Making space: spatial and microwear analysis of flint tools associated with structures and settlement at the Early Mesolithic site of Star Carr

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March 2022

Abstract

This thesis explores tool-using activities at the Early Mesolithic site of Star Carr in North Yorkshire, by analysing spatial patterns of flint use. It uses microwear and spatial analysis to first examine the use of a specific tool type - awls - and secondly, to investigate tool use associated with three potential post-built structures. Microwear results associated with the structures are examined as a means of discerning potential activity zones associated with the working of particular materials (e.g. wood, bone, antler, plant, hide, meat, fish). With 386 flints analysed, this research represents the first microwear study focused on the hut structures at Star Carr: the earliest evidence for structures in Britain. Therefore, this study extends our current understanding of Mesolithic inhabitants in Britain, using microwear analysis on a range of tool types to explore how these early structures were used.

Awls were interpreted as multi-functional craft tools, used to perforate and pierce a range of materials, most notably shale and wood. Those displaying hide and shale working traces were found closely associated, possibly indicating use in tasks linked to clothing production. Spatially structured areas for processing different materials were identified in the eastern structure, which was interpreted as a dwelling with a sustained internal organisation. The central structure, though fewer flints were found, was interpreted as a possible specialised activity area, from potentially related tool use on wood. From the spatial distribution of tool use, technological assessment and associated faunal remains, the western structure was interpreted as a possible dwelling, last used for depositing clearance material. Rather than identifying family units as has been the focus of previous studies on Mesolithic structures, this research presents a new approach that explores tool-using activity areas as a means to better understand the social dimensions of these spaces.

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This thesis is accompanied by an Excel spreadsheet named Appendix 2, which details all the microwear data on flints analysed during this research. A zip folder also accompanies this work, named Appendix 3: Micrograph archive, which contains micrographs taken of flints with signs of use.

Acknowledgements

This work was supported by the Arts & Humanities Research Council (grant number AH/L503848/1) through the White Rose College of the Arts & Humanities. The project would not have been possible without the incredible support network of many people, who have guided and helped me from the very beginning. My supervisors, Aimée and Nicky have been unfaltering in their support and advice throughout this research and before I even came back to York. They have also been incredible mentors, inspiring me with their passion and dedication and helping me through the challenges of academia, for which I will be forever grateful. A special thank you must also go to Aimée for all of her patience and guidance in training me in microwear analysis, especially as I had never worked with flint before. I would like to thank Kevin Walsh, my Thesis Advisory Panel chair, for all of his insightful comments on my thesis and for the many helpful discussions we had during the TAP meetings. Huge thanks must also go to my external and internal examiners, Jodie Lewis and Geoff Bailey, who made the whole process enjoyable, inspiring and incredibly helpful.

I would have been unable to carry out this research without the kind support of staff at the Yorkshire Museum, particularly Lucy Creighton and Melanie Baldwin, who allowed me to loan the Star Carr material. The previous work of Chantal Conneller and Aimée Little was integral to this project; I was very fortunate to have their permission to use the technological and microwear lithics data. I also owe a great deal of gratitude to Diederik Pomstra for our thought-provoking discussions and his work in producing and using the experimental flint tools that were used as reference collection materials in this research. My training in GIS was made possible by the guidance and expert knowledge of Hen Goodchild. Hen was incredibly patient with me and helped troubleshoot a lot of issues as I learnt the ropes (and even after that). Use of the high-power Olympus microscope was invaluable for this research, and was made possible through the tireless help from Chris at Olympus. Chris helped set up the microscope, fix many problems and answered emails about issues that were definitely not part of his job! Matt von Tersch has also helped a huge amount with access to equipment and has been a massive support throughout.

I also owe a huge amount to all of the friends and colleagues that have provided lively discussions and often emotional support. During my PhD, we lost two incredibly talented Mesolithic researchers, taken far too soon - Don Henson and Caroline Wickham-Jones. I am forever thankful to them both for inspiring my passion for the Mesolithc and being some of the warmest guiding lights in academia, always greeting you with a smile. Their infectious enthusiasm and love for the discipline has had a lasting impact on me and many others. All of the Star Carr Project team have been wonderful, but I would especially like to thank Mike Bamforth, Charlie Rowley, Becky Knight, Andy Needham, Ben Elliott, Annabell Zander and Harry Robson for all of their help with archives, understanding the data and the site, and welcoming me into the group. I feel very fortunate to call them friends, and in particular, Andy and Becky who have regularly listened and offered support over the past three years.

I would also like to thank all those in: the YEAR centre team, Material Cultural and Experimental Archaeology (MCEA) lab group, the York Prehistory Network, the Lithics Studies Society committee team, fellow WRoCAH students, the Mesolithic and Hunter-Gatherer Research (MAHGR) group and the staff and students in the Department of Archaeology at York. I was lucky enough to be a part of these groups where many inspiring and stimulating discussions have taken place, some of which have fed into this thesis.

Last but not by no means least, to my loved ones, who have been a constant source of comfort, laughs and emotional support - Tom, Digs, Anni, Kate and Les. Their belief in me has been unwavering and has carried me through. I also must thank my cat, Sossidge, who has provided me with a warm lap and lots of furry cuddles throughout the final months of writing. Finally, to my Mum, whose love, strength, and determination has inspired me for a lifetime, thank you for everything that you gave to us.

Author’s Declaration

I declare that this thesis is a presentation of original work. All contributions to this work are acknowledged below. This work has not previously been presented for an award at this, or any other, University. All sources are acknowledged as References. Aspects of this thesis have been accepted for publication.

Sections of chapters 3, 4 and 5 are accepted for publication in *Journal of Archaeological Science: Reports* with the following reference:

Bates, J., Needham, A., Conneller, C., Milner, N., Pomstra, D. and Little, A. (2022) ‘Flint awls at the Mesolithic Site of Star Carr: Understanding tool use through integrated *Archaeological Science: Reports* 43, 103478.

Chapter Contributions

All chapters which are not explicitly mentioned below were the sole work of JB.

Chapter 3: Star Carr flint research

- Andy Needham assisted with writing parts of section 3.3. on Dumont’s analysis of Star Carr borers, and parts of section 3.4.2. on the microwear results from awls recovered during the Star Carr Project

Chapter 4: Methodology

- Andy Needham contributed detail on the experimental reference collection created for awls in section 4.4.

Chapter 5: Awls

- Chantal Conneller generated the typological classification of the Star Carr Project awls
- Andy Needham provided data on experimental awls
- Data processing and analysis were completed by JB, including figures and maps
- Tables were completed by Andy Needham and JB
- Andy Needham, Chantal Conneller, Nicky Milner and Aimée Little all contributed to manuscript preparation, including data interpretation

Chapter 1: Introduction

1.1. Aim and Objectives

The aim of this research is: To investigate activities at the Early Mesolithic site of Star Carr through spatial analysis of flint microwear patterns.

A combination of microwear and spatial analysis will be employed to better understand tool-using activity areas at Star Carr, an Early Mesolithic site (9300-8500 cal BC) located in North Yorkshire, UK. This is investigated using two approaches: firstly, by examining a specific tool type - the awls - to determine whether varied usage can be detected and if so, whether this is spatially significant; and secondly, by examining tool use associated with three potential hut structures found on the dryland. A previous microwear study (Conneller *et al.* 2018a) indicated discrete areas where particular activities were undertaken across the site, such as plant working at the lake-edge; however there is insufficient data to fully interpret activity within and around the structures. These results demonstrated that wear traces on the flint are well-preserved, providing potential to broaden our understanding of tool use at the site and to better understand activities carried out by hunter-gatherers over 11,000 years ago. Star Carr has recently been excavated on a large scale using cutting-edge methods, so offers significant potential to understand tool use as results from microwear analysis can be integrated with high-resolution spatial analysis, technology and refitting studies.

The following objectives will be achieved through this research:

1. **To establish how microwear studies have been previously used to understand tool-using spaces at European Mesolithic sites.** Interpretations from these studies will be evaluated to demonstrate the potential of microwear analysis, current gaps in our understanding, and a rationale for this research.
2. **To assess what is already known about tool use at Star Carr.** This will be achieved using previously published work from Star Carr, initially excavated by Clark and the more recent Star Carr Project, directed by Milner, Conneller and Taylor. A focus on flint refitting, technological and microwear assessments will provide context for how space was used across the site, highlighting outstanding questions that remain.
3. **To focus on the use of awls and examine the spatial patterning across the dryland and structures.** This will discuss the large number of awls found at Star Carr, which were associated with the western structure, and significantly, close to the recovered shale beads.

Microwear analysis will be used to understand how this specific tool type was used, and whether awl-using activities can be related to the western structure.

4. **To present new insights into tool use in and around the structures at Star Carr.** New microwear data will provide information on the materials worked in and around the three dryland structures, making it possible to assess the extent of each structure. Zones of specific activity will be established to explore spatial organisation in these areas.
5. **To explore new interpretations of the structures at Star Carr.** This will be achieved by comparing patterns in tool use, refitting data and any associated faunal remains. In doing so, connections in the nature and spatial distribution of tasks will be explored. From this, the use of each structure will be interpreted.
6. **To develop a new approach for exploring the social dimensions of Mesolithic structures.** An overview of how the social aspects of Mesolithic structures have been previously interpreted, summarising key theoretical approaches, will be presented before developing a new theoretical approach to the Star Carr structures.

1.2. European Mesolithic context

1.2.1. Introduction

This section will provide a brief overview of the Mesolithic and how it is defined in the context of European research to situate Star Carr within a broader context. A short summary of notable themes in European Mesolithic discourse will then be presented, discussing: technology, climate and lifeways. Some of the key sites in Britain will be compared to those found in mainland Europe, drawing out differences and similarities in the archaeological record.

1.2.2. Definition

First referred to by Hodder Westropp in 1872 to define the hiatus between the Palaeolithic and Neolithic, the Mesolithic was not widely acknowledged as a distinct time period until the 1930s (Nicholson 1983; Peake 1934; Rowley-Conwy 1996). Once an established archaeological period, many continued to see the Mesolithic as merely a point of reference for researchers seeking to further define the Palaeolithic and Neolithic (Childe 1946; Clark 1932; Price 1987; Spikins 2007). Scholars researching the Mesolithic even considered the period as somewhat deprived and deficient, with Mesolithic individuals being described as ‘poverty-striken folk … [of] a poor culture’ (Clark 1932, 9-10). The work of trailblazers, like Clark, ensured that the Mesolithic was separated from the preceding Palaeolithic through a culmination of: stratigraphic distinctions found during excavations; the presence of new technological industries; behavioural changes; and the identification of significant ecological changes resulting in different faunal species (Clark 1932; Larsson 2010; Mellars 1981). As a result of these efforts and the discovery of sites like Star Carr, the Mesolithic was reconsidered by most archaeologists as a significant period, key to furthering our understanding of hunter-gatherer life (Jacobi 1976; Milner 2009; Price 1987; Reynier 2005; Zvelebil 1986).

The Mesolithic period, roughly dating to 9650-4000 BC in Britain, can be characterised as a time of unprecedented change, innovation and complexity (Conneller and Overton 2018; Conneller *et al.* 2012; Milner 2009; Milner *et al.* 2013; Tolan-Smith 2008). Owing to a significant climatic shift that occurred around 9650 BC with the end of the Younger Dryas, Mesolithic hunter-gatherers had to adapt to new landscapes containing a multitude of new resources and opportunities, including extensive vegetation and faunal species (Spikins 2007; Taylor 2018; Weber, Grimm and Baales 2011). Despite a continually changing landscape with rising sea levels, expanding coastlines and abrupt climatic events, hunter-gatherers persisted and developed new strategies to thrive (Blockley *et al.* 2018a; Mithen 2002; Tolan-Smith 2008).

1.2.3. Technology

A fundamental aspect to characterising the Mesolithic is the identification of particular stone, bone and antler tool types (Clark 1932; Mithen 2002; Tolan-Smith 2008). Antler barbed points (see figure 1), elk antler mattocks, and bone and antler bevel-ended tools have been found in Britain although more commonly, in mainland Europe, highlighting the dominance of *Cervus* species in the landscape (Mithen 2002; Price 1987). Stone is one of the most ubiquitous materials in Mesolithic contexts; flints and tools made of other geologies are often used to establish chronologies, site function, and for interpreting human behaviour (Cahen *et al.* 1979; Collins 1975). Microliths, micro-burins and *tranchet* axes (see figure 2) are some of the archetypal tools found throughout the European Mesolithic (Clark 1932; Jacobi 1976; Mithen 2002). It is generally considered that the manufacture of different tool forms did not subscribe to fixed, formal typologies, thus leading to significant variation in tool forms found within a single site (Warren 2009). Of the archetypal tools, microliths are considered to be the single most distinct Mesolithic indicator when defining the period (Clark 1932; Clark 1933; Conneller 2021; Mithen 2002; Tolan-Smith 2008).

Figure 1: Barbed points found at Star Carr (Elliott and Milner 2010, 90).


Figure 2: Early Mesolithic tranchet axes from south-eastern Norway (Solheim et al. 2018, 563).

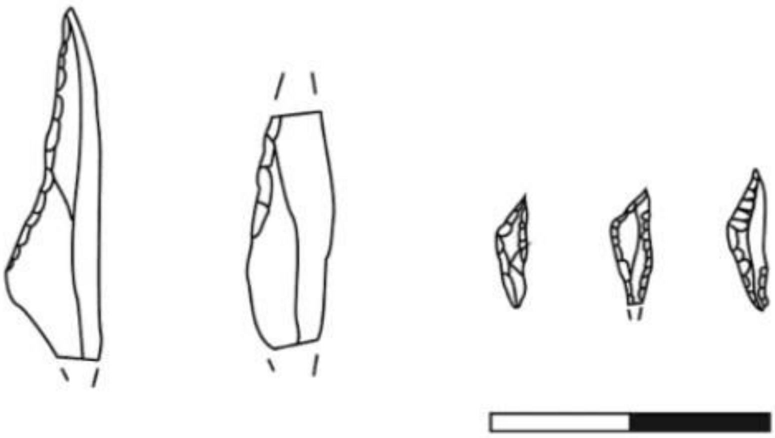


Figure 3: Early Mesolithic 'broad blade' microliths (left) and Late Mesolithic 'narrow blade' microliths (right) (Conneller 2021, 4).

Microliths are small flint points (usually between 2-3cm) commonly associated with hunting technology and found on most European Mesolithic sites (Clark 1932; Crombé 2019; Evans 2009; Finlayson and Mithen 1997; Price 1987). A tool-based chronology was developed in many European countries, including Britain, from observed changes in microlith shape and manufacturing technique, alongside radiocarbon dating (Conneller *et al.* 2016; Conneller 2021; Larsson 1990; Reynier 2005). In Britain, this chronology is often based on a change in morphology, splitting the Mesolithic into two broad stages; the Early (c.9600-8000 cal BC) and Late, or later (c.8000-3800 cal BC) Mesolithic (Bayliss *et al.* 2007; Conneller 2021; Crombé and Robinson 2014; Jacobi 1976; Mithen 2002; Saville 1981; Warren 2009). Early British Mesolithic microlithic assemblages are generally considered as made from broad blade blanks (see figure 3), dominated by obliquely blunted points and made from higher quality flint, whereas Late Mesolithic microliths have a small geometric shape made from narrow blade blanks (see figure 3) (Bayliss *et al.* 2007; Conneller 2021; Conneller *et al.* 2018b; Jacobi 1976; Mithen 2002; Morrison and Bonsall 1990; Saville 1981). However, the utility of such a generalistic distinction between Early and Late Mesolithic tools has been contested due to the variability in lithic assemblages across Britain (Conneller 2021).

1.2.4. Climate

Alongside the identification of key technological features, the Mesolithic is also defined by a significant climatic change. After cooling periods in the Pleistocene, the mean annual temperature dropped to 7.5°C during the Loch Lomond stadial in Britain. The onset of the Holocene in c.9650 cal BC saw a more temperate climate with summer temperatures rising by 8-10°C in a matter of decades (Bickerdike *et al.* 2016, 2018; Blockley *et al.* 2018a; Taylor, B. *et al.* 2018a). These warmer temperatures triggered significant ecological change across Europe with the spread of open grassland, scrub vegetation and herbaceous plants in a relatively short period of time (Rasmussen *et al.* 2014). In mainland Europe, birch and pine woodland became park tundra, enabling the fauna that had retreated to environmental niches during the glacial periods to repopulate regions (Burdukiewicz 2011). Across Europe, glacial areas covered by ice sheets retreated and, in some places, melted to form palaeolakes, such as palaeo-Lake Flixton at Star Carr (Ballin 2017; Taylor 2011, 2018). These palaeolakes became inhabited by wetland vegetation such as reeds, sedge, rushes and a number of aquatic plant species (e.g. water lily, pondweed) (Taylor 2011, 2018; Taylor, B. *et al.* 2018a). The Holocene prompted the growth of an ideal environment for hunter-gatherer occupation, with a landscape full of abundant resources and water sources.

Throughout the Mesolithic however, there continued to be periods of rapid temperature change. Over a 500 year period within the 10th millennium BC there were four significant abrupt climatic events (ACEs), which directly impacted on the growth of woodland and the infilling of palaeolakes

(Blockley *et al.* 2018a). Climatic fluctuations observed across Europe can be seen most acutely in Britain, with a significant effect on individuals inhabiting the area (Clark 1952; Conneller and Overton 2018; Jacobi 1976; Mithen 2002; Sturt *et al.* 2013). In the Early Mesolithic, a more temperate climate triggered a new ecology and repopulation of Britain, and, by c.8700 BC, hunter-gatherers began occupying new environments, such as upland regions (Clark 1972; Conneller and Overton 2018; Tolan-Smith 2008). By 4050 BC, rising sea levels throughout the period lead to the submersion of Doggerland, a landmass that connected Britain to mainland Europe (Ballin 2017; Jacobi and Higham 2011; Sturt *et al.* 2013). The area was a settlement location for individuals during the Late Palaeolithic and Early Mesolithic (Ballin 2017; Leary 2009). Set against a backdrop of several ecological transitions, Mesolithic individuals would have needed to acquire the knowledge and skills to adjust to their environment (Milner 2009; Sturt *et al.* 2013).

1.2.5. Lifeways

Mesolithic communities utilised and exploited a vast range of resources in order to thrive across Europe (Milner 2009; Price 1987). Reliant on an intricate knowledge of the landscape and the materials around them, a raft of different techniques would have been implemented to harness the full extent of these resources (Taylor 2018; Zvelebil 2008). Across Europe, Mesolithic sites have evidenced a plethora of different lifeways: from a nomadic approach, exploiting seasonal resources, to a more sedentary one, establishing more permanent sites with structures (Woodman 1985; Zvelebil 2008). It is clear from different strands of evidence that most Mesolithic communities had a congruent relationship between humans and animals, beyond merely subsistence, which is woven throughout and consistent in many of the observed lifeways (Conneller 2004; Conneller and Schadla-Hall 2003; Overton 2014; Pasarić and Warren 2019; Živaljević 2016). Sites showing settlement evidence (e.g. hearths, postholes, hollows), in conjunction with faunal and organic remains, therefore offer the richest potential for accessing a spectrum of daily activities undertaken by Mesolithic individuals.

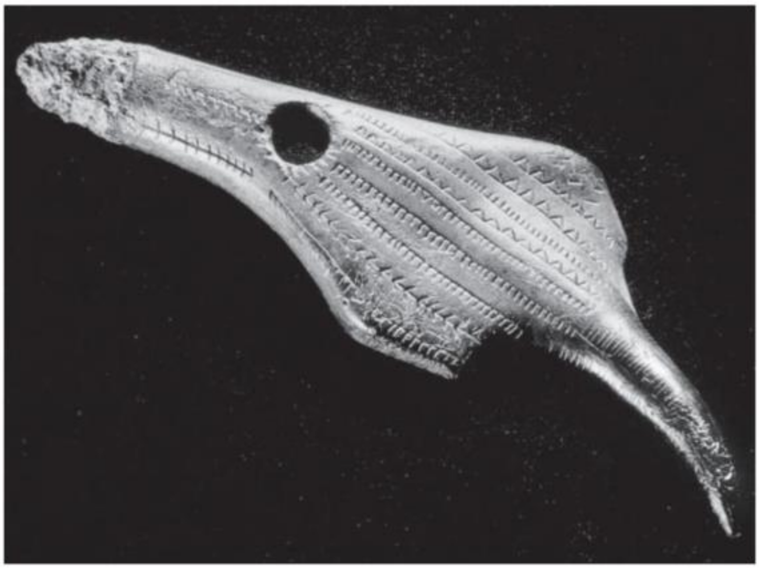


Figure 4: Decorated elk antler from Ugerløse, an Early Mesolithic site in Denmark (Gebauer and Price 2003, 21).

In mainland Europe, abundant Mesolithic remains have been uncovered in the form of: settlement sites (found in rock shelters and open-air contexts), flint scatters, bone deposits, hearths, shell middens, underwater sites and burial sites (Bicho *et al.* 2010; Price 1987; Skriver *et al.* 2017; Spikins 2007; Svoboda 1983; Tolksdorf *et al.* 2009). Owing to a predominance of wetland environments, a number of sites in Scandinavia have good levels of organic preservation. Large quantities of modified animal bone and antler tools (see figure 4) and wooden artefacts (see figure 5) have been excavated, as seen at Ugerløse and Hjarnø Sund, Denmark (Gebauer and Douglas Price 2003; Price 1991; Sørensen *et al.* 2018). Settlement sites have also been found in Scandinavia, observed from structures and concentrations of flints (e.g. Årup, Sweden); however, these rarely contain well-preserved organic remains (Larsson 1990; Sørensen *et al.* 2018). Across mainland Europe, the preservation of organics at settlement sites is similarly rare, especially those dating to the Early Mesolithic. The highest concentration of these sites (six) can be found in Germany: Duvensee, Friesack, Hohen Viecheln, Rothenklempenow, Bedburg-Königshoven and Mönchengladbach-Geneicken (Sørensen *et al.* 2018; Tolksdorf *et al.* 2009). When found with organic remains, settlement sites have been frequently interpreted as small, more temporary task-specific camps (e.g. Duvensee, Germany) (Nærøy 2018; Sørensen *et al.* 2018). This limits interpretations to activities undertaken over a short period of time, rather than exploring sustained patterns in behaviour.

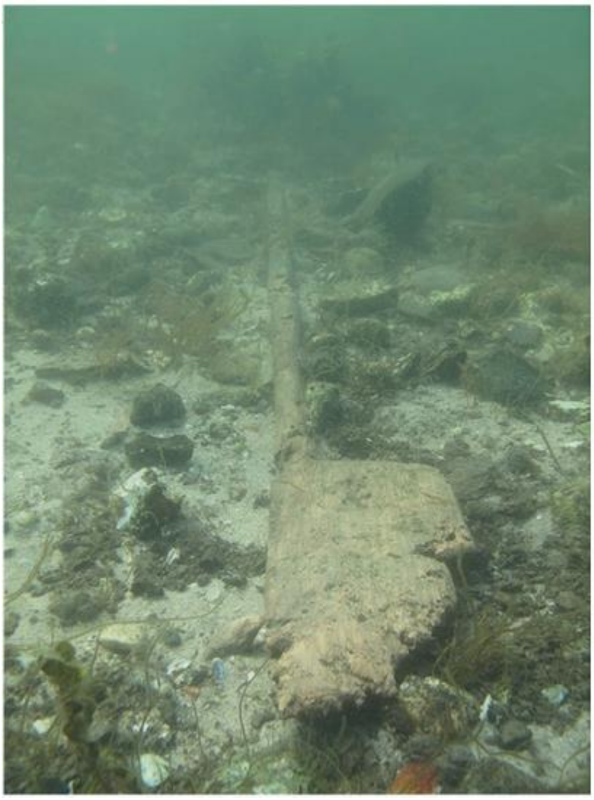


Figure 5: Wooden boat paddle found at Hjarnø Sund, a submerged Late Mesolithic site in Denmark (Skriver et al. 2017, 138).

In Britain, preservation issues are also prevalent and the discovery of non-lithic Mesolithic remains is incredibly rare (Conneller and Overton 2018; Conneller *et al.* 2012; Price 1987; Tolan-Smith 2008). Most Mesolithic faunal remains are found in shell middens or in discrete finds spots (Elliott and Griffiths 2018; Meiklejohn *et al.* 2005; Mellars *et al.* 1980). At these locations, the significant deposition of faunal, and sometimes human remains (e.g. Oronsay, Scotland), aligns more to a transitory site where interpretations are often focused on subsistence strategies rather than the different strands of human lifeways (Mellars *et al.* 1980; Milner 2009). Settlements have been identified in Britain (e.g. Deepcar, Yorkshire; Morton, Fife; Howick, Northumberland), though similar to mainland Europe, the archaeological remains consist largely of lithics (Bailey and Milner 2007; Mithen 2002; Tolan-Smith 2008). These have been interpreted as settlements based on flint concentrations, hearths or in some cases, the presence of hollows and/or post holes (Coles *et al.* 1971; Radley and Mellars 1964; Waddington 2007a). Without faunal remains or the application of high-resolution methods to investigate activities undertaken, the diversity in hunter-gatherer lifeways are difficult to access (Odell 1980; Rowley-Conwy 1987).

Thatcham is the only settlement contemporary to Star Carr in Britain, where microwear analysis of flints has been applied (see figure 6) (Wymer and King 1962). Limited faunal remains were found, including bone points and red deer teeth, with the majority not well preserved (see figure 7) (Carter 1997; Wymer and King 1962). Functional analysis of the flint was undertaken to interpret the types of activity and subsistence strategies present (Carter 2001; Wymer and King 1962). From this, Thatcham was interpreted as a short-lived but densely occupied 'home base', sporadically occupied in the Early Mesolithic, which was reiterated in the subsequent re-analysis of faunal remains (Carter 2001; Nærøy

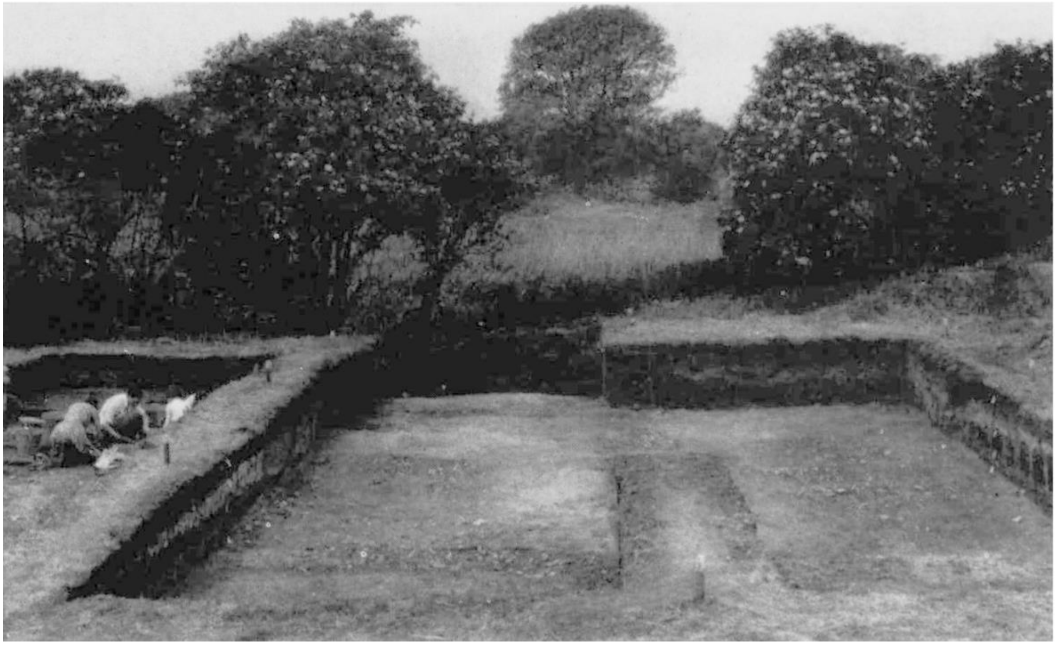


Figure 6 Excavations at Thatcham, an Early Mesolithic site in Berkshire (Wymer and King 1962, Plate XLVII).

Figure 7: Red deer antlers excavated from Thatcham (Wymer and King 1962, Plate XLVIII).

2018; Wymer and King 1962). Therefore at Early British Mesolithic sites, the recovery of substantial quantities of well-preserved faunal remains alongside abundant and spatially discrete flints, hearths and hollows is rare (Conneller and Overton 2018; Milner 2009; Mithen 2002; Tolan-Smith 2008).

1.2.6. Terminology

This research uses terminology from the Star Carr Project to refer to groups of postholes alongside any additional cut features as 'structures' (Taylor, B. *et al.* 2018b). It is a neutral term that does not presume function, therefore appropriate for discussing the variable evidence at Star Carr. In published literature, terms such as 'substantial structure' or 'pit-houses' are used to refer to more permanent habitation, usually consisting of postholes and/or dense depositions of material associated with longer-term dwellings (Fretheim 2017; Grøn and Bicho 2021; Marchand and Dupont 2021; Mithen and Wicks 2018; Molin and Gummesson 2021). Whereas, 'hut', 'tent' or 'shelter' tend to refer to temporary structures, based on more ephemeral evidence, such as spatially clustered flint scatters (Fretheim 2017; Larsson and Sjöström 2011; Mithen and Wicks 2018). These distinctions are necessary to differentiate between the nature of settlement at different sites; places where people sporadically visited in the landscape, versus those that were repeatedly occupied with depositions of different materials. 'Dwelling' will be used in interpretations of the Star Carr structures, where results indicate that sustained and varied activity was undertaken (Fretheim 2019; Grøn 2021a).

1.3. Excavations at Star Carr

1.3.1. Introduction

In order to provide context for this thesis it is important to detail the history of research at Star Carr and the main discoveries made. This section starts with the previous excavations by Moore, Clark and Schadla-Hall before detailing key discoveries from the more recent 'Star Carr Project'.

1.3.2. Moore and Clark

Star Carr is located in the Vale of Pickering in North Yorkshire, UK and dates to around 9300-8500 cal BC (see figure 8) (Taylor *et al.* 2019). Since its initial discovery by John Moore in 1948, it has been at the centre of research exploring life in Early Mesolithic Britain, with unique levels of organic preservation and thorough excavation techniques employed from the earliest excavations (Clark 1954, 1972; Mellars 2009; Mellars and Dark 1998; Milner *et al.* 2018a, b; Taylor 2011). This section summarises the excavations undertaken at Star Carr in chronological order, discussing what was found and how our knowledge has developed since the site was first uncovered.

John Moore was an amateur archaeologist who fieldwalked in the area of Seamer, located to the south-east of Scarborough in the Vale of Pickering (Clark 1954; Milner *et al.* 2018b). After finding flint, preserved animal bone, and antler in a drainage ditch, Moore contacted Grahame Clark, who at that time was a lecturer in archaeology at the University of Cambridge specialising in the Mesolithic and lithic typologies (Milner *et al.* 2018b; Taylor *et al.* 2019). Clark was interested in excavating a Mesolithic site which had sufficient organic preservation to provide environmental context to lithic

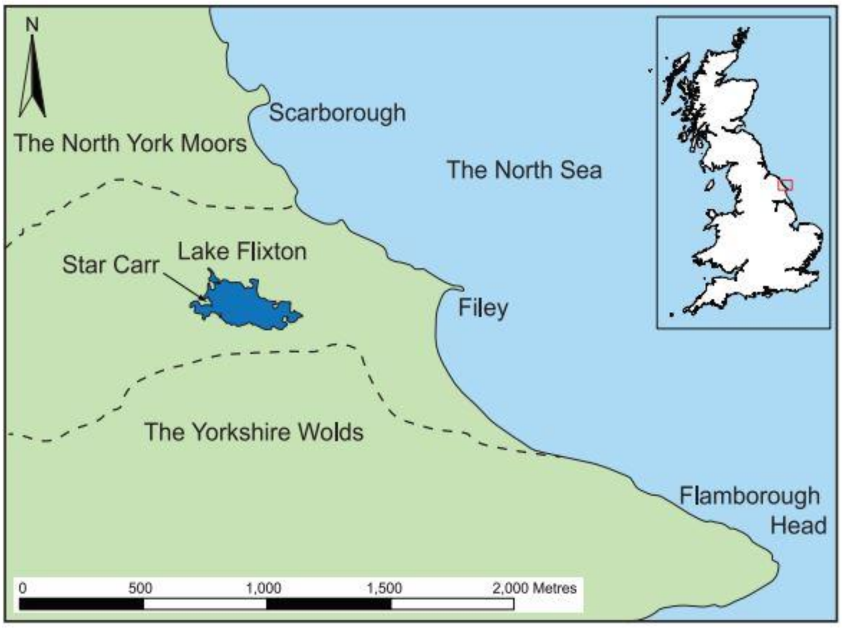


Figure 8: Location of Star Carr (Copyright Star Carr Project, Milner et al. 2018c, 4).

evidence, which would allow him to characterise the people and landscape of Mesolithic Britain (Clark 1954). The potential of Moore's findings greatly appealed to Clark and his research agenda, thus leading to an excavation of Star Carr over three seasons from 1949 to 1951 (Milner *et al.* 2011).

Clark's excavations uncovered far more than was originally anticipated, from which he established a detailed picture of the nature and development of settlement at Star Carr (Clark 1954). The breadth and quantity of excavated material (see figure 9) enabled Clark to interpret social aspects of the site, including: subsistence strategies employed, procurement of materials and the manufacture of objects, group size and group composition (Clark 1954, 1972; Taylor *et al.* 2019). Clark used tool types and densities to interpret activities undertaken and the extent of settlement, which will be further discussed in Chapter 3. Pollen analysis and faunal remains were implemented to explore subsistence and diet, and cosmology and belief systems were interpreted through 'miscellaneous finds' such as beads and antler frontlets (Clark 1954, 1972). Clark also employed ethnography to enrich his interpretations, suggesting that only a few families (made up of men, women and children) would have lived at Star Carr at any one time (Clark 1954, 12). From this, Clark developed one of the most detailed conceptualisations of the British Mesolithic at that time (Milner *et al.* 2011, 2013, 2018b; Taylor *et al.* 2019).

Figure 9: Brushwood 'platform' uncovered by Clark at Star Carr (Copyright Taylor and Francis Group in Milner et al. 2011, 4).

Following Clark's unique discoveries and his innovative narrative of occupation, Star Carr attracted significant attention within the academic community, becoming a 'type site' for the British Mesolithic (Conneller and Overton 2018; Evans 2009; Sørensen *et al.* 2018). In particular, estimates of occupation length based on faunal remains and subsistence strategies prompted further discussion and reassessment from other researchers (Andresen *et al.* 1981; Carter 1997, 1998; Caulfield 1978; Legge and Rowley-Conwy 1988, 1990; Pitts 1979; Price 1983). Clark himself reconsidered some of these original interpretations in a follow-up publication (Clark 1972). By using modern red deer behavioural observations along with additional data from Mesolithic upland flint scatters in the Pennines, he reassessed the function of Star Carr. It was considered a lowland winter camp with individuals splitting into smaller groups and tracking the deer into upland sites over the summer (Clark 1972; Reynier 2005; Spikins 2000). Clark's later work situated Star Carr within a wider social and environmental network of Early Mesolithic sites in the North York Moors (Conneller and Schadla-Hall 2003; Milner *et al.* 2013, 2018b).

1.3.3. Schadla-Hall and the Vale of Pickering Research Trust

Tim Schadla-Hall carried out work from the 1970s largely focused on the site of Seamer Carr (another Mesolithic site found by Schadla-Hall located on the northern edge of Lake Flixton). In 1985, the Vale of Pickering Research Trust (VPRT) was established and further investigation was undertaken at Star Carr in 1985 and 1989, after plans for construction and increased agricultural activity became serious threats to the archaeological material (Schadla-Hall 1987). Schadla-Hall's excavations aimed

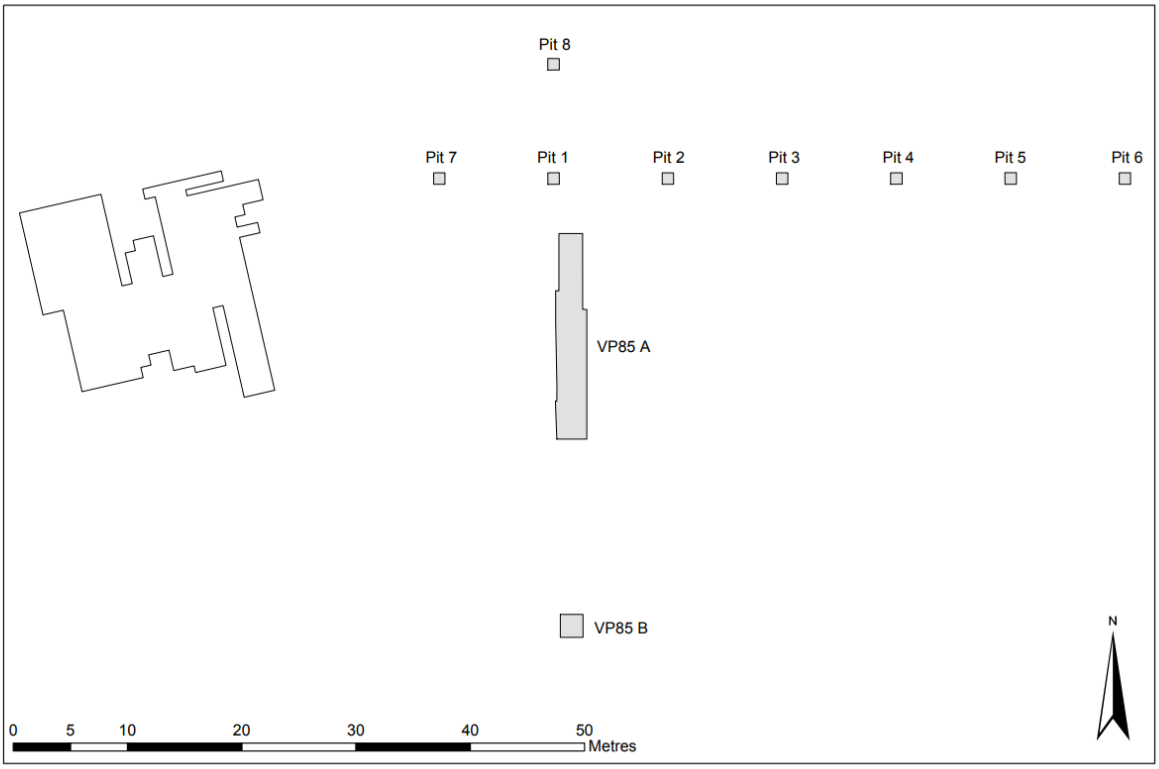


Figure 10: Plan of VPRT trenches excavated in 1985 and 1989 with Clark's trenches on the left (Copyright Star Carr Project, in Milner et al. 2018b, 18).

to gain insight into the ecology at Star Carr during its occupation (Cloutman 1988; Conneller and Schadla-Hall 2003; Day 1993; Mellars and Dark 1998; Schadla-Hall 1987). The trench was located 30 metres from Clark's excavations to avoid any archaeology (see figure 10) but unexpectedly uncovered dense evidence of human activity (timber trackway, faunal and lithic remains). Palaeoecologiocal analysis suggested the presence of human impact in intentional reed burning and that the site was occupied for about 300 years (Day 1993; Schadla-Hall 1987). A timber 'platform' was uncovered suggesting split and hewn wood: the earliest evidence of carpentry in Europe. Nuances were observed in differing lithic assemblages within the two areas, with more blades, utilised flakes and less cores compared to Clark's findings, as well as evidence of *in situ* knapping (Mellars and Dark 1998). The same trench was further excavated in 1989.

Exploratory work by the VPRT identified a further 14 Early Mesolithic sites located around Palaeolake Flixton, though they did not have the richness of organic material uncovered at Star Carr (Conneller and Schadla-Hall 2003; Taylor *et al.* 2019). Subtleties between the material recovered by Clark and the VPRT enabled a more complex understanding of the site's use during the Early Mesolithic, suggesting that it was part of a larger network around Lake Flixton (Mellars and Dark 1998; Taylor *et al.* 2019).

1.3.4. The Star Carr Project

1.3.4.1. Introduction to the project

Research undertaken by the VPRT was instrumental in prompting further, more extensive, exploratory work and excavation directed by Nicky Milner, Chantal Conneller and Barry Taylor. This period of work is referred to as the 'Star Carr Project' that ran from 2004 to 2015 (Milner *et al.* 2011, 2018b). Field walking, augering and test-pitting were used to assess the full extent of the site and the state of organic preservation in the dryland area, around the lake edge and to the north of the Hertford Cut (a drainage waterway) (Milner *et al.* 2011, 2018b). From 2004 to 2010, based on the flint scatters and archaeological deposits found in test pits extending far beyond the previous trenches, the team established that only around 5% of the site had been excavated (see figure 11) (Milner *et al.* 2015).

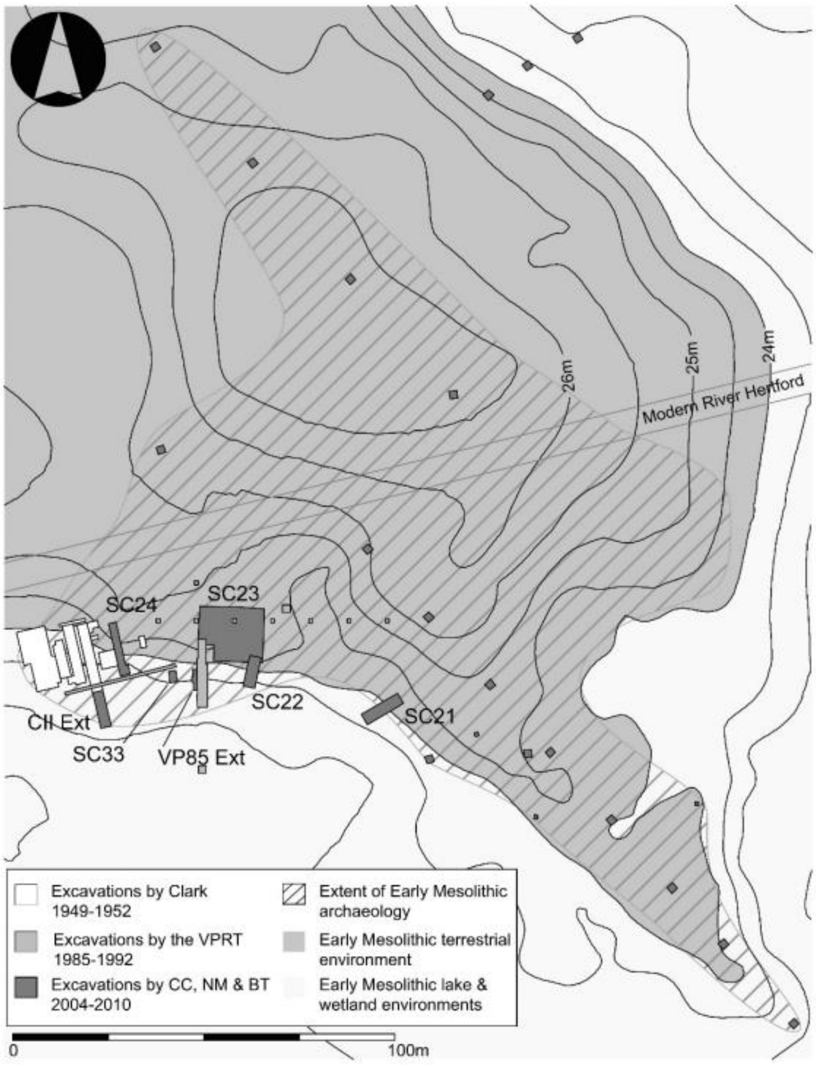


Figure 11: Plan of all excavated trenches at Star Carr (Milner et al. 2015, 130).

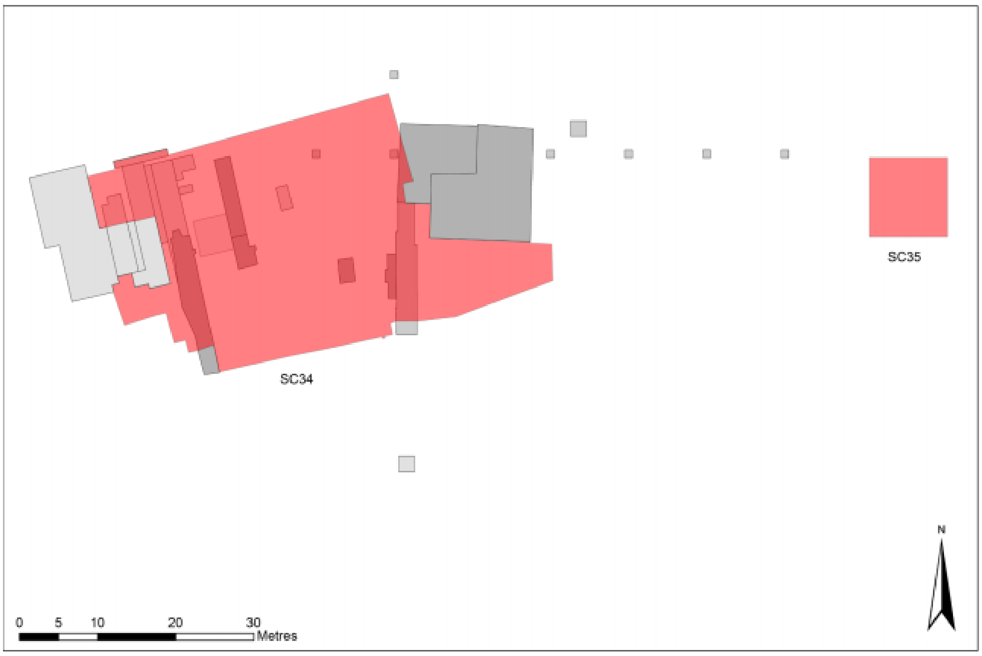


Figure 12: 2012-2013 excavations in red, with previous excavations by the VPRT and the Star Carr Project in dark grey. Clark's trenches are in light grey (Copyright Star Carr Project in Milner et al. 2018a, 32).

Figure 13: Aerial view of excavations showing trench SC34 (Copyright Star Carr Project in Milner et al. 2018a, 33).

Figure 14: Western platform excavated in 2014 (Copyright Star Carr Project in Milner et al. 2018b, 35).

After demonstrating the increasing degradation of the organic remains, European Research Council and English Heritage funding was secured for large-scale excavation from 2013 to 2015 (Milner *et al.* 2011, 2018a) (see figures 12 and 13). These excavations resulted in a range of new discoveries: new faunal species, such as pike, perch, wild cat and vole, the earliest British Mesolithic art found on a shale pendant, evidence for at least three dryland structures and substantial wooden platform-like structures on the lake edge (see figure 14), craftworking and plant processing (Milner *et al.* 2018d; Knight *et al.* 2018a, 253).

Figure 15: Examples of how the Mesolithic environment may have looked at Star Carr during its occupation (Copyright Star Carr Project in Taylor, B. et al. 2018a, 50).

Different analyses were implemented to gain a wider and more comprehensive understanding of activity (Milner *et al.* 2018a). For instance, geochemical, microwear, refitting and technological analysis, as well as faunal and spatial analyses, enabled the tentative identification of organised task areas (Conneller *et al.* 2018a; Milner *et al.* 2018a; Rowley *et al.* 2018; Taylor, B. *et al.* 2018b). Alongside evidence of at least three post-built structures, discrete areas of activity across the site could be used to understand the behaviour of its inhabitants (Milner *et al.* 2018d; Milner *et al.* 2018e). From Bayesian statistical modelling and additional radiocarbon dating, a new model of occupation could be proposed which demonstrated that people had been occupying the site for c.800 years (Bayliss *et al.* 2018; Conneller *et al.* 2009; Dark *et al.* 2006).

Environmental changes through time were observed by examining plant macrofossils, pollen, taxonomic wood identifications and radiocarbon dating, using data from previous excavations, as well as the Star Carr Project work (Radini *et al.* 2018; Taylor, B. *et al.* 2018a; Taylor 2019). In the initial phases of human activity, deeper waters of the lake were dominated by numerous aquatic plants, such as bogbean, waterlily and pondweed, with wetland edge species of sedge, reeds and bulrushes near to the lake's shore (Taylor, B. *et al.* 2018a, 47). The dryland was characterised by open-areas of shrub-land with some areas of dense tree-cover from species like birch, willow and aspen (Taylor, B. *et al.* 2018a, 48; Taylor *et al.* 2019, 8). Towards the lake edge, ferns, shrubs and trees (birch and aspen) grew in the damp soils alongside vegetation like nettle and gypsywort (see figure 15) (Taylor, B. *et al.* 2018a, 47).

After an abrupt climatic event (ACE) which saw annual temperatures drop by 4℃ and a spreading of shrubland, herbs and grasses across the dryland, birch repopulated the area causing a rapid change (over decades) from an open to a woodland landscape (Blockley *et al.* 2018a, 815; B. Taylor, B. *et al.* 2018a, 48). The lake gradually became shallower as it was infilled with organic sediments, causing reeds and sedges to expand further into the lake and enabling trees, grasses and shrubs to grow on the seasonally flooded lake's edge; this created a larger wetland area with boggy sediments close to the dryland (Taylor, B. *et al.* 2018a, 49). Willow and aspen were the most common trees growing on the waterlogged shore, over the lake-edge peat (Taylor, B. *et al.* 2018a, 49). Human activity persisted throughout these fluctuations, with new environments in the earlier phases likely providing opportunities for inhabitants. For example, the swampy shallow areas of water would have provided good hunting areas for waterborne animals, water-fowl and game (Taylor 2019). It was suggested that the site was abandoned once the lake environment had become dominated by fen carr, with trees encroaching into the lake, changing the landscape and the ecosystem it supported (Blockley *et al.* 2018a, 815; Taylor *et al.* 2019, 11).

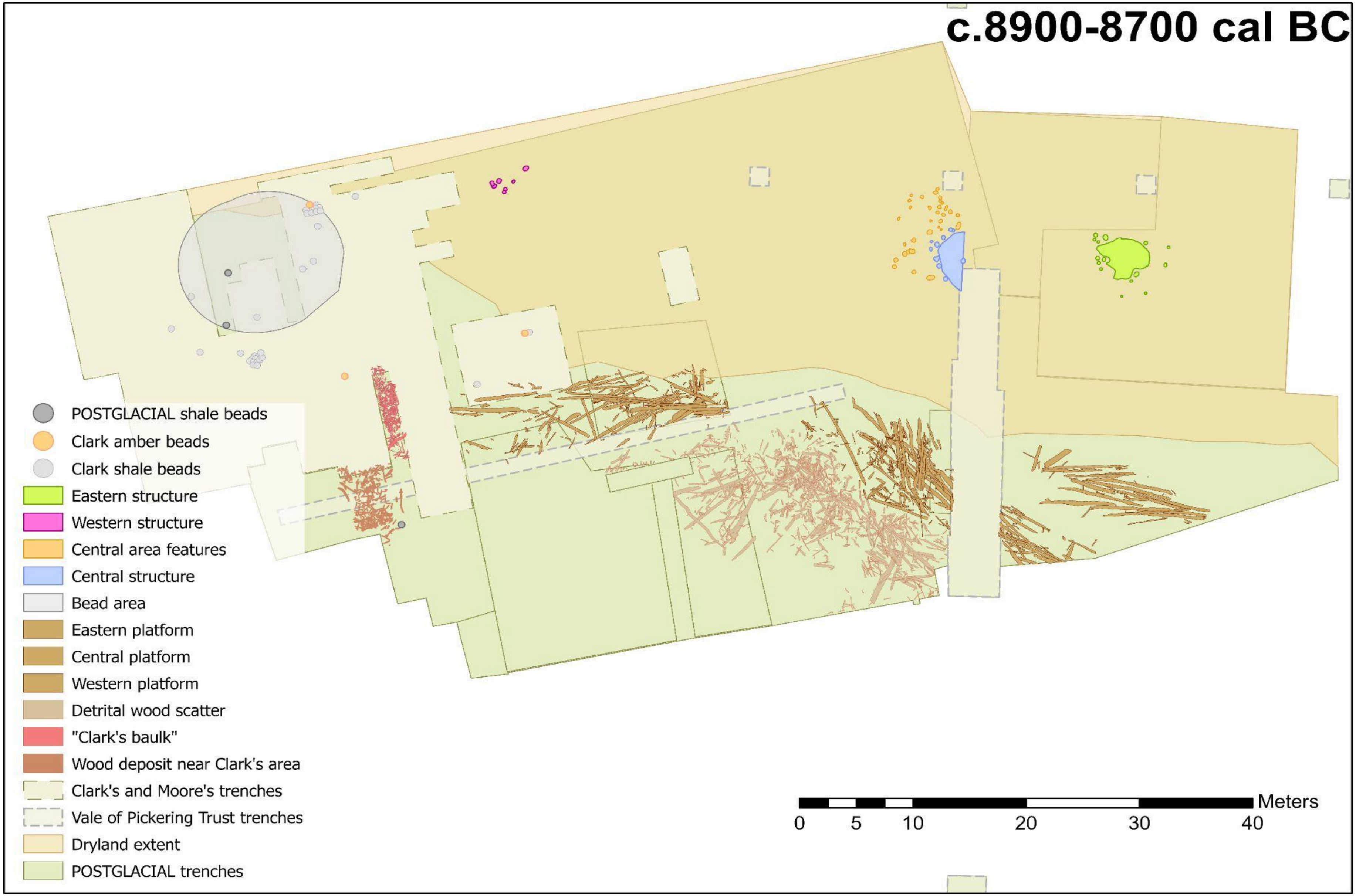
Only approximately 10% of the overall site has been excavated to date, but research from the Star Carr Project has transformed what is known about its Early Mesolithic inhabitants (Milner *et al.* 2018a, d; Piper 2019). By applying a forensic approach to excavation, there is now an even greater breadth of data from which nuanced interpretations can be gleaned (Milner *et al.* 2018e; Piper 2019). Through the careful integration of different analytical methods, detailed narratives have been constructed regarding the changing intensity of human activity and environmental fluctuations, which have been linked to a specific chronological sequence of events (Bayliss *et al.* 2018; Milner *et al.* 2018e). This has resulted in a comprehensive reassessment of the way that Mesolithic individuals are interpreted. Mesolithic communities who inhabited Star Carr were resilient, adaptable and innovative, capable of creating and maintaining a sense of place within a changing landscape (Blockley *et al.* 2018b; Conneller *et al.* 2012; Milner *et al.* 2018e; Taylor 2018; Taylor *et al.* 2019).

1.3.4.2 The site through time

Figure 16: (Below three images) Generalised sequence of human activity at Star Carr, with associated features (after Milner et al. 2018a, 33). Note that the brushwood was overlain by the western platform in the later phase of activity, as seen in the last image.

Central structure
Central area features
Detrital wood scatter
Brushwood
Dryland extent
POSTGLACIAL trenches
c.9300-9100 cal BC
Meters
0 5 10 20 30 40


Central structure
Central area features
Central platform
Detrital wood scatter
Brushwood
Wood deposit near Clark's area
Dryland extent
POSTGLACIAL trenches
c.9000 cal BC
Meters
0 5 10 20 30 40



c.8900-8700 cal BC
POSTGLACIAL shale beads
Clark amber beads
Clark shale beads
Eastern structure
Western structure
Central area features
Central structure
Bead area
Eastern platform
Central platform
Western platform
Detrital wood scatter
"Clark's baulk"
Wood deposit near Clark's area
Clark's and Moore's trenches
Vale of Pickering Trust trenches
Dryland extent
POSTGLACIAL trenches
Meters
0
5
10
20
30
40

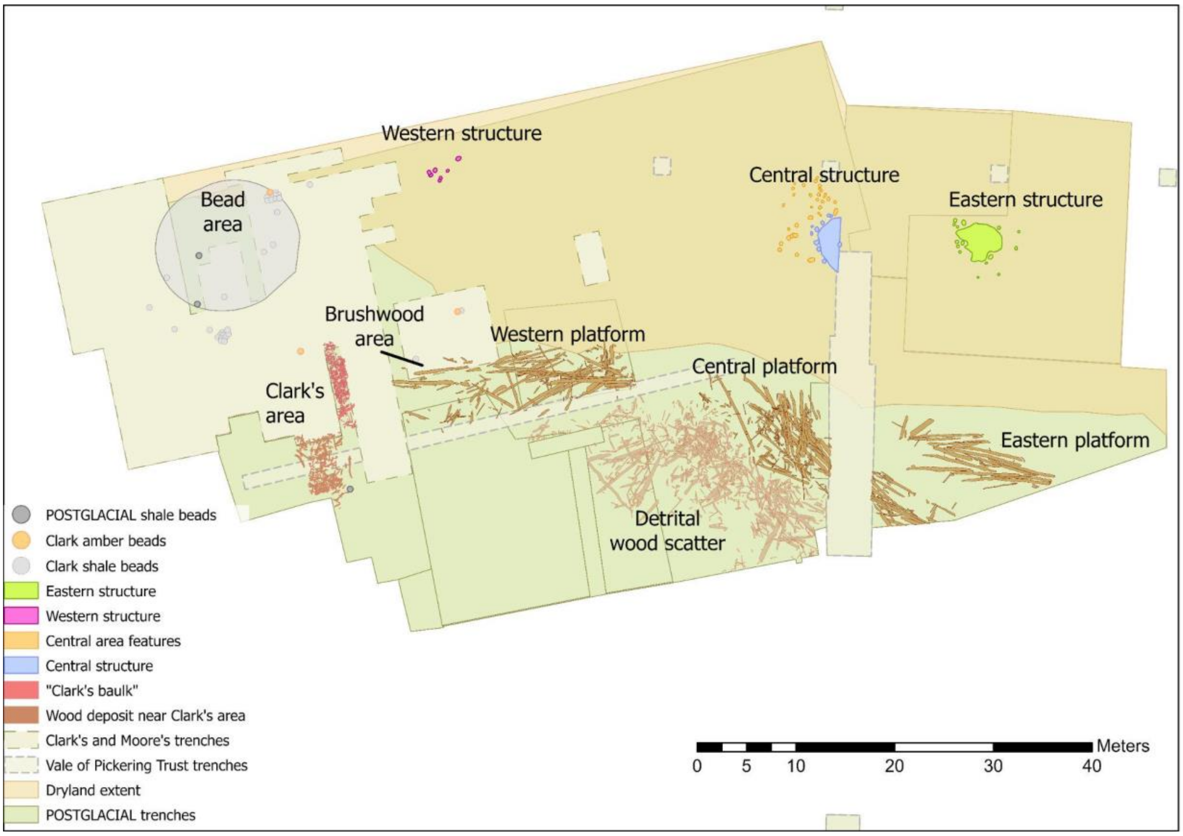


Figure 17: Key discoveries and areas referred to in this discussion about site use at Star Carr.

Prior to the first evidence of Mesolithic human activity at Star Carr between 9385–9260 cal BC (95% probability), likely in 9335–9275 cal BC (68% probability), animals were active in the landscape with traces of beaver gnawing identified (Bayliss *et al.* 2018, 75; Milner *et al.* 2018e, 226). From radiocarbon dates, initial areas of intentional human activity were: the brushwood (near to the lake edge) where tasks focused on woodworking, the central structure on the dryland and the detrital wood scatter (see figures 16 and 17). The first intense deposition of material was seen in the detrital wood scatter (see figure 18), and contained vast quantities of wood, limited quantities of animal bone (141 specimens), antler (19 fragments) and lithics (120 pieces) (Bamforth *et al.* 2018a; Milner *et al.* 2018e; Taylor *et al.* 2019). It was suggested that hunter-gatherers could have been stabilising the shallow lake waters to enable occupation of wetland areas (Milner *et al.* 2018e, 230; Taylor *et al.* 2019, 8).

Depositions occurred here over 135–310 years (95% probability), probably for a period of 160–250 years (68% probability). The sustained nature to depositional activity suggests that practices may have been passed down through generations of inhabitants, with an estimated 7 or 8 artefacts placed into the lake each year (Milner *et al.* 2018e, 230). Towards the beginning of the 9th millenia cal BC, activity began to extend beyond the central areas, with burnt birch bark found to the north of Clark's trenches, foreshadowing expansion of activity into different areas (Bayliss *et al.* 2018; Milner *et al.* 2018e, 230). At this time, the central structure may have been in use; although radiocarbon dates presented two possible periods of activity, either 9300-9200 cal BC or 8800 cal BC.

From 9000 cal BC, there was a surge in the scale of activities, with frequent burning events over several generations and construction of the central platform, measuring at least 17m long (see figure 19) (Milner *et al.* 2018e, 232; Taylor *et al.* 2019, 10). These events were interpreted as interconnected, with burning used to clear lakeside vegetation for the platform (Law 1998). The central platform had a similar alignment to the detrital wood scatter (see figure 17), which had likely fallen out of use −55–170 years (95% probability; end wood scatter/central platform), probably for 40−140 years (68% probability) before (-55 years indicates potential overlap between the use of the detrital wood scatter and the central platform) (Milner *et al.* 2018e, 232). This was the largest (see figure 17) and only platform to have notable associated material deposits of faunal remains and lithics, with 15 pieces of antler, 16 specimens of animal bone (mostly red deer and aurochs), 177 pieces of flint recovered (Bamforth *et al.* 2018a, 102).

Figure 18: Photograph of detrital wood scatter (Copyright Star Carr Project in Milner et al. 2018a, 36).

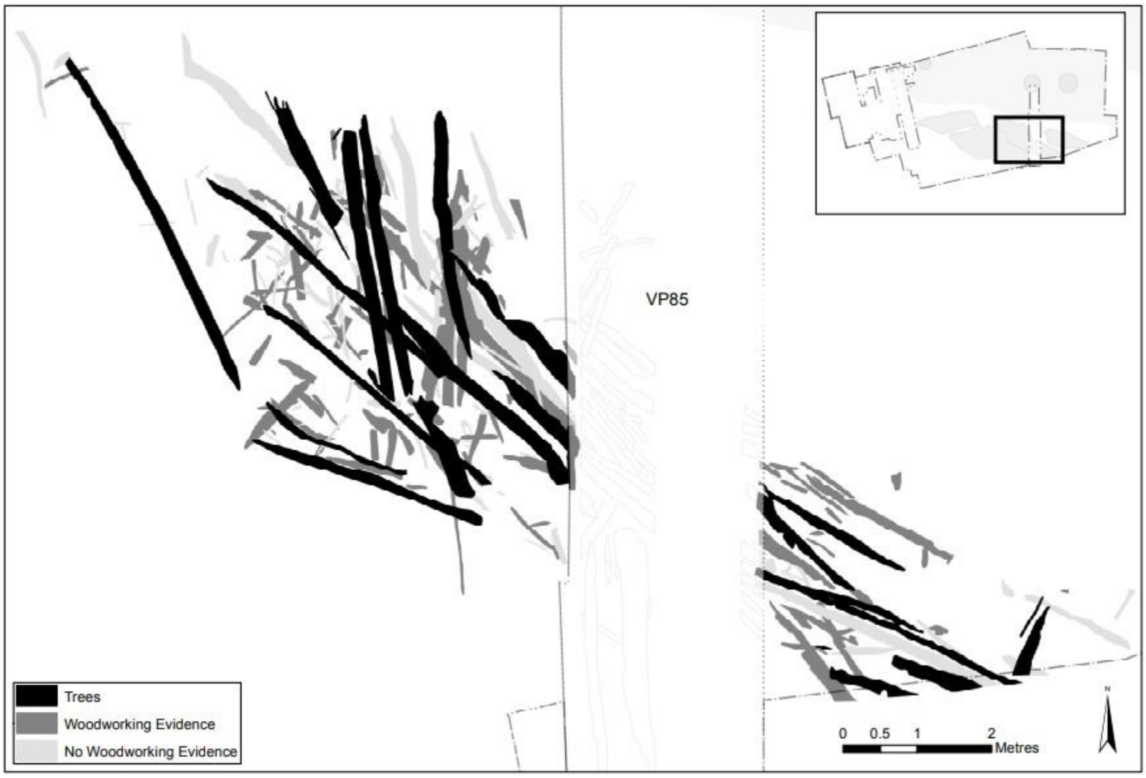


Figure 19: Plan of central platform, indicating trees, woodworking evidence and no woodworking evidence (Copyright Star Carr Project in Bamforth et al. 2018a, 108).

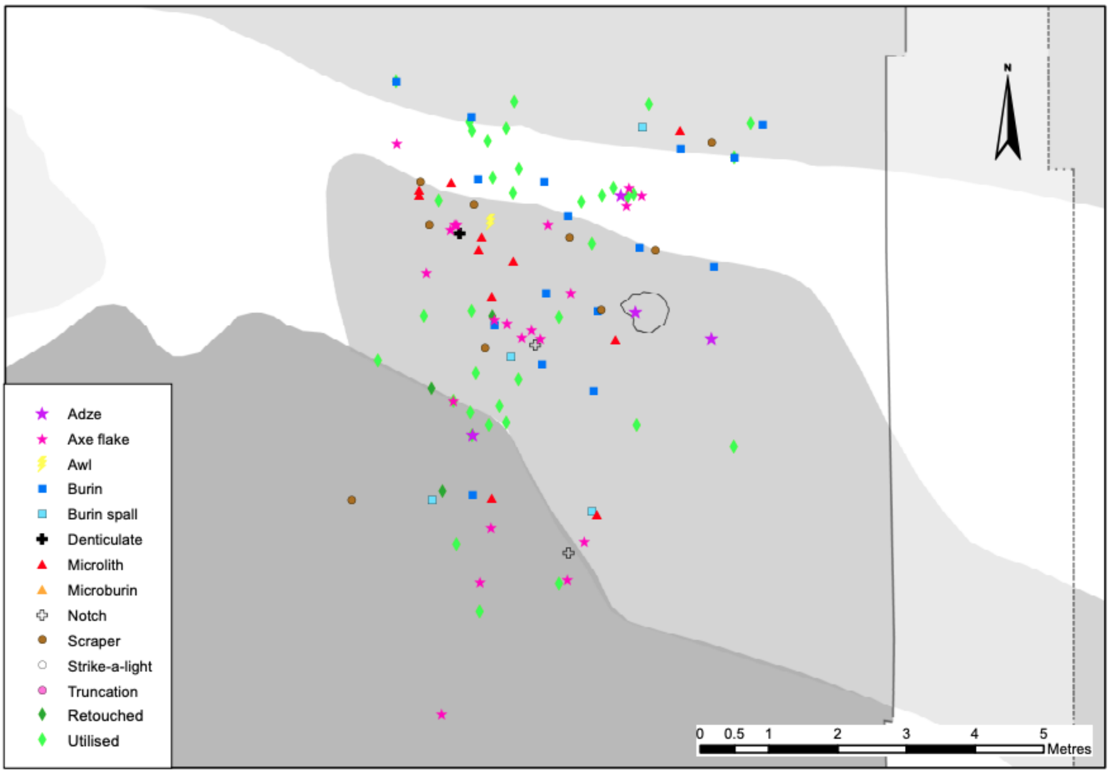


Figure 20: Axe workshop scatter, north of the central platform. Round outline of a feature denotes an area of charcoal (Copyright Star Carr Project in Conneller et al. 2018a, 202).

Clustered deposits of modified bone and antler on the central platform were interpreted as waste from tool manufacture, perhaps dumped from the dryland, with the flint deposits consisting of worn out flint cores, tools and waste chips (Conneller *et al.* 2018a, 198; Milner *et al.* 2018e, 234). When considered as a whole, the alignment, deposition of material, and perhaps even function of the central platform appear to resonate with the detrital wood scatter, despite being built c.100 years later (Milner *et al.* 2018e, 232). Similar to the sustained deposition of material in the detrital wood scatter across c. 200 years, behaviour associated with the central platform appears to respect past behaviours of previous inhabitants (Taylor, B. *et al.* 2018c, 272).

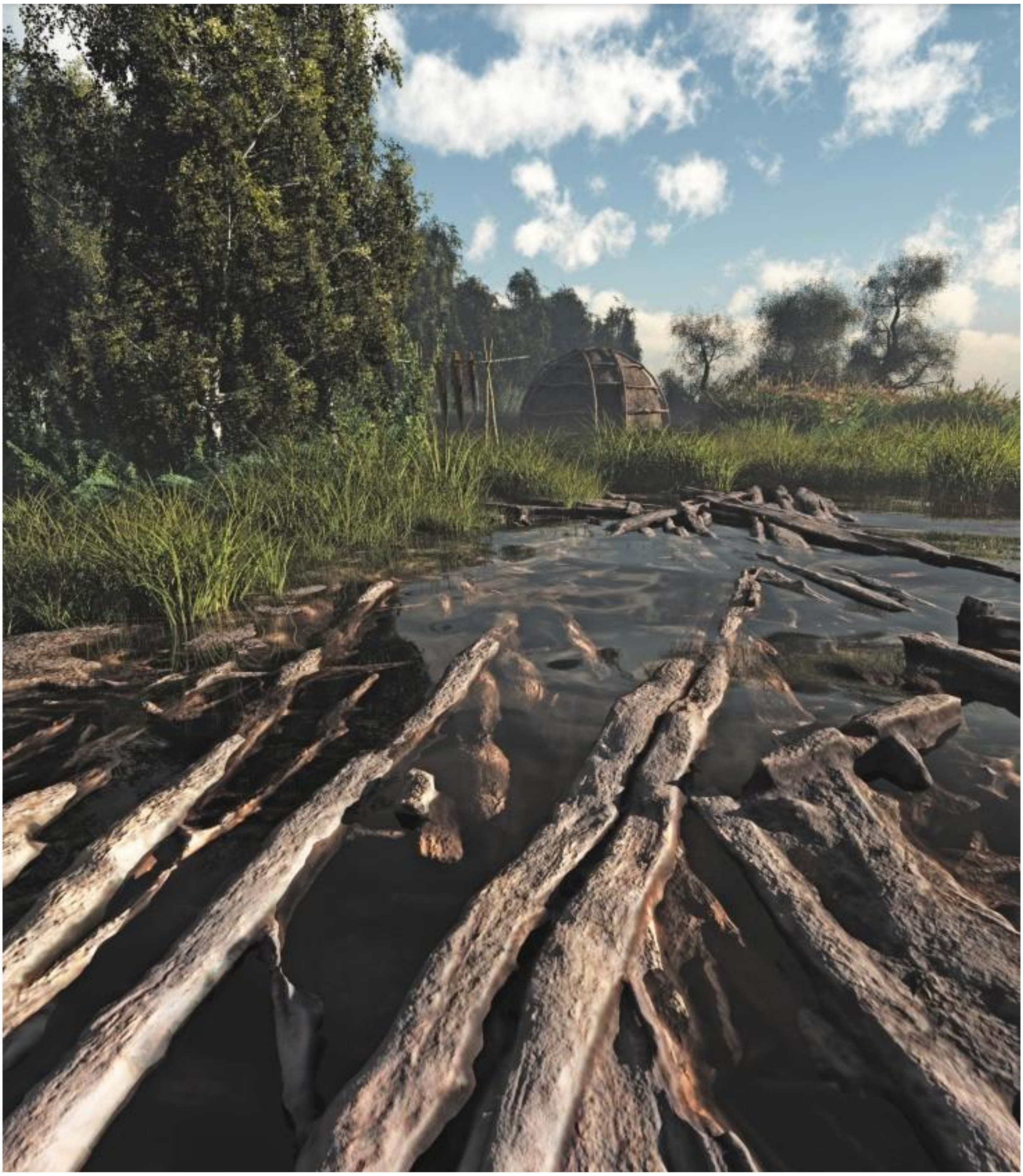


Figure 21: Reconstruction of post-built structure and wooden platform at Star Carr (Copyright Marcus Abbott in Milner et al. 2018e, 239).

Towards the end of activity on the central platform, roughly two to three generations after its construction, in 9015–8650 cal BC (95% probability), probably 8955–8795 cal BC (68% probability), its use appeared to change as the lake infilled with peat (Milner *et al.* 2018e, 234; Taylor 2019). Peat formation over the platform likely stabilised the surface, enabling individuals to produce and use tools, as observed from utilised microliths, burins, scrapers (Conneller *et al.* 2018a, 201). This area was interpreted as an axe workshop from the high densities of adzes and axe flakes (see figure 20).

Activity at Star Carr increased in intensity from c. 8900 cal BC with the construction of two more platforms, two post-built dryland structures (see figure 21), and dense deposition of faunal remains, lithic and organic artefacts in Clark's area (see figure 17) (Milner *et al.* 2018e, 242; Taylor *et al.* 2019, 10). Between −5–205 years (95% probability) after the central platform was no longer in use, probably 55–165 years (68% probability), and likely after a second phase of burning, the eastern platform was constructed using split timbers, measuring 11m long (see figure 22) (Milner *et al.* 2018e, 236). It was situated parallel to the edge of the dryland with limited associated flints. At a similar time to the eastern platform construction, between 8945–8760 cal BC (95% probability), probably 8915–8895 (9% probability) or 8880–8795 (59% probability), the western and eastern dryland structures were also likely built (Milner *et al.* 2018e, 236; Taylor *et al.* 2019, 10). Excavation of a fallen tree on top of the eastern platform, dated to several decades after its construction, suggests that it was likely used for a relatively short time before becoming damaged (Bayliss *et al.* 2018; Milner *et al.* 2018e, 236).

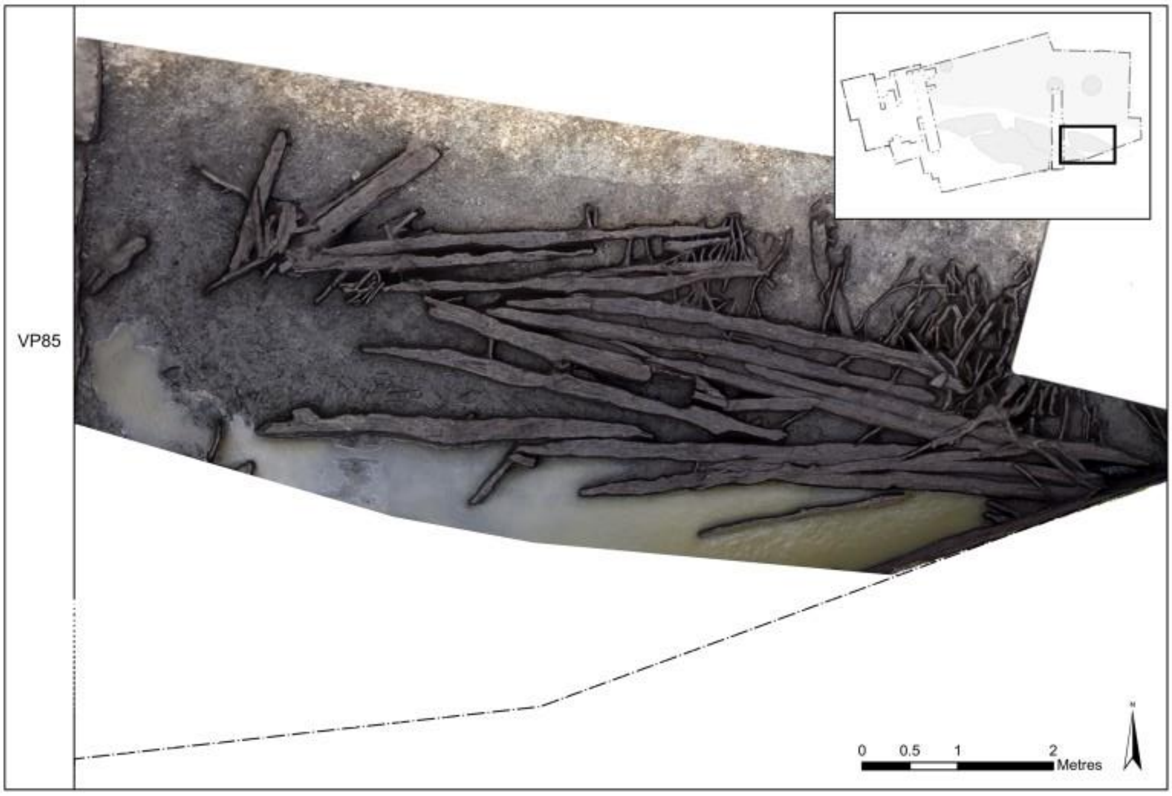


Figure 22: Composite image of the eastern platform (Copyright Star Carr Project in Bamforth et al. 2018a, 112).

Figure 23: Clark's baulk excavated by the Star Carr Project (Copyright Star Carr Project in Milner et al. 2018a, 37).

Alongside dense flint accumulations in and around the dryland structures, substantial quantities of different materials were deliberately placed into the shallow waters of the lake, to the south-west of the western structure (see figure 17) (Milner *et al.* 2018e, 238). This contained vast quantities of: woodworking debris and roundwood (450 items), worked animal bone and antler (298 items) and lithics (621 pieces) (Bamforth *et al.* 2018a, 76; Knight *et al.* 2018b, 146; Conneller *et al.* 2018a, 190). The curation and deposition of material in this area occurred over 1–145 years (95% probability), probably for a period of 1–65 years (68% probability); a relatively short period of time for such a vast quantity of items (see figure 23) (Milner *et al.* 2018e, 238; Taylor *et al.* 2019, 11). These depositions were interpreted as intentionally placed into the lake, possibly taking place over a few occasions, or by several individuals at the same time (Taylor, B. *et al.* 2018c, 255–6).

By 8805– 8755 cal BC (95% probability), probably in 8795–8765 cal BC (68% probability), the western platform was constructed in a single event (see figure 24) (Milner *et al.* 2018e, 238; Taylor *et al.* 2019, 11). It had a similar alignment and size to that of the eastern platform (see figure 17), despite an interval of −25– 170 years (95% probability), probably 15–120 years (68% probability), between their construction (Milner *et al.* 2018e, 238). The western platform extended at least 14.7m and had

Figure 24: Photograph of the western platform once fully excavated (Copyright Star Carr Project in Milner et al. 2018a, 35).

scattered associated depositions of faunal and lithic material (Bamforth *et al.* 2018a, 98; Taylor, B. *et al.* 2018c, 269). From 8700 cal BC, the western platform was likely out of use. The development of fen within the lake edge corresponded to fewer traces of human activity at Star Carr - although variable preservation in later phases meant that limited archaeological material was excavated (Milner *et al.* 2018e, 240).

In addition to several discrete episodes of burning, tool-using activities continued from 8795–8605 cal BC (95% probability), probably from 8750–8655 cal BC (68% probability) in the western part of the site (Milner *et al.* 2018e, 240). The location of this activity reflected changes in the lake edge environment, with growth of terrestrial dry land and the emergence of trees and fen vegetation on previously waterlogged or boggy peat sediments (Taylor 2019; Taylor *et al.* 2019). A large portion of the western area was excavated by Clark, so evidence of human activity was partly identified in his excavations as well as some traces from more recent excavations (Milner *et al.* 2018a).

Flint scatters excavated by the Star Carr Project in the western area reflect small knapping sequences and varied tool using tasks. The production of microliths, burins and scrapers took place, and awls were found near to where Clark excavated 39 probable shale and amber beads, some of which displayed use (Clark 1954, 19; Conneller *et al.* 2018a, 187; Milner *et al.* 2018e, 240). This was interpreted as crafting activity, likely occurring in the later phases of occupation, with associated flint refits identified near to the eastern structure, suggesting movement between these areas (Milner *et al.*

2018e, 241). Evidence of animal-related tool use near to the eastern structure was interpreted as indicating persistent domestic activity in the later phases of the site (Milner *et al.* 2018e, 241). Between 8555–8380 cal BC (95% probability; end Star Carr), probably in 8525–8440 cal BC (68% probability), Star Carr appears to have been abandoned (Milner *et al.* 2018e, 241; Taylor *et al.* 2019, 11).

An overview of the site through time, using the Bayesian model, highlights the development and continuity of certain practices. From structural similarities, such as those between the detrital wood scatter and central platform, and depositional behaviours, it is possible that practices of previous inhabitants were continued over generations (Taylor, B. *et al.* 2018c, 272; Taylor *et al.* 2019, 12). The scale of construction from c.8800 cal BC suggests that several skilled and knowledgeable individuals worked together as a group (Taylor, B. *et al.* 2018c, 269). Constructing wooden platforms and post-built structures would have likely required multiple component tasks and a collaborative effort; felling timbers, processing timbers to the correct size, manipulating posts into correct position (Taylor, B. *et al.* 2018c, 269). Unlike the ephemeral traces of architecture typically seen in the Early Mesolithic, the vast commitment of effort in all aspects of the site, over multiple generations, denotes Star Carr as a significant place in the Mesolithic landscape (Milner *et al.* 2015, 133; Taylor *et al.* 2019, 12).

1.4. Chapter outlines with objectives

Chapter 2 will outline the history of microwear analysis as a method and summarise previous relevant microwear studies applied to Mesolithic assemblages, in order to address objective 1. Chapter 3 will present an overview of flint research undertaken at Star Carr, from Clark's earlier excavations and the more recent Star Carr Project, thus providing the necessary background to achieve objective 2. Chapter 4 will provide the methodology undertaken for sampling flints, and spatial and microwear analysis. Chapters 5-8 will specifically address objectives 3 and 4, as results from the microwear analysis of awls will be presented, followed by an individual discussion of tool use and zones of activity within each structure (Chapter 6: Eastern structure, Chapter 7: Central structure, Chapter 8: Western structure). Chapter 9 will compare patterns in tool use across the three structures, thereby achieving objective 5. Chapter 10 will present a new way of exploring the social dimensions embedded within Mesolithic dwellings, which will be applied to the eastern structure at Star Carr, thus addressing objective 6. To conclude, Chapter 11 will summarise key findings of this research and the implications for our understanding of Mesolithic structures, with suggestions for areas of future work.

Chapter 2: Microwear history of research

2.1. Introduction

This chapter will focus on microwear analysis and its application within Mesolithic research. The development of microwear analysis in Europe will be discussed first, with reference to how the method has been viewed since the 1940s. A focused critique of how microwear analysis and other complementary techniques, such as spatial analysis, have been applied to investigate activity in Mesolithic structures will follow. The chapter will conclude with an evaluation of microwear analysis when applied to tool-using areas. Insights into the social aspects of tool use will be discussed, to justify the use of the method in this research.

In this chapter, “functional analysis” is used to refer to any method of analysis applied to identify tool use. “Microwear analysis” denotes microscopy that examines traces relating to manufacture, use, curation and deposition of a flint, whereas “use-wear analysis” refers to traces resulting from tool use alone (van Gijn 1990; van Gijn and Little 2016; Little and van Gijn 2017). Microwear analysis together with spatial analysis offer different scales of observation, from a single episode of tool use to composite tool-using activity areas (Keeley 1991). To discuss these varying scales, some key terms will be used: actions, activities, techniques, practices. I will use ‘action’ to refer to the smallest scale of tool use, the way that an individual interacts with a tool. The term “activities” will be used to encompass a general category of actions, the act of doing something that may involve several functional processes. “Techniques”, as a term, is used here to define the particular way of doing something, for example building a dwelling in a specific manner. The term “practices" relates to broad routines or behaviours, such as choosing specific types of materials for constructing a dwelling.

2.2. History of microwear analysis

Flints reflect the decision-making of past individuals and are one of the few materials ubiquitously found on prehistoric sites (Cahen *et al.* 1979; Collins 1975). Lithics provided one of the few ways that archaeologists in the 19th and early 20th centuries could track human development and behaviour across large expanses of time (Finlayson 1989; Yerkes and Kardulias 1993). Studies of stone tools most frequently focused on developing chronologies, meaning that the function of the tools was not of particular importance (Vaughan 1985).

John Evan’s (1897) book on ‘The Ancient Stone Implements, Weapons and Ornaments of Great Britain’ is cited as one of the earliest examples of exploring traces of use on lithics (van Gijn 1990;

Olausson 1980; Tringham *et al.* 1974). These initial investigations were rooted in assumed analogies between the ethnographic and archaeological record (Evans 1897; Olausson 1980). Most early ethnographic examples came from North America as tools used by indigenous groups were seen as most comparable to those observed at prehistoric sites (Grace 2012; van Gijn 1990). Functional interpretations of prehistoric flints were restricted to certain tool types, as function could only be assigned to those observed ethnographically (e.g. scrapers) (Evans 1897; Grace 2012; Jensen 1988). These interpretations were based on a key assumption: the form of a tool directly translated to its function, thereby all flints with the same form were used in the same way. There are clear limitations in relying solely on ethnographic analogies to interpret the use of prehistoric stone tools. Mostly notably, presuming lithics were used by Mesolithic individuals and indigenous North American groups in the same way. These studies were, however, the first to consider ways of examining tool use, which enabled the field to develop.

In the early 20th century, polishes from use were observed on archaeological flints. Experimentation consequently became a more favourable avenue of functional research, as the development of different polishes could be tested in an attempt to identify the contact marerial (Curwen 1930; van Gijn 1990; Olausson 1980; Spurrell 1892). By working a range of materials with a replica tool (based on lithic types found in the archaeological record), researchers aimed to reproduce archaeological polish to assign a function to the archaeological flint (Curwen 1930; Spurrell 1892). Spurrell's 1892 study of flint sickle blades documented the first observation of a polish on a tool, which was subsequently tested using experiments (Spurrell 1892). Flint was sourced from the same country, and tested on a range of materials in different states ('clean bone, wood wet or dry, or horn … ripe straw'), thereby producing a relatively sound testing procedure (Spurrell 1892, 57). The progress of functional analysis is seen through Spurrell's work, as polish was observed and experiments were developed to replicate the archaeological use, so the function of archaeological tools could be tested rather than assumed (Olausson 1980; Skakun and Terekhina 2017; van Gijn 1990).

The translation of Sergei Semenov's 1957 book (originally written in Russian) on 'Prehistoric Technology' into English was another turning point in functional analysis. A microscope was incorporated to observe traces of use not visible to the naked eye (Semenov 1964). Semenov's work triggered the spread of use-wear analysis in the West, which is reflected in the increase in Western literature on tool use during the 1960s (e.g. Frison 1968; Keller 1966; MacDonald and Sanger 1968; Sackett 1966; Wilmsen 1968; Witthoft 1967). A pioneering methodology was employed for the functional analysis of flints, which included: the use of a microscope to analyse all aspects of a flint (e.g. manufacture, use and post-depositional traces); application of both low and high microscope magnifications to assess use at different scales; the incorporation of scientific experimental tests; documenting use traces through photographs and the use of ethnographic studies (Keeley 1974; Semenov 1964; Vaughan 1985; van Gijn and Little 2016). This robust methodology built on past research was developed, which could be applied to any flint from any time period to investigate its use. However, there were limitations to Semenov's work. Explicit details of his suggested methodology were unclear, and thus unable to be replicated, and the equipment used in Russia at the time was inaccessible to researchers in other countries (Keeley 1977; Vaughan 1985; Yerkes 2019). This led to European and American researchers adopting modified and hugely variable versions of Semenov's methodology, subsequently resulting in a number of debates regarding analytical methods in the 1970s and 80s (Keeley 1974; Hayden 1979; Odell and Odell-Vereecken 1980; Odell 1975; Tringham *et al.* 1974).

Two different methodologies of microscopic analysis were used in the 1970s by western researchers. The low-power approach, using magnifications under 100x, predominantly assessed microscopic edge damage patterns (e.g. Odell 1996; Tringham *et al.* 1974). The high-power approach, using magnifications between 100-500x, investigated polishes and changes in the flint's topography (e.g. Keeley 1974; Moss 1987a; Unrath *et al.* 1986). Two decades of criticism surrounding both methods followed, resulting in the methodological refinement (Bamforth 1988; Finlayson 1989; Keeley 1974; Newcomer *et al.* 1988; Odell and Odell-Vereecken 1980; Odell 1975; Olausson 1980). The high-power approach, figure-headed by Keeley, was heavily criticised with no system for validating interpretations of archaeological polish, and no way of proving that polishes could be distinguishable (Halley and Del Bene 1981; Newcomer and Keeley 1979; Odell 1975; Olausson 1980; Vaughan 1985; Yerkes 2019). The low-power approach was critiqued as it was not able to identify specific worked materials, owing to the lower magnifications and focus on macro-damage (Keeley 1974; Olausson 1980; Yerkes and Kardulias 1993).

In response to criticism of the high-power approach, Newcomer and Keeley developed a 'blind test' (Newcomer and Keeley 1979). Replica tools worked on known materials were assessed by a microwear analyst (Bamforth 1988; Newcomer and Keeley 1979; Unrath *et al.* 1986). The analyst was fully removed from the production and use of the experimental pieces, enabling a more realistic replication of how most microwear analyses are undertaken. Once the analyst had assessed each piece, their observation could be compared against the actual use and an overall score of accuracy established. A score could be produced for each aspect of the observation: the area of the flint used; the direction of use; and the material worked (Newcomer and Keeley 1979). Subsequent blind tests were undertaken to test both the high-power and low-power approach, which further fuelled debates as the accuracy of both methods was measured on scores from the blind tests (Halley and Del Bene 1981; Odell and Odell-Vereecken 1980; Yerkes 2019).

This methodological debate was resolved in 1989 at the Use-Wear Conference in Uppsala. Both approaches were seen as complementary and to be applied in unison when analysing tool use (Odell 2001; van Gijn 1990; Yerkes and Kardulias 1993). It was established that functional analysis should consider all forms of use traces (microchipping, edge damage, polish etc.), and different magnifications of analysis should be utilised to provide a thorough assessment (Jensen 1988; Odell 2001; Vaughan 1985). Blind testing was also established as a method for testing the accuracy and validity of interpretations, which has some use in more recent microwear studies (Evans 2014; Jensen 1988; Rots *et al.* 2006). Following this, microwear research was more widely implemented in studies of different time periods (mainly prehistoric), to answer a diverse range of questions regarding past behaviours (Dumont 1990; Fischer *et al.* 1984; Jensen 1988; Moss 1987a; van Gijn 1990). Through the identification of otherwise invisible materials (e.g. plants), some considered microwear analysis as key to tackling issues in lithics analysis (Blankholm 1987; Clemente and Gibaja 1998; van Gijn and Little 2016; Unger-Hamilton 1985).

Despite methodological refinements and an ever-growing body of research, microwear analysis continues to be overlooked by some (Evans 2014; Grace 1990; Yerkes and Kardulias 1993; Newcomer *et al.* 1988). The criticisms of microwear analysis as interpretative, subjective and un-scientific have led some researchers to dismiss it when assessing tool use (e.g. Shott 1989). There remain two limitations of microwear analysis; reproducibility and transparency (Evans 2014; van Gijn 2014; Jensen 1988; Rots and Plisson 2014). There is little standardisation in: the way that analyses are undertaken, details of the explicit methods applied, terminology used to describe polishes and varying degrees of polish documentation. This results in difficulties in reproducing microwear data. Previous microwear analyses cannot be incorporated into new research, thus limiting the impact of interpretations gained compared to other developing scientific methods of analysis (Jensen 1988; van Gijn 1994). There also remain uncertainties regarding the formation of polish on lithics, which continues to impede how microwear analysis is perceived by others (Fullagar 1991; Jensen 1988; Macdonald *et al.* 2018; van Gijn 1990).

A number of microwear researchers have developed quantifiable methods to assess how stone tools were used, namely the application of confocal microscopy and Scanning Electron Microscopy (SEM) (Arrighi and Borgia 2009; Anderson 1980; Cnuts and Rots 2018; Evans and Donahue 2008; Ibáñez *et al.* 2016; Martín-Viveros and Ollé 2020; Ollé and Vergès 2014; Pedergnana *et al.* 2020; Pichon *et al.* 2021; Stevens *et al.* 2010). These methods have the potential to further strengthen microwear assessments as they are more prone to objective testing and are more reproducible than relying on subjective observation.

2.3. Microscopic methods to understand tool function

2.3.1. Microwear analysis

Microwear analysis requires two different types of microscope; a stereoscope for low-power observations and a reflected-light (also called optical) microscope for high-power assessments. A stereoscope uses two separate two-dimensional images in the left and right eye-pieces, and combines them to give a perception of a three-dimensional image. The stereoscope is limited to 50x magnification as the light intensity when observing a sample decreases as magnification increases; creating lower quality images at higher magnifications (Keeley 1980, 12). A reflected-light microscope enables higher magnification (up to 200x, depending on lens attachments) to closely examine microwear traces such as polish, striations and microscopic edge-damage. Reflected-light microscopes maintain high-quality images at higher magnifications as lighting can be adjusted. Though the image down the microscope is two-dimensional, the light can be filtered in different ways (polariser and analyser slides, and intensity) to adjust the reflectivity and texture of the image, helping to illuminate any observed wear traces. When connected to a computer, the reflected-light microscope has the ability to produce composite photographs of small areas by stacking multiple photos taken from one location at different depths of field.

2.3.2. Confocal microscopy and SEM

Microwear analysis is one of a few microscopic methods that can be applied to lithics, with previous studies also highlighting the use of confocal microscopy and Scanning Electron Microscopy (SEM), often in conjunction with microwear analysis (Alvarez *et al.* 2001; Evans and Donahue 2008; Hayes and Rots 2019). Microwear analysis is reliant on observations and interpretations of the analyst, as well as analogies with experimental reference material, meaning it has been criticised as subjective, and thus, unreliable (Evans 2014; Evans *et al.* 2014a; Ibáñez *et al.* 2014; Stevens *et al.* 2010). Analysts have applied additional microscopic methods in attempt to: 1) aid more accurate observations by increasing magnification and image resolution (Martín-Viveros and Ollé 2020; Ollé and Vergès 2008); 2) introduce a quantitative element to provide a more objective source of data (Evans and Donahue 2008; Ibáñez *et al.* 2016, 2018). Confocal microscopy and SEM microscopy, and their applications to microwear analysis, will be briefly discussed to justify why these techniques have not been implemented in this research.

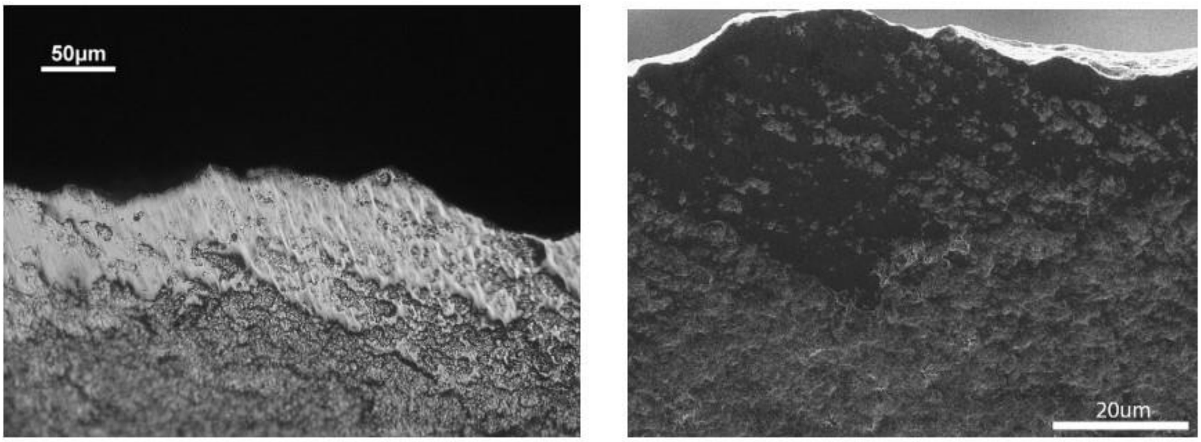


Figure 25: Left - Optical microscopy image of a tool used for whittling soaked antler using 20x objective lens. Right - SEM image of same area in left image, worked area appears dark (Evans and Donahue 2008, 2226).

Analysing tool function using SEM can be traced back to 1983, where it was used to explore the development of hide polish, with a study that assessed the impact of different variables (e.g. abrasion, moisture) on polish development (Mansur-Franchomme 1983). SEM, when applied to stone tools, provides a high magnification (up to 800x) and high resolution image of the flint topography (Hayes and Rots 2019; Ollé and Vergès 2008; Pedergnana *et al.* 2020). Textural information of microwear traces and potential residues on the flint can be observed without reflectivity of inclusions within the flint or of the polish itself (Martín-Viveros and Ollé 2020; Pedergnana and Ollé 2017). The use of SEM in functional analysis can be separated into four categories:

1) to explore the development of polish (Mansur-Franchomme 1983; Ollé and Vergès 2008);

2) to analyse microwear polish on quartz and obsidian (i.e highly reflective materials) (Ollé *et al.* 2016; Pedergnana and Ollé 2017);

3) to identify and analyse residues (often on modern replica tools rather than archaeological tools) (Hayes and Rots 2019; Martín-Viveros and Ollé 2020);

4) to observe microwear traces across large surface areas at a high magnification and resolution (Alvarez *et al.* 2001).

None of these categories were seen as significant to the identification and interpretation of microwear traces on flint from Star Carr for the following reasons: 1) the assemblage does not contain any quartz or obsidian (Conneller *et al.* 2018b); 2) no notable residue was found on a sample of the flint tools in a previous analysis, likely due to preservational issues (Croft *et al.* 2018). A SEM image (see figure 25 - right image) can show the distribution of wear traces on the flint edge, but it is unhelpful for characterising and interpreting key aspects of polish (brightness, texture of the polish etc), which can be clearly observed in optical microscopy (figure 25 - left image). The use of SEM in this research is therefore unnecessary, with optical microscopy offering sufficient detail for polish identification.

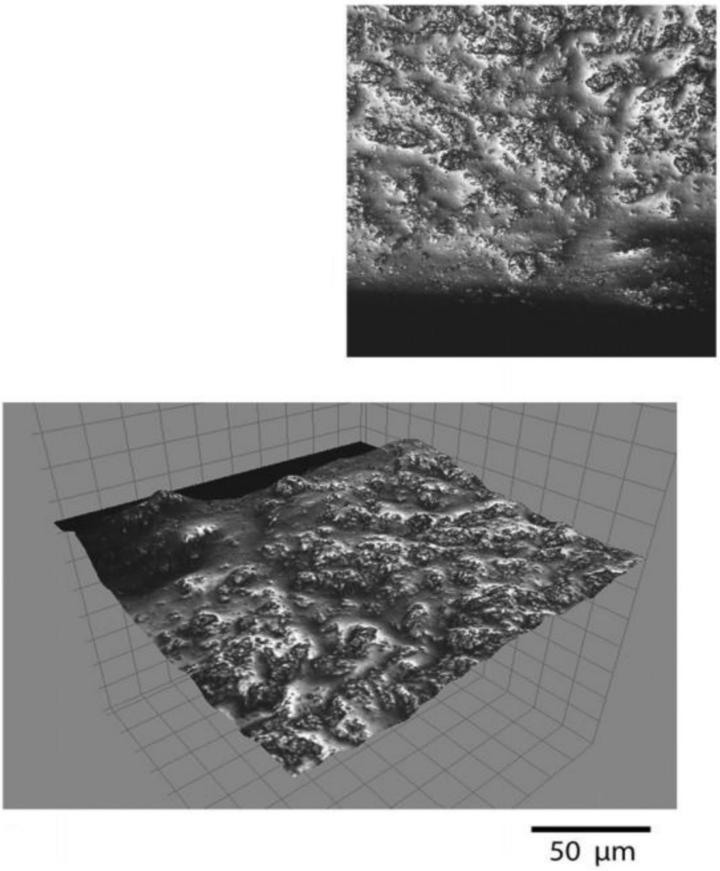


Figure 26: Top - replica experimental tool used for cutting soft plants. Bottom - 3D projection of the flint edge seen in top image (using LSCM) (Stevens et al. 2010, 2672).

Confocal microscopy (also called laser scanning confocal microscopy, or LSCM) is a more recent complementary method used alongside microwear analysis. Confocal microscopy enables the quantification of wear traces by producing 3D data (see figure 26) (Álvarez-Fernández *et al.* 2020; Evans and Donahue 2008; Ibáñez *et al.* 2014; Ibáñez *et al.* 2018; Stevens *et al.* 2010). It was applied to stone tools as a quantifiable method to identify function, specifically targeting textural changes observed in microwear traces (Stemp *et al.* 2013).

Different variables of the polish (e.g. roughness) can be measured with confocal microscopy and so in some circumstances, contact materials can be interpreted from scans of the archaeological samples (Ibáñez *et al.* 2018; Macdonald 2014). This is done through texture analysis, where several variable measurements are taken from a 3D image of developed archaeological polish. Models built from these statistical measurements are then used to differentiate and group the images based on their characteristics, thus assigning them to a known contact material group (Ibáñez *et al.* 2018). However, the method is limited by similar issues that analysts face in microwear analysis, as confocal microscopy can only differentiate between polishes if they are well developed and sufficiently distinct from each other. To summarise, these issues are:

1. differentiating between visibly similar microscopic polishes (e.g. antler and wood; reeds and cereals; dry and fresh hide)

2. identifying contact material from less developed traces
3. post-depositional effects on polish preservation
4. assessing the duration of activity (Evans and Donahue 2008; Evans *et al.* 2014b; Ibáñez *et al.* 2014; Ibáñez *et al.* 2018; Stevens *et al.* 2010).

At its current stage of development, confocal microscopy does not appear to offer a significant contribution to functional tool analysis that cannot be gained through a reflected-light microscope for microwear analysis.

2.3.3. Residue analysis

Another technique often implemented in conjunction with microwear analysis is residue analysis, defined as the analysis of microscopic archaeological residues, organic and inorganic, that can adhere to the surface of archaeological materials, and preserve post-depositionally (Langejans 2010, 2011; Loy 1993). It uses a reflected or transmitted light microscope as an initial baseline, alongside use of experimentally produced reference collections, similar to those produced for microwear analysis (Cnuts and Rots 2018; Fullagar *et al.* 1996; Langejans 2010; Langejans and Lombard 2015; Loy 1993; Wadley *et al.* 2004). Increasingly, other microscopic techniques are also applied to aid the identification of residues: confocal Raman microspectroscopy (micro-Raman) (Bordes *et al.* 2020; Croft *et al.* 2018); Scanning Electron Microscope-Energy Dispersive X-Ray Spectroscopy (SEM-EDS) (Hayes and Rots 2019; Martín-Viveros and Ollé 2020); Fourier-transform infrared spectroscopy (FTIR) (Lemorini *et al.* 2014; Venditti *et al.* 2021). These other microscopy techniques offer both physical and chemical characterisations of the residues, which can provide additional information, aiding more accurate identifications.

On flints, archaeological residues may relate to use of the tool (Bordes *et al.* 2020; Cristiani and Zupancich 2020; Hayes and Rots 2019; López-Tascón *et al.* 2020). This can include: hafting traces (e.g. adhesives from securing a tool in a haft may have remained on the flint's surface), the tool's use (e.g. if the tool was used to cut bone, there are some specific depositional contexts where bone residue might remain on the flint), treatment of the tool (e.g. if the tool has been covered in a material, like ochre). Rather than reflecting use, residues may also relate to depositional context, as deposits from the soil or elements within the soil may adhere to the flint over time (Croft *et al.* 2018). Additionally, contamination can be introduced during excavation and post-excavation. Residues adhering to a flint's surface therefore may not always relate to its use and may not always be sufficiently preserved (Croft *et al.* 2018; Kozowyk *et al.* 2020; Langejans 2010, 2011).

Successful residue analysis on flints in particular relies on a number of factors:

1. depositional contexts that preserve particular types of residue (e.g. bone residue is more likely to preserve in arid environments (Wadley *et al.* 2004);
2. sufficient material must exist on the flint surface for identification;
3. analysis must be integrated with macro- and microwear assessments;
4. the flint must have been excavated and archived using particular protocols that prevent modern contaminants from being introduced;
5. geochemical knowledge of the depositional soil context to distinguish between depositional contaminants and anthropogenic residues (Croft *et al.* 2016; Hayes and Rots 2019; Kozowyk *et al.* 2020; Langejans 2010, 2011).

If any of these factors are not considered, the integrity of residue analysis will be significantly undermined and the results potentially misleading.

During excavations at Star Carr, residue analysis was applied as the waterlogged environment present at the site can be favourable to the preservation of some organic residues (Croft *et al.* 2018; Langejans 2010). A sub-sample of 138 flints was selected and excavators extracted the pieces alongside associated sediment from the surrounding depositional area, which were stored in a fridge (Croft *et al.* 2018, 431–2). Reflected light microscopy was used to initially identify areas of potential residue that could be targeted for further analysis using micro-Raman, which can identify chemical composition (Croft *et al.* 2018, 432). Despite strict adherence to protocols in sampling and analysing any possible residue, results indicated that all identified residues were pedogenic (from the soil) and not anthropogenic, with micro-Raman identifying iron oxide and gypsum (Croft *et al.* 2018, 435). Birch bark tar was recovered from Star Carr, so it is likely that at least some of the flints may have been hafted using tar; however the burial environment was not conducive to their survival on lithics (Aveling and Heron 1998; Croft *et al.* 2018, 436; Fletcher *et al.* 2018). As a result, residue analysis was not implemented in this research.

2.4. Microwear studies undertaken on Mesolithic assemblages

2.4.1. Introduction

Microwear analysis has been utilised to study Mesolithic flints from different contexts: axes found in cremation pits, tools found in shell middens and discrete scatters found in upland sites (Briz y Godino *et al.* 2009; Fretheim 2019; Guéret *et al.* 2014; Little *et al.* 2017; Paixão *et al.* 2019; Warren *et al.* 2018). In these studies, microwear analysis provided in-depth insights into object use, curation and deposition, going beyond typological identifications (Conneller *et al.* 2018b; van Gijn 1990). The scale of interpretation can vary significantly, from understanding the relationship between an individual and a single object, to tracking changes in subsistence strategies within transitional periods (Dumont 1987; Gibaja *et al.* 2018; Gibaja *et al.* 2020; Ibáñez *et al.* 2016; Little *et al.* 2017; Little and van Gijn 2017; Mazzucco *et al.* 2020).

This section will present a brief overview of how prehistoric settlements were first interpreted, with a summary of how flints from settlements were assessed prior to the application of microwear analysis. Specific examples of microwear analysis undertaken on Mesolithic settlements will then be discussed. A focused review will highlight the current state of knowledge regarding tool use on settlements. Microwear analysis undertaken during the Star Carr Project will be discussed in depth in Chapter 3.

2.4.2. Interpreting Mesolithic settlements: background

Key to interpreting any prehistoric settlement is the determination of site function. Discussions often focus on the inferred purpose of a site and how it was situated within the wider landscape (Ashmore 2002; Binford 1979; Blankholm 1987; Parsons 1972; Willey 1953). Settlement function was essential to earlier interpretations of Mesolithic sites. From the 1940s, discourse was centred around economic models of subsistence and resource exploitation (Davies *et al.* 2005; Gendel 1987; Milner 2009). By determining function, sites could be categorised into types and linked to large-scale narratives concerning hunter-gatherer mobility and land-use (Clark 1972; Dumont 1987; Radley and Mellars 1964; Woodman 1985). These grand narratives can be traced to Willey's (1953) chronological study of prehistoric settlement in the Virú Valley, Peru, which introduced the concept of 'Settlement Archaeology' (Trigger 1967).

Settlement Archaeology relies on ethnographic data to interpret economic aspects of archaeological data, specifically relating to settlements and social structure (Stjernquist 1977; Trigger 1967). In this model, hunter-gatherers are seen as highly mobile and their sites considered a part of a wider settlement pattern, with individual settlements comprising specialised task camps connected to others (Binford 1978; Torrence 1983). From this, a collective economic network can be formed, and the functional relationship between sites assessed to establish a settlement system. The system can then be used to trace hunter-gatherer behaviour across landscapes (Binford 1978, 1979; Trigger 1967; Willey 1953; Winters 1969).

2.4.3. Interpreting Mesolithic settlements: tool types

Prior to the application of microwear analysis, archaeologists interpreted Mesolithic site function through tool types, site context and faunal remains, where present (Clark 1954; Mithen *et al.* 1992; Woodman 1981). Tool types played an integral role in assigning function to settlements, with certain types associated with particular activities (Binford 1979; Blankholm 1987; Stapert 1992; Verhart 1996; Whallon 1978). Frequencies of tool types present were then used to infer activities undertaken (Radley and Mellars 1964; Reynier 2005). In doing so, a site could be assigned a ‘type’; for example butchery, woodworking and hunting activities would lead to a categorisation of a home base (Binford 1980; Chkhatarashvili and Manko 2020; Reynier 2005; Schilling 2003). Associations between tool types and activities have previously been based on simplistic comparisons between archaeological and ethnographic tools, such as flint scrapers and hide working, based on limited ethnographic examples (Gould 1971; Martelle Hayter 1994).

A key example of site function inferred from tool types can be seen through microliths. Prior to the application of microwear analysis, microliths were frequently interpreted as projectiles for hunting (Evans 2009; Rozoy 1990; Saville 1981). In past assessments, if microliths were the dominant tool type found, a site was often interpreted as a hunting camp (Crombé *et al.* 2009; Finlayson and Mithen 1997; Verhart 1996). Conversely, a more balanced assemblage of blades, scrapers and microliths would be categorised as a residential base camp (Jensen and Petersen 1985; Mithen *et al.* 1992). However, it is now clear that microliths can have a multitude of functions, with microwear studies documenting plant, hide and woodworking (Cooper *et al.* 2017; Conneller *et al.* 2018b; Crombé *et al.* 2001; Healy *et al.* 1992). In the absence of microwear data, more recent studies of Mesolithic settlements continue to implement this approach of inferring activity areas from tool types and assigning site function (Chkhatarashvili and Manko 2020; Domańska and Wąs 2007; Holst 2011; Kompatscher *et al.* 2016; Nærøy 2018; Tolksdorf *et al.* 2009).

2.4.4. Interpreting Mesolithic settlements: microwear analysis

Similar focus on site function is seen in early microwear studies on Mesolithic flint assemblages. The main trends can be summarised as: 1) to investigate the relationship between form and function of key tool types (Crombé *et al.* 2001; Finlayson and Mithen 1997; Fischer *et al.* 1984; Jensen 1986; Odell 1988) in order to 2) determine the function of sites (Anderson *et al.* 1996; Dumont 1988; Jensen and Petersen 1985). Rather than relying on ethnographic comparisons and inferences of tool type, archaeologists could identify the “true use” of flints (Grace 1990; Shott 1986; van Gijn 1990). Associations of specific tool types with particular activities (e.g. scrapers = hide processing) became challenged and studies investigating the form of certain tools and their function emerged (Fischer *et al.* 1984; Jensen 1986; Willis 1990).

Assessments into the form and function of flints highlighted the need for site-specific investigations, owing to variability in tool use (Adams 1988; Cantwell 1979; Fischer *et al.* 1984; Jensen 1988; van Gijn 1990). Microwear analysis offered a rich source of data to assess site function. Flints could be analysed and interpreted, alongside archaeological materials from the settlement, resulting in a more accurate understanding of site function (Conneller *et al.* 2018a; Crombé *et al.* 2003; van Gijn 2012; Little and van Gijn 2017). The development of radiocarbon dating and Bayesian modelling has also meant recent microwear studies on settlements have implemented a more refined chronology of activity (Bayliss *et al.* 2018; Bayliss and Woodman 2009; Mithen and Wicks 2018; Warren 2018). Occupation length and duration of use of specific features, such as structures, can now be incorporated into site narratives (Bayliss *et al.* 2018; Mithen and Wicks 2018). Microwear analysis and detailed radiocarbon dating can help reconstruct a detailed understanding of activities undertaken by prehistoric hunter-gatherers (Bayliss 2009). However, tool types remain fundamental to the application of microwear analysis, as they provide a baseline of information for sub-sampling (e.g. Cahen *et al.* 1979; Crombé *et al.* 2001; Finlayson and Mithen 1997).

2.4.5. Microwear case studies

The scale of microwear analysis varies considerably in studies of British and European Mesolithic settlements. Insights can range from a rudimentary presentation of the types of material worked, to more in depth exploration of Mesolithic hunter-gatherer behaviour (Dumont 1987; Jensen and Petersen 1985; van Gijn 1990; van Gijn 2012; Little and van Gijn 2017; Petrović *et al.* 2021; Reis *et al.* 2019; Roda Gilabert *et al.* 2016; Soares and Tavares da Silva 2018; van Gijn *et al.* 2001a; b; Warren *et al.* 2018). Scales of interpretation can also be diverse, as microwear data can be used to understand intrasite organisation and use (e.g. Crombé *et al.* 2003; Noens 2013; Reis *et al.* 2019; Roda Gilabert *et al.* 2016), as well as intersite patterns concerning settlement systems and hunter-gatherer movements across regions (e.g. Guéret 2013a; Knutsson and Knutsson 2020).

Microwear analyses from Mesolithic settlements can also have a technological focus. To give an example, the frequency of used un-retouched flints has been analysed to explore how often knapping debris was utilised as a tool (Guéret 2013b; Hardy and Shiel 2007). Microwear analysis derives from research on tool types and how tool form relates to function, so it is hardly surprising that discussions of technological insights dominate settlement studies more than social implications of microwear data (Finlayson and Mithen 1997; Gassin *et al.* 2013; Puchol *et al.* 2014). Social aspects of tool production were only incorporated into a limited number of Mesolithic settlement studies from the late 1980s (Blankholm 1987; Gendel 1987; Longo and Skakun 2008). To explore these trends in more depth, a spreadsheet comprising published microwear studies from European Mesolithic settlements has been created; a full version can be found in Appendix 1. It is worth noting that most studies which discuss social dimensions of tool use are located in mainland Europe (22/36). Some sites could not be added due to restricted access to publications, particularly those not published in English. To highlight the variability in microwear studies on Mesolithic settlements, three case studies from Denmark, Scotland

and Poland will be critically examined. The case studies demonstrate how microwear results have been implemented to different degrees to interpret Mesolithic lifeways and the social aspects of tool using activity areas.

Vænget Nord in Denmark is a Mesolithic site dating to c. 5900-5800 BC, where hearths, cooking pits and a depression were uncovered along with significant flint densities (Petersen 1990). Radiocarbon dating methods available at the time limited interpretations; however, microwear analysis was used in an innovative way to investigate Mesolithic settlement behaviour. In total 846 flint pieces were examined for microwear analysis, of which 140 had been used (Jensen and Petersen 1985; Petersen 1990). Hide and plant traces were observed most frequently, with meat, wood and bone/antler working also found (Jensen and Petersen 1985).

Spatial patterning of activities was observed from the microwear data (see figure 27). Craft working (e.g. working bone or antler with burins) was located at the centre near to hearths, with messier activities requiring more space (e.g. hide working) located at the periphery. Refuse areas were located to the north and south and flint working to the east of the central zone (Jensen and Petersen 1985; Petersen 1990). However, the implications of such an apparent structure to activities and what that could imply about the inhabitants' behaviour are not explored. Despite these limitations, the study was one of the first to use microwear data to gain an insight into specialised zones of activity at a Mesolithic settlement (van Gijn 1990).

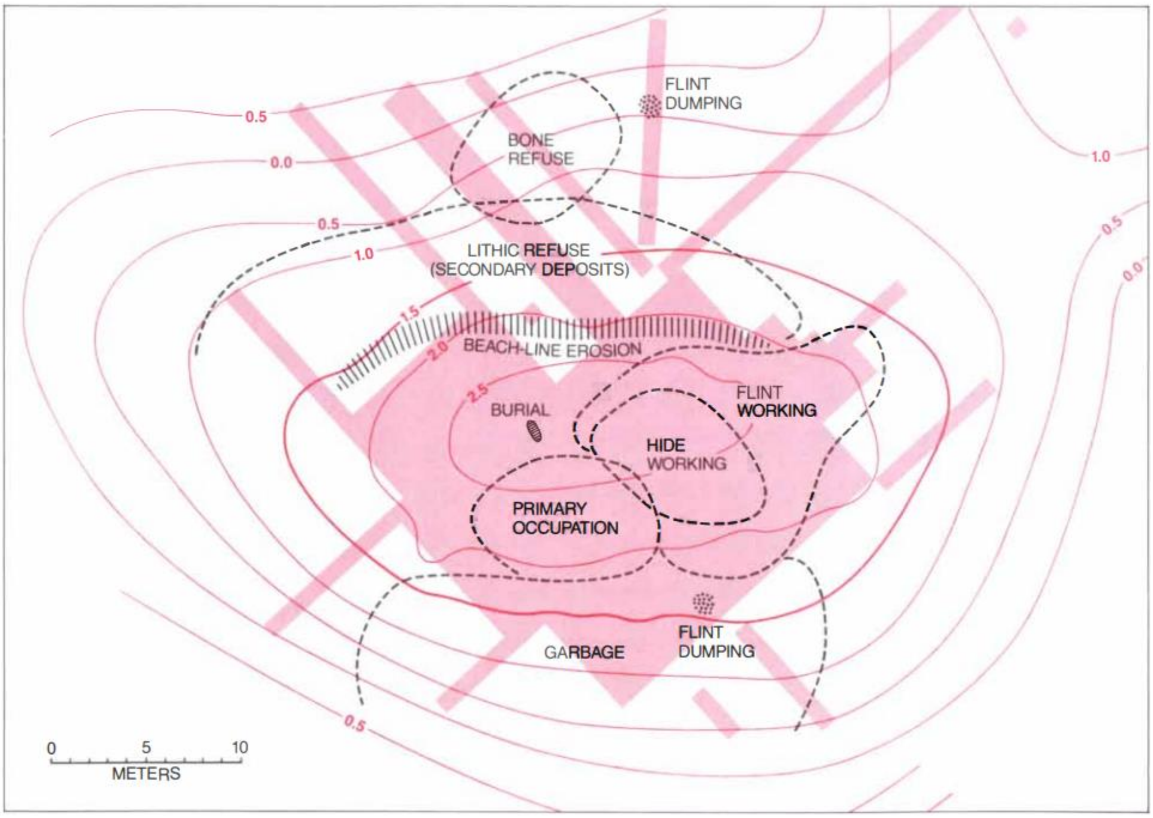


Figure 27: Spatial organisation of Vænget Nord based on microwear analysis (Price and Petersen 1987, 118).

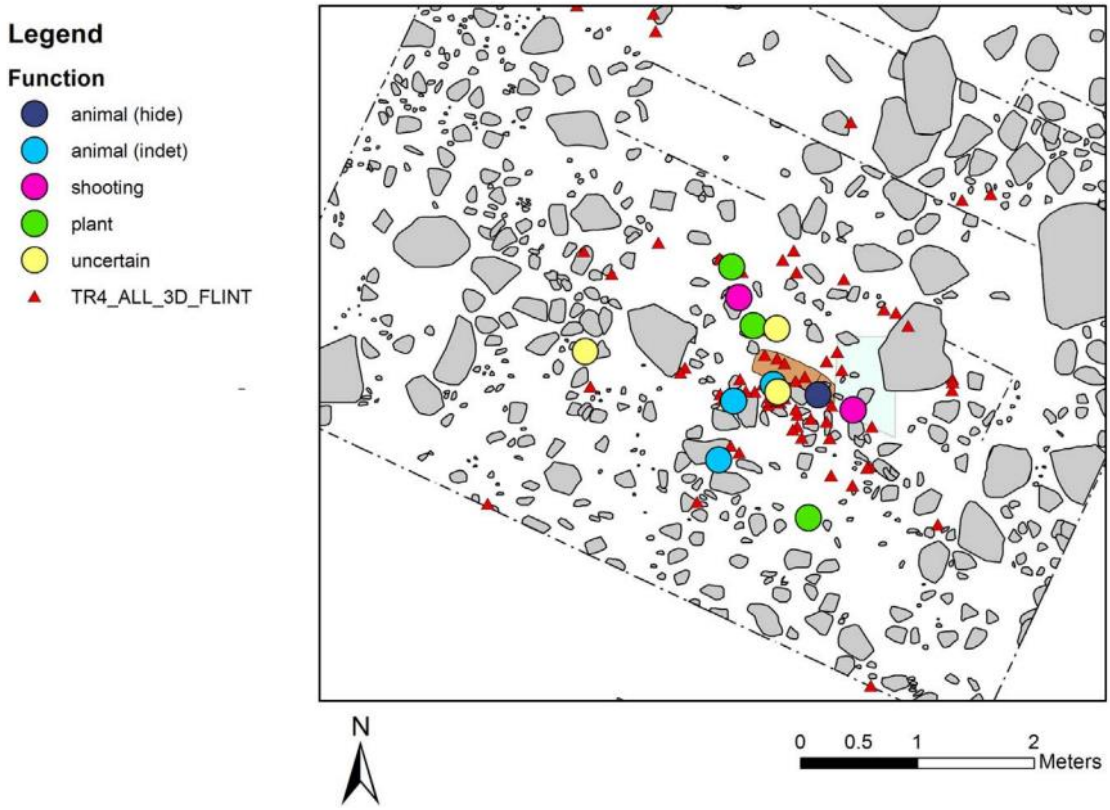


Figure 28: Spatial distribution of microwear results from Caochanan Ruadha (Warren et al. 2018, 943).

More recently, microwear analysis was undertaken at Caochanan Ruadha, in the Cairngorm mountains in Scotland (Warren *et al.* 2018). Functional tool data was used alongside spatial information to investigate the organisation of activity (Warren *et al.* 2018). The site dates to c. 7210 cal BC and evidenced a small oval feature, along with a fire setting and 132 *in situ* flint pieces (Mithen and Wicks 2018; Warren *et al.* 2018). A light-weight structure was interpreted based on the density of flint artefacts restricted to an oval area around the fire setting (see figure 28) (Mithen and Wicks 2018; Warren *et al.* 2018). Microwear analysis was undertaken on 28 flint tools, of which 13 had been used; eight pieces were identified as being in contact with plant or animal (Warren *et al.* 2018). Activities observed were: hunting (impact traces on microliths); butchery (cutting soft animal on a blade); hide processing (scraping on debitage piece); retooling; and craft (scraping of siliceous plants on a blade) (Warren *et al.* 2018).

From spatial plots of the microwear results, a tentative pattern of animal-related tasks in the south of the structure was observed, with plant working mostly in the north (Warren *et al.* 2018). As acknowledged by the authors, interpreting spatial patterns of use from a small sample must be taken with caution (Warren *et al.* 2018). Due to the nature of tool use, traces from a single activity of making twine, for example, could be observed on several tools if the maker changed their tool for different processes (i.e. cutting plants, scraping to extract the fibres) or for efficiency (Little and van Gijn 2017). In microwear analysis, this may be interpreted as a plant working area, when in fact it is a discrete episode of activity. These limitations are most notable when interpreting activities within a defined area from a small quantity of data. Interpretations need to acknowledge the limits of the available data and explore different explanations for any patterns in tool use, as was the case at Caochanan Ruadha (van Gijn 1990; Little and van Gijn 2017).

In contrast, Ludowice 6 in Poland sampled a larger quantity of flints for microwear to examine the social dimensions of tool using activity areas (Osipowicz 2018). Ludowice 6 is a Late Mesolithic settlement, dated from c.5710-5581 cal BC, with evidence of habitational areas, 4026 flint pieces and some preservation of bone fragments. Microwear analysis was undertaken on flints from the western habitation area, with 198 pieces displaying use. Wood was the dominant material worked, followed by hide, meat and siliceous plants. Three structures, interpreted as dwellings, were identified and three hearths were observed (one in each structure). A multi-analytical approach was implemented to investigate spatial patterning of tasks; the distribution of flint, refitting patterns, identified features and faunal remains were plotted and analysed. Utility zones were inferred across the settlement based on these spatial plots (Osipowicz 2018).

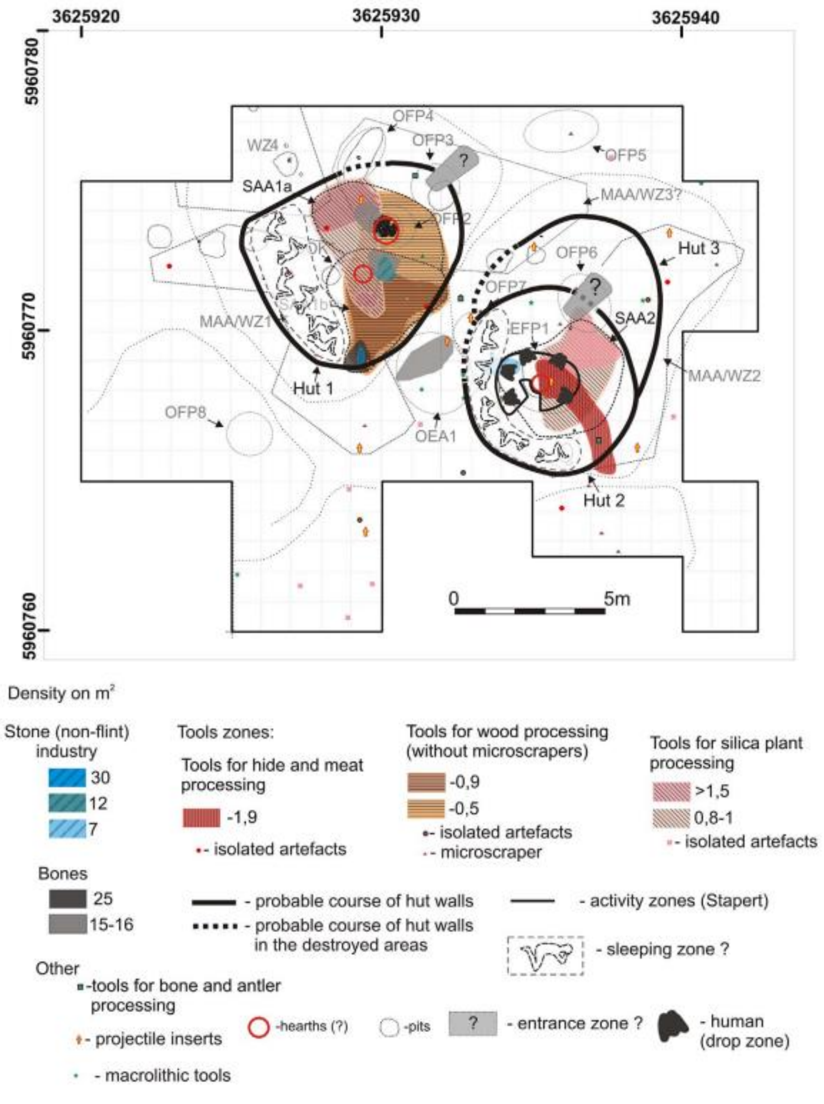


Figure 29: Three structures identified at Ludowice 6, with internal layouts (Osipowicz 2018, 968).

Possible internal structuring of space at Ludowice 6 was identified through areas of variable artefact density and wear traces. A sleeping space was interpreted from the sparsity of material, and in structure 1, siliceous plant processing was observed in the western region, with woodworking seen in the eastern and southern areas (see figure 29) (Osipowicz 2018). An interpretation of how hunter-gatherers were using structures was gained and rich insights into the social aspects of tool-using areas and areas of interaction were presented.

An interpretation was also made regarding the structure's inhabitants. The paper states that there is no evidence to support the conclusions, however 'activities of women (... siliceous plants and hide processing)' were interpreted and the absence of microliths was taken to suggest an absence of males (Osipowicz 2018, 967). This association of women with domestic activities and men with hunting perpetuates 'Man the hunter' theory (Washburn and Lancaster 1968). This model is widely considered as outdated and largely unsupported by ethnographic studies of hunter-gatherer communities (Estioko-Griffin and Griffin 1981; Jordan 2014; Jordan and Cummings 2014; Sterling 2014). Microwear data is unable to provide information concerning the biological identity of those who made and used flints. The study at Ludowice 6 highlights how microwear and spatial data can demonstrate variability in the use of space. However, specific information regarding the individuals inhabiting these spaces, such as their sex, cannot be ascertained through microwear data.

2.5. Summary

This chapter has highlighted how previous studies have applied microwear and spatial data to investigate the organisation and structure of Mesolithic settlements (Crombé *et al*. 2003; Hardy and Shiel 2007; Healy *et al.* 1992; Jensen and Petersen 1985; Osipowicz 2018; Warren *et al.* 2018). Microwear analysis has been successfully incorporated and woven into discussions at varying scales, from settlement systems, to site function and discrete activity areas (Crombé, Perdaen and Sergant 2003; Healy *et al.* 1992; Jensen and Petersen 1985). However, very few of these analyses consider the social implications for identifying activity zones within a structure, or across a site. Interpretations often fall short of putting humans back into the picture, despite the role of individuals in the creation and working of tools (Cahen *et al.* 1979; Odell 1980).

When the social dimensions of tool use are addressed, a top down approach to microwear analysis has been applied: ideas about the use of space relating to social structure are superimposed from the ethnographic record and used to interpret wear traces (e.g. Osipowicz 2018). Appendix 1 highlights that social questions are rarely tackled: can we infer preferences for certain activities in specific areas from the organisation of a site; can we gain insights into cultural practices through the structuring of particular tasks (Jensen and Petersen 1985; Osipowicz 2018). Microwear studies must also acknowledge the interpretative limits of the data, especially when exploring behaviour across a site from a limited amount of analysed flints. Studies may be inclined to extrapolate social interpretations from a small data set, owing to the time investment of carrying out microscopic analysis and frequency of tool use (where generally not all tools are used). However, the tendency to push the boundaries of the data can compromise genuine insights gained from microwear analysis (van Gijn 2014).

There is a clear gap for a study that implements microwear and spatial analyses to explore the social dimensions of activity areas, through a bottom-up approach. Tool use needs to be characterised prior to the interpretation of social aspects to the organisation of space. This is especially pertinent for Mesolithic settlements in the UK, which, to date, have not been sufficiently analysed. To further advance the field, social dimensions of tool use on a range of scales (from wear traces on individual pieces to intra-site patterns) need to be examined, whilst considering the limits of what can be inferred from the results.

Chapter 3: Star Carr flint research

3.1. Introduction

Star Carr is renowned for its excellent preservation of organic remains, though flint is the most abundant and consistently well-preserved material (Conneller *et al.* 2018b; High *et al.* 2018). Tools were found across the site, providing insights into the extent and nature of activities undertaken. Distributions of lithics were used by Clark to establish the size of settlement, as well as areas of intense activity (Clark 1954, 1972). Subsequent analyses of flints have detailed the movement of people across the site and tasks carried out by inhabitants (Conneller *et al.* 2018a; Dumont 1988). In this chapter, previous analyses undertaken on the Star Carr flints will be discussed: Clark's typological assessment, Dumont's microwear analysis, and the recent work undertaken by the Star Carr Project (Clark 1954; Conneller *et al.* 2018b; Dumont 1988).

In this work, 'technological analysis' will be used to differentiate between methods that assess and classify flints based on manufacturing techniques (i.e. tool types and refitting), with the term 'functional analysis' used to refer to methods that explore the use of lithics (i.e microwear and experimental archaeology) (Cahen 1987; van Gijn 1990). The terms 'flint', 'or 'pieces of flint', will be used to denote any flint object that may or may not have been used. 'Tool' or 'utilised flint' refers to those which show signs of use, interpreted either from macroscopic edge damage (often noted during technological assessments) or microwear analysis (Conneller *et al.* 2018b, 502). In technological studies, the term 'tool' can also be used to refer to flints that have the potential to be utilised, as flints are categorised as either informal or formal tool forms. Informal tools often relate to those which have not been significantly modified once knapped from the core (i.e. blades, flakes, bladelets), and can be considered debitage from knapping. Blades and flakes are used as blanks for formal tool types, where additional modification, such as flaking or retouch, are required to turn them into formal forms like scrapers, burins, and microliths (Andrefsky 2008).

3.2. Historical context

The classification and identification of tool type was conventionally used in Western archaeology up until the 1960s to track increasingly complex tool manufacture. Periods were subsequently defined by the presence, or lack of, particular tool types (Nicholson 1983; Roe 1985). In the late 1960s, a distinct shift away from traditional assessments of tool types from Clark's era led to new functional methods for analysing lithics, including microwear analysis (Dumont 1988; Gendel 1987; Jensen 1982, 1983, 1986, 1988; Keeley 1980; Moss 1987a; Vaughan 1985).

Grahame Clark was a pioneer in Mesolithic studies, and of early prehistory, at a time when the Neolithic was seen as the beginning of civilised society (Childe 1925; Desmond Clark 1999; Marciniak and Coles 2010; Milner 2009; Milner *et al.* 2013). A doctoral student in the 1920s, Clark studied Mesolithic flints in Britain from a typological perspective (i.e. assigning tool types) to explore the lifeways of prehistoric individuals (Clark 1932; Desmond Clark 1999; Milner *et al.* 2013, 11). He went on to develop a new chronology for the Mesolithic, rooted in classifications of material culture and social organisation, integrated with data from the natural sciences (Clark 1936; Desmond Clark 1999). From this, it was possible to assess lithics within a chronological framework, enabling interpretations of how humans adapted their technological and economic strategies to the environment around them (Clark 1936, 1954, 1972; Desmond Clark 1999; Milner *et al.* 2018a). Owing to the diversity of finds and preservation uncovered at Star Carr, a suite of methods was used to analyse the materials excavated (Clark 1954). Clark's monograph on Star Carr was innovative and thorough, enabling detailed insights into a wetland settlement with preserved organic remains and stratigraphic sequences; a rarity for the British Mesolithic (Clark 1954; Clark *et al.* 1949; Milner *et al.* 2018b).

John Dumont undertook the first microwear analysis of Star Carr lithics in the 1980s. During Dumont's doctoral studies at the Donald Baden-Powell Quaternary Research Centre, University of Oxford, he was a contemporary of numerous notable researchers exploring lithic technological analysis and/or use-wear (Dumont 1988, iii): Nick Barton (Barton and Bergman 1982), Jill Cook (Cook 1980; Cook and Dumont 1987), Emily Moss (Moss 1983, 1987a, b), Alison Roberts (Berridge and Roberts 1986). It is unclear at what stage Dumont trained in microwear analysis as his supervisor, Derek Roe, was not trained in the method. Despite this, Dumont's results from Star Carr and Mount Sandel demonstrate the high levels of competency and detail in the methods used and interpretations presented (Dumont 1988; Guéret 2013b; Conneller *et al.* 2018b, 508).

3.3. Clark

During three three-week excavation seasons at Star Carr from 1949-1951, Clark uncovered 16,937 flints from across an area of 16.5 metres by 14.5 metres (Clark 1954). This comprised 1,215 (c. 7.2%) finished tools forms, 1,279 (c. 7.5%) pieces showing macroscopic signs of use and 14,443 (c. 85.3%) 'waste' pieces, which are defined by Clark as cores, micro-burins, primary flakes, core-rejuvenation flakes and axe- and adze-sharpening flakes (Clark 1954). Sieving was not undertaken as it was not widely implemented at the time, so the totals do not include pieces smaller than 'finger-nail size' (Clark 1954, 96; Legge and Hacker 2010). Assessment of flint focused on quantifying formal tool types, with the archetypal Mesolithic tool, microliths, described at length in comparison to others (Clark 1954). Clark also provided information on the potential sources of flint, production methods and assigned tool sub-types (Clark 1933, 1934, 1954; Clark and Rankine 1939).

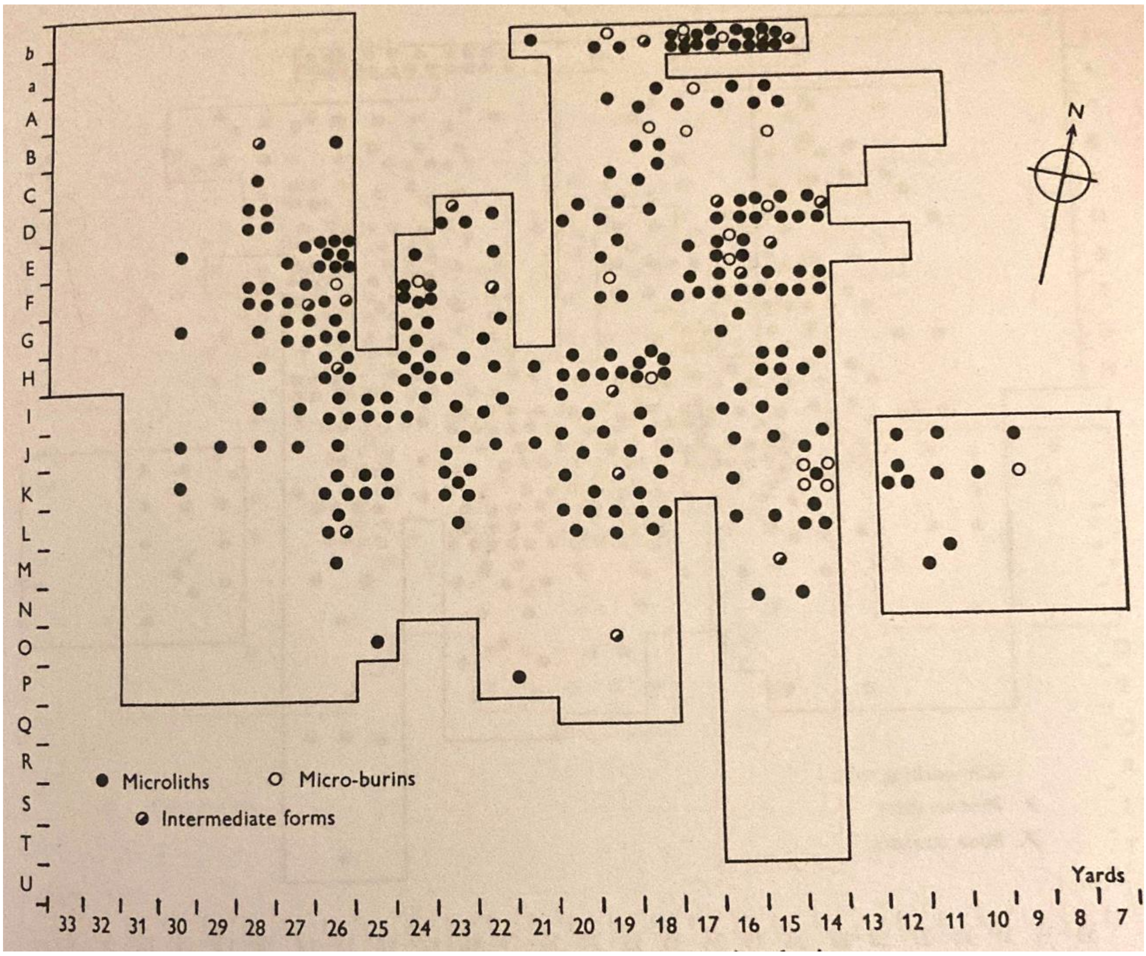


Figure 30: Distribution map of microliths and microburins from Clark's excavations (Clark 1954, 21).

Figures were presented showing the distribution of certain tool types (cores, microliths/micro-burins, adzes, scrapers, burins) across the site. During excavations, the spatial location of finds was recorded by grid square, enabling plots of different tool types (see figure 30), as well as faunal remains, beads, evidence of fire, and barbed points (Clark 1954). These were used to make some cursory interpretations on the use of space and the people who inhabited Star Carr. A homogenous pattern of activities across the settlement was seen in the predominantly even distributions of key tool types, with activities undertaken by most individuals 'of the same sex' (Clark 1954, 22), though a detailed description of each tool type and its spatial distribution was not given.

Based on tool types and direct ethnographic analogy with Inuit communities, Clark generated a list of activities undertaken at the site, which he believed could be assigned to particular members of a group. Evidence of hunting (microliths) and tool production was used to indicate a male presence, whereas hide processing (scrapers) was interpreted as evidence of women's work and, by default, the presence of children (Clark 1954, 10-11). Clark went so far as to use 'hide-processing tool' in lieu of scraper, in his interpretation demonstrating the large extent to which he used ethnography to assume function (Clark 1954, 21; Jensen 1988). However, it is important to consider that very few archaeologists in the 1950s considered the role of women on prehistoric sites beyond child bearing (Sterling 2014; Tanner and Zihlman 1976). More recent microwear research has further confirmed Clark’s application of ethnography to infer tool function was not reflective of actual use. This is seen particularly for scrapers, which are now considered a multi-functional tool in prehistoric contexts (Conneller *et al.* 2018b; Jensen 1988). Despite this, Clark's characterisation of the Star Carr inhabitants was a significant development as it considered the people behind tool use (Desmond Clark 1999).

Clark’s flint assessment was later incorporated into wider discussions concerning the movement and settlement of Mesolithic hunter-gatherers in Britain (Clark 1972; Mellars 1976; Pitts 1979). Tool frequencies found at Star Carr were compared to upland settlements (e.g. Deepcar) to suggest that a network of lowland and upland sites were inhabited and used by hunter-gatherers in the surrounding area (Clark 1972; Mellars 1976; Preston and Kador 2018; Radley and Mellars 1964). Star Carr was interpreted as a lowland, winter site based on the dominance of burins and a potential association between burins and antler/bone working, alongside the presence of scrapers and perceived domestic tools (Clark 1972; Mellars 1976). Excavations of upland sites uncovered largely microliths and less extensive settlement evidence, so were interpreted as summer short-term hunting camps (Preston and Kador 2018; Radley and Mellars 1964).

3.4. Dumont

After Clark’s excavations, the flints were stored at the Museum of Archaeology and Anthropology at the University of Cambridge, where they were later analysed by Dumont (1983; 1988). Dumont used microwear analysis to reconcile previous attempts at interpreting settlement function and the activities undertaken (e.g. Andresen *et al.* 1981; Clark 1954, 1972; Pitts 1979), through an in-depth analysis of key tool types (Dumont 1988). Depositional sequences of tool use could not be distinguished, so specific activity areas were not identified (Dumont 1988). Conclusions made by Dumont are more generalistic, providing broad information on the tasks undertaken, enabling a reinterpretation of the settlement’s function (Dumont 1988).

Activity	**Frequency of traces observed**	**Relative frequency (%)**
Woodworking	21	41.8
Antler working	18	21.5
Hide working	25	18.3
Unidentified worked materials	11	7.9
Bone working	18	7.5
Meat working/butchering	1	3

Table 1: Relative frequency of activities undertaken at Star Carr based on microwear results from Dumont (1988).

Clark's tool types were used to identify which pieces to study, these were: scrapers, borers, burins, retouched and backed blades, cores, microliths and denticulates (Dumont 1988). From microwear assessment of 156 pieces, 91 were used for six broad activity groups (see table 1) (Dumont 1988, 1990). These findings challenged hypotheses of Andresen *et al.* (1981), Clark (1972) and Pitts (1979), who interpreted large quantities of red deer remains as evidence for a specialised site, or where a few focused activities were undertaken, such as hide working. In addition to identifying tool-using activities, Dumont (1988) refined the function of certain tool types. He suggested that microliths were not used solely as projectiles and that scrapers should be assessed on an individual basis rather than assuming all were used for hide processing (Dumont 1987, 1988). Dumont (1988) analysed 27 awls (called 'borers') of which 14 showed use, consistent with: bone (8), wood (1), hide (1), and indeterminate materials (4). Of those displaying indeterminate material wear traces, three showed macroscopically observable edge rounding and striations which Dumont suggested might be consistent with working shale (Dumont 1988, 78; figure 31). This was the first time that drilling of shale beads using awls was recognised and discussed at the site.

Organic materials excavated by Clark and analysed by different researchers (Fraser and King 1954; Walker and Godwin 1954), as well as subsequent analyses (e.g. Noe-Nygaard 1975), were incorporated in Dumont's interpretations. This enabled Dumont to directly address wider debates surrounding seasonality and the site's function through microwear results. He concluded that Star Carr was occupied intermittently throughout the year, with individuals undertaking different tasks and subsisting on a mixed diet (Dumont 1988, 153).

Figure 31: Micrograph of Dumont's analysis depicting SC53, a borer used to work possibly shale. Note the striations (Dumont 1988, 453).

Certain contact materials are notably absent from Dumont's microwear results, the most obvious being plants. Microscopic identifications of particular plant wear traces (e.g. those from non-siliceous plants) on archaeological flints can be difficult, as soft materials do not always leave diagnostic traces unless worked for a significant length of time (Jensen 1988). More recent microwear assessments of Mesolithic flints have also shown that plant traces more commonly occur on unretouched flakes and blades, none of which were analysed by Dumont (De Stefanis and Beyries 2021; Gassin *et al.* 2013; van Gijn and Little 2016; Little and van Gijn 2017). Therefore, it is possible that very few pieces analysed by Dumont were used to process plants. However, a recent re-assessment of Dumont's results using micrographs has been undertaken by Colas Guéret, where he suggests that at least 13 pieces were incorrectly assigned to woodworking when they are more akin to plant working (see figure 32) (Guéret 2013b). It is important to note that these reassessments were based on micrographs alone, which provide a two-dimensional perspective of microwear traces, so accuracy is limited.

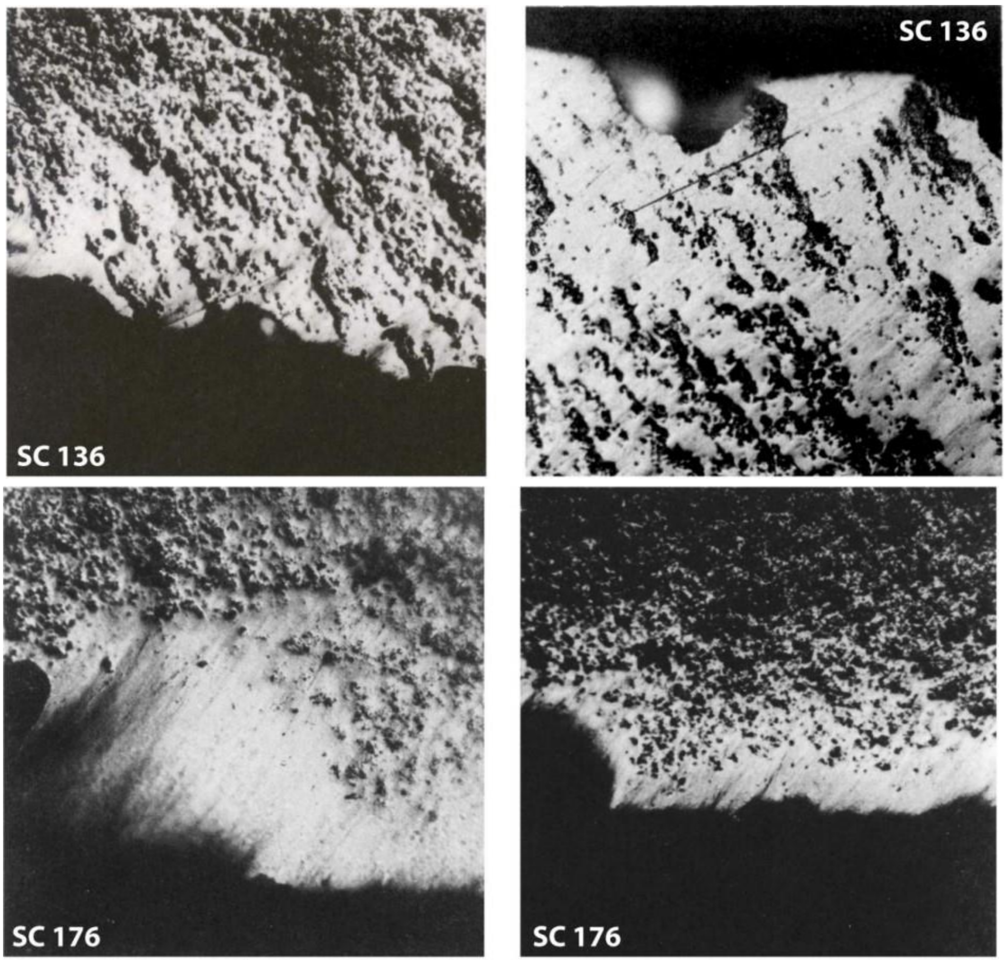


Figure 32: Micrographs of Star Carr blades <SC136> and <SC176> interpreted as wood polish by Dumont but reinterpreted as plant polish by Guéret (Dumont 1988; Guéret 2013b).

The experimental tool collection used by Dumont may have also led to an unfamiliarity with plant processing traces. Dumont studied Keeley's (1977; 1980) experimental flints to familiarise himself with wear traces present in prehistoric contexts. In principle, this is unproblematic as the collection was produced for aiding interpretations of British Lower Palaeolithic flint industries. Climatically, the British Early Mesolithic was broadly similar to the Lower Palaeolithic, as it was relatively temperate, dominated by deciduous woodland and abundant with vegetation, including reed beds (Ashton and Lewis 2012). However, Keeley's experimental collection included a single example of plant working, a classic "sickle" gloss", found frequently in Neolithic contexts (Ibáñez *et al.* 2016; Keeley 1980). Not only was the inclusion of sickle gloss inconsistent with Keeley's own Lower Palaeolithic work but also with Mesolithic assemblages.

Sickle gloss varies significantly from Mesolithic plant traces, in both appearance and location of the polish on tools. This archetypal Neolithic gloss is more developed, it can be 'macroscopically visible' and tends to appear on both edges of the tool's cutting edge (van Gijn 2010). In contrast, Mesolithic plant polish is rarely observed macroscopically and is often found on one edge, likely relating to the different actions needed when using a flint blade compared to a sickle blade (Little and van Gijn 2017). The inclusion of sickle gloss in Keeley's reference collection provides a poor comparison to plant traces present on the Star Carr flints (Gassin *et al.* 2013; Guéret *et al.* 2014; Mazzucco *et al.* 2016). This highlights that a comprehensive understanding of raw materials and the wider landscape is a necessity for preventing microwear interpretations based on conjecture (van Gijn 1994; Grace 1990). In doing so, the data from microwear analysis can be observed more accurately, with a greater understanding of the site's environmental niche.

Dumont's (1990) results provided a greater understanding of potential site function and activities undertaken at Star Carr. A provisional frequency list of activities was generated from his results, despite issues with sample size and representivity, and it was the first published quantitative assessment of activities undertaken (see table 1). Woodworking was observed as the dominant activity, and thus more significant than had been previously considered as much discussion had focused on animal-related tasks (Andresen *et al.* 1981; Clark 1954; Dumont 1988; Pitts 1979). Dumont also emphasised that backed blades and other informal tool types (i.e flakes and blades with no visible macro edge damage) must be reconsidered as potential tools and included in microwear analysis (Dumont 1987, 1988, 1990). This continues to be a pivotal contribution to sampling strategies employed in microwear analysis of flints from any archaeological period (Grace 1990; van Gijn 2012).

3.5. The Star Carr Project

3.5.1. Technological analysis

Of the 24,883 pieces of flint excavated by the Star Carr Project between 2004 and 2015, 2475 (9.95%) were identified as formal tool types, 935 (3.76%) flints were associated with core preparation or tool spalls and 21,473 (86.29%) pieces were considered debitage (Conneller *et al.* 2018a, b). Due to careful excavation methods and detailed recovery of all material, significantly more lithics were found than those recovered by Clark, though this is also due to the larger area excavated (Conneller *et al.* 2018a, b; Milner *et al.* 2018b). Different analyses were applied to further understand flints in a social context, including: detailed technological analysis, refitting, residue analysis and microwear analysis. These aimed to provide a rich and refined understanding of the manufacture, use and deposition of flint, thus exploring spatial and temporal patterns of tool-using behaviours. Owing to the high quantity of flints and variable depositional contexts of dryland and wetland, flints were sub-sampled for microwear analysis from six main areas.

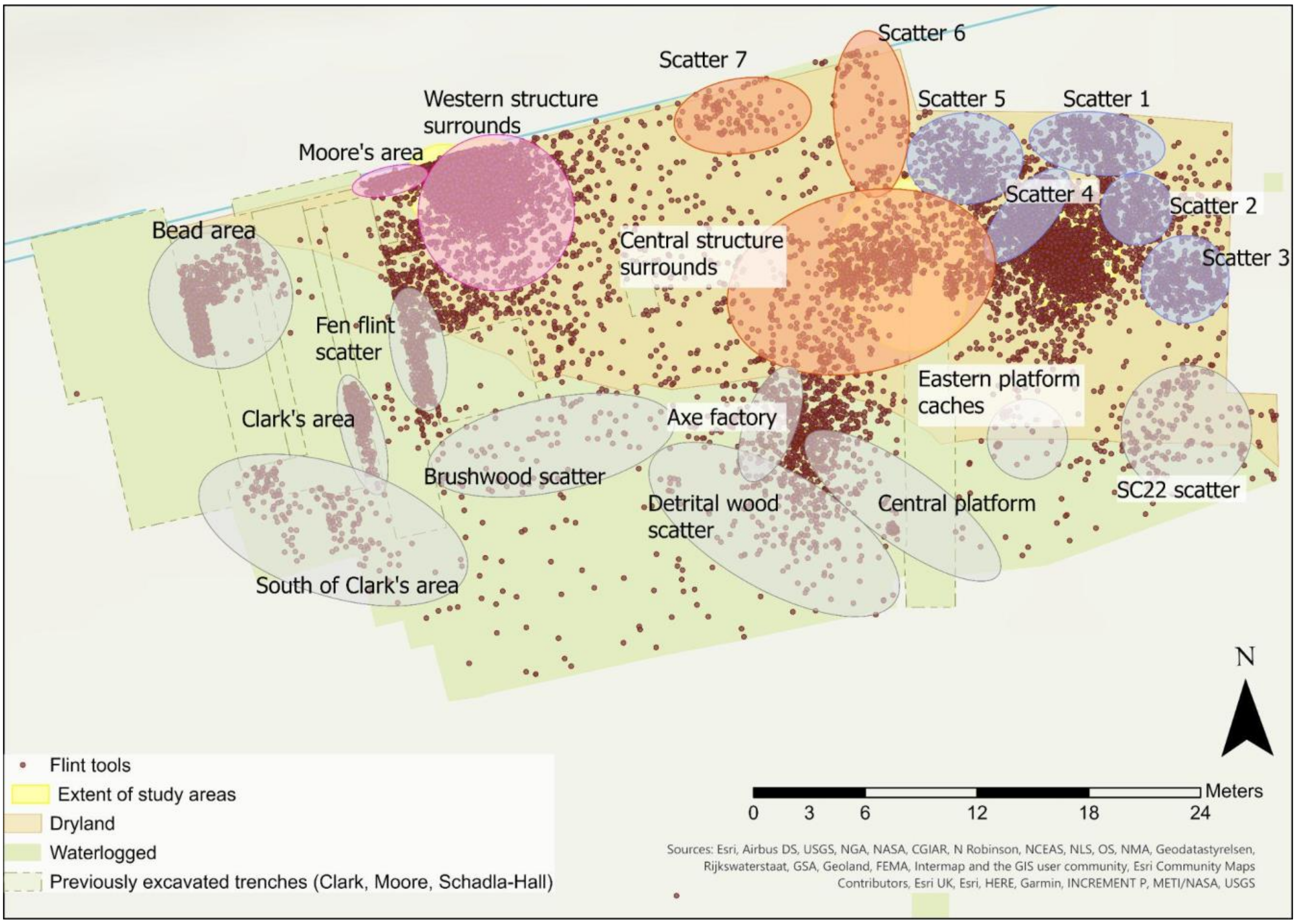


Figure 33: Key sub-groupings of flints. Scatters associated with each structure are denoted in pink (western structure), red (central structure), blue (eastern structure). Grey = wetland scatters. After Conneller et al. (2018a).

These six areas were further split into wetland and dryland sub-assemblages (see figure 33). Some of these sub-groups were associated with particular features such as the structures, whereas others were discrete flint scatters (Conneller *et al.* 2018a). On the dryland, technological analysis and refitting showed both frequent tool manufacture and middening, resulting from clearance of the structures (Conneller *et al.* 2018a). Refitting analysis indicated that some flints (e.g. burins, awls, truncations) were frequently moved from production areas to different areas of the site (Conneller *et al.* 2018a, b). These findings led to the interpretation that knapping debris and tools from previous occupations were likely visible and probably sporadically moved and used by later inhabitants (Conneller *et al.* 2018a, b). The influence of human action on the final deposition of flint was significant and warrants consideration when interpreting spatially discrete results.

	Central structure	**Central structure surrounds**	**Eastern structure**	**Scatter 2** (associated eastern struc)	**Scatter 4** (associated eastern struc)	**Western structure**	**Western structure surrounds**
	No.	No.	No.	No.	No.	No.	No.
Flint pieces	407	1192	1921	1256	1341	5058	580
Burnt	17 4.18 %	69 5.79%	448 23.32%	355 28.26%	406 30.3%	1760 34.8%	25 4.3%

Table 2: Table showing the quantity of flint pieces found associated with each structure and its surrounds, and the levels of burning. After Conneller et al. (2018a).

Variable densities of flint scatters and refitting analysis within the central structure and its surrounds (scatter 6) were interpreted as clearance activity (Conneller *et al.* 2018a). Compared to the other structures, the central structure was a relatively sparse area, containing only 407 flints, of which 4.2% was burnt (see table 2) (Conneller *et al.* 2018a). Only half of the hollow was excavated by the Star Carr Project, with the other half lost during previous excavations by the VPRT (Vale of Pickering Research Trust). Flints excavated from the hollow and surrounding postholes were interpreted as part of the structure (see figure 34). Technological analysis and refitting indicated that the majority of flints within the central structure post-dated the structure itself. Eight refit groups stretched across the hollow and beyond the postholes, which was taken to suggest that activity was not constrained by a physical structure (Conneller *et al.* 2018a). When the structure was in use, it was posited that it was either cleared regularly or was used differently to the other structures, which both show higher flint densities (Conneller *et al.* 2018a).

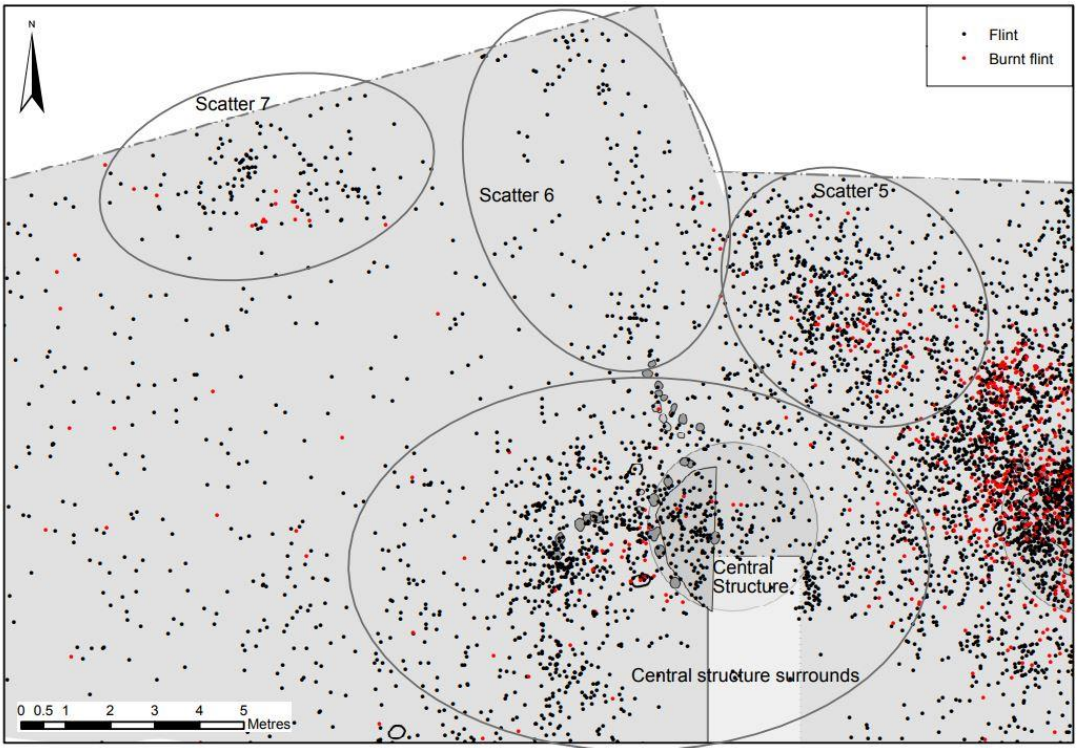


Figure 34: Distribution of flint and burnt flint within and around the central structure (Copyright Star Carr Project in Conneller et al. 2018a, 165).

Significant flint deposits were found in the eastern structure, with 1921 lithics of which 23.3% were burnt. Most flints were found in the upper fill, located above a rich organic layer containing very few flints. This has been interpreted as a possible organic matting, such as reeds or bark, which may have prevented most flints from moving down the soil profile (Taylor, B. *et al.* 2018b, 63). Matting may have collected pieces of flint within the structure, which could then be moved to nearby areas for use or for disposal. Refits highlighted multiple knapping production sequences from different raw materials, with only a few pieces from each sequence remaining inside the structure. Flints were interpreted as moved between the inside and outside of the structure over a significant amount of time. It was noted that larger pieces were cleared from within the structure whilst smaller, more fragmented material resulting from *in situ* knapping were left inside the hollow (Conneller *et al.* 2018a).

The presence of *in situ* activity within the eastern structure was further argued through distribution of different tool types. Burins and burin spalls were seen most frequently in the north-west of the hollow, some scrapers were also found in this area but were largely spread across the structure (see figure 35) (Conneller *et al.* 2018a). Microliths and microburins were observed at the periphery of the hollow, with a group of microliths found in the southern part of the structure near to a possible hearth: as identified by a density of burnt flint (Conneller *et al.* 2018a). More microliths (33) were found compared to microburins (14). Microburins are a by-product of microlith manufacture, so it was suggested that tools were deposited rather than manufactured here (Conneller *et al.* 2018b; Cooper *et*

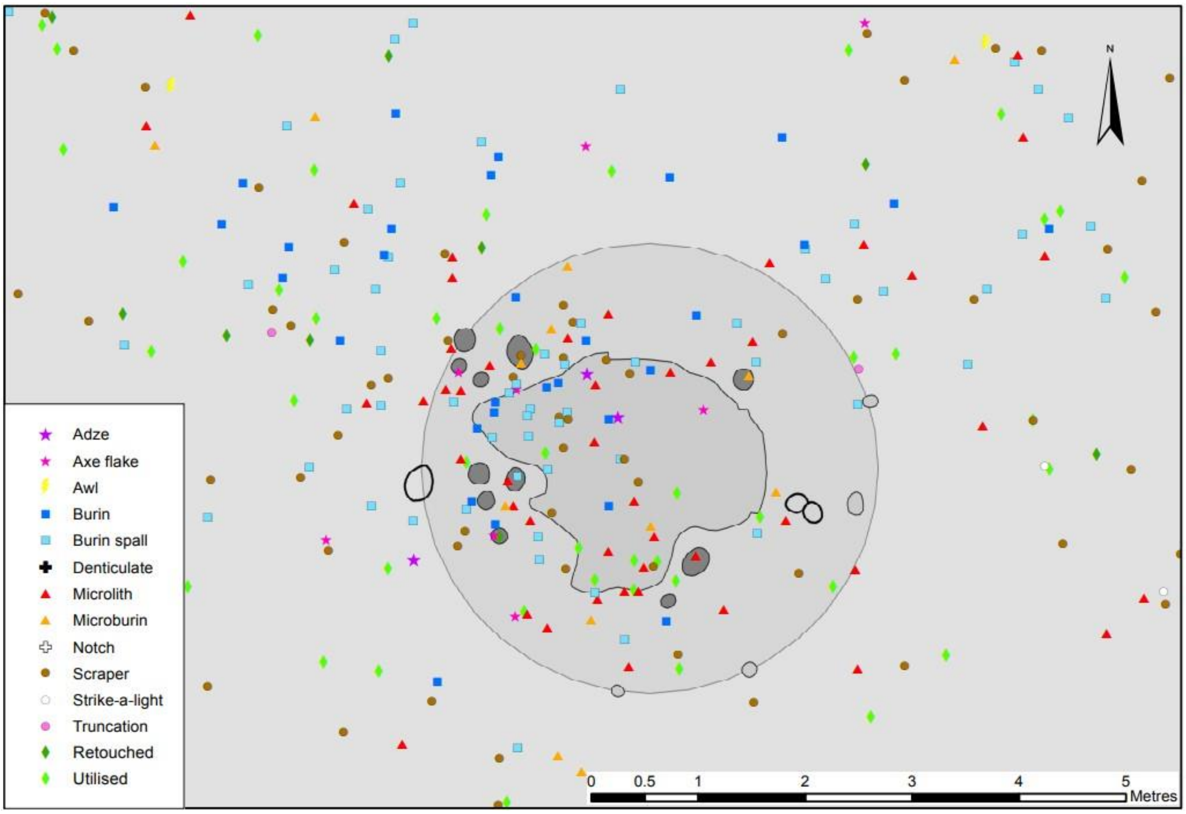


Figure 35: Distribution of tool types within and around the eastern structure, blue squares = burins and burin spalls, red triangles = microliths, orange triangles = microburins (Copyright Star Carr Project in Conneller et al. 2018a, 179).

al. 2017). Two axes were re-sharpened inside the structure which also suggested maintenance rather than manufacturing activities took place (Conneller *et al.* 2018a). Conversely, scrapers and burins were likely to have been produced inside the structure, with most burins subsequently used and deposited elsewhere (Conneller *et al.* 2018a). The eastern structure was therefore interpreted as an area for manufacturing particular tools (burins, scrapers) alongside the maintenance of composite tools (e.g. hafted axes, microliths).

Five scatters surrounded the eastern structure, and owing to their technological character and spatial distribution, Scatters 2 and 4 appeared closely associated with the structure (see figure 36). Both contained high quantities of burnt flint, and evidence of burins, burin spalls, microliths and scrapers with no clear spatial patterning. They were interpreted as clearance scatters from the structure, with a possible two-way movement of material between the structure and scatter 4. In contrast, scatter 1 and 5 displayed no clear link to the structure and instead were interpreted as separate knapping and tool use areas. Lastly, scatter 3 appeared to post-date activity associated with the structure. There were largely undisturbed clusters of flints and knapping debris surrounding a group of burnt lithics, indicating a short-term hearth (Conneller *et al.* 2018a).

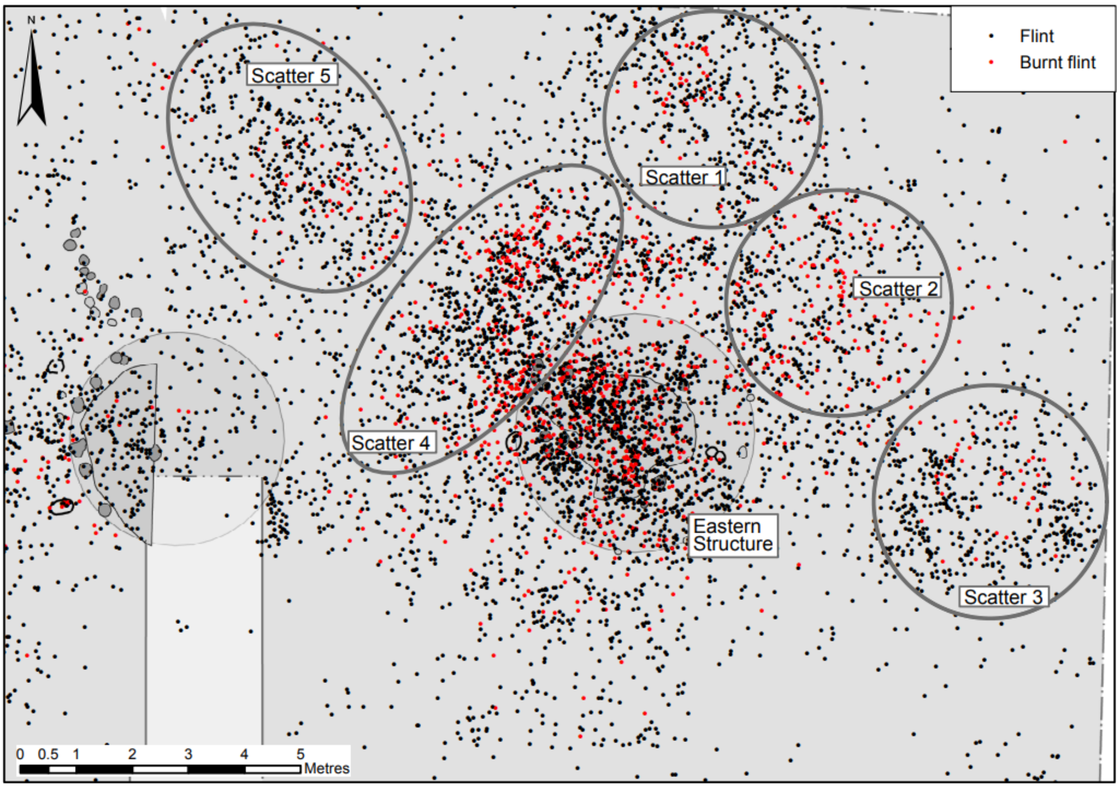


Figure 36: Distribution of burnt and unburnt flint in and surrounding the eastern structure (Copyright Star Carr Project in Conneller et al. 2018a, 173).

A small collection of post holes with no hollow present was identified as the western structure. This area contained a density of flint (5058 pieces), with a high proportion of burning (38.4%) (see figure 37) (Conneller *et al.* 2018a). With such vast quantities of flints, refitting was limited to pieces from unusual raw materials (red, grey and white, and black flint). One refitting sequence was identified in the production of two red blades (Conneller *et al.* 2018b). Burins, microliths and scrapers were largely found, as well as unburnt microdebitage and two axes. Microdebitage was interpreted as either evidence of *in situ* knapping or possibly knapping waste from an emptied mat (Conneller *et al.* 2018a, b). The presence of burin spalls suggested that the production and resharpening of burins took place here, along with *tranchet* flakes indicating axe resharpening and thinning (Conneller *et al.* 2018a). Due to limited refits, spatial patterns were assessed using tool type distribution. Apart from some discrete patterning of awls, generally tool types were interspersed. A higher quantity of awls was located south of the postholes, which was also observed across the western part of the site, including during Clark's excavations (Clark 1954; Conneller *et al.* 2018b). From the technological results, as well as the presence of unburnt animal bones and burnt lithics, the western structure was interpreted as a midden located on top of a previous structure (Conneller *et al.* 2018a).

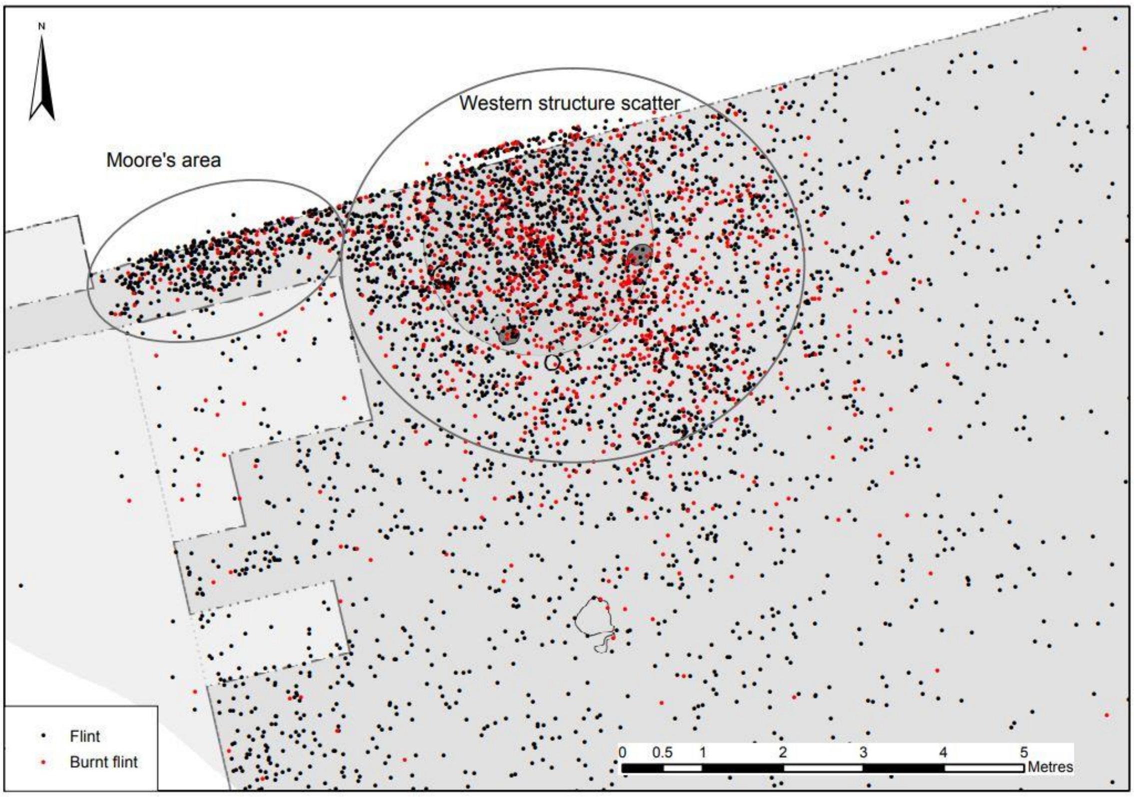


Figure 37: Distribution of burnt and unburnt flint in the western structure and surrounds (Copyright Star Carr Project in Conneller et al. 2018a, 160).

Tentative interpretations of each structure's function(s) were established from technological analysis, based on the manufacture, maintenance and/or deposition of flints. However, these interpretations are limited to activities involving the reduction of flint rather than actual use of these pieces once knapped or resharpened (van Gijn 1990). From this, we cannot access the variability and range of activities undertaken. To address this, microwear analysis was undertaken by Aimée Little, assisted by Virginia García-Díaz, on 220 flints.

3.5.2. Microwear analysis

Out of 220 analysed pieces, 166 were utilised on: antler, bone, fish, hide, meat, mineral, plant, wood or had projectile impact traces (Conneller *et al.* 2018b). A targeted sub-sampling approach was applied to flints found within key contexts (e.g features, caches) and of interest (identified during technological analysis) (Conneller *et al.* 2018b). The analysis aimed to uncover the range of activities at Star Carr as well as choices in tool use, therefore a spatially scattered, targeted sub-sampling strategy was appropriate (van Gijn 2014). Microwear results enabled insights into *why* flints were manufactured, curated and deposited, further elucidating the technological analysis. On the dryland, pieces appear to have been moved from their place of manufacture for use, so it is important to explore these movements further to assess intentionality in these individual actions (Conneller *et al.* 2018a).

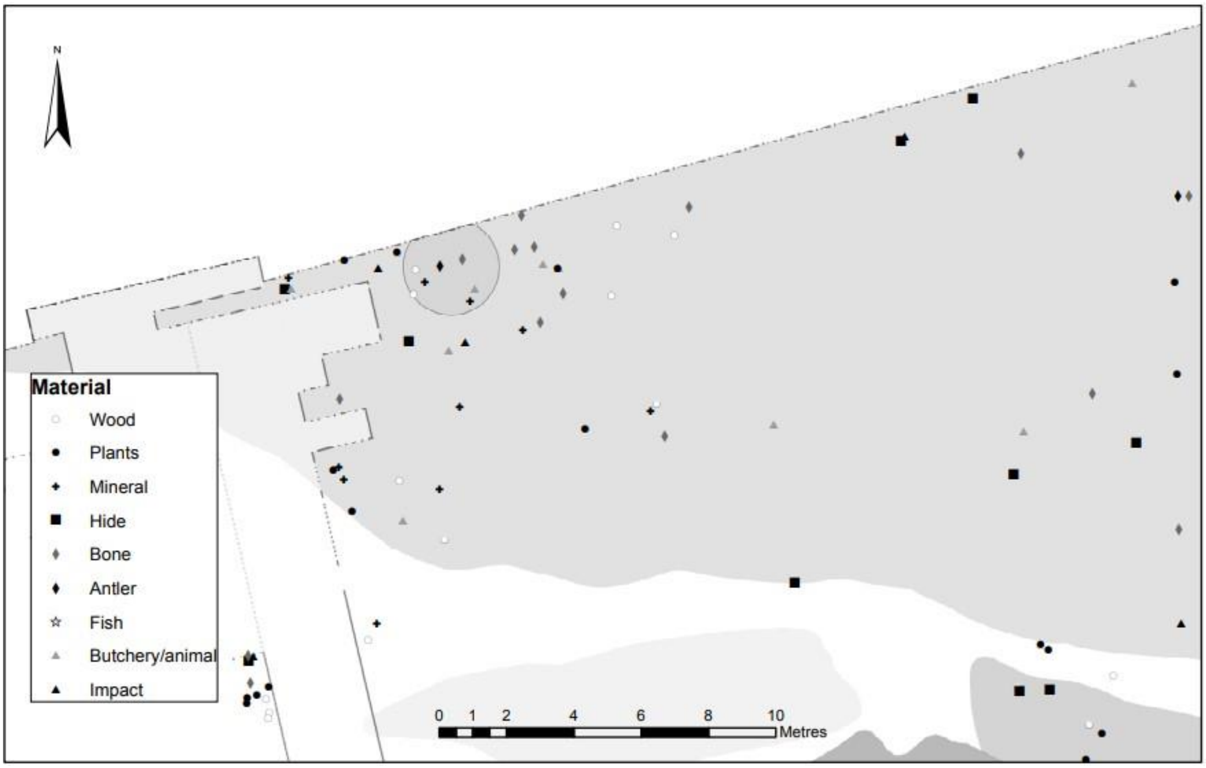


Figure 38: Star Carr Project microwear results from the western structure area (Copyright Star Carr Project in Conneller et al. 2018a, 163).

In and around the western structure, microwear traces displayed re-use of some tools, in-situ butchery and craft activities (i.e. bead production, plant working, antler working), thus adding nuance to the interpretation of a midden (see figure 38) (Conneller *et al.* 2018a). Tentative spatial patterns of bone scraping and grooving in the eastern part of the structure and surrounds were observed (Conneller *et al.* 2018a, 163). These patterns correlate with densities of animal bone also found nearby, and thus suggest *in situ* activity (Conneller *et al.* 2018a; Knight *et al.* 2018b). A craft-working area was proposed on the basis of wear traces observed on awls, alongside antler and woodworking on different tool types (Conneller *et al.* 2018a). Of 70 awls recovered by the Star Carr Project, 19 were studied by Little. Wear traces were observed on 17, in varying motions and on different contact materials, consistent with: drilling mineral (6), piercing hide/mineral (2), cutting/scraping (siliceous) plant (3), drilling bone (4), drilling/sawing an indeterminate hard material (1), an indeterminate use (1), and unused examples (3) (Conneller *et al.*, 2018b, 515). The re-use of a microlith hafted and shot as a projectile to cut siliceous plants also supported the suggestion that this was a busy crafting area with sporadic re-purposing of material from the midden (Conneller *et al.* 2018a).

Microwear analysis of seven pieces from the eastern structure not only evidenced how particular tools were used, but also provided some clarity as to why certain flints were moved to this area. Two scrapers were hafted and used to work hide, a hafted blade was used to scrape wood and cut plants and an axe had traces of wood chopping (Conneller *et al.* 2018a, 181). Interestingly, the blade was de-hafted and the previously hafted end was then used to scrape plants, showing re-use. One scraper had been re-sharpened and not subsequently used. From this, it was suggested that particular flints, namely composite (hafted) tools, were taken to the structure for maintenance and repair (Conneller *et al.* 2018a). Maintenance of previously used and hafted pieces, as well as traces resulting from wood and hide working were used to suggest that a personal toolkit was stored there. The eastern structure was tentatively interpreted as a place for tool production, with a selection of tools taken there for repair, as evidence for *in-situ* tool use inside the structure was minimal. Due to sample size, these insights were speculative. However, microwear data provided a rationale for the movement of some material into the structure (Conneller *et al.* 2018a).

Tool use was identified on three pieces from the central structure. Wear traces from possible projectile re-tooling was observed in a cluster of microliths and a bladelet showing traces of hide and impact (Conneller *et al.* 2018a, 168). A blade used for scraping bone was found inside the hollow, suggesting butchery-based activities were undertaken (Conneller *et al.* 2018a, 168). A selection of tools found in the surrounds of the structure displayed a prevalence of animal-related traces (scraping bone, hide, butchery), with some minimal plant and woodworking (Conneller *et al.* 2018a). Most activity was considered to post-date the structure, so only a limited number of pieces were analysed from the hollow and interpretations could not be taken further.

3.6. Chapter summary

Clark and Dumont's work on Star Carr flints was pivotal in our understanding of the site's inhabitants. Interpreting the types of activities undertaken by individuals, through direct evidence of tool use, was pioneering for a Mesolithic site. The subsequent analysis of flint excavated by the Star Carr Project built a more detailed picture of the nature and intensity of settlement, at a larger scale than had been identified previously (Milner *et al.* 2018d). The integration of tool types, refitting and microwear analysis facilitated rich insights of tool use across the site (Conneller *et al.* 2018a; Taylor, B. *et al.* 2018c). Some examples are seen through plant and woodworking activities associated with the wetland areas and the formal deposition of a flint cache associated with the central platform, where most tools were used in butchery-related tasks (Conneller *et al.* 2018a).

For the structures, results from technological analysis indicated close associations between the manufacture and repair of tools in particular structures: discrete knapping episodes post-dating the central structure; production of burins, microliths, scrapers and the maintenance of axes in the eastern structure; production of burins and re-sharpening of axes in the western structure (Conneller *et al.* 2018a). Microwear analysis expanded these findings by providing small-scale insights into individual tool use, with evidence that certain tools were potentially afforded value. However, there remain questions regarding spatial patterns in how tool use was organised. For example, though results from

Little and Dumont were comparable showing awls as a multi-functional craft tool, only limited insights into the spatial patterns of awl use are available from a small sample size.

Three utilised tools from the central structure offer limited insights into tool use and the types of activities undertaken. There is tentative evidence of projectile maintenance and dehafting, and butchery. Additional microwear assessment is required to explore these observations further: is the area exclusively used for animal-related activity associated with hunting or are there a range of tasks undertaken? If animal-related tasks exclusively took place, could this indicate that it was a specialised area? Additionally, it might be possible to interpret the scale of tasks undertaken and whether these could have been feasibly undertaken within a structure or whether they indicate a more open space (i.e. whether the activities post-dated the structure).

More tools (seven) were studied from the eastern structure though insufficient for discerning internal spatial patterning of activities. Some flints were likely brought into the structure after use, inferred from the impracticality of undertaking tasks like chopping wood inside. However, it is unclear whether this could also be the case for other flints brought to the structure. Was this an area for storing and making tools rather than using them? The western structure showed the most diverse range of tool-using activities, though this was only observed from a small sample (seven). An interpretation of the area as a midden was based primarily on technological assessments. Further microwear data is needed to elucidate whether there was any spatial organisation to activities, as an example, a discernible spatial pattern might indicate that the area was used similar to the other structures rather than a midden. If the distribution of microwear traces suggests the area was a midden, do we see tool use on a full suite of materials or only a limited range? There is significant potential to further discern tool using behaviours from additional microwear analysis. To achieve this, first it is necessary to present a detailed overview of how the method has been applied to this research, which will be explored further in Chapter 4.

Chapter 4: Methodology

4.1. Introduction

Microwear is used in this research as an analytical technique that provides otherwise invisible insights into activities associated with the Star Carr structures. The method initially generates a bank of raw data that shows individual episodes of tool use for each analysed object. If the microwear results are then plotted spatially, using GIS (Geographic Information Systems), possible patterns both *within* each spatially defined area and *between* each area can be examined. Due to the large-scale excavations, level of preservation and spatial integrity of finds at Star Carr, the site offers a unique opportunity to implement this methodological approach.

Microwear analysis is a time-consuming method with unpredictable elements, therefore sampling strategies must ensure that insightful results are gained, even if time constraints mean that not all tool types can be sampled (Roe 2004). Two phases of sampling were used to select flints for microwear analysis. The first phase involved plotting flints in GIS to initially define areas of interest, before sub-sampling those areas for microwear analysis. The second phase of sampling was developed to speed up analysis. Rather than selecting tools through GIS, flints from a small defined area were analysed based on signs of use, which were observed through an initial scan. Cleaning protocols developed for the flint will be discussed alongside details of the reference collection, which was used to aid interpretations of microwear traces. The process for training in microwear will be detailed along with the method of analysis, including how microwear traces were recorded.

4.2. Sampling methodology

4.2.1. Plotting flint finds

The flint tool assemblage analysed for this research was excavated by the Star Carr Project from 2004 to 2015, recovered from fieldwalking, test pits and trenches (Conneller *et al.* 2018b). There have been significant flint finds prior to the work of the Star Carr Project; however, the available information for these varies considerably. Excavation protocols followed by Clark were inconsistent (e.g. flint debitage was not retained from all seasons) and due to the technology available, no 3D coordinates (no real geographic location) were taken to map the finds onto GIS software (Clark 1954; Conneller *et al.* 2018a). In addition, flint from previous excavations are stored across a number of museums, whereas the Star Carr Project assemblage is archived at the Yorkshire Museum, with full access to the pieces approved for the duration of this project. Therefore, this research focuses exclusively on 24,883 pieces of flint found from 2004 to 2015 and includes unretouched flint flakes and blades, debitage, as well as more formal tool types. Technological analysis was previously carried out by Chantal Conneller, with corresponding information inputted into an Excel spreadsheet (Conneller *et al.* 2018b).

The flint spreadsheet from the Star Carr Project was fundamental to this research and access was gained via the Archaeological Data Services (ADS) archive (POSTGLACIAL Project 2018). It contains X Y Z geolocation coordinates for the majority of finds (89.4%). Flints lacking coordinates predominantly comprise fragments and debitage, which were not prioritised for microwear analysis. Information regarding tool type categories and subcategories of each piece was available on the spreadsheet, as well as length measurements for some (17.8%) and whether they were burnt.

Distributions of flints were plotted using ArcGIS Pro (version 2.9.1 ©2021 Esri Inc.) across the whole site and dryland. Practicalities of implementing microwear analysis on the dryland assemblage, which had a high frequency of burning, required significant consideration as microwear traces are variably preserved once burnt (Conneller *et al.* 2018b; Finlayson and Mithen 1997; Rutkoski *et al.* 2020). Each tool type was separately mapped onto a site plan, which was created using GIS, available data from the ADS archive and the site monograph (see figure 39) (Conneller *et al.* 2018b; Milner *et al.* 2018a; Taylor, B. *et al.* 2018b). All tool types found in the dryland and in/around the structures were quantified and from this, specific tool types were isolated and identified as priorities for microwear analysis (detailed in section 4.2.3).

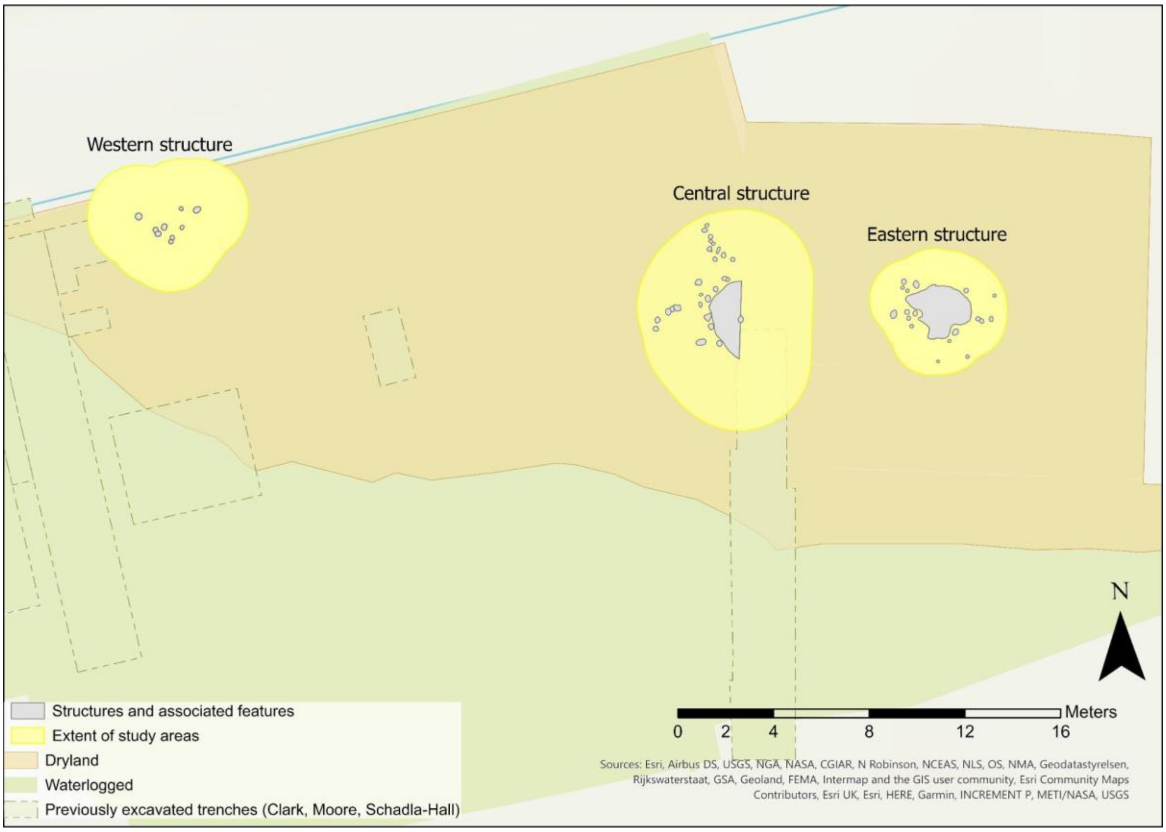


Figure 39: Blank backdrop map showing Star Carr trenches, dryland area and the three structures with their surrounds (the sample areas for this research).

4.2.2. Identifying sample areas

Each feature associated with the structures had associated X and Y coordinates. A 3D image of these features was not possible as there were no 3D scans. Z coordinates were available for the flints, meaning that they could be plotted in 3D; however, issues with bioturbation meant that they were likely to have been disturbed post-deposition. As a result, only 2D plots were used to identify flints of interest associated with the features. Postholes can be used to infer the possible extent of structures, although it should be noted that the structures themselves may have covered a larger area (e.g. roof rafters may have extended beyond the postholes). The actual form of the structures may have differed to what was interpreted by the Star Carr Project (Taylor et al 2018b). Therefore, a larger periphery around the structures was established to enable comparisons of results from both within and immediately surrounding the structures.

Firstly, the Optimised Hot Spot Analysis tool was used in GIS to assess where key concentrations of flint were located in the dryland. Hot Spot Analysis identifies and visualises statistically significant spatial clusters of high (red) and low values (blue) (see figure 40). There are clear clusters around the western and eastern structures, with the central structure appearing to have no significant flint densities (see figure 40). To establish sample areas, a buffer was applied to the feature hollows (and postholes for the western structure) to include all the associated features, and the size of each buffer was specific to each structure (see figure 40). The Star Carr Project observed a vertical post-

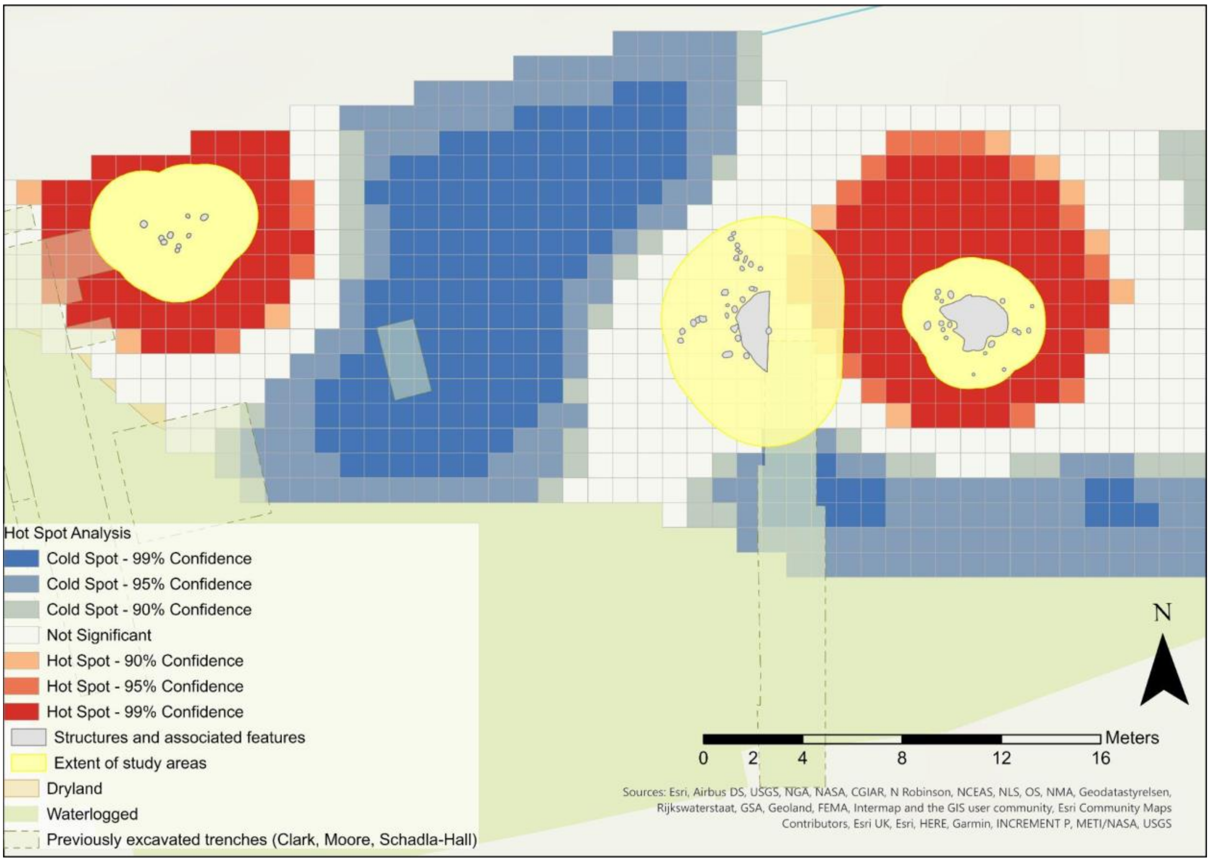


Figure 40: Optimised Hot Spot Analysis results; key concentrations around the western and eastern structures, and to the north-east of the eastern structure.

depositional movement of flints but less lateral movement, so the buffers were not extended to include any lateral movement from inside or close to the structures (Conneller *et al.* 2018a; Milner *et al.* 2018a; B. Taylor, B. *et al.* 2018b). The visible effects of bioturbation on the preservation of microwear traces will be discussed in the results chapters.

Established sample areas are shown in yellow on all maps. A 1.5 metre buffer was sufficient to encompass all associated features for the eastern structure (Taylor, B. *et al.* 2018b). If the buffer had been extended further, the results may instead reflect activities undertaken beyond the structure's vicinity. A two-metre buffer was applied to the western structure as the structural features were more ephemeral (Taylor, B. *et al.* 2018b). The central structure had the largest buffer (three metres) to encompass the hollow and 43 postholes located predominantly to the north of the structure (Taylor, B. *et al.* 2018b); there are 43 postholes when 'unconvincing' or 'natural' postholes are excluded (POSTGLACIAL Project 2018).

4.2.3. Isolating tool types (first phase of sub-sampling)

A typical sample analysed within one microwear study is between '200-500 pieces' due to the time intensive method (van Gijn 1990, 9). Initially, it was hoped that between 350-400 flints could be analysed for this research. Due to the COVID-19 pandemic, the final quantity of tools from this first phase of analysis (256) was less than originally planned and some tool types could not be analysed (axe/axe flakes, truncations). To mitigate this, a second phase of sub-sampling was undertaken which used a different approach to select pieces. Flints from one structure were identified and briefly scanned, if signs of use were observed they were analysed fully. This sped up the number of pieces that could be assessed, giving an overall total of 332 flints that were fully analysed from the structures, and 54 awls.

The criteria used to establish the first phase of sub-sampling was based on the following, where at least one criterion had to apply:

1) there is a high quantity of the tool type found within the study areas when compared to the rest of the site;
2) a variable distribution of the tool type was observed across the three structures;
3) the frequency of burnt pieces was not high;
4) there is little known about the working traces of the tool type.

Tools that adhered to any of the criteria were highlighted in table 3. Criterion 1 and 2 directly addressed the depositional flint patterns in and around the structures, so were prioritised. The criteria were used to prioritise the order of analysis, with the most important tool types analysed first. Key

Flint typology	Total - across site	Total - dryland	% on dryland	Total - structure areas	% in structure areas	Quantity burnt	% burnt in structure areas	Included in sample?
Awls	70	27	38.6%	7	10.0%	0	0.0%	Y
Axe/ Axe flakes	112	63	56.3%	27	24.1%	3	11.1%	Y
Blades	621	290	46.7%	106	17.1%	3	2.8%	Y
Bladelet	2866	1812	63.2%	776	27.1%	66	8.5%	Y
Burins	232	131	56.5%	58	25.0%	6	10.3%	Y
Burin spalls	188	150	79.8%	87	46.3%	15	17.2%	Y
Core fragment/core preparation flakes	562	333	59.3%	142	25.3%	24	16.9%	Y
Core or ?core	296	161	54.4%	58	19.6%	8	13.8%	No
Denticulates	12	5	41.7%	1	8.3%	0	0.0%	Y
Flakes	4231	2807	66.3%	1273	30.1%	165	13.0%	Y
Fragments	7453	5508	73.9%	2968	39.8%	1061	35.7%	No
Knife	0	0		0		n/a	n/a	N/a
Microburins	83	47	56.6%	32	38.6%	5	15.6%	Y
Microdenticulat es	0	0		0		n/a	n/a	N/a
Microliths	261	165	63.2%	81	31.0%	15	18.5%	Y
Misc. retouch	19	11	57.9%	4	21.1%	1	25.0%	Y
Notch	6	3	50.0%	2	33.3%	0	0.0%	Y
Scrapers	317	204	64.4%	94	29.7%	11	11.7%	Y
Strike-a-lights	20	14	70.0%	3	15.0%	0	0.0%	Y
Truncations	31	9	29.0%	6	19.4%	1	16.7%	Y
Totals	**17380**	**11740**	**67.5%**	**5725**	**32.9%**	**1384**	**24.2%**	
Formatting			*highlighted >50%		*highlighted >25%		*highlighted >16%	

Table 3: Tool types and frequencies across particular areas, using on the Star Carr Project flint spreadsheet (flints with no coordinates removed) and spatial analysis through GIS.

tool types were: flakes, microburins, scrapers and strike-a-lights. A relatively high proportion (over 25%) of flakes, scrapers and microburins were found associated with the structures (see table 3). Strike-a-lights were prioritised as all three located in the study areas were found in the western structure, adhering to criteria 2 (see figure 41). Blades and awls were also included as a key tool types as previous microwear results from the Star Carr Project showed well developed traces of use and little has been published about the use of flint awls (Conneller *et al*. 2018b).

Additional tool types to investigate were: microliths, denticulates, burins, burin spalls, axe/axe flake, bladelets and truncations. Cores and fragments < 2cm were excluded from the analysis as they provide a more technological perspective of tool production. Previous microwear analyses have suggested that it is unlikely that small fragments (i.e. debitage) were commonly used (van Gijn 1990).

Any tools identified as burnt on the spreadsheet were not chosen for the analysis to improve the likelihood of well preserved microwear traces and to reduce the complexities of interpretation for a newly trained analyst (Clemente-Conte 1997; Rutkoski *et al.* 2020). Tools previously analysed by Little and identified as showing signs of use (126 pieces across the whole site) were also largely excluded from this first phase of sampling to ensure that new data was produced (Conneller *et al.* 2018b). Fragmented tools (i.e. partially broken) were also selected for analysis alongside complete tools to reflect the variability in tool condition. Tool length was not provided for most of the flint finds, therefore sometimes the selected pieces were < 2cm and these were excluded; often microwear analysis is not undertaken on flints measured ≤ 2cm as they are defined as debitage (Chan *et al.* 2020; van Gijn 1990).

Each tool type was dealt with individually: one tool type was identified, taken out of the archive and analysed before this was repeated with another sample from a different tool type. This process was particularly time intensive, with locating and retrieving 85 flints taking four hours. However, sampling each tool type as separate entities ensured that valuable and coherent results could be obtained, even if time constraints limited the number of tools analysed. Conclusions could still be made even if it wasn't possible to explore patterns in tool use for all tool types. Each tool type was plotted and flints were randomly selected to ensure an even spatial distribution from within and around the features (see figures 42 and 43).

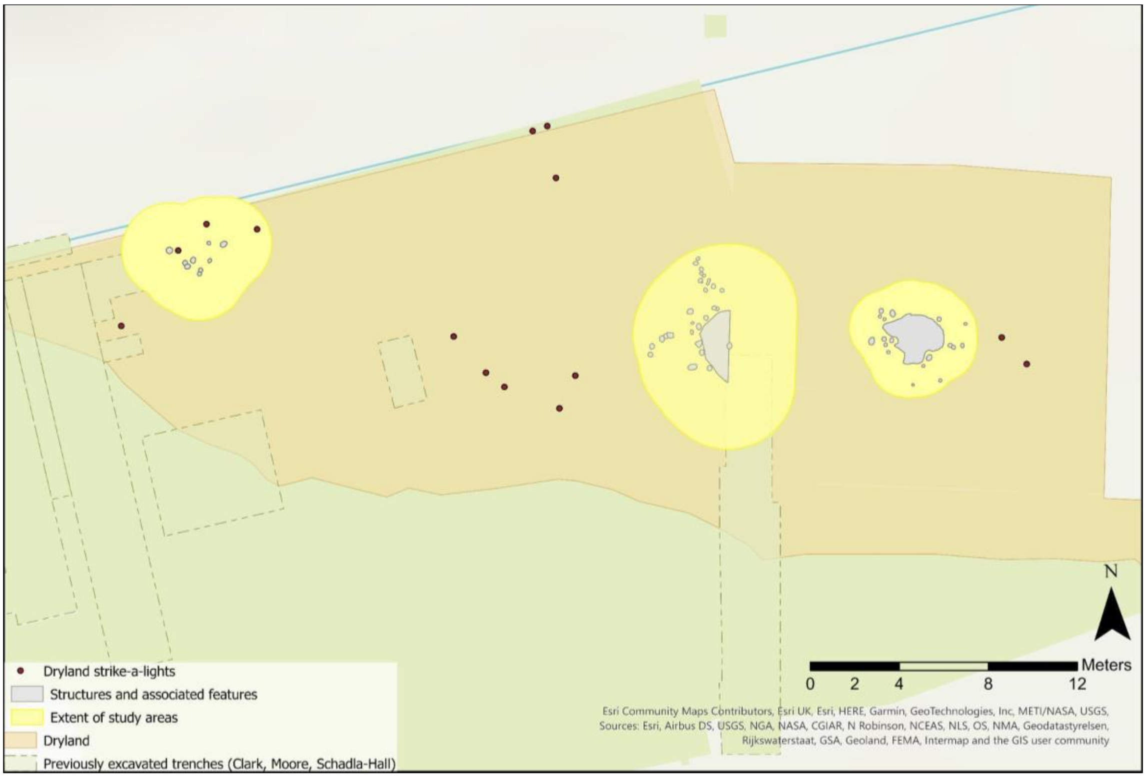


Figure 41: Distribution of strike-a-lights, which were identified as key for microwear analysis, based on the spatial patterning.

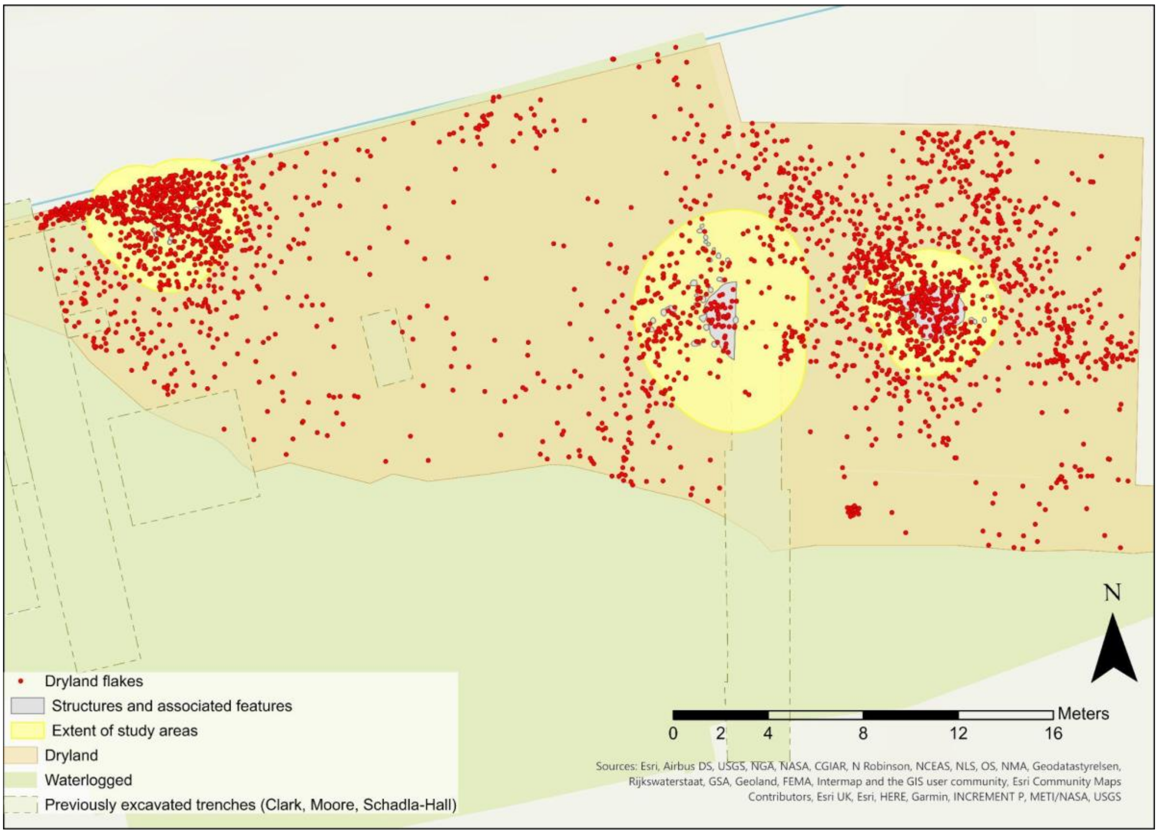


Figure 42: Distribution of flakes across the dryland.

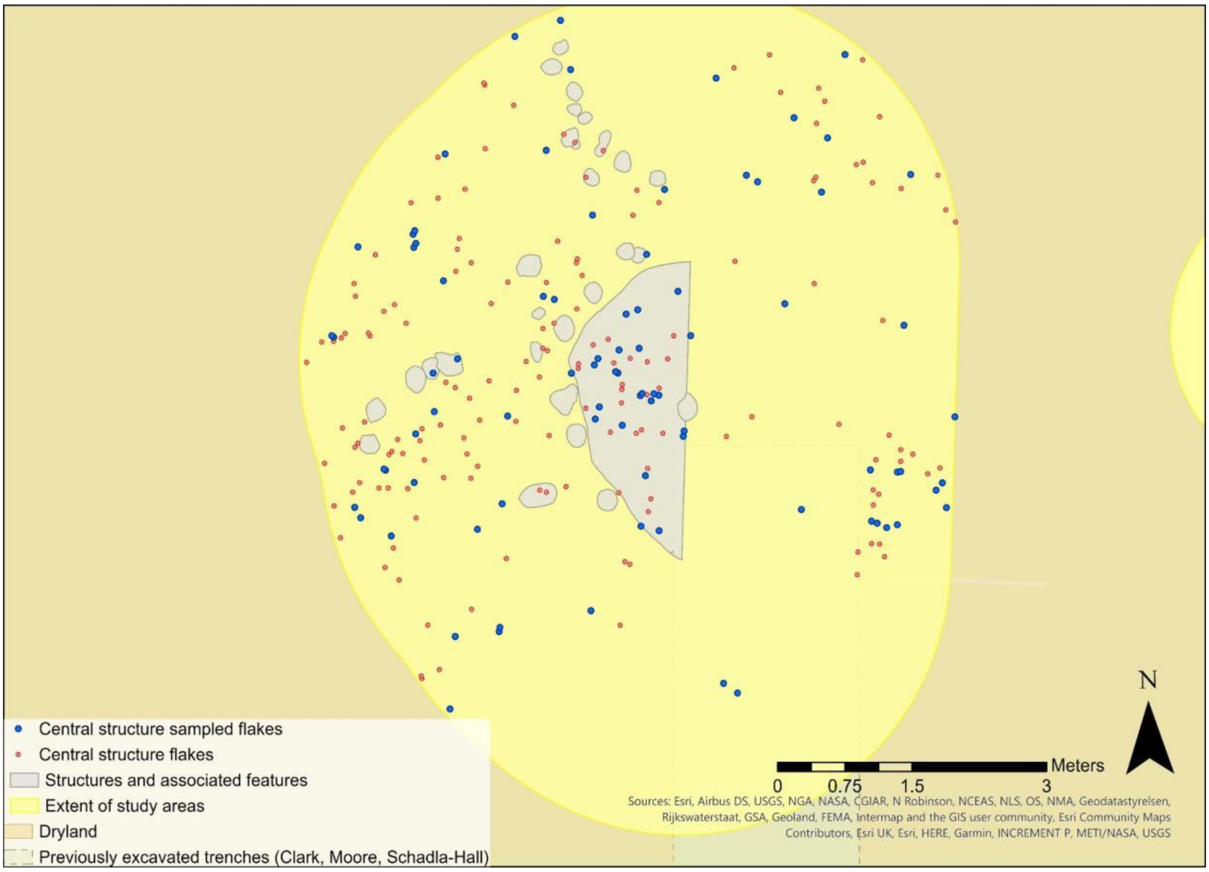


Figure 43: Central structure flakes (in pink) and those sampled for microwear analysis (in blue); an even spatial distribution of the analysed pieces can be observed.

For some tool types, all pieces could be included in the study (e.g. 3 strike-a-lights - see figure 41), whereas others contained over 300 pieces (e.g flakes - see figure 42) and so had to be sampled. Where the amount of one tool type in each study area exceeded 40 pieces, a sub-sample was selected. The quantity selected varied for each tool type as some flints could not be located within the archive. Some tools had large variations in the quantity found within each structure, so when a sample was selected, an equal quantity of flints across the three structures was chosen (e.g. 85 flakes from each study area). This meant data collection data was not biased towards one structure. The frequencies of tool types analysed in the first phase of sampling can be seen in table 4. In the case of flakes, after analysing 40 pieces from the central structure, it could be demonstrated that they showed limited use and so no further flakes were analysed. However, it is possible that flakes from the western or eastern structures may have shown higher rates of use.

Key tool types	**Quantity analysed**
Awls	54
Blades	42
Flakes	40
Microburins	23
Scrapers	19
Strike-a-lights	3
	Sub total = 181
Additional tool types	
Microliths	16
Denticulate	1
Burins	11
Burin spalls	17
Bladelets	80
	Sub total = 125
Total quantity of flint	**306**

Table 4: Frequency of tool types analysed in the first phase of the microwear assessment.

Often microwear analysis is undertaken in conjunction with the technological assessment, and flints are selected by the lithics specialist based on various factors, including: tool type, macro observations (i.e. use retouch), or spatial location. These flints can then be quickly scanned by the microwear analyst to identify those with preserved, well developed microwear traces, which warrant in depth analysis (i.e. cleaning, microwear forms, high-power magnification).

For the first sampling approach, full microwear analysis was undertaken on pieces which would have ordinarily been excluded after a brief scan. A number of time-consuming steps were undertaken prior to actually assessing the flints: selecting pieces on GIS, retrieving them from the archive, cleaning and drawing them. Once these flints were mounted under the microscope, such a significant time investment had been made that any minor signs of use were analysed comprehensively. Together with my inexperience of microwear analysis in the early stages of data collection, this led to a slow pace of analysis.

4.2.4. Second phase of sampling

A new approach was developed in response to the aforementioned issues. This enabled a greater quantity of flints to be scanned and analysed in a shorter period of time. Between June and July 2021, 832 pieces from the eastern structure and its surrounds (51% of all unburnt flints from the area) were scanned and 616 were assessed for potential microwear analysis. The eastern structure was chosen for a more focused analysis because:

1) microwear results from the first phase of sampling indicated lower levels of post-depositional surface modification (PDSM) and iron oxide staining. PDSM encompasses physical or chemical alterations to the flint, which can obscure or even remove wear traces, thus limiting analysis. This can include surface patination, metallic striations, dull smoothing of the surface and staining from depositional context. If PDSM is not observed, there are better chances of finding well preserved polish;
2) the eastern structure is the most convincing of the structures excavated at Star Carr, with associated faunal remains and the presence of a possible organic matting;
3) flints appeared to be used more frequently in the eastern structure compared to the others in the first phase of sub-sampling, meaning that more interpretations of use could be made;
4) the structure had been excavated at the end of one season, with little else found on site, so flint was bagged together in the archive making archive retrieval less time consuming.

Rather than using GIS to identify individual flints to extract from the archive, all flints recovered from the eastern structure were compiled into a spreadsheet. Finds numbers were allocated to flints chronologically, based on when they were excavated, so it was possible to isolate several boxes which largely contained pieces found from in and around the eastern structure.

Most flints (616 out of 832) were assessed under low and high-power magnification for signs of use and PDSM. Due to time constraints, pieces were excluded if they were observed to: have poor surface preservation; were predominantly cortex (outer surface of a flint nodule); or had very faint, uncertain use traces. It is likely that the total analysed underestimates the true quantity of flints used in and around the structure. Additionally, this may have created a bias in the results as those used for a short duration of time and/or on softer material were less likely to be recorded. In total, 80 pieces were assessed as showing some wear traces. These flints were cleaned (see cleaning protocols in section 4.3.) and a microwear form was made for each piece (see section 4.6.). Microwear results from the second and first phase of sampling have been combined.

4.2.5. Overview of complete sample

Based on a count of finds numbers, 386 flints were analysed. Two pieces, a microlith <86199> and a blade <102404>, had broken in two in the same bag. These flints were still analysed but considered as two pieces, taking the total to 388. Most (341) came from within the structure areas and 47 were awls located outside of these areas (see table 5).

	Central structure	**Eastern structure**	**Western structure**	**Total analysed**
Category	**No.**	**No.**	**No.**	**No.**
Tools total:	**14**	**32**	**29**	**122**
Awl	0	0	7	54
Axe	0	1	0	1
Burin	3	4	5	12
Denticulate	0	0	1	1
Microlith	5	12	6	23
Scraper	6	15	7	28
Strike-a-light	0	0	3	3
Tool spalls:	**9**	**11**	**20**	**40**
Burin spall	5	6	6	17
Microburin	4	5	14	23
Debitage total:	**79**	**104**	**41**	**224**
Blade	13	19	14	46
Bladelet	26	60	27	113
Flake	40	11	0	51
Fragment	0	14	0	14
Total number:	**102**	**147**	**90**	**386**

Table 5: Composition of final analysed microwear assemblage across the three structures and awls, with number of pieces analysed.

4.3. Cleaning protocols

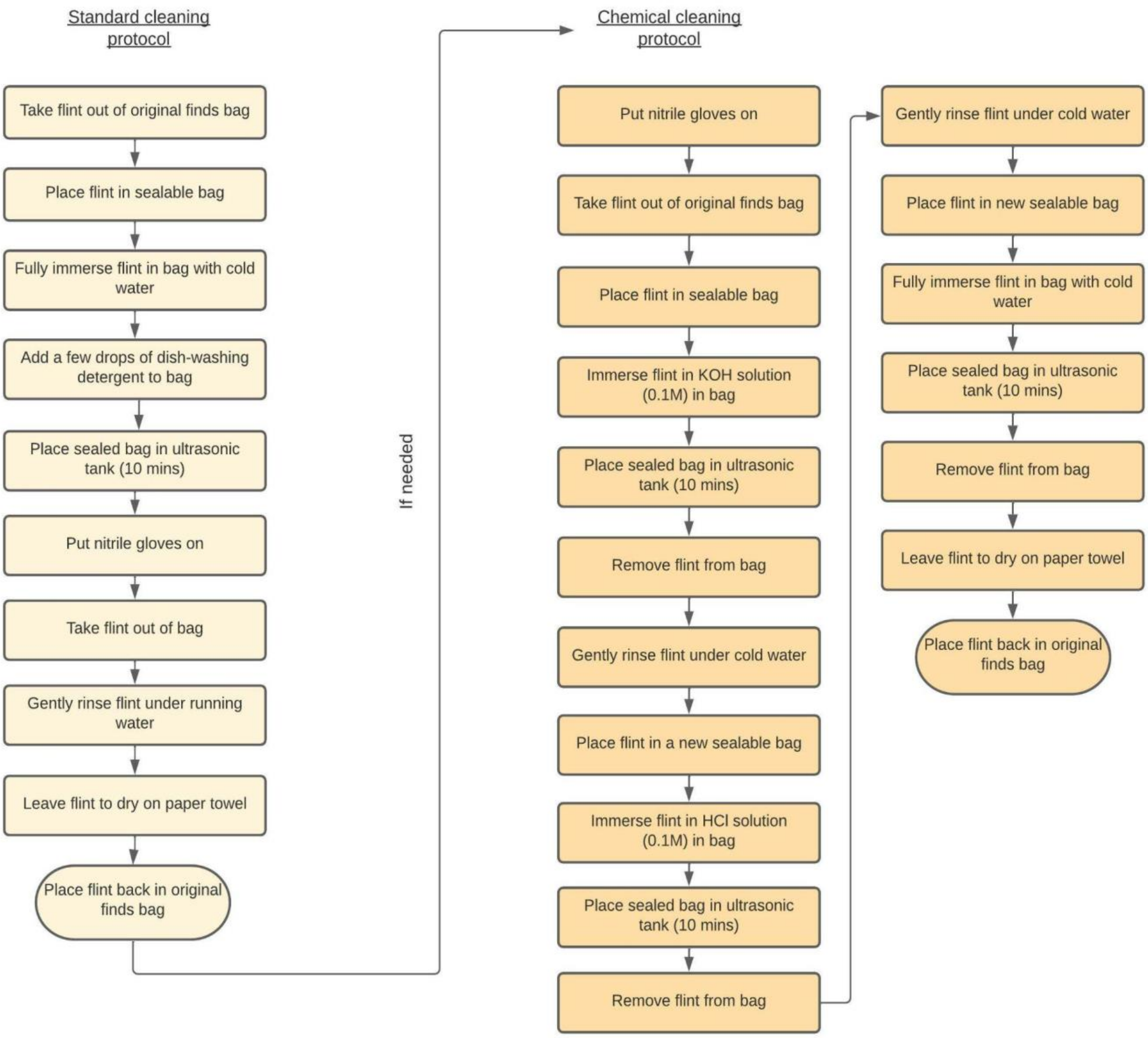


Figure 44: Cleaning procedures for standard and chemical cleaning.

Limited published literature exists that specifically discusses different cleaning protocols for microwear analysis (Macdonald and Evans 2014). A standard cleaning procedure was developed using an Ultrawave U300 ultrasonic cleaning bath to remove residual dirt and finger grease on all flints (see figure 44) (Evans *et al*. 2014a; van Gijn 2010). Each piece had its finds number written onto its surface with ink and most of these had not been secured with varnish, so they were sometimes removed unintentionally during the cleaning process. This method is the simplest form of cleaning and avoids damage to the artefact which occurs if rubbed clean with your hands or using a soft-bristle brush (Dubreuil and Savage 2014; Dumont 1988; Keeley 1980). In addition to standard hand-washing, chemicals can be used in cleaning to remove dirt and grease from the flint surface, though there are significant disagreements regarding their use and/or combination of chemicals.

Analysed flints were generally in a good condition, but PDSM was still observed on a significant proportion of the assemblage (54% based on sample from across the site) (Croft *et al.* 2018; High *et al.* 2018). This includes: surface patination (white and gloss); trampling; post-excavation marks; iron oxide deposits and staining. Patination is a form of chemical weathering most commonly caused by more extreme pH depositional environments (highly alkaline for white patina, highly acidic for gloss patina), although the burning of flints can also cause a similar type of colouration (Andrefsky 1998; Fiers *et al.* 2021; Halbrucker *et al.* 2021; van Gijn 1990). Patination creates a white or glossy film that covers part or most of the flint surface, obscuring any underlying polish (see figure 45) (Andrefsky 1998, 103; Howard 2002; van Gijn 1990, 51). The dryland depositional context at Star Carr meant that a large proportion of flints had iron oxide staining over some or, in some cases, most of the flint edge (see figure 46) (High *et al.* 2018; Howard 2002).

An adapted version of previous chemical cleaning methods was developed, using an acid and alkaline solution to remove different types of residue/staining (Keeley 1980). Hydrochloric acid (HCl) and sodium hydroxide (KOH) are used to remove both mineral and organic deposits, respectively. However, extended soaking in sodium hydroxide can cause discolouration and white-ish patination on the flint (Keeley 1980). The chemical cleaning method developed for the Star Carr flint used 10% HCl solution (0.1M) followed by 10% KOH solution (0.1M), see figure 44 (Evans *et al.* 2014a; van Gijn 2010). Owing to the thickness of the iron oxide staining and the time investment of chemical cleaning, pieces that had extensive staining and/or deposits were excluded from the analysis (see figure 46). This is normal procedure for flints that have significant post-depositional surface modification.

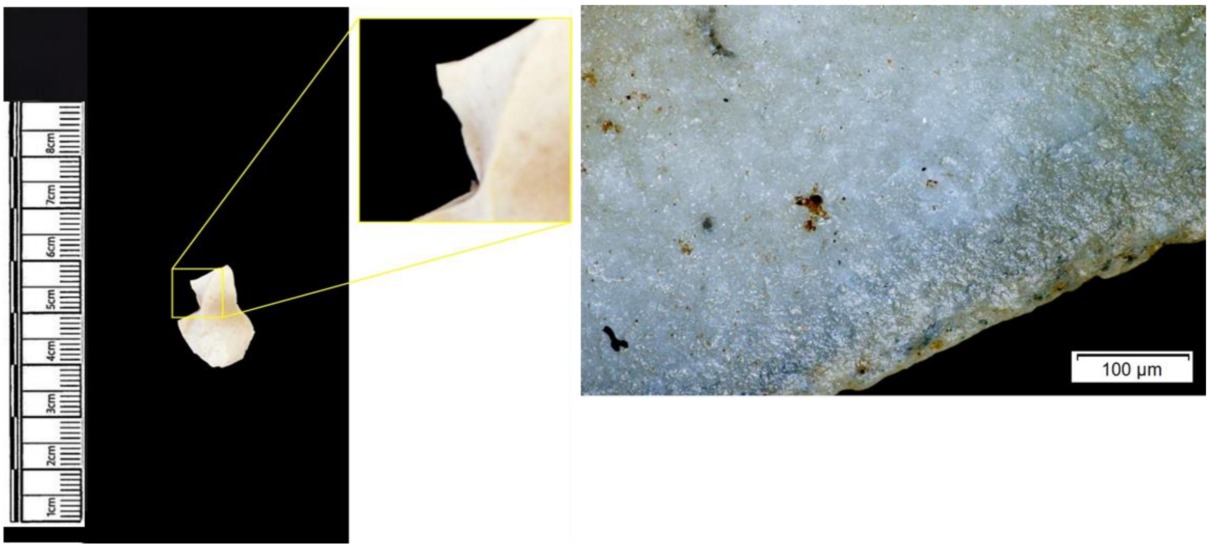


Figure 45: SC95068, a microburin from the central structure displaying white surface patination with some minor iron oxide deposits on the dorsal aspect.

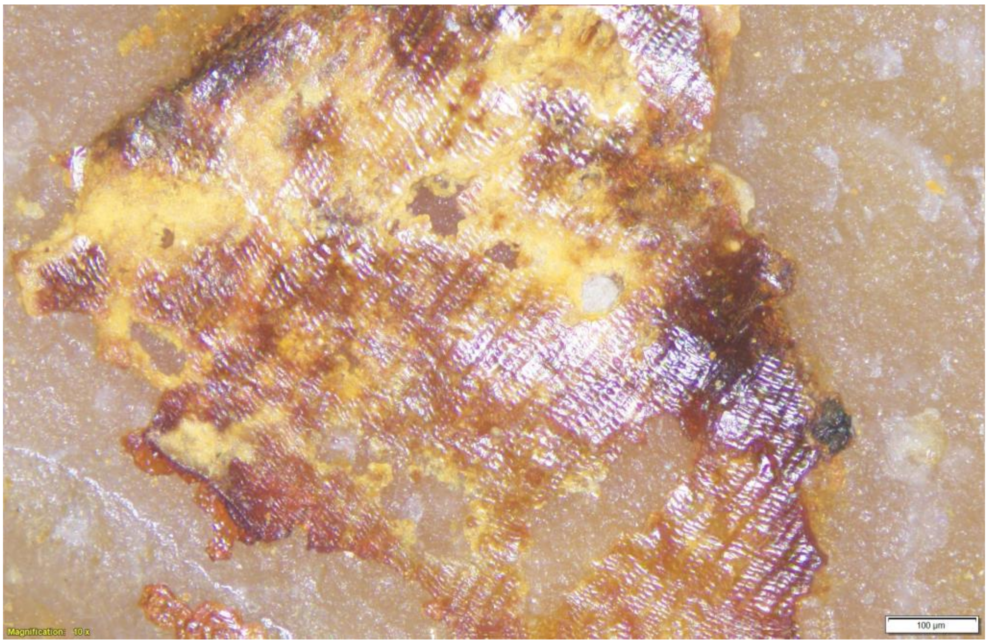


Figure 46: Flake from the central structure at Star Carr, SC102768, at 10x magnification displaying iron oxide depositional residue after basic soap and water clean in the sonic bath.

Several precautions were taken during microwear analysis to avoid contamination from finger grease. Flints were dabbed intermittently with an ethanol (alcohol) soaked cotton pad and cotton buds throughout (or each time it was moved around the microscope stage), as ethanol removes finger grease and grease from the mount used to anchor a flint on the microscope stage (van Gijn 1990; Macdonald and Evans 2014). Nitrile gloves were worn throughout to ensure that no new finger grease was introduced to the flint. The mount used to anchor the flint during microwear assessment was covered in parafilm to mitigate against the transferal of grease.

4.4. Experimental reference collection

The Microscopy Lab at the PalaeoHub has a reference collection of replica tools used experimentally on a broad range of contact materials. Replicas were mostly used by students at the YEAR (York Experimental Archaeology Research) centre. Students are generally unfamiliar with using flint tools, so the types of wear produced was not always representative of what might be expected on archaeological flints. For example, pieces were sometimes used for long durations of time, despite attrition to the edge causing blunting, making them no longer effective. To rectify this, an experienced experimental archaeologist, Diederik Pomstra, produced and used different types of tools. These were employed in the types of tasks - working on contact materials - that previous studies have shown were likely to have occurred at Star Carr (table 6).

For awls, a dedicated collection of utilised tools was produced by Andy Needham. It included examples of working shale, amber, seasoned wood, dry bone (red deer), teeth (red deer), and hide (red deer) with ochre inclusion, expanding on previous work by Needham *et al.* (2018). Awls were used freehand in each experiment. Replicas were commissioned from Diederik Pomstra and were stored in individual plastic bags after production and prior to experimentation. At the end of each experiment the awl was placed in a new, individual plastic bag.

A series of blind tests were conducted on experimental tools produced by Diederik Pomstra, as I had not made or used the flints. Contact material, motion, duration and area of use were detailed on a spreadsheet for each tool and sent to A. Little. Blind tests were conducted during supervisions with Little so that the rationale for identifications could be observed and progress could be assessed. Flints used for short duration periods were included in blind tests, as they were used for actualistic tasks (e.g. planing wood to make a bow). Results of the blind test were: 4 out of 5 (80%) correctly identified contact material (siliceous plant, green wood, hide, with difficulty in identifying wood); 4 out of 5 (80%) correctly identified directionality (scraping, boring, with difficulty in identifying cutting). Blind tests were initially planned on all of Diederik's experimental flints, as part of the final stages of training. Due to the COVID-19 pandemic, microwear analysis was stopped and training could not be restarted once the lab reopened due to social distancing regulations, which meant that only one individual was allowed in at one time. An assessment by Little and the results of the blind testing were used as evidence that I was proficient enough to carry out independent microwear analysis.

To adhere to social distancing regulations, if I was unsure on interpreting a contact material, I shared micrographs of problematic pieces with Little via email for discussion. Micrographs do not replace an in-person microscopic assessment of an object; however, the circumstances meant that it was the most effective way of gaining a second opinion of interpretations. During the final stages of this research, earlier interpretations were reviewed by assessing micrograph images alongside the microwear forms.
A photographic database comprising micrographs of known wear traces was also created. When interpretations of archaeological microwear traces were uncertain, micrographs were used as an initial aid for comparing known replica use to unknown archaeological tools. Images were collated from previous microwear analysis of material from Star Carr (2014-2016), alongside new micrographs of experimental tools. Some micrographs from previous analyses were taken using a lower specification microscope camera so were excluded from the image database. Those of the new experimental tools were high quality TIF images, processed using Olympus stacking software on STREAM.

Mic row ear no.	Typo logy	grain size	hafting	retouc hed	length mm	width mm	wear location	activity	action	edge angle	material worked	variety of material worked	state	duration (mins)	intensité usure
357	Blade	Fine	No	No	74	35	Ridge on dorsal side	Scraping dry birch wood to tiller bow	Scraping/ planing	90 degrees?	Wood	Narrow (max 25 mm wide) piece of dry birch wood	Dry	20+ mins	Intense
358	Blade	Medi um	No	No	80	31	Edge dorsal side left	Cutting green reeds	Cutting (both pulling and pushing)	28	Plant	Mostly green, but also some dry reeds. Backed blade ! Stopped use as getting too blunt	Dry	24 mins	moderate
361	Blade	Medi um	No	Yes	52	23	Serrated edge + area behind edge	Scraping green nettlebast for fibre. Used twisting motion with toolhand to comb fibres.	Scraping	43	Plant	Green nettle bast & fibre	Fresh	20+ mins	Moderate
362	Blade	Fine	No	No	43	19	Edge dorsal side right	Cutting bark of young (growing) fomes fomentarius for tinder making	Cutting	34	Plant	Fairly young, still growing fomes fomentarius. Cut both bark and unlying tissue.	Fresh	22 mins	intense

365	Scraper	Medium	Yes	Yes	36	18	Tip scraper edge	Scraping hair side of dry summer deer skin. Tool hafted in dry hazelwood handle with buckskin binding	Scraping	66	Skin	Dry fallow deer skin. Summer skin, some hair fallen out already	Dry	4.5 min	Intensive
366	Scraper	Fine	Yes	Yes	54	28	Tip scraper edge	Scraping hair side of dry summer deer skin. Tool hafted in dry hazelwood handle with buckskin binding.	Scraping	79	Skin	Dry fallow deer skin. Summer skin, some hair fallen out already	Dry	10 min	Intensive
368	Scraper	Fine	Yes	Yes	57	24	Tip scraper edge	Scraping hair side of dry summer deer skin. Tool hafted in dry hazelwood handle with buckskin binding.	Scraping	68	Skin	Dry fallow deer skin. Summer skin, some hair fallen out already	Dry	6 min	Intensive
371	Chunk	Fine	No	No	42	21	On ridge at 90 degrees	Whittling green oak to make figurine	Whitting	46	Wood	Green oak	Fresh	28 min	Intensive
372	Blade	Fine	No	No	67	20	On ridge at the distal end	Planing dry red deer bone to make leister spear barb. Used back-and-forth motion	Planing	90 (hard to measure)	Bone	Dry red deer bone	Dry	11 min	intensive
375	Blade	Fine	No	No	46	14	Top 2 cm of right side edge	Scraping green hazel bark from shoots	Scraping	74	Wood	Green hazel bark from thin shoot	Fresh	19 min	Intensive

Table 6: An example of the types of tools produced and used by Diederik Pomstra for the reference collection.

4.5. Background and training of microwear analyst

Interpretations of microwear traces are reliant on the analyst having knowledge and experience to recognise the characteristics of wear traces derived from various contact materials. If the characteristics are not clearly discernible, analysis of some flints can take significantly longer, requiring regular reference to the experimental collection to compare with the archaeological wear traces. Time investment is greater for some flints depending on a range of factors, including: overall size, development of the polish, if the tool was hafted (van Gijn 1990; Keeley 1980; Rots 2005). Where hafting is speculated from parallel edge damage, the whole ventral and dorsal interior of the surface is observed at 100x and 200x magnification (Rots *et al.* 2006). When the analyst is unable to interpret wear traces, different sources (e.g. published micrographs; reference collection micrographs) are typically consulted before fixing upon an indeterminate result.

The subjectivity inherent to microwear studies can be minimised through the use of blind testing, which was undertaken for this research (Evans 2014). Blind testing offers a tangible way of tackling the inconsistencies of an analyst's observations, which can be acknowledged when the data is reused in future research (Evans 2014). It is worth noting, however, that very few papers published after Evans (2014) incorporate a statement on the statistical accuracy of the analyst, more often papers simply state that blind testing was undertaken. The additional time and requirements of a blind test (e.g. previously unanalysed tools worked on known materials by another individual) might go some way to explain why the approach has not been widely implemented.

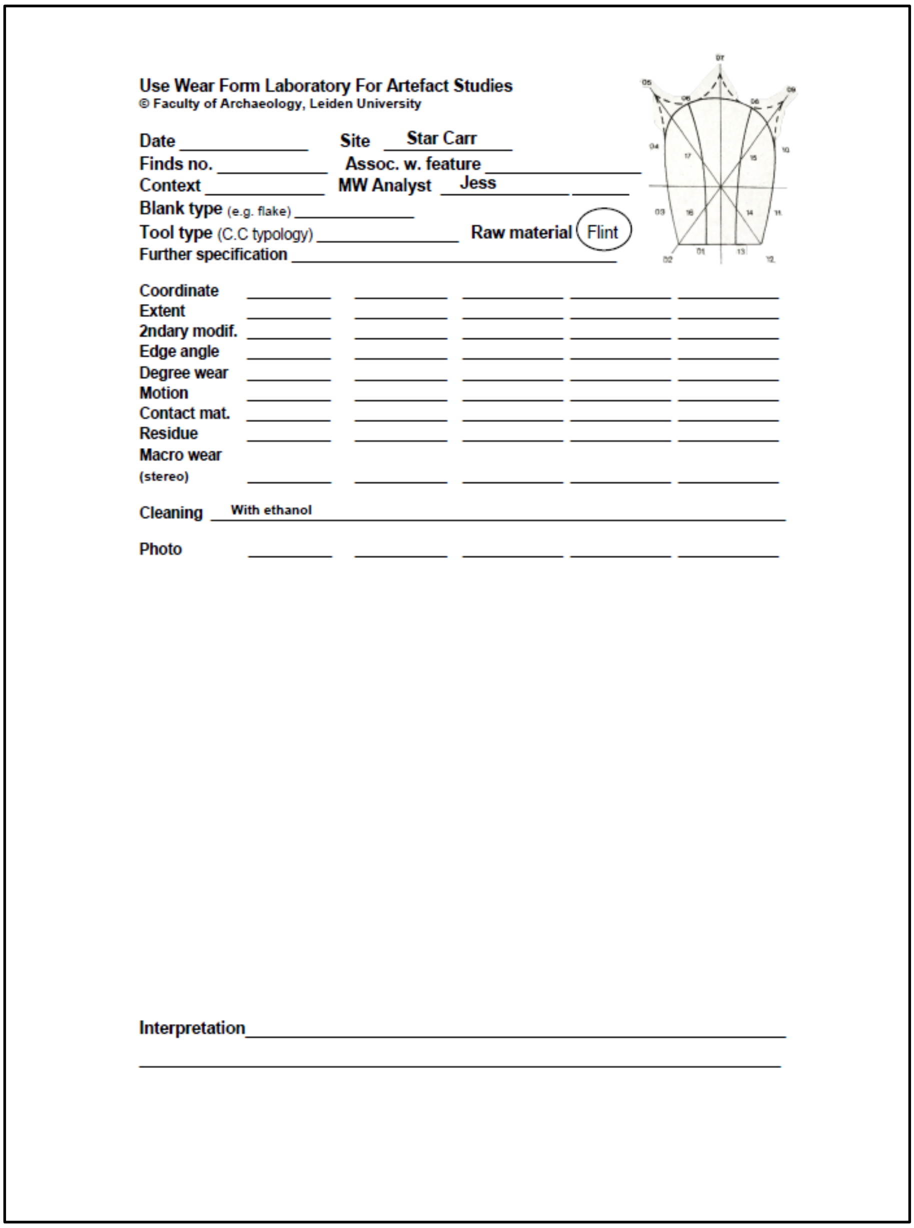
I had no previous experience of microwear analysis, and limited knowledge of working with flint tools, so considerable training was required. Alongside researching key texts on microwear analysis (e.g. Vaughan 1985; Keeley 1980; Odell 1996; van Gijn 1990), I examined unused flint surfaces of experimentally knapped pieces under low and high-power magnifications. Once familiar with unused flint surfaces and the topographic features of a fresh flint edge, I studied the experimental reference collection by material group (antler, bone, meat/butchery/fish, mineral, plant, wood). For each group, notes from key literature were collated alongside my own observations of the wear traces associated with different contact materials. Archaeological flints were then examined, starting with a low-power analysis and high-power screening of Star Carr awls. These were assessed as part of preparatory work prior to full microwear analysis, and so only location of possible polish was noted at first. Full examinations of flint from the structures and all of the recovered awls then took place. Blades were analysed first as a relatively straightforward tool type that generally does not exhibit retouched edges.

4.6. Recording microwear traces

For the first phase of analysis, a microwear recording form was created for each flint tool to ensure that consistent information was recorded, irrespective of whether the flint had been utilised. The form (see figure 47) was created by the Leiden Laboratory for Artefact Studies (van Gijn 2010, 2014). Details of the flint - finds number, associated study area (e.g. central, western or eastern structure), context, tool type, further specification - are noted. Cleaning procedures used, details of the microwear by coordinate, and a drawing of the flint outline are also included. The sequence of analysis was documented on each recording sheet so those analysed early on could then be revisited if necessary.

An outline of each flint was traced onto the form - both the dorsal and ventral aspects - so that any microwear traces observed could be annotated. Abbreviations and symbols used are presented in table 7. Drawings followed the standards set for lithic illustration, with less detail than is required of published illustrations (Martingell and Saville 1988). Location and intensity of microwear traces were noted on the drawings. Alongside the recording sheet, an Excel spreadsheet was created and used to plot results in GIS. Headings included a combination of information recorded on the microwear form and from the flint spreadsheet created by the Star Carr Project (see Appendix 2).

Microwear analysis was undertaken in the Microscopy Lab at PalaeoHub, University of York. Initially a low-power Olympus SZ61 microscope with an Olympus LC30 camera was used, along with a high-power reflected light Leica DM1750M microscope with a Leica MC170 HD camera; both cameras were attached to desktop computers. The Leica MC170 HD camera did not provide sufficient quality images during the early stages of data collection, so micrographs taken of the material analysed first are not included in this thesis (this is noted in Appendix 2). Subsequently, I had access to a new high-power reflected light microscope, an Olympus BX53M with an Olympus DP74 camera attached to a desktop computer (figure 48). This meant that high quality images of each piece could be taken during analysis.



Use Wear Form Laboratory For Artefact Studies
© Faculty of Archaeology, Leiden University

Date ____________ Site Star Carr
Finds no. ____________ Assoc. w. feature ____________
Context ____________ MW Analyst Jess
Blank type (e.g. flake) ____________
Tool type (C.C typology) ____________ Raw material Flint
Further specification ____________

Coordinate
Extent
2ndary modif.
Edge angle
Degree wear
Motion
Contact mat.
Residue
Macro wear (stereo)

Cleaning With ethanol

Photo

Interpretation ____________

Figure 47: Recording sheet used for the microwear analysis of each individual flint (© Laboratory for Artefact Studies, Faculty of Archaeology, Leiden University).

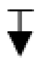
Abbreviation/symbol	**Meaning**
AD	Additive
AN	Antler
BO	Bone
FI	Fish
HA	Hafting
HI	Hide
ME	Meat
MIN	Mineral
PL	Plant
SI PL	Siliceous plants
WO	Wood
Indet.	Indeterminate/unknown
	Longitudinal direction
	Transverse direction
	Impact (evidenced from MLITs)
	Hafting
	Drilling or perforating
	Development of traces (a heavier dot = more developed traces)

Table 7: Symbols and abbreviations used for microwear analysis (after van Gijn 2010).

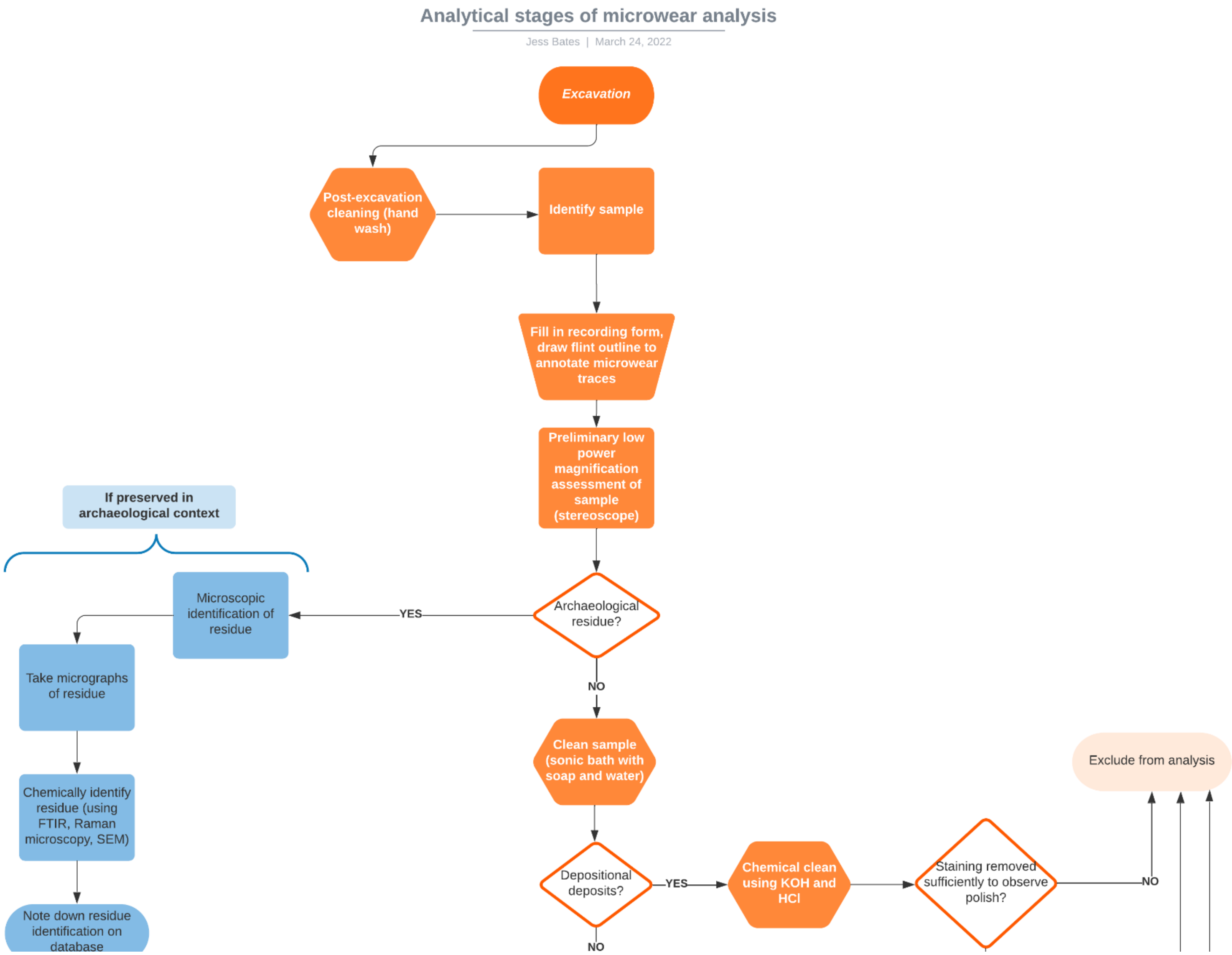
Micrographs were taken for each area of polish identified on all of the analysed flints using an Olympus DP74 camera on the high-power microscope (see Appendix 3) (van Gijn 2014; Grace 1990). These were then processed using stacking software on STREAM (Olympus microscope imaging programme) to ensure that all aspects of the flint surface were in focus. Several micrographs were taken of the polish at slightly different points to ensure that the most diagnostic areas of polish were documented. If the polish was particularly bright or notable from 100x magnification, micrographs were taken at 100x and 200x magnification to provide a range of viewpoints for additional detail.

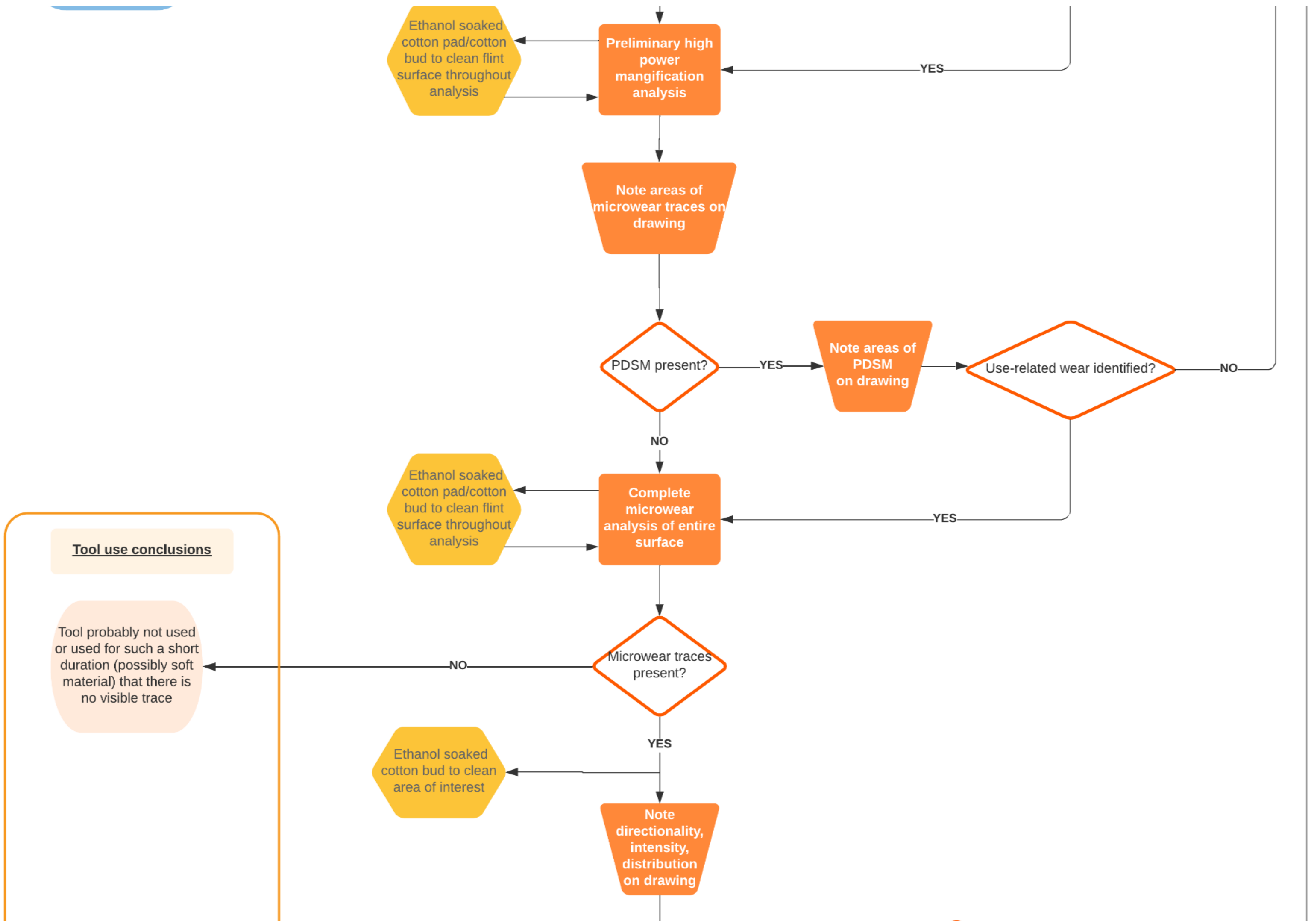
Figure 48: Set up for microwear analysis at the PalaeoHub. An annotated flint drawing can be seen, with the artefact secured on the stage using white tack covered parafilm.

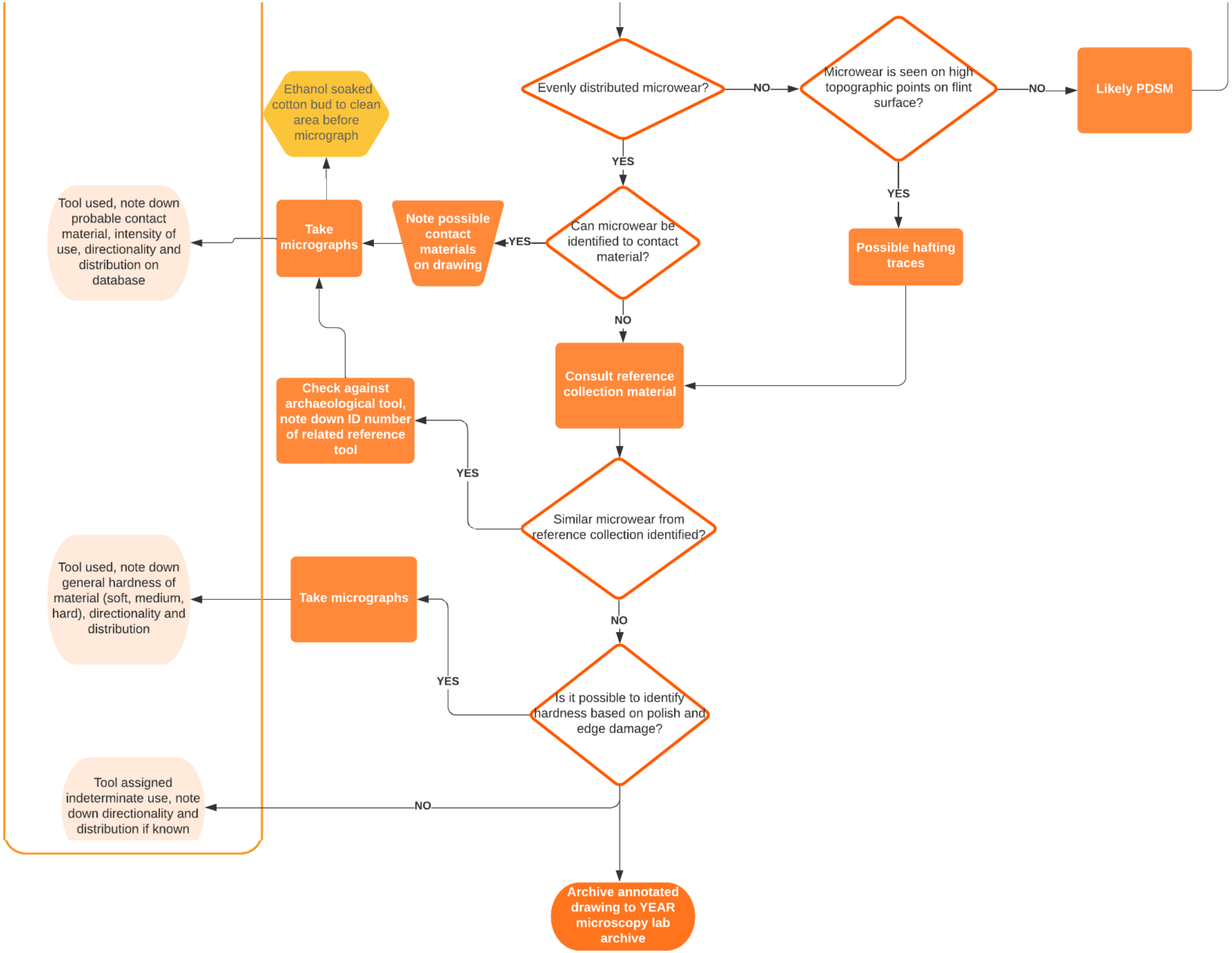
Image quality was of paramount importance to this research, as a number of previous microwear studies on Mesolithic settlements did not include micrographs or, if present, were of a poor quality (see Appendix 1). A lack of, or poor quality, images can limit the integrity and use of results in future studies (van Gijn 2014). In this research, all utilised flints were photographed and unusual or particularly well developed PDSM and/or uncertain deposits were also photographed to provide a full record of the flints analysed. Presence of PDSM and/or uncertain deposits was noted for all pieces during analysis (even when micrographs were not taken) as the preservation of flints across the three structures was of interest. Differential preservation of polish and flint surfaces within a ‘homogenous’ dryland area may hold potential for sampling strategies at similar Mesolithic sites in the future.

4.7. Interpreting microwear traces

Figure 49: (Below) Flow chart of microwear analysis and the decisions taken throughout the process for each analysed tool.


Analytical stages of microwear analysis
Jess Bates | March 24, 2022
Excavation
Post-excavation cleaning (hand wash)
Identify sample
Fill in recording form, draw flint outline to annotate microwear traces
Preliminary low power magnification assessment of sample (stereoscope)
If preserved in archaeological context
Archaeological residue?
YES
Microscopic identification of residue
Take micrographs of residue
Chemically identify residue (using FTIR, Raman microscopy, SEM)
Note down residue identification on database
NO
Clean sample (sonic bath with soap and water)
Depositional deposits?
YES
Chemical clean using KOH and HCl
Staining removed sufficiently to observe polish?
NO
Exclude from analysis
NO


Ethanol soaked cotton pad/cotton bud to clean flint surface throughout analysis
Preliminary high power mangification analysis
YES
Note areas of microwear traces on drawing
PDSM present?
YES
Note areas of PDSM on drawing
Use-related wear identified?
NO
NO
Ethanol soaked cotton pad/cotton bud to clean flint surface throughout analysis
Complete microwear analysis of entire surface
YES
Tool use conclusions
Tool probably not used or used for such a short duration (possibly soft material) that there is no visible trace
NO
Microwear traces present?
YES
Ethanol soaked cotton bud to clean area of interest
Note directionality, intensity, distribution on drawing


Evenly distributed microwear?
NO
Microwear is seen on high topographic points on flint surface?
NO
Likely PDSM
YES
YES
Possible hafting traces
Ethanol soaked cotton bud to clean area before micrograph
Tool used, note down probable contact material, intensity of use, directionality and distribution on database
Take micrographs
Note possible contact materials on drawing
YES
Can microwear be identified to contact material?
NO
Consult reference collection material
Check against archaeological tool, note down ID number of related reference tool
YES
Similar microwear from reference collection identified?
NO
Tool used, note down general hardness of material (soft, medium, hard), directionality and distribution
Take micrographs
YES
Is it possible to identify hardness based on polish and edge damage?
Tool assigned indeterminate use, note down directionality and distribution if known
NO
Archive annotated drawing to YEAR microscopy lab archive

A flow chart detailing the full process of microwear analysis can be found in figure 49. Interpretations of microwear polish were generally categorised as falling into one of three groups; present, not used (no clear signs of use), or indeterminate. During high-power analysis, the flint needed to be moved and repositioned regularly to ensure that the most beneficial angle for interpreting wear traces was found. When polish was observed, that area was cleaned *in situ* with a cotton bud soaked in ethanol to ensure that the polish was genuine, not superficial grease. The characteristics of the polish were then noted on the recording sheet, with brightness, invasiness, directionality, developedness. as well as edge damage (or rounding) noted.

Intensity of polish denotes the development of wear traces, often correlating to the duration of use (Ibáñez and Mazzucco 2021). Invasiveness is defined as how far the polish extends from the flint's edge into the interior surface, and can be connected to observations of removals; for example, a polish that extends beyond removals from use would be considered invasive. This information can be used to infer the angle of the flint's edge to the contact material, aiding interpretations of tool motion. For example, an invasive transverse polish would indicate a low angle of use, which is more indicative of planing rather than scraping (Keeley 1980, 18)

For particular materials, the state or condition (i.e. fresh, dry, siliceous vs non-siliceous plant) can be interpreted from wear traces. This is relevant for hide, wood, and plants in particular. Experiments have been undertaken to replicate the different stages of hide processing, which has resulted in the ability to differentiate between 'fresh' and 'dry' hide working (van Gijn 2010, 81). Where possible, hide working tools are described as used on fresh or dry hide. Fresh hide is more likely to indicate the earlier stages of hide processing when tissue and membrane is removed from the skin, whereas dry hide often relates to the later stages of processing, once the skin has been treated (i.e. tanned or smoked) and can be softened to make supple leather (Hurcombe and Emmerich Kamper 2016). Use of additives can also be observed through microwear traces, which can be worked into skins using flints. Soft mineral additives, such as ochre, have been documented to help soften and tan hides (Dubreuil and Grosman 2009; Rifkin 2011). When dry hide working is interpreted with mineral additives, it is possible that flints were used to process hide for the production of clothing, coverings for structures, and containers, among other objects (Hurcombe and Emmerich Kamper 2016). Minerals like ochre were found at Star Carr, so hides may have been worked with ochre, which can also be used for symbolic purposes (e.g. for colouration) (Needham *et al.* 2018).

Plant polish can vary hugely, from a high-sheen, smooth polish (for plants with a high silica content), to a more grainy striated bright polish (non-silica rich plants) (De Stefanis and Beyries 2021; Jensen 1994). The working of soft wood can also look a lot like plant polish owing to their similar properties, like willow fronds. It is sometimes possible to differentiate between siliceous plants (e.g. reeds, grasses, sedges) and non-siliceous plants (e.g. nettle, bramble, willow bast) from microwear polish, provided that it is well developed and well preserved (van Gijn and Little 2016). In some cases, the addition of dirt or grit can cause siliceous plant polish to appear more similar to non-siliceous plant polish, as the grit can cause striations. Therefore, where polish is identified as a non-siliceous plant, it must be taken with some caution.

If the contact material could not be interpreted, the hardness of material and directionality was noted, where possible. Hardness of contact material does not provide the level of detail given by a specific contact material (e.g. plant); however, it can help to reduce the range of possible materials worked. Soft indeterminate traces relate to materials that may cause minor or no edge modification, such as plants, meat, certain types of fresh green wood (e.g. willow fronds). Soft/medium indeterminate identifications are more likely to show minor edge modification, such as limited edge rounding and microremovals. From experiments, working materials such as fresh hide, non-siliceous plants, fish, and, for a limited time soaked bone and fresh green wood, can cause this type of microwear. However, properties of the material (i.e. fresh, soaked, dry), and direction of use can impact the development of microwear.

Tools used on medium indeterminate materials were identified by rounding and/or removals that may or may not be visible at low-power but are evident at high-power. Fresh bone, green wood, bark, dry hide and hide with a mineral additive are the types of materials that may cause these traces. An identification of hard indeterminate relates to contact materials that significantly modify the working edge of a tool, causing considerable removals and/or rounding that are visible macroscopically and in some cases with the naked eye. Contact with materials like antler, bone, seasoned wood are likely to cause this type of observable microwear. An indeterminate designation was given to tools where the polish and associated microwear traces were undeveloped, and/or where significant PDSM prevented a clear idea of what was use related and what was PDSM.

Hafting traces were noted on analysed flints, and where possible, haft material was interpreted. Tools can be mounted into hafts using binding (e.g. cordage, sinew) and/or glue (e.g. birch bark tar, animal glue), making traces difficult to discern with certainty. Additionally, polish observed on hafted tools may be a result of contact with a container, for example if projectiles were made in advance of hunting or fishing and then transported (van Gijn 2010; Pyzewicz and Gruzdz 2014). Therefore, interpretations of hafting are tentative and should be considered with caution.

Once interpretations were made, flints were grouped based on primary contact material: bone, meat, hide, projectiles and hafted microliths, fish, antler, plant, wood and mineral. This enabled clarity when observing spatial patterns in tool use. Projectiles are defined as flints with clear signs of hafting or microscopic linear impact traces (MLITs), where MLITs indicate use as a projectile from subtle striations formed. If the piece becomes damaged on puncturing an animal, broken chips from the tip become embedded and make contact with the tool's surface (Rots and Plisson 2014, 156). However, MLITs do not always form on a projectile, as if an insert is hafted into the side rather than on the tip, it will not bear the brunt of the impact (Crombé *et al.* 2001; van Gijn 2010). Similarly, hafting does not necessarily indicate use as a projectile, as hafted microliths may be used together as a knife. Flints with MLITs or hafting traces are considered composite objects. Compared to non-composite tools, projectiles and hafted microliths are more likely to be found in areas of dehafting, rather than where they were used (Keeley 1982, 1991). For this reason, these flints are dealt with in a separate group. Flint finds numbers are included in the results chapter where they are required for spatial reference and if not stated, all relevant information and interpretations of each tool can be found in Appendix 2.

4.8. Collating microwear data

New microwear data was combined with microwear results from the Star Carr Project in key groups of: animal, vegetal, projectile impact/hafting, and mineral. These were then used to establish 'zones' of activity, which help to further examine connected or discrete tool-using behaviours. They are only suggestive of spatial patterning in tasks and are based on observation rather than statistical testing due to the sample size. Certain contact materials (largely fish and antler working) were only identified on one or two tools in each structure, so zones were not assigned. Rather than conclusive, these zones help to establish hypotheses about how space was organised in the structures, which need to be tested through future work.

There are three caveats to consider when interpreting this data. Firstly, any spatial patterns in tool use are only representative of the analysed flints. It is indisputable that further analysis of additional pieces would enable further insights into tool use and the spatial patterning of activities. Secondly, it is presumed that most tools were used whilst there was a structure present. However, the ephemeral nature of the structural features and issues with bioturbation in the dryland prevent any certainty. Lastly, flints may not have been used where they were excavated. An individual may have used a tool elsewhere and deposited it near to the structures, meaning that tool use may not reflect activities undertaken near to or within the structures. These limitations are present in any study that employs microwear and spatial analysis, particularly where the temporal sequence of habitation levels are not well preserved or defined. The subsequent results chapters present spatial patterns in the data, whilst acknowledging these limitations in interpreting tool using activity.

Chapter 5: Microwear analysis of awls

5.1. Introduction

This chapter presents microwear and spatial analysis results of 54 flint awls from Star Carr. The sample was examined using microwear analysis, supported by a dedicated experimental archaeological awl reference collection. Results were then spatially plotted using GIS software to explore patterns in awl use.

5.2. Awls

Mesolithic flint awls are defined here as a diverse category of tools, united by having partially or fully bilaterally retouched edges that converge to a point, making the tool well suited to piercing and/or drilling tasks (see figure 50). They form a relatively minor, though persistent, component of formal tool assemblages in England (Berridge and Roberts 1986; Conneller *et al.* 2018b; Dumont 1983, 1988, 1990; Jacobi 1978; Johnson and David 1982; Radley and Mellars 1964; Smith and Harris 1982; Waddington and Pedersen 2007; Wymer 1962), Northern Ireland (Dumont 1987, 1988; Woodman 2015), Scotland (Morrison 1982; Pirie *et al.* 2006; Wickham-Jones *et al.* 2017), Wales (David 1989; David and Walker 2004; Jacobi 1980; Lillie 2015; Nash 2012). They are also recovered from continental European Mesolithic sites, though in lower quantities, possibly due to a greater prevalence of using bone awls (Alcade and Saña 2017; Bergsvik and David 2015; Marquebielle 2011; Price *et al.* 2011; Svoboda 1983; Terberger *et al.* 2015).

Figure 50: SC93663, a double mèche de foret from Star Carr with a snapped proximal end.

Few sites in Britain have large quantities of this tool, and most are Early Mesolithic in date. Of sites with small lithic assemblages (<5000 pieces) only Broxbourne 102 has more than 10 awls; of larger sites (>5000 pieces) only Star Carr (184), The Nab Head (44), Kinloch (56) and Oakhanger VII (178) have more than 20 awls (Conneller 2021). Of these sites, The Nab Head and Star Carr also have extensive evidence of bead production, often thought to have been made using awls.

The tools making up the category of flint awls have attracted debate regarding use and typological organisation. A variety of terms are used across the European Mesolithic to describe tools within this category, including: awl, piercer, borer, zinken, bec, perforator and mèche de foret (Ballin 2021). Though some of these types (zinken, mèche de foret) have precise typological definitions and others (such as the distinction between awls and borers) are generally followed, use of some of the terms can vary between different researchers.

The category of Mesolithic flint awls is a useful microcosm in which to explore some of the challenges affecting attempts to organise stone artefacts more generally. Like other lithic tool types, historically in the awl category it was common that terms used to define form were simultaneously used to infer function. For example, piercers and awls were suggested to reflect a piercing action, while borers and drill bits were suggested to be used in a drilling action. Similarly, within Mesolithic research, size has sometimes been used to define categories, and also the likely contact material: for example, smaller awls have been linked to drilling tasks and larger awls to piercing tasks (Berridge and Roberts 1986, 18; Dumont 1987; Jacobi 1976), while some have argued that larger awls were used for drilling bone and smaller awls for drilling stone (Nash 2011). Microwear results challenge this, with no clear correlations in tool size based on material reported. Instead, flint awl/drill contact materials reported via microwear have been found to be diverse, including hide, hide and mineral, wood, plant, bone and stone (Conneller *et al.* 2018b; Dumont 1988; Semenov 1964). Rarely, however, have the differences in contact materials been explored spatially to better understand connected or divergent activities using awls, likely because the method is time consuming to carry out and relies on good levels of preservation, resulting in small sample sizes.

5.3. Sample

All objects where convergent retouch had been used to produce a point were defined as awls. Awls were re-examined as a group and sub-types refined. Three sub-types were identified. The most common of these are the elegant bilaterally retouched forms known as mèche de foret, of which 44 were recovered. These are defined as lanceolate and more or less parallel in form, shaped through entire or partial abrupt, bilateral retouch, with one, or more rarely two pointed ends (see figure 51) (Brinch Petersen 1966). Other types were rare: nine awls were defined as oblique bi-truncations, with the point formed by two convergent oblique truncations only, without the lanceolate form and attention to trimming of some part of parallel laterals characteristic of mèche de foret. One piece was more irregularly and more minimally retouched to form a thick point on a sturdy support and was defined as a borer.

The length of each awl was measured to assess the relationship between tool length and function. Measurements were taken using digital calipers rounded up to the nearest mm. With the aim of standardising terminology used in functional analysis of flint awls, five categories of tip modification were developed and assigned: (0) unmodified to the naked eye; (1) rotational minor removals, (2) rounding and/or removals, (3) resharpened tip snap from use, (4) snapped. Diagnostic observations are detailed in category definitions outlined in table 8. These observations were informed by modifications to tip morphology during experimental drilling for a range of durations and contact materials.

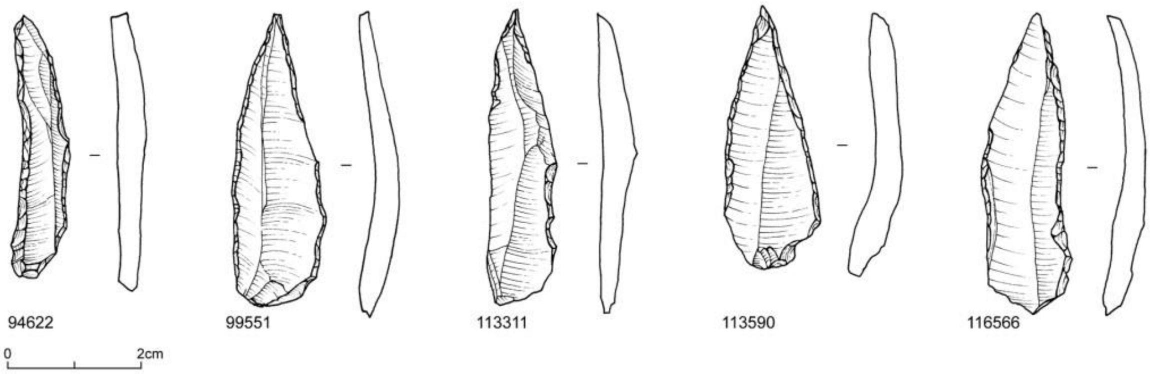


Figure 51: Variation in mèche de foret forms found at Star Carr (Copyright Craig Williams in Conneller et al. 2018b, 514).

Classification	**Definition**
0 - unmodified to the naked eye	Tip appears unused with no visible modification (e.g. crushing or removals).
1 - rotational minor removals	Diagonal removal at the very tip, indicating a rotational motion of use (i.e. drilling). Still functional.
2 - rounding and/or removals	Micro-removals and/or abrasion at the very tip, microchipping may or may not be visible. Still functional.
3 - resharpened tip snap from use	Snapping largely localised at the tip, resharpens the tool creating an angular edge so continued use is possible. Rounding and/or polish may be removed. Still functional.
4 - snapped	Severe shearing of the entire tip leaving an almost straight profile. No longer usable. (see figure 52)

Table 8: Classification of flint awl tip breakage based on the Star Carr assemblage.

Figure 52: SC92936, a mèche de foret from Star Carr, classified as a group 4 type tip modification (snapped) with hypothetical reconstruction of the complete tool.

5.4. Results

5.4.1. Microwear results

Microwear traces from use were observed on 43 awls (35 mèche de foret, seven oblique bi-truncations, one borer), of which 27 were diagnostic (22 mèche de foret, four oblique bi-truncations, one borer) thus enabling identification of contact materials. Post-depositional surface modification (PDSM) was observed on 41 awls, including iron oxide deposits and staining, metallic striations and flat, dull polish not related to use. However, PDSM did not always interfere with the identification of polish. In 18 cases, diagnostic polish from use could be discerned despite the presence of PDSM. Adhering iron oxide deposits obscured some microwear traces, so it is probable that the range of contact materials is underappreciated and where contact material can be discerned, the interpretation is necessarily tentative. There were 19 awls that required chemical cleaning. No definitive hafting wear traces were observed on the analysed awls.

The results of microwear analysis are presented below, grouped by contact material and presented alongside a GIS map to understand the spatial distribution by material type. The dryland extent in the map depicts what the site is likely to have looked like during the main phase of occupation (c.8800 cal BC), but as the palaeolake gradually became infilled the once open water became peat and was used for certain small-scale tasks (Taylor, B. *et al.* 2018a). Results of awls identified as used on soft, medium, hard indeterminate and indeterminate materials, as well as not used, can be found in Appendix 2.

5.4.1.1 Mineral

Finds number	Awl type	Length (mm)	Cleaning	Tip modification	PDSM	Contact material	Extent of polish
82401	Oblique bi-truncation	45	Soap	2	FeO staining and flat dull polish	mineral (not shale, possible amber)	undeveloped
90515	Mèche de foret	43	Soap	1	FeO staining and flat dull polish	mineral (not shale, possible amber) drilling	undeveloped
99551	Mèche de foret	45	Soap	1	n/a	soft mineral drilling	undeveloped
96336	Double mèche de foret	38	Soap and chemical	1	FeO deposits	soft mineral? drilling	undeveloped
97607	Oblique bi-truncation	26	Soap and chemical	4	n/a	soft mineral	developed
113581	Mèche de foret	44	Soap and chemical	2	Considerable FeO staining and metallic striations	soft mineral?	undeveloped
114679	Mèche de foret	29	Soap	4	n/a	soft mineral?	undeveloped
92402	Mèche de foret	30	Soap	1	FeO deposits	soft mineral drilling	developed
93991	Mèche de foret	60	Soap	2	n/a	soft mineral	developed
94227	Double mèche de foret	56	Soap	1	FeO deposits and metallic striations	soft mineral drilling	undeveloped

Table 9: Results from awls used on mineral.

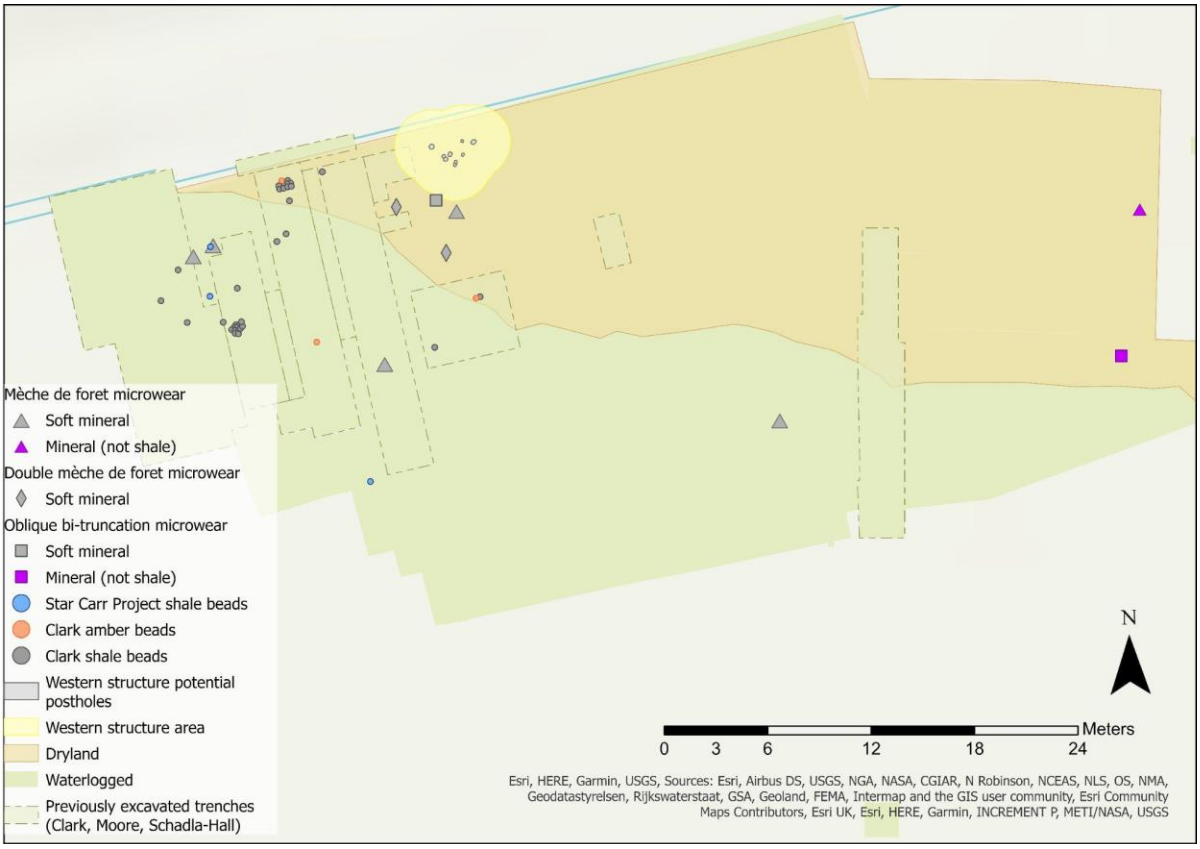


Figure 53: Distribution of microwear results from awls interpreted as used on mineral and soft mineral (shale), along with shale and beads excavated from the site.

From 8 awls identified as used on soft mineral, six are mèche de foret, two are double mèche de foret and two are oblique bi-truncations. Perforated shale was excavated from the site in close proximity to a number of the mèche de foret, together with comparable experimental working traces, so it seems likely that these traces are from shale. One mèche de foret and one oblique bi-truncation evidenced traces of a harder mineral, likely amber, which was also found at Star Carr (Needham *et al.* 2018). However, they are found on the opposite side of the site to the amber pendants, c. 40m away, possibly reflecting movement of the awls, the amber, or both (figure 53); refits of other types of lithic tools confirm connections between these two areas (Conneller *et al.* 2018a). The mèche de foret, including double mèche de foret, typically exhibited rotational minor removals at the working tip, consistent with their use as a drill using a rotational working action. There are three examples of well developed soft mineral polish (figure 54), but more typically the awls showed limited polish development. This may be because shale is soft and polish development is slow as a result. Further, the rotational action used in drilling can cause micro-removals at the tip, removing areas of more developed polish, making awls appear less utilised.

There are clear similarities in the features of the experimental mèche de foret used to drill shale freehand for 1 hour and the developed archaeological polish on SC93991 (see figure 54). Experiments of working shale freehand with a mèche de foret have shown that in excess of 40 shale beads can be made in 1 hour with the same tool. This quantity should be taken as a minimum estimate as the shale being drilled during experimentation was typically thicker than the beads recovered from Star Carr. This suggests that one awl alone could have easily produced the surviving assemblage of shale beads (33) found at Star Carr.

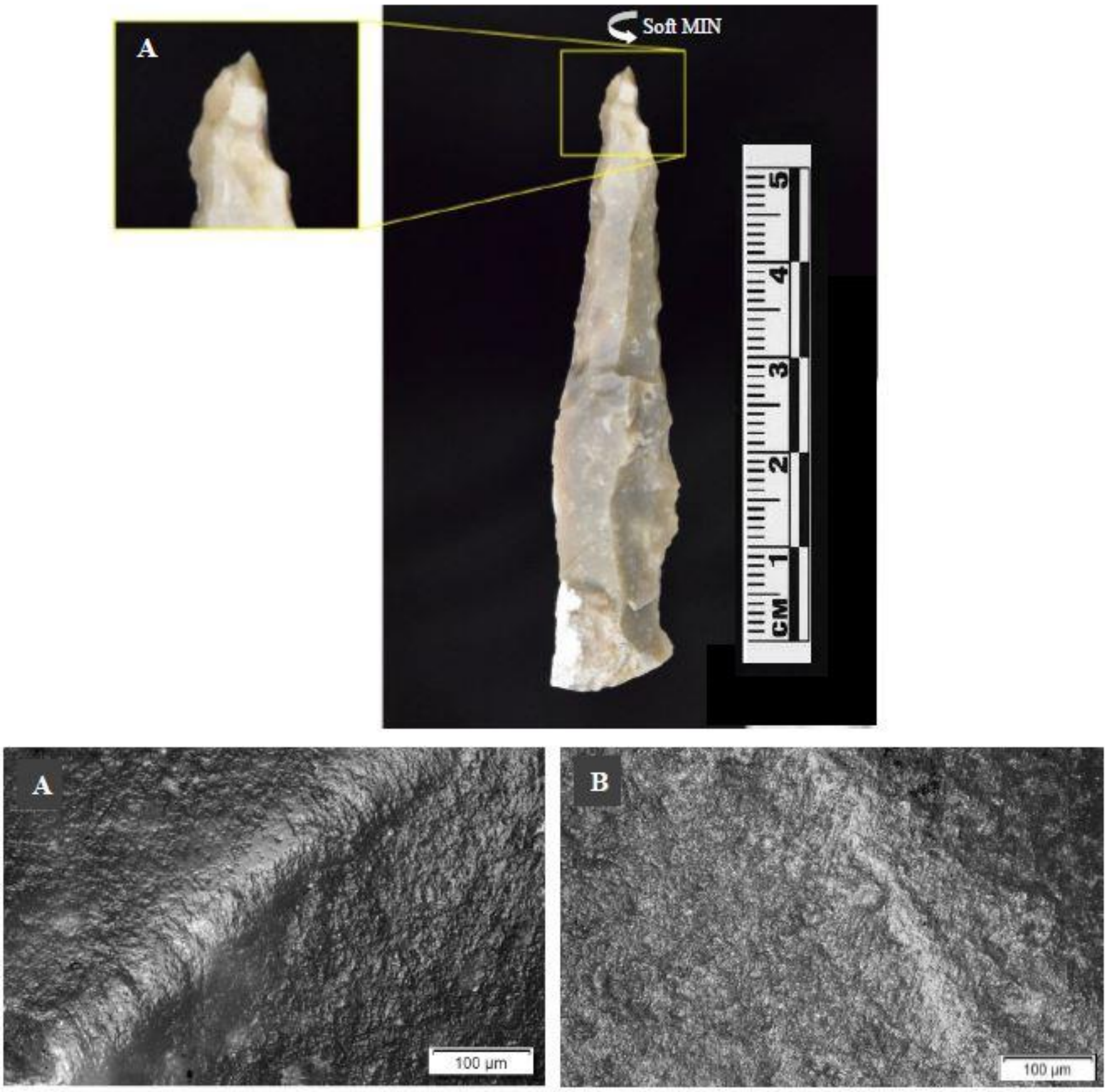


Figure 54: A - SC93991 an archaeological mèche de foret interpreted as used for drilling shale, 200x magnification. No wear was observed on the ventral aspect; B - experimental mèche de foret used for 1 hr to drill 40 shale beads freehand, 200x magnification.

5.4.1.2. Hide and hide with mineral

Finds number	Awl type	Length (mm)	Cleaning	Tip modification	PDSM	Contact material	Extent of polish
82724	Mèche de foret	47	Soap and chemical	1	n/a	hide + mineral drilling/piercing	undeveloped
85366	Mèche de foret	35	Soap and chemical	4	n/a	hide	developed
96249	Mèche de foret	36	Soap	2	Metallic striations	hide + mineral	undeveloped
113564	Double mèche de foret	51	Soap	2	FeO deposits and flat dull polish	hide	undeveloped
115294	Mèche de foret	30	Soap	4	FeO deposits	hide	developed
109731	Oblique bi-truncation	38	Soap	2	Flat dull polish	hide	developed
91454	Mèche de foret	41	Soap	1	n/a	hide (+ additive) drilling/piercing	developed
94395	Double mèche de foret	34	Soap	2	FeO staining	hide + mineral	undeveloped

Table 10: Results from awls used on hide or hide with mineral.

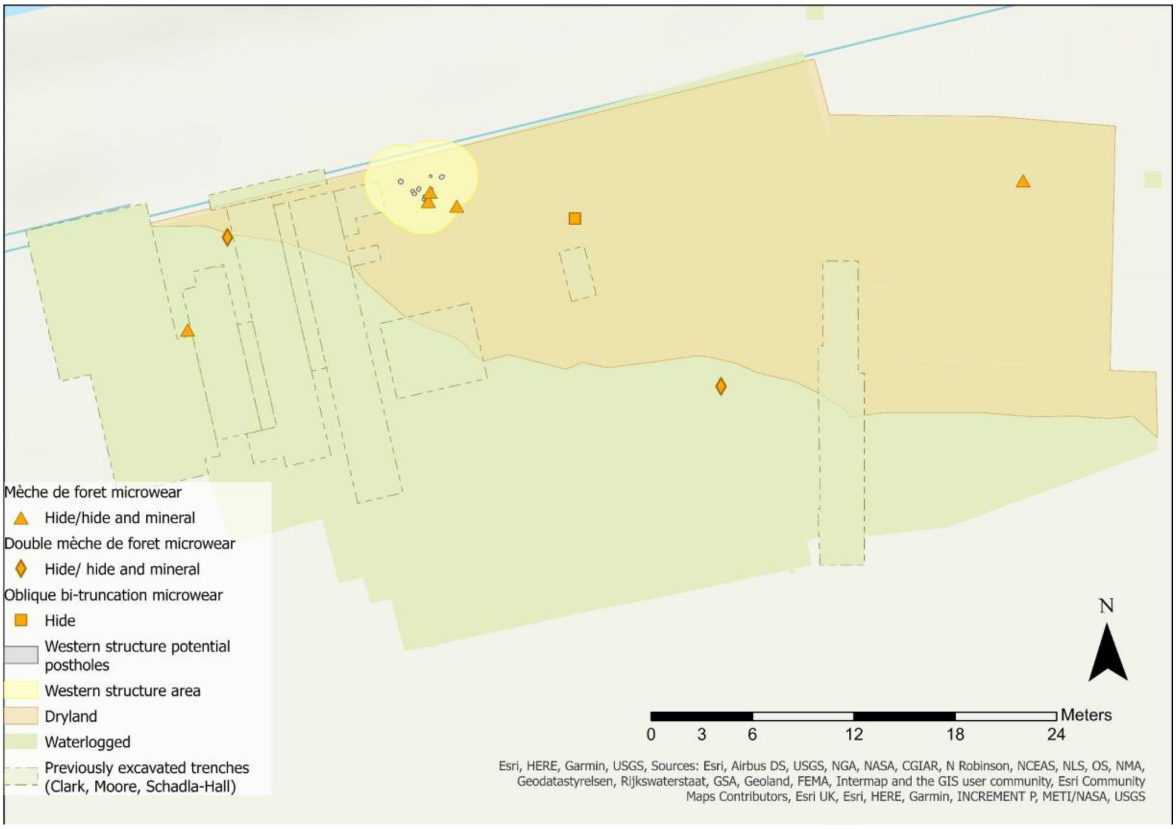


Figure 55: Distribution of awls interpreted as used to work hide and hide and mineral.

Of 8 awls identified as used to work hide and hide and mineral, five were mèche de foret, two were double mèche de foret, one was an oblique bi-truncation (see figure 55). Hide and mineral refers to the working of hide with a mineral additive, such as ochre. These awls show evidence of both developed and undeveloped polish, with developed examples exhibiting similar characteristics to an experimental awl used to pierce/drill dry hide for 30 minutes (see figure 56). The most frequently observed tip modification during experimental hide and mineral working was rounding and/or removals; this is consistent with microwear observations of heavily rounded working edges (see figure 56). Owing to the properties of hide and from experiments, a degree of rotational motion when using an awl can help to widen the perforation. Spatially, indirect evidence of hide working is spread across different areas of the site - in both the dryland and the wetland periphery (see figure 55). Unlike the other contact materials, awls used for hide working cluster within the footprint of the western structure features, with three awls found in close proximity, possibly suggesting this was an area with a particular focus on this task.

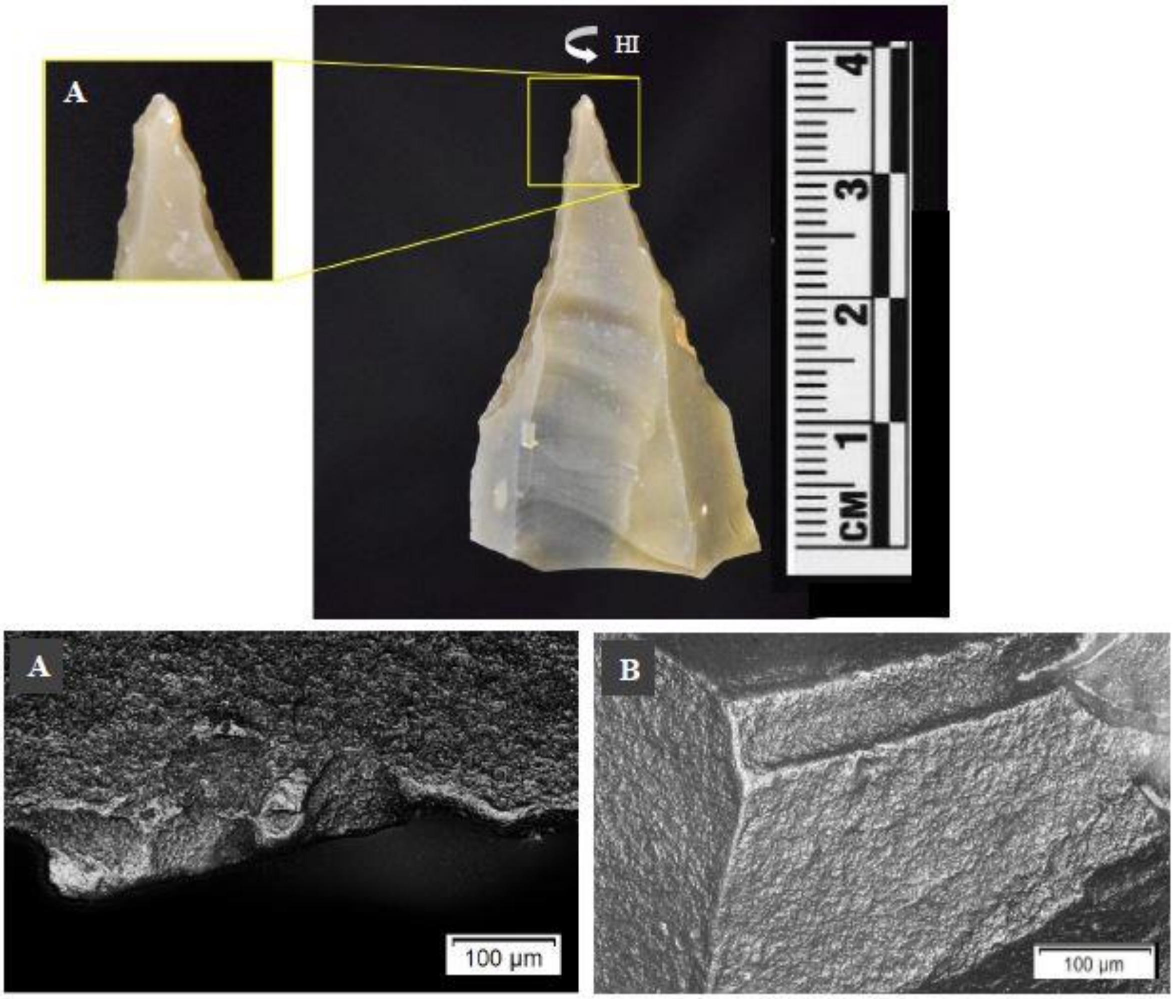


Figure 56: A - SC109731 an oblique bi-truncation interpreted as used for piercing hide, 200x magnification. No wear was observed on the ventral aspect. Note the area of tool A's edge to the right side of the image showing clear rounding; B - experimental mèche de foret used for 30 mins to pierce dry hide with red ochre freehand, image taken on the ridge of the dorsal, 200x magnification

5.4.1.3. Bone

Finds number	Awl type	Length (mm)	Cleaning	Tip modification	PDSM	Contact material	Extent of polish
96471	Mèche de foret	31	Soap	2	FeO staining	bone	developed
116369	Mèche de foret	41	Soap	2	FeO deposits	bone	developed
116995	Mèche de foret	44	Soap and chemical	1	FeO deposits	bone drilling	undeveloped

Table 11: Results from awls used on bone.

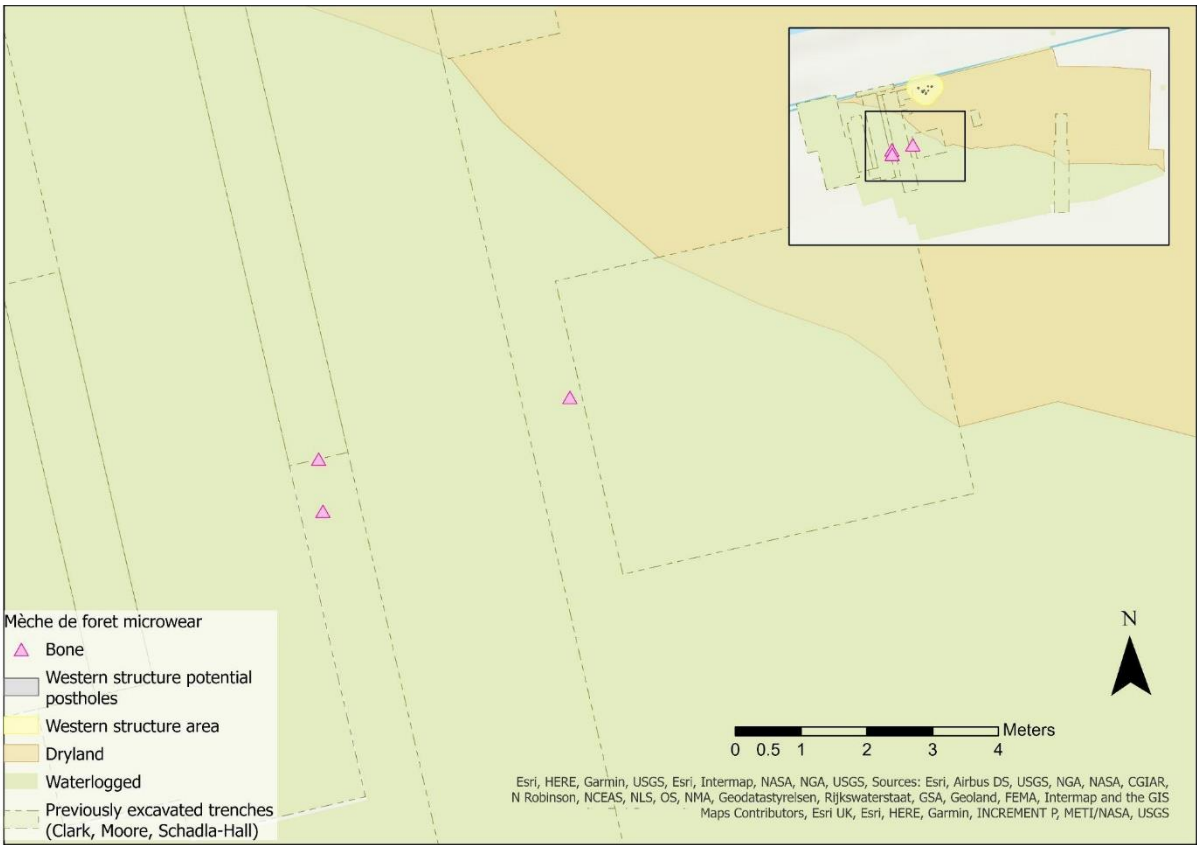


Figure 57: Distribution of mèche de foret interpreted as used to work bone.

Bone working was identified on three awls; all of which were mèche de foret. The spatial distribution of two of the mèche de foret correlates with the bone material found in this area by the Star Carr Project, which included 560 specimens of bone (including modified pieces) and antler (Knight *et al.* 2018b, 146). However, none of the bones or antler recovered evidence drilling; rather, analysis of the bone assemblage indicates it is the product of practices of formal deposition into the lake waters (Knight *et al.* 2018b, 137). The third mèche de foret located to the east of the other two mèche de foret (see figure 57), though in close horizontal proximity, is much higher in the sequence. While the deposition of the two earlier mèche de foret took place around 8800 cal BC, the third piece belongs to

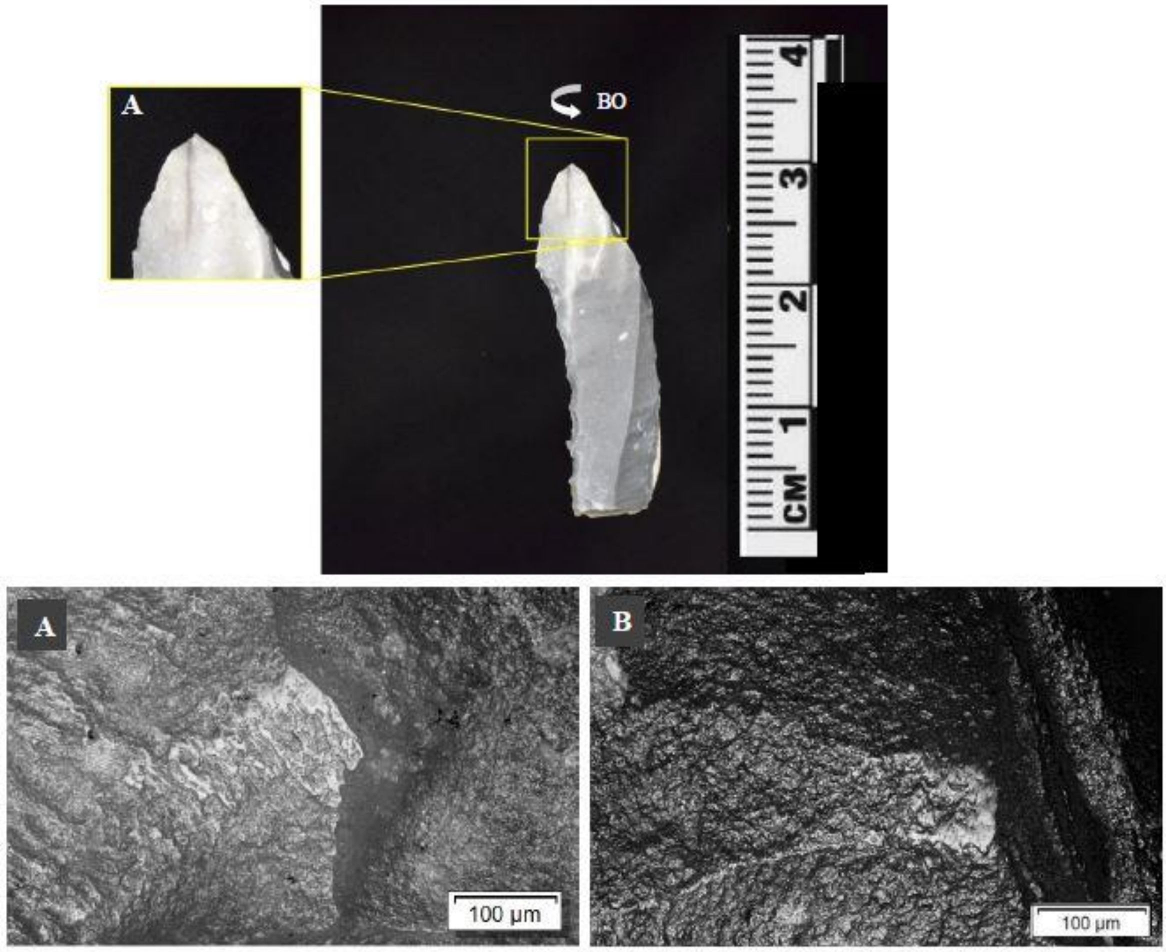


Figure 58: A - SC96471 a mèche de foret interpreted as used to drill bone, 200x magnification. No wear was observed on the ventral aspect; B - experimental mèche de foret used to drill dry bone for 1 hr, 200 magnification.

some of the latest activity two to three centuries later, when this had developed into an area of fen carr. Based on the edge damage on the mèche de foret, it is likely they were used in a rotational motion as a drill. The mèche de foret generally have developed polish and show similarities with an experimental mèche de foret used to drill dry bone for 1 hour (see figure 58).

5.4.1.4. Wood

Of the 6 awls used on wood, four were mèche de foret, one was a double oblique bi-truncation and one was a borer. Awls are spatially spread across the site although there is a general cluster to the south of the western structure area (see figure 59). Both developed and undeveloped polish was observed, although the developed examples appeared to have a less intense polish to the experimental tool used to drill seasoned wood for 40 minutes; it is possible that the Star Carr awls were used for a shorter duration (see figure 60). Awls associated with working wood are largely found to the west of the site but are most frequent near to the structure. There is no evident patterning by tool type.

Finds number	Awl type	Length (mm)	Cleaning	Tip modification	PDSM	Contact material	Extent of polish
94622	Mèche de foret	42	Soap and chemical	1	FeO deposits	wood drilling	developed
95321	Double oblique bi-truncation	81	Soap	1	FeO staining and flat dull polish	wood (one tip only) drilling	developed
110685	Mèche de foret	37	Soap and chemical	2	FeO staining	wood	undeveloped
93521	Borer	34	Soap	1	Flat dull polish	wood drilling	developed
94298	Mèche de foret	54	Soap	2	n/a	wood	undeveloped
97145	Mèche de foret	36	Soap	2	n/a	wood	developed

Table 12: Results from awls used on wood.

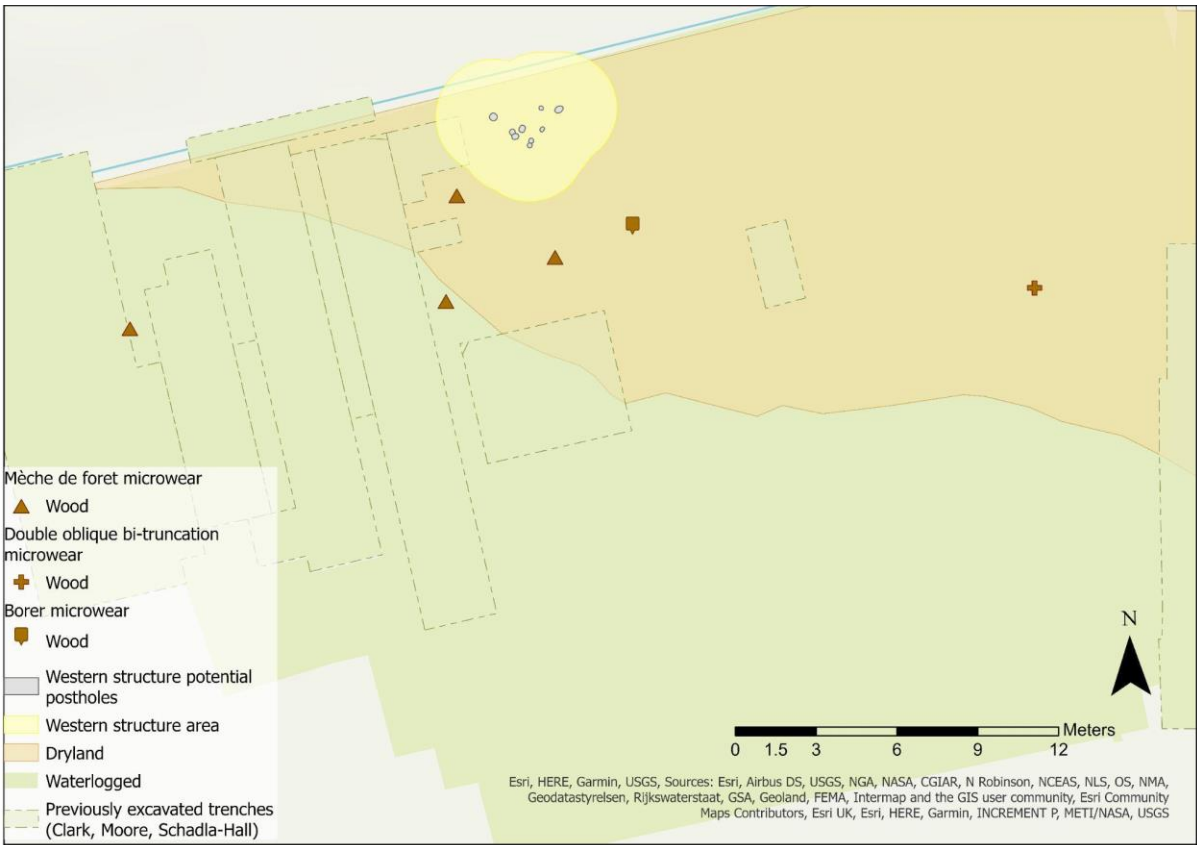


Figure 59: Distribution of awls interpreted as used on wood.

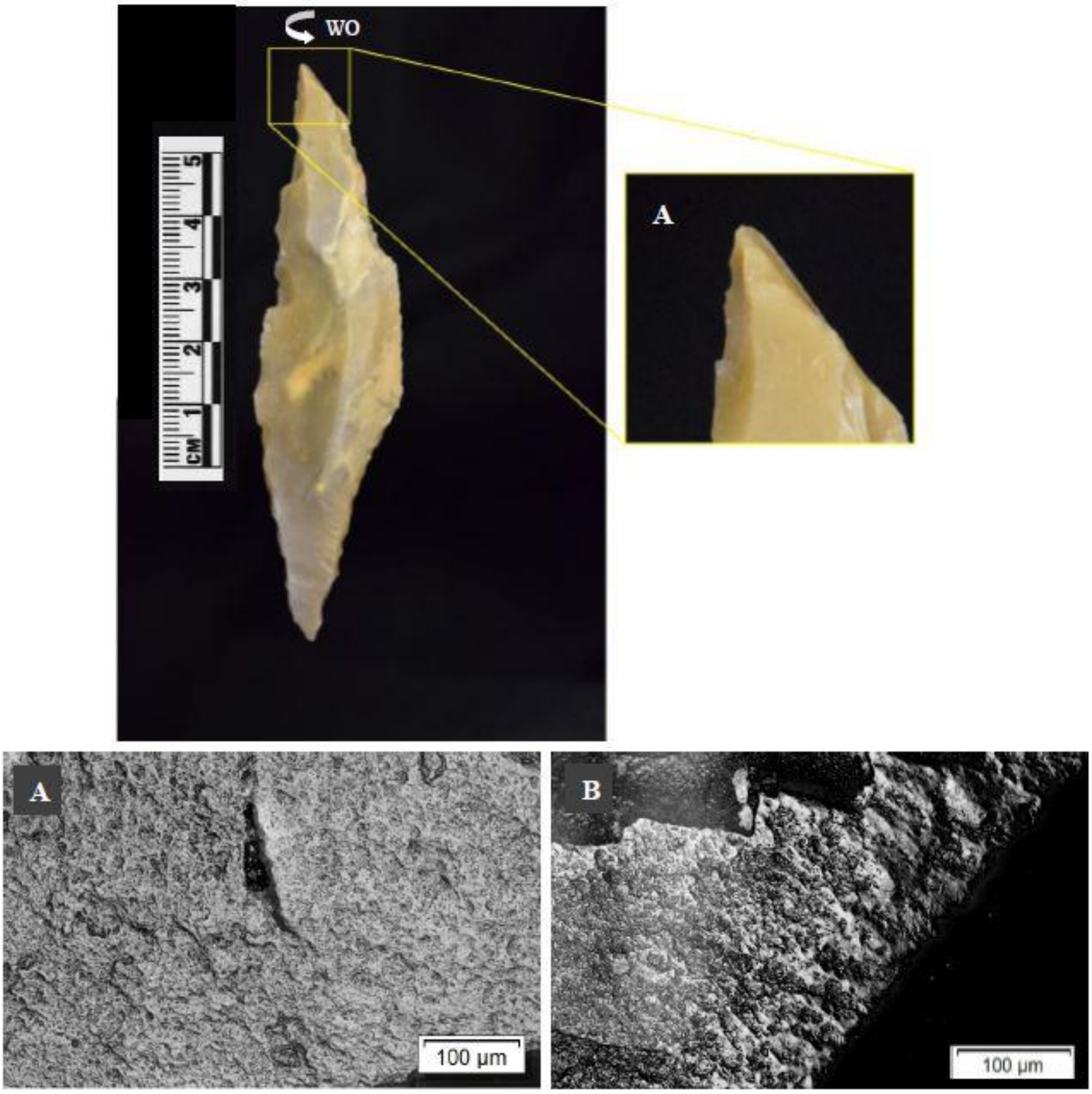


Figure 60: A - SC95321 a double oblique bi-truncation interpreted as used to drill wood, magnification 200x. No wear was observed on the ventral aspect; B - experimental mèche de foret used to drill seasoned wood for 40 mins, magnification 200x. The polish on A, the archaeological tool, is clearly less developed than the experimental tool.

5.4.2. Macroscopic results

5.4.2.1. Length

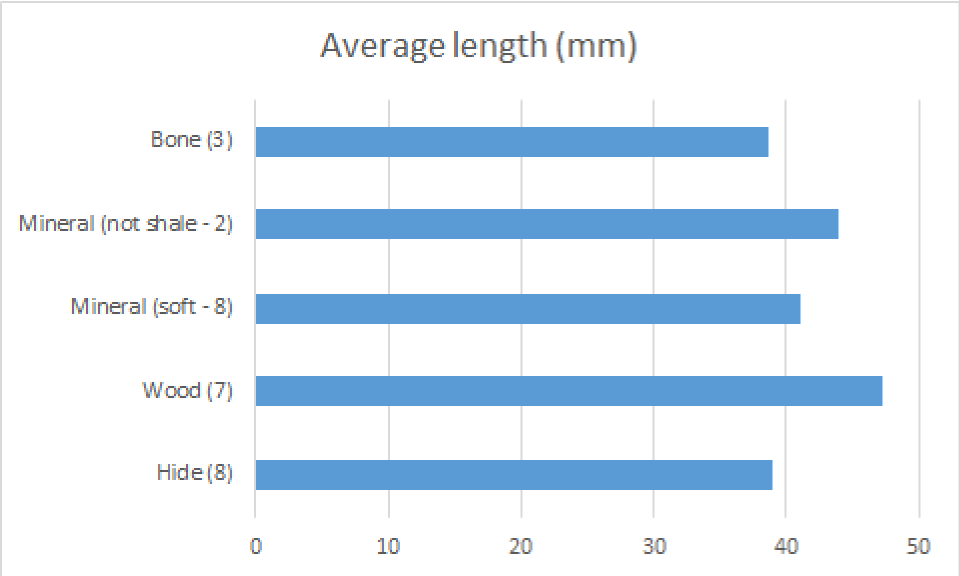


Figure 61: Graph showing the average length of awls based on contact material group.

The length of each awl was measured and the results are presented in figure 61. The data reveals only a modest difference in length of tool relative to contact material. Awls used in working wood are the largest tools, while the smallest tool was used to work bone. While it has been suggested that larger awls were likely used to work bone and smaller awls stone at Star Carr (Nash 2011), the data suggests the opposite is true. Awls for working mineral are modestly larger than those used to work bone. Tools are in the main of a similar length regardless of the contact material worked and by extension, length can be said to be a weak predictor of function at Star Carr.

5.4.2.2. Tip modification

An initial observation of the awls with the naked eye revealed 43 with some degree of tip modification, of which 12 had severe tip snapping which would prevent continued use for drilling or piercing tasks (see figure 52). The experimental results suggested that this severity of tip snap is unlikely to occur even when working with hard contact materials such as dry bone. Duration and intensity of use as well as hafting may be additional pertinent factors. The loss of awl tips may influence the quantity of tools displaying usewear. The awl tip is the primary contact area used in working, so it is probable that a number of the snapped awls were used and wear traces are now lost, leading to an underrepresentation of working traces in the sample.

5.5. Discussion

5.5.1. Introduction

The results encourage three areas of discussion that will be considered in turn: (1) functional considerations of awls at Star Carr; (2) what activities the identified contact materials might reflect and how this activity is spatially distributed; (3) whether the tools utilised and results generated can usefully augment existing Mesolithic awl typologies.

5.5.2. Awl function at Star Carr

The results provided minimal evidence to suggest an exclusive relationship between contact material and specific tool types (i.e. mèche de foret, oblique bi-truncation or borer). Instead, both mèche de foret and oblique bi-truncations were employed across a range of contact materials. In the case of hide, wood, soft mineral and hard mineral, mèche de foret, oblique bi-truncations and borers were used. The working of bone is a possible exception as only mèche de foret were used. The mèche de foret was the most common tool utilised for working each contact material, while 9/11 tools displaying rotational removals can be classified as mèche de foret or double mèche de foret. The three awls with well developed soft mineral traces, as well as 5 additional awls with less developed traces, provide an important insight into personal ornament production and use at Star Carr, suggesting significantly more shale beads were produced at the site than were excavated.

Neither mèche de foret nor oblique bi-truncations appear to have been used exclusively for a particular type of working motion at Star Carr. In both cases, mèche de foret and oblique bi-truncations were used on contact materials where drilling would be required, but were each also used to work hide, where a combination of piercing and rotational motions was likely employed to create and widen each perforation. The available data does not support a rigid distinction of discrete uses, but rather suggests that use was more nuanced and variable across different awl forms.

Previous technological studies (e.g. Nash 2011) have suggested that length could be a diagnostic measure of function. However, the results from Star Carr do not support this. There is no archaeological patterning in use based on the size of the awl (see figure 61) and similarly this did not prove to be a significant factor during experimentation. Further, tip modifications on the Star Carr Project awls, as well as comments by Clark (1954, 106) of 14 awls missing a tip, highlight that severe tip snapping is significant at Star Carr. The reason for this pattern remains unclear at this stage and requires further work.

The extent of tip wear provides important insights regarding raw material sourcing and tool use at Star Carr. As shown through the tip modification groups, not all awls were used to exhaustion. From macro-observations, 40 awls still had a functional tip, based on experimental observations from using mèche de foret extensively on different materials. This is interesting given that much of the flint used, around 90%, favours good quality till flint sourced from the coast, some 10km away (Conneller *et al.* 2018b, 499). Further work is required to understand why tools that are made from a material requiring transport might be deposited before being exhausted. Experimental data suggests that tool efficacy diminishes once the tip begins to significantly wear. In a context where raw material is plentiful, it may be preferable to discard and make a new tool rather than extend the life of a worn tool.

Mèche de foret at Star Carr have previously been interpreted as multi-functional craft working tools (Conneller *et al.* 2018b; Needham *et al.* 2018) and this can now be extended to all recently excavated awls. The primary role of this broad tool type appears to be drilling with some evidence for piercing. While microwear results have advanced understanding of use through the range of contact materials identified, translating these traces into particular activities remains challenging and in some cases necessarily speculative. The evidence for soft mineral translating to shale bead/pendant production is strong, with some possibility of mineral traces relating to amber pendant production. Relative to other materials, mineral can be expected to preserve well and there are only limited alternatives to shale or amber from the materials found at the site. Ochre would be the primary candidate, but this is discernible from shale and has been identified as used in combination with hide.

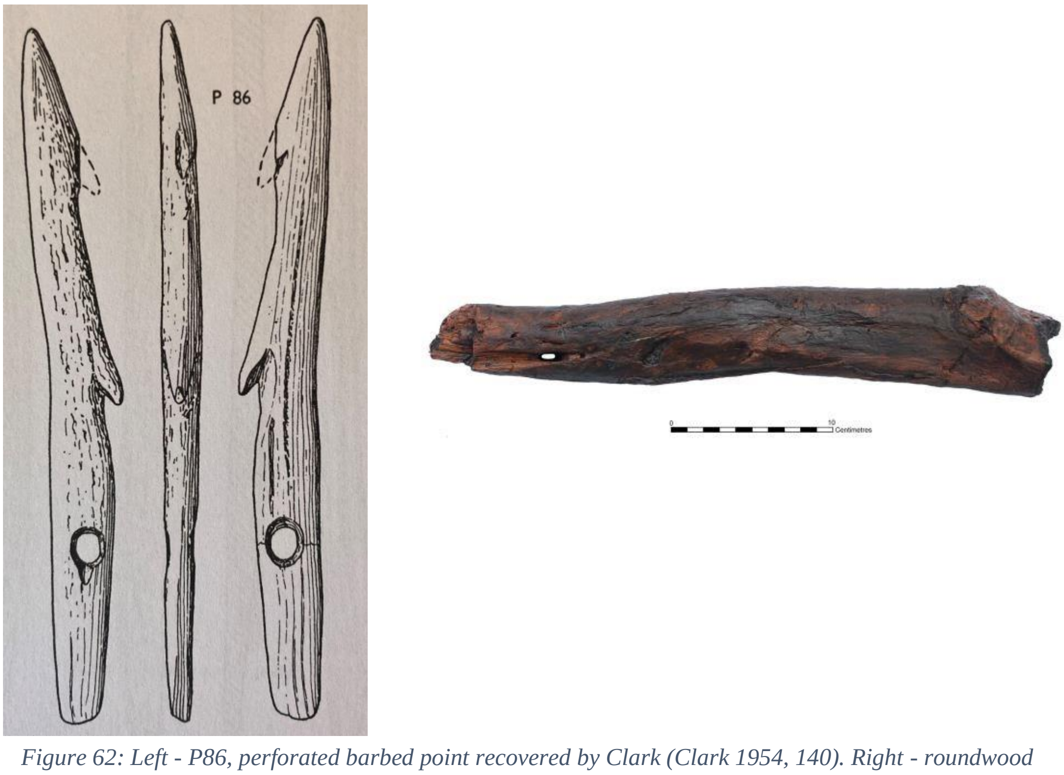


Figure 62: Left - P86, perforated barbed point recovered by Clark (Clark 1954, 140). Right - roundwood identified with hole <115952> (Copyright Michael Bamforth in Bamforth et al. 2018b, 399).

While animal hides have not been preserved at Star Carr, their use as part of clothing - sometimes decorated with beads - is widely attested in the Mesolithic (Cristiani and Borić 2012; Cristiani *et al.* 2014; Mărgărit *et al.* 2018) and seems a likely possibility at Star Carr. Equally, the sewing together of hides to cover structure is also a possibility (Taylor, B. *et al.* 2018b). Wood and bone are perhaps more difficult to interpret. In both cases, the range of preserved examples of perforated objects is minimal. For bone, it is possible that perforated teeth used as pendants could account for some of the wear. Additionally, Clark recovered an antler barbed point (P86) that appears to have been perforated, (see figure 62); however, as bone and antler microwear polish can be difficult to differentiate when undeveloped, it is possible that some awls may have been used to drill barbed points (Clark 1954, 140). Despite the plentiful recovery of wooden artefacts (Taylor, M. *et al.* 2018), only one piece of roundwood exhibited signs of a perforation, though it is morphologically very different to perforations observed from experimental drilling of wood (see figure 62). This leaves the role of drilling wooden artefacts an open question. It is likely that broken wooden objects would have been burned as fuel for fires, which could go some way to explain the lack of perforated wooden objects.

5.5.3. Spatial distribution of activities at Star Carr

Generally, microwear traces show no obvious spatial clustering based on contact material across the site. However, there are several exceptions to this: bone working was focused in and around a large deposit of bone material; soft mineral traces were primarily observed to the west of the site but across a large area along with soft/medium and soft indeterminate materials. Awls used to work hide and hide and mineral were spread across the site, though they were the only contact materials found closely associated with the western structure, from those identified. Only two mèche de foret were found next to the western structure features: both of these were interpreted as used to work hide and hide and mineral. While the western structure area may be associated with secondary deposition of flint waste (Conneller *et al.* 2018a), the microwear results suggest that patterns of awl activity in the western structure area were more clearly defined. Considering the hide and hide and mineral traces alongside the indeterminate results (soft/medium indeterminate (1), hard indeterminate (2)) from this area, the western structure maintains a smaller range of worked materials compared to the surrounding areas. This pattern is of interest as areas of secondary deposition are probably more likely to reflect a heterogenous range of materials and activities from across the site, rather than a limited selection. Alternatively, it is possible that material has been deposited here from specific working areas, supporting the hypothesis of a middening area.

The spatial results further highlight the importance of caution in assigning function based on spatial proximity of tools and artefacts. For example, awls found close to the shale beads were not more likely to show extensive microwear traces of shale. Studies which rely on spatial analysis and typology in isolation are therefore potentially limited as the true range of uses can be more complex than the spatial patterning might imply.

Given awls were used on a wide range of contact materials it is interesting to consider potential spatial relationships between different materials involved in specific tasks. Thinking about the relationships between contact materials and how they translate into separate or related functions in this way may prove fruitful in trying to understand Mesolithic craft practices; how different aspects of craft were related, and how this might manifest spatially. The theme of drilling shale beads can be extended to consider their relationship to piercing/drilling animal hides. Given the relative spatial proximity of shale and hide working, it is possible these activities could be part of a more complex chaîne opératoire of production of composite objects: in this case animal hide garments with shale bead appliqué (Needham *et al.* 2018; figures 53 and 55).

Interestingly, two awls - one mèche de foret and one double mèche de foret - were recovered from the wetland periphery to the south-east of the site; the former used on soft mineral and the latter on hide and mineral. Similar to the organic material found in this area, such as dehafted barbed points, antler headdresses, complete animal carcasses and articulated faunal remains, the awls can be interpreted as intentionally deposited. The use of these two awls and their deposition alongside material interpreted as part of a ritual deposition might further suggest that awls were seen as important tools, used to produce objects of possible ritual significance. While caution is needed when inferring spatial relationships based on proximity of tools and other artefacts, microwear can allow patterns to emerge, both within and across contact material classes, providing insight into spatial patterning of activity.

5.5.4. Moving beyond form as function: Augmenting typologies

Drawing from discussions pertaining to awl use and spatial relationships at Star Carr, suggestions can be made that are pertinent to debates surrounding Mesolithic awl typologies more widely. A significant sample of awls was analysed (54) for a single tool category when using microwear analysis and where spatial data is also available. Size does not appear to be a robust indicator of function, neither is a typological designation as a mèche de foret, oblique bi-truncation or borer. Typology remains essential in organising collections and attempting to create a common language to consistently describe artefacts. However, typologies could be usefully augmented by the addition of increasing datasets that make use of macroscopic observations and spatial analysis, providing an increasingly robust and independent means of assessing use. In turn, this could facilitate increasingly unified typologies and common languages, tackling some of the key challenges identified in lithics analysis in recent decades (Ballin 2000, 2021).

5.6. Conclusion

The results of macroscopic observations, microwear and GIS suggest awls were used to work a range of materials: soft mineral (shale), hard mineral (amber), bone, wood, hide, hide with mineral, mostly in a drilling action and more rarely a combined piercing and drilling action. Despite the typological distinction of mèche de foret, oblique bi-truncation and borer, morphological variables prove to be inaccurate when compared against results generated using microwear and macroscopic tip analysis. Plotting microwear results using GIS provides spatial insights about awl use which can be used to identify activity areas or perhaps even how different activities may connect into more complex sequences of production. In the case of Star Carr, there appears to be a connection between drilling shale and piercing/drilling hide, with the former possibly being applied to the latter via appliqué. These activities also show a spatial association with the western structure, possibly suggesting this was an area where these composite objects were produced. Awls are rarely studied in this level of analytical detail and the analysis of a large sample has demonstrated their important role as multifunctional craft tools. It seems likely they played an essential role in the Mesolithic hunter-gatherer toolkit at Star Carr and beyond.

At a broader level, the integrated methodological toolset adopted here provides a useful means of augmenting typology. Typology provides an important way of communicating precise forms in a common language, facilitating inter- and intra-site comparison and aiding in cataloguing and curation. Microwear, GIS and macroscopic modifications further understanding of use where preservation of microwear traces allows these methods to be employed. With greater application of this integrated methodological approach to the study of prehistoric lithic scatters, the data generated may allow for more rigorous inference of tool functions, specifically at sites where detailed microwear analysis cannot be undertaken.

Chapter 6: Eastern structure and surrounds

6.1. Introduction

This chapter will first set out the previous work undertaken on the eastern structure, explaining the features, excavated faunal remains and the spatial, technological and previous microwear analysis of the flint. The second part of the chapter sets out the results of the new microwear analysis: an overview is first given before presenting the results by tool type and then by worked contact material. Interpretation of the results will be presented in the third section and includes relevant previously acquired microwear data from the Star Carr Project which consists of seven flints from the structure (Conneller *et al.* 2018a).

6.2. Introduction to the structure

The eastern structure comprised a hollow measuring roughly 20cm deep and at least 2.8m wide surrounded by postholes (see figure 63) (Taylor, B. *et al.* 2018b, 63). Most features (15) were interpreted as postholes, holding largely upright posts, consisting of an outer and inner arc, with two clusters to the west (see figure 64) (Taylor, B. *et al.* 2018b, 64). Three small pits were also found (Taylor, B. *et al.* 2018b, 64). The hollow had two fills, a lower one containing high organic content and an upper fill where most lithics were recovered (Taylor, B. *et al.* 2018b, 63). Micromorphological analysis indicated that a plant layer was present in the lower fill, potentially from matting placed onto the floor made from reeds or bark (Milner *et al.* 2015, 129; Taylor, B. *et al.* 2018c, 63). No samples were taken for geochemical analysis, so interpretations of the structure relied on flints and faunal remains.

Figure 63: Eastern dryland structure with hollow and postholes that have been half sectioned (Copyright Star Carr Project in Taylor, B. et al. 2018b, 64).

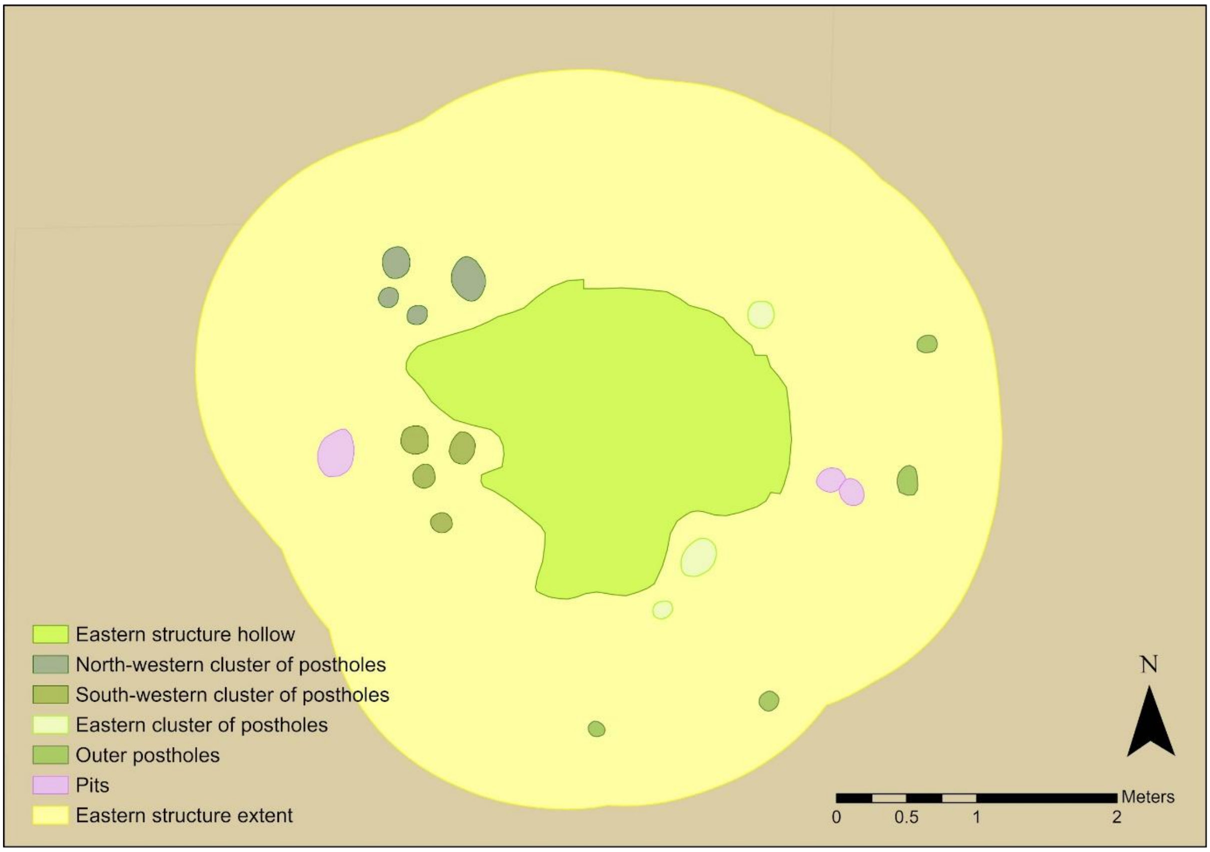


Figure 64: Plan of features associated with the eastern structure (after Taylor, B. et al. 2018b, 65).

Three spatially discrete clusters of animal bone were found, comprising 87 fragmentary and poorly preserved pieces, making species, element and modification identifications difficult (Knight *et al.* 2018b, 130). The fragments may have been lost or trampled through gaps in a possible organic floor covering, thereby not cleared from the structure. Cervid and aurochs remains are dominant, with a few pieces displaying heat treatment and/or human modification. These traces are likely associated with dietary waste and possible tool production (Knight *et al.* 2018, 130). Smaller species were identified through soil flotation, including fish, pine marten and rodents, and most displayed signs of burning (Knight *et al.* 2018b, 130). Rodent remains indicated a commensal relationship between inhabitants and rodents (Knight *et al.* 2018a). Food appears to have been processed and consumed in the structure, with longitudinally split bones suggesting craft activities. Tasks were interpreted as undertaken at separate times, based on the three separate clusters (Knight *et al.* 2018b, 131).

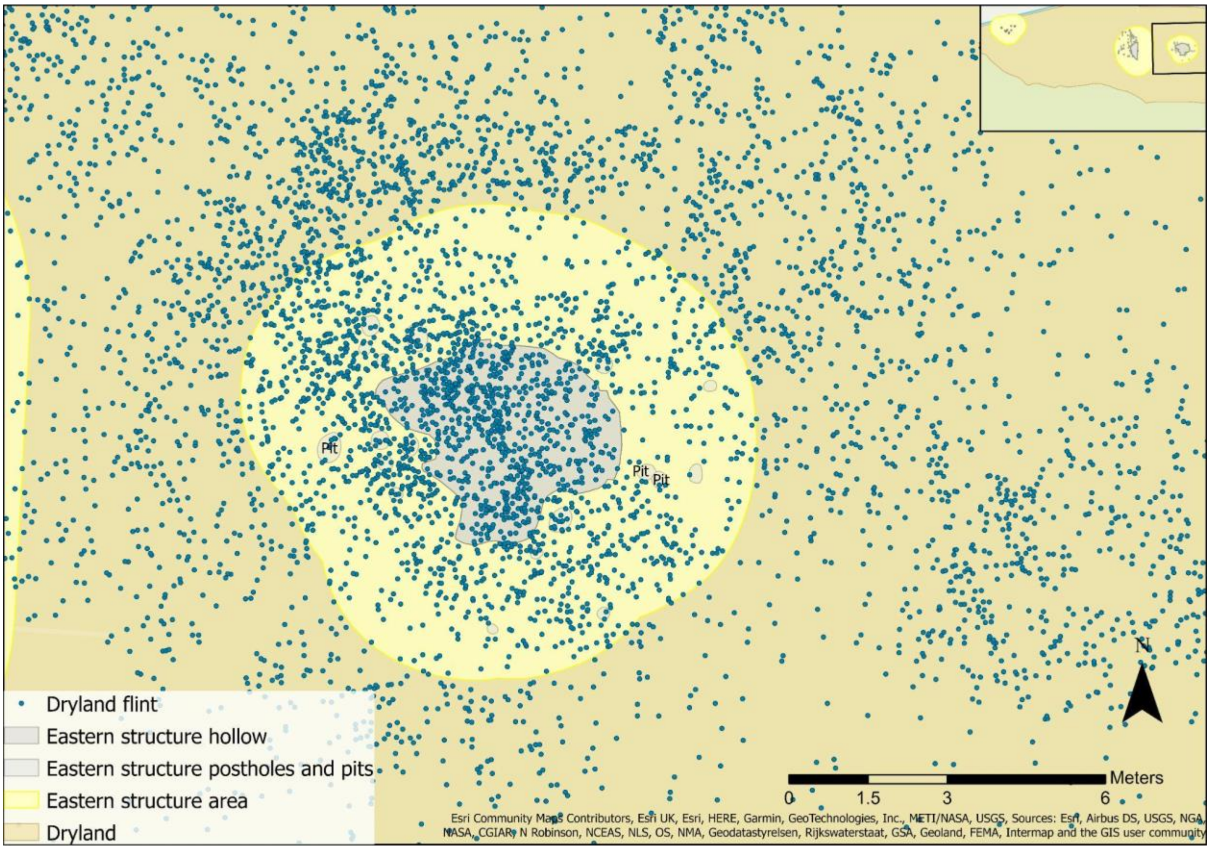


Figure 65: Density of flint associated with the eastern structure and its surrounds (after Conneller et al. 2018a, 173).

A density of flint was found within the hollow and its surrounds (see figure 65). Of the 1921 flints, 135 were tools and 50 were tool spalls, with high frequencies of fragmented material (Conneller *et al.* 2018a, 174). Most of the larger flints were interpreted as having been transported out of the structure, with *in situ* flint knapping occurring inside (Conneller *et al.* 2018a, 175). Similar to the animal bone, flint debitage was not cleared but instead may have fallen through gaps in a possible organic floor covering. The edge of the outer postholes was interpreted as the structure's boundary, based on flint densities and refits (Conneller *et al.* 2018a, 176). Microwear results from six tools showed different tasks undertaken inside the hollow and repair and re-use of some flints was used to suggest that a tool kit was stored here, indicating a 'household level of ownership of certain tools' (Conneller *et al.* 2018b, 533). Food processing, eating, tool maintenance, sporadic tool use for craft activities were all identified in the structure (Taylor, B. *et al.* 2018c, 261; Taylor *et al.* 2019, 11).

6.3. New microwear results

6.3.1. Overview

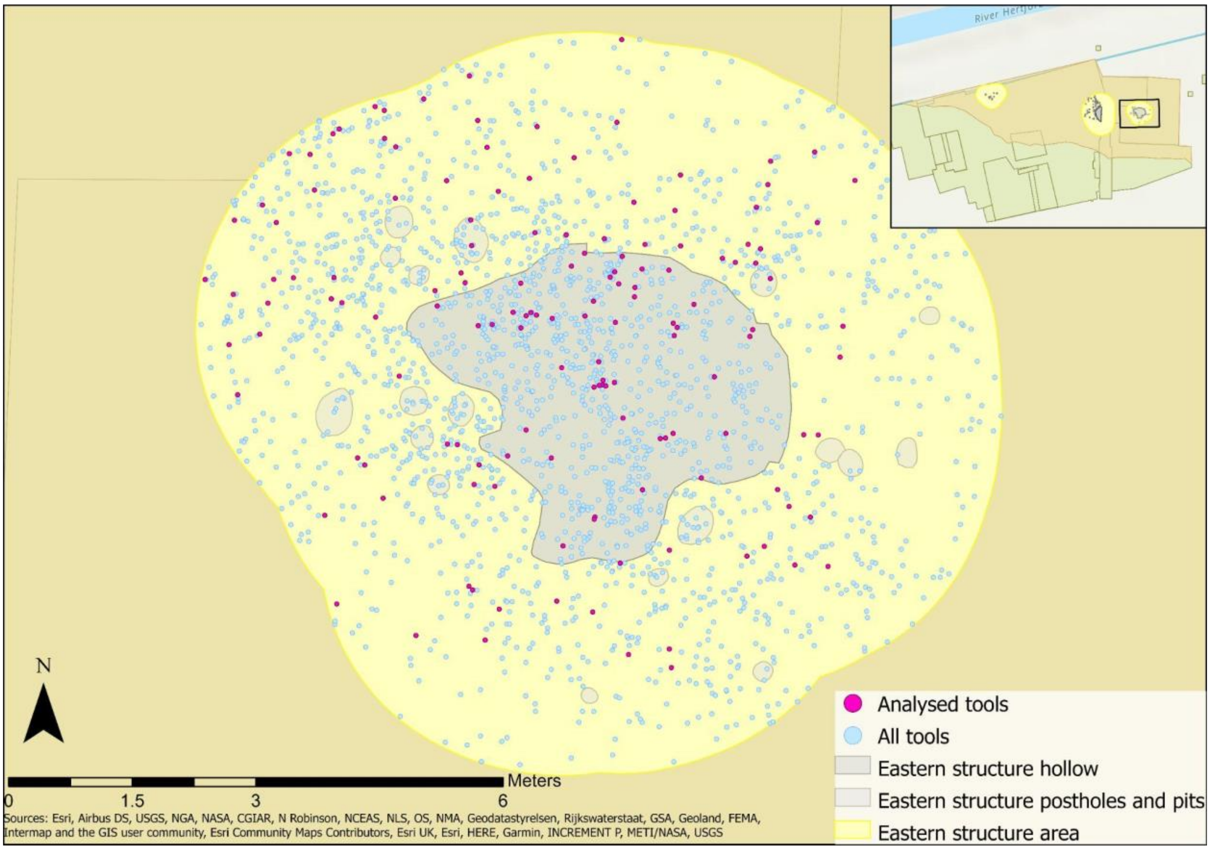


Figure 66: Distribution of analysed pieces alongside all flints found within the eastern structure area.

In total, 146 tools were analysed from the eastern structure and its surrounds; 52 (35.6% of the total analysed sample) were located within the hollow (see figure 66). From the analysed tools, 52 (35.6%) were interpreted as not used. Rates of use and PDSM (post-depositional surface modification) are unlikely to be representative of all flints, as 80 were selected during the second sampling phase. However overall, there were good levels of microwear preservation and low levels of PDSM. Wear traces were observed on 64.4% of tools. The frequency of PDSM on tools was generally low; 54 (37%) evidenced iron oxide staining or deposits, 39 (27%) flat dull smoothing, and 22 (15%) metallic striations. Only two tools were chemically cleaned, <85889> a blade and <87418> a microburin.

A range of materials were worked (see table 13). Bone was the most frequently worked material (15), followed by: meat (10), plant (8), hide (8), wood (6), use as a projectile (5), antler (1), fish (1). Where hardness of material was identified (but not specific contact material), most flints showed signs of working a medium indeterminate material (14), soft/medium indeterminate (9) or soft indeterminate (8) material. It was largely a lack of well-developed polish which meant contact material could not be interpreted.

Primary contact material	Secondary contact material	Motion of use	Number
Antler		Transverse	1
Bone		Transverse; longitudinal	11
Bone	Meat	Transverse; longitudinal	3
Bone	Hide	Transverse	1
Fish		Transverse; longitudinal	1
Hide		Transverse; perforating	6
Hide	Soft mineral	Transverse	2
Meat		Longitudinal	4
Meat	Bone	Longitudinal	6
Projectile	Bone	Longitudinal (hafted)	3
Projectile	Meat	Longitudinal (hafted)	1
Projectile	Hide	Longitudinal (hafted)	1
Plant (inc. plant/soft wood)		Transverse; longitudinal	7
Plant	Meat	Transverse; longitudinal	1
Wood		Transverse; longitudinal	6
Soft indeterminate		Transverse; longitudinal	8
Soft/medium indeterminate		Transverse; longitudinal	9
Medium indeterminate		Transverse; longitudinal	14
Medium/hard indeterminate		Longitudinal	1
Hard indeterminate		Transverse	1
Indeterminate		Unknown	7
Not used (no clear signs of use)		n/a	50
Not possible		n/a	2

Table 13: Microwear results from the eastern structure area.

6.3.2 Tool types

There were 313 bladelets excavated, and 59 (19%) were selected for microwear analysis. Signs of use were observed on 32. Bone traces were frequently identified as a primary contact material (10), with both transverse and longitudinal directionality. On these tools, meat (2) and hide (1) polishes were also observed. Two bladelets were used longitudinally on meat and bone, with meat interpreted as the primary contact material. Hide and meat scraping was identified (1) and possible transverse antler traces (1). Transverse plant and plant/soft wood polish was observed (4), of which one bladelet also had longitudinal meat traces, and two bladelets were used to cut and scrape/plane wood. Six tools had soft or soft/medium indeterminate longitudinal polish, with fewer transverse and longitudinal medium (4) or medium/hard (1) indeterminate traces. Only one bladelet had an indeterminate identification.

Of 25 blades identified, 19 (60%) were studied for wear traces and 15 had signs of use. Most were used on vegetal materials (4); to scrape/plane siliceous plants (2) or plant/soft wood (1), and to cut wood (1). Fewer tools were used to cut and scrape bone (2), and one was used transversely on hide and bone. Six blades were assigned a hardness of material, the majority were soft indeterminate (3), with less soft/medium (2) and medium indeterminate (1). These displayed both transverse and longitudinal directionality. Indeterminate wear traces were observed on two tools.

In total, 27 scrapers were recovered, of which 15 (55%) were selected for analysis and all showed signs of use. The majority with identifiable wear traces were used transversely on hide (5). Of these, two had fresh hide polish and two were possibly used alongside a mineral additive on dry hide. One scraper had transverse bone traces and another was used possibly on fish in longitudinal and transverse directions. Transverse working of medium indeterminate materials were observed (5), along with soft and soft/medium indeterminate materials (2). One tool was used on an indeterminate material.

There were 959 fragments excavated, and wear traces were studied on 14 (1%), 10 of which had been used. Most were either used to cut meat (2), or in transverse and longitudinal directions on wood (2). One had traces from cutting plant/soft wood. Soft or soft/medium indeterminate polish was observed (3), and two pieces had indeterminate wear traces.

Of 35 microliths identified, 12 (34%) were analysed, of which 9 showed signs of use. The majority had traces of longitudinal bone working (4), of which three were possibly hafted. Fewer tools were used longitudinally on meat (3), with two also used on bone. Only one possibly hafted microlith had faint microscopic linear impact traces (MLITs), alongside longitudinal bone and hide traces. One microlith had indeterminate traces.

In total, 401 flakes were recovered and wear traces were assessed on 11 (3%), five of which had wear traces. Two were used longitudinally on meat and bone. Hardness of material was identified for the remaining flakes, which were used longitudinally on soft/medium (1) and medium (2) materials. There were 32 burin spalls excavated, and six (19%) were examined, of which four had signs of use. Two were used to cut bone and meat, although one only showed possible bone traces. Transverse medium (1) and hard (1) indeterminate materials were identified on the remaining burin spalls.

Only eight microburins were identified, of which five (63%) were studied for wear traces; two had signs of use. Longitudinal meat traces were observed on one, and the other had transverse medium indeterminate polish. Of 15 burins found, four (27%) were analysed, of which one had signs of use. It had traces of dry hide perforating with a possible mineral additive. Three axes were located in the eastern structure area, one (33%) was selected for microwear analysis. It was used to chop wood and was likely hafted.

6.3.3 Bone

Fifteen tools had signs of bone working. Tools were used in both transverse and longitudinal directions, suggesting that they were used to scrape, cut and groove/engrave bone. To the south of the hollow, two bladelets (<83289>; <85065>) were interpreted as butchery tools (see figure 67). Both bone and meat polish were identified on the same edge in scraping and cutting motions, as would be expected if removing meat from a carcass. One of the bladelets was also interpreted as showing signs of bone engraving, separate from the butchery-related polish. The last bladelet in this group (<85213>) was used to cut bone, and polish was concentrated to a small area on both the dorsal and ventral surfaces. This could suggest that it was used to cut a small bone or small area. A scraper was used to scrape bone, with a non-invasive polish.

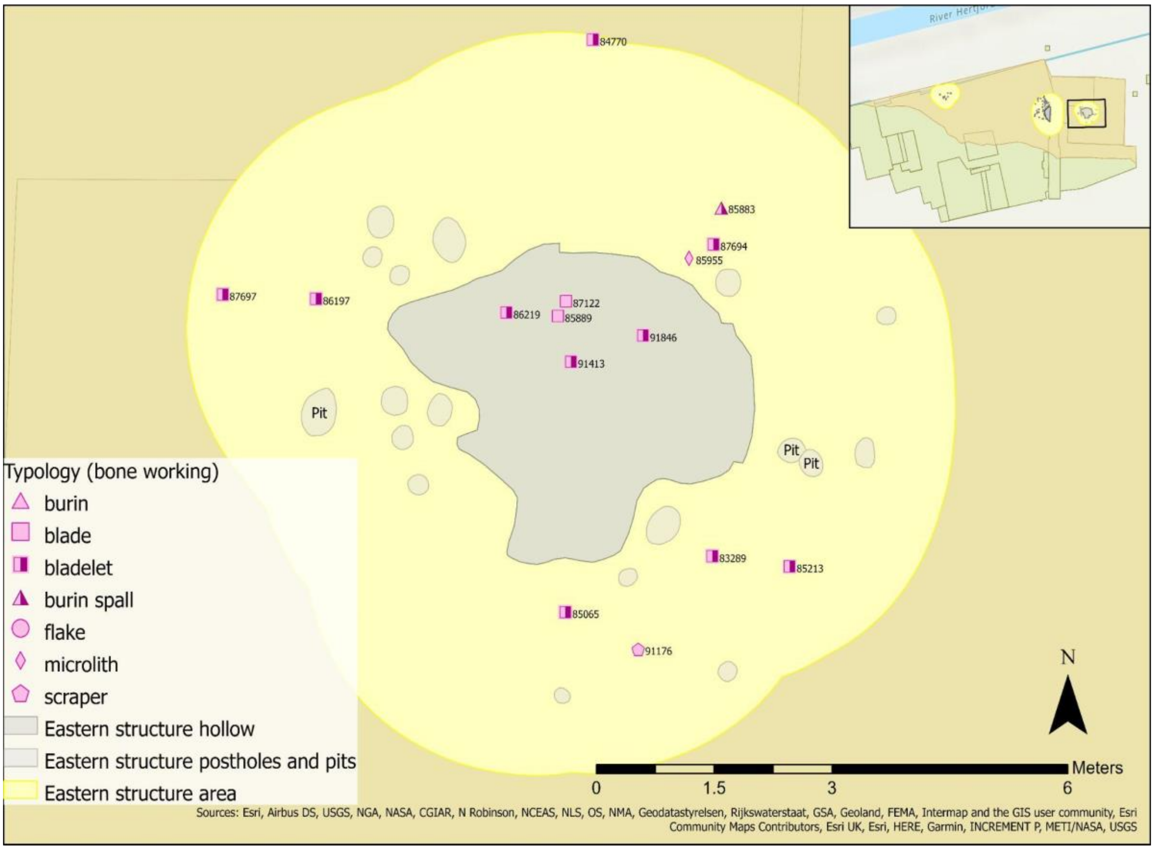


Figure 67: Distribution of bone working tools found in the eastern structure area.

Transverse bone and hide working were found on the same edge of another bladelet (<91846>) found in the hollow (figure 67). These two materials may be related to the same activity or were worked within a close timeframe. Four other flints found in the hollow displayed polish from bone engraving (<91413>; <85889>), scraping (<87122>), and cutting (<85889>; <86219>; <87122>). These tools may have been used for tasks such as cleaning, cutting and splitting bones.

A burin spall was interpreted as a butchery tool, and two tools clustered to the north-east of the hollow (see figure 67), comprising a microlith used to engrave bone and a bladelet with traces from cutting and engraving bone. The microlith had no obvious hafting traces or MLITs, which are often associated with use as a projectile. It may have been a hafted projectile with no identifiable traces, or had a secondary use to engrave bone as a composite hafted or individual unhafted tool. Alternatively, it may not have been hafted at all during its use on bone. The bladelet showed well developed bone polish from cutting and scraping; the distal tip was used to scrape and a lateral edge was used to cut (figure 68). This cluster appears similar to those within the hollow, with evidence of butchery and some actions relating to specifically to bone working.

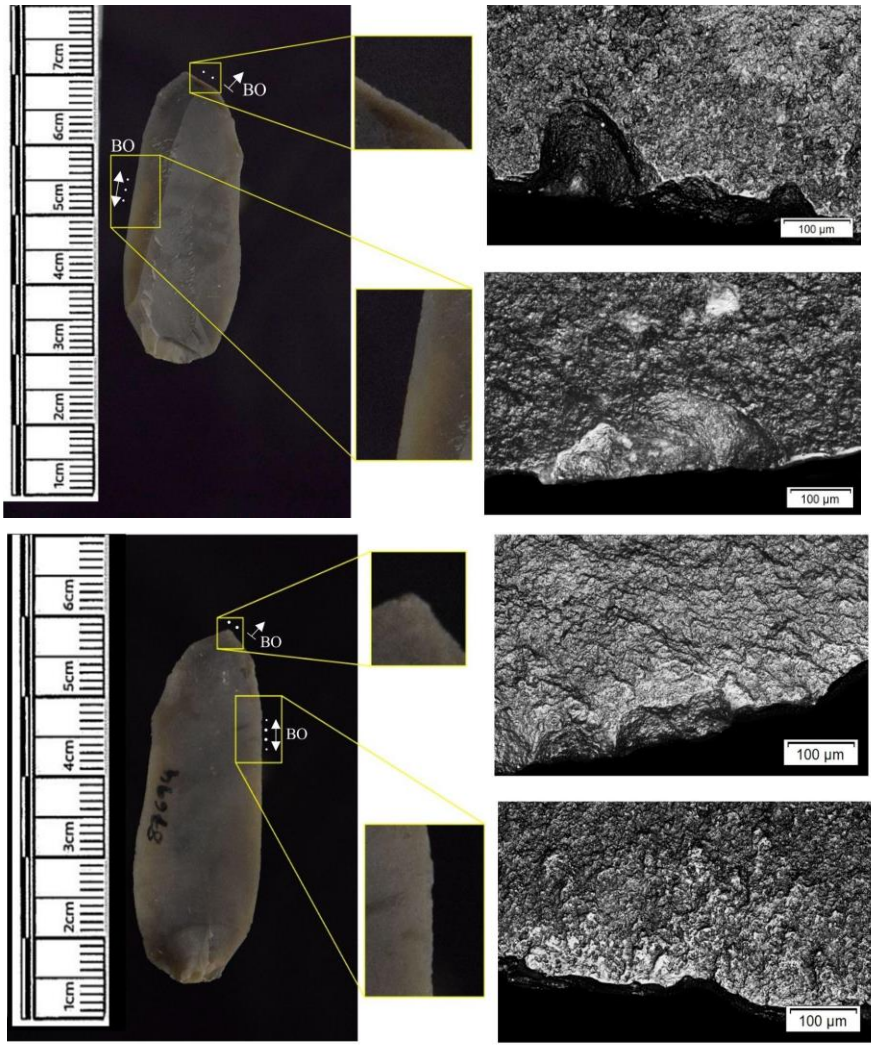


Figure 68: SC87694, a bladelet interpreted as showing well developed bone polish on ventral aspect, with some polish observable on the dorsal aspect, 200x magnification.

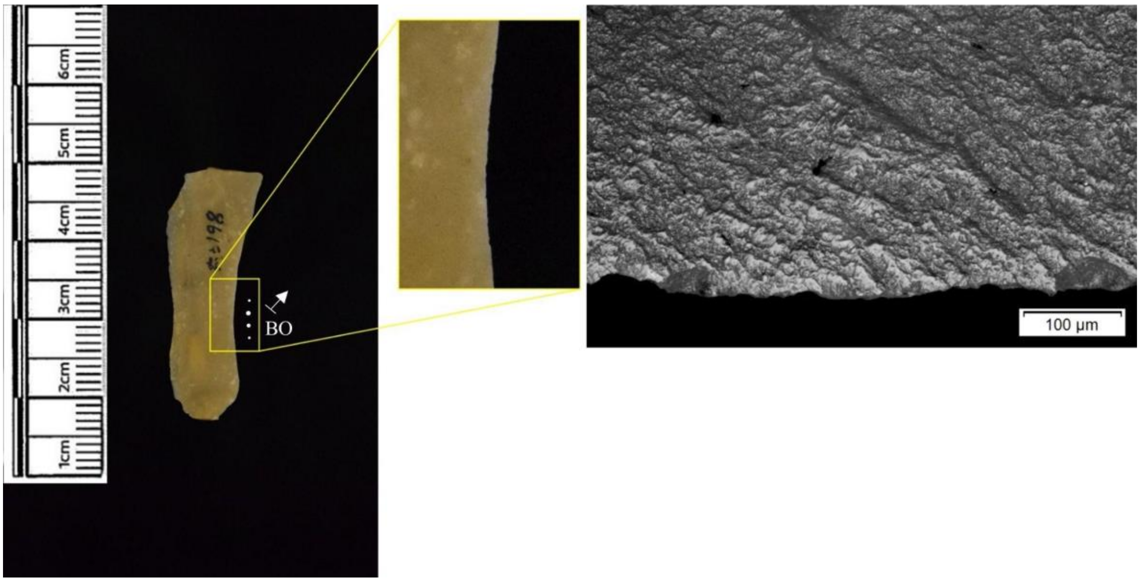


Figure 69: SC86197, a curved bladelet interpreted as showing developed bone polish from scraping on ventral aspect, 200x magnification. No polish was observed on the dorsal aspect.

Two bladelets found to the west of the hollow were both used to scrape bone. Both had a curved edge (see figure 69), which likely made them more effective at scraping a rounded surface like bone. A bladelet located at the northerly edge of the structure area, was used to groove and cut bone. The tip had traces from engraving bone, with polish from cutting seen on the lateral edge. It is possible that it was used for processing bone for secondary uses, such as bone objects.

Spatially, bone working tools in the hollow cluster in the north, with those outside of the hollow also located to the north of this area. There are no obvious differences between the actions identified on flints to the north, and those found to the south of the hollow; engraving, cutting and scraping were observed in both groups. Tool types do not vary considerably; the presence of a single scraper and a lack of blades in the south are the only notable differences. From the microwear and spatial location, there are two distinct groups that suggest related use on specifically bone: 1) two curved bladelets used to scrape bone found to the west of the hollow; 2) tools within the hollow possibly used in bone-processing tasks. The two curved bladelets may have been used in the same activity owing to their similar morphology and use. Overall, bone working in the eastern structure suggests a mixture of butchery and smaller-scale processing activities, with traces from the hollow relating to the latter. Tools located outside of the hollow display motions of use likely related to a mix of butchery and processing activities.

6.3.4. Meat

In total, ten meat working tools were identified, all of which were used in a longitudinal motion, suggesting a cutting action. Most of those found in the hollow were used on meat and bone (3) in the same area on the edge, indicative of butchery tools, see figure 70. The fragment from the hollow evidenced solely meat working and is spatially discrete. All pieces are shorter than 50mm and so if used on a large animal, it is perhaps unlikely that they were used in the early stages of butchering.

Three tools were located to the south and south-east of the hollow (see figure 70). A bladelet had traces from meat and bone working and a burin spall was used on meat with some possible bone polish. The fragment displayed meat polish. Spatially the bladelet and fragment are most closely linked, and although different traces were observed, both could have been butchery tools.

A flake located north of the hollow (see figure 71) had meat and bone wear traces and a microburin and microlith found in this area were used to cut meat. No MLITs or hafting traces were observed on the microlith, so it is possible that it was never hafted or used as a projectile, and was instead used to cut meat as an individual tool.

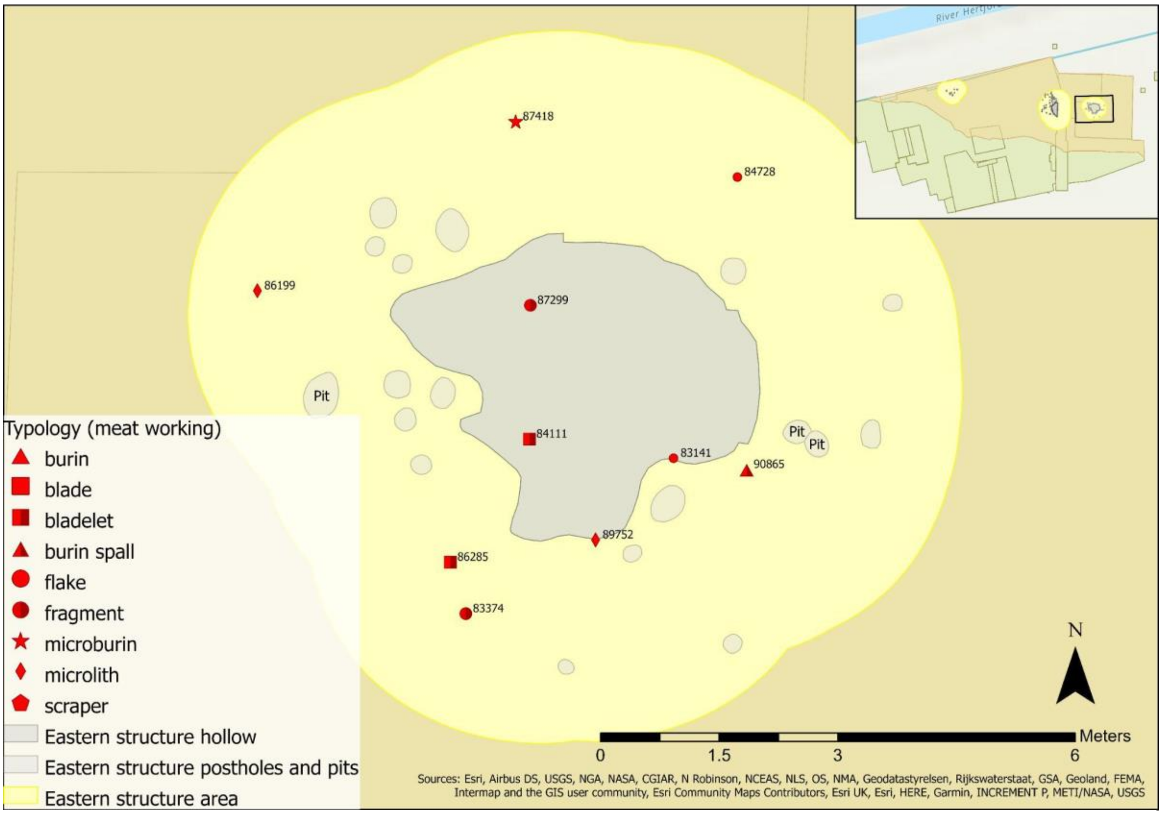


Figure 70: Distribution of meat working tools found in the eastern structure area.

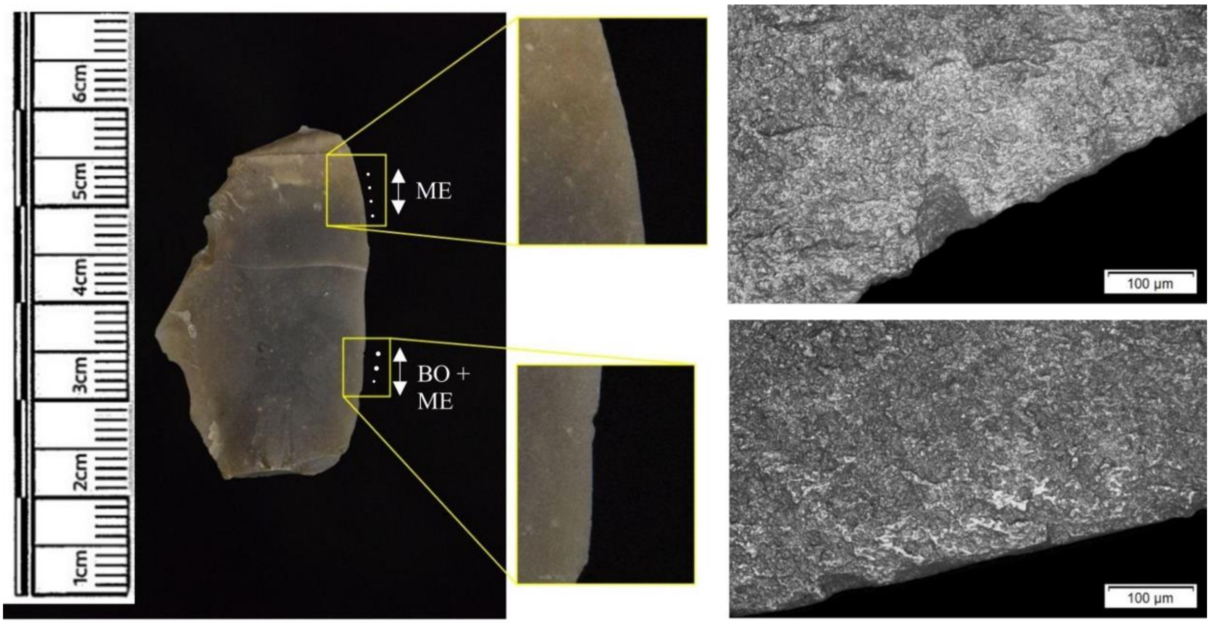


Figure 71: SC 83141 a flake interpreted as used to cut meat and bone on the ventral aspect, 200x magnification. No polish was observed on the dorsal.

Meat working tools were generally located in the southern half of the structure area. Within the hollow, most are found to the south with only one flint to the north. Those surrounding the hollow show a mixed pattern of meat, and meat and bone working, with no clear spatial distribution. Tools located to the north of the surrounds are dispersed, whereas those to the south are more spatially associated with the hollow. This could tentatively suggest that meat working tasks or butchery were more spatially constrained in the southern half of this area.

6.3.5. Hide

Eight tools were identified as showing hide working, with only two located in the hollow. All tools were used in a transverse motion, interpreted as scraping, and a burin was used to perforate. Inside the hollow, a bladelet had fresh hide polish and a scraper showed traces from working possible fresh hide (see figure 72). In both cases, the polish was not well developed, suggesting that they were not used for a significant length of time. A multi-functional blade was located immediately to the south of the hollow (see figure 72), used to predominantly scrape fresh hide with some transverse siliceous plant traces observed in a separate area on the blade.

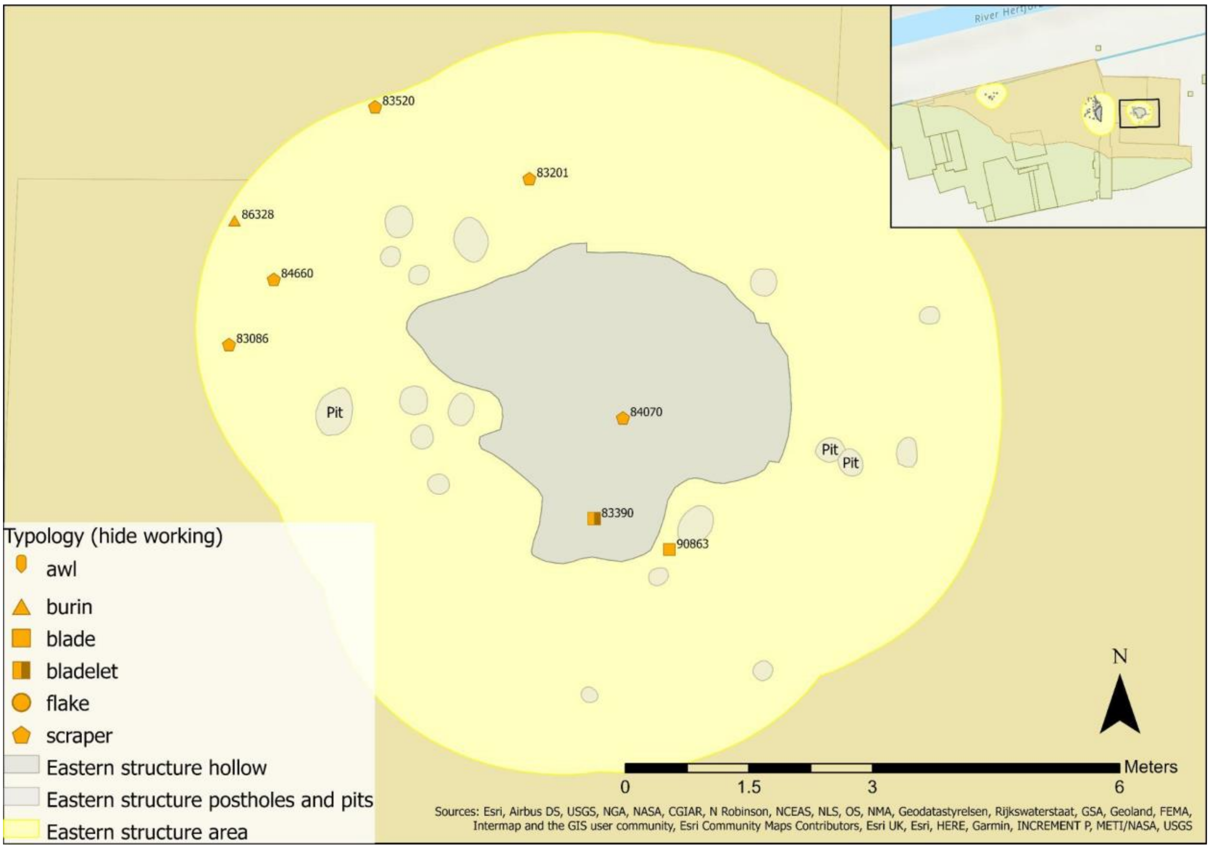


Figure 72: Distribution of hide working tools found in the eastern structure area.

A group of three hide working tools was located to the west, outside of the hollow. One scraper (<83086>) was used on fresh hide, and the other (<84660>) had polish from dry hide working with an additive. The polish was not sufficiently developed to be certain of the additive (i.e. mineral), see figure 73. Traces from the burin used to perforate hide had associated striations, which may suggest that dry hide was worked with an additive, with striations caused by inclusions (see figure 74). Two scrapers to the north of the hollow were used on dry hide and mineral, and fresh hide.

Flints located outside of the hollow to the north-east could be interpreted as connected, from similarities in their use. Most scrapers found at Star Carr were small, so size cannot be used to infer the possible scales of task (i.e. larger scrapers used to work larger hides, which would require a large open space). Three tools found within and near to the hollow may be related in use. All were likely used to scrape fresh hide and so could be associated with the earlier stages of hide processing. Dry hide working occurs on the outer periphery of the structure area, suggesting that a later stage of hide processing was undertaken.

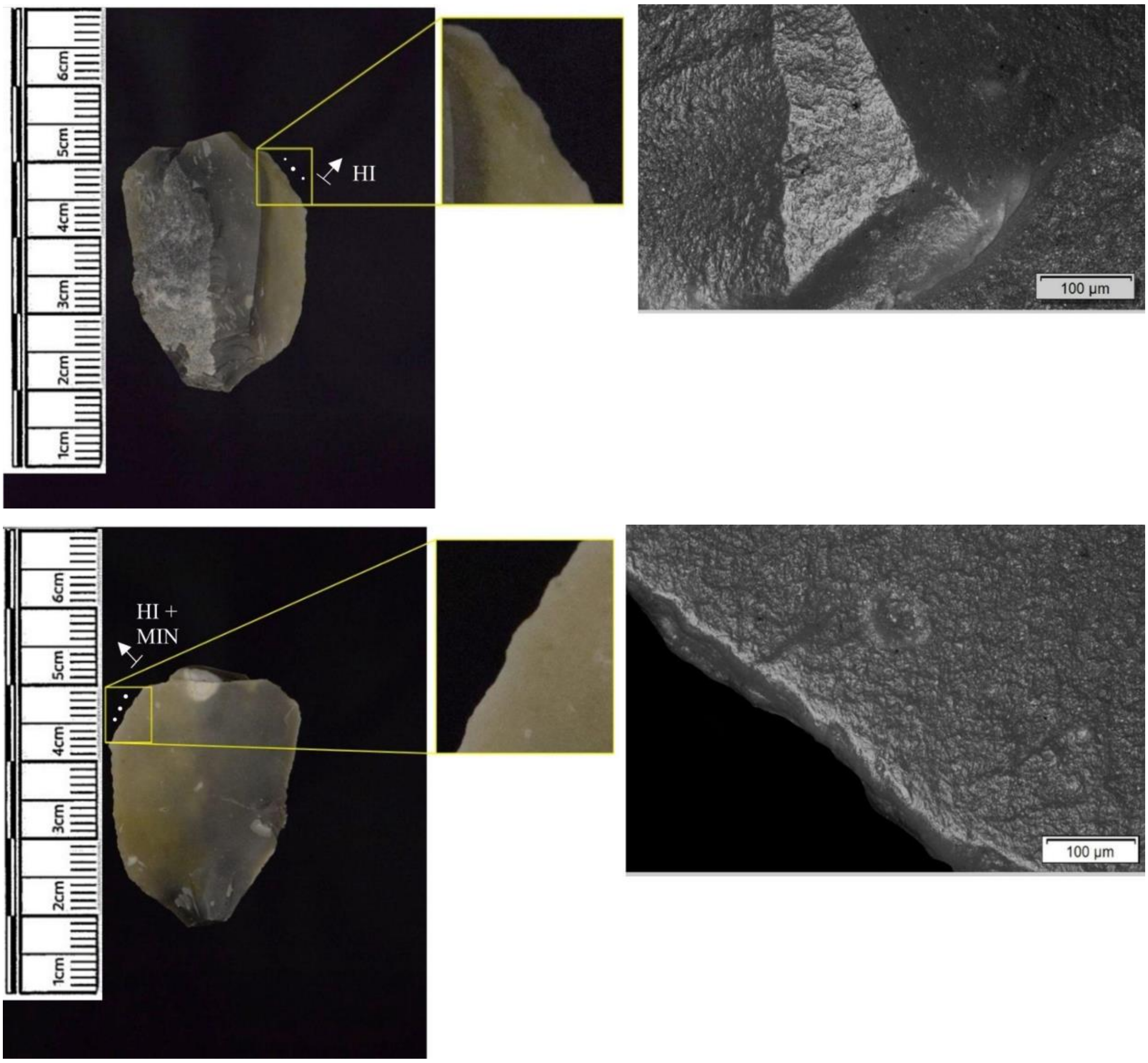


Figure 73: SC 84660, a scraper interpreted as used to scrape dry hide with an additive, likely mineral, 200x magnification. The polish appears more developed on the ventral aspect.

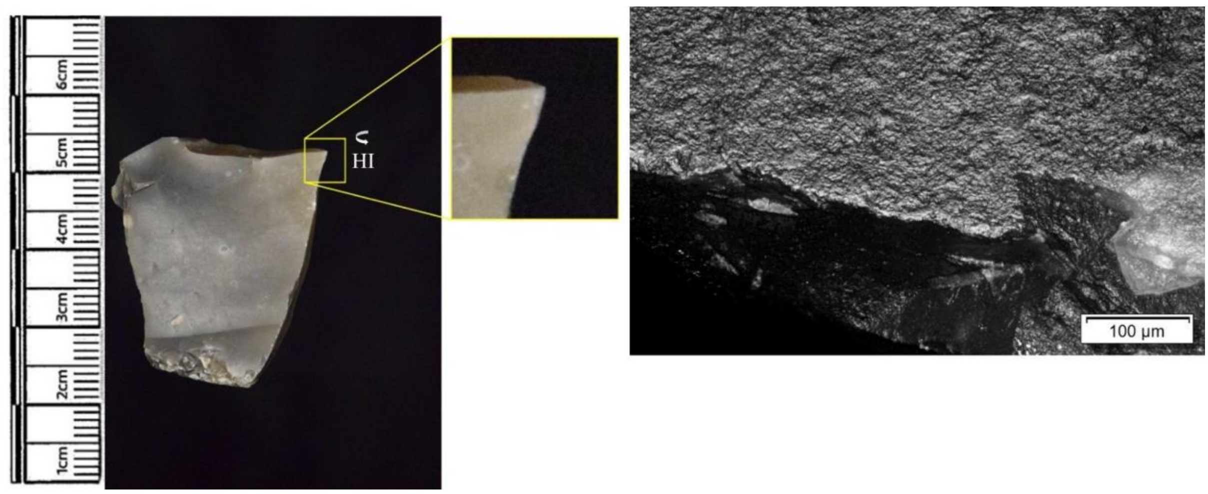


Figure 74: SC 86328, a burin interpreted as used to perforate dry hide with a possible additive, 200x magnification. There was no observed polish on the dorsal aspect.

6.3.6. Projectiles and hafted microliths

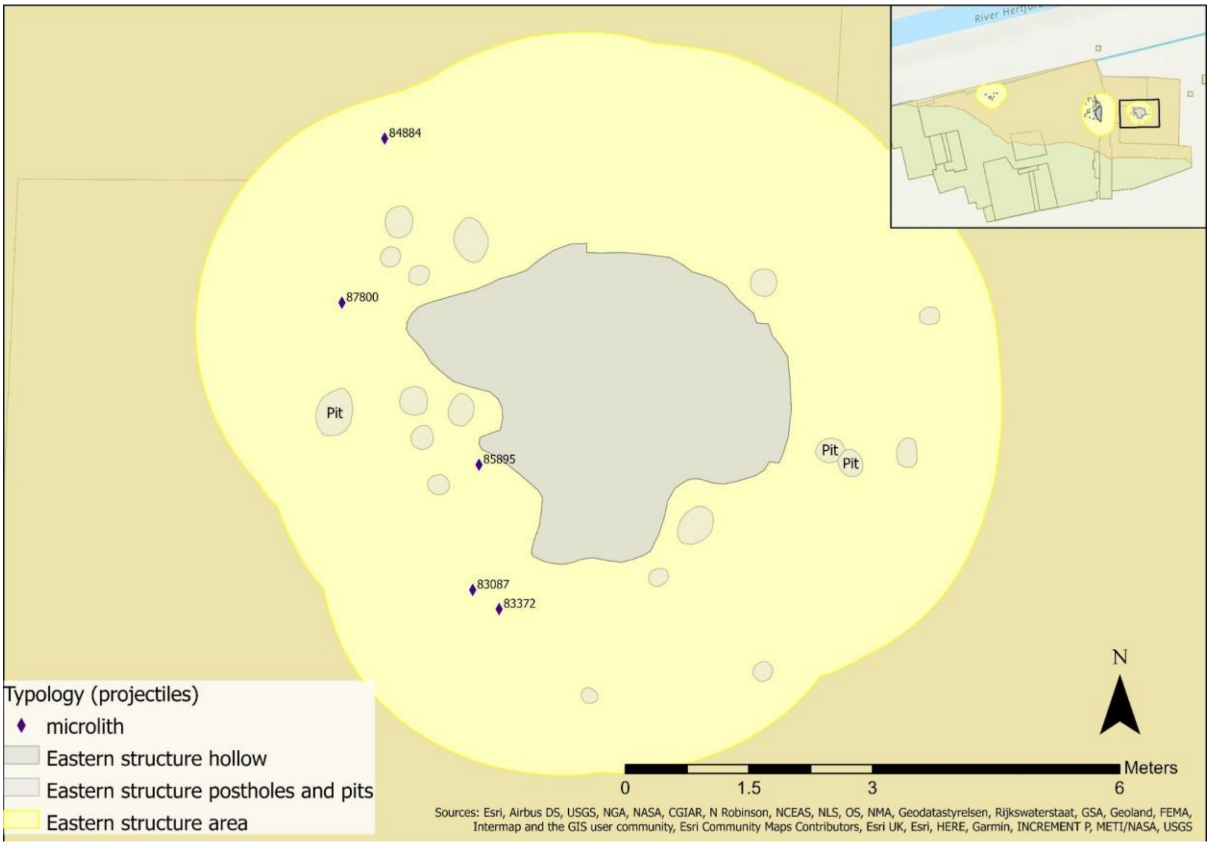


Figure 75: Distribution of projectiles and hafted microliths found in the eastern structure area.

All flints had longitudinal polish and so were interpreted as hafted to the side of a projectile or knife handle. Two microliths to the south-west of the hollow (<83087>;<83372>, see figure 75) were hafted and used on bone alongside meat or hide, with neither displaying MLITs. Hafting traces on one indicated a possible wooden haft, using Rots (2010) to aid interpretation (see figure 76).

A microlith located closest to the hollow (<85895>, see figure 75) had traces from possible bone and minor hide contact, with no MLITs. Hafting polish was developed sufficiently to suggest use of an antler haft (Rots 2010). Longitudinal bone polish was observed on another microlith (<87800>), located to the west of the hollow but hafting polish was not sufficiently developed, and no MLITs were identified. A microlith (<84884>) north-west of the hollow (see figure 75) was used on bone, and had very slight MLITs; however the striations were so faint that they could not be seen on micrographs. The polish was longitudinal, so the flint was likely hafted to the side meaning that faint MLITs would be expected as impact is most severe on the tip.

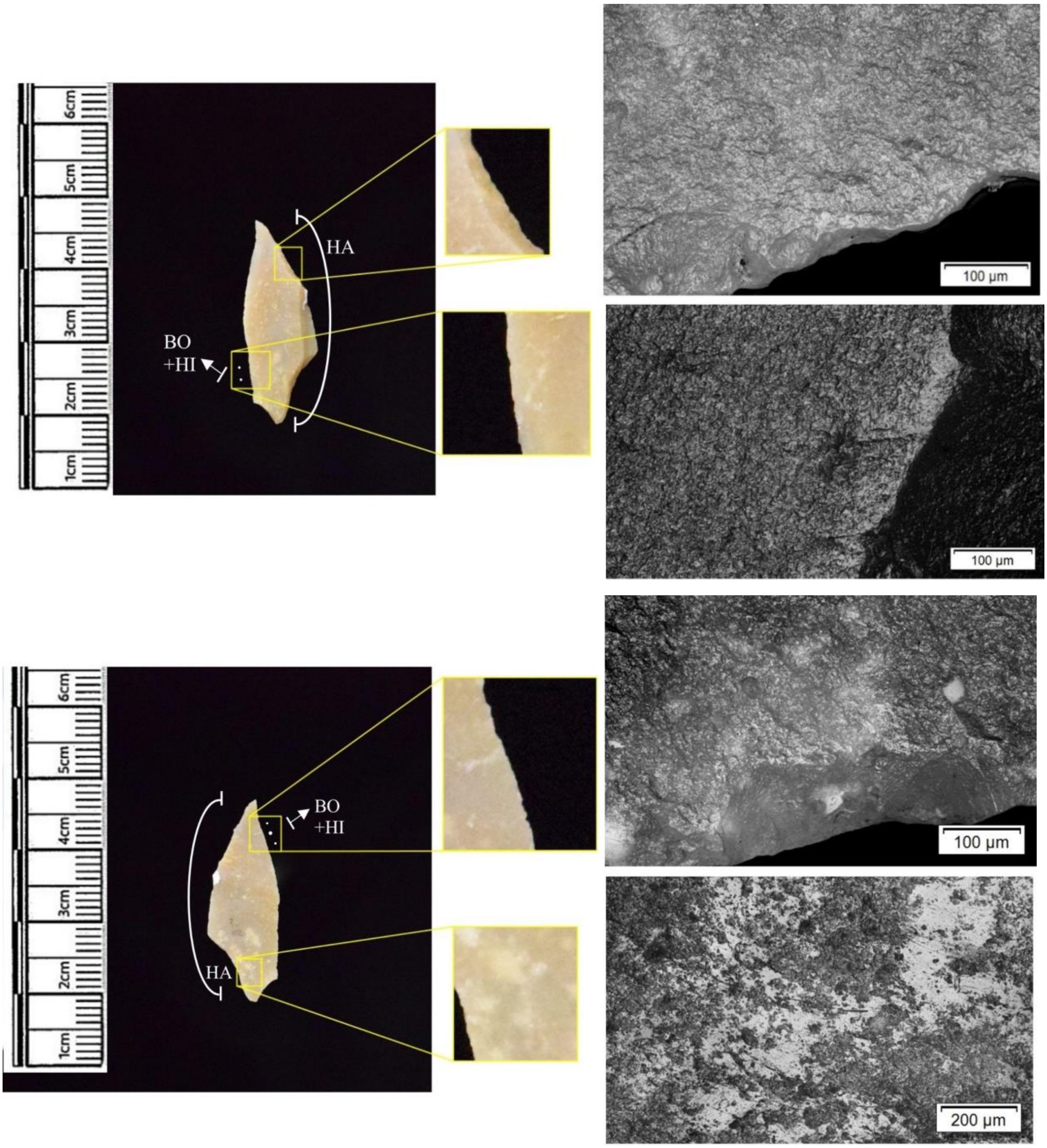


Figure 76: SC 83372, a microlith interpreted as a hafted projectile, 200x and 100x magnifications. The haft was interpreted as possibly wood.

Most projectiles/hafted microliths were located away from the hollow. They are largely dispersed with no clear localised area of dehafting and/or use. Two microliths located to the south may have been connected in use, perhaps hafted into the same projectile or dehafted and/or used at a similar time. Both tools suggest contact with bone and meat or hide, which could be consistent with them being hafted into the same projectile.

6.3.7. Fish

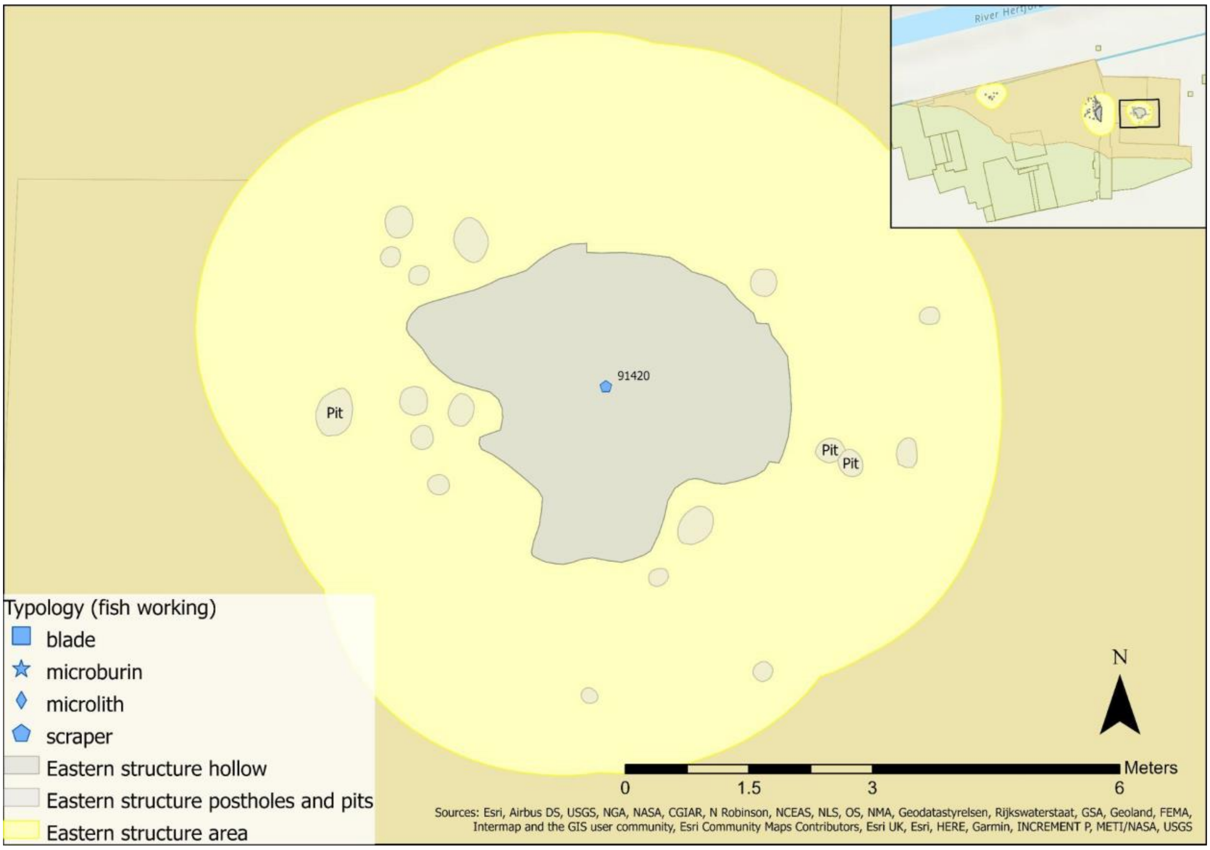


Figure 77: Distribution of fish working tools found in the eastern structure area.

One scraper located in the hollow (see figure 77) had traces of possible fish working in both transverse and longitudinal directions, indicating both cutting and scraping (see figure 78). The polish was not well developed but showed similarities with micrographs of identified fish polish from experimental tools (van Gijn 1986) and previous observations of fish working identified by Little to the north of the eastern structure area (Robson *et al.* 2018). Fish processing tool use in the hollow may indicate de-scaling activities in preparation for cooking or perhaps even fish hide processing.

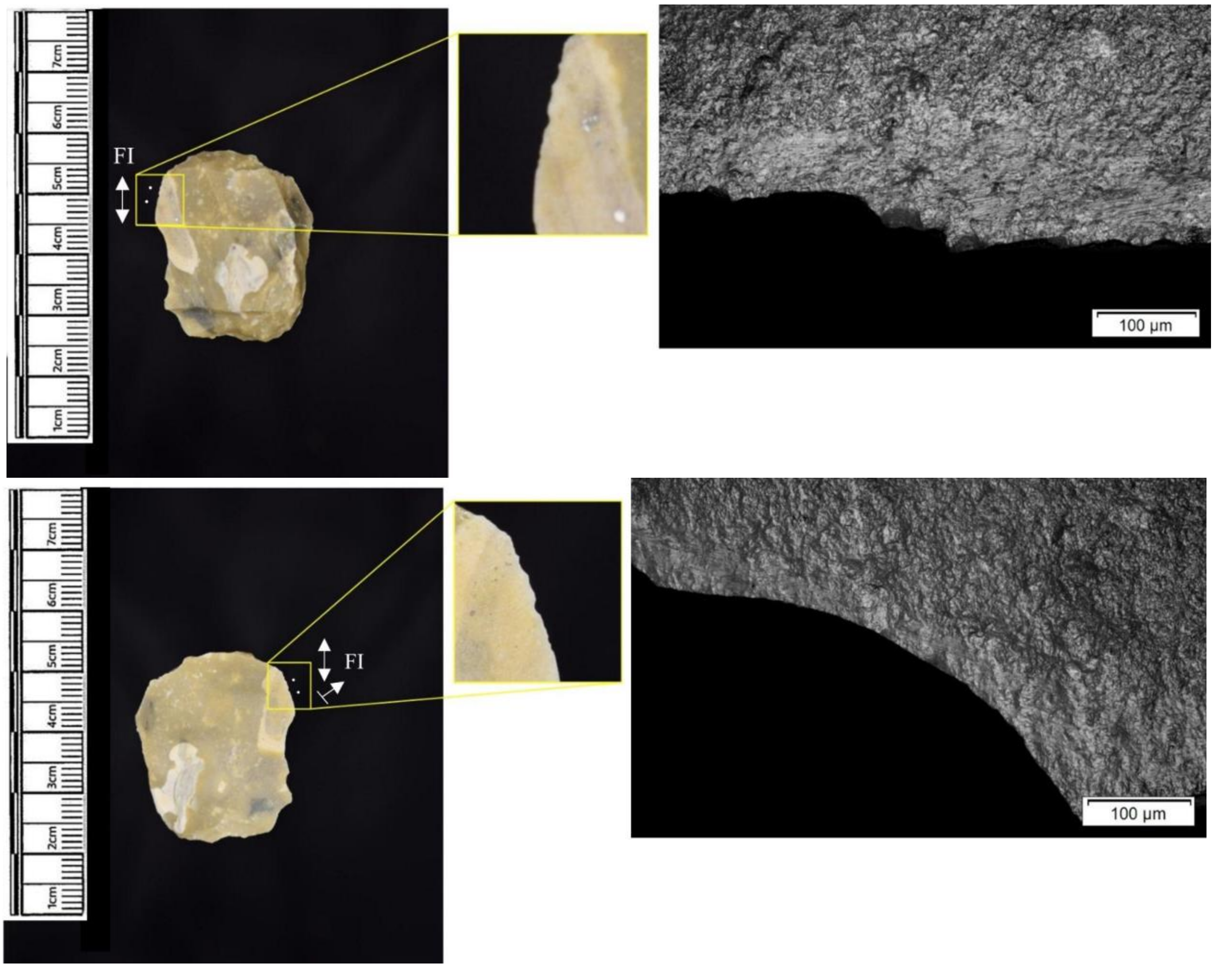


Figure 78: SC 91420, a scraper interpreted as used to possibly scrape and cut fish, 200x magnification.

6.3.8. Antler

A single instance of antler working was observed on a bladelet, located to the north-west of the hollow (see figure 79). Invasive transverse polish, predominantly on the ventral aspect, was observed, indicating a planing motion. The used edge was curved (see figure 80) which would have been effective at planing a rounded surface, such as antler. Due to the ephemeral nature of the postholes during excavation and post-depositional movement of material, it is impossible to say whether the bladelet was deliberately placed in the posthole.

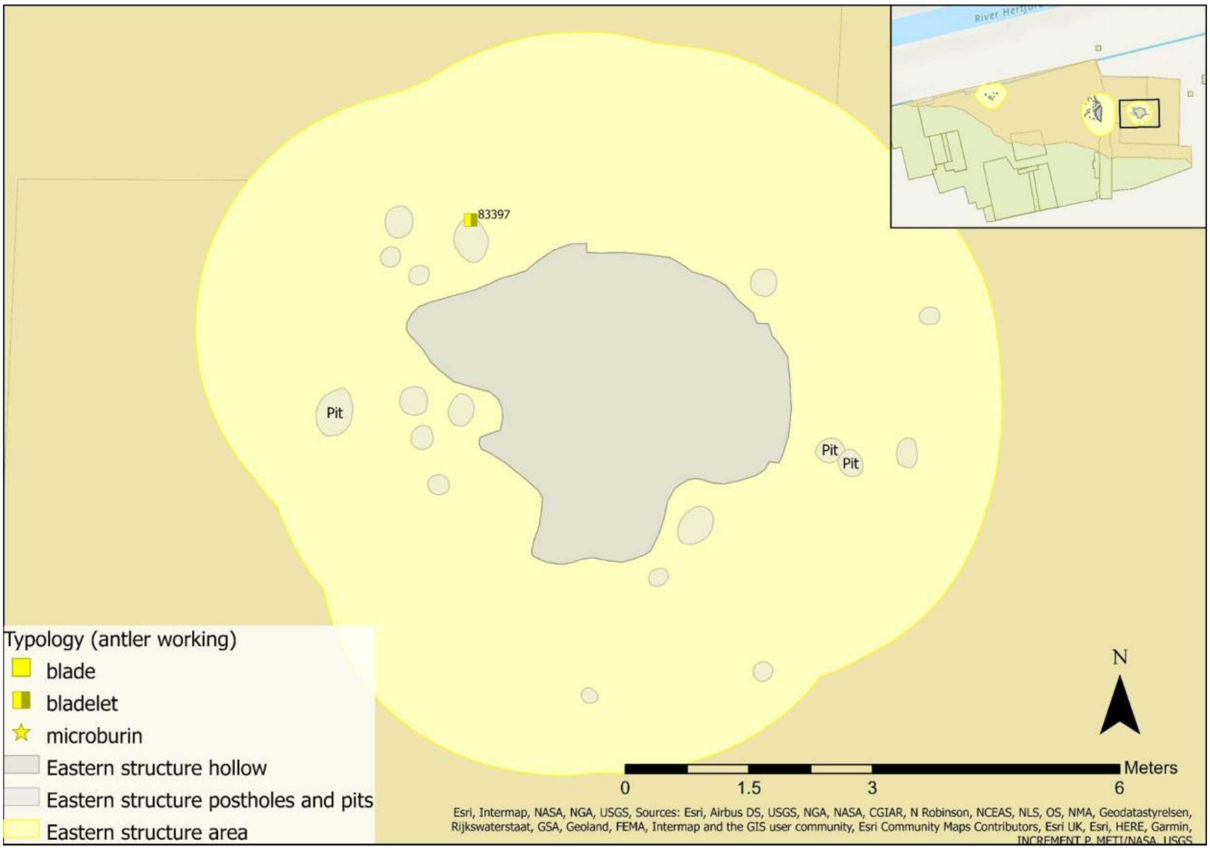


Figure 79:Distribution of antler working tools found in the eastern structure area.

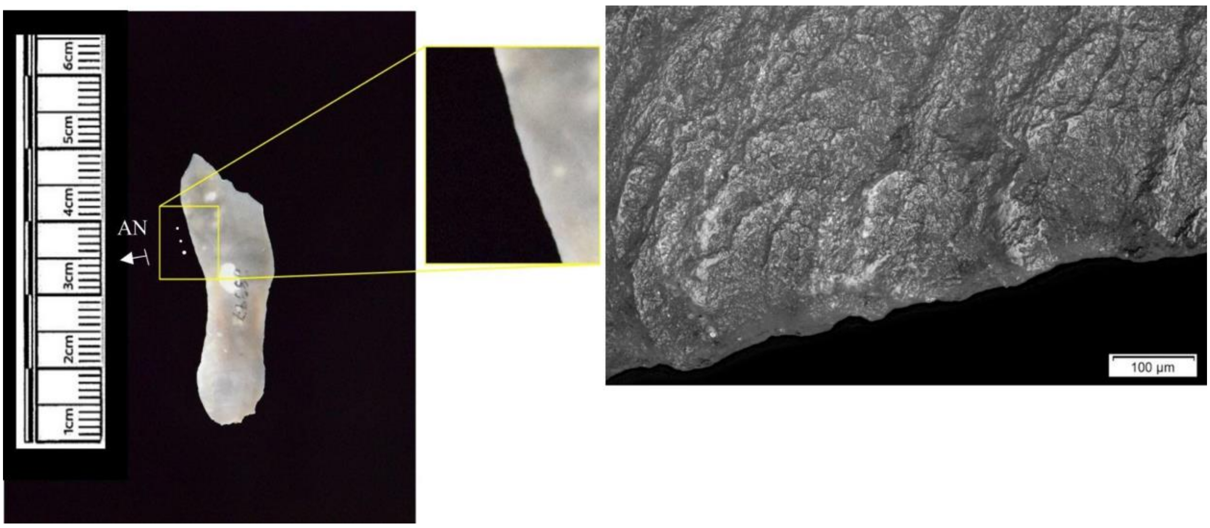


Figure 80: SC 83397, a bladelet interpreted as used to plane antler, 200x magnification. The dorsal aspect did not show any observable polish.

6.3.9. Plant

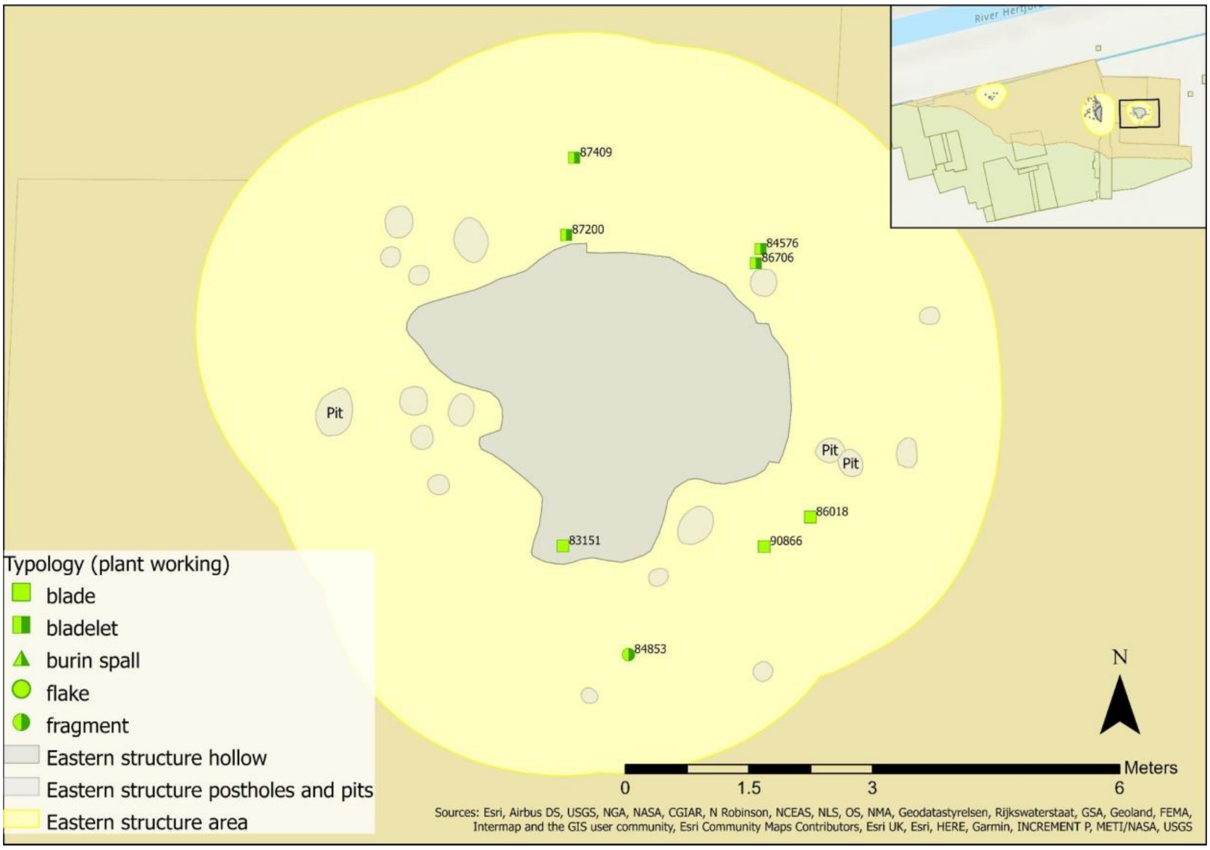


Figure 81: Distribution of plant working tools found in the eastern structure area.

Plant working traces were found on eight tools. Four bladelets were located to the north and north-east of the hollow and were all used in a transverse direction, indicative of scraping. Most had traces from scraping non-siliceous plants, although in one case (<84576>, see figure 81) plant/soft wood polish was not sufficiently developed to distinguish and meat working traces were also observed. From experimental archaeology, fibres can be extracted from many plants by scraping the surface of stems (Hurcombe 2008a). These fibres can then be twisted together to make cordage or used to construct different objects (e.g. baskets, mats) (De Stefanis and Beyries 2021; van Gijn and Little 2016; Hurcombe 2008b).

Only one flint was found in the hollow (see figure 81), a blade used to scrape siliceous plants. The polish was not particularly invasive or extensive, indicating a short duration of use or a steep edge angle (i.e. limited contact between the material and tool). Longitudinal working of a soft indeterminate material was observed on the opposite lateral edge. Two blades located to the east of the hollow (<86018>; <90866>, see figure 81) were used to scrape siliceous plants. Both had well developed and invasive polish (see figure 82). A fragment to the south of the hollow was used to cut plants or soft wood.

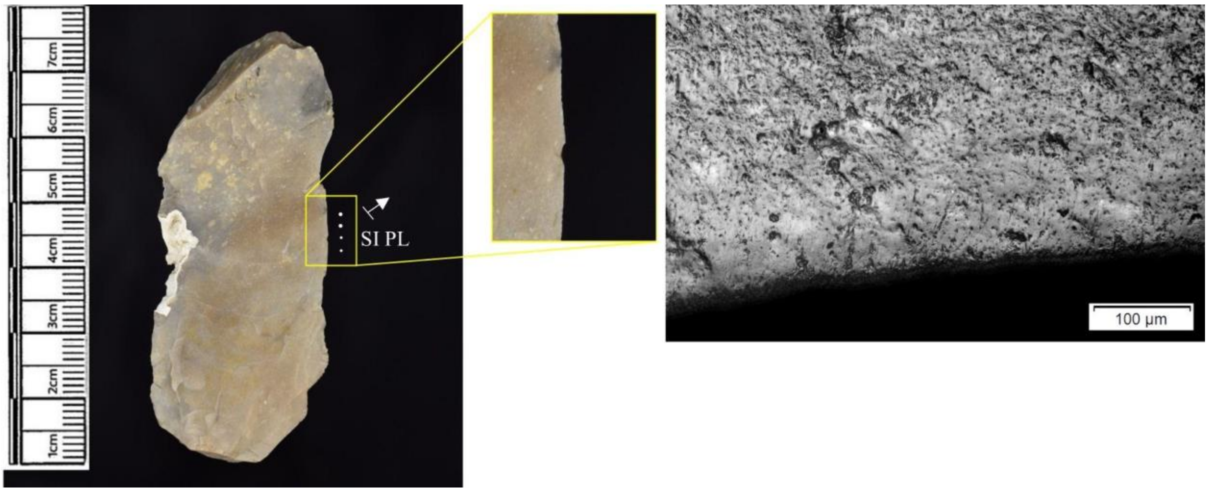


Figure 82: SC 90866, a blade interpreted as used to scrape siliceous plants, 200x magnification. The dorsal aspect did not show observable signs of polish.

Equal quantities of plant working tools are seen to the north and south of the hollow; though most cluster in the eastern half. Most flints are in close proximity to the hollow or postholes, rather than in the hollow. The types of plants worked vary between the north and south groups; siliceous plant traces are more common in the south and non-siliceous in the north. It is possible that there was a distinction between types of plants and the location of working. Alternatively, the bladelets could represent a short episode of activity where a particular non-siliceous plant was processed using multiple tools. These plants can also blunt a tool after a short duration of use, so four tools could conceivably be used for one episode of activity.

6.3.10. Wood

Six tools were found to evidence woodworking. One fragment found in the hollow (see figure 83) was used longitudinally on wood, although significant metallic striations around the area of use mean the interpretation is necessarily tentative. A blade to the north east of the hollow had traces from cutting and scraping wood. The polish was in the early stages of development, indicating a short duration of use. Two bladelets were used to engrave/scrape and cut wood, respectively. Cutting traces suggested use on a small piece or thin section of wood (e.g. a thin strip of bark or a thin branch) as the polish was concentrated to a small area on the tool’s edge (see figure 84). A second fragment found to the west of the hollow (see figure 83) displayed well developed traces of wood scraping.

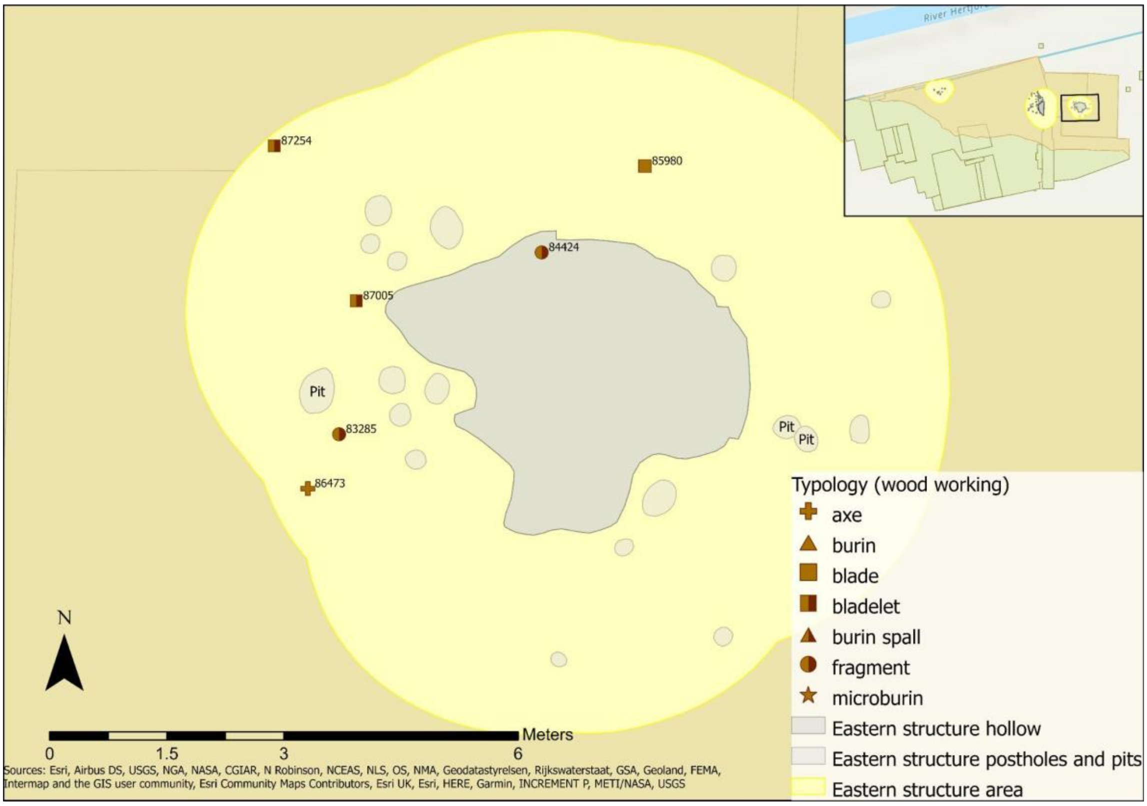


Figure 83: Distribution of woodworking tools found in the eastern structure area.

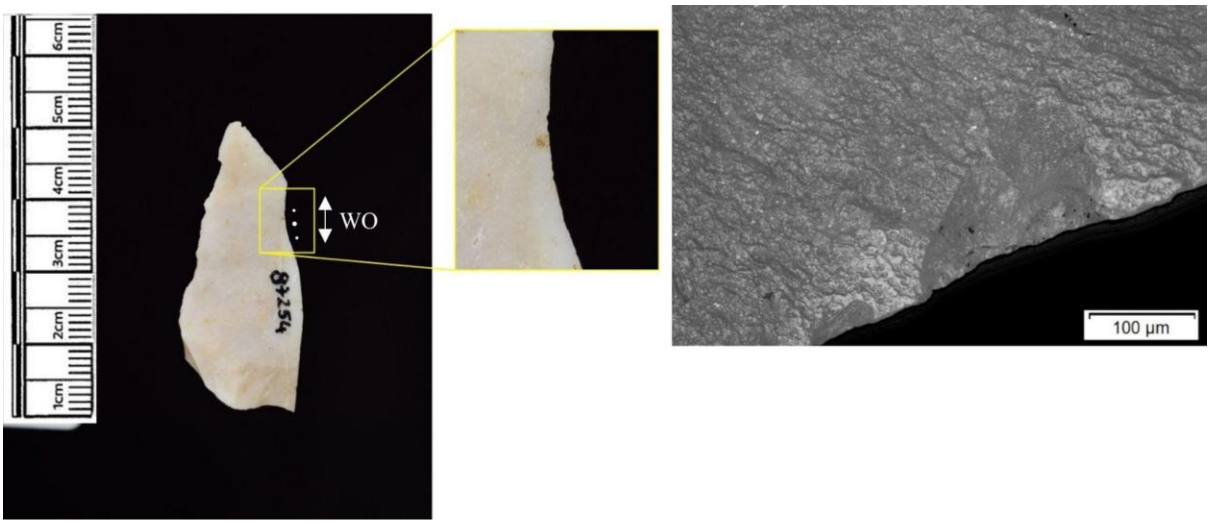


Figure 84: SC 87254, a bladelet interpreted as used to cut wood, 200x magnification. The dorsal aspect did not show observable signs of polish.

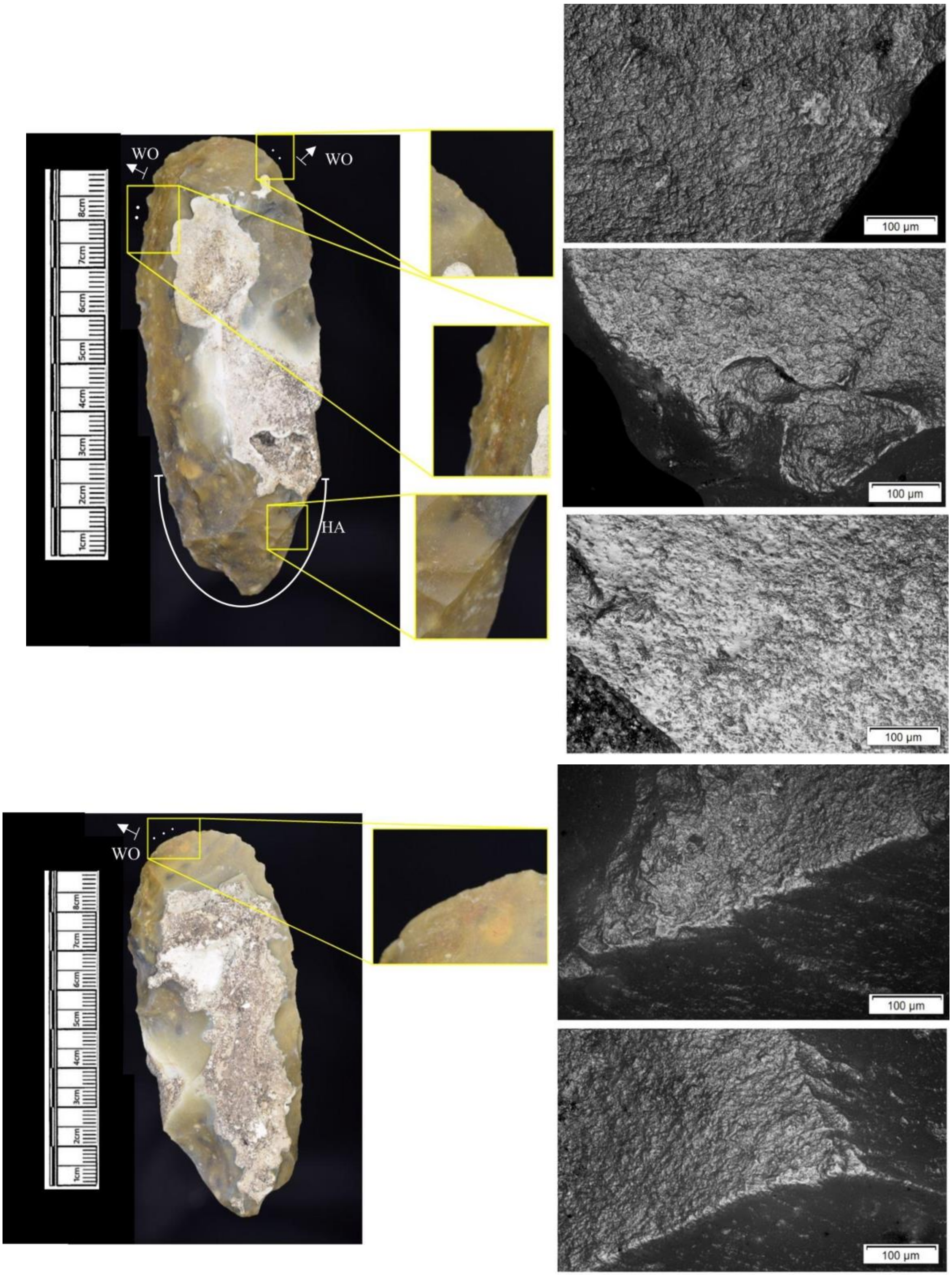


Figure 85: SC 86473, a tranchet axe interpreted as used to chop wood and hafted, possibly in a wooden haft, 200x magnification.

The only axe analysed was located to the west of the hollow (see figure 83). Axes have a high impact on contact materials, so areas of polish development can be removed as the tool is retouched during use. This can lead to undeveloped or a lack of polish. The tapered proximal end of a *tranchet* axe means that they were likely hafted or at least held in the hand with wrappings. Polish observed on the distal end of the eastern structure axe (the end used to chop) was not extensive. Possible hafting traces were found on the proximal end, and showed a wood/plant polish (see figure 85). It may have been hafted into a wooden shaft with plant bindings or used with just plant wrappings to provide a good grip. The axe was used to chop wood, so it is perhaps more likely that it was hafted in wood with plant bindings, to enable more efficient working.

A hafted axe is a composite tool, and similar to projectiles, may not have been used where it was found. It may have been dehafted and/or deposited near to the structure, as storage and curation of tools has been previously noted in this area (Conneller *et al.* 2018a). However, it is situated outside of the hollow, in a space that would likely have provided a clear space for chopping wood. Therefore, the axe may have been used *in situ* where it was excavated.

Tools used to work wood were generally found outside of the hollow, clustering to the north-west part of the study area. Half were located away from the features and were used to cut or chop wood. Apart from the fragment inside the hollow, those found close to the features were used for scraping and engraving wood. Wood is a hard material and cutting and/or chopping wood often requires a spatial clearance away from obstructions. This is reflected in the patterning of tool use. Conversely, scraping and engraving may reflect smaller-scale tasks such as de-barking and engraving or perforating wood/bark, which can be undertaken with less force. However, the scale of the task is dependent on the size of the material. For example, cutting a thin or small piece of wood could be considered a smaller-scale task. Similarly, de-barking could be a large-scale activity if bark is stripped from a large trunk. Therefore, the spatial patterning of woodworking tools remains speculative.

6.3.11. Soft indeterminate and soft/medium indeterminate materials

Eight tools interpreted as used on soft indeterminate materials and nine pieces used on soft/medium indeterminate materials were identified. A specific contact material could not be identified for these tools, although in some cases it was possible to interpret directionality of use (see figure 86). There appears to be no spatial patterning based on direction of use or hardness of material. Four tools were found in the hollow, two bladelets (<90154>;<87672>) were used longitudinally and a fragment (<83865>) and scraper (<87561>) had transverse directionality (see figure 87). Those located outside of the hollow were mostly found in the northern half of the study area (11), with only two blades found in close proximity (<84211>; <84860>, see figure 86). They may have been used in similar tasks as both have longitudinal directionality and a similar bright, greasy polish.

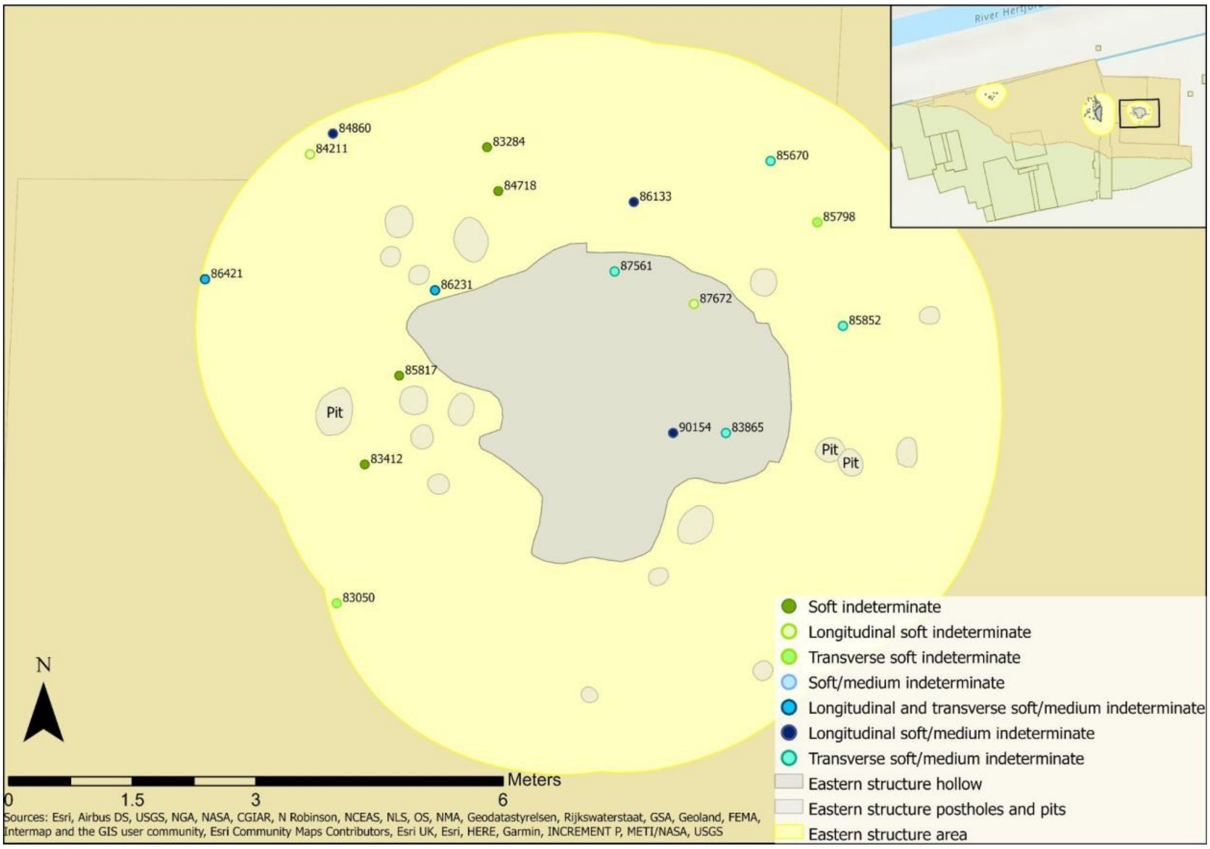


Figure 86: Distribution of tools used on soft and soft/medium indeterminate materials found in the eastern structure area.

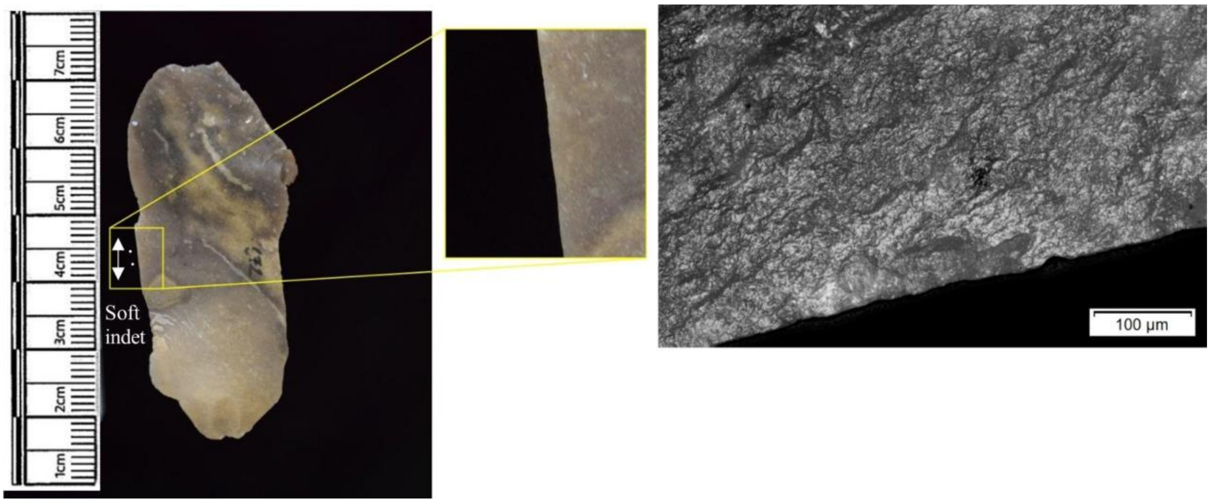


Figure 87: SC 87672, a bladelet interpreted as used in a longitudinal direction on a soft indeterminate material, 200x magnification. No polish was observed on the dorsal aspect.

6.3.12. Medium, medium/hard and hard indeterminate materials

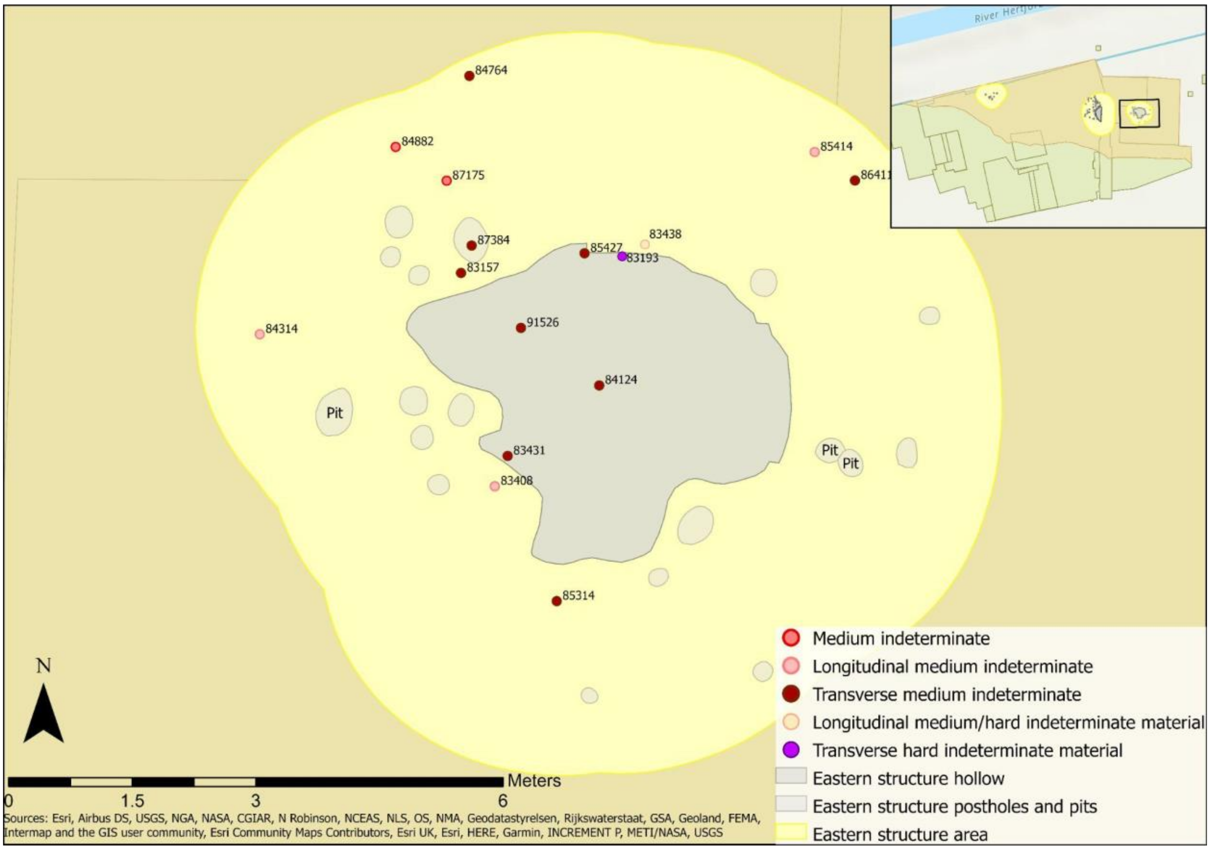


Figure 88: Distribution of tools used on medium, medium/hard and hard indeterminate materials found in the eastern structure area.

Of 16 tools, 14 were used on medium indeterminate materials, one medium/hard and one hard indeterminate material (see figure 88). A bladelet (<83438>) had medium/hard indeterminate traces with significant removals (see figure 89), though very little polish was observed so it was unclear whether they were due to use or to PDSM. Five tools were located in the hollow, most of which were scrapers (4) with transverse directionality. Flints are spread to the north west side, with only one scraper (<85427>) and a burin spall (<83193>) found in close proximity (see figure 88). Microwear traces do not indicate any obvious connection in use apart from transverse directionality. Of those located in the outer structure area, five are seen near to the outer edge of the hollow and six are spread across the northern half of the outer area. There is no obvious patterning in use or tool type.

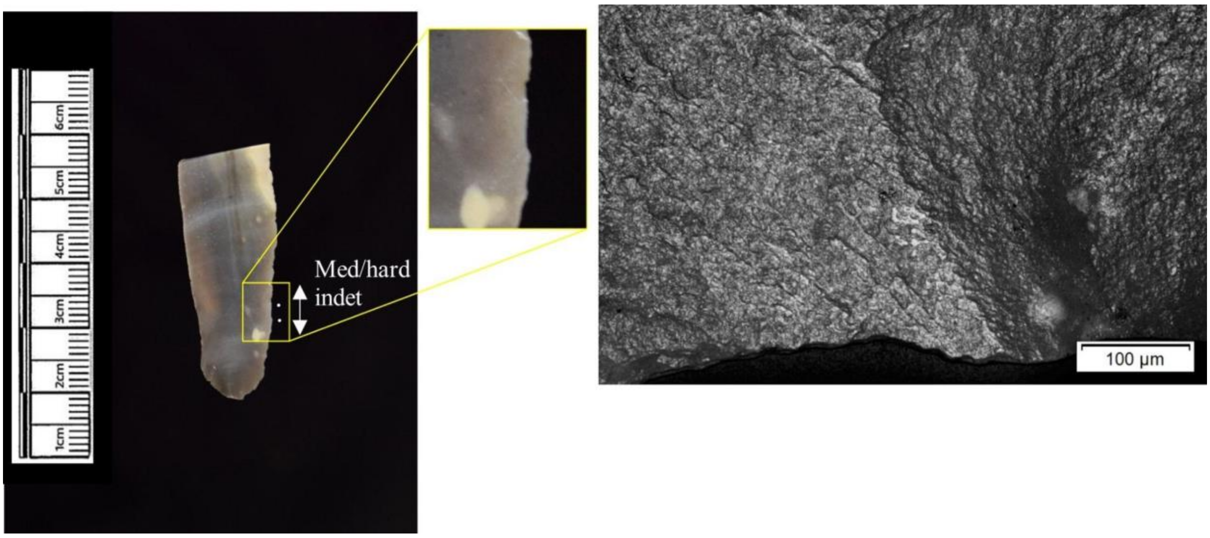


Figure 89: SC 83438, a bladelet interpreted as used longitudinally on a medium/hard indeterminate material, 200x magnification. No polish was observed on the dorsal aspect.

6.3.13. Indeterminate materials

Seven tools were used on indeterminate materials (see figure 90). No further information, apart from some limited use-related traces, could be gleaned from these pieces (see figure 91). They comprised: two blades, two fragments, one scraper, one microlith, and one bladelet.

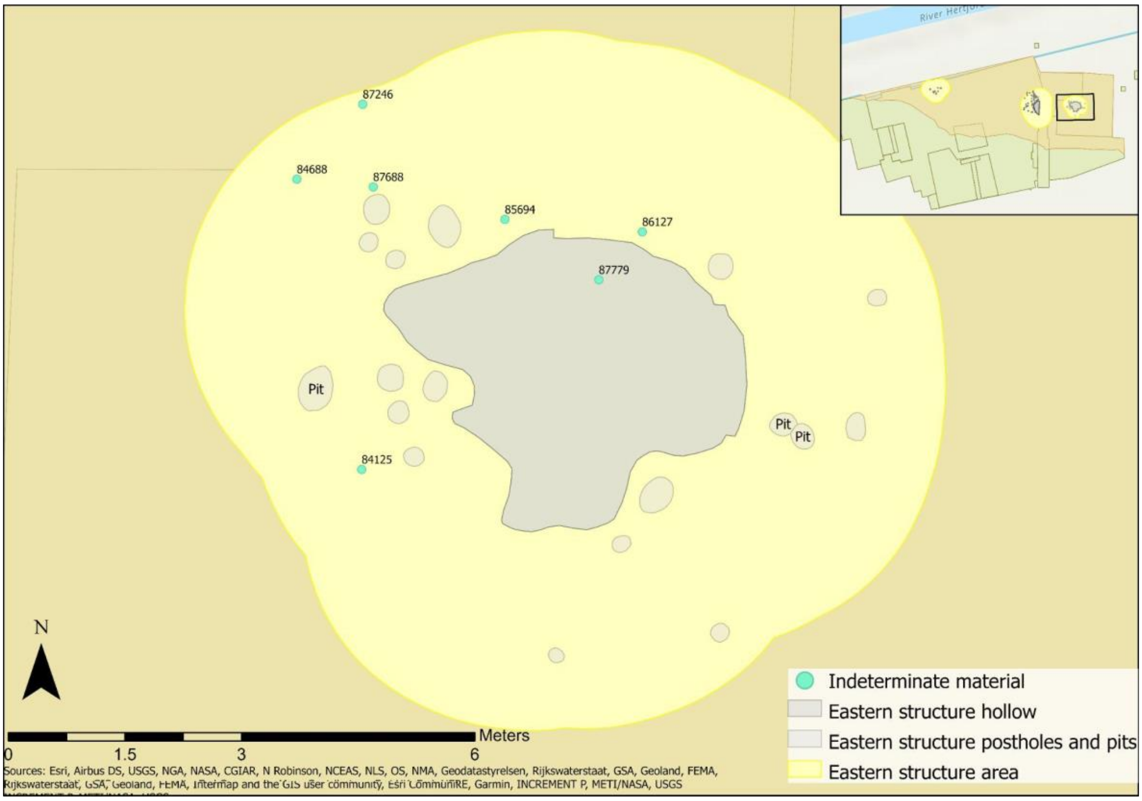


Figure 90: Distribution of tools used on indeterminate materials found in the eastern structure area.

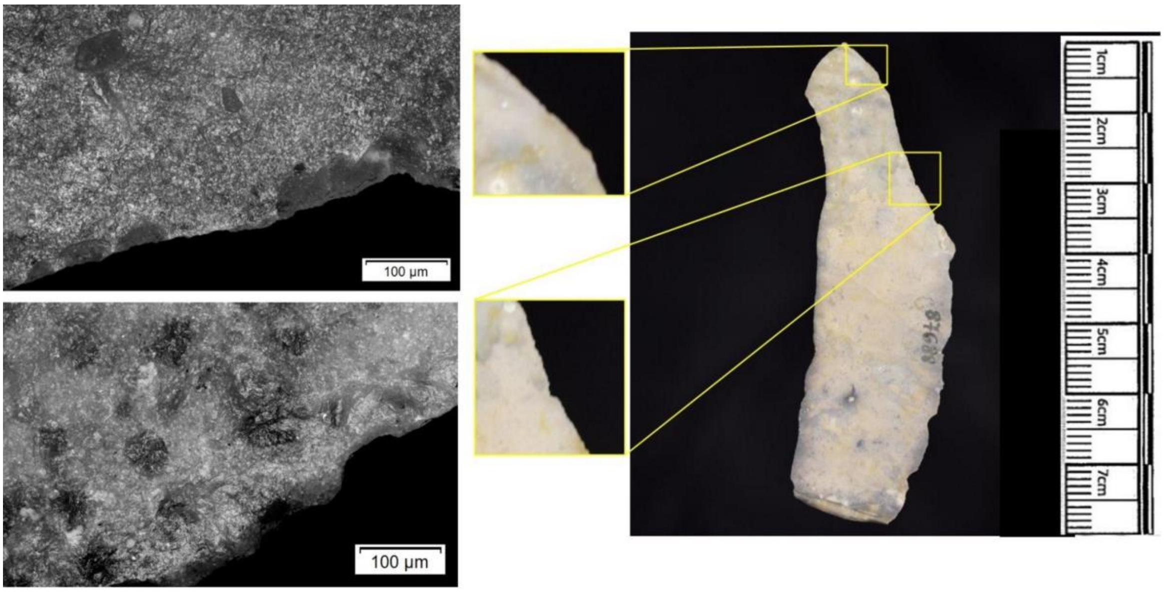


Figure 91: SC 87688, a blade interpreted as indeterminate due to PDSM observed across the surface, 200x magnification. No polish was observed on the dorsal.

6.3.14. Not used

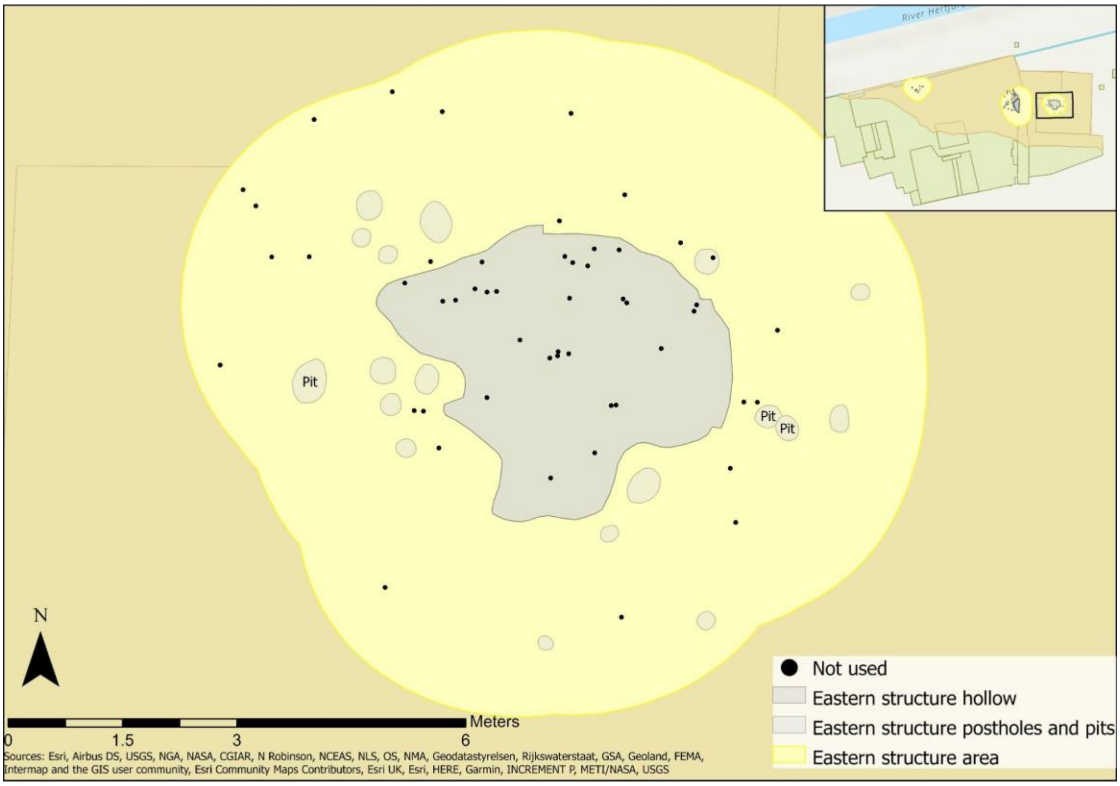


Figure 92: Distribution of unused tools found in the eastern structure area.

There were 50 flints interpreted as not used and two could not be assessed due to patination. Of these, 28 pieces were located in the hollow, over half of the group (53.8%) (see figure 92). Fewer flints were analysed from the hollow than those in the surrounds (35.6% of the total sample). Therefore, the higher rates of unused pieces in the hollow cannot be explained by a larger sub-sample. It is possible that this pattern could reflect tool manufacture in the structure. Unused tool types in the hollow are mixed, with microliths, burins as well as blades, flakes, fragments, microburins and burin spalls. Spatially most of the flints (23) are located in the northern half.

6.4. Discussion

6.4.1. Tool types

Bladelets were used mostly on animal-related materials, such as bone and meat. A large number of these were in contact with only bone, which could suggest small-scale (owing to the size of bladelets) bone processing tasks. Alternatively, these may have been hafted as composites into a knife, thus displaying similar wear traces. In contrast, blades were largely observed to have plant or wood polish from scraping or planing, with only some used on bone, or hide and bone. This indicates that they may have been preferentially selected for plant and woodworking tasks. Unretouched bladelets and blades are versatile forms that are generally used in different tasks; reed cutting, plant or plant/wood processing, butchery, hide scraping (Conneller *et al.* 2018b; Jensen 1983; Slah 2013). The eastern structure shows a different pattern, which could relate to distinct preferences in tool use in this area. However, sample size may be a factor in these observed differences, as the bladelets may have been hafted together and used on a single task.

Wear traces on scrapers were typical for the tool type; predominantly scraping motions on hide (dry and fresh), with fewer instances on bone and possibly fish. Microliths were used on a range of animal-related materials, including bone and meat. This might be expected if they were used as projectiles to hunt animals. However, MLITs were only identified on one tool, and under half displayed hafting traces. Some of these may have been barbs in a projectile, although a lack of hafting traces may suggest they were not all used in this way.

Polish observed on fragments indicates most pieces of flint were considered as usable tools; fragments are seen as knapping waste, though were clearly utilised (Conneller *et al.* 2018b, 533). This suggests that ad hoc tool use was taking place in the structure, with debris from flint knapping picked up and used for different tasks, including cutting meat and planing wood.

6.4.2. Animal-related tasks

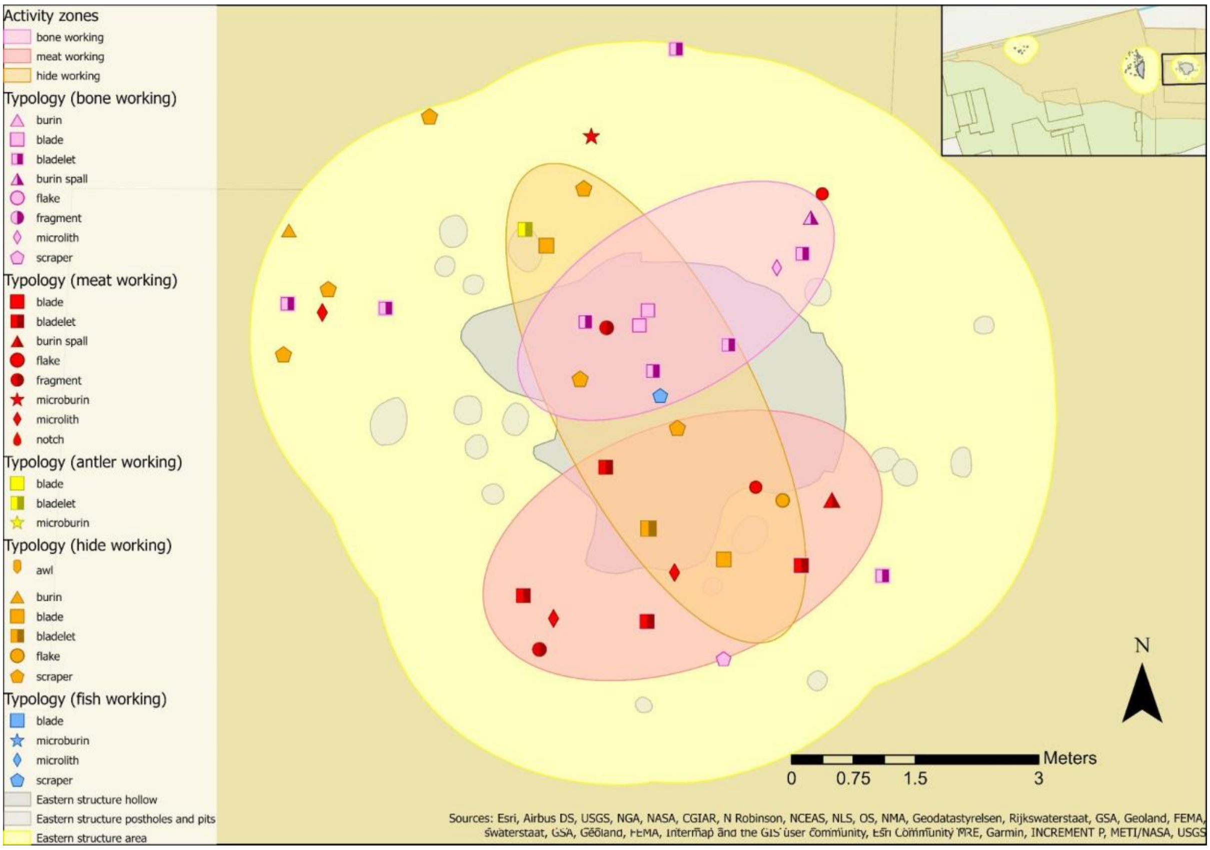


Figure 93: Spatial distribution of tools used on animal-related contact materials and associated activity zones.

Animal-related polishes in the eastern structure comprise: bone, meat, antler, hide and fish. Zones were not applied to antler- and fish working, as too few tools with these traces were found. A distinct zone of meat working was established in the southern half of the study area (see figure 93). Tools used to work bone were mostly located to the north of the hollow. Some zones contain pieces not used on the associated activity (e.g. fragment used on meat located in the bone working activity zone). However, this applies to only a small quantity of flints. Meat and bone are often interlinked in tool use (for example, in butchery), so it is interesting that bone- and meat working zones are clearly spatially defined (see figure 93).

Most bone working flints displayed solely bone polish; only two had traces from bone and meat, or bone and hide contact. An absence of meat polish on bone working flints may be a preservational bias. A hard material like bone may cause removals on the tool's edge, removing previously developed polish. However, six flints display only bone polish, and it is unlikely that meat polish was removed on all pieces. These blades and bladelets had scraping, engraving/grooving and cutting traces, and may have been used: to split bones or to process bones for making objects, such as bone bodkins or bone tools (Elliott *et al.* 2018; Knight *et al.* 2018b). These latter tasks may relate to crafting activities. This can only be defined on a case-by-case basis, for individual flints, and based on most likely scenarios from techno-morphology, microwear traces, ethnography, experimental archeology, alongside previous use wear results. For example, a bladelet with traces of planing bone may have been used to form the barbs of a barbed point. This would be interpreted as a crafting tool, with barbed point production considered a craft-related task. Crafting may, however, also relate to subsistence tasks (Little and van Gijn 2017). For example, a barbed point is used for hunting, thus connecting crafting to subsistence activity. This might seem tautological, however identifying a tool's primary use (e.g. craft or subsistence) helps deepen our understanding of how space was structured at Star Carr.

Only one tool from the meat working zone was used exclusively on meat, with most displaying a combination of meat, with bone or hide polish. The predominance of meat as a primary contact material could suggest that later stages of butchery were undertaken. Intentionally broken faunal remains recovered from the structure were interpreted as dietary waste and possible debris from bone tool manufacture (see figure 94) (Knight *et al.* 2018b, 130). The cluster of animal remains to the south of the hollow displayed spiral fractures and possible cut marks, and was spatially associated with tools displaying meat working traces. Butchery may have been undertaken here with spiral fractures associated with extraction of bone marrow (Knight *et al.* 2018a, 203). Spiral fractures were also found on faunal remains to the north of the hollow (see figure 94); however, it is possible that these were moved here for subsequent processing once marrow had been extracted.

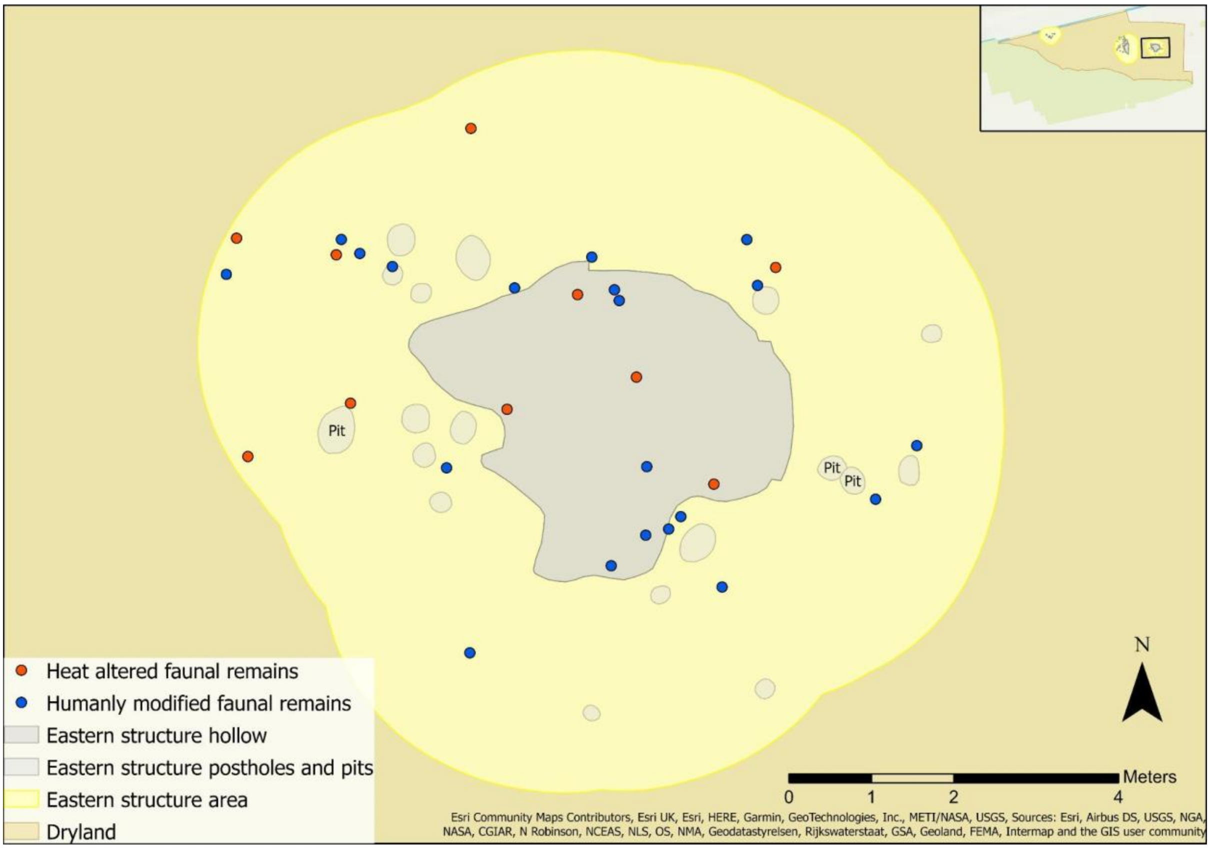


Figure 94: Distribution of faunal remains with evidence of human modification, red = heat altered bones, blue = evidence of intentional breakage (after Knight et al. 2018a).

Hide working activity intersects with the bone- and meat working zones. Flints used on hide are mostly found alongside those with meat polish, suggesting a possible connection in the processing of these materials. Of the seven hide working tools in this zone, four were used to scrape fresh hide (with an additional scraper evidencing possible fresh hide). The area to the south of the structure could have been used for processing fresh animal products, like meat and animal skins. In contrast, the northern half may have been an area of mainly bone working tasks. Two flints in this area were used to scrape dry hide, and a blade pierced dry hide and soft mineral. These activities more likely reflect later stages of hide processing, where dry hide is worked, sometimes with mineral additives for the production of containers, clothing and coverings.

Fish skin can be used similarly to hide; fish leather is as durable and effective as large animal hide so it may have been processed and utilised at Star Carr (Alla *et al.* 2017; Duraisamy *et al.* 2016). Microwear traces from working different states of fish skin (i.e. fresh, dry, tanned) are not well documented, so it is unclear if the possible evidence of fish scraping was used on dry or treated skin. Traces were similar to those from scraping fish scales and skin, as the scraper had striations within the polish, indicating contact with a harder material like scales (Clemente-Conte *et al.* 2020; van Gijn 1986; Robson *et al.* 2018). This would suggest that fresh skin was worked, with scales likely removed prior to drying, smoking or further processing (Duraisamy *et al.* 2016). Most of the 10 identified fish specimens in the structure were burnt, so it is likely that fish was cooked there (Knight *et al.* 2018a, 130). Tool use appears to relate more to food processing than making fish skin into hide, although both activities are not mutually exclusive.

Possible antler polish was observed in the northern half of the hide zone. Barbed antler points, antler mattocks, and frontlets would have all required processing, likely with flint tools (Elliott *et al.* 2018). They were likely used in the groove-and-splinter technique to make barbed points, grooving antler in a longitudinal motion (Elliott and Little 2018; Elliott and Milner 2010). However, the bladelet was used transversely, indicative of planing, and was under 4cm long. Rather than use on larger, complete antlers in the early stages of splitting, the bladelet could have been used in the final phases of barbed point production. The barbs and point would need defining by planing excess antler away (Elliott and Little 2018; Elliott and Milner 2010). A fragment of antler was found in the structure, reinforcing that antler working was an *in situ* activity, though not frequently undertaken in the area (Knight *et al.* 2018b, 130). This correlates well with bone working tasks in the northern half of the structure and evidence of working dry hide; a locus of crafting-related activities.

6.4.3. Projectiles and hafted flints

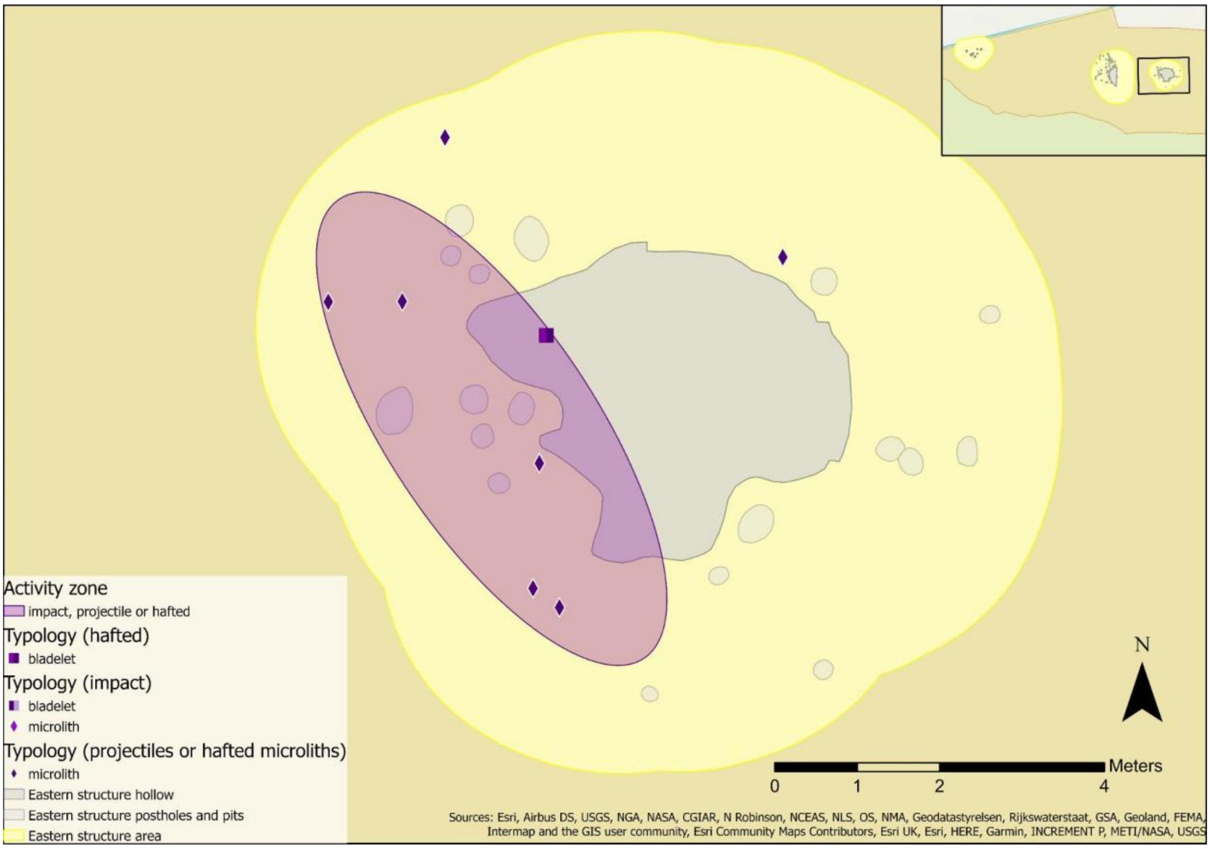


Figure 95: Spatial distribution of hafted tools or tools evidencing projectile impact and associated activity zone

Projectile impact and hafting traces were found dispersed across the structure, making an activity zone less certain (see figure 95). Hafted tools and those with microscopic linear impact traces (MLITs) were composite, so it is likely that their deposition reflects de-hafting or de-commissioning rather than where they were last used (Keeley 1982). These tools might be expected to cluster spatially if they were dehafted or retooled in a similar location, as observed at other Mesolithic sites (Cooper *et al.* 2017, 34; Odell 1980). For example, dehafting can occur around a hearth, as heat is used to soften adhesives and loosen flint inserts (Conneller *et al.* 2018b; Cooper *et al.* 2017, 34; Keeley 1982). This does not appear to be the case in the eastern structure.

Some possible explanations for the distribution of previously-hafted flints are:

1) tools were dehafted and left *in situ*;

2) tools were dehafted inside the structure hollow and were moved around the area through trampling;

3) tools were dehafted, used for other purposes inside the structure and left *in situ*;

4) tools were dehafted elsewhere and taken to the eastern structure area for retooling as they were intact;

5) tools were treated in a combination of 1), 2), 3) or 4).

Microwear results offer little clarification. Most pieces displayed longitudinal bone polish, with some also coming in contact with hide or meat. At the very least, there is some spatial connection between previously hafted tools and the eastern structure.

6.4.4. Vegetal-related tasks

Traces from plant working were dispersed: one zone comprised four bladelets near the woodworking zone, the other contained three blades, a bladelet and a fragment in the southern half (see figure 96). Of those in the southern group, three were used to process siliceous plants, whereas those in the northern half were all used on non-siliceous plants. This might suggest that plant working was organised based on the types of plants processed, as no siliceous plant working traces were found to the north. Plant type does not correlate to tool type, as a bladelet and two blades all evidenced traces of siliceous plants in the southern group. Therefore, location appears to be more closely linked to the flint's use.

Spatial patterning must be considered cautiously due to the sample size; utilised pieces may reflect a single episode of activity rather than sustained patterning of behaviour. As an example, the processing of reeds over a short duration may result in using three tools within one small area. Plant residue from silica-rich species can stick to the flint’s edge, creating a blunting effect that cannot be wiped off easily. This means scraping siliceous plants can result in high quantities of exhausted or blunted

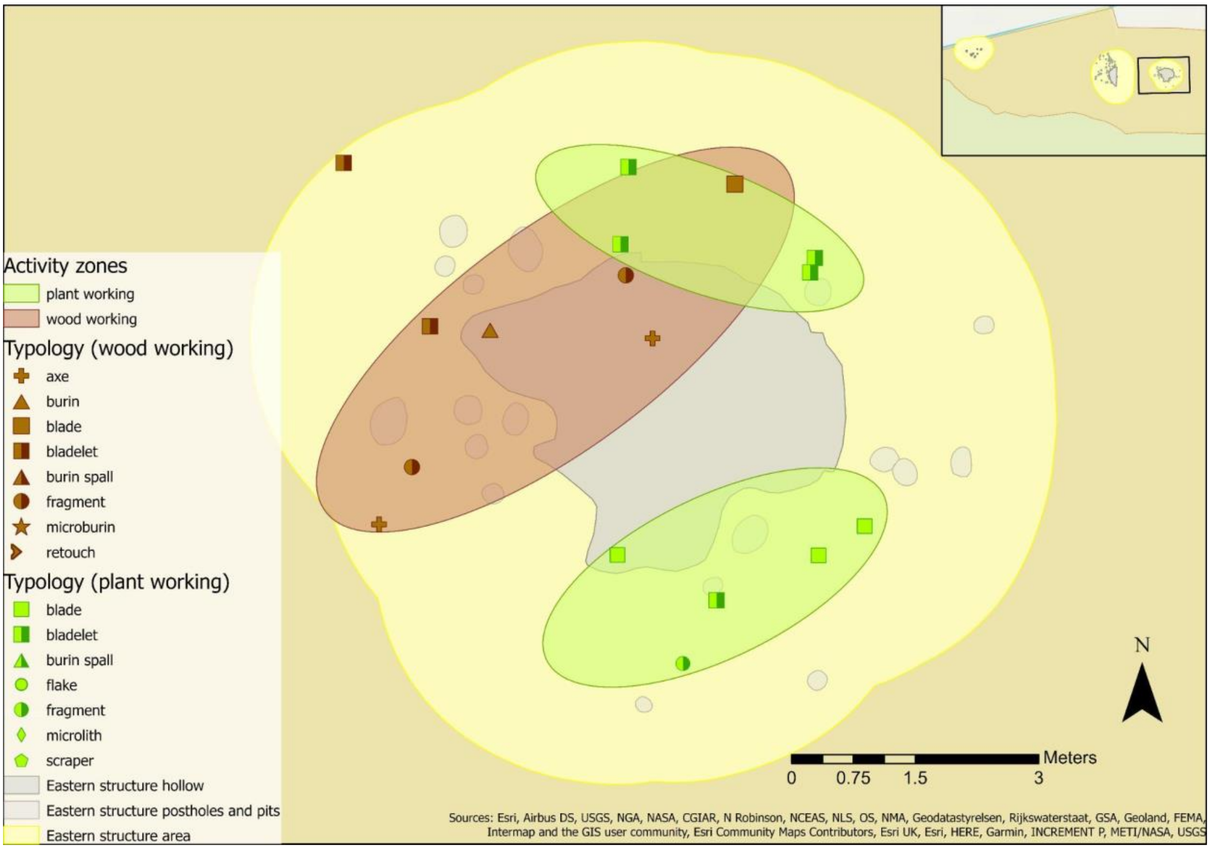


Figure 96: Spatial distribution of tools used on vegetal-related contact materials and associated activity zones.

pieces (Jensen 1994). Therefore, a clustering of siliceous plant tools in the structure may represent a single instance of plant working, if an individual or several individuals were scraping bundles of siliceous plants over a short duration.

Woodworking traces were mostly found in the northern half (see figure 96), with different tool types and directionalities represented. Cutting, scraping, planing and engraving actions were observed, indicating a range of tasks were undertaken. This could relate to crafting wooden objects as well as debarking wooden stakes, or processing firewood. In the wetland areas, numerous wooden objects were found, including: at least three hafts or handles, dowels, stakes, digging sticks, a willow and roundwood withy and a bow (Taylor, M. *et al.* 2018).

6.4.5. Extent of the structure

Several postholes surrounding the hollow are likely to have held the main weight-bearing posts of the structure (see figure 97). Two clusters of four postholes to the west of the hollow could be interpreted as indicating structural maintenance. Posts may have been repositioned or changed as they deteriorated, similar to interpretations of Howick, Northumberland (Waddington *et al.* 2007). Alternatively, the clusters could indicate additional structural post supports for the main frame (Taylor, B. *et al.* 2018b, 64). In both scenarios, all post holes are associated with the hollow and thus part of the structure.

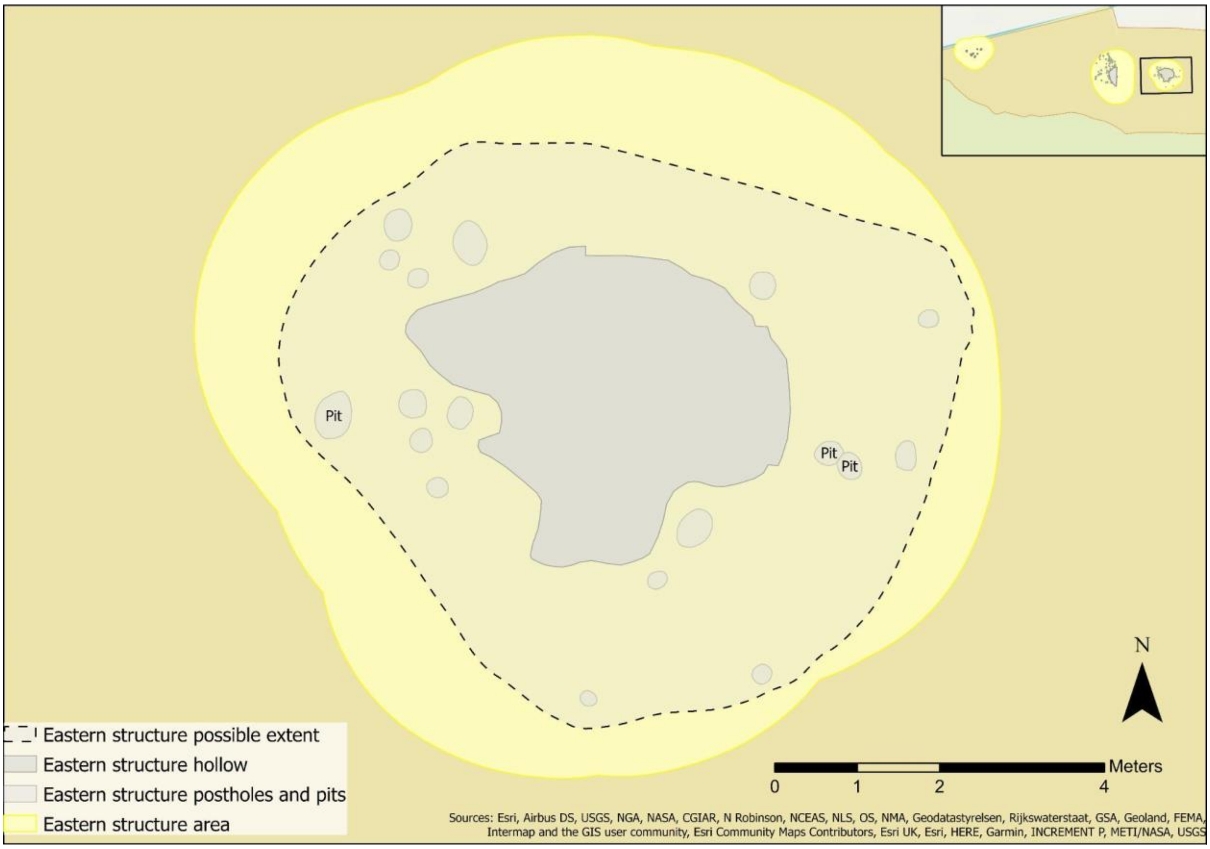


Figure 97: Proposed extent of the eastern structure.

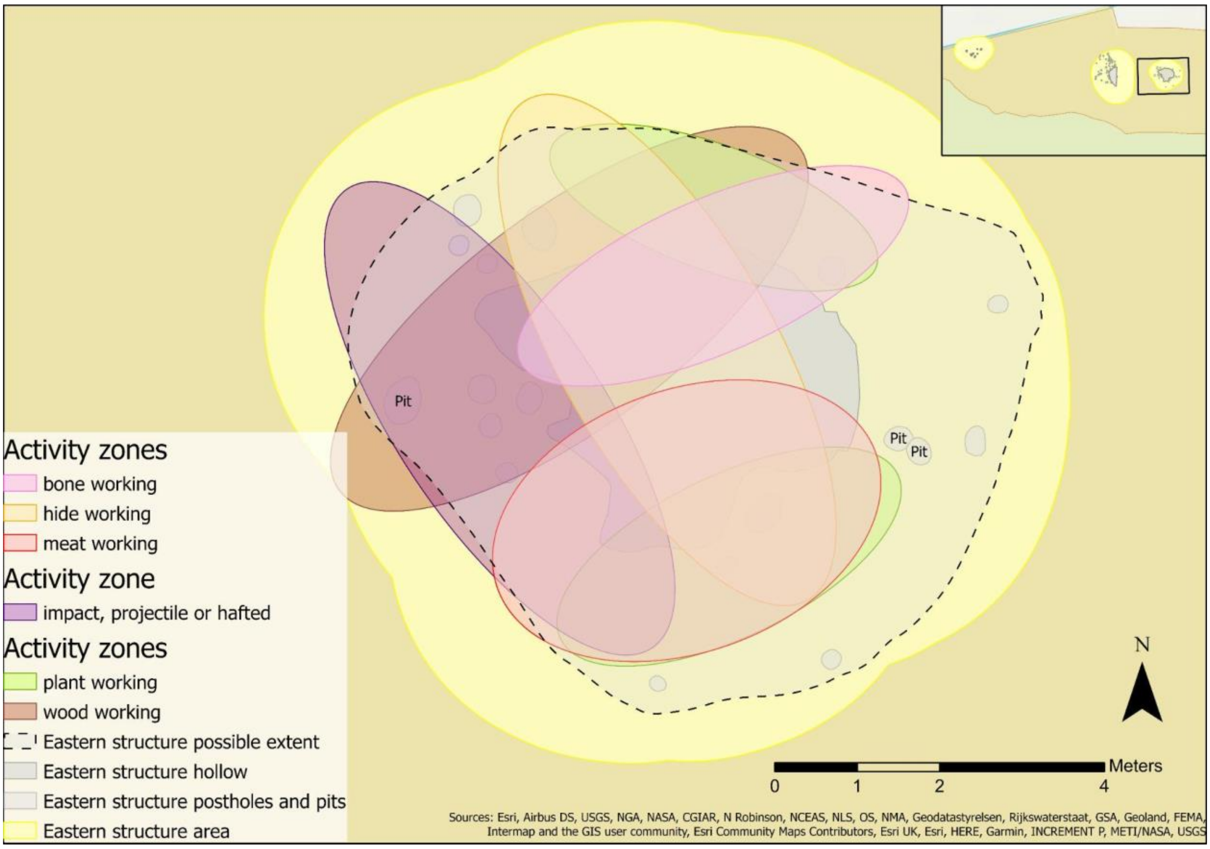


Figure 98: Composite image of proposed eastern structure extent and all of the activity zones.

Four outer postholes to the south-east follow a curve that appears to respect the hollow's shape (see figure 97). These postholes may be directly associated with the eastern structure (i.e. they contained posts that were part of the structural frame) or with a freestanding structure nearby, similar to a windbreak. Previous interpretations suggest that they held thin upright posts that 'supported a wall' of the structure, as opposed to weight-bearing stakes that were a part of the mainframe (Taylor, B. *et al.* 2018b, 64). This was based on lithic refits contained within the limits of these postholes. New microwear results further clarify the structure's boundary. Most tools within each activity zone are contained within the outermost postholes and pits (see figure 98). Therefore, a boundary of the structure, which includes these features, was established.

There is some clarity in the spatial patterning of activities in the structure. From this, it is possible that there was minimal post-depositional movement of flints in the last phases of the structure's use. If tools were brushed to the sides of the structure from movement or intentional clearing, the organisation of space appears to have been largely preserved. However, the boundary of structure may be an underestimation. For example, thatching on a conical roof would extend the groundcover beyond the postholes, as it tapered to the ground there would be a gap between the perimeter of the roof and posts. Alternatively, a dome-shaped structure covered with animal hides may not extend beyond the postholes as skins are thinner and can be tightly tied to the posts. The architecture is unclear, so the boundary presented is based on a minimum estimate.

Chapter 7: Central structure and surrounds

7.1. Introduction

Previous work undertaken by the Star Carr Project will be presented first, discussing what was excavated from the structure, and the spatial, technological and microwear assessments of the lithics. This chapter will then detail the work undertaken for this thesis and the results from new microwear analysis. The third section will present an interpretation of the result and includes relevant microwear data from the Star Carr Project, where eight flints were assessed (Conneller *et al.* 2018a).

7.2. Introduction to the structure

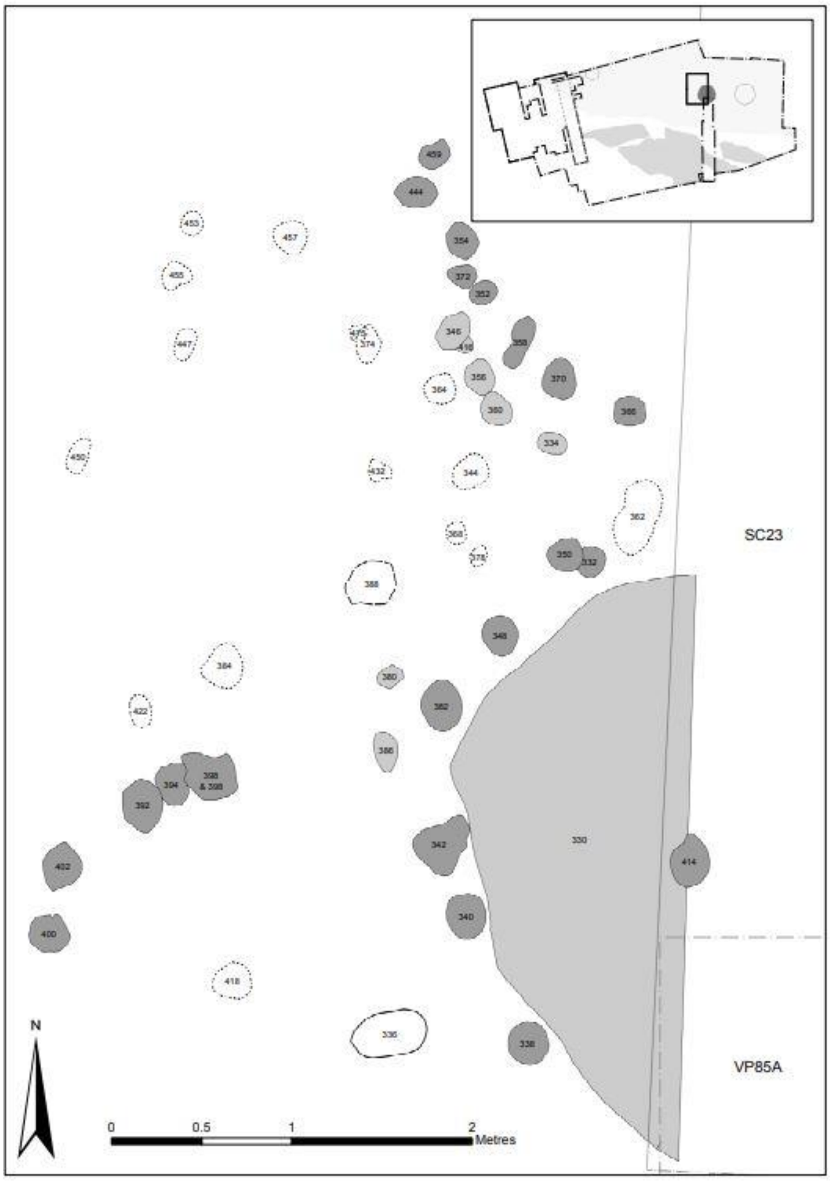


Figure 99: Plan of the central structure and associated features (Copyright Star Carr Project in Taylor, B. et al. 2018b, 60).

The central structure was the earliest radiocarbon dated structure identified on the dryland, in use between 9300-9200 cal BC, and contained the largest quantity of associated postholes and pits (Milner *et al.* 2018e, 227; Taylor, B. *et al.* 2018b, 59). A hollow, measuring 3.32m north to south, approximately 2.65m wide and 18cm deep, was surrounded by at least six postholes (see figure 99). It was truncated by previous excavations, so the full extent could not be uncovered (Taylor, B. *et al.* 2018b, 59). Geochemical analysis of the soil elements in and around the structure indicated the presence of a wall (Rowley *et al.* 2018, 171; Taylor, B. *et al.* 2018b, 63). Samples taken from inside the hollow were depleted in most elements, compared to the surrounding areas. This suggested that the inside of the structure was cleared of waste material or that different activities occurred inside the hollow compared to the surrounds (Rowley *et al.* 2018, 172).

There was sparse material recovered from the hollow (12 pieces of animal bone, 407 flints) (see figure 100) and this, alongside the truncated hollow, has meant interpretations have understandably been left largely ambiguous (Conneller *et al.* 2018a, 168; Knight *et al.* 2018b, 128; Taylor, B. *et al.* 2018b, 59). Additionally, radiocarbon dates show human activity dating to at least two different episodes: one earlier date c.9200 cal BC from the upper fill of the hollow and a later date c.8800 cal BC from post-hole [338] (Bayliss *et al.* 2018, 75; Milner *et al.* 2018e, 228).

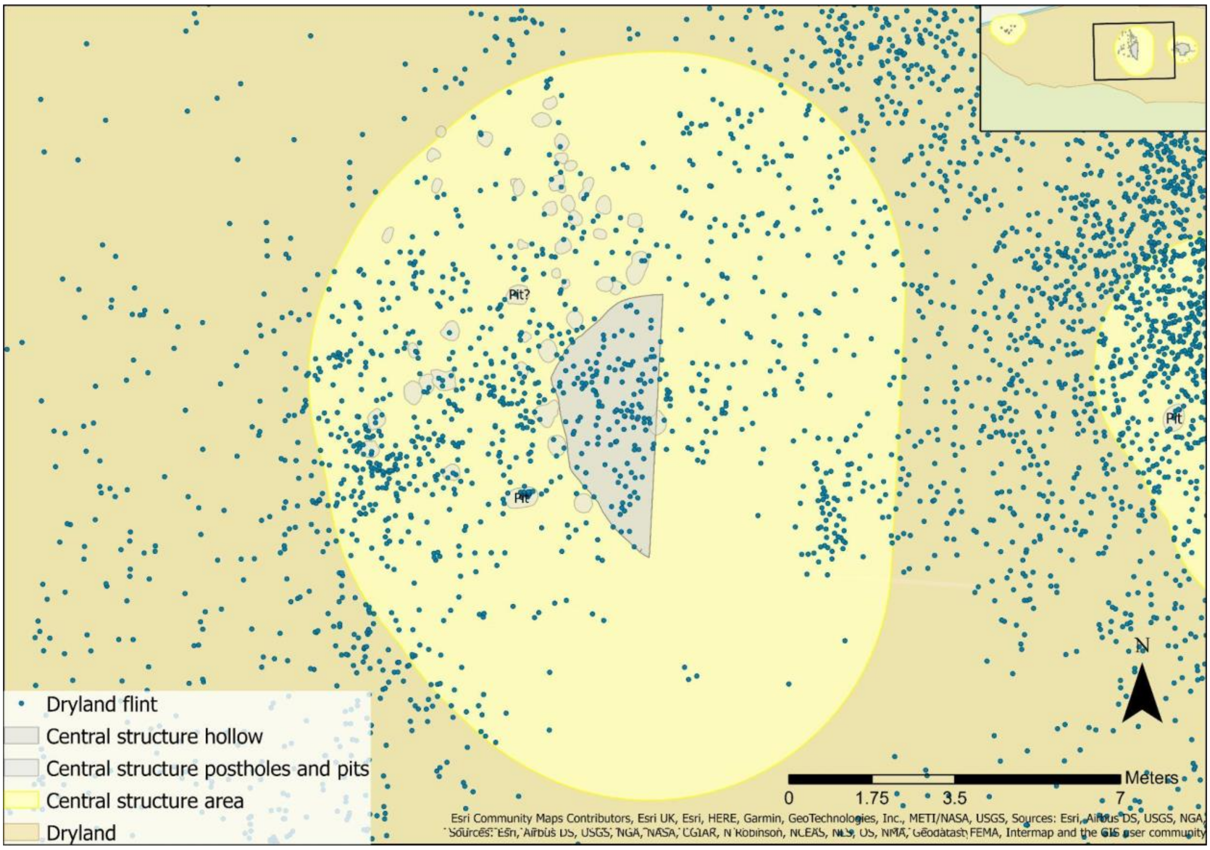


Figure 100: Density of flints found in the central structure area (after Conneller et al. 2018a, 165).

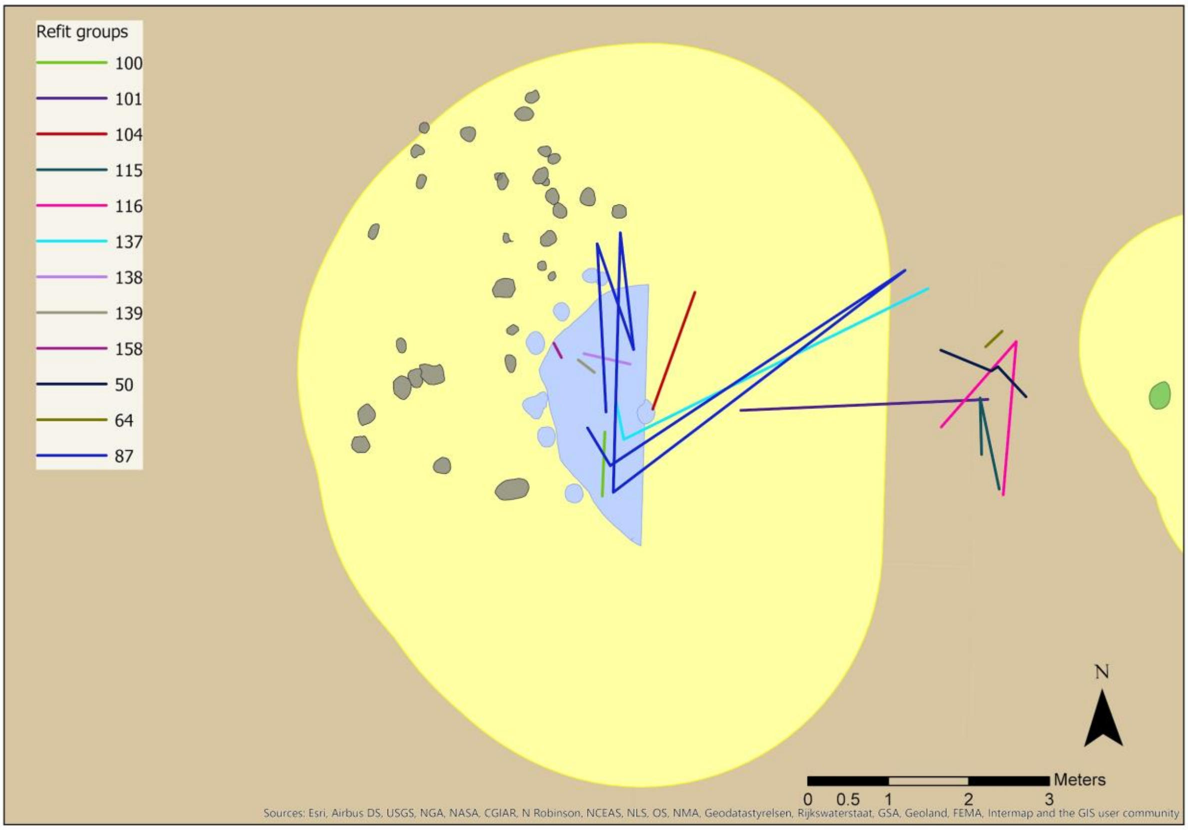


Figure 101: Close up refitting of flint pieces found in and around the central structure hollow (after Conneller et al. 2018a, 167).

Technological and microwear analysis of lithics helped elucidate some aspects of how the central structure was used. Discrete clusters of tool types were observed in the hollow: utilised blades to the west, three microliths to the north, and scrapers to the south-east (though some were excavated in the 1980s) (Conneller *et al.* 2018a, 165). Microwear analysis of a small sample revealed animal-related tasks within the hollow and refitting analysis was implemented to explore the movement of lithics, and thus people, in and around the structure (Conneller *et al.* 2018a, 168). It was suggested that most flints post-dated the structure, based on the amount of movement across the physical boundary of the hollow (see figure 101) (Conneller *et al.* 2018a, 168)

To demonstrate a lack of physical barriers (i.e. when the structure was no longer present), a back and forth movement between the hollow and the surrounds may be expected. A single movement from one position to another (i.e from A to B) does not prove that a structure was not present. For example, an individual could have moved outside or inside a structure through an entrance-way for a number of reasons (i.e. light, space, individual social dynamics). A number of the refits associated with the central structure either show a single movement from A to B (e.g. refit 101, figure 101) or they are mostly located within the outer boundary of the structure and only move beyond the hollow once (e.g. refit 87, figure 101). Movement of material slightly beyond the hollow would be expected if individuals were working in the structure or through clearance activity. It is possible that the refits 87, 137, and 101, which all appear to extend beyond the interpreted eastern extent of the structure in the same direction, indicate a possible entrance (see figure 101).

If refit 87 is predominantly located within the hollow, along with refits 138, 139, 100, 158 and 104, there does not appear to be considerable movement of material outside of this area. This could suggest that a physical barrier was in fact in place when tools were knapped (i.e. a structure was present). However, refit 87 is the only sequence that offers the most convincing evidence of contemporaneous activity as it contains multiple flints, likely from the same sequence of activity. Short refit sequences are less likely to be contemporaneous as tools may have been scavenged from earlier occupations in a single A to B movement. In refit 87, the one movement outside of the hollow was for a flint flake. This does not explain why an individual moved to the area, so cannot provide clarity on whether a structure was present at the time. Contrary to previous interpretations, it is suggested here that the available evidence is inconclusive regarding the production and use of flint tools within a structure.

Radiocarbon dating suggests that there were at least two separate episodes of activity in this area (Bayliss *et al.* 2018; Conneller *et al.* 2018a). Therefore, it is possible that some lithics were deposited when the structure was still standing, with the discrete undisturbed clusters perhaps occurring later. Alternatively, the structure may have been kept relatively clear of material during its use, as indicated by geochemical analysis, faunal remains and relative absence of flint, due to a specific function. Tools found in the area could reflect activity once the structure had been destroyed or dismantled (shown through refits to the west of the hollow) (Conneller *et al.* 2018a; Knight *et al.* 2018b; Rowley *et al.* 2018). From the work of the Star Carr Project, there is little to suggest that the central structure had a more specialised function than the others. It is possible that earlier inhabitants may have used the structure in a way that left fewer material traces to those seen later (Boric 2008; Carrer 2017; Coulson and Andreasen 2020; Taylor, B. *et al.* 2018c, 271).

Additional features and postholes were found associated with the hollow (see figure 102) (Taylor, B. *et al.* 2018b, 61). An arc of eight postholes to the north, surrounded by an outer layer of at least two postholes, was tentatively interpreted as a larger circular structure, labelled ‘the northern structure’, measuring roughly 3.8m x 2.8m (Taylor, B. *et al.* 2018b, 66). A lack of finds around the postholes and radiocarbon dates meant interpretations could not be made beyond the nature of its features (Taylor, B. *et al.* 2018b, 61). The shallow post-hole depth indicated that either: 1) the posts were short, 2) the features held structural supports in place, or 3) the depth of postholes is not reflective of their true size (Taylor, B. *et al.* 2018b, 62). Due to limited evidence, these features are included in the central area, rather than as a stand-alone structure.

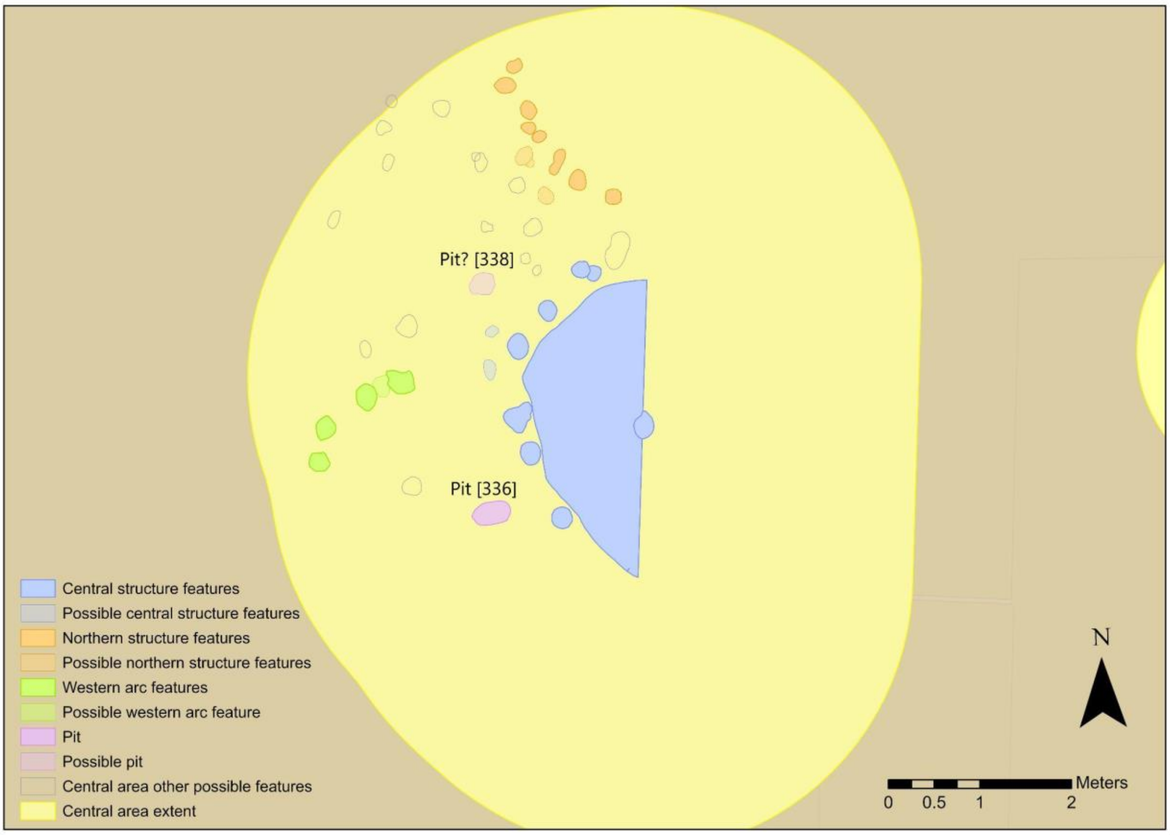


Figure 102: Central dryland structure and surrounding central area based on interpretations by Taylor, B. et al. 2018b (Image after Taylor, B. et al. 2018b, 61).

A second arc of six post holes was observed to the south-west of the hollow; these were interpreted as 'smaller structural features' (see figure 102) (Taylor, B. *et al.* 2018b, 62). Smaller structures could relate to drying racks for fish or meat, storage frames, wind breaks or frames for facilitating hide processing (Taylor, B. *et al.* 2018b, 67). Given their ephemeral nature, other more substantial structures may have been present in and around this area. A pit and one possible pit were identified to the west of the hollow. Pit [336] contained 49 pieces of worked flint (25) and fragmentary animal bone (24) that had been heat treated and later deposited into the pit, whereas the possible pit [388] had no contents (see figure 102) (Taylor, B. *et al.* 2018b, 62).

7.3. New microwear results

7.3.1. Overview

Across the central structure area 102 lithics were analysed, 28 of which were located in the central hollow area (27% of flints analysed - see figure 103). Signs of use were observed on 47 pieces (46%) with 55 tools interpreted as not used (54%). Flints were sub-sampled based on tool type and spatial location; they were selected from across the study area to ensure that those associated with different features were analysed. An even spread of pieces across the area was not always possible as some of

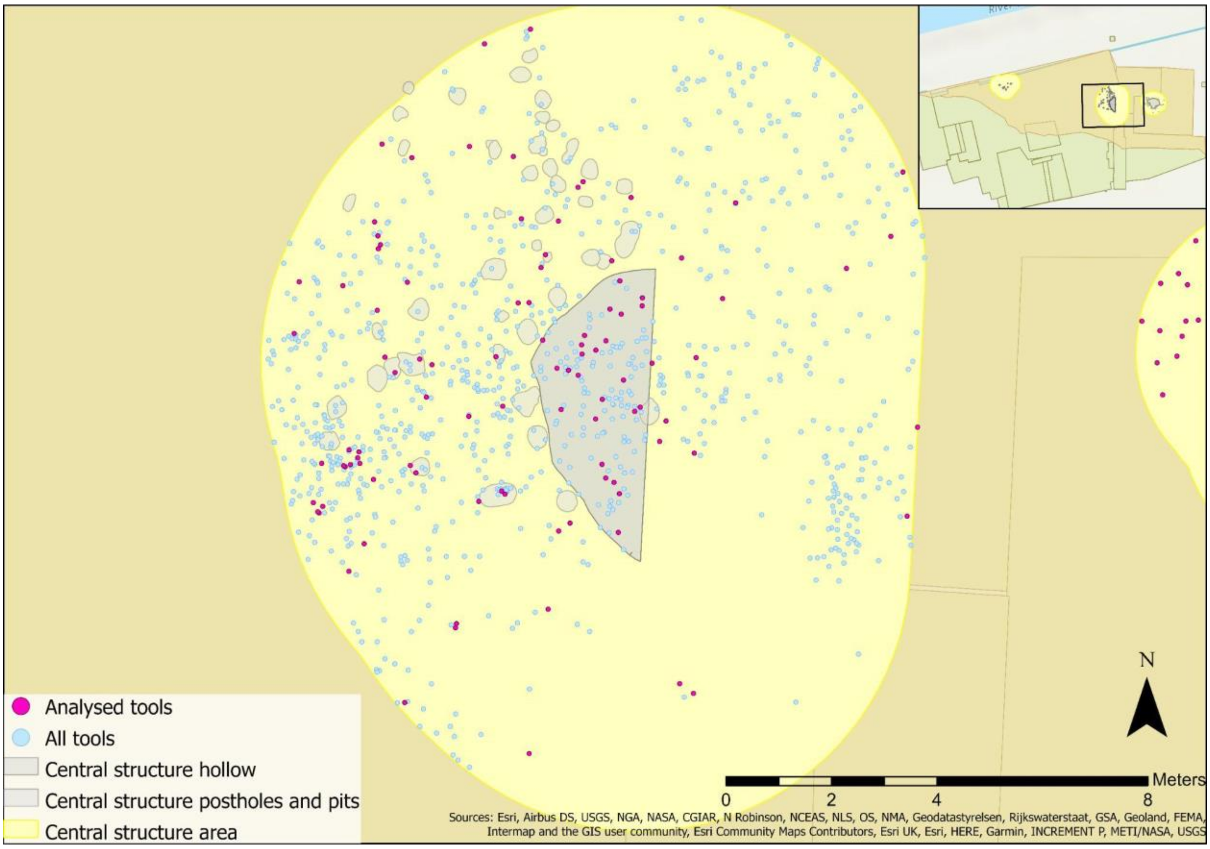


Figure 103: Distribution of analysed tools alongside all tools found within the central structure area.

the flints were missing from the archive. Where a cluster of a particular tool type was identified, if possible, several were analysed to explore potential links in tool use in certain areas.

Flints had relatively high rates of PDSM, 71% of pieces showed at least one type. Iron oxide staining was observed on 43, 22 had flat dull smoothing, 10 showed metallic striations, and three had surface patination. Where polish was identified, iron oxide staining rarely prevented an identification of contact material. In the few cases where PDSM impacted interpretations, hardness of material and directionality was noted in lieu of a specific contact material.

The most frequently identified material from the central structure was bone (10), followed by wood (6) and hide (6). Plant (3), fish (3), meat (1), antler (1) working and the use of projectiles (2) were also observed (see table 14).

Primary contact material	Secondary contact material	Motion of use	Number
Antler		Transverse	1
Bone		Longitudinal	5
Bone	Meat	Transverse; longitudinal	3
Bone	Hide	Transverse	2
Fish		Transverse; longitudinal	3
Hide		Transverse	2
Hide	Soft mineral	Transverse	3
Hide	?Wood	Transverse	1
Meat	Bone	Longitudinal	1
Projectile	Meat + bone	Longitudinal (hafted)	1
Projectile	Medium indeterminate	Longitudinal (hafted)	1
Plant (inc. plant/soft wood)		Transverse; longitudinal	3
Wood		Transverse; longitudinal	6
Soft indeterminate		Transverse	2
Soft/medium indeterminate		Longitudinal	3
Medium indeterminate		Transverse; longitudinal	4
Hard indeterminate		Transverse; longitudinal	4
Indeterminate		Unknown	2
Not used (no clear signs of use)		n/a	53
Not possible		n/a	2

Table 14: Microwear results of analysed tools found in the central structure area.

7.3.2. Tool types

There were 242 flakes excavated and 38 (16%) were selected for microwear analysis, of which eight had been used. Most had traces from cutting bone (3), and one had transverse bone and meat polish. Scraping of dry hide (1) and plants (1) were also identified. Medium (1) and hard (1) indeterminate materials were worked in transverse directions.

Of 126 bladelets found, 26 (11%) were analysed, of which seven had signs of use. Equal quantities had been used on vegetal (3) and animal-related (3) materials. Wood scraping or planing was identified (2) along with plant or soft wood scraping (1). Two bladelets had butchery-related polish:

bone and meat or hide cutting. Dry hide scraping was also observed (1). A final bladelet had transverse traces from a soft indeterminate material.

In total, 15 blades were located in the central structure area, and 13 (87%) were analysed. All blades had been used, with most (7) showing animal-related polish. Working of bone and meat or hide in scraping (1) and cutting (1) motions was identified, and one blade was used to groove bone or antler. Transverse directionality was observed on possible antler working (1) and fish working (1) tools. One blade had fresh hide scraping traces, and another had dual use of scraping fresh hide and wood. Soft indeterminate transverse polish was identified (1) and traces from a hard indeterminate material (1). Two blades had indeterminate use.

There were 16 scrapers excavated and six (38%) were selected for analysis, of which five were used. Two had traces of hide scraping, one of these had been used on dry hide with a mineral additive. Longitudinal bone polish was observed (1), and there was also evidence of bone and meat scraping (1). A final scraper was used to cut and scrape possibly fish.

All microliths found in this area were analysed (5), and four had wear traces. One had longitudinal meat and bone polish with possible signs of hafting. Tentative longitudinal traces from fish were observed (1) on another tool. Longitudinal polish from working soft/medium (1) and medium (1) indeterminate materials were also identified; the microlith used on a medium indeterminate material had hafting traces.

Overall 10 burin spalls were excavated, and of the five (50%) analysed all had signs of use. One had polish from cutting plants and another had been used to plane or scrape wood. The remaining three tools had longitudinal traces from soft/medium (1), medium (1) and hard (1) indeterminate materials.

There were four microburins found and all were assessed for wear traces. Two had been used, longitudinally on soft/medium (1) and transversely on medium (1) indeterminate materials.

In total, seven burins were recovered from this area. Three were analysed and all had signs of use. Evidence of scraping soft wood or plant was observed (1), along the lateral edge of the tool. The remaining burins had identifications of medium indeterminate polish (1) and longitudinal hard indeterminate traces (1).

7.3.3 Bone

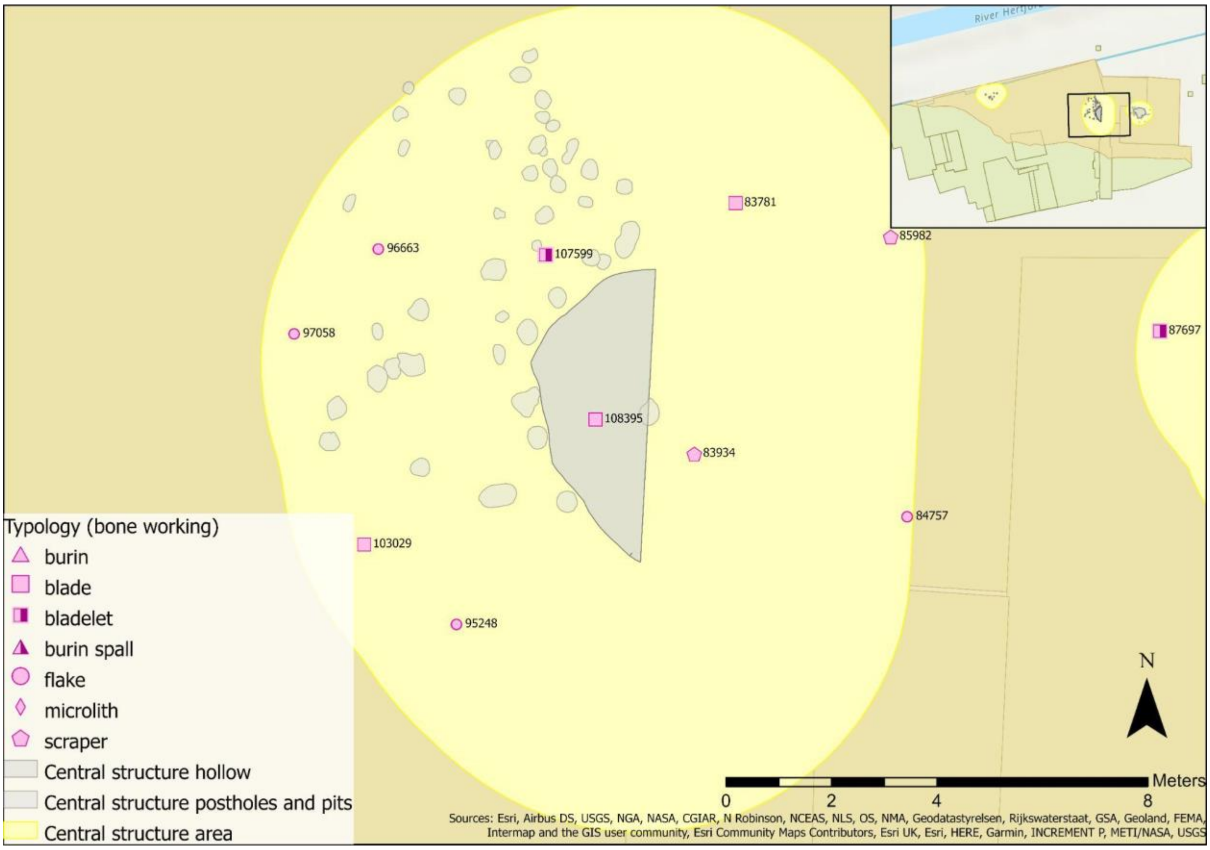


Figure 104: Distribution of bone working tools from the central structure area.

There were ten tools identified with bone traces, and generally the polish observed was undeveloped. One blade found within the central hollow was used to scrape and cut bone and meat. The other two blades were used in a longitudinal direction on bone (<103029>, see figure 104) and transversely on bone and fresh hide (<83781>). This is indicative of butchery-related tasks and the processing of bone.

Four flakes were spread across the study area. Those found closest together (<96663>, <97058>) were used to cut and scrape bone and meat (see figure 105) and cut bone. The remaining flakes were both used to cut bone. One scraper (<83934>) was found closest to the hollow and evidenced bone scraping and cutting, and the other was used to scrape bone and cut meat in separate areas on the tool's edge. The bladelet had longitudinal traces of bone and hide working in the same area.

Tools used on bone show no clear spatial patterning in the central structure area. There is a fairly even distribution, with no clustering based on use. Tasks on bone and bone with other materials like hide or meat are interspersed. This could suggest that bone working was not spatially constrained to any particular area.

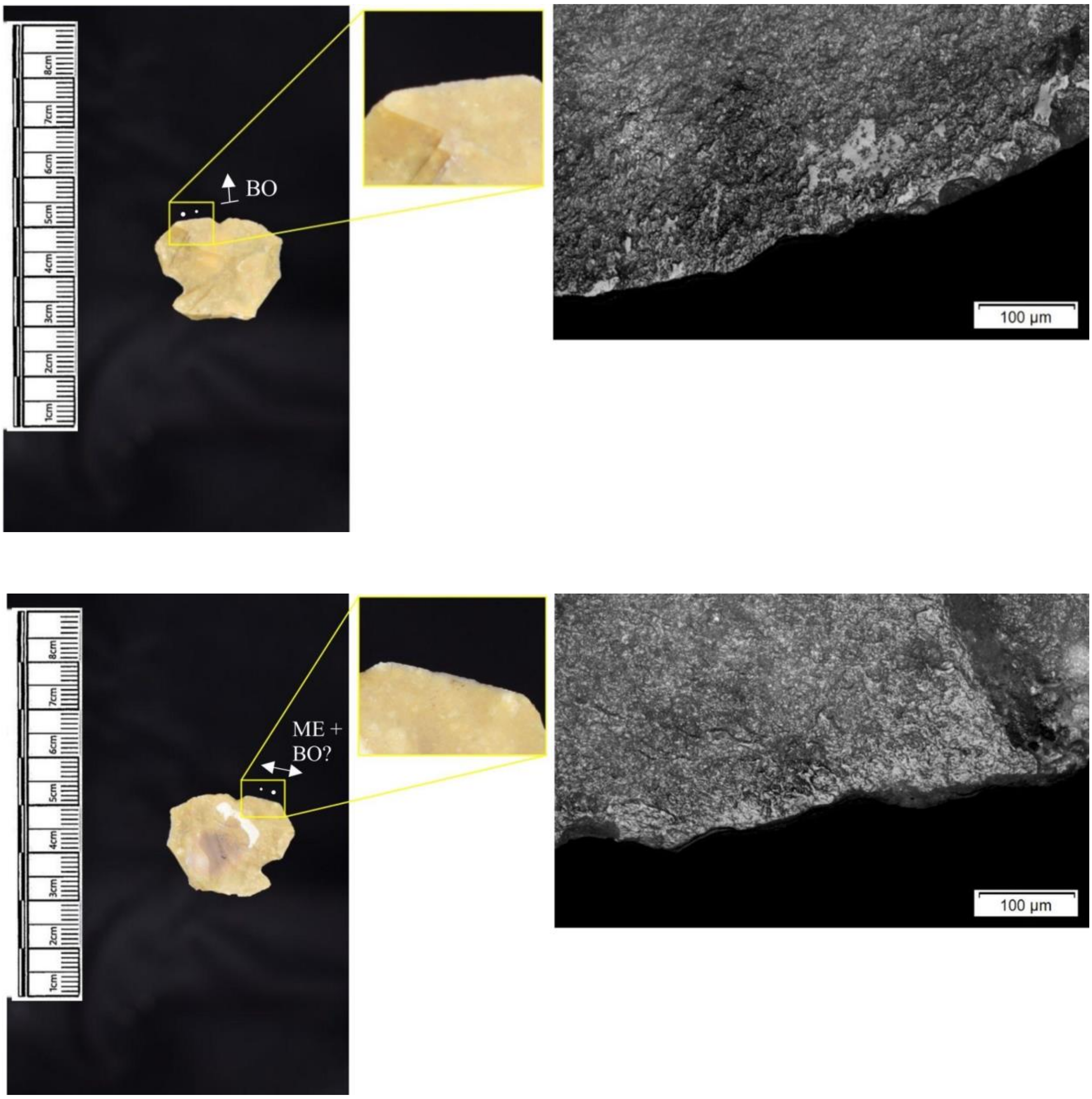


Figure 105: SC 96663, a flake interpreted as used to scrape bone and cut meat and bone, 200x magnification.

7.3.4. Meat

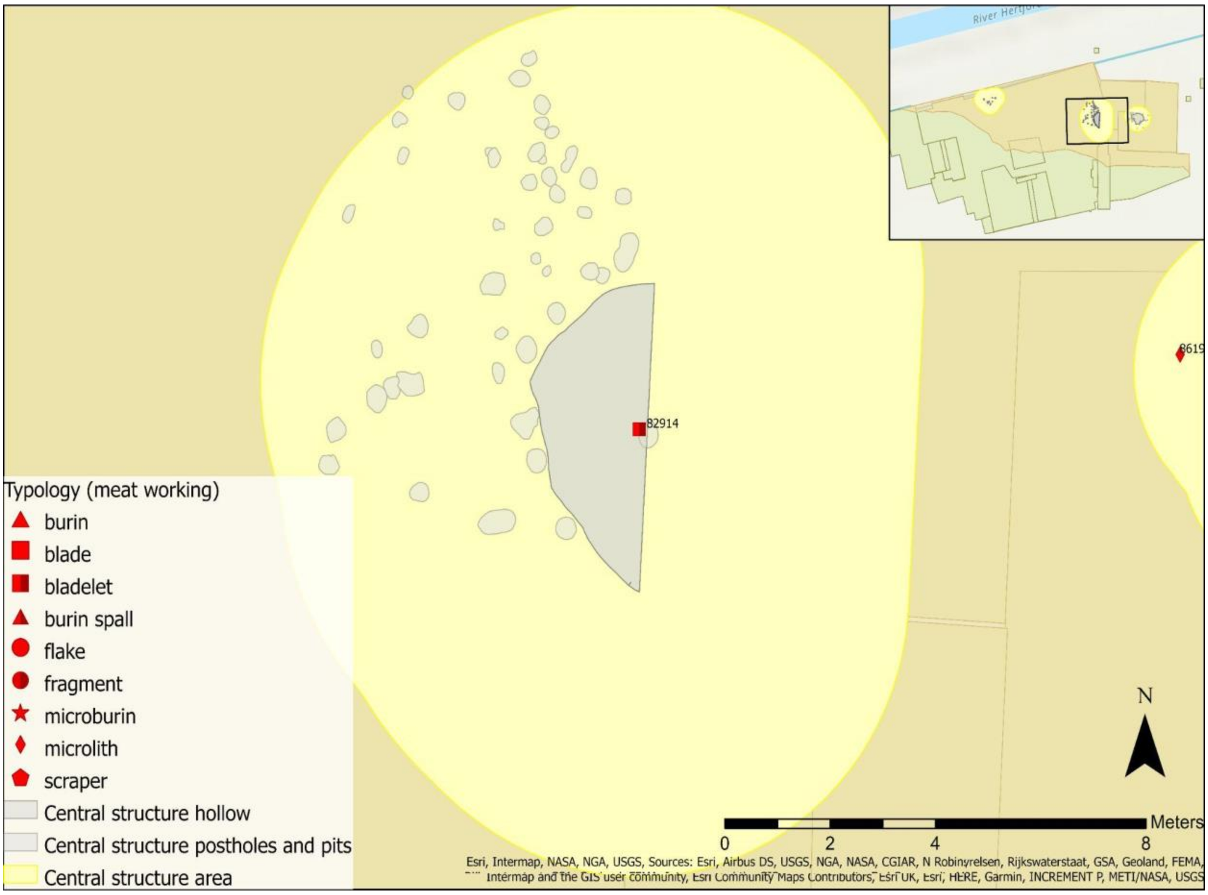


Figure 106: Distribution of meat working tools from the central structure area.

One bladelet evidenced meat as a primary contact material (see figure 106). A total of five tools showed signs of meat working, although this bladelet was the only one to show meat as a primary contact material with traces of bone, which was not used as a projectile. It was used in a longitudinal direction, indicating a cutting motion (figure 107). It is likely that the tool was used in butchery-related activities.

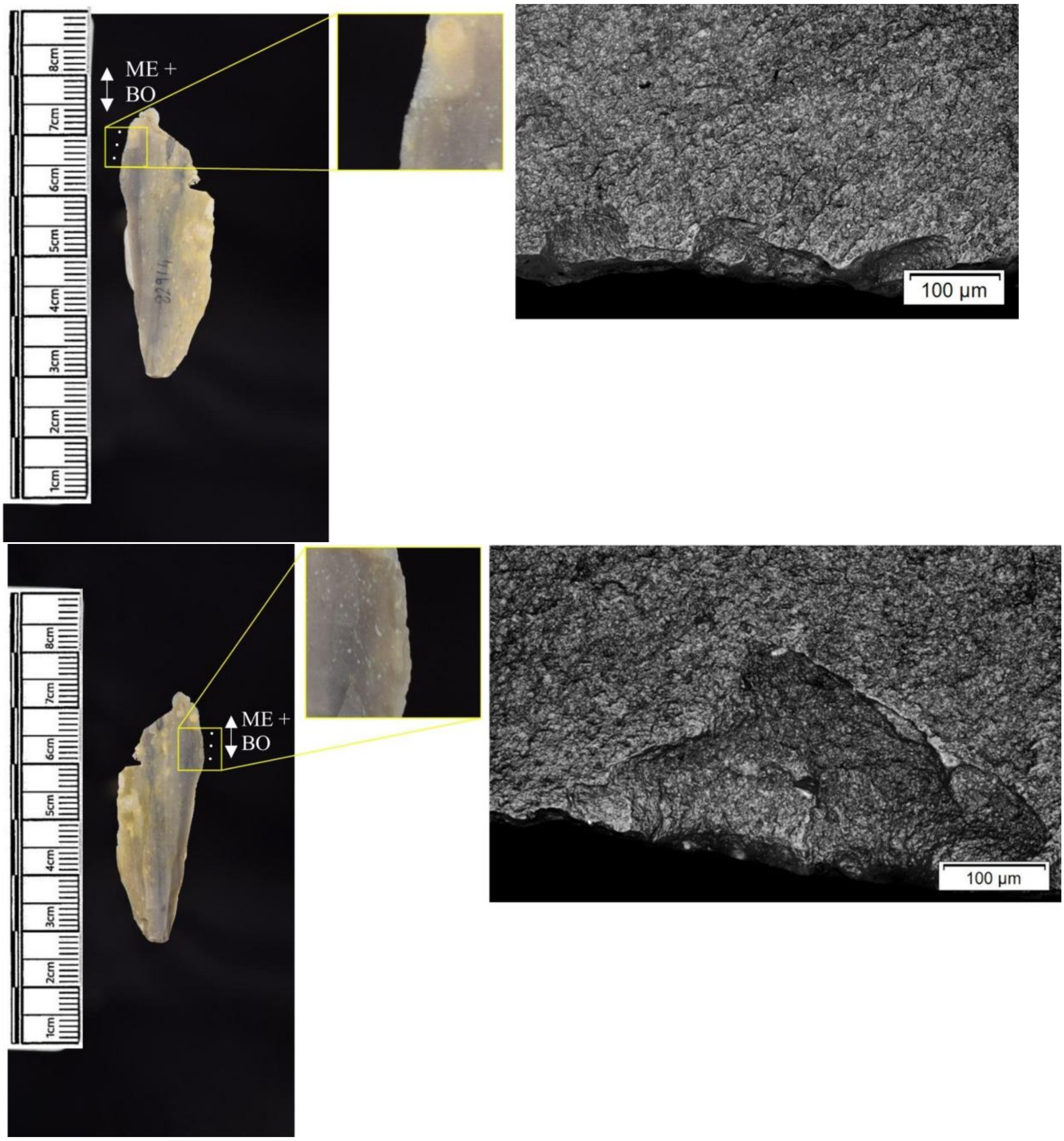


Figure 107: SC 82914, a bladelet interpreted as used to cut meat and bone, 200x magnification. The polish observed was not well developed on either aspect.

7.3.5. Hide

Six tools were used to work hide as a primary material. A scraper was found inside the hollow, and was used to scrape dry hide with soft mineral, indicated by an interlinked flat polish. Two blades found to the east of the hollow (see figure 108) were used to scrape fresh hide (see figure 109), and to scrape hide and possibly wood. This latter blade had two areas of working, one with hide and the other with wood polish, suggesting it had dual usage.

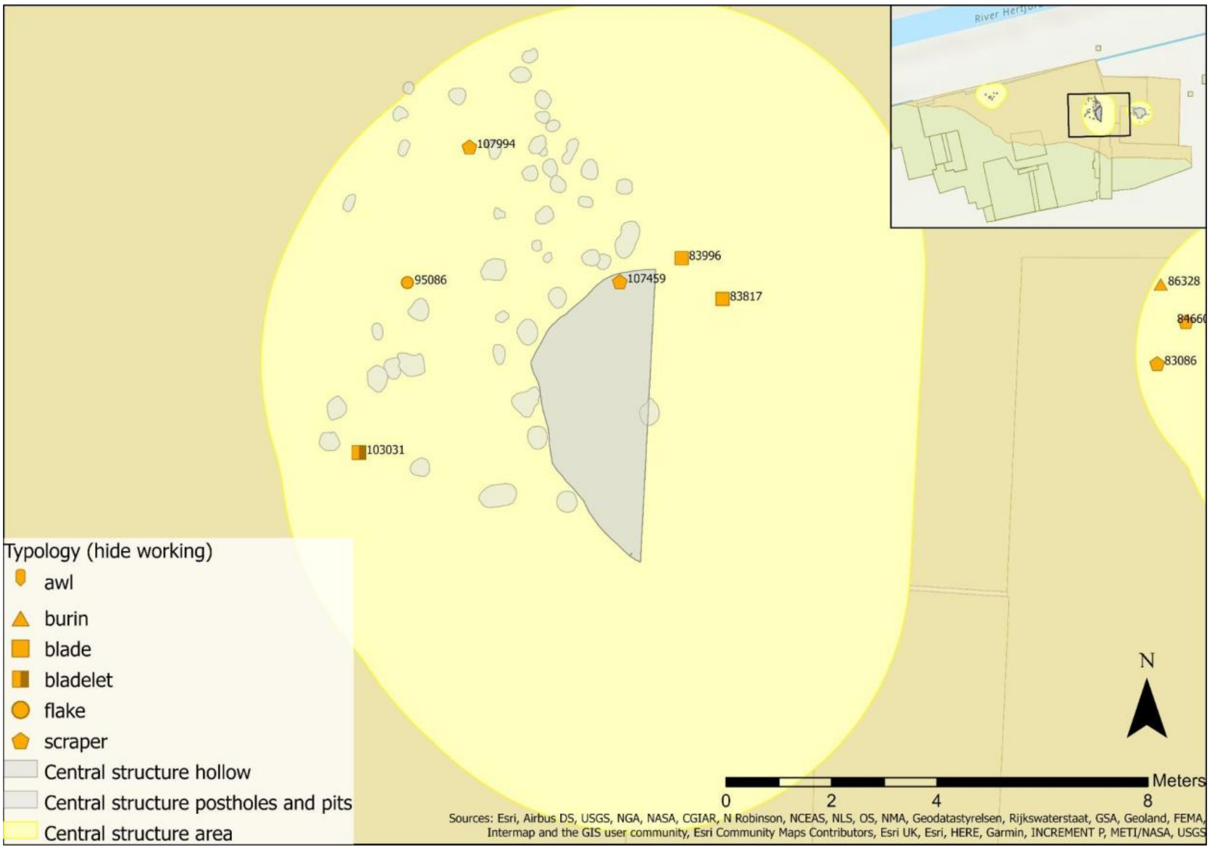


Figure 108: Distribution of hide working tools from the central structure area.

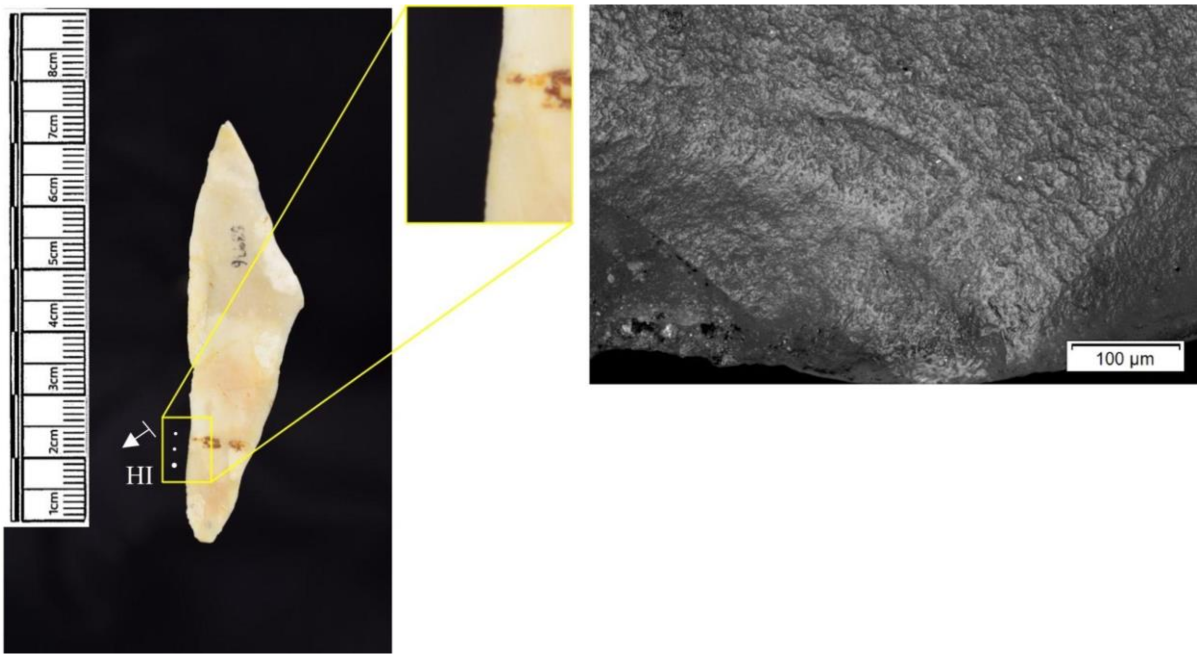


Figure 109: SC 83996, a blade from the central structure interpreted as used to scrape fresh hide, no polish was observed on the dorsal, 200x magnification.

A scraper and a flake located away from the hollow were used to scrape dry hide with a soft mineral additive. However, the observation of soft mineral polish on the flake was more tentative as a dull and flat PDSM polish was also present. A bladelet had traces of possible dry hide scraping.

Most tools (5) were located in the northern half of the central structure area. Similarly to bone working, most pieces were found outside of the hollow. Those located away from the hollow are not clustered, although the majority of pieces used on dry hide with soft mineral (2) are found away from the hollow.

7.3.6. Projectiles and hafted microliths

Two microliths had evidence of possible hafting and longitudinal polish. One was interpreted as used on meat and bone, with a striated greasy polish indicating a potential haft or binding, and was located in the hollow (see figure 110). The striated polish seen on both aspects also had a longitudinal direction, so it was likely hafted or in bindings when it came into contact with meat and bone (see figure 111). Edge rounding and areas of a smooth polish suggest that it was fixed into a haft rather than bindings. The polish indicates that it was hafted to the side of a shaft, which could relate to a projectile or another composite tool, like a knife.

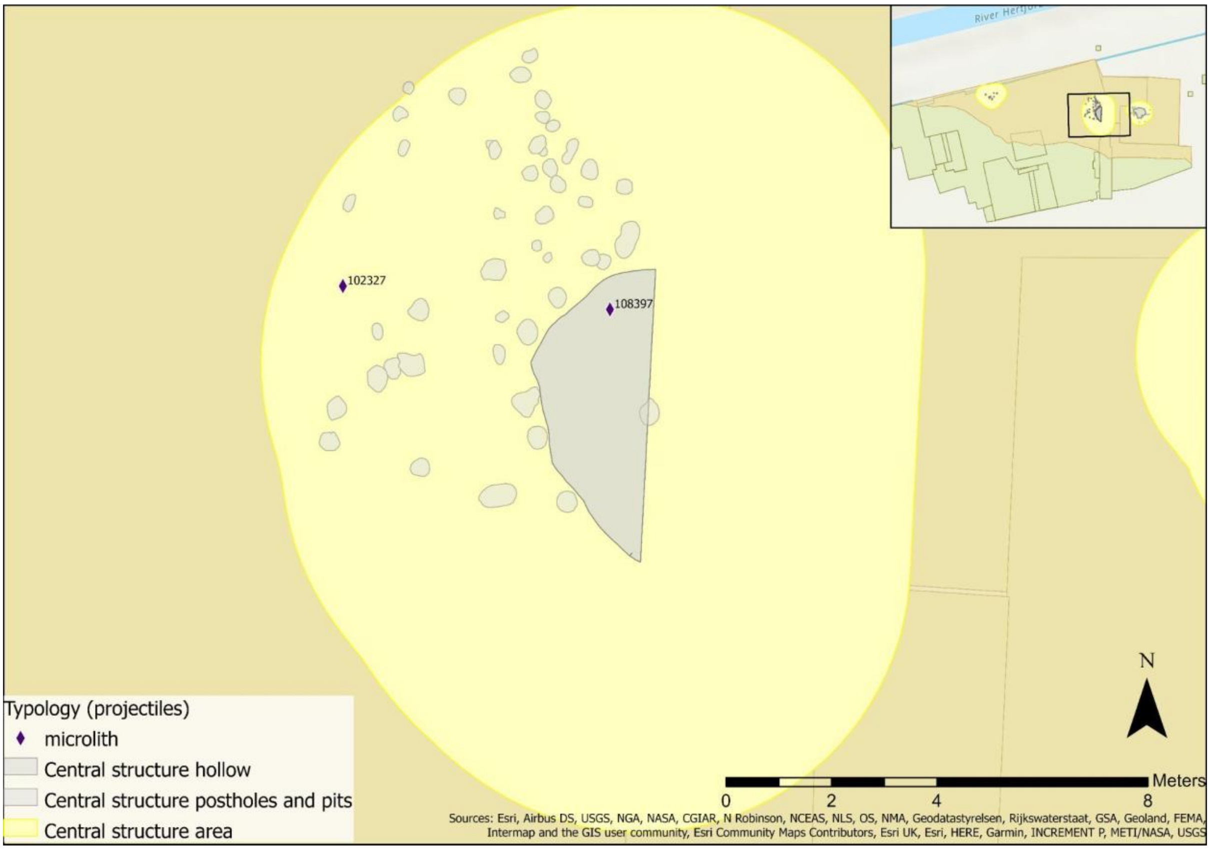


Figure 110: Distribution of projectiles and hafted microliths from the central structure area.

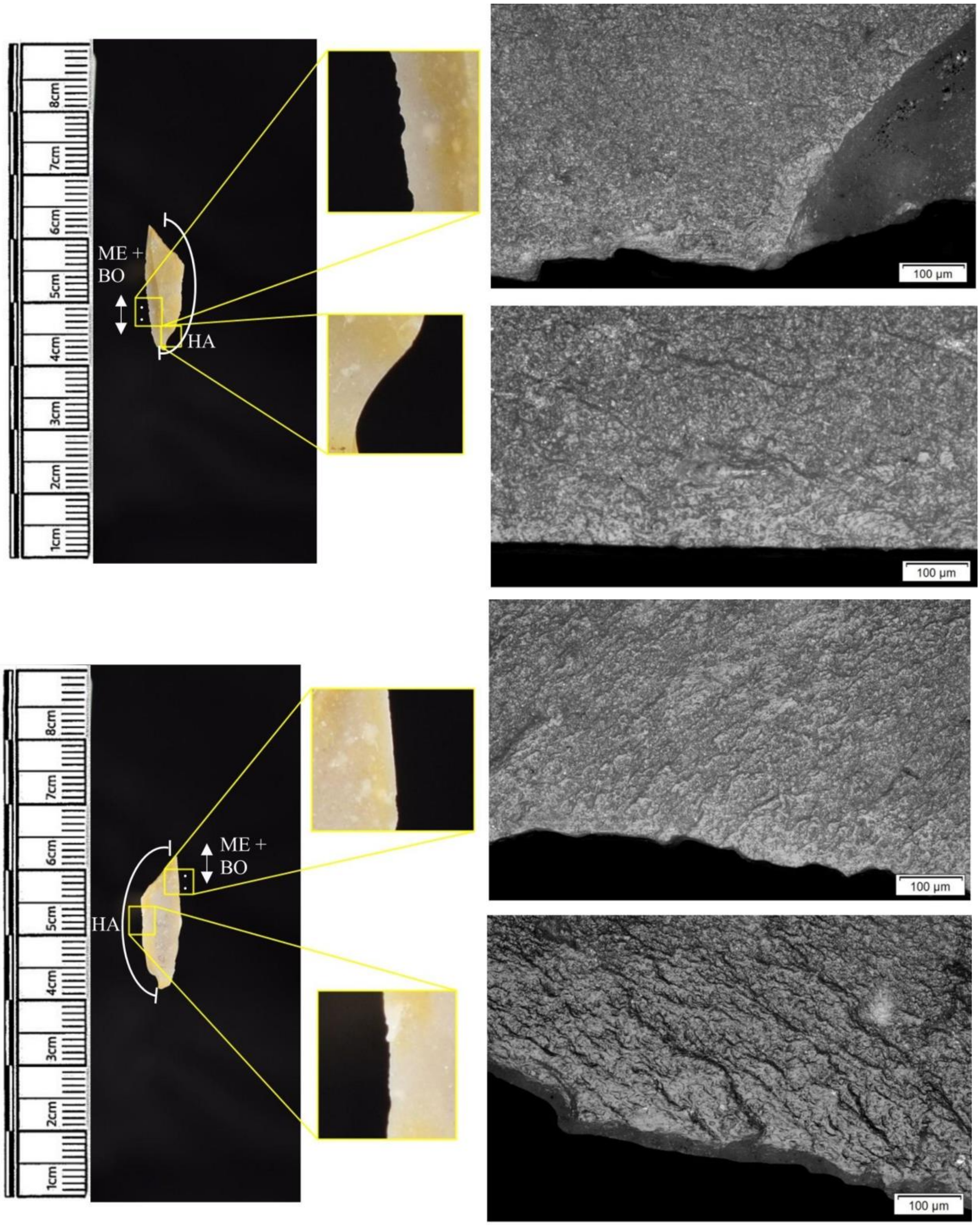


Figure 111: SC 108397, a microlith interpreted as hafted and used longitudinally on meat and bone (unclear whether used as a projectile due to absence of MLITs), 200x magnification.

Another was located to the south of the hollow, although there were metallic striations observed across both aspects of the piece, limiting interpretation to hardness of material and directionality. Traces from a medium indeterminate material in a longitudinal motion were observed, and no MLITs were identified. There were possible hafting traces, observed through an undeveloped polish towards the proximal end on the ventral aspect, associated with removals.

Overall, these microliths suggest use as hafted composite tools, as either projectiles or as part of a tool similar to a knife. The microlith located in the hollow may have been de-hafted in the area after use. There does not appear to be related activity occurring here as both tools were dispersed; however the sample size is very small so this is by no means conclusive.

7.3.7. Fish and possible fish traces

There were three tools interpreted as used to work fish. The microlith was the only one found within the hollow (see figure 112) and was used to cut fish or hide, with no MLITs. It had a greasy polish with linear striations running parallel to the edge, similar to micrographs from experimental fish butchering (see figure 113) (van Gijn 1986). Alternatively, the striations may have been caused by inclusions when working hide, therefore the tool was interpreted as fish/hide cutting. Traces of cutting and scraping fish were observed on a scraper, with a bright and greasy polish. A blade was used to scrape fish or meat; the polish lacked clear linear striations but these are often only seen in cutting fish (van Gijn 1986). Tools used to possibly work fish were spread across the area, with no spatial clustering observed.

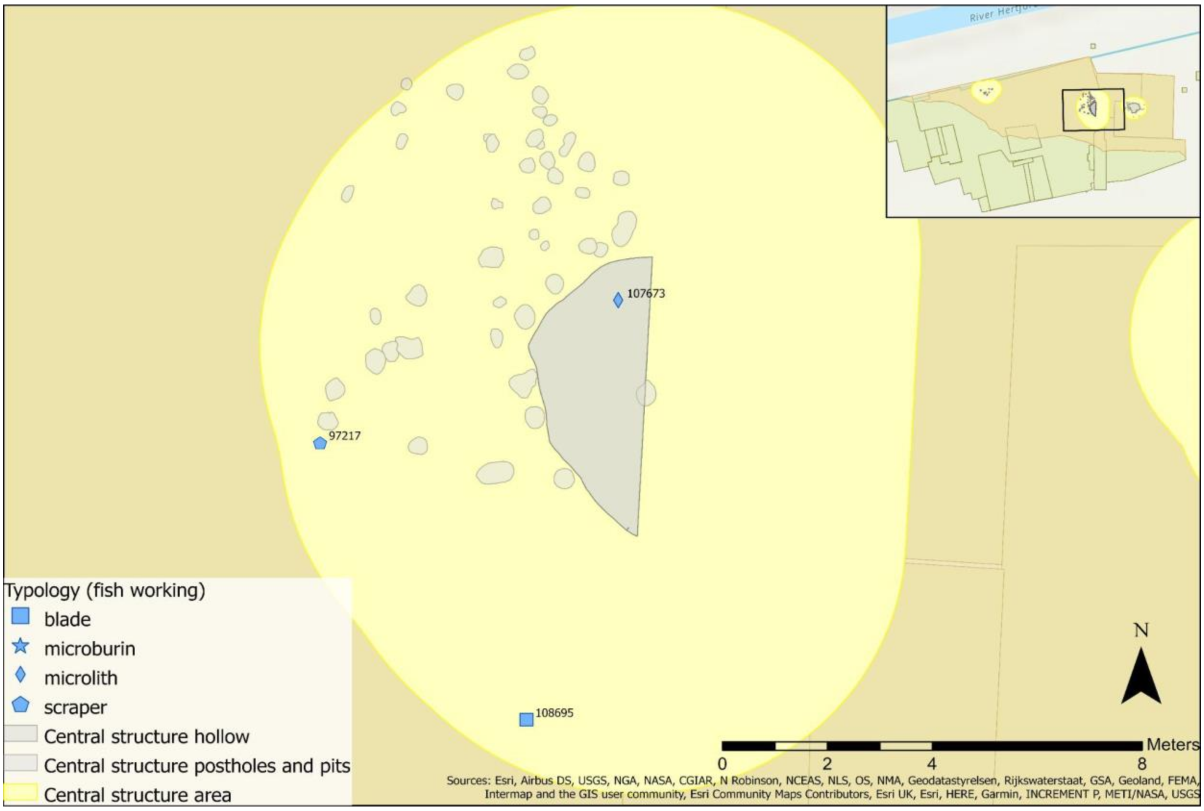


Figure 112: Distribution of fish working tools from the central structure area.

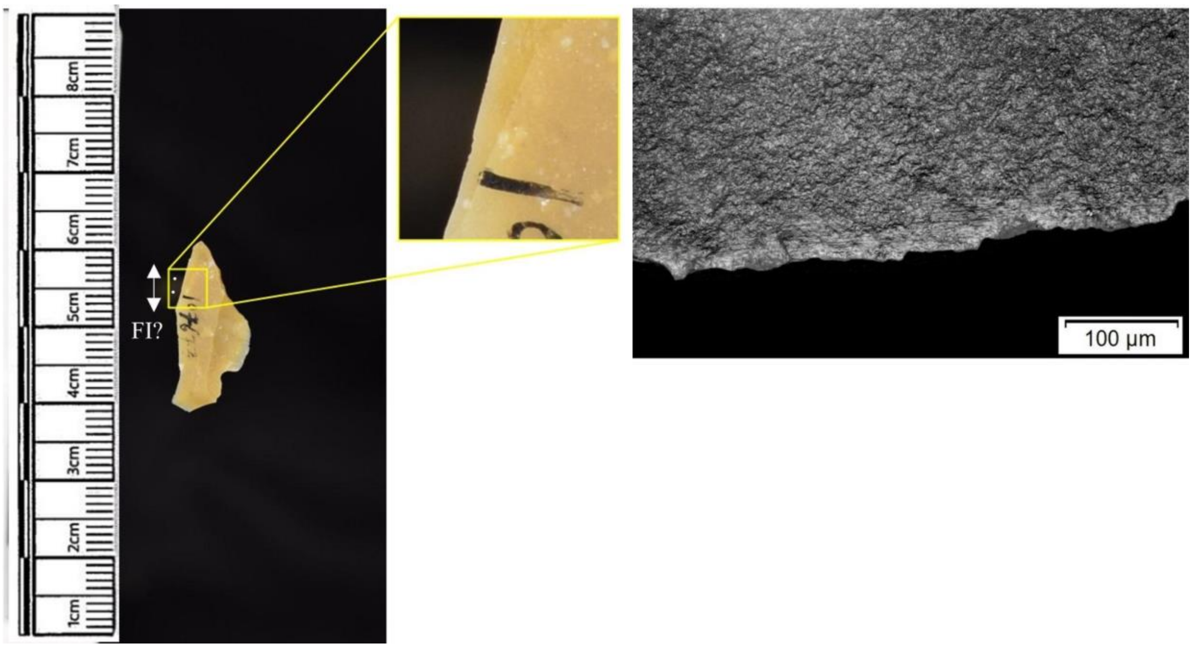


Figure 113: SC 107673, a microlith interpreted as used to cut possibly fish with polish observed on the dorsal, no polish was observed on the ventral, 200x magnification.

7.3.8. Antler

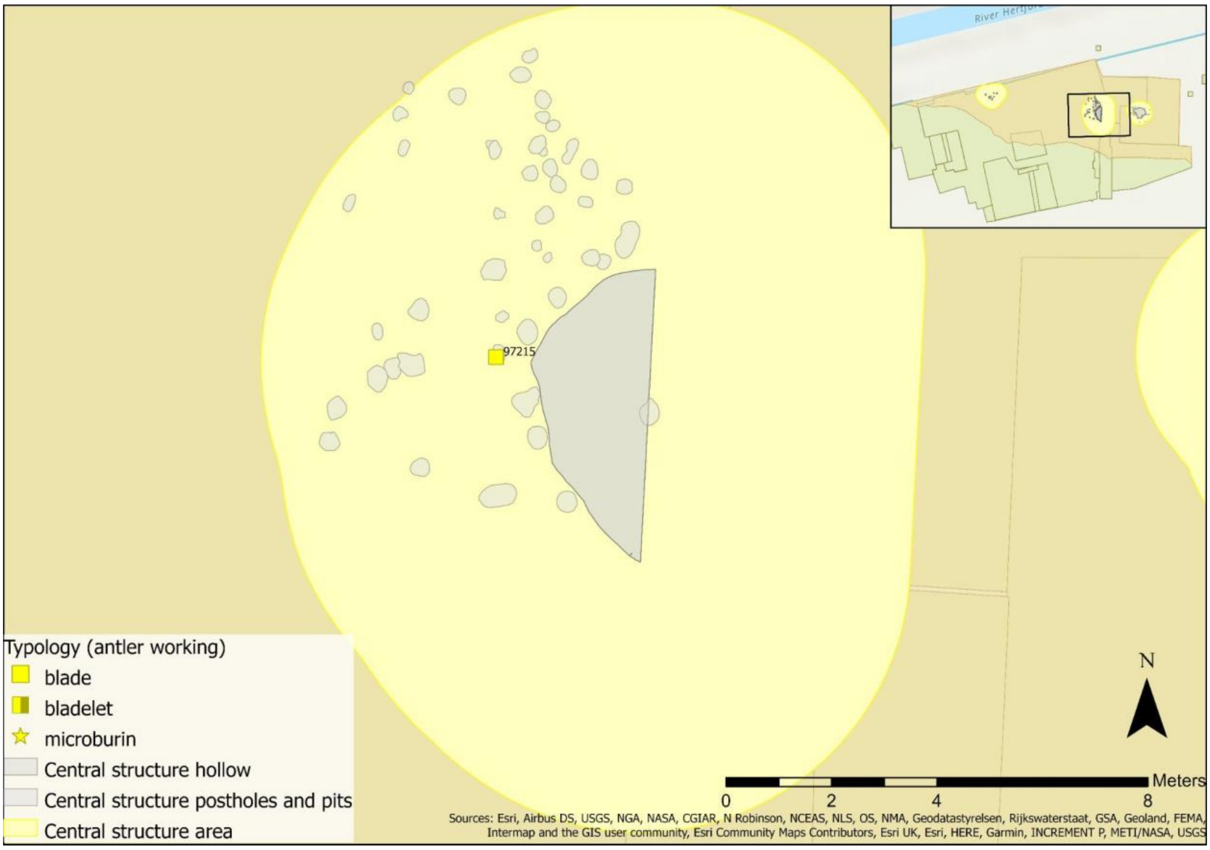


Figure 114: Distribution of antler working tools from the central structure area.

One blade had transverse antler or woodworking polish (see figure 114). There are similarities between undeveloped antler and wood polish; both can be bright, smooth, sometimes domed and removals from use can occur (see figure 115) (Keeley 1980; van Gijn 1990). From the blade's location, it's use may have been associated with the central structure.

Figure 115: SC 97215, a blade displaying possible antler scraping polish on both aspects, 200x magnification. The polish on the ventral has similarities with woodworking traces.

7.3.9. Plant

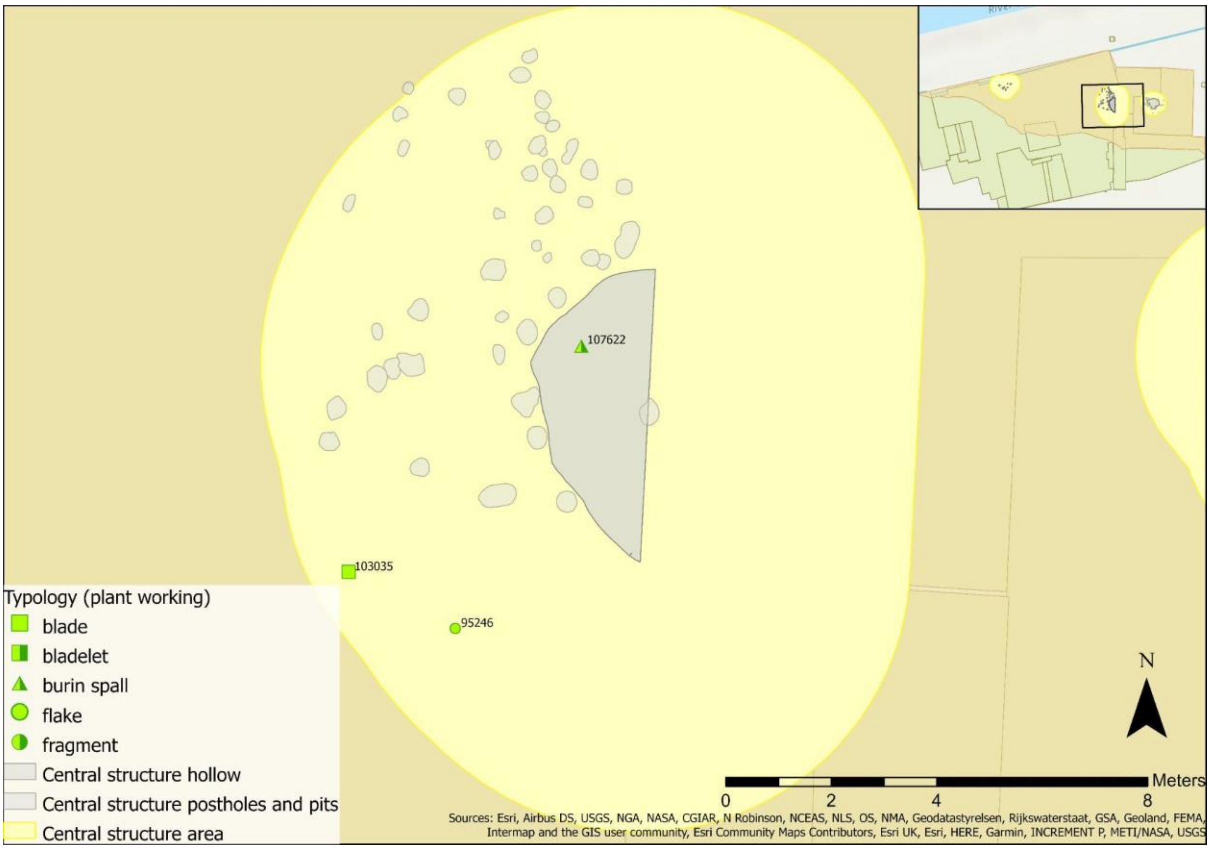


Figure 116: Distribution of plant working tools from the central structure area.

Three tools were used to work plant. A burin spall used to cut plants was the only piece found within the hollow. Microwear traces indicated use on a soft plant, with some gritty inclusions. A blade and a flake were found away from the surrounding postholes (see figure 116), both had traces from scraping plants. Polish on the flake showed the working of a harder plant material as it was domed in areas on the dorsal aspect (see figure 117). The blade had small removals associated with use, also suggesting a harder plant. Spatially, plant working may have taken place within the central structure and also away from the features.

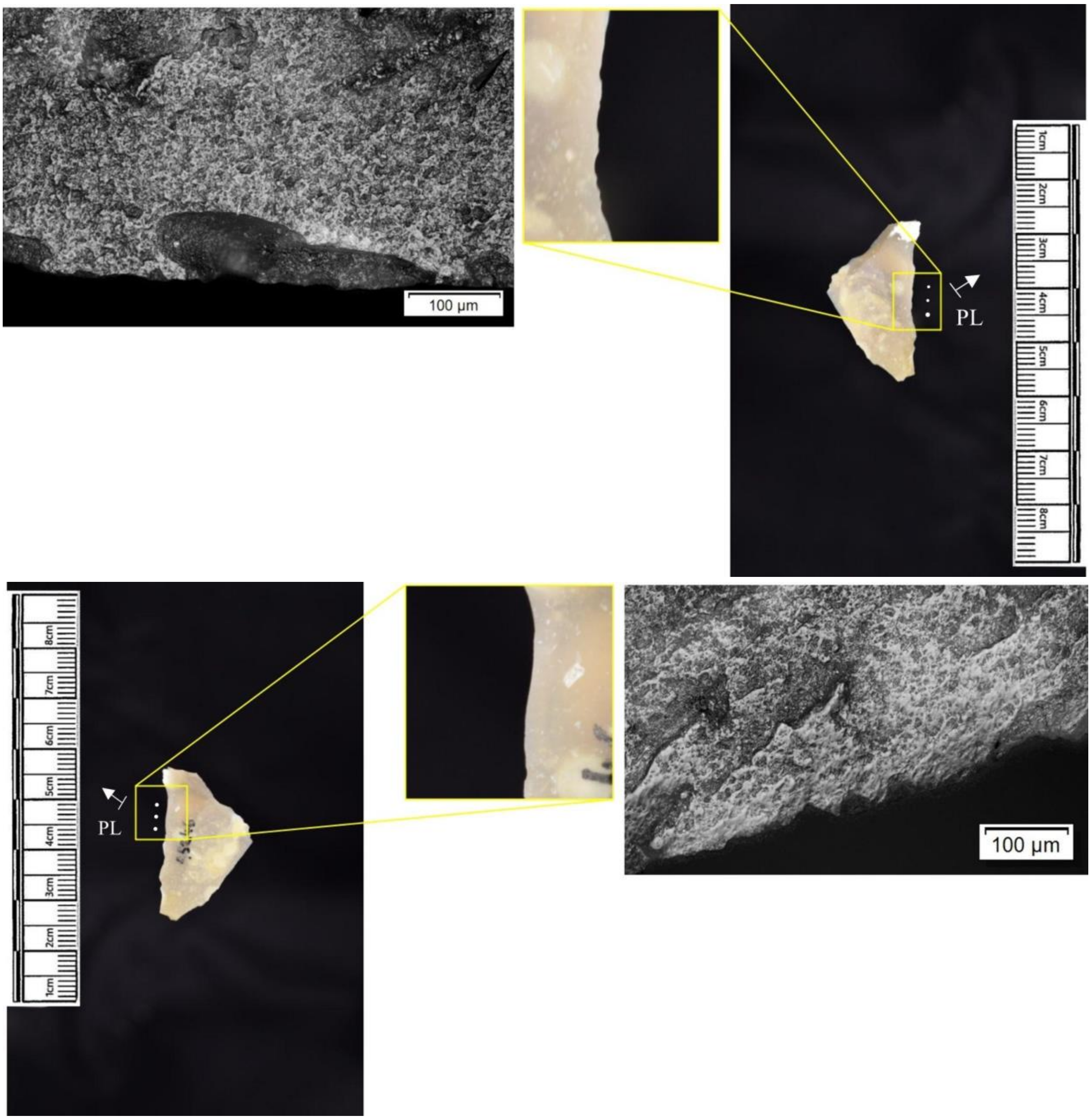


Figure 117: SC 95246, a flake used to scrape plants with well developed polish observed on the ventral aspect, and less interlinked polish on the dorsal, 200x magnification.

7.3.10. Wood

Six tools displayed woodworking. At the western periphery, a burin and one of the bladelets (<102990>) were used to scrape wood or plants (see figure 118). Both had a smooth, interlinked polish, which could relate to working plants or a soft and/or green wood (see figure 119). The bladelet was used at a high angle as would be expected when scraping or graving. Another bladelet (<107666>) was found within the hollow area (see figure 118), and was used to plane and cut wood; it had an invasive transverse polish, with some limited longitudinal traces. A burin spall and the third bladelet (<83897>) were found adjacent to the hollow (see figure 118). Both tools were used transversely on wood, and from the polish location on the burin spall, it was likely used to perforate wood. The bladelet was used on its distal end, and had an non-invasive polish suggesting an engraving rather than scraping motion. Transverse fresh wood traces were observed on the blade, indicating possible de-barking or planing.

Most woodworking tools were located close to the hollow. Only two flints were found some distance from the hollow, although the microwear results do not suggest that different tasks were undertaken in these areas. Tools associated with the hollow evidence perforating and engraving wood, which are likely to have been smaller-scale tasks.

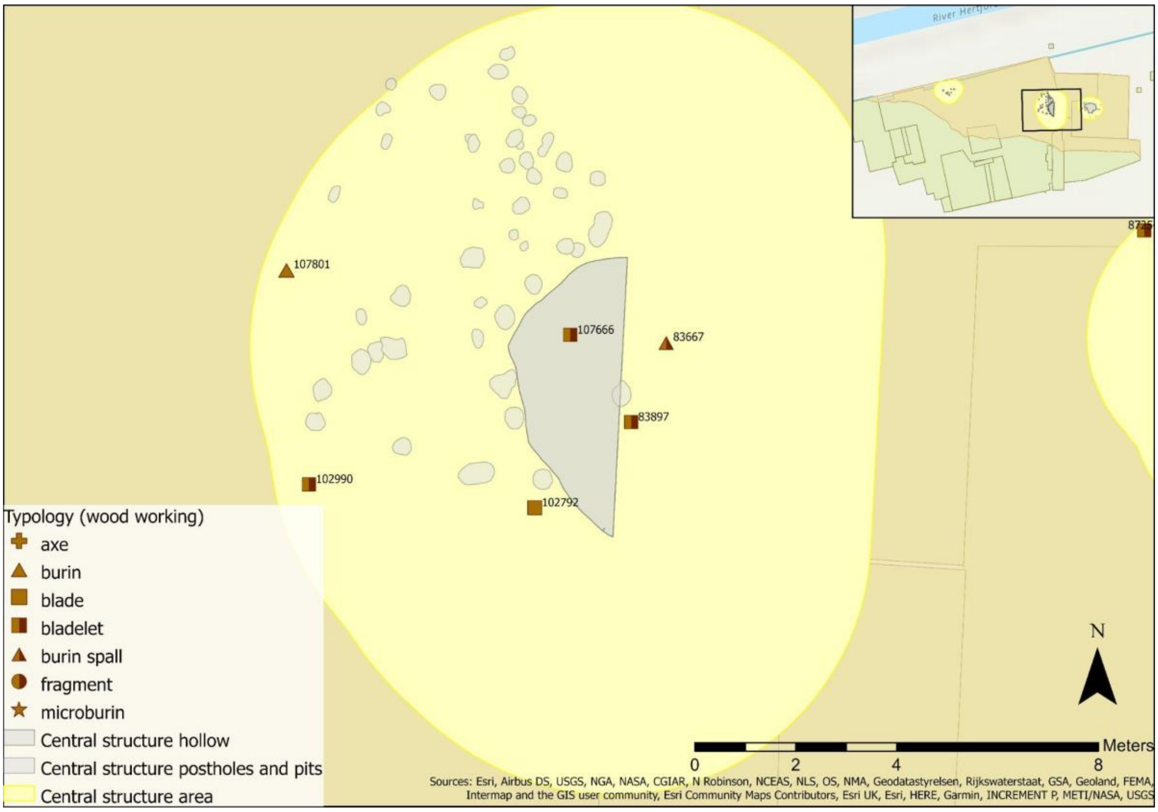


Figure 118: Distribution of woodworking tools from the central structure area.

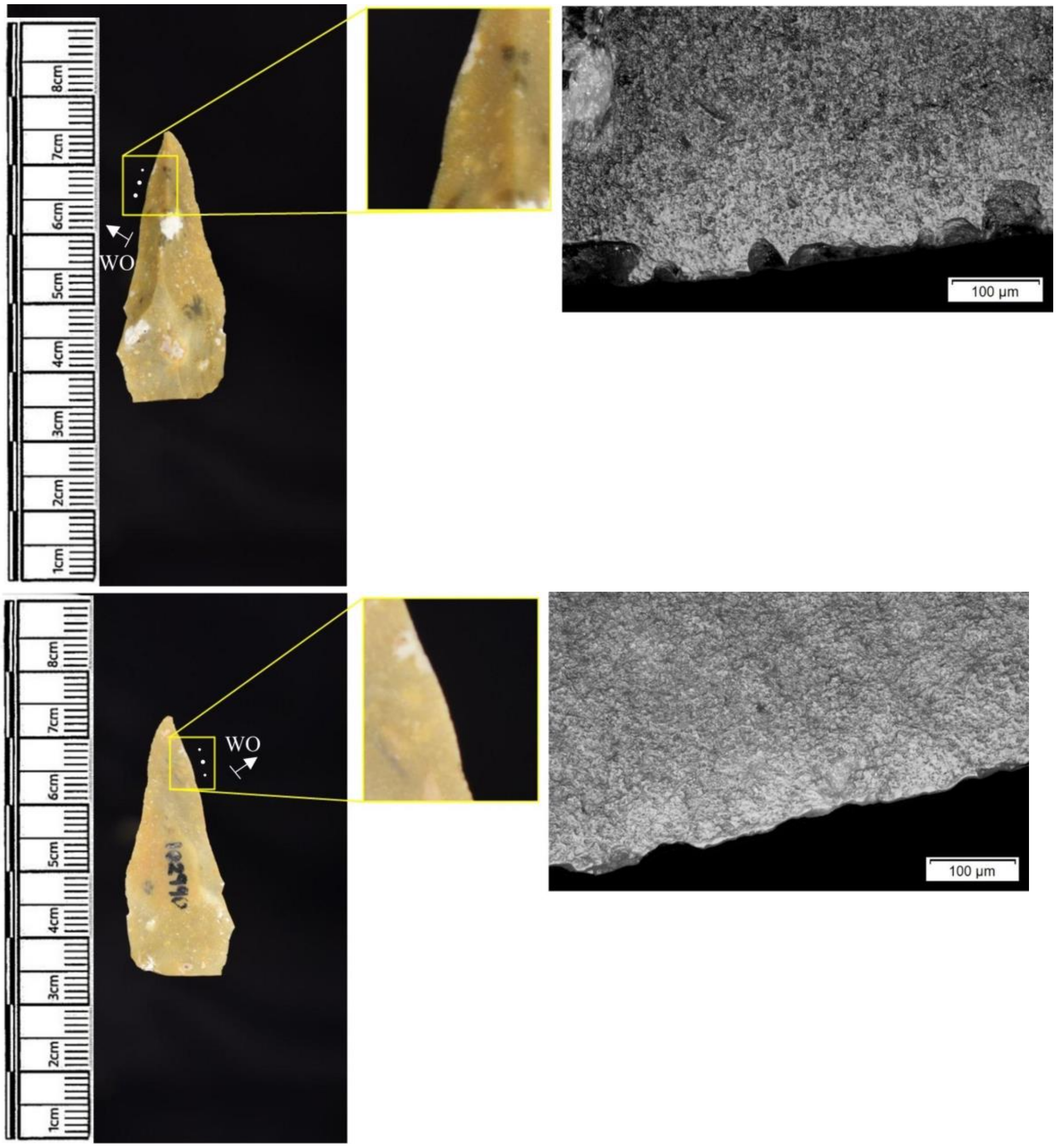


Figure 119: SC 102990, a bladelet showing developed polish from scraping soft or green wood, 200x magnification.

7.3.11. Soft and soft/medium indeterminate materials

Of the five tools identified as used on soft (2) or soft/medium indeterminate materials (3), three were used in a longitudinal direction. A blade and a bladelet had soft material traces, and a burin spall, microburin and microlith had soft/medium material polish. Only the microlith was found within the hollow, all the other pieces were associated with the surrounding postholes. There is no spatial patterning based on direction of use or hardness of material (see figure 120).

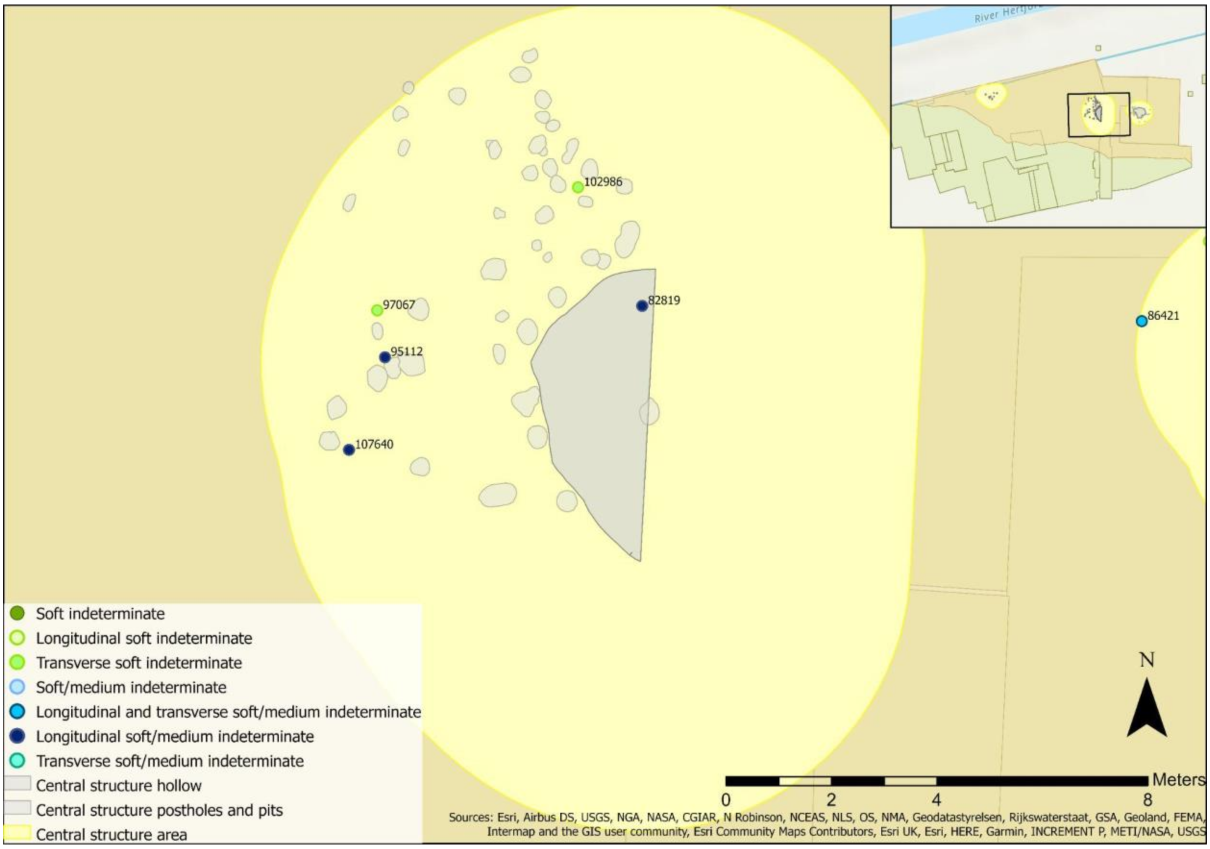


Figure 120: Distribution of tools used on soft and soft/medium indeterminate materials from the central structure area.

7.3.12. Medium and hard indeterminate materials

Eight tools were used on medium or hard indeterminate materials; five of which were used on medium materials, three on hard materials. Directionality of use could not be determined for a burin and a blade (see figure 121). One burin (<102392>, figure 121) was located within the hollow and four pieces were associated with the surrounding features; two flakes (<107452>;<102764>), a burin spall (<103042>) and a microburin (<108320>). Two flakes and a microburin were used transversely, and polish on the burin spall had both transverse and longitudinal directionality. A microlith (<102327>) and a burin (<95092>) were located north-west of the hollow, both used in longitudinal directions on medium and hard materials (see figure 122). A burin spall and a blade were found to the east of the hollow and had traces from hard materials, with the burin spall used longitudinally (see figure 121).

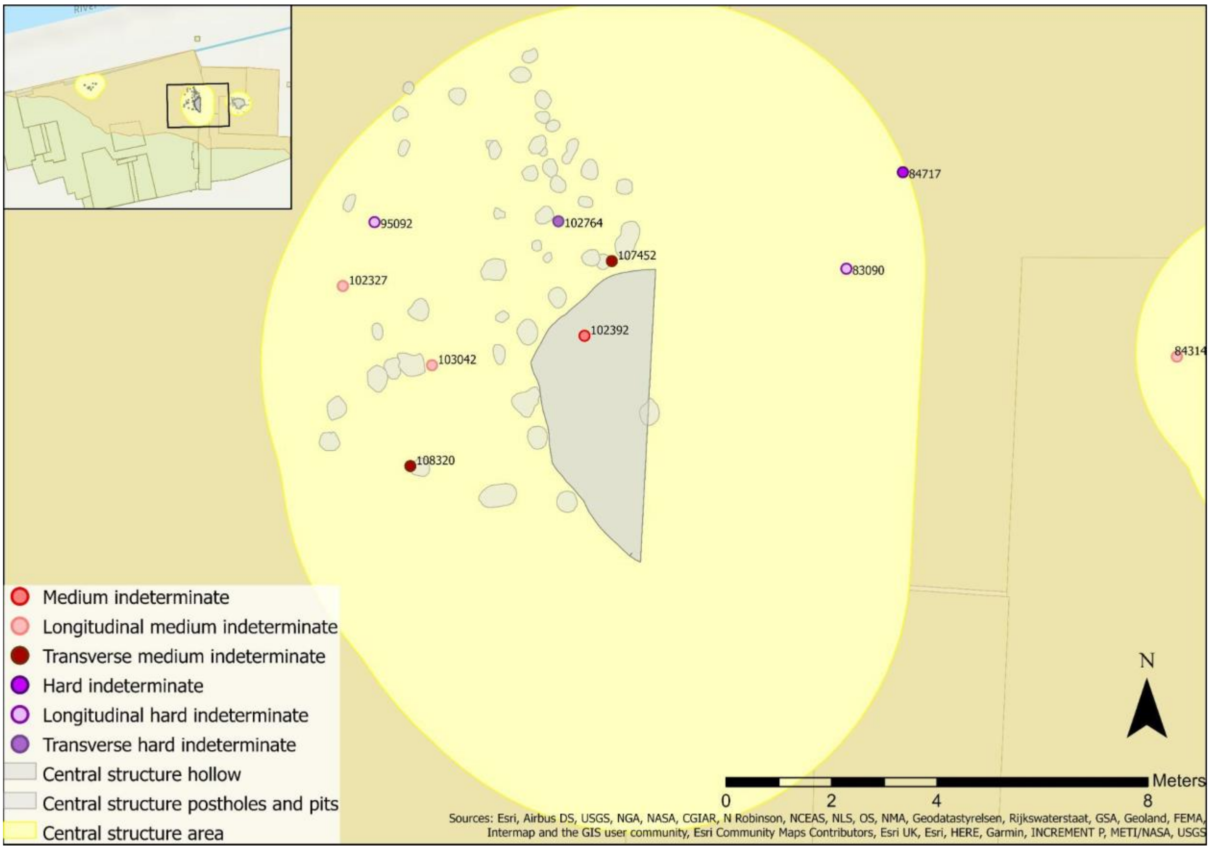


Figure 121: Distribution of tools used on medium and hard indeterminate materials from the central structure area.

Flints used on medium indeterminate materials were generally found to the west and north of the hollow, whereas those with hard indeterminate material traces were found to the north-west and north-east. This could suggest that materials with similar properties were worked in spatial proximity, although the hard materials are not particularly clustered. Overall, there is minimal spatially patterning in this group, and most tools are associated with the features to the west.

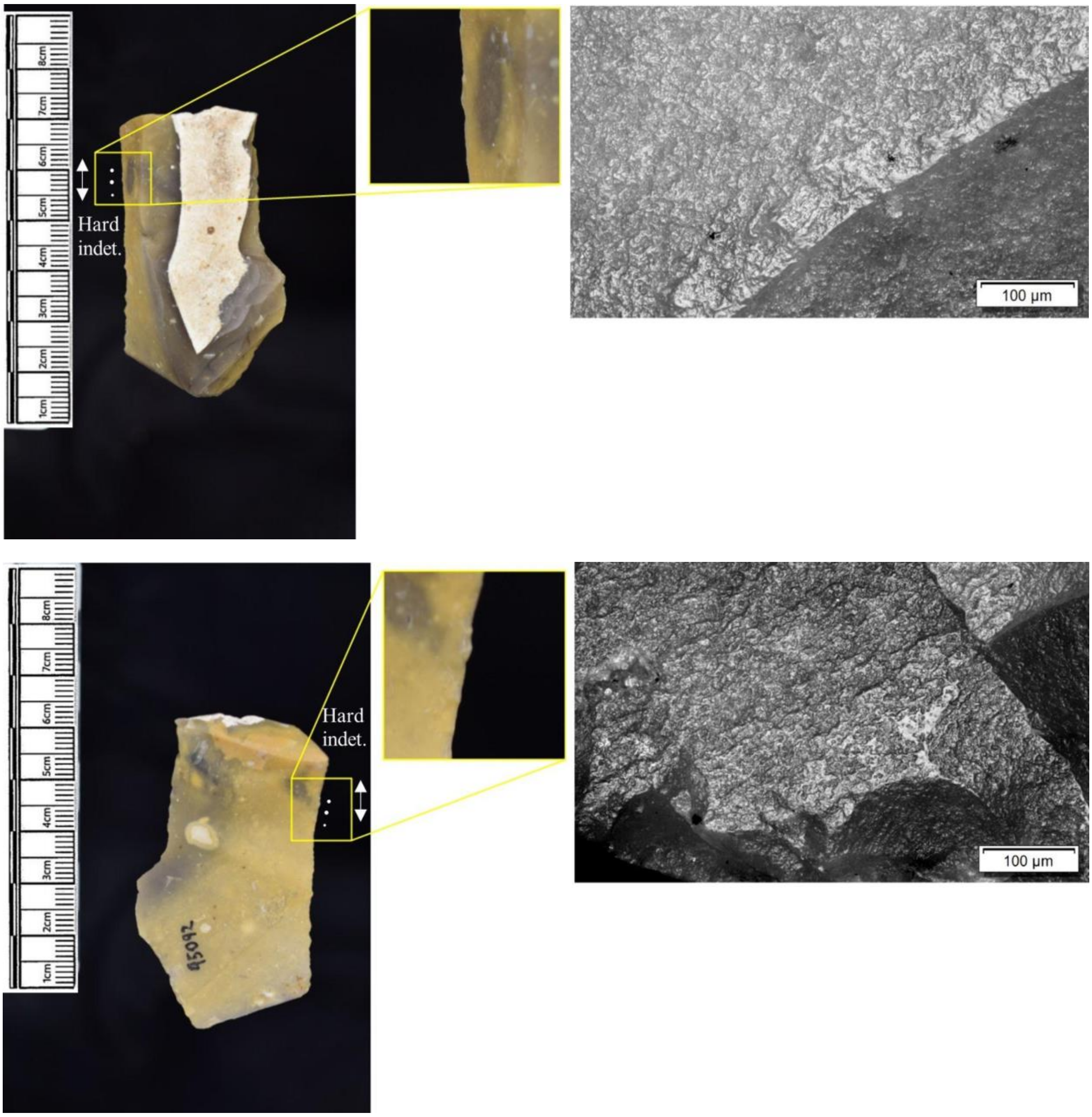


Figure 122: SC 95092, a burin used longitudinally on a hard indeterminate material, 200x magnification. A smooth polish is observable near to removals. Significant PDSM meant a certain identification of polish was not possible.

7.3.13. Indeterminate materials

Two pieces had traces from working on indeterminate materials, both were blades. One was found within a pit [336] near to the hollow (see figure 123). The other was located in between two possible postholes.

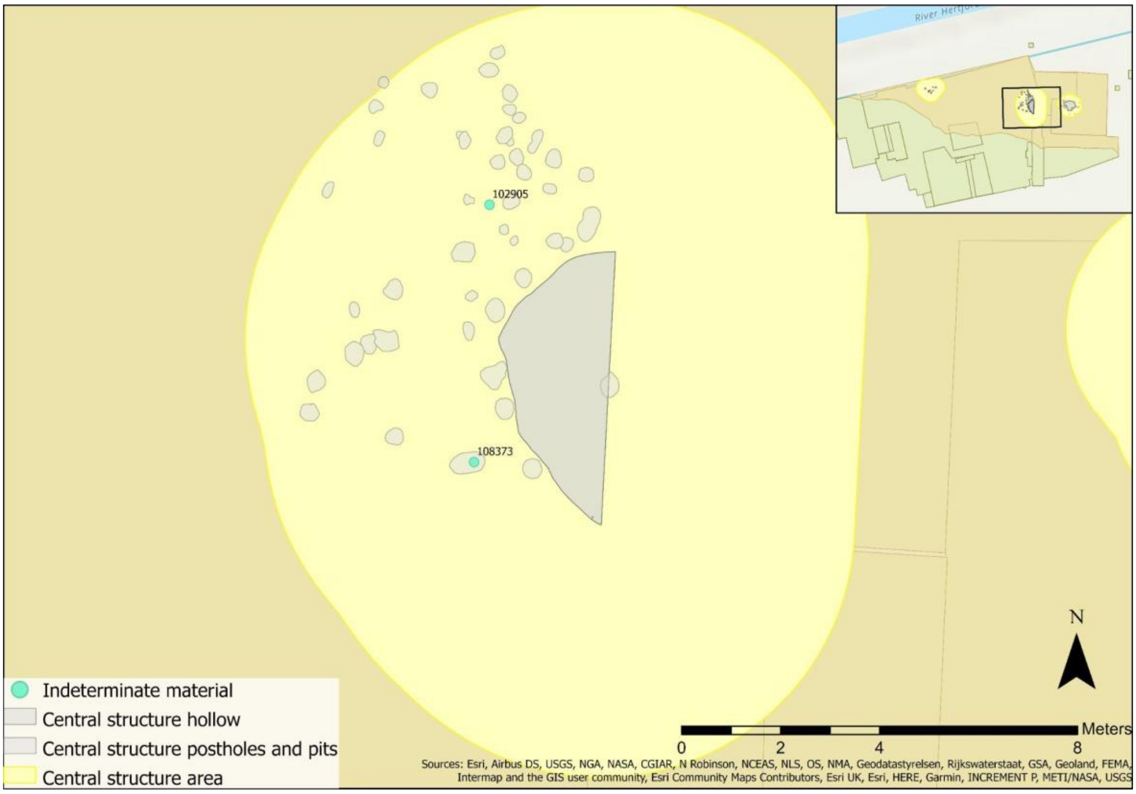


Figure 123: Distribution of tools used on indeterminate materials from the central structure area.

7.3.14. Not used

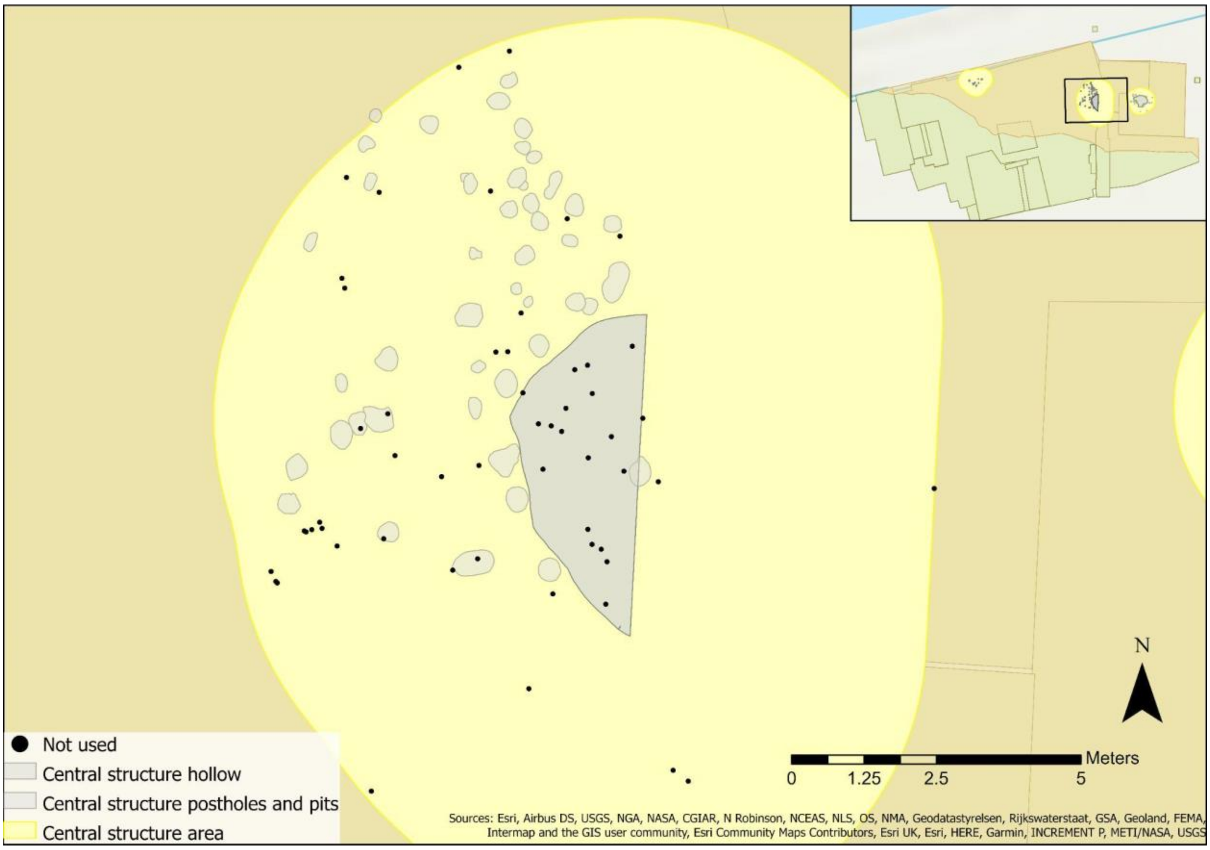


Figure 124: Distribution of unused tools from the central structure area.

A total of 55 tools were interpreted as not used, two of which could not be analysed due to extensive PDSM. Of these unused pieces, 19 (35%) were located within the hollow (see figure 124), which largely reflects the proportion of flints analysed from this area (27%). Unused pieces are dominated by flakes and bladelets, with fewer microliths, microburins, scrapers. The distribution of these flints reflects the general spread of tools across the central structure.

7.4. Discussion

7.4.1. Tool types

Flakes were used on different tasks in the central structure area, which highlights that unworked pieces of flint were considered and utilised as tools; however the low rates of use suggest that this did not occur frequently. Similarly, not all bladelets were used (less than 25%), which might indicate that more tools were manufactured here rather than used. When wear traces were identified, tasks relating to vegetal and animal-related materials were observed in equal frequencies. In contrast, blades had largely bone, antler and hide working traces. Only one blade had woodworking traces, which was also used to scrape fresh hide. This differs from bladelet and blade use identified by the Star Carr Project. Bladelets were mainly used on animal-related materials and there was an even split of animal and vegetal traces observed on blades. Differences in use of these two tool types indicates that individuals may have been behaving differently inside the structure compared to across the site. Choices made regarding the use of specific tools for particular tasks appear to have been different inside the structure.

More formal tool types, such as scrapers, microliths, and burins, had higher rates of use. Of those assigned a specific contact material, most were used for tasks that might be expected. Scrapers were mostly used to scrape hides or bone, with one possibly used on fish skin. Microliths were identified as having meat, bone and possible fish polish, although only two showed hafting traces and none had MLITs. These tools may not have been used as projectiles, but instead hafted into a composite knife or used as individual small blades, to cut different materials. Most burins had uncertain material traces, with one used on soft or green wood. A long lateral edge was used to scrape wood/plants, providing a blunted edge as the tool was thick in profile. This is typical for burin use at Star Carr, with microwear from the Star Carr Project showing mostly wood scraping traces (Conneller *et al.* 2018b, 521).

7.4.2. Animal-related tasks

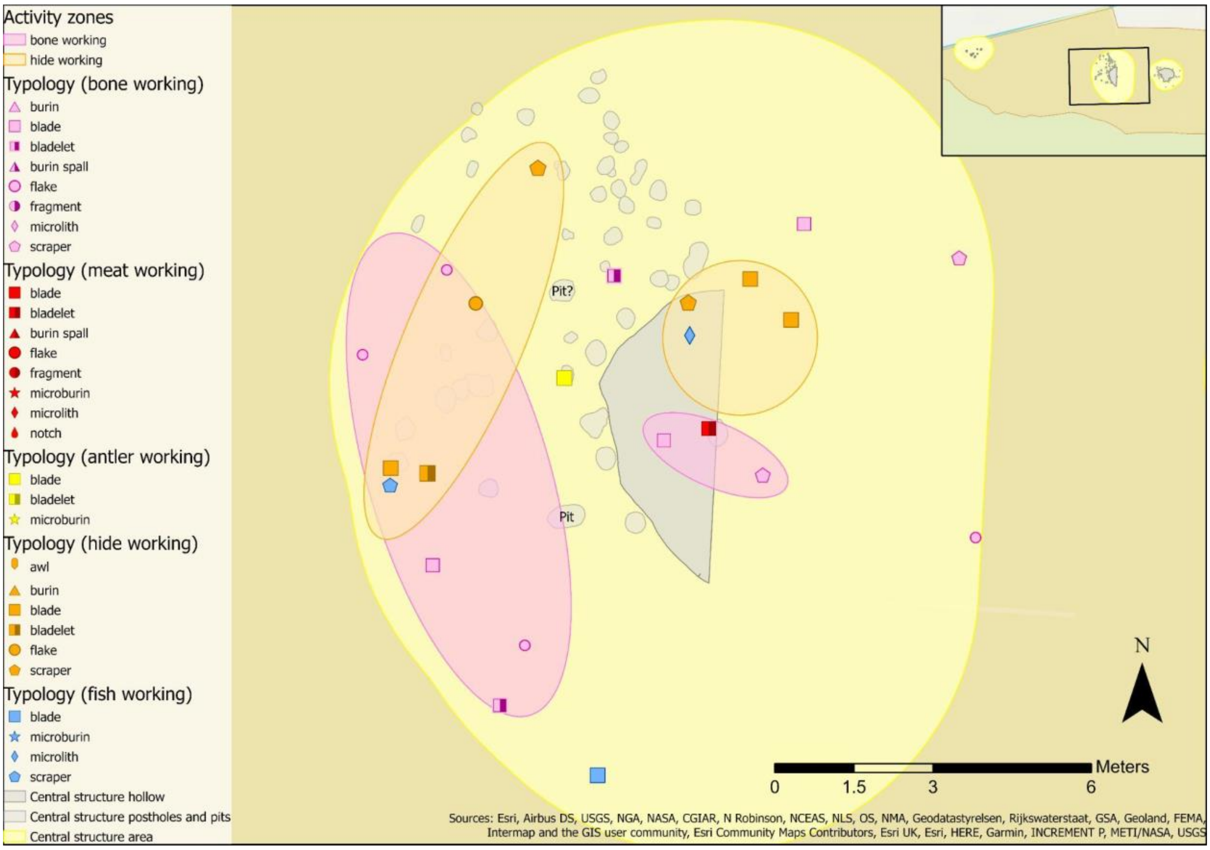


Figure 125: Spatial distribution of tools used on animal-related contact materials and associated activity zones.

Spatially defined areas of specific tasks are difficult to identify due to limited tool use. These complexities are further exaggerated as the full extent of the structure is unclear (Taylor, B. *et al.* 2018b, 59). Very few flints cluster together, so any related tool use could be interpreted as short episodes of activity, or just coincidence, rather than sustained structured behaviour. This hypothesis requires further testing from additional microwear results. However, from the current data presented, it seems the most likely interpretation.

Traces of working bone, hide, fish, meat and antler were identified. Preservation of faunal remains in and around the central structure is generally poor, owing to high levels of burnt and calcined bone (Knight *et al.* 2018b, 130). Antler was not observed in the hollow and surrounding features (pit [336] and two postholes from the northern structure) (Knight *et al.* 2018a). Therefore, a blade used on antler may not be *in situ* or the task may not have left any *in situ* deposits, apart from the tool.

Bone working flints were largely dispersed with no clear spatial clustering or patterns in tool type. Five were located away from the hollow to the west and south-west, of which four were interpreted as used longitudinally on bone. This could indicate some homogeneity in the types of tasks undertaken. An assemblage of 26 bone fragments was found in pit [336], located partially within this bone working zone. All except one piece was burnt or showed signs of heat exposure (Knight *et al.* 2018b, 130). This may suggest *in situ* bone working or butchery, with a high percentage of heat altered bones indicative of food waste. Alternatively, bone fragments may relate to waste material cleared to the pit from the structure or from elsewhere. The latter hypothesis is implied by microwear traces as no meat traces were identified alongside bone polish, which might be expected from butchery tools. A second bone working zone overlaps the hollow of the structure (see figure 125) and contains a blade used longitudinally on bone and meat, and a scraper with longitudinally bone traces. Meat and bone polish was also found on a bladelet in this area. These tools might have been connected in butchery-related tasks, based on their use and spatial proximity.

A group of three hide working tools associated with the hollow had both fresh hide and dry hide (with a possible mineral additive) traces. Different stages of hide processing were observed and may not have been spatially defined. Alternatively, these tasks could have been undertaken at different times with the tools coincidentally deposited close together. Also in this area, a microlith was identified as used to cut fish or hide and had no MLITs or hafting traces. From polish and spatial proximity, these tools may have been related in their use; hide or fish skin may require cutting for further processing.

Four tools used for dry hide scraping were located in a second hide working zone, of which two had soft mineral traces. This zone is located away from the hollow, although flints are dispersed making it difficult to interpret an additional hide working area. Polish from bone and meat working was also found in this area, so it is possible that messier work (e.g. cutting up bones) and work requiring open spaces (e.g. hide scraping, perhaps using a rack) was undertaken here. A possible fish working scraper used to cut and scrape fish was also found. In the structure area, flints used on fish were more often associated with hide than with other fish working tools. This may suggest that these materials were processed in a similar way or at a similar time, possibly indicating that fish skins were being processed as hides.

7.4.3. Projectiles and hafted flints

A zone was established for projectiles and hafted tools, though it is tentative due to the sample size (see figure 126). A bladelet and microlith had MLITs, suggesting that they were hafted and possibly brought to this area for dehafting. An assemblage of burnt flint and calcined animal bone was found in pit [336], so it is feasible that a hearth, perhaps in the hollow, was cleared into it (Conneller *et al.* 2018a, 165). This hearth could have been used for dehafting the flints. Equally, the two pieces may have been dehafted near to a hearth outside and brought into the structure to be hafted again or perhaps used as individual tools. Maintenance and storage of flints has been identified in the eastern structure, so it could also be happening here (Conneller *et al.* 2018a, 177). Alternatively, the

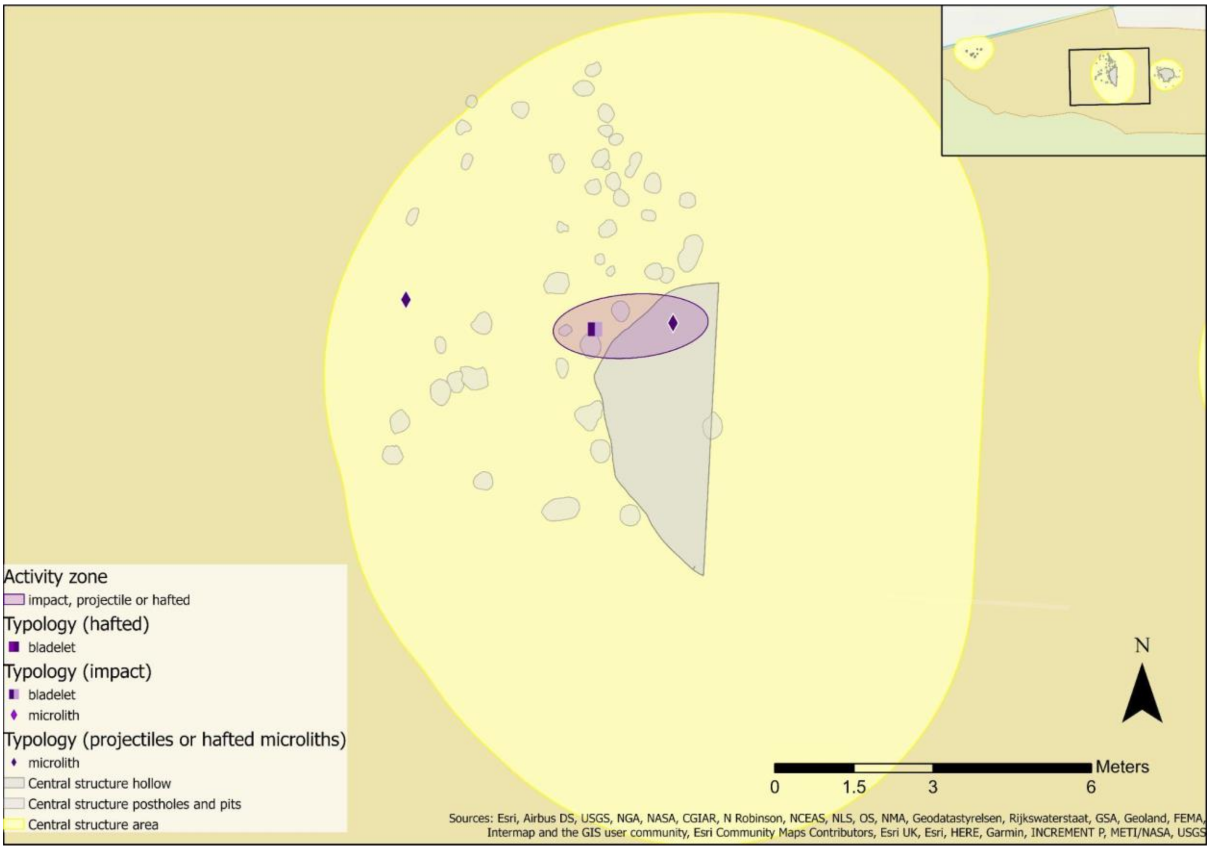


Figure 126: Spatial distribution of hafted tools or tools evidencing impact/use as a projectile and associated activity zone.

projectiles could have been removed from a carcass that was butchered in the structure. In any case, they were at the end of their use lives, or at least last used, when deposited in and near to the hollow.

7.4.4. Vegetal-related tasks

Traces of plant or woodworking are dispersed and so activity zones must be considered tentatively. There is a clear separation between four plant working tools; two were located towards the north, and two further south (see figure 127). Both groups comprise a piece used on siliceous plants and one used on non-siliceous plants/soft wood. Both flakes were interpreted as used to scrape siliceous plants, however they were spatially distinct suggesting that they were not connected in use.

All woodworking tools had transverse polish, with one bladelet also showing longitudinal polish. A bladelet and burin spall located to the east of the hollow were used to groove and perforate, respectively. These motions could be indicative of crafting activity to produce wooden objects or tools. A bladelet, less than 5cm long, located within the hollow had traces of planing wood with minor evidence of cutting. Owing to its size, it was more likely used to cut a smaller piece of wood. This is implied further by the location of polish on a discrete protruding area on the it’s edge. It could have been used to craft wooden hafts, arrow shafts or handles, which may have required planing to shave

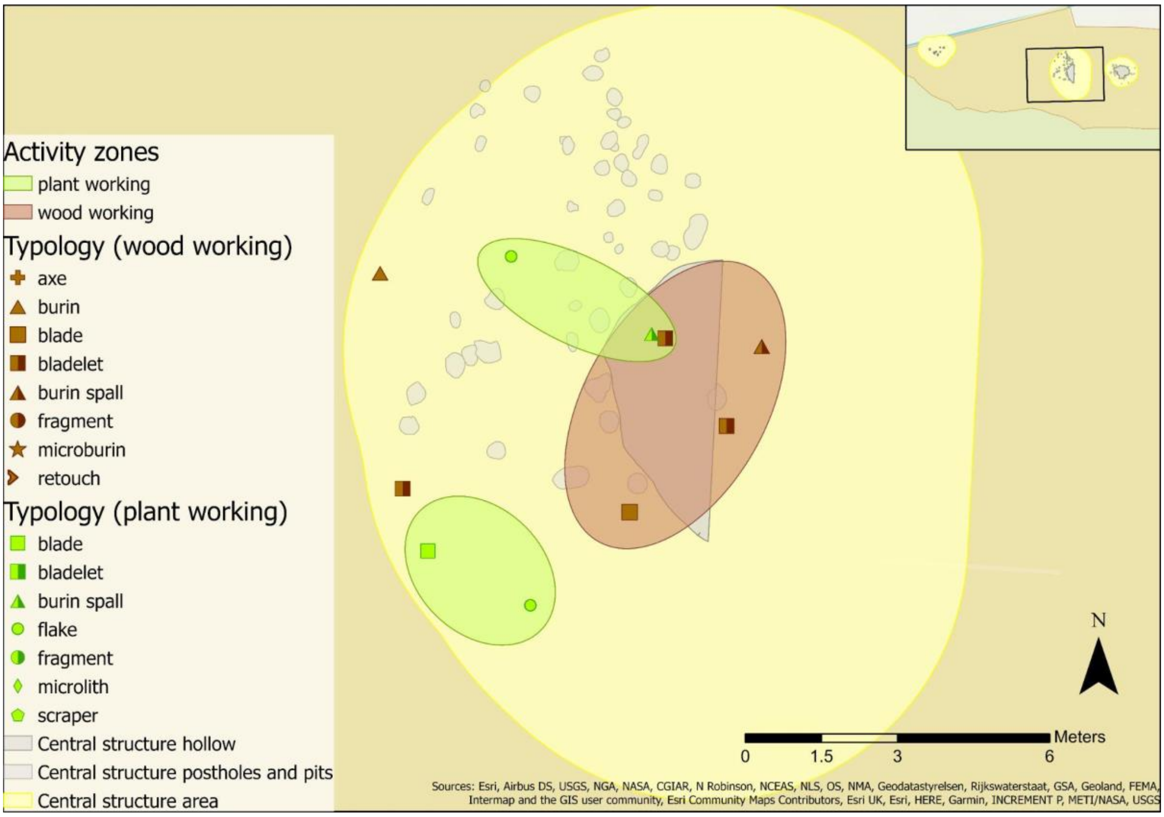


Figure 127: Spatial distribution of tools used on vegetal-related contact materials and associated activity zones.

off excess material. A blade found near to the postholes was used to scrape or engrave fresh wood. Polish was limited to the corner of the distal tip, so it is perhaps more likely that it was an engraving tool. In summary, flints displayed wear traces that could indicate different stages of crafting wooden objects; planing, graving, and perforating. Of the wooden objects found at Star Carr, handles, dowels, digging sticks would have required planing and at least two objects had holes in, likely requiring perforation (Taylor, M. *et al.* 2018).

7.4.5. Extent of the structure

There were two possible structures identified in addition to the central structure (see figure 102); a northern structure and a western arc of features. The northern structure area was generally sparse of flints, and of the four sampled, three showed no signs of use. These results are by no means conclusive; however there appears to be minimal identifiable tool use. Further dedicated microwear analysis of tools found in this area is required to explore patterns in the use of the space, and to identify any possible links to the central structure.

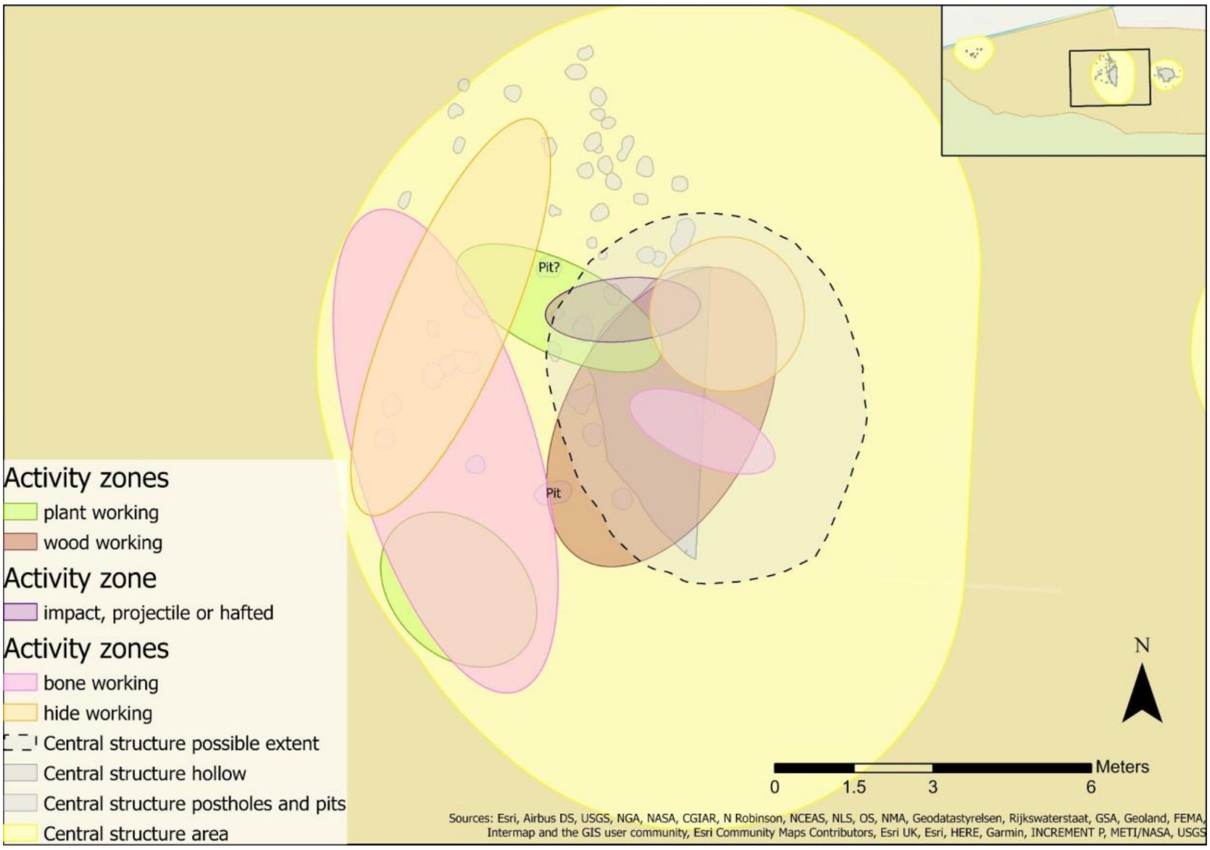


Figure 128: Composite image of proposed central structure extent and associated activity zones.

Two zones were associated with the western arc of features; bone and hide (see figure 128). Most flints analysed from this area showed no identifiable signs of use. A cluster of three hide working tools and a scraper with possible fish polish were located near to the arc, and one was found within feature [400], a possible posthole (Taylor, B. *et al.* 2018b, 62). Other postholes may not have been identified during excavations, which makes the area complex to interpret. A rack or frame may have been constructed to aid the scraping of hides, or a drying rack to smoke skins for tanning. Microwear traces also suggest that tools in this area were used in tasks relating to animal skin processing.

Postholes in the arc may have continued round to form a complete ring, which could have held a more substantial structure. The proximity of these postholes to those surrounding the central hollow (roughly 0.5 metres away) makes it unlikely that two structures would have co-existed. The hollow dates to around 9300-9200 cal BC, so a second structure could have been built during subsequent occupations, overlaying part of the hollow. Alternatively, the western arc might indicate an earlier, more ephemeral structure built during initial visits (Milner *et al.* 2018e). From limited tool use and uncertain radiocarbon dates, it is unclear whether the western arc was directly associated with the central structure. Similarly to the northern structure, further microwear analysis of the tools found here will help elucidate the relationship between the features and the central hollow.

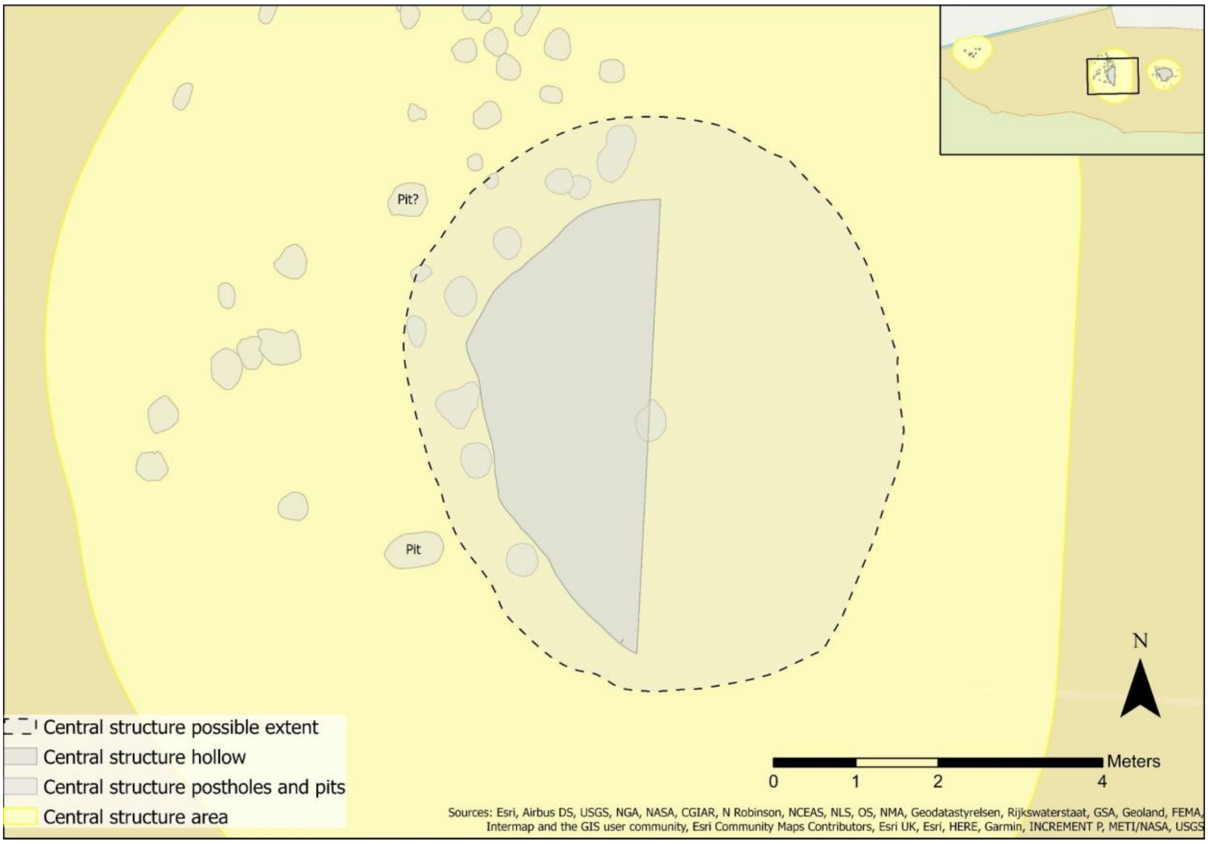


Figure 129: Proposed extent for the central structure.

A proposed boundary for the central structure is based on conjecture from the shape of the features and the microwear results located in the eastern half of this area (see figure 129). A mirror-image of the hollow and associated postholes was used to establish a minimum boundary. Activity zones located across the eastern half of the study area are also encompassed (see figure 128). The structure may have extended beyond this, as it could have been oblong rather than circular in shape meaning that the excavated hollow may be under half the size of the actual hollow. However, zones for working hide, bone, wood and projectiles or hafted tools are largely contained within the proposed boundary. Plant working is a notable exception as it overlaps the boundary and surrounds, although very few plant working tools were identified, so the zone is likely not representative of all plant-use.

Chapter 8: Western structure and surrounds

8.1. Introduction

This chapter will first set out the previous work undertaken on the western structure, explaining the features of the structure, and the spatial, technological and previous microwear analysis of the flint. The second part of the chapter details work undertaken for this thesis and the new microwear results. Interpretations of the results will be presented in the third section and will include relevant microwear data from the Star Carr Project, where 19 flints were analysed from the structure (Conneller *et al.* 2018a).

8.2. Introduction to the structure

The western structure consisted of nine small features without an associated hollow, making it the most tentatively identified structure (Taylor, B. *et al.* 2018b, 58). Seven of these features were interpreted as likely postholes due to their profile and shape (see figure 130). The other two were identified as a possible posthole [508] and a pit [526] (Taylor, B. *et al.* 2018b, 59). Post-depositional processes significantly impacted the integrity of the features, thereby limiting interpretations of the structure's composition and function. It is highly likely that features extended beyond the excavated area, into the bank of the canalised River Hertford. Dense scatters of animal bone, antler and lithics were found in and around the structure. Geochemical soil analysis was applied; however due to methodological problems, results from the soil geochemistry could not be used as samples were taken too deep down into the sediment (Rowley *et al.* 2018, 171).

Of 137 faunal remains excavated from the area, 29 pieces came from the circumference of the postholes and 108 from the area surrounding the postholes (Knight *et al.* 2018b, 126–8). Generally both assemblages are characterised by highly fragmented remains, dominated by limb and long bones from large and medium mammals, such as red deer and aurochs (Knight *et al.* 2018b, 128). Only three pieces show signs of human modification. However, this was impacted by the fragmentary and poor preservation of the remains, which were interpreted as deriving from dietary waste and craft activities (Knight *et al.* 2018b, 126–8). A cluster of burnt bone was observed in the area surrounding the structure, possibly representing a hearth (Knight *et al.* 2018b, 128).

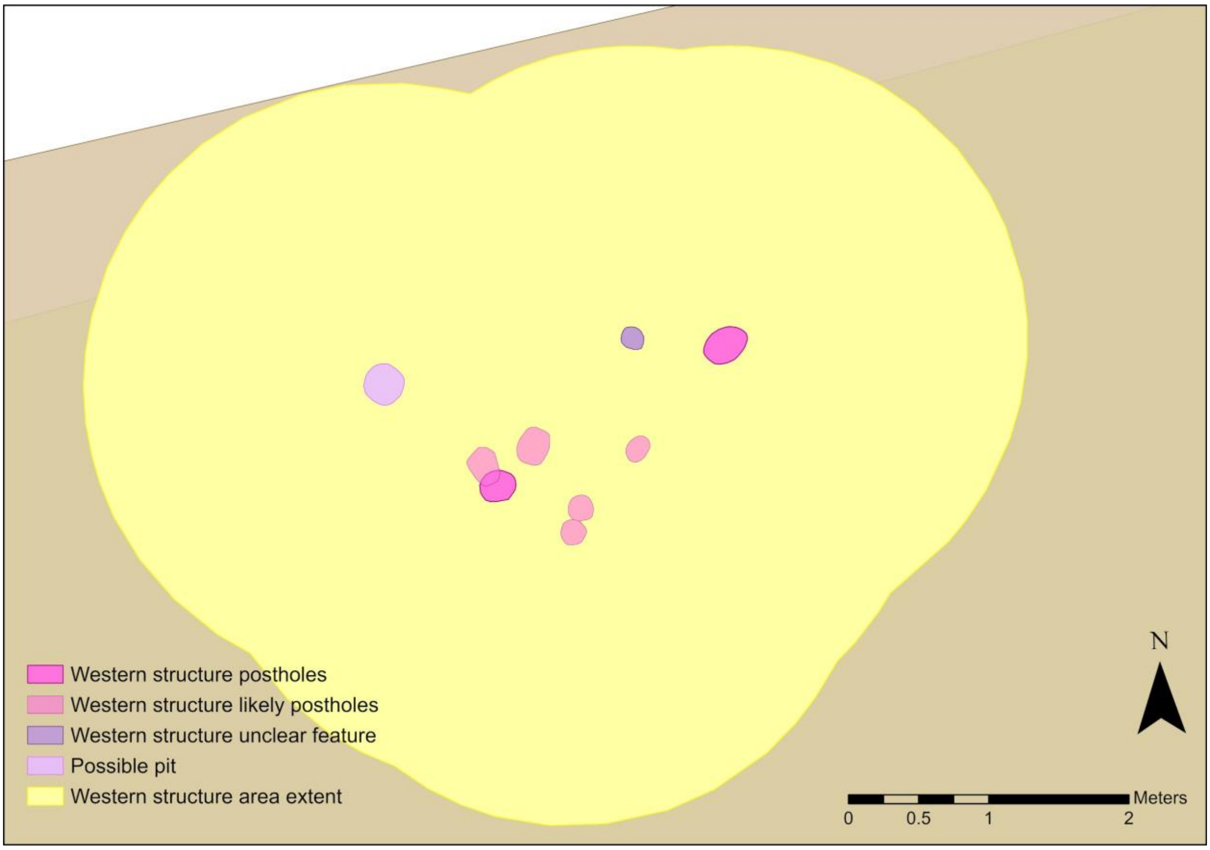


Figure 130: Western structure features (Image after Taylor, B. et al. 2018b, 58).

There were 5058 lithics associated with the western structure, c.35% were burnt. Technological analysis identified 329 tools and 109 tool spalls; the highest density of flint and burnt material of all the structures (Conneller *et al.* 2018a, 161). Worn out flints, a lack of clear spatial patterning and unburnt likely *in situ* microdebitage present conflicting interpretations of this area (Conneller *et al.* 2018a, 162). Previous microwear results indicated that craft-based activities were undertaken and traces of bone working correlated with densities of animal bone found nearby, suggesting *in situ* activity in and around this area (Conneller *et al.* 2018a; Knight *et al.* 2018a). This evidence, together with high levels of burning observed within the circumference of the postholes, was used to suggest that either: the structure had burnt down, or it was a midden on top of a previous structure (Conneller *et al.* 2018a, 162; Taylor *et al.* 2019b, 11).

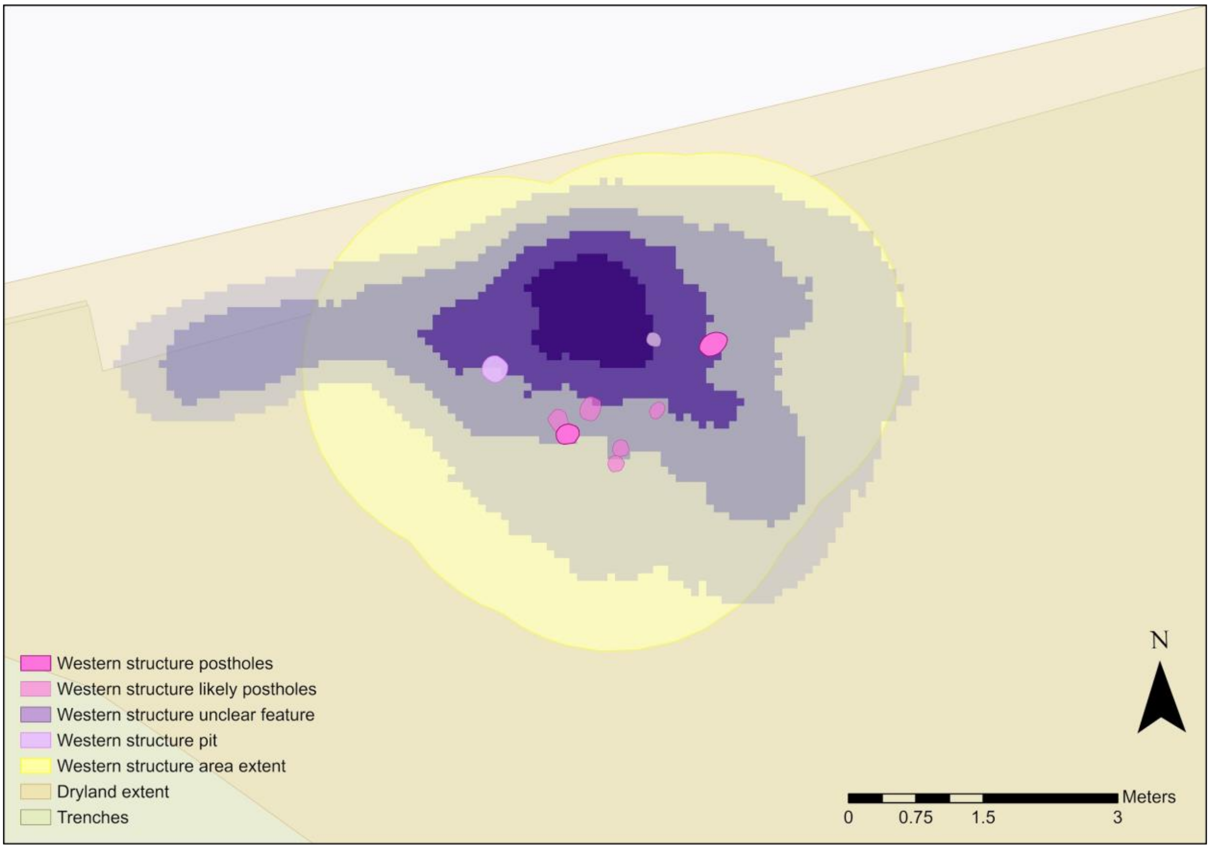


Figure 131: Western structure flint densities overlain by features; the darker purple tones show higher densities of flint (Image after Conneller et al. 2018a, 160).

Flint densities are concentrated to north of the postholes (see figure 131), meaning that several hypotheses can be established (see table 15). Firstly, it is possible that the excavated features are not complete. A structure may have extended beyond the excavated area to the north, with unidentified or unexcavated postholes. In which case, those identified by the Star Carr Project could relate to the southern aspect of a structure. If the excavated features and materials are complete, the high flint density might suggest that it was used differently to the eastern and central structures. Large quantities of burnt lithics could suggest that some were present within the structure and became burnt, perhaps if it was destroyed by a fire (Hypothesis 2, table 15) (Conneller *et al.* 2018a, 162). In this scenario, remaining unburnt flint and *in situ* knapping debris would have been deposited after the event in later phases of occupation, if the area was used as a midden.

Alternatively, significant accumulations of flint may have occurred near to a drying or smoking rack, or on top of a previous rack (Hypothesis 4, table 15) (Taylor, B. *et al.* 2018b, 67). Flint densities, in this case, may represent a refuse area, which naturally created a sub-circular distribution. Ethnographic accounts of the Hadza have observed middens with circular concentrations of ‘up to 2 m in diameter’, without a physical boundary limiting the shape or spread of material (O’Connell *et al.* 1991, 67). If a rack structure burnt down, it would also impact flint in the area (Hypothesis 3, table

15). Burning may conversely suggest that lithics from hearths, alongside other waste materials, were deposited together within the structure, above a previous dwelling structure, or near a drying/smoking rack (Hypothesis 1, table 15) (Milner *et al.* 2018e, 236).

	Hypothesis 1	**Hypothesis 2**	**Hypothesis 3**	**Hypothesis 4**
Summary	Dwelling structure that was used as a midden area	Midden area above former dwelling structure (that may have burned down)	Midden area above or near to drying/smoking rack that burnt down	Drying/smoking rack with associated midden area
Material traces	● Flint produced and used in the structure ● Clearance materials spatially restricted to structure area	● Flint produced and used in the structure (if burned down, burnt flint produced and used) ● Clearance materials spread more widely	● Burnt flint produced and used relating to the structure ● Clearance materials spread more widely	● Flint produced and used relating to the structure ● Clearance materials spatially associated to postholes
References	Not previously published	*(Conneller et al. 2018a; Milner et al. 2018e; Taylor, B. et al. 2018b ; Taylor et al. 2019)*	Not previously published	*(Taylor, B. et al. 2018b)*

Table 15: Summary of hypotheses presented in the Star Carr monograph and those presented in current discussion.

From microdebitage, some *in situ* tool production and use likely took place in the western structure, either within it or near to the postholes (Conneller *et al.* 2018a; Taylor, B. *et al.* 2018c, 268). The 3D distribution of lithics could not be used to examine the stratigraphic sequence of deposition, therefore *in situ* tool manufacture and use may have occurred before or after burnt flints were present in the area. The presence of *in situ* activity does not discount a midden interpretation as they can be convenient work areas, with individuals clearing activity waste directly onto the midden (Coulson and Andreasen 2020).

Radiocarbon dating of two fills from postholes [507] and [515] provided two possibilities of when the western and eastern structures were in use, c.9100 or 8800 cal BC (Bayliss *et al.* 2018, 54). These dates could relate to material packed into the western postholes during construction, thereby contemporaneous with its use (either as a dwelling or as a rack). Alternatively, the dated material may have infilled the postholes from later activity once the posts had rotten; for example, if the area was used as midden after the structure was no longer present. Therefore, it is possible that the western and eastern structures were used at different times, particularly if the dates from the western structure are interpreted as associated with a later midden. The Star Carr Project used the intensity of activity across the site to suggest c.8800 cal BC as the most likely date (Milner *et al.* 2018e, 236); however it could equally be c.9100 cal BC. Building additional structures may have been necessary if the central structure fell out of use after c.9200 cal BC. In any case, both dates for the western and eastern structures can be seen as reasonable within the narrative of the site, and so neither should be discounted from interpretations.

8.3. New microwear results

8.3.1. Overview

In total, 88 flints were analysed from the western structure area, 35 (40%) were located within a triangular area created by the features (see figure 132). Where pieces were chosen based on spatial location, those close to features were prioritised. Flints found in the wider area were also sampled to capture possible differences in use. Overall, 36 pieces showed no signs of use (41%), making the rate of used tools 59%. If a cluster of the same tool type was observed, a selection was analysed, where possible.

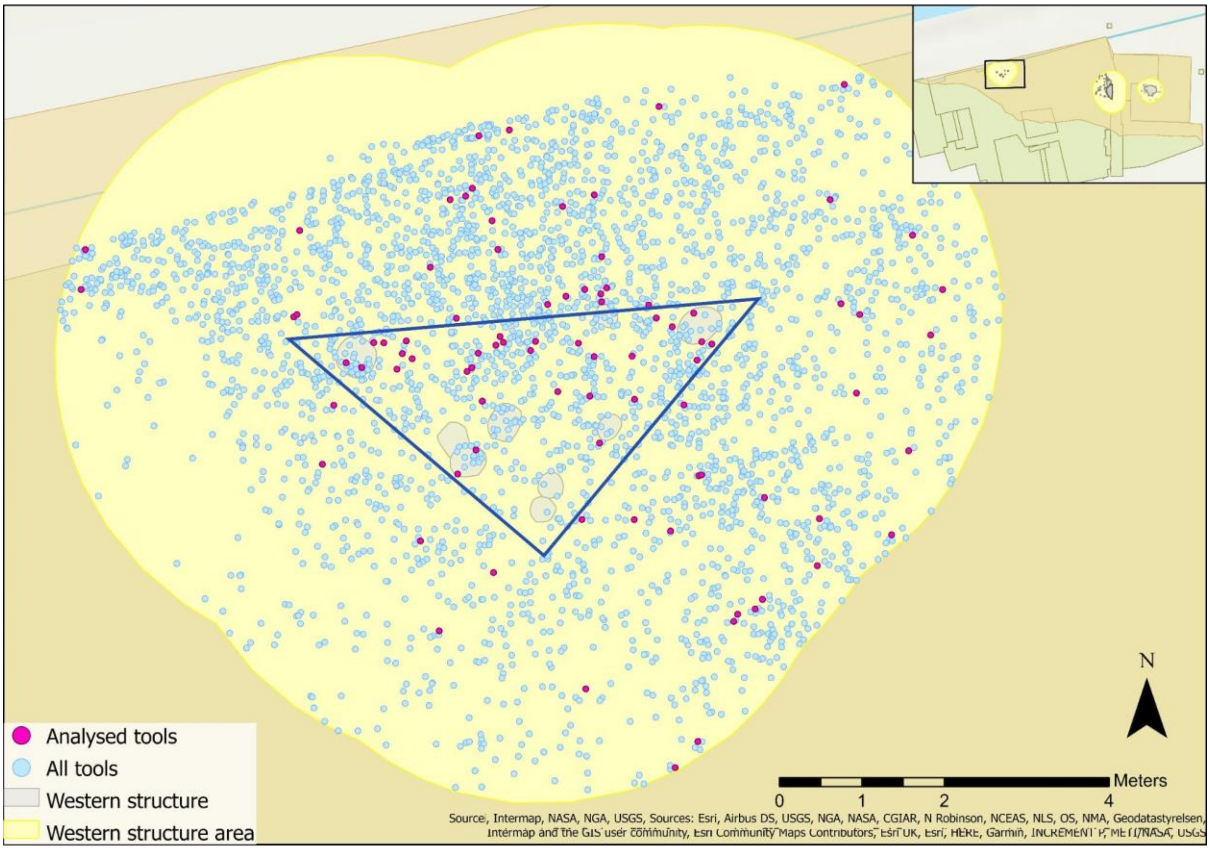


Figure 132: Distribution of analysed and not analysed tools from the western structure area, with woodworking contained within the triangle.

Rates of PDSM were high: 72% of pieces showed at least one type. Iron oxide staining (30) and flat dull smoothing (39) were the most frequently observed, with 13 flints displaying metallic striations and five had surface patination. Levels of flat dull smoothing were the highest compared to the other structures. This type of PDSM often occurs from trampling or contact with other flints, suggesting that the depositional conditions in the structure differed from the other two (Werner 2018). Generally, PDSM did not prevent the identification of microwear traces as 33 tools were interpreted as used despite the presence of PDSM.

Materials worked within the western structure were diverse (see table 16). Meat was most frequently identified (8), followed by: hide (7), bone (5), wood (5), projectile impact (2), mineral (2), fish (2), plant (1) and antler (1). Tools assigned only hardness of material were mostly used on soft/medium indeterminate materials (5) or medium indeterminate (5).

Primary contact material	**Secondary contact material**	**Motion of use**	**Number**
Antler		Transverse	1
Bone		Transverse	4
Bone	Meat	Transverse; longitudinal	1
Fish		Transverse; longitudinal	2
Hide		Transverse	3
Hide	Soft mineral	Transverse	4
Meat		Longitudinal	4
Meat	Bone	Longitudinal	3
Meat	Hide	Transverse; longitudinal	1
Projectile impact	Bone and meat	Longitudinal (hafted)	2
Mineral (strike-a-light)		Striking	2
Plant (inc. plant/soft wood)		Longitudinal	1
Wood		Transverse; longitudinal	5
Soft indeterminate		Transverse; longitudinal	2
Soft/medium indeterminate		Transverse; longitudinal	5
Medium indeterminate		Transverse; longitudinal	5
Hard indeterminate		Transverse; longitudinal	2
Indeterminate		Unknown	5
Not used (no clear signs of use)		n/a	34

Not possible		n/a	2

Table 16: Microwear results of analysed tools found in the western structure area.

8.3.2. Tool types

There were 337 bladelets found in the western structure, 27 (8%) were analysed and seven had been used. Three had traces from woodworking, with transverse and longitudinal directionality. Siliceous plant cutting was observed on another piece. Soft transverse (1) and soft/medium indeterminate (2) polish was observed on the remaining tools.

Of 20 microburins excavated, 14 (70%) were selected for microwear analysis and seven had signs of use. Most had animal-related polish; meat cutting (1), possible fish scraping (1), and possible antler engraving (1). One piece was used to plane wood. Longitudinal traces from soft/medium (1) and medium (2) indeterminate materials were also observed.

In total, 66 blades were identified, 12 (18%) were assessed for wear traces, and 11 had been used. Animal-related use was observed on four tools, with meat working most commonly observed. Longitudinal traces of meat (1), meat and bone (1), and meat and hide (1), indicated butchery-related tasks. Bone engraving was seen on another blade. One tool had been used to cut wood, likely associated with de-barking. The remaining blades had transverse traces from soft/medium (1), medium (3) and indeterminate (2) materials.

There were seven awls found, all were analysed and six showed signs of use. Traces of hide with soft mineral were observed on two, both in puncturing/perforating motions. Another had hide polish with a similar motion of use. One awl had traces from a hard indeterminate material. Polish from soft/medium (1) and indeterminate (1) materials were also observed.

Of 51 scrapers excavated, seven (14%) were selected for microwear analysis and had all been used. All wear traces were transverse and animal-related. Three scrapers were used on hide and traces from fresh hide (1) and hide with soft mineral (2) were observed. Bone scraping was seen on two scrapers, with possible fish scraping and cutting on another. A final scraper was used to scrape a hard indeterminate material.

Across this area, 41 microliths were recovered. Six (15%) were assessed for signs of wear, and five had been used. All had been used on either bone or meat, and two had MLITs, indicating use as a projectile. Transverse bone (1), together with transverse and longitudinal bone and meat (2) polishes were observed. Traces from longitudinal contact with meat (1), and meat and bone (1), were also seen. Of the two microliths with MLITs, one had been used as the tip of a projectile with bone and meat polish. The other had been in contact with meat and was possibly hafted as a barb of a projectile.

In total, 45 burin spalls were found and five (11%) were analysed for wear traces. Three had been used to either cut meat (2) or cut a soft indeterminate material (1). There were 37 burins excavated, five (14%) were selected for microwear analysis, 2 showed signs of use. One was interpreted as a butchery tool, with longitudinal traces of bone and meat, and possibly hide working. A burin with indeterminate polish was also observed (1).

Three strike-a-lights were located in the western structure area, and all were assessed for signs of use. Of these, two had been clearly used as strike-a-lights, with hard mineral polish observed. A denticulate was recovered and was selected for microwear analysis. It had a glossy patina across the surface, so it was interpreted as used on an indeterminate material.

8.3.3. Bone

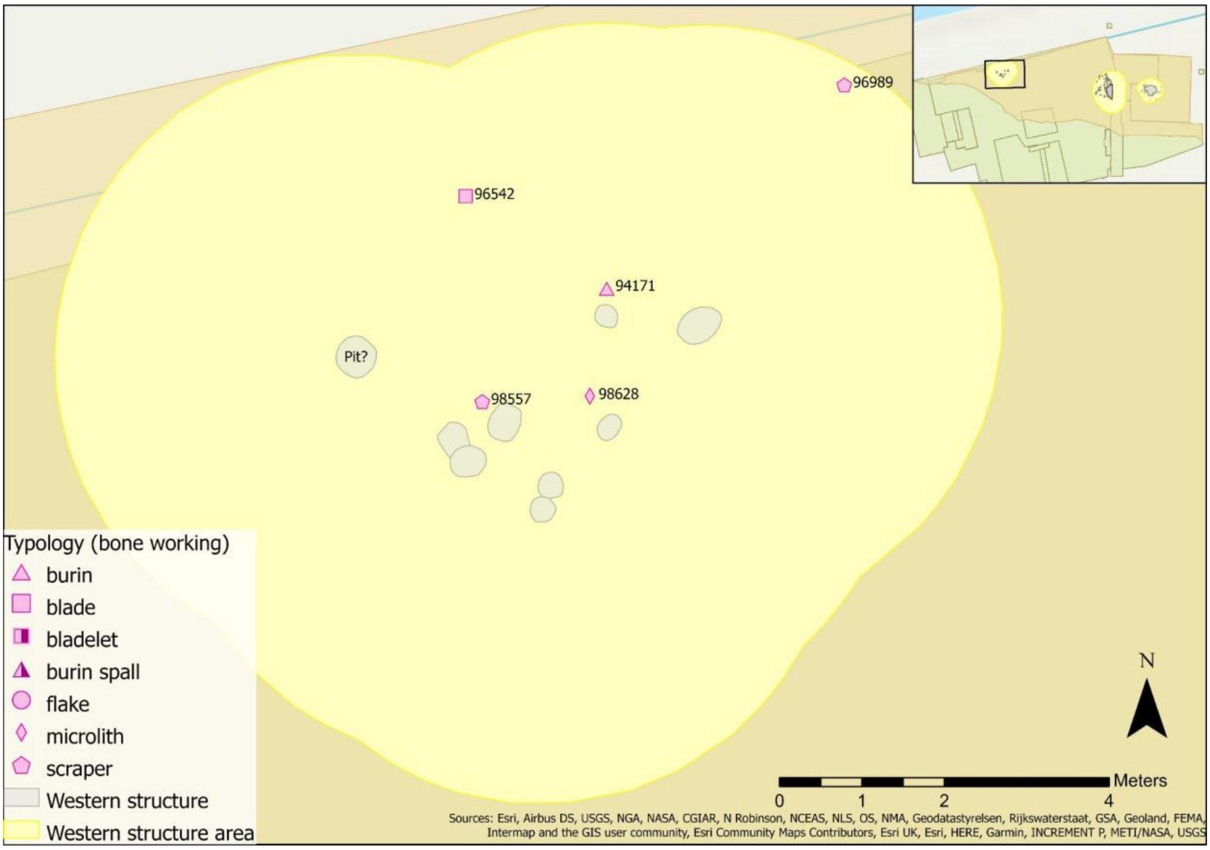


Figure 133: Distribution of bone working tools from the western structure area.

Five flints were found with bone working traces, three of which were found in close proximity to the postholes (see figure 133). Both the scraper and microlith displayed traces from scraping bone. Polish on the microlith was poorly developed and no hafting or MLITs were observed. Along with the transverse directionality, this led to an interpretation that it was not used as a projectile. A burin was used as a butchery tool, with longitudinal traces of bone and meat working, and possibly some hide working. To the north and north-east of the structural features, a blade and scraper both displayed transverse bone polish. An engraving motion was observed on a protruding point of the blade at its distal end (figure 134). The scraper had less developed polish and was interpreted as used to scrape bone.

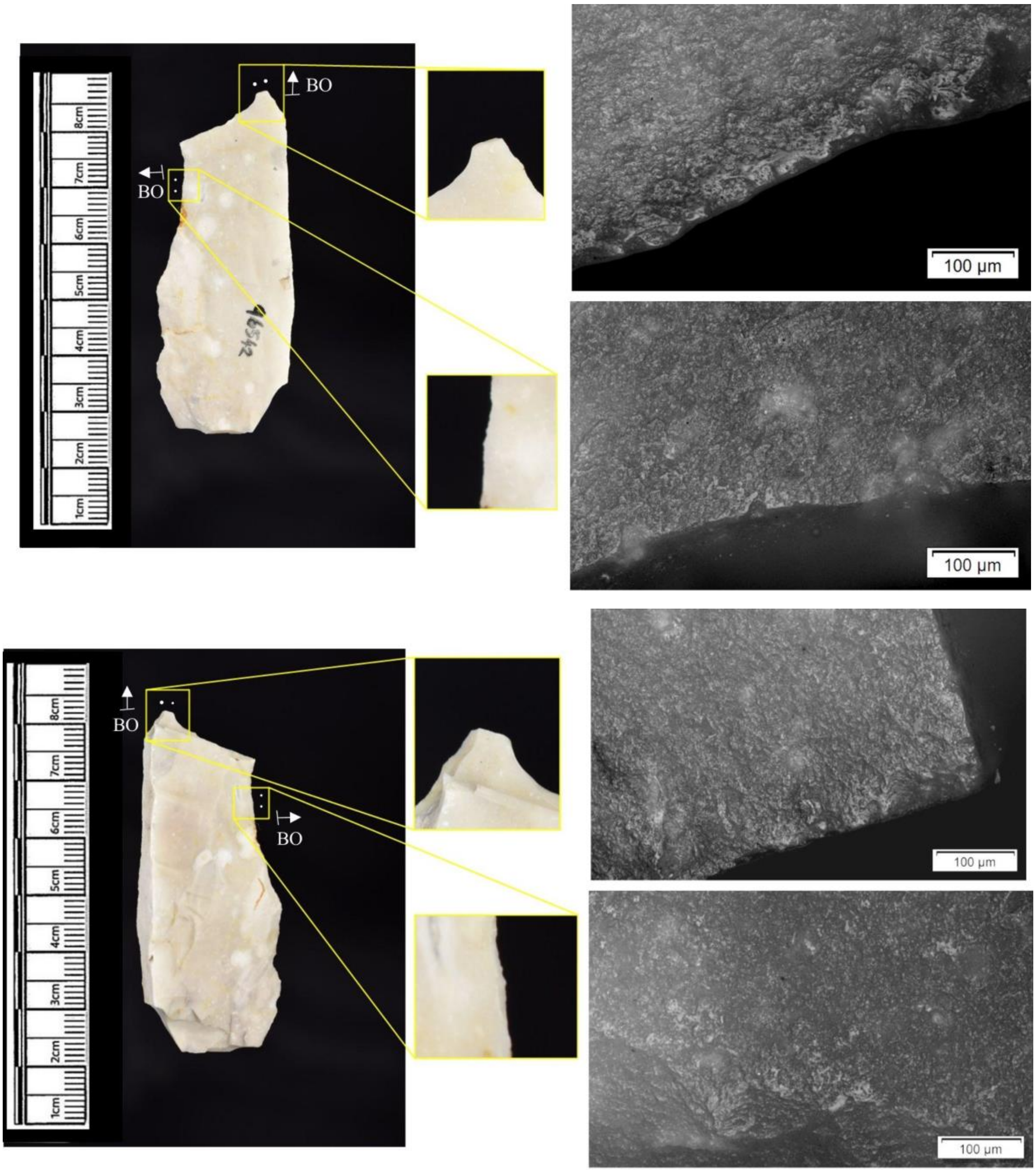


Figure 134: SC 96542, a blade interpreted as used to engrave and scrape bone, 200x magnification.

Whilst few in number, bone working tools suggest mixed patterns of activity: butchery, bone scraping and bone engraving were all observed. Spatially there are no discernible differences in those found close to the features and those found towards the periphery of the study area.

8.3.4. Meat

Of the meat working tools, there were: blades (3), burin spalls (2), microliths (2) and a microburin. Most meat working tools (4) were associated with the features and were used longitudinally (see figure 135). Both of the burin spalls displayed a greasy meat polish (see figure 136), suggesting use as butchery tools. Two microliths also exhibited meat polish, with no MLITs or obvious hafting traces observed. One had significant metallic striations and the other had iron oxide staining across the surface, so hafting traces may have been obscured.

Four flints were found around the outer perimeter of the study area (see figure 135). All blades had primary traces from meat, alongside either bone or hide. Two blades (<96226> and <95880>) had longitudinal polish from meat and possibly bone. Rates of dull flat smoothing from PDSM were high, so it was sometimes difficult to distinguish poorly developed bone polish from PDSM ‘polish’. The remaining blade had longitudinal and some transverse directionality of working meat and hide, with minor rounding observed alongside a greasy meat polish. Longitudinal meat traces were observed on a microburin, although they were not overly developed or invasive, possibly suggesting limited use.

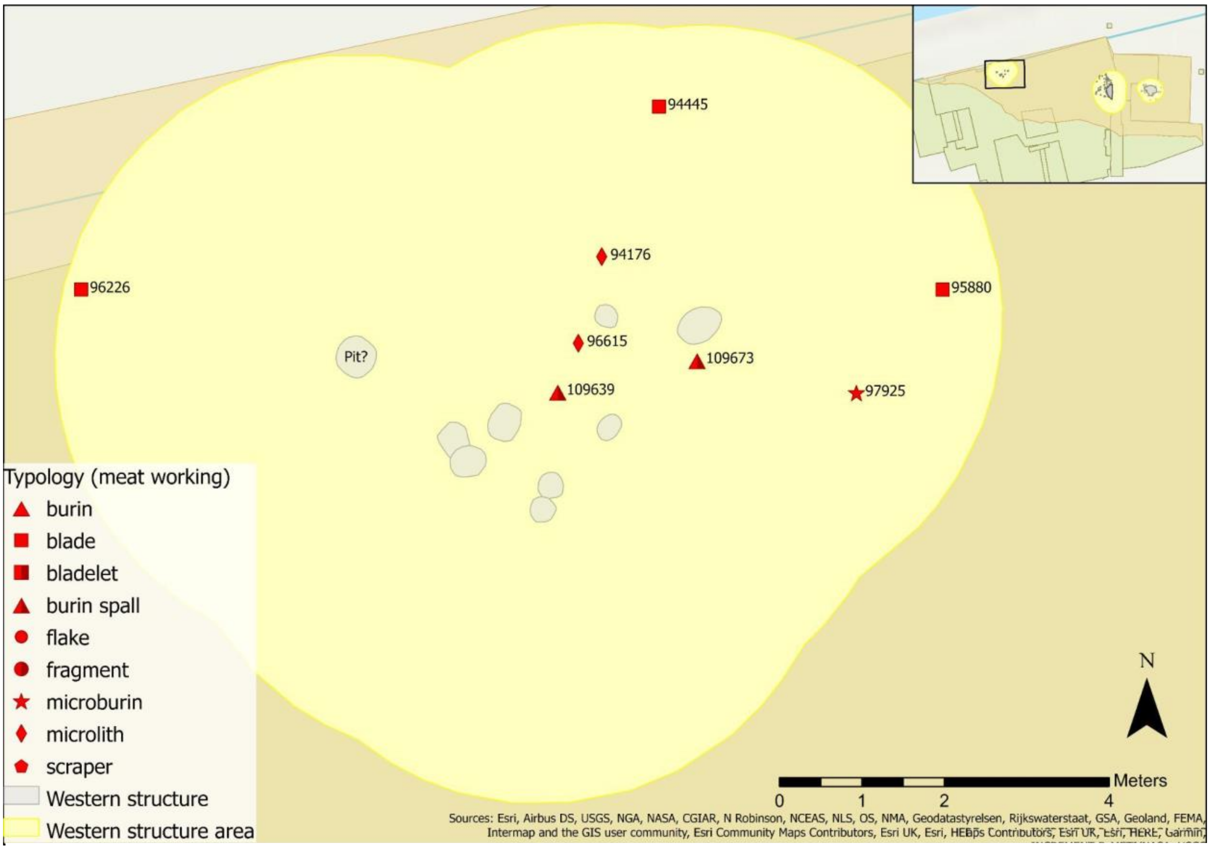


Figure 135: Distribution of meat working tools from the western structure area.

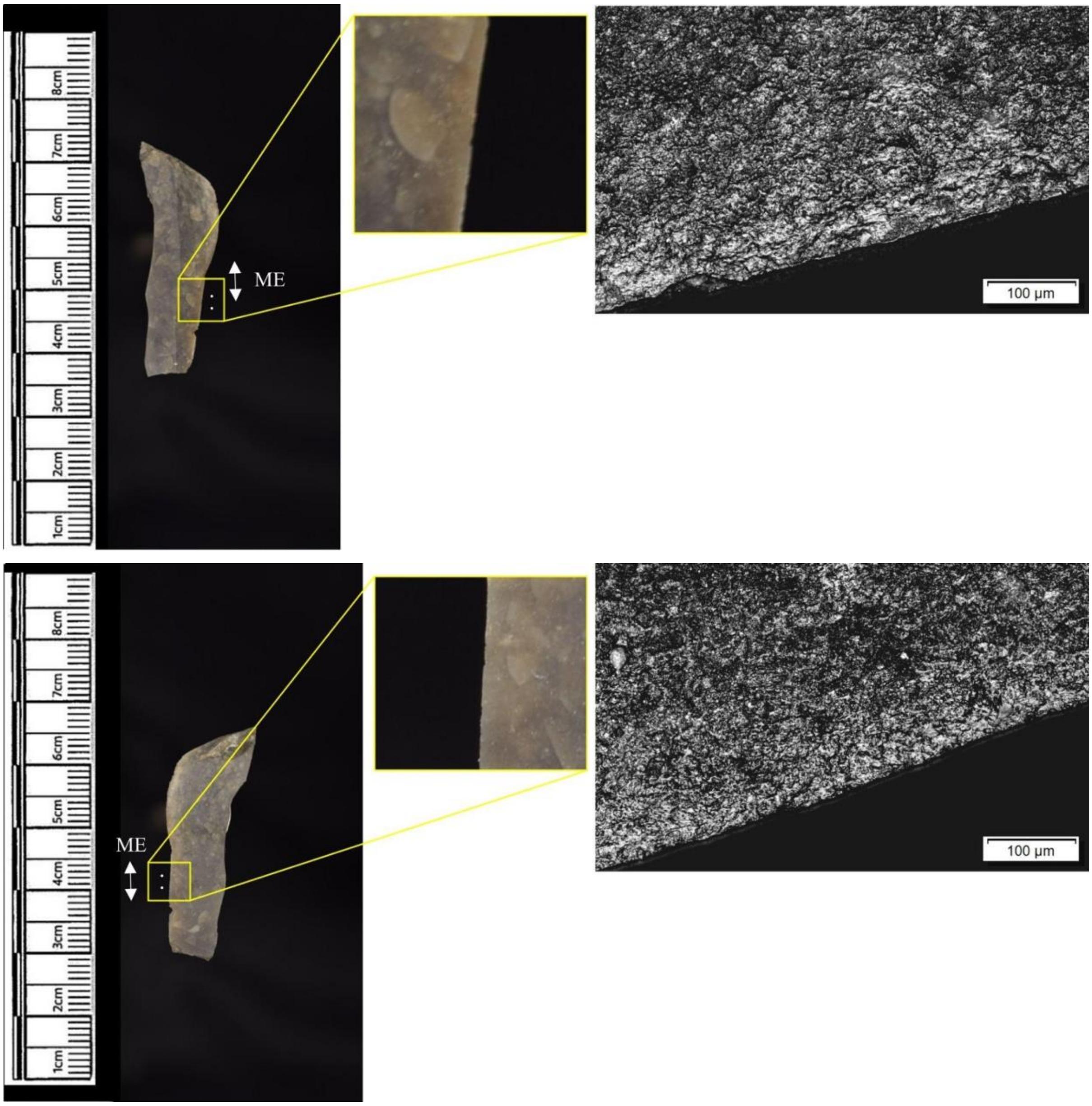


Figure 136: SC 109673, a burin spall interpreted as used to cut meat, 200x magnification.

Most tools with meat traces were cutting tools with only one showing both longitudinal and transverse directionality. Those spatially associated with the structural features were used on both meat and meat and hide, similar to those found on the periphery. The only notable difference between these two groups is the presence of meat and bone working traces on flint located away from the features.

8.3.5. Hide

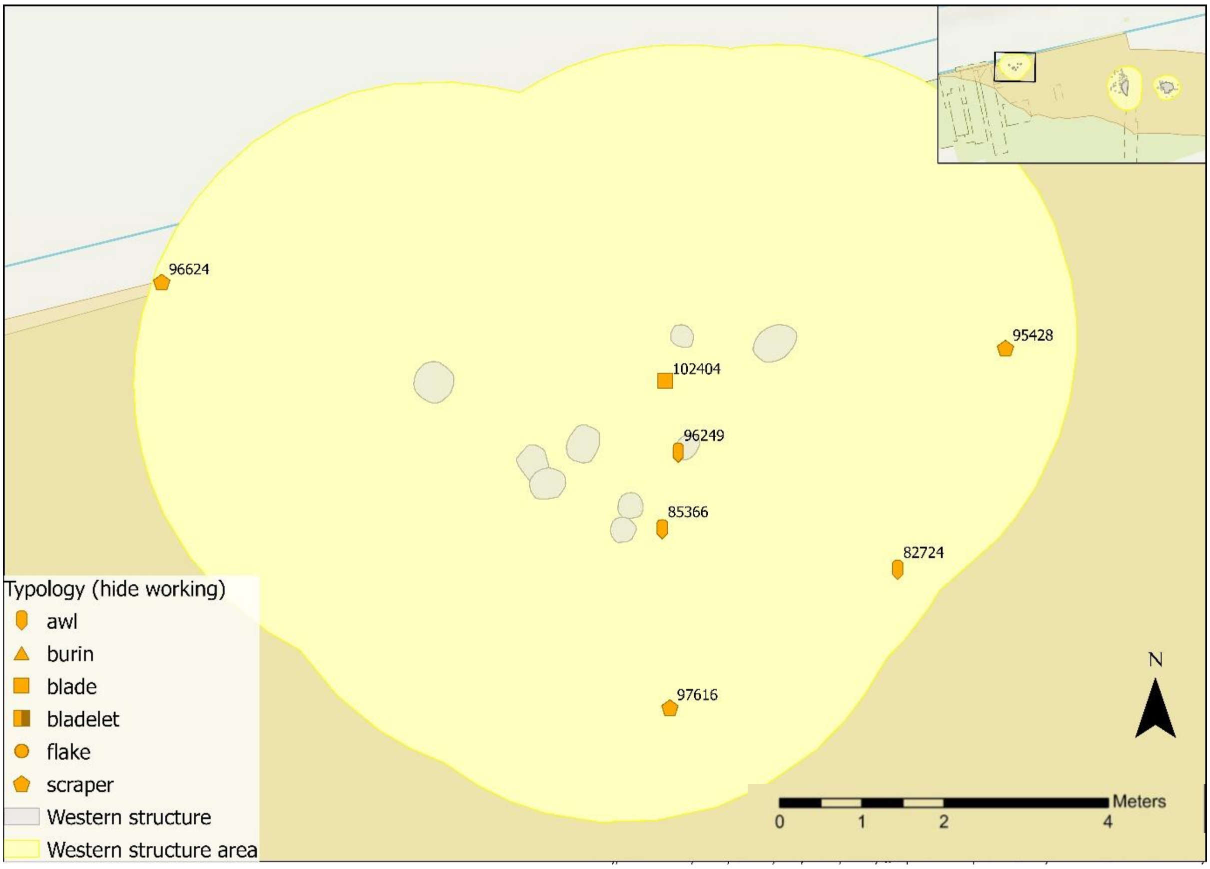


Figure 137: Distribution of hide working tools from the western structure area.

Seven tools (3 scrapers, 3 awls, 1 blade) displayed hide working. Two awls and one blade were found in close proximity to the features (see figure 137). The blade was used to scrape fresh hide and one awl was probably used to puncture/perforate dry hide with a mineral additive. The directionality of the polish on the awls analysed from Star Carr together with the tool's morphology (a retouched tapered tip), suggests they generally functioned as puncturing/perforating implements (Ballin 2021).

All three scrapers were found at the outer edge of the structure area, though located apart (see figure 137). Two (<96624>, <95428>) were interpreted as used to scrape dry hide with a mineral additive (see figure 138). A third scraper had traces from working fresh hide, although the polish was not overly invasive, indicating that the tool was held at a high angle when scraping. An awl (<82724>) exhibited traces from dry hide working with a soft mineral additive in a transverse, rotational direction, consistent with the interpretation of puncturing/perforating.

Overall, there appears to be no clear spatial patterning in hide working. Two awls and a blade were spatially associated with the features but the microwear results suggest that hide and hide with a soft mineral additive were worked across the study area.

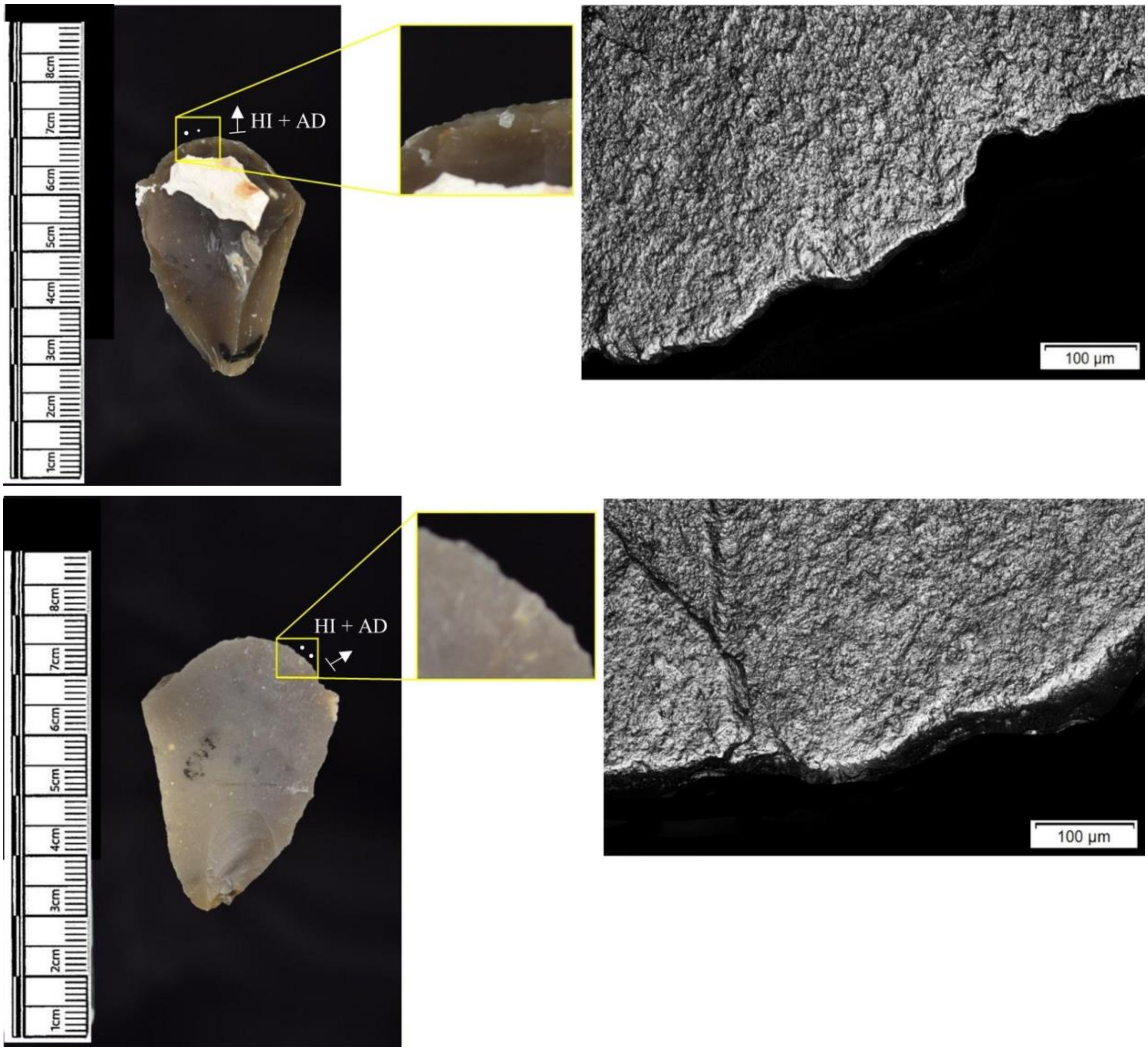


Figure 138: SC 95428, a scraper used to scrape dry hide with an additive, likely mineral due to the flat areas of the polish, 200x magnification. The polish is particularly well developed on the ventral aspect.

8.3.6. Projectiles and hafted microliths

Two microliths were interpreted as projectiles and possible MLITs were observed (see figure 139). Both were interpreted as having contact with bone and meat, as expected if used for hunting. Some MLITs were found on the dorsal aspect towards the distal tip of one piece (see figure 140). Linear striations ran vertically down the centre of the flint which, along with it's morphology, suggests that it was hafted at the tip of a projectile. No hafting traces were noted but the presence of MLITs implies that it was hafted at some point during use. A second microlith (<94552>) displayed faint possible MLITs. It was an oblique blunted pointed lateralised to the right, meaning it had an off-centre pointed tip. It is unlikely that it functioned as a projectile tip, given the off-centre point, but it could have been hafted as a barb of a projectile. It is also possible that linear striations were formed from inclusions during use., as MLITs are rarely observed on barbs (Crombé *et al.* 2001).

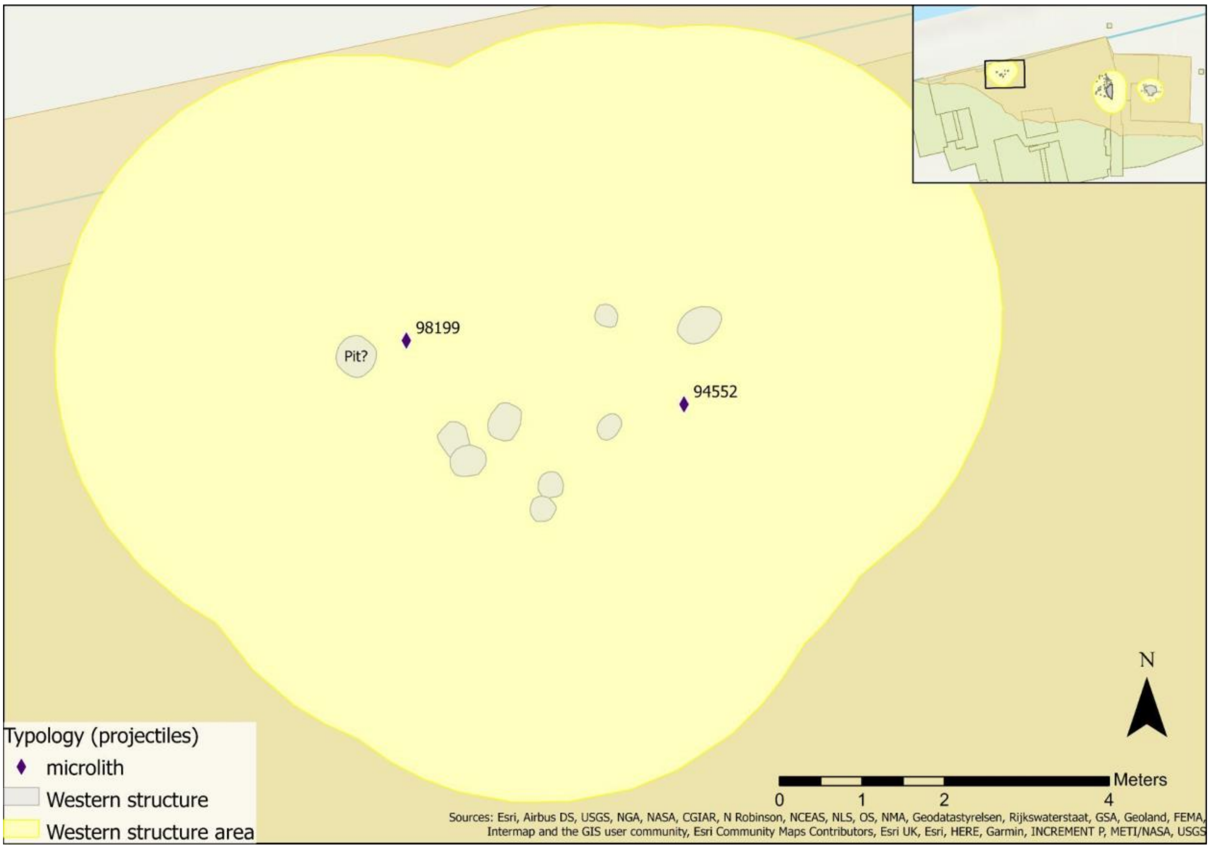


Figure 139: Distribution of projectiles and hafted microliths from the western structure area.

No patterns in spatial distribution can be discerned from two pieces. However, both were found in close proximity to the structural features and possible pit. This could tentatively suggest that de-hafting or deposition took place in spatial association with the structure, although this requires further testing.

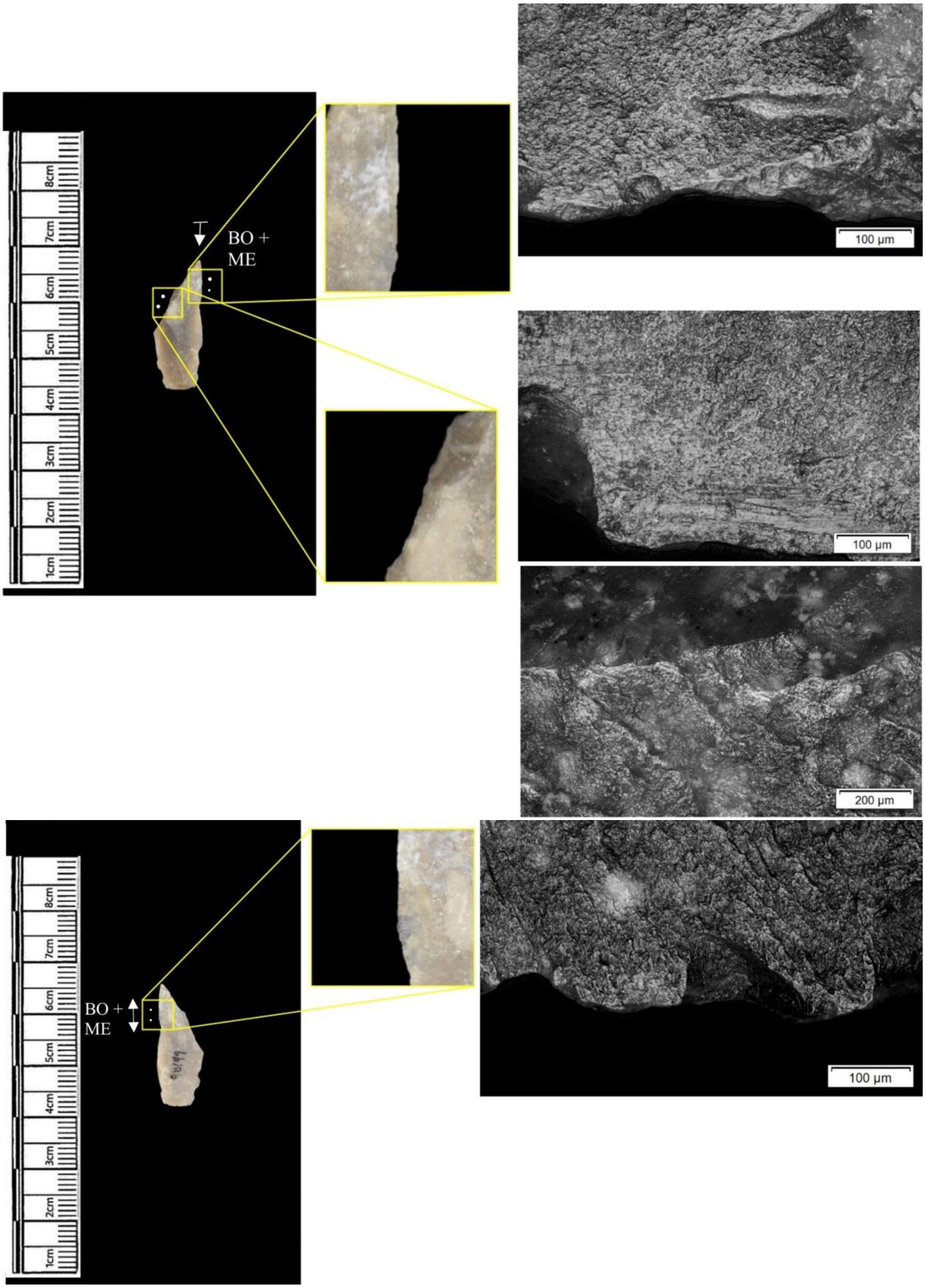


Figure 140: SC 98199, a microlith interpreted as a projectile based on faint MLITs on the dorsal aspect, as seen in the bottom two micrographs from the dorsal aspect. The projectile displayed contact with bone and meat, 200x magnification and 100x magnification for the lower dorsal image.

8.3.7. Fish and possible fish working

A scraper and a microburin had tentative signs of fish working, associated with the structural features and possible pit (see figure 141). Cutting and scraping traces from fish were interpreted on the scraper. Faint transverse polish was observed on a microburin, which had short linear striations similar to some types of fish polish (see figure 142) (van Gijn 1986). Both tools were associated with the structural features, so fish working may have been undertaken near to this area.

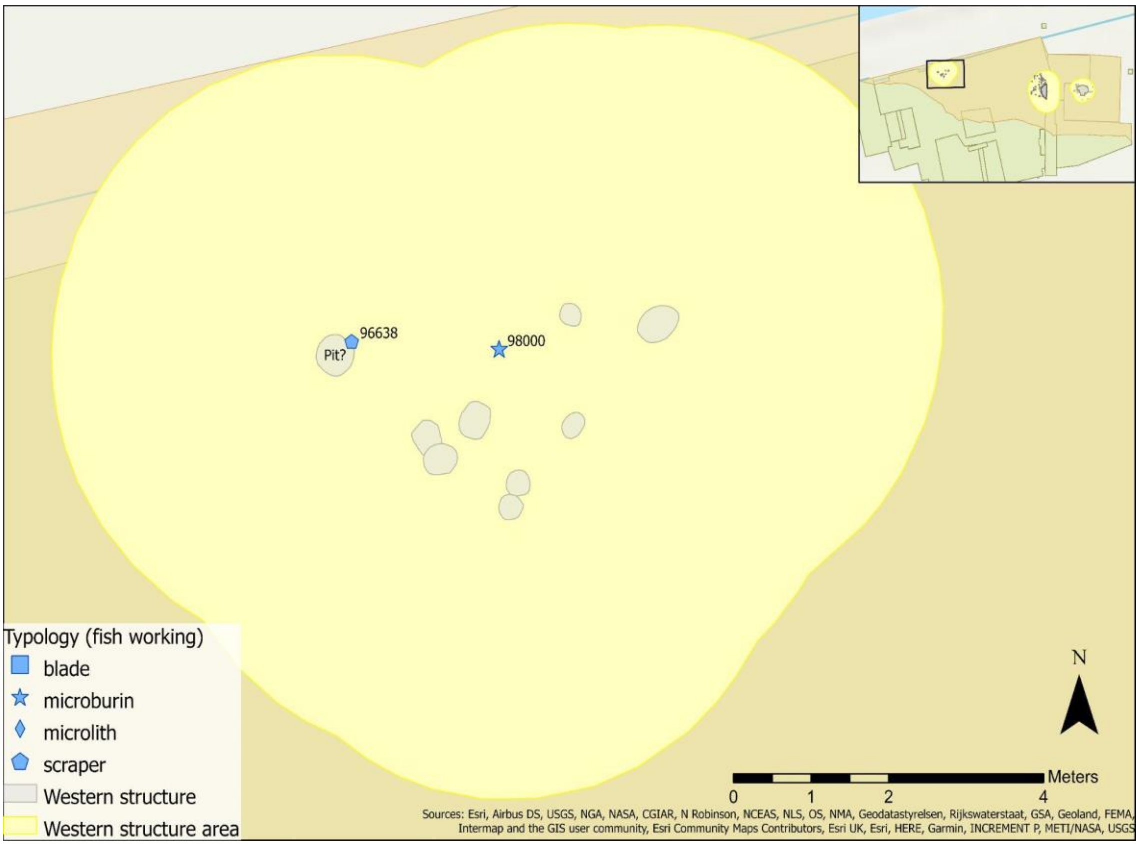


Figure 141: Distribution of fish working tools from the western structure area.

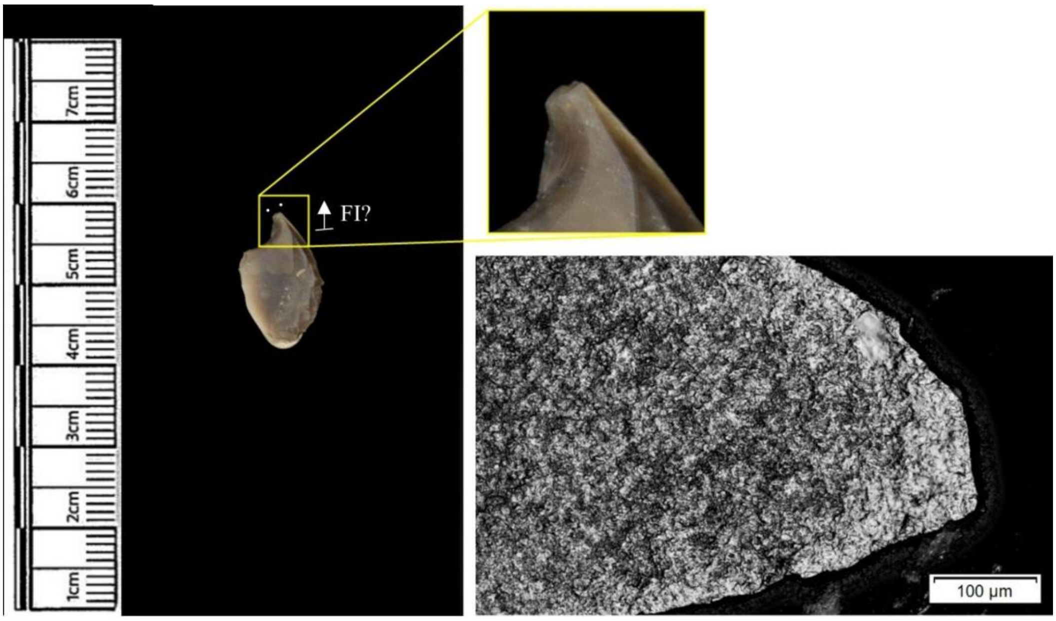


Figure 142: SC 98000, a microburin interpreted as used in a transverse direction on possibly fish, 200x magnification. Very faint perpendicular striations were observed in the polish. No polish was observed on the ventral.

8.3.8. Antler

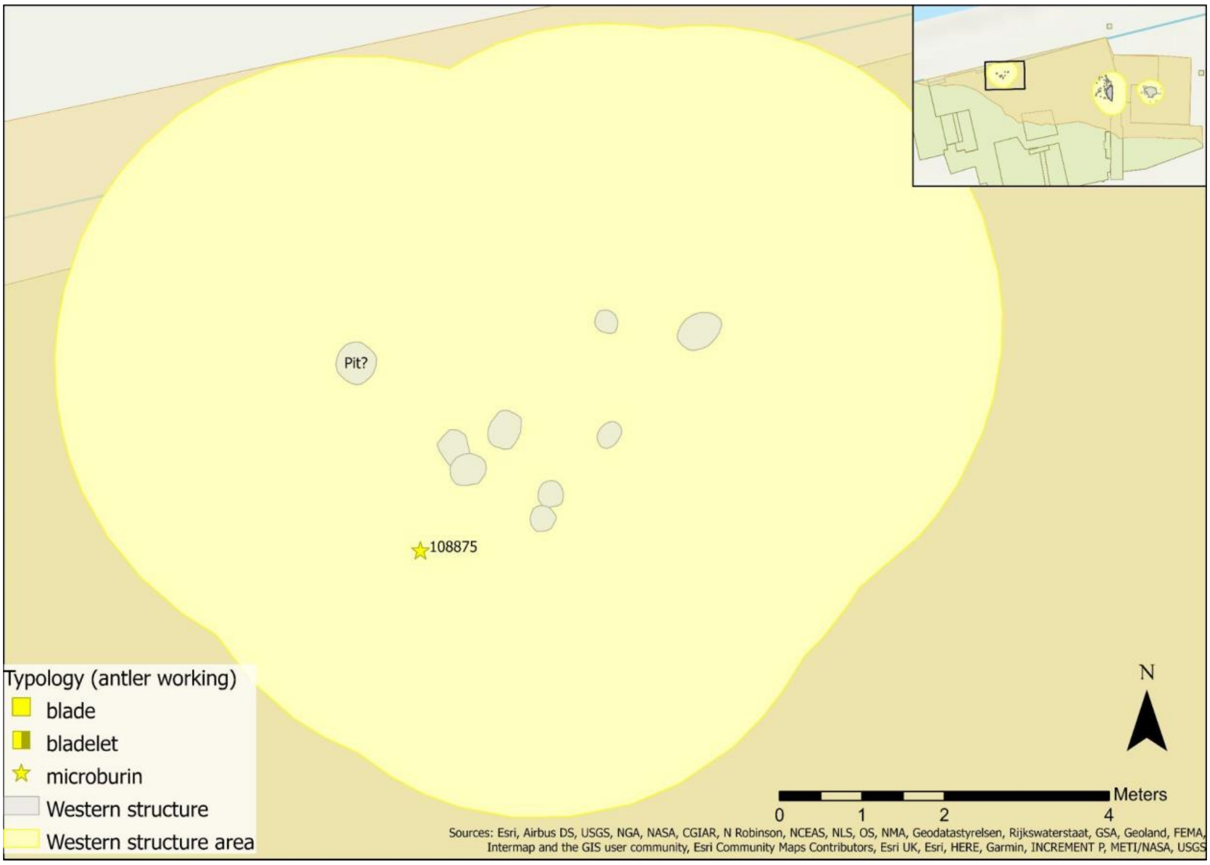


Figure 143: Distribution of antler working tools from the western structure area

A microburin located to the south-west of the postholes had antler working polish and developed transverse traces were observed (see figures 143 and 144). From the directionality of use and location of working, it was interpreted as used to groove and plane antler. It was found near to the features, so could be associated with the structure area.

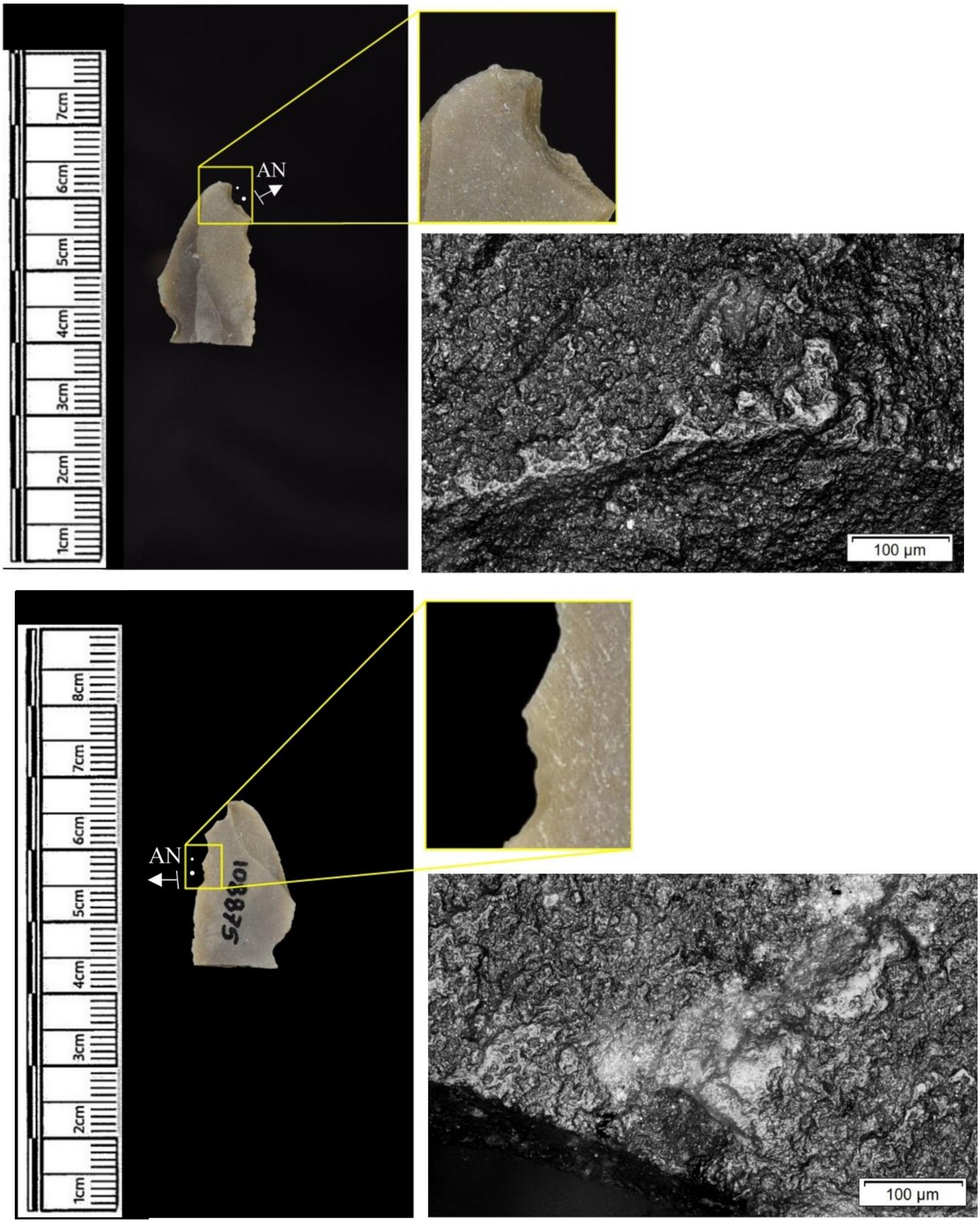


Figure 144: SC 108875, a microburin interpreted as used to groove and plane antler, 200x magnification.

8.3.9. Plant

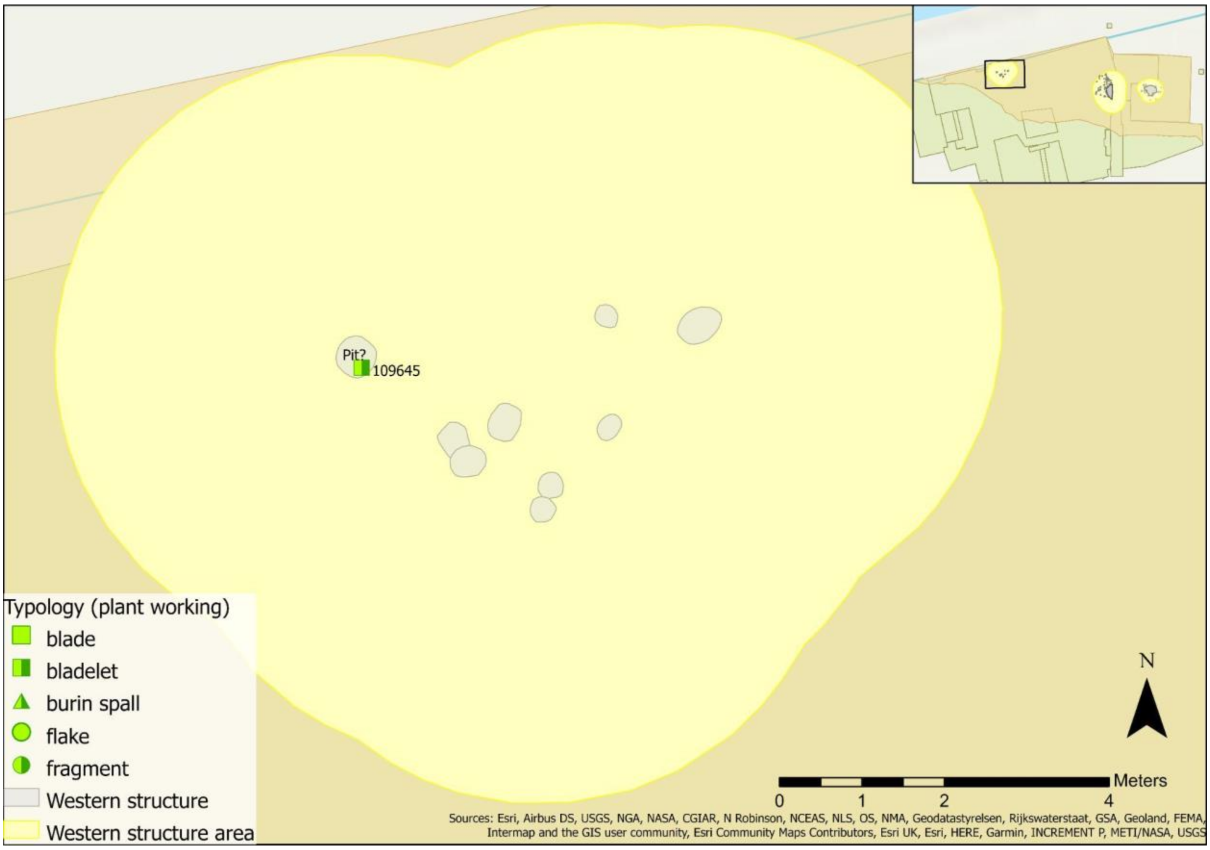


Figure 145: Distribution of plant working tools from the western structure area.

A bladelet was the only tool with plant working polish in the western structure (see figure 145). It was used to cut and scrape siliceous plant as there was a bright, interlinked smooth polish observed (see figure 146). The polish was more developed on the ventral than the dorsal aspect and was not invasive. This indicates that the piece was held at a high angle limiting the amount of contact between the tool and plant. No finds were excavated from the possible pit [526], so it is unlikely that the bladelet was deposited there. However, this cannot be discounted due to the effects of bioturbation.

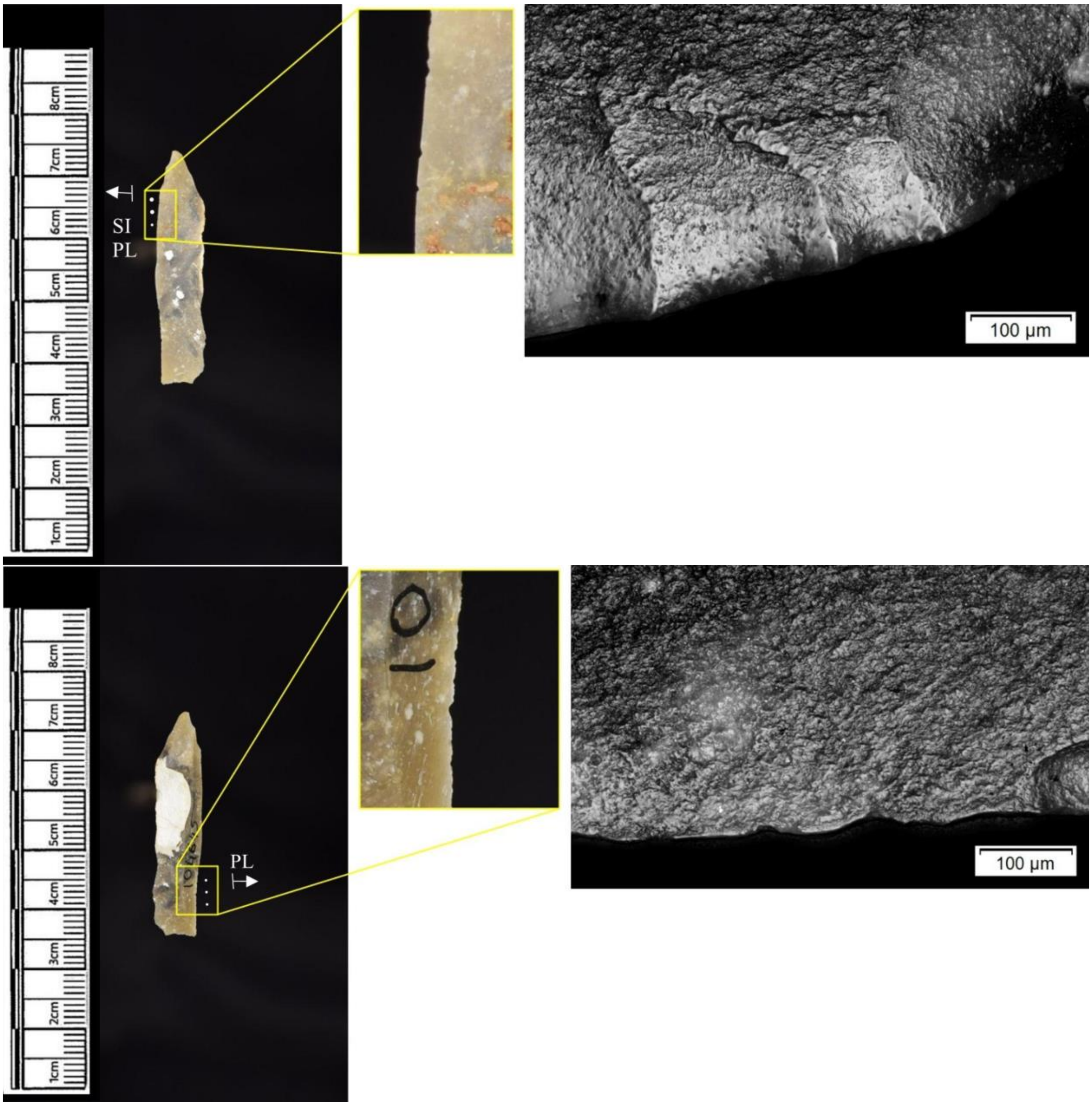


Figure 146: SC 109645, a bladelet interpreted as used to scrape siliceous plants, with well developed polish observed on the ventral aspect, 200x magnification.

8.3.10. Wood

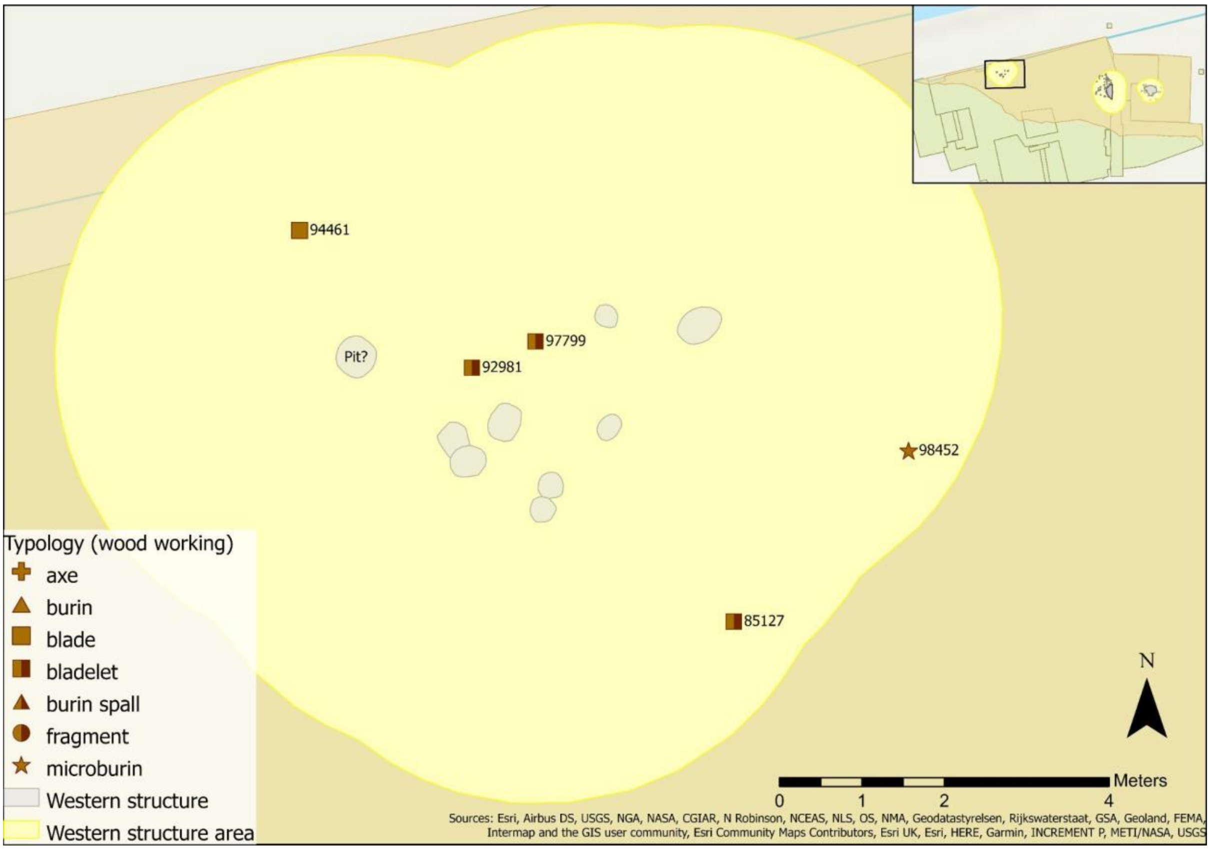


Figure 147: Distribution of woodworking tools from the western structure area.

Five tools were used on wood, two of which were bladelets located close to the structural features (see figure 147). Longitudinal and transverse woodworking were observed on both, suggesting that they were used to plane and possibly cut wood, although the polish was not well developed. They had significant iron oxide staining across large areas, which may have obscured more developed areas. A blade was used to cut soft wood on a lateral edge and to scrape wood on the distal end (see figure 148). This may have been used in crafting activities, like making wooden objects. A final bladelet and a microburin located to the south-east were both interpreted as used transversely on wood. The polish was not invasive, indicative of scraping with limited contact between the flint and wood.

Flints used to work wood were scattered across the study area, with no obvious spatial clustering around the features or surrounding area. Two bladelets were found in close proximity, which could suggest woodworking activity took place near to the structure. Other tools were spread in the surrounds of the structural features.

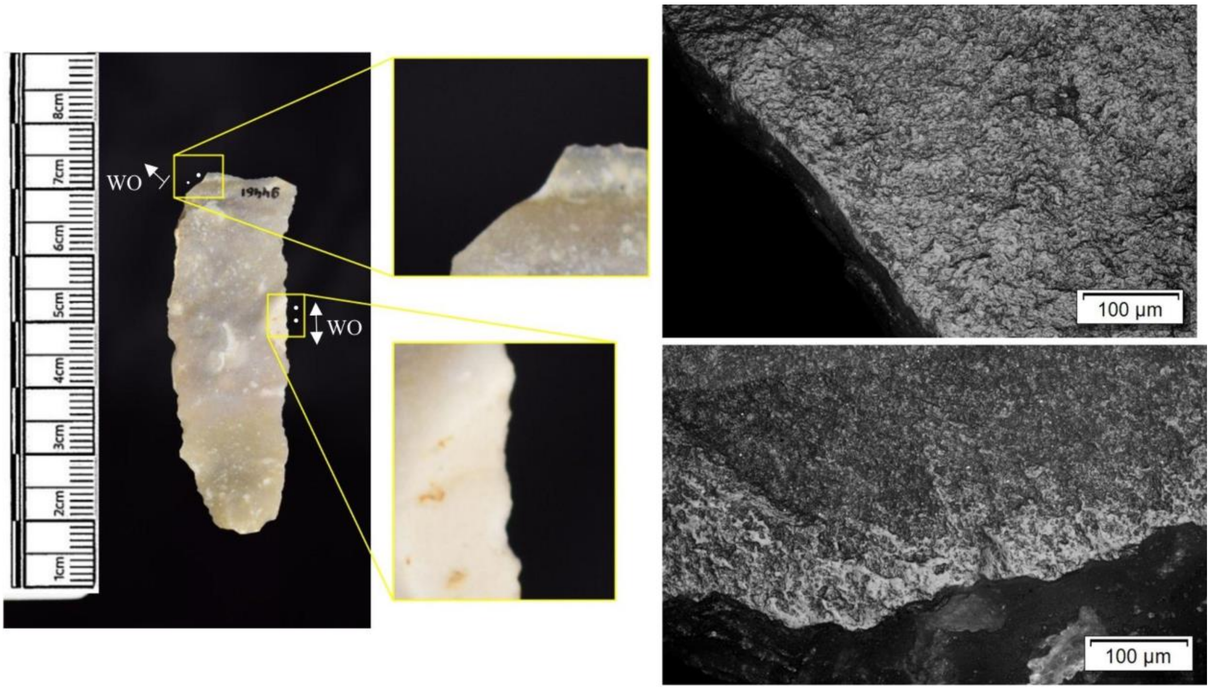


Figure 148: SC 94461, a blade interpreted as used for de-barking wood and cutting soft wood from developed polish on the ventral aspect, 200x magnification. No polish was observed on the dorsal.

8.3.11. Mineral

Both strike-a-lights were located in the western structure area (see figure 149). One was found near to the features and displayed multiple areas of use as a strike-a-light (see figure 150). Grooved striations suggest that a hard mineral material (e.g. pyrite) was used against the tool, as would be expected for creating a spark to start a fire (Sorensen *et al.* 2018). The other strike-a-light also had at least two areas of use, and was located to the north of the features (see figure 149). A flat and bright polish was observed in some areas, with deep grooves and striations embedded within it. This could indicate that a different type of mineral was used or perhaps a shorter duration of use.

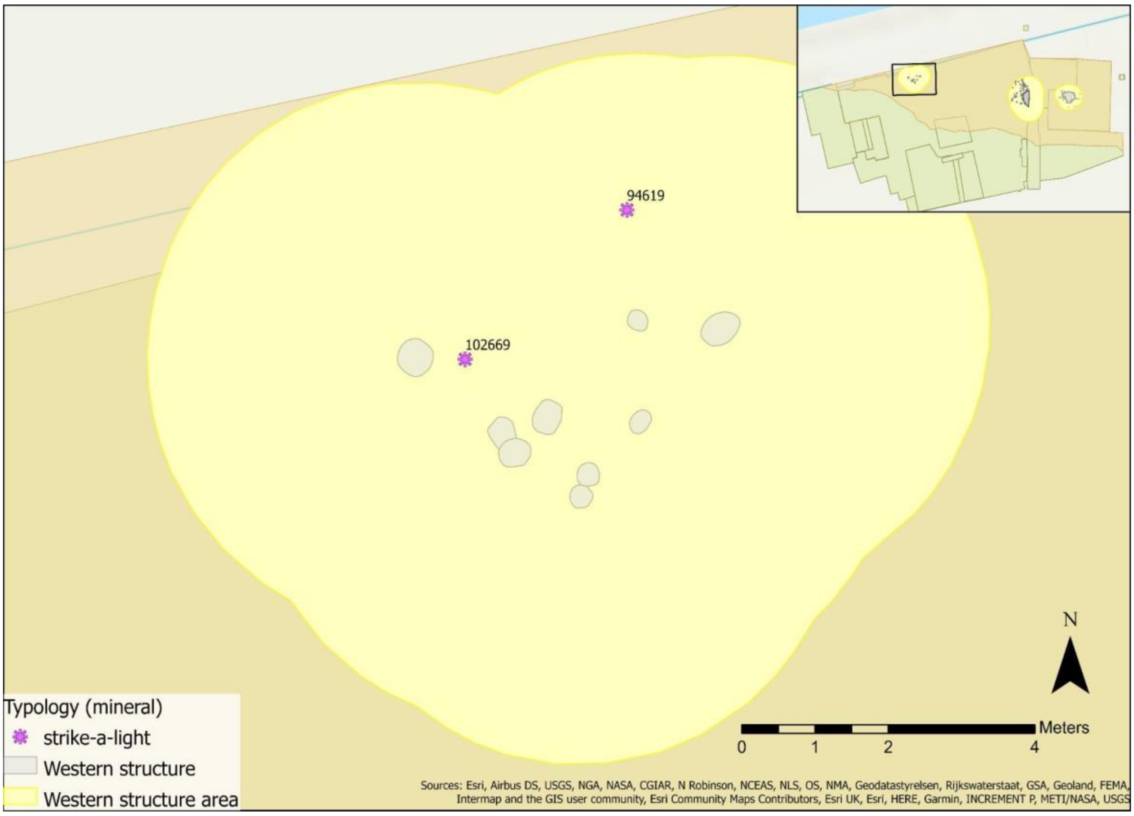


Figure 149: Distribution of used strike-a-lights from the western structure area.

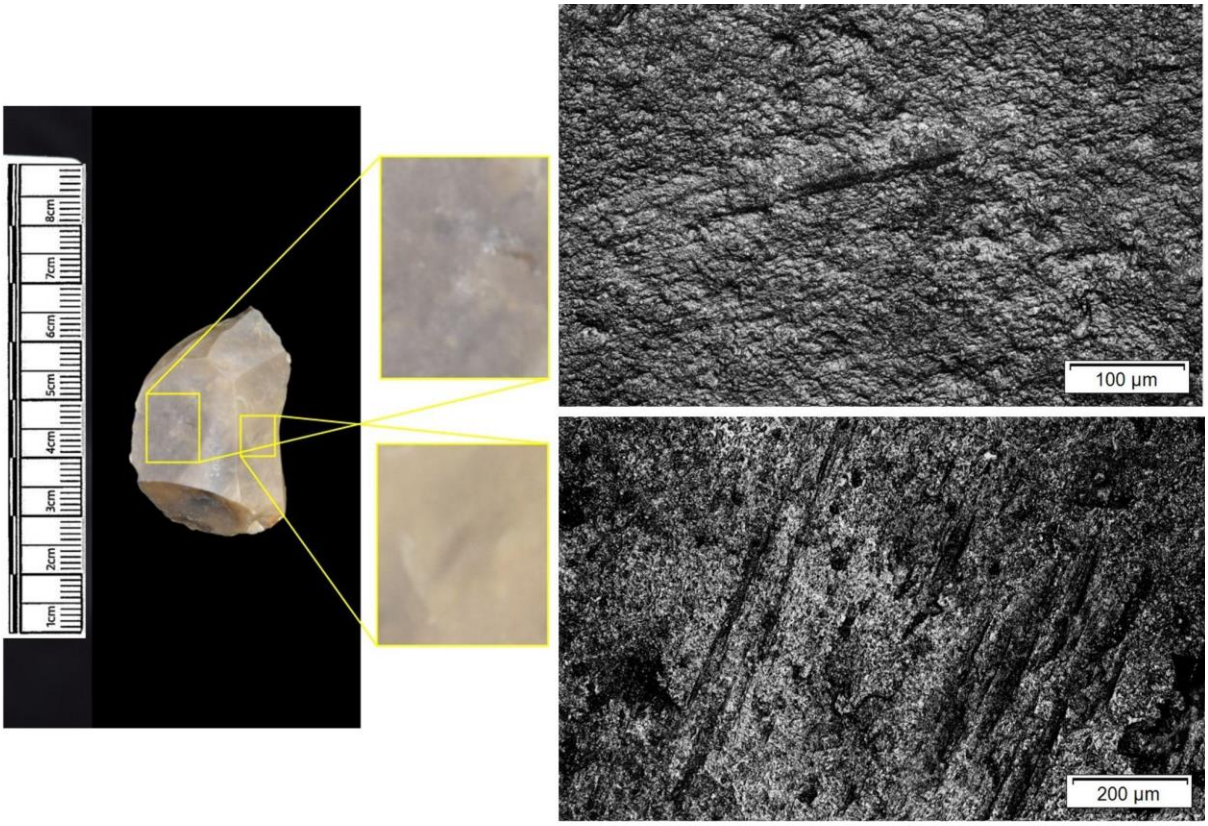


Figure 150: SC 102669, a core interpreted as used as a strike-a-light in two areas, 100x and 200x magnification. There was no polish observed on the dorsal.

8.3.12. Soft and soft/medium indeterminate materials

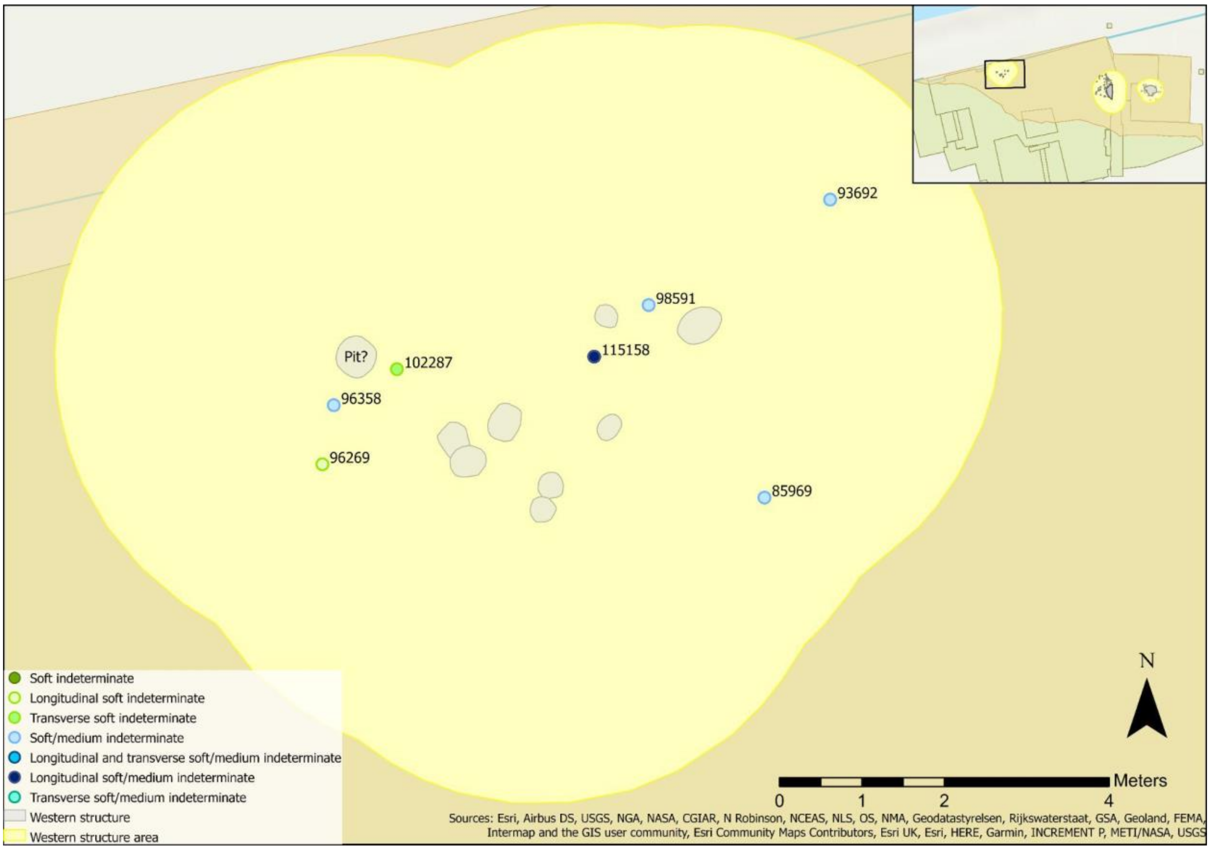


Figure 151: Distribution of tools used on soft and soft/medium indeterminate materials from the western structure area.

There were two flints used on soft materials, a bladelet with transverse directionality and a burin spall used longitudinally. Two bladelets, one blade, one microburin and one awl had soft/medium indeterminate polish. Directionality could not be discerned for four of these, largely due to the extent of PDSM; however a microburin (<115158>, see figure 151) was used longitudinally. Most tools (5) were located near to the features.

8.3.13. Medium and hard indeterminate materials

Eight tools displayed polish from medium (5) and hard (2) indeterminate materials. Of those used on medium materials, three blades had transverse directionality (<96213>, <96886>, <94933>), and two microburins were used longitudinally (<94988> and <116256>). Motion of use for the awl (<82607>; see figure 152) could not be determined. Most tools were found in the area surrounding the features.

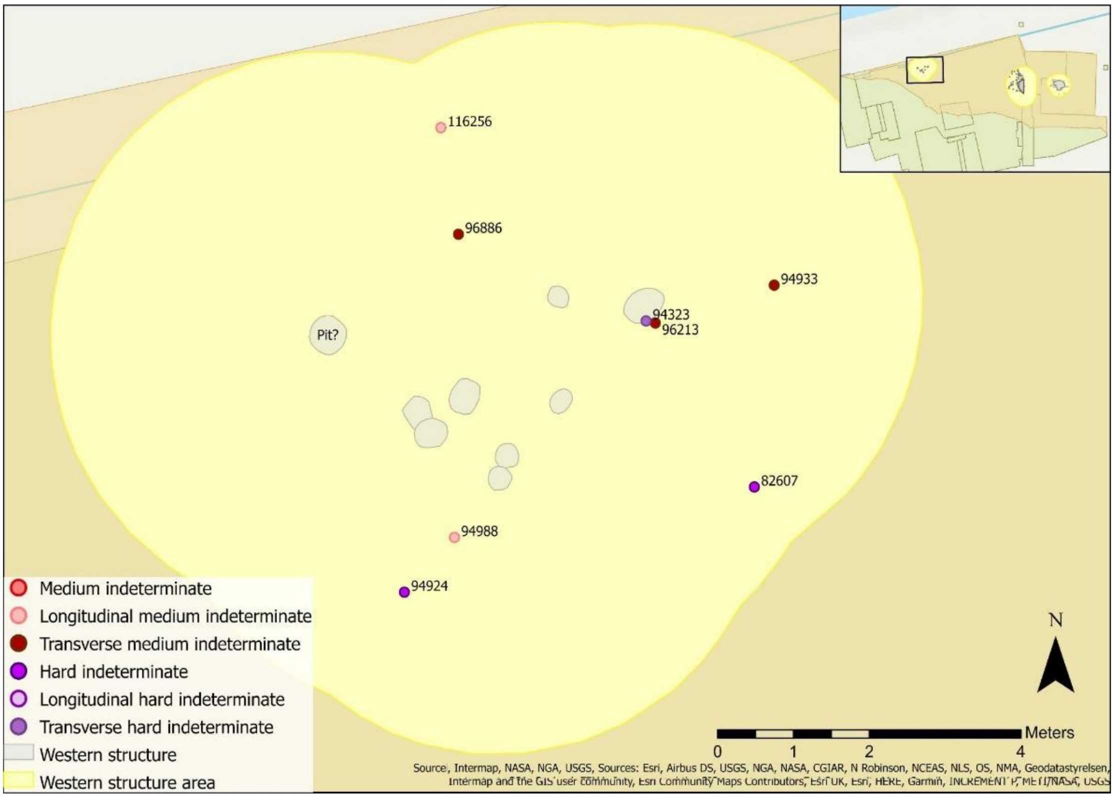


Figure 152: Distribution of tools used on medium and hard indeterminate materials from the western structure area.

8.3.14. Indeterminate materials

Indeterminate material traces were observed on five flints; two blades, a burin, a denticulate and an awl. Pieces were scattered across the study area, with two located near to the structural features and three found towards the outer periphery (see figure 153).

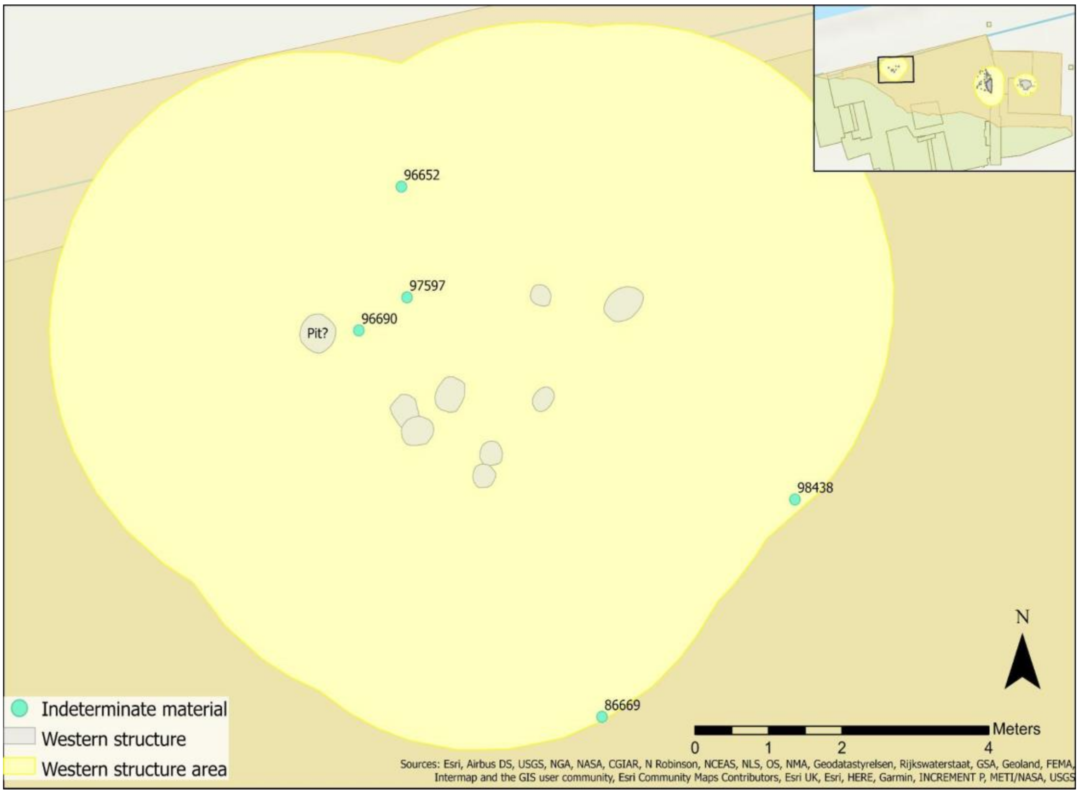


Figure 153: Distribution of tools used on indeterminate materials from the western structure.

8.3.15. Not used

Thirty-four flints were interpreted as not used. Of these, 19 were located in close association with the structure features and possible pit (see figure 154). Unused pieces are distributed evenly across the study area, with limited clusters associated with features and the surrounding area. These generally correlate to groups of bladelets specifically selected for microwear analysis due to their spatial patterning. Tool types are mixed across the area, with burins, blades, and an awl as well as microburins, bladelets, burin spalls and a strike-a-light.

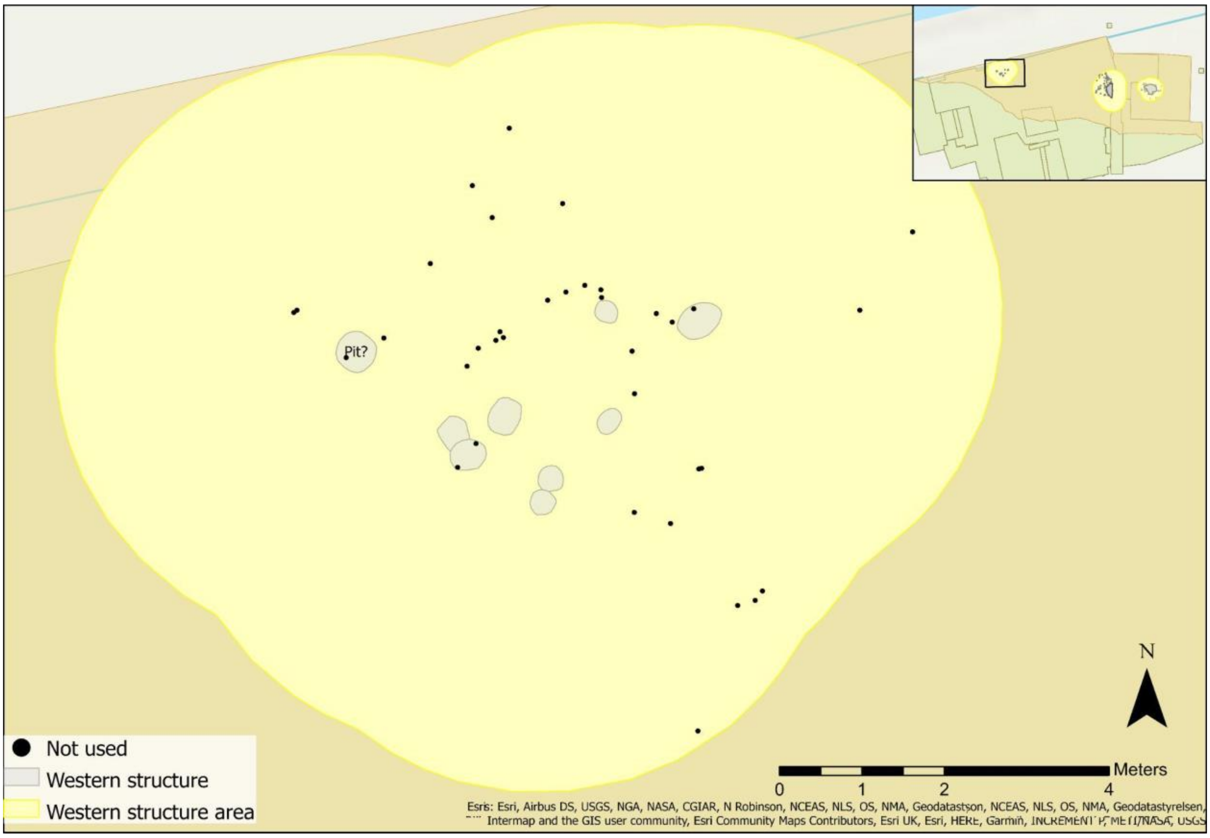


Figure 154: Distribution of unused tools from the western structure area.

8.4. Discussion

8.4.1. Tool type

Generally all tool types in the western structure show animal-related use, with the exception of bladelets. Interestingly, they also had the lowest rate of use compared to other tool types (26%). The treatment of bladelets suggests that their use was perhaps more sporadic, with only some selected for carrying out tasks. The sample of those with wear traces is small, so observations must be tentatively made; however they appear to have been utilised for specific tasks involving wood and siliceous plants. This suggests some homogeneity in the use of bladelets in the area. Together with the observation that most other tool types were used on animal-related materials, the microwear data could indicate that repeated tool-using behaviours took place here. This would contrast the wide ranging and mixed frequencies of tasks that might be expected in a midden.

Other tool forms have high-rates of use, with typical working traces. For example, microliths had meat and bone polish, with two showing MLITs, and scrapers were used to scrape hides, bone and possibly fish. Microburins had traces from a range of tasks, indicating that they were a versatile tool; polishes from cutting meat, engraving antler, planing wood, and scraping fish were observed. These tools were not previously analysed by the Star Carr Project or Dumont, but 50% had wear traces. Polish observed might relate to residual traces from use prior to being manufactured into microliths and microburins. However, the morphology of microburins, small with a pointed distal end, makes them effective tools for small-scale tasks. Future microwear studies should not discount them as they can offer useful insights into varied tool use.

Awls and strike-a-lights were only found in the western structure area. Strike-a-lights had hard mineral polish from use for lighting fires, as might be expected. Where contact material was interpreted, awls were mainly used to puncture/perforate hides, indicative of craft-working for producing clothing or sewing coverings.

8.4.2. Animal-related tasks

A clear density of flints used on different animal contact materials was associated with the structural features, with those in the surrounds more dispersed. As a result, two bone- and two meat working zones were established. Near to the features, a fragment and scraper in the bone working zone were used to scrape bone. This may reflect cleaning of excess fleshy material, suggesting that bones may have prepared here prior to further processing. A second bone activity area to the east (see figure 155) comprised bone tools used to scrape and to groove/engrave. Activity in the western

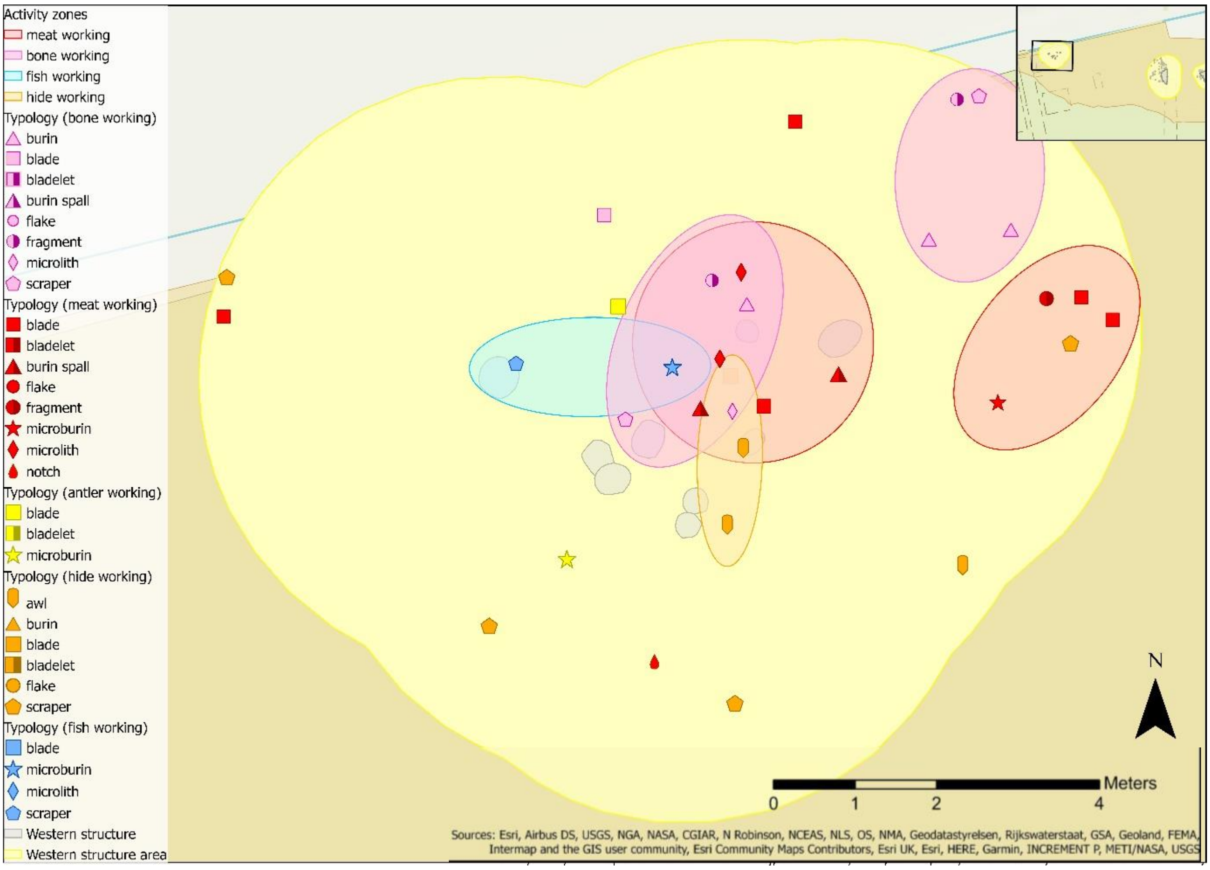


Figure 155: Spatial distribution of tools used on animal-related contact materials and associated activity zones.

structure suggests a combination of processing of bone for subsequent uses or craft work, as well as butchery.

Faunal remains were fragmented and poorly preserved, making it difficult to identify human modification (Knight *et al.* 2018b, 126). A small cluster of animal bones found to the east were exposed to heat and comprised remains of wild boar, wild cat, and roe deer (Knight *et al.* 2018b, 128). These have been interpreted as an *in situ* hearth or clearance debris from a nearby hearth (Knight *et al.* 2018b, 128); both suggest the cooking of animals near to or within the study area, which could relate to meat working traces observed.

Traces of hide working appeared to group most frequently with flints used on meat (see figure 155). These pieces were used to scrape or perforate dry hide with a soft mineral additive, and to scrape fresh hide. Hide working appears largely homogenous from the microwear results; however the spatial distribution of these tools suggests dispersed activity. Multiple hide working tools used on dry hide were found across the area. This could indicate repeated visits for later stages of hide processing or that subsequent activity or deposits moved these flints from where they were originally deposited. Alternatively, a lack of clustering may reflect the presence of a midden, with hide working tools deposited here at different times. In this scenario, spatial associations between hide- and meat working could suggest tasks were undertaken at a similar time and then deposited together, or were cleared from the same location.

The possible fish working zone is tentative due to sample size. A scraper was used to cut and scrape, and a microburin had transverse polish, indicative of scraping. Two flints used to cut meat, and meat and bone found close to the microburin might be connected in use. Scraping fish could be part of the butchering process, with fish scales removed prior to cooking. Therefore these tools could be interpreted as displaying some connected activity.

Overall, a mixed pattern of animal-related tasks is observed. Flints used on bone, meat, fresh and dry hide and fish are in close proximity to each other and to the features (see figure 155). The presence of a midden might be observed through these traces, as tools from a range of materials were deposited in one place with no clear spatial pattern. Alternatively, interspersed animal-related tool use could be interpreted as a structure where different tasks were undertaken with no spatial organisation. This would create a palimpsest of tool deposition, with utilised pieces from butchering of different animals, processing bone and animal hides. In contrast, only hide- and meat working tools were spatially linked in the surrounds. These flints may also be associated with the structure but reflect individual episodes of activity.

8.4.3. Projectiles and hafted flints

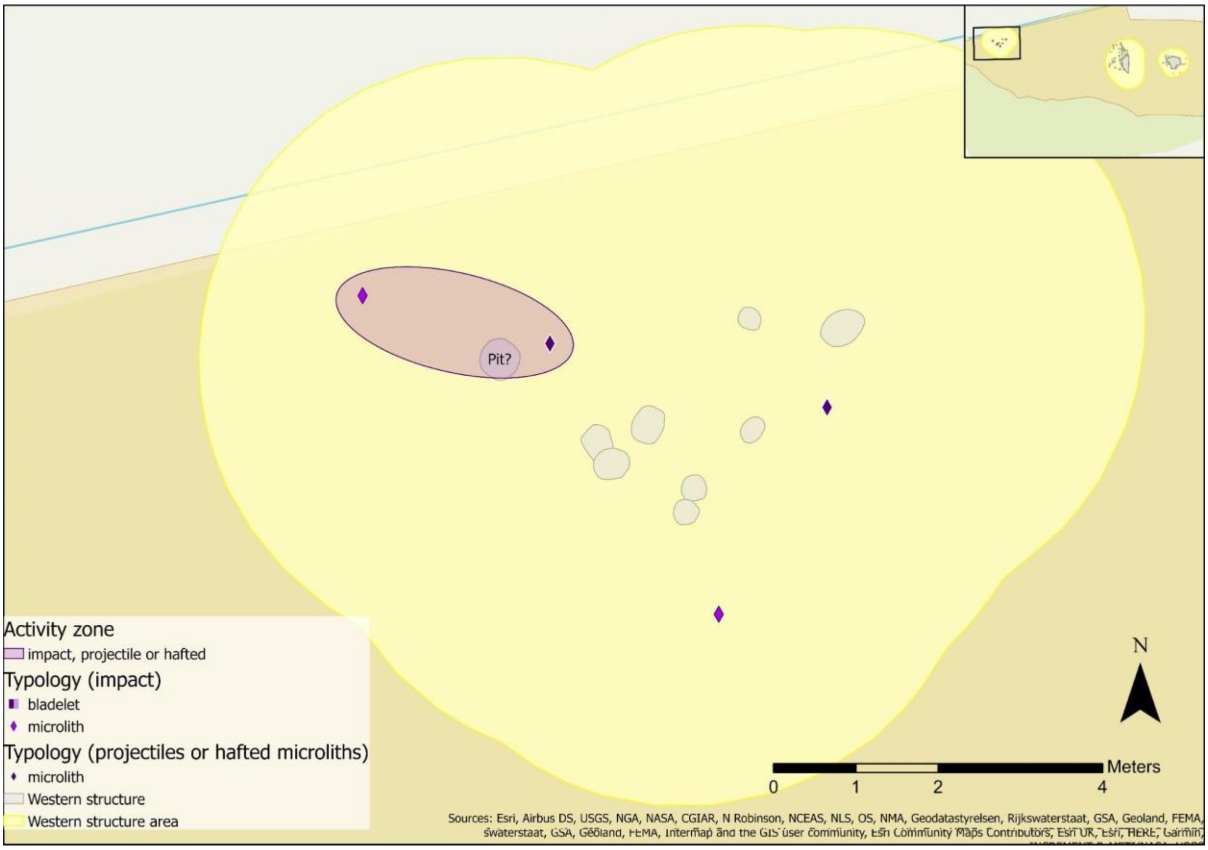


Figure 156: Spatial distribution of hafted tools or tools evidencing impact/use as a projectile and associated activity zone.

A zone of activity was created from four flints with hafting or MLITs, though this is speculative due to sample size (see figure 156). Two pieces evidenced MLITs, and one was also used to cut siliceous plants. This secondary use was observed on both lateral edges of the tool, suggesting that it had been dehafted beforehand. Three other microliths displayed no secondary use. There is no convincing case to suggest that the tools were related in their use or deposition; microwear traces are mixed and the pieces are spatially distinct. Secondary use of a dehafted flint could indicate *in situ* ad-hoc re-use. The dispersed distribution could be interpreted as middening activity, with tools cleared to this area over time.

8.4.4. Vegetal-related tasks

A plant working zone was not established as flints were too scattered (see figure 157). Four of the woodworking tools were found close to the features and a blade was in close proximity to these. Microwear results are mixed, with both hard and soft woodworking, longitudinal and transverse directionality. These actions are indicative of cutting, scraping/graving and debarking, which could relate to cutting firewood, processing wooden poles for structures, as well as crafting objects. Mixed patterns of tool use could also imply secondary deposition.

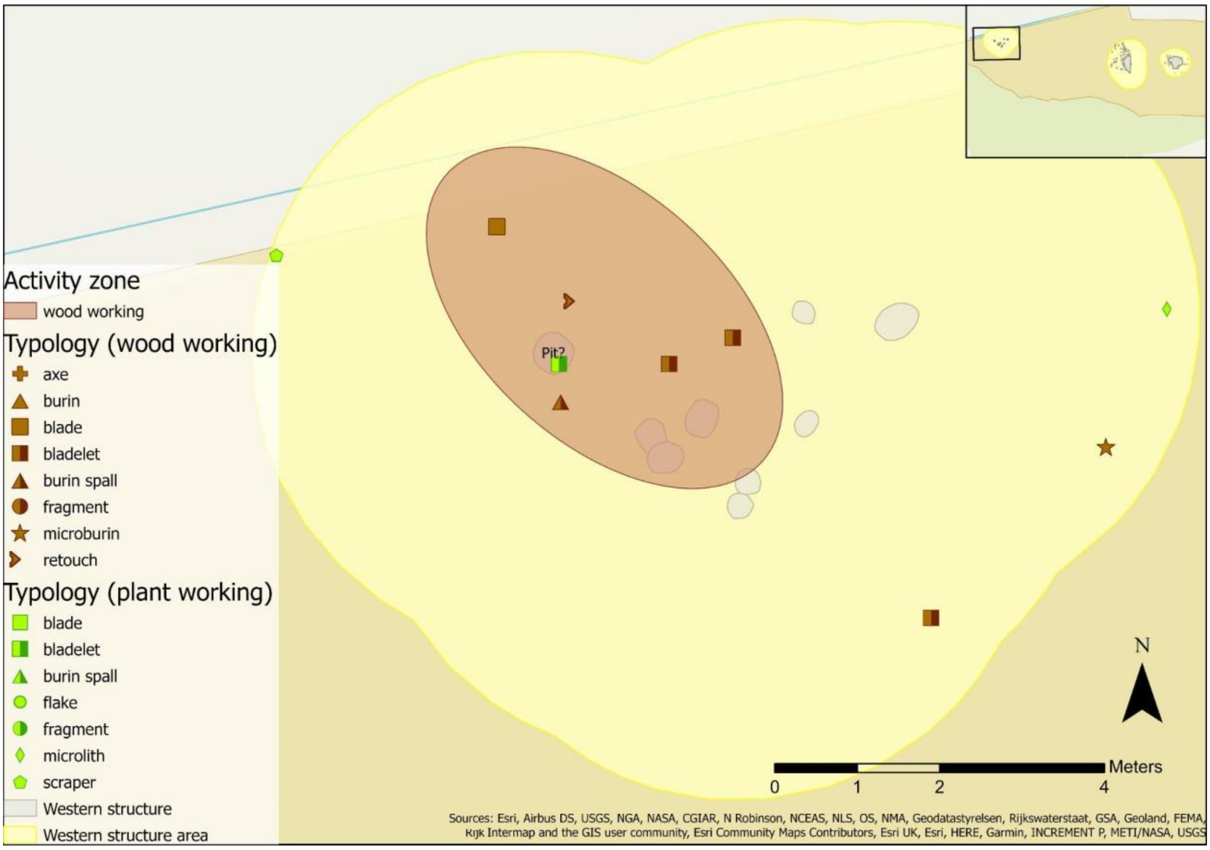


Figure 157: Spatial distribution of tools used on vegetal-related contact materials and associated activity zone.

8.4.5. Mineral-related tasks

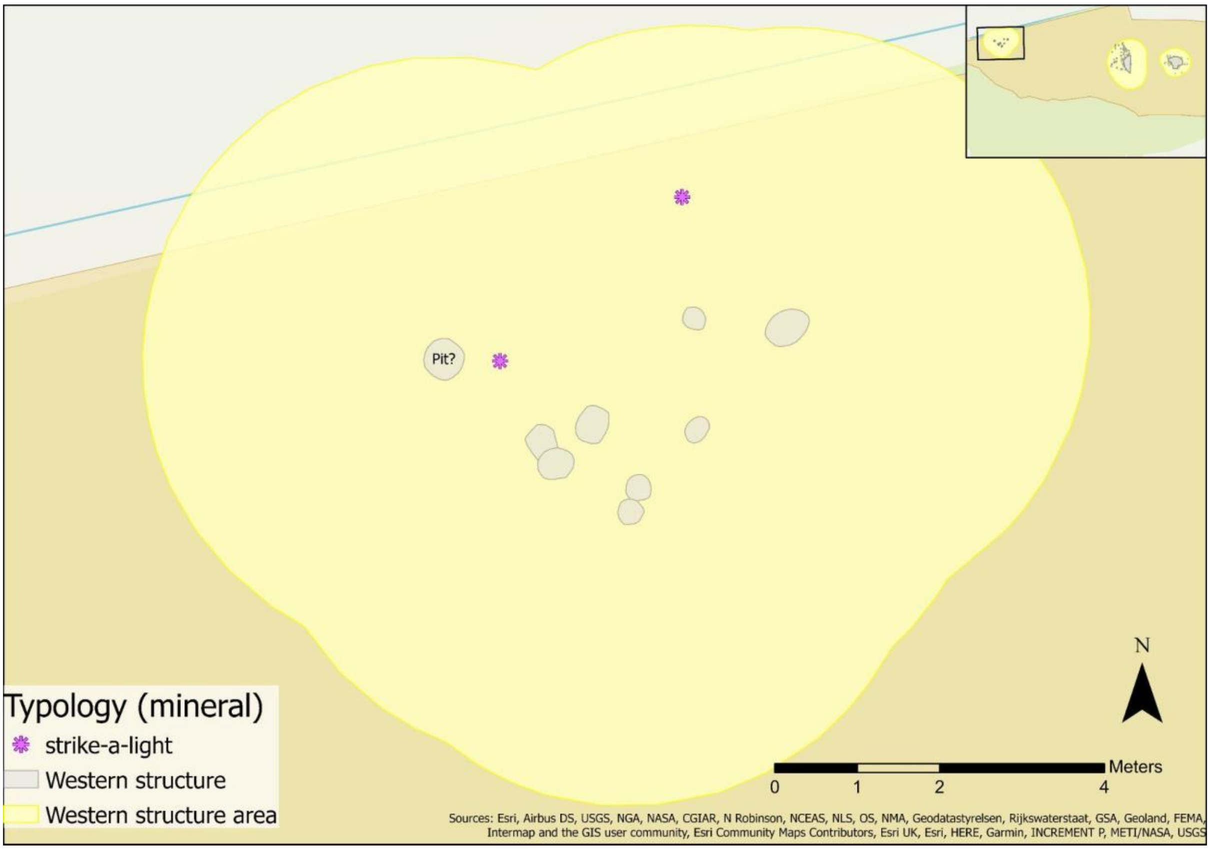


Figure 158: Spatial distribution of tools used on mineral.

Two strike-a-lights were located alongside a large quantity of burnt flint tools amongst the features, though there was no evidence of an *in situ* hearth (Conneller *et al.* 2018a, 162). Neither had signs of burning, and faunal remains also showed no exposure to heat. This suggests that if the flints were burnt *in situ*, unburnt material was subsequently deposited here (Knight *et al.* 2018b, 126). Alternatively, the mixed treatment of flints and animal bones could indicate the presence of a midden, where tools from different areas (some from cleared hearths) were deposited.

The strike-a-lights were both used to light fires, so it might be expected that they would remain where they were last used (see figure 158). As the structure did not have a hearth, this suggests that:

1) the strike-a-lights were brought to the western area for deposition;

2) the strike-a-lights were used in the area, the fires were subsequently cleared and the tools left;

3) the strike-a-lights were used elsewhere and brought back to the area for storage.

A density of tools, both burnt and unburnt, could indicate that clearance activity did not occur frequently, making hypothesis 2) unlikely. The strike-a-lights may have been left in the area for storage, although the high quantity of burnt flint remains unexplained. A more likely suggestion is that the strike-a-lights were brought to the area for deposition.

8.4.6. Extent of the structure

The features alone do not aid interpretations of the structure's boundary, as only two postholes were identified with certainty (Taylor, B. *et al.* 2018b, 59). The postholes could: indicate centre posts of a structure that was rebuilt or remodelled during its use, be the southern limits of a structure that extended beyond the trench or relate to a frame for a drying or smoking rack, or windbreak. The boundary in these three hypotheses alone would vary significantly. Microwear results aid interpretations about the tasks undertaken rather than the spatial extent of activity. Consequently, flint densities were incorporated.

A higher flint density was found north of the features, with significantly lower densities to the south and west (see figure 159). Higher densities extended up to the area that is now the Hertford Cut, possibly indicating that further unexcavated tools and perhaps features are located there. The postholes have been previously interpreted as holding the central posts for a more substantial structure (Taylor *et al.* 2019, 10). In this interpretation, the distribution of flints would be very uneven, if they are taken to reflect the use of the structure. It is arguably more likely that the structure extended further north beyond the excavated site, with areas of higher flint densities potentially situated in the main habitation area. However, the subsequent use of the structure as a midden cannot be discounted, and this would likely disturb any previous spatial patterning.

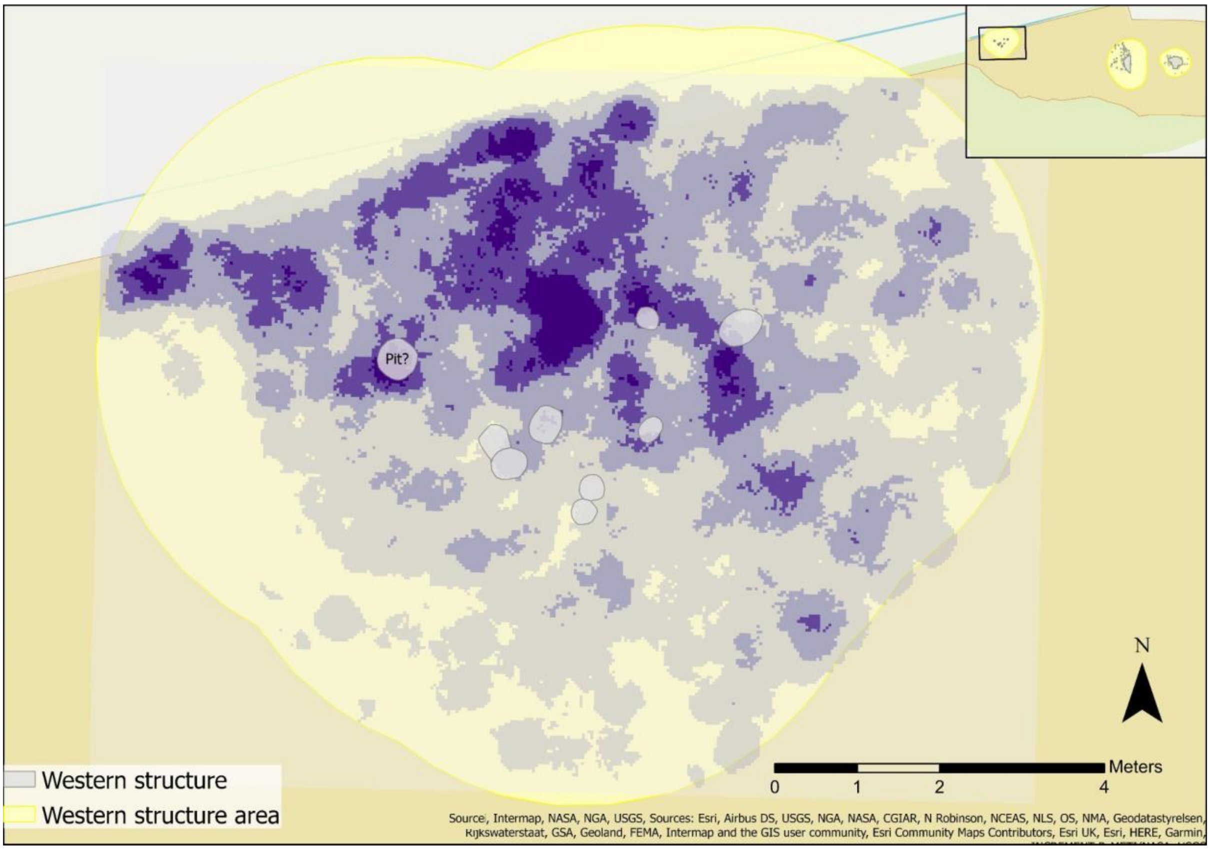


Figure 159: Density of flint tools found in the western structure study area, areas of shading indicate the density of flint within each 10cm radius; the darker the shade of purple, the higher the density.

A boundary for the western structure can be established, using activity zones and flint density (see figure 160). It encompasses most of the areas with highest tool density as well as the hide, meat, bone, and fish zones of activity. All woodworking tools are located within this area, and only one projectile is situated outside. Similar to the other structures, the proposed boundary provides a conservative estimate of overall activity associated with the structure. It is highly likely that the structure extended beyond the boundary presented.

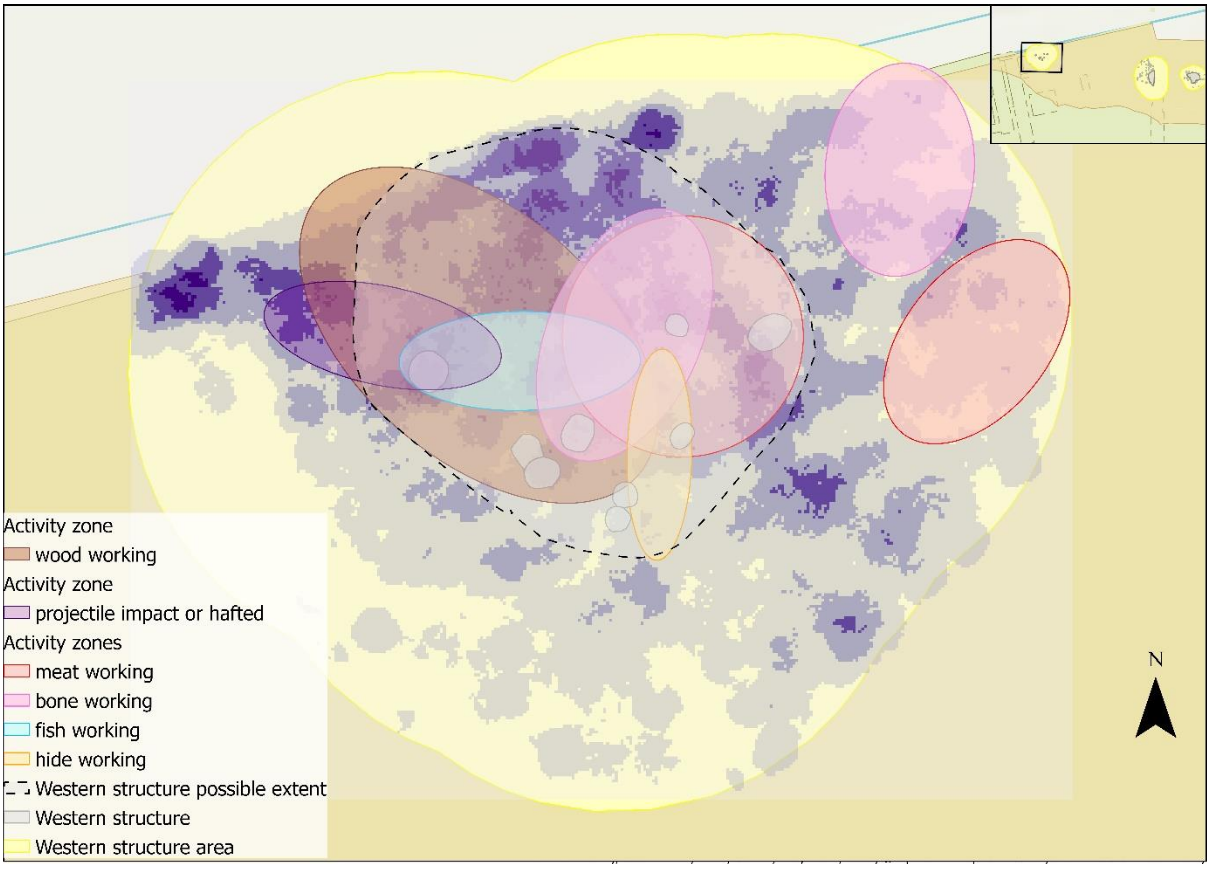


Figure 160: Composite image of western structure proposed extent, associated activity zones and flint density as shown by the purple shading.

Chapter 9: At the scale of the site

9.1. Introduction

Radiocarbon dates from the eastern and western structures indicate that there may have been contemporaneous activity across these areas (Bayliss *et al.* 2018, 54). Even though the site was occupied for 800 years, there are aspects of continuity in the way that space was used. This is seen through the construction of three consecutive wooden platforms and repeated structured depositions in the wetland areas (Taylor, B. *et al.* 2018c). Previously there was insufficient data to explore ideas of continuity or connection in the way that the structures were used - from the earlier central structure to the later western and eastern structures. For these reasons, it is of interest to examine the relationship between structures as a means of investigating patterns in use across a larger spatial scale.

This chapter compares variability in tool-using behaviours within the three structure areas. Additional data from faunal remains and technological analysis is discussed in order to draw connections between the structures and potentially associated activity across the settlement. It will then be possible to characterise the structures in relation to each other and the rest of the site.

9.2. Overview of microwear comparisons

Minimal evidence of well-developed microwear polish was found on lithics within the three structure areas. Generally flints showed limited use, indicating that they were not frequently used to exhaustion. This might be explained by plentiful raw materials for tool manufacture, with the ability to produce new pieces relatively easily (Conneller *et al.* 2018b, 498). It is important to remember, however, that intensively utilised flints can also display underdeveloped polish as some contact materials, such as meat and fish, show ephemeral traces even when worked intensively (van Gijn 1990). Equally, materials like siliceous plants create wear traces relatively quickly, meaning duration of use estimates for these materials may have been overestimated (van Gijn and Little 2016).

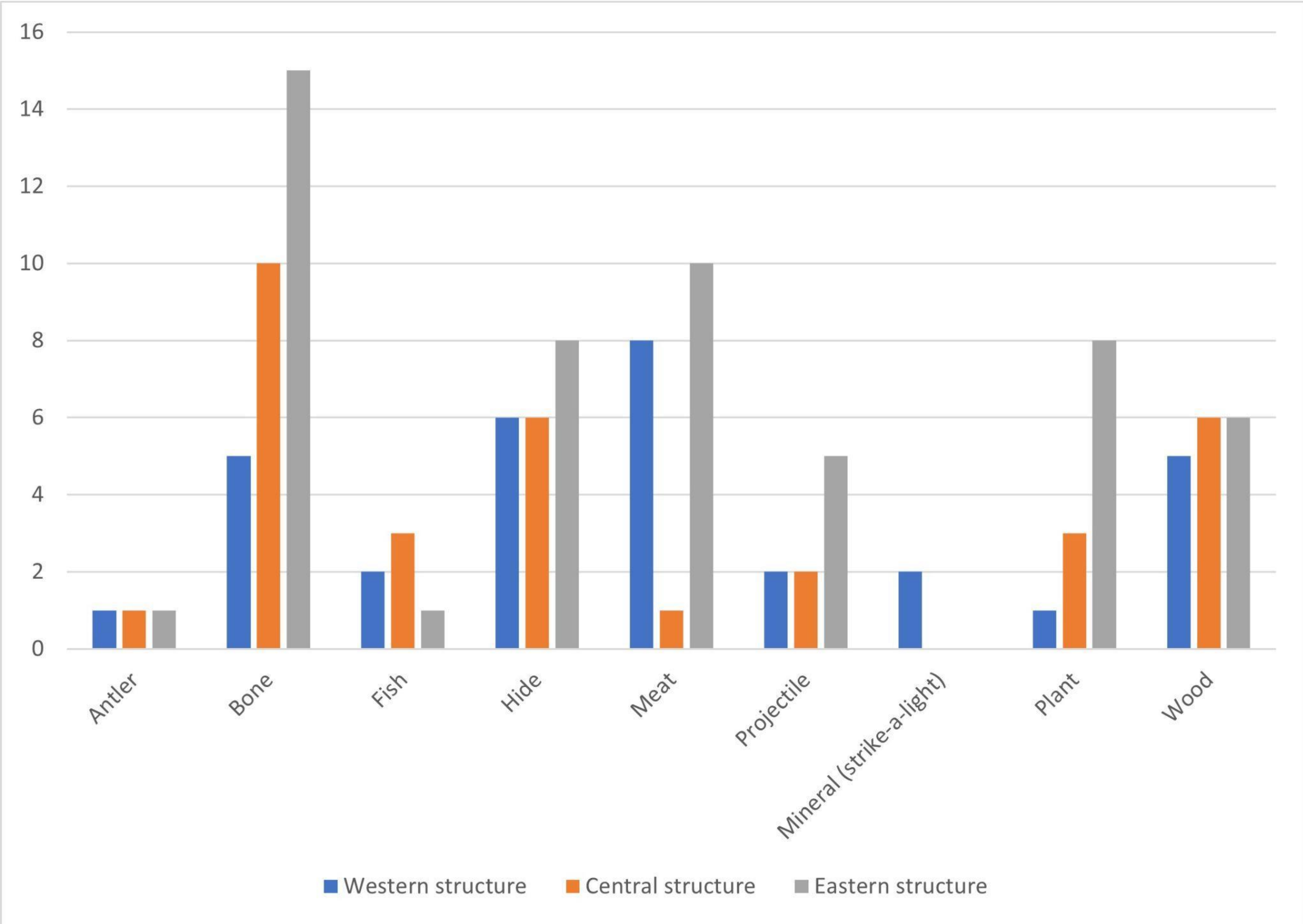


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Figure 161: Quantity of contact materials identified in each study area, from new microwear results.

Overall, there are some observable similarities between all three structures, particularly regarding rates of antler, fish and woodworking. Quantities of contact materials worked also show some comparable features between the eastern and central structures, with a predominance of bone working (see figure 161). Traces from working hide and wood were found in notably higher quantities within the central structure, compared to other contact materials. The eastern and western structures have more evenly distributed rates of tool use across several contact materials. Bone, meat, hide and plant working were found in high numbers in the eastern structure and meat, hide, wood and bone traces were observed most frequently in the western structure.

9.3. Tool type comparisons

Across all structures, bladelets and blades were some of the most analysed tool types. Rates of use varied considerably for bladelets, with c.25% (7) displaying wear traces in the central and western structures, compared to over 50% (32) in the eastern structure. Frequency of utilised blades showed the reverse, with highest levels observed in the central and western structures (over 90%, N = 13, 11), and less than 80% (15) in the eastern structure. This might indicate that use of knapping debris, like bladelets, took place more frequently in the eastern structure. Wear traces on fragments from this area further supports this hypothesis.

Microwear results from blades and bladelets also highlight variability across the three areas. Blades from the western and central structures were mostly used to work animal-related materials, whereas those in the eastern structure had largely vegetal traces. Those analysed by the Star Carr Project from across the site (45) had balanced quantities of animal (18) and vegetal (19) polishes. A diverse range of activities were observed across the settlement, whereas blades in the structures indicate that a few specific tasks were carried out most frequently.

Polish from vegetal materials was mostly seen on bladelets in the western structure, with a predominance of animal-related use in the eastern structure. A similar number of animal and vegetal wear traces was observed in the central structure. Bladelets previously assessed from across the site (16) were comparable to those from the eastern structure, as most (7) displayed animal-related traces with no plant or wood polish. This suggests that bladelet use in the western and central structures may have been specialised; few were utilised and those that were had a limited range of wear traces. It is possible that these may have been composite tools used in the same task, with several bladelets hafted together to form a knife; though no hafting traces were observed. In contrast, bladelets from the eastern structure displayed use on a range of tasks, as was observed in previous results from across the settlement.

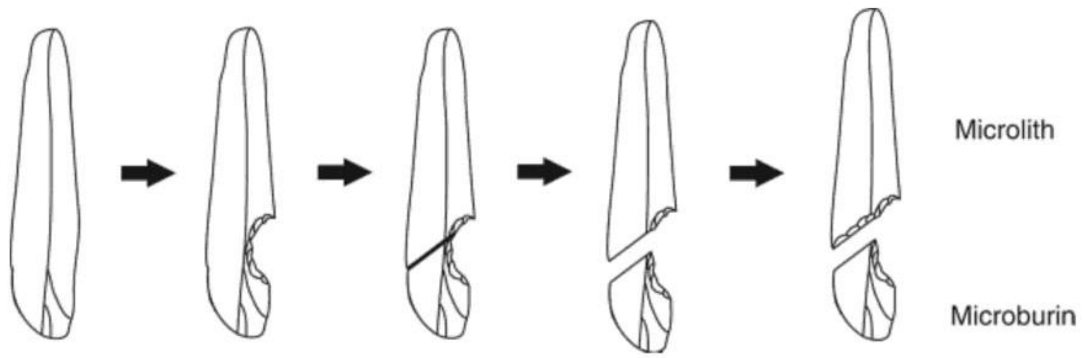

Figure 162: The production of microliths with microburins as by-products (Conneller 2021, 26).

Microburins are a by-product of microlith manufacture and are often considered as debitage (see figure 162) (Conneller *et al.* 2018b, 509). They were found in significantly higher quantities in the western structure, and were utilised for meat cutting, planing wood, possible fish scraping and antler engraving. In contrast, most found in the central and eastern structures displayed indeterminate polish. The western structure is characterised by high densities of lithics, so it is unlikely that these pieces would have been picked up for *in situ* tasks. Microburins were often no longer than 3cm so may have been difficult to locate amongst other flints. Their use might instead relate to activities undertaken in connection with microlith production across the site. To give an example, a microburin may have been picked up in a microlith production area and used to make an antler or wooden haft so that the microliths could be made into a projectile. The microburins might have then been moved to the western structure as part of a clearing process. This might also explain a lack of used microburins in the other structures, if utilised pieces were deposited in the western structure. Microburins have not been previously analysed at Star Carr, which is the case for most microwear studies on settlements (see Appendix 1). Results from this study suggest that microburins were used, although perhaps might be connected to areas of microlith production rather than the structures.

The majority of scrapers studied across all three areas had been used. This is consistent with technological patterns identified by the Star Carr Project, with scrapers noted as ‘expedient tools for immediate use’ (Conneller *et al.* 2018b, 521). They were largely used to work hides, in both fresh and dry states, with polish from soft minerals also observed in some cases. Wear traces associated with bone and fish scraping were also noted in the three structures, with the latter possibly indicating fish leather production. Previous analysis found similar tool use, as most of those utilised displayed polish from dry and moisturised hide (Conneller *et al.* 2018b, 525). However, nearly 25% of scrapers across the site appeared unutilised, which contrasts with high rates of scraper use in the structures. Hide working with scrapers can be interpreted as showing a strong correlation to structures, indicating that it was undertaken either inside, or in close proximity, potentially associated with postholes. In the western structure, awls with hide polish displayed a similar spatial association with the postholes, further suggesting that potentially craft-related hide working was undertaken in these areas.

Microliths were recovered in higher quantities in the western and eastern structures, with most utilised in all three structures. Generally, these displayed meat and bone polishes with fewer used on only bone, or possibly fish. These suggest use as projectiles for hunting (meat with bone and possible fish contact), or as bone processing tools. MLITs were observed on three pieces, located in the western (2) and eastern (1) structures. An absence of MLITs in the central structure does not suggest that microliths were not used as projectiles, merely that none were hafted to the tip. A mixture of projectile and non-projectile-related use was also noted by the Star Carr Project, although a broader range of tasks was observed, including plant working (Conneller *et al.* 2018b, 508). Microliths were utilised more exclusively for animal-related tasks in the structures, suggesting a more specialised use in comparison to those analysed across the settlement. Flints were knapped in the structures, so it is likely that there were greater quantities of blanks to hand for different tasks, meaning that bladelets or flakes may have been utilised instead.

9.4. Spatial comparisons

9.4.1. Introduction

Spatial distributions of tasks across the three structures are notably different. All activity zones for the eastern structure are well contained within the proposed boundary (see figure 98, page 142). In contrast, most zones in the central structure comprise two discrete groups, one associated with the boundary and the other to the west of the hollow (see figure 128, page 174). This might reflect the larger sample area for the central structure, compared to the eastern structure. Activity zones appear quite discrete in the central structure compared to the eastern structure where there is overlap and mixing of most contact materials. Similar crossover of tasks is observed in the western structure.

9.4.2. Comparisons of animal-related tool use

Similarities in tool use are observed between the eastern and western structures, particularly in the spatial distribution of flints used on animal-related materials (see figure 163). Wear traces on tools associated with western structure features are generally interspersed. Similarly, the eastern structure exhibits scattered tool use within these zones. However, tool use in the eastern structure is seen as reflecting *in situ* activity, along with flints that may have fallen through a form of organic matting or moved to the structure's boundary through trampling/clearance (Conneller *et al.* 2018a, 181; Grøn 2011).

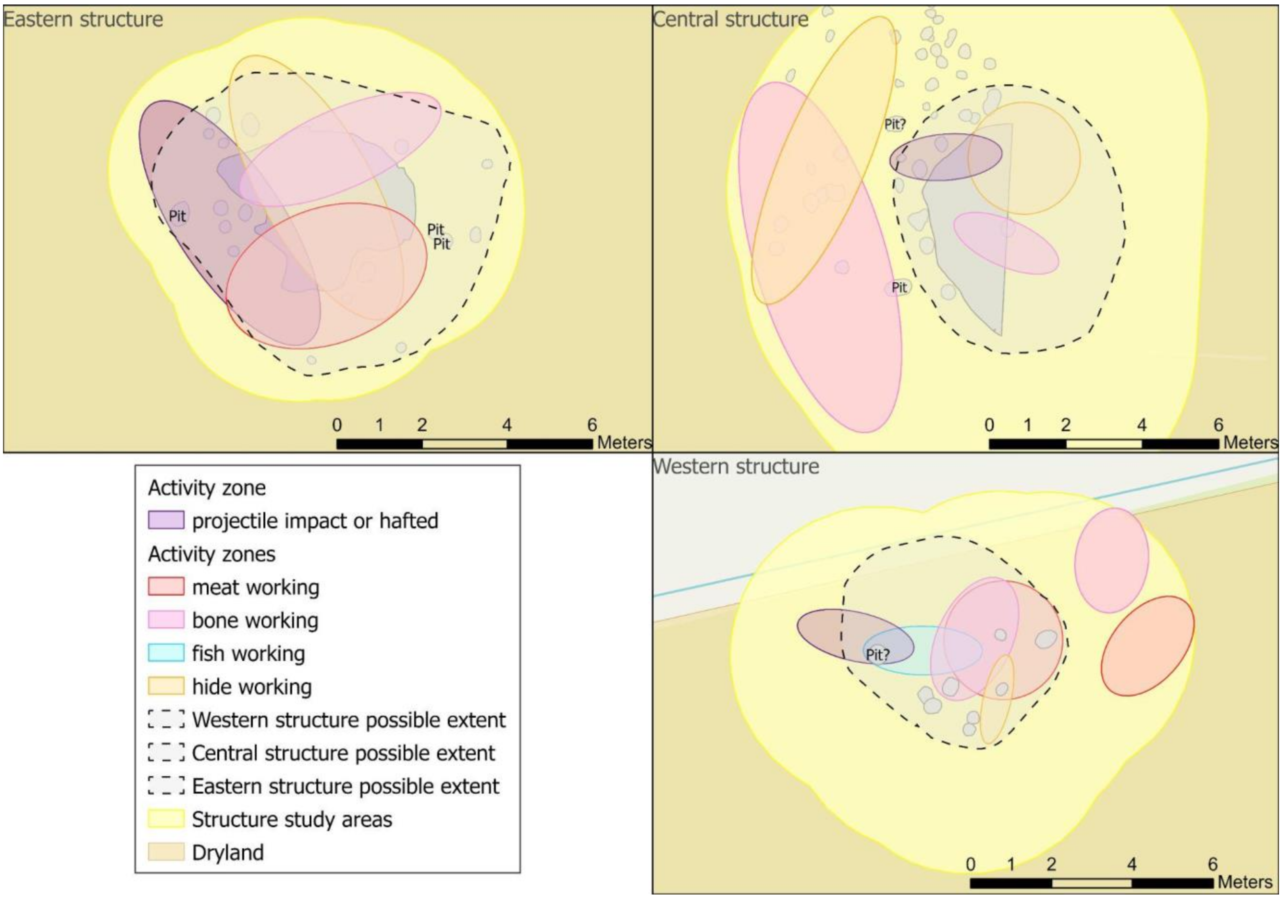

Figure 163: Animal-related activity zones in each structure.

In contrast, available data suggests that most flints from the western structure are likely to have been cleared from across the site (Conneller *et al.* 2018a). Flint densities in both structures suggest that activity took place at different times and accumulated; however all tool use associated with the western structure cannot be interpreted as *in situ* (Conneller *et al.* 2018a). There may be parallels in the organisation of animal-related tasks in these structures, but there is no way of distinguishing possible *in situ* tool use from secondary deposition in the western structure without temporal data.

Comparisons between the three structures further highlights the clear spatial patterning in the eastern structure. Certain tasks appear to have been undertaken in particular areas. The working of bone and meat can be clearly seen in two distinct areas to the north and south of the structure (see figure 163). Microwear suggests that bone working tasks - relating to the processing of bone and possible crafting activities - were likely carried out in the northern part of the structure. These displayed largely scraping, engraving and cutting motions, and so were interpreted as indicative of cleaning, splitting and processing bones for subsequent use; however, butchery activity can not be fully discounted. Meat working tools reflected butchery, with some flints displaying minimal contact with bone. Some of this material may have accumulated over time, as well as *in situ* episodes of later phases of activity, yet these zones are notably distinct (Conneller *et al.* 2018a, 181). It is possible that the analysed pieces only reflect the last episodes of activity in the structure, thus creating distinct working areas,

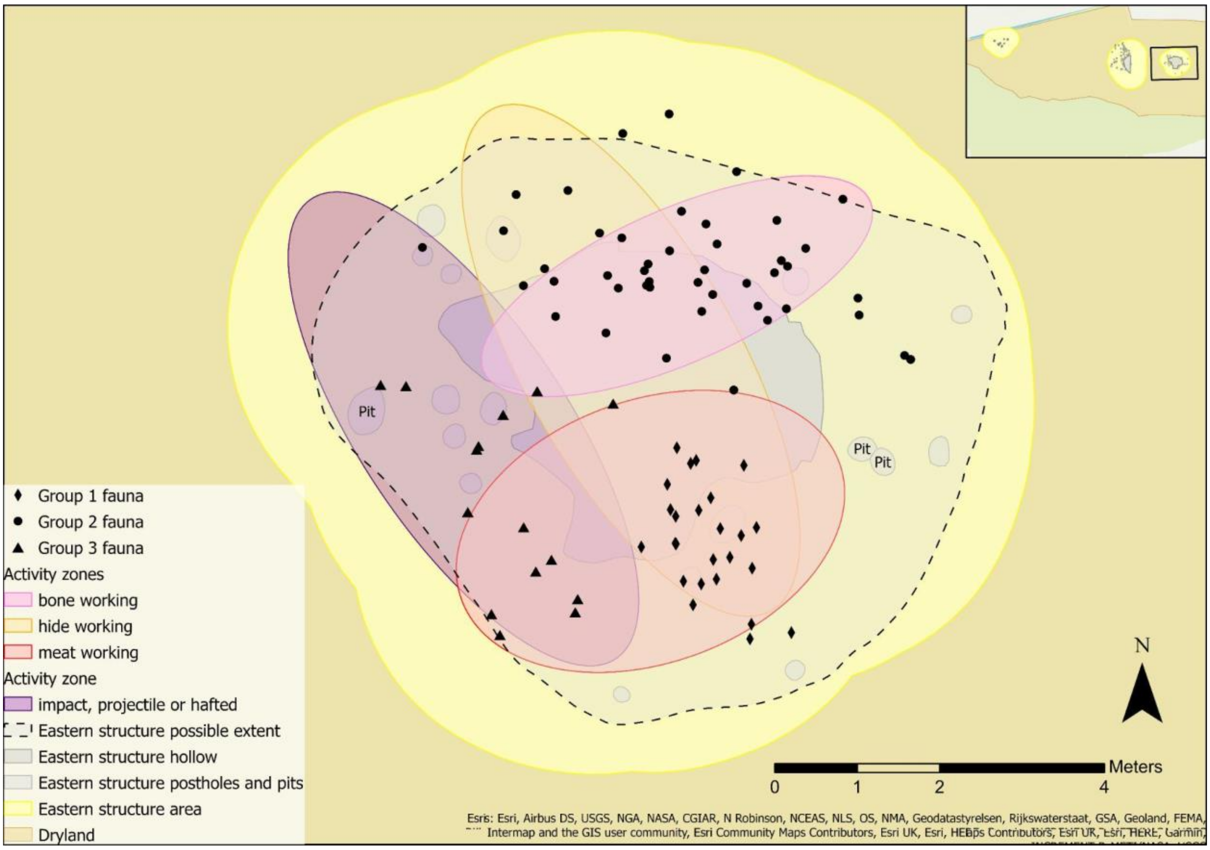

Figure 164: Clusters of three faunal assemblages within the eastern structure plotted against the animal-related and projectile activity areas and the possible structure extent (after Knight et al. 2018b, 129).

rather than a messy palimpsest from different depositions. Such delineated areas of activity identified at other Mesolithic settlements have been interpreted as short-term occupations, for example, Årup Context 1 (Sweden, 9150-8450 cal BC) and Caochanan Ruadha (Scotland, 6215-6605 cal BC) (Karsten and Nilsson 2006; Warren *et al.* 2018).

Faunal remains found in close association with the eastern structure mirror the zonal areas; three concentrations were identified which correlate with the meat, bone and projectile activity (see figure 164). These concentrations are largely similar in character, with large quantities of highly fragmented specimens, mostly identified as cervids, with some evidence of charring or heat (Knight *et al.* 2018b, 130). The only notable difference is that the majority of one bone assemblage (Group 1, located in the eastern part of the meat working zone in figure 164) did not display human modification. This contrasts with the others, which had signs of spiral fractures, percussion breaks and/or longitudinal splitting (Knight *et al.* 2018b, 130). Breaks and longitudinal splitting of bones can be an initial step for crafting bone objects, so it is possible that crafting rather than food preparation was undertaken here. There is also an association between Group 3 fauna and the projectile activity zone (see figure 164). Evidence of longitudinal splitting of bones in Group 3 could suggest that hafts for projectiles were produced and maintained here.

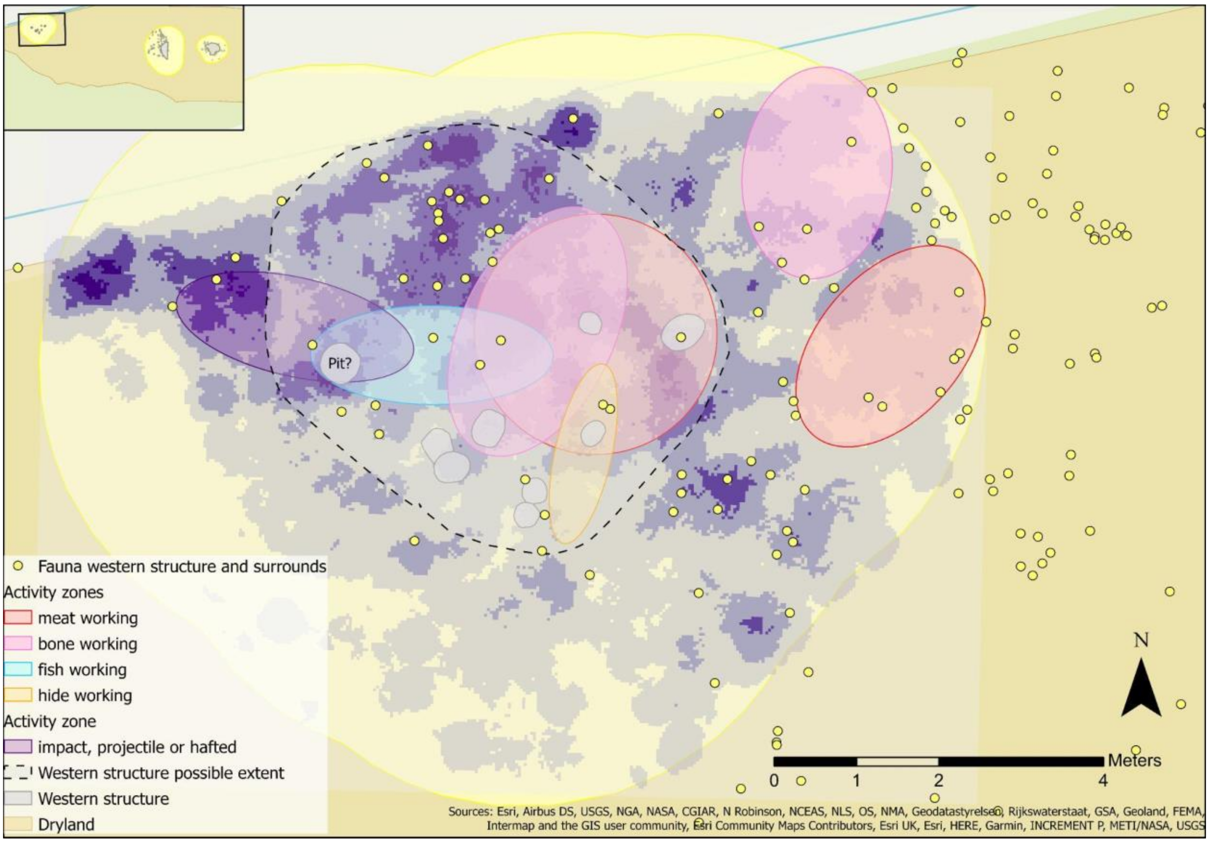

Figure 165: Faunal assemblage associated with the western structure plotted against the animal-related and projectile activity areas. Flint density is in purple and the possible structure extent (after Knight et al. 2018b, 127).

Further evidence of animal-related activity extends beyond the eastern structure, from densities of faunal remains to the south-east and north-west of the hollow. These were interpreted as reflecting butchery activity, carcass processing, and bone artefact production waste: likely as clearance debris from the structure based on tool refits (Conneller *et al.* 2018a, 176; Knight *et al.* 2018b, 131). The structure was a busy area of activity with different animal-related tasks undertaken. Clearance of material from within the structure might suggest that these activities were sustained rather than single occurrences.

Faunal deposits in the western structure showed no obvious clustering, though there was some correlation with areas of higher flint density (see figure 165). A small number of humanly modified specimens (2, a humerus and a tibia) and some limited exposure to heat (4 specimens) were identified (Knight *et al.* 2018b, 128). There is a density of faunal remains to the east of the structure study area, containing burnt specimens, interpreted as a hearth or hearth debris (see figure 165) (Knight *et al.* 2018b, 128). Previous microwear analysis of seven tools in this area revealed traces derived from bone working (5) and butchery (2), possibly indicating *in situ* activity to the east of the structure (Conneller *et al.* 2018a, 163). From faunal remains, limited refits and the types of microwear traces in the structure, there appears to be a dispersed and unstructured nature to animal-related activities. An interpretation of this area as a midden correlates well with the evidence. Similarities in the spatial distribution of tool use in the western and eastern structure might indicate that some flints from the eastern structure were cleared and deposited in the western structure. The association between high flint and faunal densities, and possible *in situ* working, could be explored through further microwear analysis on tools found in close proximity to animal bone.

The social implications of two potentially distinct working areas for animal-related tasks (butchery and processing bone/crafting bone objects) in the eastern structure are significant. Identifiable spatial patterns suggest that these tasks were undertaken in similar and spatially delineated ways throughout the structure's use. Tool density suggests that flints accumulated throughout the structure's use (Grøn 2011), therefore the microwear results are interpreted similarly. A second possibility is that these tools were from a few concentrated episodes of activity with an individual or several individuals intensely working.

Observations of patterned and potentially repeated behaviour in Mesolithic structures is not new, though the motivations behind why people acted in these ways are rarely explored (e.g. Donahue and Evans 2021; Jensen and Petersen 1985; Osipowicz 2018; Pawlik 2011; Warren *et al.* 2018). Specifically, the spatial organisation of animal-related tasks such as antler/bone working and butchery has been noted on other Mesolithic settlement sites, in Britain (Thatcham) (Healy *et al.* 1992) and mainland Europe (Årup, Vænget Nord, Lepenski Vir) (Jensen and Petersen 1985; Karsten and Nilsson 2006; Petrović *et al.* 2021). Distinct areas for specific tasks within the eastern structure at Star Carr provides the opportunity to explore the cultural practices present in these spaces.

9.4.3. Comparisons of vegetal-related tool use

In contrast to animal-derived materials, tools used on plants are the least spatially constrained within all structure areas (see figure 166). There are two clear zones located to the north and south of the eastern structure (zones 1 and 2, figure 166). Similarly, the central structure has two separate areas, though comprising fewer tools (zones 1 and 2, see figure 166). Flints used to work plant materials in the western structure were dispersed. Plant working is the only contact material across all three structures where one main zone of activity could not be established. Conversely, most utilised pieces from woodworking could be grouped into a single activity zone within each structure. There is a clear area of woodworking associated with the central structure boundary, and the eastern structure (see figure 166). No wooden or plant artefacts were recovered from the dryland, so it is difficult to examine direct possible connections to activity in the wider surrounds.

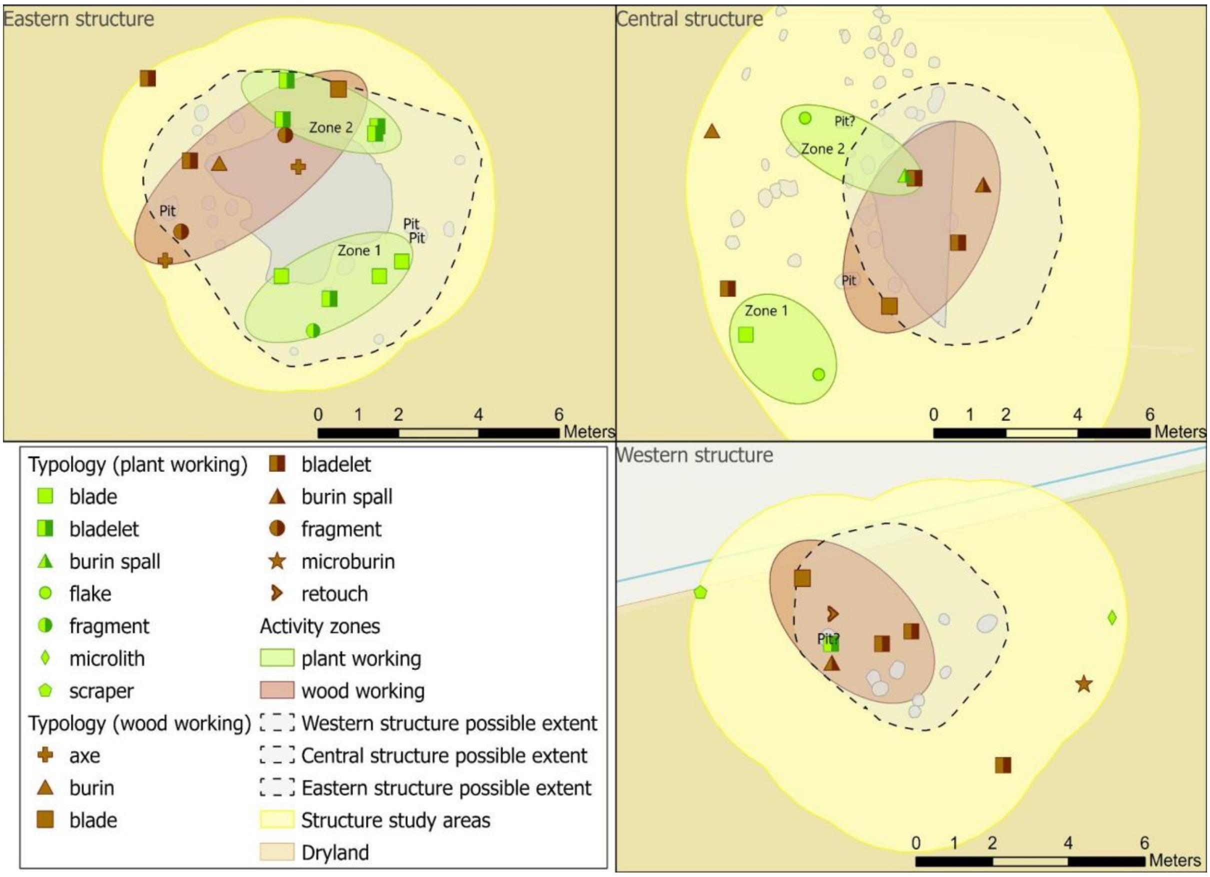

Figure 166: Vegetal-related activity zones in each structure.

Distinct patterns in plant processing could reflect the differential treatment of plants compared to animal-derived materials, with perhaps less constraint on the location of plant working activity within a structure. Alternatively, these tasks may have been more ad-hoc and therefore less spatially structured compared to the working of other materials. It is important to note that interpreting plant working activity from flint tools alone is problematic. A lot of plant-processing can be carried out without any tools, or with bone tools, leaving no wear traces on flints (Crombé and Beugnier 2013; Guéret *et al.* 2014; Little and van Gijn 2017; van Gijn and Little 2016). However, unique spatial patterns in plant working have been observed at other Mesolithic sites, such as Rosnay in France. Across the settlement, tools with plant polish were more dispersed compared to butchery, hide and mineral working, which led to an interpretation of ad-hoc plant working on a specialised skin-processing site (Souffi *et al.* 2015). A similar distribution of multiple plant working areas was noted at Ludowice 6, a Mesolithic site in Poland, though plant wear traces observed here were significantly more frequent (Osipowicz 2018). From these two sites, the potentially sporadic plant working activity interpreted at Rosnay correlates most convincingly to the dispersed tool use observed at Star Carr. However, as flints are not always required, it is also possible that this dispersed pattern in plant working has been artificially created by using flints as a proxy for areas of plant-processing.

Two zones of plant working activity were established in both the central and eastern structure (see figure 166). Only one tool used on plants was recovered from the central structure boundary whereas all plant working tools were located within the eastern structure. Two zones in the central structure comprise flints used on different plant types, both siliceous and non-siliceous, and tools within each zone are located at least two metres apart. This suggests potentially distinct episodes of plant working activity, based on the types of plants worked and distance between tools. Activity is also largely located outside of the structure's boundary. A potentially more structured use of plant working zones was identified in the eastern structure. All flints in zone 2 were used on non-siliceous plants, and the majority of pieces in zone 1 used to work siliceous plants (see figure 166). At least two tools within each zone are in close proximity (less than 0.75 metres). Though dispersed at a general level, there appears to be some patterning to the distribution of tools used on plants in the eastern structure that is not seen in the central structure. These differences could be a result of sample size, with significantly more pieces analysed from the latter.

Woodworking zones in all structures are contained within the proposed boundaries (see figure 166). In the central structure, at least three pieces were used to groove or engrave and one small bladelet had traces from planing and cutting a smaller piece of wood, owing to the distribution of polish. This could reflect small-scale activity, possibly interpreted as crafting wooden objects, rather than larger scale actions that might reflect the processing and construction of wooden structures (Crombé and Beugnier 2013). An association between woodworking and structural features has also been observed within other Mesolithic structures (e.g. Karsten and Nilsson 2006; Osipowicz 2018). Similar small-scale woodworking traces were identified on settlements in northwest Belgium and the Netherlands, where the tools were interpreted as used for engraving slits into arrow shafts, planing wooden bows, and grooving wooden handles (Crombé and Beugnier 2013).

In contrast, the eastern and western structures at Star Carr suggests a mixed range of small- and larger-scale actions. Located in the eastern structure, an axe was used to chop wood, flints were used to cut and scrape and two pieces suggested small-scale actions of grooving and cutting from the limited distribution of polish. A blade and bladelets were used to cut, scrape and plane wood in the western structure, indicating different tasks were undertaken. There is also more cross-over in the activity zones for wood and plant working in the eastern structure, which is not observed to the same extent in the central structure.

Activity relating to woodworking in the central structure appears to be more specialised. Similar to plant working, additional microwear analysis from the central structure might demonstrate a wider variety of tasks. From the current results, woodworking in the central structure could be interpreted as indicative of small-scale craft activities, potentially providing insight into cultural practices, where specialised types of woodworking were permitted. In Context 6, one part of a Mesolithic settlement in Årup, Denmark, two huts and associated activity areas were interpreted as workshops based on small-scale wood and bone working tasks (Karsten and Nilsson 2006, 155). It is possible that the central structure may have also at one point been used to craft wooden objects, similar to a workshop.

9.4.4. Discussion of spatial comparisons

When exploring tool use at the site scale and comparing quantities of worked contact materials, there are identifiable similarities between all three structures. Yet, the spatial distribution of wear traces highlights differences within each contact material group. This highlights the importance of using microwear to anchor interpretations, as detailed observations require shifting scales, building up incrementally from micro to larger scales of interpretation. These observed differences may be a result of sampling, with more flints sampled from the eastern structure. From the available data, these differences in activity suggest that people used the structures in distinct ways. For example, fewer flints were utilised in the central structure and related tool use was observed on pieces with woodworking traces, along with dispersed bone and both fresh and dry hide working. This could suggest that it was used similarly to a workshop, where task-specific wood related activities took place. In contrast, the eastern structure evidenced diverse activities, which seem to have had some internal organisation. It is equally plausible that the earlier generation of individuals who constructed and used the central structure had a different way of organising their space or using structures compared to later inhabitants.

By discussing activities at different scales, and comparing evidence from the flint tools, faunal remains and structural features, it is possible to characterise each structure. The following section presents interpretations based on the available evidence, whilst acknowledging that sample size varied across the structures and the presence of taphonomic bias in these areas.

9.5. Characterising the structures

9.5.1. Central structure

The central structure is considered as a substantial post-built structure. Only a portion of the hollow was excavated, but the features indicate that it would have provided some level of shelter and could withstand the elements. Evidence of activity is generally sparse, with limited flints, refits, faunal remains and indications of clearance from geochemical analysis. Despite this, there appears to be tool use associated with the boundary of the structure, specifically from working bone, hide and wood. Previously, tool use was interpreted as post-dating the structure (i.e. it was not standing when the activity took place) (Conneller *et al.* 2018a). However, the presence of three activity zones within the boundary suggest that at least some tool use may have occurred within the structure. A sparsity of flints within the structure creates difficulties in interpreting any potential sustained activity. If a dwelling is defined as a focal point for activity, where individuals came together to process materials and prepare food, an accumulation of used tools would be expected even if clearance activity occurred (Grøn 2021a). Conversely, some Mesolithic structures with minimal associated tools have been interpreted as dwellings because of the sparsity of material (Donahue and Evans 2021).

Small quantities of flints in the structure create difficulties when defining its use; three hide working, two bone working, and four woodworking tools are not sufficient to characterise it as a dwelling. There are, however, patterns in wood-related tool use that help interpret the types of tasks undertaken. All pieces were used to groove or engrave wood, or plane a small piece of wood; actions indicative of small-scale activities. It is possible that the sparsity of material reflects that the area was kept clear except for the processing of certain materials, similar to a workshop (Carrer 2017; Karsten and Nilsson 2006, 155). Alternatively, it may have been cleared throughout its use, with only the last episodes of activity recovered, which might explain the limited tool use and faunal remains which appear to derive from short duration activities.

9.5.2. Western structure

Limited and uncertain identification of features excavated in the western structure area make interpretations problematic. There remain ambiguities, notably the extent of the structure and when the area was in use. It is probable, from the current distributions of flint tools and faunal remains, that the structure extended north beyond the field boundary, into the bank of the canalised River Hertford. Therefore, the materials and features excavated are potentially only a part of the overall activity area, skewing interpretations. Different tasks appear to have been interspersed, exhibiting very little patterning. Technological assessment of the flints evidenced some possible *in situ* flint knapping whilst the accumulation of burnt tools and animal remains, alongside unburnt material suggests that this area was also used to deposit clearance debris (Conneller *et al.* 2018a; Knight *et al.* 2018b). Microwear traces further highlight heterogeneous activity that was largely dispersed across the area.

The structure may have been a palimpsest of multiple separate episodes of activity, which accumulated over time. In this scenario, the interspersed and jumbled wear traces would suggest that *in situ* activity was later disturbed by clearance material. This would create a complex palimpsest that is impossible to untangle without clear depositional sequences. However, a residual patterning in some tool use might still be expected, as was observed in the central structure despite possible clearance activity.

It is most likely that this area was last used for middening, where clearance material from other areas was deposited (Conneller *et al.* 2018a). Based on the densities of flints and faunal remains extending to the north, there may have been a more substantial structure present, perhaps a dwelling, that was subsequently deserted and repurposed. Complete abandonment of a dwelling is not uncommon. In some cultures, such as for the Evenki in Siberia, placing a new dwelling on top of a previous one is seen as insulting to the previous inhabitants, whose spirits live in the hearth (Anderson 2006, 11; Grøn and Kuznetsov 2004, 49). The Khanty of western Siberia only reuse dwellings of deceased individuals for storage, rather than as a dwelling for other individuals (Jordan 2003). It is therefore possible that the complex patterns of activity observed in the western structure are the result of cultural customs. In this light, it is conceivable that this structure was abandoned by its original inhabitants with structure/area then reused as a midden rather than a dwelling place.

9.5.3. Eastern structure

Of the three structures, the eastern one exhibits the most convincing evidence of a dwelling place (Fretheim 2019; Grøn 2021a). It has the most complete features and additional material deposits, enabling a more detailed understanding of how this space was used. Refits and faunal remains highlight that the area was a hub of activity. There was movement of material within and outside of the structure, as well as food preparation evidence and modification of bone and possibly antler material (Conneller *et al.* 2018a, 176; Knight *et al.* 2018b, 131). Even rodent remains were found, indicating that animals and humans likely used the structure for shelter (Knight *et al.* 2018b, 131). Microwear traces further emphasise the range of activities undertaken. There is an identifiable organisation to where specific types of tool use took place, particularly bone, meat and siliceous plants. This suggests that some activities were spatially defined and potentially repeatedly undertaken in these areas, as has been identified on other Mesolithic settlements (Jensen and Petersen 1985; Karsten and Nilsson 2006; Osipowicz 2018).

Clearance activity interpreted in the structure from flint refits and faunal deposits in the surrounding area suggests that there was a sustained intensity of activity. In particular, there is additional evidence of tool manufacture and maintenance, as well as butchery and crafting bone objects, in spatial association with the surrounding areas (Conneller *et al.* 2018a, 181; Knight *et al.* 2018b, 131). Therefore, the structure can be seen as a place where activity was structured in specific ways, with lots of associated activity occurring around it.

9.6. Chapter summary

Distinctions can be made between how different materials were worked across the three structures from the activity zones established, enabling characterisations of each structure. Despite low quantities of flints, the central structure is considered a substantial structure which may have been last used for specialised crafting activity. It is possible that a post-built dwelling also stood in the western structure area, was later abandoned and used as a middening area. Any previous spatial patterning in tool use may have been disturbed by this later activity, preventing interpretations of the structure's function prior to the midden. The eastern structure is interpreted as a dwelling, with sustained activity reflected across the different data from the area.

There may have been connections between the structures during their use, particularly for the contemporaneous eastern and western structures; however, the ways that individuals last used and organised these spaces was distinct. The spatial patterning in each structure highlights the new insights gained from this research, as well as interpretations that require further investigation. Different strands of evidence from excavated material provide an insight into the tasks undertaken within or associated with the structures. However, the possible reasons for why activities were organised in these ways have not been addressed. An exploration into the meaning of these spaces to the people who built and used them is therefore required.

Chapter 10: Conceptualisations of Dwellings

10.1. Introduction

A description of tool-using areas within each structure provides a narrative of accumulated actions but not of social dimensions, and why individuals behaved in particular ways. The results from Star Carr can only go so far in deciphering why people may have undertaken certain tasks in the structures, or why activities were organised in some areas of the structures. It is impossible to fully reconstruct the meanings attributed to structures; however, they warrant further exploration as it is widely acknowledged that Mesolithic settlements were arenas for habitual activities and social interactions (Blinkhorn and Little 2018; Conneller 2010; Edmonds 1997; Finlay 2004; Grøn 2020; Mithen 2019). Theoretical approaches, aided by ethnographic analogy, can facilitate an exploration into the diversity of lifeways and world views present in the archaeological record, and specifically within settlements (Grøn and Kuznetsov 2003; Grøn 1989, 2021a; Jordan 2002, 2003, 2006).

The following chapter will first provide an overview of how Mesolithic structures have been interpreted from a theoretical perspective. Ethnographic observations from different hunter-gatherer groups will be used 'to help formulate expectations … [regarding] variability in architectural remains' and in the ways that people engaged with structures (Tringham and Chang 1991, 13). It will provide inspiration and problematisation for interpreting the social dimensions of Mesolithic dwellings. A new application of multiple authorship and biography to Mesolithic structures will be presented through a discussion of the eastern structure, as it has the richest data and so provides an opportunity to explore explicit human-material interactions. Experimental archaeology will be used to interpret the more intangible aspects of its construction. The interpretation presented is necessarily speculative, but endeavours to provide a more holistic understanding of Mesolithic dwellings whilst acknowledging that not all structures were used in the same way. An evaluation of this approach will then be presented, with reference to how it could be applied to other Mesolithic structures within Britain and Europe.

10.2. Theoretical approaches to Mesolithic domestic structures

10.2.1. Functionalist / typological approaches

Microwear analysis is a useful tool to infer the use of structures; however, these inferences can also be extended to assign an economic function to the whole site (e.g. Healy *et al.* 1992; Osipowicz 2018;

Waddington 2007b). In Chapter 2 it was noted that at Vænget Nord in Denmark, internal zoning was identified in one of the structures. Bone/antler and hide were undertaken more frequently in the western and eastern areas, with a central zone of minor craft activity (Jensen and Petersen 1985). It was identified as a specialised camp, although the cultural practices that may have influenced these spatial patterns were not explored (Jensen and Petersen 1985; Petersen 1990, 2015). For example: why might bone/antler and hide have been undertaken in different areas, and why was craft limited to a small central area? Categorisations of Mesolithic settlements (as base camps, hunting camps or specialised camps) can be used to identify broader patterns in site use across larger scales. However, this functionalist approach to interpreting sites and structures should be acknowledged as a starting point, rather than an end goal, from which social perspectives can be developed and explored (Conneller 2005).

Functionalist approaches interpret the use of space as an accumulation of activities undertaken, with a focus on archaeologically visible evidence. Activities play a significant role in understanding how the space was utilised, although a structure can provide a community with more than just a place for activity or shelter (Blinkhorn and Little 2018; Lavi and Bird-David 2014; Rapoport 1990). Structures are created to enable or assist behaviours; they are premeditated and often require input from multiple individuals (van Gijn and Pomstra 2016; Kent 1993). Materials excavated from structures often shape our interpretations, however this fails to acknowledge them as anything more than a setting for tasks. Activities are one aspect of a complex web of associated behaviours and interactions associated with structures, as its use is only one part of its biography (Büster 2021; Carsten 2018).

10.2.2. Ethnography and social psychology

Grøn's work has been a key development in exploring the social meanings of Mesolithic dwellings, using ethnographic case studies and social psychology (Grøn 1989, 1991, 2014, 2018, 2020, 2021a, b, in press). He first noted the similarities in the size of structures, number of hearths and location of microlith concentrations identified on Maglemosian sites (Early Mesolithic in Northern Europe) (Grøn 1987, 1989). One explanation presented for this was the presence of cultural norms or rules that guided behaviours within structures (Grøn 1989). Further evidence of culturally constrained behaviour in dwellings was sought from ethnographic accounts, largely Evenki hunter-gatherers from Siberia. This offered some explanation of the archaeological spatial patterns, for example the number of fireplaces can sometimes reflect the number of family groups in shared dwellings (Grøn 1987). However, this relied on the assumption that all hunter-gatherer social groups comprise nuclear family units (Grøn 1987, 81), which has since been perpetuated in interpretations of Mesolithic dwellings and social space (Loeffler 2000; Molin *et al.* 2018; Osipowicz 2018). Despite relying in part on generalisation, the impact of Grøn's work was notable as it became a reference point for social interpretations of how Mesolithic dwellings were organised (Fretheim 2019; Grøn 2003; Osipowicz 2018).

Grøn (1989) evidenced persistent rules in spatial organisation through social psychology, as it was noted that people are inherently more likely to place themselves physically closer to those who are more familiar. By extension, it was considered that the placement of people within a dwelling is informed by their relationship to others present in the same space, thereby providing insights into social units (Grøn 1989, 2014). Tools, namely microliths, and 'dirty' activities were used to identify male seating locations, whereas female positions were identified through hearths or cooking materials (Grøn 2003, 2020, 2021b). New possibilities for identifying less archaeologically visible spaces, such as sleeping areas, and the relationships between inhabitants within Mesolithic structures were developed (Grøn 2003). However, this was partly reliant on assumptions of gendered roles in Mesolithic society. It is now widely acknowledged that such gendered patterning is not universal and should not be projected onto archaeological data without exploring alternative social structures (Finlay 2012; Lew-Levy *et al.* 2018).

10.2.3. Ethnography and contemporary hunter-gatherer dwellings

Ethnography can also offer different perspectives on how aspects of identity might be expressed throughout a structure's life, beyond social organisation. Contrary to previous approaches, a range of ethnographic examples from mainly northern latitude hunter-gatherer groups are cited here to highlight the diversity in how people interact with structures (Zvelebil 2003). Ethnographic examples were identified using the electronic Human Relations Area Files (eHRAF) World Cultures database, a searchable online database for cross-cultural research (http:// ehrafworldcultures.yale.edu). By providing insights into different construction processes and the social functions of more contemporary hunter-gatherer structures, we can speculate some of the meanings embedded in Mesolithic dwellings. In archaeological interpretations of dwellings, there is a focus on the social dynamics present in finished structures, with little attention paid to the materials and process of building (Anderson 2006). Research from different ethnographies suggests that material sourcing and construction can facilitate group interactions and opportunities for identity expression, therefore providing a more holistic understanding of dwellings when combined with function.

When sourcing materials for construction, accounts of Nakoda summer dwellings note that these can be brought to site rather than locally sourced. Nakoda are a migratory hunter-gatherer community from the north-west of the Great Plains in Canada, who transported wooden frames for their structures as they moved site (Snow 1977). Portable dwellings were largely used during the warmer seasons, when most were highly mobile to track animals, so needed an efficient and immediate form of shelter

(Snow 1977). Often, these comprised three poles to create a teepee structure, with buffalo, moose or elk hides as coverings, and would house small extended-family groups (Snow 1977, 18). The choice of construction materials was connected to cultural preferences and subsistence, as hides could be easily transported along with the wooden poles. Nakoda dwellings of this type were associated more with what might be considered short-term or temporary shelter.

Cultural preferences and material availability are also noted as key factors in the selection of covering materials for the Innu, also known as the Montagnais-Naskapi, an indigenous semi-nomadic hunting and fishing community from the Labrador Peninsula in Canada. Typically birch bark was a common but, in far northern areas where birch trees were unable to grow, caribou hides were used (Lips 1947). Prior to the 20th century some Ojibwe hunter-gatherer communities based in North America (across Ontario and Michigan) also used birch bark coverings for their dwellings (Brown and Hallowell 1991). Conversely, hides were commonly used by the Siksika, also called Northern Blackfoot, despite living in a generally similar climate to Ojibwe groups (located in comparable latitudes of 49.34 and 47.33, respectively). The Siksika were nomadic hunter-gatherers prior to 1900, living across Montana and Alberta in conical dwellings made from wooden poles and tanned animal skins, usually buffalo (Grinnell 1962). This might suggest cultural preference was a more pertinent factor to the material choices of Ojibwe and the Siksika, rather than resource availability.

For the Orochen Evenki in central Siberia, the choice of covering was explicitly connected to cultural preferences and symbolism. Coverings of lodges often comprised at least one skin panel that had been gifted (Anderson 2006, 16). Through gift-giving, relationships between different individuals would have been embedded into the structures and expressions of different identities visible. It is possible that structures became more symbolically significant to the Orochen Eveki through this gesture of giving, connecting the new dwelling and its inhabitants to the wider community.

Connections between individuals can also be seen through the production of coverings, as sewing large pieces of hide or bark together could involve several people. Historically, female members of Ojibwe communities were responsible for constructing winter dwellings. They cut saplings for the frame, harvested and sewed bark sheets together, and weaved rush mats (Buffalohead 1983, 241). Working together, they could construct a dwelling in a matter of hours (Buffalohead 1983, 241). It is likely that this facilitated Ojibwe group dynamics, perhaps reinforcing notions of commonality as people worked together and collectively contributed time and effort.

Once a dwelling has been erected, further significance may be attached to it through decoration of coverings. The Siksika painted designs on hide coverings with natural pigments, often depicting their personal dreams and spiritual beliefs, with each covering telling a story relating to the inhabitants (Hungry Wolf 1977). Identities of each inhabitant were visibly and physically embedded into Siksika dwellings to such an extent that the coverings were destroyed and the structure abandoned after the death of its inhabitants (Hungry Wolf 1977, 67). The decorated hides were offered to the Underwater Spirits by being sunk in a lake with rocks, or to the Sun by leaving them exposed and weighed down by rocks (Hungry Wolf 1977, 68). These less tangible but visible aspects of identity expression demonstrate that dwellings can be closely connected to the world view and beliefs of their inhabitants.

Ethnographic accounts from Evenki, Martu and Nayaka hunter-gatherer groups also highlight variability in how dwellings were used; however, it is important to note that Martu and Nayaka groups are southern latitude hunter-gatherers. Grøn's work noted that nuclear families occupy Evenki dwellings, with no variation in this arrangement documented (Grøn and Kuznetsov 2003). This contrasts with Martu residential groups, who are foragers from the northwest region of Australia. Within each settlement there are hearth groups, who eat, sit and sleep together in a dwelling (Bird et al. 2019). The belonging of an individual to a hearth group is fluid and not always associated with biological relatedness. They can comprise kin connected by common ancestors, by marriage and unmarried biologically unrelated individuals (Bird et al. 2019, 101). For Nayaka, forest-dwelling hunter-gatherers based in South India, their huts were constructed by the community, with 'blurred distinctions between inhabitants and visitors' as people frequently moved in and out of a given dwelling place (Lavi and Bird-David 2014, 411). Privacy for Nayaka individuals was not found within dwellings but instead in the forest, whereas activities associated with the home were undertaken in open public spaces or in clear view of others, reinforcing 'plural living-together and sharing' (Bird-David 2009, 209).

From the discussed ethnographic examples, structures in contemporary hunter-gatherer groups are constructed and used in diverse ways. Different construction materials are used, impacted by cultural preferences and resource availability, and subsistence of hunter-gatherer groups can influence the architecture of their dwellings. Some materials used to build a dwelling have a symbolic meaning, from being gifted to the inhabitants from other group members or from decoration. At least some phases of construction require or connect multiple individuals, which invites a consideration of how group dynamics are created or maintained through these activities. Dwelling use presented through ethnographic accounts highlights the variability in those occupying these spaces. Those living in a dwelling are not always nuclear family units, as they can be communal spaces with a fluid group of inhabitants. These insights invite us to consider the different phases of Mesolithic dwellings, and the interactions between people and structures, the treatment of dwellings, and their connection to the wider landscape. In doing so there is the potential to provide a more holistic understanding of these spaces.

10.2.4. Multiple authorship and the biographies of dwellings

Originally applied to explore the social dimensions of microliths, multiple authorship considers multiplicity and collective effort to better understand social relationships embedded in technology (Finlay 2003). The approach is grounded in ethnographic accounts from Papua New Guinea and the Waiwài of Guiana and Brazil, where identity, and therefore personhood, were observed as fragmented (Finlay 2003). Personhood was seen to comprise different aspects beyond the individual, including objects, events and interactions, meaning that the identity of people and things was fluid and changeable (Finlay 2003). To capture this fluidity, multiple authorship is informed by a biographical approach to explore how objects, or dwellings, made by a collective can mean different things to different people throughout their lives (Hoskins 1998).

The application of object biography through multiple authorship acknowledges different phases of an item, rather than purely its use. However, there is a particular focus on contributions from craftspeople and makers, who may alter the object throughout its life. Processes of production are as important as use in assessing where and how meaning might be bestowed on an object or group of materials. For microliths, Finlay considered that meaning may have been imparted in the choices made during production, such as the tool's symmetry and type of haft (Finlay 2003, 174). This is also relevant to dwellings as the use of a structure is likely to *reflect* cultural identity. However, the discussed ethnographic examples suggest that the process of construction and the choices made may have *embedded* cultural identities into a structure.

Mesolithic dwellings would have been composite, requiring different material forms. At the simplest level, wood was required for a frame, plants or animal sinew for cordage, animal skins, reeds, bark or turf for coverings. It is possible that these materials were collected and processed by one individual, though experimental research from Neolithic house reconstructions demonstrates that certain tasks are time-consuming and logistically difficult with fewer than 2-3 people (van Gijn and Pomstra 2016, 183). Specifically, the harvesting of reeds for thatching and erecting a post-built frame almost certainly requires more than one person. These insights are based on reconstructing a rectangular Late Neolithic dwelling (9.10 m. long and 3.8 m. wide), which was larger in plan than interpretations for the eastern structure (over 4.1 m long and 3.6 m wide) (van Gijn and Pomstra 2016; Taylor, B. *et al.* 2018b). However, the logistics of harvesting materials and size of timbers can be considered largely similar, with time investment likely to vary considerably.

The construction of a Mesolithic dwelling may have therefore facilitated 'a forum for group participation and expression' (Finlay 2003, 175). Group interaction was probably central to Mesolithic lifeways, so by breaking down the process of construction and use, it might be possible to access how these habitual behaviours were reflected in dwellings. Jordan refers to 'ongoing social and material dialogues between the human collective and other sentient forces in the land' in his work on ethnographic analogy (Jordan 2006, 99). 'Dialogues' as a term will be used to characterise the interactions entangled in the building of a structure, to capture their multi-faceted and ever-changing nature. Those present in the earliest phase of a Mesolithic dwelling's biography have been summarised into three groups, starting from the smallest to the largest scales (see figure 167); human to material, human to human, human to landscape. These should not be considered as representative of all possible engagements bound to a structure during its life. In this model, there are several points at which cultural practices or identities could be embedded in the choices made: types of materials collected, material processing methods and style of construction.

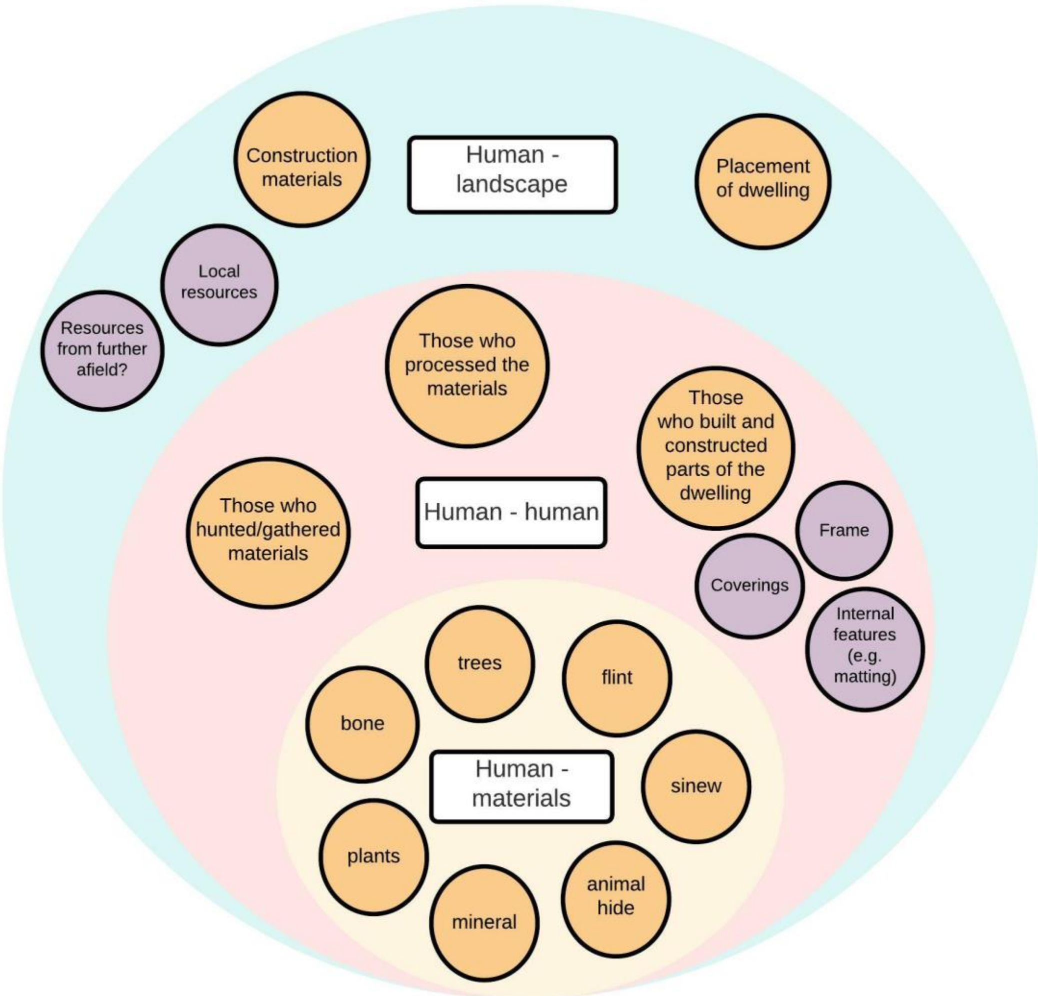

Figure 167: Conceptual diagram summarising some of the dialogues or interactions that may have taken place during the construction of a dwelling.

10.3. A dwelling at Star Carr: multiple authorship and biography

10.3.1. Introduction

The eastern structure provides the most convincing evidence for a dwelling space at Star Carr, so it is an ideal example for applying multiple authorship. Activities undertaken there have been characterised; however, this is just one part of the structure's biography. The construction, maintenance and eventual disuse of the dwelling are also important biographical aspects to consider (Büster 2021; Hurcombe and Cunningham 2016). Data from the structure and wider site will be used to discuss the potential interactions between individuals, materials and the landscape in the construction and use of the dwelling. A biography will be created from activities undertaken and specific data from the Star Carr Project, such as palaeoenvironmental work. Observations from experimental archaeology and ethnography will be used to speculate aspects of the biography which cannot be interpreted through archaeological data. Aspects of multiple authorship highlighted in the biographical narrative will be discussed to explore the implications on how we interpret meanings attached to Mesolithic dwellings.

10.3.2. Construction

At least 15 postholes were associated with the hollow, though these may not have all been in use at the same time. Timber posts for the frame were likely felled from the surrounding area, similar to the wooden platforms which used largely aspen timbers (Bamforth *et al.* 2018a). It is possible that wooden poles may have been brought to the site, as documented ethnographically for Nakoda summer dwellings. However, these structures were efficient and briefly occupied before being moved to a new location, which contrasts with the material excavated from the eastern structure at Star Carr.

None of the excavated postholes from the eastern structure had a diameter larger than 190 mm, and some were as small as 60 mm, suggesting that numerous wooden timbers of different sizes were used. Timbers of the wooden platforms were specifically selected due to their straightness and minimal side branches, so those used for the structure may have been similarly chosen with specific properties in mind (Bamforth *et al.* 2018a). Based on taxonomic identifications, willow, aspen, birch, and alder were present at the site, all of which could have been used to construct the frame (Bamforth *et al*. 2018b; Taylor, B *et al.* 2018c, 262). From the early stages of building a dwelling, it is likely that multiple individuals were involved, from procuring timbers to constructing the frame. Felling trees for larger posts (190mm) would have probably required multiple individuals, with smaller ones more easily procured by one person. These larger trunks would need chopping down, transporting, and trimming before the dwelling could be built. Once at the right size, several people were likely needed to erect the timbers and secure them in place (van Gijn and Pomstra 2016).

Cordage or bindings were probably used to secure timber posts together, as well as coverings for shelter; this is inferred from microwear traces as well as experimental insights (Hurcombe and Emmerich Kamper 2016; Hurcombe 2008; Little and van Gijn 2017). One plant withy was recovered at Star Carr, which could have been used to tie posts together: two willow stems were twisted together with a coppice heel to facilitate holding the stems during twisting (Taylor, B. *et al.* 2018c, 402). Cordage can also be made by processing sinew from animal carcasses, extracting plant fibres or bast and twisting them together, or harvesting willow withies and gently loosening the inner fibres (Hurcombe 2008; Hurcombe and Emmerich Kamper 2016; Mansrud 2017). Wetland plants present on site, such as reeds, would have provided easy and abundant access to cordage, and animal sinew could be extracted from the backbone of ungulates, such as deer or aurochs, which were found at Star Carr (Mansrud 2017; Taylor *et al.* 2018a). Possible evidence of an organic matting was also found, which would have likely required materials from the surrounding landscape, such as twigs or branches, reeds, or bark (Grøn 2021a; Taylor, B. *et al.* 2018b).

Material choices for the ties and matting are likely to have been affected by different factors, including seasonality (i.e. when the materials were at their best). Plant fibres and bast rely on seasonal new growth and moisture levels to be at their strongest, whereas bark is best harvested in the spring and ungulates may not have been hunted all year round (Fletcher *et al*. 2018; Hurcombe 2008b; Overton and Taylor 2018; Zvelebil 1994). Some construction materials, such as animal sinew and plant fibres that were likely used frequently, may have been extracted and stored dry for later use (Hurcombe and Emmerich Kamper 2016, 65). This would minimise difficulties of resource availability at the time of construction.

Animal skins, bark, thatching, turf, or earth are all possibilities for coverings used on the eastern structure (Grøn 2021a). The density of material suggests that the structure was fixed in place and not a temporary fixture, so it might be inferred that the coverings did not need to be easily transported. Birch bark is waterproof and birch woodland is often associated with the Holocene climate, so it is a likely option for Mesolithic roofs or coverings (Grøn 2021a; Hurcombe and Emmerich Kamper 2016, 64). Experimental research from the Freilichtmuseum Oerlinghausen in Germany also suggests that birch bark is more robust than hide or thatching (Hurcombe and Emmerich Kamper 2016, 71). Birch bark was recovered at Star Carr, though generally in the form of birch bark objects such as torches, rolls and containers (Fletcher *et al.* 2018, 419). A birch bark mat was also recovered, and though no perforations or evidence of stitching were found, it demonstrates that inhabitants were harvesting large pieces (750 mm × 970 mm) (Fletcher *et al.* 2018, 423). These large sheets can then be sewn or tied together, creating a continuous large covering.

10.3.3. Multiple authorship and dwelling construction

A biographical narrative of constructing the eastern dwelling highlights the numerous choices made, from methods utilised to selection of materials. It is likely that numerous factors influenced these decisions, including individual preferences, cultural practices and resource availability (Büster 2021; Ingold 2006). The narrative presented also suggests that some parts of construction would have required multiple individuals, meaning that decisions may have taken place in a group setting. These choices may have involved interactions and negotiations that embedded meanings into the dwelling, concerning both individual and group identity. Some may have left observable traces, for example the chosen method of chopping down and processing a tree (van Gijn and Pomstra 2016; Taylor, B. *et al.* 2018c, 263). If a *tranchet* axe was used to chop trees, as shown by microwear traces in the eastern structure, it would leave distinctive traces on the trunk signifying how it was felled to others (Bamforth *et al.* 2018b, 354). Even if it is assumed that tools were produced and used by one individual, there is a case to be made for multiplicity in some tasks required to build a dwelling. Alongside increased efficiency, group working may have also influenced the meanings attached to dwellings, if multiple identities were embedded at different points of construction.

The concept of collective or collaborative action is often discussed in relation to later prehistoric monuments, to evidence developing behaviours over time in large-scale societies or states (Blanton and Fargher 2007; Büster 2021; DeMarrais 2016; Müller 2014). Rarely is collective effort explored within smaller-scale sites or architecture, such as Mesolithic dwellings. However, there has been some discussion of working together in relation to mortuary practices, with reference to individual and communal acts of mourning (Little *et al.* 2017, 237). The absence of narratives regarding collaboration and collective effort in Mesolithic dwellings may reflect a focus on establishing the function and use of these spaces, rather than processes of construction.

Notions of commonality (identity, traditions, material culture) and collective communication are implicated in discussions of monumental or communal structures, which are often interpreted as an expression of a community (Çevik 2019; Makarewicz and Finlayson 2018; Notroff *et al.* 2014). These insights into the social significance of communal structures could also be considered in the collective action observed in smaller-scale dwellings. Insights from the Martu hunter-gatherers and Nayaka groups highlight that hunter-gatherer dwellings may not have always been inhabited by traditional family units of parents and children. Instead, dwellings are considered by these communities as open communal spaces, with their use reflecting group identities. Group membership of those living together in a Mesolithic dwelling is also likely to have changed over time, whether relating to biological relationships (i.e. births) or due to changing social dynamics between unrelated individuals.

Therefore, Mesolithic dwellings could be similarly considered in part as communal dwellings, and so an expression of the community.

In summary, dwelling construction arguably provided an arena for both individual and communal identity expression. It is likely that different individual preferences were negotiated, with choices of materials, methods and architecture also reflecting group cultural practices and resource availability (Büster 2021). Similar to later prehistoric structures, some Mesolithic dwellings may have been places where collective behaviours were expressed, with multi-faceted identities bound to dwellings facilitating a fluid rather than a fixed group of inhabitants (Bird-David 2009). By exploring multiple authorship in the building of the eastern structure, the potential for intra-community engagement during the construction is demonstrable.

10.3.4. Use

New microwear results together with previous flint tool and faunal data demonstrate that the eastern structure was a hub of activity, with various tasks taking place there. If we accept that multiple identities and social relations were embedded within its construction, it is important to explore how this could be reflected in the use of space. Microwear analysis highlights spatial patterning in tools used to work bones, meat, siliceous plants and possible projectiles. If these tools are considered to have been deposited throughout the structure's use, the spatial patterns could be interpreted as sustained. Persistent and related activity has been interpreted in material deposition in the detrital wood scatter, earlier in the site's occupation (Milner *et al.* 2018e, 230). As such, the continuation and transfer of cultural practices may have occurred within different types of human-material interactions, for example, in the eastern structure. However due to bioturbation, the temporality of activities in the eastern dwelling cannot be interpreted with any degree of certainty (Milner *et al.* 2018f).

In the northern half of the dwelling, bones were fractured and split, and flint tools were used to cut, scrape and groove bones. This contrasts with the southern half, where tools were used primarily on meat with limited contact with bone. Limited signs of modification were observed, suggesting that food processing was dominant in this area. A possible hearth was identified through a cluster of burnt flint in the southern part of the dwelling, which further indicates food processing and cooking was undertaken (Conneller *et al.* 2018a, 177). Siliceous plants were scraped in the southern half, likely to extract fibres for cordage, which could then be used to make different types of plant or composite objects (Hurcombe 2008a). A tentative area of projectile making and maintenance was identified to the west of the dwelling, from microwear results and evidence of split, fractured and intentionally broken animal bones.

Some activities, such as hide and woodworking were less structured in their spatial distribution, therefore the patterning that was observed warrants further discussion. Owing to the density of flints excavated from the eastern structure, it is feasible that some tool use was from separate episodes of activity, undertaken in similar ways. This is most convincing for the meat, bone and projectile impact zones, owing to the larger assemblage of tools. The duration of time between different tool-use episodes may have been short, but this would still evidence sustained organisation of some activities.

10.3.5. Multiple authorship and dwelling use

Patterning and organisation in how space was used may be interpreted as reflecting cultural group practices more than individual preferences. There were persistent distributions of tool-using activity, which could indicate the presence of cultural customs that were understood and carried out by all inhabitants. Interestingly, working different animal-related materials in specific areas has also been observed at other Mesolithic dwellings (e.g. Årup, Vaenget Nord and Sąsieczno); animal carcass processing was spatially distinct from bone/antler work (Karsten and Nilsson 2006; Osipowicz 2021; Petersen 1990). This might instead suggest common cultural practices were enacted within dwelling spaces by inhabitants of Star Carr and Mesolithic individuals at sites in Sweden, Denmark and Poland. Other comparable features, relating to material culture, have previously been noted between early Maglemosian settlements and Star Carr (Sørensen *et al.* 2018). Alternatively, tasks may have been organised due to practicalities. Spatially differentiating crafting, such as processing bone and possibly projectile hafts, and food processing might be expected as they are distinct tasks that produce different end products. Food processing could also be considered a messy activity, involving fresh meat, bone and possibly blood.

A discussion of collective action and its implications are required when considering the many component parts, materials and phases of a dwelling. It is possible that group interactions during parts of the construction process may have facilitated 'a socio-centric sense of personhood' whereby relationships to others in community are part of and define an individual's identity (Bird-David 2009, 209). Insights from ethnography highlight the variability in how space can be organised and suggest that Mesolithic communities did not use dwellings in a universal way. Few interpretations of Mesolithic dwellings present alternatives to Grøn's approach to explain why activities may have been spatially structured (Grøn 2018, in press). Such spaces may have represented a family unit with fixed places for individuals, as Grøn suggests (Grøn 2021a, b); however, it cannot be considered the only possible narrative for the spatial organisation of Mesolithic dwellings. We gain rich insights into social structure and division of labour if we assume that a nuclear family occupied each dwelling with different tool-using areas denoting spaces for each individual. However, is this representative of

Mesolithic communities and dwellings? The discussed ethnographic examples invite us to consider that inhabitants of Mesolithic dwellings may not have been a fixed unit.

There are other valid alternative explanations for the organisation of activities within dwellings, from practicalities of working with different materials, to culturally embedded practices that required tasks to be undertaken in separate areas. In this way, multiple authorship as an approach has highlighted different possibilities for interpreting the social dimensions of Mesolithic dwellings. For the eastern structure at Star Carr, spatial organisation in tool use is most convincingly interpreted as influenced by cultural customs. Even if tasks were located in certain areas based on practicalities, it suggests that the inhabitants had a collective understanding of what was a messy activity, and what wasn't, and thus where each respective task should be undertaken. This implies that behaviours inside the dwelling adhered to accepted cultural practices, either specific to that dwelling or more general customs of the community. If inhabitants of a structure were not fixed, then it could be inferred that these practices were shared at a group level. The observation of similar patterns in other Mesolithic dwellings may imply the sharing of, or at least similarities in, some cultural customs at a significantly larger scale.

10.3.6. Disuse

Structures can become disused for different reasons, from functional issues (i.e. deterioration of the construction materials) to social events (i.e. death of the inhabitants). There is less archaeological evidence to suggest why the eastern structure became disused, so this discussion is necessarily speculative. At Star Carr, it is possible that the changing lake-edge environment with an expansion of peat formation and fen vegetation caused inhabitants to move their settlement elsewhere (Taylor, B. *et al.* 2018a, 51). In which case, any structures may have been moved to a new site or left to deteriorate. However, the disuse of the eastern structure is dated to c. 8650-8700 cal BC, when fen developed around the lake edge, but human activity was still present on site (Milner *et al.* 2018e, 240). These dates must be considered with caution but could suggest that the structure became disused prior to the last phases of activity. Other factors that may have caused inhabitants to leave a dwelling, beyond environmental change, should therefore be considered.

If a structure starts to degrade, it is possible that inhabitants might decide to abandon it and build a new one or repair it *in situ*. From the density of flint deposits and several clusters of postholes surrounding the eastern structure, it is possible that it underwent repair and maintenance during its life, with effort taken to prolong its use. Therefore, the suggestion it became disused because of its condition appears to contradict the available archaeological evidence, as it is likely that inhabitants could repair the structure. It might be inferred from this that there was an intentionality to its disuse, as inhabitants chose to abandon it or no longer make repairs.

The treatment of objects and other structures at Star Carr might offer further insights. In the wetland parts of the site, fully functioning, in-tact objects were placed into the lake and on the wooden platforms through acts interpreted as structured depositions (Taylor, B. *et al.* 2018c, 255). Materials treated in this way include: a flint cache used in butchery tasks, whole animal carcasses, antler frontlets, barbed points, and a bone bodkin. Objects such as frontlets and barbed points took considerable effort to produce, yet were deposited before what could be considered the natural conclusion of their use life (i.e. when they had become broken or no longer usable) (Elliott *et al*. 2018). From this indirect evidence, it could be suggested that the eastern structure was not left to deteriorate but intentionally decommissioned, where it no longer served as a dwelling.

Changes in group dynamics, such as disagreements, or life events like births and deaths might cause a dwelling to be decommissioned. In Chapter 9, two ethnographic examples from the Evenki and Khanty highlighted how cultural customs can cause a dwelling to be abandoned or repurposed. If inhabitants of Evenki or Khanty dwellings die, the structures are either abandoned to not offend the spirits of the deceased who live in the hearth, or they are used for storage (Anderson 2006; Jordan 2003). Dwellings are not damaged or symbolically destroyed, but their function changes. As seen with the structured deposition of intact objects at Star Carr, which were taken out of circulation, it is possible that the eastern structure was similarly decommissioned by a change in function. From the density of flint deposits in the dwelling, it may have been repurposed as a storage area for tools (Conneller *et al.* 2018a, 177) or used to deposit clearance material, as has been interpreted for the western structure. The reasons for its transition from a dwelling to serving a potentially different function are difficult to access; however, insights from the Evenki and Khanty invite a consideration of social motivations linked to cultural beliefs.

10.4. Biography and multiple authorship: Applications to other Mesolithic structures

Using biography and multiple authorship to explore the social dimensions of dwellings has been demonstrated at Star Carr. Excellent levels of preservation along with abundant flint tools provides empirical data to ground theoretical perspectives. But not all Mesolithic settlements have such densities of material, so the applicability of this approach needs to be considered for structures where the data is not as plentiful, either through preservation or human action, or both. For the eastern structure, insights provided by biography and multiple authorship would have been more difficult without palaeoethnobotany, faunal and flint data; however, the approach would have still provided new perspectives. Despite identifications of flora and fauna species, evidence directly connecting materials to the dwelling was variable as the specific materials used in construction are unknown. The biographical narrative developed for the dwelling's construction was based on conjecture and the most likely interpretation. Therefore, this type of approach, combining archaeological data with speculations based on what is available, could be applicable to most Mesolithic huts or dwellings.

Evidence of Mesolithic structures varies significantly, from a hollow surrounded by postholes, to cut features with hearths (see Appendix 1) (Fretheim 2017; Mithen and Wicks 2018). If there is a convincing case for the presence of a structure, it is likely that a post-built frame of some sort was built; where no postholes are excavated, lithic distributions or depressions can be used to identify possible structures (Mithen and Wicks 2018). Using the structural frame as a starting point, a biography can be created. From general contextual information, such as date estimates (or radiocarbon dates, if available) and palaeoenvironmental studies, likely sources for the wooden posts and possible species can be inferred. Very few Mesolithic sites have roofing materials or coverings preserved, so the possible materials that could have been used, based on studies of the surrounding landscape and resources, should be discussed. Most Mesolithic structures would likely have been composite in nature, requiring different raw materials and/or processed items (such as cordage) (Hurcombe and Emmerich Kamper 2016). These are unlikely to have all been made by one person. From this, multiple-authorship and its social implications could feasibly be considered in discussions of other Mesolithic structures.

Bolsay Farm provides a good example of the broader application of biography and multiple authorship to structures. Located on the Isle of Islay, Western Scotland, Mesolithic settlement here dates to 6400-6090 cal BC, with cut-features, flint concentrations and pits identified (Mithen *et al.* 1992; Mithen 2000). Based on high quantities of flint knapping debris, the site has been interpreted as a repeatedly visited residential camp with several shelters or huts, although the permanency of these structures is unclear due to poor preservation (Milner and Mithen 2009; Mithen and Wicks 2018; Mithen *et al.* 1992). Palaeoenvironmental data from nearby Gleann Mor suggests that Bolsay Farm was surrounded by hazel woodland at the time of occupation (Milner and Mithen 2009). No direct evidence of woodworking was found as microwear analysis was limited to microliths and no axes were recovered. This could suggest that the posts were brought to site, so additional woodworking was not required to erect the structure. Alternatively, an axe may have been used to possibly fell hazel timbers but was transported from the site once the group moved on. Axes have been interpreted as curated Mesolithic tools that may have been exchanged, so it is feasible that they were moved from site to site (Conneller *et al.* 2018b, 498). Birch was not dominant in the landscape, which suggests that alternative coverings were likely used, such as animal hides, thatching or turf. It is probable that these required a collective effort to source and produce effective coverings (van Gijn and Pomstra 2016).

No faunal remains were preserved and only microliths were studied for wear traces, so the tasks undertaken in the structure are more difficult to ascertain (Finlayson and Mithen 2000). Large quantities of microliths and the site's location have been used to suggest this was a hunting camp, though the diversity of other tools suggests that there were additional activities also taking place (Mithen *et al.* 1992). Scrapers, blades and flakes were also found in large numbers. Microliths were used in a variety of ways, some were used as projectiles and others had traces from shaving medium or hard materials, found in association with the structure(s). It has been suggested they were manufactured and made into composite forms as projectiles in the structure (Finlay 2003; Finlayson and Mithen 2000). The negotiation in social relations and working-together inferred through its construction might have also been reflected in the making of composite projectiles. Components of a projectile - microliths, hafts, adhesives or bindings - could have been made by one individual, although it is equally possible that some were made by different people (Conneller 2021; Finlay 2003).

Most microliths did not show signs of projectile use, the majority had been used to cut or shave (Finlayson and Mithen 2000, 592). This indicates that there may have been a selection process where only particular pieces were chosen and hafted into a projectile. Tool morphology may have been a factor in these decisions, for example whether the piece had a specific form to make an effective projectile. The maker of a tool, their ability and method of production, would be visible in the microlith's overall form (Finlay 2003). Therefore, in selecting specific pieces to be hafted into a composite tool, potentially different identities were brought together and negotiated in the creation of a projectile (Finlay 2003). By reflecting on collective working within different technologies (building a structure and potentially in the manufacture of projectiles), the social dimensions of the structure can be interpreted. From this, it could be suggested that inhabitants of Bolsay Farm may have maintained an interconnected and relational sense of community.

10.5. Chapter summary

Dwellings are more than just a setting for activities. Functionalist perspectives are a useful baseline for interpretations but provide very limited insights into the social dimensions of these spaces (e.g. Crombé and Beugnier 2013; Domańska and Wąs 2007; Jensen and Petersen 1985; Noens 2011). The discussed ethnographic examples demonstrate the huge variety in the physical construction of dwellings, as well as the social customs associated with them (Grøn and Kuznetsov 2003; Jordan 2002; Lavi and Bird-David 2014). Structures have significant potential to inform our understanding of Mesolithic people, if we explore the social dynamics involved in their making and use. Siksika coverings highlight how customs within different lifeways can provide new areas for consideration, as social identity was embedded through decoration on dwellings. Layers of meaning potentially attached to Mesolithic dwellings during construction can be explored through a new application of biography and multiple authorship. Published biographies of prehistoric dwellings do exist, though they generally consider later prehistoric settlements with built houses containing separate rooms (e.g. Çatalhöyük) (Büster 2021; Carsten 2018; Kay 2020; Tringham 1995).

Aspects of fluidity and 'plural living-together' offer new perspectives on how Mesolithic people may have lived. This approach is also relevant for more ephemeral structures that may have been previously dismissed as temporary or transitory. Where Mesolithic structures are present, there is an opportunity to explore the social dynamics and cultural practices of past communities. Variation in household membership is clear from ethnography, which encourages different interpretations regarding the inhabitants of Mesolithic dwellings. This is a new avenue for discussing Mesolithic dwellings as more than just proxies for social units (Kay 2020). Multiple authorship provides a way to acknowledge the possible different strands of meaning and the different identities that may have been woven into the construction and use of a dwelling.

Chapter 11: Conclusion

11.1. Introduction

This chapter discusses the main conclusions that can be drawn from this research. The primary aim was to investigate activities at the Early Mesolithic site of Star Carr through spatial analysis of flint microwear patterns. A summary of why microwear was selected and how it has been previously applied to Mesolithic settlements and Star Carr highlights the potential for future studies. Hypotheses regarding the use of each structure at Star Carr are developed to demonstrate how this research has contributed to this field of study, as well as areas requiring further analysis. After which, a discussion of the wider implications of this research will be reflected upon, notably the methodology and interpretations. The sampling strategies utilised will be discussed to evaluate their utility for addressing different research questions. Finally, suggestions for future research areas regarding the structures at Star Carr and those found in the wider British Mesolithic landscape will be presented.

11.2. Conclusions on the potential of using microwear to study Mesolithic structures

In Chapters 1-4, the motivation for undertaking this research was presented. A detailed discussion on the application of microwear analysis to different Mesolithic flint assemblages, specifically from settlements, demonstrated that the method offers vast potential. Alternative microscopic methods, such as confocal microscopy and SEM, can also be used to examine tool use. However, these were not relevant to the assemblage at Star Carr as flint was the main raw material used and adhering residues were not preserved (Croft *et al.* 2018; Conneller *et al.* 2018b). Microwear analysis was therefore an appropriate and suitable method for interpreting tool use as it offers scalable insights regarding individual flints or larger scale interpretations such as intra-site activity patterns. Additionally, it can provide a foundation for interpreting behaviours of the communities who used the tools.

From summarising existing microwear studies on Mesolithic settlements, there is a clear need for additional studies on other British Mesolithic structures, enabling interpretations to go beyond assigning function. Appendix 1 highlights a lack of in-depth analysis of these structures, despite the application of microwear assessments and the growing quantity of structural evidence from Britain (Conneller 2021; Mithen and Wicks 2018; Waddington *et al.* 2020). Interpretations of tool use at these sites often have a technological focus or assign the whole settlement as a certain type (base camp, specialised camp, hunting camp) without examining and understanding tool use associated with structures. Microwear traces are well preserved at these settlements, so they have the potential to highlight: spatial patterns of tool use within structures, related activity across different structures, as well as connections between use of structure(s) and the surrounding area. From this, it would be possible to explore why there might be some observed patterns in tool use, thereby interpreting social aspects of these areas. This could aid our understanding of daily practices at British Mesolithic settlements, and comparisons between sites might shed light on shared behaviours or cultural customs. Without further work on Mesolithic structures in Britain that enable specific insights, an understanding of the use of these structures and the communities that built them will remain lost.

11.3. Conclusions on the insights gained from tool use at Star Carr

Microwear results from the analysis of awls and structures were presented and interpreted in Chapters 5-8. Comparisons of tool use across the structures were discussed alongside associated faunal remains and lithic refitting data in Chapter 9. An analysis undertaken on all awls recovered from the site highlighted their use as a multifunctional craft tool, with some spatial association in those used to drill shale and pierce hide. New data on utilised flints from all three structures was produced, which aided greater understanding of tasks undertaken in these areas. Overall, PDSM was observed on a large quantity of tools; however, it did not interfere with the majority of microwear assessments. A range of materials were worked across the three structures: bone, antler, hide, meat, fish, wood, plants. Evidence of projectile impact was also identified and use on mineral (strike-a-light) was observed in the western structure. At a broad level, the structures appeared to show similar types of use with all but one contact material observed across all three areas. The advantages of spatially plotting microwear results were highlighted, leading to observable differences in the spatial distribution of tasks between the structures.

Flints from the eastern structure showed the lowest frequency of PDSM and a high frequency of use (64.4%). Where a contact material was interpreted, traces of working bone, meat, plants and hide were mostly observed. Spatially, zones of activity relating to bone, hide and siliceous plants were distinct. This suggested that inhabitants were undertaking certain activities in particular areas: bone processing and possibly crafting in the northern half, and food preparation and siliceous plant fibre extraction in the southern half. Flints interpreted as projectiles were located in the western part of the structure. It is possible that this reflects practicalities in working with different material properties. However, cultural practices might better explain the spatial organisation, as even practicalities can be informed by notions of what is appropriate (i.e. which materials can be processed in the same place).

There was a general sparsity in lithics found in the central structure and fewer flints were analysed compared to the eastern structure. Rates of PDSM were higher than observed in the eastern structure, with nearly half of the analysed pieces exhibiting iron oxide staining from the soil sediments. Tool use was lower than the eastern structure (46%), though this in part reflects the different sampling strategies. Bone, wood and hide working were observed most frequently. Despite being truncated, the area showed some patterning in activities over a potentially limited time frame. Woodworking was identified in the hollow, with dry and fresh hide working also observed. Flints used on wood were interpreted as related to making wooden objects, with perforating, grooving, planing motions and cutting using a small bladelet. The central structure was tentatively interpreted as an area of specific activity, similar to a workshop. This was based on limited tool use on other materials in the hollow and from inferences of other Mesolithic structures (Karsten and Nilsson 2006).

In the western structure, a flat dull smoothing and iron oxide were observed on nearly half of the analysed pieces, the highest rate observed. Wear traces were seen on 59% of tools, and overall PDSM did not prevent microwear assessments. Meat, hide, bone, and woodworking were interpreted most frequently. Tool use on different materials was scattered across the area with no patterning observed, although flints associated with the postholes exhibited some discrete spatial clustering. A more substantial structure may have extended north beyond the excavated area; however, there was no evidence to suggest that spatial patterning of tasks was intact. The most convincing interpretation of tool use was of a middening area, perhaps within or above a previous structure.

From new microwear results, in combination with the Star Carr Project data and insights from other Mesolithic structures, hypotheses have been developed. These relate to the use of space associated with the three structures. They should not be taken as the only interpretations; however, from current evidence, they are considered the most convincing. The hypotheses will enable further work on the structures, implementing microwear or other methods, to examine and substantiate key findings from this research.

- Hypothesis 1 - the eastern structure was a dwelling used for a range of tasks, some of which were specifically undertaken in particular areas such as food preparation, maintenance of projectiles and and siliceous plant fibre extraction.
- Hypothesis 2 - the central structure was used for discrete and short episodes of processing materials, most notably wood. The area appears to have been cleared throughout its use, perhaps relating to a specialised use for a limited range of tasks, similar to a workshop.
- Hypothesis 3 - the full extent of the western structure extended into the bank next to the canalised Hertford river, with the structure being left or abandoned by its inhabitants. It was last used as an area for depositing clearance material from different activities.

11.4. Wider implications of conclusions

11.4.1. Methodological implications

Two sampling strategies were used for microwear assessments: both produced different types of results, which impacted on the insights gained. A first approach, sampling based on tool type and spatial location, was effective. Flints that were largely representative of the overall assemblage from the study areas were selected. Particular tool types were prioritised and chosen from across the structure areas, with fragments as well as complete tools selected. Results produced from this approach were as representative as possible, considering the sample was selected. However, there were limitations as pieces were chosen, cleaned and drawn prior to macroscopic analysis. Significant time was spent on preparing and analysing flints that did not always significantly contribute to understanding tool use.

For the second phase of sampling, flints from one specific area were scanned and filtered by signs of use. This approach meant that a large number of pieces exhibiting well-developed microwear traces were selected. These results contributed most to discussions of tool using activity zones within the eastern structure, as many more utilised flints were analysed, relative to the time invested. More detailed insights into tool use were accessible as patterns could be observed across a larger sample and the identification of activity zones was more convincing. However, there was a clear bias in that the approach preferentially selected utilised pieces, so the sample may not have been representative of all flints.

Future studies assessing tool use from specific areas may opt for the second sampling strategy, as it is the most efficient approach, which is particularly relevant for such a time-consuming method. Despite this, research into tool use should also try to include flints that do not show wear traces, as unused pieces provide important insights into tool using behaviours. To give an example, the eastern structure had high numbers of unutilised flints in the hollow compared to the surrounds, relative to the overall quantity analysed. This suggests that flints were knapped in the dwelling and left there, perhaps for subsequent use. Research aims should be used to establish the most appropriate sampling strategy. Archive access and the archiving system should also be considered, as if only utilised pieces are selected, large quantities of the archive must be accessible for scanning. A sampling approach that prioritises well-developed wear traces is understandable, though the limits and biases of using such a strategy must be considered when interpreting the results.

Variable rates of PDSM across the structures were unexpected. All study areas were located within the dryland part of the site, so it was anticipated that levels of tool surface preservation would be generally consistent (Conneller *et al.* 2018b). The eastern structure had the lowest occurrence of PDSM, with the central and western structures showing largely similar high rates. Iron oxide was most frequently observed in the central structure, whereas a flat, dull smoothing was most common in the western structure. Differential tool surface preservation may in part be a result of the depositional environments associated with each structure (Taylor, B. *et al.* 2018b).

Stratigraphic and micromorphological analysis indicated that western structure features were found in a layer of mottled grey clay, and the eastern and central structure features within a mineral deposit of very fine sand/silt brown earth, with varying levels of gravel inclusions (Milner *et al.* 2018f). High levels of flat, dull smoothing observed in the western structure cannot be explained through clay deposits, as this type of PDSM is more often related to sandy and abrasive contexts (van Gijn 1990). Therefore, it is possible that the anthropogenic treatment of flints may have impacted the frequency of PDSM (Petrović *et al.* 2021). Dense tool deposits and the interpretation of a midden could explain these high rates of flat, dull smoothing as direct contact from other flints can cause abrasion of the tool's surface (Vaughan 1985). Iron oxide staining on a large number of pieces from the central structure likely reflects the depositional environment.

To assess the feasibility of microwear assessments on a site, flints need to be sampled from across different depositional contexts and in key areas of interest, even if they are located within a broadly homogenous context. This is particularly important in sandy or silty deposits where tool surfaces are frequently less well preserved. Preservation may also vary due to anthropogenic factors as well as post-depositional processes. Therefore, future microwear studies should detail the presence of PDSM on all analysed pieces. This can aid interpretations of how flints were treated prior to their final deposition, thereby shedding light on how the space was used.

11.4.2. Interpretative implications

Dryland structures at Star Carr do not show repeated patterns in use. In fact, it is difficult to discern many similarities apart from the range of contact materials worked, though even then, the western structure evidenced strike-a-light use, which was not seen elsewhere. Inter-site variability in Mesolithic structures is to be expected; however, the level of intra-site variability identified at Star Carr is rarely observed. This might be explained by a lack of Mesolithic sites with more than one convincing structure, but also perhaps a result of trying to identify similarities between Mesolithic structures rather than acknowledging differences (Warren 2014). An example of this can be seen through Grøn's work at Ulkestrup I, Denmark (Grøn 1995), where the internal organisation of a 'two-family' dwelling has become a typological system to identify this type of structure at other Mesolithic settlements (Fretheim 2019; Grøn 2003; Osipowicz 2018).

At Star Carr, though excavated features showed some similarities between the structures, tool use presented a different picture. This contributes significantly to our understanding of Mesolithic structures and our expectations regarding how they were used; we should anticipate variability in how space within structures was organised, even within one site. Whilst there were notable differences observed at Star Carr, behaviours and practices can still be connected between structures, through the movement of material or cultural norms. It is possible that some cleared flints from the eastern structure were deposited in the western structure, thereby highlighting a point of potential connection despite observable differences in the use of both structures. Interpretations that acknowledge and explore intra- and inter-site *connection* might offer more fruitful insights into Mesolithic structures than those looking for similarities. Chapter 10 highlighted the variability in how structures have been built and used by different hunter-gatherer communities, as well as the different ways that identities can be embedded within them. Therefore, attempting to identify similarities may be inhibiting our understanding of Mesolithic dwellings and a different approach needed to explore the many uses and potential meanings of Mesolithic structures.

A move beyond functional assessments is required to access the full potential that structures have for aiding our understanding of Mesolithic lifeways. Grøn's (2021a) work on social psychology and ethnography is one approach. A new application of multiple authorship to Mesolithic structures, through a biographical lens, was discussed as another way to explore social significance and meaning. Interactions between humans and materials, humans and other humans, and humans and the landscape offer insights into the possible cultural practices involved and enacted in a dwellings' biography. It was suggested that there may have been multifaceted identities linked to a dwelling through the process of construction, and this may have led to a fluid group of inhabitants using the space. Contrary to previous social interpretations that focus on family units, multiple authorship opens up a new narrative for these spaces as shared living areas. By pushing interpretations of Mesolithic architecture past functionalist assessments, the potential complexities embedded within structures can be acknowledged. In doing so, new possibilities for exploring social dynamics in Mesolithic dwellings are created.

11.5. Future research

There are key areas to be explored through future work, both in relation to the structures at Star Carr and more widely relating to Mesolithic settlements. Comparisons in utilised tool types across the three structures highlighted a strong correlation between these areas and hide working scrapers. This pattern could be explored further by analysing other scrapers found in the structure areas to establish if the majority of scrapers were used in this way. The association of hide working and structures or postholes could also be investigated at other Mesolithic settlements, to explore if hide processing may have necessitated use of a rack or similar structure, thereby explaining the spatial connection.

Microburins were utilised for a range of tasks in the western structure, demonstrating that future microwear studies should not discount them. Similar to other informal tool types, they have been previously considered as indicative of tool production rather than utilised as tools themselves, but this is not the case at Star Carr. Their use could reflect the manufacture of different projectile components; however, additional microwear assessments of microburins across the site could investigate this further. Analysis of all awls indicates that they were a key crafting tool used on a range of materials. Future work on those found at other Mesolithic sites might shed light on whether this pattern of use is unique to Star Carr or observed more widely within the European Mesolithic.

Additional microwear assessments could also verify the hypotheses presented or add further nuance to tool use in the structures. Ideally, the second sampling approach applied to the eastern structure could be used to select utilised flints from the other two structures. A more detailed picture of activity zones might then be possible, which could aid less tentative characterisations of these areas. Further sampling of the northern structure area and western arc of features would provide clarification whether tool use is generally low, or whether there are clusters of activity that may help to define these structures, and their connection to the central structure. There was also an overall lack of well-developed tool use across all analysed flints. Microwear analysis of more pieces from these areas could examine this behavioural pattern, to establish if individuals were consistently not using pieces until exhaustion, across all structures.

At a larger scale, microwear studies on other British Mesolithic structures could explore how patterns in tool use and activity zones compare to those identified at Star Carr. Connections between Star Carr and settlements within the wider landscape have already been highlighted (Conneller and Schadla-Hall 2003). Therefore, inter-site comparisons would elucidate whether this relationship also translates into the use of structures. Further microwear assessments would provide additional data on the variability of Mesolithic structures or confirm similarities with the observations from Star Carr. In turn, this could be used to explore wider networks of communities and cultural practices relating to structures at a more regional scale.

A discussion of different biographical phases together with multiple authorship was successfully applied to the eastern structure at Star Carr. This approach was also shown to have potential for understanding more ephemeral evidence of Mesolithic structures, such as Bolsay Farm. Further work is needed to test these theoretical frameworks on other Mesolithic dwellings and to fully test the limits of this approach. Specific data, such as microwear traces, or good levels of preservation may be prerequisites for this approach to offer useful insights. Additionally, there may be other theoretical tools that could provide different perspectives of Mesolithic dwellings. Relational theory is implicit within the discussions of dialogues and interactions, but it could be examined in greater detail to add a new dimension to understanding dwellings. To give an example, this approach could explore how structures are situated and connected to the surrounding landscape, including the sourcing of raw materials.

The interpretative potential of Mesolithic dwellings has yet to be fully uncovered, and it is only through further microwear analysis and experimenting with different theoretical approaches that this can be realised (Cuenca-Solana *et al.* 2018). These spaces of sustained daily activity provide a rare but crucial opportunity to gain a more holistic understanding of Mesolithic life and the people behind the lithics (Zvelebil 2003).

Appendix 1: Microwear studies on Mesolithic settlements

Site name	**Location**	**Date**	**Structural evidence**	**Number of flints analysed**	**Microwear results**	**Micro-graphs provided?**	**Social implications?**	**References**
Star Carr (pre-1990)	North Yorkshire, UK	7607 +- 2106 bc and 7538 +- 350 bc	Flint concentrations, wooden platform;	156/2689 (not including un-utilized or un-retouched flakes) 94/187 showed evidence of use	Hide; bone; antler; wood; meat; mineral (tentative)	6 (more in vol 2)	Functional interpretation that tool typology ≠ tool use; retouched areas not only area of use; no clear specialisations at site as previously thought	(Dumont 1988; Dumont 1990)
Star Carr (2004-2015)	North Yorkshire, UK	9300-8500 cal BC	At least 3 structures evidenced by post holes and/or hollows; flint concentrations; three wooden platforms	202/24,883 152/220 showed evidence of use	Antler; bone; plant; meat; mineral; fish; hide; meat; impact; wood	6	Occupied across 800 years, persistent and different types of activity in different areas - tool manufacture, domestic and craft based activities. Plant working associated with the lake edge. Formal acts of deposition of some flint tools associated with the lake edge - repeated across site's occupation.	(Conneller *et al.* 2018a,b)
Thatcham	Berkshire, UK	9180-9020 BP 8564-8201 cal BC (93.9% probability)	Flint concentrations and 'domestic rubbish' (20 ft in diameter); presence of hearths; clearance of woodland	70/383	Plant; antler; bone; wood; fish; meat; hide	No	'home base'; spatial differentiation within site - southern area bone and antler working, northern area working of soft materials	(Healy *et al.* 1992; Wymer and King 1962)
Asfordby	Leicestershire, UK	8220-7530 cal BC (95% probability)	Flint concentrations; hearth; five equivocal 'postholes'	Microliths - 31/107	Plant; bone/wood; hide; meat; impact	No	Technological focus; identification of site 'type' as resource procurement location	(Cooper *et al.* 2017)
				Other tools - 15/40	Bone/wood; hide; meat; strike-a-light; wood	No		

Howick	Northumberland, UK	7850-7650 cal BC	Three hut structures (continuously built one after the other); central hearths inside structures; burnt animal bones; charred hazelnuts shells; lithics within structures; some ochre fragments	100/13,219 inside hut analysed 50 retouched pieces + 50 unretouched from inside hut	Plant?; hide; wood; bone/antler/horn; pigment (from residue)	No	Domestic settlement site (no obvious ritual behaviour); a base camp type settlement used by the same group lasting c. 200 years; family-sized group (based on hut size); possible present of other huts at same time	(Hardy and Shiel 2007; Waddington *et al.* 2007)
Goldcliff East	Newport, Wales, UK	Site A - 5630–5480 cal BC Site J - c. 4900–4710 cal BC	No postholes, cut features or stone-lined areas, but lithic clusters used to infer presence of some light-weight tent-like structures. And presence of heat-fractured stones and worked wood (site J)	19/50 analysed fully from preliminary assessments scrapers, microliths and blades targeted as tools 'most likely to have been used' **15/19 show use**	soft animal; siliceous plant, butchery, hide, MLITs, 'polish 10' - bone tools also present	6	Site A - craft, food preparation and/or smoking activity, microlith production, associated within an area c.2m in diameter, interpreted as a small shelter or activity area Site J - red deer butchery, skin processing, food processing, some knapping, cooking with heated stones, processing plant foods, associated with an area 3m in diameter, possibly a small tent or shelter - interpreted as possible base camp (revisited temporally and periodically, rather than permanently occupied) Shelter interpreted as wigwam-type structure, easily erected by 4-5 people, sleeping 4 people.	(Bell 2007)

Stainton West (CNDR)	Carlisle, UK	Structure 1 + 2 = 7th- early 6th mill. BC Structures 3-6 = 5th mill. BC	Post holes, hearths, middens, lithic distributions, ground stones, worked ochre. Structure 1 + 3-6 = sub-circular tent like structures, structure 2 post holes in a linear arrangement	Not specified	butchery, antler/bone, dry hide, plant, MLITs	No	A seasonal residential encampment occupied regularly, wide range of activities undertaken, mixture of craft and domestic activity. *only 1/8th island excavated so could be larger occupation than excavated	(Brown 2021)
Mount Sandel	County Derry, Northern Ireland	7800-7500 cal BC	As many as 4 pit houses based on arcs of postholes; four hearths	273/1355 76/273 showed evidence of use	Hide; bone; antler; meat (butchery); stone-working; wood; haematite/mineral	No	Follows Woodman's 1978 interpretation of 'base camp'	(Bayliss and Woodman 2009; Dumont 1988; Mithen and Wicks 2018)
Caochanan Ruadha	Cairngorm mountains, Scotland	6215-605 cal BC (95% probability)	Flint concentrations; hearths	28/132	Plant; hide; animal; impact	5 (poor quality)	Spatial differentiation in structure - plant working in northern area, animal working in south	(Warren *et al.* 2018)
Sands of Forvie	Aberdeen, Scotland	Late Mesolithic	Flint scatters	96/?? 67/96 suggested evidence of use	Microwear only identified directionality of use (not material) Residue: Plant; plant/wood; animal/plant;	No	Flint tool processing site (blades and microliths); possible plant working (from residue)	(Hardy *et al.* unpublished)
Gleann Mor	Isle of Islay, Western Scotland	9090-7130 BP (thermoluminescence dating of burnt flint) 10217-5318 cal BC	Flint concentrations; ephemeral stake holes	Microliths - 93/327 46/93 showed evidence of use	No materials, just motion and location of used edge	No	Technological focus; no relationship between microlith form and function. Cutting soft materials appears more frequent than at Bolsay.	(Finlayson and Mithen 1997; Finlayson and Mithen 2000)

Bolsay Farm	Isle of Islay, Western Scotland	7250 ±145 BP 6450-5000 cal BC (95.4% confidence)	Flint concentrations of knapping debris; 7 possible stake holes, circular pit containing lithics; numerous features, generally shallow cut features	Microliths - 101/969 51/101 showed evidence of use (% according to paper, raw data not available)	Impact identified, and soft and medium materials on 6. Actions: cutting, shaving, boring and projectiles use. No materials, just motion and location of used edge.	No	Technological focus; microliths used in variety in ways not just as projectiles. Activities regarding shaving medium/hard materials appears more frequenct than at Gleann	(Finlayson and Mithen 2000; Mithen *et al.* 1992)
East Barns	East Lothian, Scotland	8278-8022 cal BC and 8200-7954 cal BC (house in use - between 75 ad 150 years)	Substantial house' Sub-circular house pit (4-6m in diameter); 13 pit and post hole features; lithics, charcoal; faunal remains; cobbles; hearths (some surrounded by postholes); nearby associated features - cooking pit, two refuse pits.	291/25,553 taken for analysis 73/291 showed evidence of use	Impact; meat; hide; bone/antler	No	Similar activities occurring inside and outside the structure - primary manufacture, butchery, hide working, and tool/ornament maintenance and manufacture. Inside house, activities concentrated arond the central hearths. Deliberate spatial organisation inside the house, absence of liths and other deposits on the platform suggest an area of social and domestic activities centred on hearths. Interpreted as a 'home'	(Donahue and Evans 2021)
March Hill	West Yorkshire, UK	c. 5800 BP ??	Flint concentrations; four hearths	47/986	Bone; wood; hide	3	Identification of site as ‘hunting’ camp, high frequency of unused artefacts	(Briz i Godino *et al.* 2009)

Verrebroek	Flanders, Belgium	8410-7930 cal BC	Flint concentrations; artefacts and ecofact distributions; 12 hearth pits; 3 possible storage pits	384/79382 lithics analysed out of total assemblage 182/384 showed use (Crombe and Beugnier 2013) 467 microliths (Crombe *et al.* 2015)	Hard animal materials; wood; siliceous plant; hide; butchery; strike-a-light (Crombe and Beugnier 2013) Plant; impact; abrasion (Crombe et al 2015)	3	Spatial differentiation of activities around hearth areas - repeated occupation based on different frequencies of typologies rather than microwear. Microwear of microliths used for technological discussion.	(Crombé *et al.* 2001; Crombé *et al.* 2003; Crombé *et al.* 2015)
Doel-’Deurganckdock J/L’	Flanders, Belgium	Concentration 2: 8016-7753 cal BC (63.0% probability)	Hazelnut shells; burnt lithics; distinct spatial clusters of lithics	252/671 lithics in total	Butchery; skin; hard animal materials; siliceous plant; wood; strike-a-lights; plant; vegetal material;	9	Single, brief occupation with diverse range of activities	(Guéret 2013a; Noens 2013)
		Concentration 3: 7796-7546 cal BC (95.1% probability)	Carbonised hazelnut shells, surface hearth, heavy density of flints	124/14,316 lithics in total 33/124 showed use	Butchery; skin; hard animal materials; siliceous plant; wood; strike-a-lights;	No	Short-term residential camp-sites occupied by complete families during summer and/or early autumn (plant material widely available) Functional coherence in Mesolithic occupations (Crombe and Beugnier)	(Crombé and Beugnier 2013; Noens 2013)
Ede Kernhem	Holland	7900-7300 cal BC Early to Middle Meso	Huge density of flnint, three round to oval shaped features, interpreted as hearth pits - away from settlement. Small amounts of charcoal found within features. Flint clusters but most not associated with features.	50/23,272 35/50 showed use	Hide working (some with additive), siliceous plants, wood, plants,	No	Hunting and base camp - Encampments occupied for several weeks processing dry skin with or without additives - advanced stage of skin processing. Also also activities relating to plants and soft wood. Occupied intermittently at other times during earlier and later phases	(Crombé and Beugnier 2013; Müller and Devriend 2015)

Evergem 'De Nest'	Belgium	Early Meso	Flint concentrations; charcoal; hazelnut shells; charred faunal remains	50/10,975 28/50 showed use	Hide, siliceous plants, wood, strike-a-lights	No	Short-term occupation site	(Crombé and Beugnier 2013; Devriendt *et al.* 2010)
Hempens	Holland	Late Meso - 7100-6000 cal BC	Hearth pits; charred hazelnut fragments; charcoal; lithic concentrations (burnt and unburnt) - no obvious structures	354/75,500 lithics analysed out of total assemblage 198/354 showed use	Hide, bone/antler, siliceous plants, wood	21	Successively occupied habitation site. Skin processing in southern half of site, processing plant objects into finished products, transverse bone/antler working to the north, Woodworking on periphery. Overlap in activities observed too.	(Crombé and Beugnier 2013; Noens 2011)
Ageröd V	Scania, Denmark	4910-4590 b.c.	Flint concentrations; wooden stumps; hearths	43/102 showed wear traces	Plant; wood; hide; antler/bone	4	Spatial differentiation of plant and hide working - but small numbers	(Jensen 1983; Larsson 1983)
Dąbrowa Biskupia 71	Poland	Boreal period (Middle Mesolithic)	Lithics - no anthropogenic features	396/482 lithics analysed in total (microliths, retouched flakes, retouched blade, flake/blades, blades, flakes and rejuvenation flakes **76/396** show evidence of use	Hide; wood; impact; hafting; soft material NB: some unspecific observations, treat results with caution + no mention of cleaning	6 - poor quality	A hunters' camp for obtaining food; likely to have been shortlived, 'a manifestation of specific economic strategy pursued by its users'	(Domańska and Wąs 2007; Winiarska-Kabacińska 2007)
Ludowice 6	Poland	5710-5481 cal BC (95.4% probability)	Two habitational areas - flint scatters; pits; hearth; 3 huts	212/4026 showed evidence of use out of total flints found	Siliceous plant; wood; hide; meat; bone/antler; soft stone	No	Highly specialised encampment 'used mainly by women'. Internal organisation of utility zone and sleeping space in structures	(Osipowicz 2018)

Rosnay	France	8628-8340 cal BC	Hearth structure; burnt bones; burnt hazelnut shells; possible hollow?	1,463 lithics found in total 161 analysed (56 retouched tools + 105 unretouched tools)	Hide working; dry hide; plant; butchery; soft animals material; mineral	9	Short, well-specialised domestic occupation. Specialized in skin working. Organization of various activities around hearth - microlith manufacturing (east of the hearth). Skin scraping at two separate places depending on the tools used : scrapers (north-west of the hearth) or unretouched tools (east). Plant-related activities were more dispersed	(Souffi *et al.* 2015)
Hardinxveld-Giessendam Polderweg	Netherlands	C.9000-4700 cal BC Most activity 5500-5000 cal BC	Flint concentrations; post holes; pits;	155/3517 104/155 showed evidence of use	Plant; siliceous plant; antler; bone; fish; hide; mineral; impact; wood	18	No spatial pattern identified; technological focus; site identified as specialised base camp	(van Gijn *et al.* 2001a)
Hardinxveld-Giessendam De Bruin	Netherlands	3 phases: P1 5500-5100 cal BC P2 5100-4800 cal BC P3 4700-4550 cal BC	Flint concentrations; pits; post holes; hearths; organic remains/deposits; burials; traps, canoes	104/6970 73/104 showed evidence of use	Plant; siliceous plant; antler; bone; hide; hafting; impact	8	No spatial pattern identified due to low sample density; technological focus; site identified as long-term base camp	(van Gijn *et al.* 2001b)
Yangtze Harbour	Netherlands	8500-6500 BC	Flint concentrations; faunal remains; charcoal; burning of reeds. Shelter struuctures presumed as destroyed from slopewash	99/170 pieces showed evidence of use	Plants, wood, hide (some with mineral), bone, fish, soft and hard animal materials, shell, jet, meat	16 (varying quality)	Domestic or residential base camp - where one or more families resided. Activity not continuous - inhabited for short durations at a time	Boon *et al.* 2015

Vænget Nord	Denmark	C. 5000 bc (parts of site under water)	3 oval constructions - 200 stake holes, six meters in length by four meters wide; depressions; cooking pits; small heap of fire-cracked stones; 15 wooden stake posts; flagstones in front of entrance; single hearth; 'bag' of flakes from axe production; core 'wrapped up' with flakes deposited in pit inside structure	623/846 analysable (total flint found unknown) 140/623 showed evidence of use	Wood; hide; bone/antler; siliceous plant; plant; MILT; meat	5	Brief and specialised encampment for 5-10 people at one time; some internal organization of two major zones (bone/antler; hide) and central zone where minor crafts are undertaken near hearths	(Jensen and Petersen 1985; Petersen 1990, 2015; Price and Petersen 1987)
Ringkloster	Denmark	C. 4700-3990 b.c	Pits; hearths; postholes; associated 'dump-zone'; flint concentrations	Scrapers only - 39/42 had been used	Hide; wood	No	Technological focus; characterised as a winter hunting camp	(Andersen 1995; Jensen 1982)
Årup settlements	Eastern Scania, Sweden	Context 1 9150-8450 cal BC (Late Palaeolithic Ahrensburg culture)	Flint concentrations - two main rounded flint rich areas with 3 visible concentrations and an empty area in south-eastern central area; small temporary hearth; activity area of approx. 33m₂;	Context 1 only 76/2118 pieces analysed 34/76 showed signs of wear (All formal scrapers, all microliths, 3 formal blade knives, 13 blades and 7 blades fragments analysed	Hide; antler/bone; wood; hafting; meat; siliceous plant	7	Site was briefly occupied for hunting activities by a few people. Short stay, a few hours? Tools made, used and discarded on site. Hide scrapers found in north-eastern area, awls and wood and antler/bone working in western flint-rich area. Butchery tools edge inner/central circle + arrowhead with impact traces	(Karsten and Nilsson 2006)

		Context 2 Late Palaeolithic-Early Mesolithic transition (morphology and technology)	4 postholes; hearth (burnt flint); hut floor based on soil colour change; windbreak?; flint concentrations near to naturally occuring boulder (flint knapping?)	34/3552 analysed 21/34 showed evidence of wear	Bone; dry + fresh hide; meat; wood; antler?	No	Hunting station occupied by no more than 2-3 people. Windbreak (approx. 6.2m long and 2.5m wide) and joining activity area. Several activities performated in the hut - fine handicraft and ordinary household activities (manufacturing arrow shafts, reshafting microliths, softening hides etc), with a sleeping/storage area. Activity area = butchery zone, bone working zone, knapping zone.	
		Context 3 Early Mesolithic	Flint concentrations; four postholes, two furrows; large stones; charcoal	10/129 analysed 2/10 showed wear traces	Wood; antler/bone	No	Temporary field camp used seasonally in connection with hunting/fishing. Simple, temporary windbreak from a single short duration event	
		Context 4 middle/late Early Mesolithic (based on technological and morphological evidence)	Flint concentrations; 17 postholes, 3 pits, 2 furrows	11/1876 analysed (microliths only) 3/11 showed wear traces	MLITs; hafting traces	No	Temporary field camp used in connection to hunting (short-term), containing a hut and associated activity area, housing 5 to 8 people.	
		Context 6 6390-6100 cal BC early Middle Mesolithic	Flint concentrations; fire-cracked stones; 6 postholes; furrow; a pit containing one posthole; hearth containing burnt flint and charcoal	24/2291 analysed (blade fragments) 4/20 showed wear traces	Wood; bone/antler	No	A specialised site for manufacturing slotted bone points and daggers, with structures interpreted as workshops	

Vale Marim I	Sines, Portugal	6075–5840 cal BCE	Hearth; dwelling structures; flaked tools	1213/7614 analysed 132 used edges on 1213 tools	Wood; antler/bone; butchery; fish processing	5	Production centre for flaked tools; large camp occupied all year round (not based from microwear, previous (Soares and Tavares da Silva 2018)	(Clemente-Conte *et al.* 2020; Soares and Tavares da Silva 2018)
Beg-er-Vil	Brittany, France	6200-6000 BC	Faunal remains; charcoal; lithics; postholes; pits (possible storage pits); hearths with stones; shell middens	404 analysed (microliths only) 64/404 showed use	MLITs; mineral (hunting of birds or fish)	6	Technological focus - microliths weren't used for large mammal hunting	(Gómez *et al.* 2021; Marchand *et al.* 2018)
Font del Ros	Spain	10,150-9925 cal BP	Charcoal; lithics; faunal remains (poorly preserved); hearths	43 ground stone tools (cobbles) not flint 42/43 had been used	Bone, meat, plants. animal materials, hide, knapping, mineral	11	Identification of activity areas: multipurpose domestic area around hearth, knapping and tool production area, hide working area, plant processing area	(Roda Gilabert *et al.* 2016)
Katra 1st settlement	Lithuania	Late Upper Palaeolithic to Early Mesolithic	Flint concentrations	248 bladelets analysed 37/248 used on fish (other wear traces not yet published)	Fishing or fish processing, with tar residue	Low-power only - 15	Technological and function focus - specifically looking for evidence of fishing on bladelets (hafted on a bone point). Larger more permanent settlement	(Rimkus 2016)
Aukštumala	Lithuania	Middle Mesolithic	Flint concentrations	5/17 had wear traces	Dry wood, hide processing, tar residue	Low-power only - 9	Technological focus - looking at bladelet/microlith manufacturing techniques, interpreted as embedded into hafts from tar residue	(Slah 2013)

RAÄ 71	Markaryd, Sweden	8.215±55 BP 9.200 cal BP	Circle of stones interpreted as a hut; fire-cracked stone; hazelnuts;	120/586 analysed no number for quantity identified as used	Wood; hafting; hide; meat/hide; bone/antler;	8	No activities were performed that led to the deposition of flint pieces inside the hut; used recuurently; flint tools rarely made at site; activities undertaken to south of hut comprising microblade and flake production, hide/meat processing, bone/antler processing. *NB Only few examples of each activity evidenced on flint so tentative of saying spatial 'patterns' are clear	(Högberg and Persson 2019)
Ullafelsen	Tyrol, Austria	Early Mesolithic	14 hearth structures; flint concentrations; charcoal; birch bark tar	Approx. 8000 flints excavated 139/323 with signs of wear	Projectiles, hide, bone, antler, wood	n/a	Seasonal base camp for hunting activities in an alpine environment of major ecological and hunting resources, tools mainly used for hunting, repaired and maintained on site	(Groβ 2013)

Appendix 2: Complete microwear data

This is an Excel spreadsheet uploaded as Accompanying Material. It contains information on all 386 flints analysed as part of this research, under the headings:

- Study area – western, central or eastern structure, or awls
- Typology – flint tool type
- Flint No – Star Carr finds number
- X, Y, x – coordinates for finds location
- Context – specific context when excavated
- Year – year of excavation
- Sq No – excavation grid square location. Not present for all flints.
- Cat – tool type category e.g. awl, microlith, bladelet etc. Abbreviations are based on those used in the ADS Star Carr flint catalogue, which are detailed as a comment on the 'Cat' cell.
- Sub Cat – tool type subcategory, where relevant e.g. secondary burin spall. Abbreviations are based on those used in the ADS Star Carr flint catalogue, which are detailed as a comment on the 'Sub Cat' cell.
- Previous usewear – Y/N analysed by the Star Carr Project
- Previous usewear notes – details of previous interpretations
- Notes – any pertinent information on flint from this research. Note: if micrograph is not present, this is detailed here.
- Cleaning protocols – either: soap and sonic bath or soap and sonic bath; chemical
- Usewear present – Yes/No observed from this research
- GIS Summary – summary of interpretation, abbreviations are detailed in Chapter 4, page 81
- Microwear summary
- Microwear coordinates – location of any wear traces, corresponds to coordinates used in file names of micrographs
- Microwear notes – full description of microwear observations
- Refit group – if flint was part of a refit group, the number is listed here
- Refit number – refers to where the flint sits in the refit sequence
- Micrograph? – if present, a number is provided to detail how many micrographs relate to that flint in the archive

Appendix 3: Micrograph archive

This is a digital appendix, comprising a ZIP folder named: Appendix 3_Digital Appendix

File name key:

INFO = scale bar and magnification information on image

SC xxxxx = Star Carr finds number

Dorsal/ventral = aspect of flint

Coordinates = area on the tool, relates to information in spreadsheet

10x = image taken at 10x magnification, as opposed to 20x

PDSM = post-depositional surface modification, as opposed to use-related wear

HA = hafting traces

MLITs = microlinear impact traces

Sub-folder name	**Folder contents - Micrographs (TIF files)**
Awls (50 items)	INFO_SC82401_dorsal_0607coordinates INFO_SC82607_ventral_0506coordinate INFO_SC82724_ventral_07coordinate INFO_SC82724_ventraltip_08coordinate INFO_SC85366_dorsal_0607coordinates INFO_SC85969_dorsal_06coordinate INFO_SC86195_dorsal_0809coordinates INFO_SC86669_ventral_04coordinates INFO_SC86195_dorsal_0809coordinates INFO_SC91454_dorsal_06coordinate INFO_SC92402_dorsal_07coordinate INFO_SC92402_ventral_0708coordinates INFO_SC92936_ventral_09coordinate INFO_SC93267_dorsal_0607coordinates_PDSM INFO_SC93521_dorsal_0708coordinates INFO_SC93991_dorsal_07coordinate INFO_SC94227_ventral_07coordinate INFO_SC94395_dorsal_07coordinate INFO_SC94622_ventral_08coordinate INFO_SC94924_dorsal_0607coordinates INFO_SC94924_ventral_0607coordinates INFO_SC95321_dorsal_07coordinate INFO_SC95321_ventral_0809coordinates INFO_SC95431_ventral_08coordinate INFO_SC95871_dorsal_0607coordinate INFO_SC96249_dorsal_08coordinate INFO_SC96336_ventral_08coordinate INFO_SC96471_dorsal_07coordinate INFO_SC96840_ventral_0708coordinates INFO_SC97145_dorsal_07coordinate INFO_SC97607_dorsal_06coordinate INFO_SC99551_ventral_07coordinate

	INFO_SC109731_ventral_07coordinate INFO_SC110685_dorsal_07coordinate INFO_SC111496_dorsal_07coordinate INFO_SC113311_dorsal_0708coordinates INFO_SC113564_ventral_07coordinate INFO_SC113581_dorsal_07coordinate INFO_SC113871_ventral_07coordinate INFO_SC114507_dorsal_07coordinates_PDSM INFO_SC114679_dorsal_03coordinate INFO_SC114679_ventral_07coordinate INFO_SC114706_ventral_0506coordinates INFO_SC115006_ventral_0607coordinates INFO_SC115214_dorsal_07coordinates INFO_SC115294_ventral_06coordinate INFO_SC115375_ventral_07coordinate INFO_SC116369_dorsal_07coordinate INFO_SC116566_ventral_07coordinate INFO_SC116995_dorsal_07coordinate
Axes (2 items)	INFO_SC86473_dorsal_14coordinate_possHA INFO_SC86473_ventral_06coordinate
Bladelets (53 items)	INFO_SC82914_dorsal_09coordinate INFO_SC83289_ventral_10coordinate INFO_SC83390_ventral_05coordinate INFO_SC83397_ventral_04coordinate INFO_SC83408_ventral_10coordinate INFO_SC83438_ventral_11coordinate INFO_SC83897_ventral_07coordinate INFO_SC84111_ventral_0405coordinates INFO_SC84576_ventral_04coordinate INFO_SC84576_ventral_10coordinate INFO_SC84764_ventral_06coordinate INFO_SC84770_dorsal_09coordinate INFO_SC84770_ventral_0708coordinates INFO_SC85065_dorsal_03coordinate INFO_SC85065_ventral_10coordinate INFO_SC85127_ventral_0304coordinates INFO_SC85213_ventral_05coordinate INFO_SC85414_ventral_04coordinate INFO_SC85817_ventral_0304coordinates INFO_SC85952_ventral_03coordinate INFO_SC85952_ventral_05coordinate INFO_SC86133_dorsal_03coordinate INFO_SC86197_ventral_11coordinate INFO_SC86219_ventral_10coordinate INFO_SC86231_dorsal_04coordinate INFO_SC86285_dorsal_1011coordinates INFO_SC86411_ventral_0304coordinate INFO_SC86421_ventral_10coordinate INFO_SC86706_ventral_10coordinate INFO_SC87005_ventral_10coordinate INFO_SC87200_ventral_11coordinate INFO_SC87254_ventral_10coordinates INFO_SC87409_ventral_11coordinate INFO_SC87672_ventral_0304coordinate INFO_SC87694_ventral_10coordinate INFO_SC87697_ventral_1011coordinates INFO_SC90154_ventral_0304coordinates

	INFO_SC91413_ventral_06coordinate INFO_SC91846_ventral_04coordinate INFO_SC92981_dorsal_1011coordinates INFO_SC93692_dorsal_05coordinate INFO_SC97776_ventral_0809coordinates_PDSM INFO_SC97799_ventral_0708coordinates INFO_SC98591_ventral_11coordinates INFO_SC102287_ventral_10coordinate INFO_SC102380_ventral_09coordinate_PDSM INFO_SC102986_dorsal_04coordinate INFO_SC102990_ventral_09coordinate INFO_SC103031_ventral_04coordinate INFO_SC107582_ventral_03coordinate_PDSM INFO_SC107599_ventral_09coordinate INFO_SC107666_ventral_0809coordinates INFO_SC109645_ventral_03coordinate
Blades (45 items)	INFO_SC83050_ventral_05coordinate INFO_SC83151_ventral_10coordinate INFO_SC83151_ventral_11coordinate INFO_SC83817_ventral_04coordinate INFO_SC83817_ventral_11coordinate INFO_SC83817_ventral_0809coordinates INFO_SC83996_ventral_11coordinates INFO_SC84211_dorsal_08coordinate INFO_SC84718_dorsal_03coordinate INFO_SC84860_dorsal_06coordinate INFO_SC85852_dorsal_04coordinates INFO_SC85889_dorsal_06coordinate INFO_SC85980_ventral_06coordinate INFO_SC86018_dorsal_04coordinate INFO_SC86018_ventral_11coordinate INFO_SC87122_dorsal_09coordinate INFO_SC87122_dorsal_09coordinate INFO_SC87175_dorsal_08coordinate INFO_SC87175_dorsal_0809coordinate INFO_SC87688_dorsal_09coordinate INFO_SC87688_ventral_09coordinate INFO_SC87830_ventral_06coordinate INFO_SC90863_dorsal_04coordinate INFO_SC90863_ventral_09oordinate_10x INFO_SC90866_ventral_05coordinate INFO_SC94445_dorsal_09coordinate INFO_SC94461_ventral_10coordinate INFO_SC94933_ventral_04coordinate INFO_SC95880_dorsal_04coordinate INFO_SC95880_ventral_10coordinate INFO_SC96213_ventral_05coordinate INFO_SC96213_ventral_0708coordinates INFO_SC96226_ventral_05coordinate INFO_SC96358_ventral_03coordinate INFO_SC96542_ventral_07coordinate INFO_SC96690_ventral_0708coordinates INFO_SC96886_ventral_08coordinate INFO_SC96886_ventral_08coordinate INFO_SC97215_ventral_12coordinate INFO_SC102404_largefrag_ventral_09coordinate INFO_SC102792_dorsal_0809coordinates INFO_SC102792_ventral_07coordinate

	INFO_SC103035_ventral_04coordinate INFO_SC108395_dorsal_0708coordinates INFO_SC108395_ventral_0506coordinates INFO_SC108395_ventral_0910coordinates
Burin spalls (8 items)	INFO_SC83193_dorsal_05coordinate INFO_SC84124_ventral_09coordinate INFO_SC85883_ventral_05coordinate INFO_SC90865_ventral_04coordinate INFO_SC90865_ventral_04coordinate INFO_SC109639_dorsal_04coordinate INFO_SC109673_dorsal_09coordinate INFO_SC109673_ventral_05coordinate
Burins (8 items)	INFO_SC86328_ventral_09coordinate INFO_SC94171_dorsal_11coordinate INFO_SC94171_ventral_08coordinate INFO_SC95092_dorsal_05coordinate INFO_SC97597_ventral_05coordinate INFO_SC102392_ventral_09coordinate INFO_SC107801_ventral_05coordinate INFO_SC107801_ventral_0506coordinates
Denticulate (2 items)	INFO_SC98438_dorsal_04coordinate INFO_SC98438_dorsal_07coordinate
Flakes (17 items)	INFO_SC83141_ventral_09coordinate INFO_SC83141_ventral_11coordinate INFO_SC84314_ventral_10coordinate INFO_SC84728_ventral_04coordinate INFO_SC84728_ventral_0304coordinate INFO_SC84757_ventral_08coordinate_10x INFO_SC84882_ventral_0910coordinate INFO_SC85670_ventral_07coordinate INFO_SC95086_ventral_04coordinate INFO_SC95246_ventral_09coordinate INFO_SC95248_ventral_05coordinate INFO_SC96663_dorsal_0607coordinates INFO_SC96663_ventral_0708coordinate INFO_SC97058_ventral_07coordinate INFO_SC102764_ventral_06coordinate INFO_SC102821_ventral_09coordinate_PDSM INFO_SC107452_ventral_05coordinate
Fragments (9 items)	INFO_SC83284_dorsal_11coordinate INFO_SC83285_ventral_10coordinate INFO_SC83374_ventral_11coordinate INFO_SC83412_ventral_09coordinate INFO_SC83865_ventral_0607coordinates INFO_SC84424_ventral_11coordinate INFO_SC84688_ventral_0405coordinate INFO_SC84853_ventral_04coordinate INFO_SC87299_ventral_04coordinate
Microburins (13 items)	INFO_SC85314_ventral_10coordinate INFO_SC87418_dorsal_05coordinate INFO_SC94988_ventral_06coordinate INFO_SC95068_dorsal_04coordinate_PDSM INFO_SC95112_ventral_06coordinate

	INFO_SC97925_ventral_10coordinate INFO_SC98000_dorsal_07coordinate INFO_SC98452_dorsal_11coordinate INFO_SC108320_ventral_11coordinate INFO_SC108875_dorsal_05coordinate INFO_SC108875_ventral_04coordinate INFO_SC115158_dorsal_09coordinate INFO_SC116256_ventral_04coordinate
Microliths (29 items)	INFO_SC82819_dorsal_10coordinate INFO_SC83087_ventral_03coordinate INFO_SC83087_ventral_10coordinate INFO_SC83372_dorsal_0405coordinates INFO_SC83372_ventral_07coordinate INFO_SC83372_ventral_14coordinate_HA INFO_SC84884_ventral_12coordinates INFO_SC85895_ventral_03coordinate INFO_SC85895_ventral_11coordinate INFO_SC85955_ventral_07coordinate INFO_SC86199_dorsal_10coordinate INFO_SC86199_ventral_1011coordinate_possMLIT INFO_SC87246_ventral_0809coordinates INFO_SC87800_dorsal_08coordinate INFO_SC87800_ventral_0304coordinate INFO_SC89752_dorsal_0607coordinates INFO_SC94176_ventral_06coordinate INFO_SC94552_dorsal_06coordinate_possMLITs INFO_SC94552_ventral_0708coordinate INFO_SC96615_dorsal_04coordinate INFO_SC98199_dorsal_09coordinates INFO_SC98199_dorsal_0708coordinates INFO_SC98199_dorsal_middleofflint_10x_possMLITs INFO_SC98628_ventral_0607coordinates INFO_SC102327_ventral_0304coordinate INFO_SC107673_dorsal_04coordinate INFO_SC108397_dorsal_12coordinate INFO_SC108397_dorsal_0708coordinates INFO_SC108397_ventral_0809coordinates
Scrapers (30 items)	INFO_SC83086_dorsal_0809coordinate INFO_SC83086_ventral_0708coordinate INFO_SC83157_ventral_06coordinate INFO_SC83201_ventral_0607coordinate INFO_SC83431_ventral_08coordinate INFO_SC83520_ventral_06coordinate INFO_SC83934_ventral_06coordinate INFO_SC84070_ventral_10coordinate INFO_SC84125_ventral_06coordinate INFO_SC84660_ventral_05coordinate INFO_SC85427_ventral_06coordinate INFO_SC85798_ventral_06coordinate INFO_SC85982_ventral_08coordinate INFO_SC87384_dorsal_07coordinate INFO_SC87561_ventral_05coordinate INFO_SC91176_ventral_06coordinate INFO_SC91420_dorsal_05coordinate INFO_SC91420_ventral_06coordinate INFO_SC91526_ventral_05coordinate INFO_SC94323_ventral_08coordinate

	INFO_SC95428_ventral_07coordinate INFO_SC95428_ventral_0708coordinate INFO_SC96624_ventral_07coordinate INFO_SC96638_ventral_0607coordinate INFO_SC96989_ventral_08coordinate INFO_SC97217_ventral_07coordinate INFO_SC97616_ventral_08coordinate INFO_SC98557_ventral_07coordinate INFO_SC107459_ventral_06coordinate INFO_SC107994_ventral_05coordinate
Strike-a-lights (4 items)	INFO_SC94619_dorsal_9coordinate INFO_SC94619_dorsal_10coordinate INFO_SC102669_ventral_15coordinate_10x INFO_SC102669_ventral_15coordinate_10x

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