FROM POLISHING TO BURNING: DECIPHERING A MIDDLE NEOLITHIC HOARD FROM BERINGEN BROUWERSHUIS (BELGIUM) THROUGH FUNCTIONAL ANALYSIS

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ABSTRACT

The Beringen Brouwershuis hoard, distinguished by its well-documented and radiocarbon-dated context, offers a unique opportunity to explore the hoarding practices of the Middle Neolithic period in the Campine region of Belgium. As one of the few excavated hoards from this period, it provides rare contextual information about these hoarding practices. This study aims to provide new insights into the life cycles of buried lithic artefacts through a detailed functional and contextual analysis. By employing macro- and microscopic analytical methods, we examined residues and use-wear traces on 17 artefacts, including six polished axes, seven endscrapers, and four smaller tool fragments. The detailed functional analysis of these stone tools confirmed that they were hafted, used, and resharpened before being deposited. Moreover, it enabled the reconstruction of a unique biography for each individual artefact, demonstrating that each had a distinct life encompassing own set of lifecycles stages.

Keywords: Neolithic, Michelsberg, hoards, functional study

Introduction

Here, we present a detailed functional analysis of axes and endscrapers recovered from a depositional context at the Beringen Brouwershuis site during developer funded excavations. This deposition pit is composed of a diversity of artefact types including a core, flakes, bladelets, different axe types, multiple scrapersHoarding practices are a well-documented phenomenon among Neolithic societies in Northwestern Europe (Hamon & Quilliec 2008; Wentink 2006). Archaeologists have traditionally distinguished between dryland and wetland hoards, recognising differences in both their composition and presumed function (Bradley 1990). Dryland hoards typically consist of broken or unfinished polished stone axes, flint tools, and other lithic objects. These are often interpreted as "workshop hoards"—collections of surplus material, possibly intended for redistribution, trade, or future use (Bruck 2016). In contrast, wetland hoards commonly contain complete objects, such as highly polished ceremonial axes. These items are frequently recovered from rivers, lakes, and bogs and are widely interpreted as votive offerings, given their frequent placement in difficult-to-access wetland environments, the unusually large sizes of the deposited objects, the deliberate selection of specific artefacts, and evidence of intentional destruction, such as exposure to intense heat (Larsson 2000, Sørensen et al. 2020).

However, a major challenge in interpreting prehistoric hoards is that many have been discovered incidentally, outside of progammed archaeological excavations, and thus lack crucial contextual information that would aid in understanding their precise function and significance (Sørensen et al. 2020). This limitation complicates efforts to discern the motivations behind hoarding practices, emphasising the need for detailed biographical analyses of these objects to reconstruct their role within Neolithic societies. Recent developments in functional analysis have allowed archaeologists to study these hoarded artefacts through a highly detailed approach, providing deeper insights into their manufacture, use-life, and deposition processes. By employing microscopic wear analysis and residue studies, researchers can reconstruct the biographies of these objects, tracing how they were produced, used, repaired, and ultimately deposited (e.g., Rots 2010a, Van Gijn 2010, van den Dikkenberg 2024, Wentink 2006).

Functional analysis has been applied only to a limited extent on Neolithic hoard deposits, particularly those from the Drenthe region within the TRB (Funnel Beaker Culture). Wentink's (2006) study examined 67 flint axes (25 from graves, 13 single finds, and 29 from multiple-object deposits), using high-power microscopy to analyse use-wear and residue. The results indicated that small axes from graves had been used and resharpened before burial, whereas axes from wetland contexts remained unused but showed traces of repeated wrapping in a specific yet unidentified material, as well as red ochre on their cutting edges—suggesting a ceremonial function. Sørensen's (2020) study in Denmark, based on 14 axes from four deposits in central Jutland, challenged the assumption that TRB hoards exclusively contained unused axes, demonstrating that both used and unused axes appeared in the same deposits. Additionally, Sørensen questioned the traditional wetland-dryland typology, arguing that deposition practices varied significantly, with blurred distinctions between ritual and profane contexts.

A final application of functional analysis on Neolithic hoard deposits concerns the study by Bamforth and Woodman (2004) on Neolithic hoards in northeastern Ireland. Their research applied functional analysis to five hoards of flaked stone tools, located in the lowlands and intermediate elevations west of the Antrim Plateau, dating to c. 4000–2500 BCE. Their microscopic analysis of 280 scrapers revealed that they had been resharpened multiple times before deposition, indicating functional use before being stored.

Due to the limited application of functional analysis, little is known about the status of hoards within other Neolithic cultural traditions. For the Michelsberg Culture, which emerged in the late 5th millennium BCE and represents the Middle Neolithic of Belgium, there is currently no systematic study of hoarding practices comparable to those conducted on TRB or Irish Neolithic deposits. While Michelsberg material culture is well-documented in the fertile loess regions, including its distinctive flint mining activities (Allard et al. 2008; Bostyn et al. 2023) and its characteristic tranchets, polished axes, and end scrapers (Vanmontfort et al., 2002; Schreurs

2016), little attention has been given to the intentional deposition of these objects. Unlike TRB hoards, where structured depositions have been confirmed through microscopic wear analysis, Michelsberg deposits often lack secure contexts, making it difficult to determine whether polished axes and other tools found in isolation represent ritual depositions, caches, or simply stray finds.

However, a few possible Michelsberg hoard deposits have been identified in Belgium. In the immediate vicintiy of the Neolithic enclosure of Chaumont-Gistoux, a surface find of five axes that were found together has been interpreted as a potential structured deposition (Capouet 2020). The same interpretation has been proposed for five other finds of each time two or three axes in Limburg (Belgium and the Netherlands): at Opgrimbie, Megelsum, Borgharen, Geleen and Neeroeteren (Verhart 2024). In the case of Neeroeteren the three axes were polished, while in all other finds exclusively unpolished axes were found (*ibid.*). While these finds lack stratigraphic integrity, their location within Michelsberg territory suggests that similar deposition practices might have occurred. Unlike TRB hoards, which often contain both ceremonial and functional tools, the Michelsberg hoards have not been studied in detail, particularly regarding functional aspects.

To address these gaps in knowledge, a recent discovery of a deposition pit at Beringen Brouwershuis provides a unique opportunity to expand our understanding of Michelsberg deposition practices. The find consists of an isolated pit that contained a diverse range of artefact types, including a core, flakes, bladelets, different axe types, multiple scrapers, and a hammerstone, with most tools showing significant heat damage (Geerts et al. 2021). This has led to the hypothesis that these artefacts were deliberately selected and burned, possibly as part of a ritual act (Geerts et al., 2021). Notably, the fire did not occur directly in the deposition pit, as evidenced by the scarcity of charcoal pieces or other in situ indications ~~for~~of heating. The ~~missing~~absence of certain fragments further suggests that the tools were exposed to fire elsewhere before being deposited. The dating of charcoal fragments, combined with the typological characteristics of the objects, attributes the assemblage to the Michelsberg Culture (Geerts et al., 2021).

~~The Michelsberg culture, which emerged in the late 5th millennium BC, represents the Middle Neolithic in Belgium and is primarily associated with sites in the country's fertile loess region (Bakels 2009; Vermeersch & Burnez-Lanotte 1997; Vanmontfort 2004, 2022). This culture originated in the Paris Basin and expanded into the Rhine and Neckar valleys (Scollar 1959; Jeunesse 1998; Beau et al., 2017), with flint mining as a distinctive cultural marker (Allard et al. 2008; Bostyn et al. 2023). Michelsberg material culture has been characterised through studies of various artefact types, including ceramics (Vanmontfort et al. 1997), macrolithic tools (Messiaen et al. 2019), and lithic tools (Vermeersch et al., 1990). The lithic assemblage of the Michelsberg culture is notable for its specific tools, such as tranchets, polished axes, and a significant number of endscrapers (Vanmontfort et al., 2001/2002; Vanmontfort 2004; Schreurs 2016). While the evidence for the Michelsberg culture in Belgium is well-documented in the fertile loess belt, little is known about it in the sandy Campine region (Vermeersch & Burnez-Lanotte 1998). The discovery of the deposition pit at Beringen Brouwershuis, located within the Campine region, provides thus a unique opportunity to enhance our knowledge in this area.~~

~~In this study, we adopt a biographical approach inspired by Van Gijn and Wentink (2013) to explore the lifecycle of artefacts recovered from the Beringen Brouwershuis site.~~Here, we present a detailed functional analysis of axes and end scrapers recovered from this depositional context. We adopt a biographical approach, inspired by Van Gijn and Wentink (2013), to explore the lifecycle of a selection of artefacts recovered from the site. This approach considers that artefacts often accumulate diverse meanings and functions throughout their existence, reflecting changing social and ritual contexts. By examining wear traces and residues ~~that were~~ accumulated during all stages of the active life (e.g., production, hafting, use, maintenance, and recycling) and afterlife (e.g., deposition, destr~~oy~~uction~~g~~, burying) of the artefacts, the ~~often~~ complex biographies of these lithic ~~artefacts~~objects can be reconstructed (Van Gijn 2009).

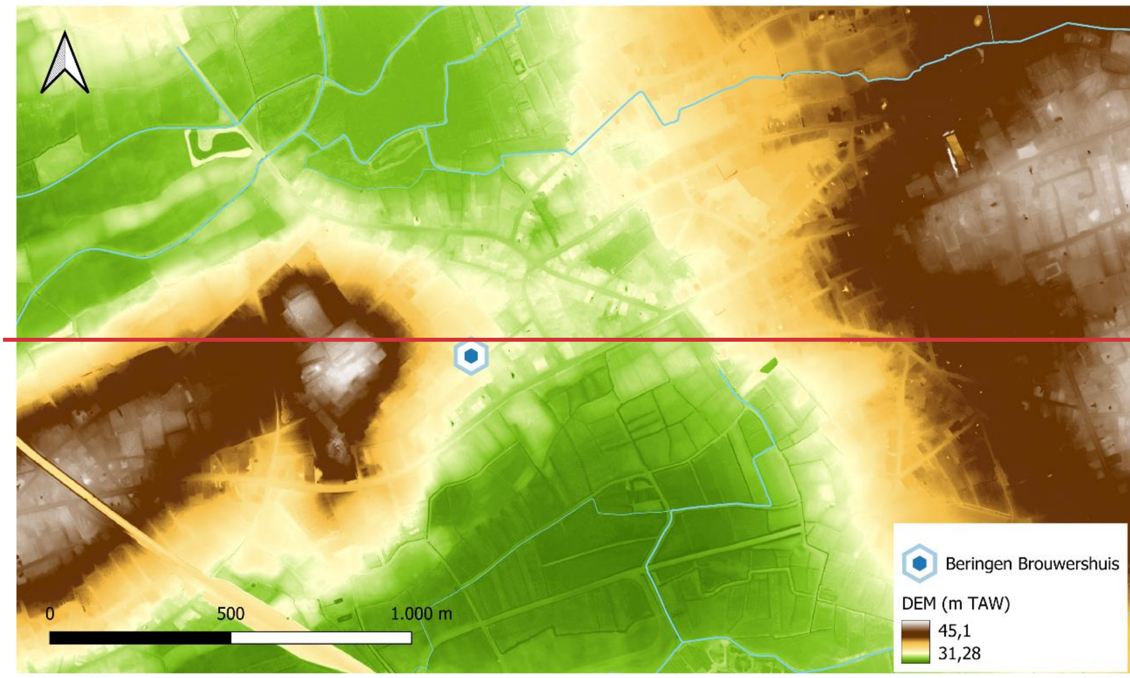
Material and methods

Site context

In 2020, a developer funded excavation was conducted in Koersel (Beringen, Limburg province, Belgium), located in the heart of the Campine region, which is known for its characteristic drift sands. This area lies geomorphologically on the intersection of the glacis of Beringen-Diepenbeek to the east and the Lummen hills to the west (Beerten et al., 2018), forming a unique transition zone between the elevated Campine Plateau to the east and the lower Campine Plain to the west.

The site has an interesting position within the local topography as it is situated approximately 34.5 meters above sea level, at the eastern ~~footslope~~foot slope of one of the easternmost Lummen hills that reaches 44.5 meters above sea level. The 2 km long and 400 m wide hill is oriented southwest to northeast. The subsoil consists of a well-drained loamy sand, where a moderately dry podzol soil has developed (Fig. 1). The site location may have provided strategic and environmental advantages, with a connection to the top of the hill at only 300 m distance that will have offered a comprehensive view of the surrounding landscape. Additionally, the site is positioned near water sources, with the Zwarte Beek and Schansbeek to the north and the Welderbeek to the south, factors that may have influenced past settlement choices.

One of the most important discoveries at this site was a deposition pit (SP8) containing 53 lithic artefacts (see Table 1), including polished axes and scrapers (see Fig. 3) two pottery sherds, and fragments of charcoal. The pit, about 0.5 square meters large, was centrally located within a zone surrounded by an approximately four-meter-wide feature with distinct soil development, interpreted as a ditch (~~see Fig. 2).~~ SP6) (see Fig. 2). This broad, four-meter-wide feature (SP6) may have functioned as a boundary or enclosure, though no artefacts were directly associated with it. Beyond the deposition pit, the excavation also revealed several additional archaeological features of yet unknown date, indicating a more complex site structure. Three charcoal-rich pits were recorded, though their connection to SP8 remains unclear. These pits contained no lithic artefacts, suggesting they may represent separate activity events. Furthermore, postholes, a trench, and additional pits were identified, but their chronological and functional relationships to the deposition pit remain uncertain.



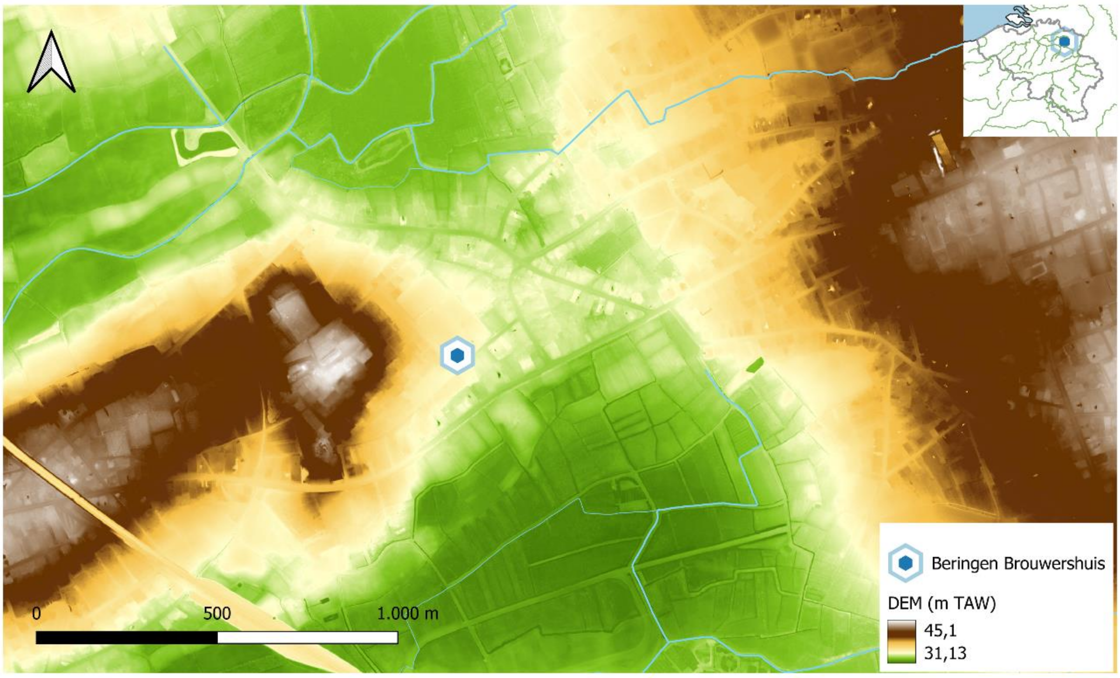


Figure 1 - The location of the archaeological site within the local topography. DEM © Digitaal Vlaanderen.

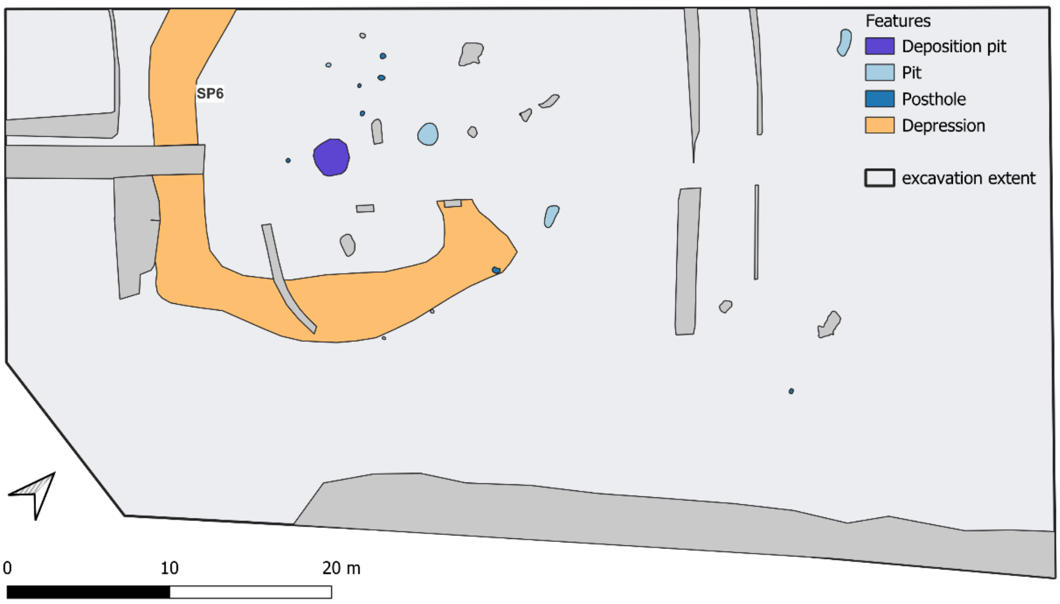


Figure 2 - Plan of the Beringen Brouwershuis site with indication of the observed archaeological features (adapted from Claessen et al. 2021, fig. 32).

The deposition pit has been attributed to the Michelsberg culture, on the basis of radiocarbon dating and the typological characteristics of the scrapers (Geerts et al., 2021). Radiocarbon dating of two charcoal samples from different depths in the fill of the deposit pit SP8 provided a date of 5200 ± 38 BP (Ua-67453), between 4059 and 3949 cal BC (with a probability of 87.1%), and 5144 ± 37 BP (Ua-67454), between 4041 and 3803 cal BC (with a probability of 95.4%). Additionally, the typological characteristics of the scrapers, particularly the hoof shape of some, support a cultural attribution to the Middle Neolithic Michelsberg culture (Schreurs 2016). The types of polished axes and the use of flint mined from the Lanaye chalk (Schreurs 2016; Vandendriessche et al., 2015), further reinforce this attribution. The chronological relationship between the features at Koersel (Beringen - Brouwershuis) remains partially unresolved, with SP8 as the only securely dated feature to the early 4th millennium BCE. The surrounding ditch-like feature (SP6) lacks direct dating evidence, making its function as an enclosure or later soil development uncertain. Similarly, the charcoal-rich pits remain undated, with no clear link to the deposition pit. Additional postholes, trenches, and pits suggest further anthropogenic activity at the site, possibly from later prehistoric or historic periods.

Artefact type	*Quantity (N)*	*Damaged by fire (N)*
Core	1	1
Flake	20	20
(Micro)blade	5	5
Axe	4	3
Tranchet	1	1
Axe pre-form	1	1
Scraper	10	7
Retouched flake	1	1
Tool fragments	8	7
Hammerstone	1	0
Pebble	1	0
Total	*53*	*46*

Table 1 - Typo-technological characteristics of the 53 lithic materials that were found in the deposition pit

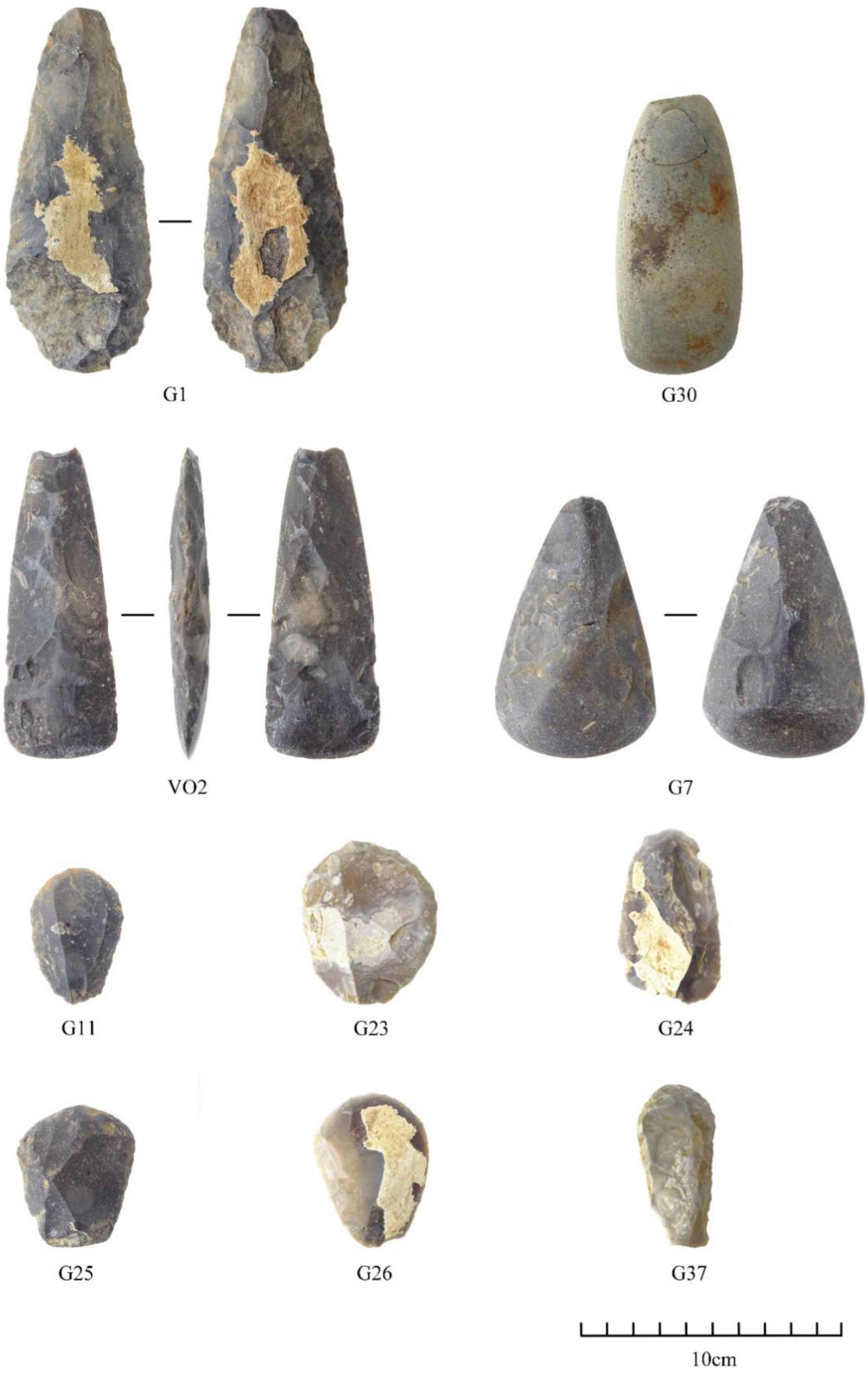


Figure 3 - Morphological variability of the deposited axes and scrapers (Geerts et al., 2021, Fig. 4)

~~**Materials and methods**~~

~~**A total of 17 artefacts, most promising for functional**~~ **Microscopic analysis**~~,~~

In this preliminary study, only the axes and scrapers were ~~selected from the 53 lithic artefacts. This included~~ analysed, comprising six polished axes ~~and one associated potlid fragment~~, seven ~~mostly~~nearly complete scrapers, and ~~three~~four scraper fragments~~.~~, making a total of 17 out of the

53 artefacts. As this research was part of a developer-funded programme with a limited budget, the decision was made to prioritise the analysis of axes and scrapers in the initial phase. This approach aligns with standard sampling strategies in developer-led archaeology, where time and financial constraints often necessitate a phased investigation, initially focusing on artefacts most likely to yield significant insights, as they are formal tool types. In addition, this selection allowed for comparison with results from previous functional studies on hoard deposits, as these studies included axes or scrapers. The remaining artefacts will be examined in a follow-up study.

The preservation state of each tool was first determined, thereby focussing on a meticulous documentation of traces that result from post-depositional processes and their distinction from possible functional wear (Cnuts and Rots 2024, Tomasso et al. 2021). The presence and intensity of six types of alteration were evaluated: patina, gloss, heat damage, rounding, and metal traces. Alterations resulting from intense heat exposure received special attention, such as fractures, potlids, cracks, or discoloration.

Microscopes with varying technical characteristics (e.g., magnification, lighting techniques) were used to detect edge and surface modifications and residues. A Zeiss Macro-Zoom V16 microscope, equipped with PlanApo Z objective lenses (0.5×/0.125 and 1.0×/0.25) and offering a magnification range from 5.6× to 180×, was employed. For higher magnifications, a Zeiss Axio Imager M2m metallographic microscope was utilised, featuring 10× oculars and six objective lenses (EC Epiplan 5×/0.13 HD; EC Epiplan-Neofluar 10×/0.25 HD DIC; LD EC Epiplan-Neofluar 20×/0.22 DIC; LD Epiplan 20×/0.40; LD Epiplan 50×/0.50; and LD EC Epiplan-Neofluar 100×/0.75 DIC) with magnification capabilities ranging from 50× to 1000×.

To better visualise certain microscopic details, a JEOL IT 300 scanning electron microscope (SEM) was used. The interpretation of all wear traces and residues relied on comparisons with the large experimental reference collection TRAIL of TraceoLab, which includes more than 7,000 lithic artefacts (Rots 2021). TRAIL includes artefacts submitted to a wide variety of processes and is representative for wear traces from production (Rots 2010b), hafting (Rots 2010a), and use (Rots 2021), including projectile impact (e.g. Coppe 2020; Coppe & Rots 2017; Lepers et al., 2024). TRAIL also includes artefacts from taphonomic experiments (e.g. Michel et al. 2019, Michel and Rots 2022, Cnuts and Rots 2024) and experiments related to the impact of excavation (e.g., contact metal tools, sieving) (Cnuts et al 2021) and storage (eg. Rots 2010b). The elemental composition of the residues was further characterised with a JEOL IT300 scanning electron microscope (SEM) equipped with energy-dispersive X-ray spectroscopy (EDX).

Results

Post-depositional traces and residues

Thirteen of the selected artefacts exhibited clear damage from heat, consisting of potlid negatives, fractures and edge scarring (Fig. 4), which indicates direct and intense exposure to fire and significantly limits the potential of functional analysis for some tools. In contrast, three scrapers and one axe lacked clear evidence of exposure to heat. Little or no impact from other post-depositional processes was observed in the sample. The absence of traces from mechanical weathering, such as rounding, abrasion, or edge damage, indicate a rapid burial of the material.

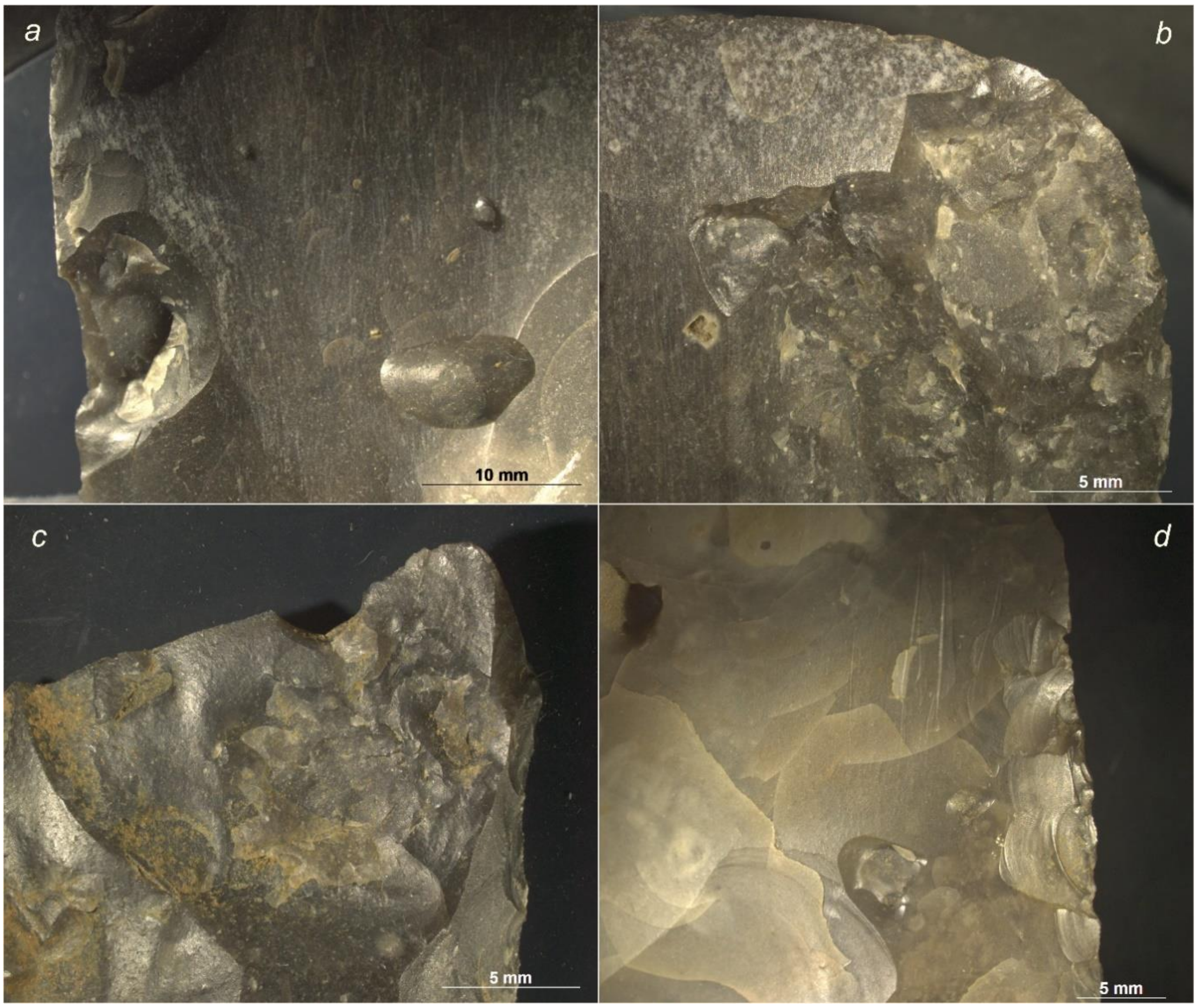


Figure 4 - Examples of heat altered artefacts with (a) potlids, (b+c) fractures, (d) incipient cracks

All artefacts were also screened for taphonomic residues to make sure that these would not be confused with functional evidence. Interestingly, an iron oxide deposition was observed on several artefacts, including axes and scrapers (Fig. 5). The absence of a clear distribution pattern, such as a direct association with the used edge or an exclusive presence on the passive part of the tool, rules out the possibility that these residues were deposited through either use or hafting of these tools. Furthermore, the presence of iron oxide within the potlid negative of one scraper (Fig. 5a) suggests that the deposition occurred at a later stage, after the burning of the artefacts.

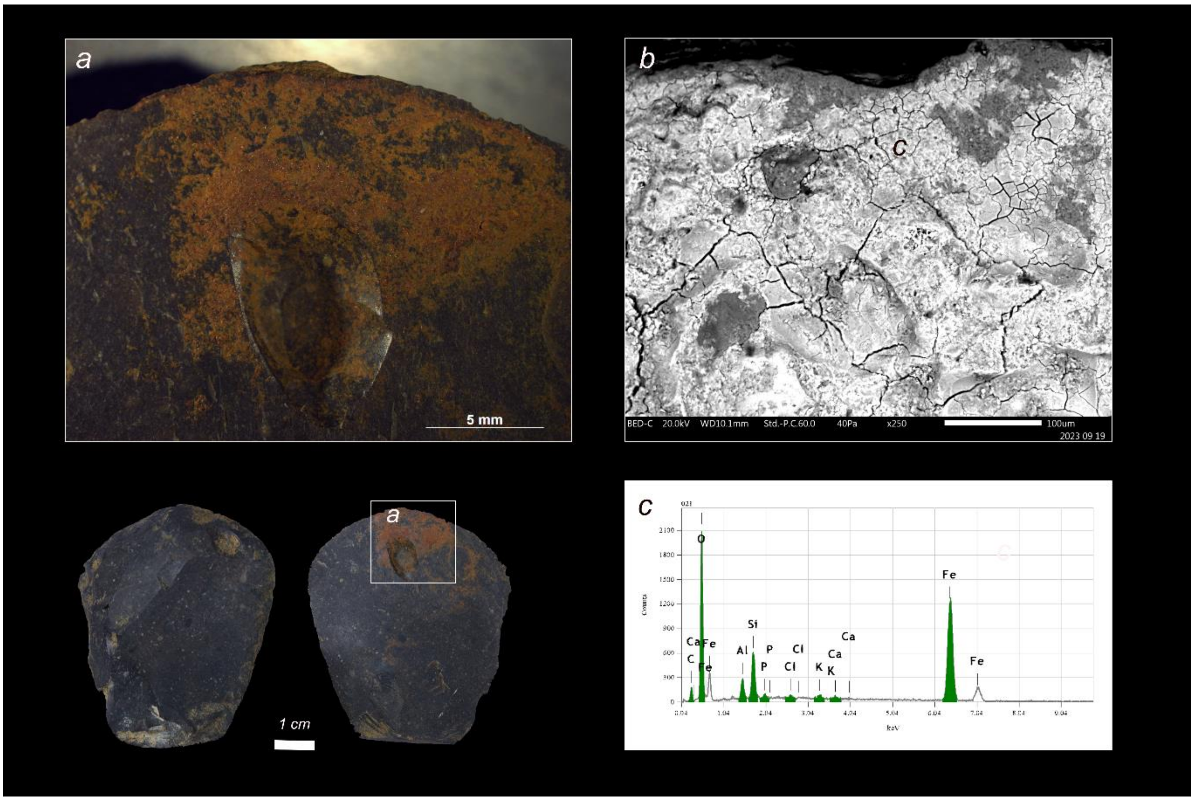


Figure 5 - (a) Overview of the iron residue on the ventral surface of the scraperhead (x10), (b) detail of the iron residue with the scanning electron microscope (x250) and (c) the elemental analysis indicating high peaks of iron elements

During analysis, an intriguing azure-blue residue was observed on two artefacts that also show heat damage. An elemental analysis using the scanning electron microscope permitted to determine that these residues were predominantly of organic nature, which indicates their recent origin as the exposure to intense heat would have caused the destruction of all organic residues of functional origin. In addition to the organic-rich peak, a subtle presence of titanium was also detected and this combination is similar to what is observed when analysing very small remnants of plasticine. Plasticine had indeed been used during the initial photographic documentation of the objects.

Production traces on axes

The sample includes five bifacial axes and one unifacially shaped axe, with several phases of manufacturing still visible. Evidence of grinding was observed on at least three axes, consistently overriding flaking negatives (see Fig. 6a). Observations of deep, large, linear, and parallel grooves, along with polish and a white sheen, were most likely the result of grinding the tools on coarser-grained sandstone to achieve the initial desired shape (van den Dikkenberg, 2024) (see Fig. 6). In a subsequent phase, or the finishing phase, evidence of more regular abrasion or a smoother surface, accompanied by fine parallel striations, suggests the use of finer grains than in the initial stage for abrasion. However, at this stage of the analysis, it was not possible to determine whether the second phase involved the same raw material, such as sand with finer grains, or if other materials like ash were employed to complete the production phase of the axes.

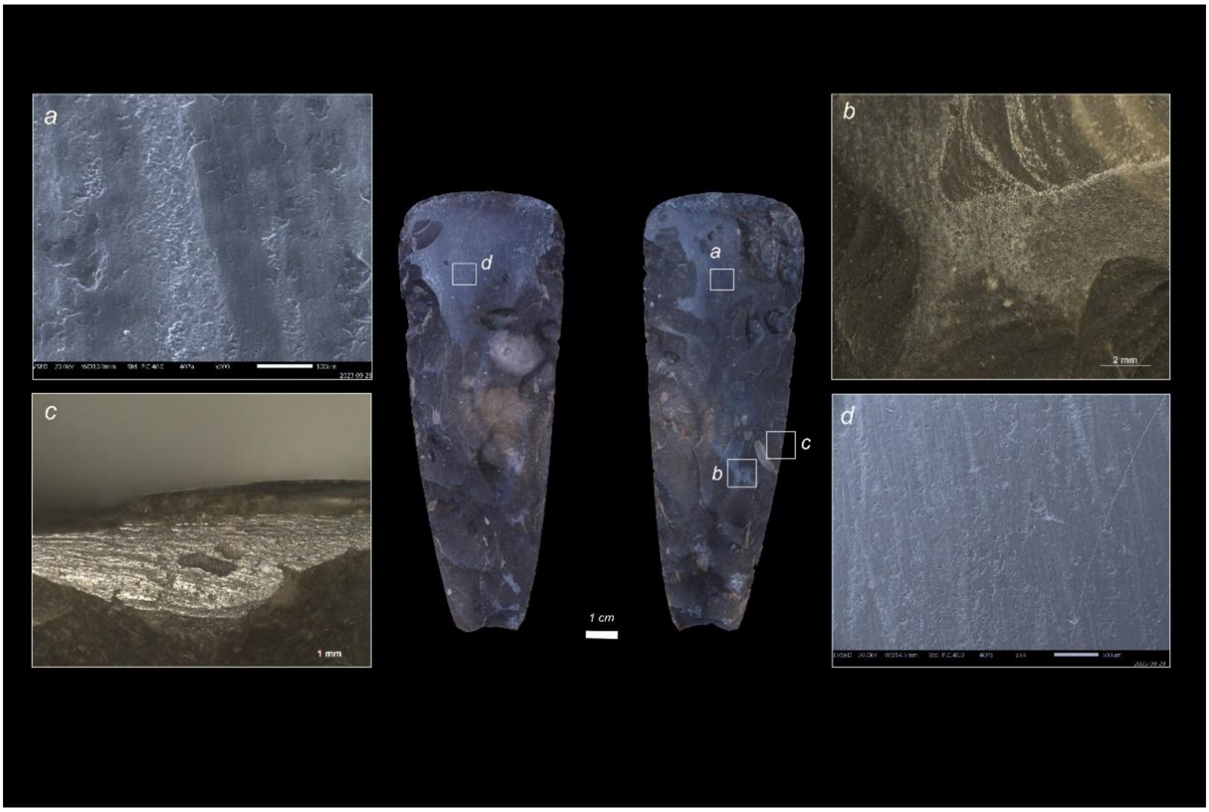


Figure 6 - Examples of the production traces, with (a) microscopic detail of linear striations with parallel orientation (x200), (b) linear abrasion posterior to the shaping (x16.0), (c) deep linear grooves recorded on the lateral edges of the axe, indicating the longitudinal grinding motion on a coarse grained mineral material (x32.0), (d) fine striations with parallel orientation that are most likely the result of grinding and polishing the axe on a finer grained mineral material (x33.0)

Use-wear traces on axes

Although few functional traces could be observed on the axes, the absence of use-wear traces does not mean that these axes were unused. First, the polished sheen of the axes can be attributed to the manufacturing (grinding) process, which may complicate the identification of use-wear polish. Second, if the axes were resharpened after use, any developed use-wear would have been removed and, therefore, cannot be observed. Third, the intense heat damage on some of the axes, in the form of potlids and edge damage, may have also removed any initial use-wear, as portions of the potential active edges were destroyed.

Even macroscopic functional traces proved to be very limited, which is unsurprising given that the grinding procedure of the flaked axes rendered the edges more resistant to damage. Indeed, it is known that a polished edge offers enhanced strength and longevity compared to a rough, flaked edge (Hayden 19~~8~~79, Madsen 1984, Barkai 1999). Only one of the examined axes suggests that it was used on moderately hard material, such as fresh wood. In this case, a polish was developed along the cutting edge (see Fig. 7), posterior to the polished surface from manufacture, in association with concentrations of macroscopic and microscopic scars.

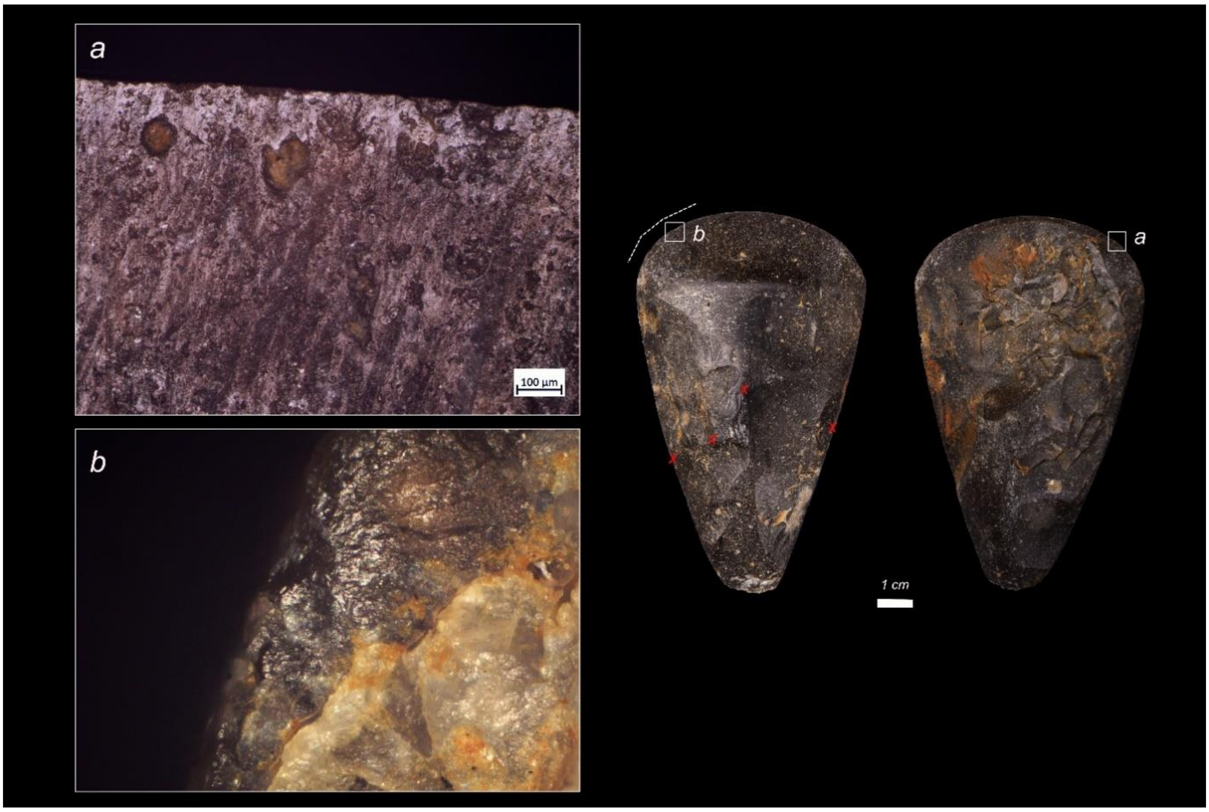
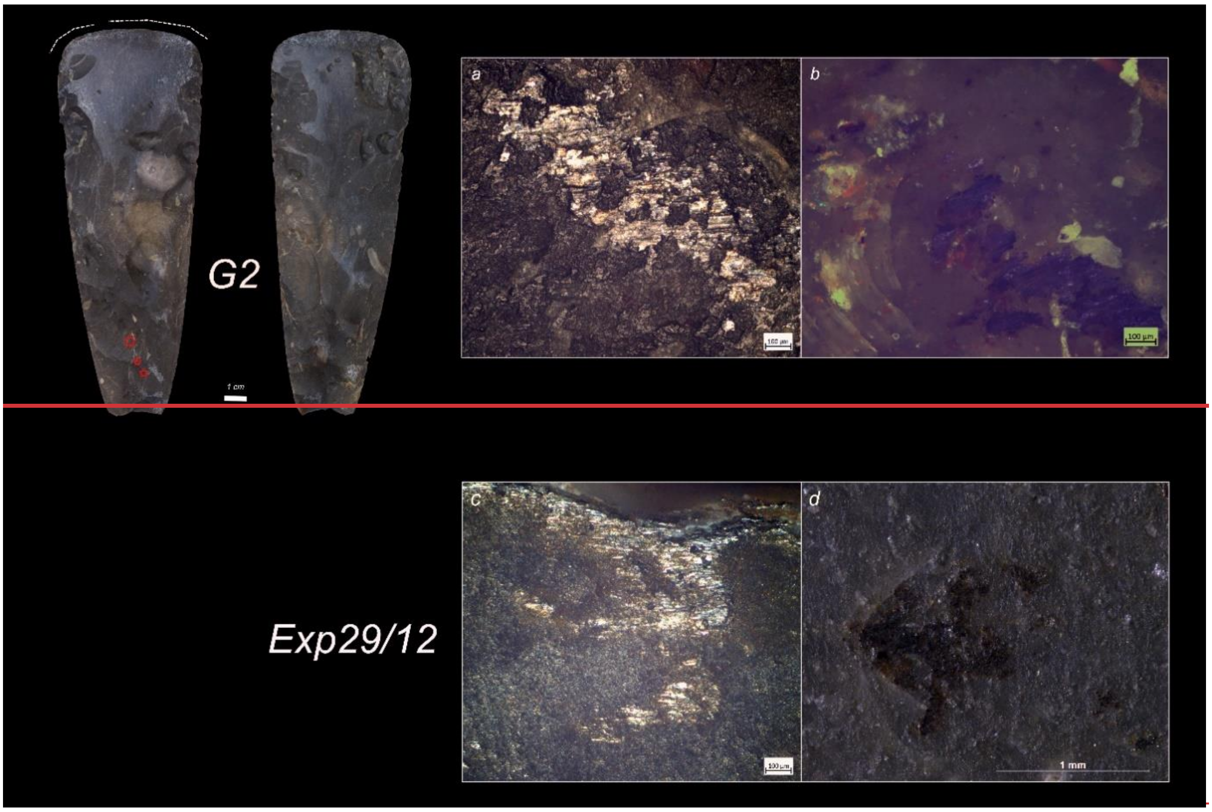


Figure 7 - Distinctive polish developed on the cutting edge of the axe (x100) (a), also linked with microscopic and macroscopic scarring (step fissured termination) (b)

Evidence of hafting wear is also scarce. When identifiable (n=3), it consisted of concentrations of feather- and step-terminating scars with perpendicular orientations on the lateral mesial edges. However, this does not necessarily imply that these tools were not hafted. It is possible that the mesial parts or lateral edges of the axes were ground or polished after flaking to dull sharp edges, likely to prevent cutting of binding materials (e.g., ropes, strings, leather) during hafting (Barkai 1999). This process may have obscured or eliminated evidence of hafting.

One axe is particularly notable for its evidence of use as a strike-a-light, suggesting a complex or multifunctional use history. Characteristic fire production traces include parallel striations and percussion marks (c-pits) associated with a shiny layer of red residue from contact with pyrite (Sørensen et al., 2018). The iron oxide component of pyrite was identified with EDS analysis, but the more fragile sul~~f~~phur component had disappeared (see Fig. 8 and 9). It could not be determined at which stage of the artefact's lifecycle the use as a strike-a-light occurred—whether this function preceded its hafting and primary use or took place in a later phase.


G2
1 cm
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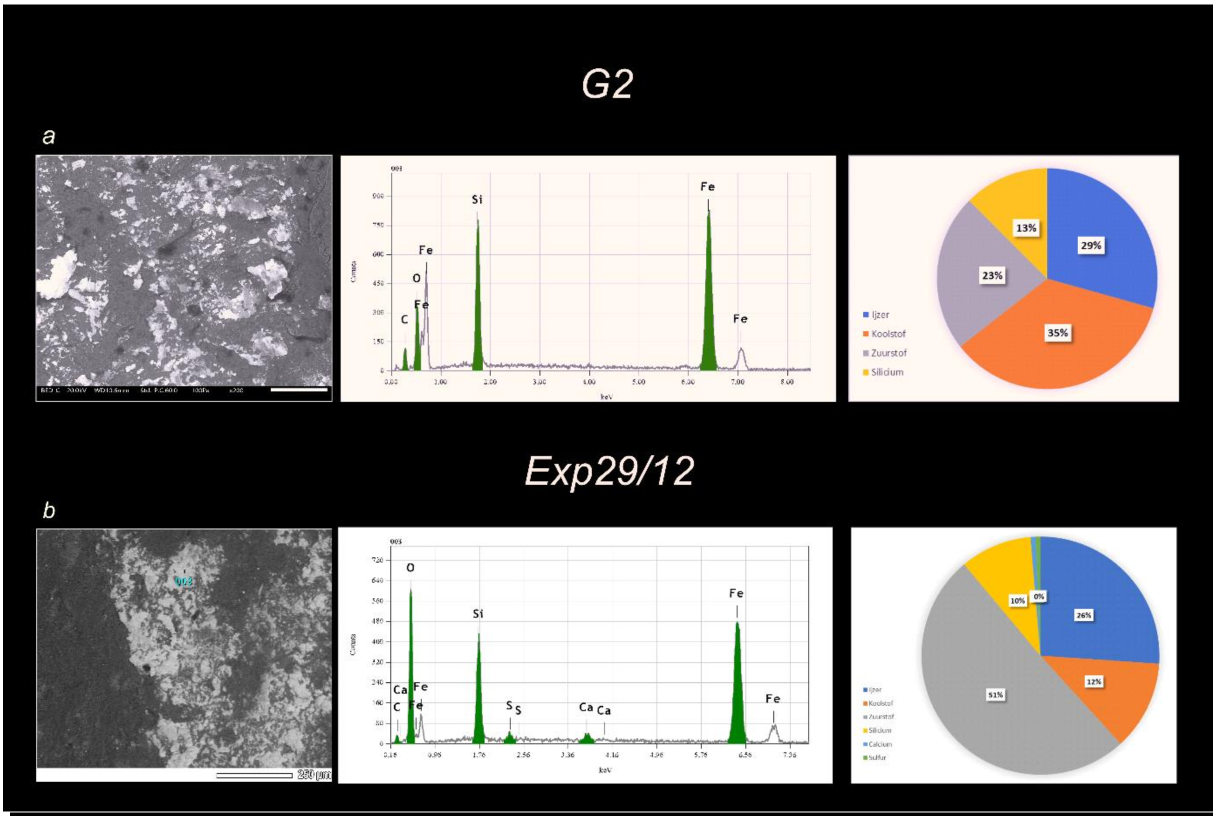
G2
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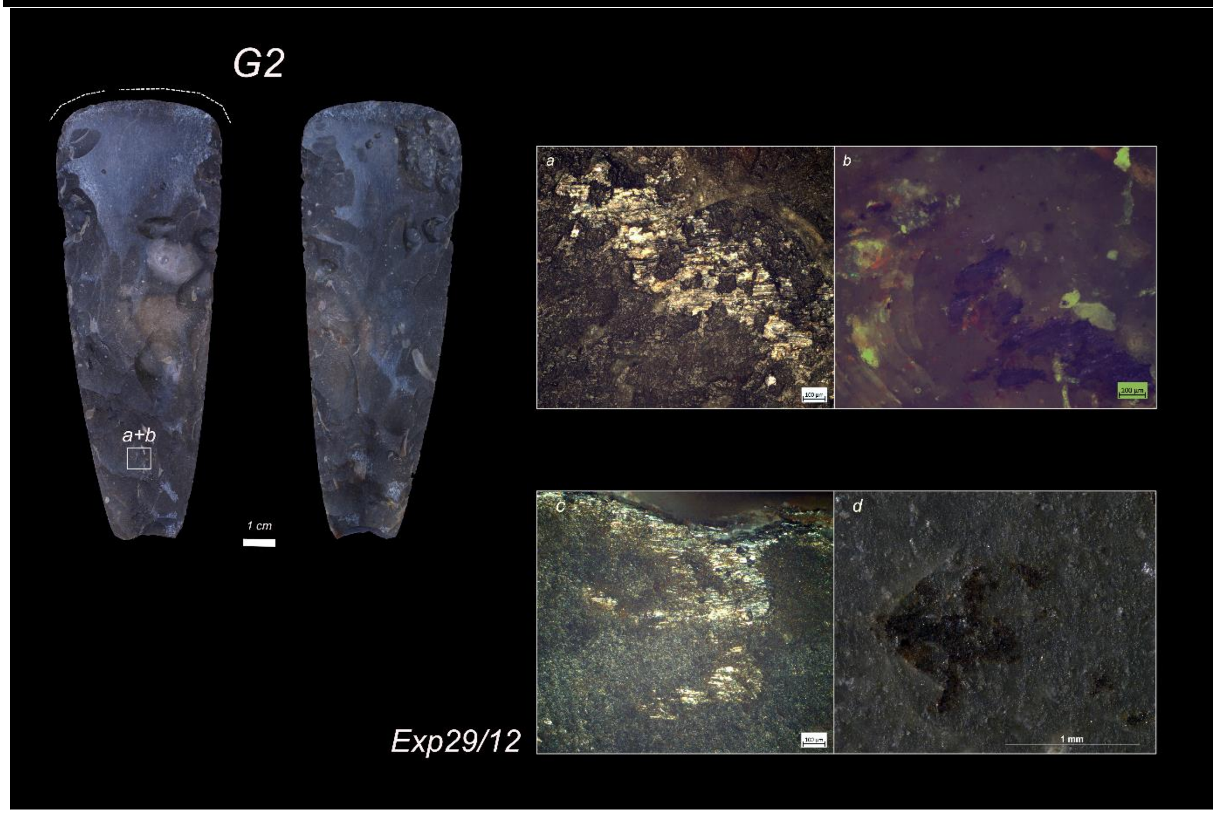
G2
a+b
1 cm
a
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c
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Exp29/12
1 mm

Figure 8 - Details of mineral wear recorded on axe G2 with high magnification~~,~~ (a+b), compared to experimental evidence on a strike-a-light using pyrite (Exp 29/12). (a+b) striations with parallel orientation associated with abrasion and incipient cracks from percussion similar to what has been observed on experimental tool Exp 29/12 (see c+d)

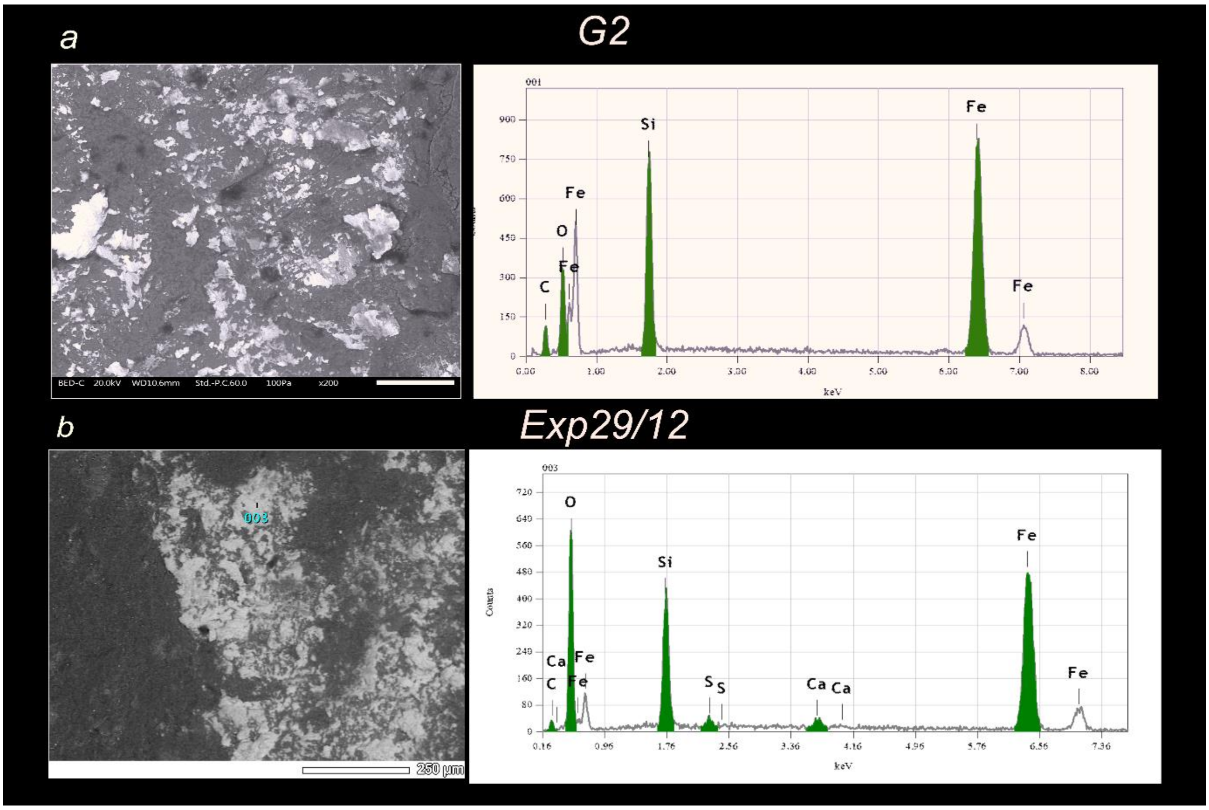

Figure 9 - Elemental analysis of the fire production traces on axe G2 and experimental artefact Exp29/12:
(a) EDS spectrum of red residue on axe G2 showing a strong presence of iron
(b) EDS spectrum of fire production residue on Exp29/12 showing peaks of iron and sulfur.

Use-wear traces on scrapers

Distinct use-wear evidence was visible on all endscrapers and could be interpreted with varying levels of confidence. In comparison to the axes, the scrapers were generally better preserved and not as heavily impacted by heat alteration. Four tools show explicit use-wear from hide processing with transverse motion consisting of polish with varying development associated with moderately to strongly developed edge rounding. The relatively bright appearance of the polish and its greasy aspect suggests use on fresh hide (e.g., Keeley, 1980; Rots, 2005). Evidence of hafting with varying levels of confidence was observed on all scrapers~~ in the form~~, characterised by a combination of macroscopic edge damage and microscopic features such as bright spots (see Fig. 10), which occur in diagnostic patterns (cf. Rots, 2002, 2010a~~) (see Fig. 10) and~~). On the lateral edges of the tools, scars were always concentrated around the haft limit. While the intensity of microscopic wear varied, it ~~could be interpreted with varying levels of confidence~~was generally distinct enough to differentiate from post-depositional alterations. Evidence for multiple resharpening cycles could be identified, and, combined with the well-developed hafting traces, this indicates that the tools were intensively used and maintained over time. This suggests that the scrapers were valuable implements, likely subjected to repeated use and upkeep to extend their functional lifespan, highlighting the importance of these tools in the daily activities of their users.

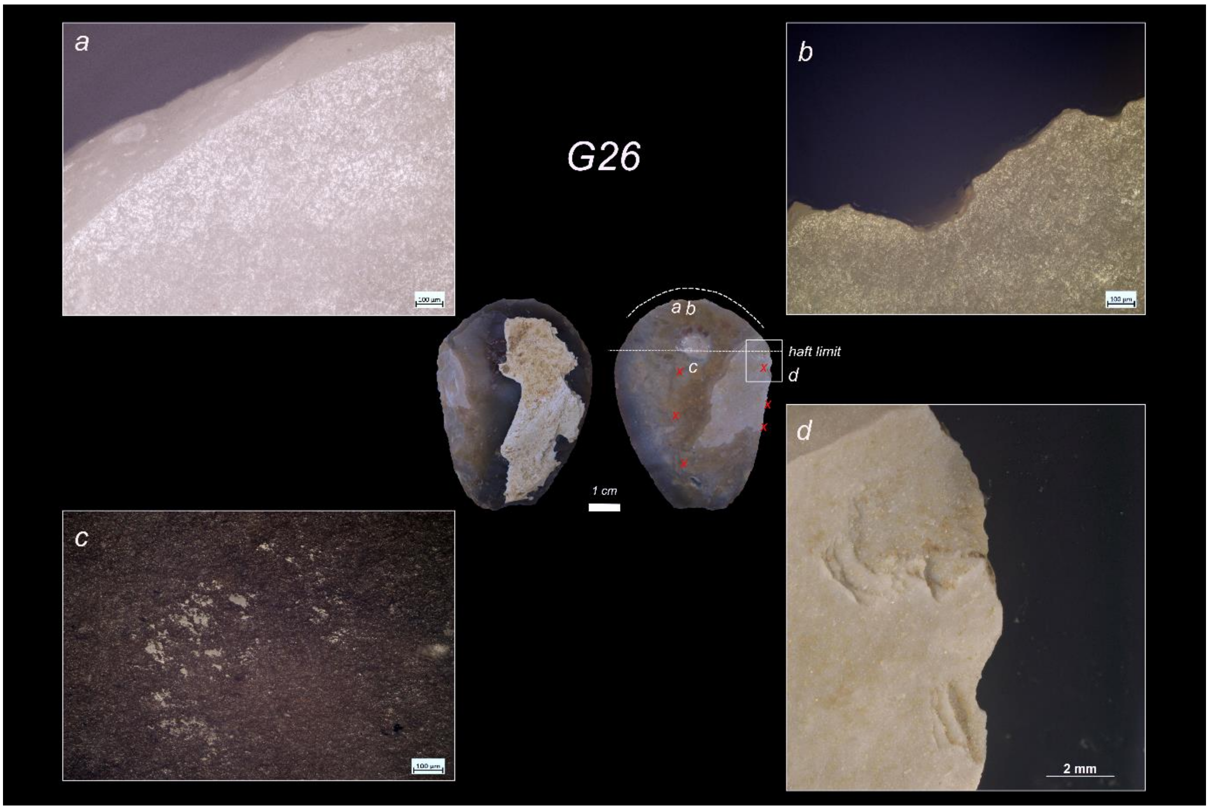

Figure 10 - Overview of the use and hafting traces observed on scraper G26: (a) edge rounding due to use (x100), (b) edge rounding cut by removals from resharpening (x100), (c) bright spot on the ventral mesial zone located close to the potential haft limit (x100), (d) lateral edge damage oriented obliquely to the egde indicating the potential haft limit (x16.0).

Despite being subjected to fire, which caused incipient cracks and potlids, one scraper still exhibits evidence of two distinct uses. Well-developed use-wear from hide-working (polish and pronounced edge rounding) was observed on the ventral scraper-head and well-developed use-wear from plant processing on the lateral right mesial edge. The latter traces include well-developed edge rounding and a very bright reflective polish on the dorsal and ventral surface of the edge (Fig. 11). On the ventral face, very fine striations with a parallel or slightly oblique orientation to the edge were visible with the scanning electron microscope and indicate a longitudinal cutting motion. Superposing edge scarring on the right edge and a concentration of scars on the left edge are most likely due to posterior hafting, although this remains uncertain. If confirmed, it would suggest that the tool was first used on its lateral right edge and subsequently hafted and used as a scraper on its distal part.

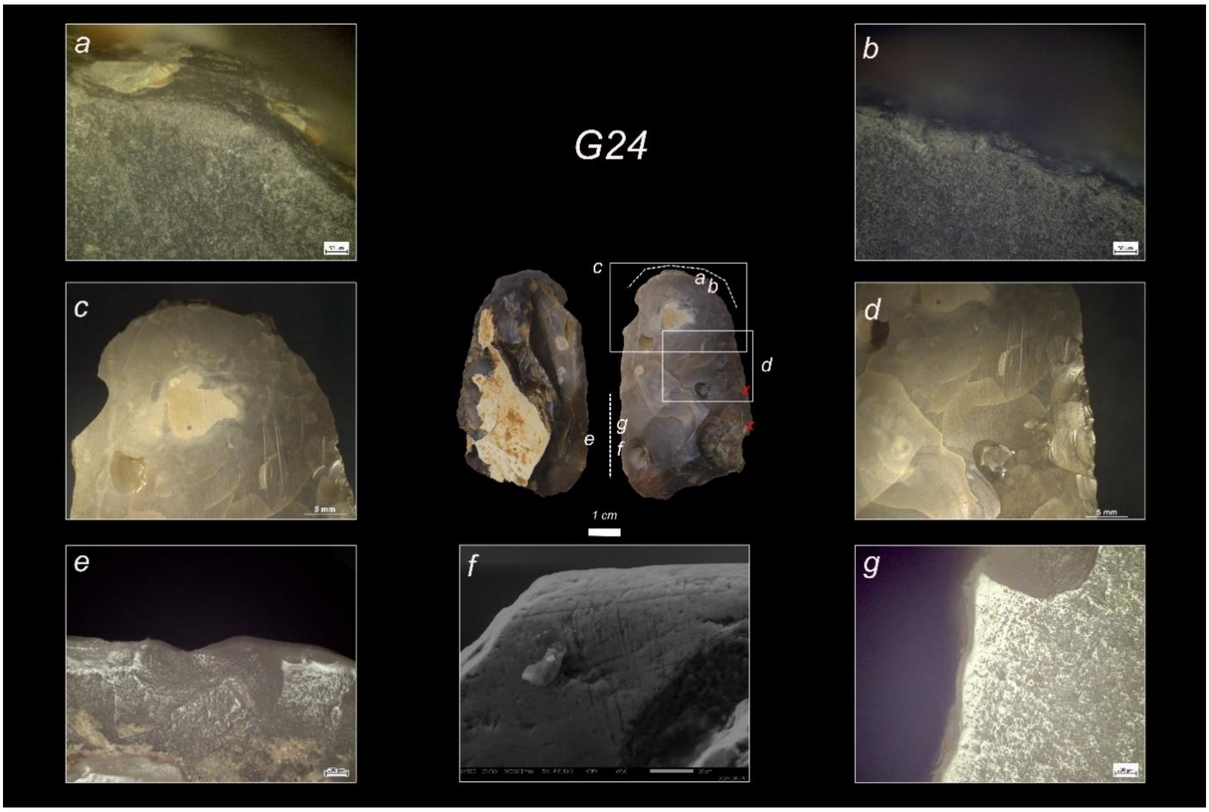

Figure 11 - Overview of the use-wear traces found on scraper G24: (a + b) strongly developed edge rounding from use on hide (x200), (c) macroscopic detail of incipient cracks and negatives of potlids from exposure to intense heat (x6.3), (e + f + g) well-developed polish, pronounced edge rounding, and scratches caused by use on silica-rich plant material (x8), (x100) for e+g, and (x950) for f.

Discussion

This study employed a biographical approach, inspired by Van Gijn and Wentink (2013), to investigate the lifecycle of artefacts from the Beringen Brouwershuis site. By examining the wear traces and residues accumulated during different stages of active use, including production, hafting, use, maintenance, and recycling—as well as their subsequent afterlife, such as deposition, destruction, and burial, we aimed to reconstruct detailed biographies of these lithic artefacts. This method provided a deeper understanding of the complex histories and multifaceted roles these objects played over time.

The axes from the Beringen Brouwershuis site exhibited limited functional traces. In one case, use wear patterns along the cutting edge, developed after the original polished surface from manufacture, suggest that the axe was used on moderately hard material, likely wood. Although potential woodworking traces were identified on only this axe, the significant diversity in the shapes of the other axes could suggest they may have been used for various wood-related tasks, such as felling trees, producing planks, or other wood technologies (Elburg et al., 2015; Holsten and Martens 1991; Jørgensen 1985). This inference is further supported by previous studies (e.g. Jørgensen 1985, Van Gijn 2009; Out 2017; Roy et al. 2023; Tegel et al. 2012), which have underscored the functional versatility of axes and align with the observed diversity in shape and use-wear traces at the Beringen Brouwershuis site.

Interestingly, the use of one of the axes as a strike-a-light may reflect its symbolic significance in Neolithic communities, as suggested by its inclusion in grave offerings and its potential connection to ritual activities (Baales et al. 2016). This observation is particularly noteworthy, as such wear is typically associated with other tool types (e.g., blades) or indicated by pyrite remnants (Baales et al., 2016; Van Gijn et al., 2013).

In contrast to the polished axes, clear functional traces were observed on the scrapers. Hide-working traces were identified on five of the seven endscrapers, highlighting the importance of hide-working in Neolithic daily life, where hides were essential for making clothing, containers, and other items (Van Gijn 2005, 2009). Frequent resharpening traces, combined with well-developed hafting evidence, suggest that these tools were intensively used while being hafted. Hafting traces appeared as bright spots and residues, possibly originating from vegetal components within the hafting arrangement. Notably, one scraper demonstrated multifunctional use, with hide-scraping wear on one end and plant-processing traces along a lateral edge. The wear traces observed on both the axes and scrapers indicate their intensive use, emphasising their critical role in Neolithic daily tasks such as woodworking and hide processing

Functional analysis also revealed traces associated with the afterlife of these artefacts. Heat-related evidence, including potlids, fractures, and scarring, indicated exposure to temperatures likely exceeding ~~270~~350°C (Bustos-Pérez & Baena 2016; Cnuts et al. 2018; ~~Larsson 2000).~~Fiers et al. 2020). However, the absence of extreme discoloration (whitening) or complete fracturing suggests ~~controlled burning, likely reflecting an intentional transformation rather than destruction, aligning with Neolithic fire mastery (Larsson 2011).~~that the artefacts were not exposed to temperatures beyond 500–550°C, as significant color changes and structural breakdown typically occur above this threshold (Fiers et al. 2020). This controlled exposure ~~implies that the tools were purposefully modified before deposition, potentially carrying~~may indicate incidental burning in open hearths rather than deliberate thermal modification. While experimental studies have demonstrated that high-temperature exposure (above 600°C) can intentionally whiten flint (e.g., Bustos-Pérez & Baena 2016; Fiers et al. 2020), such as the ritual ~~significance.~~ fire transformations observed at Neolithic sites in Sweden (Larsson 2000), the burning identified in this assemblage is fundamentally different.

Larsson (2000) describes a distinct practice in which Neolithic flint artefacts, particularly axes, were deliberately exposed to temperatures exceeding 600°C, often reaching 1000°C, as part of ritual acts. This high-temperature burning resulted in complete color transformation (whitening) and sometimes total fragmentation. The goal was not just to destroy the artefacts but to symbolically alter them, possibly mimicking the cremation of human remains. In contrast, the absence of extreme heat indicators in the lithic assemblage of Beringen suggests a lower-intensity burning process. Further research is needed to evaluate whether this burning was intentional and controlled or merely incidental.

The most likely explanation for the presence of iron oxide on these artefacts is a natural origin. The absence of a clear distribution pattern, such as a direct association with the used edge or an exclusive presence on the passive part of the tool, also rules out deposition through use or hafting. Additionally, the presence of iron oxide within the potlid negative of one scraper suggests that the deposition occurred at a later stage, after the burning of the artefacts. The high iron content of the surrounding soil, combined with the site's location at the footslope of an iron-sandstone hill, makes it highly plausible that the iron oxide is a post-depositional feature related to pedogenesis. Context pictures further support this interpretation, clearly showing the iron-rich composition of the soil.

Alternatively, the concentrated iron oxide deposits observed on the tools might present a more complex picture. One possibility is that the iron oxide resulted from ochre deposition, a practice commonly associated with Neolithic traditions. If this were the case, the presence of iron oxide could reflect ritualistic behaviour, aligning with the symbolic significance of ochre in burial rites and other ceremonial activities (Jadin et al., 1989). Further geochemical analysis (e.g., XRD, Raman spectroscopy, FTIR) is required to confirm the mineral composition of the iron oxides (e.g., goethite) and refine interpretations of their origin.

Our biographical approach, supported by comprehensive functional analysis, provided deeper insights into the Beringen Brouwershuis deposit and reinforced the hypothesis that it represents a hoard. The deliberate modification and careful deposition of the tools suggest ritual and symbolic undertones. As Belgium's only excavated axe hoard attributed to the Michelsberg culture, this deposit offers unique insights into Neolithic hoarding practices. Hoarding was common in Neolithic and Bronze Age Northwestern Europe (Fontijn 2019; Hamon & Quilliec 2008; Wentink 2006;

Wentink & Van Gijn 2008), often associated with votive offerings placed in remote or challenging-to-access areas and comprising large or damaged items. Such deposits were frequently found in isolated, waterlogged locations, leading researchers to associate them with ritual burials imbued with symbolic meaning (Larsson 2000, 2011). Over the last two decades, detailed analysis of these deposits, including functional analysis, has shown that they often contain important objects from daily life, intricately tied to their immediate surroundings (Bamforth et al., 2004; Bradley 2012; Bradley 2016). Moreover, it has also suggested that Neolithic hoards in Scandinavia were more closely linked to settlements than previously believed (Sørensen et al., 2020). Our study ~~demonstrates~~further suggests that the Beringen Brouwershuis hoard bridges both ritual and practical realms~~, illustrating~~ as previously stated by Sørensen et al., 2020. Here, the application of the biographical approach illustrates how utilitarian tools could acquire symbolic significance through their use, transformation, and intentional deposition. This finding enriches our understanding of the complexity inherent in Neolithic hoarding practices.

Conclusion

The comprehensive functional analysis of axes and endscrapers from the Beringen Brouwershuis site has illuminated the complex biographies of these artefacts, highlighting their dual roles in both practical and ritual contexts. By employing a biographical approach, we uncovered significant wear traces and residues that revealed the multifaceted uses of these tools, from woodworking and hide processing to their eventual exposure to controlled burning and ritual deposition. The analysis confirmed that the axes were likely involved in Neolithic woodworking tasks, while the scrapers demonstrated intensive hide-working, both essential activities in daily life.

Evidence of heat damage, strike-a-light wear, and ochre-associated iron precipitation further pointed to intentional, symbolic modifications of the artefacts before their deposition. These findings support the hypothesis that the Beringen Brouwershuis deposit represents a deliberate hoard with ritual undertones, aligning with known practices of the Michelsberg culture and broader Neolithic traditions. The combination of utilitarian and symbolic aspects in the Beringen assemblage bridges the gap between practical and ceremonial use, demonstrating how everyday tools could accumulate layers of meaning before their final deposition.

This study not only enriches our understanding of the Michelsberg culture, particularly within the less-documented Campine region, but also contributes to broader discussions about Neolithic hoarding practices in Northwestern Europe. By illustrating the intertwining of functional and symbolic purposes, the research underscores the importance of considering both utilitarian and ritual dimensions when interpreting archaeological assemblages. Ultimately, the Beringen Brouwershuis hoard exemplifies how artefacts can transcend their primary functions to become part of meaningful cultural and ritual practices, deepening our insight into the social complexity of Neolithic life.

Supplementary information availability

Data or any supplementary material are available at https://osf.io/qaewt/

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Conflict of interest disclosure

The authors of this preprint declare that they have no financial conflict of interest with the content of this article. Veerle Rots is a recommender for PCI.

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