backed pieces were arrowheads, while two microlith fragments and a truncated blade served as inserts for composite tools (Fig. 10). This interpretation of the use of microliths as an element of weapons is supported by the characteristic and distinctive traces, repeatedly described in the literature and also recognised through experiments (Fischer *et al.* 1984; Crombé *et al.* 2001; Rots 2008; 2010; Cristiani *et al.* 2009).

Identification of the socio-technical and functional processes of artefact deposition

Rydno

The model projection made with the use of the SURFER software took into account all of the flint material. According to the results obtained, three clusters were identified: northern, central, and southern, and the archaeological sources were divided accordingly (Fig. 11).

The northern concentration covers an area of about 12–13 m². This concentration has quite clearly defined spatial boundaries; tools and cores were found on its periphery, and only three flakes were refitted. It was possible to identify two spots with the presence of

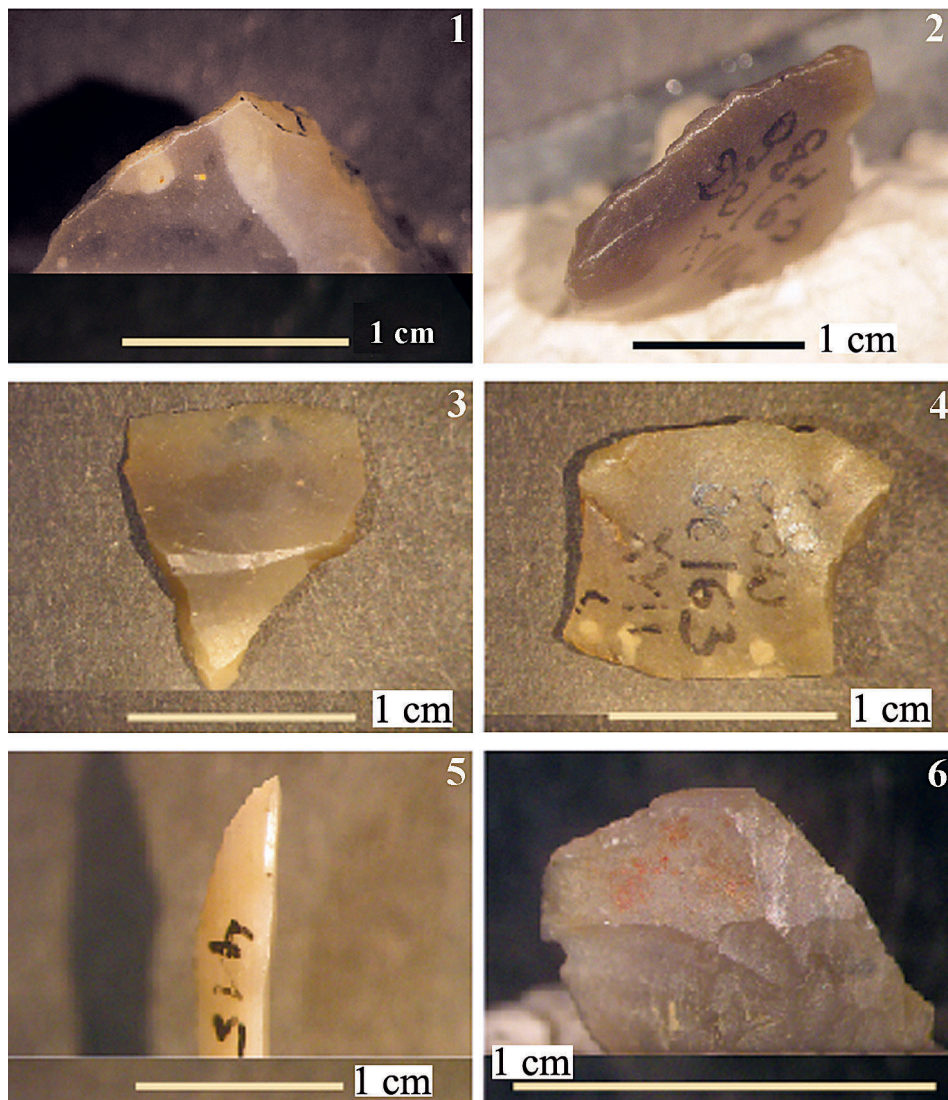


Fig. 10. Wieliszew, trench XVIIc. 1–2 – rounding on scraper's edge; 3 – broken trapeze; 4 – trapeze with an impact scar; 5 – backed piece with an impact scar; 6 – stains visible on blade dorsal face (photo by M. Winiarska-Kabacińska).

flints with diagnosed microwear. The first one contains finds associated with the processing of plant material (wood, plants), while the second has finds associated with the processing of bone and hides (butchering) (Fig. 12).

Central concentration, which covers about 13–14 m², is characterised by the greatest number of finds. The variety of tool types recorded here is much greater than in the northern and southern concentrations. Several blocks were refitted – most often consisting of two elements (Fig. 4: 3); only blocks 1 and 2 contained more artefacts. Block 1 is a refitting

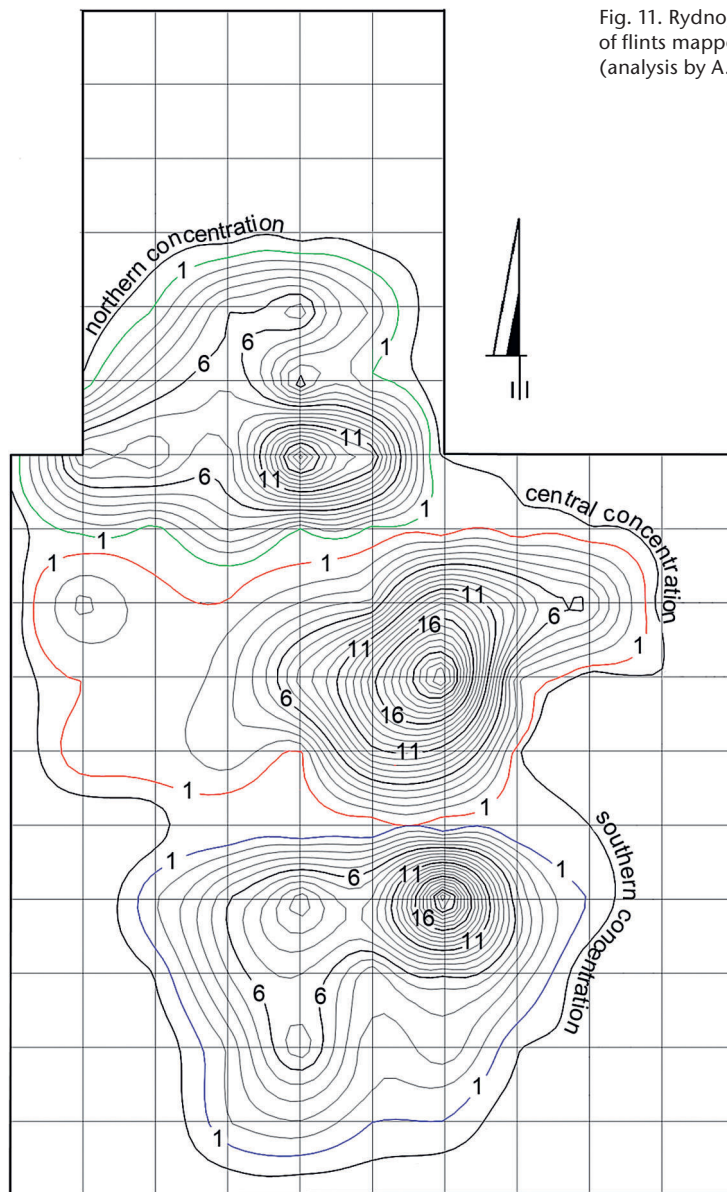


Fig. 11. Rydno, trench IV/47. Frequency of flints mapped with SURFER software (analysis by A. Sotodko).

of four platform rejuvenation flakes (*Fig. 4: 1*), while block 2 constitutes a crested blade and flakes from the preparation of the flaking surface, including an endscraper (*Fig. 4: 2*). Within this concentration, a zone with the highest density of lithics was identified, in which all the refittings are also grouped. This may suggest that this was the area of a presumed workshop, especially since nearly all platform rejuvenation flakes were also recorded there. Two distinct zones of activity were recorded around the campfire: one associated with the repair of hunting weapons and the other with the butchering of game. Other identified

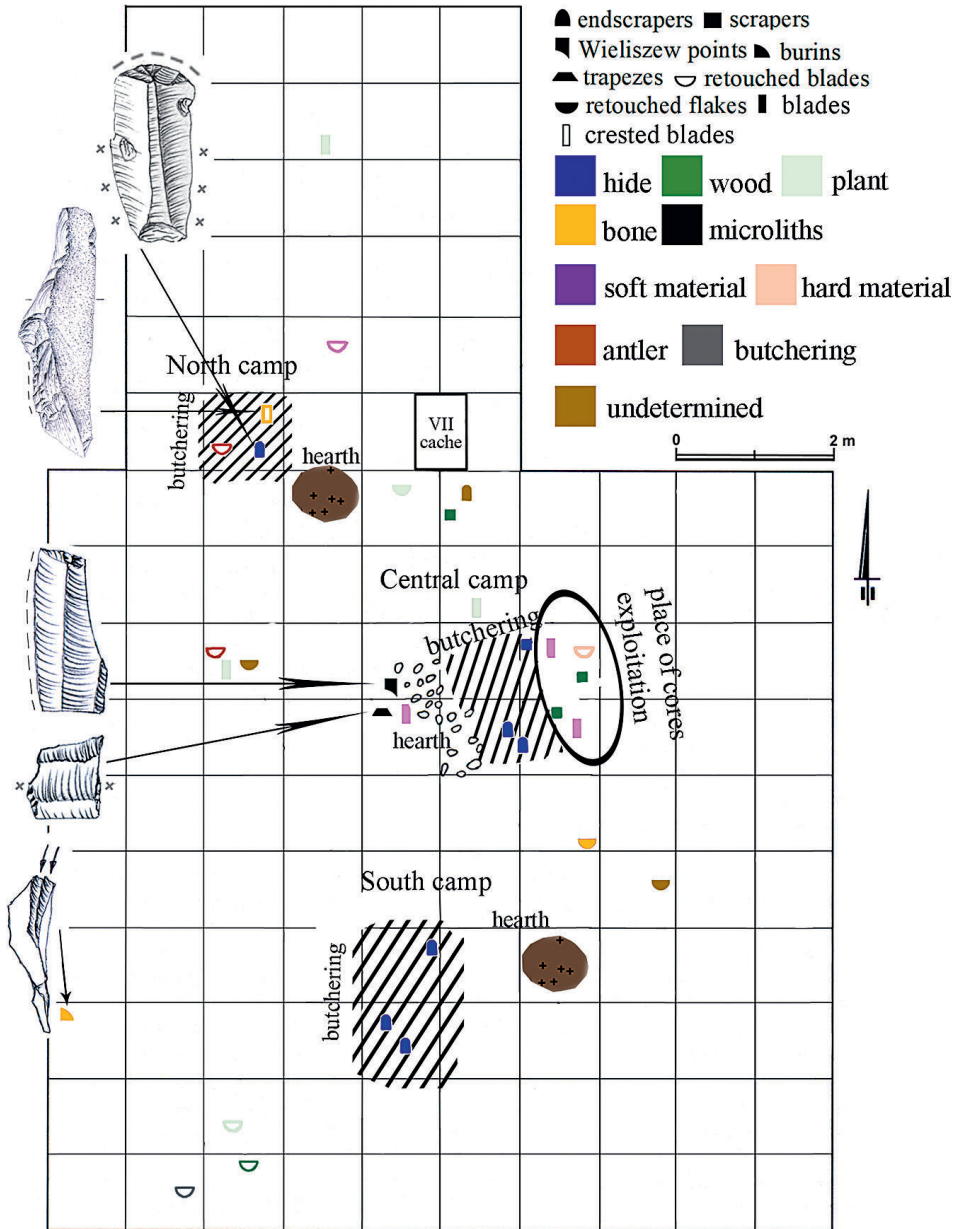


Fig. 12. Rydno, trench IV/47. Model of the last phase of the formation of the flint assemblage, taking into consideration the layout of the activity zones. The model presents the separation of three distinct camps and their spatial relationships. The individual areas of activity were determined on the basis of the dispersion of functionally identified flint material. Chipped stone tools: dashed line – the course of use-wear traces; crossing – haft (map by A. Sołodko).

Function	Rydno IV/47			Wieliszew XVIIc	
	North camp	Central camp	South camp	South camp	North camp
Hide					
scraping	1-endscraper	2-endscrapers; 1-scraper	3-endscrapers	25-scrappers; 4-endscrapers; 1-backed piece	
Wood					
grooving				1-retouched blade	
cutting				1-retouched blade	
scraping	1-scraper	2-scrappers		1-retouched flake; 1-retouched blade	1-retouched flake
perforating				1-borer	
working			1-retouched blade	3-retouched blades	
Plant					
scraping	1-retouched flake				
working	1-unworked blade				
cutting		2-retouched blades	1-retouched blade		
Bone					
scraping	1-unworked blade	1-retouched flake		1-retouched blade	1-truncated piece
working				3-scrappers	1-scraper
engraving			1-burin		
Microliths					
		2 arrowheads (1-trapeze; 1-Wieliszew point)		2-projectile's side inserts; 6-arrowheads	1-projectile's side insert 1-arrowhead
Soft raw materials					
scraping				scraper	
working	1-retouched blade	3-retouched blades			
Hard raw materials					
cutting		1-retouched blade			
Undetermined raw materials					
grooving				1-bec	
scraping				2-scrappers; 1-truncated piece; 1-retouched blade	
working	1-endscraper	1-retouched flake	1-retouched flake		
unspecified activity				1-bec	
butchering			1-retouched blade		
Antler					
cutting	1-retouched blade	1-retouched blade			

Tab. 3. Raw materials and work performed at the respective sites. The table presents the distribution of activities according to the concentrations identified at individual camps, as this highlights the similarities and differences between them.

activity zones included the area of core processing and the site of processing wood, soft and hard raw material, and plants. The location of the abandoned microliths next to the campfire in the central campsite supports the hypothesis, and it is documented by several discoveries suggesting that the potential repair of hunting weapons took place mostly in this area (*Caspar – De Bie 1996*, 451; *Fitatova 2004*, 45; *Wenzel 2011*, 154). On the other side of the campfire, where the presumed ‘butchering’ activity zone was identified, no flint artefacts were recorded, which seems quite significant considering the activity of quartering game and processing hides. Flints with sharp and piercing edges lying on the ground could have made walking difficult. The absence of even chips suggests that the spot may have been intentionally cleared of flint remains.

The southern concentration covers the largest area, about 18–19 m². As in the northern concentration, the finds are loosely scattered. From this area comes the refitting of the crested blade and three flakes – block 3 (*Fig. 4: 4*), in addition to other two-element refittings. The refitting of a crested blade with flakes may indicate that core exploitation also took place here, although perhaps of an *ad hoc* nature. A zone used for dressing hides and processing plant material was identified in that concentration. The presence of plant processing tasks diagnosed based on the use-wear analysis of flints from all three concentrations described here is not unusual in terms of the set of activities performed in a hunting camp. However, it was not a main activity (*Lemorini 1992*, 55; *Petru 2004*, 202; *Langlais et al. 2018*, 525).

Wieliszew

The most intensive activity carried out on the site was dressing hides. The largest assemblage of tools related to this activity was found in the southern concentration. Outside this area, the number of artefacts with identified traces of such work decreased significantly (*Fig. 13*).¹ Woodworking (broadly understood as the processing of wood comprising a variety of activities – *Tab. 3*) was located in three distinct places on the periphery of the hide dressing zone. These correspond to the locations of retouched blades. Finds associated with bone processing were also placed in different zones. Likewise, the spots containing worn components of hunting weapons constitute spatially distinct areas. They are most often found next to the areas associated with processing wood. In the northern concentration, based on the use-wear analysis, bone and wood processing were identified (*Fig. 13*).

Due to the small size of the flints, refitting did not yield results comparable to Rydno. The dominating type is two-element blocks, such as the refitting of a truncated blade with an overpassed blade from a single platform core (*Fig. 6: 3*). Others include a flake core with a matching flake, a retouched flake and an endscraper (*Fig. 6: 1*), and two scrapers and a bec (*Fig. 6: 2*). In the northern part of the trench, the presence of adjustments of a core and flakes, as well as the refitting of a truncated blade with a flake, suggests that this was also the site of obtaining blades and flakes. The functionally diagnosed tools attest to the processing of bone material. Two damaged microliths were also recorded there.

¹ The site plan of the trench does not include the location of the scraper with recorded traces of working in a soft material. This was associated with the lack of an inventory number.

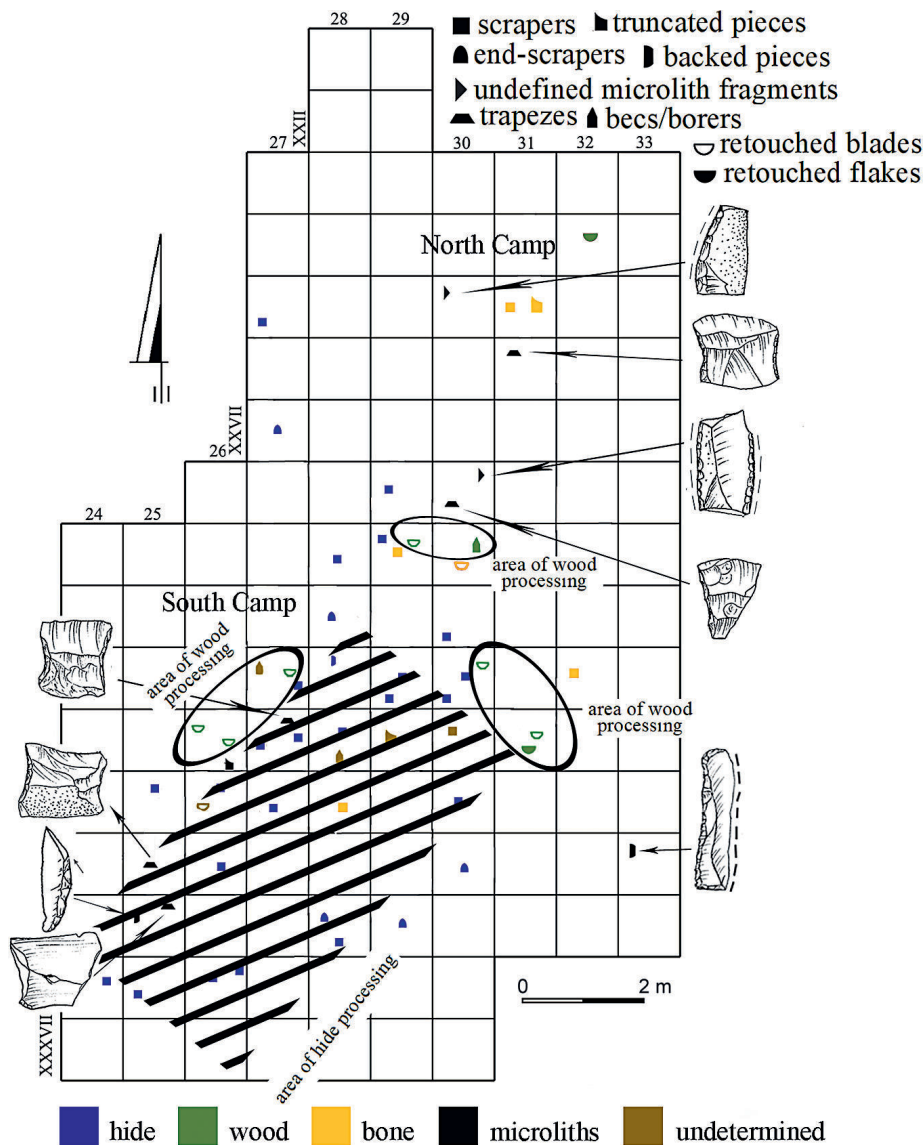


Fig. 13. Wieliszew, trench XVII c. Reconstruction of the model of the last phase of the formation of the flint assemblage, taking into consideration spatial relationships between the southern and northern clusters. The individual areas of activity were determined on the basis of the dispersion of functionally identified flint material. Chipped stone tools: dashed line – the course of use-wear traces (map by A. Sołodko).

The lack of refittings between the southern and northern clusters may indicate that these are flint assemblages from different periods. The few refittings show that the miniaturisation of scrapers, but also of other tools, was not the result of their transformation but is related instead to the size of the flakes, and the retouching only corrected minor irregularities on the edges.

Discussion

Settlement and behavioural interpretation of Rydno

Three zones of find accumulations were identified at the Rydno site. All activity remains are grouped on the same side of the campfires, which is an astonishing correlation with the Verrebroek ‘Dok’ site (*Crombé et al. 2003*, 211). However, the question remains whether these three zones are related to each other or are separate spatio-temporal settlement episodes. Considering the first option, if Rydno was simultaneously inhabited by a single common group of hunter-gatherers, each zone should have been characterised by different activities. This is the case at the Vaenget Nord site in Denmark (*Price – Petersen 1987*, 117), the site at 62 rue Henry-Farman à Paris, locus 5 (*Souffi et al. 2013*, 24), and the Siebenlinden site in Germany, where the model of a Mesolithic living unit included several varying activity zones (*Kind 2009*, 145). Similar assumptions also apply to several sites near Havelte in the Netherlands, based on differences in the type of wood in hearths and pits (*Price et al. 1974*, 57), and the site Doel-‘Deurganckdok J/L’, C3 in Belgium (*Noens 2013*, 229). At the Meer IV site in Belgium, two Mesolithic concentrations several metres in diameter were discovered. In each of them, zones with separate flint-working activities were identified. These are interpreted as a single occupation (*Nijs 1990*, 505).

At Rydno, each of the three zones has a similar functional character, fairly similar flint inventory, and traces of campfires, which basically rules out the aforementioned model of spatial organisation. If the northern and southern campfires at Rydno were to be treated as ‘foyer satellites’, they should have a different function from the central hearth (*Julien 1984*; *Moseler 2011*, 123). At the Pen Hoat Salaün site in France, three zones with a parallel arrangement of flint deposition were distinguished within a single large concentration, which – according to the authors – may suggest cyclical returns of the Mesolithic community (*Nicolas et al. 2012*, 491). The final argument in favour of the lack of interdependence between the zones at the Rydno site is the absence of refittings between them. According to researchers, refitting lines determine the coherence between individual clusters (*de Bie 2007*, 42; *Souffi et al. 2018*, 556). However, the lack of flint circulation between individual concentrations proves the lack of synchronicity between them (*Bodu et al. 1990*, 159). In addition to the identified use-wear evidence, some transformations associated with mounting tools in hafts were also recorded. Mounting tools in hafts, shafts or handles undoubtedly increased efficiency and productivity (*Keeley 1982*, 799).

In summary, Rydno either represents three independent but simultaneous episodes, which reflect the simultaneous presence of three human groups, or these three episodes are cyclical returns of one group. The first possibility seems unlikely.

The handling and processing of plant-based raw materials may be related to the manufacturing of items necessary for daily use, such as bark containers, baskets, ropes, and mats (*Martínez-Sevilla et al. 2023*, 8), food production (*Jacomé – Vandonpe 2022*, 7; *Bishop et al. 2023*, 75) and the use of plant dyes in dressing hides. The short-term settlement at the Rydno site suggests that the optimum explanation for processing plants may have been consumption. The camps were associated with short-term hunting activities, so it is difficult to imagine that the inhabitants were also engaged in the production of objects from organic raw materials. It seems reasonable to assume that the processing of plants was related to food production.

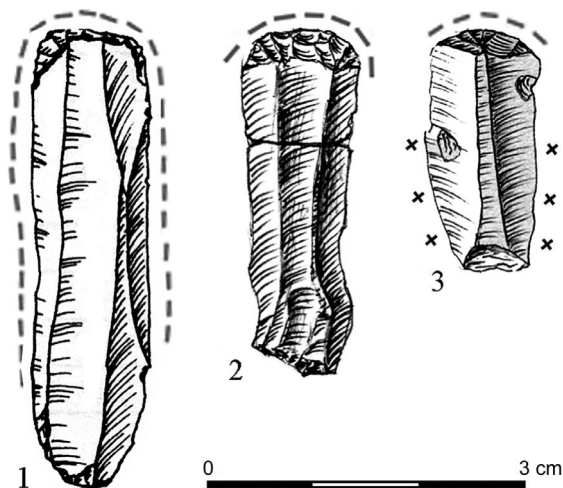


Fig. 14. Rydno, trench IV/47. Endscrapers. Dashed line – the course of use-wear traces; crossing – haft. (drawing by E. Gumińska).

In the case of reconstructing the supply of flint tools to hunting sites, the first option to consider is their production on site, which was the case here (Fig. 4: 1–4). However, the second option may also be their transport (Nelson 1991, 83). An example illustrating such a possibility is a large, massive blade, 104 mm long and 14 mm thick, with traces of butchering game, recovered from the northern campsite at Rydno (Fig. 4: 6).

Moreover, some tools may have been used in another location than where they were discarded (Keeley 1987, 95). Prehistoric communities moving from place to place also carried the necessary equipment constituting their personal belongings (Kuhn 1994, 427), and most often this group of artefacts is in some sense different from the inventory produced in a given place, e.g. it is distinguished by the raw material or morphological features (Fiedorczuk 2006b). The suggestion that the massive blade was brought in is based largely on the interpretation of the assemblage of artefacts in this cluster. The parameters indicate that it was removed during the early phase of core exploitation, while the other blades are 30–40 mm shorter, with regular straight edges and small thickness – up to 2.5 mm. This apparent gap in the length of the blades shows a lack of continuity in the production of blades or the extraction of a very specific length group. The remaining blades were most likely removed from other cores – smaller and already preliminarily exploited.

Regarding the endscrapers (Fig. 14), eight were produced from blades and three from flakes. Seven specimens had traces of use. Among the blade specimens, only three were complete forms, while five were fragments preserved in the form of a broken working part. The shortest complete specimen is the one with diagnosed marks of hafting (Fig. 14: 3), which could indicate long-term use, well beyond the time of the hunters' stay at the Rydno site. In contrast, when people abandoned the campsites, they may have taken cores and blades with them.

Settlement and behavioural interpretation of Wieliszew

Based on the planigraphy of the finds and the arrangement of the activity, it was concluded that there were two spatial units (campsites). At the southern campsite, a central

feature in the form of a dwelling structure is presumed. Similar indications of dwellings were identified at the Aggemose site located in Denmark (*Grøn 1995*, 8) and the Rönneholm 6 site located in northern Sweden (*Larsson – Sjöström 2011a*, 239). The dwelling of Wieliszew is characterised by the artefact concentration related primarily to dressing hides. The location of these activities indicates that much of the work took place inside the building and directly around it. However, it seems that the northern cluster constitutes an area where people processed bone raw material and fixed their hunting weapons (*Fig. 13*). This is evidenced by the trapeze that served as an arrowhead and a fragment of microlith that formed a part of a composite weapon (insert). These finds suggest that this cluster can be interpreted as an indicator of a short-term stay of hunters, perhaps at the same time of year. The similar method of core exploitation and the use of the same type of flint (Cretaceous) and the miniaturisation of tools indicate that it may have been the same group of people.

During the excavations at the Wieliszew site, worn and damaged armament components such as trapezes and other microliths were discovered next to zones associated with woodworking, indicating separate sites for repairing hunting weapons (*Fig. 13*). Given that woodworking took place near the hafting-and-retooling area, it can be assumed that this activity may have been related to the preparation of arrow shafts. Similar conclusions drawn on identical grounds were presented for the Mesolithic inventory from the Laghetti del Crestoso site (*Lemorini 1997*, 57).

Temporal and functional patterns

Each of the campsites at Rydno represents a distinct settlement event and this thesis is confirmed by the typologically similar flint inventory in each of these camps, with preserved quantitative proportions between the different classes of tools, the performance of the same activities using a specific group of artefacts, and, above all, the recorded activity of chopping meat and dressing hides (butchering), which were carried out close to the hearths, with the occasional presence of other identified activities.

Flint inventories with a small number of artefacts are also found at other sites associated with hunting, such as Jardinga in the Netherlands (*Prummel et al. 2002*, 417) and Vignes in France (*Lelouvier et al. 2012*, 110). Multiple instances of hunter-gatherers returning to the same site are not uncommon. For example, successive stays by groups have been recorded at the Verrebroek site in Belgium (*Crombé et al. 2001*, 256), the Bergumermeer S-64B site in the Netherlands (*Niekus et al. 2018*, 959), the Rönneholms Mosse sites in Sweden (*Larsson – Sjöström 2011b*, 462), and the Paliwodziczna 29 site in Poland (*Osipowicz et al. 2023*, 19). Systematic re-occupations have also been recorded at the Mesolithic site of Strandvägen in Sweden (*Molin et al. 2018*; *Gummesson et al. 2019*).

The successful returns of the bearers of the Janisławice culture to Rydno may be due to favourable environmental conditions, which can also be explained by the idea of resource monitoring (*Kelly 1983*, 287), which is consistent with the ‘optimal foraging theory’ (*Bayliss-Smith 2004*, 183). In total, nine flint assemblages and many individual elements distinctive of the Janisławice culture, such as the Wieliszew point, have been identified at Rydno. Ethnographic data (*Houtsma et al. 1996*, 98) show that where there is ample food, there is a significantly greater accumulation of sites. In addition, there are many other possible reasons for the presence of the Janisławice culture community at Rydno, in particular the extraction of hematite. Rydno was a place where hematite was extracted by prehistoric

communities for many thousands of years, so it seems obvious that this possibility should not be ruled out.

In contrast, the site in Wieliszew is presumably a hunting campsite of late autumn provenance, because the highly specialised tools were mainly used for processing delicate hides, which would be acquired in late autumn, when the animals would already have their winter fur (Boroń – Winiarska-Kabacińska 2018). Thus, these camps would have been associated with the seasonal migration of the Mesolithic community. A similar interpretation was presented for the Pod Zębem campsite (Hardy 1999; Hardy – Svoboda 2009, 168), where excavated faunal remains also point to this explanation (Horáček 2003).

The campsites at Rydno and Wieliszew, although their character is determined by hunting activity clearly indicated in the flint material through use-wear analysis, vary in the implementation of this process, expressed in different behavioural and social aspects. The former illustrates the *ad hoc* need to provide food and can be described as a satellite hunting camp (Jochim 1976, 142), while the latter is an example of the gathering of skins of small fur-bearing animals during the late autumn season. It seems that a certain indication of the temporary nature of the campsites is the rather spatially limited activity zones. In the case of campsites with a significantly longer settlement episode, there is a gradual expansion of the utilised sectors, which is associated with a greater dispersion of flints (Carr 1984, 127). On the other hand, the longer the period of settlement, the shorter the time of use of individual tools (Bamforth – Becker 2000, 283). Thus, the anticipation that the shorter the time of settlement, the more intensively the tools would be used is consistent with the above assumptions, as confirmed by the analysed flint inventory from Wieliszew and Rydno. The implication of the longer period of settlement at Wieliszew in relation to Rydno is the greater diversity of tool types recorded at the former site. As Schiffer (1975) notes, there is a correlation between longer settlement and the diversity of tool forms.

Conclusion

In the literature, the flint scatter at Rydno is referred to as a ‘*middle-sized flint processing workshop*’ (Schild *et al.* 2011, 351). Of course, when considering the area of a flint processing workshop, due to the distribution of lithic artefacts, this designation is legitimate. The use of research methods such as refitting of flint artefacts, planigraphic analysis, and use-wear analysis has allowed us to redefine its context and significance. The concentration does not represent a single settlement episode, but three different ones, all interpreted as hunting camps.

This methodological package made it possible to highlight differences between the camps at Rydno and Wieliszew. Despite the functional similarities within the lithic assemblages, their spatial organisation and the method of depositing flint artefacts pointed to distinct variants of hunting camps.

A detailed analysis of the processes involved in the formation of sites shows that a medium-sized concentration, such as that at the Rydno site, need not always be the result of a single continuous settlement episode, but rather the consequence of successive returns by hunter-gatherers to the same location, thereby demonstrating the repetitiveness of their behavioural patterns. Perhaps many similar Mesolithic sites are also the result of rhythmic, short-term settlement episodes. Functional verification of the campsite at

Wieliszew, pointing to hunting aspects associated with the pursuit of small fur-bearing mammals, not only implies a new significance for the campsite but also defines the seasonality of its occupation.

We contextualised our case studies within a broader European and sometimes global background, looking for convincing and expressive analogies for the described camps and the processes that shaped them. We aimed for comparisons in many areas, such as flint resource management, spatial organisation of campsites, and the comparison of the spatial arrangement of artefacts, which are both the result of diverse depositional processes manifested, e.g. in the accumulation of particular groups of finds, as well as the result of various aspects of human behaviour such as discarding, transferring, and the selective use of tools and their re-use. The relationship between the size of the camps and the duration of settlement was also assessed in our studies.

The article indicates new possibilities for the reinterpretation of many previously explored Mesolithic flint concentrations. The research results show that studying archival collections also contributes to a deeper understanding of the processes of Mesolithic site formation through the identification and description of settlement structures, which also allows us to determine the spatial and even temporal relationships between them. The revision of previous findings introduces new research perspectives for many other Mesolithic sites studied in the 1960s and 1970s, which can contribute to the discussion on the methodological aspect of revising views and the state of research. The scientific potential of archival flint collections – and the analysed clusters that can be regarded as such – is undeniable. The theories built on this basis are authentic and in line with contemporary expectations based on materials acquired through modern excavation methods developed over many years of fieldwork experience.

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RESEARCH ARTICLE – VÝZKUMNÝ ČLÁNEK

Digital spatial modelling for encampment localisation related to the Battle of Mohi (1241), Hungary

Digitální prostorové modelování lokalizace tábora spojeného s bitvou u Mohi (1241), Maďarsko

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The Battle of Mohi in 1241 was a major clash between the Kingdom of Hungary and the Mongols invading Europe. Recent research on the battle has increasingly refined our understanding of the events surrounding the confrontation. Although these studies build on a shared scholarly foundation, they rely on heterogeneous spatial datasets, as no unified GIS database is yet available. This limits the full use of tools such as Historical GIS (HGIS), which can integrate these heterogeneous datasets into a unified, archaeologically oriented database to facilitate analysis and interpretation. The present study introduces a high-resolution potential-mapping approach aimed at identifying the likely position of the Hungarian camp. The analysis integrates archaeological, military–historical, and relevant environmental data, weighted through the Analytic Hierarchy Process (AHP), resulting in a five-meter-resolution potential map. The findings contribute to a more spatially grounded reconstruction of the battle and offer a methodological basis for future archaeological investigations.

GIS – Battle of Mohi – AHP weights – REM – LiDAR

Bitva u Mohi roku 1241 představovala zásadní střet mezi Uherským královstvím a Mongoly postupujícími do Evropy. Nedávné výzkumy této bitvy zpřesnily naše chápání událostí spojených s touto konfrontací. Ačkoli tyto studie vycházejí ze společného badatelského základu, opírají se o heterogenní prostorová data, protože dosud neexistuje jednotná databáze GIS. To omezuje plné využití nástrojů, jako je historický GIS (HGIS), který by mohl tato různorodá data integrovat do jednotné, archeologicky orientované databáze a podpořit jejich analýzu a interpretaci. Tato studie představuje přístup založený na tvorbě detailního potenciálového modelu, jehož cílem je identifikovat pravděpodobnou polohu uherského tábora. Analýza propojuje archeologická, vojensko-historická a relevantní environmentální data, vážená metodou analytického hierarchického procesu (AHP), přičemž jejím výsledkem je potenciální mapa s rozlišením pět metrů. Zjištění přispívají k prostorově ukotvenější rekonstrukci bitvy a poskytují metodologický základ pro budoucí archeologický výzkum.

GIS – bitva u Mohi – váhové koeficienty AHP – DMR – LiDAR

Introduction

One of the most consequential processes in the 13th-century Eurasian realignment of power was the expansion of the Mongol Empire, which from the 1230's onward posed an increasingly direct threat to Eastern Europe. The Mongol invasion of Europe was grounded in a complex strategic system based on rapid mobility, a unified command structure, and the multi-layered use of intelligence (Jackson 2017, 92–94). Their operations against the Rus' principalities demonstrated this efficiency vividly: between 1237 and 1240, the Mongols systematically conquered and devastated the fragmented Rus' polities, while

simultaneously seeking to integrate local political networks into the imperial system as tribute-paying client structures (*Halperin 1987*, 3–6). After consolidating their dominion over the eastern Slavic territories, the offensive shifted westwards, where the Carpathian Basin held key strategic importance both militarily and economically.

The Hungarian Kingdom at this time was experiencing a period marked by internal tensions, especially concerning the settlement of the Cumans and the balance of power among the nobility (*Engel 2001*, 99). Prior to the campaign, the Mongol leadership dispatched envoys to King Béla IV demanding his submission, a request the king rejected while seeking diplomatic support from the papacy, which ultimately did not translate into effective military assistance (*Berend 2013*, 34). In the spring of 1241, Mongol forces entered Hungary from three main directions, overcoming the defensive structures constructed at the Carpathian passes, which in any case did not constitute a coherent or adequately organised system (*Kristó 2007*, 226). The Mongol army had advanced as far as the Danube line, reaching the region of Pest by mid-March 1241, prompting Béla IV to mobilise a rapidly assembled Hungarian force composed largely of cavalry. Avoiding a pitched battle, the Hungarian army followed the Mongols eastward and on April 10 reached the Sajó River, where the Hungarian camp was established along the riverbank.

The reconstruction of the battle is nevertheless constrained by the scarcity of near-contemporary narrative sources, chiefly Rogerius and Thomas of Split. Both sources provide descriptions of the battle with differing levels of detail and perspective. However, two locations stand out as particularly important: the Hungarian camp, located close to the Sajó River, and the bridge over the Sajó, which is considered the site of the initial engagement. The two sources are somewhat confused regarding the location of the camp and the bridge. They mention a bridge crossed by the Hungarian army, but do not always specify the river. They also indicate that the camp was on the left bank when advancing from west to east. At first glance, this seems contradictory, because the Hungarian forces are also reported to have repelled a Mongol detachment at the Sajó Bridge on the night of April 10, which, according to the description, should have been either near the Hungarian camp or even to its west. In that case, continuous military supplies would not have been able to reach the Hungarian camp from the west. In this context, it is important to add that the distance between the Hungarian camp and the Sajó Bridge may have been substantial.

Négyesi (1997, 296) offered a detailed discussion of the events preceding the clash at the Sajó Bridge on April 10. According to his calculations, sunset on that day likely occurred at 18:29, with suitable visibility lasting until approximately 19:30. Even so, the bridge may have been located roughly 7 km away, while the engagement there reportedly took place around midnight. The return from the clash to the camp then followed around 3 a.m. In the subsequent Hungarian defeat at the bridge on April 11, it is striking that reinforcements were apparently not sent from the theoretically nearby Hungarian camp, and that neither the sounds nor the sight of the battle were perceived by the camp itself or by Hungarian soldiers patrolling the area. This observation underlies one of the conceptual bases of the present study, namely the establishment of an average audiovisual range of approximately 1 km. As a result, the exact locations associated with the battle cannot be fixed with full certainty, and both the reconstruction of the battlefield and the estimated size of the armies have long remained matters of scholarly debate.

The battle itself, fought on 12 April 1241, ended in a devastating defeat for the royal Hungarian army. Fragmented command, the tactical limitations of heavily armoured cav-

alry, and the Mongols' concentrated ring of mounted archers all contributed to the disaster (Pow 2022, 185–186). Following the battle, the Mongols quickly occupied significant parts of the Great Plain and Transdanubia, during which numerous towns and ecclesiastical centres were destroyed. The scale of demographic losses remains debated: while contemporary chronicles report widespread destruction, archaeological evidence indicates that the settlement network suffered unevenly and certain areas remained largely unaffected (Laszlovszky *et al.* 2016a, 189–191; Wolf 2018, 138). The Mongol withdrawal in the spring of 1242 has traditionally been explained by the death of the Great Khan and the ensuing internal political transitions; however, environmental factors such as the freezing of the Danube may also have influenced strategic decision-making (May 2012, 25–28). The long-term consequences of the Mongol invasion in Hungary included a royal castle-building programme, the emergence of new types of stone fortifications, and a transformation of settlement policies, all of which strengthened royal authority and partly reoriented the kingdom's subsequent medieval development.

The localisation of the Battle of Mohi and the Hungarian camp

Research into the location of the April 1241 battle and the possible position of the Hungarian camp remains a prominent topic in both archaeology and military history. The complexity of the issue arises partly from uncertainties in reconstructing contemporary conditions such as road networks and settlement patterns, and partly from natural geographical factors including ambiguities surrounding the former channels and drainage systems of the Sajó and Hernád rivers. Nevertheless, contemporary European and Chinese sources consistently place the events of the battle within the same broader area (P. Szabó 2022, 114). This includes the Sajó Bridge on the right bank of the river, where the first clash occurred, the sites of several smaller clashes in the vicinity of the settlement of Muhi (Mohi) and the Hungarian camp, where the final battle unfolded. However, the exact locations of both the bridge and the camp remain unidentified. Although the medieval settlement of Mohi has been excavated, the investigations have not yielded a quantity or type of finds that would conclusively demonstrate that the area was directly involved in the military events (Wolf 2018, 136–139).

Determining the chronology and assessing involvement in the battle pose significant challenges even at the international level, despite the application of modern methodologies and careful analyses (Krapiec – Piekalski 2019, 323–324; Piekalski 2023, 125–127). The Mongol invasion was brief yet unfolded abruptly across dispersed regions, while its effects lasted for years, complicating the stratigraphic record. As a result, the secure identification of layers attributable specifically to the invasion, as opposed to other destructive events or later rebuilding activities, becomes methodologically problematic.

Even though many fundamental questions concerning the Mohi battle have persisted for centuries, the continuous processing and interpretation of an expanding corpus of textual, archaeological, and interdisciplinary sources has allowed research to advance steadily toward a more nuanced, realistic, and methodologically grounded reconstruction of the event (P. Szabó 2022, 114). On the basis of growing knowledge, it has become possible to refine estimates of the number of participants, the circumstances surrounding the establishment of the camp, and the possible scenarios of the engagement itself (Bánlaky 1932, 369–372; Veszprémy 1994, 28–35; Wolf 2014, 139). Two key areas of investigation are the

reconstruction of contemporary physical–geographical conditions and the assessment of the medieval settlement network (Laszlovszky *et al.* 2016b, 32; Pusztai 2014, 29). Despite technological advances, research aimed at localising the battlefield and the encampment still has not fully exploited the potential offered by modern geoinformatics and high-resolution spatial data (Négyesi 1997, 295; Laszlovszky – Nagy 2023, 950; Négyesi 2024). This is largely due to the absence of unified, GIS-based databases that would enable the widespread application of archaeological GIS methodologies and geostatistical analyses. As a result, several important analytical perspectives and evaluative opportunities remain underutilised, even in cases where high-resolution datasets (e.g. LiDAR) and maps are available.

To address these deficiencies, we launched a multi-stage research programme that employs the framework of the Geographic Information System. GIS databases and tools provide a framework for integrating heterogeneous spatial, temporal, and archaeological data into a coherent research platform, enabling high-resolution analysis and predictive modelling. This framework is complemented by Historical GIS (HGIS), which treats GIS not merely as a mapping tool but as an analytical approach that integrates spatial, temporal, and attribute information to address historiographical questions (Gregory – Ell 2007, 64–65; Sarris 2024, 9–10). Within this framework, the project examines the potential inundation (flood) limits of the Sajó River on the basis of morphological and hydrological indices derived from a digital elevation model (DEM) with a spatial resolution of five metres (such as the Topographic Wetness Index – TWI, slope, flow accumulation, and watershed analysis), as well as data from the Flood Risk Management Plan by the Hungarian Water Directorate (ÉMVIZIG 2014).

Our previous analyses enabled the delineation of the local catchment areas of the Hejő, Szinva, and Hernád streams within the 140 km² study area, and identified potential flow branches on the right-bank watersheds of the Sajó that could be reactivated during flood events and form a coherent hydrological system. These were designated by the study as Sajó I, Sajó II, and Sajó III flow branches (Dobai – Dobos 2022, 103–104; 2023, 360). In the absence of modern flood control, these former channels would likely still be active today (e.g. Sajó–III, which even now requires pumping within the urban area of Ónod). This suggests that in the event of flooding, crossing the Sajó as described ‘then encamping on its left bank’ would have been possible, since one of the Sajó’s branches was indirectly connected to the Hejő marshlands. The encampment on the left bank is, in fact, confirmed by both Rogerius and Thomas of Split (Wolf 2018, 138). From a geological perspective, this concerns flow processes along the former branches of the Sajó within Late Pleistocene to Early Holocene deposits (fQ_{h1hal} , fQ_{h2alh}) belonging to the third river-generation, which can be identified at three locations on the DEM (Gábris 2022, 55–56; Csoma 1972, 10–13).

The primary aim of the present study is to produce a potential map of locations suitable for encampment, using the databases assembled by earlier research. In addition, the investigation addresses the evaluation of spatial characteristics of the identified archaeological site. The GIS-based Encampment Suitability Map (ESM), which integrates archaeological perspectives, provides a solid foundation for the future spatial analysis of artefacts (Laszlovszky – Rácz 2020, 186–187). Furthermore, it may contribute to the interpretation of archaeological finds and help confirm potential alternative hypotheses regarding the location of the camp, including the predominantly eastern camp location between the Hejő

and the Sajó, as well as the debatable but not entirely dismissible possibility of a campsite along the Hejő (Wolf 2018, 138).

Materials and methods

Study area

The analysis was carried out within the study area extending between Sajópetri, Emőd, and Kesznyéten, based on a comprehensive GIS database. The study area lies on the Sajó–Hernád alluvial fan plain in northeastern Hungary. The region is a Late Pleistocene, filled, low-relief alluvial plain formed by the Sajó and Hernád rivers through the deposition of gravelly, sandy, and silty sediments during the Quaternary. Its surface is generally very uniform, interrupted only by minor depressions, abandoned channels, and weakly expressed levees (Dövényi 2010, 215–216).

Presentation of GIS Database input data

The criteria for identifying an optimal campsite were fundamentally based on Tamás Pusztai's research on the early medieval settlement network (Fischl – Pusztai 2018, 84–85). The geographical interpretation is built upon our previous results and the studies of József Laszlovszky and Balázs Nagy, as well as the relevant military-historical literature (Veszprémy 1994, 30; Dobai – Dobos 2023, 360; Laszlovszky – Nagy 2023, 950–961; Négyesi 2024, 13). To define the environmental characteristics of a suitable campsite, such as a secure position, defensibility, and protection from flooding, we classified multiple geospatial layers, including slope, TWI, the relative elevation model (REM), potential drainage density (Dobos – Daroussin 2005, 40–42), and estimated flood-inundation boundaries (Kiss 2018, 46). Analysing the hydrological conditions of the study area and expanding the associated knowledge remains an ongoing task. In this context, an archival document HU MNL BAZML IV.501.e. 2393/1791 detailed, coloured map (Fig. 1) was digitalised and then analysed. The map was dated 1775 and originally created to establish the territorial affiliation of Alberek Forest, situated between Ónod, Sajóhídvég, and Köröm on the Sajó and Hernád floodplains (Bodnár 2021).

The map's features provided crucial guidance for localising the former church site of the Sajóhídvég settlement. This site is particularly important because the place name itself (Sajó – referring to the river, *híd* – bridge, *vég* – end; literally meaning 'end of the bridge over the Sajó') implies the former existence of a bridge associated with the Sajó River. However, the present-day settlement is located along the Hernád River, which suggests a possible shift in the fluvial or settlement context. Therefore, the related information is essential for expanding our understanding of the historical landscape (Bodnár 2021). For this reason, sites located in the area between the Sajó and Hernád rivers (e.g. churches) can be used as reference points for the reconstruction of the contemporary settlement network. The scanned map was first georeferenced and then converted to vector format, producing a digital dataset that served as a reliable validation tool for the previously identified archaeological sites.

Among the DEM-derived variables employed in this study, particular attention was given to the Topographic Wetness Index (TWI) and the Relative Elevation Model (REM)

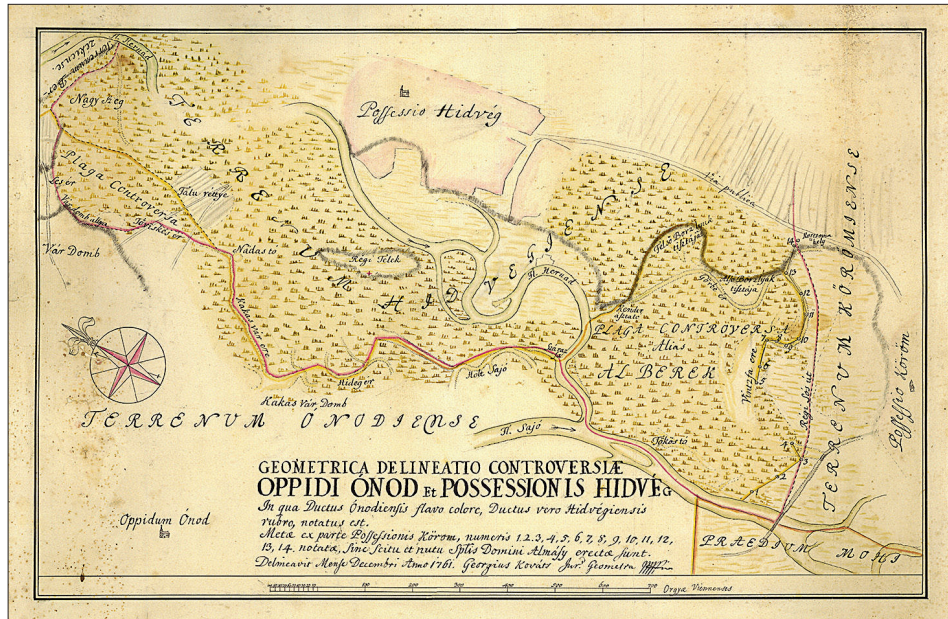


Fig. 1. Original 1775 map of the Alberek Forest (National Archives of Hungary, HU MNL BAZML IV.501.e. 2393/1791).

(Mohamed 2020). The TWI is fundamental for characterising the spatial distribution of surface moisture and the organisation of runoff processes. Within the mapping framework, its classification proved especially valuable, as it enables the identification of topographic controls on runoff as well as areas susceptible to water accumulation. High TWI values delineate convergent landforms with enhanced water-retention capacity, whereas low values correspond to divergent slope segments associated with rapid drainage. As a result, the TWI is effective not only for delineating potential flow pathways but also for supporting the spatial differentiation of surface–water features in relation to local terrain properties.

The TWI quantifies the potential for soil–moisture accumulation (Mohamed 2020, 10–11). Its classical formulation is expressed in the equation:

$$TWI = \ln\left(\frac{a}{\tan \beta}\right),$$

where,

a denotes the upslope contributing area per unit contour length ($m^2 m^{-1}$), and β is the local slope angle (radians).

The Relative Elevation Model (REM) is a terrain-derived metric that expresses the elevation of each surface point relative to a reference line or surface, most commonly an interpolated riverbed level or drainage baseline. Rather than absolute altitude, the REM highlights fine-scale topographic variation within floodplains and low-relief landscapes by quantifying how much a location rises above the hydrologically relevant reference elevation (Greco *et al.* 2008, 71). This makes the REM particularly effective for identifying microrelief, distinguishing geomorphic units, and analysing floodplain morphology

in situations where absolute elevation values offer limited contrast. Its computation is based on a simple elevation difference, expressed by the following formula:

$$\text{REM}(x, y) = \text{DEM}(x, y) - E_{\text{ref}}(x, y),$$

where,

DEM(x, y) represents absolute terrain elevation

$E_{\text{ref}}(x, y)$ is an interpolated reference surface at the same location.

Beyond these physical parameters, we also delineated perceptual and spatial factors relevant to the battle, such as the approximate one-kilometre impact zones of battlefield noise, smoke, and fire effects, including the shooting range by siege engines. Moreover, travel-time and distance calculations were performed to model horse-based movement between the bridge and the potential campsite (Markku 2023, 9–11). As outlined above, the Hungarian army was composed primarily of highly mobile cavalry and had pursued the Mongol forces for several days, thereby rendering cavalry movement the most appropriate basis for evaluating distance, mobility, and response time between relevant locations. The determination of this distance assumes that the sounds of battle (e.g. weapons firing, distant rumble, echoing noises) and visual signals (such as fire or smoke) could have been perceived in this latitudinal range during the early vegetation period, particularly around April 10. The low canopy cover and wet environmental conditions likely facilitated the propagation of both auditory and visual cues over greater distances. The maximum distance of 3 km was derived from the realistic distance that could be covered while riding at a gallop on horseback, fully equipped for battle. It should be noted that the actual distance from the right bank of the Sajó River to the marshy boundary of the Hejő–Szinva area averages 3.5 km, which thereby defines the upper limit of the potential movement range within the study area. As an additional component, a hypothetical 500-m-wide epidemiological buffer zone was assigned to the reconstructed medieval settlement network (Fischl – Pusztai 2018, 84). This experimental buffer, defined as half of the approximate one-kilometre impact zone, serves as a conservative spatial threshold for assessing the limits of encampment possibilities in relation to the medieval settlement network. The primary GIS vector and raster datasets employed in this study are illustrated (Fig. 2).

In the next phase, the GIS database layers were weighted using the AHP-derived weights. The Analytic Hierarchy Process (AHP) is a multidimensional decision-support method developed by Thomas L. Saaty. In this approach, the criteria and alternatives are evaluated through pairwise comparisons on a predefined scale, expressing their relative importance (Choudhury *et al.* 2022, 121). The weighting of the rasterised map classes followed the scale proposed by Saaty, and the resulting AHP-based class weights reflected the relative suitability of each layer for camping. The pairwise comparison matrix $A=(a_{ij})$ of the decision hierarchy for a set of n elements was constructed such that a_{ij} expresses the relative importance of objects i and j , where $a_{ij} > 0$ and $a_{ij} = 1/a_{ji}$. The weight vector (w) is obtained using the eigenvector method:

$$A w = \lambda_{\max} * w$$

where,

W represents the principal eigenvector,

A stands for pairwise comparison matrix (a_{ij});

$\lambda_{\max}$ denotes the largest eigenvalue of the eigenvector.

	DEM indices	Hydrology	Flood ind. boundary	Landuse – Landcover	Visibility (1km)	Route distances
DEM indices	1.0	1.8	3.30	6.3	13.5	15
Hydrology	0.55	1.0	1.82	3.60	7.4	8.5
Flood ind. boundary	0.30	0.5	1.0	2.04	4.5	5.4
Landuse – Landcover	0.15	0.27	0.49	1.0	2.3	2.6
Visibility (1km)	0.07	0.13	0.21	0.42	1.0	1.15
Route distances	0.06	0.11	0.18	0.37	0.8	1.0

Tab. 1. Analytic Hierarchy Process (AHP) comparison matrix for GIS layers.

Finally, the weights are normalised according to $\sum W_i = 1$, yielding the final priority weights (*Salomon – Gomes 2024*, 8–9). The evaluation process results (*Tab. 1*) in a comparison matrix that serves to calculate weights and determine priorities, enabling the numerical ranking and weighting of the input variables relevant to the study. The method also incorporates the consistency ratio (CR), which ensures the internal coherence of the pairwise comparisons (*Eroglu – Meral 2021*, 505). In this approach, complex problems are represented within a hierarchical structure: the overall decision goal (in this case, defining the characteristics of an optimal campsite) occupies the highest level, followed by the relevant criteria and alternatives (secondary environmental attributes of the campsite). The internal coherence of the pairwise judgements was evaluated using the Consistency Index (CI):

$$CI = \frac{\lambda_{\max} - n}{n - 1},$$

where,

CI represents the Consistency Index;

$\lambda_{\max}$ is the principal eigenvalue of the pairwise comparison matrix;

n stands for number of criteria;

and the Consistency Ratio (CR).

$$CR = \frac{CI}{RI},$$

where,

CI represents the Consistency Index;

RI denotes Random Index for a matrix of size n ;

The CI measures the deviation from perfect consistency ($\lambda_{\max} = n$) and quantifies the degree of logical inconsistency in pairwise comparisons; the closer the CI is to zero, the more consistent the judgment structure. CR value below 0.10 was considered acceptable (*Salomon – Gomes 2024*, 6). The derived DEM indices used in this study include slope, maximum and minimum DEM, and REM, etc. (*Tab. 1*). Hydrology was assigned as a separate category based on hydrological information. This is followed by datasets representing the flood boundaries of the Sajó River branches. The Landuse–Landcover group integrates the relevant DEM (maximum and minimum), TWI, hydrological feature (Hejő–Tisza Marshland), settlement network, and road network datasets. The visibility group includes perceptual distances of 1 km, 2 km, and 3 km, while route distances define the limits based on potential accessibility and travel–time calculations.

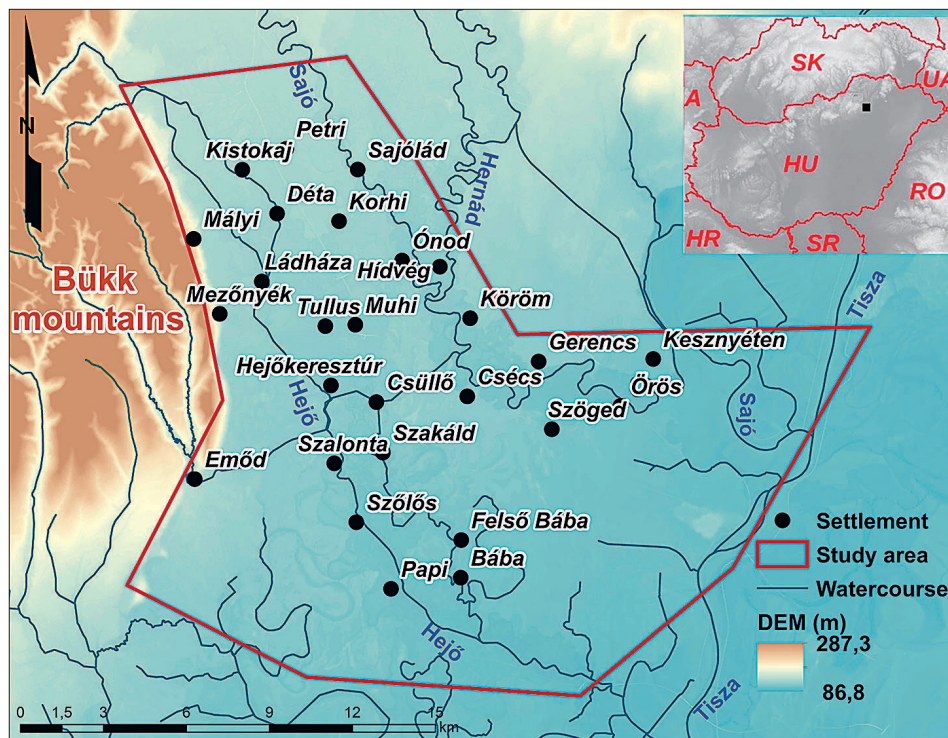


Fig. 2. Map of the study area.

Based on the considerations outlined above, the rationale for selecting the applied methodological framework becomes evident. The AHP method was selected because the encampment localisation problem involves heterogeneous criteria whose relative importance cannot be derived directly from quantitative measurements. As emphasised by *Malczewski* (1999, 414–415), AHP is particularly useful in such cases, as it allows expert knowledge to be expressed through structured pairwise comparisons rather than direct weighting. This form of consistency control is not available, for example, in the simple additive weighting (SAW) approach (*Malczewski* 1999, 419–420). While the SAW method was considered, it requires predefined weights without a formal mechanism to test their logical coherence. According to *Malczewski* (*Malczewski* 1999, 419), SAW is more appropriate when weights are empirically derived or relatively unambiguous, which is not the case for historically and environmentally conditioned criteria such as those used here. For these reasons, AHP was considered the most appropriate framework for integrating archaeological, environmental, and military–historical factors in the GIS-based encampment suitability model.

Results and discussion

The consistency statistics of the six-element AHP pairwise comparison matrix are presented (*Tab. 2*). The calculated Consistency Ratio (CR $\approx$ 7.37%) is below the 10% thresh-

hold, indicating that the matrix can be considered consistent (*Eroglu – Meral 2021, 505*). Although the value approaches the upper limit, it is deemed acceptable, particularly because this type of analysis has not previously been applied to the study area.

$\lambda_{\max}$	CI	RI (n=6)	CR
6.456	0.091	1.24	0.0737

Tab. 2. Statistics of the Analytic Hierarchy Process (AHP) comparison matrix.

Based on the AHP weighting, an ESM probability map was produced with a spatial resolution of 5 m (25 m²). The distribution of the AHP-weighted GIS classes followed a Jenks natural breaks classification, based on which the ESM map was divided into three suitability categories for settlement: suitable (S1), moderately suitable (S2), and unsuitable (N). The ESM is available to researchers working in this field (*Online Supplementary Material 1*). All maps presented in this study are in the Hungarian Unified National Projection (EOV). The map enables the analysis of areas most suitable for temporary camps and permanent settlement, and can therefore be applied in the further study of early medieval settlement networks (*Fischl – Pusztai 2018, 84*). Subsequently, the estimated minimum–maximum size ranges of the camps were examined at spatial extents of 3 km², 1 km² and 0.4 km² (*Wolf 2018, 138–139; Négyesi 2024, 73–75*). To facilitate the spatial analysis, areas labelled as A, B, and C were delineated along historically significant commercial and military routes accepted by archaeologists (*Fig. 3*). In addition, alternative crossing routes were identified along the stable banks of the Sajó River, defined by the flood-inundation boundaries along the coast. These boundaries together constitute a refined version of the perceptual limit. To verify the occurrence of the camp-size categories, we generated a fishnet grid in ArcMap using the previously defined spatial extents (in km²). Finally, based on the *Hungarian National Museum Archaeology Database* (KRÉTA), we extracted the Árpadian-period, early medieval, and undated archaeological sites to facilitate the evaluation of the results and to delimit those areas that are most suitable for further archaeological investigation along previously documented excavation locations.

Nine locations were identified from the areas suitable for encampment, ranging in size from 0.4 to 1 km². Their correspondence with events associated with the Battle of Mohi and with historically documented battle sites (*P. Szabó 2022, 116*) varied across locations. Field surveys have already been conducted in certain parts of the presumed encampment areas labelled A (*Tab. 3*). Additionally, zone B includes the Kerengő-ér near the settlement of Szakáld, which is recognised as one of the currently accepted battle sites (*Négyesi 2024, 69–70*).

Campsite label	Associated research
Areas of zone A	Only a field survey was conducted
Areas of zone B	<i>P. Szabó 2022, 116; Négyesi 2024, 69–70</i>
Areas of zone C	<i>Wolf 2018, 138–139</i>

Tab. 3. Summary of the campsite locations and the associated research.

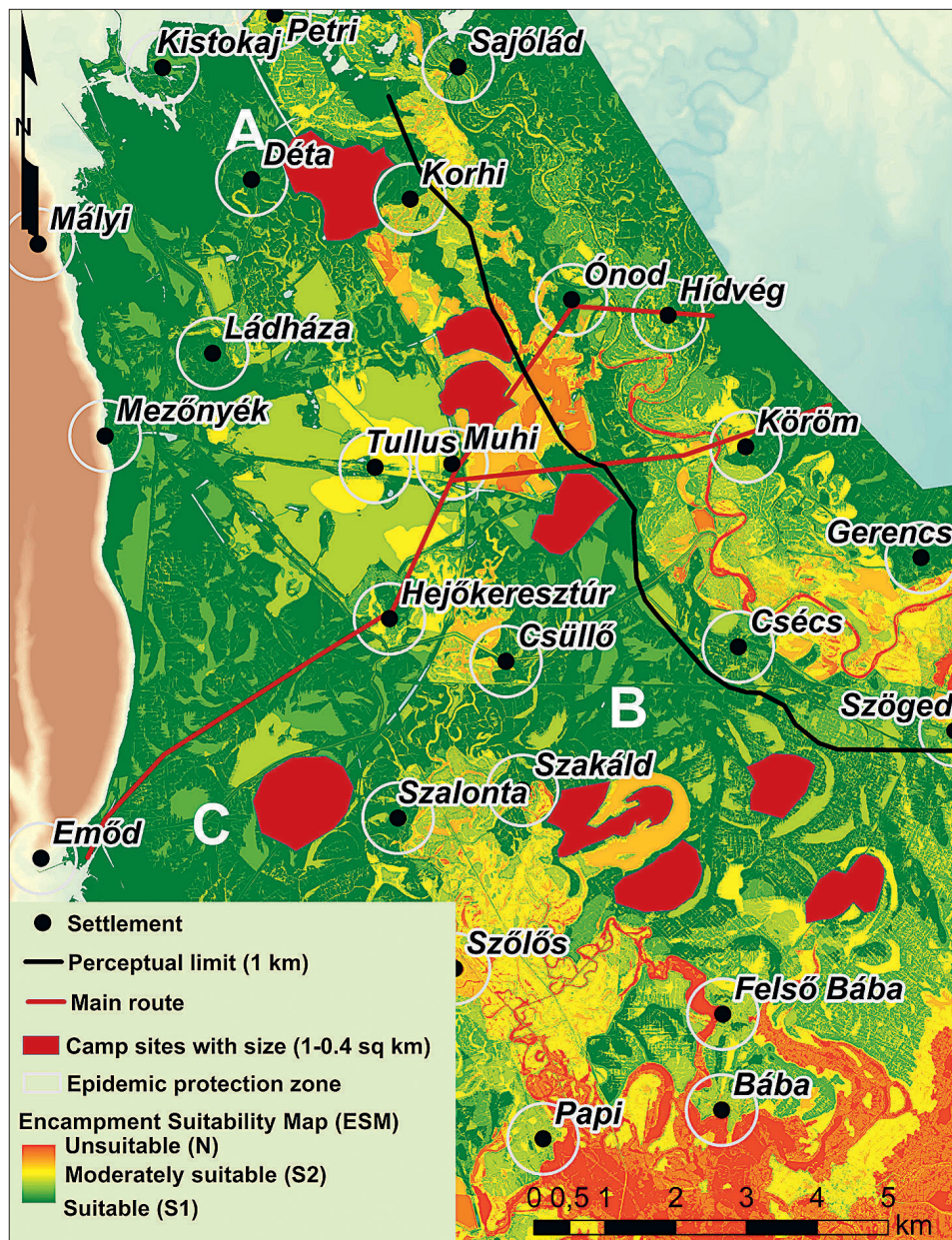


Fig. 3. Resulting Encampment Suitability Map (ESM) for the study area.

A novel aspect of the study is represented by the area designated as C for potential encampment, which was indirectly highlighted through the analysis of the literature. Based on the tactics of the Hungarian army, it cannot be ruled out that the forces did not engage in a frontal confrontation but rather aimed to gain time to consolidate different army units

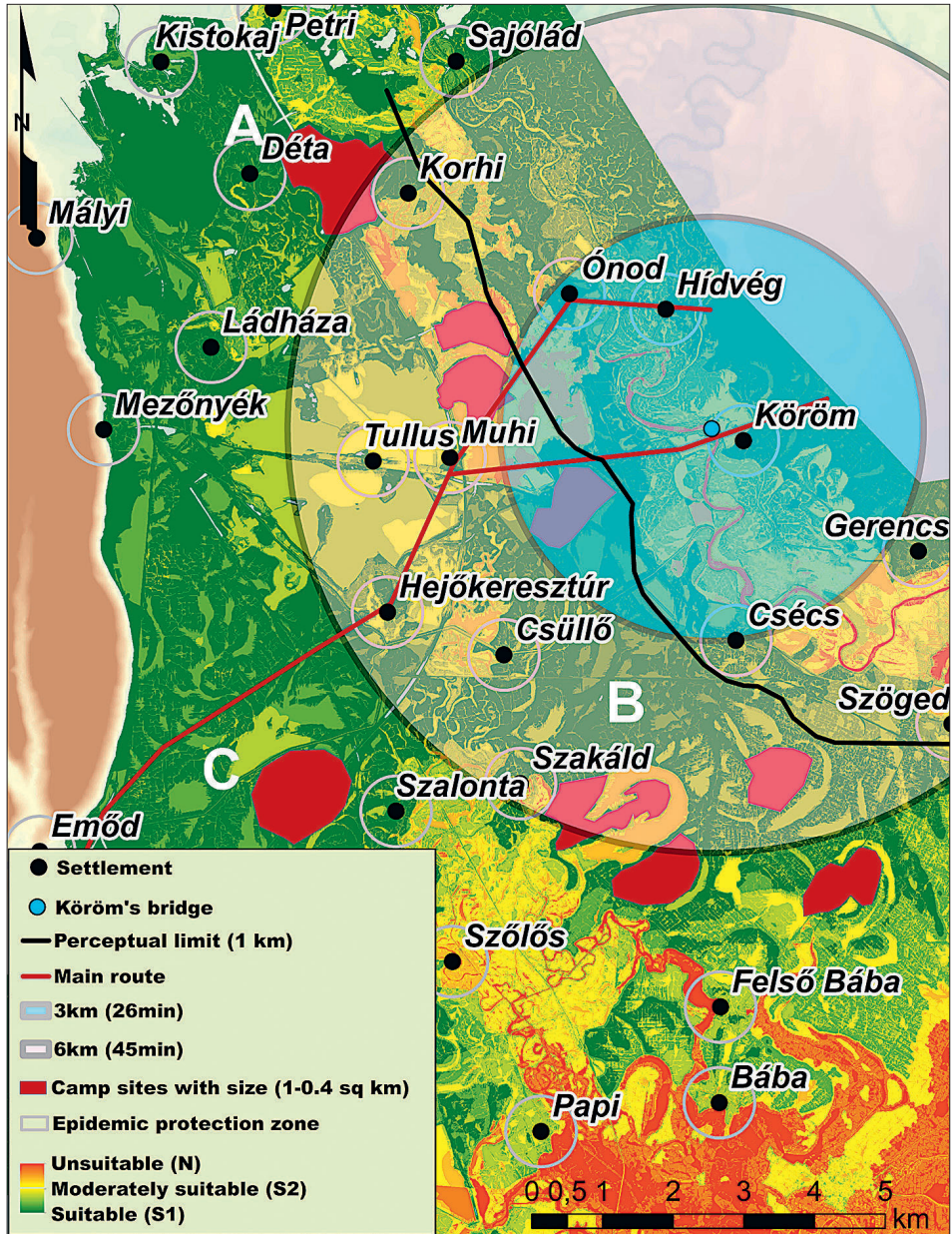


Fig. 4. Encampment Suitability Map (ESM) with travel distances within the study area.

across the country, while also ensuring supply lines (Négyesi 1997, 299). Such tactical considerations may have influenced the selection of the encampment site, suggesting that the choice was a deliberate and carefully considered decision, potentially involving several days of encampment (Veszprémy 1994, 29).

The initial confrontation of the battle took place at the Sajó Bridge, which, according to Rogerius, was located near the Hungarian camp, whereas Thomas of Spalato's account suggests a camp situated further away both spatially and temporally (*Gyórfy 1981*, 111; *P. Szabó 2018*, 119–121). Consequently, average travel times were analysed along the Körömi crossing on the Sajó River. Average travel times were simplified by assuming a medium-quality route to the crossing and considering the movement of heavy cavalry carrying full equipment weighing approximately 50–70 kg. At a gallop, cavalry units could achieve speeds of 8–12 km/h (*Markku 2023*, 15–17). Under worst-case conditions (maximum load and slowest movement), the distance of roughly 3 km from the presumed Körömi zone would be covered in about 26 minutes, whereas 6 km would require approximately 52 minutes on horseback or 1 hour 12 minutes on foot (assuming a walking speed of 5 km/h), reaching the western edge of the Hejő marshlands (*Fig. 4*).

Taking the above-outlined distances into consideration, as well as the fact that no request for reinforcement was made at the bridge, it is worth reassessing the possible location of the encampment during future research. Following the account given by *Négyesi (1997, 296–297)*, the conditions during the night action before the day of the Battle of Mohi may have affected how well the troops could orient themselves in relation to the bridge. However, if the camp had been located nearby, it is unlikely that no attempt would have been made to call for assistance. It is also important to note that, apart from the marshes, the terrain is essentially flat.

Based on these considerations, the possibility cannot be ruled out that the Hungarian camp was situated near a bridge on the right bank of the Hejő. In this case, the Hejő would have afforded natural protection from the east, while the Bükkalja region, situated approximately 1.5 km to the west, would have constituted additional geomorphological protection. Based on this assumption, a roughly 1 km² area lying west of Hejőszalonta and south of Hejőkeresztúr (along the former course of the Hejő, today corresponding to the Hejő–Szarda drainage channel) may be considered an acceptable location, as its environmental and topographical characteristics align with several of the conditions expected for such an encampment. Although a camp located at such a distance was previously proposed in the research tradition, the currently available archaeological material does not substantiate the establishment of a camp in this sector of the Hejő marshland (*Wolf 2018*, 138–139). A certain area of zone C has been analysed as potentially suitable. However, taking into account the route- and time-related considerations discussed above, a review of the characteristics of zones A and B indicates that more fieldwork and detailed analysis are required.

Localisation of the Kakasvár site

A secondary aspect of the research, based on the GIS input data, should also be noted. While not directly related to the localisation of the camp, it contributes to a better understanding of the study area. Analysis of the REM-based raster layer within the GIS database enabled the spatial delineation and identification of a previously undocumented fortified site, thereby further expanding knowledge of the area (*Dobai et al. 2025*, 128–129). The origin and exact function of Kakasvár are not known; the available sources only indirectly suggest that a former watchtower may once have stood at the site, the remains of which can today be identified only in part (*Édes 1858*). Consequently, the analysis of the area is

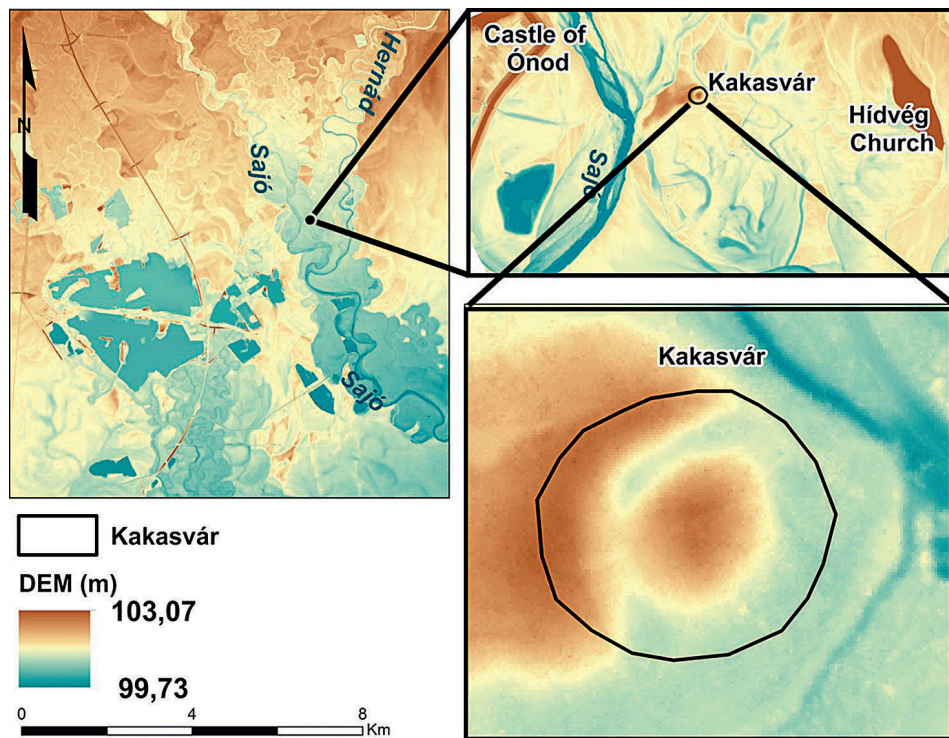


Fig. 5. Location of the Kakasvár site.

justified and may serve as a basis for subsequent archaeological verification. The REM makes it easier to detect topographic features such as elevations, and it can also be used to model changes in water surfaces or territorial stability (Rybczyk *et al.* 1998, 30–34). Based on the analysis of the model, we located an atypical landform on the left bank of the Sajó River, 240 m from the river's centreline, 683 m southeast of Ónod Castle, and 623 m from the remains of the Sajóhídvég church (Fig. 5). The area rises on average two metres above its surroundings, with strong erosion visible in the southern and eastern parts. In terms of its location, it lies in a flow stagnation zone only minimally affected by flooding, where even during extreme high-water events the maximum flow velocity is very weak (0.0–0.5 mm/s). Such low velocities cannot generate channel-forming discharges (Kiss 2018, 45). The area is located on parcel number 0159 in the outer area of Ónod, within the locality known as Kakasvár (Ónod Settlement Development Plan 2014).

Based on the map materials of the First, Second and Third Military Surveys, as well as earlier aerial photographs of the area from fentrol.hu and Google Maps, it was established that the site had been continuously forested. The surface cover of the site is still forest, with dense undergrowth, therefore only the following approximate measurements can be provided until further excavations take place. The site is situated within an area of 2,006 m², consisting of an inner circular area of 496 m², surrounded by a circular ditch and an outer elevated rampart (outer wall). The highest point of the inner area is 102.8 m, while the ditch is generally 5–6 m wide, with its deepest point at 100.7 m. Considering its location within

the flood zone and the sandy texture of surface material, the formation nevertheless cannot be linked to an alluvial feature. This is because it is surrounded from the north toward the south (from the direction of the Sajó River) by a semicircular area of loamy but predominantly sandy material, averaging 2 m in height and 60 m in length. This surrounding formation effectively separates or removes the circular feature from its natural environment as a result of anthropogenic activity. Between the outer and inner sections, on the western side, there is a narrow connection, although this may simply result from the accumulation of eroded material. The site is the remnant of a former alluvial fan, which is bordered in several places on the eastern side by former flow channels (*Dobai et al. 2025*, 135–137).

The areas of Kakasvár and the church at Sajóhídvég can be clearly identified based on the vectorised reconstruction of the 1775 map. These features served as reliable reference points for the further interpretation of the cartographic content, enabling the identification of previously unrecognised elements. The fluvial channels between the Sajó and Hernád rivers become clearly discernible, and the former bed of the Holt–Sajó can also be distinctly delineated. In the northern section of the map, traces of the former outlets of the Bársonyos stream are observable, while the Szabacs area can be identified in the southern sector. These results substantially expand the dataset underlying the analysis and demonstrate a strong spatial correspondence with the reconstructed cartographic framework. The study of Kakasvár and its surroundings is significant because Sajóhídvég lies in the immediate vicinity of the Battle of Mohi; its earliest written mention, in 1261, already records it as Hídvég. If the battle fought along the Sajó on 11 April 1241 truly took place near Muhi, the bridge that gave the settlement its name must have been located at this site (*Bodnár 2021*).

As part of the subsidiary research associated with the main study, the existing knowledge was expanded and organised into an archaeology-oriented GIS database, thereby increasing the potential for quantitative analyses. The analyses and resulting findings corroborate the earlier research by *Pusztai (2014, 141–150)*, which aimed to reconstruct the medieval settlement network. Another outcome of the study is that based on the digitised maps of 1775, *Laszlovsky and Nagy (2023, 953)* refined investigations concerning the former course of the Hernád River and its hydro–morphological characteristics. In addition, the research designates as a new area of archaeological interest the zone situated between the confluence regions of the Hernád and Sajó rivers. Earlier archaeological, geographical, and hydrological literature had interpreted this zone as a floodplain (*Dövényi 2010, 215*) and therefore did not examine it. However, preliminary flood–inundation models challenge this assumption (*Fig. 6*). Second-degree flood levels affect the area only marginally, and even the boundaries associated with third-degree, extreme water levels (*Kiss 2018, 46–47*) do not fully cover it. Flood inundation is primarily determined by local elevation conditions; however, an equally important factor is the extent of additional water supply entering the system from the north. It is also crucial whether the Tisza exerts a backwater effect from the south. During Level I–II flood stages, the Tisza can back up the Sajó as far as the area of Sajóörös. This effect naturally influences the lower Sajó and indirectly causes backwater conditions in the Sajó–Hernád confluence zone as well. Consequently, the occurrence of Level III (Extreme) inundation requires the simultaneous presence of multiple contributing factors (*Kiss 2018, 47; ÉMVIZIG 2014*).

Based on these results, new research directions can be defined, including the investigation of the Szabacs area (*Fig. 6*), a site that has likewise not been examined before. This

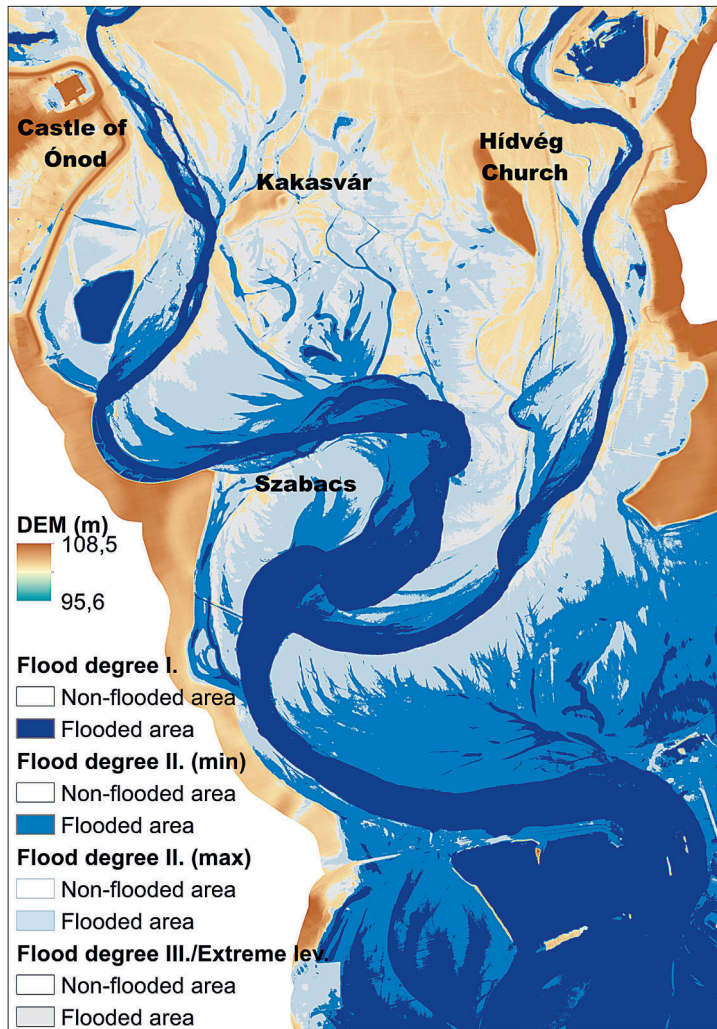


Fig. 6. Degrees of flood inundation (I–III) in the Sajó–Hernád region.

area is marked both on the military surveys and on the digitised map, and it may play a central role not only in the analysis of the landscape but also in the interpretation of the battle itself, as it lies at the core of the investigations along the Sajó. Consequently, it holds considerable research potential.

Conclusion

Although the Battle of Mohi is remembered as a national tragedy in Hungarian history, recent research has enabled a more nuanced understanding of encampment conditions, troop movements, and the psychological dimensions of decision-making. This study developed a GIS-based mapping procedure to identify areas suitable for encampment (ESM)

by considering spatial, temporal, and operational factors. The methodological approach intersects with early medieval battlefield research (*Williams 2015*, 352–353; *Bellón Ruiz et al. 2016*, 90–91; *Hewitt 2016*, 143–144) but focuses on an earlier analytical stage: the *a priori* spatial localisation of encampments using environmental, hydrological, and perceptual criteria. This choice is driven by the relatively sparse archaeological record and limited historical source material available for Mohi. Consequently, the research necessarily lacks well-documented sites in terms of identifiable archaeological locations and assemblages. Even with this limitation, while the presented study aligns with landscape-oriented battlefield research (*Hewitt 2016*, 143–144; *Hodgkins 2016*, 108–110) that emphasises terrain analysis and movement constraints, it offers an important advantage in that it extends these approaches by integrating historical GIS, high-resolution DEM-derived indices (e.g. Topographic Wetness Index, Relative Elevation Model), historical flood dynamics, and military-historical considerations within a formal Analytic Hierarchy Process (AHP) framework. The AHP allows explicit weighting and consistency testing of heterogeneous criteria, an approach that has rarely been applied within medieval battlefield archaeology at this spatial resolution. Comparable methodological frameworks and regional battlefield syntheses (e.g. *Foard – Partida 2018*, 30–34) highlight the value of integrating landscape analysis with artefact-based surveys. The present study complements these approaches by prioritising predictive encampment loci for targeted field survey.

Our Encampment Suitability Model (ESM) therefore extends artefact-based methodologies by providing a predictive spatial framework for non-destructive investigation, as exemplified by the identification of the previously undocumented Kakasvár site. ESM outputs broadly corroborate prior findings while expanding analytical scope through additional spatial, temporal, and operational criteria. One methodological limitation is scale sensitivity: the aggregation and normalisation of weighting factors tended to down-rank smaller, locally favourable patches (e.g. Tullus–plain; *Négyesi 2024*, 68). Sensitivity analysis, multi-scale runs, or local recalibration are recommended to mitigate this effect. Despite this limitation, the GIS database and model outputs can be applied to other research (e.g. diachronic settlement–network studies), and the approach has rendered previously unexamined zones discoverable, thereby enriching the empirical dataset and demonstrating the practical value of GIS in battlefield research.

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RESEARCH ARTICLE – VÝZKUMNÝ ČLÁNEK

Medieval grain from Křivoklát Castle in Central Bohemia: An emergency food store from 1422

Středověké obilí z hradu Křivoklát ve středních Čechách:
Nouzová zásoba potravin z roku 1422

Josef Hložek – Petr Kočár

As a crucial food staple, grain was stored in castles in medieval and Early Modern Bohemia in granaries or in sections of farm buildings designated and adapted for storage purposes. However, during periods of conflict, other spaces intended for different purposes were also occasionally used for storage. During research into the palace complex in the north-western part of Křivoklát Castle in Central Bohemia, a large find of burnt grain and other crops from the 1421 harvest was uncovered. The results of an archaeobotanical analysis provided a completely new perspective on the creation of emergency food supplies during times of conflict within the context of medieval castles, both in terms of the composition of these food supplies and their location on castle grounds.

Middle Ages – castle – Křivoklát – bulk find – cereals – field crops – rye (*Secale cereale*)

Jako klíčová základní potravina bylo obilí ve středověkých a raně novověkých Čechách na hradech skladováno v sýpkách nebo v částech hospodářských budov určených a upravených ke skladovacím účelům. V obdobích konfliktů však byly ke skladování příležitostně využívány i prostory původně určené k jiným účelům. Během výzkumu palácového komplexu v severozápadní části hradu Křivoklát ve středních Čechách byl objeven rozsáhlý soubor zuhelnatělého obilí a dalších plodin pocházejících ze sklizně roku 1421. Výsledky archeobotanické analýzy přinesly zcela nový pohled na vytváření nouzových zásob potravin v době válečných konfliktů v prostředí středověkých hradů, a to jak z hlediska složení těchto zásob, tak z hlediska jejich umístění v rámci hradního areálu.

středověk – hrad – Křivoklát – hromadný nález – obiloviny – polní plodiny – žito (*Secale cereale*)

Introduction

Křivoklát Castle in Central Bohemia is one of the most prominent castles in the Czech Republic, not only due to its architecture and history, but also to a thorough excavation campaign led by Tomáš Durdík (e.g. Durdík 1982; 1996a; 1997; 1999, 299–303; 2001; 2002, 50; 2008). The castle's north-eastern sector features the abandoned palace complex, which is interpreted as the 'vassal house' (Durdík 1988; 1991; 1992; 1995a–g; 2002; 2003; 2010). This site was used as accommodation by the castle's vassals from the ranks of the nobility while fulfilling their obligations at the castle. On 18 March 1422 this vassal house was damaged by an extensive fire, which spread from the horse stables and virtually engulfed the castle. The vassal house suffered the greatest degree of fire damage and collapsed. Unique Pompeian-style archaeological contexts have been preserved on its premises. In addition to an extensive assemblage of artefacts dating from around 1400–1422, archaeological

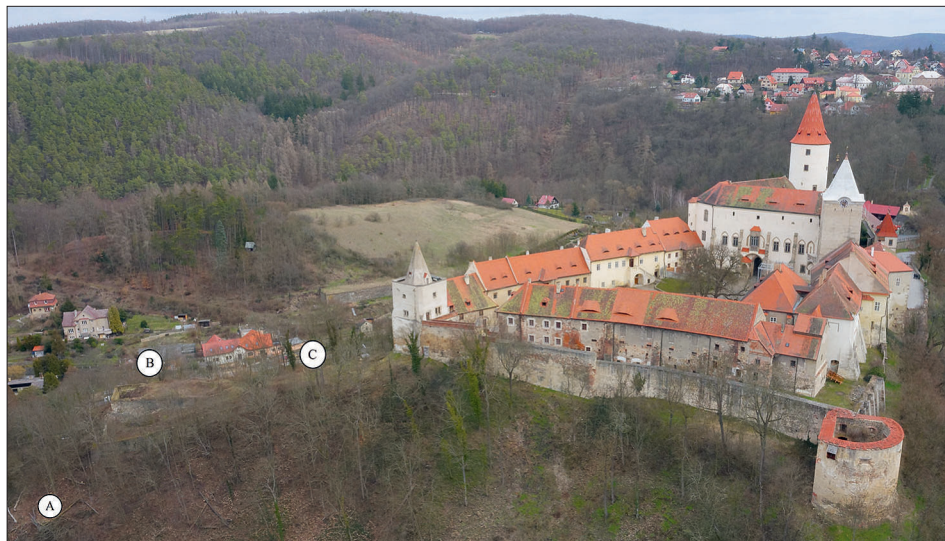


Fig. 1. Křivoklát Castle. Aerial view of the castle site from the south-west. A – outer ditch; B – the palace complex, the ‘vassal house’; C – the narrow communication corridor defined by the walls (photo archive of J. Hložek).

excavations revealed an unusual concentration of 230 kg of charred grain and other field crops, which ranks among the largest assemblages of its kind from the medieval period in Bohemia. A preliminary interpretation associated this grain with a small brewery of the castle serfs presumed to have been part of the ‘vassal house’ (Durdík 1995g). However, this was based only on a macroscopic examination of the grain.

The current text presents a new, detailed archaeobotanical analysis of the grain find that refutes the original interpretation. We consider the stored crops to be an emergency food store from the period of the Hussite Wars. This uniquely well-preserved find allows us to address questions relating primarily to 1) the choice of the storage location on the castle grounds; 2) a reconstruction of the significance that the discovered assemblage of field crops held for the inhabitants of Křivoklát Castle; and, last but not least, 3) the possibilities of reconstructing agricultural practices in the cultivation and harvesting of field crops in the Middle Ages.

Historical context of the events at Křivoklát Castle in 1422

Křivoklát Castle (*Fig. 1*), which had been loyal to the Catholic side since the start of the Hussite Wars, suffered a fire on the afternoon of 18 March 1422 (Benešová – Žižka 1987), destroying the extensive palace complex situated in the north-western part of the castle grounds. This catastrophic fire also affected other parts of the castle, especially the wooden galleries of the castle fortifications and other burnable parts of the buildings. Křivoklát probably remained inhabitable to some extent, but was extremely limited in terms of defensibility. Immediately afterwards, it was therefore abandoned by the Prague burghers, who were hiding there and later found safer refuge within the walls of the Catholic town

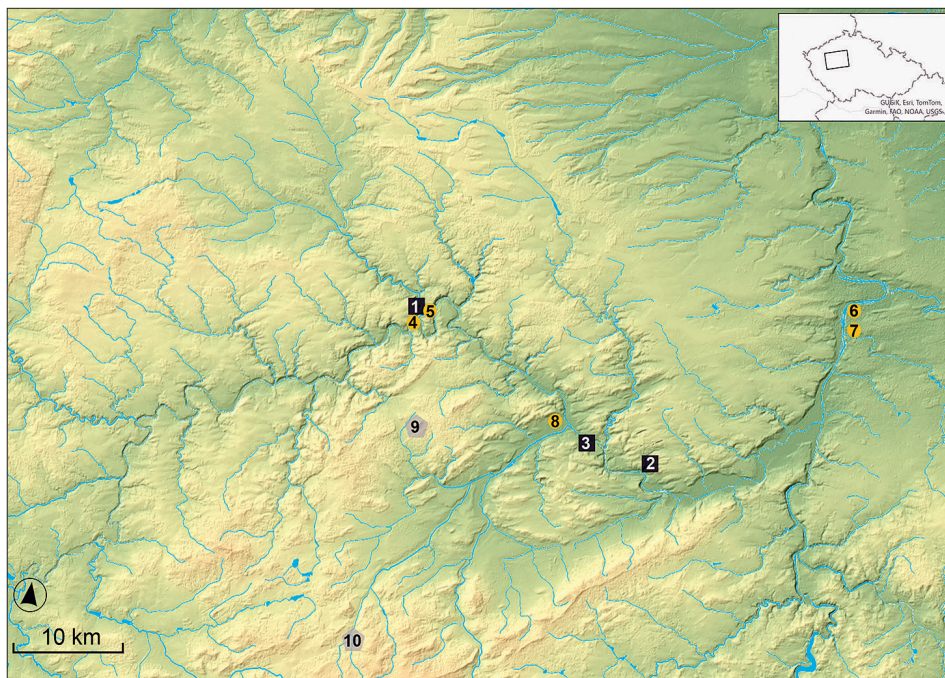


Fig. 2. The situation around Křivoklát Castle at the beginning of the Hussite Wars. Castles: 1 – Křivoklát, 2 – Karlštejn; 3 – Tetín; Settlement agglomeration: 4 – Roztoky u Křivoklátu; 5 – Křivoklát-Městečko; 6 – Prague–Old Town; 7 – Prague–New Town; 8 – Beroun; ecclesiastical sites: 9 – provost's residence at Velíz; 10 – Svatá Dobrotivá Monastery (edited by K. Hanáková).

of Plzeň (*Sedláček* 1891, 22–23; *Durdík* 1988, 295). In April 1422, the damaged castle was captured without much difficulty by Hussite troops led by Absolon Bělbožek of Chříč, who, however, was unable to hold it. In August of the same year, probably without great trouble, the damaged Křivoklát was conquered by Hanuš of Kolovrat, who left only a small garrison there. This circumstance was taken advantage of by Absolon's brother, Žibřid of Chříč. In the months that followed, the castle was seized three more times, once by Hussite forces and twice by the Catholic side (e.g. *Sommer – Razím* 1988, 54).

Military actions at the outset of the Hussite Wars impacted life not only at the Křivoklát Castle itself but also in the wider region. Between May and November 1422, the other important royal castle – Karlštejn – was besieged, and the nearby Tetín Castle probably suffered some damage as well. However, this siege was preceded by a military campaign in November 1421, which was aimed at capturing Karlštejn's supplies stored in buildings under the castle (*Sedláček* 1889, 47, 81). In 1421, the Hussite army conquered the town of Beroun (*Kuča* 1996, 100), while the provostry at Velíz and the monastery of Svatá Dobrotivá in Zaječov were burnt down (*Vlček et al.* 1998, 320–321, 691). As a result, Křivoklát remained a relatively isolated structure at the beginning of 1422, as other key royal towns in the wider area had been held by Hussite unions from 1421 (*Fig. 2*). These events likely led to the creation of extensive grain stores in places that were not primarily designated for storing grain and other foodstuffs.

Material and methods

Archaeological excavation at the palace complex

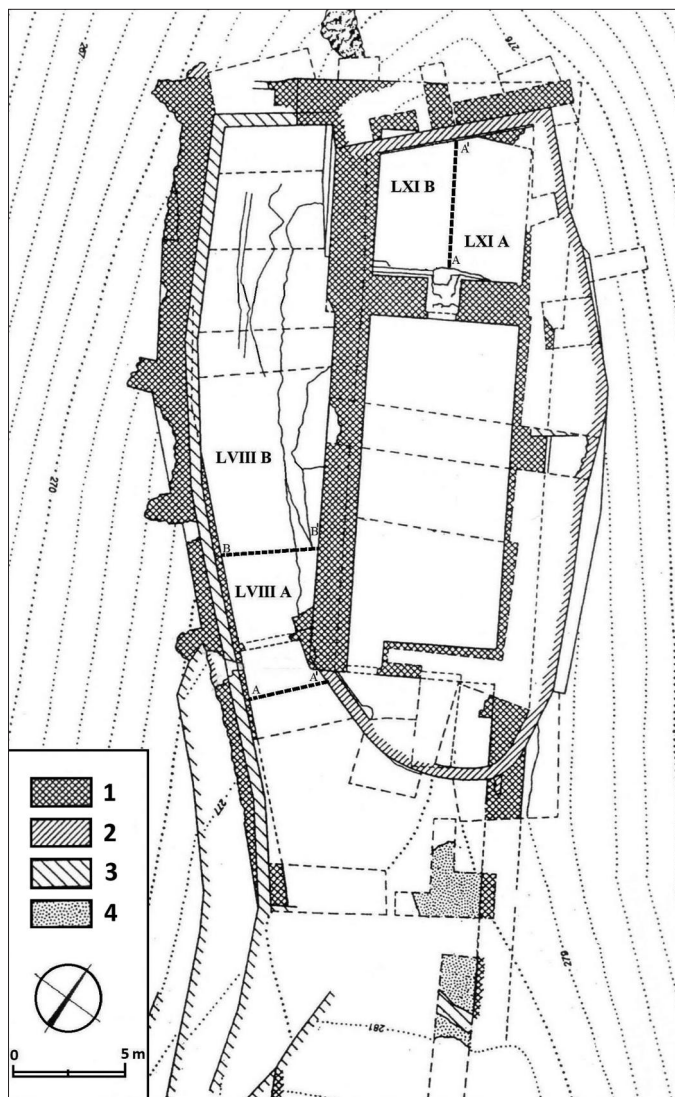
As part of the unusually large-scale excavation of the Křivoklát Castle complex, which commenced in 1973 (e.g. *Durdík 1988*, 285; *1992–1996*; *1996b*; *1996–2001*; *2008*; *Razím 2010*, 101), the area of a late Gothic bulwark in the north-western part of the castle grounds was excavated in 1983–1987 (*Durdík 2008*, 182; *Durdík 1999*, 70–71). Here, the remains of a vanished palace complex were excavated beneath the late Gothic fortification. They consisted of a rectangular palace, a square donjon, and a narrow sloping courtyard secured on both sides by gates (*Durdík 1988*; *Durdík 1999*, 354–355; *1995a–g*; *2002*; *2003*; *2010*). This area, interpreted by T. Durdík as a vassal house (*Figs. 3–6*), was built as part of the extensive reconstruction of the castle by the Wenceslas IV, King of Bohemia in 1378–1419 and Holy Roman Emperor in 1376–1400 (*Durdík 1979–1985*; *Durdík 1996a*, 246; *Durdík 2010*, 292). The house thus reflects an extensive vassal system that was associated with the castle, originating likely in the time of the King John of Luxembourg (reigned 1311–1346) (*Laštovka 1995*, 46; *Šimicová 2004*; *Razím 2010*, 66–68; most recently *Hložek 2018*, 85–86).

The choice of the construction site of the palace complex, which has the dimensions of a small castle, fell on a rocky ridge in the central part of the northward sloping spur of the castle promontory, surrounded on three sides by the Rakovník Stream (*Fig. 1*; *Fig. 5*: A). This part of Křivoklát was separated on the outer side by a wall and ditch with a wooden bridge leading to the first gate (*Fig. 1*: A). The inner courtyard of the vassal house was enclosed by another gate. From the south-east, the palace complex was accessible via a gate and a narrow passage from the first castle courtyard (*Fig. 1*: C; *Figs. 2–6*). After the destruction of the vassal house, Huderka Tower was erected during the Jagiellonian reconstruction on the site of the former gate between the vassal house and the first castle courtyard (*Durdík 2008*; *2010*, 292; *Fig. 6*: B). A lighter, presumably domestic building was attached in the Middle Ages to the north wall delimiting the narrow passageway to the vassal house, and the mortar floor of this domestic building has been preserved (*Fig. 3*; *Fig. 4*). The core of the vassal house complex consisted of a rectangular palace, ending on the north-western side with a square donjon. The ground floor of the palace contained a large storage room with a smaller partitioned space, and a portal connected the palace basement with the lower level of the donjon.

Context of the grain samples

The grain samples that the study focuses on come from three segments of the preserved stratigraphy. The first segment is the interior of a square donjon uncovered in the area of trenches LXI A and B. Here, a concentration of burnt grain was recorded within the black burnt layer 11 below the eastern wall of the donjon (not captured on the profile documentation) and layers 8 and 9 (*Fig. 3*; *Fig. 7*). The greatest concentration of burnt grain was found at the entrance to the donjon basement (*Durdík 1979–1985*; *1985–1987*). According to the documented 1985 profile of the lower parts of the donjon's ground floor oriented in the NW–SE direction, black burnt layer 9 was 4–20 cm thick. It was superimposed on the modified bedrock, which was partially overlain by reddish, locally grey to brown ash layer 8 containing daub, bricks, and tiles. This was overlain by layer 7, up to 180 cm thick,

Fig. 3. Křivoklát Castle. 1 – masonry of the vassal house and fortification (around 1400); 2 – masonry of the late Gothic bulwark; 3 – masonry of the modern park arrangements; 4 – mortar floor of the building in the communication corridor. Thick black dashed lines mark the excavated profiles (drawn image according to *Durdík 1999*, 254, edited by J. Hložek).



consisting of coarse whitish rubble, covered by an equally thick layer consisting of black organic burnt layer 4 with abundant slag and layer 3 consisting of yellowish clay-mortar debris.

The second segment of the stratigraphy with a recorded concentration of grain is trench LVIII A situated in the palace complex courtyard (*Fig. 3; Fig. 8*). The trench uncovered a part of the palace courtyard wall, the area of the upper (south-eastern) gate and a part of the steep passageway embedded in the bedrock, which connected the palace complex with the path under the castle leading through the Rakovník Stream valley. A concentration of charred grain was recorded in layer 5. In the surveyed area, greyish clay layer 6 with sharp-edged gravel representing the original walked-on level of the courtyard was

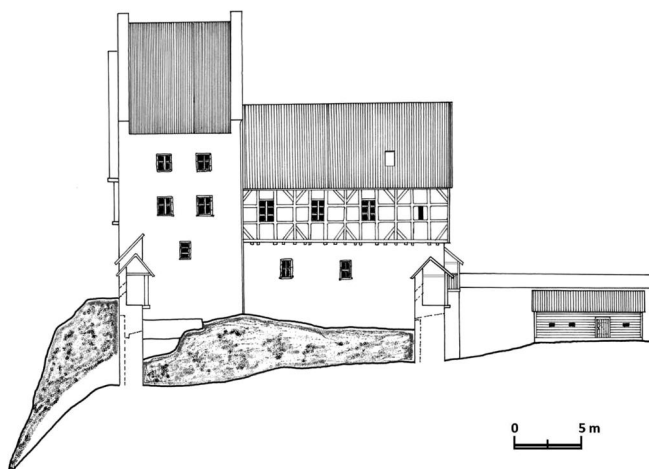


Fig. 4. Křivoklát Castle. Reconstruction of the palace complex of the vassal house (drawing by J. Hložek).



Fig. 5. Křivoklát Castle. 3D reconstruction of the palace complex of the vassal house at the National Museum in Prague (photo by J. Hložek).

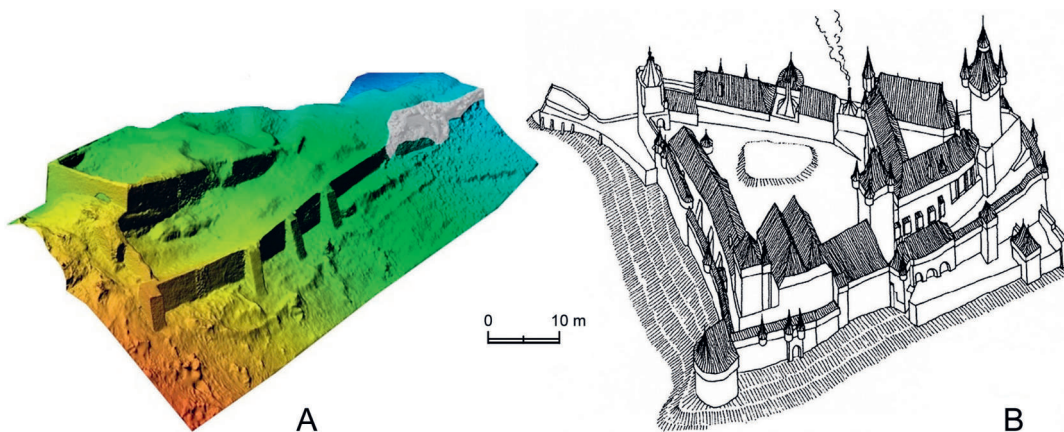


Fig. 6. Křivoklát Castle. A – 3D model visualising the current state of the site where the vassal house stood; B – drawn image of the castle after the Wenceslasian reconstruction with a bulwark built on the site of the abandoned vassal house (3D visualization by P. Hlavenka, drawn image according to Durdík 1999, 303).

superimposed on the sloping, north-west-facing bedrock. This layer was overlain by burnt layer no. 5, which resulted from the fire in the vassal house and filled almost the entire width of the yard area behind and in front of the upper gate. This layer was overlain by yellow mortar layer 4 with stones, on which thin greyish clay layer 8 with sharp-edged gravel was deposited. On top of it was layer 3, consisting of coarse stone rubble.

The third segment is trench LVIII B, which was also situated in the courtyard of the palace complex (Fig. 3; Fig. 9). This trench likewise captured a part of the palace courtyard wall, the course of the passageway leading through the courtyard, and the inner face

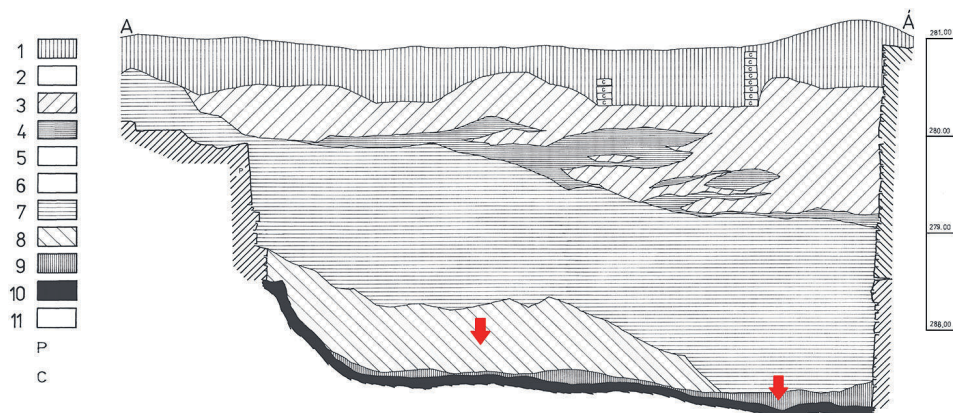


Fig. 7. Křivoklát Castle, trenches LXI A and B (section through the basement of the residential tower of the vassal house). 1 – turf and garden humus; 2 – dark grey loamy infill in a recent pit; 3 – yellow loamy layer with mortar rubble; 4 – black burnt organic layer with abundant slag; 5 – brown loamy layer between 1 and 3 at the south-western corner; 6 – brown loamy layer between 1 and 3 at the eastern profile; 7 – brown whitish rubble layer; 8 – red ashy layer with daub, brick, and tile, locally grey to brown layer; 9 – black burnt layer; 10 – rock; 11 – black burnt layer with grain below the eastern wall (LXI-B). Between layers 1 and 3, brown clay layers 5 and 6 were present in the area of trench LXI B, which were not captured on the profile documentation. Contexts with grain finds depicted in the profile are marked with an arrow (drawing by J. Durdíková based on the original by T. Durdík).

of the south-eastern line of the fortification. In this part of the examined structure, layer 11 consisted predominantly of red burnt daub blocks and was overlain by layer 3, which featured coarse yellow lime rubble. Its upper part contained lentils forming darker loamy rubble represented by layer 9. This was overlain by light-brown loamy layer 10 with pebbles.

Methodology of the archaeobotanical analysis

A total of 230 kg of charred grain and other field crops originating from the area of the ‘vassal house’ at Křivoklát Castle became the subject of archaeobotanical analysis. The concentration of grain and other field crops from Křivoklát Castle ranks among the largest finds of this kind from the medieval period in Bohemia. While the original volume of grain samples collected at the site in the 1980s cannot be reconstructed today, the possibility that it represents all the material collected during the archaeological excavation cannot be ruled out. Thanks to the high concentration and purity of the find, charred plant macroremains (PMR) were extracted directly from the original samples. Twenty-four subsamples were collected in the laboratory from each sample taken in the field and analysed. It was possible to analyse these subsamples without prior preparation (e.g. by floating or sieving). The PMRs were directly selected under a stereomicroscope at a magnification of 7–90×. The archaeobotanical material obtained was determined using a comparative collection of plant diaspores in combination with basic literature on identifying plant macroremains (Bertsch 1941; Beijerinck 1947; Katz *et al.* 1965; Schermann 1967; Berggren 1969; 1981; Anderberg 1994). The botanical nomenclature is provided according to Kubát (2002). The results of the analysis are stated using the abundance of the PMRs of each species; the weight of the analysed components of the samples was not determined.

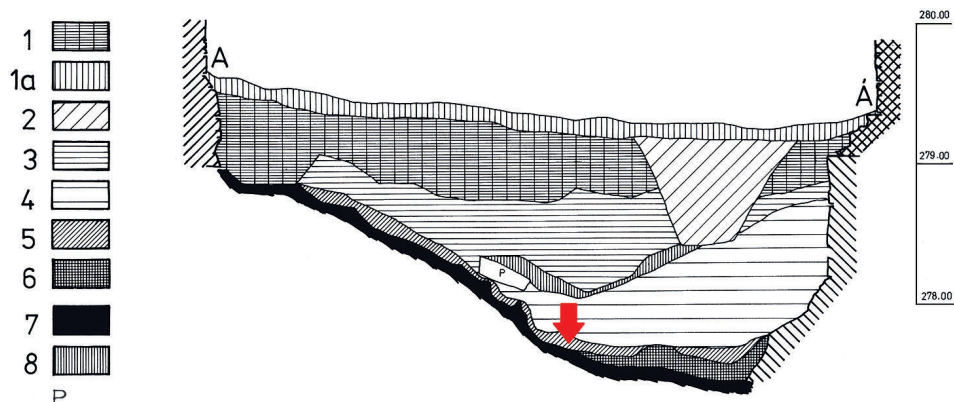


Fig. 8. Křivoklát Castle, trench LVIII A (section through the south-eastern part of the courtyard of the vassal house behind the upper gate). 1 – brown organic layer, 1a-turf; 2 – brown organic layer; 3 – coarse stone rubble; 4 – yellow mortar layer with stones; 5 – burnt layer; 6 – greyish loamy layer with sharp-edged gravel; 7 – rock; 8 – greyish loamy layer with sharp-edged gravel. Contexts with grain finds depicted in the profile are marked with an arrow (drawing by J. Durdíková based on the original by T. Durdík).

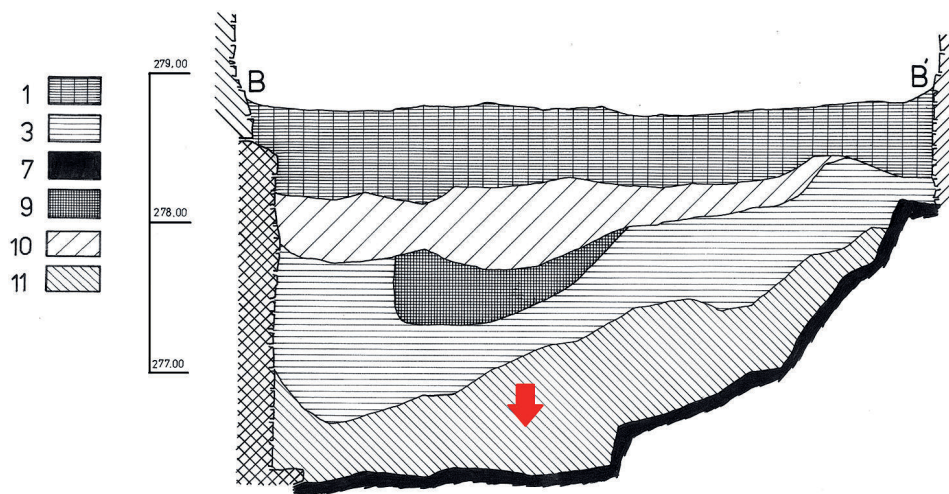


Fig. 9. Křivoklát Castle, trench LVIII B (section through the south-eastern part of the courtyard of the vassal house). 1 – brown organic layer; 3 – coarse yellow limey rubble; 7 – rock; 9 – darker loamy rubble; 10 – light brown loamy layer, loose with pebbles; 11 – red blocks of burnt daub. Contexts with grain finds depicted in the profile are marked with an arrow (drawing by J. Durdíková based on the original by T. Durdík).

Seed cleaning after harvest was reconstructed from the characteristics of weed diaspores contained in the samples (*Jones 1984; Van der Veen 1992*). In particular, the following properties of weed seeds are monitored using the following method:

- relative seed size: B – big seeds, S – small seeds
- tendency to form clumps: F – single seeds (free), H – seeds forming clumps (headed)
- relative weight: L – light seeds (light), H – heavy seeds (heavy)

Traditional grain cleaning was carried out in a relatively simple way in several steps, always eliminating diaspores of weeds with certain characteristics. The first step is the winnowing of the crop, which mainly removes small, single and light weed seeds (SFLs), i.e. wind-dispersed seeds. In the second stage, the pre-cleaned product is stripped via the coarse sieving of all the seeds forming clumps (all ‘headed’ categories of SHH, SHL, BHH) on the basis of size (everything larger than the grains is removed). In the third stage, small heavy non-clumping seeds (SFHs) are removed and can be separated on the basis of size (everything smaller than the grains is removed).

Results

A total of 77,571 PMRs were analysed, among which 45 plant species were identified (Tab. 1; Tab. 2). All the analysed samples were very similar in composition, except for sample 19, 23, and 24. The proportion of the main crop of rye (*Secale cereale*) in most samples was on average 97.7% (22 very similar samples, Fig. 10). The admixture of other crops was minor and averaged only 0.7%. The following field crops were found to be admixed: common wheat (*Triticum aestivum*), emmer wheat (*Triticum dicoccon*), oats (*Avena sp.* and *Avena sativa*), millet (*Panicum miliaceum*), common barley (*Hordeum vulgare* subsp. *distichon*), hemp (*Cannabis sativa*), and peas (*Pisum sativum*, *Pisum/Vicia*).

A higher proportion of wheat grains was found in two samples, sample 19 and 23. In sample 19 from the LVIIIA-5 context, wheat makes up 9.6% of the PMRs. In sample 23 from context LVIII/B-11, wheat was the main crop (98.6%). An admixture of rye (1.3%) and a marginal weed admixture (0.04%) were also recorded. Peas in sample 24 from context LXI/B-8 were the dominant crop and accounted for 80% of the PMRs, mixed with rye 19% and a weedy admixture (less than 1%).

The admixture of other crops in the predominant rye can be understood as a consequence of crop rotation on cultivated land or as a secondary admixture during storage. The admixture indicates the cultivation of rye in a three-field system with alternating winter crops, spring crops and fallows. Although there are several possible crop combinations in this field system, the most likely crop is a winter one consisting of rye and wheat, a spring crop of barley and oats and a fallow partially sown with intensively cultivated crops, i.e. crops requiring hoeing and weeding (millet, peas, hemp).

The weed admixture in the samples was low and averaged 1.6% of the PMRs analysed. Weedy (segetal) communities have a relatively strong link to habitat conditions and periodic disturbances caused by agrotechnical interventions (Deyl 1956; Chytrý *et al.* 2009, 75). This relationship between weed species and habitat/habitat management has been used to indicate habitat conditions and past agricultural practices (e.g. Kaiser *et al.* 2005).

The weeds from the examined samples demonstrate medium habitat conditions without obvious extremes common in the Czech uplands (e.g. medium fertile cambisols). The grain was not grown on fertile loamy land (brown earth, chernozem), nor did it come from the outright infertile soil conditions of the soils of the higher forest areas (e.g. podzol, pseudogley).

The weed admixture seems to indicate a common agricultural technique for rye in the High Middle Ages. However, weed species diversity seems to be relatively high and allows for further agro-technical considerations. Rye was grown as a winter crop, as evidenced

Context			DONJON INTERIOR								PALACE COURTYARD			Total
Sample number			LXI/A-9	LXI/B-11	LXI/B-8	LXI/B-9	LXI	LXI-9	LXI-8	LXI/B-8	LVIII-5	LVIII/A-5	LVIII/B-11	
Agrostemma githago	d		16	58	11	22	16	2	4		8	34	1	172
Agrostemma githago	d	fr	2	8	0	3	0	1	0		1	1		16
Allium sp.	d		1	1	0	0	0		0		2	0		4
Anthemis arvensis	d			1	0	0	0		0		0	0		1
Apera spica-venti	d			5	0	1	6		0		0	0		12
Atriplex patula	d		1	0	0	0	0		0		0	0		1
Avena sp.	d		1	1	1	2	0		0		0	0		5
Avena sativa	d			1	0	0	0		0		0	0		1
Avena sativa	d		1	0	0	0	1		0		0	0		2
Bromus secalinus	d		5	18	11	9	1		1	1	9	21		76
Bromus secalinus	d	fr	1	5	4	0	2		0		1	2		15
Bromus cf. arvensis	d		3	7	0	5	2	1	3		1	1		23
Cannabis sativa	d			0	0	5	0		0		0	0		5
Cannabis sativa	d	fr		0	0	2	0		0		0	0		2
Camelina microcarpa	d			0	0	0	1		0		0	0		1
Centaurea cyanus	d		11	39	10	15	9	2	4		2	5		97
Centaurea cyanus	d	fr	1	6	3	4	1		2		0	0		17
Cerealia	nd	fr		0	0	0	0		0		0	1		1
Cirsium vulgare	d			0	0	0	0	1	0		0	0		1
Consolida regalis	d		3	38	30	6	11	5	0		0	0		93
Convolvulus arvensis	d		1	2	0	0	0		0		0	0		3
Corylus avellana	d	fr		1	0	1	0		0		0	0		2
Echinochloa crus-galli	d		1	0	0	0	0		0		0	0		1
Fallopia convolvulus	d			0	0	0	1		0		0	0		1
Fallopia convolvulus	d	fr		0	0	0	0		0		1	0		1
Galeopsis tetrahit	d		1	2	1	0	0		0		0	0		4
Galium aparine	d		19	48	23	14	17	2	2	2	1	0		128
Galium spurium	d		17	28	12	13	9	3	4	1	5	1		93
Hordeum vulgare distichon	d			1	2	1	0		0		1	1		6
Chenopodium album	d			1	0	0	2		0		0	1		4
Knautia arvensis	d			1	0	0	1		0		0	0		2
Lapsana communis	d		1	23	4	21	10	5	1		0	0		65
Lolium temulentum	d			1	0	0	1		0		0	0		2
Matricaria chamomilla	d			0	0	1	2		0		0	0		3
Malva neglecta/sylvestris	d			0	1	0	0		0		0	0		1
Panicum miliaceum	d			1	0	0	0		0		0	0		1
Pisum sativum	d			0	0	6	0		3	76	0	0		85
Pisum/Vicia	d	fr		0	0	6	0		14	852	0	0		872
Plantago lanceolata	d			0	0	0	0		0		0	1		1
Ranunculus repens	d	fr		1	0	0	0		0		0	0		1
Rumex crispus	d			1	1	1	0	1	0		0	0		4
Rumex obtusifolius	d			0	0	0	1		0		0	0		1
Secale cereale	d		3378	14235	5549	19422	6876	3378	3618	223	7480	6273	56	70283
Secale cereale	d	fr		0	0	0	0		0		0	0	4	4
Securigera varia	d		1	1	0	0	0		0		0	0		2
Sinapis sp.	d			2	1	2	0		1		0	0		6

<i>Sinapis</i> sp.	d	fr		0	0	1	0		0		0	0		1
<i>Stachys arvensis/annua</i>	d		1	2	1	0	0		0		0	0		4
<i>Stellaria graminea</i>	d		1	0	1	0	0		0		0	0		2
<i>Trifolium arvense</i>	d			1	0	0	0		0		0	0		1
<i>Triticum aestivum</i>	d		10	19	15	13	4	5	1		4	297	3528	3896
<i>Triticum aestivum</i>	d	fr		0	0	0	0		0		0	0	980	980
<i>Triticum dicoccon</i>	d			0	0	0	0		0		1	0		1
<i>Valerianella dentata</i>	d		17	34	21	4	7	5	1		2	0		91
<i>Vicia hirsuta</i>	d		14	28	6	26	8	4	7	1	32	36		162
<i>Vicia hirsuta/tetrasperma</i>	d	fr	4	12	14	9	3	4	2		7	22		77
<i>Vicia tetrasperma</i>	d			0	0	0	0		0		0	0	1	1
<i>Viola arvensis</i>	d			1	0	0	0		0		0	0		1
<i>Indeterminata</i>	d		4	4	2	1	3	1	0	1	0	3		19
			3516	14638	5724	19616	6995	3420	3668	1157	7558	6700	4570	77562
Volume (ml)			140	590	230	805	285	140	150	35	310	260	1000	3945
Rodent excrement				4	0	0	0		0		0	0		4
Textile	ch			1	3	0	0		0		0	0		4
Textile	uch			1	0	0	0		0		0	0		1

Tab. 1. Křivoklát Castle, the vassal house. Results of archaeobotanical analysis. d – diaspore; nd – non diaspore; fr – fragment; ch – charred; uch – uncharred.

Sample	Context	Main crop – rye (%)	Main crop – wheat (%)	Main crop – peas (%)	Presence of weeds (%)	Admixture of other crops (%)	Volume of the analyzed sample (ml)
1	LVIII-5	98.8	-	-	1.08	0.13	155
2	LVIII-5	99.2	-	-	0.82	0.03	155
3	LXI/A-9	96.1	-	-	3.58	0.34	140
4	LXI/B-11	97.7	-	-	2.2	0.06	125
5	LXI/B-11	96.2	-	-	3.62	0.19	165
6	LXI/B-11	96.8	-	-	3.01	0.17	140
7	LXI/B-8	98.4	-	-	1.45	0.18	160
8	LXI/B-8	95.2	-	-	4.51	0.32	125
9	LXI/B-9	99.4	-	-	0.43	0.14	115
10	LXI/B-9	98.3	-	-	1.44	0.26	110
11	LXI/B-8	99.1	-	-	0.55	0.31	105
12	LXI	97.9	-	-	1.95	0.16	125
13	LXI	98.6	-	-	1.38	0	160
14	LXI-9	98.8	-	-	1.08	0.15	140
15	LXI/B-9	99.2	-	-	0.69	0.13	125
16	LXI/B-9	98.9	-	-	0.96	0.16	180
17	LXI/B-9	99.3	-	-	0.64	0.11	110
18	LXI/B-9	99.1	-	-	0.87	0.07	165
19	LVIIIA-5	88	9.63	-	2.33	0.04	100
20	LVIIIA-5	97.5	-	-	1.64	0.86	160
21	LXI-8	98.8	-	-	0.75	0.48	60
22	LXI-8	98.5	-	-	0.95	0.5	90
23	LVIII/B-11	1.3	98.6		0.04	0.06	1000
24	LXI/B-8	19	-	80	0.49	0.51	35

Tab. 2. Křivoklát Castle, the vassal house. Overview of main crops and admixtures in the analysed samples.



Fig. 10. Křivoklát Castle. Charred rye grains from the 1421 harvest from a bulk find at the site of the vassal house (photo by J. Hložek).

by the prevalence of winter weeds (*Agrostemma githago*, *Apera spica venti*, *Bromus secalinus*, *Bromus cf. arvensis*, *Camelina microcarpa*, *Centaurea cyanus*, *Consolida regalis*, *Fallopia convolvulus*, *Galeopsis tetrahit*, *Galium aparine*, *Lapsana communis*, *Matricaria chamomilla*, *Sinapis sp.*, *Stachys arvensis/Stachys annua*, *Trifolium arvense*, *Valerianella dentata*, *Vicia hirsute*, and *Viola arvensis*). A smaller proportion of spring weeds was also recorded (*Anthemis arvensis*, *Atriplex patula*, *Avena sp.*, *Echinochloa crus-galli*, *Galium spurium*, *Chenopodium album*, *Lolium temulentum*, and *Malva neglecta/sylvestris*), accompanied by grassland species (*Allium sp.*, *Knautia arvensis*, *Plantago lanceolata*, *Ranunculus repens*, *Rumex crispus*, *Rumex obtusifolius*, *Securigera varia*, and *Stellaria graminea*), and an admixture of perennial weeds (*Cirsium vulgare*, *Convolvulus arvensis*). The presence of spring weeds can be explained as a consequence of the wide ecological amplitude of these ‘ubiquitous’ species.

Nitrophilous species (e.g. *Galium aparine*, *Atriplex patula*, *Chenopodium album*, *Malva neglecta/sylvestris*, *Rumex crispus*, *Rumex obtusifolius*) indicate the use of organic fertilisers, probably manure. In particular, both *Rumex ssp.* are typical weeds whose diaspores pass through the digestive tract of cattle and contaminate manure-fertilised land. Fertilisation in the High Middle Ages usually took place before sowing the main crop (i.e. the winter crop) on the fallow field area. The inclusion of fallow (a short period when a field lies fallow) is indicated mainly by grassland weeds and less specifically by perennial weeds.

Low-growing weed species (e.g. *Anthemis arvensis*, *Galium spurium*, *Matricaria chamomilla*, *Malva neglecta*, *Trifolium arvense*, *Valerianella dentata* and *Viola arvensis*) indicate the harvesting of cereals on low stubble. In the High Middle Ages, the harvesting of field crops with a grain sickle was clearly predominant.

The identified weed species also provide us with information on seed cleaning before sowing. Particularly important are the speirochorous weed species (e.g. the abundant taxa *Agrostemma githago*, *Bromus secalinus*, *Lolium temulentum*). These are highly specialised species of weeds that require the dispersion of diaspores via ‘sowing’ with the culture

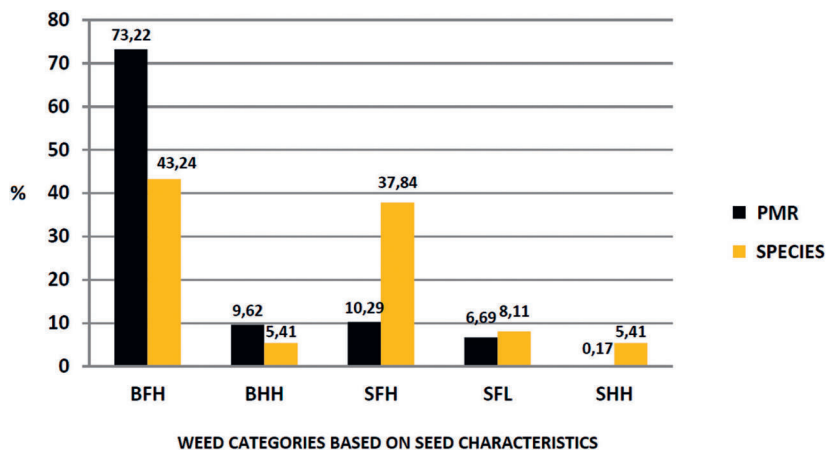


Fig. 11. Křivoklát Castle, the vassal house. Proportions of weeds based on aerodynamic properties of seeds/fruits, determining their distribution during field crop cleaning by winnowing and sieving (Van der Veen 1992). BFH – weeds with large heavy seeds not forming clumps; BHH – weeds with large heavy seeds forming clumps; SFH – weeds with small heavy seeds not forming clumps; SFL – weeds with small light seeds not forming clumps; SHH – weeds with small heavy seeds forming clumps; PMR – plant macroremains.

crop (rye). Speirochorous weeds form only a small grain bank (grain supply) in the soil and spread exclusively by grain (Chytrý *et al.* 2009, 75). The occurrence of these species can therefore be used as a good indicator of a low level of grain cleaning before sowing (the weeds must have reproduced using poorly cleaned grain).

Mainly large and heavy weed seeds that do not form clumps (BFHs) and are difficult to separate from cereal grains (in this case rye) remain in the cleaned cereal stock, when in the traditional methods of cleaning are used. A good illustration of rye cleaning after harvesting is provided by an ethnographic description from Wallachia: ‘*The grain, already rid of larger impurities, was gathered to the edge of the threshing floor, with the farmer scooping up the grain on a wooden shovel and throwing it in a higher arc. The heaviest grain fell furthest; it was also the best grain – the dreck fell closest. The part of the winnowed grain which came into contact with the chaff was winnowed again and then the grain was cleaned up on a sieve, first on a sieve with a coarser mesh and then with a finer one*’ (Štastný 1971).

When we consider this cleaning method for the analysed material (Fig. 11), we find that the grain from Křivoklát Castle was cleaned using a combination of winnowing and double sieving. The small number of wind-dispersed seeds (SFLs) indicates that post-harvest cleaning by winnowing was probably employed. The relatively high diversity of species with small, loose and heavy SFH seeds (38% of the species), but only a very small proportion of their diaspores in the whole assemblage (10% of the PMRs of the weeds) and the small number of clump-forming weed seeds (SHL, SHH, BHL) indicate that the stored grain may also have been sieved through coarse and fine sieves. In addition, the prevalence of weed species with relatively large free and heavy BFH seeds (e.g. *Agrostemma githago*, *Avena sp.*, *Bromus secalinus*, *Bromus cf. arvensis*, *Convolvulus arvensis*, *Fallopia convolvulus*, *Galeopsis tetrahit*, *Galium aparine*, *Knautia arvensis*, *Lolium temulentum*, *Ranunculus repens*, and *Vicia hirsuta*; 43% of the species) and the marked prevalence of

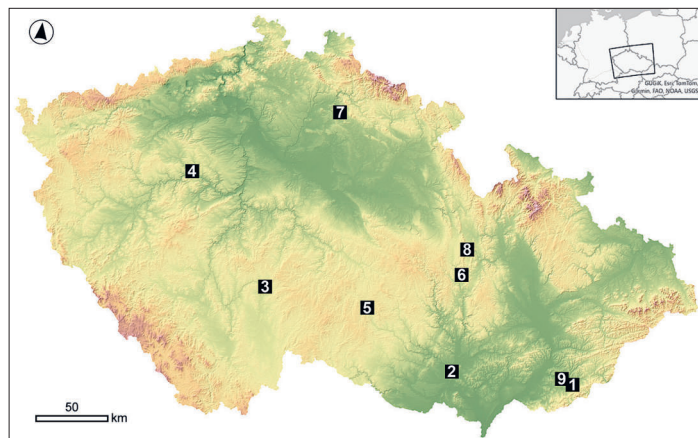


Fig. 12. Castles with cereal finds in the Czech Republic. 1 – Bánov; 2 – Chanovice; 3 – Koválov u Žabčic; 4 – Kozí Hrádek; 5 – Křivoklát; 6 – Rabí; 7 – Rokštejn; 8 – Rumberský Hradisko; 9 – Trosky; 10 – Udánské Hradisko; 11 – Uherský Brod (map by K. Hanáková and J. Hložek).

their diaspores in the whole study population (73% of the weed diaspores) suggest that the stored cereals were a purified cereal stock. The large and heavy seeds of these species, such as those dominated in our dataset by the seeds of *Agrostemma githago*, the grains of *Bromus secalinus*, and the seeds of *Vicia ssp.*, are only partially removed by this simple cleaning procedure. These remaining seeds may have been the source of further problems. Flour milled from grain heavily contaminated with *Agrostemma githago*, *Vicia ssp.*, and *Bromus secalinus* is greyish in colour, bitter, and poisonous even after baking (Jirásek *et al.* 1957). The examined samples from Křivoklát, however, do not have a high share of poisonous admixtures (total contamination 1.7%), and it can be assumed that they did not cause major difficulties after milling.

Discussion

Purpose of the stored crops

To date, the grain supply found in the area of the north-western palace complex of Křivoklát Castle, interpreted by Tomáš Durdík as a vassal house related to the extensive manor system of Křivoklát Castle, has been considered as a stock of malting material, which could hypothetically be related to the existence of a small brewery of the castle vassals (cf. Durdík 1995g). This interpretation, however, was based on a cursory evaluation of the small amount of grain found, which was submitted for analysis to Jelena Majerfková in the 1980s, who evaluated the samples macroscopically and identified them as high-quality wheat with a minor admixture of weeds.

However, the archaeobotanical analysis of the assemblage presented in this study did not reveal any cereal residues that could be interpreted as malt residues. In particular, we lack the remains of germinated grain and a large number of cereal species preferred for malting in the High Middle Ages (common wheat or common barley). Small sample 23 from context LVIII/B-11, with predominance of ungerminated wheat, may have been used for general baking purposes. The rye found is the least suitable of Central European cereals for malting. Cultivated in the territory of the Czech Republic since the Iron Age, rye domi-

	Uherský Brod	Rokštejn	Udánky	Koválov – Žabčice	Bánov	Kozí Hrádek 1	Kozí Hrádek 2	Kozí Hrádek 3	Rumberk	Trosky	macroresidues (%)	frequency (%)
Cereals	macroremains (%)											
<i>Secale cereale</i>	0.34	10.9	8.3	70.3	22.1	91.8	94.04	91.4	94.8	77.8	56.18	100
<i>Triticum aestivum</i>		63.9	10.3	28.6	74.95				2.9		18.06	62.5
<i>Avena sativa</i>	82.5	14.7	13.04	0.03	0.18						11.05	62.5
<i>Hordeum vulgare</i>	2.02	0.99	2.37	0.35	0.003				0.01		0.58	75
<i>Panicum miliaceum</i>			1.58	0.44							0.2	25
<i>Triticum dicoccon</i>			0.4								0.04	12.5
Legumes												
<i>Vicia sativa</i>	6.73		1.19	0.04							0.8	37.5
<i>Lathyrus sativus</i>			6.32	0.01							0.63	25
<i>Lens esculenta</i>				0.15	0.72						0.09	25
<i>Pisum sativum</i>			0.4	0.01	0.02						0.04	37.5
<i>Vicia faba</i>			0.4								0.04	12.5
Presence of weeds (%)	8.42	9.44	62.1	?	2.03	8.16	5.96	8.63	2.3	22.2		
Reference	Tempír 1961	Kühn 1977	Kühn 1980	Kühn – Vrabelová 1983	Tempír 1968	Tempír 1973	Tempír 1973	Tempír 1973	Kočár 2009	Kočár – Kočárová 2013		

Tab. 3. Proportions of field crops in the bulk finds of plant macro-remains from castles in the Czech Republic.

nated as a staple bread cereal from the 12th century to the late modern period (*Kočár – Dreslerová 2010*). Moreover, one sample contained a predominance of pea seeds, a common legume of the High Middle Ages. This finding again indicates a non-malting function of the stored field crops. The analysed PMRs assemblage can thus be interpreted as a sacked stock of bread grain and a smaller stock of legumes stored for general consumption rather than malt production.

Finds of field crops at castles in the Czech Republic

Archaeobotanical finds of field crops in castle contexts of the Czech Republic have been scarce so far (*Tab. 3*). In particular, there is a lack of systematically sampled sites. The samples examined so far are mostly bulk finds of cereal crops obtained haphazardly during excavations of high medieval castles without a clear sampling strategy or the use of flotation; they were noted for their conspicuousness during standard excavation.

Bulk finds of cereals were obtained at the abandoned castle of Kulatý Kopec near the deserted medieval village of Koválov in South Moravia (*Fig. 12: 3; Kühn – Vrabelová 1983*). The analysis confirmed charred stocks of rye and common wheat with an admixture of other cereals. The PMRs come from a large number of contexts of varying dates (from the 13th to 16th century), but were published, unfortunately, in aggregate. A bulk find of wheat with admixtures of other cereals dated to 1468 comes from Rokštejn Castle in the Bohemian-Moravian Highlands (*Fig. 12: 7; Kühn 1977*). A mixture of cereals, mainly

oats, wheat, and rye, was identified in a sample from the Udánské Hradisko Castle in East Bohemia (Fig. 12: 10), with uncertain dating to the period from the 13th to 16th century (Kühn 1980). An unpublished bulk find of rye from the 14th century comes from Rumburk Castle in South Moravia (Fig. 12: 8; Kočár 2009). The assemblage contains a marked predominance of winter weeds. The 15th-century castle of Kozí Hrádek u Tábora in South Bohemia (Fig. 12: 4) yielded, among others, three samples with a predominance of charred rye and a significant proportion of winter weeds, especially corncockle and rye brome (Tempír 1973). The medieval castle in Bánov u Uherského hradiště in South Moravia (Fig. 12: 1), dated to the mid-13th century, yielded a bulk find of charred wheat and rye with a smaller admixture of other cereals and legumes (Tempír 1968). The 14th-century royal castle in Uherský Brod (Fig. 12: 11) yielded a bulk find of oats with an admixture of barley and spring weeds (Tempír 1961). A smaller unpublished set of macro-remains of rye and winter-indicating rye brome from the 14th and 15th centuries is also documented from Trosky Castle in Central Bohemia (Fig. 12: 9; Kočár – Kočárová 2013).

In two cases, actual malt remains were probably found at Czech castles (involving bulk finds of germinated grains). Remains of barley malt from the 15th century come from Rabí Castle in West Bohemia (Fig. 12: 6); they were excavated directly on the premises interpreted as a medieval malthouse and brewery (Foster *et al.* 2013). At Chanovice Castle in West Bohemia (Fig. 12: 2), a bulk find of germinated oats was found in an Early Modern malthouse (Kočár 2014; Kočár *et al.* 2015). A bulk find of field crops with a predominance of barley and a significant presence of wheat, rye, and, in some samples, also peas and buckwheat, was made at Rokštejn Castle, situated in the Bohemian-Moravian Highlands (Fig. 12: 7; Havlicová 2018). The analysis identified a large number of germinated grains, especially barley, in the samples.

Our current understanding of the archaeobotanical material is thus primarily based upon assemblages obtained during earlier archaeological excavations. Nevertheless, it is possible at least to approximate the significance of individual field crops from these data. Leaving aside the two latter bulk finds of germinated cereals, which are very well interpreted given their find context, we can evaluate the remaining finds of unsprouted cereals in the following manner.

Rye is the only cereal crop found at all the studied sites, and it also shows the highest abundance (average 56% of PMRs). The second cereal in order of importance is undoubtedly wheat (63% of the sites and 18% of the PMRs on average), which is particularly important at Moravian sites (Rokštejn, Bánov, Udánské Hradisko, Koválov), while appearing to be less significant at Czech sites (Kozí hrádek, Trosky, and Křivoklát). This corresponds to the data obtained from high medieval towns, where a similar distribution pattern can be observed (Kočár *et al.* 2014, 136). The third cereal in order of importance appears to be oats, detected at 63% of the sites but with a somewhat lower representation in the set of PMRs (on average, only 11%). Barley was detected at a relatively large number of castles (75% of the sites), but only in a small amount (on average, 0.6% of the PMRs). Millet appears to be the least important cereal, with a low frequency at sites (25%) and very low abundance in macro-remains (on average 0.2% of PMRs per site).

A comparison with other castle sites that have undergone archaeobotanical study shows that the charred cereal stock from Křivoklát, despite being a random bulk find, may reflect the contemporary reality in the preferences of individual types of field crops stored at castles in Bohemia. Both rye and peas seem to have played a leading role among the

consumed field crops of castle sites. The consumption of winter rye as the dominant cereal of the High Middle Ages can be traced, especially in Bohemia, from the lowest levels of society to the nobility.

In terms of its original location, the find of grain and other field crops from Křivoklát Castle is unique. In the medieval and Early Modern periods, we encounter granaries (*Varhaník 2018*) or multifunctional farm sites in Bohemian castle contexts that allowed for the storage of grain and other foodstuffs (*Úlovec 2004*, 216–217). Finds of cereals on the premises of castle breweries are by no means exceptional. In the case of Křivoklát Castle, grain and other crops were stored in extremely unsuitable and undoubtedly damp spaces in the basement of the keep, in the residential areas of the vassal palace, and, last but not least, in the narrow corridor above the second gate in the upper part of the vassal house (*Durdík 1995g*, 6). However, in terms of access to the castle via a turn-off from the road running through the valley of the Rakovnick Brook, this was the first accessible part of the castle complex. As it is evident from the historical assessment of the situation at the start of the Hussite Wars, a significant number of the castle's vassals failed to fulfil their obligations to the castle or simply joined Hussite forces. In 1422, some of Křivoklát's vassals directly participated in the siege of the castle to which they were bound by vassalage. With regard to this situation, we can assume that the vassal house did not serve its original purpose at the start of the Hussite Wars, but was a vacant palace complex situated in the lowest-lying part of the castle grounds and directly linked to one of the access routes to the castle. The grain and other crops found in this part of Křivoklát Castle do not, therefore, represent a standard food store. Given the historical circumstances and the location of the deposit, we can assume that this was an emergency store of grain and other field crops from the 1421 harvest, which was held for supply purposes in the most accessible part of the castle grounds.

Grain stores were originally kept in sacks. Samples from the layers LXI/B-8 and LXI/B-11 yielded remnants of coarse textiles, probably sackings, which confirm the storage of grain in these containers. For this reason, the archaeological evidence of rodent infestations of some of the stored grain in the basement of the keep in the form of mouse burrows containing grain is hardly surprising (*Durdík 1995g*, 6–7). The charred excrement of small rodents was detected in samples from context LXI/B-11. The storage of rye in sacks has also been documented at other medieval sites, for example, in the vicinity of the emerging town of Starý Plzeňec in West Bohemia (*Kaiser et al. 2005*). The storage of large quantities of flammable material in the form of grain and other field crops in this part of the castle could then have been the reason why the area of the vassal house was damaged by fire the most severely within the entire castle complex and why the majority of the buildings in the vassal palace complex collapsed during the fire.

Conclusion

Archaeobotanical analysis and the interpretation of the assemblage of cereals and other field crops from Křivoklát Castle damaged by fire on 18 March 1422 provide key insights into the possible nature of emergency reserves of field crops and their somewhat unusual location on the grounds of a large royal castle at the beginning of the Hussite Wars. The results of the archaeobotanical analysis of the largest bulk find of crops from the medieval

castle context in Bohemia provide crucial insights into the quality of food available in High Middle Ages and the preferences for certain types of field crops among the castle milieu, where rye and peas in particular played a dominant role among the consumed food staples. The consumption of winter rye as the dominant cereal can then be traced, particularly in the Bohemian context, from the lowest classes of high medieval society all the way up to the highest social strata. The content of weeds in the samples was very low, averaging just 1.6% of analysed plant macroremains. The weed admixture detected in the examined samples reflects the common agricultural technique of rye cultivation in the High Middle Ages, involving selection and location of the land intended for rye cultivation, probably a three-field fallow system, knowledge of organic fertilisation, low stubble cereal harvesting, practices used for cleaning seeds and harvested grain, and the storage of field crops. The content of other crops in the predominating rye can be interpreted as a consequence of crop rotation in the fields, or as a secondary admixture during storage. As such, the earlier interpretation regarding the storage of malting grain on the grounds of the vassal house of Křivoklát Castle and the existence of a small vassals' castle brewery was not confirmed.

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RESEARCH ARTICLE – VÝZKUMNÝ ČLÁNEK

**Metallography of medieval mining tools
from Bohemian-Moravian Highlands****Metalografie středověkých hornických nástrojů
z Českomoravské vrchoviny**

Filip Vološin – Petr Hrubý – Lenka Klakurková – Pavel Gejdoš

This study focuses on the technological examination of medieval mining chisels from the Bohemian–Moravian Highlands in the Czech Republic. The analysed artefacts originate from three silver-mining areas (Opatov, Čejkov, Utín) dated to the 13th and 14th centuries. Mining chisels belong among the most characteristic tools of underground extraction, yet their metallographic study has so far remained relatively limited. The presented research aims to contribute to a more detailed understanding of their manufacture, material composition and internal construction. Five chisels and a mallet of different sizes were selected to investigate potential technological variability. The selected assemblage includes both slender and robust chisels, allowing a comparison of technological choices in relation to tool size and presumed function. Full-length cross-sections were prepared to assess the composition of the bodies, points and striking heads, and to document forging procedures and applied heat treatment. Findings that individual chisels were adapted to the type of rock and work and that they were used not only for ore extraction but also for other mining activities expand our knowledge of toolmaking and offer new insights into technological approaches of medieval smiths working for mining communities in the Bohemian–Moravian Highlands.

medieval mining – Bohemian-Moravian Highlands – iron chisels – material analysis – metallography – blacksmithing

Tato studie se zaměřuje na technologický výzkum středověkých hornických železek z Českomoravské vrchoviny. Analyzované artefakty pocházejí ze tří stříbrných revírů (Opatov, Čejkov, Utín) datovaných do 13. a 14. století. Přestože hornická želízka patří mezi nejcharakterističtější nástroje pro podzemní těžbu, jejich metalografické studium dosud zůstávalo poměrně omezené. Cílem předloženého výzkumu je přispět k podrobnějšímu pochopení jejich výroby, materiálového složení a vnitřní konstrukce. Pro zkoumání potenciální technologické variability bylo vybráno pět železek různých velikostí a mlátkek. Vybraná kolekce obsahuje štíhlá i robustní želízka, což umožňuje srovnání technologických možností ve vztahu k velikosti nástroje a předpokládané funkci. Pro posouzení složení těl, hrotů a konců železek a pro zdokumentování postupů kování a technik tepelného zpracování byly provedeny řezy v celé délce předmětů. Zjištění, že jednotlivá želízka byla přizpůsobena typu horniny a druhu práce a používala se nejen k těžbě rudy, ale i k dalším hornickým činnostem, zpřesňují naše poznatky o výrobě nástrojů a nabízejí nové pohledy na technologické postupy středověkých kovářů pracujících pro hornické komunity na Českomoravské vrchovině.

středověké hornictví – Českomoravská vrchovina – želízka – analýza materiálů – metalografie – kovářství

Introduction

Chisels with handle holes represent the most frequent mining tools at the excavated medieval mining sites in Europe. Their shape remained basically unchanged during the medieval and Early Modern periods (Mihok *et al.* 1998; Hebenstreit 2000; Hrazdil *et al.* 2007; Luna – Zimola 2007; Méaudre *et al.* 2023). They have a square or rectangular neck, while

handle holes tend to be small (with dimensions often less than 10 mm) and usually rectangular- or square-shaped; in some cases, they do not perforate the tool completely but extend only a few centimetres into the body. Metric and morphology indicate a high degree of standardisation, which is usually interpreted as evidence of specialised production and the increasing organisation of mining work. The fact that these artefacts cannot be dated prior to the 13th century raises the question of previous rock-breaking methods.

Very similar mining tools used to break rock in high and late medieval mines were iron wedges. Their blades are typically axe-shaped, but their overall morphology corresponds to that of handheld chisels. They could likewise have been used in the same manner as chisels (Mihok *et al.* 1998). They probably appeared as early as the 12th century (Straßburger 2017). Scrapers were also commonly used mining tools made from iron, and the earliest of them could be dated to the 12th century (Smolnik 2016; Straßburger 2017). These artefacts were found in mining areas that prospered mainly in the 13th century (Schröder 2018). Finally, picks have also been found at medieval mining sites dated to the 13th century (Richter 1982; Mihok *et al.* 1998). As was the case with handed chisels, there were different sizes of scrapers, which could have been used as chisels, too.

The use and size variations of these tools are captured by iconographic documents, such as the late medieval illuminations of Kutná Hora (Studničková – Purš 2010), Georgius Agricola's book from the mid-16th century (Agricola Georgius, *De Re Metallica*, VI, 150–151: Hoover – Hoover 1912), the *Schwazer Bergbuch* from the same period (Binger *et al.* 2006), and in stone tile in Wirksworth Church in Derbyshire (Hickey 2024).

Weaknesses of past research and definition of issues

Metallographic analyses of chisels are relatively sporadic, not only in the Czech Republic but throughout Europe. While there are some notable studies (Guillot *et al.* 1988; Mihok *et al.* 1998; Haubner – Strobl 2015; Méaudre *et al.* 2023), researchers have usually examined specific sections rather than the entire artefact. These studies have often focused on selected areas, such as the points (Haubner – Strobl 2015) and heads of chisels (Mihok *et al.* 1998), except for work on chisels from the Pampailly region of central-eastern France (Guillot *et al.* 1988) and from Castel-Minier in south-eastern France (Méaudre *et al.* 2023).

With this in mind, we aimed to examine the entire length of the analysed artefacts to gain a comprehensive understanding of the tool's composition. The main goal of this study is to conduct a comparative analysis of the production of chisels from the Bohemian-Moravian Highlands. The observed differences in size and weight raise the question of whether these characteristics influenced the craftsmanship of these tools, which required the use of tough steel and hardening processes to withstand the difficulties of daily use in mining environments.

It is often postulated that the different sizes and weights of chisels were tailored to accommodate different types of rocks or specific mining conditions within the region (Hrazdil *et al.* 2007). This paper aims to test the prevailing narrative about the manufacture of chisels, particularly, the practice of attaching hardened steel points to ferritic bodies by welding techniques. It also aims to identify differences in the production of various types of chisels.

Material

Geology and ore deposits

The Bohemian-Moravian Highlands are an extensive area of hills and low mountains situated in the south-central part of the Czech Republic, creating a border between Bohemia and Moravia. The area roughly coincides with the administrative borders of the Vysočina Region. (Fig. 1: A). The landscape of the Bohemian-Moravian Highlands is composed of crystalline metamorphic or igneous rocks of the Moldanubic with brown soils typical of sloping terrains that developed on the metamorphosed and consolidated sedimentary bed-rock (Cháb *et al.* 2007). Deposits of polymetallic sulphide ores are developed in the central Highlands (Houzar *et al.* 2021).

Typical ores include sphalerite, pyrite, galena, arsenopyrite, and pyrrhotite, while chalcopyrite, stannite, pyrargyrite, cassiterite, and silver sulphosalts are less frequent; tetrahedrite, freibergite, and argentite occur only rarely. The gangue is composed of quartz with chlorite and dolomitic carbonate (Dobeš – Malý 2001). From Havlíčkův Brod ore district, the chisels found in the Utín mining site (Hrubý *et al.* 2021) have been chosen for the analysis (Fig. 1: B-1).

Mineralised structures in the Jihlava ore district are associated with so-called dislocation zones (Fig. 1: B). Ore minerals are represented by sphalerite, galena, less frequently chalcopyrite, arsenopyrite, pyrite and tetrahedrite. Gangue minerals are represented by barite and quartz (Pluska – Vosáhlo 1998).

The ore structures in the Pelhřimov ore subdistrict in the west of the Bohemian-Moravian Highlands are found in the contact of metamorphic rocks (gneiss or paragneiss) and granites (Fig. 1: B). In the quartz ore veins striking NE–SW, pyrite, pyrrhotite, arsenopyrite, sphalerite, galena, tetrahedrite, and chalcopyrite can be mentioned. The uppermost subsurface parts can also contain acanthite (Litochleb 1996). From this ore district, the chisels found in the mining sites of Čejkov (Fig. 1: B-4) and Opatov (Fig. 1: B-2) have been chosen for analysis.

Historical context

Based on archaeological and archaeoenvironmental data, the initial medieval human impact on the Bohemian-Moravian Highlands dates from the 8th to the 11th century AD (Hrubý *et al.* 2014). Intensive colonisation began in the early 12th century and culminated in the 13th century (Kaiser *et al.* 2020; Duffek *et al.* 2023; Hrubý *et al.* 2024). In the mid-13th century, the Kingdom of Bohemia induced under the rule of the Přemyslid dynasty a ‘silver boom’ (Hrubý *et al.* 2012; 2016; 2019; 2021), i.e. the intensive production of non-ferrous metals, especially of lead and silver, triggering unprecedented economic development and wealth in this region. The discovery and use of silver-bearing ores resulted after the mid-13th century in the significant development of mining, urban, and agrarian cultural landscapes in the Bohemian-Moravian Highlands (Hrubý *et al.* 2014; Crkal *et al.* 2019). The most important territorial owner in the 13th century was the king of Bohemia, who possessed the mining town of Jihlava, followed by the bishop of Prague, as well as Premonstratensian Želiv Abbey in the western part of this region.

Spatial and chronological context of the analysed artefacts

The medieval mining site Opatov (*Fig. 1: B-2*) is situated in the western part of the Bohemian-Moravian Highlands, where the land of Premonstratensian Želiv Abbey has been established since the 12th century. The analysed chisels were recovered between 2014 and 2020 as part of an assemblage of exclusively medieval metal artefacts found mostly during metal-detector survey in the vicinity of the mining shafts. A more accurate dating of the site is provided by the timbering of one of the shafts (*Fig. 1: E*), where dendrochronological measurements have shown the tree-felling dates to be 1266/1267 and 1267/1268 AD (*Kyncl 2015*).

The mining site Čejkov is located southwest of Opatov (*Fig. 1: B-3*). This area belonged to the Prague bishopric since the 12th century. Chisels and other various metal artefacts dated to the 13th and 14th centuries were also found here by a metal-detector survey around the shafts and heaps (*Hrazdil et al. 2007; Luna – Zimola 2007*).

The medieval mining area of Utín (*Fig. 1: C*) can be identified as the historical mine of *Mons Fagus* in Latin or *Buchberg* in German sources, first mentioned in 1258. The site is dominated by two linear clusters of shafts and heaps, indicating the NW–SE striking of the ore veins (*Fig. 1: B*). Magnetic prospection, carried out on adjacent fields, detected numerous anomalies, which can be interpreted mostly as pit houses and metallurgical facilities. The three analysed chisels were found during excavations of bloomeries and forges, which were situated immediately at the metallurgical workplace, which is a significant circumstance. According to archaeological findings, this context can be dated to the 13th and 14th centuries (*Hrubý et al. 2021*).

Analysed artefacts and their typology

The metal-detector surveys and rescue excavations between 2014 and 2020 produced a collection of 30 pieces of mining tools (chisels, picks, and wedges). Although this number is not large, it corresponds to the intensity and extent of mining activities in the given period. The finds are deposited in the collections of the Vysočina Museum in Jihlava. Five chisels and a mallet were selected for detailed analysis due to their different blacksmithing characteristics (*Tab. 1*). The set was deliberately divided into three more robust and three more slender specimens to compare the technological aspects of their production.

The basic typological classification is based on the shape of the body of the chisel. In Agricola's sixth book on mining and smelting, it is possible to find a description of four types of mining tools. Three types of chisels are morphologically identical, differentiated only in their lengths and widths; the last type of mining tool is a wedge (*Agricola Georgius, De Re Metallica*, VI, 150–151; *Hoover – Hoover 1912*). Even though the length of the depicted tools does not correspond to archaeological evidence, the width and thickness appear to be comparable (*Večeřa 2018*, 18, 30–31).

The first and numerically dominant type is characterised by maximum width in the area of the opening for the handle and a smooth tapering towards the tail and point (*Fig. 2: C-0032, O-0033; U502-1; Luna – Zimola 2007*, 307, type A). This type can be associated with Agricola's description of chisels. The second and rarer type has a triangular shape. Its widest dimension is in the tail area and it tapers evenly towards the point (*Luna – Zimola 2007*, 307, type B). This variant is represented by two artefacts in the analysed set (*Fig. 2: U-0107, U502-2*).

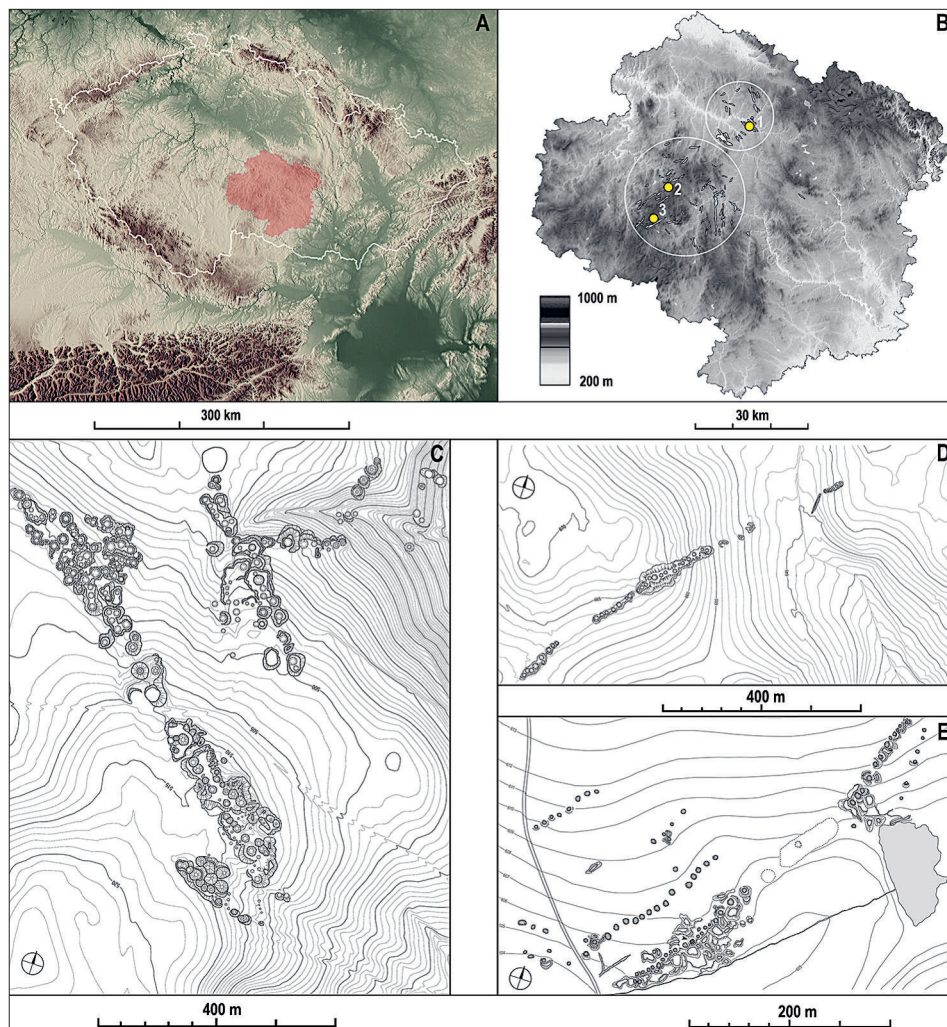


Fig. 1. A: The Vysočina Region in the Czech Republic. B: The Vysočina Region, showing the locations of the medieval chisels. 1 – Utín (historically known as Buchberg); 2 – Opatov; 3 – Čejkov. C: The Utín mining area (historically known as Buchberg). D: The Čejkov mining complex. E: The Opatov mining complex.

In the archaeological literature, chronological differentiation based on the size and weight of the tool is sometimes considered. Smaller specimens are hypothetically classified as belonging to the earlier period of the 13th–14th century, while larger and heavier pieces are usually considered to be products of the later stages of the 16th–18th century (Hrazdil *et. al.* 2007, 294–296, 302). However, it should be emphasised that this classification is rather artificial, as the variability in size and shape could reflect different work tasks, the individual preferences of miners, or different mining techniques (Hrazdil *et. al.* 2007, 302). A good example demonstrating the limits of such categorisation is the set of

Number	Site	Chronology	Point			Body			Head			Heat treated
			Microstructure	Hardness (HV) 30g load	Figure	Microstructure	Hardness (HV) 30g load	Figure	Microstructure	Hardness (HV) 30g load	Figure	
O-0005	Opatov	13–14th century	ferritic	100	3: a	ferritic	100		ferritic	130	3: b	no
O-0033	Opatov	13–14th century	martensitic-pearlitic	460	3: e	ferritic/ferritic-pearlitic	110–130	3: c–d	ferritic/ferritic-pearlitic	235	3: f	yes (hardening)
C-0032	Čejkov	13–14th century	martensitic-pearlitic	505	4: c	ferritic/ferritic-pearlitic	96–130	4: a–b	spheroidised-pearlitic/pearlitic	310	4: d	yes (hardening)
U-0107	Utín	13–14th century	martensitic	460	4: f	ferritic	100	4: e	pearlitic/cainitic	220–250	4: g–h	yes (hardening)
U-0502-1	Utín	13–14th century	pearlitic-ferritic	110–180	5: b	ferritic-pearlitic	110–180	5: a–d	ferritic-pearlitic	110–180		yes (tempering)
U-0502-2	Utín	13–14th century	martensitic-pearlitic	480	5: f	ferritic/pearlitic (Widmanstätten)	130–215	5: e–g	ferritic-cementitic	220	5: h	yes (hardening)

Tab. 1. A summary of the chisels, metallographic results and Vickers hardness test.

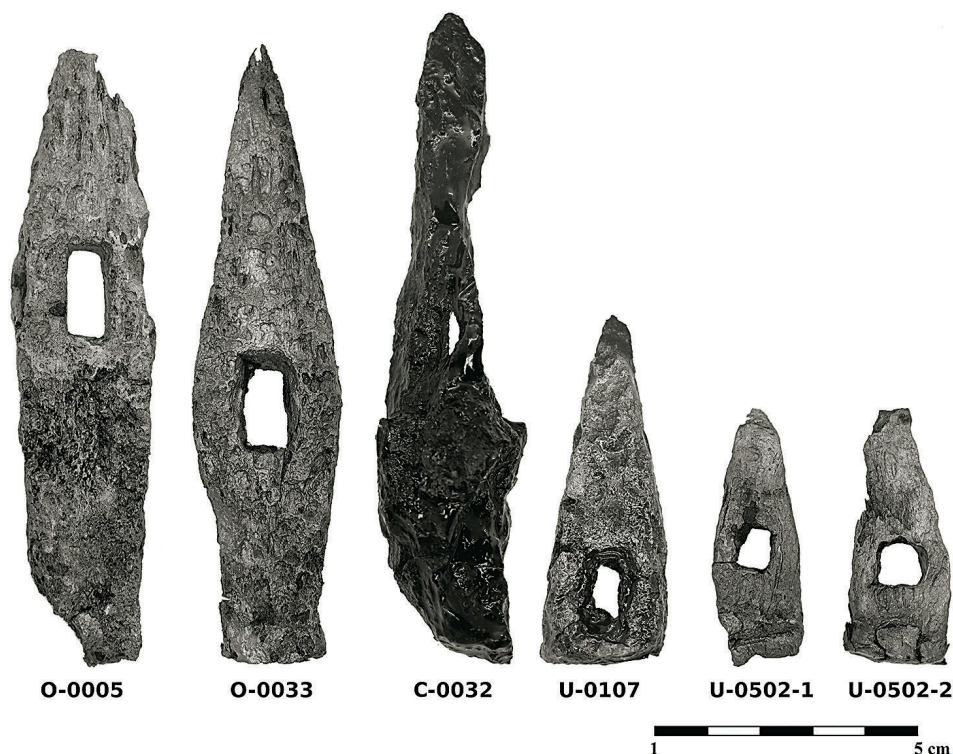


Fig. 2. Chisels and mallet used for metallographic analysis (photo by Filip Vološin).

irons from Banská Štiavnica (*Labuda 1997*, 131, tab. III), which is dated to the 13th century. Based solely on size, the set would fall into the younger group of the 16th and 18th centuries (*Luna – Zimola 2007*, 307). Similarly, different blacksmithing practices in the shaping and final finishing of the tool must also be considered as contributing factors (*Večeřa 2018*, 30–31).

The analysed collection also includes a mallet that was used to strike the tail end of the chisel during work (*Fig. 2*: O-0005). The selection of analysed finds thus forms a representative sample capable of contributing to a better understanding of the technological, functional, and user aspects of these mining tools.

Methods of metallographic analysis

As many of the objects were affected by corrosion, measures were taken to ensure the preservation of the artefacts by storing them in a non-corroded state prior to analysis to prevent deterioration of the samples during the polishing process. The selected tools contained sufficient metal content to allow for comprehensive analysis and were subsequently sectioned along their length. Following this initial preparation, the samples were embedded in epoxy, polished to a mirror-smooth surface of 1 µm and etched with 2% nital. To reduce the risk of the rapid corrosion of the samples, an ethanol-based suspension was

used during the polishing process to minimise surface degradation. The Vickers hardness test (QATM Qness 60 A+ EVO) was performed on reagents with known structures to evaluate the hardness of the declared structures. Chemical analysis using OES and SEM-EDS was performed on all artefacts, but did not yield any meaningful results.

Results

Mallet O-0005 is the tool discovered at the Opatov site. It stands out from the analysed samples as a remarkably heavy specimen. Initially, in accordance with common toolmaking practices of the period, the presence of hardened steel components was expected. However, this tool does not conform to that concept. Severe corrosion degraded the material integrity (*Fig. 3: g; Fig. 6: O-0005*) to such an extent that detailed metallographic analysis seemed to be almost impossible, as extensive voids (*Fig. 3: a, g*), islands of corrosion products, and slag inclusions hindered the polishing process. Subsequent etching revealed a pervasive ferritic iron structure (*Fig. 3: a*) extending along the entire length of the mallet, with corrosion primarily affecting the boundaries of the ferritic grains. A distinct area with a pearlitic structure was revealed on the left side of the chisel (*Fig. 3: b*), which, in this case, is associated with the heterogeneity typical of materials produced through the bloomery iron-smelting process, rather than with intentional improvement. Overall, the results suggest that the mallet was probably used in surface ore processing and was involved in post-mining activities such as crushing ore and slag, rather than playing a role in subsurface rock extraction. These results are further supported by hardness measurements, which show very low values of 100 HV at the working edges, and approximately 130 HV at the head (*Tab. 1*). These values correspond well to the predominantly ferritic microstructure and indicate the absence of intentional hardening of working edges.

Chisel O-0033 was discovered in 2019 through careful metal-detector prospection at the Opatov site. In the non-etched state, conspicuous linear inclusions consisting mainly of slag were documented along the entire length of the chisel, accompanied to varying degrees by corrosion products. Subsequent etching revealed a predominantly ferritic microstructure (*Fig. 3: c*) in the body of the artefact, which was clearly visible on the left-hand side. The right side showed a distinct ferritic-pearlitic microstructure (*Fig. 3: d*). The chisel point has a martensitic structure with pearlite along the boundaries of the martensitic grains (see *Fig. 3: e*). No weld line is visible between chisel point and body. This area is defined by a gradual transition from martensitic structure to predominantly ferritic body. The striking head of the chisel has a pearlitic and ferritic-pearlitic structure with flattened grains (*Fig. 3: f*) that indicate cold-working. This suggests that the chisel was struck by a hammer during use, which explains the wear associated with its prolonged use. Hardness measurement corresponds well to these observations, showing significantly higher values at the working edges of approximately 460 HV (*Tab. 1*). It confirms the presence of martensite and indicates hardening of the tool point. In contrast, the body of the chisel shows lower hardness values of approximately 110–130 HV, consistent with the ferritic and ferritic-pearlitic microstructure. The head shows values of 235 HV, which correspond to a pearlitic cold-worked structure.

Chisel C-0032 was discovered at the Čejkov mining and ore processing site. Before the etching, conspicuous linear inclusions consisting mainly of slag were observed along

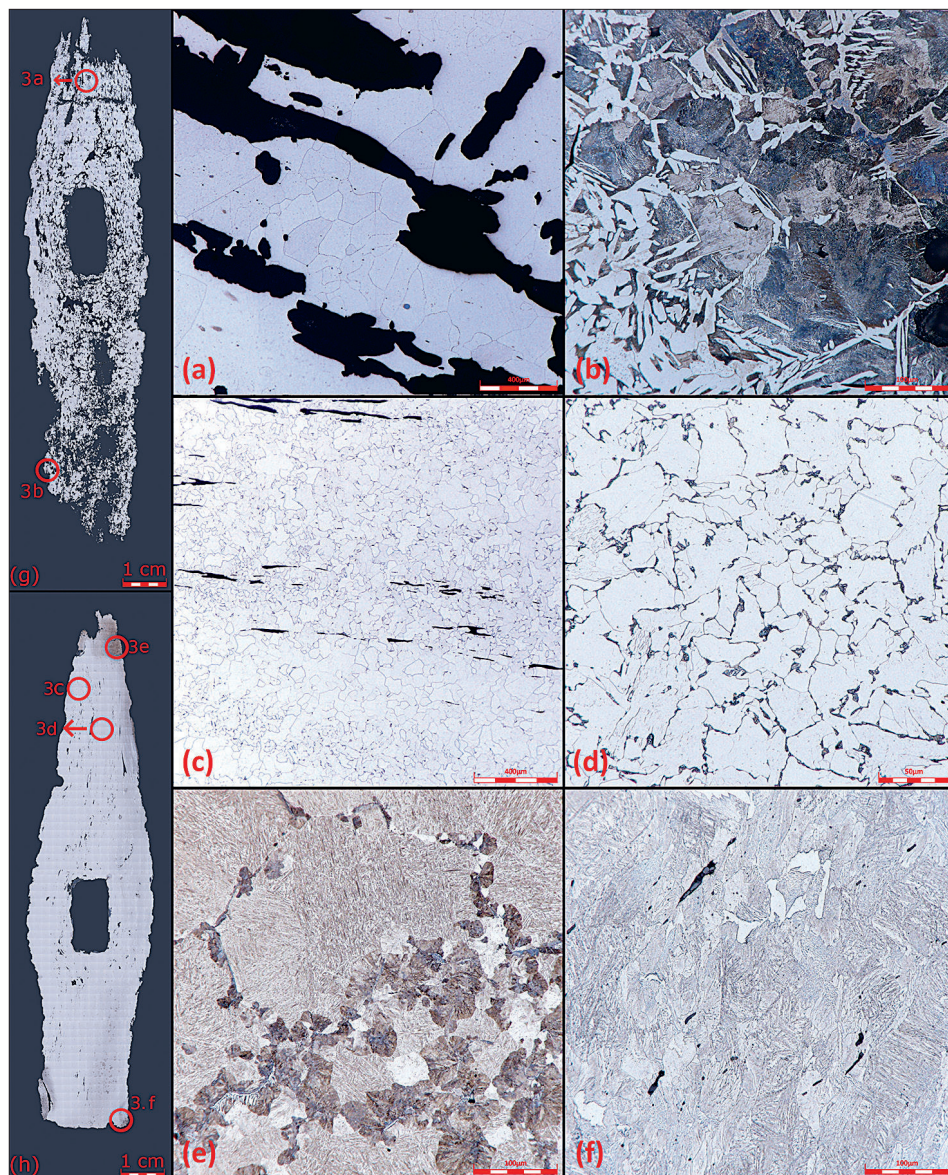


Fig. 3. Metallographic sections of mallet O-0005 (g) and mining chisel O-0033 (h). Etched surface of mallet O-0005: a – ferritic structure; b – pearlitic structure. Etched surface of chisel O-0033: c – ferritic structure; d – ferritic-pearlitic structure; e – martensitic structure with pearlite formations along the edges of the martensitic grains; f – flattened pearlitic and ferritic-pearlitic structure.

its entire length, along with varying amounts of corrosion products. The preserved body of the chisel is characterised by ferritic (Fig. 4: a) and ferritic-pearlitic (Fig. 4: b) structures. These are separated by a slag line, indicating that two bars were welded together (Fig. 6: C-0032). The point shows martensitic grains with some pearlite at their boundaries

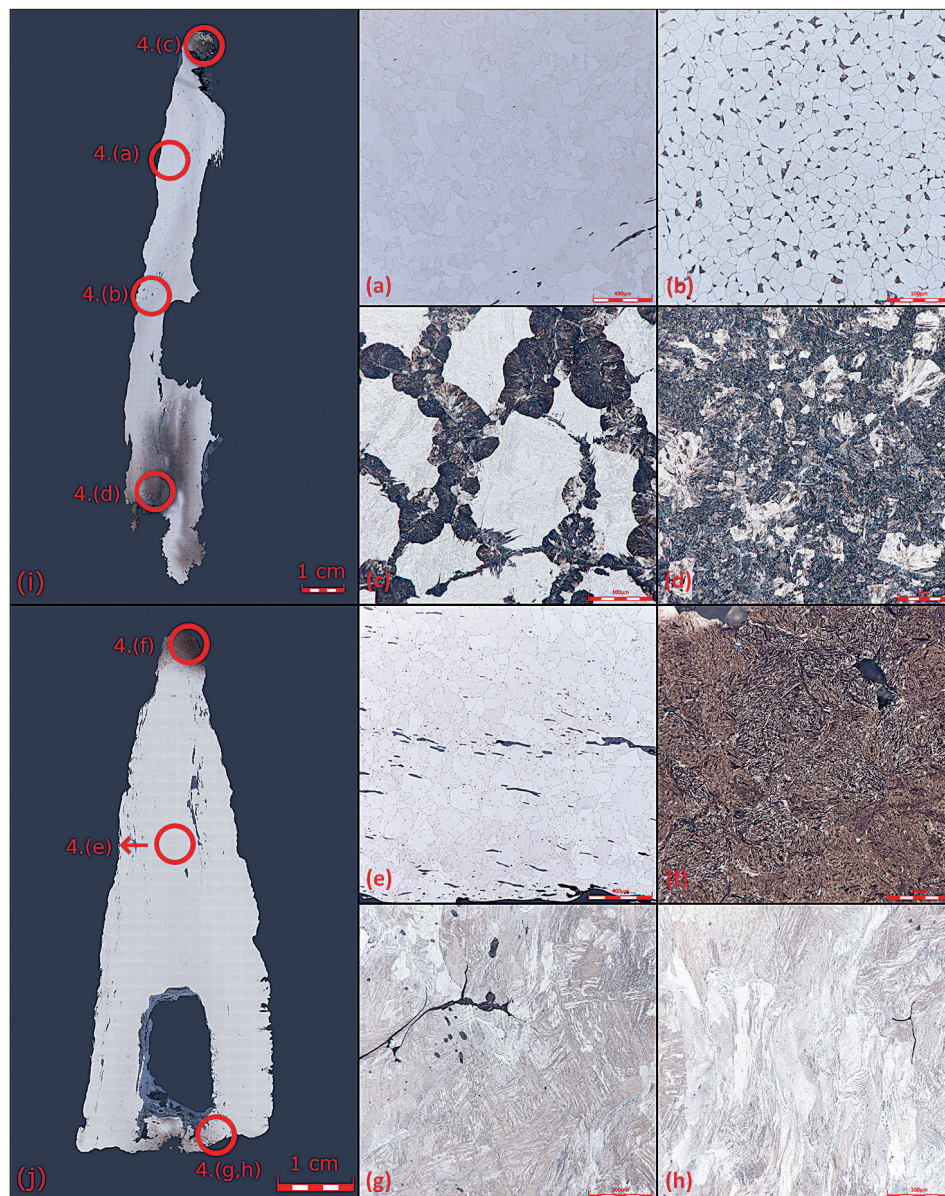


Fig. 4. Metallographic sections of mining chisels C-0032 (i) and U-0107 (j). Etched surface of chisel C-0032: a – ferritic structure; b – ferritic pearlitic structure; c – martensitic structure with radial pearlite grains bordering the edges of the martensitic grains; d – spheroidised-pearlitic structure. Etched surface of chisel U-0107: e – ferritic structure; f – martensite structure; g – pearlitic or bainitic structure; h – area has flattened grain of pearlite and ferrite.

(Fig. 4: c). There is no clear weld line between the point and body; a gradual transition from a martensitic to a ferritic structure is visible. The area between the handle hole and the striking head of the chisel shows a partially spheroidised pearlite (Fig. 4: d), which appears to have formed unintentionally during the manufacturing process. This is the longest examined chisel with a hardened point that was intended for ore mining. The hardness measurement corresponded well to these observations, showing approximately 505 HV in the point area (Tab. 1). While the body of the chisel shows significantly lower values of about 96–130 HV, which correspond to the ferritic and ferritic-pearlitic microstructure, the hardness of the area between the handle hole and the head measured around 310 HV, which corresponds with the microstructure of spheroidised pearlite.

Chisel U-0107 is from the Utín mining site (Fig. 1: C). In a non-etched state, substantial linear inclusions were documented running down the entire length of the artefact, consisting mainly of slag, along with a smaller amount of corrosion products. These chains of inclusions indicate that three bars were welded together. Nital etching revealed a predominantly ferritic structure (Fig. 4: e) in the body of the chisel. The point consists of an acicular martensite (Fig. 4: f). No clear welded line is visible, just a gradual transition between the martensitic structure of the point and the ferritic body. A pronounced structure dominated by pearlite and/or bainite is visible between the handle hole and the head (Fig. 4: g), where a cold-worked structure with flattened pearlitic (bainitic?) and ferritic grains is also present (Fig. 4: h). Using this material for the head would be advantageous, as it can better withstand repeated hammer blows. The hardness measurement reflects a martensitic structure at the point of the chisel, with a recorded hardness of 460 HV (Tab. 1). The body shows lower values around 100 HV, corresponding to the ferritic structure. The head of the chisel shows intermediate values of around 210–250 HV, which correspond well with the pearlitic or bainitic structures and with cold deformation caused by repeated hammer blows.

Chisel U-0502-1 was at the Utín mining site (Fig. 1: C). Prior to etching, extensive linear inclusions were observed along the entire length of the chisel, primarily consisting of slag and, to a lesser extent, of corrosion products, clearly delineating the welded bars (Fig. 5: i, Fig. 6: U-0502-1). The side bars exhibit a predominantly ferritic structure (Fig. 5: a), while the central bar features a lamellar pearlitic structure with some proeutectoid acicular ferrite that transitions via a fully developed Widmanstätten ferrite to a ferritic structure (Fig. 5: b) along its length. This transformation was caused by decarburisation, likely resulting from prolonged exposure to high temperatures (above 600°C) in an oxidising atmosphere prior to the bar's use. Towards the side edges, the structure changes to a ferritic-pearlitic composition (Fig. 5: c, d). This chisel was made from several bars with various carbon contents. Bars with a pearlitic structure were probably selected intentionally for their suitable toughness, while the remaining bars were used without specific selection criteria and may have been sourced from scrap metal. Hardness measurements show relatively uniform values across the whole chisel, ranging from 110 HV to 180 HV (Tab. 1), which correspond to the observed structure and indicate that working parts were not hardened.

Chisel U-0502-2 comes from the same site and context as previously discussed chisel U-0502-1. In the non-etched state, significant linear inclusions were observed along the entire length of the chisel, consisting mainly of corrosion products and, to a lesser extent, of slag (Fig. 5: e, h; Fig. 6: U-0502-2). The body of the chisel consists of a ferritic structure

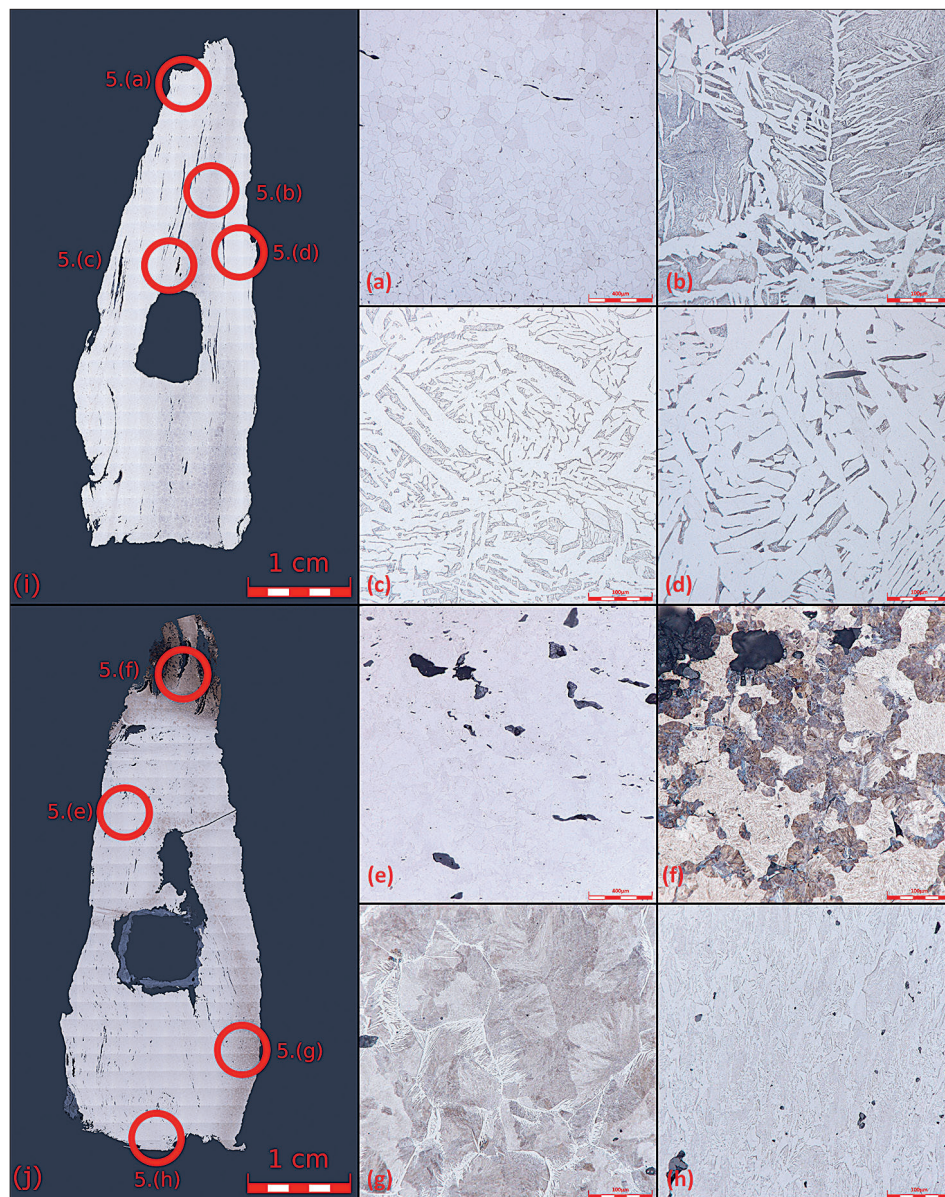


Fig. 5. Metallographic sections of mining chisels U-0502-1 (i) and U-0502-2 (j). Etched surface of chisel U-0502-1: a – ferritic structure; b – pearlitic-ferritic structure transitioning to Widmanstätten ferrite; c–d – ferritic-pearlitic structure. Etched surface of chisel U-0502-2: e – ferritic structure; f – pearlitic grain on the edges of martensitic grains; g – Widmanstätten ferrite features present at the edges of the pearlitic grain; h – flattened ferritic and ferritic-cementitic structure.

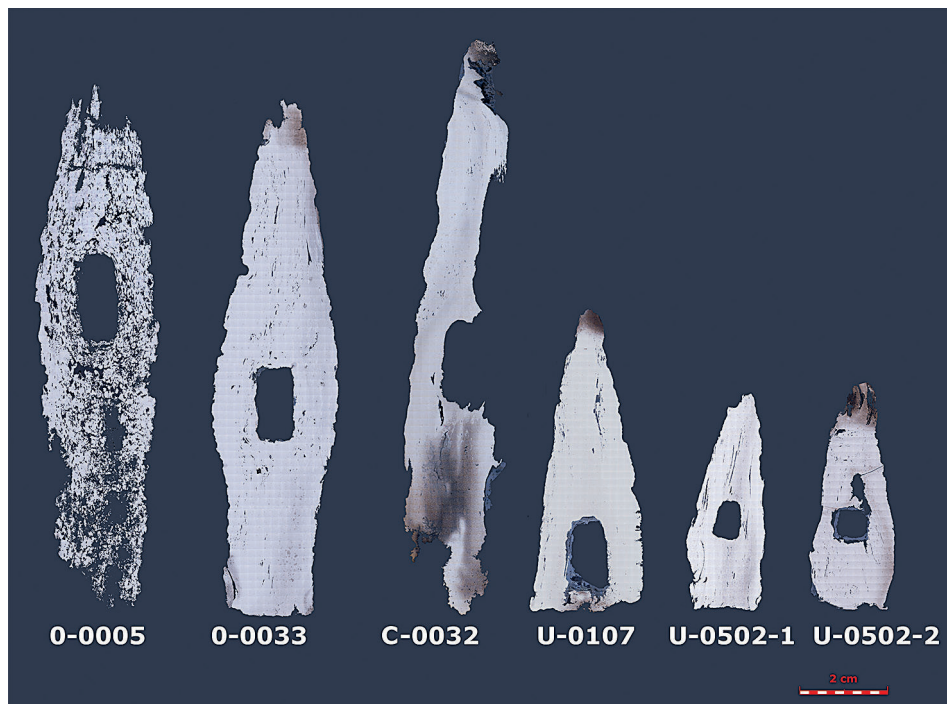


Fig. 6. Overall view of the etched surface of the analysed mining tools.

(Fig. 5: e). The point contains martensitic grains with pearlite at their boundaries (Fig. 5: f). The right side of the artefact shows pearlite and proeutectoid acicular (Widmanstätten) ferrite (Fig. 5: g). The head shows a cold-worked structure consisting of ferritic and ferritic-cementitic grains (Fig. 5: h).

Measurement of hardness in the point area shows values around 480 HV (Tab. 1), which corresponds to the martensitic structure. Lower values, about 130 HV, were measured in the body, corresponding to the ferritic and ferritic-pearlitic structure. The right side of the body shows a higher value around 215 HV, which aligns with pearlite and proeutectoid acicular (Widmanstätten) ferrite. The rear-end measurements show intermediate values around 220 HV represented by a cold-worked structure of ferritic and ferritic-cementitic grains.

Discussion

The use of chisels to break the rock was the most common method of ore extraction documented in the Bohemian-Moravian Highlands from the 13th century onwards (Hrubý 2019, 81). Metallographic analyses of medieval mining chisels from Banská Štiavnica, Slovakia, and 16th-century chisels from Leoben, Austria, have shown that the chisel points were rich in carbon and deformed. Additionally, these studies revealed that steel pieces were, or could be, welded onto the chisel bodies during repairs (Mihok *et al.* 1998, 493–511;

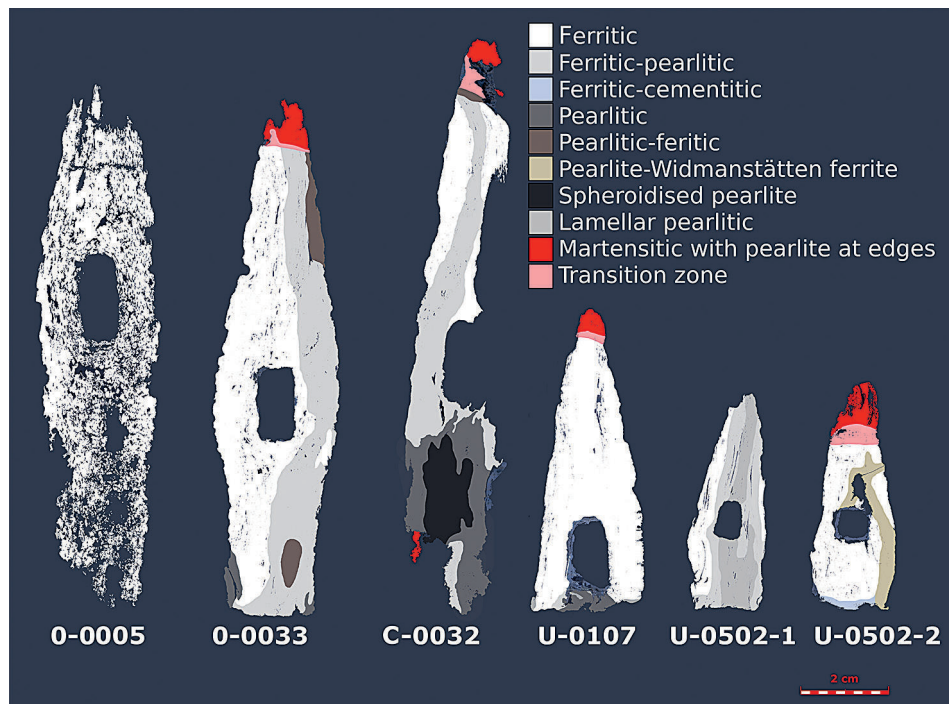


Fig. 7. Overall view of structures of analysed mining tools.

Haubner – Strobl 2015, 217–222). This practice could explain the frequent occurrence of broken-off points and chisels missing their points. In fact, Georgius Agricola noted that 16th-century miners used their chisels until they were completely worn out or destroyed (*Agricola Georgius, De Re Metallica: Hoover – Hoover 1912*).

All the chisels from the Bohemian-Moravian Highlands selected for metallographic analysis are, except for mallet O-0005, of good quality and made of deliberately chosen materials that could withstand daily use in the mines. The points were intentionally made of steel with a martensitic (O-0033; C-0032; U-0107; U-0502-2) or pearlitic-ferritic (U-0502-1) structure to increase durability (*Fig. 7*). This approach is similar to that employed in other tools, whose working parts must resist excessive wear, such as knives, agricultural implements or wood-cutting tools (*Tylecote – Gilmour 1986, 93; Blakelock – McDonnell 2007*). The pointed part of a chisel is subjected to considerable stress during mining, often leading to breakage. Consequently, new points had to be welded onto or into the bodies of the chisels during repairs. Evidence of such repairs was observed in the case of finds from Castel-Minier in south-eastern France (*Méaudre et al. 2023, 20*) and Banská Štiavnica, and Špania Dolina in central Slovakia (*Mihok et al. 1998, 503*). An intriguing observation is that each chisel in this study with a hardened point or steel structure has a steel bar with a pearlitic-ferritic structure on one side, with occasional occurrences of martensite (*Fig. 6, O-0033, C-0032, U-0502-2*). This may indicate that the semi-finished ingots from which the chisels were made were specially made for the production of these tools and the use of harder material in the body of the tool was intentional. Such features are also documented

in other studies of similar materials across Europe (Guillot *et al.* 1988; Mihok *et al.* 1998; Méaudre *et al.* 2023, 80). Interestingly, there is no evidence of tempered or welded-in points (Fig. 6, O-0033, C-0032, U-0502-2), as no clear wedge-shaped weld lines were observed in any of the analysed chisels from the Bohemian-Moravian Highlands. Instead, only a gradual transition from martensitic to ferritic structures was detected. The weld region is not visually distinguishable; it is characterised by a smooth, gradual transition between the ferritic body and martensitic point. This may indicate either an exceptionally high-quality weld or the formation of a diffuse bonding zone. No sharp weld line or abrupt change in microstructure is evident, resulting in a gradual transition area rather than a clearly defined weld boundary. Welded-in points have been documented on chisels from Pampailly (Guillot *et al.* 1988, 646–652) and Castel-Minier (Méaudre *et al.* 2023, 79–81).

The material requirements for the chisel bodies were clearly less stringent than those for the points. While the carbon content of the bodies was appropriate, the metal frequently contained numerous large slag inclusions. A cold-worked structure observed in the striking heads of chisels (O-0033; U-0107; U-0502-2) results from their usage. Intentionally cold-worked artefacts are rather uncommon in the Middle Ages (Tylecote – Gilmour 1986; Mihok *et al.* 2003; Blakelock – McDonnell 2007; Thomas *et al.* 2016; Larreina – Quirós 2018, 1306–1323), and cold-worked structures generally reflect how the artefacts were used (Swiss – McDonnell 2003). In our case, it confirms that the heads of the chisels were constantly struck with a hammer during mining activities. The practice of using mining chisels in this way is depicted in medieval illuminations, referred to by Agricola in 1556 (Agricola Georgius, *De Re Metallica*: Hoover – Hoover 1912). Additionally, similar features were documented on chisels from Špania Dolina and Banská Štiavnica (Mihok *et al.* 1998, 409–507) and Castel-Minier (Méaudre *et al.* 2023, 20).

Although the material chosen was of good quality, the amount of large slag inclusions suggests that the internal structure of the bodies of the artefacts was not as important as the points of the chisels. The reason why the points were welded in this way is that this part of the tool was subjected to considerable stress during mining; the points commonly broke off, and new ones were then welded into the body. This feature is observable on points from Castel-Minier (Méaudre *et al.* 2023, 20), Banská Štiavnica and Špania Dolina (Mihok *et al.* 1998, 503). Curiously, none of the chisels (O-0033, C-0032, U-0107, U-0502-1, U-0502-2) from this analysis has a point that is just tempered, not with wedged point, as has been demonstrated for chisels from Pampailly (Guillot *et al.* 1988, 646–652) and Castel-Minier (Méaudre *et al.* 2023, 19–21). We can conclude that the preferred constructions of mining chisels varied throughout Europe and that these tools were produced on a nearly mass scale, with slight differences, yet generally serving the same purpose. As these artefacts had to be produced quickly and cheaply, they are commonly made from materials of very poor purity (Guillot *et al.* 1988, 646–652; Mihok *et al.* 1998; Haubner – Strobl 2015, 217–222; Méaudre *et al.* 2023, 19–21).

Overall, the hardness measurements (Tab. 1) correspond closely to the metallographic observations. While some tools show clear evidence of intentional hardening of the working areas (point and head, O-0033; C-0032; U-0107; U-0502-2), reflected in high hardness values and martensitic microstructures, others were produced from relatively soft ferritic iron without deliberate heat treatment (O-0005; U-0502-1). These differences most likely reflect both technological choices and specific functional requirements of the tools used in mining and ore-processing activities.

Even though chemical analysis using OES and SEM-EDS was performed, it did not yield any meaningful results from which conclusions could be drawn. Rapid corrosion prevented SEM-EDS analysis, and the artefacts' matrix heterogeneity, with slag inclusions, prevented OES measurements. These analyses do not represent a suitable method for this type of material. Future work should therefore focus on Wavelength-dispersive X-ray spectroscopy (WDS) for more suitable data.

Conclusion

This study is one of the initial steps towards reconstructing the technological approach to the production of medieval mining chisels from the Bohemian-Moravian Highlands and, more generally, in Central Europe.

The metallographic analyses revealed that the chisel bodies were made of poor-quality metal, suggesting that these tools were regarded as consumables, intended for heavy use and at risk of significant wear or loss. Of the six samples, four had points of quench-hardened steel and predominantly ferritic iron bodies (O-0033, U-0502-2, C-0032, U-0107). There appears to be no weld line between chisel points and bodies. This might be due to the high-quality welding that has resulted in a diffuse bonding zone with a gradual transition between high-quality points and soft ferritic bodies. One chisel point (U-0502-1) was made from a predominantly pearlitic-ferritic steel, but quench hardening was not documented. Mallet O-0005 was primarily iron, including its working parts. These findings imply that individual chisels were adapted to the nature of the rock and the type of work for which they were intended. In addition, this variation may indicate that the chisels were used not only for ore extraction, but also for other mining activities, such as crushing ore or slag before smelting, as evidenced by the historical sources. In the future, further chemical analyses (WDS) will be conducted, which will contribute to a more detailed understanding.

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NEWS – ZPRÁVY

New Approaches in Music Archaeology (ISGMA, Vienna, 17–21 November 2025)

The thirteenth symposium of the International Study Group on Music Archaeology (ISGMA) took place from 17th to 21st November 2025 at the Austrian Archaeological Institute of the Austrian Academy of Sciences (ÖAW), situated in the historic centre of Vienna. This biennial conference (for the previous meeting, see *Chroustovský 2023*), which boasts a steadily expanding membership, was structured across a full week. The programme comprised fifteen thematic sessions, two parallel workshops, and the evening concert performed by the participants themselves. In keeping with the platform's tradition, the chronological and geographical scope of the meeting was exceptionally broad; contributions reflected periods ranging from the Palaeolithic to the present day.

The presented papers reflected the current state of scholarship in the fields of archaeology, history, iconography, and ethnomusicology, as well as organology, acoustics, and linguistics. Historico-linguistic research included the refinement of terminology regarding Mesopotamian lutes (D. Shehata), Ancient Greek instruments (M. Kotyl), and Shang Dynasty bronze bells (L. Xiǎotóng). Significant attention was also devoted to the reinterpretation of Hurrian hymn notation (D. L. Gibson), the symbolism of the sistrum and the serpent during the reign of Tutankhamun (H. Köpp-Junk), diacritics in Homeric writings (T.-L. Altunin), the meaning of the term organon in Greek philosophy (F. Aguirre), and reflections on the perception of sounds associated with intense movement in satyr plays (L. Gianvittorio-Ungar). Regarding non-European regions, recent finds of bamboo slips (P. Huang) were presented, alongside a description of the journey to the underworld in Taoist China (W. Tiān – Z. Yǔ). The synthesis of textual and archaeological evidence was represented by a reconstruction of the instrumental inventory on the *Limes Romanus* (F. Leitmeir).

Inferences regarding playing techniques and the role of instruments in past cultures were drawn from iconographic sources, such as Greek vase painting (A. Gandossi-Boshnakova), Mayan reliefs (M. Ciura), and paintings and sculptures in Chinese royal tombs (W. Xīdān – W. Ruòyáng – Z. Míng). The social role of specific instruments and their players was discussed through cases such as Assyrian harpers (B. Bellucci), Hellenic ithyphallic lyre players (C. Romero Mayorga), the status of the tympanum in Ancient Rome (M. Mungari), the sistrum as evidence of the Isiac cult in mainland Greece (S. Perrot), and the Indian dappu drum (D. Gupta). Ethnomusicological projects, which are instrumental in reconstructing conceptions of the musical past, focused on the dance music of Mayan descendants (M. Howell), acoustic measures accompanying lunar eclipses in Andean cultures (A. Gruszczyńska-Ziółkowska), and the role of percussion in the vanishing traditional societies of the North China Plain (R. Tóng – Y. Hóngbīn).

Experimental studies continue to play a vital role in the archaeology of music. Presentations in Vienna included: use-wear analysis and the acoustics of Upper Palaeolithic bullroarers (M. Praxmarer); the replication of conch-shell horns using stone and metal tools (L. Chroustovský); the replication of a unique Early Bronze Age whistle (J. Bátor – B. M. Pomberger); the use of horn as a raw material for chordophone bridges in Ancient Greece (M. Sciascia – F. Aguirre); the reconstruction of ancient zithers in Sri Lanka (I. Dehideniya); new acoustic research into the famous Wicklow pipes (S. O'Dwyer); and the reconstruction of a medieval bone flute in England (L.-A. Taylor). The potential of virtual modelling was demonstrated by the digital reconstruction of prehistoric rattles (I. Czajka – K. Tatoń), the presentation of chordophones in China (Z. Yǔ – W. Tiān), and the digital replication of Indian double-headed drums based on textual sources (A. R. Kondi). Furthermore, papers presented laboratory tests on the music-therapeutic effects of Iron Age metal idiophones in Central Europe

(800 BC – AD 800) in reducing psychological and physiological stress (M. Foramitti), and an unusual collective experiential-acoustic project involving horns and shields in the Danish landscape (E. Fock). Modern acoustic research was represented by two Scandinavian projects focusing on the connection between natural sacred sites and local folklore (G. Kolltveit – R. Rainio; J. Shpinitskaya – R. Rainio).

Regarding specific organological categories, aerophones (15) traditionally predominated, followed by chordophones and idiophones (10 each); membranophones (5) were the least represented. Among the aerophones, the aulos (tibia) was the dominant subject, appearing in the context of current research projects (Pompeii: E. Rocconi), new finds (Iberia: R. Jiménez Pasalodos – S. Hagel), reinterpretations (the double silver tibia from Pompeii: K. Wysłucha – S. Hagel), and general surveys of Egypt (M. Sciascia – B. Brown) and Archaic Greece (L. Isotalo). Additionally, presentations covered finds of carnyces in La Tène Europe (A. Kocánková), Avar double flutes (or reed instruments, P. Rozs), wind instruments of Germanic societies (S. Réto), and musicological and acoustic analyses of specific flutes from pre-Hispanic Ecuador (J. Pérez de Arce).

Chordophones were discussed in terms of their representation in the funerary contexts of Hellenic Greece (M. Stamatopoulou – Ch. Terzis) and Anglo-Saxon elites (G. Lawson). The programme also included an overview of arched harps in Central Asia (G. Currie) and studies dedicated to idiophones—Caucasian specimens in the Natural History Museum Vienna (B. M. Pomberger – S. Makhortykh), bronze bells in Ancient China (S. Yíméng; W. Yǒuhuá) and the Malay Peninsula (M. Yuè), and the history and contemporary status of Andean lithophonic rock blocks associated with rock art (C. M. Muñoz). The acoustic character of Roman ornaments was also considered (A. Zangrando – E. Braidotti – A. de Franzoni). In the field of membranophones, promising new Upper Palaeolithic sites in the USA were introduced, yielding the oldest known frame-drum beater found to date (R. M. Gramly).

Among the more theoretical contributions was a proposal for a new archaeological terminology for aerophones based on the neutral characteristics of material finds rather than musicological interpretations of function (B. M. Pomberger – M. Hackl). Other papers included an overview of recent research in China (D. Jingyí) and a critique of the colonialism still present in the study of Ancient Egyptian music, where an *a priori* assumption of continuity from antiquity leads to the misinterpretation of historical notations (W. Sherbiny).

The programme was complemented by two workshops focusing on the ancient civilisations of the Mediterranean and the Near East. R. Gehler, N. Thym, and D. Shehata presented experimental approaches to the tuning of stringed instruments in Mesopotamia (see *Goodnick-Westernholz et al. 2014*). M. Mungari shared practical experience in playing frame drums across various cultures, including their relevance to the interpretation of ancient iconography (e.g. *Mungari – Wysłucha 2021*).

The public concert held on Thursday in the ÖAW theatre hall opened with wind instruments: a La Tène carnyx (S. Hagel), a bronze horn from Loughnashade (K. Wysłucha), a Palaeolithic flute, and the silver pipes of Ur (B. Brown). This was followed by a demonstration of the sonospheres of the European Palaeolithic and Neolithic (M. Praxmarer, L. Chroustovský, A. Kocánková, J.-L. Ringot). Music from Bronze Age to Early Medieval Europe was performed by the ensembles ArchäoMusik Vienna and Ars Serena (B. M. Pomberger, M. Hackl, I. Wagner-Kraft, B. Winkler). A new interpretation of a Hurrian hymn from Ugarit (14th century BC), arranged for harp, was also performed (N. Thym). Ancient civilisations were further represented by an Egyptian flute, lute, and frame drum, alongside an Ancient Greek lament accompanied by the kithara (S. Hagel) and diaulos (K. Wysłucha). The concert, which was very well received by the audience, concluded with the medieval harp (N. Thym).

The ambitious title of the meeting reflects the fact that in this dynamically developing and highly interdisciplinary field, there is truly no shortage of novel approaches. While the symposium did not herald revolutionary or sensationalist shifts in theory or methodology, it demonstrated consistent,

diligent scholarship that remains open to the application of new technologies and ideas alike. It is precisely such interdisciplinary gatherings that facilitate this progress. It is anticipated that the majority of the contributions will be published in the Journal of Music Archaeology, published by the Austrian Academy of Sciences.

Luboš Chroustovský

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BOOK REVIEW – RECENZE

Jan Turek: První Evropané. Archeologie počátků evropské identity. Academia, Praha 2026, ISBN 978-80-200-3701-5, 360 pages, published in Czech.

If one were to characterise Jan Turek's *První Evropané* (*First Europeans*) in a single sentence, it would perhaps be best described as an archaeological essay on the long-term cultural foundations of Europe. The book is far more than a conventional synthesis of European prehistory. Rather, it represents an ambitious attempt to interpret the emergence of European civilisation through the transformative processes associated mainly with the Neolithic. Although the volume is published only in Czech, it deserves particular attention from an international audience interested in current Central European archaeological thought and in broader debates concerning the cultural significance of early agricultural societies.

The book is substantial in both physical and intellectual scope. Richly illustrated and stylistically polished, it combines scientific synthesis with essayistic reflection and occasionally openly philosophical commentary. Turek is already well known internationally for his work on European prehistory, monumentality, Bell Beaker archaeology, gender, and symbolic systems. Many themes familiar from his earlier scholarly publications reappear here, yet transformed into a more accessible and synthetic form. The result is neither a popularisation in the simplistic sense nor a narrowly academic monograph. Rather, the book occupies an intermediate genre that has become relatively rare among contemporary Central European scholars: a deeply informed civilisational essay grounded in archaeological evidence. The chronological emphasis placed throughout the volume on the Neolithic is hardly accidental. These periods are presented as formative stages in the emergence of specifically European cultural patterns, but they also reflect the author's own long-term scholarly specialisation in the archaeology of the European Copper Age and specifically Bell Beaker societies.

The central argument is introduced already in the preface. Turek explicitly frames the Neolithic as the decisive threshold in the formation of European cultural identity. The first farmers are presented not merely as one prehistoric population among many, but as the creators of enduring cultural patterns that still shape Europe today: attitudes toward landscape, domesticated food, alcohol consumption, kinship, monumentality, social hierarchy, warfare, gender, mobility, and religion. Throughout the volume, archaeology is repeatedly mobilised not simply as a method for reconstructing the past, but as a means of reflecting critically on the contemporary world, including the Anthropocene, ecological crisis, globalisation, pandemics, and the future sustainability of civilisation itself.

This broad interpretative ambition gives the book its coherence. Individual chapters often move far beyond the descriptive presentation of archaeological data and instead ask how long-term historical processes shaped specifically European mentalities and social habits. The final chapter, significantly entitled *What Makes Us Europeans*, synthesises these reflections into a larger argument concerning migration, hybridity, openness, and the shared cultural inheritance of Europe. Turek explicitly rejects ethnically essentialist conceptions of Europe and emphasises the continent's millennia-long history of population movement, admixture, and cultural synthesis instead. Such reflections inevitably resonate with current political debates, yet the author generally avoids simplistic ideological formulations and grounds his interpretations in archaeological and archaeogenetic discourse.

Humans, animals, and the making of culture

The first chapter introduces the tension between nature and culture as one of the book's recurring themes. Turek forcefully rejects romantic notions of primordial harmony between humans and nature and instead presents humanity as a fundamentally transformative species. Human evolution is described through the development of cooperation, technology, hunting strategies, cooking practices, and eventually domestication. Particularly memorable are the sections devoted to the domestication

of dogs and cats, where archaeological evidence, genetics, behavioural ecology, and historical anecdote are woven into an engaging narrative. The discussion of domestication repeatedly emphasises reciprocity and co-evolution: humans domesticated animals, but domesticated plants and animals simultaneously transformed humans themselves. Wheat becomes metaphorically ‘the slave-master’, agriculture a process of mutual dependence rather than simple human triumph over nature.

One of the strongest qualities of the book is precisely this ability to connect archaeological evidence with broader anthropological interpretations. Turek constantly moves between empirical detail and general reflection. Discussions of stable isotopes, archaeogenetics, or settlement archaeology are interwoven with myths, literary references, historical parallels, and contemporary social observations. Occasionally, this associative method produces speculative or deliberately provocative interpretations, but more often it succeeds in making archaeological evidence intellectually vivid and culturally meaningful.

Domus, ancestors, and the Neolithic transformation

The second and third chapters focus on the origins of farming societies in the Near East and the spread of the Neolithic into Europe. Here Turek develops one of the core conceptual oppositions of the volume: *domus* versus *agrios* — the domesticated human world contrasted with wilderness. The emergence of permanent houses, ancestor cults, household continuity, and genealogical thinking is treated as a revolutionary transformation in human consciousness. Sites such as Jericho and Çatalhöyük are interpreted not merely as archaeological settlements, but as places where entirely new concepts of home, ancestry, and sacred space emerged. Particularly interesting is the treatment of plastered skulls and intramural burials as material manifestations of new relationships between the living and the dead.

The chapter *Neolithic (R)evolution?* is among the most theoretically ambitious sections of the volume. The deliberately stylised title already signals a degree of scepticism toward simplistic revolutionary narratives. Turek engages critically with current debates surrounding the pace and variability of Neolithisation and repeatedly stresses the complexity, reversibility, and regional diversity of these processes. Especially notable is his discussion of Graeber and Wengrow’s (2021) ideas concerning gendered dimensions of early cultivation and sedentism. Rather than accepting such models uncritically, Turek integrates them cautiously into a broader framework of gradual experimentation and mixed subsistence strategies.

The archaeology of consumption and social practice

Many readers will likely remember above all the more unconventional thematic chapters, which distinguish this book from standard archaeological syntheses. Particularly remarkable is the chapter *In the Beginning There Was Beer*, devoted to alcohol, fermentation, ritual drinking, and sociality. Turek argues that collective alcohol consumption became one of the defining social institutions of early farming societies and eventually a deeply rooted feature of European civilisation. The discussion moves from Near Eastern fermentation practices to prehistoric drinking feasts, ritual hospitality, and even modern cultural differences in attitudes toward alcohol. Some readers may find parts of this argument somewhat overstated or intentionally provocative, yet it undeniably succeeds in demonstrating how archaeology can illuminate long-term cultural practices that extend far beyond subsistence alone.

Similarly original is the chapter on the milk revolution. Here Turek combines archaeogenetics, dietary adaptation, dairying technologies, and cultural history into a compelling discussion of lactase persistence and the symbolic importance of milk products in Europe. The passages devoted to bog butter are especially memorable, balancing scientific explanation with vivid storytelling and historical imagination. Such examples illustrate one of the author’s major strengths residing in the ability to transform seemingly marginal archaeological phenomena into windows onto broader civilisational processes.

Ritual landscapes and the symbolic order

Another major thematic block concerns monumentality, ritual landscapes, sacred mountains, and cosmology. Long barrows, ditch enclosures, megalithic monuments, solar symbolism, and ritual topographies are interpreted as expressions of collective memory and ancestral time. Turek repeatedly returns to the relationship between landscape and identity, especially within the Central European context. The discussion of Mount Říp and other symbolic landscapes is particularly revealing in this respect, connecting prehistoric cosmologies with later national mythologies.

This part of the book is especially important because it reflects one of the author's principal current research specialisations. The interpretations presented here build on Turek's long-term research into Late Neolithic monumentality and ritual landscapes, recently synthesised in the volume *The Tombs of Forefathers: Neolithic Long Barrows in Ritual Landscapes* (Turek – Křišťuf 2025; reviewed by Bradley 2026).

Turek consistently interprets long barrows and related ritual structures not as isolated funerary monuments, but as elements of broader symbolic landscapes linking ancestry, territory, cosmology, and social memory. Particularly convincing is his emphasis on the long-term persistence of sacred places, many of which retained symbolic importance for millennia. Sacred mountains, rivers, causewayed enclosure sanctuaries, and burial mounds are presented as interconnected components of prehistoric cosmological systems rather than isolated ritual features.

Equally noteworthy is the author's attention to the sensory and spatial dimensions of ritual landscapes. Monument orientation, visibility, movement through the landscape, and relationships to prominent topographic features are all interpreted as meaningful aspects of prehistoric ceremonial practice. These sections rank among the strongest and most conceptually coherent parts of the book and demonstrate particularly clearly Turek's ability to combine detailed archaeological knowledge with broader interpretative synthesis.

Bodies, identities, and the archaeology of power

The chapters devoted to epidemics, warfare, and gender demonstrate the breadth of the book's ambitions. Turek discusses prehistoric disease within the wider history of global pandemics and explicitly links Neolithic demographic growth, sedentism, and domestication to the emergence of epidemic vulnerability. The chapter on warfare ranges from Copper Age daggers to nuclear deterrence, occasionally producing intentionally unsettling analogies between prehistory and the modern world. Likewise, the chapter *Gender, Graves and Amazons* combines funerary archaeology, symbolic systems, and contemporary debates about gender identities. The famous Bell Beaker burial from Tišice receives substantial attention as evidence that biological sex and socially performed gender roles need not coincide. Such passages clearly aim not only to interpret prehistory but also to contribute to present-day discussions concerning identity and social norms.

A significant contribution to European prehistoric studies

Stylistically, the book is unusually readable for a work so deeply saturated with archaeological material. Turek writes with considerable rhetorical confidence and evident pleasure in storytelling. He frequently employs irony, metaphor, and provocative formulations. At times, the text resembles a scholarly essay; elsewhere, it approaches philosophical reflection or even cultural criticism. This stylistic hybridity is both one of the book's greatest assets and one of its potential weaknesses. Readers seeking a strictly neutral or methodologically restrained archaeological synthesis may occasionally feel uncomfortable with the author's readiness to generalise or to draw long interpretative arcs connecting prehistory and modernity. Yet such risks are inseparable from the intellectual ambition of the project itself.

The volume is also visually impressive. Photographs, reconstructions, site images, maps, and artefact illustrations are integrated thoughtfully throughout the text and often become part of the argument itself. Particularly striking is the recurring motif of the 'Amazon' from Tišice (once excavated

by the author himself), appearing on the cover and within the gender chapter. The visual programme reinforces the book's broader attempt to bridge academic archaeology and public imagination.

A minor reservation concerns the treatment of references and primary literature. While some sections of the book are carefully documented and guide the reader directly to the relevant scholarly debates, other interpretative passages rely more heavily on synthetic narrative without equally detailed citation support. Given the intellectual richness of the volume, a more consistently explicit referencing system throughout would have further strengthened its value for specialist readers wishing to follow particular arguments back to their empirical and theoretical foundations.

Naturally, a work of this scale and interpretative breadth invites criticism. Specialists in individual subfields will undoubtedly disagree with certain generalisations or with the degree of confidence attached to some hypotheses. At times, the book tends toward cultural-essentialist formulations concerning 'Europeans' and 'European mentality', even if these are elsewhere moderated by explicit emphasis on hybridity and migration. Some comparisons between prehistoric and contemporary social phenomena occasionally appear more metaphorical than analytically rigorous. Yet these reservations should not obscure the larger achievement of the volume.

What makes *První Evropané* genuinely important is its attempt to restore archaeology to the centre of broader intellectual and societal reflection. In an academic environment increasingly dominated by specialisation and methodological fragmentation, Turek offers a rare synthetic vision connecting material culture, environment, symbolism, genetics, economy, ritual, and long-term historical identity. The book demonstrates how prehistoric archaeology can contribute not only to knowledge about the past, but also to contemporary debates concerning ecology, migration, identity, inequality, and civilisation itself.

For non-Czech readers, the publication is additionally valuable as an insight into current Czech archaeological thought. Central European archaeology has long cultivated broad synthetic and interdisciplinary traditions, yet much of this intellectual production remains linguistically inaccessible internationally. *První Evropané* deserves attention precisely because it represents a mature and distinctive contribution to ongoing European debates about the meaning of the Neolithic and the cultural roots of Europe itself.

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