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Faculty of Arts and Philosophy

Possibilities of the use-wear analysis of the lithics from the hunter-gatherer context in
Bohemia.
Bachelor Thesis

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Zásady pro vypracování

English version:

The aim of this work is to introduce the student with main principles of the use-wear analysis, especially with its theory and methodology. Student should understand main approaches how the functional analysis should be used and describe its possibilities and limits. Emphasis will be given to the necessary entanglement with experimental approach. Case study will be focused on chosen problem from the hunter-gatherer settlement context from Bohemia. Student should demonstrate, that he/she is able to apply use-wear analysis and solve questions connected to this approach. Lithic collection will be chosen according to students preferences and with special emphasis to possible understanding basics of this method.

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2. Possibilities of the function determination of lithics by use wear analysis
3. Materials worked by hunter-gatherers
 - 3.1. Anorganic
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5. Conclusion

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Hroníková, L. 2011: Jak rozmluvit kámen? aneb Pár odstavců o traseologii. Živá archeologie 13, 18-21.
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ANNOTATION

The submitted bachelor's thesis explores the potential of use-wear analysis in understanding the function of lithic tools within a Late Upper Paleolithic hunter-gatherer context in Bohemia. The work is based on a comparison between archaeological artifacts from the Hostim site and a newly created experimental set of flint tools made from glacial sedimentary silicite (SGS). These experimental tools were used on a range of materials, including slate, wood, bone, and antlers, to simulate prehistoric activities and generate comparable use-wear traces. The thesis outlines the theoretical background of traceology, describes the experimental process and materials, and offers a microscopic analysis of the wear patterns. Through this comparative approach, the study aims to assess the relevance and limitations of experimental archaeology for interpreting the function of prehistoric tools and offers reflections on methodological consistency. The results indicate both similarities and specific differences between the experimental and archaeological sets.

KEYWORDS

Traceology, experimental archaeology, burin, Upper Paleolithic, lithic industry, Hostim, use-wear analysis, SGS

Obsah

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1. INTRODUCTION

Lithic technology is one of the longest-used technological systems in human history and represents one of the most enduring traditions of prehistory. Although past research has primarily focused on typology and chronology, functional analysis—examining the actual functions and use contexts of these tools—has long been underrepresented. However, with the advent of modern methods such as traceology (use-wear analysis) and experimental archaeology, new opportunities have arisen for interpreting these artifacts in terms of their use, production, and cultural context.

This bachelor's thesis examines the possibilities and limitations of this methodological framework in lithic studies within hunter-gatherer communities in Bohemia, with a specific focus on burins from the Magdalenian site of Hostim. The primary objective of the thesis is to understand the fundamental principles of identifying wear marks on experimentally produced and used burins and then apply this knowledge to the analysis of a selected archaeological collection. Through this comparison, the thesis evaluates the extent to which experimentally obtained knowledge can enhance functional interpretations of prehistoric tools.

The thesis includes several essential sections. The theoretical section describes the key principles of functional analysis, tracing its development, possible applications, and methodological constraints. It particularly highlights the importance of experimental material as essential support for comprehending archaeological findings. This is followed by a chapter dedicated to the experiment itself—the production of tools, their usage, and the documentation of the resulting traces. Next, the archaeological material from Hostim is presented, and a comparison is conducted between experimental and archaeological burins. The concluding discussion summarizes the results obtained, evaluates the contributions of the employed methodology, and suggests directions for future research in this field.

2. TRACEOLOGY

2.1. TRACEOLOGY AS A SCIENTIFIC DISCIPLINE

Traceology, also referred to as use-wear analysis or functional analysis, is a distinct sub-discipline of archaeology that concentrates on studying and identifying microscopic traces on the surfaces of tools and artifacts, especially along the edges and residues left behind. While the term use-wear analysis focuses on verifying or rejecting hypotheses about the actual use of

tools by examining microscopic wear traces, functional analysis concentrates on understanding the structure of the tools and evaluating the functional potential of their different parts based on their morphology and production technology.¹ These minor marks, created during the production and use of these objects, provide invaluable clues for experts trying to reconstruct the activities and processes engaged in by our prehistoric ancestors.

Traceology originally emerged as an auxiliary investigative method in criminalistics,² focusing on the identification and forensic analysis of traces. The criminalistics discipline is *trasology*, and the names can be confused or interchanged.

The primary goal of traceology is to determine the specific functions of individual artifacts by identifying the activities for which they were used and the materials prehistoric people processed with them. It helps us reconstruct the particular uses of the tools and allows us to understand patterns of human behavior, including daily activities, technological skills, and environmental adaptation. Although traceology primarily focuses on the study of stone tool usage, modern approaches enable the analysis of traces on other materials used during prehistoric times, such as teeth or wood, thereby extending its relevance.

These marks are key to the analysis and are what the experts mainly focus on. These details, often only visible under the microscope, allow the activity of prehistoric people to be reconstructed. For example, it can determine whether a tool was used to process plant materials, cut meat, trim leather, or carve out bones and horns into desired shapes. Traceological analysis offers insight into the daily lives, technologies, and environmental adaptations of prehistoric people. It is an indispensable tool for understanding the prehistoric past.

2.2. HISTORY OF TRACEOLOGY

Traceology is fundamentally grounded in the microscopic examination of the working edges of tools. It mainly studies the traces left by working the tool, but those are not the only traces left on the surface. One of the first objects of learning to use the tools through microscopic examination was studying the gloss on the surface. These are visible even without magnifying equipment, and they sparked interest. The first person to focus on the gloss on the surface was

¹ MARCIANI, Giuseppe – ARRIGHI, Silvia – AURELI, Daniele – SPAGNOLO, Vincenzo – BOSCATO, Paolo – RONCHITELLI, Annamaria. *Middle Palaeolithic lithic tools: techno-functional and use-wear analysis of target objects from SU 13 at the Oscurusciuto rock shelter, Southern Italy*. *Journal of Lithic Studies*, pp. 6-10.

² ŠAJNEROVÁ, Andrea. *Svědectví kamenných nástrojů - využití traseologie v archeologii*. *Živa*, vol. 6 (2004), p. 245.

F. Spurrell, who, in 1892, wrote a study questioning what these tools were used for and experimented with different materials to try and reproduce the shiny gloss.³

Since the 1950s, the principles of criminal trasology have also been applied in experimental archaeology, garnering attention and appreciation thanks to the work of Sergei Aristarkhovich Semenov. In his book *Prehistoric Technology: An Experimental Study of the Oldest Tools and Artefacts from Traces of Manufacture and Wear* (1964),⁴ Semenov laid the foundations for archaeological traceology as a distinct discipline, highlighting its role in interpreting tools and understanding their functions. It is also the year that many consider the year of the creation of traceology in a multinational context. He presumed that every tool artifact bore some traces of the material it was used on. Semenov is said to be the founding father of traceology as a discipline.

Archaeologists Lawrence H. Keeley, Ruth Tringham, and G. H. Odell built on the foundations of the interpretation of workmarks introduced by Semenov. They developed them further, formulating the key principles of methodological approaches to functional analysis in archaeology. One of the methods for studying traces is microwear analysis. Lawrence H. Keeley directly references Semenov's work in his study *Technique and Methodology in Microwear Studies: A Critical Review*.⁵ He also defined his microwear analysis goal as reconstructing the economic activities of historical people and interpreting and investigating archaeological tools.

Patricia Phillips also refers to the *Laboratory of Traceology* in Leningrad as the birthplace of traceology. Semenov was also the first person to experiment with and utilize a microscope. Tringham was one of the visitors who went to Russia and transferred the low-power microscopic investigation program to the USA. Meanwhile, Keeley worked on a high-power microscopic approach at the University of Oxford in the United Kingdom.⁶ Both of these techniques had supporters, but it was decided that to discover the full potential of the analysis, both methods needed to be applied.

Today, traceology is closely related to anthropology in many ways. By studying the tools, we can gain even more information about their development and the changes in relations and economic interactions within prehistoric communities.⁷ One thing to note is that the

³ SPURRELL, Flaxman Charles John *Notes on Early Sickles*. The Archaeological Journal. vol. 49 (1982) p. 53.

⁴ Cf. SEMENOV, Sergei Aristarkhovich. *Prehistoric Technology: An Experimental Study of the Oldest Tools and Artefacts from Traces of Manufacture and Wear*. New York: Barnes & Noble Books, 1985.

⁵ Cf. KEELEY, Lawrence H. *Technique and methodology in microwear studies: a critical review*. World Archaeology, vol. 5 (1974), no. 3, pp. 323–336.

⁶ Cf. PHILLIPS, Patricia. *Traceology (Microwear) Studies in the USSR*. World Archaeology, vol. 19 (1988), no. 3, p. 349.

⁷ PAVLŮ, Ivan. *Life on a Neolithic Site*. Praha: Institute of Archaeology, Czech Academy of Sciences, 2000, p. 13.

methods used to study microwear on flint and other stone materials also apply to tools made from different organic materials. Studies and even these have recently focused on various industries made from antlers, bones, or wood. A relevant comparative analysis is the work of A. Alea (2022), which focuses on the formation and characterization of use-wear traces in various lithic materials, including flint.⁸ The research was based on controlled experiments in which flint tools were worked on different types of materials and subjected to multiple movements, and then analyzed using microscopy. The results revealed specific wear features on flint, including pronounced polish and striations, which are comparable to the traces observed in this work. In recent years, advanced quantitative approaches have been introduced, in particular the use of confocal laser scanning microscopy combined with surface texture analysis. This method enables researchers to analyze not only the static characteristics of usage traces but also their dynamic development over time by evaluating changes. In surface texture at different stages of tool use, it is possible to more accurately distinguish between materials that have been worked, even after a short period of use.⁹ These findings contribute to a more accurate interpretation of the traces identified on the analyzed archaeological tools and to a deeper understanding of their functional development.

Microanalytical methods are not confined to the prehistoric period; they are also applied in the study of medieval archaeology. This is demonstrated by a study by Scibè et al. (2024), which utilized microanalytical and paleoproteomic techniques to analyze medieval textiles, confirming the broader applicability of these methods beyond prehistoric materials.¹⁰

2.3. EXPERIMENTAL ARCHAEOLOGY

Experimental archaeology is an essential part of studying traces on the tool's surface. Comparing an archaeological set of artifacts with an experimentally produced one has been employed in various ways. It is a significant source of information on basic data that helps in understanding not only the prehistoric times, but also experimental archaeology may have multiple applications. Use-wear analysis is a crucial tool for understanding production and use. Experimental archaeology bridges the gap between hypothesis testing, experimentation, and

⁸ ALEA, Alessandro. *Comparing the Formation and Characteristics of Use-Wear Traces on Flint, Chert, Dolerite and Quartz*. *Lithic Technology*, vol. 47 (2022), no. 3, pp. 123–140.

⁹ IBÁÑEZ, Juan J. – MAZZUCCO, Niccolò – GIBAJA, Juan F. – CLEMENTE-CONTE, Ignacio. *Quantitative use-wear analysis of stone tools: Assessing variability in surface texture measurements*, pp. 2-3.

¹⁰ Cf. SCIBÈ, Cristina – ENG-WILMOT, Kira – LAM, Thomas et al. *Palaeoproteomics and microanalysis reveal techniques of production of animal-based metal threads in medieval textiles*. *Scientific Reports*.

interpretation. Experimental archaeology bridges the gap between hypothesis testing, experimentation, and interpretation.¹¹

The main contribution of experimental archaeology to use-wear analysis is to reconstruct working traces by creating a new, clean set of tools and attempting to imitate working conditions and the materials being worked on, or even those from which the tool was made. Semenov viewed experimentation as a key tool for refining interpretations of the tools' functions and the formation of working marks¹². Practical testing allows researchers to gain a deeper understanding of the processes that result in specific wear marks, leading to more objective conclusions in their analyses. Furthermore, experiments paired with blind tests act as an essential control mechanism to validate assumptions and rectify interpretive errors when needed. This approach not only enhances the credibility of functional analysis but also supports the ongoing development of methodology in the field of traceology.¹³

3. LITHIC TECHNOLOGY

In archaeology, "lithic" refers to stone tools and artifacts crafted through knapping, an ancient practice that involves precisely splitting and shaping stone. The process involves producing the tools and creating by-products, such as core residue, chip flakes, or waste material. However, the term "tool" refers to a specific object created with the explicit intention of further and practical use, distinguishing it from unworked artifacts or random fragments. These tools also exhibit signs of human intervention, such as traces of use, specific design elements, or wear and tear. Experts can later put those marks under a microscope for further information about the past, how they were used, or even how they interacted with their environment. They are also one of the earliest pieces of evidence of surviving manufacturing technology.¹⁴

Mineral rocks, such as flint, quartzite, jasper, crystal, and even black obsidian, are the primary materials that possess properties allowing for precise machining. Semenov said in his book, "Due to their isotropic structure and their consequent conchoidal fracture, when struck,

¹¹CURRIE, A. *Speculation Made Material: Experimental Archaeology and Maker's Knowledge*. Philosophy of Science, vol. 89 (2022), pp. 337–359.

¹²SEMENOV, S. A. *Prehistoric Technology: An Experimental Study of the Oldest Tools and Artefacts from Traces of Manufacture and Wear*, pp. 1-3.

¹³SMIDOVČINOVÁ, Nikola – HRONÍKOVÁ, Linda. *Kostěný nástroj, nebo ohlodaná kost? Zn. Zeptejte se traseologů. Živá archeologie – Rea*, vol. 18 (2016), p. 49.

¹⁴INIZAN, Marie-Louise – REDURON-BALLINGER, Marie – ROCHE, Hélène – Jacques TIXIER. *Technology and Terminology of Knapped Stone*. Nanterre: CREP, 1999, p. 16.

these rocks yield an uneven surface with receding concentric waves and very sharp cutting edges.”¹⁵

Different cultures have developed and practiced specific technological approaches in working with stone, making lithic technology a key source of archaeological information. These tools provide information on the way of life and technological sophistication of prehistoric societies, serving as an essential means of dating and cultural classification of archaeological finds due to their poorer degradability.¹⁶

3.1. PRODUCTION PROCESS

Lithic cores, the bases from which knapped stone is produced, undergo a series of transformations to achieve the desired shape and function. The process begins with selecting a suitable material, from which blanks are made and further refined by retouching to create tools such as blades or edges. The final shape reflects cultural context, geographical conditions, and user needs, and these variations will be further discussed in the following chapters¹⁷. Lithic production was not a singular event. Tools were often reworked and recycled to extend their function and value, highlighting the resourcefulness of prehistoric people and their economic use of raw materials.

A key concept for understanding lithic technology in the *chaîne opératoire*¹⁸ is the description of the sequence of production, use, and abandonment. Introduced by Marcel Mauss and André Leroi-Gourhan. Mauss connected technology with social and historical contexts. As Frédéric Sellet defined it: “*It is a chronological segmentation of the actions and mental processes required in the manufacture of an artifact and in its maintenance into the technical system of a prehistoric group.*”¹⁹ It not only focuses on the physical aspect of creating the tool but also on the mental aspect of how to create it. Within a *chaîne opératoire*, conceptual and operational schemas are interconnected, complemented by knowledge, skills, techniques, and methods that are systematically arranged among them²⁰. Researchers nowadays agree that even though the product is finally manufactured, the chain of production continues until the product is discarded or destroyed.

¹⁵ SEMENOV, S. A. 1985. *Prehistoric Technology: An Experimental Study of the Oldest Tools and Artefacts from Traces of Manufacture and Wear*, p. 33.

¹⁶ ANDREFSKY, W. Jr. *The Analysis of Stone Tool Procurement, Production, and Maintenance*. Journal of Archaeological Research, vol. 17 (2008), p. 66.

¹⁷ ROTS, Veerle. *Prehension and hafting traces on flint tools: A methodology*. Leuven: Leuven University Press, 2010, pp. 19–23.

¹⁸ Operational chain

¹⁹ SELLET, F. *Chaîne Opératoire; The Concept and Its Applications*. Lithic Technology, vol. 18 (1993), p. 106.

²⁰ INIZAN, M.-L. et al. *Technology and Terminology of Knapped Stone*, pp. 30-32.

Material selection was crucial. Prehistoric people demonstrated the ability to identify, transport, and process high-quality raw materials, sometimes working with them directly at the site or reshaping them as needed.

Knapping is the primary step in the production of tools. It is an intentional action when working with raw materials, reflecting the mental and physical capabilities of prehistoric people. Knapping involves chipping, shaping, retouching, and debitage (flaking) of the stone. The process is also partially influenced by the properties of the stone, working conditions, and the maker's ability.

Knapping is the primary technique in tool production, reflecting both mental and physical capabilities. It involves chipping, shaping, retouching, and flaking. Knapping methods include direct percussion, where the core is struck with a hammer made of stone, bone, or antler, and soft hammer percussion, which offers better control and enables the production of thinner flakes. Soft hammer techniques became prominent over time and were used as early as 700,000 years ago in Africa²¹. If a soft hammer was used, it had to be larger and heavier to deliver a more forceful blow²². Direct percussion was primarily used to create simple tools and control factors such as width, length, and thickness. The experimental setup in this study utilized soft hammer percussion.

Indirect percussion involves placing a punch between the hammer and the tool, allowing for more precision but requiring either two individuals or a supported core²³. It reduces cracking and shattering but demands significant pressure to detach flakes. Pressure flaking, using bone, hardwood, or antlers tools, applies steady force to remove flakes from a platform. This technique enables fine, regular shaping and is used to sharpen and refine tools repeatedly.²⁴

3.2. DEBITAGE

Chips or flakes are pieces of stone detached from the core by percussion or flaking. The core is a mass of lithic material whose primary purpose is to supply flakes later modified into various tools. A striking platform is a flat section or core that is the central point for delivering blows during flake creation. Unidirectional cores have flakes removed from a specific direction,

²¹ Ibid.

²² CRABTREE, Don E. *An Introduction to Flintworking*. Pocatello: Idaho Museum of Natural History, 1982, p. 9.

²³ Ibid., p. 13.

²⁴ Ibid., p. 9.

whereas multidirectional cores have several striking platforms²⁵. Flakes can also be used as cores for future modification processes.

Debitage refers to all the by-products created during knapping. These flakes are usually discarded without being used as tools or modified into tools. When a flake is situated in the *chaîne opératoire*, it should be specified whether it was created during work on the core, work on shaping a tool, or a retouched flake.²⁶

Waste products are flakes that cannot be situated into *chaîne opératoire* and have no use. Their presence may be a sign of knapping activities. It may be a tiny flake created during the retouching process. Debris is a shapeless fragment that was fractured and cannot be identified. However, broken fragments can be later restored; the same cannot be said about debris. Debris differs slightly from flake waste because it lacks a distinct platform and can be shattered into tiny pieces²⁷. It also depends on the skill of the craftsman – a skilled one can detach a single piece using a single impact, while a less experienced maker can detach a piece of stone that breaks into multiple parts upon applying force. Flakes may also break while being discarded, either by being stepped on or through other processes post-disposal²⁸.

Knapping accidents are unintentional and uncontrolled phenomena that occur during splitting, shaping, or retouching due to defects in raw material or errors made by the splitter. These accidents result in the formation of characteristic products with specific morphologies, such as fractures, submerged chips, or stepped breaks, whose shapes have been documented both archaeologically and experimentally. Although prehistoric craftsmen likely learned to recognize and exploit some accidents over time, today the analysis of knapping accidents primarily helps us better understand the physical processes involved in knapping, the skill level of prehistoric craftsmen, and the cultural traditions associated with specific technologies.²⁹

3.3. TERMS IN STUDYING LITHIC

During controlled knapping, the fractures that break away exhibit characteristics of conchoidal fractures. This type of fracture typically has a smooth, curved surface whose smooth lines resemble those of shell growth. Conchoidal fractures are commonly observed in quartz

²⁵ ANDREFSKY, William Jr. *Lithics: Macroscopic Approaches to Analysis*. Cambridge: The Press Syndicate of the University of Cambridge, 1998, pp. 138-139.

²⁶ INIZAN et al. *Technology and Terminology of Knapped Stone*, p. 59.

²⁷ *Ibid.*, p. 34.

²⁸ ANDREFSKY, W. Jr. *Lithics: Macroscopic Approaches to Analysis*. Cambridge, p. 159.

²⁹ INIZAN et al. *Technology and Terminology of Knapped Stone*, pp. 34-38.

and other types of glass. Each flake produced has two sides: the ventral and the dorsal sides (Fig. 1).

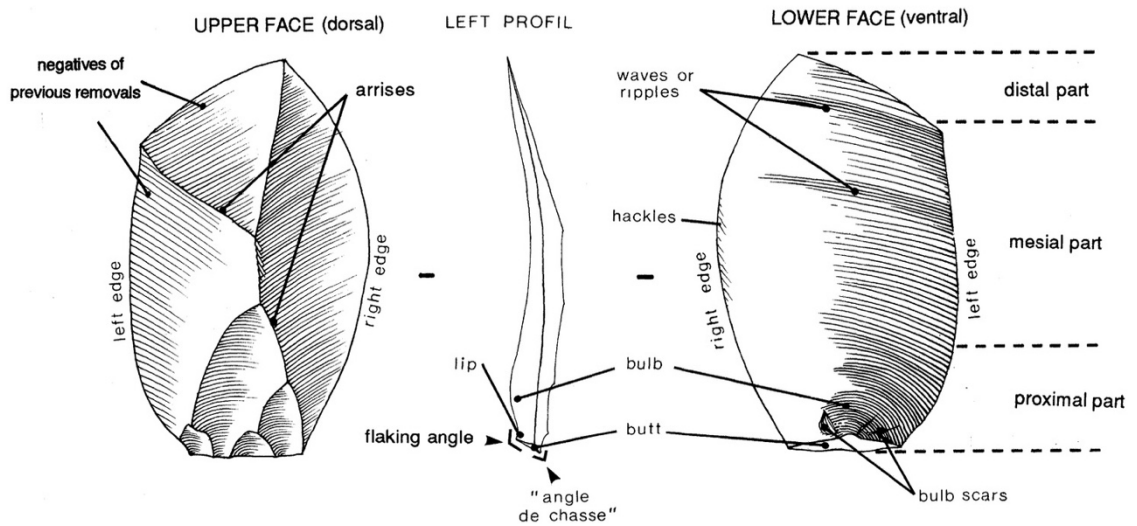


Figure 1: Schematic depiction of a lithic flake. Extracted from Inizan et al. (1999)³⁰, Fig. 5, p. 33.

The ventral side is the part that has been detached from the core by a splitting process. It has no distinctive features or marks, except for a smooth surface with soft, linear lines created by breaking away from the core. The fracture's dorsal side may already show signs of work done on the exterior, including scars from knapping and some evidence of the original exterior rock.³¹

The area where the craftsman detached the flake is referred to as a striking platform or flaking angle. There are various striking platforms: some are flat, some have multiple facets, and others may be rounded due to grinding. If a mark is present on the ventral side of the flake, it is termed a lip, which may have resulted from a soft blow or pressure impact. The proximal end is the origin of the flake, while the distal end is located on the opposite side, where the force of the blow concludes. The distal end may terminate smoothly or finish abruptly, possibly leading to a fracture.³²

3.4. TYPOLOGY OF BURINS

Burins represent a distinct category of Upper Paleolithic lithic tools, characterized by a

³⁰ INIZAN et al. *Technology and Terminology of Knapped Stone*, p. 33.

³¹ ANDREFSKY, W. Jr. *The Analysis of Stone Tool Procurement, Production, and Maintenance*. Journal of Archaeological Research, vol. 17 (2008), pp. 76-78.

³² ANDREFSKY, W. Jr. *Lithics: Macroscopic Approaches to Analysis*. Cambridge, p. 18.

chisel-like edge formed through the removal of one or more narrow flakes known as burin spalls. According to Inizan et al. (1999), this so-called burin blow can be applied by pressure or percussion—either by striking with a hammer or against a fixed support—to detach a narrow flake along a prepared edge. The result is one or more facets that may define the active part of the tool. These facets can appear in various configurations depending on the preparation of the blank, and burins may even serve as cores for the production of spalls rather than as finished tools.³³

Tomášková (1999) highlights that burins have traditionally been classified into three major types based on the technological method used to create the working edge: dihedral, truncation, and break burins. Dihedral burins are formed by intersecting two angled facets; truncation burins involve removing spalls from a truncated edge; and break burins are produced by spalling a transversely broken blank. However, Tomášková also points out that many of these categories overlap and that burins often result from a continuum of reduction strategies rather than strict typological intentions. Their frequency in assemblages and diversity in form suggest a complex role in prehistoric toolkits, whether as formal tools, cores, or intermediary forms.³⁴

Despite these typological ambiguities, burins remain a vital object of functional study due to their consistent morphology and preserved edges. Their use-wear patterns—whether on facets, tips, or lateral edges—can indicate various uses beyond engraving, including scraping and cutting.

4. MICROWEAR ANALYSIS

4.1. METHODS

Traceology, as was said earlier, focuses on trace analysis. It connects two main scientific fields, the humanities and science. Using lithic artifacts and their analysis, not only under the microscope, can help identify prehistoric cultural groups, their movement tracks, and where they settled to live. Microwear analysis is a method that can help archaeologists understand the dynamics of human behavior and the processes of cultural change³⁵. Microwear analysis aims

³³ INIZAN et al. *Technology and Terminology of Knapped Stone*, p. 84.

³⁴ TOMÁŠKOVÁ, Silvia. *What Is a Burin? Typology, Technology, and Interregional Comparison*. *Journal of Archaeological Method and Theory*, vol. 12 (2005), no. 2, pp. 86-87.

³⁵ YERKES, Richard W. – KARDULIAS, Nick P. *Recent Developments in the Analysis of Lithic Artifacts*. *Journal of Archaeological Research*, vol. 1 (1993), no. 2, p. 90.

to identify the functions of stone tools by closely examining their edges for direct evidence of use.³⁶

In the 1930s, Semenov used microscopic examinations via a binocular microscope to look for traces on the surface of tools or flint. He stated that some were visible to the eye, sufficiently large, but some could be only detected using magnification. Lawrence Keeley noted that microwear analysis was the most effective while using the high-magnifying technique, also called the High-Power Approach (HPA), using an incident light microscope with magnification ranging from 100x up to 500x.³⁷ While Keeley highlighted the high-magnifying technology on polishes to determine which material the tools were used on, George Odell's (1977) research was based on a low-magnifying technique called the Low Power Approach (LPA), using a binocular microscope with magnification typically between 20x to 100x. He tried to determine the tools and actions that they were used for – slicing, cutting, sawing, and what materials they were used on – hard or soft ones³⁸. Nowadays, those two approaches – LPA and HPA – are typically used together.

In connection with these methods, wear marks are generally categorized into two types: macroscopic and microscopic. Macroscopic wear includes damage to edges and rounding of edges, which provide information about the kind of movement (e.g., cutting or scraping) and the approximate hardness of the worked material. Microscopic wear, including polishing, scratches, and residues, enables more accurate identification of the specific machined material.³⁹

Analyzing the tool may be difficult because many artifacts interact with other materials, leaving traces on their surfaces. The stone's properties must also be taken into consideration. Due to various kinds of retouching and patination, traces might be covered or distorted. But those are not the only damages done to the surface. A. L. van Gijn stated that several types of damage could be inflicted upon the tool: edge removal/retouch (edges may be fractured by not only the impact of a worked material), edge-rounding, polish, and striation. Residues and patination are also a part of surface modification, which will be included.⁴⁰

³⁶ ANDREFSKY, W. Jr. *Lithics: Macroscopic Approaches to Analysis*. Cambridge, p. 5.

³⁷ KEELEY, Lawrence H. *Technique and methodology in microwear studies: a critical review*. *World Archaeology*, vol. 5 (1974), no. 3, pp. 323–336.

³⁸ ANDREFSKY, W. Jr. *Lithics: Macroscopic Approaches to Analysis*. Cambridge, p. 5.

³⁹ FISCHER, Anders – HANSEN, Peter Vemming – RASMUSSEN, Peter. *Macro and Micro Wear Traces on Lithic Projectile Points: Experimental Results and Prehistoric Examples*. *Journal of Danish Archaeology*, pp. 22–28.

⁴⁰ GIJN, Annelou van. *The Wear and Tear of Flint: Principles of Functional Analysis Applied to Dutch Neolithic Assemblages*. Leiden: Universiteit Leiden, 1990, pp. 3–9.

4.2. POSSIBILITIES AND LIMITATIONS OF EXPERIMENTAL TRACEOLOGY

One of the main questions that repeatedly arose during the experiment was the length of the experiment itself and whether twenty minutes of work on each material was sufficient to create comparable and legible traces. When preparing the experiment, a minimum duration of twenty minutes was selected for working with each tool, partly due to time constraints, but also as a rough estimate of the time frame in which the first signs of wear should become apparent. The results show that after this time, some signs of interaction with the material became evident, including the presence of polish on the edges, small chip-away spots, visible edge-rounding of the burin's work edge, and the presence of residues. However, work with most of the tools exceeded the established minimum limit, in several cases lasting up to about an hour. The results of the experiment indicated that after just twenty minutes of work, legible traces appeared on the tools, which could be further analyzed. For trace comparison, this duration can be considered adequate. In some cases, where working time was extended, this led to more intense traces; however, the basic type of wear was already visible after the recommended minimum time. For future experiments, I recommend working with the tools for at least twenty minutes, with longer working times allowing finer differences to be detected.

As for the scope of the material and the actual number of burins analyzed, the number of samples I worked with was more than sufficient for the purposes of this experiment. Each burin was used on a different raw material, allowing me to observe various types of wear and better understand how these traces vary depending on the material and type of movement. Although some might argue that a larger number of samples would have yielded more representative results, it was more important to document each step in detail so that I could return to each tool with a specific comparison in mind. Another researcher who decides to expand this research may obtain different results, especially when working with a larger sample or a broader selection of raw materials. However, for my purpose, which was to examine the fundamental legitimacy of traces and their possible correspondence with archaeological material, the scope of this experiment was sufficient. Although the analyzed sample is relatively small, this was a deliberate choice. Why was such a limited number of archaeological burins selected for the study? Due to the time-consuming nature of microscopic analysis, each tool required more than two hours of detailed examination, including the observation of its entire surface rather than just selected areas. Additional time was also needed for scanning and documentation, which further restricted the number of artifacts that could be processed within

the available timeframe.

Looking back, I managed to uncover several key findings that may be useful for further research in the field of traceological analysis. Firstly, it became apparent that even short-term use of stone tools on various raw materials, even in domestic settings and with a limited number of burins, can lead to the creation of clearly visible wear traces. In some cases, these traces were so pronounced that their presence was noticeable even without the aid of a microscope. At the same time, during microscopic analysis, I observed similarities between the experimental and archaeological burins, especially when examining them with wood and slate. These similarities do not indicate mere coincidence but instead open up space for deeper interpretation, such as a hypothesis about the specific use of the archaeological burins. Although it is not possible to reach a definitive conclusion in some cases, these findings contribute to a better understanding of how wear is created, what it looks like, and how it can be analyzed effectively in the future.

5. OVERVIEW OF WEAR TRACES

5.1. POLISH

Polish is a crucial feature in microwear analysis, providing valuable information about the materials worked by prehistoric tools. However, it remains a complex phenomenon, partly because it is challenging to distinguish polish from residues, and the mechanism of its formation is still debated. Meeks et al. (1982) argue that sickle gloss results primarily from mechanical friction rather than the accumulation of silica on the tool's surface.⁴¹ Van Gijn (1990) defines polish pragmatically as “*everything which cannot be washed off with soap and water*”⁴², but notes that many plant juices, blood residues, and other greasy substances cannot be removed solely by washing.

Two main hypotheses account for the formation of polish: the abrasive model, which indicates that physical abrasion occurs between the tool and the material, and the additive or silica gel model, which suggests that a thin amorphous silica film develops on the surface through chemical reactions during use.⁴³

In microwear analysis, polish characteristics are carefully studied because they offer

⁴¹ MEEKS, Nigel D. – SIEVEKING, G. de G. – TITE, M. – COOK, J. *Gloss and use-wear traces on flint sickles and similar phenomena*. Journal of Archaeological Science, vol. 9 (1982), pp. 317–340.

⁴² GIJN, Annelou van. *The Wear and Tear of Flint: Principles of Functional Analysis Applied to Dutch Neolithic Assemblages*. Leiden: Universiteit Leiden, 1990, p. 5.

⁴³ SCHMIDT, Patrick – RODRIGUEZ, Alice – YANAMANDRA, Kaushik - K. BEHERA, Rakesh – IOVITA, Radu. *The mineralogy and structure of use-wear polish on chert*. Scientific Reports, p. 1.

insights into the nature of contact materials. Different materials tend to produce distinct types of polish. Bone and antler working typically creates a bright, smooth polish with a domed appearance, often with a high gloss. Fresh hide produces a dull, rough polish that can have a matte-like texture, while dry hide results in a similarly dull surface with roughness and sometimes rounding of tool edges due to extensive use. Woodworking activities generate a matte, striated, and pitted polish, reflecting the fibrous structure of wood.⁴⁴

Despite these general tendencies, polish characteristics are not entirely exclusive to specific materials. There is considerable overlap in polish appearance, and external factors such as taphonomic processes can further complicate interpretations. Therefore, polish must be analyzed alongside the other microwear traces such as striations and edge damage to ensure a more reliable functional interpretation.⁴⁵

5.2. STRIATIONS

Striations typically occur when a scratching agent produces small scars along the edges, which is common for hard materials processing. It is challenging to find striation marks on the tool's handle, as they do not have a definite point of occurrence.⁴⁶ One element primarily associated with them is foreign particles between the flint's surface and the material being worked on, such as sand and dust. The second type is micro flakes removed from the edge during work and leaving marks.⁴⁷

Some forms of striations resulted from being used on hard materials, such as stone. These lines are usually sharp and can be detected without the use of any equipment. If the tool was used on softer materials, such as wood or antlers, striation lines and scratches can be seen with the aid of magnifying devices. Additionally, their depth and arrangement can differ. Through analysis, one can identify the contact material and gain a clearer understanding of the specific work activities that have been performed in the past.⁴⁸

They can also result from natural phenomena, such as being discarded on sandy or stony layers. Being left on sandy layers resulted in short, narrow, dark, and superficial striations.

⁴⁴ BECKER, M. a WENDORF, F. *A Microwear Study of a Late Pleistocene Qadan Assemblage from Southern Egypt*. Journal of Field Archaeology, vol. 20 (1993), no. 4, pp. 389–398.

⁴⁵ GIJN, A. L. van. *Not at all obsolete! The use of flint in the Bronze Age Netherlands*. In ERIKSEN, B. V., *Lithic Technology in Metal Using Societies*, 2010, pp. 45-59.

⁴⁶ SEMENOV, S. A. *Prehistoric Technology: An Experimental Study of the Oldest Tools and Artefacts from Traces of Manufacture and Wear*, p. 4.

⁴⁷ MANSUR, María Estela. *Microwear Analysis of Natural and Use Striations: New Clues to the Mechanism of Striation Formation*. Studia Praehistorica Belgica, vol. 2 (1982), p. 216.

⁴⁸ SEMENOV, S. A. *Prehistoric Technology: An Experimental Study of the Oldest Tools and Artefacts from Traces of Manufacture and Wear*, p. 4.

Meanwhile, the ones that were left on a stony layer, although also superficial, showed multiple parallel-running tracks and were of two different types: on one side, rough-bottomed, narrow, and shallow; or on the other side, wide, long, and sometimes smooth-bottomed.⁴⁹

5.3. EDGE DAMAGE

The term “edge damage” refers to traces of wear on the edge of a stone tool that occur during its use. Typically, these are micro-fragments, step-terminating fractures, bending fractures, or small chips that can be observed macroscopically or under a microscope. These traces can result from activities such as cutting, scraping, stabbing, or striking, and serve as a valuable indicator of the tool's function. The origin and form of edge damage depend on a combination of factors, including the material's hardness, the direction and intensity of the applied force, and the tool's usage time.

Claud et al. (2019) emphasize in their analysis of Paleolithic tools that similar types of damage can occur during different activities. For example, step fractures can occur both when slaughtering animals with accidental contact with bones and when scraping tough wood. It is therefore essential to analyze edge damage within the broader context of the find, particularly in relation to faunal remains, tool types, and the results of experimental studies. The interpretation of these traces is therefore not straightforward and requires comparison with experimentally obtained patterns. Only then can it be determined whether the damage was caused by cutting meat, preparing a retoucher, or using it as a weapon. The professional literature also often points out that certain types of damage (e.g., broken tips) may result from post-depositional processes, such as trampling, and do not necessarily indicate a specific function.⁵⁰

5.4. EDGE-ROUNDING

Edge-rounding is the fourth type of damage inflicted on the tool's surface, caused by basically any contact with the material it was worked on. To some extent, the degree of rounding can give clues as to what material the tool has encountered.⁵¹

Although various contact materials that induce tool edge alteration differ in hardness and abrasiveness, even softer or medium-hard materials like wood, soil, or dry clay can lead to

⁴⁹ MANSUR, M. E. *Microwear Analysis of Natural and Use Striations: New Clues to the Mechanism of Striation Formation*, p. 217.

⁵⁰ CLAUD, Émilie et al. *The use-wear studies on the lithic industries*. *Palethnologie*, 2019, no. 10.

⁵¹ GIJN, Annelou van. *The Wear and Tear of Flint: Principles of Functional Analysis Applied to Dutch Neolithic Assemblages*. Leiden: Universiteit Leiden, 1990, p. 8.

noticeable edge wear with extended or repeated use. Edge-rounding matters, particularly in terms of how long the tool was used, the angle of the edge, and the chosen movement. Abrasion is frequently confused with edge-rounding. However, abrasion represents the unintentional loss of small portions of an artifact's material after it is deposited. The absence of deliberate fractures characterizes it, while the surface may be uneven and bumpy.⁵²

5.5. PATINATION

One of the other possible marks left on the surface is called patination. It is the most fundamental change that the tool goes through due to natural causes. Patina makes the tool look shiny, but it is a chemical process that can also cause deterioration and damage or alter the stone entirely.⁵³ All types of patina can complicate the analysis or even make it impossible due to their coloration and surface alteration. High levels of patination often hinder the identification of microwear traces, particularly polish, because the original surface is obscured. However, macrowear analysis—especially the observation of edge damage—is usually still feasible, even if the artifact is heavily patinated⁵⁴. There can also be multiple patinas on one tool, showing the sequence of modifications to the tool.⁵⁵

5.6. RESIDUES

The last type of alternation that occurs while using flint is the deposition of residues on the tool's edges. As mentioned before, it is difficult to recognize polish from residue. An example by van Gijn (1990) raises a question: “*For instance, are the plant-phytoliths, sometimes present in 'sickle-sheen', to be included in the category residue or polish?*”⁵⁶. Residues are also challenging to identify because they do not stay on the surface of the tool for long. Under the soil and with water, residues can be “washed away.” Microorganisms also consume the organic residues left behind; at times, these residues can even be absorbed into clay soil. Although residue analysis constitutes an independent and well-developed area within traceological research, its in-depth exploration lies beyond the current focus of this study.

⁵²HRONÍKOVÁ, Linda. *Traseologická analýza neolitické štípané industrie z lokalit Bylany, Miskovice, Mšeno a Tachlovice*. Prague, 2010. Doctoral dissertation. Charles University, Faculty of Humanities, pp. 52-53.

⁵³ SEMENOV, S. A. *Prehistoric Technology: An Experimental Study of the Oldest Tools and Artefacts from Traces of Manufacture and Wear*, pp. 11-12.

⁵⁴ HRONÍKOVÁ, Linda. *Traseologická analýza neolitické štípané industrie z lokalit Bylany, Miskovice, Mšeno a Tachlovice*. Prague, 2010. Doctoral dissertation. Charles University, Faculty of Humanities, p. 54.

⁵⁵ INIZAN et al. *Technology and Terminology of Knapped Stone*, p. 92.

⁵⁶ GIJN, Annelou van. *The Wear and Tear of Flint: Principles of Functional Analysis Applied to Dutch Neolithic Assemblages*. Leiden: Universiteit Leiden, 1990, p. 8.

6. LOCATION AND MATERIAL

The Magdalenian represents one of the most significant phases of the Upper Paleolithic in Central Europe. Its origins are usually traced to southwest France, approximately 18,000 years ago, from where it spread throughout western and central Europe in a relatively short period. In Central Europe, especially in Poland, Moravia, and Silesia, its presence can be documented in several regional settlement “provinces”. For example, the Magdalenian settlement in the Maszycka cave in Poland is dated to approximately 14,250 ± 240 years BP. The subsequent settlement mainly falls within the period between 15,500 and 13,000 years BP, specifically at the end of the last glacial period, during the Bølling and Allerød phases.⁵⁷

The Hostim site in the Beroun district of Central Bohemia is one of the most essential Early Paleolithic sites in the Czech Republic. It is in the Bohemian Karst, approximately 110–130 meters from the Berounka River, at an altitude of 255–260 meters above sea level. Its location in a side valley provided natural protection from the wind and may have played an essential role in the settlement of Central Europe during the Magdalenian period. The site was first recorded during surface collection in the 1940s by J. Petrbok and F. Prošek, with systematic research conducted by Slavomil Vencl from 1963 to 1969.⁵⁸ During this research, almost 300 m² were uncovered, and a rich collection of artifacts was obtained, including chipped stone tools, animal bones, charcoal, engraved and painted stone plates with animal motifs, ochres, and various stone tools such as bowls, hammers, and retouched blades.

The Magdalenian layer was identified at a depth of 5–80 cm, exhibiting signs of redeposition in some areas, but most of the finds were recovered from a stratified context. The absence of bone tools and triangular points, together with the presence of rectangular and shortened dorsal blades, helped to place the site in the early Magdalenian period chronologically. Vencl originally dated the site to between 16,500 - 14,000 years BP, but current calibrated data place it more likely in the interval 15,500–14,000 years BP.⁵⁹ More recent radiocarbon data also indicate repeated use of the site, which increases the significance of the archaeological assemblage preserved here.

⁵⁷ POŁTOWICZ, Marta. *The Magdalenian period in Poland and neighbouring areas*. Archaeologia Baltica, 2006, 7.2: pp. 21-28.

⁵⁸ VENCL, Slavomil. *Hostim: Magdalenian in Bohemia*. Praha: Institute of Archaeology, Czech Academy of Sciences. Památky archeologické – Supplementum 4. 1995, pp. 13-16.

⁵⁹ KAPUSTKA, Katarína – KOŠTOVÁ, Nikola – KOVAČIKOVÁ, Lenka – ZAZVONILOVÁ, Eliška – FLORIÁNOVÁ, Simona. *The Magdalenian Site of Hostim, Czech Republic, Central Europe: New Insights into the Old Record: Seasonality Within the Bohemian Magdalenian*. 2023, p. 4-7.

The inventory includes over 16,000 stone artefacts and represents a typical Magdalenian industry. The most frequently identified artifacts are retouched blades, comb-shaped microliths, scrapers, and burins, with the latter constituting a significant portion of the analyzed collection.

The burins originate from well-documented stratigraphic contexts, and their classification as Magdalenian is based on a combination of stratigraphic evidence, typological features, and comparisons with parallel sites. Hostim thus provides a reliable basis for studying the functional aspects of the Late Paleolithic chipped industry.



Figure 2: Archaeological burins. Photo by author.

6.1. MATERIALS

For the purposes of this work, a collection of lithic tools from the Hostim site was analyzed. A total of 267 m² was excavated during systematic archaeological research conducted between 1963 and 1969, yielding 16,528 pieces of lithics. This collection mainly includes blades, scrapers, burins, drills, points, and microliths. Based on the current analyses, burins represent approximately 8,73% of all finds, which corresponds to roughly 1,443 burins.⁶⁰

⁶⁰ VENCL, Slavomil. *Hostim: Magdalenian in Bohemia*, pp. 32-65.

The distribution of burins shows an increased concentration in the central residential area of the settlement, defined by quadrants 51-200, where the concentration of artifacts exceeded 100 pieces/m². The highest concentration of burins was recorded in quadrant 81, where up to five pieces were identified. Burins appear both as separate tools and as part of combined artifacts, with sector 101-150 m² showing the highest percentage of burins (24.82%).⁶¹

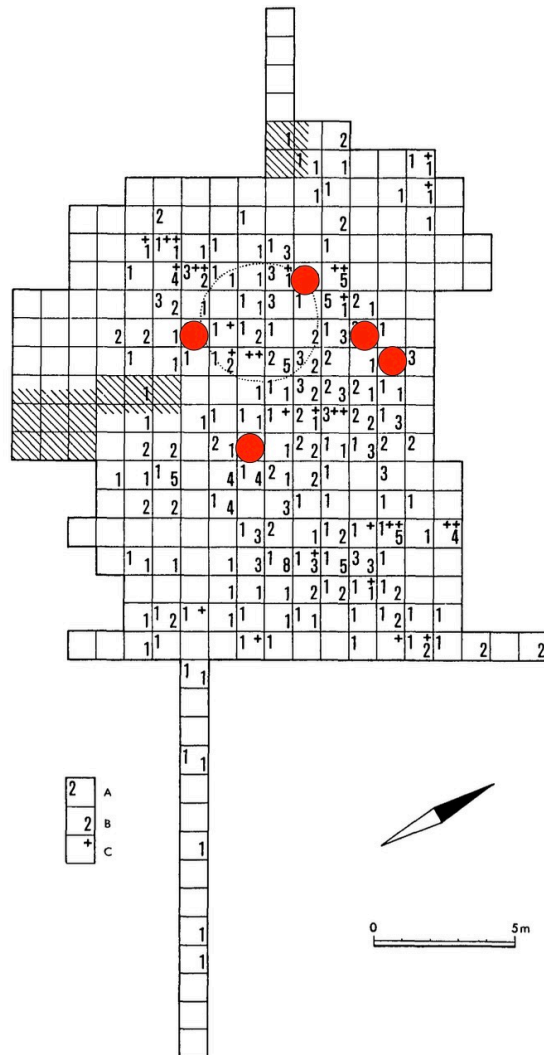


Figure 3: Spatial distribution of burins (A), burin spalls (B), and burins in combined tools (C) at the site of Hostim. The dotted line marks the outline of the dwelling ground plan. Adapted from Vencl (1995, p. 71, Fig. 28).

A set of five burins, marked A35, E68, E95, E98, and E104, was selected for detailed experimental use-wear analysis. The artifact distribution map (refer to Fig. 3) indicates the precise locations of five of these burins, which are highlighted at the point marked in red. The burin marked XX00 could not be located due to the absence of a registration number in the

⁶¹ Ibid., pp. 66-112.

available documentation. Localizing this artifact would require a detailed review of the entire site inventory, which is beyond the scope of this work.

The research was carried out according to the standard methods of the time – the area was divided into 1 x 1 meter squares, and the sediment was removed in 5 cm layers using small tools. The material was not wet sieved, which may have affected the capture of minor artifacts. Hostim was initially interpreted as a single settlement, probably a camp under a tent structure.⁶² However, more recent radiocarbon data indicate repeated use of the site, retrospectively increasing the significance of the preserved lithic assemblage as evidence of repetitive use of the site.⁶³

7. EXPERIMENT

In the following part of the thesis, I will focus on the experiment used to create and subsequently analyze the traces of use on lithic. Here I present the materials used, the specific activities carried out with the tools, the methods of trace monitoring, and reflections on the reliability and repeatability of the procedure.

7.1. MATERIAL AND TOOLS PREPARATION

For the experimental analysis, tools made of a pre-selected lithic material were used, whose properties meet the requirements for comparability with the archaeological finds and allow the observation of traces of use in different working contexts.

One of the key raw materials used for making chipped stone tools in Central Europe is siliceous rocks, commonly known as flints. Although the term "flint" is technically accurate only for Maastrichtian-age rocks, Přichystal (2009) proposed the broader term "silicites of glacial sediments" to capture their origin and diversity better. Transported by glaciers during the Würm glaciation, these materials are often found as large pebbles or cobbles, some weighing several dozen kilograms. In Moravia, eastern Czech Republic, glacial silicites were essential for prehistoric communities and are well-documented in archaeological sites. Their delicate texture and conchoidal fracture make them ideal for tool production, making them suitable for both functional and traceological analysis. In this study, we focused on artifacts crafted from erratic flint, chosen for its homogeneous structure, which allows for predictable fracturing and

⁶² Ibid., pp. 24-26.

⁶³ KAPUSTKA, K. et al. *The Magdalenian Site of Hostim, Czech Republic, Central Europe: New Insights into the Old Record: Seasonality Within the Bohemian Magdalenian*. 2023, p. 3-4.

sharp edge formation. This quality made flint a popular material for toolmaking in the Paleolithic period, contributing to its prevalence in Central European archaeology.⁶⁴

The material was already obtained in a worked form through collaboration with Petr Zítka, who specializes in replicating prehistoric, knapped tools. His years of experience are positively reflected in the quality of the individual pieces. All the instruments were created using the soft hammer technique, which involves gentle striking, and the resulting assembly showcases a high level of technical craftsmanship and consistency.

In total, exactly 30 experimental instruments were produced. These artifacts were divided into two groups: one part was used in a functional experiment, while the other half was left aside. The actively used tools were further divided into three groups based on their size: small, medium, and large. This division has been deliberately introduced to observe how the different sizes affect tool handling, ergonomics, and sustainability for specific work activities during the experiment.

Small burins had an average height of 38.02 mm, an average width of 21.25 mm, and an average thickness of 5.73 mm, which falls within the small category (see Figure 4).

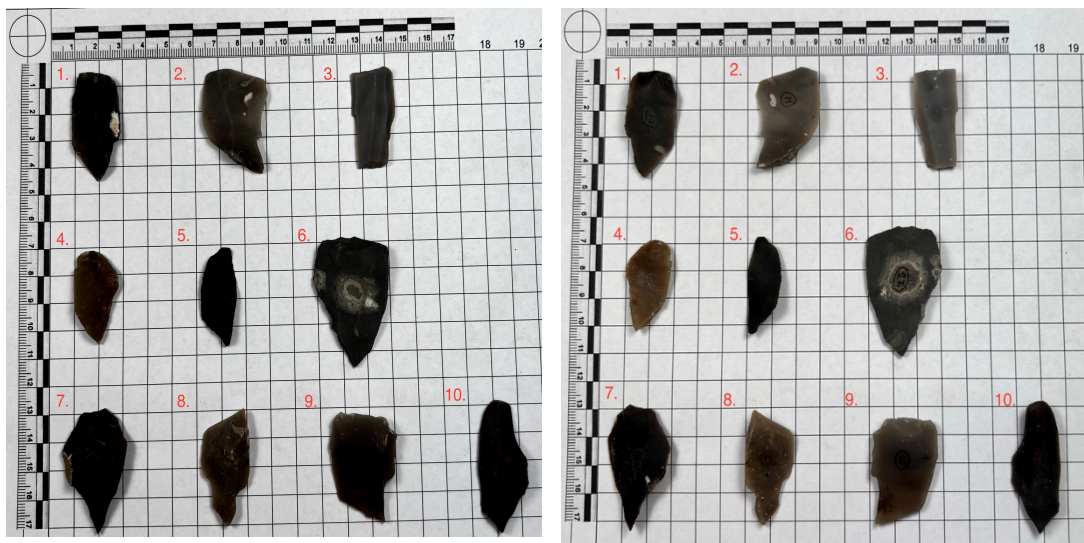


Figure 4: Small burins. Photo by author.

Medium burins had an average height of 50.70 mm, an average width of 21.38 mm, and an average thickness of 6.97 mm (see Figure 5).

⁶⁴ PŘICHYSTAL, Antonín. *Lithic Raw Materials in Prehistoric Times*, Brno: Masaryk University, 2013, pp. 51–54.

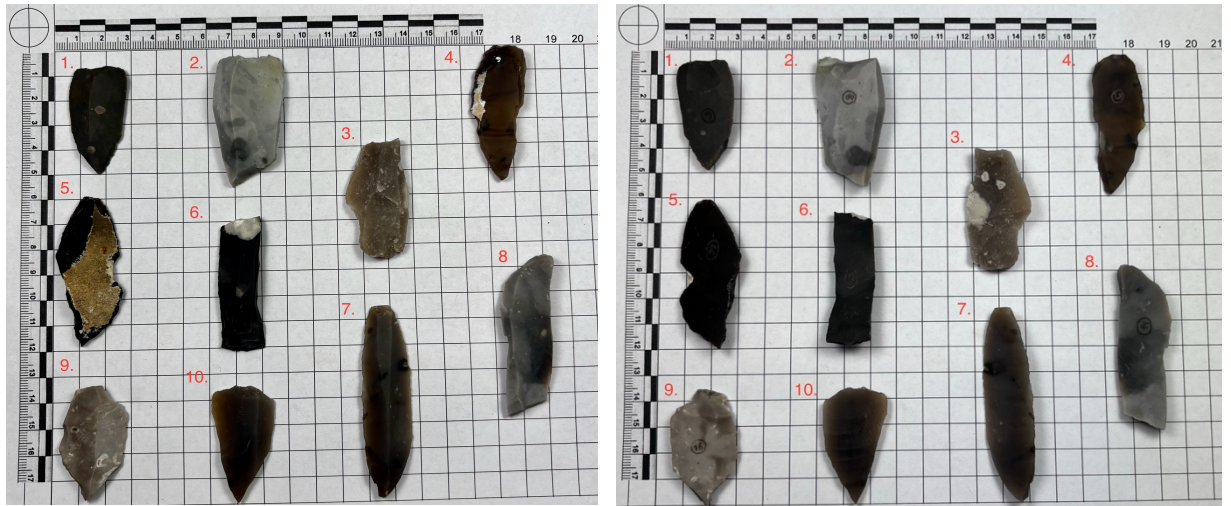


Figure 5: Medium burins. Photo by author.

Large burins had an average height of 72.97 mm, an average width of 22.27 mm, and an average thickness of 6.57 mm. Each category contains exactly ten burins (see Figure 6).

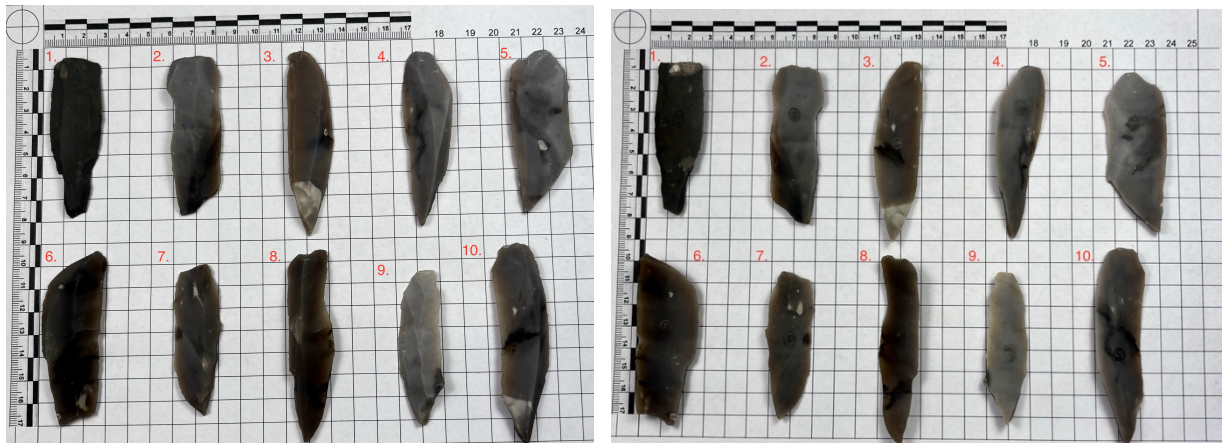


Figure 6: Large burins. Photo by author.

During testing, I focused on which sizes felt most comfortable in the hand, how they naturally responded to different movements, and their functional potential for scraping, cutting, or counterstriking. The way the tool set was categorized established a crucial framework for future comparisons of use traces based on tool shape and size.

Before the experiment, all instruments were carefully stored and accounted for. Each piece was numbered so the subsequent traces could be assigned to a specific tool and work activity. This record-keeping not only ensured the experiment's control and repeatability but also served as a basis for later microscopic analyses, which require an accurate knowledge of each tool's history. Due to the high quality of the lithic material, the analysis could mainly concentrate on use traces, free from significant biases stemming from manufacturing

technology flaws.

Finally, it must be emphasized that the selection and preparation of the material were guided by the desire to create as close to controlled and realistic conditions as possible, which would allow later comparison with archaeological material, especially with tools from the Hostim site.

Burin number	Material	Date	Processing time	Height	Width	Thickness
30	Slate	05.02.2025	40 minutes	34.51	14.39	4.29
18	Slate	05.02.2025	60 minutes	42.17	23.06	5.08
15	Slate	05.02.2025	40 minutes	79.46	19.6	7.9
17	Slate	05.02.2025	50 minutes	69.81	23.3	5.73
4	Wood	08.02.2025	25 minutes	44.23	18.31	4.62
6	Wood	08.02.2025	30 minutes	41.68	21.85	6.45
19	Wood	08.02.2025	30 minutes	63.27	19.84	5.96
29	Bone	01.03.2025	30 minutes	39.14	19.0	7.18
14	Bone	01.03.2025	30 minutes	62.23	18.82	7.86
27	Bone	01.03.2025	20 minutes	71.09	27.57	4.84
22	Antlers	03.02.2025	40 minutes	45.07	29.93	7.4
8	Antlers	04.02.2025	40 minutes	48.93	26.27	11.19
1	Antlers	03.02.2025	40 minutes	70.35	18.12	6.8
24	Antlers	03.02.2025	30 minutes	69.1	23.01	5.61

Figure 7: Table of burins worked on by material, including usage date, working time, and measured dimensions in millimeters

7.2. PROCESS OF EXPERIMENTAL ACTIVITIES

The experimental component of the research aimed to verify the practical applicability of lithic stone tools, specifically burin-type tools, used for creating engravings on various materials. The objective was not only to confirm a single function of the tool based on its typological classification but primarily to explore its functional variability, ergonomics, and interactions with different organic and inorganic materials under simulated conditions that mimic real use in prehistoric environments.

Although the set of experimental artifacts consisted exclusively of tools referred to here as burins, I did not limit their use to only engraving and perforating. On the contrary, I consciously worked with the assumption that prehistoric tools did not have to serve only one clearly defined function but could be used adaptively according to the user's needs of the moment. I took inspiration from the chaîne opératoire approach, which understands tools as a part of a broader process during which their functions could have been modified, altered, or repeatedly adapted. In this sense, I tested individual burins in various working contexts besides

engraving. I employed these tools for cutting, scraping, and drilling tasks, affirming their potential for multifunctional use. This methodology aligns more closely with the understanding that prehistoric material culture was not static but instead responded flexibly to the needs of the user and the characteristics of the material being manipulated.⁶⁵

I selected one representative tool from each size category – one small, one medium, and one large – with which I then worked for a specific type of raw material. Four types of material were selected for testing: bone, antler, slate, and wood, specifically birch wood. These raw materials were selected based on their relevance to the prehistoric environment – they represent commonly available sources that prehistoric people demonstrably worked with and were also well preserved in the archaeological record.⁶⁶ However, these materials represent a different type of resistance and structure: from hard and fibrous bone to porous but rigid antlers to a relatively brittle slate and soft but flexible wood, if only used for hafting (handling).⁶⁷

After completing the first testing phase, I made a subjective assessment of the ergonomics and effectiveness of the tool – i.e., how well the size worked and how suitable it seemed for the activity. Based on this evaluation, I selected another burin from the same size category with which I worked the raw material again. In this way, I used a minimum of three burins for each raw material (see Figure 4). In some cases, especially for slate and antler, I tested more than one specimen to check the repeatability of the marks or compare details.

The time allotment for each activity ranged from approximately 20 to 60 minutes (see Figure 4), depending on the material being worked on. In one case, the task reached the upper limit of this range, particularly when attempting to shape a specific object. This included creating a button from slate, with a drilled hole.⁶⁸ With other materials, I concentrated more on generating representative marks through repetitive movement – engraving lines, scratching into the surface, outlining, and hollowing. When working with wood and bone, I also tried multiple types of tool grip, including holding the tool “flat” or at an angle, which directly affected how the tool dug into the material and the marks it left behind.⁶⁹

⁶⁵ ROTS, Veerle. *Prehension and hafting traces on flint tools: A methodology*. Leuven: Leuven University Press, 2010, p. 23.

⁶⁶ PYŻEWICZ, Katarzyna – WIŚNIEWSKI, Tadeusz. *Biographies of the Magdalenian Lithic Tools from Klementowice*. Brunswick, Germany: 56th Annual Meeting of the Hugo Obermaier Society, 22–26 April 2014. Poznań–Lublin: Adam Mickiewicz University – Maria Curie-Skłodowska University, 2014.

⁶⁷ ROTS, Veerle. *Prehension and hafting traces on flint tools: A methodology*. Leuven: Leuven University Press, 2010, p. 15.

⁶⁸ LINDNER, Christopher and FOLB, Lisa. Lopuch 3 and microdrills: site report and use-wear analysis. *Archaeology of Eastern North America*, vol. 26 (1998), p. 122.

⁶⁹ ROTS, Veerle. *Prehension and hafting traces on flint tools: A methodology*. Leuven: Leuven University Press, 2010, pp. 9-14.

I carefully documented each stage of the experiment in notes. I recorded the beginning and end of each working sequence, a brief description of the activity, the type of raw material, the tool used (by assigned number and designation), and any complications. I also noted subjective perceptions, such as ease of handling, hand fatigue, and material adhesion. This information is essential for analyzing outcomes and identifying subtle differences after usage.

All experimental activities were conducted indoors, which offered ample space and tranquility for focused work. To prevent the tool's grip from being compromised by sweat, I used rubber-coated work gloves at the start of the experiment. Later, I replaced them with a colorless version with the exact grip to minimize the possible transfer of dirt to the surface of the tools. During the subsequent microscopic analysis, I noticed a green coloration on one of the tools that was not present on the others. Reflecting on the timing and conditions of the experiment, I concluded that the trace originated from the original pair of gloves. This finding illustrates that even short contact with external materials can leave recognizable marks on a tool's surface. Although the marks should have been removed by washing before microscopic analysis, as is standard protocol in professional traceological studies, I chose not to clean the tool in this case, as the residues did not interfere with the observation of edge wear traces.

During the experiment, movements when working with tools were not strictly defined in advance. Still, they were adapted according to the properties of the material being worked on and the type of activity. This approach better corresponds to the real use of tools in prehistory, where the way a tool was handled depended on the physical properties of the material and the desired result of the work. A similar approach was employed, for example, in experimental studies focused on traceology, where the variability of movements and the type of material played a crucial role in interpreting the results.⁷⁰

7.2.1. ANTLERS

Working with antlers as a raw material presented a significant challenge due to their complex structure and durability. Antlers are an organic material that, unlike bone, is more porous but elastic and hard. Working with them was difficult at first because of their hardness; despite soaking the antlers overnight in water, the softening was only partial. Due to the age of the antlers, the water probably did not penetrate deeply enough, so the structure remained very compact at the core. Still, it worked relatively well overall. I tried various methods using the tools, mainly for cutting and scraping, which was done surprisingly efficiently. However,

⁷⁰ Ibid., p. 23.

working on the surface of the antlers proved problematic for me. Although we know from archaeological finds that in some cases the antlers were decorated with engraved motifs, in my case, this method proved to be ineffective.

I tried to make a simple needle from the tip of the antler. The result was somewhat crude — the needle was sharp at the tip, yet its body remained thick and solid. An attempt to drill a hole for threading proved unsuccessful, as the hard and dry antler offered a high resistance to my advances even after several minutes of work. During the machining process, small fragments of the material detached from the main body, resulting in some regions of the antlers crumbling, while fine dust settled on the tool and in my workspace. Even after the initial working process, the stone tool displayed residue containing the antler particles.

Due to the hardness of the material, I also noticed visible damage to the stone tool while cutting the antlers. Even to the naked eye, some edge-removal and edge-rounding were evident, which will be further documented through photographs and analyzed under a microscope. These traces suggest that the antlers likely played an essential role in the wear of tools, helping to create clear diagnostic features.

Regarding tool use, the medium-sized variants proved to be the most practical in creating the needle, allowing sufficient pressure and reasonable movement control. I also used the small tool, but it was too small to machine a larger area effectively. On the other hand, it proved helpful for sharpening the tip of the needle, as the size gave me precise control in my hand. However, I chose a medium-sized tool for the final shaping, as it fit the best in my hand – it was long enough to not slip out of my hand when cutting, yet it did not protrude or get in the way, making it the most efficient option for precision work.

7.2.2. BONE

Working with bone was less comfortable than the other materials tested. Although skull bone is not the most appropriate material for experimental work with burins, since such tools were more likely used on long bones, I only had an older deer skull available at the time. Before the experiment, I anticipated that its compact and dense structure would still offer sufficient resistance to produce observable use-wear traces on the tool's surface. However, the bone was not only hard but also dried out and brittle in places, which allowed me to engrave my way through to the opposite side of the skull bone after a while.

Due to the skull's specific shape and nature, I concentrated solely on engraving as I worked. Other types of work, such as cutting, were practically impossible here. The material's hardness allowed for the creation of marks, but any significant decoration would have been

very time-consuming and required considerable physical effort.

Working with the small tool was once again problematic in terms of ergonomics. When engraving, I only had the tool between my fingers, which led to frequent slippage and loss of control over the direction of movement. The large tool was sturdy enough, but the length meant that I had to rest it on the knuckles of my hand. This led to reduced stability and difficult control as only the tool tip moved, while the body remained unnaturally fixed. Therefore, medium-sized instruments proved to be the most suitable again. These allowed for adequate pressure and a stable grip across the whole palm, giving control over not just one point but the entire tool. This was essential when engraving into the bone surface.

7.2.3. SLATE

During the experiment, slate proved to be the most pleasant raw material for working on. Compared to antlers or bone, it was softer and more pliable, allowing for relatively quick and efficient work. At the initial stage, I modified the slate into a specific shape, trying to create a simple bead – the result turned out to look more like a button. Unlike previous materials, it was no problem to drill a hole in it, which was easily accomplished with minimal pressure or force.

In addition to shaping, I tried to engrave a simple motif into the surface of the slate. In this case, the tool was very smooth to work with – the tool glided over the surface, did not snap, and there were no sudden brakes. The image transferred well into the material, but its visibility depends on the light – it almost disappears under direct illumination and only becomes legible when viewed at a certain angle.

Unlike antlers or bone, slate did not cause any significant damage to the tool – no chipping or rounding was noted. Instead, there was a tendency for the tool to slide gently across the surface. At the same time, the material was sufficiently cohesive to prevent unwanted breakage during working. The only disadvantage of the slate was the fine black dust released when scraping and engraving, leaving a mess around the work area and on the tools themselves.

In terms of tool ergonomics, there was no significant difference between sizes – the low resistance of the material made it easy to work with both small and medium tools, and excessive pressure was not required. If more force were used, the tool might chip away better, making the image more transparent. This experience confirms once again that the nature of the raw material being machined significantly influences the formation of marks, how the tool is handled, and the preferred tool size.

7.2.4. WOOD (BIRCH)

Wood proved to be a very suitable material for machining during the experiment. Working with it was smooth and, to some extent, enjoyable, but it presented some difficulties, especially concerning its texture and moisture content. Initially, I focused on working the wood itself (not the bark), specifically birch. The tree was young and freshly cut, but the bark was still damp and hard. This made it difficult to carve and limited the visibility of the marks left by the stone tool, which were not very noticeable at this stage. The choice of birch was not accidental – birch (along with pine) was the dominant component of vegetation in the late Paleolithic and early Mesolithic periods in Central Europe, when forests gradually replaced the previous cold steppes as a result of climate change at the end of the Pleistocene⁷¹.

Therefore, I gradually moved on to working the bark itself and the transition areas between the bark and wood. Despite being stored in a dry environment, the bark remained moist, which paradoxically helped in its processing. The bottom layer below the white surface of the birch bark was the best to work with—it was red-orange in color and softer, more cohesive, and pliable. This layer was effortless to cut into; the tool easily penetrated the material and left distinctive marks visible to the naked eye.

When working with the wood, particles of the material were also caught on the tool's surface. These residues were already observable by visual inspection without instruments and were later confirmed by microscopic analysis, which will be described in the following chapters.

Overall, the wood provided a good contrast to previous material; unlike hard antlers or brittle bone, it allowed smooth instrument guidance without breaking or resistance. However, its softer texture also meant that the marks were less destructive and could be more prone to rubbing off or later deterioration, particularly in the wetter areas.

8. TRACE ANALYSIS AFTER USE

This chapter summarizes the results of microscopic and visual observations of traces formed on stone tools during the experimental processing of different types of materials. Each tool was subjected to systematic analysis under several layers of magnification (20x-400x) to capture both macroscopically visible changes (e.g., rounded edges) and microscopic traces of

⁷¹ MLEJNEK, Ondřej – Denis ŠTEFANISKO. *An alien in the microlithic assemblage: Functional analysis of a large tanged tool from the early Mesolithic settlement of Městec/Ostrov (Czech Republic)*. *Anthropologie*, vol. 60 (2022), no. 1, p. 62.

wear (polish, striation, and residues).

The observed features were documented in terms of their type, intensity, location, and possible interpretative implications. The analysis is divided by the material being worked on, with each subsection presenting a specific example of a tool, its method of use, and the observed marks at each level of magnification. The final appendix will include references to relevant microphotographs and images.

8.1. ANTLERS (BURIN No. 8)

The burin No. 8 was used for approximately 40 minutes in the experimental treatment of the antler, specifically for cutting and scraping. It was a medium-sized tool that provided a good balance between downforce and maneuverability, and as a result, proved to be practical when working with more rigid organic material. At the end of the experiment, different types of wear marks were visible on its surface, corresponding to the nature of the activity performed.

At a magnification of 20x, the remnants of the green material from the protective gloves used while working with the substance were visible (see Figure 8a). This finding indicates that the tool surface is highly sensitive to even brief contact with external substances. As mentioned earlier, the tool was not washed prior to microscopic analysis, although this would be standard procedure in traceological research. In this case, however, the residues did not interfere with the observation of wear traces. In the same area, the initial signs of striation – fine grooves associated with the tool's repeated movement over the antler's surface – were also noticed. Light from the left side highlighted the contrasting structure of the marks due to the so-called *optical shade effect* (OSE).

After switching to 40x magnification, traces of wear became more pronounced, including edge rounding and regular striations corresponding to the movement direction during cutting. At the same time, settled antler residues along the lower edge were observable, clearly caught while working with the material. Additionally, there was a hint of flaking scales in one part of the edge, likely due to increased pressure or impact during the work process (see Figure 8b and 8c).

At 200x magnification, the left edge displayed a fine polish, which was partially connected to the visible residual layer. In contrast, the right edge of the tool appeared rougher and showed signs of light erosion, along with less noticeable abrasions. The combination of observations across all three magnifications suggests typical tool use when working with hard organic material. The traces are legible both as mechanical wear and as direct residues of the raw material being processed (see Figure 8d).

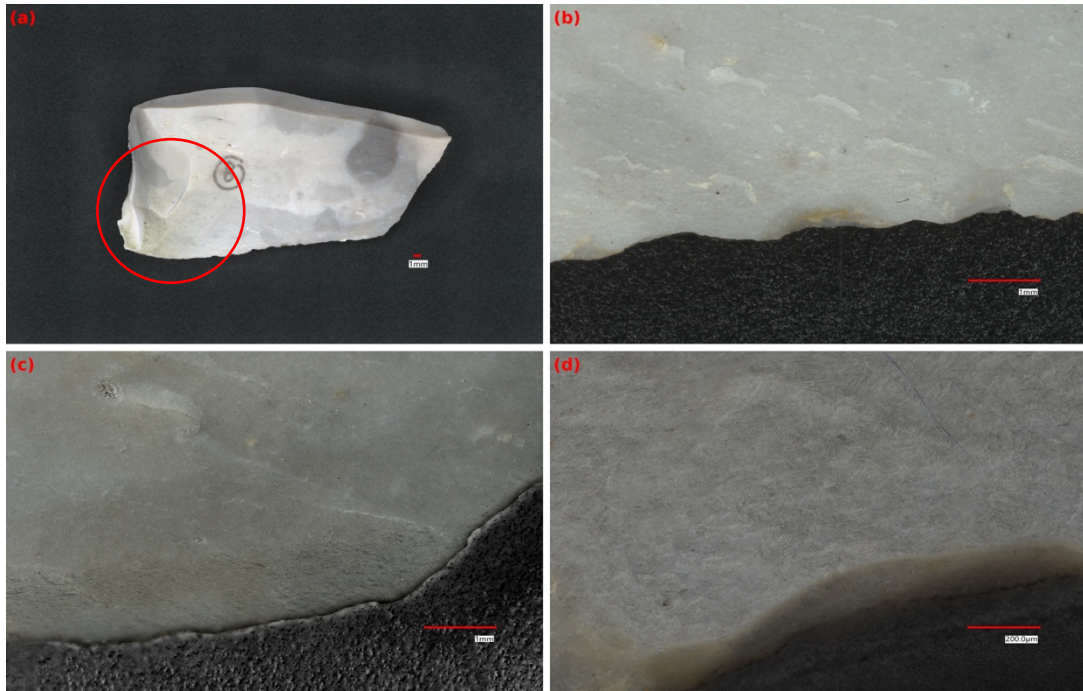


Figure 8: Burin No. 8, used on antlers. (a) - 20x magnification; (b) - 40x magnification; (c) - 40x magnification; (d) - 200x magnification. Photo by Kristýna Budilová, Keyence VHX-7000 digital microscope.

8.2. BONE (BURIN No. 14)

The burin No. 14 was used to engrave into dry deer bone for approximately 30 minutes. The material exhibited high hardness and brittleness, as reflected in its interaction with the tool and the texture of the observed marks. Higher pressure had to be exerted during use, which led to more pronounced mechanical wear, as well as the trapping of bone particles on the surface of the blade.

At 40x magnification, transverse abrasions were clearly visible, particularly at the tip of the tool and along the lower edge (see Figure 9b). The abrasions were quite pronounced, in some areas appearing to “grind” the surface of the stone and diminish its original roughness. Additionally, cracks and micro-cracks in the bone material were evident in certain areas, potentially transferring to the stone surface as fine abrasions. Polish was either absent or very weak at this magnification. Nonetheless, a layer of residue from the bone material was present, deposited not only on the edge but also within the surface irregularities.

At a magnification of 200x, the striae appeared with greater sharpness and resolution (see Figure 9c). It was possible to observe both fine linear grooves and deeper traces, indicating repeated and targeted contact with the hard material. Streaks were observable on the edges and the tool face, indicating complex contact at different angles of application. At the same time, the surface showed a granular type of polish, especially at the lower part of the edge where the tool was in the most intense contact with the bone. The polish was neither smooth nor

continuous, but had a coarser, more diffuse character. In some places, it was also possible to observe the bone residue deposited behind the striae line.

Photo documentation taken at high dynamic range (HDR) highlighted the lower edge of the tool, where the wear was most pronounced, especially visible at 400x magnification (see Figure 9d). The overall character of the marks indicates intense contact with hard and abrasive material, which did not cause visible rounding of the edge but left a combination of distinct striations, residue, and granular polish on the tool, consistent with use on dry bone.

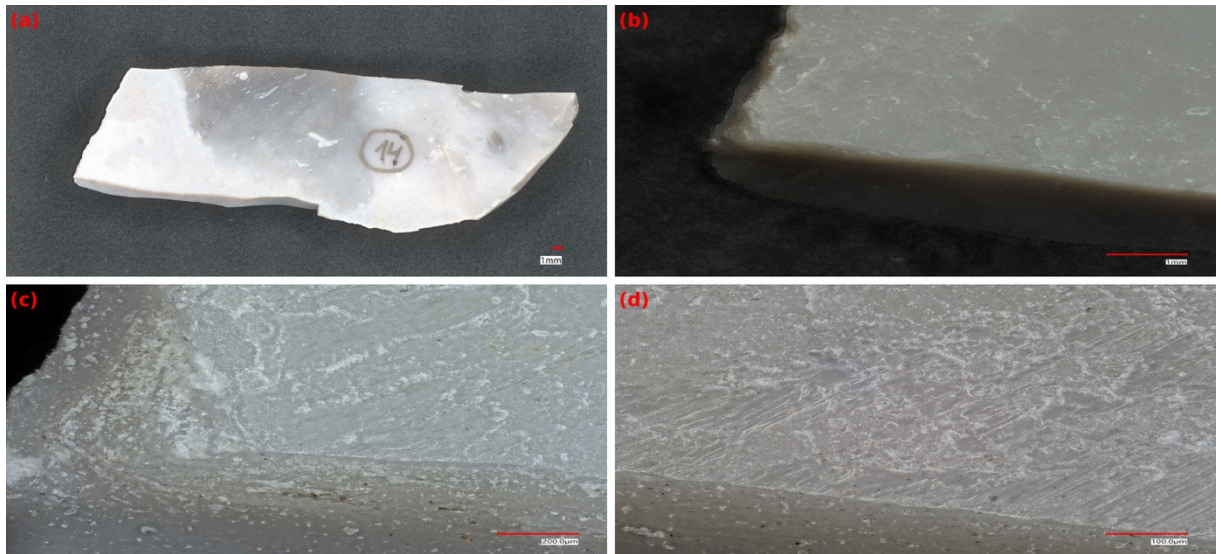


Figure 9: Burin No. 14. (a) - 20x magnification; (b) - 40x magnification; (c) - 200x magnification; (d) - 400x magnification. Photo by Kristýna Budilová, Keyence VHX-7000 digital microscope.

8.3. SLATE (BURIN No. 18)

Burin No. 18 was used to engrave into the slate for 60 minutes. This material proved to be very workable during the experiment—it was soft and pliable and produced characteristic marks without excessive damage to the tool. The features indicate good compatibility between the tool and the material, with both edge wear and the worked-on material residue retention occurring.

At 20x magnification, distinct layers of slate residue were evident on the tool surface, which was deposited mainly between structural irregularities (see Figure 10a). Before microscopy, the residue was also captured as a fine coating, visible to the naked eye. After washing the tool (at 70 °C, for 30 minutes, with an intensity of 9), the surface layers were removed, but the distinctive luster around the edges was retained. Even after cleaning, the surface showed clear signs of wear.

At 40x magnification, a smooth and continuous polish, evenly spread over the worked-on tool's edge, was particularly evident. Edge-rounding could be identified in the left corner of

the tool, caused by repeated mechanical movement on the soft but abrasive material. The slate left visible marks without destroying the edge; instead, it rounded and smoothed it. The surface appeared compact, with no cracks or detached parts (see Figure 10b).

At a magnification of 200x, it was possible to observe the material's interaction with the stone's microstructure. The slate particles were deposited on porous areas, while the surrounding edges showed signs of fine polishing. This phenomenon supports the hypothesis that the engraving process involved simple contact and the “filling” of micro-spaces with slate, which spread over the surface during repeated movement and contributed to the formation of polish. The polish was so pronounced in some places that it covered even minor surface irregularities (see Figure 10c).

The overall character of the marks is consistent with intensive work with soft mineral material. The slate caused rounding of the edges, the presence of a smooth light polish, and visible residues, with no chipping or significant destruction of the tool. The features found are clearly legible across the magnifications, especially the 400x magnification (see Figure 10d), and will be further used in comparison with the archaeological material.

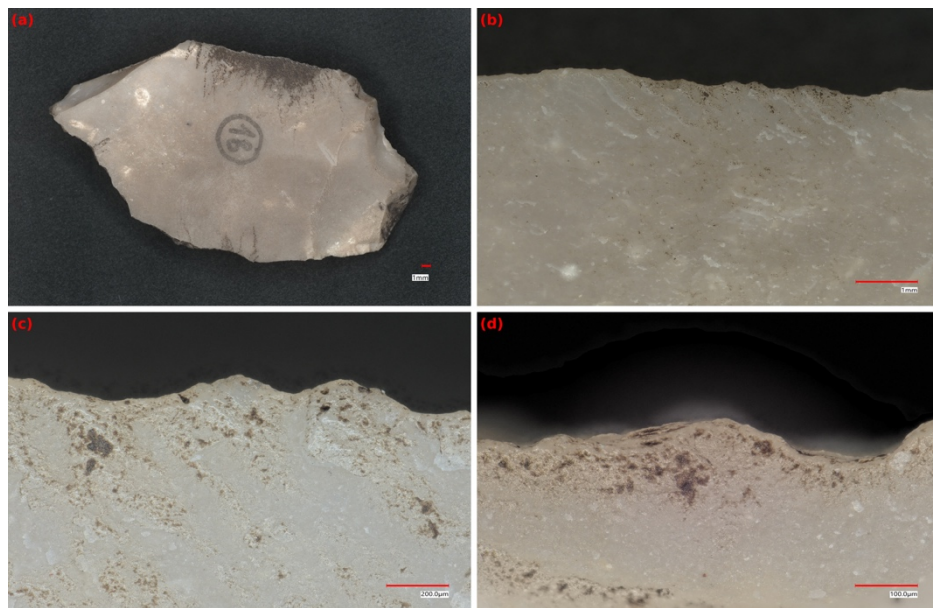


Figure 10: Burin No. 18. (a) - 20x magnification; (b) - 40x magnification; (c) - 200x magnification; (d) - 400x magnification.
Photo by Kristýna Budilová, Keyence VHX-7000 digital microscope.

8.4. WOOD (BURIN No. 6)

The No. 6 burin was used to work birch wood, specifically to engrave and scrape, for approximately 30 minutes. Work was carried out on the fresh logs' outside and bark. For the most part, the material was still wet, which affected both the method of working and the subsequent marks on the tool. During the experiment, the wood proved to be a well-workable

but relatively soft material, which produced marks differently from harder organic materials.

At a magnification of 20x, residue of fine wood fibers could be seen on the tool's surface, especially around the edge and bottom. The residues were also visible to the naked eye and appeared under the microscope as partially dried fibers trapped within the stone's microstructure (see Figure 11a). The surface was not visibly damaged, but the material left a dull, slightly greyish coating.

At 40x magnification, edge-rounding was noticeable, although less pronounced than in other materials. The instrument's wood surface was smooth without significant stretching. In regions of greater work intensity, especially during engraving on the log's edge, minor grooves appeared; however, they were not deep or sharply defined (see Figure 11b). This aligns with the wood's soft and fibrous nature, which compresses rather than breaks under pressure.

At 200x and 400x magnification, remnants of woody material were distinctly observable in the tool's porous depressions. A striking feature observed at this analysis stage was the conspicuous circular-shaped pores, which gave the impression of a “bubble-like structure” (see Figure 11c-d). These pores are probably formed by the action of silicic acid contained in the plant material, which reacts with the tool's surface and leaves microscopically legible traces. This type of trace proved to be very important, as a similar pattern was subsequently identified on one of the archaeological handpieces, creating a strong comparative clue between the experimental and historical material (see Figure 23c, 23e, and 23f).

At the same time, a faint, diffuse polish could be observed, with no clearly defined shape. The luster was diffuse and not continuous – it corresponded to a fine shaving rather than a classic domed polish. This type of polish is probably the result of prolonged rubbing on soft material without the presence of hard mineral residue. The tool had not been washed before microscopic analysis, not only due to the lack of awareness of standard procedure at the time, but also out of curiosity to observe the appearance and behavior of potential residues under magnification. In this particular case, the unwashed condition did not hinder the identification of microwear traces.

Overall, the observed traces can be assessed as delicate and less contrasting than those of other materials. The wood did not cause any destructive damage to the tool but left fibrous residues on its surface, diffuse polish, slight rounding of the edges, and characteristic porous traces, which proved to be potentially diagnostic for working with plant material.

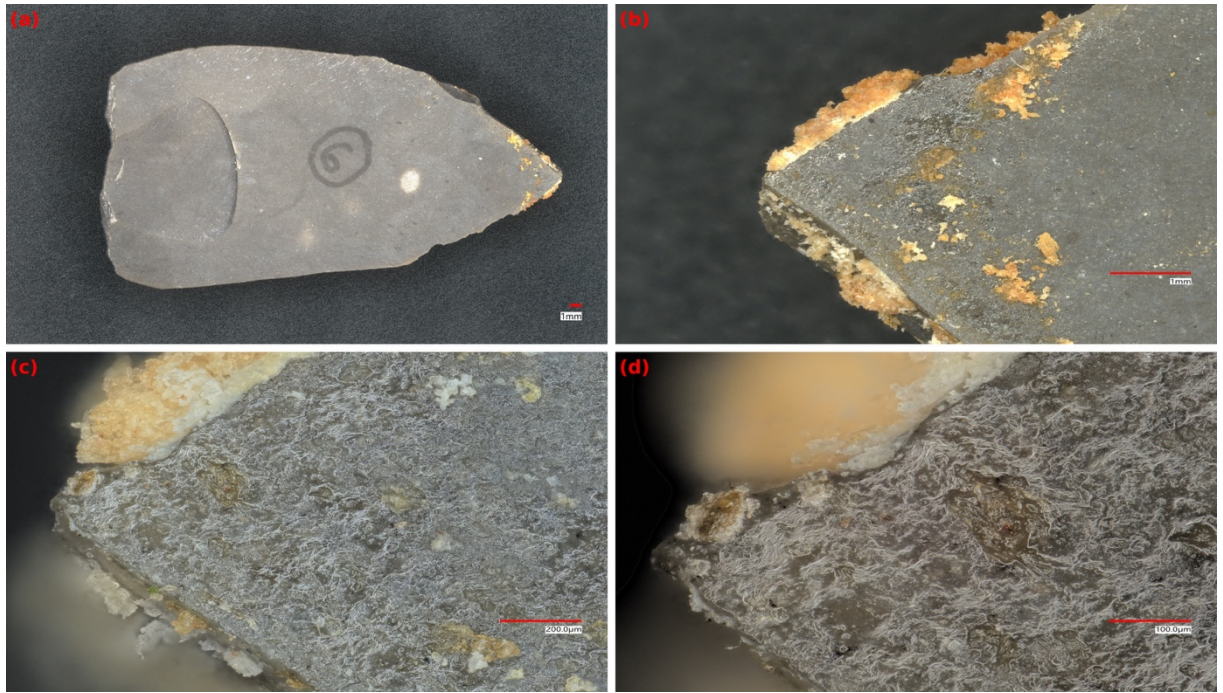


Figure 11: Burin No. 6. (a) - 20x magnification; (b) - 40x magnification; (c) - 200x magnification; (d) - 400x magnification. Photo by Kristýna Budilová, Keyence VHX-7000 digital microscope.

9. ARCHAEOLOGICAL MATERIAL

This chapter provides a basic overview of selected archaeological burins analyzed under a microscope in this study. For each artifact, basic dimensions and a brief description of observed use traces are provided. A more detailed analysis and comparison of traces are provided in the following chapters.

9.1. Burin E104

The burin E104, measuring approximately 49 mm in height, 33 mm in width, and 10 mm in thickness, is characterized by a more robust shape. Preliminary microscopic analysis revealed minor traces of surface modification, including a slight sheen and minimal signs of flaking on the working edge (see Figure 12c). Overall, the traces of use on this tool can be assessed as moderately pronounced. Additionally, white traces were observed, which I interpreted as patina (see Figure 12d).

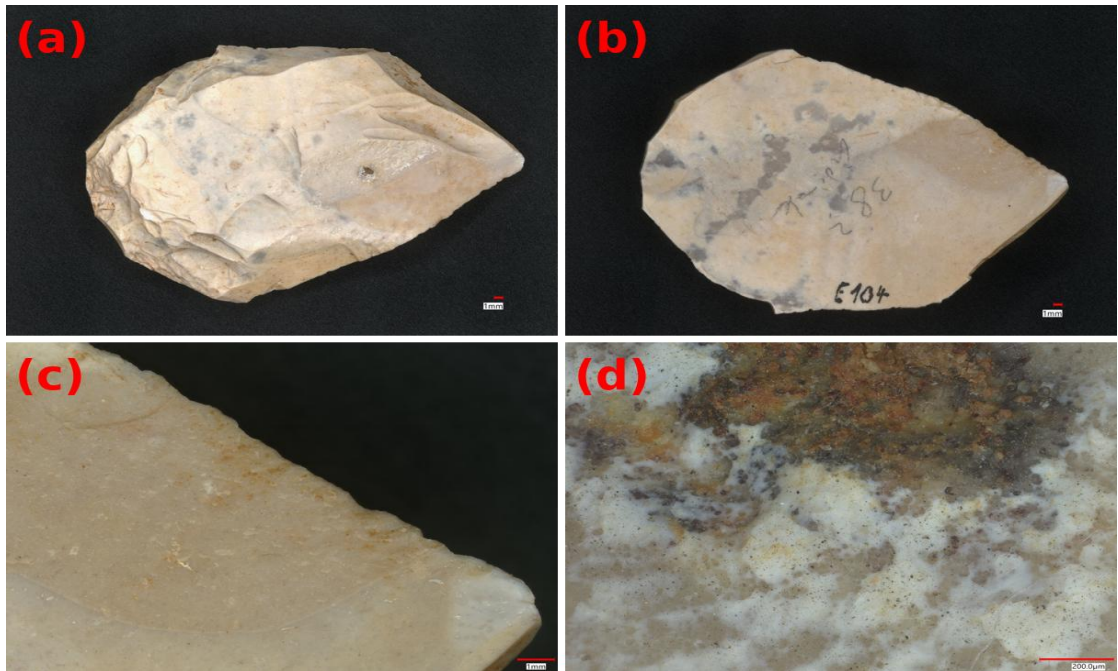


Figure 12: Burin E104. (a) dorsal side at 20x magnification, (b) ventral side at 20x magnification, (c) signs of use-wear traces at 40x magnification, (d) signs of white patina at 200x magnification. Photo by Kristýna Budilová, Keyence VHX-7000 digital microscope.

9.2. Burin E95

The burin E95, measuring 48 mm in height, 12 mm in width, and 4 mm in thickness, has a slender, elongated shape. During the initial examination, fine scratches and rounding of the edge were found (see Figure 13c). Small areas with polish and the presence of residues were also noted (see Figure 13d). The intensity of the use traces is moderate, and they are clearly visible even at lower magnification.

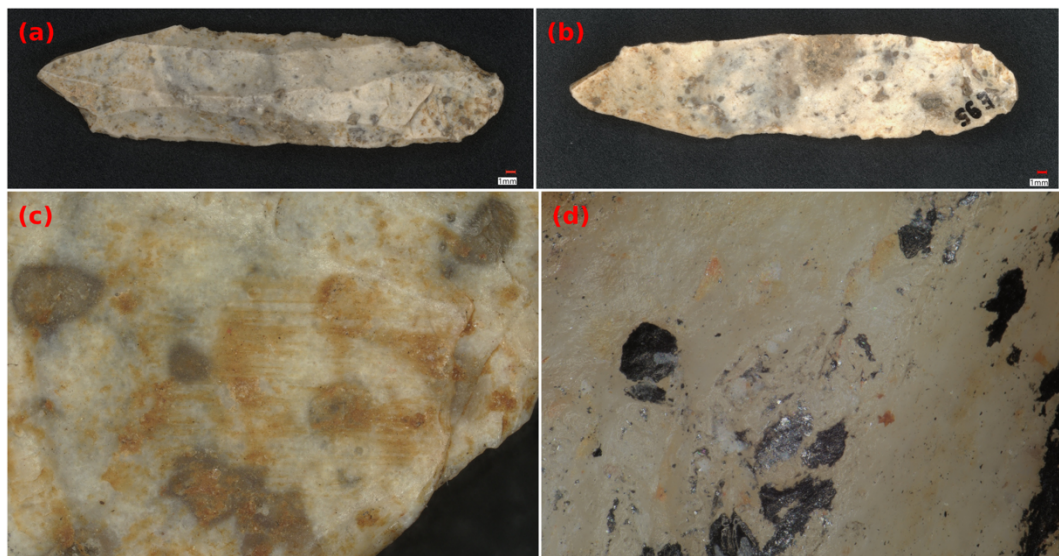


Figure 13: Burin E95. (a) dorsal side at 20x magnification, (b) ventral side at 20x magnification, (c) signs of use-wear on the surface at 50x magnification, (d) residues visible at 400x magnification. Photo by Kristýna Budilová, Keyence VHX-7000 digital microscope.

9.3. Burin E68

Measuring 40 mm in height, 22 mm in width, and 5 mm in thickness, the burin E68 features a wider working edge. Observations revealed more distinct signs of use, including the presence of polish and minor edge flaking (see Figures 14c and 14d). In this case, the traces of use are more pronounced compared to the other samples.

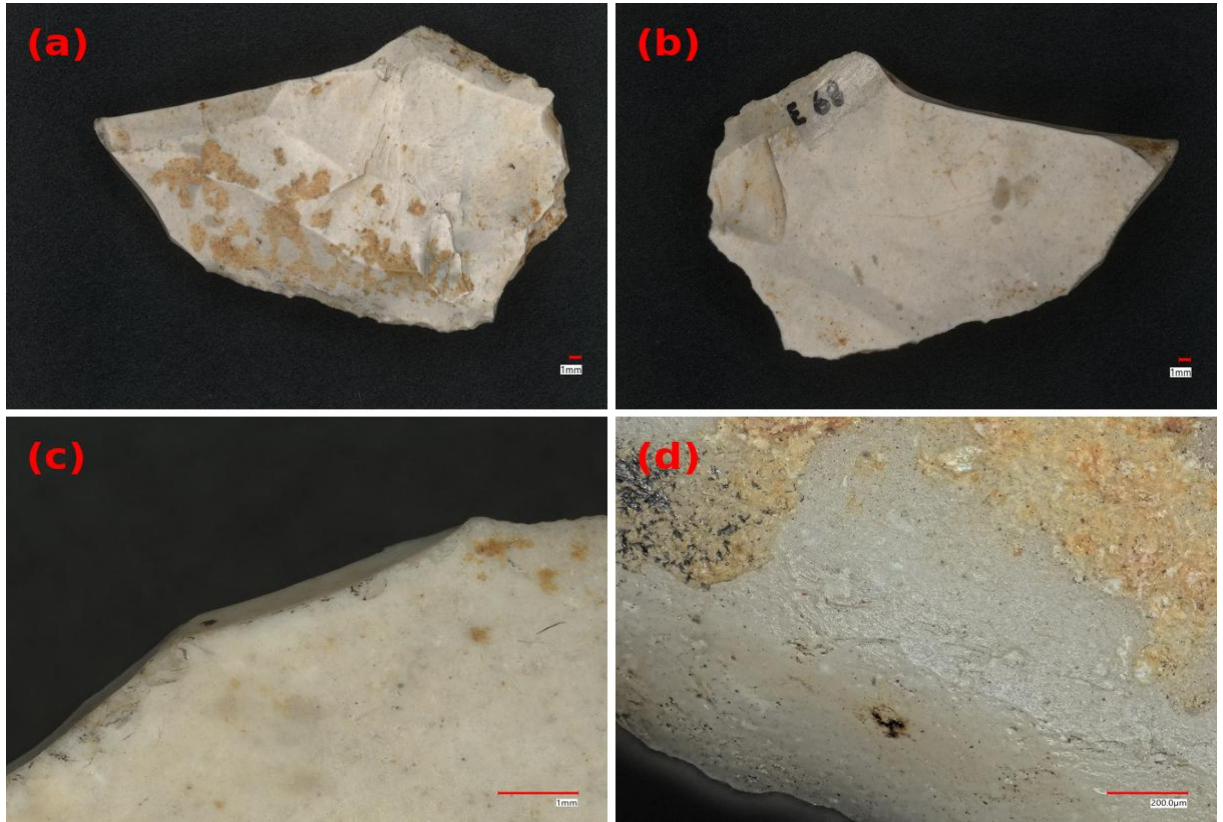


Figure 14: Burin E68. (a) dorsal side at 20x magnification, (b) ventral side at 20x magnification, (c) signs of use-wear at 40x magnification, (d) signs of use-wear at 400x magnification. Photo by Kristýna Budilová, Keyence VHX-7000 digital microscope.

9.4. Burin A35

The burin A35, measuring 67 mm in height, 177 mm in width, and 6 mm in thickness, is one of the larger artifacts analyzed. Surface analysis revealed the presence of a fine polish and weak signs of edge modification (see Figures 15c and 15d). Traces of use are less pronounced, indicating a moderate degree of wear.

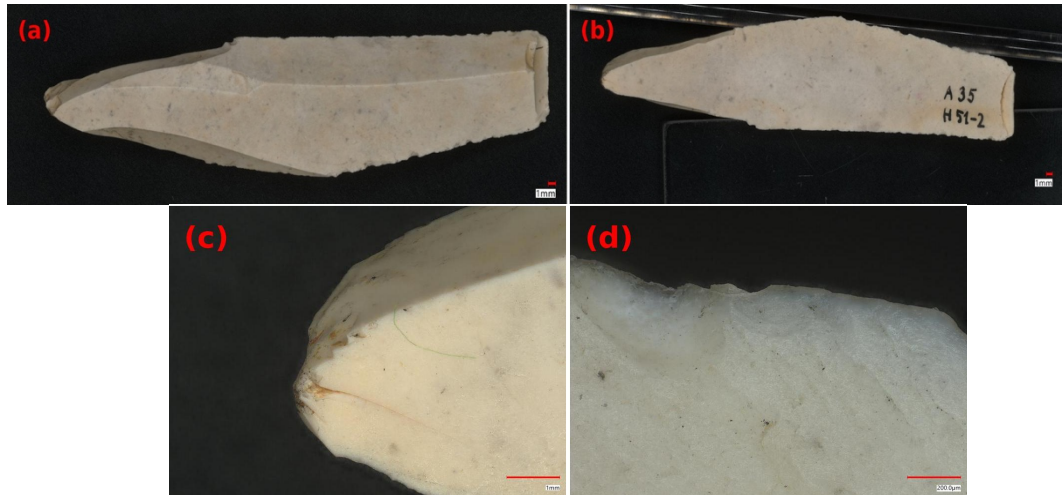


Figure 15: Burin A35 H51-2. (a) dorsal side at 20x magnification, (b) ventral side at 20x magnification, (c) signs of use-wear at the tip of the burin, 40x magnification, (d) signs of use-wear at the end of the burin, 200x magnification. Photo by Kristýna Budilová, Keyence VHX-7000 digital microscope.

9.5. Burin XX00

The burin XX00, measuring 28 mm in height, 9 mm in width, and 4 mm in thickness, is one of the smallest tools in the collection. Despite its size, it exhibits distinct edge-rounding and clearly visible striations (see Figure 16c). The intensity of wear can be described as significant (see Figure 16d).

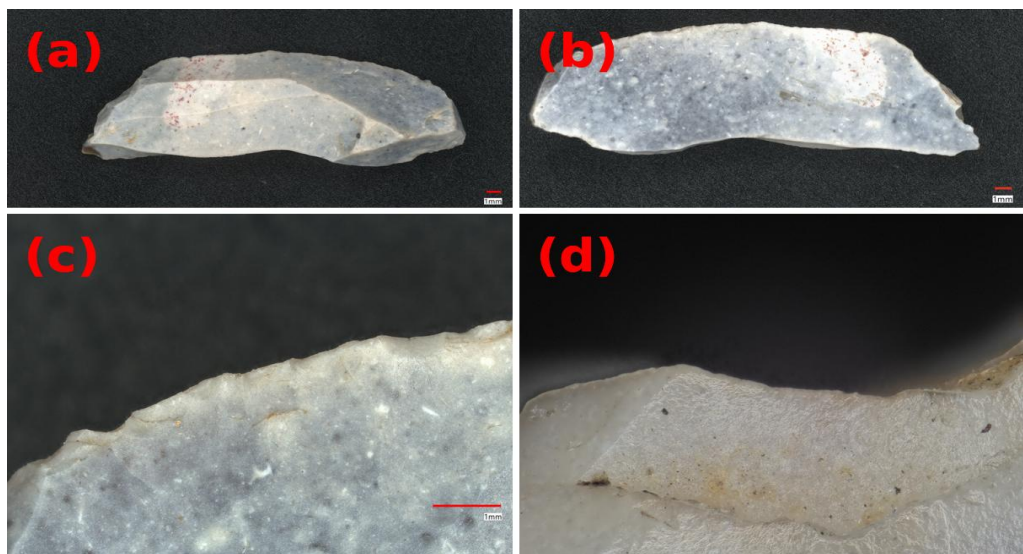


Figure 16: Burin XX00. (a) dorsal side at 20x magnification, (b) ventral side at 20x magnification, (c) signs of use-wear at 40x magnification, (d) signs of use-wear at 200x magnification. Photo by Kristýna Budilová, Keyence VHX-7000 digital microscope.

10. RESULTS OF COMPARATIVE ANALYSIS OF THE BURINS

This chapter summarizes the results of experimental testing and subsequent microscopic analysis, comparing them with observations made on archaeological subjects. The discussion aims to assess whether and how traces of the working of different materials can be identified based on visual and microscopic features, and to consider the significance of the experimental data for interpreting the archaeological context. In this section, the different materials (antlers, bone, slate, and wood) will be analyzed in terms of the specific traces they left on the tools, and these results will be contrasted with the findings from selected archaeological subjects. Particular attention will be paid to cases where the experimentally produced traces align with, or closely resemble, the archaeological ones.

During experimental testing, it was observed that each of the materials used left distinct types of microscopic and macroscopic marks on the tools. The hardest raw materials, such as bone and dry antlers, often caused edge-removals, edge-rounding, and fine parallel striations, which in some cases could be observed at magnifications as low as 40x (see Figure 9b). Softer materials, such as wood and slate, although not causing destructive damage to the tool's surface, produced a very readable polish and left residues that were often visible (see Figures 10 and 11). Particularly pronounced were traces of a bubble-like structure in the wood (see Figures 11c and 11d), likely due to interaction with silicic acid, which was also evident in some archaeological burins. The slate showed a finer but uniform matte polish on the tools, with dark deposits that, at higher magnification, were distinct from traces of other organic materials. In general, despite some overlap in trace types between materials, specific combinations of polishes, abrasions, and residues showed sufficiently significant differences to allow an educated hypothesis to be formulated about the nature of the raw material being worked, based on microscopic observations.

The traces produced by the antlers in the experimental material exhibited a moderate edge-removal, localized polish, and regular fine striations (see Figure 17). These features were particularly evident in the case of the No. 8, with scale-like chips, the presence of light-colored residues, and edges that were rounded but not evenly, rather fragmentary. These features were consistent with what would be expected from contact with hard and dry organic material. Another important feature was the residue of a green color observed during microscopic examination, which was attributed to the primary protective gloves. It also highlighted the

importance of controlling contaminants during handling.

Comparison with archaeological tool E104 shows several potentially identical features (see Figure 18). Again, there is a faint luster, possible edge-removal in the form of chipped scales, and edge-removals. Although the traces are not entirely like the experiment, this could serve as an analogy. The note of possible patina or crust, which may partially obscure the original trace and complicate identification, plays a crucial role here.

It is also worth noting that while the experimentally produced polish was light and localized, the polish on the archaeological tool is weaker and more diffuse, which could indicate a shorter period of use, poorer preservation, or a different type of contact. A visual comparison of photographs of experimental burin No. 8 and archaeological E104 shows a striking similarity in the form of “serrated” cutting marks, which are visible even without significant magnification. These teeth may correspond to repeated contact with hard organic material, which led to the formation of rhythmically repeated micro-chips. Their location and similarity in shape on both burins support my hypothesis that the mechanics of use for both tools may be similar. At the same time, no visible residue appeared on E104, which does not necessarily rule out antler contact, but rather reflects the limited ability to preserve organic residue under environmental conditions.

Thus, in terms of overall assessment, the E104 burin cannot be directly identified as an antler implement; however, the combination of edge-removal, polish, and edge-rounding suggests the possibility of contact with hard organic material, of which antlers are one example. It is therefore a vital sub-result that, when combined with other tools or context, may reinforce specific functional interpretations. One of the main questions that repeatedly arose during the experiment was the length of the experiment itself and whether twenty minutes of work on each material was sufficient to create comparable and legible traces. When preparing the experiment, a minimum duration of twenty minutes was selected for working with each tool, partly due to time constraints, but also as a rough estimate of the time frame in which the first signs of wear should become apparent. The results show that after this time, some signs of interaction with the material became evident, including the presence of polish on the edges, small chip-away spots, visible edge-rounding of the burin's work edge, and the presence of residues. However, work with most of the tools exceeded the established minimum limit, in several cases lasting up to about an hour. The results of the experiment indicated that after just twenty minutes of work, legible traces appeared on the tools, which could be further analyzed. For trace comparison, this duration can be considered adequate. In some cases, where working time was extended, this led to more intense traces; however, the basic type of wear was already visible

after the recommended minimum time. For future experiments, I recommend working with the tools for at least twenty minutes, with longer working times allowing finer differences to be detected.

As for the scope of the material and the actual number of burins analyzed, the number of samples I worked with was more than sufficient for the purposes of this experiment. Each burin was used on a different raw material, allowing me to observe various types of wear and better understand how these traces vary depending on the material and type of movement. Although some might argue that a larger number of samples would have yielded more representative results, it was more important to document each step in detail so that I could return to each tool with a specific comparison in mind. Another researcher who decides to expand this research may obtain different results, especially when working with a larger sample or a broader selection of raw materials. However, for my purpose, which was to examine the fundamental legitimacy of traces and their possible correspondence with archaeological material, the scope of this experiment was sufficient.

Looking back, I managed to uncover several key findings that may be useful for further research in the field of traceological analysis. Firstly, it became apparent that even short-term use of stone tools on various raw materials, even in domestic settings and with a limited number of burins, can lead to the creation of clearly visible wear traces. In some cases, these traces were so pronounced that their presence was noticeable even without the aid of a microscope. At the same time, during microscopic analysis, I observed similarities between the experimental and archaeological burins, especially when examining them with wood and slate. These similarities do not indicate mere coincidence but instead open up space for deeper interpretation, such as a hypothesis about the specific use of the archaeological burins. Although in some cases it is not possible to reach a definitive conclusion, these findings contribute to a better understanding of how wear is created, what it looks like, and how it can be analyzed effectively in the future.

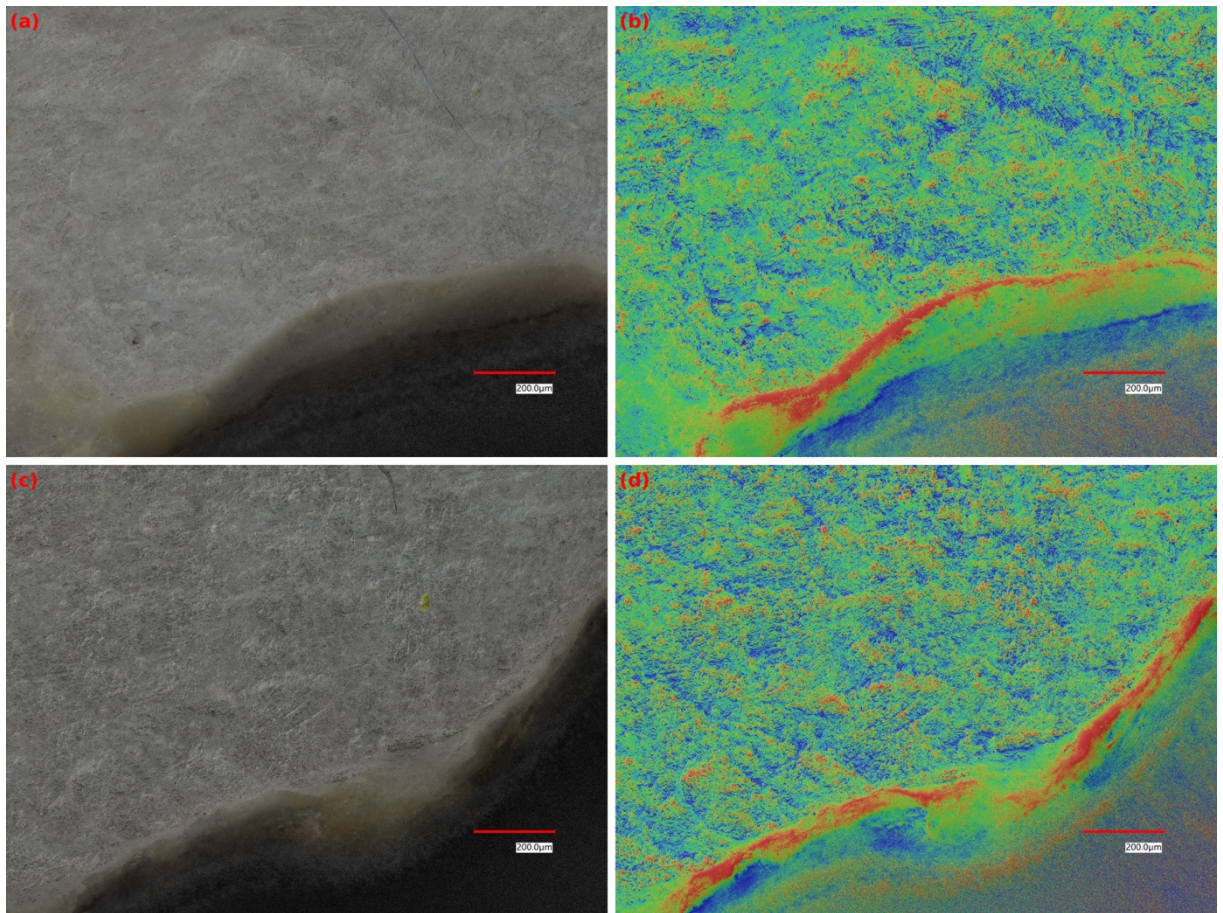


Figure 17: Use-wear analysis of the ventral side of burin No.8. Figures (a) and (c) show the working edge with visible polishing and micro-chipping; figures (b) and (d) show the corresponding surface topography using 3D mapping. Photo by Kristýna Budilová, Keyence VHX-7000 digital microscope.

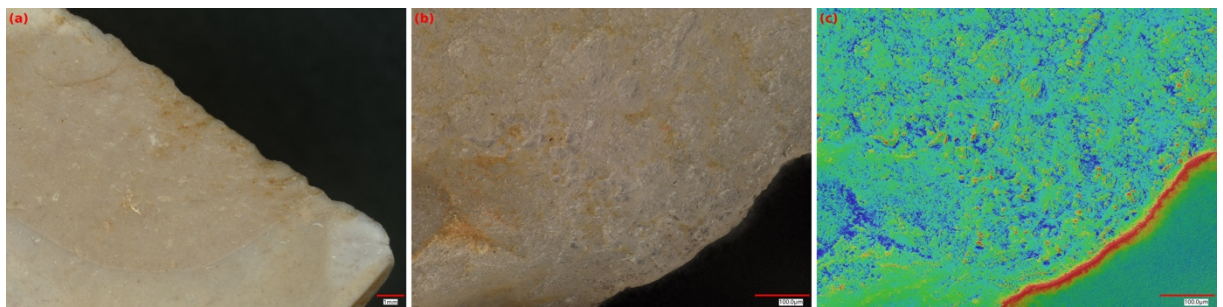


Figure 18: Use-wear analysis of the ventral side of the E104 burin. (a) shows the working edge with cutting marks in the form of fine teeth; (b) shows polish and micro-chipping at 400x magnification; (c) shows the surface topography using 3D mapping. Photo by Kristýna Budilová, Keyence VHX-7000 digital microscope.

During the experimental processing of the bone, the tools produced very legible marks, particularly in the form of distinct, deep striations that often occurred in multiple directions and varied in length and width. The striations were most pronounced in the tips of the active zones, where the most significant friction occurred, and on medium-sized tools, which allowed better hand control. These striations were often sharp and visible at lower magnifications (e.g., 40x), which distinguishes bone from other materials (see Figure 9b). Accompanying features included a dull polish with irregular distribution and minor edgewear, often accompanied by

slight surface granulation.

On burin No. 14, there were deep striations, mainly at the tip, where contact was the most intense. Similar features can be observed on the archaeological burin E95, which exhibits signs of striations, rounded edges, and dark residues at the tip (see Figure 20). This residue is located inside larger pitted depressions, which may indicate that highly abrasive material, such as slate, became trapped in these structures (see Figures 20b and 20c).

The nature of the dark deposit is strikingly similar to that observed during the experimental working of slate – the material disintegrates into a fine black dust that tends to settle in microstructures on the surface of the tool (See Figure 10d). In the experiment, this deposit on burin No. 18 was preserved longest in the depressions and around the tip. Nevertheless, it should be noted that the worked surface on E95 is not as smooth and consistent as it was in the experimental burin used on slate, which means that the identification of slate as the worked material remains uncertain. The dark coloration may or may not be the result of working with slate; alternatively, it may be a different type of softer organic material or a mineralized deposit of another origin.

In addition, E95 also has small chip-aways of material that are visually very similar to those found on experimental burin No. 8, which was used on antlers (see Figure 20c). These small teeth, also located at the tip, may be the result of contact with hard organic material, and it cannot be ruled out that the tool was used repeatedly for different purposes.

Overall, E95 exhibits characteristics that correspond to multiple materials: the deep striations and teeth indicate a more rigid material that the tool was used on (such as bone and antlers), while the dark residue in the depressions may or may not be associated with slate. This combination of clues supports the hypothesis of multiple use, whereby the tool was reused on a different material or was used in parallel for various activities. This possibility is also consistent with archaeological assumptions about the adaptability of tools in prehistoric everyday life.



Figure 19: Burin E95. (a) ventral side at 20x magnification. Photo by Kristýna Budilová, Keyence VHX-7000 digital microscope.

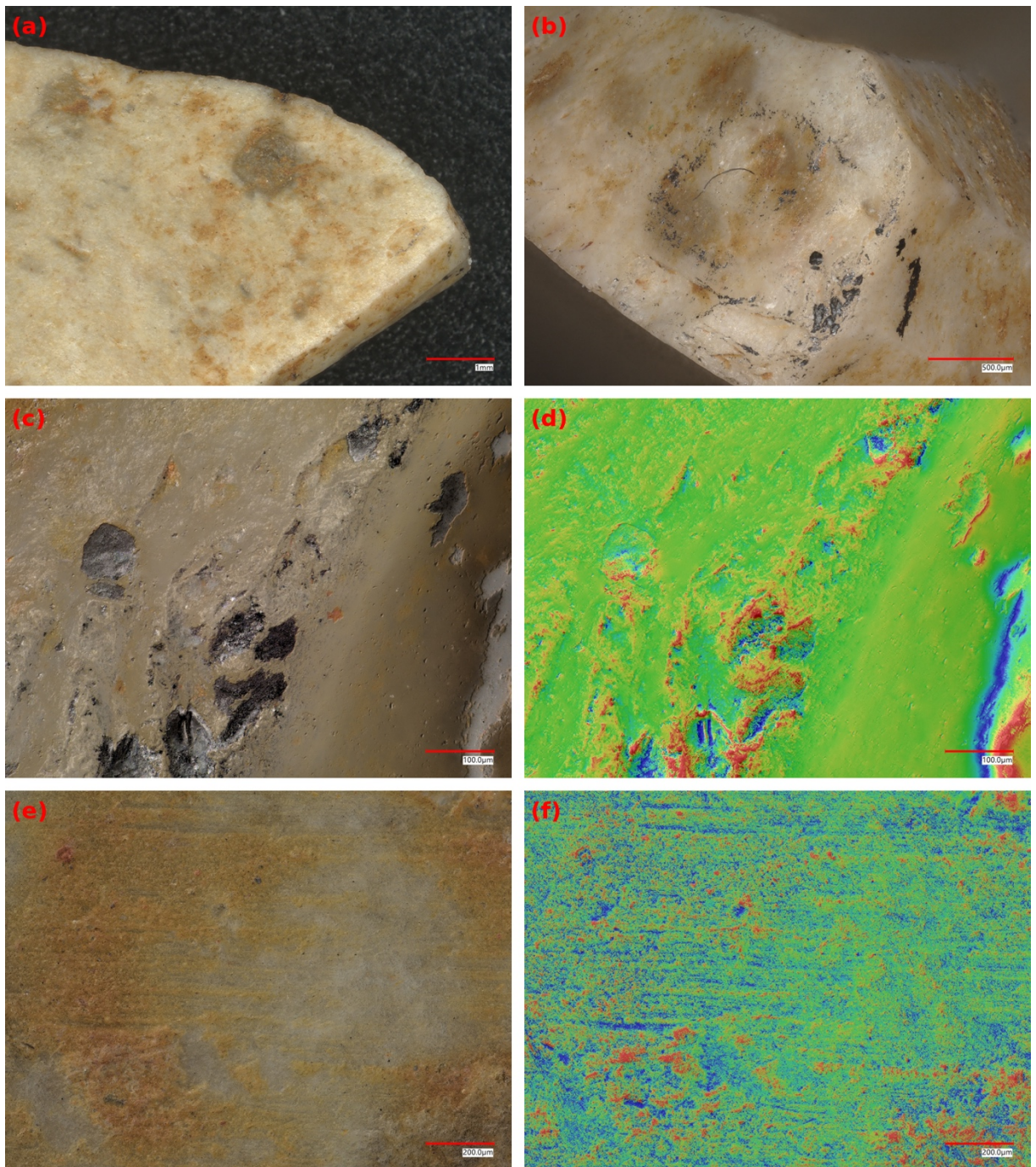


Figure 20: Microscopic analysis of the working edge of burin E95. (a) overview of the tip at 40x magnification, (b) detail of the tip at 100x magnification, (c) detail of the tip at 400x magnification, (d) 3D topographic map of the tip surface at 400x magnification, (e) surface with striations at 200x magnification, (f) 3D topographic map of the surface at 200x magnification. Keyence VHX-7000 digital microscope.

Archaeological burin E68 exhibits significant signs of use-wear, primarily evident in the pronounced edge-removal on the underside of the tool. This destructive modification of the edge does not indicate that the burin was used only as a tool for fine engraving, but rather as a tool used for intense scraping or cutting, which may be related to the processing of softer materials such as leather or wood. This hypothesis is supported by bubble-like structures visible

on the OSE map on the right side of the tool, which resemble the characteristic marks left by contact with materials containing silicic acid, such as birch wood (see Figures 23c-f).

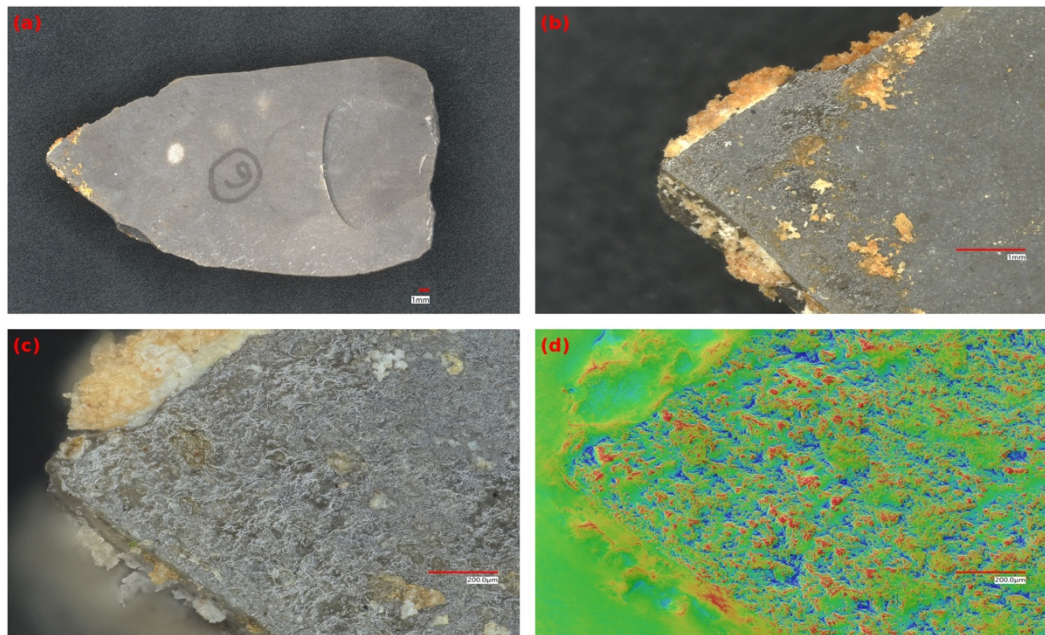


Figure 21: Burin No. 6. (a) Overall view of the burin at 20x magnification, (b) detail of the tip of the tool at 40x magnification, (c) detail of the tip at 200x magnification, (d) 3D topographic map of the tip surface at 200x magnification. Keyence VHX-7000 digital microscope.

When interpreting this tool as a means of working wood, it is essential to note that similar and shiny edges also appeared on the experimental burin No. 6, which was used to work on birch wood. When magnified, similar surface effects were observed – a polished surface with a rugged micro-relief and small craters (see Figure 21c), which could correspond to the surface observed on E68. The presence of a distinct polish on the edge further supports the idea that the tool was not only used for engraving, but rather moving “across” the material, i.e., for cutting or scraping.

Given the absence of striations typical of harder materials, such as antlers or bone, it seems likely that this tool was used on softer, organic material, which is confirmed by both the shape of the edge removal and the presence of microdamage, as well as the nature of the polish.

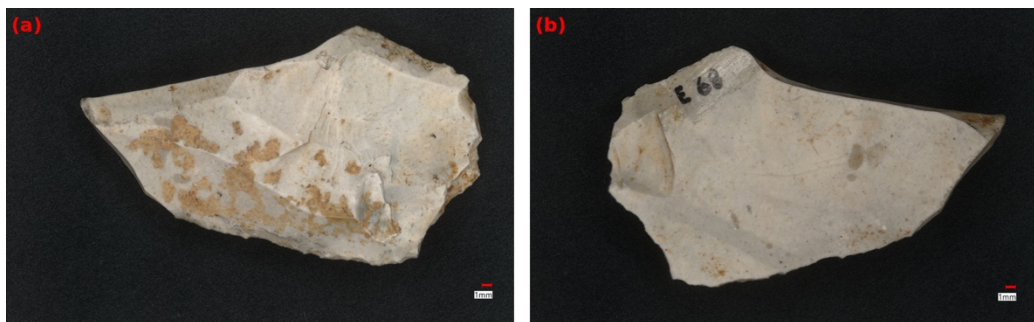


Figure 22: Burin E68. (a) dorsal side of the burin, (b) ventral side of the burin. Keyence VHX-7000 digital microscope.

Based on these observations, E68 can be considered clear evidence of the use of a woodworking tool. The similarities with experimental results and the absence of traces of a more rigid material strongly support this interpretation.

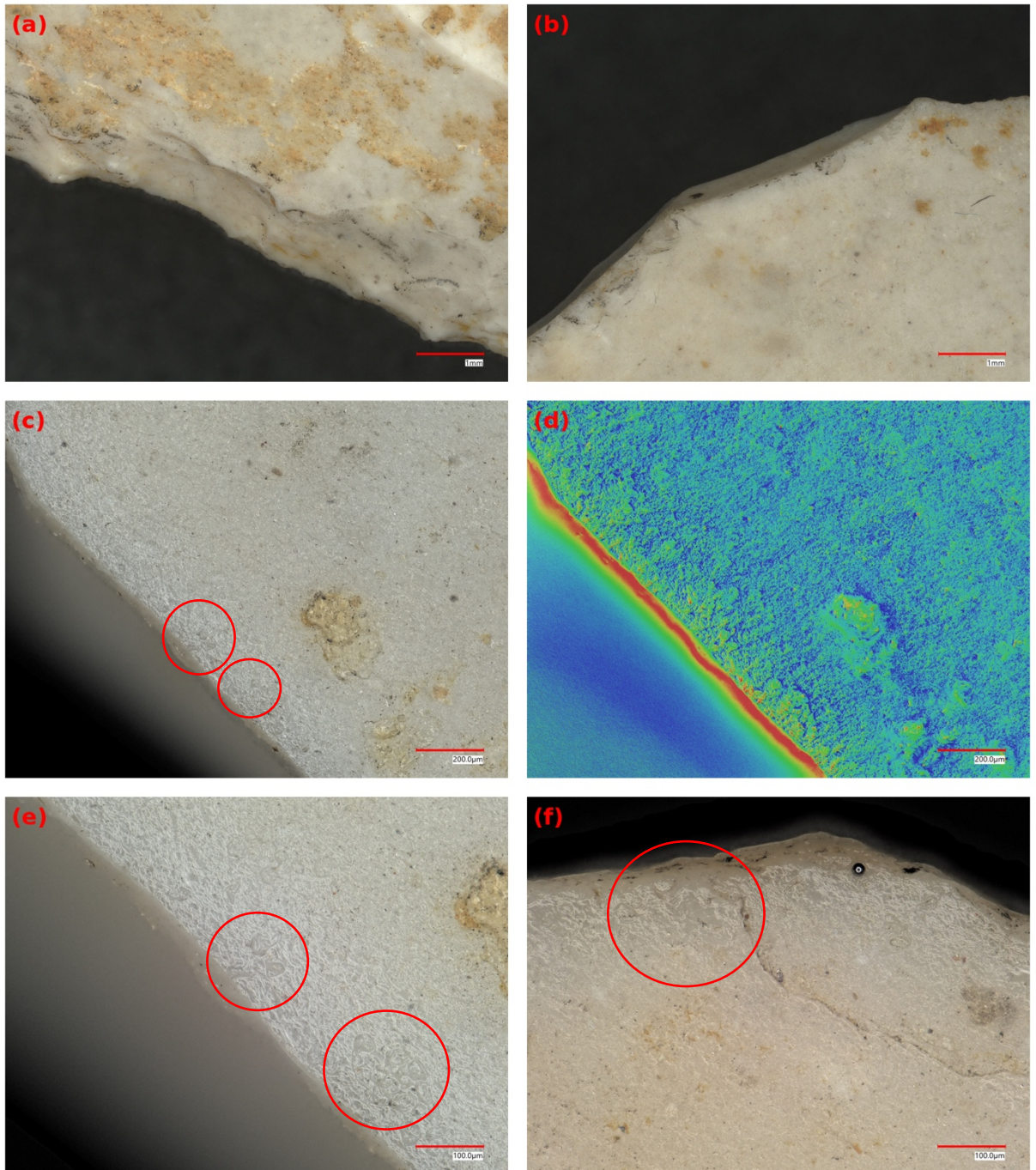


Figure 23: Microscopic analysis of the burin E68. (a) signs of teeth on the dorsal side at 40x magnification, (b) edge-rounding on ventral side at 40x magnification, (c) polish and bubble structure, formed by contact with wood at 200x magnification, (d) 3D topography map showing signs of polish and bubble structure at 200x magnification, (e) close up of the bubbles, formed by contact with wood at 400x magnification, (f) close up of the bubbles, formed by contact with wood, on top of the tool at 400x magnification. Keyence VHX-7000 digital microscope.

One of the experimental burins examined under a microscope was not assigned a

number, so I have decided to name this burin myself and assigned it the designation XX00. The burin XX00 is characterized by significantly smoothed working edges, which appear to be the result of a combination of mechanical chipping and subsequent intensive smoothing. This type of wear usually occurs when in contact with soft, homogenous material that has not left typical residues, such as slate (see Figure 10c), or characteristic craters caused by silicic acid, which would indicate wood (see Figure 21).

Edge-rounding, i.e., the rounding of sharp edges resulting from friction during use, is visible on the working edges (see Figure 24c). In addition, chipped flakes of flint can be observed, indicating repeated mechanical stress on these parts of the tool. There are no significant slate-like deposits, which may be the result of working with a different type of material or their removal over time.

The upper edge exhibits fine serrations, which could have been caused either during production or due to the different uses of individual parts of the tool. For example, one part may have been subjected to greater stress, while the other served primarily to stabilize the tool.

Although it is not possible to clearly identify the specific material being worked on, the combination of smoothing, edge rounding, chipping, and the absence of deposits suggests that the use was on soft material of a different nature than the wooden or slate samples tested in the experimental section.

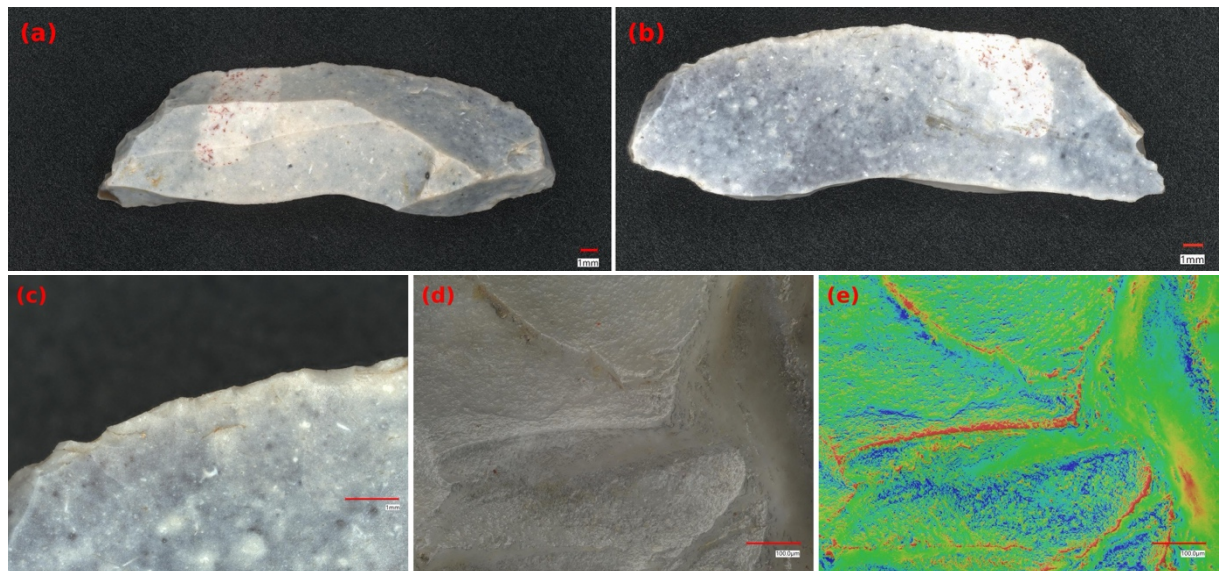


Figure 14: (a) dorsal side of the burin XX00 at 20x magnification, (b) ventral side of the burin XX00 at 20x magnification, (c) signs of use-wear at 40x magnification, (d) polish on working edge at 400x magnification, (e) 3D topography map at 400x magnification. Keyence VHX-7000 digital microscope.

The A35 burin represents, in many respects, an atypical example of wear, which differs from the other tools analyzed. While one might expect that the sharper side of the tool would form the leading working edge, this area shows virtually no signs of wear – it is smooth and without striations, polish, or any visible residues. On the contrary, the flatter, seemingly less active part of the tool, located more towards the “end” of the tool, bears significant traces of use (see Figure 26a).



Figure 25. (a) burin A35 H51-2, ventral side at 20x magnification. Keyence VHX-7000 digital microscope.

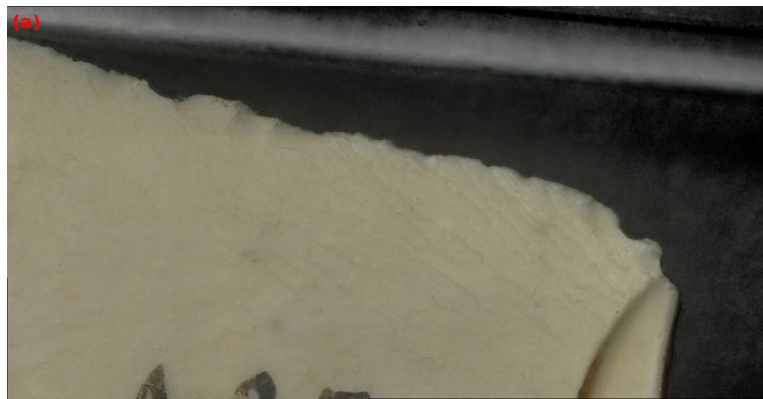


Figure 26. (a) burin A35 H51-2, detail on the end at 40x magnification. Keyence VHX-7000 digital microscope.

It is in this area that deep, wide striations have been identified, which appear as microscopic “mounds” oriented in a uniform direction. This directionality could correspond to a specific way of guiding the tool across the surface, probably associated with repeated linear movement against a harder or more resistant material. However, it has not been possible to assign this type of trace to any of the experimental samples with certainty, which may indicate either a different type of material being worked, a different way of handling the tool, or a different type of movement (e.g., pulling at an angle).

There is also edge-rounding and visible chipping on the edge, which may indicate greater stress or impact use. The surface in some areas shows a color change – a brownish tint – which could be related to interaction with organic material, although no specific residues have been convincingly identified.

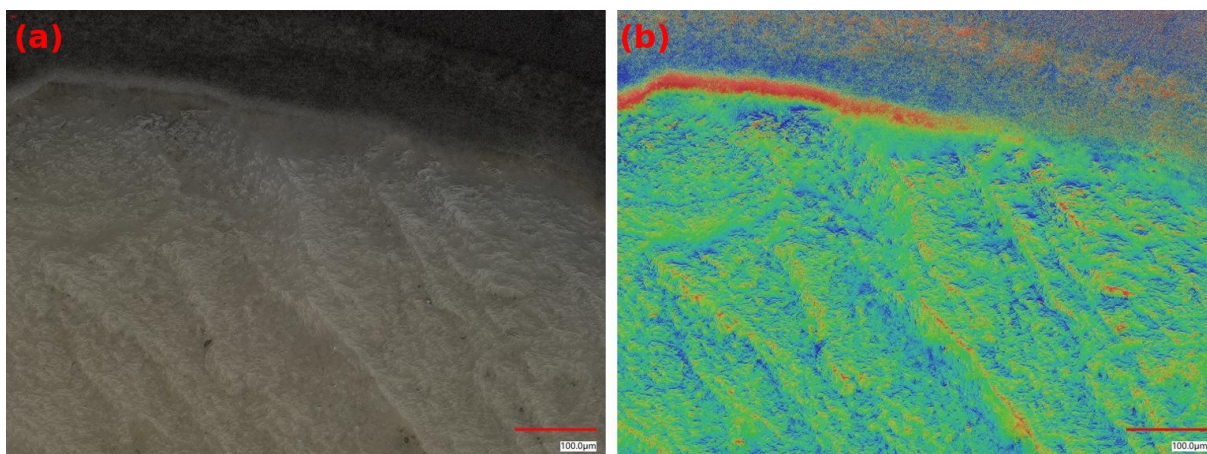


Figure 27: (a) surface of the working edge of the burin A35 H51-2 at 400x magnification, (b) 3D topographic map of the same area at 400x magnification. Keyence VHX-7000 digital microscope.

One of the striking and unifying features of the archaeological burins is the presence of patina on their surface. This patina, formed by long-term exposure to the environment, primarily occurs on the dorsal side of the tool, specifically on the original surface of the core, which has a more uneven surface that allows dirt or mineral particles to accumulate more easily. In contrast, the ventral side, which was created by breaking off and is smoother, is less prone to such deposits. In cases where patina is disturbed or completely absent, these areas may have been secondary worked or served as a working edge.

This phenomenon can be observed, for example, on the E104 burin (see Figure 12d), where a preserved patina is visible on the dorsal side. At the same time, the working areas and the edges show signs of active use, and the patina is missing or significantly disturbed.

11. DISCUSSION

Based on the experiment, it was possible to observe various types of wear on the burins used to work with different materials. The most significant marks, including visible “edge-removals” and greater damage to the cutting edge, were recorded when working with harder materials, specifically bone and antler, as was also stated by Mansur. Mansur, in their experiment, stated that striations and micro-chips were observable when working on hard materials.⁷² With these contact materials, frequent chipping or breaking off part of the active edge occurred. In contrast, when burins were used on softer materials such as wood or slate, wear became more evident in the form of slight rounding and blunting, without causing significant damage to the edge, which was also observed in the experiment conducted by Gijn.

⁷² MANSUR, M. E. *Microwear Analysis of Natural and Use Striations: New Clues to the Mechanism of Striation Formation*, p. 216.

(1990).⁷³ Furthermore, there was a particular polish similar to one, from an experiment carried out in 1998 by Christopher Lindner and Lisa Folb.⁷⁴

All experimental burins and archaeological pieces were made of flint, minimizing variables associated with the raw material. During visual observation, it was possible to identify reflections on some pieces that could indicate the formation of a so-called “polish.” However, due to the absence of a metallographic microscope, it was not possible to confirm these reflections with certainty or classify them in more detail. Polish, as one of the essential diagnostic features, therefore, remained outside the scope of this analysis.

When compared with archaeological graters from Hostim, it was possible to note some signs of wear, similar to those observed during experimental work with harder materials, consistent with results from an experiment conducted by Gijn (1990).⁷⁵ Although it is not possible to determine the specific use with certainty, the nature of the damage suggests that contact with similarly hard materials may have occurred.

The limitations of the analysis primarily involve visual evaluation without instrumental techniques, the lack of quantitative measurements, and restricted opportunities for documenting fine traces. The study shows that a simple and inexpensive experiment can effectively support basic wear recognition and help develop hypotheses regarding tool usage. To achieve more in-depth and accurate results, it would be advisable to expand the experimental set in the future by increasing the number of tested tools, repeating individual tasks, and employing microscopic methods to confirm the presence of polish and other fine traces.

12. CONCLUSION

This bachelor’s thesis aimed to explore the possibilities and limitations of functional analysis of the lithic in the context of a hunter-gatherer environment in Bohemia. Attention was focused primarily on burins, which are frequently found in Magdalenian assemblages, and the methodological approach combined experimental archaeology with the analysis of an archaeological assemblage of burins from the Hostim site.

The thesis aimed to familiarize myself with traceological analysis principles and verify their practical applicability by creating an experimental burin collection used on various

⁷³ GIJN, Annelou van. *The Wear and Tear of Flint: Principles of Functional Analysis Applied to Dutch Neolithic Assemblages*. Leiden: Universiteit Leiden, 1990, p. 4.

⁷⁴ LINDNER, Christopher – FOLB, Lisa. *Lopuch 3 and microdrills: site report and use-wear analysis*, p.128.

⁷⁵ GIJN, Annelou van. *The Wear and Tear of Flint: Principles of Functional Analysis Applied to Dutch Neolithic Assemblages*. Leiden: Universiteit Leiden, 1990, p. 4.

materials. The wear marks documented served as a basis for comparing archaeological tools in stratified contexts. Results indicate that, at a basic level, wear marks from specific activities and material contact can be recognized and interpreted. However, the work also highlights the analysis's limitations, particularly the subjectivity of interpretation. Despite these challenges, it demonstrates that combining experimental and archaeological analysis can enhance understanding of Early Paleolithic tool use.

The methods used could be expanded in future research to include a broader range of tool types, contact materials, and the use of microscopic techniques. The experience gained in preparing this thesis provides a solid foundation for further study of the functional analysis of lithics in Czech archaeology.

Parts of this thesis were revised for language improvement using Grammarly. Suggestions for proofreading and language refinement were also taken from OpenAI's ChatGPT. All interpretations, experimental results, and conclusions remain the original work of the author.

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