From axe to grooved stone: Evidence of recycling practices in the Neolithic

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Abstract:

This paper examines the recycling and reuse of Neolithic stone tools, with a focus on a modified shaft-hole axe fragment discovered at Wierzbie, southwestern Poland. The study involved technological and use-wear analysis, supported by 3D modelling, to trace the life cycle of this tool and its transformation into a grooved stone. Stone tool recycling in prehistoric times often involved practices like edge resharpening and the adaptation of damaged tools, reflecting a pragmatic approach to resource management. The modified axe from Wierzbie illustrates a shift in tool function, highlighting a broader trend of reusing Neolithic implements, particularly in Late and Final Neolithic and Early Bronze Age contexts.

The tool's chronology was determined through detailed morpho-typological analysis and 3D model comparisons with complete Corded Ware culture (CWC) shaft-hole axes, confirming its origins within the CWC. The axe made from diabase was modified after it was damaged. The unusual nature of its modification suggests it was likely recycled during the Final Neolithic or Early Bronze Age, possibly linked to the Bell Beaker culture. This is supported by similar grooved stones used as shaft straighteners in Central Europe, particularly within Bell Beaker contexts. Microscopic analysis of the tool's surface reveals wear patterns consistent with its new function, including polishing and striation marks associated with shaping plant-derived material.

The results of this study highlight the adaptive strategies employed by prehistoric communities to prolong the lifespan of tools and materials, influenced by cultural and economic factors. This study highlights the complex life cycle of stone tools, demonstrating that recycling was not merely a functional necessity but also a culturally ingrained practice that helped maintain valuable resources within specific social and economic spheres. Through this lens, the Wierzbie artefact offers important insights into the technological ingenuity and material culture of prehistoric societies in Central Europe.

Keywords: Neolithic; recycling; shaft-hole axe; shaft straightener; use-wear; 3D modelling

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1. Introduction and background

Stone tool recycling represents a significant aspect of the technological process, powered by various factors and circumstances, including resource and waste management strategies, living conditions, and everyday needs. Evidence of such practices dates back to early prehistoric times, when recycling involved edge resharpening to maintain the original function of a lithic tool (Iovita & McPherron 2011) or the reuse of waste products from resharpening (Lazuén & González-Urquijo 2015). Tool resharpening persisted within agricultural communities, with a primary focus on bifacial flint implements (Barkai 1999; van den Dikkenberg 2024; van Gijn 2010). However, it evolved into adapting objects for new purposes when repairs were no longer feasible. An example of using broken axes as flake cores illustrates an adaptation to mineral resource scarcity (van den Dikkenberg *et al.* 2023).

1.1. Recycling of the Neolithic tools

Examples of stone tool modifications became more frequent from the Neolithic period onward. In Central Europe, numerous discoveries of hammerstones, pestles, and handstones modified from the Neolithic adzes and shaft-hole axes (Figure 1A & 1B) illustrate a rational approach to managing metabasite and serpentine resources by communities of Linear Pottery culture (LBK) and Lengyel culture (LC) (Kufel-Diakowska *et al.* 2024; Tichý 2021). During the Early Bronze Age, the transformation of sickle-shaped knives into bifacial axes further highlighted this resourceful strategy, particularly with flint (Budziszewski & Pyżewicz 2024). Single discoveries of the early Neolithic edge tools made from metamorphic rocks in the younger Eneolithic contexts exemplify both a practical and a non-utilitarian approach (Kufel-Diakowska *et al.* 2022; Szydłowski 2017). The use of Neolithic polished stone axes in modern times as thunderbolts, whetstones or remedies is documented in archival records and confirmed by ethnographic and use-wear data (Johanson 2009; Kufel-Diakowska *et al.* 2024; Kurasiński 2021). In this article, we discuss the complex life cycle of Neolithic stone tools, exemplified by a highly modified stone object from Poland, through the use of technological and use-wear analysis, as well as 3D modelling.

1.2. Modified stone tool

The find from Wierzbie (Figure 2) is linked to archival records mentioning the discovery of a 'half-mace' by Rector Wagner in 1939 at site no. 5 in *Weidengut, Kreis Falkenberg* (Gechwendt 1939: 122). The artefact was registered in the Inventory Book of the Conservation Office in Racibórz (ger. *Ratibor*) in 1943 under the number R. 70:43. Along with the 'mace', Rector Wagner also transferred a stone axe found in 1932 in Wierzbie (Geschwendt 1933: 20), registered under the number R. 50: 32 from site no. 2. This artefact has, to date, not been identified within any museum collections. Following surface verification surveys conducted at the beginning of the 20th century (AZP programme), the 'mace' was reassigned to site no. 1 (according to the new numbering system) and described in the record sheet for the archaeological sites (KESA) as a fragment of a stone hoe lost after the war. It was re-discovered due to a stone artefact query at the Museum of Opole Silesia.

Figure 1. Tool modifications in the Neolithic: A) Linear Pottery Culture (LBK), metabasite shoe-last adze (ID_448, Strachów 2/2a, Poland) and modified shoe-last adze (ID_451, Strachów 2/2a, Poland); B) Lengyel Culture (LC), serpentinite shaft-hole axe (MNA/81, Średnia Wieś, Poland) and modified shaft-hole axes (Zarzyca 6, Poland, MAW/13/80, MAW/6/80) (photographs by Ł. Melski); C) modified tool from Wierzbie 1, Poland (MŚO-A-N-1247/1) (photograph M. Chłoń). (Scale bars are 3 cm wide.)

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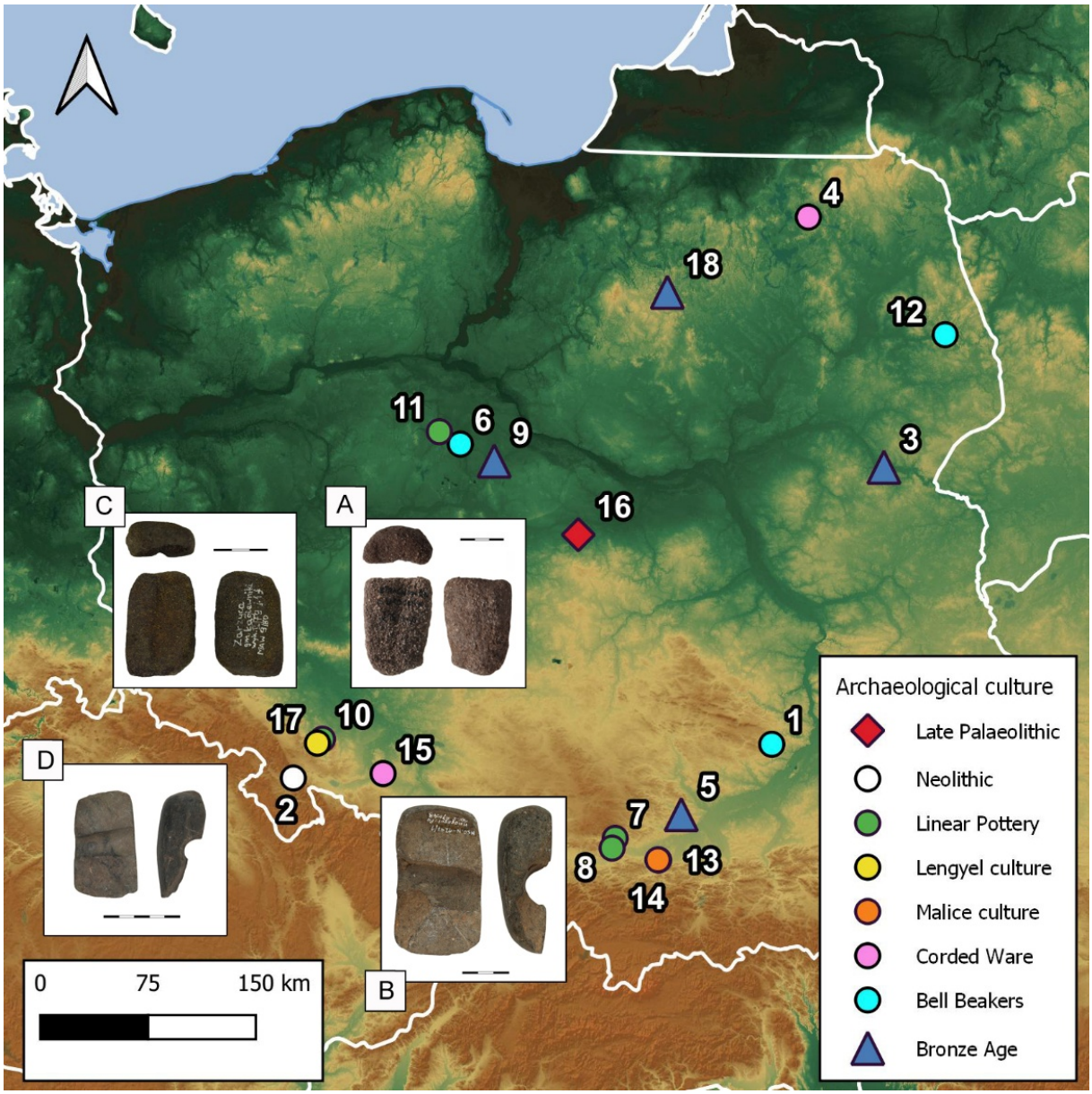

Figure 2. Location of the archaeological sites with finds of shaft straighteners, grooved abraders and modified tools. Late Palaeolithic: 16) Witów 1; Linear Pottery culture: 7) Modlnica 5; 8) Olszanica; 10) Strachów 2a; 11) Strzelce 2; Lengyel culture: 17) Zarzyca 6; Malice culture: 13) Targowisko 14-15; 14) Targowisko 16; Corded Ware culture: 4) Dudka; 15) Wierzbie 1; Bell Beaker culture: 1) Beradź 1; 6) Lachmirowice; 12) Supraśl 3; Bronze Age: 3) Drohiczyn-Kozarówka 13; 5) Jakuszowice 2; 9) Rybiny 17; 18) Ząbie; Neolithic (undetermined): 2) Dębowina; A) find from Starchów 2a; B) find from Wierzbie 1; C) find from Zarzyca 6; D) find from Dębowina (photographs by M. Chłoń and Ł. Melski, drawn by M. Chłoń).

The artefact is a side fragment of a shaft-hole axe with the opening oblique to the main axis and ground surfaces, both original and damaged (Figure 1C). It was produced from diabase, a rock that originated from the Fore-Sudetic Block. The object underwent repairs and modifications following damage. At its current stage, the tool is complete, measuring 86.3 × 30.38 × 48.72 mm, and may be classified as a grooved abrader or a shaft straightener with a U-shaped groove variant (Adams 2013: 86-92; Hamon 2008; 2016). The area from which the artefact originated is encompassed by a dense distribution of the Neolithic sites, including those of the Danubian and post-Danubian tradition, TRB and CWC units, para-Neolithic and final Neolithic discoveries (Furmanek 2019: figs 1-10).

2. Methods

2.1. 3D modelling

The 3D models necessary to clarify the object chronology were generated using photogrammetry with Agisoft Metashape 2.1.0, based on 360 images. The alignment of photographs, as well as the generation of the point cloud and mesh, were conducted using high-quality settings. All measurements and analyses were performed in Blender 4.2.

2.2. Use-wear analysis

The use-wear analysis method examined the different stages of a tool's life cycle. For observations of various types of traces, we used a Nikon SMZ25 stereomicroscope (3.15-315×) equipped with a coaxial light illuminator and a ring illuminator with a VisiLED MC 1100 controller, as well as a Nikon ECLIPSE LV100 metallographic microscope (50-500×). Micrographs of the traces were captured using Nikon DS-Fi3 and DS-Ri2 cameras attached to the microscopes, along with NIS-Elements image analysis software. After the initial microscopic observations focusing on potential macro-residues, the artefact was cleaned in an ultrasonic tank (Sonic-14). The interpretation of micro-traces was carried out based on reference material collected in the database of experimental samples from the research project 'Breaking the Code of Stones. The economic, social and symbolic meaning of the macro-lithic stone artefacts of the Neolithic societies (6^{th}-3^{rd} millennia BCE) in SW Poland - biographical approach'. The results of experimental research and microscopic analysis of replicas, which were used for comparative analysis, are presented in the text.

3. Chrono-typology of the axe

The type of mineral raw material used to produce the primary tool strongly suggests that the shaft-hole axe was made no earlier than by the post-Danubian communities. Axes of the Funnel Beaker culture (TRB) and the Corded Ware culture (CWC) were produced from serpentinite, amphibolite, diabase and basaltoid (Borowski *et al.* 2024). Petrographic studies indicate that these rocks were not utilized by the LBK societies in the southern part of Central Europe, who primarily relied on Jizera Mountains-type metabasite (Borowski *et al.* 2024; Přichystal 2013; Šída & Burgert 2024) and hornblende-rich hornfels (Masclans *et al.* 2021). The post-linear LC technology of shaft-hole axe production was based on serpentinite, with a small percentage of metabasite and basaltoid (Borowski *et al.* 2024).

There are three parts of the original surfaces of the axe distinguished based on microscopic observations: two parallel flat sides and a portion of the butt part (see below). The arrangement of these surfaces relative to one another helps narrow down the types of axes from which the tool was modified. Most shaft-hole axes and battle-axes associated with the Funnel Beaker culture (TRB) and the Corded Ware culture (CWC) exhibit one or two surfaces with varying convex or concave curvatures. The two types that align with the formal description of the tool from Wierzbie are the R-type shaft-hole axe of the TRB culture (Turek 2011; Zápotocký 1989) and the G-type shaft-hole axe of the CWC (Włodarczak 2006). TRB R-type axes were rectangular in cross-section and had a straight longitudinal profile, with a shaft-hole located either in the central part of the tool or closer to the butt. The upper and lower surfaces were flat, while the sides were slightly convex. CWC G-type axes were slender and narrow, with a height exceeding the width of the specimen. The longitudinal profile was intersecting flat; in a top view, the side edges exhibit a curved shape. Moreover, the CWC axe exhibits a blade that slopes to one side, a characteristic absent in TRB axes.

The G-type axes appear to be contemporary with other morphotypes that are dated to the younger phase of the CWC, as exemplified by the find from Budziszów Wielki 2/3 in

southwestern Poland (Bronowicki 2022; Pawleta & Zapłata 2009). At this site, a G-type axe made from diabase or microgabbro was found alongside three battle-axes of other types, in the same pit. Two of the latter were also made from diabase and represent younger variant of most characteristic boat-shaped form without its primary (older) defining features, such as curvature and horseshoe-shaped butt. The fourth battle-axe found in the pit was made from serpentinite and represents also a younger, H-type form, one of the most commonly found in the territory of Poland (Libera & Sobieraj 2016, Włodarczak 2006, to cite only a few). Because of the morphometric characteristics of the original parts of the axe from Wierzbie, including interrelations of the height and angle of the planes and the type of raw material, we focused on the CWC G-type shaft-hole axe. Other younger morphotypes of CWC axes were excluded due to differences in the location of the shaft-hole or the shape of the surfaces (rounding).

Using high-precision 3D models, it was possible to align the axe fragment with two complete examples of G-type CWC shaft-hole axes (Figure 3). To ensure consistency in the analysis, all objects were normalized in scale, enabling accurate comparisons and differentiation between them. Despite some noticeable differences, the analysis revealed that the object shares key morphological features with the reference artefacts, suggesting possible formal connections between the three. In both horizontal and vertical projections, significant morphological similarities were noted, indicating a high degree of typological consistency (Figure 4A & 4B). The shape, butt, and blade of the axes are comparable, with one side slanted at a similar angle to the opposing side (Figure 4C, 4D & 4E).

4. Manufacture and the use-life of the tool

The stone object from Wierzbie displays traces of several life cycle stages, including the manufacture of the shaft-hole axe, its use, transformation and re-utilisation of the new tool (Figure 5). Two original sides of the shaft-hole axe, parallel to each other, show flat macrotopography and linear grinding traces from the production phase. Scratches are shallow and smooth due to the subsequent use of the axe. The bright polish, which developed due to axe finishing and use, covers both surfaces (Figure 5A), contrasting with the dull areas abraded after the axe was damaged (Figure 5B). A similar bright polish was discovered on one end. We assume that this was a butt part of the axe. This section exhibits a concentration of small depressions resulting from pecking as evidence of axe usage (Figure 5C). A shaft hole was drilled at a slight angle. Traces of drilling are preserved as concentrically arranged striations on a small section of the groove (Figure 5E), marginally offset relative to the perforation axis. A minor misalignment of the drill bit during the drilling process resulted in a slight deviation from the intended axis of rotation.

The shaft-hole axe broke unusually along its central axis. Afterwards, damaged parts were ground, resulting in a handheld object with smooth surfaces, two poles, and a U-shaped groove. Two different types of use-related traces indicate the multifunctionality of the new tool. The groove bears marks of shaping or smoothing narrow, rounded objects made from plant-derived material. Its surface is covered by bright, smooth gloss and densely distributed striations located only in the central part (Figure 5F). The concentration of craters produced from pecking is preserved on the abraded surfaces (Figure 5D). In contrast to the mentioned similar marks on the original butt, these areas are not weathered, which means they developed later.

We used comparative data collected from replicas used in experimental trials to determine the complex biography of the stone object from Wierzbie. The separation of successive phases of production, use, and recycling was made possible by accounting for the differences between ground and polished surfaces (see van den Dikkenberg 2024). As

reference material in this case, we used a basalt preform, which was ground on a sandstone grinding stone with the addition of quartz sand. The ground surface exhibits a flattened macrotopography, though the surface microlevelling is rough. The edges of all marks from preceding actions, such as scars from flaking, craters from pecking, or remaining natural depressions, are sharp and irregular. A characteristic feature of the ground surface on the replicas was the presence of linear traces, including long, metallic linear polish and short, shallow scratches. Remarkably, the ground surface does not display any diagnostic polish (Figure 6A).

Figure 3. Shaft-hole axes used in 3D modelling: A) Maciejowice 30 (MNa/A/569); B) Budziszów Wielki 2/3 (2/08/W001); C) Wierzbie 1 (MŚO-A-N-1247/1) (photographs by M. Chłoń and Ł. Melski, 3D models by A. Kobyłka).

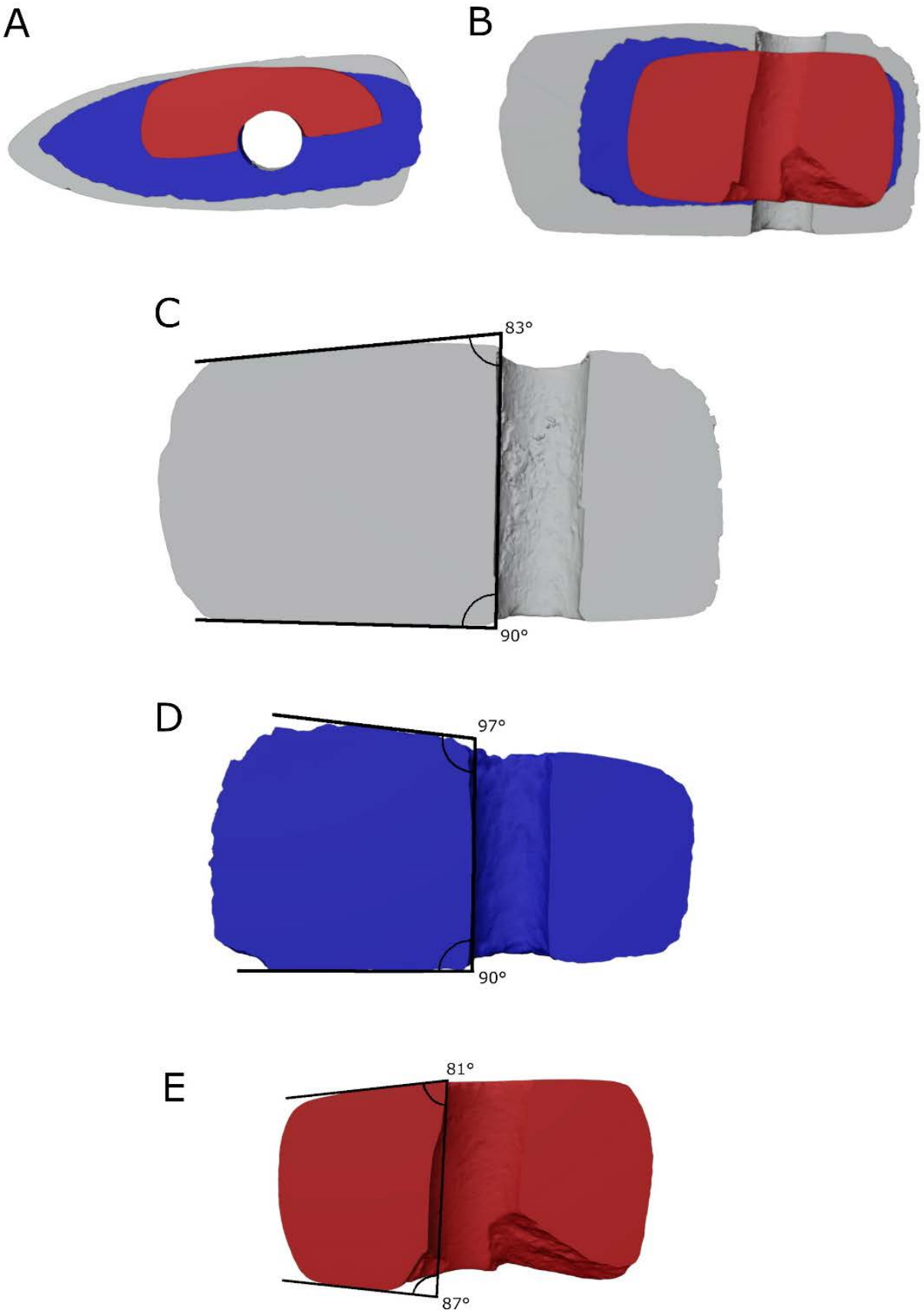

Figure 4. Results of 3D modelling analyses: A) vertical projection; B) horizontal projection; C, D & E) angles presenting slanting of two parallel sides of shaft-hole axes; C) Maciejowice 30 (MNa/A/569); D) Budziszów Wielki 2/3 (2/08/W001); E) Wierzbie 1 (MŚO-A-N-1247/1) (drawn by A. Kobyłka).

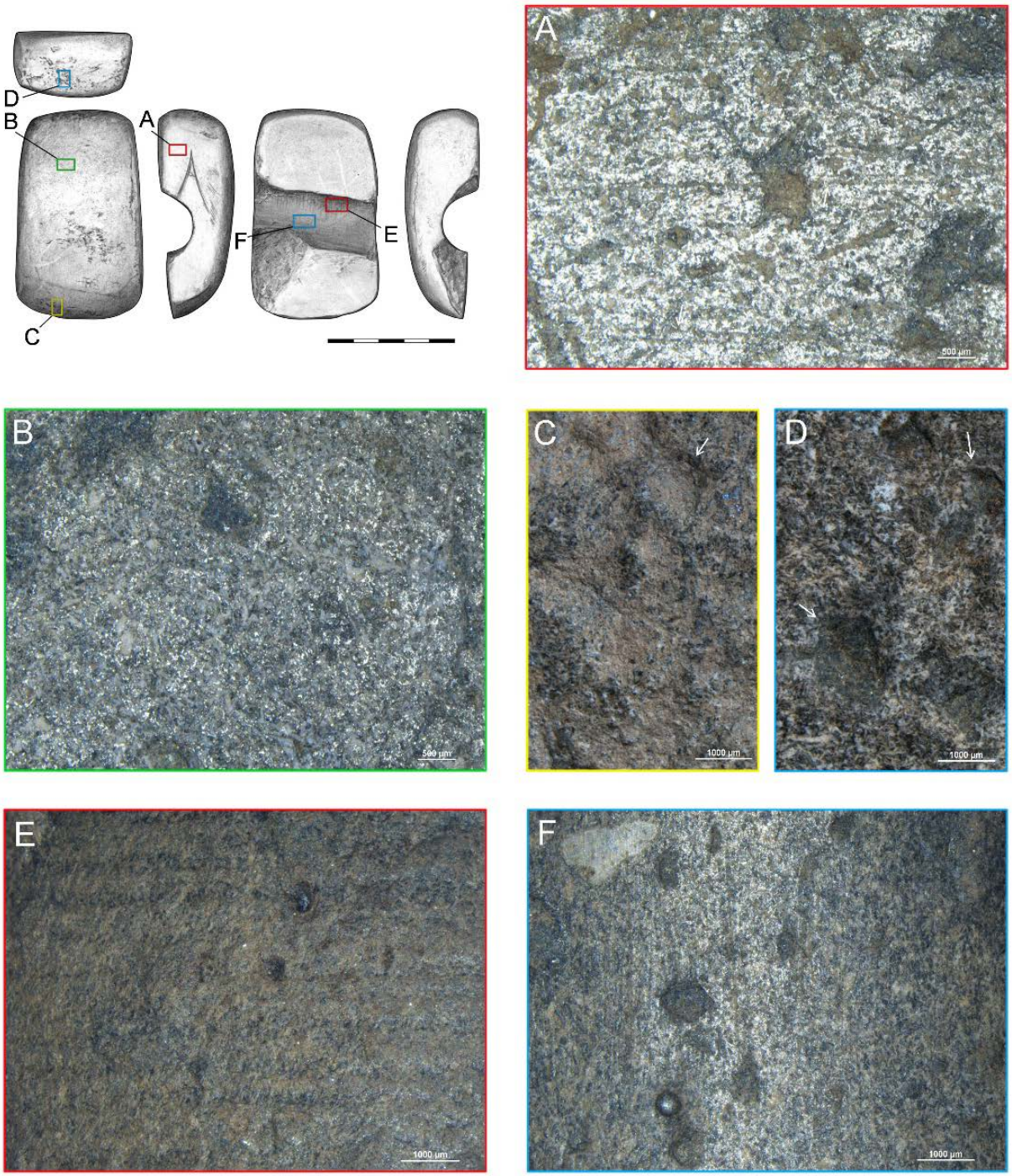

Figure 5. Grooved stone from Wierzbie 1, Poland (drawn by N. Lenkow) (scale bar is 5 cm wide). Traces of life cycle stages: production of a shaft-hole axe (red box): A) grinding and E) drilling; use of a shaft-hole axe (yellow box): C) pecking; transformation to a new tool (green box): B) abrading; use of a new tool (blue box): D) pecking and F) working of organic objects (photographs by B. Kufel-Diakowska). (Scale bars are as follows. A and B, 500 µm; C, D, E, and F, 1000 µm.)

Figure 6. Traces of production on replicas: A) grinding of the basalt preform; B) polishing of the basalt preform; C) drilling in a serpentinite preform; Traces of use and hafting on TRB/CWC battle-axes: D) traces of pecking/hammering, abraded surface on the butt, concentration of craters (B.955/4273:58, Otmuchów-Sarnowice, Poland); E) traces of hafting, vertical linear traces occurring inside the hole (ML/A433, undetermined site in the Legnica County, Poland) (photographs by M. Chłoń, W. Bronowicki, and M. Czarnik). (Scale bars are 1 mm or 1000 µm.)

In the part of the experiment focused on finishing the ground surface (polishing), we polished a basalt preform on leather with basalt dust used as abrasive material (additives of the same hardness). The polished surfaces are smooth, with a characteristic bright polish that covers the macrotopography. Traces from previous production stages, such as flaking and grinding, became altered— for example, the edges of technological traces become rounded (Figure 6B). To some extent, this highlights certain features, but as polishing traces develop, earlier technological traces are preserved only fragmentarily.

The issue of drilling in macro-lithic tools was addressed by several researchers (Osipowicz 2005; Tichý *et al.* 2021; Tichý *et al.* 2022). In our experiment, we used a drilling device with antler drill bits, a tool preform made of serpentinite, and quartz sand as the abrasive material. Here are the most important observations. On the inner walls of the drilled hole, numerous concentric and horizontal grooves and scratches are visible (Figure 6C). Changes in the width and depth of the linear traces, slight deviations from the horizontal position, and variations in the distances between the traces are the result of the drill's motion instability.

5. Discussion and conclusions

Two aspects merit discussion based on the recovered data: the chronological determination of the initial tool and the timing, rationale, and methods of its reuse. The use of diabase and the conformity of parameters in the 3D scan analysis indicate that the shaft-hole axe might have been produced and used within the communities of CWC. The circumstances surrounding its damage remain unexplained. We excluded the fracture during the shaft-hole drilling process. The drilling was completed in this case, as indicated by the characteristics of the hole's edge adjacent to the original surfaces of the axe. Failed drilling attempts from the Neolithic are recorded as axes with incomplete perforations and detached rock fragments (Tichý *et al.* 2022).

More likely, damage occurred as a result of utilisation. We have limited data on axe use due to alterations. Unfortunately, the blade, a crucial part of the tool in functional interpretation, has not survived. Pecking traces recorded on the butt part indicate a kind of percussive action related to a main or secondary function, such as wedging or hammering. These traces are not exceptional— we discovered similar use-wear on the axe butts, as was the case of the broken TRB battle-axe from the Otmuchów-Sarnowice (Figure 6D). Pecking traces were also found by A. Roy (2022) on the surfaces opposite the blades of battleaxes of the CWC and Single Grave Culture. The unusual aspect is that the artefact from Wierzbie represents a side fragment of a shaft-hole axe that is rarely encountered in Neolithic stone tool assemblages, regardless of the chronology or cultural tradition. More common are blades or butt portions of axes broken transversely or obliquely, also repaired by secondary drilling (Bronicki & Kadrow 1998; Kurasiński 2021; Šebela 1999; Verhart 2012). The author's experimental studies on axes, including tree felling, wood chopping, and the processing of bone and antler, have confirmed that these tools tend to fracture across the main axis rather than longitudinally. However, stresses during operation were not the only factor influencing the fracture pattern. Latent defects or mineral inclusions within the rock also played a significant role (see also Wentink 2020: fig. 5.20).

We assume that the tool was not recycled within the CWC, but rather later, at the end of the Neolithic or Early Bronze Age. From the morpho-typological perspective, the artefact from Wierzbie represents a kind of grooved stone with a U-shaped groove. Not only does this type of artefact have few analogues in the CWC stone assemblages in this part of Central Europe (Gumiński & Kowalski 2011), but there are also no examples of such curation practices among CWC communities (Budziszewski & Włodarczak 2010; Šebela 1999;

Włodarczak 2006). The strategy of stone tool management in the CWC was manifested by repairing broken axes, which involved edge re-sharpening and re-drilling, but without altering their original function. Modifications led to changes in the axe's morphotype only, as, in fact, tools were significantly shortened (Bronicki & Kadrow 1998; Kufel-Diakowska & Skuła 2015; Šebela 1999).

Grooved stones are associated with chronologically broad European and Eurasian contexts, spanning from the Mesolithic to the Bronze Age. Fewer are finds dated to the Palaeolithic (Figure 2). Commonly encountered are grooved abraders made from sandstone or other abrasive raw materials (Hamon 2016; Usacheva 2016; Vered 2013; to cite only a few). In most cases, they are primary tools used for shaping, abrading or polishing objects made from organic materials. There are two examples of quartz sandstone objects from southwestern Poland with longitudinal traces of use inside the groove: one from the LBK settlement Strachów 2/2a (Kufel-Diakowska *et al.* 2025a; 2025b)(Figure 2A) and one from the LC site Zarzyca 6 (Figure 2C). Grooved stones modified from broken axes are very rare and primarily composed of metamorphic rocks, which exhibit lower abrasive properties (Kowalski *et al.* 2021; Szydłowski 2017). Modifications of shaft-hole axes into axes which morphologically resemble grooved stones, also occur infrequently. One example made from serpentinite comes from the area of our study (Figure 2D).

Use-wear evidence recorded on the tool from Wierzbie suggests two functions: a percussive action that engages hard materials (see Tsoraki *et al.* 2020) and shaping or smoothing narrow objects from plant-derived materials. By analogy to other findings regarding use-wear, the artefact falls into the functional category of arrow shaft straighteners (Dmochowski 2015; Kowalski *et al.* 2021; Usacheva 2016). Since they are distinguished based on vertical linear traces and internal polish elements within the groove, we need to be aware that in the case of modified tools, there is a possibility of overlapping traces from two actions: hafting and secondary use. In the course of detailed microscopic observations of shaft-hole axes from various chronological contexts in southwestern Poland, we identified numerous tools with vertical scratches on the internal surface of the axe holes (Kufel-Diakowska *et al.* 2024), as in the case of the CWC battle axe made from diabase discovered in the Legnica County (Figure 6E). The only feature we considered distinguishing is the location and distribution of vertical lines: in the case of hafting, traces occur throughout the entire concavity of a hole, while in the case of reuse, traces are concentrated in one of the lowest point of the groove or hole (Kowalski *et al.* 2021; Pyżewicz 2015).

In Central Europe, artefacts with a groove are primarily associated with the Bell Beaker “archers” societies, as recognised from graves furnished with arrowheads, wrist guards, and grooved stones (Budziszewski & Włodarczak 2010; Cetwińska *et al.* 2024; Clément 2020; Włodarczak 2017). Dense clusters of finds associated with the Bell Beaker occupation, two of which are located about 50 km east and west of Wierzbie, were mapped in SW Poland (Furmanek 2019: fig. 10). It is worth mentioning that stone shaft-hole axes were not included in the Bell Beakers stone tool kit in the studied area. Shaft straighteners primarily appear as burial furnishings, either individually or in pairs. They were made from fragments of rocks or pebbles, with grooves deliberately carved. The discovery of a grooved stone transformed from a shaft-hole axe and used within the area of Bell Beaker communities represents an exceptionally rare find, with its only analogy from Lachmirowice in Kuyavia (Kowalski *et al.* 2021). Both tools were reworked from stone axes manufactured by people associated with the earlier cultural units and displayed traces of multifunctional uses. Both implements are decontextualised finds, which strongly confirms that the value of stray finds cannot be overstated, particularly in the case of stone tools, which have a complex life cycle (see Johanson 2006; Kufel-Diakowska *et al.* 2024).

In prehistoric communities, recycling that involved tool alteration had strong socio-economic contexts and was related to significant activities. Metabasite and serpentinite hammerstones and handstones, modified from broken adzes and shaft-hole axes, were used for abrading querns and producing other stone tools, as well as other production processes (Chłoń *et al*. in preparation; Tichý 2021). Cultural determinants played a crucial role in recycling practices, driven by the necessity to maintain objects made from a specific type of rock in circulation or within the same functional sphere, such as weaponry or ensuring safety. The tool from Wierzbie exemplifies an adaptive strategy likely employed by Bell Beaker societies to extend the utility of existing stone objects by repurposing tools beyond their original function, reflecting an efficient use of available materials.

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Data accessibility statement

This study had financial support provided by the National Science Centre, Poland. We used the microscopy equipment, infrastructure and area for the experimental studies available in the Lab for Archaeometry and Conservation of Archaeological Artefacts at the Institute of Archaeology the University of Wrocław. The data supporting the findings of this study are available within the paper. For further information, please contact the corresponding author.

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Od topora do kamienia z rowkiem: Ślady recyklingu w neolicie

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Abstrakt:

Artykuł podejmuje tematykę recyklingu i reutylizacji neolitycznych narzędzi kamiennych, bazując na przykładzie zmodyfikowanego fragmentu topora, odkrytego w miejscowości Wierzbie w południowo-zachodniej Polsce. Artefakt ten, znajdujący się w zbiorach Muzeum Śląska Opolskiego, został pierwotnie sklasyfikowany jako fragment motyki, jednak szczegółowe badania technologiczne i funkcjonalne, wsparte modelowaniem 3D, pozwoliły na ponowną interpretację jego formy, funkcji i chronologii. Celem badań było odtworzenie cyklu życia tego narzędzia - od jego pierwotnej postaci jako topora kultury ceramiki sznurowej (KCSz), przez uszkodzenie i przekształcenie, aż po wtórne wykorzystanie jako narzędzia z rowkiem o funkcji prawdopodobnie związanej z prostowaniem drzewców lub innego rodzaju obróbką przedmiotów z materiałów organicznych.

Zastosowano interdyscyplinarne podejście badawcze, obejmujące analizę technologii produkcji, mikroskopową analizę śladów użytkowania oraz modelowanie przestrzenne 3D. Modele 3D zostały wykonane metodą fotogrametrii z użyciem programu Agisoft Metashape, a porównania morfometryczne przeprowadzono w środowisku Blender. Do analizy śladów użytkowania wykorzystano mikroskop stereoskopowy Nikon SMZ25 i metalograficzny Nikon Eclipse LV100, a uzyskane dane porównano z wynikami badań eksperymentalnych prowadzonych w ramach projektu badawczego dotyczącego produkcji i użytkowania narzędzi kamiennych w neolicie.

Wyniki badań wykazały, że pierwotnym narzędziem był topór wykonany z diabazu - surowca charakterystycznego dla narzędzi produkowanych przez społeczności KCSz na Dolnym Śląsku. Analiza porównawcza z kompletnymi egzemplarzami toporów typu G, charakterystycznych dla późnej fazy tej kultury, wskazała na istotne podobieństwa morfologiczne, szczególnie w zakresie kształtu ostrza, obucha oraz ułożenia płaszczyzn bocznych. Zarejestrowane na powierzchni narzędzia ślady szlifowania, wiercenia, jak również ślady użytkowania, pozwoliły fragmentarycznie zrekonstruować cykl życia topora aż do momentu jego uszkodzenia. Artefakt charakteryzuje nietypowy sposób złamania wzdłuż osi narzędzia, co ułatwiło wtórne przekształcenie fragmentu. Mamy więc do czynienia z celową adaptacją uszkodzonego narzędzia do nowej funkcji.

Przekształcony artefakt charakteryzuje się obecnością rowka w kształcie litery U, zlokalizowanego w centralnej części jednej z powierzchni. Analiza mikroskopowa wykazała obecność intensywnego wyświecenia i gęsto rozmieszczonych rys w centralnej części zagłębienia, co wskazuje na wykorzystanie narzędzia do obróbki wąskich, wydłużonych przedmiotów - najprawdopodobniej wykonanych z materiału pochodzenia roślinnego. Na pozostałych powierzchniach zarejestrowano także ślady punktowych uderzeń w formie koncentracji kraterów, świadczące o zastosowaniu narzędzia jako tłuka na obu etapach jego funkcjonowania. Sugeruje to wielofunkcyjność przekształconego narzędzia, które wykorzystywano zarówno do kształtowania, wygładzania przedmiotów drewnianych lub kościanych, jak i do obróbki twardych materiałów.

Na podstawie formy oraz analogii z innymi znaleziskami, uznać można, że narzędzie zostało ponownie wykorzystane w późnym neolicie lub we wczesnej epoce brązu, prawdopodobnie przez społeczności kultury pucharów dzwonowatych. Kamienie z rowkiem, interpretowane jako prostowniki drzewców strzał lub gładziki, stanowią typowy element wyposażenia grobów tej kultury i są rzadko spotykane w inwentarzach związanych z KCSz. Znalezisko z Wierzbia, podobnie jak pojedyncze analogie z Kujaw i Dolnego Śląska, wskazują na praktykowanie przez społeczności neolityczne przekształcania narzędzi starszych społeczności w nowe przedmioty, o odmiennych niż pierwotnie zastosowaniach.

Praktyki recyklingu narzędzi kamiennych w społecznościach epoki kamienia były częścią bardziej złożonego systemu gospodarowania surowcami kamiennymi, w którym kluczową rolę odgrywały zarówno uwarunkowania funkcjonalne, jak i kulturowe. Transformacja topora KCSz w nowe narzędzie, jakim jest kamień z rowkiem świadczy o wysokim poziomie umiejętności technologicznych i adaptacji, a także o możliwości długotrwałego obiegu przedmiotów kamiennych w różnych kontekstach kulturowych.

Słowa kluczowe: Neolit; recykling; topór; prostownik do strzał; analiza mikrośladów; modelowanie 3D