Sabine Gaudzinski-Windheuser · Olaf Jöris (Eds.)

The Beef behind all Possible Pasts

The Tandem-*Festschrift* in Honour of Elaine Turner and Martin Street

Volume 2

Römisch-Germanisches
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Leibniz-Forschungsinstitut
für Archäologie
RGZM

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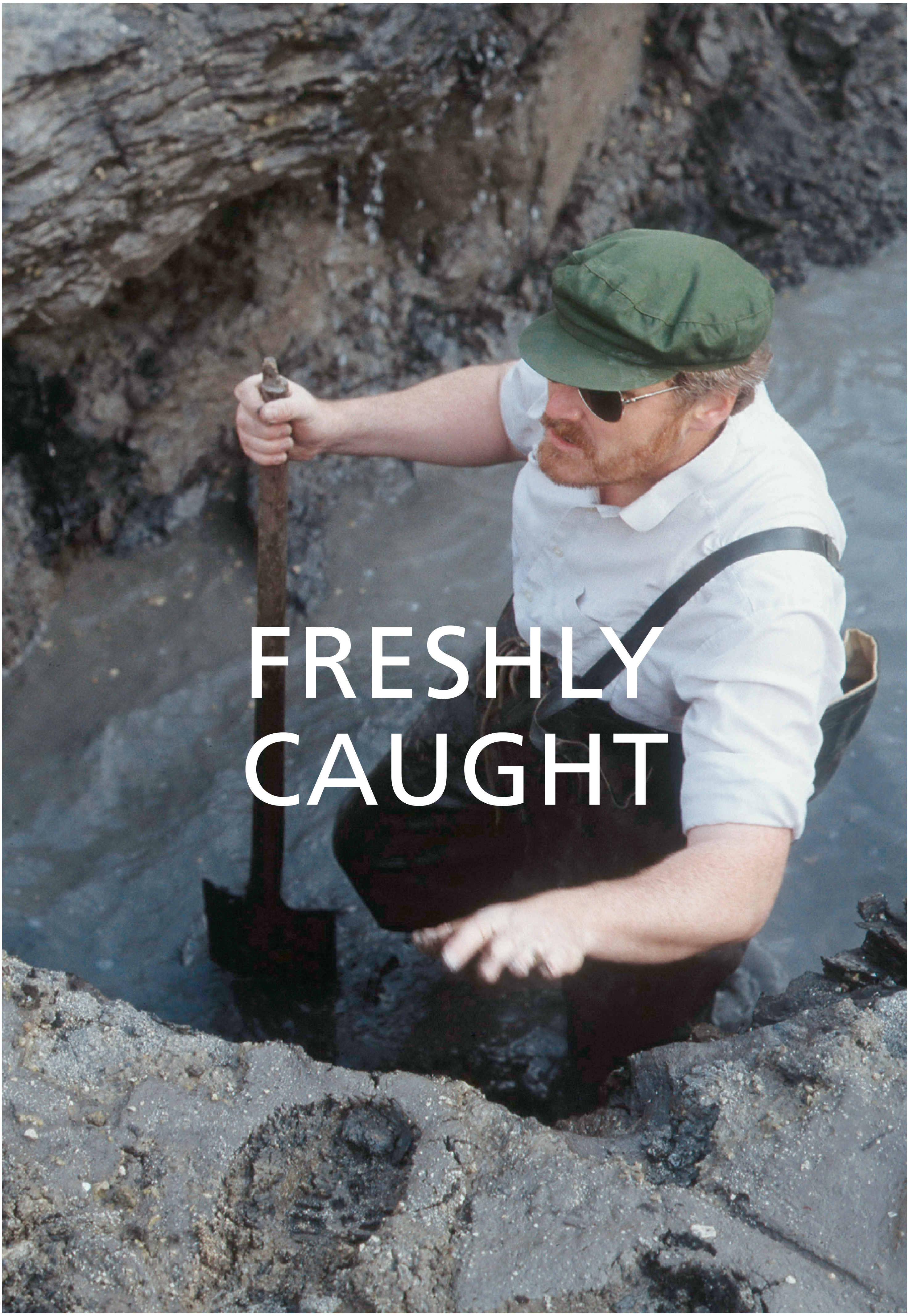
Elaine and Martin, MONREPOS, 2021.

FRESHLY CAUGHT



Elaine and her Schöningen-Team – Jarod Hutson, Alex García-Moreno and Aritza Villaluenga with the newly arrived Hippo skeleton, MONREPOS, 2015.

Starting at around the Late Glacial, adaptation strategies diversified in most regions of the inhabited world and on average, preservation of sites is of better quality than before. During this period the Neuwied Basin can even be described as an Ice Age Pompei, in analogy to the Roman city buried under volcanic deposits – archaeology "freshly caught" indeed.

Thus, it is no wonder Elaine and Martin spent a lot of time in the field over the years to recover and uncover the unique archaeology of this region. The archaeology perserved in the Late Glacial forests of the region shows how much life had changed compared to the preceeding periods, with hunter-gathers turing into hunter-gatherer-fishers whereever possible and succeeded by relying on the regional resources that defined their territories. Martin was probably also "freshly caught" unaware when he was summoned by Gerhad Bosinski to undertake the rescue excavations at Bedburg-Königshoven, where he discovered two examples of very rare deer antler masks, interpreted in the realm of shamanism, as well as an early specimen of "man's (new) best friend" – an early dog.

Elaine and Martin share an interest in wolves, that Martin managed to act out professionally with his research on the dogs from the Bonn-Oberkassel burial and Elaine took to comparative zoo-archaeological actualistic studies to explore (but this in another chapter…).

Martin during excavations at Miesenheim IV, 1989. Do not show this picture to anybody responsible for safety regulations during excavations!

In: S. Gaudzinski-Windheuser · O. Jöris (Eds.), The Beef behind all Possible Pasts. The Tandem-*Festschrift* in Honour of Elaine Turner and Martin Street. Monographien des RGZM 157 (Mainz 2021). DOI: 10.11588/propylaeum.950.c12571

Martin with Gerhard Bosinski and Bernhard Gramsch in Brohltal, ca. 1894.

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Elaine with her partner Walter Mehlem in Miesenheim IV, 1989.

Balancing act with shovel. Martin during excavations at Bedburg-Königshoven, 1988.

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Elaine with another tree trump in Brohltal, ca. 1984.

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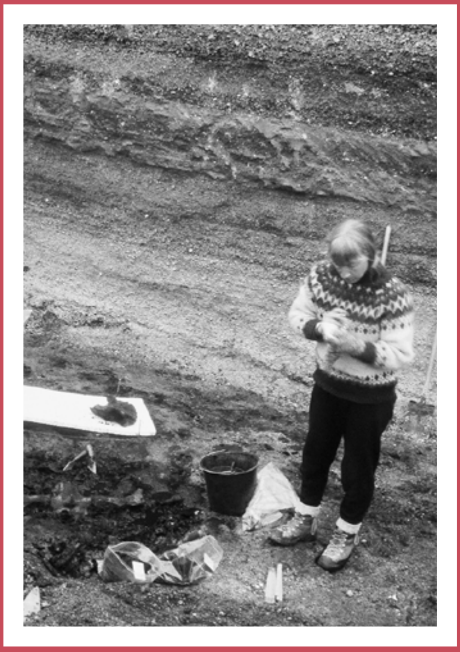
Martin the mudlark, looking astonishingly clean during excavations in Miesenheim IV, 1989.



Elaine with bucket at Miesenheim IV, 1989.

Martin having a break during excavation of the famous deer antler masks at the Mesolithic site of Bedburg-Königshoven, 1988.

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Martin at Miesenheim IV, 1989.

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Martin with Jean-Philip Fagnard in Amiens (France), ca. 1994.

Very postmodern. Elaine in 2015, bodily experiencing the past, mimicking the posture of a female buried at Taforalt (Morocco).

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LATE GLACIAL OCCUPATION OF NORTHERN GERMANY AND ADJACENT AREAS. REVISITING THE ARCHIVES

Abstract

This contribution presents the status quo of research on the Final Palaeolithic occupation of Schleswig-Holstein. Over the last two decades new insights became possible based on isotopic, genetic, biostratigraphic, tephrochronologic, and archaeological analyses. Some of these projects and studies are still on-going. The material on which these analyses were performed was mainly uncovered during the 20th century. We particularly focus on the chronology and the different challenges associated with the Late Glacial record. To do so, we review the radiocarbon dating record of Schleswig-Holstein and adjacent areas, especially Denmark, including 11 new radiocarbon dates from the sites of Stellmoor and Meiendorf. At present, in particular, the period of the Federmessergruppen (i. e., curve-backed point industries) appears poorly represented in this record. This shortage is due to preservational conditions on the one hand, as well as the often uncertain attribution of osseous single finds to archaeological entities on the other. Hence, a synoptic analysis of osseous remains of Late Glacial northern Germany and southern Scandinavia is desirable.

The recently introduced partially laminated biostratigraphic lake sequence from Nahe LA 11 contains three cryptic tephra layers including the first geochemically identified evidence of the Laacher See Tephra in Schleswig-Holstein. The palynological analysis of this archive interlinks palaeoenvironmental with archaeological research questions. Amongst other implications, the data provided here suggest a continuity of human and reindeer presence in the area until the early Holocene. This result lines up with observations of shifting ecological zones throughout the Weichselian Late Glacial in Schleswig-Holstein.

Keywords

Schleswig-Holstein, Final Palaeolithic, Weichselian Late Glacial, chronology, osseous material

INTRODUCTION

At the MONREPOS Archaeological Research Centre and Museum for Human Behavioural Evolution Elaine Turner and Martin Street represented the well-established field of zooarchaeology to inform us about past human settlement and land use behaviour (Turner, 2004; Street et al., 2006; Street and Turner, 2013). Their studies in the Central Rhineland were made possible by the excellent preservation of organic material underneath the ignimbrites and pumices of the Laacher See volcanic eruption. The organic preservation further allowed for the establishment of a reliable chronology of the Late Glacial re-settlement of north-western central Europe after the Last Glacial Maximum (Street et al., 1994; Housley et al., 1997; Terberger and Street, 2002; Street and Terberger, 2004; Stevens et al., 2009; Fiedel et al., 2013). With the increasing industrial exploitation of the Laacher See pumice in the 1950s and 1960s, Late Glacial/Allerød surfaces were uncovered and thereby revealing archaeological remains from Late Magdalenian and *Federmessergruppen* (FMG) contexts which accordingly became a focus of research (Bosinski, 1979; Baales, 2002). Besides the excellent preservation conditions, these relatively recent discoveries also paved the way to apply modern standards of excavation, documentation, and archiving. These conditions allowed for some of the most

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detailed insights into the reconstruction of Late Upper and Final Palaeolithic lifeways. Furthermore, the Laacher See volcano – like many of the volcanic craters in the Eifel volcanic field – has transformed into a maar lake. Laminated sequences from these natural sediment traps were used to build up a stacked record of Late Glacial climatic and environmental change, which is in large parts annually laminated (ELSA; Sirocko, 2016). Hence, for the Late Glacial and early Holocene periods, a detailed vegetation history with relevance for the wider region was also established (Litt and Stebich, 1999; Sirocko et al., 2016). These high-resolution records helped to contextualise the archaeological findings of the Central Rhineland. Researchers in other areas aimed to synchronise their records with these high-resolution archives through the use of archaeological comparison or by bio- or tephrochronology (Housley et al., 2013). The Laacher See tephra (LST) has been of particular interest as a short-term chronostratigraphic marker horizon (Litt et al., 2001; Blockley et al., 2008; Wulf et al., 2013).

Recently, the LST has been geochemically confirmed for the first time in Schleswig-Holstein (Krüger and van den Bogaard, 2021). In contrast to the Rhineland, research on the Late Glacial in Schleswig-Holstein has been more or less continuous since the 19th century, with numerous collections but few excavations and variable standards of documentation (Schwantes, 1923, 1928, 1933; Schwabedissen, 1944; Taute, 1968; see below). Hence, to understand the occupation history of the region and attempting to base this on a solid chronostratigraphic framework, this area offers a large amount of legacy data and all the challenges that come with it. In the last years, some new analyses were made, especially at the Centre for Baltic and Scandinavian Archaeology (ZBSA) and in the context of the subproject "Pioneers of the North" of the DFG-funded collaborative research centre 1266 "Scales of Transformation". The results allow new insights that are outlined in the following, with a focus on the Late Glacial chronology of Schleswig-Holstein, supplemented with data from adjacent areas.

RESEARCH HISTORY

The excavations of Alfred Rust and his interdisciplinary team in the Ahrensburg tunnel valley in the 1930s, 1940s, and early 1950s (**Fig. 1**; Rust, 1937, 1943, 1958) provide a first milestone in the Palaeolithic archaeology of Schleswig-Holstein. In these campaigns, Palaeolithic organic material uncovered from Late Glacial lake deposits included the oldest wooden arrows (unfortunately lost during World War II; cf. Hartz et al., 2019). Especially the excavations at Stellmoor (Ahrensburg LA[1] 78.1) provided the stratigraphic evidence that the Hamburgian preceded the Ahrensburgian. Furthermore, these technocomplexes were associated with the palynologically well-defined bio zones that were (later) named Meiendorf and Younger Dryas (i.e., Dryas 3) (Menke, 1968; cf. Krüger et al., 2020) and allowed for a first general chronostratigraphy. Following this pioneering work, few systematic excavations of Late Glacial material have been conducted in the Ahrensburg tunnel valley and in entire Schleswig-Holstein. This research will be shortly presented in the following.

In the late 1960s/early 1970s Gernot Tromnau excavated different concentrations of Late Glacial archaeological material on the sandy Teltwisch ridge in the Ahrensburg tunnel valley. This showed the potential for further excavations of Late Glacial organic material by corings and test trenches in nearby kettle holes (Tromnau, 1975). Besides Hamburgian and Ahrensburgian material, he also identified two small concentrations with FMG material. In the Vierbergen area in the northern part of the Ahrensburg tunnel valley,

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[1] LA = Landesaufnahme (register of prehistoric and historic artefacts and archaeological sites and monuments of Schleswig-Holstein).

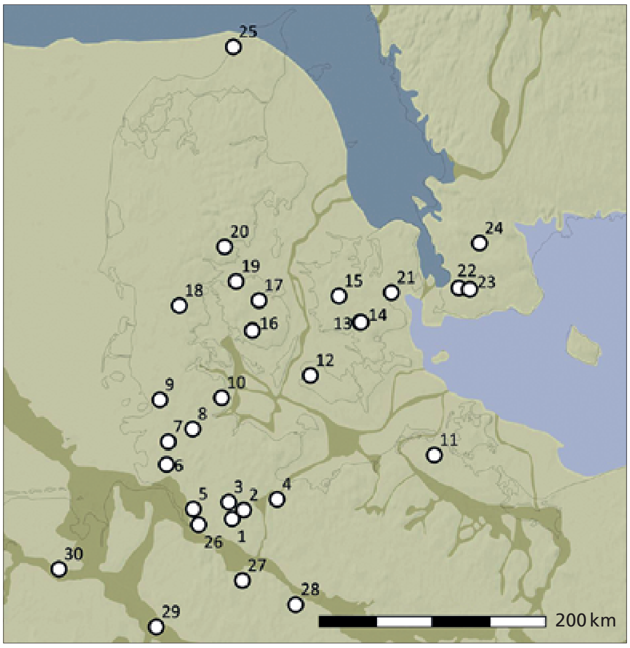

Fig. 1 Map of northern Germany and southern Scandinavia during GI-1c-a with major glacial valleys and drainage channels indicated (darker green) and sites mentioned in the text and the tables (map: www.epha.zbsa.eu – Allerød map with the addition of drainage systems). **1** Ahrensburg tunnel valley; **2** Lasbek; **3** Nahe; **4** Lüdersdorf; **5** Klein Nordende; **6** Eggstedt; **7** Schalkholz; **8** Alt Duvenstedt; **9** Ahrenshöft; **10** Klappholz; **11** Endingen; **12** Krogsbølle; **13** Trollesgave; **14** Fensmark Skydebane; **15** Bromme; **16** Arreskov; **17** Odense Kanal; **18** Slotseng; **19** Fogense Enge; **20** Tyrsted; **21** Køge Bugt; **22** Bara Mosse; **23** Hässelberga; **24** Mickelsmosse (Munkarp); **25** Nørre Lyngby; **26** Rissen; **27** Melbeck; **28** Grabow 15; **29** Hämelsee; **30** Querenstede.

east of the Borneck site (Ahrensburg LA 76), in 1985 Klaus Bokelmann could not find any archaeological remains in a 6-7 m deep survey trench and hence identified the limits of the concentration of Palaeolithic sites that he assumed was due to the geomorphology of the Late Glacial landscape (Bokelmann, 1996). In 2008 Ingo Clausen conducted a survey of test trenches and corings (Ahrensburg LA 78.2) to locate A. Rust's Stellmoor excavation trenches more precisely and to test if archaeological material was still present and preserved (Clausen, 2010). In January 2010, most of the Ahrensburg tunnel valley became a "Natura 2000" conservation area within the EU Habitats Directive (92/43/EEC) and the accompanying management plan prohibited any further penetration into the ground. However, in the context of the planned expansion of the railway line S4 through the Ahrensburg tunnel valley, further test pits and trenches on the mineral soils near Stellmoor (Stellmoor-Lusbusch, Ahrensburg LA 105, 160, 162, and 187), around Meiendorf (Ahrensburg LA 79 and 140), and into the Hamburgian area of the tunnel valley became possible in summer 2015 (Clausen and Guldin, 2016, 2017). These identified the limits of the accumulation of Late Glacial sites around Meiendorf, which was almost congruent with the modern border of the federal states of Schleswig-Holstein and Hamburg. Furthermore, corings in Late Glacial lake sediments south of Stellmoor (Ahrensburg LA 187-191) revealed the preservation of bone and antler material in an area larger than hitherto known. New palynological samples were taken during these efforts (Krüger, 2015) and, most importantly, Sascha Krüger could obtain access to the archival data of the region collected by Hartmut Usinger.

Outside the Ahrensburg tunnel valley, Hermann Schwabedissen's work in 1948 at the site of Rissen 14/14a to the west of Hamburg, where an Ahrensburgian horizon was underlain by a FMG horizon, clarified the chronostratigraphic sequence of the northern German Final Palaeolithic (Schwabedissen, 1954): The Hamburgian present during the Meiendorf period was followed by the FMG during the Allerød period and in turn was followed by the Ahrensburgian during the Dryas 3. In 1959, Wolfgang Taute excavated typical Ahrensburgian material associated with long and large blades in Eggstedt (LA 50), but only some material was recovered *in situ* as previous amateur excavations had disturbed the area (Taute, 1968). In 1960 he excavated Ahrensburgian material including a few faunal remains in an area of the Lieth Moor near Klein

Nordende (LA 2; Taute, 1968). South-west of this site, K. Bokelmann and the amateur Alfred Rasmussen uncovered several concentrations of FMG and faunal material in the 1970s (Klein Nordende LA 37: Bokelmann et al., 1983). In 2013, Ingo Clausen and Annette Guldin tested an area north-west of this and west of W. Taute's site because – over the course of several decades – collectors had reported (mainly) Ahrensburgian artefacts from there, and geologists had reconstructed Late Glacial wetlands in the vicinity. However, only fragmented stratigraphic sequences were found that showed significant movement of sediment due to various natural processes such as water level changes or cryoturbation. This was explained by the very complex geomorphological situation in the region that often included significant changes over short distances.
Furthermore, in 1970 another Hamburgian site was rescue excavated in a single day by A. Rust and G. Tromnau at the limits of a gravel pit near Schalkholz (LA 116; Tromnau, 1974). Nearby, Volker Arnold found a partially destroyed FMG concentration (Schalkholz LA 65) that was also uncovered in a rescue excavation by K. Bokelmann and Dieter Stoltenberg in late 1975 (Bokelmann, 1978). From the mid-1980s to the early 1990s I. Clausen and Sönke Hartz – excavating near Alt Duvenstedt – uncovered a total of nine Late Glacial concentrations of lithic material that in some cases centred around a still identifiable hearth (Clausen and Hartz, 1988; Clausen, 1995, 1996a; Kaiser and Clausen, 2005). Most assemblages were attributed to the FMG but two were of a very early Ahrensburgian origin (Clausen and Schaaf, 2015). In the mid-1990s two sites with Hamburgian material were excavated at Ahrenshöft in the context of a renaturalisation program (Clausen, 1997). Especially the site Ahrenshöft LA 73 has major relevance for the Late Glacial chronology as, for the first time, a horizon containing an inventory dominated by classic Hamburgian shouldered points was overlain by a horizon with mostly Havelte tanged points. Palynological analyses further showed that both horizons were deposited at different stages within the Meiendorf period (Usinger, 1997). In 2008 Mara-Julia Weber extended the excavation area at the Havelte concentration Ahrenshöft LA 58 D (Weber et al., 2010). Finally, the most recently identified area of finds is situated around the north-western outlet of the modern Lake Itzstedt where Thomas Poelmann had collected Ahrensburgian and Hamburgian material since 1986 (Nahe LA 11). In 2003, I. Clausen made some test trenches in the wetlands of the present-day Rönne valley and found some faunal material dominated by reindeer (Weber et al., 2011; Wild, 2017). I. Clausen's work was complemented by 68 sediment cores that H. Usinger took along and across the valley. The results of these corings helped S. Krüger to identify the basin of a former incision lake (palaeolake Nahe) and to locate the currently best Late Glacial environmental archive of Schleswig-Holstein. This was cored in October 2017 (Dreibrodt et al., 2021; Krüger, 2020; Krüger and van den Bogaard, 2021; Krüger et al., 2020). In addition, H. Usinger has left a large archive of palaeoenvironmental information from his coring campaigns in different locations throughout Schleswig-Holstein. This material is currently under revision.
In summary, most excavated sites with Late Pleistocene archaeology are clustered in seven find areas: the Ahrensburg tunnel valley, Rissen, Klein Nordende, Nahe, Alt Duvenstedt, Schalkholz, and Ahrenshöft. Therefore, most research was focused on these areas, making predictive modelling across most of Schleswig-Holstein rather difficult (Hamer et al., 2019). Furthermore, in total very few pieces of faunal material were found after the Ahrensburg tunnel valley excavations of the 1930s to 1950s, no further wooden artefacts could be detected. In addition, some mostly single faunal remains were collected during different dredging works. Hence, the material from A. Rust's excavations remained the most relevant assemblages and have been re-analysed on different occasions (Grønnow, 1985; Bratlund, 1990, 1996; Weinstock, 2000a, 2000b; Pasda, 2009; Wild, 2020). In contrast to the Central Rhineland, a documentation record that allows each artefact to be located precisely within the site is mostly missing; this is partially due to the excavation standards at the time and partially due to difficult excavation circumstances underneath the groundwater table (cf. Slotseng; Wild, 2020). The exclusive preservation of organic material in discard zones or as single finds

from waterlogged contexts makes the approach to understanding the occupation history and settlement behaviour through zooarchaeological analyses for the Final Palaeolithic of Schleswig-Holstein impossible. Nevertheless, especially in combination with palynological data, this material allows for further chronological considerations. In a few publications, radiocarbon dates from northern German sites were compiled and re-evaluated, in collaborations including researchers from both MONREPOS and Schleswig (Grimm and Weber, 2008; Riede et al., 2010; Weber et al., 2011). Based on these and on additional studies and analyses of the last decade, we will establish a more detailed chronology of the Final Palaeolithic of this region and discuss human-environment interactions during the Weichselian Late Glacial.

ARCHIVES

As the research history in Schleswig-Holstein encompasses more than 150 years, a wealth of material and data is known. It can roughly be divided into two categories: on the one hand the actual material that was collected from surface surveys or during excavations and coring programs, and on the other hand the documentation and reports of such activities or materials. Archaeological sites in Schleswig-Holstein including those of single finds are reported in the register of prehistoric and historic artefacts and archaeological sites and monuments of Schleswig-Holstein (*Landesaufnahme*, see footnote 1). This collection of sites, their location, reports about their discovery, and description of the identified features and archaeological material is maintained at the Archaeological State Office Schleswig-Holstein (*Archäologisches Landesamt Schleswig-Holstein*: ALSH). The actual archaeological material as well as the documentation that does not remain with the collector is archived at the State Museum for Archaeology in Schloss Gottorf (*Museum für Archäologie*: MfA). These archives allow queries on authenticity, spatial and chronological attribution, and different new approaches, but they also require different lines of source criticism. Many of the archaeological excavations and collections and/or their documentation do not conform to modern standards. Before the reliability of the data can be assessed, meticulous comparisons with the old documentation and the results of modern analytical methods and techniques are necessary so that further information from the material can be extracted (e. g., Groß et al., 2021; Hinrichs, 2020).

For the identification of potential taphonomic processes and possible palimpsests, more precise documentation of the context and location of artefacts is necessary. However, this is rarely available for older excavations. For instance, A. Rust recorded the spatial position of artefacts in two dimensions only during his later excavations, and only on a square metre basis (Rust, 1958). Although there are some uncertainties with the available coarse-grained 2D spatial information, it does allow some testing of the integrity of assemblages and implications for understanding settlement behaviour (Hinrichs, 2020). A general outline of the stratigraphy is also usually given and frequently accompanied by a palynological analysis allowing insights into the chronostratigraphic development of the site. 3D documentation of artefact positions and of higher resolution stratigraphic data became standard much later in Schleswig-Holstein, but proved that many of the sites studied with these refined methods were affected by complex geomorphological processes (Bokelmann et al., 1983; Kaiser and Clausen, 2005; Wild, 2017).

Usinger's palaeoenvironmental archive – comprising the documentation of analysed stratigraphic sequences – includes information on their location, counting sheets of the samples taken from these sequences, as well as occasional personal comments. In general, remains of the sediment cores or samples are preferably stored in cooling chambers, while prepared samples (such as the material from palaeolake Nahe) are stored in the archives of the respective laboratories.

RECENT CONTRIBUTIONS TO LATE GLACIAL CHRONOLOGY AND ARCHAEOLOGY

The general stratigraphic succession of the Palaeolithic archaeological units in Schleswig-Holstein has been known for over 70 years (see above research history); also, the vegetation history of the region has been well established for several decades (Usinger, 1985). Yet the biostratigraphic terminology occasionally causes some confusion and discussion. For the Rhineland, this was settled by the definitions based on the nearby maar sequences from the Eifel (Litt and Stebich, 1999), whereas in northern Germany and especially in Denmark the use of the term Bølling remained controversial, depending on which part of Iversen's classical palynological definition (Iversen, 1942) was used: "the first spread of tree birch" in the sense of a "biozone" (Usinger, 1978, 1985) or "the temperate climatic oscillation that preceded the Allerød" in the sense of a "chronozone" (Krüger and Damrath, 2020). Hence, in the following the INTIMATE event stratigraphy with its recognition of Greenland Stadials (GS) and Interstadials (GI) will be used in a chronozone and event stratigraphy approach (**Tab. 1**; Rasmussen et al., 2014). In a recently published article about a sequence from the Lake Bølling type locality (Krüger and Damrath, 2020), one of the authors highlighted the problem of the double characterisation of Bølling that was previously addressed (Usinger, 1997; De Klerk, 2004). Nevertheless, with the new stratigraphy from the palaeolake Nahe, some new considerations about the development of the biozones in Lower Saxony, Schleswig-Holstein, and southern Denmark became possible (Krüger et al., 2020). Inter-regional comparison of three high-resolution palaeoenvironmental archives from these regions showed different onsets, durations, and appearances of woodland phases shifting from south to north (Krüger et al., 2020: fig. 7). This puts Schleswig-Holstein in a transitional zone for most of the Late Glacial, making precise palaeoenvironmental studies accompanying archaeological research important tools for locating the sites not only chronologically but also ecologically. Furthermore, it indicates that chrono- and biozones must be clearly differentiated when discussing this area.

The record of palaeolake Nahe comprises a robust age-depth model based on radiocarbon dates, three crypto-tephra layers including the first geochemical finger-print of the LST from the region (Krüger and van den Bogaard, 2021), and a laminated section covering the period of GI-1c_3 to GI-1a (Dreibrodt et al., 2021). The palaeoenvironmental data from the palaeolake Nahe reflects the developments in southern Schleswig-Holstein with relevant find areas such as the Ahrensburg tunnel valley, Klein Nordende, the immediate surroundings of the palaeolake itself, and the Hamburg area of Rissen. Based on lithological, geochemical, and palynological data, the Dryas 3 biozone has been bisected in this stratigraphy into an upper, more humid, and a lower, drier part at around the fallout deposition of the Islandic Vedde Ash (Krüger et al., 2020), a distinction that was already observed in other archives (Overbeck, 1975; Bakke et al., 2009; cf. Weber et al., 2011). Although the generally accepted development of the vegetation in Schleswig-Holstein is confirmed by the palaeolake Nahe sequence, the development within the biostratigraphically defined Allerød period can be further refined here. Furthermore, the Meiendorf period proves to be more complex than generally considered. When comparing the onset of these biozones to the onsets in the western German Meerfelder Maar (Litt and Stebich, 1999) with the chronozones based on the current INTIMATE event stratigraphy (Rasmussen et al., 2014), we find offsets that can only partially be explained with the successive ecological reaction to general climatic changes, reflecting the complexity of regional environmental transformations (Krüger et al., 2020). Yet, the palaeolake Nahe sequence also demonstrates that charcoal particles and non-pollen palynomorphs (NPPs) can help answering archaeological questions (Krüger, 2020).

The palaeoenvironmental studies were embedded in the previously mentioned large scale cooperation project (CRC 1266), in which also some archaeological and genetic studies were accomplished (Burau, 2019;

Palaeolake Nahe			INTIMATE event stratigraphy	Meerfelder Maar		
Palynological characteristics of NAH PAZ lower boundaries	Age estimate for boundaries **[yrs cal BP]**	NAH bio-stratigraphic terminology	Mean Age for boundary **[yrs cal BP]**	MFM bio-stratigraphic terminology	Age estimate for boundaries **[varve yrs BP]**	Palynological characteristics of MFM PAZ lower boundaries
Betula pub.-type ↑, Filipendula, Typha lat.-type ↗ Poaceae, Artemisia, Empetrum, other NAP-types ↘		Preboreal	Holocene	Preboreal		Betula, Pinus ↑, Juniperus ↓, NAP-types ↓
	11,560 *		**11,653**		**11,590**	
Betula pub.-type ↘, B. nana-type ↗ Poaceae, Artemisia, other NAP-types ↗		Dryas 3	GS-1	Younger Dryas		Betula, Pinus ↓, Salix ↑ NAP-types ↑
	12,540		**12,846**		**12,680**	
Betula pub.-type ↗, Juniperus ↘ Poaceae, other NAP-types ↘		Allerød 3	GI-1c$_1$-1a	Allerød		Pinus, Filipendula ↑ NAP-types, Artemisia ↓
	13,610		**13,550**		**13,350**	
Betula pub.-type ↘, Juniperus ↗ Poaceae ↗		Allerød 2/ Dryas 2	GI-1c$_2$	Older Dryas		Betula ↓ Artemisia ↑
	13,710		**13,610**		**13,650 ****	
Betula pub.-type ↑, Hippophaë ↗ Poaceae, Helianthemum ↘		Allerød 1	GI-1c$_3$	Bølling		Betula ↑ NAP-types, Artemisia ↓
	13,830		**13,904**		**13,780 ****	
Hippophaë, AP ↘ Poaceae, Helianthemum, Rumex acet.-type ↗		Dryas 1	GI-1d	Oldest Dryas		Betula, Salix ↓ NAP-types ↑
	13,940		**14,025**		**13,910 ****	
Pinus ↘, Betula pub.-type, B. nana-type ↗ Artemisia, Hippophaë ↗		Meiendorf	GI-1e	Meiendorf	end of lamination: **14,560 ****	Pinus ↓, Betula, Salix, Juniperus ↑
	14,510		**14,642**		unknown	
		Pleniglacial	GS-2.1	Pleniglacial		

Tab. 1 Comparison of terminology and age estimate of the Meerfelder Maar (MFM; Litt and Stebich, 1999: Tab. 2), the Palaeolake Nahe (NAH; Dreibrodt et al., 2021: Tab. 2 modified according to Krüger et al., 2020 for boundaries and terminology), and the INTIMATE event stratigraphy (Rasmussen et al., 2014). PAZ Pollen assemblage zones.
* age estimate (varve yrs cal BP; cf. Merkt and Müller, 1999) used to create present age- depth modelling.
** original age estimates of Litt and Stebich (1999) have been shifted by 110 years to the older, considering a hiatus according to Brauer et al. (2001).

Hamer et al., 2019; Grimm et al., 2020; Hinrichs, 2020). Additionally, a number of dissertations and smaller cooperation projects increased our knowledge of the Late Glacial in the last decade (Rivals et al., 2020; Wild, 2020; Wild et al., in press). Results from all these projects are combined in the following overview.

Classic Hamburgian / Havelte Group

The available radiocarbon dates have been discussed in a previous review of the Hamburgian (Grimm and Weber, 2008). Since then 20 new radiometric results have been obtained in the course of various projects (**Tab. 2**). Five additional dates on worked reindeer antler (**T2: 15-17, 19-20**[2]) confirmed the thus far accepted dating range for the Meiendorf site (Ahrensburg LA 79) in an early phase of GI-1e, which cannot be defined chronologically more precisely due to a radiocarbon plateau during this interval (Wild, 2020). Two new results (KIA-53517; KIA-53518; **T2: 12-13**) obtained on petrous bones in the framework of a genetic study of reindeer confirm this picture and even extend the dating range into GS-2.1, whereas a third one (KIA-53519; **T2: 21**) prolongs the range to mid-GI-1e (cf. **Tab. 1**), which corresponds to the occupation of the neighbouring Poggenwisch site (Ahrensburg LA 101 and 137; Wild, 2020). The genetic study considerably enlarged the radiocarbon record for Stellmoor by seven new dates (**T2: 3-9**), which, when calibrated, show a similar distribution to the dates from Meiendorf. Another five measurements were made on reindeer bones attributed to the classic Hamburgian sites of Stellmoor (n = 3) and Meiendorf (n = 2), but produced dates that fall into the Ahrensburgian (**T2: 47, 50, 52, 69-70**; cf. Rivals et al., 2020; see below Ahrensburgian). Hence, in total we currently know of 61 dates that are associated with the Hamburgian in Schleswig-Holstein, of which 32 appear to be reliable (cf. Pettitt et al., 2003).

In Denmark, two further dates were obtained on a modified reindeer antler and bone dredged from the Køge Bugt, where another worked reindeer antler had already been found that was dated to the Hamburgian (**Tab. 3**; Fischer and Jensen, 2018; Wild, 2020). The new date on the antler from the Køge Bugt (AAR-18732; **T3: 13**) is very similar to the previous one (AAR-1036; **T3: 14**), and the date on a reindeer bone (AAR-18733; **T3: 12**) is only slightly older. Both dates support a presence of hunter-gatherers in eastern Denmark during the second half of GI-1e. Altogether 13 radiocarbon dates are published and judged as reliable for the Hamburgian in Denmark mostly coming from Slotseng in eastern Jutland (n = 10; Grimm and Weber, 2008). In addition to the radiocarbon dates, the excavation of the new site Krogsbølle – containing material attributable to the Havelte Group – substantiated the corpus of Havelte Group material in Denmark (Riede et al., 2019). After correction of the marine reservoir effect, a gull (*Larus* sp.) from a palaeolake adjacent to Krogsbølle dates to GI-1e, but cannot be linked to human activity (AAR-17464: 12,710 ± 55 ^{14}C-BP; Riede et al., 2019).

In sum, the calibrated radiocarbon dates for the Hamburgian indicate that hunter-gatherers visited the area of Schleswig-Holstein throughout GI-1e and GI-1d. According to isotope analyses on reindeer bone and micro-wear analyses on reindeer molars from Meiendorf and Stellmoor, the GI-1e environment of these animals presented little soil maturation and provided limited lichen availability, but more than in other European regions (Drucker et al., 2011; Rivals et al., 2020). The Havelte Group occupation at Ahrenshöft LA 58 D may even be attributed to GI-1c$_3$, which would correspond to the palynological characterisation of the occupation layer confirmed by analyses in 2008 and 2009 (Weber et al., 2010). Nevertheless, the calibrated date (AAR-2784; **T2: 32**) also spans into GI-1d and the site underwent considerable post-depositional processes.

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[2] References to specific radiocarbon dates listed in **Table 2** and in **Table 3** are referred to in the following format: **T2/3: #ID#**, where it is specified whether **Table 2** or **Table 3** are meant, followed by the reference to the ID(s) within that table.

At a chronological micro-scale, the combination of zooarchaeological and technological observations on different Hamburgian sites and on the French Magdalenian site of Verberie led to a model of hunter-gatherer economy and settlement throughout different phases of the autumn season (Wild, 2020).

Federmessergruppen (FMG)

The number of radiocarbon dates associated with the FMG in Schleswig-Holstein is limited (n = 12). Some dates have previously been revised, highlighting the frequently problematic association of the dated material and the archaeological remains (Riede et al., 2010). In total, only eight dates can be associated with human occupation during the time of the FMG (**Tab. 2**). The uncertain association with the FMG is partially due to the generally limited and/or poor preservation of organic material from this period and the subsequent lack of identified human modification of the material, and partially due to the lack of knowledge about what happened to the Hamburgian groups as well as about how the Brommean and Ahrensburgian developed. Only charcoal from Alt Duvenstedt LA 120 b (AAR-2244; **T2: 38**) was found in association with lithic material (Kaiser and Clausen, 2005); a bone sample from the same site lacked collagen and resulted in a much too young age (AAR-2243-3: 4,420 ± 70 ^{14}C-BP; Kaiser and Clausen, 2005), and was consequently excluded from our compilation.

The faunal material from Borneck was mostly recovered in wetland excavations adjacent to the site where Hamburgian, FMG, and Ahrensburgian material had been excavated (Rust, 1958). Although the dated specimens from box trench ("*Kammer*") III display no cut-marks, their position near the accumulation of archaeological remains at Borneck suggests a connection to human activities, yet a natural origin (background fauna) cannot be excluded. The dates (Riede et al., 2010) rule out an attribution to the Ahrensburgian but an association of a reindeer humerus (KIA-33949; **T2: 36**) with a very late Hamburgian is still possible though not likely (see above Classic Hamburgian/Havelte Group). Rudolf Schütrumpf conducted a palynological analysis of the stratigraphy in this trench and attributed the lower horizon from which the faunal material originated to the Older Dryas period (Rust, 1958: 88; Allerød 2/Dryas 2 according to: Krüger et al., 2020; **Tab. 1**). This attribution fits well with the calibrated results but makes an attribution to the late Hamburgian very unlikely (see above).

For Klein Nordende LA 37, the fish remains seem to form part of a natural thanatocoenosis (Benecke and Heinrich, 2003), and the previously dated twigs (**T2: 33-34**) also reflect a natural event that was stratigraphically correlated with the lower archaeological deposits of the area CR (Bokelmann et al., 1983). However, the stratigraphy in the area of Klein Nordende is highly complex not only due to halokinetic processes but also due to soil creep and displacing of layers due to changing water levels, sediment admixture at the banks, freezing and thawing processes. Hence, the relation of the dated samples to the archaeological material remains uncertain but likely determines a *terminus post quem* for the human presence at the locality (cf. Riede et al., 2010). Hence, only the cut-marked elk bone from the Allerød gyttja in the area D unambiguously dates human activity at Klein Nordende (KIA-33951; **T2: 35**), but in this area no lithic archaeology was found, potentially allowing its attribution to the FMG or to the early Ahrensburgian. A conventional radiocarbon date (Y-442: 11,220 ± 350 ^{14}C-BP; Barendsen et al., 1957) from the site of "Lieth" (i.e., Klein Nordende LA 33) was obtained from a peat sample but was excluded from the study for technical reasons, although the top of the dated peat-lens within dune deposits produced a curve-backed point indicative of a FMG context. Certainly, the area of the Lieth Moor around Klein Nordende was visited repeatedly during the Late Glacial by different groups, but in order to reconstruct the settlement history more radiocarbon dates would be required.

Outside of Schleswig-Holstein, five dates were measured in the late 1950s on samples from the Rissen area in Hamburg that is known for its FMG material. Unfortunately, the association of the sample material with the archaeology remained uncertain and the results are technically questionable. Moreover, two samples were dated from Grabow 15 (**T3: 15-16**), which is located near to the well-known site of Weitsche (Veil and Breest, 2002; Veil et al., 2012), and yielded some evidence of amber working and amber artefacts besides a rich FMG assemblage (Tolksdorf et al., 2013). The Grabow samples originated from archaeological features associated with FMG artefacts similar to the lithic material found in Weitsche (Tolksdorf et al., 2013). The sedimentation as well as the palynological analysis suggests that the site dates to the transition from the Dryas 1 to the Allerød period. This attribution matches with the calibrated ages. The dates are slightly older than the dates correlated with the lower horizon of Klein Nordende CR and, hence, represent the earliest FMG in northern Germany. Two dates on bulked samples of cremated bones from Weitsche are slightly younger. The younger date (**T3: 18**) had a sufficient amount of carbon preserved (5.2 mg), whereas the older date (**T3: 17**) yielded small amounts only (0.5 mg). But the very similar results indicate no significant source of contamination affected the samples. Both dates further support the presence of FMG in northern Germany during this period.

In total, the FMG radiocarbon record reflects discontinuous settlement in northern Germany and Schleswig-Holstein. However, the appearance of this discontinuous record may result from the poor preservation of datable material from this period. This contrasts with the amount and the distribution of sites associated with FMG material; both suggest a wide extent over a period of noticeable duration. Additionally, the major results of a modelling approach indicate that the FMG were rather well established in their local environments (Hamer et al., 2019), from which we can cautiously conclude that they knew their environments well, supporting a more continuous presence in the landscape. In contrast, the number of Danish FMG (lithic) assemblages is small. Association of lithic assemblages with radiocarbon dates is not given in a single case (Pedersen, 2009; Petersen, 2009). Hence, this could well reflect the only occasional presence of FMG groups in this area (Eriksen, 2000, 2002).

Furthermore – due to their radiocarbon dates pointing into the Late Glacial Interstadial – two artefacts made of reindeer antler have to be mentioned in the context of the FMG occupation of the region: the double bevelled point from Lasbek LA 14 (**T2: 73**; Wild and Weber, 2017; ZooMS-determination by Th.T.Z. Jensen) and the so-called antler axe (Lyngby type artefact) from Klappholz LA 63 (**T2: 72**; Clausen, 2004). However, the technological habitus in which these specimens were made resembles other Final Palaeolithic technocomplexes, namely the Hamburgian in the case of the Lasbek piece (Wild and Weber, 2017), and the Brommean or Ahrensburgian for the Klappholz specimen (Clausen, 2004).

This discrepancy may suggest (i) problems with the radiometric results, (ii) that our current knowledge about the presence of the various archaeological entities is incomplete, or (iii) that the osseous industry may have developed asynchronously to the lithic industries. The first aspect does not appear very likely in view of increasingly rigorous protocols at the radiocarbon laboratories. That our knowledge is incomplete should become apparent in this contribution and also the desideratum for osseous studies from Late Glacial northern Germany and southern Scandinavia. In fact, several other osseous artefacts were dated to this overlapping period of the FMG, the Brommean, and, possibly, the early Ahrensburgian.

For Denmark, some further dates in this age range need to be discussed in this context (**Tab. 3**), although the sampled material is usually associated with the Brommean. In particular, results from Nørre Lyngby were frequently mentioned in this context, since one of the first Bromme points was found and described from this site; also the eponymous Lyngby antler artefact has been defined at this locality (Eriksen, 1999; Fischer et al., 2013a; cf. Petersen, 2021). However, these finds were not made together and, although the new palaeontological investigation focused on the same freshwater deposits, there is no established connection with the previous artefact finds. From the new investigations, only one specimen showed traces of possible human modification and was dated to the GI-1c$_1$ (AAR-1511; **T3: 28**; Aaris-Sørensen, 1995). The original Lyngby antler artefact dates to the early Holocene (AAR-8919: 9,110 ± 65 ^{14}C-BP), which is comparable to the antler artefact from the Swedish Bara Mosse (OxA-2793: 9,090 ± 90 ^{14}C-BP; Larsson, 1996; Fischer et al., 2013a); yet, both were subject to contamination with conservation material and considered as potentially too young. The date from Arreskov (OxA-3173; **T3: 32**) was made on a single find of a reindeer antler artefact (Fischer, 1996). It dates slightly later than the Brommean dates from Denmark (see below). The slightly older Lyngby antler artefact from Odense Kanal (AAR-9298; **T3: 30**; Stensager, 2006) dates close to the dates from Alt Duvenstedt LA 121 (AAR-2245-1; AAR-2245-2; **T2: 40-41**) and 123 (AAR-2246; **T2: 39**) and, hence, could be viewed in an early Ahrensburgian context. The bone point from Fogense Enge (AAR-15025; **T3: 31**) dates between these two implements (Petersen, 2021), and can also be discussed within FMG, early Ahrensburgian as well as Brommean contexts (Jensen et al., in prep). An antler club from Mickelsmosse in southern Sweden (OxA-2791; **T3: 29**) was dated to a similar period as the Odense Kanal specimen (Larsson, 1996), but – due to its geographical position – should rather be discussed within the Brommean.

This short review reveals some important points: firstly, reindeer seems to have been used as a resource throughout the Final Palaeolithic, thus revising a long obsolete picture of FMG as only elk hunters (Clausen, 2004; Riede et al., 2010, Wild and Weber, 2017; Weber and Wild, 2019). Further, newly dated reindeer antler artefacts suggest that in Denmark reindeer antler may even have been used predominantly as osseous raw material during the Allerød (Wild et al., in press). Secondly, the transitional character of the environment in Schleswig-Holstein and southern Scandinavia may have played a role in the potential co-occurrence of groups adapted to different environments (cf. Eriksen, 2000, 2002; Mortensen et al., 2014; Burau, 2019; Krüger et al., 2020).

Moreover, in northern Germany and southern Scandinavia, remains of giant deer (*Megaloceros giganteus*) were found occasionally (Bratlund, 1993; Street, 1996; Aaris-Sørensen and Liljegren, 2004), and at least the northern German specimens from Lüdersdorf (Bratlund, 1993) and Endingen, Horst VI showed traces of human modification (Street, 1996). Both were directly dated but the Lüdersdorf date (OxA-3615: 11,600 ± 105 ^{14}C-BP; Hedges et al., 1993) might be subject to technical problems (column resin bleed; Burky et al., 1998) and – as the δ^{13}C value was considerably low for Late Glacial giant deer – this date has been rejected. The Endingen date (ETH-13585; **T3: 27**) fell well within GI-1c$_1$; hence, giant deer was probably also a prey of the Final Palaeolithic hunters as an increasing number of identified Late Glacial specimens suggest (Immel et al., 2015; Baales et al., 2019). However, the cultural association remains also a matter of debate for these finds. Furthermore, we do not yet know enough about the variability and development of the lithic technology of the FMG in Schleswig-Holstein to be certain about the distinction to the material of the late Hamburgian, the Brommean, and early Ahrensburgian. Currently this desideratum is approached by an on-going dissertation (Reuter, in prep.). Only a better understanding of this chronologically intermediate group will facilitate more precise interpretations of the cultural developments during the Late Glacial in northern Germany and southern Scandinavia.

Brommean

The Brommean forms the most uncertain archaeological unit in Schleswig-Holstein. Although large Brommean points are well known from this region, their relation to the FMG assemblages remains unclear. Inventories that were stratigraphically attributed to the Allerød period and thought to represent the Brommean or FMG in Alt Duvenstedt (LA 85, 86, and 89; Clausen and Hartz, 1988; Kaiser and Clausen, 2005: fig. 2) became subject to discussion when very early Ahrensburgian material was found in Allerød sediments of the same site (LA 121 and 123). Besides the lack of knowledge about the variability of the FMG (see above), the small numbers of datable material from archaeological sites limits our understanding of the presence and possible development of the Brommean in Schleswig-Holstein. Due to these uncertainties, there are no ^{14}C-dates that are reliably connected with the Brommean in the region, and we cannot reach conclusions regarding their presence and / or duration (see above FMG).

In contrast, Brommean presence and preferences are well established in Denmark (Eriksen, 1991, 1999, 2000; Mortensen et al., 2014), but the development there also remains a matter of debate (Eriksen, 2002). Although single finds of the prominent Bromme tanged point may result in a biased picture of the settlement activity, the number of reliable settlement sites remains significant (cf. Eriksen, 1999; Fischer et al., 2013b). The small number of radiocarbon dates (n = 6) originates from only three, geographically close Brommean sites (Bromme, Fensmark Skydebane, Trollesgave; cf. Fischer et al., 2013b). A further sample of a reindeer antler fragment from Bromme lacked collagen and delivered no result (AAR-4538; Heinemeier and Rud, 2000).

In addition, reindeer antler material was found near Tyrsted in a kettle hole in a well-preserved Late Pleistocene / Early Holocene palaeoenvironmental sequence with lithic material that was partially washed in from a small concentration on the north-western shore of the kettle hole (Borup and Nielsen, 2017; Eriksen et al., 2018). The lithic material can be attributed to the Brommean. Some characteristics of the archaeological material may already suggest a very late date and possibly displays even Ahrensburgian resemblance. Geophysical investigations have shown additional kettle holes in this area with high potential for Late Glacial archaeology (Corradini et al., 2020). Palaeoenvironmental and archaeological analyses are still on-going.

The limited amount of datable faunal remains and the lack of information on osseous typo-technology restricts the insights in Denmark as in Schleswig-Holstein. A project on reindeer in Denmark during the ice age aimed to revisit the faunal material and to record and study the potential human modifications. This project increased the corpus of modified osseous material significantly (Wild et al., in press).

The reliable dates assigned to the Brommean span a relatively short period. Compared to the considerable number of Brommean sites over most of Denmark (Eriksen, 1999), this would speak for intensive settlement activities and / or a particularly well-preserved section of the Late Glacial. In light of the generally difficult preservation conditions for this period, such an interpretation appears highly unlikely. Moreover, the samples of the few reliable dates come from one region only and possibly represent just one stage of a longer development (Fischer et al., 2013b). However, the numerous Brommean sites indicate the first established settlement of southern Scandinavia.

Ahrensburgian

In total we currently know of 44 dates that are associated with the Ahrensburgian in Schleswig-Holstein. Of these we consider 32 dates to be reliable (**Tab. 2**).

In comparison to a previous evaluation (Weber et al., 2011), eleven more dates can be attributed to the Ahrensburgian in Schleswig-Holstein. Three measurements were carried out on mammal bones from species other than reindeer recovered at Stellmoor: a date on bison (KIA-3331; **T2: 62**; Benecke, 2004) was overlooked in the previous evaluation, a date on elk (KIA-51382; **T2: 56**; Wild and Weber, 2017) was obtained in order to check if the remains of this species are intrusive into the Ahrensburgian horizon or not (cf. Bratlund, 1999), and a date on horse (KIA-48960; **T2: 54**; Drucker et al., 2016; Rivals et al., 2020) was made in the context of a project on understanding Late Glacial reindeer migrations. The remaining new dates on reindeer also originate from this project (**T2: 46-49, 51-52, 61**; Rivals et al., 2020) as well as from ongoing genetic studies (**T2: 50**). Four Ahrensburgian dates (**T2: 46-49**) confirmed a date which was produced at Yale University during the early years of the development of the radiocarbon method (Y-159.2: 10,320 ± 250 ^{14}C-BP; Barendsen et al., 1957), which is not considered here due to its large standard deviation but which points to Ahrensburgian presence in Stellmoor at around the middle of GS-1.

Five further samples from Stellmoor (n = 3; KIA-48959; KIA-53523; KIA-47378; **T2: 47, 50, 52**) and Meiendorf (n = 2; KIA-46301; KIA- 47380; **T2: 69-70**) were attributed to the classic Hamburgian but resulted in Ahrensburgian dates (cf. Rivals et al., 2020). In Stellmoor this can be explained by the mixture of material during its recovery or during the following storage period. However, no younger horizon has been suggested for Meiendorf thus far, although a barbed point from the pond has been discussed as an Ahrensburgian specimen (Tromnau, 1992). This attribution is further strengthened by different studies indicating that various bone point types that were previously attributed only to the Mesolithic seem to have a longer tradition and to originate in the Final Palaeolithic (Cziesla and Pettitt, 2003; Groß et al., 2020). Wild (2020) showed that collagen was preserved in the aforementioned barbed point from the site of Meiendorf, but in contrast to other faunal remains from the site the collagen yield was so low that currently a too large sample would be necessary to date the specimen directly. Another sample from Meiendorf was previously considered as a falsely labelled specimen from the Stellmoor site when it was dated to the Ahrensburgian (K-4330; **T2: 71**; Fischer and Tauber, 1986; Weber et al., 2011). Yet, this date and the two additional Ahrensburgian dates from Meiendorf as well as the barbed point could alternatively indicate that the Meiendorf pond preserved a second, younger archaeological horizon which remained undetected during the early excavations.

In the context of Ahrensburgian chronology, a series of seven radiocarbon measurements intended to determine the age of two potential arrow shaft fragments found in A. Rust's legacy need to be mentioned (Meadows et al., 2018). As their provenance remains unknown and both items have been contaminated with consolidants, the dates cannot serve as evidence for the Ahrensburgian settlement. The oldest and reliable results of the seven dates (KIA-49753: 10,050 ± 90 ^{14}C-BP; KIA-49754: 9,915 ± 45 ^{14}C-BP; Meadows et al., 2018) fall into the range of the accepted Ahrensburg dates obtained from faunal remains.

At Nahe LA 11, four radiocarbon dates indicate the presence of Ahrensburgian hunters at both the beginning and the end of GS-1 (Weber et al., 2011). Continued human presence into the Preboreal period is indicated from sediment cores retrieved in the vicinity of the archaeological site within the palaeolake (Krüger, 2020; Krüger et al., 2020). This indication consists of charcoal particles most likely to originate from anthropogenic fires at the shores of the lake. The situation at Nahe thereby corresponds to that at Poggenwisch where reindeer remains were found in peat attributed to the Preboreal period (Herre and Requate, 1958), and to that at Stellmoor where the uppermost Ahrensburgian horizon can be associated with the early Preboreal period on the basis of the partly revised biostratigraphy (Krüger, 2020). In addition, the Stellmoor radiocarbon dates confirm a continuation of the Ahrensburgian into the early Holocene, and a comparison of Ahrensburgian and Mesolithic radiocarbon dates shows that in northern Germany the transition between the two archaeological entities only occurred at the end of the GH-11.4 ka event (Grimm et al., 2020). Considering all reliable radiocarbon dates for Schleswig-Holstein, the presence of Ahrensburgian groups from possibly as early as GI-1b throughout GS-1 into GH-11.4 can be suggested.

The most restrained explanation for the continuation of the Ahrensburgian into the early Preboreal would lie in the development of favourable feeding conditions for reindeer during this period. For GS-1, the results of isotope and micro-/meso-wear analyses of reindeer remains suggest that a tundra landscape with a considerable amount of lichen was present in southern Schleswig-Holstein (Drucker et al., 2011; Rivals et al., 2020). At the onset of the Preboreal period, an increasing availability of young birch shoots can be observed in the Nahe record, where they coincide with maximum values of coprophilous fungal spores (originating from fungi that germinated on reindeer feces). This coincides with the highest frequency of larger charcoal particles indicative of local anthropogenic fires (Krüger, 2020), leading to the hypothesis that longer seasonal stays of reindeer herds led to the intensification of human presence at the site.

Groups classified as Mesolithic due to techno-typological criteria seem to have established earlier in Denmark than in Schleswig-Holstein (Jessen et al., 2015; Jensen et al., 2020). However, the Ahrensburgian technological tradition has continued in the osseous material adapted to different faunal species (Wild et al., in press).

At an annual scale, seasonal migrations in east-west direction of the reindeer hunted at Stellmoor and Meiendorf are suggested on the basis of further isotope analyses carried out within the abovementioned reindeer project (Price et al., 2017). An even smaller temporal scale was aimed at by attempts to refit the lithic material from two neighbouring Ahrensburgian units at Borneck. The analysis showed, however, that a contemporaneous occupation of both units under study can be excluded (Hinrichs, 2020).

CONCLUSION

If we focus on the chronological indications of the material and their relation to human activity, we can identify the presence of humans throughout most of the Late Glacial in Schleswig-Holstein and their frequent presence in Denmark. However, if we try to link the dating evidence to specific technocomplexes defined on the basis of lithic material (Hamburgian, FMG, Brommean, Ahrensburgian), we clearly see the limits of our legacy data and single finds. For several sites in Schleswig-Holstein we must admit that much desirable information is forever lost with respect to old excavations or collections. Nonetheless, material studies of this old material are still possible and new analyses show the potential of these old finds to speak for themselves beyond chronological considerations. Furthermore, the surveys showed that at a site such as Stellmoor more material is still preserved in the ground. Although hydrological changes and interventions occasionally lead to the destruction of archaeological organic remains which had preserved until now (e.g., Star Carr, Satrup), demanding archaeological rescue, so long as natural protection remains high and the hydrology of this area is monitored, the archaeological remains seem well protected and waiting for future investigations requiring only minimal invasive and destructive measures.

The lack of additional data makes it difficult to correlate archaeological and palaeoenvironmental data. The need of this correlation becomes particularly relevant in transitional areas of different ecological zones such as in Schleswig-Holstein during the Late Glacial. A potential step forward for bringing together the palaeoenvironmental and archaeological data lies in the examination of additional charcoal particles, as the palaeolake Nahe data showed (Krüger, 2020). The observation of shifting ecological zones implies that in different parts of Schleswig-Holstein different habitats existed contemporaneously during the Late Glacial, which might explain observed temporal overlaps of different technocomplexes, such as the Hamburgian in northern Schleswig-Holstein and the FMG in southern Schleswig-Holstein (Burau, 2019). Comparably, in later phases the geological and pedological differences could explain different developments of the landscapes and subsequent cultural phenomena in a roughly east-west direction (Mortensen et al., 2014). The picture is further complicated by species that are not restricted to one of these ecological zones. Hence, a simple eco-deterministic correlation is not possible in these areas.

Finally, another consequence of these shifting ecological zones is the irregular offset of chronozones (as in the INTIMATE event stratigraphy) and biozones documented for Schleswig-Holstein and most of northern Europe during the Late Glacial. This calls for rigorous considerations of the chronology of archaeological sites to allow comparison on a supra-regional European scale.

ID	site	district	material	species	method	lab. no.	Age ^{14}C [BP]	± [BP]	Age [cal BP *]	Age [cal BP **]	δ^{13}C [‰]	comment	references
	Hamburgian												
1	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone, bulked material	x	conv.	KN-2223	12,590	80	15,200-14,560	15,258-14,453	-	classic Hamburgian	Grimm and Weber, 2008
2	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone/antler, bulked material	Cervidae	conv.	KN-2224	12,530	160	15,340-14,060	15,291-14,126	-	classic Hamburgian	Grimm and Weber, 2008
3	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone	*R. tarandus*	AMS	KIA-53524	12,510	55	15,060-14,420	15,072-14,352	-20.0	classic Hamburgian	this contribution
4	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone	*R. tarandus*	AMS	KIA-53520	12,485	55	15,000-14,360	15,011-14,317	-19.2	classic Hamburgian	this contribution
5	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone	*R. tarandus*	AMS	KIA-53522	12,485	55	15,000-14,360	15,011-14,317	-20.1	classic Hamburgian	this contribution
6	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone	*R. tarandus*	AMS	KIA-53525	12,460	55	14,970-14,290	14,973-14,308	-17.8	classic Hamburgian	this contribution
7	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone	*R. tarandus*	AMS	KIA-53527	12,450	55	14,950-14,270	14,962-14,297	-20.0	classic Hamburgian	this contribution
8	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone	*R. tarandus*	AMS	KIA-53521	12,305	50	14,600-14,000	14,812-14,081	-19.8	classic Hamburgian	this contribution
9	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone	*R. tarandus*	AMS	KIA-53526	12,210	55	14,350-13,910	14,772-13,887	-19.4	classic Hamburgian	this contribution
10	Stellmoor (Ahrensburg LA 78.1)	Stormarn	antler	*R. tarandus*	AMS	K-4261	12,190	125	14,650-13,730	14,835-13,792	-18.6	classic Hamburgian	Fischer and Tauber, 1986
11	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone	*R. tarandus*	AMS	K-4328	12,180	130	14,630-13,710	14,838-13,787	-18.0	classic Hamburgian	Fischer and Tauber, 1986
12	Meiendorf (Ahrensburg LA 79)	Stormarn	bone	*R. tarandus*	AMS	KIA-53517	12,525	55	15,080-14,480	15,112-14,371	-20.6	classic Hamburgian	this contribution
13	Meiendorf (Ahrensburg LA 79)	Stormarn	bone	*R. tarandus*	AMS	KIA-53518	12,520	55	15,060-14,460	15,101-14,361	-19.5	classic Hamburgian	this contribution
14	Meiendorf (Ahrensburg LA 79)	Stormarn	bone		conv.	KN-2220	12,470	250	15,480-13,760	15,521-13,817	-	classic Hamburgian	Grimm and Weber, 2008
15	Meiendorf (Ahrensburg LA 79)	Stormarn	antler, humanly modified	*R. tarandus*	AMS	KIA-52178	12,455	55	14,960-14,280	14,967-14,304	-18.3	classic Hamburgian	Wild, 2020
16	Meiendorf (Ahrensburg LA 79)	Stormarn	antler, humanly modified	*R. tarandus*	AMS	KIA-52180	12,425	55	14,920-14,200	14,938-14,260	-18.7	classic Hamburgian	Wild, 2020
17	Meiendorf (Ahrensburg LA 79)	Stormarn	antler, humanly modified	*R. tarandus*	AMS	KIA-52176	12,405	55	14,880-14,160	14,896-14,208	-19.2	classic Hamburgian	Wild, 2020
18	Meiendorf (Ahrensburg LA 79)	Stormarn	antler	*R. tarandus*	AMS	K-4329	12,360	110	14,940-13,940	14,948-14,077	-18.3	classic Hamburgian	Fischer and Tauber, 1986
19	Meiendorf (Ahrensburg LA 79)	Stormarn	antler, humanly modified	*R. tarandus*	AMS	KIA-52177	12,355	55	14,770-14,050	14,841-14,115	-19.2	classic Hamburgian	Wild, 2020
20	Meiendorf (Ahrensburg LA 79)	Stormarn	antler, humanly modified	*R. tarandus*	AMS	KIA-52179	12,355	55	14,770-14,050	14,841-14,115	-19.1	classic Hamburgian	Wild, 2020
21	Meiendorf (Ahrensburg LA 79)	Stormarn	bone	*R. tarandus*	AMS	KIA-53519	12,270	50	14,520-13,960	14,805-14,056	-20.2	classic Hamburgian	this contribution
22	Poggenwisch (Ahrensburg LA 101)	Stormarn	bone	*R. tarandus*	AMS	K-4332	12,570	115	15,280-14,320	15,268-14,299	-18.6	classic Hamburgian	Fischer and Tauber, 1986
23	Poggenwisch (Ahrensburg LA 101)	Stormarn	bone		conv.	KN-2754	12,470	95	15,090-14,170	15,077-14,213	-	classic Hamburgian	Grimm and Weber, 2008
24	Poggenwisch (Ahrensburg LA 101)	Stormarn	wood	*Betula* sp.	conv.	GrN-11254	12,460	60	14,990-14,270	14,982-14,297	-28.6	classic Hamburgian	Tromnau, 1992: 81, Anmerk. 8
25	Poggenwisch (Ahrensburg LA 101)	Stormarn	bone	*R. tarandus*	AMS	K-4331	12,440	115	15,090-14,050	15,069-14,135	-18.8	classic Hamburgian	Fischer and Tauber, 1986
26	Poggenwisch (Ahrensburg LA 101)	Stormarn	bone, humanly modified	*R. tarandus*	AMS	K-4577	12,440	115	15,090-14,050	15,069-14,135	-17.4	classic Hamburgian	Fischer and Tauber, 1986
27	Poggenwisch (Ahrensburg LA 101)	Stormarn	antler, humanly modified	*R. tarandus*	AMS	KIA-32926	12,365	60	14,790-14,070	14,848-14,138	-20.4	classic Hamburgian	Grimm and Weber, 2008

Tab. 2 Reliable radiocarbon dates of Final Palaeolithic material from Schleswig-Holstein. * 95 % confidence interval, using the CalPal-2019-Hulu calibration curve in CalPal program, Version 2020.2 (Weninger and Jöris, 2008) ** 95,4 % confidence interval, unmodelled, using IntCal 20 (Reimer et al., 2020) in the OxCal program, version 4.4 (Bronk Ramsey, 2009)

ID	site	district	material	species	method	lab. no.	Age ^{14}C [BP]	± [BP]	Age [cal BP*]	Age [cal BP**]	δ^{13}C [‰]	comment	references
28	Poggenwisch (Ahrensburg LA 101)	Stormarn	antler with attached cranial bone	*R. tarandus*	AMS	KIA-32927	12,330	55	14,700-14,020	14,829-14,091	-21.3	classic Hamburgian	Grimm and Weber, 2008
29	Poggenwisch (Ahrensburg LA 101)	Stormarn	antler, humanly modified	*R. tarandus*	AMS	KIA-32925	12,265	55	14,490-13,970	14,804-14,051	-21.6	classic Hamburgian	Grimm and Weber, 2008
30	Ahrenshöft LA 73 South, layer I	Nord-friesland	charcoal	*Pinus* sp.	AMS	KIA-3605	12,200	60	14,340-13,900	14,777-13,871	-	Havelte Group	Clausen, 1997
31	Ahrenshöft LA 73 North, layer II	Nord-friesland	charcoal	*Salix/ Populus*	AMS	KIA-3833	12,130	60	14,170-13,850	14,153-13,807	-	classic Hamburgian and Havelte Group	Clausen, 1997
32	Ahrenshöft LA 58 D	Nord-friesland	charcoal		AMS	AAR-2784	12,030	60	14,050-13,730	14,050-13,794	-25.7	Havelte Group	Clausen, 1997
	Federmessergruppen (FMG)												
33	Klein Nordende LA 37 C	Pinneberg	wood, twigs	*Hippophaë* sp.	conv.	KI-2124	12,035	110	14,180-13,620	14,166-13,607	-	archaeological connection uncertain	Bokelmann et al., 1983
34	Klein Nordende LA 37, erosion channel (south of A)	Pinneberg	wood, twigs	*Hippophaë* sp.	conv.	KI-2152	11,990	100	14,070-13,590	14,075-13,607	-	archaeological connection uncertain	Bokelmann et al., 1983
35	Klein Nordende LA 37 D	Pinneberg	bone, femur proximal sin.	*A. alces*	AMS	KIA-33951	11,035	50	13,090-12,810	13,086-12,840	-20.5	with cut-marks	Riede et al., 2010
36	Borneck Kammer III (Ahrensburg LA 76)	Stormarn	bone, humerus distal sin.	*R. tarandus*	AMS	KIA-33949	11,940	50	13,950-13,630	14,025-13,609	-17.5	archaeological connection uncertain	Riede et al., 2010
37	Borneck Kammer III (Ahrensburg LA 76)	Stormarn	bone, tibia distal sin.	*A. alces*	AMS	KIA-33950	11,770	55	13,750-13,430	13,766-13,502	-19.5	archaeological connection uncertain	Riede et al., 2010
38	Alt Duvenstedt LA 120 b	Rendsburg-Eckernförde	charcoal		AMS	AAR-2244	11,780	110	13,880-13,360	14,003-13,430	-		Clausen, 2004
	Ahrensburgian												
39	Alt Duvenstedt LA 123	Rendsburg-Eckernförde	charcoal		AMS	AAR-2246	11,060	110	13,150-12,750	13,161-12,761	-		Clausen, 2004
40	Alt Duvenstedt LA 121	Rendsburg-Eckernförde	charcoal		AMS	AAR-2245-1	10,810	80	12,900-12,660	12,920-12,627	-		Clausen, 1996b
41	Alt Duvenstedt LA 121	Rendsburg-Eckernförde	charcoal		AMS	AAR-2245-2	10,770	60	12,820-12,660	12,830-12,679	-		Clausen, 1996b
42	Nahe LA 11	Segeberg	bone, humic acid, humerus	*R. tarandus*	AMS	KIA-23369	10,610	80	12,820-12,340	12,747-12,336	-		Weber et al., 2011
43	Nahe LA 11	Segeberg	antler with cranial bone attached	*R. tarandus*	AMS	KIA-23372	10,544	49	12,740-12,340	12,699-12,473	-20.5		Weber et al., 2011
44	Nahe LA 11	Segeberg	bone, lumbar vertebra	*R. tarandus*	AMS	KIA-23370	10,172	45	11,930-11,650	11,969-11,620	-19.3		Weber et al., 2011; Wild, 2017
45	Nahe LA 11	Segeberg	bone, lumbar vertebra	*R. tarandus*	AMS	KIA-23371	10,142	49	11,900-11,540	11,943-11,406	-16.7		Weber et al., 2011; Wild, 2017
46	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone, mandibula	*R. tarandus*	AMS	KIA-46300	10,445	40	12,680-12,080	12,614-12,102	-16.3		Rivals et al., 2020
47	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone, tibia sin.	*R. tarandus*	AMS	KIA-48959	10,335	30	12,350-11,870	12,461-11,949	-18.6	attributed to classic Hamburgian	Rivals et al., 2020
48	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone, mandibula dext., human modification (part of the so-called Kultpfahlschädel)	*R. tarandus*	AMS	KIA-51367	10,294	54	12,340-11,740	12,461-11,830	-17.9		Rivals et al., 2020

Tab. 2 (continued)

ID	site	district	material	species	method	lab. no.	Age ^{14}C [BP]	± [BP]	Age [cal BP*]	Age [cal BP**]	δ^{13}C [‰]	comment	references
49	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone, tibia dext.	*R. tarandus*	AMS	KIA-48958	10,245	32	12,040-11,760	12,095-11,818	-18.5		Rivals et al., 2020
50	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone	*R. tarandus*	AMS	KIA-53523	10,205	40	11,980-11,700	12,001-11,741	-18.4	attributed to classic Hamburgian	this contribution
51	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone, mandibula	*R. tarandus*	AMS	KIA-46299	10,200	40	11,970-11,690	11,998-11,739	-17.0		Rivals et al., 2020
52	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone, mandibula	*R. tarandus*	AMS	KIA-47378	10,195	40	11,960-11,680	11,996-11,655	-19.2	attributed to classic Hamburgian	Rivals et al., 2020
53	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone, bulked material		conv.	KN-2222	10,160	90	12,130-11,330	12,433-11,338	-		Grimm and Weber, 2008
54	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone, costa sin., possible human modification	*Equus* sp.	AMS	KIA-48960	10,155	35	11,880-11,640	11,940-11,626	-21.9		Drucker et al., 2016; Rivals et al., 2020
55	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone	*R. tarandus*	AMS	K-4326	10,140	105	12,140-11,260	12,432-11,274	-		Fischer and Tauber, 1986
56	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone, scapula	*A. alces*	AMS	KIA-51382	10,136	51	11,900-11,500	11,941-11,405	-20.1		Wild and Weber, 2017: Anm. 1
57	Stellmoor (Ahrensburg LA 78.1)	Stormarn	antler	*R. tarandus*	AMS	K-4327	10,130	105	12,110-11,230	12,429-11,269	-17.7	attributed to classic Hamburgian	Fischer and Tauber, 1986
58	Stellmoor (Ahrensburg LA 78.1)	Stormarn	antler	*R. tarandus*	AMS	K-4262	10,110	105	12,040-11,240	12,098-11,261	-		Fischer and Tauber, 1986
59	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone	*R. tarandus*	AMS	K-4578	10,100	100	12,000-11,240	12,001-11,266	-		Fischer and Tauber, 1986
60	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone/antler, bulked material	Cervidae (*R. tarandus*?)	conv.	KN-2221	10,080	80	11,900-11,260	11,934-11,317	-		Grimm and Weber, 2008
61	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone, mandibula	*R. tarandus*	AMS	KIA-47379	10,080	+45 / -40	11,850-11,330	11,821-11,399	-17.0		Rivals et al., 2020
62	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone	*Bison* sp.	AMS	KIA-3331	10,070	50	11,830-11,310	11,820-11,351	-		Benecke, 2004
63	Stellmoor (Ahrensburg LA 78.1)	Stormarn	bone	*R. tarandus*	AMS	K-4325	10,010	100	11,850-11,170	11,872-11,238	-		Fischer and Tauber, 1986
64	Stellmoor (Ahrensburg LA 78.1)	Stormarn	antler	*R. tarandus*	AMS	K-4581	9,990	105	11,830-11,150	11,829-11,218	-		Fischer and Tauber, 1986
65	Stellmoor (Ahrensburg LA 78.1)	Stormarn	antler	*R. tarandus*	AMS	K-4579	9,980	105	11,830-11,150	11,821-11,218	-		Fischer and Tauber, 1986
66	Stellmoor (Ahrensburg LA 78.1)	Stormarn	antler	*R. tarandus*	AMS	K-4323	9,930	100	11,760-11,120	11,805-11,196	-		Fischer and Tauber, 1986
67	Stellmoor (Ahrensburg LA 78.1)	Stormarn	antler	*R. tarandus*	AMS	K-4324	9,900	105	11,760-11,080	11,811-11,166	-		Fischer and Tauber, 1986
68	Stellmoor (Ahrensburg LA 78.1)	Stormarn	antler	*R. tarandus*	AMS	K-4580	9,810	100	11,520-10,960	11,687-10,794	-		Fischer and Tauber, 1986
69	Meiendorf (Ahrensburg LA 79)	Stormarn	bone, mandibula	*R. tarandus*	AMS	KIA-46301	10,350	45	12,420-11,860	12,471-11,951	-18.3	attributed to classic Hamburgian	Rivals et al., 2020
70	Meiendorf (Ahrensburg LA 79)	Stormarn	bone, mandibula	*R. tarandus*	AMS	KIA-47380	10,145	55	11,940-11,500	11,946-11,404	-19.0	attributed to classic Hamburgian	Rivals et al., 2020
71	Meiendorf (Ahrensburg LA 79)	Stormarn	bone	*R. tarandus*	AMS	K-4330	10,110	85	11,990-11,270	11,971-11,315	-18.3	attributed to classic Hamburgian, considered as falsely labelled Stellmoor	Fischer and Tauber, 1986
	Osseous artefacts												
72	Klappholz LA 63	Schleswig-Flensburg	Lyngby antler artefact	*R. tarandus*	AMS	AAR-2785	11,560	110	14,180-13,620	13,731-13,179	-		Clausen, 2004
73	Lasbek LA 14	Stormarn	antler artefact: double bevelled point	*R. tarandus*	AMS	KIA-51380	11,169	64	13,190-12,910	13,181-12,910	-18.7		Wild and Weber, 2017

Tab. 2 (continued)

ID	site	country	material	species	method	lab. no.	Age ^{14}C [BP]	± [BP]	Age [cal BP*]	Age [cal BP**]	$\delta^{13}C$ [‰]	comment	references
	Hamburgian												
1	Querenstede	D (Lower Saxony)	charcoal		conv.	KN-2707	12,650	320	16,020-13,780	15,988-13,879	-	Hamburgian	Lanting and Van der Plicht, 1996
2	Slotseng, kettle hole	DK (South Jutland)	antler/bone, humanly modified	*R. tarandus*	AMS	AAR-906	12,520	190	15,400-13,960	15,365-14,069	-18.6	Havelte Group	Holm and Rieck, 1992; Holm, 1991
3	Slotseng, kettle hole	DK (South Jutland)	antler	*R. tarandus*	AMS	AAR-8159	12,410	70	14,920-14,120	14,938-14,191	-19.6	Havelte Group	Aaris-Sørensen et al., 2007
4	Slotseng, kettle hole	DK (South Jutland)	antler, humanly modified	*R. tarandus*	AMS	AAR-8157	12,299	41	14,540-14,020	14,806-14,083	-19.1	Havelte Group	Aaris-Sørensen et al., 2007; Grimm and Weber, 2008
5	Slotseng, kettle hole	DK (South Jutland)	bone, vertebra with flint projectile	*R. tarandus*	AMS	AAR-8165	12,290	75	14,660-13,940	14,831-14,050	-19.4	Havelte Group	Aaris-Sørensen et al., 2007
6	Slotseng, kettle hole	DK (South Jutland)	bone, vertebra with flint projectile	*R. tarandus*	AMS	AAR-8160	12,240	50	14,400-13,960	14,782-14,042	-19.0	Havelte Group	Aaris-Sørensen et al., 2007
7	Slotseng, kettle hole	DK (South Jutland)	antler	*R. tarandus*	AMS	AAR-8162	12,220	100	14,610-13,810	14,822-13,809	-18.9	Havelte Group	Aaris-Sørensen et al., 2007
8	Slotseng, kettle hole	DK (South Jutland)	bone, tibia	*R. tarandus*	AMS	AAR-8163	12,205	65	14,370-13,890	14,795-13,863	-19.5	Havelte Group	Aaris-Sørensen et al., 2007
9	Slotseng, kettle hole	DK (South Jutland)	bone, costa	*R. tarandus*	AMS	AAR-8164	12,190	50	14,290-13,890	14,311-13,881	-18.6	Havelte Group	Aaris-Sørensen et al., 2007
10	Slotseng, kettle hole	DK (South Jutland)	antler/bone, humanly modified	*R. tarandus*	AMS	AAR-8158	12,165	55	14,240-13,880	14,305-13,813	-19.0	Havelte Group	Aaris-Sørensen et al., 2007
11	Slotseng, kettle hole	DK (South Jutland)	antler, humanly modified	*R. tarandus*	AMS	AAR-8161	12,065	80	14,130-13,730	14,113-13,781	-19.7	Havelte Group	Aaris-Sørensen et al., 2007
12	Køge Bugt	DK (Zealand)	bone, humanly modified	*R. tarandus*	AMS	AAR-18733	12,238	46	14,390-13,950	14,769-14,045	-	Final Palaeolithic (Hamburgian?)	Fischer and Jensen, 2018; Wild, 2020
13	Køge Bugt	DK (Zealand)	antler, humanly modified	*R. tarandus*	AMS	AAR-18732	12,170	45	14,210-13,890	14,301-13,866	-	Final Palaeolithic (Hamburgian)	Fischer and Jensen, 2018; Wild, 2020
14	Køge Bugt 1 (also: off-shore Solrød Strand)	DK (Zealand)	antler, humanly modified	*R. tarandus*	AMS	AAR-1036	12,140	110	14,440-13,720	14,801-13,770	-	Final Palaeolithic (Hamburgian)	Fischer, 1996; Petersen and Johansen, 1996
	Federmessergruppen (FMG)												
15	Grabow 15	D (Lower Saxony)	charcoal	*Betula* sp.	AMS	KIA-41862	12,125	50	14,130-13,850	14,113-13,810	-27.7	from archaeological feature (FMG)	Tolksdorf et al., 2013
16	Grabow 15	D (Lower Saxony)	bone, calcined, one fragment unburnt		AMS	KIA-41861	12,070	100	14,200-13,680	14,218-13,614	-23.8	from archaeological feature (FMG)	Tolksdorf et al., 2013
17	Weitsche	D (Lower Saxony)	bone, cremated, bulked sample	*C. fiber* & unidentified	AMS	KIA-26439	11,980	120	14,120-13,520	14,108-13,591	-	from lithic (FMG) and amber concentration	Veil et al., 2012
18	Weitsche	D (Lower Saxony)	bone, cremated, bulked sample	*C. fiber* & unidentified	AMS	KIA-35664	11,755	50	13,720-13,440	13,756-13,501	-	from lithic (FMG) and amber concentration	Veil et al., 2012
	Brommean												
19	Trollesgave	DK (Zealand)	charcoal	*Salix* sp.	AMS	AAR-16021	11,126	44	13,130-12,890	13,155-12,916	-28.0	Brommean	Fischer et al., 2013b
20	Trollesgave	DK (Zealand)	charcoal	*Salix* sp.	conv.	K-2509	11,100	160	13,270-12,710	13,298-12,750	-24.6	Brommean	Fischer, 1996: 158; Fischer et al., 2013b

Tab. 3 Reliable radiocarbon dates of Final Palaeolithic material from adjacent areas. *95 % confidence interval, using the CalPal-2019-Hulu calibration curve in CalPal program, Version 2020.2 (Weninger and Jöris, 2008) **95,4 % confidence interval, unmodelled, using IntCal 20 (Reimer et al., 2020) in the OxCal program, version 4.4 (Bronk Ramsey, 2009)

ID	site	country	material	species	method	lab. no.	Age ^{14}C [BP]	± [BP]	Age [cal BP *]	Age [cal BP **]	δ^{13}C [‰]	comment	references
21	Trollesgave	DK (Zealand)	charcoal, bulked material	*Salix* / *Betula* / *Populus*	conv.	K-2641	11,070	120	13,180-12,740	13,166-12,761	-24.5	Brommean	Fischer, 1996: 158; Fischer et al., 2013b
22	Trollesgave	DK (Zealand)	charcoal	*Salix* sp.	AMS	AAR-16019	10,826	49	12,860-12,700	12,838-12,722	-27.0	Brommean	Fischer et al., 2013b
23	Fensmark Skydebane	DK (Zealand)	charcoal	x	AMS	OxA-3614	10,810	120	12,990-12,590	13,071-12,510	-25.5	Brommean	Fischer, 1996: 158 f.
24	Bromme	DK (Zealand)	bone fragment, vertebra lumbalis	*A. alces*	AMS	AAR-4539	10,720	90	12,810-12,570	12,835-12,491	-20.4	Brommean	Heinemeier and Rud, 2000: 302
	Ahrensburgian												
25	Melbeck	D (Lower Saxony)	charcoal	*Pinus sylvestris*?	conv.	Hv-17306	10,515	95	12,790-12,030	12,722-12,060	-	Long Blade Technology	Richter, 1992
	Osseous artefacts												
26	Endingen, Horst VI	D (Mecklenburg-West Pomerania)	bone, blade-like shaped rib	*Equus* sp.	AMS	UtC-5681	11,830	50	13,820-13,500	13,792-13,526	-	Final Palaeolithic (FMG / Brommean)	Kaiser et al., 1999: 115
27	Endingen, Horst VI	D (Mecklenburg-West Pomerania)	antler with groove and splinter technique remain	*M. giganteus*	AMS	ETH-13585 (UZ-3798)	11,555	100	13,560-13,200	13,601-13,186	-	Final Palaeolithic (FMG / Brommean)	Terberger, 1996; Kaiser et al., 1999
28	Nørre Lyngby, new investigations	DK (North Jutland)	bone, costa, cut-marks	*R. tarandus*	AMS	AAR-1511	11,570	110	13,600-13,200	13,737-13,182	-17.9	Final Palaeolithic (FMG / Brommean)	Aaris-Sørensen, 1995: 358
29	Mickelsmosse (Munkarp)	S (Scania)	antler club	*R. tarandus*	AMS	OxA-2791	10,980	110	13,110-12,710	13,094-12,749	-19.4	Final Palaeolithic (FMG / Brommean / Ahrensburgian)	Hedges et al., 1995; Larsson, 1996
30	Odense Kanal	DK (Funen)	Lyngby antler artefact	*R. tarandus*	AMS	AAR-9298	10,815	65	12,880-12,680	12,890-12,700	-	Final Palaeolithic (FMG / Brommean / Ahrensburgian)	Stensager, 2006
31	Fogense Enge	DK (Zealand)	bone rod	*A. alces*	AMS	AAR-15025	10,726	27	12,760-12,680	12,747-12,698	-	Final Palaeolithic (FMG / Brommean / Ahrensburgian)	Petersen, 2021
32	Arreskov	DK (Funen)	Lyngby antler artefact	*R. tarandus*	AMS	OxA-3173	10,600	100	12,840-12,240	12,756-12,105	-18.4	Final Palaeolithic (FMG / Brommean / Ahrensburgian)	Fischer, 1996: 158-162

Tab. 3 (continued)

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MIND THE GAP: FUNERARY BEHAVIOUR DURING THE IBEROMAURUSIAN

Abstract

Archaeological sites in Morocco and Algeria preserve a rich record of mortuary behaviour. There is a marked proliferation of visible funerary activity in the Late Pleistocene associated with the Iberomaurusian (Later Stone Age). This includes evidence of funerary caching, deliberate burial, evidence for processing of the human body including removal of soft tissues and application of ochre, curation and secondary burial, and incorporation of a range of funerary items. Among the most impressive of these burial objects are horns cores from Barbary sheep, bovids and gazelles. Funerary contexts vary in scale from sites with just one or two individuals to sites with dozens of burials of all age groups spanning several generations or longer. These larger sites can be envisaged as places that have come to be associated with the dead. Despite a large number of archaeological investigations over more than a century, there is at present an interval of around 8,000 years between the onset of the Iberomaurusian at ~25,000 cal BP and the earliest dated human burials. It remains to be seen whether this "gap" is real and whether it reflects a genuine transition in the treatment of the dead in the later part of the Iberomaurusian.

Keywords

Later Stone Age, Morocco, Algeria, burial, funerary caching, post-mortem manipulation

INTRODUCTION

The Iberomaurusian is a Later Stone Age (LSA) industry represented at archaeological sites across North West Africa dating between ~25,000 cal BP and ~12,600 ka cal BP (Hogue and Barton, 2016). The period is associated with a proliferation of human mortuary contexts, revealing complex and varied patterns of funerary behaviour, and culminating in the appearance of the earliest cemeteries in Africa (Humphrey et al., 2012). Grotte des Pigeons at Taforalt in eastern Morocco is of particular importance due to the extensive archaeological investigations undertaken during the 1950s and more recently by a team from INSAP in Morocco and institutions from the UK, France, Germany and Spain. Elaine Turner (**Fig. 1**) has been part of this project team from the onset and has undertaken the massive task of recording and interpreting the large mammalian fauna from the Iberomaurusian and earlier archaeological contexts across the site (Turner, 2019). The faunal remains associated with a series of intersecting burials located in a small alcove at the back of the cave (Sector 10) were of particular interest, and included horn cores, jawbones and other objects that had been carefully placed alongside the bodies of the deceased or surrounding and overlying their graves.

In this paper, we review Iberomaurusian funerary activity at sites in North West Africa, starting at the Atlantic coast in Morocco and travelling east through Morocco and into Algeria (**Fig. 2**). Only a few of the burials attributed to the Iberomaurusian are from securely dated contexts, and only one site has burials that are directly dated by radiocarbon dates on human bone (Humphrey et al., 2014). Some burials and isolated bones and teeth have been attributed to the Iberomaurusian by association with diagnostic lithic assemblages. Dental and skeletal characteristics have also been used as supportive evidence including robust skeletal features or tooth evulsion, a cultural modification involving deliberate removal of teeth from one

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Fig. 1 Elaine Turner excavating one of the Ammotragus horn cores that surrounded the burial Individual 5 at Sector 10 at Grotte des Pigeons, Taforalt. – (Photo: Louise Humphrey).

or both jaws during the lifetime of an individual. Evulsion of one or typically both maxillary central incisors is considered characteristic but not diagnostic of the Iberomaurusian period (De Groote and Humphrey, 2016). Following evulsion, the alveolar bone that surrounded the lost teeth gradually remodels to form a ridge. The mandibular anterior teeth often form a distinctive arch caused by uneven wear of the anterior dentition and continued emergence of the lower incisors (Humphrey and Bocaege, 2008). Although this type of dental modification continued into subsequent cultural phases in the Maghreb, the nature of the intervention diversified, and often involved a larger number of incisors from both upper and lower jaws. In some cases, direct dating of human bone may be the only way to establish the age of the burials with any certainty, but this is not always possible due to the poor physical condition of the bones. In this review, we have omitted several sites where the dating is disputed and others, such as Taza and Tamar Hat in Algeria, which have yielded only isolated bones or teeth.

WESTERN MOROCCO

Iberomaurusian funerary deposits have been uncovered during excavations of a series of caves and rock shelters along the Atlantic Coast in western Morocco. Excavations at El Harhoura 2 revealed a well-preserved skeleton of a young adult male (H3) in layer 2 (Oujaa and Lacombe, 2012). The body appeared to have been tucked into an existing empty space between boulders with no evidence for preparation of a pit or any other structure to accommodate the body, so strictly speaking this is an example of funerary caching rather than a burial (Pettitt, 2011). The body was placed on an east-west orientation with the head towards the west, but given the advantageous use of an existing crevice, this orientation may have been incidental. The body rested on the right side with the head tilted to the side. The legs were flexed at the knees and slightly elevated compared to the rest of the body, resting on a rocky surface with the feet wedged against a small heap of rocks. The skeleton remained in anatomical articulation indicating decomposition in a filled space. The upper right central incisor was completely missing but the upper left central incisor had broken at the base of the crown leaving the root in the jaw (Oujaa and Lacombe, 2012). The skeleton has not been directly dated but is derived from a level assigned to the Iberomaurusian (Stoetzel et al., 2014). Layer 2 has also yielded two isolated teeth and several isolated hand and foot bones (Oujaa and Lacombe, 2012).

A few kilometres to the north at Dar-es-Soltane I, bones representing an adult male and a juvenile with an estimated age of 10-12 years were recovered from beneath a large rock that separated layer C from the overlying layer B. The adult finds comprised a fragmentary cranial vault with three finger bones of the left hand cemented against the left side of the cranium, three teeth, vertebral and rib fragments, and several ankle and foot bones. The juvenile was represented by parts of the cranial vault and several teeth. The two individuals were attributed to the Iberomaurusian based on their robusticity and presence in level C1 (Vallois, 1951).

Excavations at the neighbouring site of Dar-es-Soltane II yielded two partial skeletons and a fragmentary mandible, found in couche 3 in 1971 (Debénath, 1972, 2000). The more complete skeleton, of a young female, was found in a highly flexed position on the left side, with the left side of the face resting on the right hand. The body had been placed on a slab of rock and covered with smaller stones. No funerary objects were found in direct association with the burial but a large stone with a concave surface showing traces of red ochre was found close to the head. Remains of a second individual found nearby were too poorly preserved and incomplete to infer the original body position, and it is possible that the skeleton had been pushed aside to make space for the subsequent deposition (Debénath, 2000). Couche 3 has been dated to 13.4 ± 0.7 ka (OSL4-X2402) (Schwenninger et al., 2010). The adult female had experienced loss of both maxillary central incisors and the left maxillary lateral incisor during life with complete remodelling of the alveolar bone, and this is likely to have been caused by tooth evulsion.

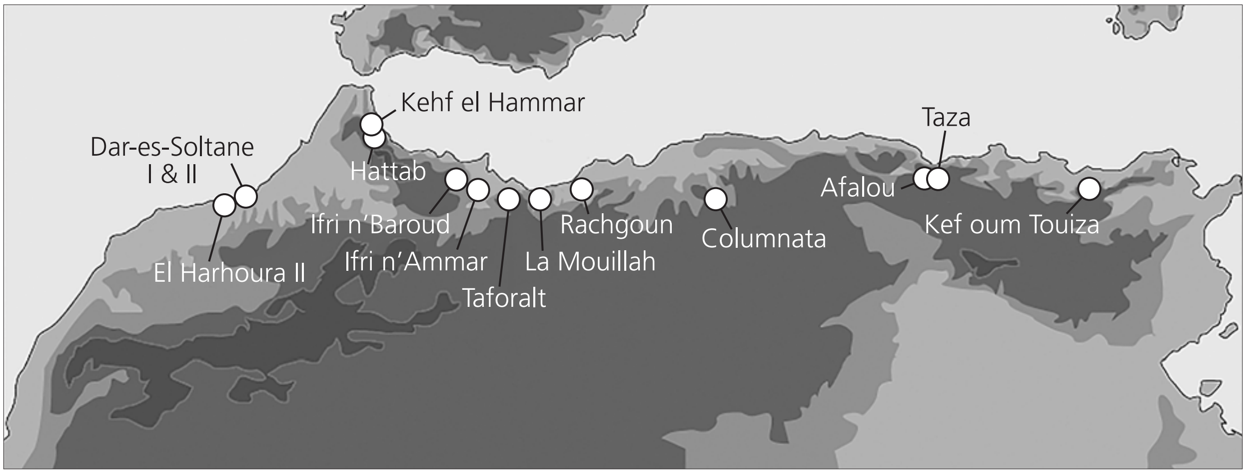

Fig. 2 Map of key sites with Iberomaurusian funerary contexts.

NORTH AND WEST MOROCCO

Moving away from the Atlantic coast, a remarkably complete skeleton of a young adult male was found at Hattab II Cave in northwestern Morocco. The body was placed in a flexed position on its left side with an approximately north-south orientation in a well-defined burial pit adjacent to the rear wall of the cave (Barton et al., 2008). The burial appeared undisturbed with most of the skeleton in anatomical articulation indicating that the body was covered soon after death, presumably by backfilling the burial pit. The burial incorporated several decorative or functional objects considered to be funerary items. The most culturally diagnostic of these was a small bladelet core of Iberomaurusian type found resting on the right femur. A marine shell located within the grave fill must have been transported from the coast, at least 10 km away. A vertebra of a large mammal was found in direct contact with the thoracic region of the skeleton. Two bone points were located within the grave fill including one found adjacent to the left ribcage that might have been used to secure some form of covering. Finally, a gazelle horn core was located directly above the skeleton close to the left knee. The burial was dated indirectly at 8,900 ± 1,100 years BP on the basis of a thermoluminescence age determination on a burnt lithic artefact from the burial fill (Barton et al., 2008). This date is unexpectedly recent but the inferred pattern of teeth evulsion is consistent with an Iberomaurusian attribution. Both upper central incisors were absent and the alveolar bone at the front of the maxilla had remodelled to form a sharp ridge, consistent with tooth evulsion some years prior to death. The mandibular teeth exhibited a pattern of differential wear and emergence that is characteristic of individuals who had experienced evulsion of the upper central incisors (Humphrey and Bocaege, 2008). Isolated bones and teeth found elsewhere at the site may indicate the presence of further disturbed burials.

Several isolated human bone fragments were recovered during excavations at the nearby cave site of Kehf el Hammar in 2002 (Barton et al., 2005). The finds represent at least five individuals, including an infant, a child aged about 7 years, an adolescent, a young adult and an older adult. The bones have not been dated either directly or by association but the young adult is represented by a fragment of the right side of the maxilla showing evulsion of the upper central incisor, which is consistent with an Iberomaurusian attribution.

Ifri n'Ammar is a rock shelter in north eastern Morocco with a deep sequence of archaeological deposits. The site has yielded five Iberomaurusian burials, including four infants and an adult male (Mikdad et al., 2002). Radiocarbon dates on charcoal from the infant burials range from 12,290 ± 133 BP to 11,009 ± 144 BP (Moser, 2003; Linstädter et al., 2012). The infants were buried side by side near the left side wall of the shelter. Three of them were arranged with the head orientated to the north, suggesting deliberate placement of the body and each of these burials was marked by a block of stone placed directly above the body but separated by a few centimetres of sediment (Mikdad et al., 2002). The unexpected arrangement of the bones of the fourth infant suggested that the body may have been decapitated and partially dismembered prior to burial (Ben-Ncer, 2004a). A photograph of the adult burial at Ifri n'Ammar reveals that the body was placed in a seated position with the lower limbs flexed and parted at the knees and the feet resting at the base of the burial close to the pelvis. The upper limbs were folded across the body with the wrists meeting just in front of the hips (Eiwanger, 2006). The sternum had slipped downwards to rest against the lower vertebrae. The cranium was found lying on its side immediately above the pelvis and right forearm and may have fallen into this position during decomposition. The position of the cranium and sternum indicate the presence of an empty space during decomposition and suggest that the seated body may have been covered, leaving a temporary void between the upper body and parted lower limbs.

The nearby rock shelter of Ifri n'Baroud yielded a single Iberomaurusian burial of an adult female (Ben-Ncer, 2004b). The body was placed in a seated position in an oval pit with a diameter of about 60 cm. The legs were flexed in front of the body, tilted slightly towards the right with the knees uppermost. The lower left arm and hand rested alongside the body at the base of the pit. The close anatomical articulation of the bones suggests that the body decomposed in a gradually filling space. The mandible was found in a disturbed context at a higher level and several bones were absent including the cranium, all of the right arm bones and the left humerus. This may reflect intentional or unintentional disturbance of the burial during subsequent human activity at the site or burrowing (Ben-Ncer 2004b). Charcoal located close to the burial has yielded radiocarbon dates between 9,677 ± 60 BP and 12,198 ± 65 BP (Ben-Ncer, 2004b; Görsdorf and Eiwanger, 1999).

Grotte des Pigeons at Taforalt is located in North East Morocco, close to the border with Algeria (Barton et al., 2019). Archaeological investigations between 1952 and 1954 revealed a remarkable assemblage of burials in two areas towards the back of the cave designated Necropolis I and Necropolis II (Roche, 1963). Recent study of the osteological assemblage (Belcastro et al., 2010; Mariotti et al., 2009; Aoudia Chouakri, 2013) and photographs and plans of some of the burials (Mariotti et al., 2014) has revealed further insights into funerary behaviour at the site. Many of the burials excavated by Roche contain multiple individuals (Ferembach et al., 1962) and at least one (Grave XV) comprises of a large collection of non-articulated bones in secondary position (Mariotti et al., 2014). Further excavations between 2005 and 2016 revealed the partially articulated skeletons and an isolated skull belonging to eight adults and six infants representing a succession of individual primary burials (Humphrey et al., 2019a). All of the adults apart from the isolated skull (Individual 10) had undergone ablation of the upper central incisors. The burials were tightly packed in the deepest recess of the cave (referred to as Sector 10), and are situated below or adjacent to the burials excavated in the 1950s. Six of the burials in Sector 10 have been directly dated to between 12,485 ± 80 BP (OxA-16689) and 12,255 ± 50 BP (OxA-23779) suggesting that they took place over several generations (Humphrey et al., 2014).

Where articulations have been preserved enough to identify body position, the legs are always flexed, usually tightly at the knee, and ranging from loosely flexed at the hips to tightly flexed against the torso. The bodies were placed in a seated or reclining position, or on their side. Bodies may have been wrapped or tied to maintain a seated position. This may have been for practical purposes, as the amount of space to manoeuvre the body within the burial area would have been limited. Despite this the bodies were placed with care, including those of infants. In most cases individuals were buried facing broadly towards the entrance of the cave, and hence facing towards those conducting the burial. The degree of anatomical articulation indicated that the bodies were covered by sediment during decomposition, but some settling occurred within the burials. In several seated burials the skull, usually with two or three cervical vertebrae still in articulation, had collapsed forwards or fallen to the base of the grave due to a weakness of the neck during decomposition, suggesting an open space in front of the body.

Two features appear to differentiate Taforalt from other Iberomaurusian funerary contexts. One of these relates to the treatment of the body after death, which includes defleshing, dismemberment, and direct application of ochre to bones or bone fragments. Grave XII is particularly complex with extensive cut-marks on an adult and two children suggesting defleshing and possible dismemberment, and unhealed depressed cranial fractures on an adult and child suggesting perimortem violence (Belcastro et al., 2010). Although incontrovertible, the evidence for post-mortem manipulation and secondary burial is sporadic and so far only seen amongst burials closer to the cave opening (Necropolis I).

The burials at Sector 10 are also remarkable for the range and diversity of associated fauna and other objects. Many of the burials were associated with horn cores, placed either alongside the body, around the edges of the burial pit or directly overlying the body or cover stone (**Fig. 3**). At least two of the graves excavated by Roche (Grave I and IV) and one in Sector 10 (Individual 5) were overlain by an arrangement of Barbary sheep horn cores surrounding or held in place by a large stone (Roche, 1953a, 1953b; Turner, 2019).

Horn cores from a large bovid were found in association with the burials of Individuals 1 and 13 (Humphrey et al., 2012; Turner, 2019) and burial XX from Necropolis I was, apparently uniquely, overlaid by an antelope skull with horn cores (Mariotti et al., 2014). Animal jaws and teeth were recorded in several burials including a fox mandible found alongside the left foot and another canid jaw by the pelvis of Individual 14 and horse teeth associated with Individuals 1 and 12. Other burial items include marine shells (Freyne, 2019), several species of large bird (Cooper, 2019), bone tools (Desmond et al., 2018) and ochre stained grinding tools (Humphrey et al., 2019a).

ALGERIA

Two exceptionally important sites in Algeria have yielded human osteological assemblages representing dozens of individuals. Excavations at Columnata carried out between 1938 and 1959 revealed a series of burials from the Iberomaurusian, Columnatian and Neolithic, incorporating partial skeletons and isolated skeletal elements from numerous adults and subadults (Cadenet, 1957; Maître, 1965; Chamla, 1970). Nine of the burials, incorporating 13 individuals, were considered to be Iberomaurusian (Maître, 1965). However, the stratigraphy of the site is unusual and the burials have not been dated, and the attribution of burials to a particular period is now considered insecure (Aoudia Chouakri, 2013). It is notable that one individual previously considered to be Iberomaurusian (3-VI-1938: H1/a) had undergone evulsion of all eight incisors. This pattern of tooth evulsion is not otherwise documented during the Iberomaurusian and is more typical of later periods (Humphrey and Bocaege, 2008).

Excavations at Afalou Bou Rhummel in Algeria between 1927 and 1929 revealed human bones in two different stratigraphic horizons (Arambourg et al., 1934). A substantial deposit of human bones representing nearly 50 individuals, spread over an area of about 34 m × 4 m and reaching a thickness of up to 75 cm was found at a depth of about 3 m (Arambourg et al., 1934). Only six of the skeletons were found in anatomical association, and some of those were incomplete due to disturbance or truncation by subsequent depositions or other agents. Two of the adults lay on their backs with their lower limbs folded against the chest and one of these appears to have been clutching the body of a child, pointing towards a purposeful arrangement of the bodies. No burial items were identified. Arambourg discussed three possible explanations for the assemblage but none of these can fully account for the distribution and representation of skeletal elements. The first suggestion, that the bodies had been lowered or dropped onto the cave floor through an opening in the roof of the cave (described as a chimney from the shelter above), is unlikely because the closely articulated position of some of the bodies demonstrates that they were covered by sediment prior to decomposition. The second suggestion was that some of the skeletons were secondarily deposited in the cave following partial or complete decomposition elsewhere, and this may account for the under representation of post-cranial bones. The third suggestion, that the bodies were deposited at the site following a massacre is perhaps least likely as it does not account for the varied extent of anatomical articulation or uneven representation of bones. A more plausible explanation is that the deposit accumulated through a succession of closely spaced burials, with earlier remains truncated or pushed aside to make space for later burials. More than 2 m below the main assemblage, a complete adult male skeleton (H28) was found in an extended position with the right hand resting across the pelvis. A lump of crushed iron oxide was found on top of the cranium, together with a piece of polished bone. The fragmentary cranium of a child (H16) was found close to the feet but it is unclear whether this association was deliberate (Arambourg et al., 1934).

Fig. 3 Horn cores associated with burials in Sector 10 at Grotte des Pigeons, Taforalt. **a** *Ammotragus* horn core alongside the articulated knee of Individual 14; **b** Large bovid horn core alongside the crania of Individuals 13 and 14. – (a photo: Louise Humphrey; b photo: Paul Berridge).

Subsequent excavations at Afalou revealed a further assemblage of eight partially articulated human bones in a small niche on the southern wall of the rock shelter (Hachi, 1996, 2006). The bones closest to the front of the alcove were disordered and lacking anatomical associations, but at least four of the skeletons retained some anatomical connections between the vertebrae and ribs, revealing that the bodies had been deliberately placed on their back or side in a highly contracted position. These burials have now been assigned to layer IV, which is dated between 13,120 ± 370 BP (Alger 0008) and 12,020 ± 170 BP (Gif 6532) (Hachi, 1996, 2006). At a much deeper level, in layer X, two human skeletons (HIX and HX) and the skeleton of a macaque were found close to the south wall of the rock shelter (Hachi, 2006). The less complete skeleton (HIX) was represented by parts of the spine, ribs and pelvis and the right upper arm and was buried lying on the back. The second skeleton (HX) was almost complete and separated from the HIX by a limestone slab. The body had been placed in an outstretched position on the left side with the left hand in front of the pelvis. The right arm was tightly flexed with the right hand close to the chin and holding a bone knife. The body had been placed on two large grindstones with traces of red ochre, one close to the pelvis and the other in the shoulder area. The burials from layer X (Hachi, 2006) and the double burial from the first phase of excavations (Arambourg et al., 1934) have not been directly dated but are likely to be the earliest human burials known for the Iberomaurusian (Hachi, 2006; Aoudia Chouakri, 2013).

Rachgoun is an open-air marine shell midden in Algeria, situated about 800 m from the current shoreline. The partial skeletons of several adults were found at Rachgoun between 1953 and 1966 (Camps, 1966). Many of the human bones were uncovered opportunistically during agricultural and construction work. Details of funerary context are limited and it is uncertain how many individuals are represented. Camps recorded parts of the H1 skeleton *in situ* during a visit to the site in 1954 and inferred that the body had been placed on the side in a flexed position. There was an accumulation of non-burnt stones approximately 70 cm thick and 1.5 m long directly above the space occupied by the H1 skeleton. During the same visit, Camps observed an assemblage of long bone fragments with traces of ochre on the proximal left femur, particularly on the greater trochanter. Camps inferred that the body had rested on the right side and was covered with significant quantities of ochre, which adhered to the more prominent and uppermost parts of the skeleton. Camps revisited the site in 1964 and conducted a small-scale excavation of the remaining parts of the H4 skeleton that had not been disturbed and damaged by previous works at the site. The body had been placed lying on the back with the left arm outstretched alongside the body and parallel to the vertebral column. The orientation of the proximal part of one femur implied that the leg had been flexed with knee upwards. Several months later another partial skeleton was found, represented by a mandible and a femur and tibia in anatomical connection with the leg flexed and knee pointing upwards, suggesting a similar body position to H4 (Camps, 1966). No associated items were reported for any of the burials and they have not been dated. A sparse microlith industry recovered at the site was reported as similar to the Iberomaurusian industry from the upper level at Taforalt (Camps, 1966). Three maxillae (H1, H2 and H4) exhibited evulsion of the upper central incisors, with one adult male (H3) also showing evulsion of both upper central and the upper right lateral incisor. Three mandibles recovered at the site including those of H1 and H4 lacked tooth evulsion (Camps, 1966). Individuals H1, H2, and H3 were reported as skeletally robust and resembling individuals from other Iberomaurusian sites, whereas the H4, a female, was gracile and considered to be more typical of skeletons from later sites in the region (Chamla, 1966).

The site of La Mouillah in Algeria encompasses three small rock shelters, less than 5 m deep. Human bones were recovered from at least two of these shelters during excavations by Barbin between 1908 and 1910 (Balout, 1954; Hachi, 2006). The rock shelters appear to have been reserved for funerary purposes with most other archaeological materials at the site recovered from deposits in front of the shelters (Hachi, 2006). In one of shelters human bones representing an unspecified number of individuals were found on a layer of ashes, snail shells and flat stones. Three other individuals were recovered from a smaller shelter. These skeletons were almost complete and found in anatomical connection with the bodies extended to the knee and the legs bent. Several flat, heated stones had been placed on the bodies, in the lumbar, abdominal or chest regions. All three individuals had been buried with an east-west orientation, with the heads to the west. One of the shelters appeared to have been sealed by large rocks (Hachi, 2006). Early reports indicate that fragmentary remains of at least 12-13 adults and three juveniles were recovered (Balout, 1954). More recently Aoudia Choukari (2013) has reevaluated the assemblage and identified at least seven immature individuals, including three foetuses, two infants and two children. The human bones have not been dated but the lithic industry and fauna from deposits in front of the rock shelters are consistent with the Iberomaurusian (Balout, 1954). Many of the adults exhibited evulsion of the upper incisors, typically the upper centrals, consistent with an Iberomaurusian attribution (Marchand, 1936).

At Kef-oum-Touiza a burial of a young adult male was discovered opportunistically in 1938 alongside a road cutting at the base of a sandstone cliff. The body was placed in a crouched position with the legs tightly flexed against the trunk and the hands crossed on the legs (Balout and Briggs, 1949). No ochre or burial items were reported. The skeleton has not been dated but the relatively sparse lithic assemblage collected at the site was consistent with the Iberomaurusian. Unusually for this period, the maxilla appeared to lack tooth evulsion, but this may reflect the unusual natural configuration of the anterior dentition (Humphrey and Bocaege, 2008). The maxilla had both incisors present on the left side but only one double rooted and exceptionally broad tooth on the right side. This may be a fused central and lateral incisor, giving the appearance of a single tooth crown, or an exceptionally wide single incisor with two roots.

SUMMARY

The sites described in this review demonstrate a diversity of Iberomaurusian funerary contexts, but some consistencies are apparent. The majority of Iberomaurusian funerary deposits have been found in caves and rock shelters or, in the case of Kef-oum-Touiza, at the base of a cliff. It is unclear whether this is an archaeological bias or genuinely reflects the preferences and behaviour of the Iberomaurusians, but it is worth noting that the only open-air burial site reported here (Rachgoun) was discovered during construction work. Relatively few authors have reported on the presence or absence of burial pits. Deliberate modification of a site prior to placement of the body, typically by digging a grave, is considered a key factor in identification of a burial, as distinct from funerary caching (Pettitt, 2011). Identification of the boundaries of a burial pit is also important for other reasons. Burials may extend into a lower stratigraphic level and may be inadvertently linked to the wrong cultural horizon if the original boundaries of the burial pit are not detected archaeologically. Recognition of the edges of a burial pit can help demonstrate which objects are securely linked to a burial. This information may be lacking due to the circumstances of discovery (e. g., Rachgoun) or the nature of deposits (e. g., burials in ashy deposits at Taforalt). Research has shown that some bodies were placed in a pre-existing rocky fissure or niche (El Harhoura 2, and some individuals at Afalou) during the Iberomaurusian, but a degree of anatomical connection was maintained in all of these cases indicating that the bodies had been covered prior to decomposition and not simply abandoned.

Many publications report the extent and nature of anatomical articulation, which is relevant for identification of a primary deposition, establishing the position of the body and ascertaining whether a body decomposed in an empty, partially or completely filled space. Most bodies were placed in flexed or contracted position, either on their side or back, or seated or reclining. Some bodies may have been bound or wrapped to achieve or retain this position. Several primary single burials have been identified (e. g., Hattab, Ifri Baroud), but other sites have yielded relatively complete and articulated skeletons alongside disturbed burials and scattered human bones, suggesting successive depositions in a restricted area with previous remains disturbed or pushed aside to accommodate subsequent burials (Taforalt, Afalou, Dar-es-Soltane II). Deliberate modification and manipulation of the body before or after decomposition appears to be relatively unusual during the Iberomaurusian. The unusual distribution of the skeletal elements of infant IV at Ifri n'Ammar has been interpreted as evidence for decapitation and dismemberment prior to burial (Ben Ncer, 2004a). At Taforalt there is evidence for cut-marks, suggesting defleshing or dismemberment, and direct application of pigments to bones and bone fragments after decomposition (Belcastro et al., 2010), but only a few individuals were treated in this way (Aoudia Choakri, 2013). Interestingly, these behaviours appear to pre-empt the diversity of mortuary treatments afforded to the dead in later periods, particularly during the Capsian.

Most of the sites include the burials or disarticulated remains of more than one individual. The distribution of articulated, partially articulated and disarticulated human bones suggests that many Iberomaurusian funerary contexts represent individual primary burials or a succession of primary burials, in a restricted amount of space, with the implication that these spaces were designated as spaces for the dead that were distinct and apart from the areas designated for the living. The presence of skeletal elements with indisputable evidence for post-mortem manipulation clearly represents a diversification of funerary treatment, which could be interpreted as evidence that selected body parts were returned to a significant location for secondary burial. The shared funerary treatment and spatial proximity of two infant siblings buried at Taforalt further reinforces the sense of importance attached to the place of the burial and reveals that kinship contributed to the patterning of funerary behaviour during the Iberomaurusian (van de Loosdrecht et al., 2018; Humphrey et al., 2019b).

Placement of a stone, grindstone or pile of stones above or adjacent to a burial has been reported at numerous sites including Dar-es-Soltane II, Taforalt, Ifri n'Ammar, La Mouillah, Rachgoun and Afalou. These stones may serve to protect the body from disturbance, identify the location of the burial or commemorate the deceased. Many Iberomaurusian burials are associated with other burial items, both functional and decorative, which must have had a symbolic significance or a personal value to the deceased. Marine shells were included in burials at two sites in Morocco (Taforalt, Hattab II). Horncores were also found in association with the burials at these sites. The diversity of fauna, both mammalian and avian, observed at Taforalt has not been recorded at any other site (Turner, 2019; Cooper, 2019). The use of ochre was noted at Dar-es-Soltane II, Taforalt and Rachgoun. Mineral deposits were found alongside the earliest two burials at Afalou (Hachi, 2006). Bone tools were recorded with burials at Taforalt, Hattab II and Afalou, including the remarkable case of HX at Afalou, buried clutching a bone tool (Hachi, 2006). No other site displays the diversity of burial objects recorded at Taforalt, but it is likely that the prevalence and range of burial items at other sites has been underreported. In some cases, burial objects may have been overlooked due to the circumstances of recovery, and at other sites funerary objects may have been displaced by subsequent burials.

Most of the burials that have been dated belong to the later part of the Iberomaurusian. The infant burials from Ifri n'Ammar are dated between 12,290 ± 133 BP and 11,009 ± 144 BP (Moser, 2003). The burials from Sector 10 at Taforalt are slightly earlier with dates spanning the period 12,485 ± 80 BP (OxA-16689) to 12,255 ± 50 BP (OxA-23779), and it is likely that the burials from Necropolis I closer to the front of the cave are more recent (Humphrey et al., 2019a). At least two sites in Algeria have yielded isolated bones or burials from earlier Iberomaurusian horizons that have been dated indirectly by radiocarbon dates on other materials. An isolated skull of a female with evulsion of the upper central incisors from Taza Cave I in Algeria was found close to the base of a horizon dated between 16,100 ± 1,400 BP and 13,800 ± 30 BP (Meier et al., 2003). The burials from level III (Arambourg, 1934) and level X (Hachi, 2006) at Afalou are also likely to be earlier than the directly dated burials at Taforalt. There remains at present a significant temporal hiatus between the onset of the Iberomaurusian at ~25,000 cal BP and the earliest well dated burials and it is hoped that further archaeological investigation will fill or explain this gap.

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SEXUAL SYMBOL OR DOMESTIC TOOL? THE USE OF BEAR *BACULA* – AN ASSESSMENT OF THE ARCHAEOLOGICAL AND ETHNOGRAPHICAL RECORD

Abstract

The present paper attempts at understanding the background to and possible use of bear bacula in Stone Age contexts. Particular focus is given to the *baculum* from the Late Palaeolithic site of Bonn-Oberkassel. In order to allow for a more general interpretation of such finds, their meaning and symbolism, we compare the Palaeolithic evidence with ethnographic contexts.

Keywords

Ursus spelaeus, Ursus arctos, human-bear relationship, Upper Palaeolithic, Rhine valley, Swabian Jura

INTRODUCTION

Ursines have always been fascinating to humans due to their ability to walk upright on their hind limbs and to mimic human gestures. Numerous ethnographic sources document a very deep relationship with bears in more recent times (Giemsch, 2017), which has had a strong impact on the palaeontological and archaeological research history on cave bears between the end of the 19th and the beginning of the 20th century (Pacher, 1997, see references therein). Even though the rich archaeological record documents human-bear interactions (Morel, 1993; Münzel et al., 2001; Germonpré and Hämäläinen, 2007; Wojtal et al., 2015), their relationship often remains difficult to interpret.

With the beginning of systematic speleological research in the early 19th century, regular finds of huge amounts of cave bear remains associated with Middle Palaeolithic artefacts led to the erroneous conclusion that these animals were hunted by Neanderthals (Bächler, 1921; Hörmann, 1923; Abel and Kyrle, 1931; Ehrenberg, 1954). The idea of a 'cave bear culture' with Neanderthals as *Kulturträger* (makers of the culture) emerged. Supposed tools made from cave bear bones were taken as an indication for such a culture, and numerous findings in caves, of cave bear skulls under rock slabs or in niches, as seen in Drachenloch and Wildenmannlisloch in Switzerland (Bächler, 1921, 1940), in Petershöhle in Germany (Hörmann, 1933; Hilpert and Kaulich, 2005), in Drachenhöhle near Mixnitz (Abel and Kyrle, 1931) and in Salzofenhöhle in the Totes Gebirge (Ehrenberg, 1954), both in Austria, in Veternica in Croatia (Malez, 1959), in Peştera Rece in Romania (Lascu et al., 1996; Rosendahl and Döppes, 2015) and Zeda Mgvime Cave in the Tsutskhvati Cave Complex in Georgia (Tushabramishvili, 1978) were interpreted as evidence for ritual practices associated with a cave bear cult (but see review in: Pacher, 1997; Rabeder et al., 2000). Relatively early in this discourse, taphonomic arguments were brought up to explain such accumulations of cave bear remains in caves, through processes such as natural death of cubs and old individuals after hibernation (Kurtén, 1958, 1995; Rabeder et al., 2000). Soergel (1940) estimated the sedimentation rates in caves to prove the slow and natural deposition of cave bear remains due to taphonomic processes. Other taphonomic approaches con-

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Fig. 1 Ritual birch-bark storage vessel for keeping spoons that were used in bear feasts, decorated with 15 brown bear (*Ursus arctos*) penis bones. Siberian Udege culture from the Amur-region, early 20th century. – (Collection MAE RAS: № 2336-1, Image ID: 3845867).

cerning the 'cave bear bone industry' postulated by Bächler (1921) argued for the presence of pseudo-tools as the result of natural sediment rounding (*charriage à sec*), and excluded anthropogenic modification (Koby, 1943). Gradually, a general scepticism against cave bear hunting and cave bear bones as a resource for bone tools arose amongst scientists, however, brown bear hunting was never questioned (Koby and Schäfer, 1961). More recently, zooarchaeological research has documented both hunting and exploitation of cave bears (Münzel et al., 2001; Münzel and Conard, 2004; Germonpré and Hämäläinen, 2007; Wojtal et al., 2015; Terlato et al., 2019). But even symbolic or ritual behaviour seemed to occasionally involve bear remains in the Palaeolithic, as highlighted by the clay sculpture of a bear in Montespan cave (Begouën and Casteret, 1923) or the skull deposition in Grotte Chauvet (Chauvet et al., 2001), both in France, or the ochre stained cave bear bones in Goyet and Trou de Chaleux in Belgium (Gemonpré and Hämäläinen, 2007). Another indication of the important role bears played in the life of Palaeolithic hunters are their depictions in Palaeolithic parietal art, such as in Grotte Chauvet (Clottes, 2001), in Grotte du Péchialet (Breuil, 1927), in Les Trois-Frères (Breuil et al., 1956), all in France, and in mobile art as the ivory sculptured bear from

Geißenklösterle cave in SW-Germany (Hahn, 1986). Overall, 55 depictions in 23 caves (parietal art) and nearly 80 depictions on objects (mobile art) are known from Europe (Rouzaud, 2002). Aside these, the close ties between humans and bears are also documented in personal ornaments, such as bear tooth pendants (of canines or incisors), probably worn as amulets, which have been found at several Palaeolithic cave sites (Pacher, 2005; Kölbl and Conard, 2003), or in Mesolithic burial contexts (Grünberg, 2000, 2013). All these examples attest to a special relationship between humans and bears.

In the following, our contribution focuses on a rather rare ursine bone, the penis bone or *baculum*. The possible use and/or symbolism of the *baculum* provides some peculiarities in ethnological as well as archaeological contexts.

ETHNOGRAPHIC EVIDENCE

The ethnographic record provides a frame of reference that may give an idea on the metaphysics of current indigenous people. This record serves as analogy, though it cannot be transferred to Palaeolithic- or any other archaeological contexts

Ceremonies and rituals related to bears are manifold in circumpolar ethnographies (Pacher, 1997; Germonpré and Hämäläinen, 2007; Giemsch, 2017). Several ethnographic sources refer to the use of brown or polar bear *bacula* amongst indigenous populations across the circumpolar sphere.

In general, it is documented for several Siberian peoples that bear *bacula* were worn by women directly on their bodies in order to ward off or cure infertility and ease birthing (Vasil'ev, 1948). For example, the Udege people of the Amur region in Siberia see the bear as their forebear and therefore regard him as untouchable (Albert, 1956). No woman was to sleep on a bearskin and should at all times keep the *os penis* safe at her side and pass it on to her descendants along the female line. These customs are still strictly adhered to by the Udege people (Albert, 1956). There are other observations of Udege women carrying amulets of bear penis bones as an Apotropaion or amulet against infertility (Okladnikova, 1979). A highly interesting cylindrical ritual vessel of the Udege comes from the Khabarovsk Region (**Fig. 1**). The vessel was used to store ritual spoons used to serve boiled bear's meat during the bear feast and a total of 15 ursine penis bones are attached to the upper part of it. The records of the Kunstkamera archive further state that "when a bear cadaver was divided, the hunter who killed a he-bear received its penis. This he would pass on to his wife or another close female relative. This organ symbolises the relationship between man and bear and was seen as a powerful amulet that could heal infertility or ease childbirth" (Kunstkammer St. Petersburg, 2020). The Tuva people from southern Siberia also see penis bones of bears as a symbol of power and strength (Clottes, 2016).

The Ket people, who settle along the Yenisei river in Siberia are known to deposit the bear skull, skin, snout, lips, gallbladder, eyes and penis in a box, together with an image of a bear sketched on birch bark, upon killing a bear. Together with a cedar-twig, braided into a ring, which symbolically joins the different body parts, this deposition makes it possible for the bear to be reborn in the forest (Ivanov and Levin, 1964; Kiriyak, 2007).

Several authors relate to the Saami of northern Scandinavia, who understood penis bones of bears to be particularly powerful and strong, therefore kept them and attached them to sacred drums (Hultkrantz, 1992; Kroik, 2006). Some sources mention that amongst the Finnish Saami (Pentikäinen, 2006), anyone killing a bear received its skin, head and *baculum*. The *baculum*-tradition is part of a fundamental sexual key aspect of typical bear stories in which the mythical bear of the North tends to be male. Other sources state

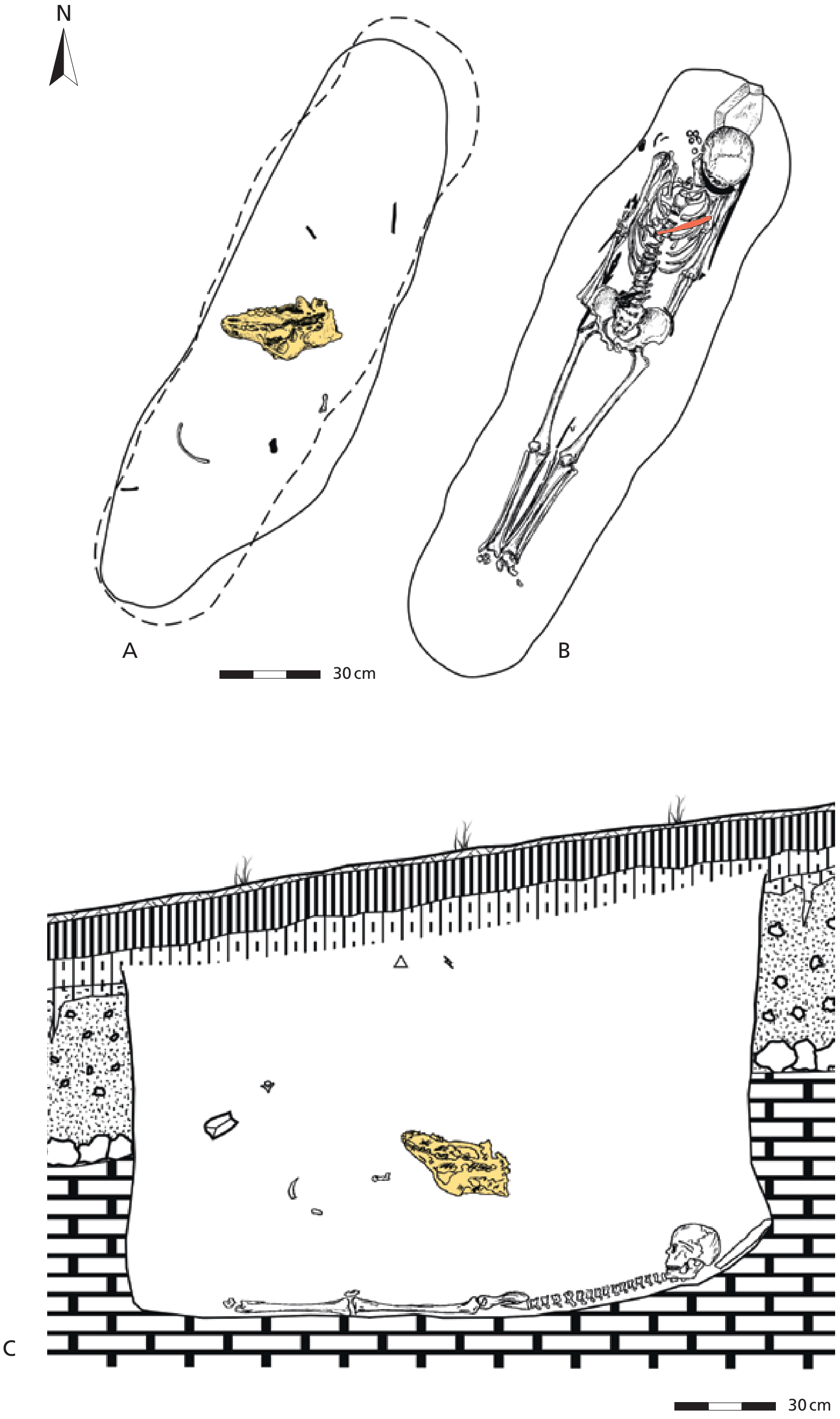

Fig. 2 Shamanka II (Sibiria): Burial no. 22 with bear remains (*Ursus* sp., probably *U. arctos*). While the bear skull was placed above the buried individual (**A, C**), the bear *baculum* (filled object in B) was diagonally placed directly onto the chest of the individual (**B**). – (From Losey et al., 2013: Fig. 4.3).

Fig. 3 Cut-marked penis bone of a bear (*Ursus* sp., probably *U. arctos*) from the Magdalenian of the site Teufelsküche (Baden-Württemberg, Germany). In addition, the distal (upper) end is broken, probably during work. – (From Pasda, 1994: 166 Pl. 43,6).

that Saami men would greet bears in the manner of an approaching groom, whilst Saami women would avoid bear penises and penis bones and instinctively protect their abdomens (Frog, 2008).

In native cultures of Alaska, in which *bacula* of other carnivores are frequently used, the fossilised *bacula* of polar bears were often polished and used as hilts for knives and other tools (Long, 2012). In indigenous people from the northern American continent the successful bear hunter received a dog whip with a handle made from a bear's penis bone (Saladin d'Anglure, 1990; Mithen, 2003).

The Inuit, on the other hand, associate the bone with male initiation rites to adulthood. Shamans use Polar Bear penis bones in traditional Inuit ceremonies. Here, the penis bone is believed to aid communication with the spirit world. By holding the bone in his hand, the Shaman is able to receive the thoughts and will of the spirits (oral communication of Shaman Hivshu, 19th March 2016 in the Archäologisches Museum Frankfurt).

The contexts in which *bacula* are used in indigenous societies are distinguished very clearly by their bringing power and strength to the owner, independently of their use as a tool, such as handles, or for Shamanistic ceremonies. Noteworthy is their ubiquitous significance in protecting women against infertility. As with tools, this might be related to their assumed property of giving the owner the power and strength to ease potency. Moreover, male or he-bears are not only seen as the forbear, but also as grooms replacing the human husband.

Fig. 4 Bonn-Oberkassel (Germany). Late Palaeolithic double burial, as arranged in the permanent exhibition in the LVR-LandesMuseum Bonn. – (Photo: Jürgen Vogel/LVR-LandesMuseum Bonn).

ARCHAEOLOGICAL EVIDENCE

In this light we try to evaluate the rare archaeological evidence of ursine penis bone use, which is difficult to decipher. In contrast to ethnographic sources the archaeological evidence does not provide written or oral communications. Most archaeologists are therefore extremely cautious with their interpretations. Contrary to usual archaeological praxis we will provide some examples of *bacula* use from the youngest to the oldest evidence.

The most important source for prehistoric use of bear *bacula* was found in the spectacular stone age burial site of Shamanka II[1] at Lake Baikal in Siberia (Losey et al., 2013). Whereas the available dates (ca. 8,000-7,000 cal BP) hint at an early Neolithic context, the archaeological remains speak in favour of a late Mesolithic hunter-gatherer context. 35 of the 154 stone age burials contained bones of brown bears (*Ursus arctos*). The assemblage consists mostly of bear teeth, skull bones as well as *bacula*. In contrast to the skull fragments, the *bacula* were found directly on the human skeletons or in concentrations directly adjacent to the buried individuals (**Fig. 2**). Overall, there are 16 fragmented or intact *bacula* spread across eight human burials, six of which contained human adult males. One *baculum* lay beneath the shoulder of a 1.5

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[1] The site of Shamanka II revealed also burials from the early Bronze Age (ca. 5,400-4,000 cal BP).

to 3 year old child and two more were found amongst the dissociated and spread remains of seven adult human individuals of both sexes. One *baculum* had been smoothed intensively at its distal end in order to create a sharp gouging tool such as an awl. Nine other bones bear slight traces of smoothing or use, while one specimen was deeply scored circumferentially, possibly in order to fasten a string. Another bone shows striations along its base. Because the majority of *bacula* of Shamanka II are associated with human male adults, they may be understood as a symbol of the direct transmission bestowed by the male reproductive organ onto the generative potency and virility of the men (Losey et al., 2013). The use of a *baculum* as a grave good for the 1.5 to 3 year old child, however, may imply a belief that the bone helped to transfer the power or strength of the bear at early age to this individual.

While brown bear bones and teeth, used as grave-goods have also been identified at some Mesolithic burial sites (Grünberg, 2000, 2013), no penis bones have been found in Mesolithic contexts to date.

An ursine penis bone (*Ursus* sp.) was found in the late Magdalenian cave site Teufelsküche close to Ehrenkirchen in Baden-Württemberg (Germany), located in the Upper Rhine valley. The bone bears longitudinal traces of scraping along the shaft, most likely from skinning. The distal end of the *baculum* is broken, most likely during its use, probably as an awl (**Fig. 3**) (Pasda, 1994: 166 Pl. 43,6; Bosinski, 2008).

One of the most interesting finds from a Late Palaeolithic context, is the penis bone of a brown bear (*Ursus arctos*) found in the ca. 14,000 year old double-burial of Bonn-Oberkassel (**Fig. 4**; cf. Giemsch and Schmitz, 2015). This *baculum* is generally interpreted as a grave good (Szombathy, 1920; Mollison, 1928; Street, 2002; Giemsch et al., 2015). The grave of a 35-45 year old male and a ca. 25 year old female was discov-

Fig. 5 Bonn-Oberkassel (Germany). Penis bone of a brown bear (*Ursus arctos*) with scraping traces from the Late Palaeolithic double burial. – (Photo: Jürgen Vogel / LVR-LandesMuseum Bonn).

Fig. 6 Brillenhöhle, Blaubeuren (Swabian Jura, Germany). Decorated cave bear (*Ursus spelaeus*) *baculum* from the Gravettian layer AH VII. The distal (upper) end is worked and shows use wear. – (Photo: Landesmuseum Württemberg, Fabian Haack).

ered in the course of quarry-work in 1914. In addition to the human skeletons and the ursine penis bone it contains early dog remains and two art objects, highlighting the exceptional character of the site (Giemsch and Schmitz, 2015). Unfortunately, given the early discovery of the site during quarrying work, there is no map of the location of the skeletons and their grave goods. Martin Street was able to identify a series of cuts along the convex edge of the bear *baculum* (**Fig. 5**). These were later overlain by haematite and must have been created before their deposition in the grave (Street, 2002). This suggests a purposeful deposit in the grave as a grave good. As early as 1919, the original investigator, Max Verworn, interpreted the bone as a grave good and suggested that it had been used as an awl or similar tool (Verworn et al., 1919).

Originating from Gravettian contexts are two other *bacula* found in cave sites of the Swabian Jura (Germany). One comes from the Gravettian layer AH VII of Brillenhöhle in the Ach Valley near Blaubeuren. The penis bone of a cave bear (*Ursus spelaeus*) shows six deep notches (**Fig. 6**) and dates to roughly between >29 and >25 ka (uncal.) ^{14}C BP (conventional radiocarbon dates published in: Riek, 1973[2]). The tip of the *baculum* displays an old fracture; its use as an awl was considered (Riek, 1973; Barth, 2007; Barth et al., 2009). During an inspection of the *baculum* in the Württembergisches Landesmuseum Stuttgart by com-

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[2] From layers AH VII and VIII charred bone samples have been conventionally dated in Bern: AH VII: > 25 ka (uncal.) ^{14}C BP (B-492) and AH VIII: > 29 ka ^{14}C BP (B-491) (see Riek, 1973: 156). Based on by lithic refits of Gravettian layers between Hohle Fels, Geißenklösterle and Brillenhöhle, AH VII of Brillenhhöhle is to be dated to 27-30 ka ^{14}C BP (Scheer, 1986; Moreau, 2009).

Fig. 7 Hohle Fels, near Schelklingen (Swabian Jura, Germany). Polished cave bear (*Ursus spelaeus*) *baculum* from the Gravettian layer AH IIcf. – (Photo: M. Malina, © Universität Tübingen).

paring it with a complete cave bear *baculum*, we recognized that a considerable part of the distal end (in the anatomical sense; in reference to tool orientation this would be the proximal end) is missing. The distal end shows longitudinal thinning facets towards the tip implying a re-sharpening of the pointed end. The use as an awl is evidenced by a broken off flake at the tip displaying the cancellous tissue in the inner part of the *baculum*, furthermore, fine circular striae at the tip support the interpretation as an awl. The cave site Hohle Fels, also situated in the Ach valley between Schelklingen and Blaubeuren (Germany), yielded several complete and fragmented penis bones of *Ursus spelaeus* (n = 49) and brown bear (n = 2). One cave bear *baculum* (**Fig. 7**) from the Gravettian layer IIcf is intensively polished on all sides. The polished surface is covered with fine scratches pointing in all directions, in addition there are longitudinal cut-marks probably caused by defleshing (Münzel et al., 2001; Münzel and Conard, 2004). We suggest the marked polish to be use wear originating from leather working similar to the polish seen on smoothers (Münzel et al., 2001: 324; Scheer, 1995).

Another *baculum* find of *Ursus spelaeus* comes from the cave site Vindija in north-western Croatia. The stratigraphic provenience is heavily debated. Karavanić (1998) argues that the organic tools, mainly bone points, but also the decorated *baculum*, from layer G1 are of Upper Palaeolithic character, but produced or traded by Neanderthals (Karavanić, 1998). The cave bear penis bone is exceptionally decorated with multiple circumferential scorings (**Fig. 8**) – a pattern that we only know from Upper Palaeolithic contexts. It obviously provides no traces of use as a tool, but closer study of the object is needed.

Fig. 8 Vindija cave (Croatia). Carved cave bear (*Ursus spelaeus*) *baculum* with circumferential scoring from Stratum G1 (Aurignacian I). – (From Malez, 1988).

CONCLUDING REMARKS

Manipulated or decorated ursine penis bones in archaeological context are firstly recognized at Vindija cave. Its potential Middle Palaeolithic age, however, is contradictory (Karavanic, 1998; Malez, 1988) and not securely established. Furthermore, the kind of decoration found on this specimen hints at symbolic communication, which is interpreted as an essential feature of modern human behavior and which is thought to first appear with the Upper Palaeolithic (Dutkiewicz et al., 2018). Other specimens from Upper Palaeolithic contexts display different anthropogenic modifications, like longitudinal striations or cuts, as described from Hohle Fels (**Fig. 7**), Teufelsküche (**Fig. 3**) and Bonn-Oberkassel (**Fig. 5**), which most probably relate to skinning of the penis bone or removal of the periost. In a second step, some of these items were used as tools, most probably as awls, as shown by old-fractures and respectively removed tips (distal end), such as in the case of Brillenhöhle (**Fig. 6**), Teufelsküche (**Fig. 3**), and Bonn-Oberkassel (**Fig. 5**). The intensively polished *baculum* from Hohle Fels (**Fig. 7**) is likely linked to leather working. In all these cases, the *bacula* reflect a *chaîne operatoire* that informs us on technological choices and sequences of production. In Shamanka II several modifications are reported, but unfortunately these are not documented in further detail (Losey et al., 2013). Seemingly, at Shamanka II *bacula* were used as tools and a gender related association with male graves appears apparent.

Against this context, we would like to return to our initial question: did *bacula* of the archaeological record serve as sexual symbols or as tools? The use of these bones as awls is evidenced in several cases during the Upper Palaeolithic period, however, the penetrating action by working with awls might also have a wider symbolic, potentially sexual, background. These two aspects might have been combined in the contexts *bacula* were implemented.

In relation to this another observation might be also worth mentioning: The Gravettian layer AH IIcf of Hohle Fels (the same layer that yielded the polished *baculum*) also contained an elongated pebble shaped and modified by engravings into a phallus and was used as a retoucher (Conard and Kieselbach, 2006). The fact that these items occur for the first time in Gravettian contexts might signal a change in gender roles, at least in the Swabian Jura. The emphasis on females indicated by the oldest Venus figurine in the Aurignacian (Conard, 2009) might have shifted towards male power in the Gravettian. Drawing from ethnographic analogy, we can suggest that penis bones – and probably the Hohle Fels stone retoucher, as well – gave power and strength to the owner.

Losey and colleagues (Losey et al., 2013) emphasize the close relationship between humans and bears, referring to ethnographic sources. Many indigenous societies see bears and humans as belonging to the same family, they may even marry. The perception of ursine *bacula* as a powerful tool seems to be directly connected to the life of hunter-gatherers or nomadic communities. To date no farming society has been documented, in which bear remains and, in particular, bear *bacula* are of considerable interest (Giemsch, 2017).

The burial place of Shamanka II provides obvious similarities concerning the use of *bacula* in present-day indigenous Siberian people, where *bacula* are gender-related and refer to males. Such gender-related background is also possible for the double burial of Bonn-Oberkassel, although it is not clear, whether the *baculum* as a grave good and tool covered with hematite was given to either (or both) the male or the female.

One may conclude that the use of bear *bacula* by humans developed from their use as tools towards symbolically charged objects. Most intriguingly this may be expressed through their integration into human burial contexts, as seen at the Late Palaeolithic site of Bonn-Oberkassel, and also in the extraordinary grave goods of the Siberian burial place of Shamanka II. While at Shamanka II the *os penis* was mainly used as a grave good for adult males, indigenous Siberian hunter-gatherer groups tend to see it as a symbol to enhance female fertility. However, it also reflects the fear of impotency in men, which may therefore place the object in a 'complementary' female context.

Nonetheless, it is possible to conclude that the *baculum* is generally seen as a symbol for the strength and power of the bear: by wearing or using it, men and women hope for the transmission of their strength and power to themselves.

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LUC A. A. JANSSENS · DENNIS F. LAWLER

THE EARLIEST DOMESTICATED WOLVES: ON CREATING DOGS

Abstract

The dog is man's best friend, and the wolf maybe his worst enemy in some circumstances. Yet, the former is only a wolf-type descending from the latter, modified non-intentionally and intentionally, both morphologically and in character. Much of the narrative on how dogs originated has been resolved, but certain aspects remain clouded, such as the geographical origin, chronological time or times, and originating wolf populations. Differences between dogs and wolves are visible in the archaeological record, based on morphology. Genetic analyses of ancient bone also can differentiate the two. People often have wondered why humans may have wanted to domesticate wolves, and several utilitarian reasons have been proposed. Nonetheless, it is difficult to explain how people could have known beforehand that wolves could fulfil desired tasks: There was no blueprint! Here, we propose that emotional reasons may have been pivotal, and the Bonn-Oberkassel burial, on which Martin Street published, is an excellent example of this hypothesis.

Keywords

Canis lupus, dog, domestication, wolf

INTRODUCTION

Martin Street and the first author shared several pleasant weeks in MONREPOS, and during talks it became clear that we disagreed on how wolves entered the human niche and became domesticated. Martin had gained the archaeological status of an ancient Greek demi-god by his wonderful "*Bonn-Oberkassel Arbeit*" (among much more). Martin had questioned the puppy collection hypothesis and rejection of 'protodogs', and seemed more a fan of the self-domestication theory, with domestication occurring during the early Aurignacian-Gravettian.

From those conversations and much more, this article will focus on methods of domestication and the 'protodog' hypothesis, as constructively as possible. The "why" of humans wanting to domesticate wolves also will be considered. According to Coppinger and Coppinger (2002, 2016), only an idiot would try to domesticate one.

The Eurasian grey wolf (*Canis lupus lupus*) is the recognized immediate ancestor of domestic dogs (Thalmann et al., 2013; Thalmann and Perri, 2018). Although wolves have existed for > 300 kya, a global turnover occurred about 25 kya, when Beringian wolves spread over the northern hemisphere, replacing all earlier Pleistocene wolves (Loog et al., 2020). It appears that dogs derived from this Beringian population, although scientists have struggled to define the precise temporal and geographic origins. The timing now seems to have between 25 and 15 kya, the date range between the modern wolf type and the first occurrence of the oldest archaeological dogs. Archaeological dog remains that we accept as dogs consist of about 20 Final-Pleistocene and very early Holocene specimens (**Tab. 1**). Our assessments are based on: Osteomorphology and morphometrics; an anthropogenic context that included dog-human burials; and considerably smaller size than isopatric and contemporaneous wolves. Additionally, certain specimens have

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been shown to possess dog DNA (**Tab. 1**). Most of these specimens are about 45 cm high at the shoulders and weigh approximately 15 kg (wolves: > 50-70 cm and > 40-80 kg).

Larger-sized 'protodogs' had been reported from as early as 40 kya (Camarós et al., 2016; Germonpré et al., 2009, 2012, 2015, 2017; Sablin and Khlopatchev, 2002), mainly in Eastern Europe and Asia. The species assignment of these few large specimens (Germonpré et al., 2009, 2012, 2017) was based mainly on shorter skull and snout, and wider palate (Germonpré et al., 2009, 2012, 2017). Another group of 'protodogs' (n > 30) from Predmosti was so assigned, based on shorter mandibular metrics (Germonpré et al., 2015). The assignment of these 'protodogs' as dogs has been questioned by a large number of investigators (Boudadi-Maligne and Escarguel, 2014; Crockford and Kuzmin, 2012; Janssens et al., 2019a; Jung and Pörtl, 2018; Morey 2014; Morey and Jeger, 2015; Napierala and Uerpmann, 2012; Perri, 2016; Pitulko and Kasparov, 2017; Wilczynski et al., 2020). In summary, morphology (Janssens et al., 2019a) and DNA studies (Thalmann et al., 2013, 2018) validate them as wolves. Their relevant morphometrics do not differ from Pleistocene wolves (Janssens et al., 2019a). Shortened mandibular measurements can be seen in a subgroup of specimens from one breed of modern dogs. Thus, even one dog breed can be split into two morphotypes, based on normal morphological variability (the Gaussian curve), similar to Pleistocene wolf specimens. Recently, arguments have focused on differences in 'protodog' isotopes (Bocherens et al., 2015) and dental wear (Prassack et al., 2020). However, the latter arguments have been questioned as well (Janssens et al., 2021).

Based on archaeological observations, dogs likely originated in Eurasia or the Middle East (Altuna et al., 1984; Baales, 1992; Boudadi-Maligne et al., 2018a; Célérier et al., 1999; Chaix, 2000; Day, 1996; Degerbøl, 1961a, 1961b; Gourichon and Helmer, 2008; Grosman, 2013; Leesch, 1997; Leesch and Müller, 2012; Mertens, 1936; Morel et al., 1997; Napierala and Uerpmann, 2012; Nobis, 1979, 1981; Street, 1991, 2002; Tchernov and Horwitz, 1991; Tchernov and Valla, 1997; Turnbull and Reed, 1974; Vigne, 2006; Vigne et al., 2011; Yeomans et al., 2019).

Genetic determination of "a dog" is based on differences between dogs and wolves that involve mtDNA, Y-DNA, and nDNA (Botigué et al., 2017; Fan et al., 2016; Frantz et al., 2016; Savolainen et al., 2002; Skoglund et al., 2015; Thalmann et al., 2013; Wang et al., 2013). Based on mtDNA, dogs can be described as having four mtDNA (A-D) clades, that diverge from known wolf signatures (Thalmann et al., 2013). Genetic studies point to geographic origins in Europe (Thalmann et al., 2013); Asia (Botigué et al., 2017; Brown et al., 2011; Ding et al., 2012); the Far East (Pang et al., 2009); Central Asia (Shannon et al., 2015); and with an input from Middle Eastern wolves (Sacks et al., 2013; Savolainen et al., 2002; Pollinger et al., 2010). These varying viewpoints on geography result from complicating influences, such as (not an exhaustive list):

(1) a relatively brief period of divergence, thus only minor differences being present; (2) high mobility of wolves disseminating their genes, indicating possible geographic distancing between ancestral wolf populations and the earliest domestic dogs; (3) incomplete lineage sorting (Thalmann and Perri, 2018), thus possible retention of ancestral polymorphism, clouding real time differences; (4) lack of sufficient high quality aDNA genomes to support reliable conclusions (Pickrell and Reich, 2014); (5) lack of knowledge of the origin region(s) (Irving-Pease et al., 2018; Pickrell and Reich, 2014); (6) limited understanding of long-range migrations and population replacements of humans and accompanying dogs, especially during the late Pleistocene (Botigué et al., 2017; Frantz et al., 2016; Pickrell and Reich, 2014); and (7) hybridization (Fan et al., 2016; Godinho et al., 2011; Khosravi et al., 2013a,2013b; Pilot et al., 2014; Tsuda et al., 1997; Pollinger et al., 2010; Vilà et al., 1997). To be of influence for dog domestication, early offspring must have been progeny of female dogs and male wolves, with pups born in the human niche. However, recent genetic research has pointed to almost exclusive male dog-female wolf hybridization (Bergström et al., 2020), thus complicating associated hypotheses.

Specimens	Country	Chronocultural Context	Direct dating on dog remains Lab no.	Radiocarbon Age [^{14}C BP]	Indirect datings from contexts [^{14}C BP]	mtDNA Clade	MNI	References
Eralla	Spain	Lower/Upper Magdalenian			16,270 ± 240 12,310 ± 190		1	Altuna et al., 1984; Vigne, 2006
Montespan	France	Middle Magdalenian			*ca. 15,500/ 13,500**		1	Pionnier-Capitan et al., 2011
Le Morin	France	Upper Magdalenian	OxA-23627 OxA-23628	12,540 ± 55 12,450 ± 55			1	Boudadi-Maligne et al., 2012
Bonn-Oberkassel	Germany	Late Magdalenian – Early Federmesser	OxA-4793 KIA-41162 KIA-41161 KIA-41163	12,270 ± 100 12,210 ± 60 12,110 ± 45 11,620 ± 60		C	2	Street, 2002; Janssens et al., 2018
Kesslerloch	Switzerland	Upper Magdalenian	KIA-33350	12,225 ± 45		C	1	Napierala and Uerpmann, 2012
Grotta Paglicci	Italy	Epigravettian	OxA-26316	12,175 ± 55	?		1	Boschin et al., 2020
Grotta Romanelli	Italy	Final Epigravettian			11,858 ± 85 8,048 ± 75	C	1	Boschin et al., 2020; Calcagnile et al., 2019
Le Closeau	France	Azilian			12,480 ± 70 12,050 ± 100		1	Pionnier-Capitan et al., 2011
Troubat	France	Azilian	OxA-36550	10,600 ± 45			2	Boudadi-Maligne et al., 2020
Palegawra	Iraq	Zarzian			*ca. 12,000**		1	Turnbull and Reed, 1974
Pont d'Ambon	France	Laborian	GifA 99102 Beta 411309	10,730 ± 100 10,130 ± 40		C	2	Célérier et al., 1999; Pionnier-Capitan et al., 2011; Boudadi-Maligne et al., 2018a
Saint-Thibaud-de-Couz	France	Laborian	Ly23/OxA-4405	10,050 ± 100			1	Chaix, 2000
Kartstein	Germany	Ahrensburgian			10,220 ± 75 9,995 ± 65	C	1	Baales, 1992
Bedburg	Germany	Early Mesolithic			9,780 ± 100 9,600 ± 100		1	Street, 1991
Senckenberg-Moor	Germany	Mesolithic			*ca. 10,000**		1	Mertens, 1936; Degerbøl, 1961b
Ain Mallaha	Israel	Natufian			10,540 ± 90 10,530 ± 100		2	Tchernov and Valla, 1997; Grosman, 2013
Hayonim Terrace	Israel	Natufian			11,790 ± 120 9,640 ± 100		2	Tchernov and Valla, 1997; Grosman, 2013
Shillourokambos	Cyprus	Neolithic (Middle PPNB)			9,525 ± 49 9,432 ± 49		1	Vigne, et al., 2011
Shubayqa 6	Jordan	Neolithic (PPNA)			10,072 ± 43 9,440 ± 50		?	Yeomans et al., 2019
Tell Mureybet	Syria	Late Natufian (Khiamian)			9,905 ± 60 9,945 ± 50		1	Gourichon and Helmer, 2008; Grosman, 2013
Uncertain dog remains								
Monruz	Switzerland	Upper Magdalenian			13,330 ± 110 12,800 ± 85		3?	Morel et al., 1997
Hauterive	Switzerland	Upper Magdalenian			13,050 ± 155 12,510 ± 130		1	Morel et al., 1997

Tab. 1 The earliest small stature dogs. Note: all radiocarbon dates (^{14}C) are uncalibrated.
* Age estimates based on stratigraphic data.

Genetic dating of divergence timing is based on wolf generation time and mutation rate (Botigué et al., 2017; Frantz et al., 2016; Fan et al., 2016; Koch et al., 2019; Larson et al., 2012; Larson and Bradley, 2014; Mech et al., 2016; Pang et al., 2009; Savolainen et al., 2002; Skoglund et al., 2015; Thalmann et al., 2013; Vilà et al., 1997; Wang et al., 2013). Investigators historically have suggested a timing of divergence between 6 and 135 kya (Savolianen et al., 2002; Vilà et al., 1997). The most recent dating is unrealistic, since the oldest archaeological dog finds date from 15 kya. The oldest genetic dating also is questionable, since the geographic spread from the most probable immediate dog ancestor, the modern wolf type from Beringia, began around 25 kya (Loog et al., 2020). The most used wolf and dog generation time is 3 years (Ersmark et al., 2016). However, Mech and colleagues have indicated a longer wolf generation time (4.2-4.7 years) (Mech et al., 2016), while we suggest a shorter generation time for dogs, beginning at year one, and once yearly with some variability (Spotte, 2012). The use of such different generation times would result in mean divergence timing estimates 25 % more recent.

Mutation rate uses estimates ranging from 1×10^{-8} to 6.6×10^{-9} per autosomal site, per generation (Botigué et al., 2017; Fan et al., 2016: Fig. 6; Frantz et al., 2016; Freedman et al., 2014, 2017; Koch et al., 2019; Skoglund et al., 2015; Wang et al., 2013), and depends on the accepted divergence times between wolf and coyote (varying from 750 kya to 1,000 kya) and of canids and felids. This huge variability helps to explain the large spread in estimated divergence timing dates between wolves and dogs, having occurred, in any event, just a few thousand years ago.

Hypotheses about the number of times that wolves were domesticated include: A single event (Freedman et al., 2014; Savolainen et al., 2002; Bergström et al., 2020); dual origins (Frantz et al., 2016); or multiple origins (Skoglund et al., 2015; Vilà et al., 1997). It is beyond the scope of this article to elaborate on these differences.

Here, we focus on smaller size as the most important morphological difference between wolves and dogs. We discuss probable primary causes for this difference in physiological and genetic terms and consider related historical explanations. Further, we evaluate domestication pathways that have been proposed, in light of the best circumstantially-likely hypotheses, to explain smaller size as a stress-related growth response.

MORPHOLOGY CHANGES IN DOGS VERSUS WOLVES

Osteological distinguishing of ancient dogs and wolves (Olsen and Olsen, 1977) involves morphology, morphometrics (Harcourt, 1974; Stockhaus, 1965), and geometric morphometrics (GM) (Adams et al., 2004; Ameen et al., 2017; Drake, 2011; Drake and Klingenberg, 2010; Drake et al., 2015; Fondon and Garner, 2007; Ledoux and Boudadi-Maligne, 2015; Rizk, 2012). Historically, distinguishing traits for dogs have included: more tooth crowding; greater oral pathology; smaller sagittal crest; caudal curving of the coronoid process of the vertical mandibular ramus; smaller tympanic bulla; paedomorphism; difference in mandible mass; convex ventral horizontal mandibular ramus; more caudal position of the hard palate caudal border; different micro anatomy of the maxillary p4 protocone; shorter snout-length ratio; and higher snout ratio. All of these now have been rejected (for detailed review and references, see Janssens et al., 2019a).

Smaller size is the most robust trait for distinguishing wolves from dogs (Benecke, 1987, 1994; Bökönyi, 1975; Boudadi-Maligne et al., 2012; Clutton-Brock, 1962, 1963, 2012; Davis and Valla, 1978; Dayan, 1994a, 1994b; Degerbøl, 1961b; Kurtén, 1965; Mertens, 1936; Napierala and Uerpmann, 2012; Rütimeyer, 1861, 1875; Studer, 1901; Wolfgram, 1894). The oldest archaeological dogs are about ⅔ of the size of contemporaneous isopatric wolves (Janssens et al., 2019a; Kurtén, 1965). The Hayonim (Tchernov and Horwitz,

1991; Tchernov and Valla, 1997) and Bonn-Oberkassel (Street and Jöris, 2015) human-dog burial specimens are about 45 cm high at shoulders, compared to > 60 cm for most wolves. Early Holocene and Neolithic dogs, such as in Jericho, are even smaller, at 30-40 cm (Horard-Herbin et al., 2014; Zeuner, 1963). This trend also is observed in dogs at Neolithic Alpine lake Pfahlbauten settlements (Rütimeyer, 1875).
Additional morphological wolf-dog differences that can be accepted for species assignment include, for dogs:

Differences related to smaller size:

- Isometric size reduction (cranial and post-cranial) such as shorter skull length (Lawrence and Bossert, 1967; Gaudry and Boule, 1892);
- Shorter mandibular m1 mesio-distal diameter < 21.8 mm (Janssens et al., 2019a);
- Shorter maxillar p4 mesio-distal diameter < 22.5 mm (Janssens et al., 2019a).

Differences related to change in facial morphology:

- Wider snout-width index (Morey, 1992, 2010; Wayne, 1986);
- Higher skull-height index (Pitulko and Kasparov, 2017);
- Higher orbital angle > 60° (Janssens et al., 2016);
- Higher stop (Drake et al., 2015).

Differences related to the brain:
- Smaller brain-size ratio in dogs (Arbuckle, 2006; Zeder, 2006, 2012),
- Inner ear morphology (Janssens et al., 2019b).

It is important to understand that these distinguishing facial morphology traits are not independent. They are related, based on changes such as different closure times for the maxillary, temporal, and zygomatic skull suture lines (compared to wild wolves), probably driven by differences in the Runx-2 and Twist-1 alleles (Fondon and Garner, 2007). The outcome is dorsolateral orbital expansion that creates a larger orbital angle, higher nasal stop (height difference between nasal and frontal bones), wider snout and higher skull ratio, compared to skull length (Drake and Klingenberg, 2010; Drake, 2011; Drake et al., 2015; Janssens et al., 2019a; Rizk, 2012). The smaller size and skull morphology thus should be considered as a morphological unit.
Development of smaller size (Aaris-Sørensen, 1977, 2005) appears to have occurred at the end of the Pleistocene in several species, and likely was related to Holocene temperature rise (Bergmann's law) (Tchernov and Horwitz, 1991). But in early domesticates, the proportional size reduction is substantially larger, and is localized to the specific domestication geography. Therefore, nearby wild isopatric conspecifics may not be revealing in every instance (Davis, 1977, 1981; Tchernov and Horwitz, 1991).

DIFFERENCES BETWEEN DOGS AND WOLVES THAT ARE NOT OSTEOLOGICAL

Genetics of integumental traits

Although non-osteological traits are invisible in the archaeological record, they can be explored genetically to document changes in dogs that do not occur in wolves. Some examples follow:

Coat texture

Wolves have a double coat, with a dense short undercoat, longer guard hairs, and hair-shedding during summer (Pocock, 1935). Most modern dogs also possess a double coat, although some breeds have only short hair or even baldness (mutation of FOXI3 gene on chromosome 17) (Drögemüller et al., 2008). Dogs on Egyptian bas-reliefs (Pfluger, 1947) already possess coats seen in modern breeds (long, fluffy, curly). Genetic analyses proved the involvement of three genes for these new coat forms in dogs: FGF5, KRT71, and RSPO2 (Cadieu et al., 2009). These changes in allelic composition can be searched for in archaeological specimens.

Coat colour

Wolves carry a variant of the wild colour gene (agouti) (Schmutz and Berryere, 2007) and demonstrate colour variations between dark grey and white, with coloured undercoat, although *C. l. arabs* has a light-brown coat (Pocock, 1935, 1939). Black and red colour variants in wolves are results of hybridizing: black is caused by backcrossing with dogs, red by crossing with coyotes (*Canis latrans*) (Wayne and Jenks, 1991). Dogs have a wide variety of coat colours: Red, white, grey, blue, brindle, gold, and a wide variety of different colour patterns, of which most are heritable (Ollivier et al., 2013; Schmutz et al., 2007, 2009). Coat colours are expressed by complex interactions among 1) pigment synthesis, mainly eu- and pheo-melanin produced from tyrosine through tyrosinase, and 2) receptor access (Sponenberg and Rothschild, 2001). Mutations in > 150 different colour genes have been discovered in the genome of modern dogs (Kerns et al., 2007; Kim et al., 2005). Coat colours as seen in modern dogs were present by 10 kya (Kim et al., 2005; Ollivier et al., 2013).

Ear carriage

Wolves and many dogs have prick (standing) ears, but some modern breeds possess proportionately large floppy ears. Darwin wrote that there were no wild animals with floppy ears, apart from elephants (Darwin, 1868). The genetic architecture of floppy ears in dogs is localized in regions CFA10 and MSRB3 (Boyko et al., 2010), allowing for genetic search of archaeological specimens. Clutton-Brock (1995, 1999) suggested that floppy ears are degenerate and reduce biological fitness, based on reduced hearing and a smaller social communication palette. However, no documenting scientific evidence exists to support this hypothesis.

Reproductive differences

Wolves breed annually (monestrous; Mech, 1970) and stay in family groups (Mech and Boitani, 2003). Most female wolves reach puberty between ages 2 and 5 years (Mech et al., 2016). Mating usually is restricted to the dominant (parental) pair that generally are monogamous (Stahler et al., 2013). The pack includes parents and the most recent immature offspring from the previous 1-3 years (Mech and Boitani, 2003). All pack members assist in care and feeding of pups, by carrying and regurgitating food (Mech, 1988). Mating occurs in late winter, with pup birth in spring (about 2 months after mating) depending on latitude (later at more northern latitudes).

Free-roaming dogs have no pack structure (Spotte, 2012), have mono-parenting, and lack monogamy. Bitches experience the first estrus at any time of year, starting between age 6-12 months, usually cycling twice per year, although some breeds express only one cycle per year (Basenji, Dingo, and Afghan hound). Estrus disengagement from seasons allows dog pups to be born all-year long, but pup survival can be assured only in a domestic environment. This argument is supported by the 100 % puppy death rate in feral dogs that do not whelp in spring or summer (Spotte, 2012). Hybrids between wolves and dogs are reported to have one estrous cycle per year (Buffon, 1799).

More frequent and earlier estrous cycles lead to more offspring through the breeding lifetime (Spotte, 2012). The reason for earlier sexual maturity in dogs lies in progenesis. The latter has been observed in all basic domesticates (pigs, cattle, sheep, goats) and has been related to a less stressful anthropogenic niche and to relative smaller brain-size (Healy and Rowe, 2006; Hemmer, 2005; Morey, 1992, 2010; Nehring, 1888; Nobis, 1981; Olsen and Olsen, 1977; Stockhaus, 1965; Tchernov and Horwitz, 1991; Zeder, 2012). Relative smaller brain size also is seen in island dwarfism, when stress levels are lower due to lack of competitors and/or predators (Heaney, 1978; Hofman et al., 2015; Lomolino, 1985; Lomolino et al., 2013; Meiri et al., 2004, 2008; Prothero and Sereno, 1982). Smaller brain size is not general, but is restricted to downsizing of specific brain stress centres, such as the reticulo-activated system (Kruska, 1988a, 1988b; O'Regan and Kitchener, 2005).

Based on the foregoing reports, the hypothesis states that reduced production of corticotropin-releasing-hormone results in lower production and release of adrenocorticotropic hormone (ACTH). Less circulating ACTH results in turn in less adrenal stimulation and thus lower glucocorticoid production and release (Arbuckle, 2006; Hemmer, 2005; Trut, 1999; Trut et al., 2009). This chain of events would result in greater production of gonadotropin releasing hormone (GnRH), thus activating follicle stimulating hormone (FSH) (Klütsch and De Caprona, 2010) that induces earlier gonadal estrogen production in mammals (Grumbach, 2000; Matsuo and Fujieda, 2006; Van der Eerden et al., 2003; Verdonck et al., 1998a, 1998b). Additionally, epiphyseal chondrocytes in growth plates are stimulated, leading to increased earlier chondrocyte activity and creating a growth spurt. Chondrocytes die thereafter, and growth plate closure occurs, leading to earlier growth cessation (Kreeger, 2003; Wilkins et al., 2014; Zeder, 2012; Zeder et al., 2006). Modern wolves that grow up in a human environment (Janssens et al., 2019a; Viranyi, Ernstbrunn, Austria, wolf science centre, pers. comm.), or those that grow up in the wild with an abundance of prey when competition is lacking (Gould, 1966; Mech et al., 2016; Medjo and Mech, 1976; Risenhoover and Bailey, 1988), show earlier estrus.

DOMESTICATION PATHWAYS

Pup collection

The proper age for ancient humans to have collected wolf pups from dens would have been prior to age two weeks, as after this time they will become less sociable, behave uncooperatively, and fear humans. Any success certainly would require wolf puppies younger than age 4 weeks (Fentress, 1967), and before eye opening (Darwin, 1868; Dehasse, 1994; Frank et al., 1989; Klinghammer and Goodmann, 1987; Kubinyi et al., 2007). The pups would have been breastfed and raised in the anthropogenic pack (Simoons and Baldwin, 1982), where it is likely that they were pleasant pets until sexual maturity (as demonstrated by modern ethology experiments and many individual reports) (Crisler, 2000; Hell and Paule, 1982; Hellmuth, 1965; Hillis and Mallory, 1996; Jolicoeur, 1959; Stockhaus, 1965; Wolfgram, 1894). During this period, they were fed and protected from competitors and predators, and they did not have to hunt large prey. Interestingly the foregoing are the factors that define island dwarfism (Heaney, 1978; Hofman et al., 2015; Lister, 1989; Lomolino, 1985; Meiri et al., 2004; Meiri et al., 2008; Prothero and Sereno, 1982; Wasserburg et al., 1979; Weston and Lister, 2009) that involves progenesis and smaller size, including smaller relative brain size.

Behaviourally unsuitable pups likely would have been chased away, starved, or killed, as suggested anecdotally today in some rural settings. When mature, reports suggest unruly behaviour and permanent departure, with the associated risks of being killed by surrounding wolf packs, or starving because they had not learned to hunt. Another possibility is that several collected pups were in one camp, perhaps deriving from different dens and different years. Subsequent to finding mates in the camp, they had no need to escape. If they did escape, they self-isolated from wild wolves in the region, thus creating the necessary genetic isolation for speciation. Did any of this actually happen? We do not know!

Self-domestication

In a self-domestication hypothesis, wolves sought contact with humans based on certain interests (Larson and Fuller, 2014; Zeder, 2012). For this domestication pathway, association with humans must have occurred when the domesticates were adults, as immature wolves would have been kept away from humans, safe in wolf territory. Adult wolves could not show progenesis and concurrent morphological changes in size and skull. A further complication relates to why wolves would seek human contact. The latter does not occur in modern times, and it is unreported in historical and ethnology sources up to 4,200 years ago. Finally, during the time period of wolf domestication, humans were hunter-gatherers, many following migrating herds over long distances. Rationalizing wolf self-domestication under such circumstances is quite difficult, particularly considering the possibility of humans' "companion" wolves being killed by foreign wolf packs (Binford, 1983, 1990; Campbell, 1973; Houtsma et al., 1996; Testart, 1982).

PROPOSED REASONS FOR WOLF DOMESTICATION

Most domestication hypotheses are utilitarian, yet through logic alone, we should question how people could have known what to anticipate from wolves as a part of the human niche, since they had no related prior experience or knowledge.

Hunting

The possibility that early domesticated dogs hunted in collaboration with humans, thereby increasing hunting success, was among the earliest proposed reasons to domesticate wolves (Hare et al., 2012; Hare and Tomasello, 2005). Recently, scientists are much more cautious about accepting this hypothesis, as the result of increased knowledge of past climate and landscapes, new ethnological observations, and more advanced understanding of wolf hunting behaviour in the wild. Wolves are excellent pack hunters, just as humans are skilful group hunters. Both hunted the same large ungulate species, prompting some scientists to suggest that humans, if assisted by early dogs, could reduce their own energy costs, increase prey encounter rates, and improve efficiency of attack and pursuit of prey (Lupo, 2017).

However, if dogs had been accustomed to hunting large prey, major skeletal injuries would be expected in zooarchaeological remains. Such lesions are not found in the archaeological record, whereas they are recorded routinely in wild wolves (Mech and Peterson, 2003; Spotte, 2012). Another aspect to consider is that, if cooperative hunts were done with wolves still functioning as a pack, it is difficult to imagine how the human interactions would have been possible. Contrary to dogs that can be controlled by voice commands, wolves hunt instinctively, and would hunt independently of their human companions. Also, following the wolves around would be energy-inefficient for humans, because of the speed and endurance of the wolves. In the latter circumstance, humans likely would not increase prey contact and would increase their energy expenditure. However, once wolves were domesticated (being then dogs) to the point of control by human voices, they could have been useful. If this happened over a few generations after puppy collection, such aid then may have been a powerful motivation to pursue additional domestication.

Conceivably, dogs might have been used for hunting during the Magdalenian, the period coinciding with the end of the LGM and the onset of a warmer climate and concurrent faunal changes (Aranbarri et al., 2014; Miller, 2012). The European environment shifted from an open landscape (steppe-tundra) during the LGM to a closed landscape (boreal-, later deciduous forest) (Perri, 2016). This was a time of considerable change in animal targets, weapons, and hunting strategies. Use of the spear, atlatl, and dart shifted to the bow and arrow. Group hunting shifted to more individual hunting (Angelbeck and Cameron, 2014), and hunting via sight shifted to hunting strategies that became more focused on auditory and olfactory cues. Additionally, there were new hunting challenges, such as retrieving wounded prey hiding in the bush, or locating prey hidden in dense forest.

This increasingly closed environment may have favoured use of early dogs in hunting, with Magdalenian humans benefitting from the superior auditory and olfactory abilities of dogs (Hepper and Wells, 2006). Wolves and dogs have about 200 million olfactory neurons (humans have about 5 million) and sense odours 100-1,000 times more efficiently than humans (Moulton, 1977). Dogs' auditory frequency ranges up to 80 kHz, while humans detect < 20 kHz. Wolves and dogs also detect low-decibel sounds from kilometres away (Asa and Mech, 1995; Heffner and Heffner, 2007; Lipman and Grassi, 1942). Lastly, but yet not identified in literature, dogs may have helped in guiding hunters back to camp at night (Arsenyev, 2016).

Some archaeological data challenge and complicate the hunting aid hypothesis. Bow hunting existed already in Southern Portugal during the Solutrean (25,000-20,500 cal BP), changing then to spear hunting again during the Magdalenian (Bicho, 2013). This evolution is contrary to what is known about the rest of Europe. Also, it is contrary to the logic behind a shift to bow hunting with use of dogs to retrieve prey. Dogs have been used in hunting in open landscapes, such as for beach seal (*Phoca* spp.), during the early Mesolithic in Denmark (Clark, 1936, 1946), or chasing fish into nets in Patagonian rivers (ethnographic data) (Darwin, 1868). Ethnographic data further complicate the hunting aid debate, because of contradictory reports. Some studies confirm the general beneficial use of dogs for hunting (Bicho, 2013; Kelly, 2013; Perri, 2016; Turney-High, 1941), whereas others confirm this benefit only for specific prey. Still others report opposing thoughts, with dogs chasing prey away (Hamilton, 1972), thus resulting in their exclusion from at least some hunting (Manwell and Baker, 1984).

Lastly, Lupo (2017, 2019) additionally proved that wolves do not hunt prey as large as mammoths. Intra-site archaeology of early sites with mammoth concentrations with tusk huts, such as Mezin and Mezhyrich, revealed hardly any bite marks on mammoth bones, thus excluding wolf or dog presence (Wilczynski et al., 2010).

Guarding

It is well-documented that wolves and both domestic and feral dogs guard their territory against wolves and other dangers (Boitani et al., 1995; Fritts et al., 2003). Based on these observations, some researchers have suggested that wolves were kept as guards against other wolves and carnivores, such as brown bears

(*Ursus* spp.), that repopulated the Magdalenian European landscape from southern refugia (Hescheler and Rüeger, 1942; Pacher and Stuart, 2009; Stewart and Lister, 2001; Tetzlaff et al., 2007). Other hypotheses include using dogs as alerts to signal nearby possibly dangerous prey (Shipman, 2015). Guarding could be done by barking (Harrington and Paquet, 1982; Spotte, 2012) or by alerting humans via restless behaviour. Guarding differs from hunting in that guarding behaviour can be expressed by very young dogs. This might have been the first wolf behaviour that humans appreciated, and thus a possible reason to domesticate wolves on a continuing basis.

Transport

It has been suggested that dogs were kept for transport, as seen ethnographically. There is archaeological support for this hypothesis, as dog harness-gear was excavated at a 9,000-year-old Neolithic settlement at Zhokov (Russia), confirming the existence of dog sledges (Pitulko and Kasparov, 2017). Items to be transported could include meat, various gear, and raw materials, as seen with Indigenous Americans using dogs to pull travois. Inuit (formerly Eskimo) dogs wear harnesses to pull sleds. In other populations, dogs may wear backpacks made of reeds (Aaris-Sørensen, 2005; Germonpré et al., 2017; Lupo, 2017; Pitulko and Kasparov, 2017; Turney-High, 1941).

Some archaeological publications have indicated that spinal morphological observations of archaeological dogs prove human use in transport. Such "pathology" included asymmetric dorsal vertebral spinous processes, flattening of the dorsal aspect of the dorsal spinous process, and spondylosis (Grandal-d'Anglade et al., 2019; Germonpré et al., 2015). However, these same pathological changes are observed among modern wolves and modern dog populations, in non-sporting dog breeds, and in dogs that are not loaded with weights on their backs or pulling travois. This demonstrates that these deformities are not evidence of ancient use of dogs for transport, but rather reflect either fluctuating asymmetry, normal ageing, or taphonomic changes in some instances (Lawler et al., 2016; Janssens et al., 2018). As with the hunting-aid hypothesis, aid-with-transport probably was not a motive to domesticate wolves but could have been a reason that domestication continued as humans imagined such uses for domestic dogs, over time.

Herding

Some authors proposed herding as a reason for domesticating wolves (Coppinger and Coppinger, 2002). However, domesticated animals were not available in pre-Neolithic societies, so this is not a valid hypothesis in the case of the dog.

Canophagy

Canophagy has been hypothesized as a reason to keep dogs (Degerbøl, 1961b; Horard-Herbin et al., 2014). Undoubtedly, wolves and dogs were used as food during periods of starvation (Manwell and Baker, 1984) or even symbolically when brains were eaten, as documented for some Upper-Palaeolithic canids (Germonpré et al., 2012). However, canophagy is improbable as a primary factor for wolf domestication. Dogs were rare during the Palaeolithic (Aaris-Sørensen, 2005; Pionnier-Capitan, 2010; Pionnier-Capitan et al., 2011;

Rütimeyer, 1861) and cannot have been an important food source. Cut-marks on Palaeolithic dog bones, as direct evidence for their consumption, also are rare (Boudadi-Maligne et al., 2012; Boudadi-Maligne and Escarguel, 2014; Boudadi-Maligne et al., 2018b; Harcourt, 1974; Manwell and Baker, 1984; Pionnier-Capitan, 2010), and more probably indicate skinning and opportunistic defleshing (Manwell and Baker, 1984). More recently, canophagy may have been systematic: Small dogs from the Neolithic *Pfahlbauten* villages at the Alpine lakes show many cut-marks, demonstrating defleshing (Becker and Johansson, 1981). Nevertheless, raising wolves for food would lack time and energy efficiency. Further, there would be no reason to domesticate them because humans could just use wolves.

Bed warmer

Some aboriginals sleep with dogs (huddling together) to keep warm during cold nights. Based on that information, maintaining warmth has been suggested as a reason to domesticate wolves (Manwell and Baker, 1984). Although it is easy to accept that wolf pups could be sleeping closely to humans, it is more difficult to accept the same regarding adult wolves. Still, experiments in Ernstbrunn, Austria, have demonstrated that such behaviour exists with sub-adult wolves (Viranyi, pers. comm.).

Symbolic and spiritual reasons

The Bonn-Oberkassel burial of two humans and two dogs is the oldest reported dog burial (14,300 ya) (Street and Jöris, 2015), together with the Natufian terrace dogs of Hayonim and Ain Mallaha (Grosman, 2013). Dog burials are found more frequently from more recent periods, such as the Stilwell, Stilwell II, and Koster sites, Illinois USA, and those in Mesolithic Scandinavia (10,200-6,500 ya) (Aaris-Sørensen, 1977; Morey, 2010; Perri, 2016). Dog burials became progressively more abundant during the Bronze Age (Perri, 2016). Massive dog burials took place in Ashkelon (Israel) with 1,200 dogs buried about 2,500 ya (Morey, 2010). Dog burials and human-dog burials represent symbolic behaviour in humans (Morey, 2006, 2010), possibly related to a belief in afterlife, wherein the dog would guard against evil or assist humans with hunting (Grünberg, 2013; Losey et al., 2013). A further possibility is a continued emotional bond with the deceased human. For an overview on dog burials, see Morey (2006) and Losey et al. (2013). There are rare indications wolves also were buried symbolically (Germonpré et al., 2012). We suggest that domesticating wolves exclusively for these purposes would indicate considerable human foresight.

Ornamental use

Some authors hypothesize that domestication was based on use of dog pelts, teeth, and bones for clothing and ornamentation (Boudadi-Maligne et al., 2018a). While cut-marks on dog bones and perforated dog teeth and metapodia have been documented in the archaeological record, perforated teeth and bones of wolf, bear, and other wild animals have been recovered from the Gravettian onward (Becker and Johansson, 1981; Boudadi-Maligne et al., 2018b). Thus, it is improbable that this was an important motivation for domestication. There is no indication that dogs would provide any better pelts, teeth, or bones for ornamental use, compared to wolves.

Warfare

Warfare against Neanderthals was proposed to explain their demise and the superiority of *Homo sapiens* (Shipman, 2009, 2010, 2015). Early dogs could have assisted modern humans in hunting mammoths, thus providing modern humans a competitive advantage over Neanderthals. This hypothesis is highly speculative, since there are no dog remains known from the Châtelperronian or the initial Aurignacian, the periods and contexts during which *Homo sapiens* and Neanderthals co-existed. Furthermore, the demise of Neanderthals increasingly has been suggested to be within the context of "make love not war" (Kuhlwilm et al., 2016).

THE NON-UTILITARIAN SCENARIO: AS PETS

It has been hypothesized that the emotional bond between humans and wolves, and later dogs, may have been an important drive for domestication (Aaris-Sørensen, 2005; Horard-Herbin et al., 2014; Serpell, 1995; Street, 2002; Tchernov and Valla, 1997). One of several prominent examples is suggested by the Bonn-Oberkassel human-dog burial (Street, 2002).

Wolves and dogs have several behaviours (Packard, 2003; Scott 1950, 1967) in common with humans. These include (1) a home site (the territory, campsite); (2) a group identity (the pack, eventually including close humans); (3) functioning in a dominance-ordered micro-society; (4) defence of the pack/home site; (5) expressing social altruism (sharing food, helping others, cooperation); and (6) playful behaviours.

Playful behaviours include (Harrington and Asa, 2003): 1) out-of-context or conceptual behaviour (playing with a feather or branch as if it were small prey; 2) exaggerated activity such as galloping rounds when happy; 3) meta-communication (tail wagging when expecting something positive); and 4) changing roles (running behind another pack member, "hunting" it, then turning around and asking to be hunted).

Research on attachment between either dogs or wolves and humans has not revealed important differences (Gásci et al., 2005, 2010; Topál et al., 2005), since both dogs and wolves display a complex social palette, comparable to that of primates and humans (Mech and Boitani, 2003). Therefore, it is natural for wolves and dogs to adapt to humans and their environment, but only if socialisation is initiated early enough; socialization ages are 2-4 weeks for wolves and 7-10 weeks for dogs (Darwin, 1868; Frank et al., 1989; Klinghammer and Goodmann, 1987; Kubinyi et al., 2007). The interest in the relationship is bidirectional with dogs, with humans recognizing puppy behaviour as attractive (Scott, 1950) and considering dogs as full family members (Berryman et al., 1985; Mitchell, 2001). All of the characteristics described in this section help us understand why Palaeolithic humans may have been attracted to wolves and their pups, incorporating them into their micro-social system.

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A LATE GLACIAL PALAEOLITHIC DOG FROM GOYET (THIRD CAVE, BONE LEVEL A1), BELGIUM

Abstract

Most researchers accept that by the end of the Pleistocene dogs were part of the daily life of prehistoric hunter-gatherers. Recent analyses of the mammal assemblages from the third cave of Goyet (Belgium) reveal that a large component of the material from bone level A1 postdates the Last Glacial Maximum. The biometric study of the large canid remains from this level shows that an ulna can be described as from a medium-sized Palaeolithic dog with an estimated body mass of ~20 kg. A direct AMS ^{14}C date of the bone demonstrates that the dog lived during the Bølling/Allerød interstadial. Human and carnivore modifications of the bone indicate that the animal was dismembered by a contemporaneous human individual, likely to obtain its meat, and then gnawed by a canid-sized carnivore. Presumably, Palaeolithic dogs fulfilled diverse roles in Late Palaeolithic societies including as a source of food.

Keywords

Palaeolithic dog, Late Palaeolithic, Western Europe, cynophagy

INTRODUCTION

The timing of the beginning of the domestication process of the wolf is controversial, but most researchers agree that dogs were living together with people at the end of the Pleistocene. Remains of this togetherness were famously found at Bonn-Oberkassel in Germany where two dogs were buried together with a man and a woman (Nobis, 1979, 1986; Street, 2002; Street et al., 2015; Janssens et al., 2018). In France, an intentional double dog burial, dating from the Late Palaeolithic, was recently detailed (Boudadi-Maligne et al., 2020). Much older canid remains, dating from before the Last Glacial Maximum (LGM), an extremely cold and dry period ranging in age from 23,000 years to 19,000 years ago (Mix et al., 2001), have been attributed to incipient dogs (e. g., Germonpré et al., 2012, 2015). One such remain is the canid skull (**Fig. 1**) found in the third cave of Goyet, in Belgium. With a calibrated age of ~35,700 cal BP this canid would be the oldest domesticated animal known so far (Germonpré et al., 2009, 2012, 2018). However, these attributions are subject to controversy (Boudadi-Maligne and Escarguel, 2014; Morey, 2014; Drake et al., 2015; Janssens et al., 2016, 2019; but for a rebuttal see Galeta et al., 2021).

The Goyet caves are situated in the Condroz, a region south of the Sambre and Meuse valleys in Belgium. The Condroz landscape is characterised by steep-sided valleys cutting through plateaux of relatively constant altitudes, locally reaching 350 m (Denis, 1992). The third cave of Goyet is part of a large karstic system that lies on the right bank of the Samson, a tributary of the Meuse River, at ca. 15 m above the river. Edouard Dupont, who excavated this cave in the 1860s, recovered here numerous Pleistocene mammal bones, human remains and large quantities of Middle and Upper Palaeolithic artefacts (Dupont, 1872; Germonpré, 2001; Flas, 2008; Pirson et al., 2012). It is the only site in the world where human remains from populations dating from the Mousterian, Aurignacian, Gravettian and the Magdalenian have been found at the same location (Rougier et al., 2016; Posth et al., 2016; Fu et al., 2016). The radiocarbon

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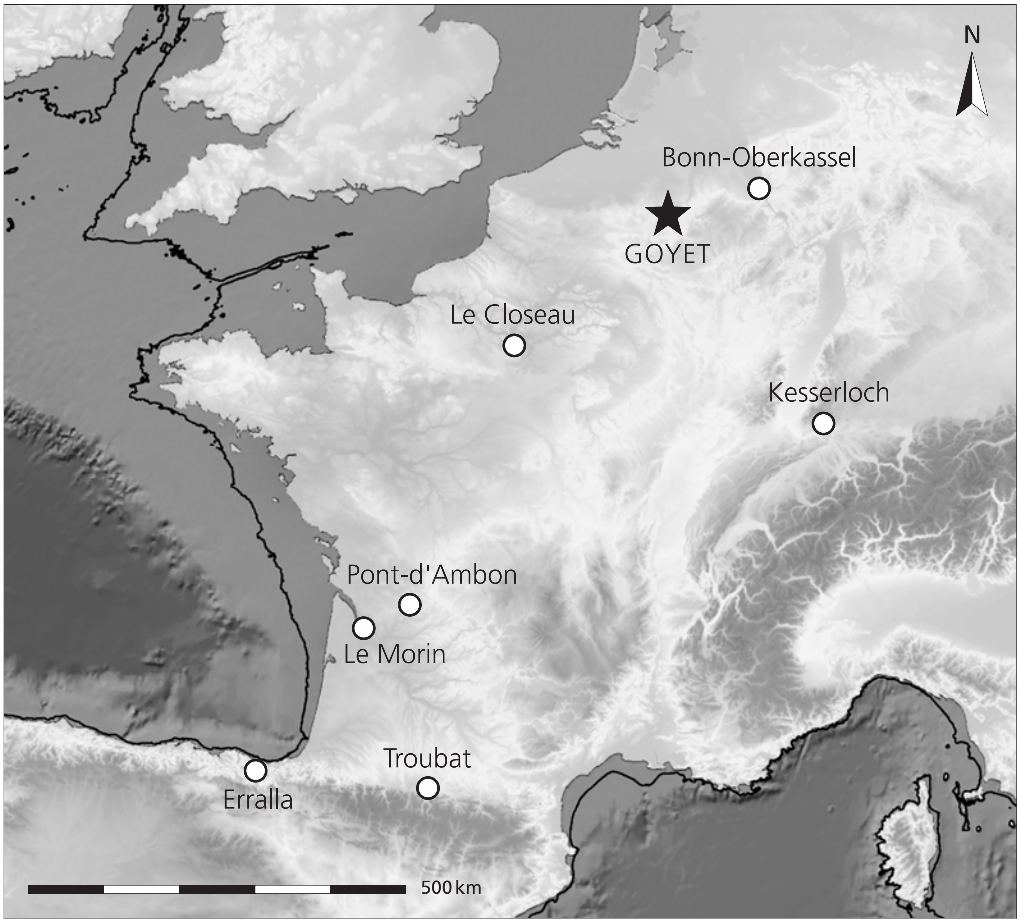

Fig. 1 Map with the most important sites discussed in the text; the estimated coastline (at -80 m) during MIS3 is based on Zickel, M., Becker, D., Verheul, J., Yener, Y., Willmes, C. CRC 806 Database: Paleocoastlines GIS dataset [08.02.2021]. – (Available from http://crc806db.uni-koeln.de/dataset/show/paleocoastlines-gis-dataset1462293239/).

dates show that occupations of the cave date from before the LGM, from the LGM and from the post-LGM (Tab. 1).

The age dispersion of several AMS ^{14}C dates and the refitting of human bones originating from different horizons indicate that at least part of the content of the bone levels recognized by Dupont is mixed, likely because Duponts' excavations methods have not met today's standards (Germonpré, 2001; Rougier et al., 2016). At the entrance of the third cave, in Chamber A, Dupont discovered in the three uppermost levels, a large number of Middle and Upper Palaeolithic artefacts, human remains and many bones of Pleistocene mammals (Dupont, 1872; Germonpré, 2001; Rougier et al., 2016). The artifacts can be assigned to the Mousterian, Lincombian-Ranisian-Jerzmanowician, Aurignacian, Gravettian, Magdalenian, Neolithic and to historical times and show that the cave was recurrently occupied from the Pleniglacial on. Unfortunately, it is not always clear from which level the artefacts originated (Dewez, 1987; Dupont, 1872; Lopez Bayon et al., 1997; Otte, 1979; Otte and Groenen, 2001; Ulrix-Closset, 1975; Flas, 2008; Pirson et al., 2012). At the rear of Chamber A and in Chamber B, Dupont (1872) distinguished a fourth and a fifth bone-bearing level, containing mainly cave bear, cave lion, and cave hyena remains. Apart from the stratigraphic attribution of the finds, Dupont distinguished three types of bone assemblages at Goyet. A first type, found at the entrance of

AMS #	Level	RBINS #	^{14}C Date [BP]		cal BP (95 %)	Taxon	Element	Human modifications	Reference
Level A1, post-LGM dates									
RICH-27945	A1	Vert00-247/ 2812-6	11,785	±48	13,740-13,480	*C. familiaris* (Palaeolithic dog)	ulna	cut-marks, red stains, gnawing	this study
UtC 8957	A1	2813-33	12,560	±50	15,140-14,530	*Equus* sp.	MC acc	cut-marks, red stains	Germonpré, 2001
GrA-3238	A1	2783-49	12,620	±90	15,290-14,460	*O. moschatus*	phalanx	cut-marks	Germonpré, 1997
GrA-3237	A1	2380-6	12,770	±90	15,590-14,900	*Equus* sp.	vertebra	cut-marks, red stains	Germonpré, 1997
OxA-V-2223-48	A1	2832-2	12,775	±55	15,440-15,040	*Equus* sp.	MC	impact marks	Stevens et al., 2009
OxA-32248	A1	2811-48	12,960	±65	15,750-15,260	*U. arctos*	canine	red stains	Ersmark et al., 2019
KIA-25296	A1	2812-10	13,680	±60	16,780-16,270	*C. lupus/familiaris*	humerus		Germonpré et al., 2009
Level A1, LGM date									
OxA-6592	A1	2814-34	16,320	±140	20,070-19,340	*C. antiquitatis*	phalanx		Stevens et al., 2009
Level A1, pre-LGM dates									
OxA-11291	A1	2814-28	23,560	±230	28,130-27,350	*C. antiquitatis*	phalanx	cut-marks	Stuart and Lister, 2012
OxA-11292	A1	2815-2	23,940	±180	28,430-27,680	*M. primigenius*	humerus		Barnes et al., 2007
GrA-3239	A1	2812	27,230	±260	31,520-30,850	*C. crocuta*	calcaneus		Germonpré, 1997
OxA-12120	A1	2814	29,330	±160	33,890-33,150	*C. antiquitatis*	M3		Stuart and Lister, 2012
OxA-V-2223-44	A1	2832-2	31,750	±200	36,130-35,150	*Equus* sp.	MC	impact marks	Stevens et al., 2009
OxA-11294	A1	2815-24	32,280	±280	36,900-35,530	*M. primigenius*	ivory		Palkopoulou et al., 2013
OxA-11293	A1	2815-8	32,840	±340	38,120-36,120	*M. primigenius*	molar		Palkopoulou et al., 2013
UtC 8958	A1	2812	35,000	±400	40,770-38,670	*C. crocuta*	P4		Germonpré, 2001
OxA-20997	A1	2815-24	35,650	±600	41,510-39,000	*M. primigenius*	ivory		Palkopoulou et al., 2013
GrA-9605	A1	2811-43	38,770	+1180 -1030	44,990-41,360	*U. spelaeus*	pisiform		Germonpré and Sablin, 2001
Post-LGM dates of other bone levels									
KIA-13550	A3	2763	10,640	±50	12,715-12,540	*U. arctos*	mandible		Germonpré, 2001
KIA-22275	A2	2830-23	12,380	±60	14,810-14,120	*A. lagopus*	humerus		Dalén et al., 2007
GrA-46168	?	Goyet Q2	12,650	±50	15,230-14,780	*H. sapiens*	humerus	red stains	Posth et al., 2016
OxA-12121	A2	2770-1	12,775	±50	15,420-15,060	*O. moschatus*	MT	cut-marks	Germonpré and Hämäläinen, 2007

Tab. 1 AMS ^{14}C dates and calibrated ages available for the bone assemblage from the first bone level A1 from the third cave of Goyet and AMS ^{14}C dates and calibrated ages available for other bone assemblages dating from the post-LGM.

					Anthropogenic traces						Carnivore traces	
Goyet third cave	**NISP**	**NISP [%]**	**MNI**	**MNI [%]**	**red stains NISP**	**red stains NISP [%]**	**cut-marks NISP**	**cut-marks NISP [%]**	**tools/orn. NISP**	**tools/orn. NISP [%]**	**gnawing NISP**	**gnawing NISP [%]**
Lepus sp.	3	0.2	1	1.0								
Canis lupus/familaris	18	1.4	3	3.0	1	5.6	4	22.2	2	11.1	4	22.2
Vulpes sp.	48	3.8	6	6.0	4	8.3	2	4.2	2	4.2	4	8.3
Ursus arctos	5	0.4	1	1.0								
Ursus spelaeus	193	15.3	14	14.0							6	3.1
Mustela putorius	1	0.1	1	1.0								
Meles meles	7	0.6	2	2.0								
Crocuta crocuta spelaea	42	3.3	5	5.0								
Mammuthus primigenius	40	3.2	2	2.0	5	8.8			3	7.5	2	5.0
Equus sp.	533	42.2	13	13.0	22	4.1	24	4.5	22	4.1	15	2.8
Coelodonta antiquitatis	43	3.4	3	3.0	4	9.3	2	4.7			1	2.3
Cervus elaphus	13	1.0	2	2.0							6	46.2
Capreolus capreolus	6	0.5	2	2.0			1	16.7				
Rangifer tarandus	250	19.8	39	39.0	17	6.8	8	3.2	7	2.8	78	31.2
Bison priscus/Bos primigenius	33	2.6	2	2.0			1	3.0				
Ovibos moschatus	4	0.3	1	1.0			3	75.0				
Rupicapra rupicapra	3	0.2	1	1.0								
Capra ibex	9	0.7	2	2.0	4	44.4	1	11.1				
Bovidae	13	1.0										
Total NISP	**1,264**	**100**	**100**	**100**	**57**	**4.5**	**46**	**3.6**	**36**	**2.8**	**116**	**9.2**

Tab. 2 Minimum Number of Identified Specimens per taxon (NISP) and Minimum Number of Individuals (MNI) of the mammal assemblage from the first bone level A1 from the third cave of Goyet with the frequencies of anthropogenic and carnivore traces.

		Anthropogenic traces			Carnivore traces	
Nr. collection	Element	red stains	cut-marks	ornam.	gnawing marks	Remarks
2751	C			×		
2751	C			×		
2812-1	C upper					
2812-2	C upper					
2812-3	C upper					
2812-4	C lower					
2812	p4 lower					
2812-5	mandible					
2812	atlas					
2812-10	humerus distal part				×	AMS and isotopes (Germonpré et al., 2009: G-5)
2812-9	humerus diaphysis				×	Isotopes (Germonpré et al., 2009: G-2)
Vert00-247/ 2812-6	ulna proximal	×	×		×	AMS
2812-8	radius diaphysis		×		×	Isotopes (Germonpré et al., 2009: G-7)
2812	radius diaphysis		×		×	
2812-11	femur caput					
2812	MC I		×			
2812-7	MT II					
2812	phalanx I					

Tab. 3 Minimum Number of Identified Specimens per taxon (NISP) and Minimum Number of Individuals (MNI) of the large canid assemblage from the first bone level A1 from the third cave of Goyet with the frequencies of anthropogenic and carnivore traces.

the cave, is associated with lithic and osseous artefacts. A number of bones displays traces of anthropogenic manipulation such as cut-marks and impact traces (**Tabs. 2-3**). The second type of bone accumulation concerns remains from cave bears, cave hyenas and cave lions. Their bones were discovered in the deep, darker parts of the cave, sometimes in anatomical connection. The last type consists of skeletal elements from herbivores that show gnawing traces, likely from hyenas (Dupont, 1872; Germonpré, 1996). The lithic and osseous material from the first, upper, bone level A1 from Goyet represents, according to Dewez (1987), several late Upper Palaeolithic occupations that could be related to an older, a middle (comparable to the occupation at the nearby Trou de Chaleux cave) and a younger (Creswellian?) Magdalenian. Spectacular finds from the first bone level include a double-barbed bone harpoon, a perforated baton (*bâton percé*) figuring a salmonid and a necklace, found *in situ*, composed of deciduous incisors from horses, incisors from bovids and two bone fragments shaped as bovid incisors (Dupont, 1872; Van Wetter, 1920; Dewez, 1987; Germonpré, 1996). In this study, we detail the remains from the large canids found in the first bone level (A1) at the third cave of Goyet.

		Mandible AL m1-m3						
Measurements	n	min	25 % quantile	mean	median	75 % quantile	max	sd
Goyet 2812-5	1			47.50				
Palaeolithic dogs	33	41.90	44.15	45.77	46.14	46.89	47.81	1.97
Archaic dogs	39	33.2	35.00	36.44	36.7	37.2	41.72	1.78
Pleistocene wolves	37	43.00	45.86	47.39	47.17	48.82	52.5	2.12
Recent northern wolves	38	43.2	45.30	46.74	46.6	48.3	50.1	1.87

		Mandible CL m1						
Measurements	n	min	25 % quantile	mean	median	75 % quantile	max	sd
Goyet 2812-5				27.80				
Palaeolithic dogs	40	24.00	27.42	28.53	28.60	30.00	31.89	1.82
Archaic dogs	39	20.44	21.50	22.45	22.49	24.00	25.13	1.22
Pleistocene wolves	40	28.00	28.75	29.93	29.66	30.88	32.60	1.50
Recent northern wolves	39	26.70	28.10	29.48	29.40	30.40	33.40	1.56

		Mandible CW m1						
Measurements	n	min	25 % quantile	mean	median	75 % quantile	max	sd
Goyet 2812-5				11.10				
Palaeolithic dogs	33	10.64	11.43	11.93	11.80	12.53	14.15	0.78
Archaic dogs	39	8.06	8.60	9.09	9.10	9.41	10.50	0.87
Pleistocene wolves	39	10.80	11.53	12.07	12.04	12.60	13.30	0.66
Recent northern wolves	39	9.90	11.40	11.86	11.80	12.30	14.60	0.85

		Mandible GB corpus						
Measurements	n	min	25 % quantile	mean	median	75 % quantile	max	sd
Goyet 2812-5				14.10				
Palaeolithic dogs	34	13.10	14.71	15.66	15.50	16.45	18.25	1.30
Archaic dogs	40	11.03	11.90	12.61	12.60	13.30	14.72	0.87
Pleistocene wolves	39	13.21	14.54	15.48	15.47	16.39	18.40	1.25
Recent northern wolves	38	11.70	13.65	14.43	14.66	15.40	16.70	1.27

		Humerus Bd						
Measurements	n	min	25 % quantile	mean	median	75 % quantile	max	sd
Goyet 2812-10	1			42.50				
Palaeolithic dogs	2	29.20		31.90	31.90		34.50	3.75
Roman dogs Belgium	8	22.90	26.15	29.10	28.90	32.15	36.10	4.25
Recent archaic dogs	11	30.50	36.90	38.28	39.60	41.10	42.00	3.44
Pleistocene wolves	11	39.20	40.90	43.46	43.00	47.00	47.20	2.97
Holocene wolves	3	39.70	39.70	45.00	46.50	48.80	48.80	4.73
Recent northern wolves	6	43.10	44.90	46.68	46.55	47.35	47.50	1.65
*dog-like in size**				*≤ 39.00*				
large canid			*39.01*		*46.99*			
*wolf-like in size**				*≥ 47.00*				

Tab. 4 Individual measurements of the Goyet large canid elements from the first bone level (A1) compared with the observed ranges (minimum, 25 % percentile, mean, median, 75 % percentile, maximum) and the standard deviation of measurements, according to von den Driesch (1976), of the data sets from Palaeolithic dogs, Belgian Roman dogs, recent archaic dogs, Pleistocene wolves, Holocene wolves and recent northern wolves; see text for more information. * from Germonpré et al. (2017).

		Ulna Bpc						
Measurements	n	min	25 % quantile	mean	median	75 % quantile	max	sd
Goyet 2812-6 (dog-like in size)	1			17.00				
Palaeolithic dogs	2	14.40		15.90	15.90		17.40	2.12
Roman dogs Belgium	6	12.00	12.53	15.02	15.70	16.95	17.10	2.23
Recent archaic dogs	10	16.40	19.36	20.55	21.06	23.16	23.26	2.02
Pleistocene wolves	3	22.90		24.20	23.90		25.80	1.47
Recent northern wolves	2	22.60		23.20	23.20		23.80	0.85
*dog-like in size **				*≤ 22.50*				
large canid			*22.51*		*24.49*			
*wolf-like in size **				*≥ 24.50*				

		Femur DC						
Measurements	n	min	25 % quantile	mean	median	75 % quantile	max	sd
Goyet 2812-11	1			23.54				
Palaeolithic dogs								
Roman dogs Belgium	5	12.80	14.30	16.98	17.80	19.25	19.40	2.73
Recent archaic dogs	10	17.80	20.35	21.90	22.15	24.03	24.90	2.19
Pleistocene wolves	1			26.80				
Holocene wolves	1			27.90				
Recent northern wolves	5	23.90	24.15	25.74	25.90	27.25	27.50	1.58
dog-like in size				*≤ 23.00*				
large canid			*23.01*		*25.99*			
wolf-like in size				*≥ 26.00*				

Tab. 4 (continued)

MATERIAL AND METHODS

The material excavated by Dupont is housed at the Royal Belgian Institute of Natural Sciences (RBINS) in Brussels (Belgium). Complete and fragmentary skeletal elements were counted in Number of Identified Specimens (NISP) and in Minimum Number of Individuals (MNI) (Lyman, 1994). The anthropogenic cut- and impact marks and the gnawing traces on the canid remains were compared with the descriptions in Binford (1981), Lyman (1994) and Fernández-Jalvo and Andrews (2016). Carnivore use of the skeletal remains is examined by looking for indications of consumption traces. Carnivore damage is described based on Haynes (1983), Fosse et al. (2012) and Fernández-Jalvo and Andrews (2016).

The dates in the text and tables are calibrated in calendar years before 1950 (BP) and are derived from the AMS radiocarbon dates given in **Table 1**. All dates have been calibrated using the Oxcal 4.3 online program (https://c14.arch.ox.ac.uk/oxcal/OxCal.html).

Biometric measurements of the mandible, given in mm, were taken according to von den Driesch (1976). The following variables were measured: ALm1m3: the alveolar length of the molar row m1-m3; CLm1: the crown length of the carnassial; CWm1: the crown breadth of the carnassial; GBcorpus: the greatest thickness of the mandible (below m1). All reference groups are adapted from Germonpré et al. (2015) and contain only adults with completely erupted teeth, showing at least slight wear. The reference group of the Palaeolithic dogs consist of large canids dating from the Upper Palaeolithic found at the Gravettian site of Předmostí (Czech Republic), the Gravettian site of Kostënki-8, of eastern post-LGM dogs from the Epigravettian site of

Eliseevichi and the late Upper Palaeolithic site of Verholenskaya in Russia (Germonpré et al., 2015) and of Western post-LGM dogs from the German Bonn-Oberkassel site (Nobis, 1986; Street et al., 2015), the Swiss Kesslerloch site (Napierala and Uerpmann, 2012), and from the French sites of Le Closeau (Pionnier-Capitan et al., 2011) and Le Morin (Boudadi-Maligne et al., 2012). The reference group of the Pleistocene wolves includes fossil wolves from Trou des Nutons and Caverne Marie-Jeanne (Belgium), Předmostí (Czech Republic), Mezin (The Ukraine) and Kostënki-17/II (Russia). The reference group of recent northern wolves is composed of Palaearctic wolves from Belgium, Sweden and Russia, including different populations from the Russian Plain to Kamchatka, dating from the 19th and 20th century. The Archaic dog group is composed of recent northern dogs from Siberia, Sakhalin Island, and Greenland, all dating from the 19th and 20th centuries, and two Holocene prehistoric dogs: a Siberian dog from Shamanka, with a calibrated age range of 7280-7425 years BP (Losey et al., 2011, 2013) and an English dog found at a ritual site near Cambridge dating from the Bronze Age (Baxter, 2007). For more details on these reference groups see Germonpré et al. (2015).

Measurements on the postcranial bones studied here, given in mm, were taken according to von den Driesch (1976). The following dimensions could be taken: the distal breadth (Bd) of the humerus, the greatest breadth across the coronoid process (BPC) of the ulna and the greatest depth of the femural caput (DC). This material is compared with several reference groups. The first reference group consists of Pleistocene wolves from the cave of Trou des Nutons in Belgium, the sites of Jaurens, Maldidier, Le Morin and Abri Pataud in France (Boudadi-Maligne, 2010; Boudadi-Maligne et al., 2012, 2020) and the National Geographical cave in the Primorskii territory in Russia (Baryshnikov, 2015). A second reference group composed of Eurasian wolves contains recent northern wolves from Sweden and Russia (Germonpré et al., 2017). The Holocene wolves contain the smallest and the largest specimens from the Danish postglacial wolves given in Aaris-Sørensen (1977), a Neolithic wolf from Lokomotiv, Siberia (Losey et al., 2011) and a Roman wolf from Braives (Belgium). The Palaeolithic dog groups includes canids from Upper Palaeolithic sites in Spain (Erralla: Altuna and Mariezkurrena, 1985; Vigne, 2005) and France (Le Morin: Boudadi-Maligne et al., 2012; Troubat: Boudadi-Maligne et al., 2020; Pont d'Ambon, Montespan: Pionnier-Capitan et al., 2011). The Belgian Roman dogs are from the Braives and Wichelen sites. The recent archaic dog group is composed of recent northern dogs from Siberia, Sakhalin and Greenland and of specimens from Siberian husky and chow chow.

As discussed in Germonpré and Sablin (2017) and Germonpré et al. (2017), we presume that the mean lengths and widths of the long bones are likely smaller in Palaeolithic dogs than in Pleistocene wolves. We propose that limb bones of large canids can be termed "dog-like in size" when at least one of their measurements falls inside the observed range of the "recent archaic dogs" and is smaller than the lower limit of the observed ranges in the wolf groups in our data set (cf. Germonpré and Sablin, 2017). The canid specimens can be described as "wolf-like in size" when the measurements on the long bone fall outside the observed ranges (rounded to the next digit) of these measurements from the "recent archaic dog" group and if at least one dimension of the bone is larger than the largest mean of this measurement in the wolf groups from our data set. These assumptions can be summarized as a "*less-than or equal*" or a "*greater-than or equal*" value of the measurements and are listed in **Table 4** (cf. Germonpré and Sablin, 2017; Germonpré et al., 2017). The long bones whose measurements do not correspond to either of these assumptions are considered here as "large canids" (**Tab. 4**). This naming does not exclude, however, that such specimens could be dogs.

The body mass estimates (BMe) of the large canids in this study were calculated based on the regression equations given in Losey et al. (2016) on the basis of wolf limb dimensions (Losey et al., 2016: tab. 4). The following regression equations were used for the following measurements:

humerus Bd: $\ln BMe = 1.781 \times \ln Bd - 3.094$ ($r^2 = 0.670$)
ulna BPc: $\ln BMe = 1.795 \times \ln BPc - 2.082$ ($r^2 = 0.620$)
femur DC : $\ln BMe = 2.377 \times \ln DC - 4.090$ (r^2)

RESULTS

The AMS ^{14}C dates available for the first bone level A1 are given in **Table 1**. In addition, AMS ^{14}C dates pertaining to the post-LGM, but on bones originating from other bone levels or unknown stratigraphic origin, are also given in **Table 1**. The calibrated ages (at 95 % probability) of the post-LGM bones range from 16,780 cal BP to 12,540 cal BP. The calibrated ages from bones with human modifications range from 15,750 cal BP to 13,480 cal BP. The calibrated age of the human humerus (15,230 cal BP - 14,780 cal BP) falls in the range of the calibrated ages of the mammal bones with human modification dating from the post-LGM. The calibrated AMS ^{14}C age of ca. 13,500 cal BP of the ulna 2815-6 is younger than the majority of the post-LGM dates at Goyet. About half of the AMS ^{14}C dates from the bone assemblage A1 point to a pre-LGM occupation of the cave by predators like cave bears, cave hyenas and modern humans.

The dominant species in bone level A1, both in NISP and MNI frequency, are horse, reindeer and cave bear (**Tab. 2**). In the A1 assemblage, cut-marks are present on 3.6 % of the identified bones. About 4.5 % of the identified bones show red stains (**Tab. 2**). In particular, bone tools or ornaments such as perforated teeth, and elements such as the marrow-rich metapodials carry red stains (Germonpré, 1996). Gnawing marks are present in somewhat higher frequencies, with 9.2 % of the bones, and especially those of red deer and reindeer, displaying evidence of carnivore actions (**Tab. 2**). In general, the gnawed bones are lightly damaged, with scratches on the compact bones. In addition, a few furrows and gouging on cancellous parts occur (Germonpre, 1996).

Table 3 lists the distribution of the skeletal elements of large canids from bone level A1. Elements of almost all body parts are represented, from loose teeth, including perforated canines, over a vertebra to a metatarsus.

The four measurements on the canid lower jaw 2812-5 do not permit to assign the mandible to a specific reference group. Their values fall in the overlapping ranges of the dog and wolf groups in our data set (**Tab. 4**). The distal breadth of the humerus 2812-10 (Bd: 42.5 mm) is larger than the maximal width expected for Palaeolithic dogs (**Tab. 4**). Although this humerus is wider than the maximum value (≤ 39.0 mm) for dogs in our data set, this width does not exceed the mean value for this dimension of the wolf reference groups (**Tab. 4**). It can thus not be described as a wolf-like canid in size, it falls in the size range of a large canid. This canid had an estimated body mass of about 36 kg (**Tab. 5**).

The border of the coronoid process of the ulna 2812-6 is not pristine and the greatest breadth across the coronoid process (BPC) is estimated at 17 mm. This width falls in between the values of these measurements of the Palaeolithic dogs from Troubat (Boudadi-Maligne et al., 2020) and Pont d'Ambon (Pionnier-Capitan et al., 2011) and is smaller than the expected threshold (≤ 22.5 mm) proposed for this measurement for Palaeolithic dogs (**Tab. 4**). The estimated body mass of this Palaeolithic dog is about 20 kg; the Pont d'Ambon and Troubat dogs have estimated body masses of about 15 and 21 kg, respectively (**Tab. 5**). Short, transverse cut-marks are present on the medial side of the olecranon of ulna 2812-6 and resemble the RCp-3 marks on reindeer ulnae as described by Binford (1981) (**Fig. 2**). In addition, an isolated, short, transverse cut-mark occurs on the diaphysis. On the distal half of the diaphysis longitudinal cut-marks are present. Red stains occur distally on the diaphysis and on the cancellous bone, proximally. Furthermore, the olecranon process has been chewed (**Fig. 2**). On the medial side of the ulna, a clear round puncture mark with bone fragments inserted in the pit can be distinguished. It overlies some of the medial short cut-marks. The size of the impression is 7.5 mm × 7 mm. Proximally to this mark, at a distance of 11.8 mm, the outer border of a second impression can be distinguished at the remaining proximal rim of the olecranon.

Three other skeletal elements from large canids bear cut-marks. On two radius diaphyses, the proximally placed cut-marks resemble those described by Binford (1981) on reindeer radii (RCp-6). On the first metacarpal, cut-marks are present on the distal half of the bone, just above the distal epiphysis.

The last canid element that could be measured is a proximal femur fragment (2812-11). The greatest depth of the femural caput (DC: 23.54 mm) slightly exceeds the expected value (≤ 23.00 mm) proposed for this measurement for Palaeolithic dogs (**Tab. 4**). This large canid had an estimated body size of about 30.5 kg (**Tab. 5**).

DISCUSSION

The bone assemblage from level A1 represents a palimpsest with remains from mammals dating from pre- and post-LGM periods (**Tab. 1**). The calibrated dates of the post-LGM scatter range from before the onset of the Late Glacial warming up to the Younger Dryas (16,780 years BP - 12,540 cal BP; cf. Rasmussen et al., 2014). Most of the post-LGM bones that show anthropogenic traces date, just as the human bone, from before the Late Glacial interstadial complex GI 1 (**Tab. 1**), that began about 14,700 years ago (Rasmussen et al., 2014). The calibrated AMS ^{14}C age of the ulna 2812-6 from a Palaeolithic dog falls in the range 13,740-13,480 cal BP and places this animal into the Bølling / Allerød interstadial, most likely into GI-1c (cf. Rasmussen et al., 2014). Possibly this Late Palaeolithic dog and its "owners" lived in the vicinity of Goyet during the transitional period from the Late Magdalenian to the Late Palaeolithic (*Feder-*

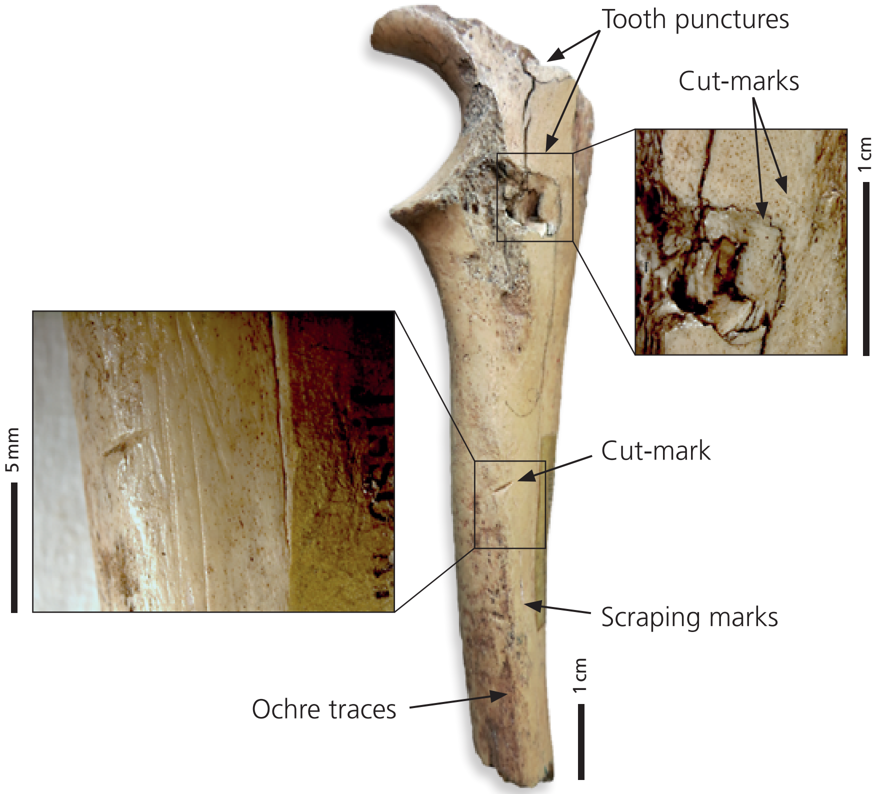

Fig. 2 Ulna Vert00-247/2812-6 described as from a Palaeolithic dog with cut-marks underlying one of the tooth impressions, with a transversal cut-mark, with scraping on the distal half of the diaphysis and with red stains on the distal half and the proximal end.

	BMe kg (Humerus Bd)			
Measurements	n	min	mean	max
Goyet 2812-10	1		36.0	
Palaeolithic dogs	2	18.5	21.7	24.8
Roman dogs Belgium	8	12.0	18.3	26.9
Recent archaic dogs	11	19.9	29.9	35.3
Pleistocene wolves	11	32.1	37.5	43.4
Holocene wolves	3	31.9	39.9	46.1
Recent northern wolves	6	36.9	41.6	46.1

	Bme kg (Ulna Bpc)			
Measurements	n	min	mean	max
Goyet 2812-6 (dog-like in size)	1		19.9	
Palaeolithic dogs	2	15.0	17.9	21.0
Roman dogs Belgium	6	10.8	16.1	20.4
Recent archaic dogs	10	18.9	28.3	35.4
Pleistocene wolves	3	34.4	38.0	42.6
Recent northern wolves	2	33.6	35.2	36.9

	BMe kg (Femur DC)			
Measurements	n	min	mean	max
Goyet 2812-11	1		30.5	
Roman dogs Belgium	5	7.2	14.0	19.3
Recent archaic dogs	10	15.7	25.7	34.9
Holocene wolves	1		45.7	
Recent northern wolves	5	31.6	37.7	44.2

Tab. 5 The estimated body mass (BMe) of the Goyet large canid elements from the first bone level (A1) compared with the observed ranges (minimum, 25 % percentile, mean, median, 75 % percentile, maximum) and the standard deviation of the BMe of the data sets from Palaeolithic dogs, Belgian Roman dogs, recent archaic dogs, Pleistocene wolves, Holocene wolves and recent northern wolves; see text for more information.

messergruppen). The dog's remains were modified by prehistoric people as evidenced by cut-marks, after which handling the bone was gnawed by a canid-sized carnivore (see below). It is somewhat younger than the Palaeolithic dogs from the French Magdalenian site of Montespan (ca. 15,500-13,500 cal BP; Pionnier-Capitan et al., 2011), the Magdalenian site Le Morin (ca. 14,500 cal BP) (Boudadi-Maligne et al., 2012), the Azilian site Le Closeau, locus 46 (ca. 14,940-13,950 cal BP; Pionnier-Capitan et al., 2011; Bignon-Lau, 2020), and the dogs from the Swiss Magdalenian Kesslerloch cave (ca. 14,600-14,100 cal BP; Napierala and Uerpmann, 2012). The Palaeolithic dog from Goyet (A1) is comparable in age to the Late Glacial dog from the German site of Bonn-Oberkassel site (ca. 14,800-13,320 cal BP) (Street et al., 2015). It is somewhat older than the Azilian dogs from the French sites of Troubat (ca. 12,700-12,520 cal BP) (Boudadi-Maligne et al., 2020) and Pont d'Ambon (ca. 12,900-12,400 cal BP) (Pionnier-Capitan et al., 2011).

Remains from horse, reindeer and cave bear dominate the Goyet bone assemblage A1. Body parts of several species have been manipulated by prehistoric humans as shown by the presence of cut-marks (3.6 % of

NISP), tools and ornaments (2.8 % of NISP) and stains of red colourant (4.5 % of NISP) (**Tab. 2**). Interesting to note is that the human humerus Goyet-Q-2, from a male child, also shows ochre stains (Fu et al., 2016; Rougier et al., 2016). The cut-marks on the mammal bones are related to skinning, dismembering and filleting (Germonpré, 1996). Carnivore induced damage, such as gnawing, punctures, furrowing, gouging and scratches, can be discerned especially on red deer and reindeer elements, including shed antlers (Germonpré, unpublished results), and also on bones of large canids (**Tables 2-3**). The features of the carnivore damages compare well with those induced by wolves as described by Haynes (1983) and Fosse et al. (2012). The stable isotopes of several large canid elements from level A1 have previously been analysed to reconstruct the diet of these animals (Germonpré et al., 2009). The results of humerus 2812-10 indicates that this large canid ate mainly horse meat (Germonpré et al., 2009: G5). The diet of the individual providing the other humerus (2812-9) was dominated by horse and bison meat (Germonpré et al., 2009: G-2). The stable isotopes analysis of radius 2812-8 revealed that this canid consumed mainly horse meat (Germonpré et al., 2009: G-7).

Human manipulation on remains from large canids can be discerned on several skeletal elements. Two canines were perforated and likely used as pendants. They testify of a symbolic utility (cf. Germonpré et al., 2018; Fosse et al., 2019). On the two radius diaphyses, cut-marks are present that are comparable to the filleting marks RCp-6, described by Binford (1981) on reindeer radii. Cut-marks, present on the distal half of the first metacarpal, were probably inflicted while the animal was skinned.

Of the four skeletal elements measured in this study, the sizes of three specimens (a mandible, a humerus, and a femur) fall in the overlapping size ranges of the dog and wolf groups in our data sets, although the femur is barely larger than the threshold for Palaeolithic dogs (**Tab. 4**). The ulna 2812-6 falls within the range of Palaeolithic dogs, based on the relatively small size of the breadth across the coronoid process (ca. 17 mm) (**Fig. 2**). The calibrated age range of the ulna 2812-6 (**Tab. 1**) indicates that this Palaeolithic dog lived during the Allerød. Its estimated body mass is about 20 kg and falls into the observed ranges of the Belgian Roman dogs and the "recent archaic dogs" of our data set. It is, just as the dogs from the Azilian site of Troubat (Boudadi-Maligne et al., 2020), a medium-sized dog. Several cut-marks are present on ulna 2812-6. Short, transverse marks on the proximal medial surface resemble the RCp-3 cut-marks on reindeer ulnae, described by Binford (1981) that are made during the dismembering process. This canid was dismembered possibly in preparation to be consumed. In addition, a transverse cut-mark is present on the diaphysis. On the distal half of the diaphysis longitudinal marks occur that could be related to scraping, maybe for tendon or periosteum removal.

Furthermore, the oleocranon process of the ulna 2812-6 of the Palaeolithic dog (**Fig. 2**) is chewed in a manner akin to the chewing of oleocranon processes of red deer by wolves, figured in Fosse et al. (2012: Fig. 4), and those of sheep chewed by dogs in Fernández-Jalvo and Andrews (2016: Fig. A.376) and resembles a carnivore-gnawed ulna from the Gravettian Předmostí site (Germonpré et al., 2017: Fig. 19). On the medial size of the ulna two traces of puncture marks are present. Inside the completely preserved puncture mark, probably made by the cusp of a premolar, the bone surface is displaced into the bone's interior (**Fig. 2**). The large size of the puncture (7.5 mm × 7 mm) is similar to the size of tooth impressions made by large carnivores (wolves, hyenas, bears) as studied in the Pleistocene bone assemblage from the Arrikutz cave in Spain (Fernández-Jalvo and Andrews, 2016) and the tooth marks made by large carnivores analysed in Andrés et al. (2012). The size of the tooth impression combined with the relatively small distance (11,8 mm) between the two tooth marks could suggest that the impressions were made by a P3 and a P4 from a large canid. Taking into account that cut-marks occur underlying the tooth impression, it is possible that remains of this dog were given by its prehistoric masters to other dogs to feed upon, or that dogs or wolves scavenged the refusal of the human occupants left in the cave. Further examinations of this ulna, including biogeochemical and genetic analyses, are currently undertaken and results will be published in a forthcoming paper.

In Central and Eastern Europe, Palaeolithic dogs and/or 'dog-like in size' canids occur at sites with mammoth mass accumulations, pre-dating (Předmostí, Kostenki-1/I, Kostenki 11/Ia, Kostenki-21) and post-dating (Eliseevichi, Yudinovo, Mezin, Mezhirich) the LGM. In most of these sites direct or indirect evidence of mammoth hunting is present (Pidoplichko, 1998; Sablin and Khlopachev, 2002; Germonpré et al., 2009, 2012, 2015; Germonpré and Sablin, 2017; Reynolds et al., 2019). We have postulated that Palaeolithic dogs could have been used as pack animals to help transport mammoth body parts from the kill to the camp site (Germonpré et al., 2012) and as sentinels to protect stored mammoth meat at the latter (Germonpré et al., 2020). In addition, during pre-LGM times, Upper Palaeolithic people could have used the protection offered by the large Palaeolithic dogs against Pleistocene predators. Once pachyderms like the woolly mammoth and the rhino, and carnivores like the cave hyena, cave lion and cave bear became rare or extinct, the presence of larger Palaeolithic dogs would have been less useful. In Western Europe, medium-sized Palaeolithic dogs would then have been more opportune, as they would have required less food (Germonpré et al., 2009, 2012, 2020). Nevertheless, such dogs could have occupied several roles in late Upper Palaeolithic and Late Palaeolithic societies. They could have acted as hunting companions, sentinels, been kept for their fur, meat and fat and participated with body and soul in ceremonies (Germonpré et al., 2020). The double-human-and-dog burial from Bonn-Oberkassel (Street et al., 2015; Janssens et al., 2018) could suggest, based on ethnographic evidence, that the soul of the dead/killed dog would have been needed to guide the human souls to the afterworld (cf. Kretschmar, 1938; Schwartz, 1997), or that the dogs could have been killed to display the high status of their masters (cf. Hayden and Schulting, 1997). In life, the young Oberkassel dog most likely was suffering from a canine distemper infection and was taken care of for several months, indicating how important this pup was to its "owners" (Janssens et al., 2018). In southern France, at the Grotte-Abri du Moulin (Troubat), there is evidence of an intentional double burial of two dogs (Boudadi-Maligne et al., 2020), dating to the Younger Dryas stadial. At the Upper Palaeolithic cave of Goyet, based on the cut-marks on the radii and the ulna, cynophagy was probably practiced just as at the late Upper Palaeolithic French sites of Le Morin (Boudadi-Maligne et al., 2012) and Pont-d'Ambon (France) (Pionnier-Capitan et al., 2011).

CONCLUSION

Although the timing of the onset of the domestication process of the wolf is highly debated, most researchers agree that by the end of the Pleistocene domestic dogs were part of the daily life of prehistoric hunter-gatherers. The AMS ^{14}C dates on bones from level A1 of the third cave of Goyet indicate that at least part of this material dates from the post-LGM. Several canid bones from level A1 were modified by Upper Palaeolithic humans; the carcasses of some animals were skinned, dismembered and filleted, presumably in order to obtain the skin and meat. Other elements (canines) were perforated or came into contact with red ochre powder (ulna). Moreover, the dismembered ulna was gnawed by a carnivore, likely a canid. The size of the ulna permits to describe this element as from a Palaeolithic dog. Its calibrated age places this animal into the Bølling/Allerød interstadial. With an estimated body mass of ~20 kg it is comparable in size to other Late Palaeolithic dogs from Western Europe. The handling of the canid bodies and bones at Goyet hints to the existence of a complex relationship, including cynophagy, between humans and large and medium-sized canids during the Late Palaeolithic.

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RAW MATERIAL AND HABITAT – THE FORMATION OF REGIONAL HABITATS DURING THE LATE GLACIAL. TWO CASE STUDIES: THE NEUWIED BASIN (RHEINLAND-PFALZ, GERMANY) AND LE MAS D'AZIL (ARIÈGE, FRANCE)

Abstract

Significant changes in the composition of lithic raw material spectra can be observed in the stratigraphy of sites along the northern edge of the French Pyrenees, from the late Pleniglacial to the Late Glacial Interstadial. This can be illustrated in particular at the site of Troubat (Hautes-Pyrenees; Lacombe, 1998a, 1998b) and in the stratigraphic sequence on the left river terrace of the tunnel-cave of Le Mas d'Azil (Ariège, Kegler, 2007). Both sites show a change, from the use of large proportions of exogenous lithic raw materials – mainly from the Périgord, the Dordogne and the French Mediterranean – during the Magdalenian period, to an almost exclusively local and regional exploitation of raw materials during the Azilian period. The ratio of exogenous to local raw materials is almost completely reversed (Kegler, 2007). From the end of the Pleniglacial to the Late Glacial period, this phenomenon can also be observed at other sites in this region, as well as in other regions of Europe, where lithic raw materials are naturally accessible to a limited extent or in low quality only. Another example of such a development in Central Europe is the well-studied region of the Middle Rhine Area, more specifically, the Neuwied Basin. The raw material spectra of the Magdalenian sites of Gönnersdorf and Andernach are dominated by exogenous silices from the north and northwest, respectively (Floss and Terberger, 2002). In contrast, local and regional raw materials (up to 20 km in the vicinity) predominate in almost all known Late Glacial sites attributed to the *Federmessergruppen* (Floss, 1994; Gelhausen, 2011; Street et al., 2006).

Keywords

Magdalenian, Azilian, *Federmessergruppen*, raw material procurement, regional territories

INTRODUCTION

In 1994, three students under the direction of the Archaeological Heritage Mangement of Rhineland-Palatinate in Koblenz, together with the excavation technician Manfred Neumann, took over supervision of an excavation on the Martinsberg in the city of Andernach. Not far from there, the first evidence of an Ice Age site in the region was provided by Hermann Schaaffhausen in 1883 (Schaaffhausen, 1888). The site became known nationwide as containing one of the first evidences of Ice Age art in Central Europe – a bird carved from antler. Between 1979 and 1983, the first regular excavations were carried out to the immediate southwest of Schaaffhausen's 1883 trench. This site was consequently named Andernach 2, and it revealed two superimposed Palaeolithic horizons (Veil, 1982), the lower attributed to the Magdalenian and the upper to the Late Glacial curve-backed point industries or *Federmessergruppen*. As a new building was planned to be constructed nearby in the Roonstrasse, our excavation started in 1994 as an emergency excavation. Our fieldwork finished in 1996, and resulted in the documentation of a further Magdalenian concentration and the spatial continuation of the *Federmesserguppen* horizon (Andernach 3; Bergmann and Holzkämper,

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Fig. 1 Location of the French Pyrenees with the site Le Mas d'Azil and the Neuwied Basin. – (Graphic: J.F. Kegler).

2002; Holzkämper, 1996; Kegler, 2002). However, the intended new building was not constructed immediately, and in 2006 a fourth archaeological campaign was realised at the site (Krahl and Maier, 2020).
The excavation technique employed between 1994 and 1996 was based on Martin Street's many years of experience, as he was responsible for the technical execution of the excavations between 1979 and 1983. The long cooperation in the former research period at the *Forschungsbereich Altsteinzeit* of the Römisch-Germanisches Zentralmuseum, Mainz, developed into a collegial cooperation in which the two jubilarians played a significant role with their profound knowledge, combined with English charm. An example of Martin Street's multifaceted scientific oeuvre is a paper published together with the MONREPOS team, entitled "*L'occupation du bassin de Neuwied par les Magdaléniens et les groupes à Federmesser*" (Street et al., 2006). This closes the circle for the author of this contribution, because the examination of material from the *Federmessergruppen* of Andernach 3 (Kegler, 1999, 2002) turned into a doctoral thesis on the eponymous site of the Azilian at Le Mas d'Azil in the French Département Ariège (Kegler, 2007) (**Fig. 1**).

THE NEUWIED BASIN "REGION"

The Neuwied Basin – a geomorphological depression in the Middle Rhine Valley, which is otherwise characterised by the low mountain ranges of the Eifel, Hunsrück, Siebengebirge, Westerwald and Taunus – provides a unique situation for the preservation of Pleistocene and Late Pleistocene sites (**Fig. 2**). Due to the eruption of the Laacher See volcano some 13,000 yrs cal BP (cf. Reinig et al., 2020), large parts of the landscape were partly buried by massive deposits of pumices and ignimbrites. The discovery of the Magdalenian site of Gönnersdorf (Bosinski, 1979) at the end of the 1960s led to a lively research exploration into the Palaeolithic archaeology of the region. In the course of this, the Magdalenian site of Andernach-Martinsberg was rediscovered and party excavated (Veil, 1982). Late Palaeolithic *Federmessergruppen* sites such

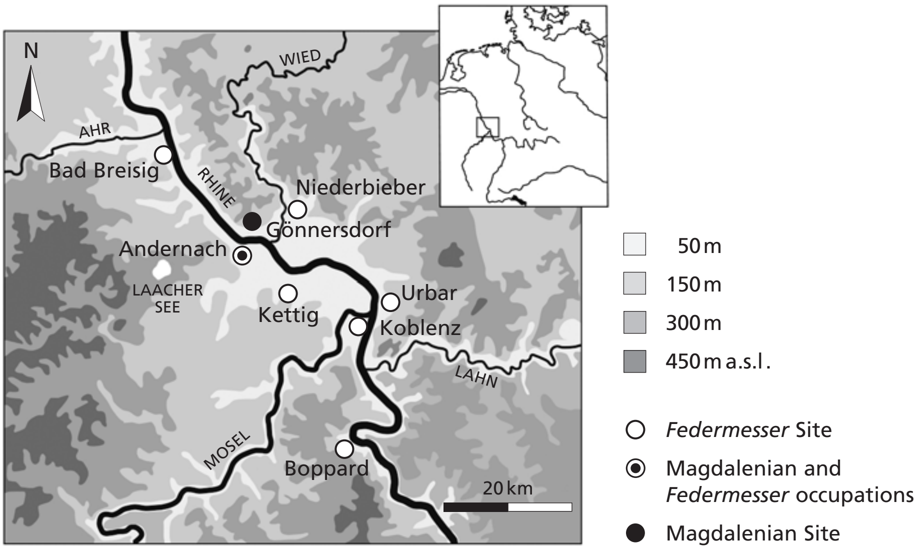
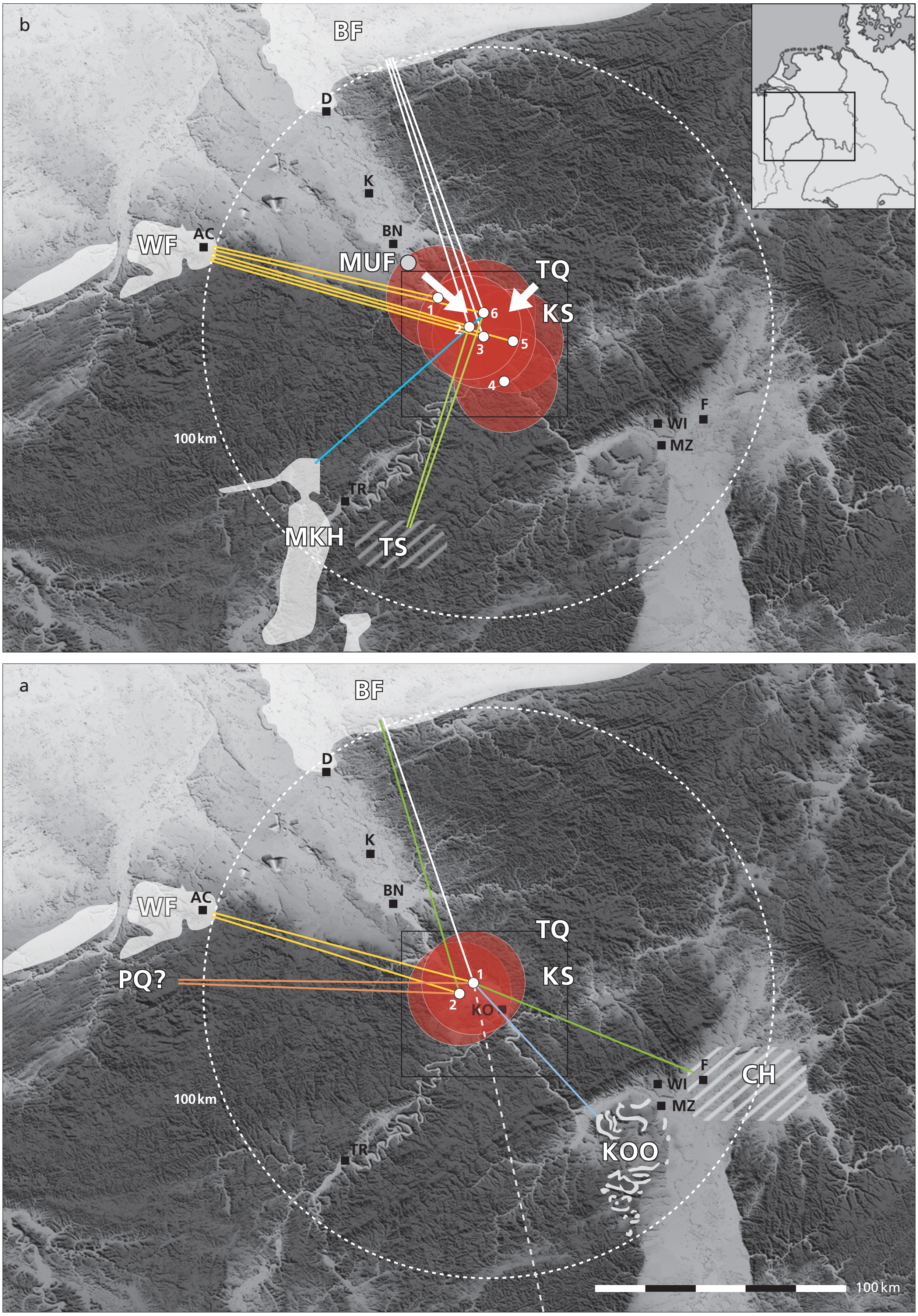


Fig. 2 Location of the Magdalenian and *Federmesser* sites in the Neuwied Basin. – (Graphic: J.F. Kegler; modified from Street et al., 2006).

as the upper horizon of Andernach (Bolus and Street, 1985) and several new sites at Niederbieber (Bolus, 1992; Gelhausen, 2011), Kettig (Baales, 2002), Urbar (Baales et al., 1998) and, at a somewhat further distance, the sites of Bad Breisig (Grimm, 2004) and Boppard (Wenzel, 2004) were discovered and excavated. Furthermore, individual fireplaces assigned to the Late Palaeolithic indicate ephemeral, short-term stays in the Neuwied Basin (von Berg, 1994). As all these sites have already been extensively acknowledged in the literature (e. g., Street et al., 2006), their in-depth presentation is not intended here. Chronologically, two main phases are represented in the region, comprising the two large Magdalenian settlement sites of Gönnersdorf and Andernach, which were settled during the end of the Pleniglacial around 15,700 cal BP (Stevens et al., 2009), and the above listed sites of the *Federmessergruppen,* which date into the Late Glacial Allerød interstadial, at about 13,800 to 12,800 cal BP. Less well documented is the period in-between, in which the find concentration of Gönnersdorf-Südwest (Buschkämper, 1993), the site of Neuwied-Irlich (Baales, 2002) and, some 30 km to the north, the site of Bonn-Oberkassel (Baales and Street, 1998), date. The latter three sites date to ca. 14,700-13,800 cal BP and are characterised by a small find scatter at Gönnersdorf and by the burials at Neuwied-Irlich and Bonn-Oberkassel.

Common to the sites assigned to the two major periods of settlement is the presence of a rich lithic inventory, composed of numerous blanks and tools. The lithic raw materials had been brought to the sites in order to be processed or further used. In 1994, Harald Floss provided the essential basis for the characterisation of the different types of raw material used. This makes it possible to differentiate between raw material types and the localities they originate from at the fine scale. With the exception of certain silicified quartzites ("tertiary quartzite") and silicified slates ("siliceous slate"), the Neuwied Basin is a region where no raw materials of sufficiently good quality are available (Floss, 1994). In order to be able to produce tools, following the characteristic reduction sequences of each period (i. e., the Magdalenian and the *Federmessergruppen*), qualitatively suitable raw materials had to be imported into the Neuwied Basin from outside. The general picture that can be sketched from these data, allows us to conclude on the extent and type of the land-use of (late) Pleistocene groups. In most cases, the lithic find concentrations within each site were examined individually. For Gönnersdorf, these are the concentrations K-I to K-IV and Gönnerdorf-Südwest,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and for Andernach the concentrations C-I to C-IV. From the younger period, 23 lithic concentrations from the above-mentioned *Federmessergruppen* sites are available, and have been studied (Street et al., 2006: 765 f.).

The Magdalenian sites of Gönnersdorf and Andernach, which are considered as base camps in a differentiated subsistence system, show quite similar raw material spectra (**Fig. 3: a**). The concentrations are mainly dominated by raw materials from the north-west. In Andernach this consists of Western European Flint (WF), from the region around Aachen and the so-called Palaeozoic Quartzite (PQ). From Gönnersdorf on the opposite side of the Rhine River, significant amounts of Baltic flint (BF) from the north are also recorded. In addition, silices such as *Kieseloolite* (KOO) and chalcedony (CH) from the Mainz Basin were used. The latter indicated a south-eastern origin. Despite the proximity to local raw materials, such as silicified slates (KS) and tertiary quartzite (TQ), these materials are only represented in marginal amounts (Street et al., 2006: 753 f.).

During the *Federmessergruppen*, however, the general pattern of raw material procurement was reversed compared to the pattern described for the Magdalenian (**Fig. 3: b**). *Federmessergruppen* find concentrations are dominated by local and regional raw materials. These are tertiary quartzites, siliceous schist, and a specific type of chalcedony from an outcrop at Bonn-Muffendorf, which is located about 35 km northwest of the Neuwied Basin. The individual concentrations of the *Federmesser* sites consist almost exclusively of a single type of raw material, so that it is assumed that only this material was brought in and processed locally. Two unprocessed raw material units of Muffendorf chalcedony in the middle of Niederbieber concentration XV indicate the import of this material (Gelhausen, 2011: 24, 204 f.).

The significantly lower proportions (volumes) of exogenous raw materials illustrate supra-regional contacts between the settlements of the *Federmessergruppen* within the Neuwied Basin and other (previously unknown) sites in mostly northern or north-western direction.

In summary, a clear link to exogenous raw materials is evident for the Magdalenian sites of Gönnersdorf and Andernach in the Neuwied Basin. The very good quality of the imported raw materials is characteristic; it was essential for reduction concepts that focused on the production of regular blades as blanks for tool production. In contrast, the 23 *Federmessergruppen* find concentrations from the Neuwied Basin, give a different picture: All known concentrations are largely dominated by local raw materials. They can be divided into three groups. The first two (concentrations Niederbieber I, III, IV, V, VI, VIII, IX, X, XII, XIII, XVII, XVIIa, Andernach 3, Bad Breisig and Urbar; Street et al., 2006: 769) are represented by eight find concentrations each. They are characterised by the locally available tertiary quartzite (first group) or by the regionally available chalcedony from Bonn-Muffendorf (second group). These two groups are followed by a third group of seven find concentrations (Niederbieber II, VII, XI, XIV, XVI, Kettig and Andernach 2; Street et al., 2006: 769) that show more diverse raw material spectra. Four concentrations of the latter group show high frequencies of exogenous materials imported from the north and north-west. Investigations into the seasonality of the hunted game from all *Federmesser* sites in the region indicate a more 'sedentary' faunal profile, consisting of temperate climate fauna which would have been present in the local region throughout the year (Street et al., 2006: 763).

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Fig. 3 Raw material procurement in the Neuwied Basin (after Street et al., 2006: 766, Fig. 7). The lines show the main import directions. **a** Magdalenian of Gönnersdorf (**1**) and Andernach (**2**). – **b** *Federmessergruppen* sites of Bad Breisig (**1**), Andernach (**2**), Kettig (**3**), Boppard (**4**), Urbar (**5**), Niederbieber (**6**). – Arrows: regional import of Muffendorf chalcedony and tertiary quartzite. Small circles: 20 km distance around the sites. A ~ 100 km circle around the centre of the Neuwied Basin is shown for comparison. – BF Cretaceous "Baltic" flint from moraine deposits; KS indurated shale; TQ Tertiary quartzites; CH chalcedony; KOO indurated oolites; TS argillaceous shale; MKH Triassic cherts (*Muschelkalkhornstein*); PQ "Paleozoic" quartzite; WF Cretaceous flint from chalk or reworked in fluvial terraces; Muf Muffendorf chalcedony. AC Aachen; BN Bonn; D Düsseldorf; F Frankfurt am Main; K Cologne; KO Coblence; MZ Mainz; TR Trier; WI Wiesbaden. – (Graphic: J.F. Kegler).

Fig. 4 Entrance of the impressive Grotte du Mas d'Azil (Ariège) with a length of ~450 m and a portal height of ~60 m and width of 50 m. – (Photo: J.F. Kegler).

LA GROTTE DU MAS D'AZIL, ARIÈGE

The cave of Mas d'Azil in the department of Ariège, on the northern edge of the French Pyrenees, is one of the most impressive natural monuments of France (**Fig. 4**). It is famous for its large galleries on the right bank of the Arize River, which streams directly through the cave. Many of the most impressive Magdalenian art objects originate from this site. The left bank river terrace of the Arize has also yielded famous artefacts, namely the engraved and painted pebbles which were found here (Couraud, 1985). The Mas d'Azil cave was the subject of several archaeological excavations from a very early date. The pioneering work of Edouard Piette at the end of the 19th century deserves special mention: between 1887 and 1891, Piette excavated in the karst galleries on the right bank, and on the river terrace on the left bank of the Arize. He summarised the finds made on both banks of the river in his classification of the Late Upper Palaeolithic and of the Final Palaeolithic in his so-called "*Phase de Transition*" (Piette, 1889, 1891, 1895a, 1895b). The "*Phase de Transition*" defined for the first time in research history the transition between the Palaeolithic cultures of the Ice Age and the Holocene Neolithic cultures in France. A few years later, Piette's pupil Henri Breuil also worked in the cave of Mas d'Azil, and discovered the first rock engravings in the gallery which, years later, was named after him (Bégouën and Breuil, 1912). Until the 1930s and 1940s new regular excavations were carried out by the Péquart family. They confirmed Piette's stratigraphy on the left bank and discovered the late Magdalenian *Galerie des Silex* on the right bank, which they excavated shortly before and during the Second World War (Péquart and Péquart, 1936, 1937, 1939, 1941a, 1941b, 1960, 1961, 1962, 1963).

The archaeological work of Piette and of the Péquarts on the left bank exposed several Magdalenian horizons, separated from each other by sterile layers of silt. Superimposed layers with Neolithic and younger finds sealed two layers from Piette's transitional period. Edouard Piette defined the lower of the two layers as "*Azilien*", named after the cave (Piette, 1895c), and the upper as "*Arisien*" (Piette, 1903). Piette based the definition of the Azilian on its characteristic backed points, short scrapers, engraved or red-painted pebbles, harpoons made of red deer antler, and the presence of red deer as the dominant hunting game

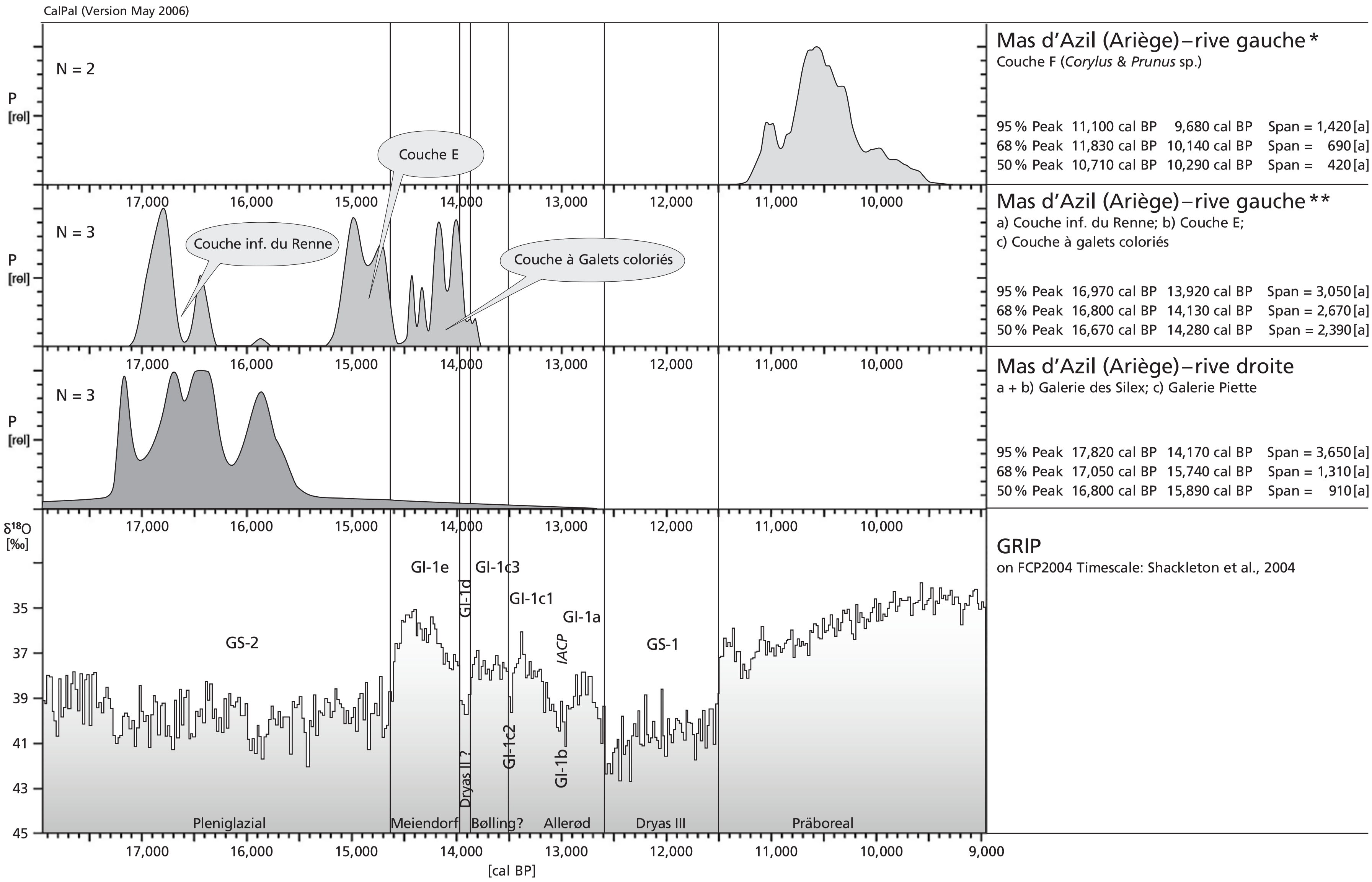


Fig. 5 Calibrated radiocarbon dates from the site of Le Mas d'Azil (Ariège). Dates from the *rive droite* after Alteirac and Bahn (1982). *AMS ^{14}C measuremnts (Dynamitron-Tandem-Laboratorium, Ruhr-Universität Bochum). **Conventional ^{14}C measurements (Cologne Laboratory for age determination). Radioocarbon dates calibrated with glacial calibration dataset <CalPal 2005 sfcp> (Weniger and Jöris, 2004). Correlation with the δ^{18}O-record of the GRIP Greenland ice core project (modified from Shackleton et al., 2004). – (Graphic: J.F. Kegler).

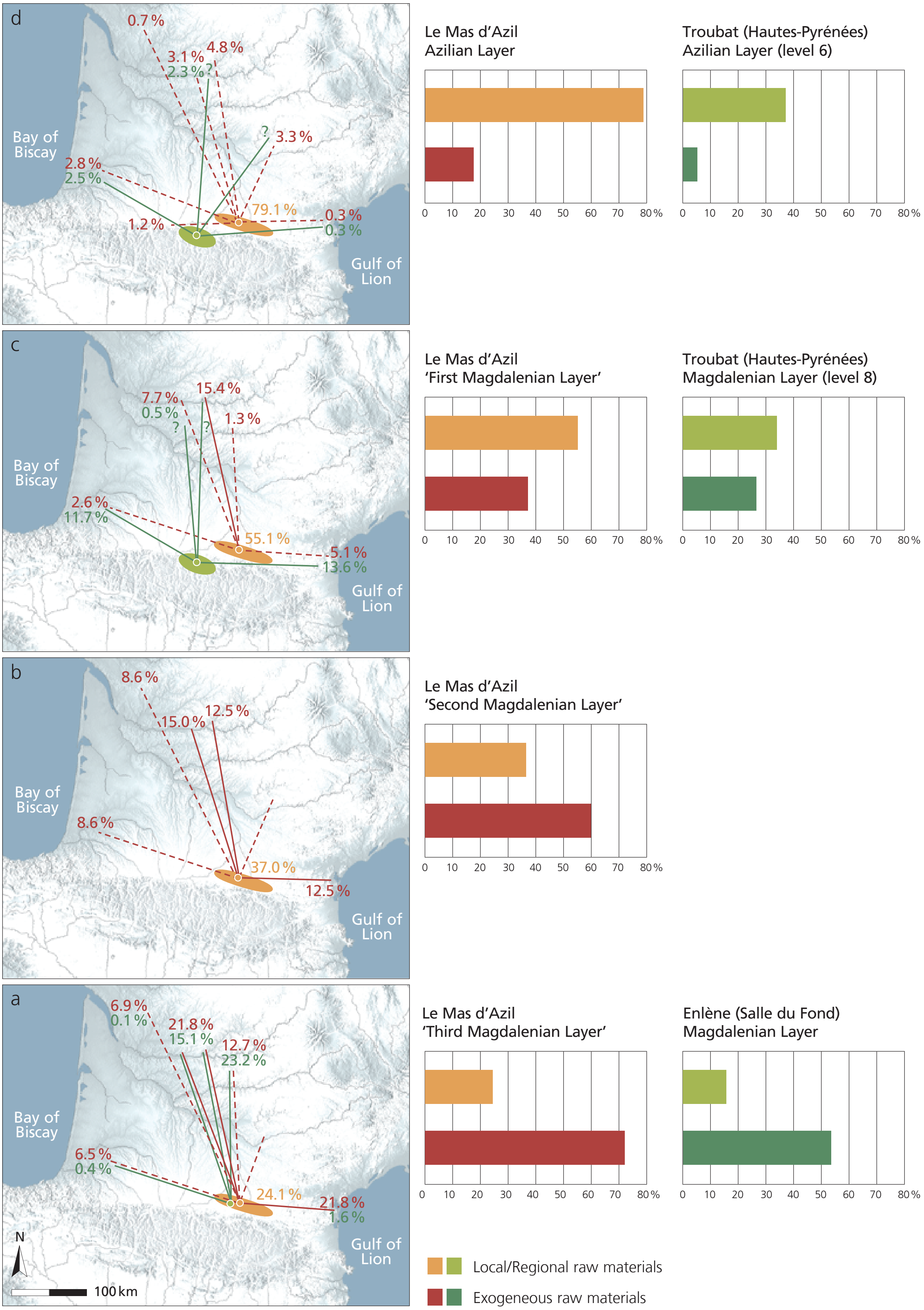
(Piette, 1895c). In analysing this "*Phase de Transition*", Edouard Piette was one of the first researchers who combined typological aspects with palaeoclimatic information derived from the fauna he found in the stratigraphic sequence. Today, the *Azilien* refers to a backed point industry at the end of the last glacial period between ~14,300 and 11,600 cal BP. It comprises the climatic phases of the Late Glacial Interstadial and the Younger Dryas period. For the transition from the preceding Magdalenian to the Azilian the term of "Azilianisation" finds widespread use in current French research (Bodu and Valentin, 1997).

Unfortunately, the basic information regarding the exact sequence of deposits on the left bank at Le Mas d'Azil can only be reconstructed from the literature, that was published between 1889 and 1907 by Piette and by the Péquart family in the 1930s and 1940s. The information available from these early sources is quite contradictory. As a reference for the origin of the eponymous find material of the *Azilien*, the sequence of layers from the "*Hiatus et Lacune*" publication (Piette, 1895c) has been used so far. One of the main questions was to reconstruct to what extent the material of the collections in the museums could be re-assigned to the original layers, as found by Piette (Kegler, 2007). With the help of a Harris Matrix, the available geological and archaeological information was linked to each other in order to clarify the temporal relationships between the individual layers. This allowed a comprehensive reconstruction of the sequence on the left river bank. Without going into the details, the sometimes-contradictory information on the individual stratigraphic sequences could be collated, and the find material from collections stored in different museums could be assigned to these layers. As a result, a succession of three Magdalenian horizons overlain by an Azilian find horizon can today be analysed in more detail.

Until now, radiometric dates have only been provided from the sequence on the right bank at Le Mas d'Azil (Alteirac and Bahn, 1982). Only recently were the first series of animal bone samples from three layers of the *rive gauche* radiocarbon dated at the Cologne laboratory for age determination (**Fig. 5**; Kegler, 2007: 158 ff.). For the lowest of the three Magdalenian horizons (*Couche inférieur du Renne*) a ^{14}C date of 13,300 ± 70 ^{14}C BP (16,670 ± 60 cal BP; KN-5590) was produced, placing this horizon into the outgoing pleniglacial. With an age of 12,580 ± 85 ^{14}C BP (14,880 ± 180 cal BP; KN-5591) the archaeologically sterile clay layer (*Couche E*) directly below the Azilian dates to the beginning of the Late Glacial Interstadial (i.e., *Interstade du Tardiglaciare*). The ^{14}C date for the Azilian *Couche à Galets* confirms the successive sequence of the stratigraphy, resulting in the ^{14}C age of 12,130 ± 70 ^{14}C BP (14,200 ± 180 cal BP; KN-5592). The latter date, however, appears somewhat too old compared to the general development of the Azilian in the region and corresponds more closely to the dates available for the regional Final Magdalenian. The stratigraphic sequence at the *rive gauche,* although limited due to early discovery and excavation, presents insights into the cultural transition into the early Late Glacial interstadial.

Due to its geological past, France is a country rich in varied flint deposits that formed in different geological eras and facies. French research has therefore a strong focus on tracing the siliceous rocks used in different archaeological periods. In particular, Robert Simonnet (1981, 1985, 1996, 1998, 1999, 2002, 2003) and Sébastian Lacombe (1998a, 1998b) have recently worked on raw materials and their areas of origin from sites in the Pyrenean region. Their publications are basic for the raw material analysis at Le Mas d'Azil. Due to the uplift of the Pyrenees in the Tertiary, flint deposits are missing, and all known deposits are mostly of

Fig. 6 Raw material procurement, Le Mas d'Azil, *rive gauche*. The lines show the main import directions. **d** *Azilien* Layer of Le Mas d'Azil (Collection Piette, Péquart, Bégouen) in comparison with the material from Abri Troubat (*Couche 6*) after Lacombe (1998a, 1998b, 2005). – **c** 'First Magdalenian Layer' of Le Mas d'Azil (Collection Péqart), in comparison with the material from Abri Troubat (*Couche 8*) after Lacombe 1998a, 1998b, 2005). – **b** 'Second Magdalenian Layer' of Le Mas d'Azil (Collection Péquart). – **a** 'Third Magdalenian Layer' of Le Mas d'Azil (Collection Péqart), in comparison with the material from Grotte Enlène (*Salle du fond*) after Lacombe (1998a, 1998b, 2005). – (Graphic: J.F. Kegler).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older geological ages. The Pre-Pyrenees themselves provide only restricted flint sources, most of which are of modest quality.

Within this region, lithic raw materials from different archaeological sites and layers show significant changes in the mode of exploitation between the Magdalenian and the Azilian periods. In a coarse grained perspective, the raw materials can be divided into two groups. The first group consists of local and regional raw materials, which are located in the immediate vicinity of the sites, or have been imported from maximum distances of ~30 km. The second group consists of exogenous raw materials, which are available at distances of approximately 100 km to a maximum of ~300 km from a specific site.

The raw materials used at Le Mas d'Azil were compared with the results of a study of raw material use in the Pyrenean region (Lacombe, 1998a, 1998b). A comparison of the outcome of these studies with the raw materials recorded from Le Mas d'Azil is presented briefly below, following successive time slices (**Fig. 6**):

In the lowermost Magdalenian layer of Le Mas d'Azil, termed as the 'Third Magdalenian Horizon', a clear dominance of exogenous raw materials can be observed (**Fig. 6: a**). In this layer, exogenous raw materials represent about 70 % of the total lithic assemblage; whereas local raw materials are represented by only ~20 %. A comparable raw material ratio has been recorded from the Salle du Fond of the neighbouring Grotte Enlène (Lacombe, 1998a, 1998b). Here, too, the proportion of exogenous raw materials is significantly higher than that of local raw materials. Most of the raw materials originate from the Dordogne, some ~250 km to the north-northwest or from the Mediterranean coast near Perpignan at about 180 km distance towards the east.

Unfortunately, there are no assemblages that correlate chronologically with the next younger 'Second Magdalenian Horizon', which succeeds at Mas d'Azil. Estimates, however, show that the amount of exogenous raw materials slightly decreases in favour of local raw materials, which now comprise percentages of ~35 % (**Fig. 6: b**).

In the uppermost 'First Magdalenian horizon' and the chronologically comparable layer 8 of the cave of Troubat this trend continues. In Troubat, the importing of raw materials from near the Atlantic and Mediterranean coasts along the Pyrenean chain is particularly evident (Lacombe, 1998a, 1998b). This is not the case in Le Mas d'Azil (**Fig. 6: c**). However, it is striking that, for the first time at both sites, the proportion of local raw materials outweighs that of exogenous materials (Kegler, 2007: 79).

At both the sites of Le Mas d'Azil and Troubat, the late Magdalenian is followed directly by an Azilian layer. The raw material spectrum of the Azilian is clearly dominated by local raw materials that comprise almost 80 %, while the exogenous materials are represented in small quantities only (**Fig. 6: d**).

Therefore, during the transition from the *Magdalénien supérieur* to the *Azilien* a clear reduction of the amount of exogenous raw materials transported to the sites along the northern edge of the Pyrenees can be observed. However, as red deer predominates in all the strata on the left river bank of Le Mas d'Azil, no difference between Magdalenian and Azilian subsistence strategies can be stated. Unfortunately, no studies on the seasonality of the Azilian hunting fauna have been carried out yet. Furthermore, for the northern foreland of the Pyrenees, there are almost no open-air sites known (neither of Magdalenian, nor or Azilian age) that could provide information on the land-use strategies outside cave sites, or between the areas of raw material occurrence and use.

INTERPRETATION – THE FORMATION OF REGIONAL HABITATS

In the stratigraphical sequences of the sites along the northern edge of the French Pyrenees, a clear change in the composition of the lithic raw material spectra can be seen during the period spanning from the late Pleniglacial into the Late Glacial Interstadial. This development is best illustrated at the sites of Troubat and the stratigraphic sequence on the left river terrace of the tunnel-cave of Le Mas d'Azil. At both sites, a development from a large proportion of exogenous lithic raw materials – mainly from the Périgord and the French Mediterranean area – during the Magdalenian period, to an almost exclusively local and regional use of raw materials during the Azilian period is evident. The proportions of exogenous to local raw materials is almost completely reversed during this transition.

This phenomenon can also be observed at other sites, both within this region and in other regions of Europe, where lithic raw materials are naturally limited or of lower quality. Another example of such a development in Central Europe is the very well-studied Middle Rhine region of the Neuwied Basin (Street et al., 2006). The raw material spectra of the Magdalenian sites of Gönnersdorf and Andernach are dominated by exogenous silicates from the north and northwest, respectively. In contrast, local (up to 30 km in the vicinity) or regional lithic raw materials predominate in almost all known *Federmesser* find concentrations.

In summary, for the two regions on the northern edge of the French Pyrenees and the Neuwied Basin, the following patterns can be identified for the transition from the Magdalenian to the Azilian. In a supra-regional comparison, the Magdalenian shows a clear preference to the use of exogenous silices, which are usually of excellent quality. This fact is associated with the Magdalenian subsistence system, which consists of a system of base and supply camps, and the relocation over large areas. This is associated with the large-scale migratory movements of herds of animals, which were the main game at the end of the Pleistocene.

In contrast, the hunting economy of the Azilian or *Federmessergruppen* is based on the exploitation of the local-bound fauna of the temperate climate. The changing composition of the species spectrum in the different regions illustrates the fundamental changes caused by Late Glacial climate change (Bridault and Fontana, 2003). The sustainability of ecological habitats is therefore limited in its regenerative and natural resources. A high degree of mobility, by the means of numerous relocations of settlement sites with rather shorter stays at each of the sites, must therefore be assumed (cf. Gelhausen, 2011: 248). With the *Federmessergruppen*, we therefore see a stronger reliance on regionally or geographically more restricted subsistence areas.

This development suggests that between the final Magdalenian and the Azilian (resp. *Federmessergruppen*), in the time-span between ca. 14,000 and 10,000 ^{14}C BP in Europe, there is a significant intensification in the exploitation of local resources, which is particularly well evidenced by the lithic raw materials used. The picture drawn from the evidence of raw material sources, leads to the conclusion that Azilian people lived permanently in regionally restricted territories and – as far as the supply of lithic raw materials is concerned – supplied themselves from the silicate deposits of the regional area. This is defined here as a "regional habitat". In anthropology, the term habitat refers to a dwelling, such as a house or tent, or even a settlement. However, the term "habitat" is not clearly defined in different disciplines. For example, at a conference in Aix-la-Provence in 1953, only a general delimitation in the sense of an architectural spatial definition was agreed upon: "The members [of the conference] were unable to define precisely what they meant by habitat, however, they generally agreed that it referred to an environment that could accommodate the 'total and harmonious spiritual, intellectual, and physical fulfillment' of its inhabitants" (Pedret, 2005: 20). The term habitat can therefore also be understood in the context of a settlement area. It refers to the region typically exploited by a group or population. The size of the habitat is irrelevant in the first instance. In the course of a seasonal rhythm, habitats provide sufficient food resources to ensure that a population of a certain size can stay all year round. Correspondingly, according to the raw material evidence discussed, a regionalisation of the habitats is documented in Azilian/*Federmesserguppen* contexts. Frank Gelhausen also assumes that the Neuwied Basin may have been the centre of such a "regional habitat", from which the surrounding low mountain ranges were accessed, and the raw material collected and transported to the sites, where they were then used (Gelhausen, 2011: 261 ff.). After Gelhausen, the individual find concentrations at the site of Niederbieber reflect very short-term stays, which can be understood as hunting preparation and post-hunting activities, embedded in a system of residential mobility similar to that described by Lewis Binford (1980; cf. Gelhausen, 2011: 265). The fact that an intensive exchange between the local habitats has continuously taken place is illustrated by the similar spectrum of tools and technologies used throughout Europe during the Azilian period (Kegler, 2007: 282 ff.). The find concentrations of the *Federmessergruppen* in the Middle Rhine area with small percentages of exogenous raw materials (Street et al., 2006; Baales, 2002), as well as the shares of exogenous raw materials in Le Mas d'Azil, can be used as evidence that such supra-regional contacts have continued (Kegler, 2007: 86-87).

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ALISON ROBERTS · NICK BARTON

AN EXAMPLE OF NOVICE FLINTKNAPPING IN THE BRITISH LATE UPPER PALAEOLITHIC?

Abstract

Excavations in 2013 in advance of new building work at Guildford Fire Station resulted in the discovery of a rare British example of a well-preserved Late Upper Palaeolithic open air site. The worked flint was in exceptionally fresh condition and preliminary assessment indicated that extensive refitting of artefacts and other studies such as microwear analysis would be possible. Subsequent work by the authors confirmed this observation and demonstrated that the flint assemblage was homogeneous and contained all stages of blade manufacture, and also evidence for the use and discard of tools. Two main knapping foci were identified which appear to have been linked to the presence of at least two skilled flint knappers. Of additional interest was the recognition near to one of these foci (Concentration 1) of a small refitting scatter of debitage apparently produced by a relatively unskilled knapper. Spatial analysis combined with refitting data suggest that this small group might indicate the presence on site of a novice learner alongside that of a more experienced flintknapper.

Keywords

Late Glacial, *Federmessergruppen,* Azilian, refitting, open air site, children

INTRODUCTION

The subject of learning in the transmission of Palaeolithic culture is a topic that continues to command widespread attention in the published literature (e. g., Stapert, 2007; Morgan et al., 2015; Assaf et al., 2016; Rivero, 2016; Lycett et al., 2016; Nishiaki and Jöris, 2019; Takakura and Naoe, 2019). Many of these studies are based on modern experimental observations or ethnographic data, but it is sometimes possible to infer various forms of such behaviour directly from the archaeological record. These range from identifying 'learner' individuals to examples of spatial evidence in which two or more actors, the teacher expert and beginner(s), are represented. Recognition of these aspects has come principally from the analysis of lithic artefacts and refitting studies which allow various levels of technical skill and locational information to be compared and dissected in detail. These have shown that it is possible to identify individual Palaeolithic flintknappers by differences in their technical abilities and sub-dividing them into separate categories ranging from 'beginners' to 'experts'. In the Late Upper Palaeolithic, for example, studies have shown the presence of knappers with divergent technical skills at sites such as Pincevent (Bodu, 1993; Bodu et al., 1990), Trollesgave (Fischer, 1989), Rekem (De Bie and Caspar, 2000), and in the Early Upper Palaeolithic Perigordian level at Solvieux (Grimm, 2000). At the fullest extreme, at least six different skillsets, presumably representing the work of six different individuals, were reported from the various refitted blade reduction sequences at the Magdalenian site of Etiolles (Olive, 1988; Pigeot, 1987, 1990, 2004). Amongst prime indicators of novice knapping in these contexts was the atypical use of hard hammer technique within an assemblage of predominantly soft hammer mode products (e. g., Pigeot, 2004: 100), and a high incidence of 'battering' and misplaced blows in detaching blades from cores which often resulted in large platforms on blanks (Stapert, 2007: 21).

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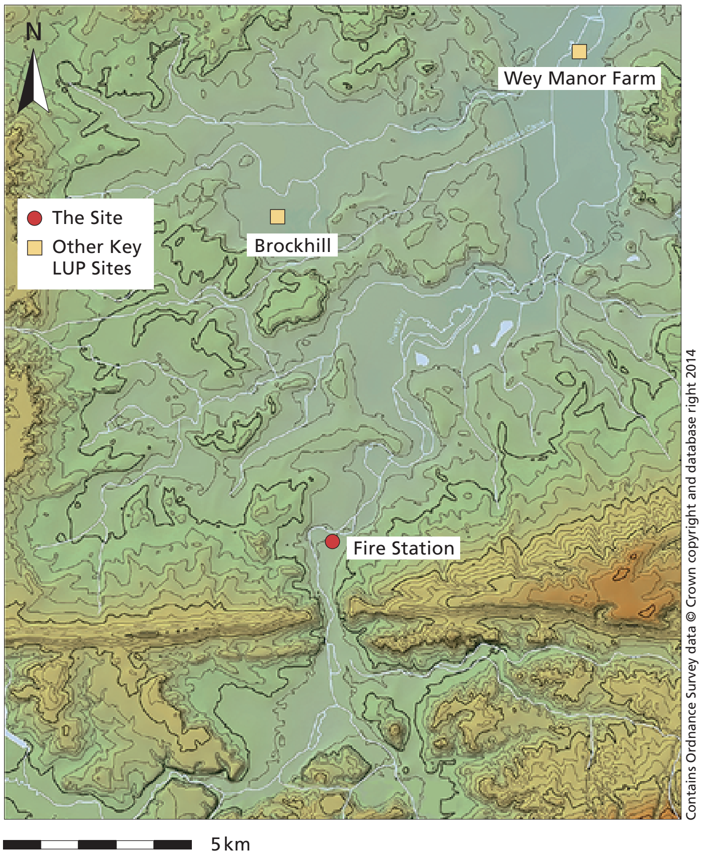

Fig. 1 Topographic relief map of the Guildford region showing the location of the Guildford Fire Station, Wey Manor Farm, and Brockhill Late Upper Palaeolithic sites. – (© Oxford Archaeology).

Arising from these studies, it has been hypothesised that the inexperienced knappers were probably children and, based on cross-cultural ethnographic studies (Murdock and Provost, 1973), some authors have even contended that they were mostly boys (Stapert, 2007; Johansen and Stapert, 2004). While such assumptions may be challenged (see for example: Archer, 2010, on female Konso flintknappers), the 'visibility' of young children of learning age in the archaeological record is now a widely accepted phenomenon, frequently referred to in various publications (e.g., Fischer, 1989; Grimm, 2000; Roveland, 2000; Sharpe and Van Gelder, 2004, 2006; Shea, 2006; Stapert, 2007; Högberg, 2008; Nowell and White, 2010; Bahn, 2015; Finlay, 2015; Nowell, 2015, 2021; Langley, 2018; Langley and Lister, 2018; Riede et al., 2018).

Despite a growing interest in the presence of children and novices at sites, there seems to have been little progress in developing these ideas along empirical lines, beyond observing variability in skillsets and how these reflect individual workmanship. In particular, only minimal attention has been given to the spatial dimension, for example in examining the organisation of occupation surfaces for evidence of novice knapping or comparing the lithic residues left by children/novices with those of more experienced or expert practitioners. An exception is the study by Anders Fischer (1989) at the Late Upper Palaeolithic Bromme site of Trollesgave. In this example, Fischer used refitting evidence to show two fan-shape flint scatters arranged close to one another and next to a large natural boulder. Although, one of the scatters showed a high degree of precision and expertise in the production of blades, the other – slightly further from the boulder – lacked the same quality in the execution of technique (Fischer, 1989: 44). This was apparent particularly from striking platforms which included little abrasion or trimming of the platform edges, and with blows delivered with less accuracy than on blades in the other scatter; the raw material in each case was of the same good quality. Fischer argued that the second scatter was the product of a child knapper training under

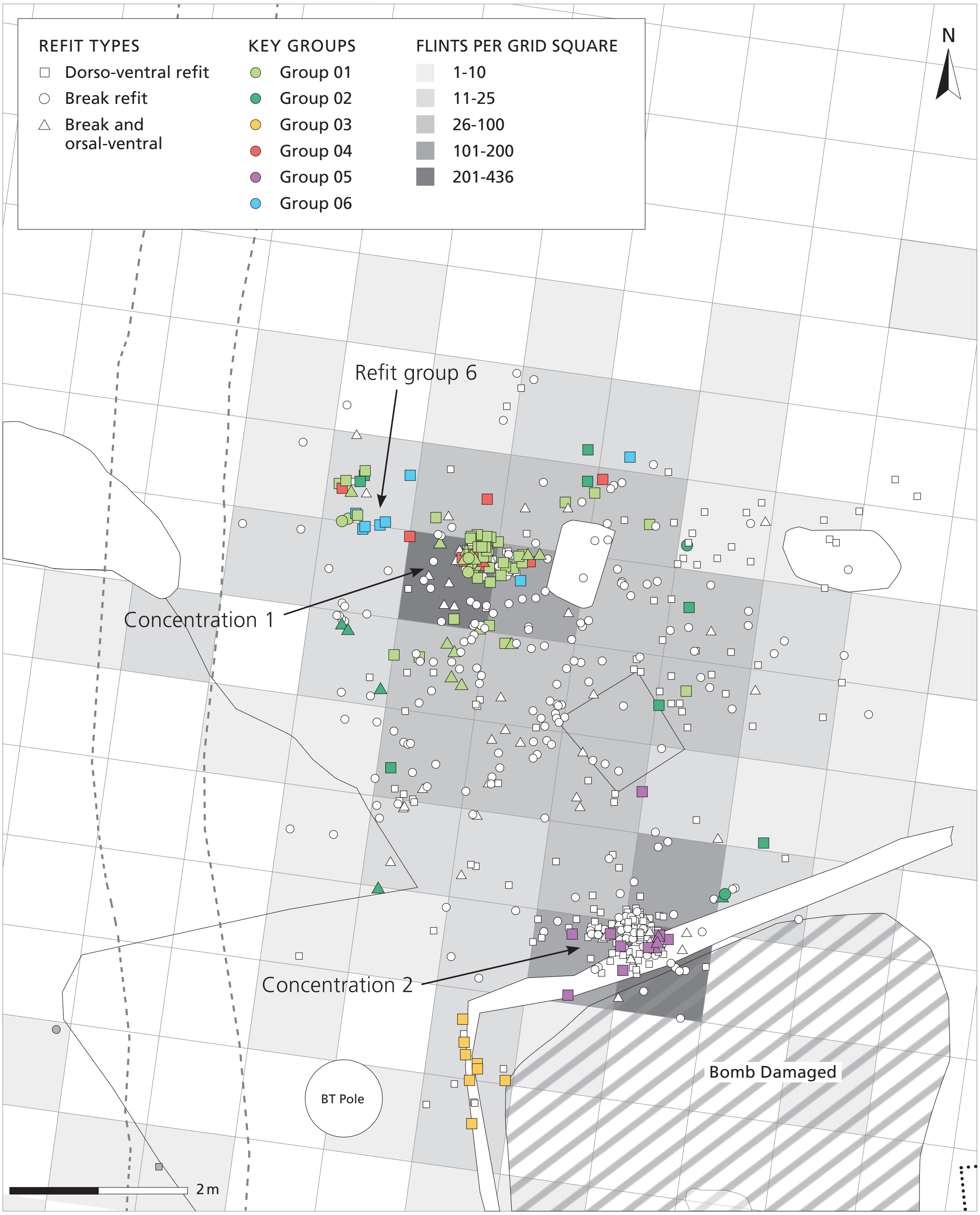

Fig. 2 Guildford Fire Station site plan showing distribution of excavated artefacts with ventro-dorsal refits. Refitting groups 1-6 in colour (RG-6 in Blue). – (© Oxford Archaeology modified by Nicole Viehöver, MONREPOS).

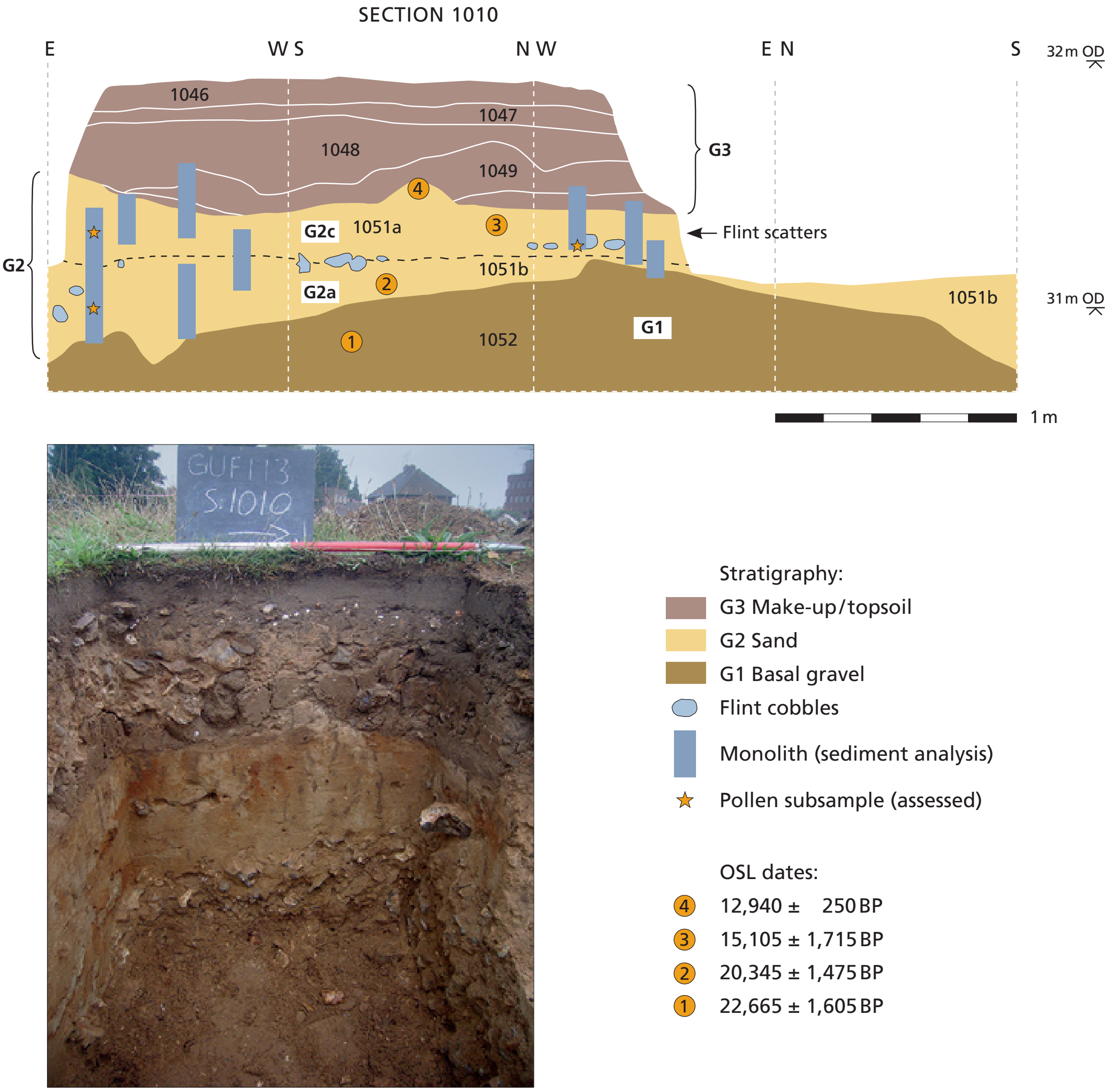

Fig. 3 Test pit sample section 1010 showing location of OSL samples (other OSL samples from section 1011 not shown). – (© Oxford Archaeology).

the guidance of a skilled (expert) craftsman who was seated in front on the boulder (Fischer, 1989: 45). Amongst the few other rare cases reported in the literature are those described by Dick Stapert and Lykke Johansen for the Late Upper Palaeolithic sites of Oldeholtwolde (Johansen and Stapert, 2004) and Gramsbergen (Johansen and Stapert, 2000) where a spatial relationship could be determined between artefacts left by an "expert knapper and an advanced pupil" (Stapert, 2007: 21). In both cases knapping scatters of markedly varying quality were observed 1 m to 1.5 m apart in configurations which would suggest "some kind of educational interaction during the work" (Stapert, 2007: 21).

In parallel with these publications a more integrated approach to the study of novice knappers at Palaeolithic sites was developed by Linda Grimm (2000). Based on her study of the Early Upper Palaeolithic location of Solvieux, she proposed five criteria which she believed could serve to distinguish novice knappers from more experienced ones. These can be summarised as follows (Grimm, 2000: 55):

1) Complete or near complete recovery of debitage clusters of novice knappers. This due to a novice's material being abandoned at the knapping location rather than being more widely disseminated, as in the case of products of more experienced knappers.
2) Poorer control of basic technical principles of knapping. This indicated by knapping errors such as removals that terminated prematurely in hinge or step fractures, in failure to maintain a correct flaking angle or the angle of the striking platform in relation to the main flaking face.
3) Cores usually abandoned at an early stage, largely due to knapping accidents (hinge or step fractures) and an inability to deal with core maintenance during reduction or to conceptualise solutions to problems.
4) Use of poorer quality raw material. Novices will have had more limited access to good quality material relying either on inferior stone or on reworked material abandoned at an earlier stage by more expert knappers.
5) A tendency to pursue activity in peripheral zones. This had already been noted in the Paris Basin Upper Palaeolithic sites where novice knapping was found to occur on the periphery of hearth-centred activity zones (Pigeot, 1990; Bodu et al., 1990).

We believe that these criteria in combination with refitting studies could provide an effective empirical means of identifying the presence of novice knappers at a site, particularly in cases where there is little likelihood of mixing from potentially intrusive material. In adopting this approach for analysing occupation surfaces, we believe that it will be possible to gain a clearer insight into pedagogic behaviour in the Upper Palaeolithic. In the best cases it will enable the activities of novices to be mapped more precisely and lead to a better understanding of knowledge transmission and the teacher-learner relationships described by Fischer (1989) and others. Here we employ this method as a basis for discussing the interpretation of a possible novice flint knapper scatter at a recently discovered Late Upper Palaeolithic site in southern Britain.

THE GUILDFORD FIRE STATION SITE

Background: Site location, topographic setting, geology, dating

The Guildford Fire Station site (NGR SU 9965 5081) at Ladymead is located on the right bank of the River Wey, near the southern edge of the medieval town of Guildford in Surrey. It occupies a relatively low-lying position at ca. 30 m OD (i.e., Ordnance Datum) in a large meander of the river and just above the present valley floodplain. The site also lies 2 km north of the point where the river forms a narrow, steep-sided gorge that cuts through a flint-rich ridge of chalk that rises to elevations of 150 m OD before opening out northwards into a wide floodplain (**Fig. 1**). The site would thus have been ideally placed in proximity to high quality flint raw material sources and potentially also to good hunting terrain for driving and trapping animal game. The site assemblage consists mostly of flint artefacts forming a scatter of occupation debris dispersed over an area of approximately 36 m^2 (**Fig. 2**; n = 15,703 including small debitage). The flints were concentrated in a relatively narrow horizon about 20 cm thick in a shallow stratified sequence of sands and silts (unit G2c) (**Fig. 3**). Immediately below the scatter was a discontinuous natural bed of cobble- and pebble-sized clasts recorded as unit G2b. The cobble layer may have formed a barrier to the downward migration of the flint artefacts. It was composed of both very large flint nodules and a smaller component of greensand chert, none worked. The cobbles had distinctively 'chattered' outer cortical surfaces and many internal flaws (frost

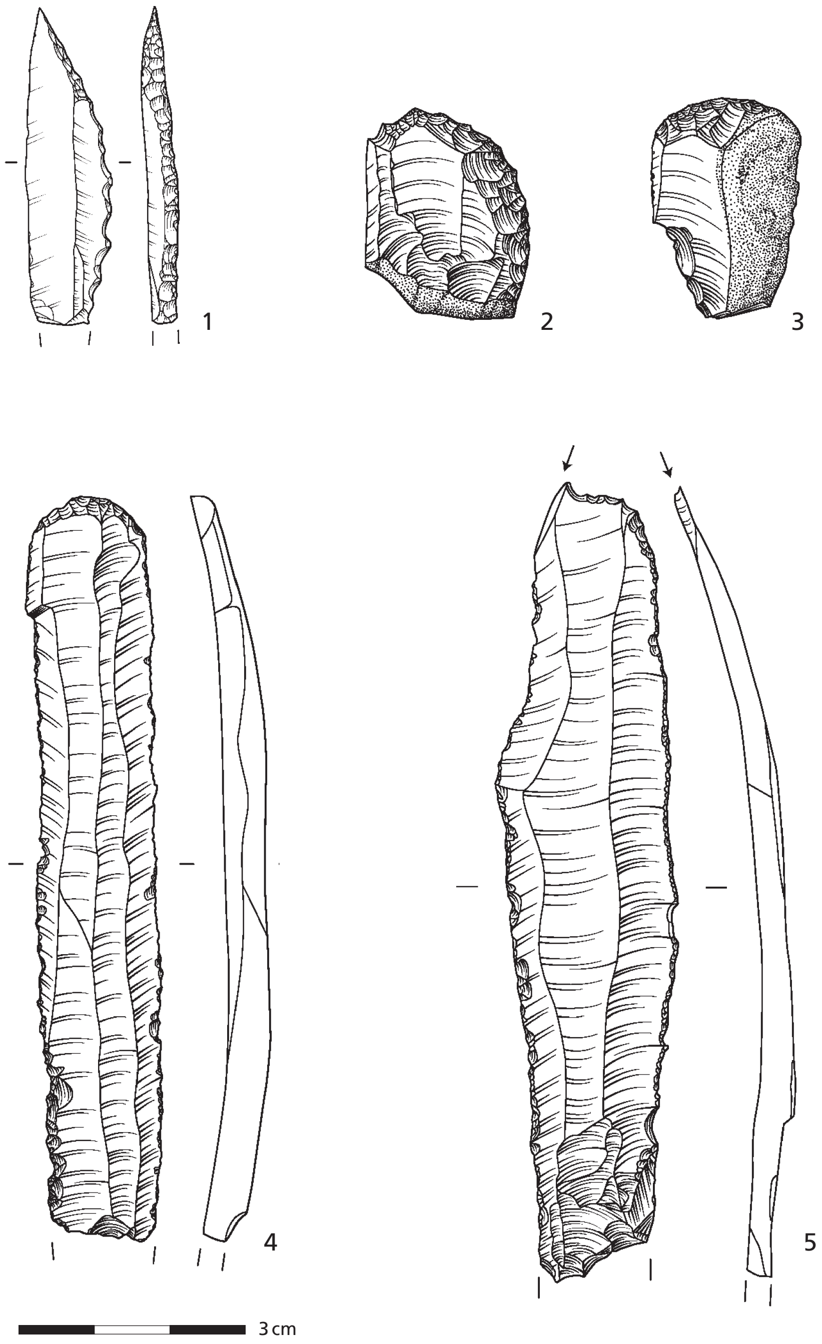

Fig. 4 Lithic artefacts from Guildford Fire Station: **1** Curved bi-point (catalogue c.308); **2-3** short end-scrapers (2: c.1272, 3: c.1408); **4-5** *lames à retouche rasante* (4: c.2471 end-scraper; 5: c.19 burin on truncation). – (© Oxford Archaeology).

cracking?) and were not the source of the flints in the archaeological layer. Despite the large size of some of the cobbles in unit G2b, there were no signs that they had been used for building hearths or other structures. No bone survived in the archaeological horizon.

Dating of the lithic assemblage is based on nine OSL (Optically Stimulated Luminescence) measurements of sediments from above, within and below the archaeological horizon. The samples that relate most closely to the archaeological material show that stratigraphic unit G2c, that contained the finds, has an estimated age of 15,105 ± 1,715 BP (absolute years). It is sealed by an upper sand sequence with an estimated age of 10,150 ± 915 BP. Sands beneath the Cobble layer (G2a) provided two OSL estimates of 20,345 ± 1,475 BP and 19,880 ± 1,020 BP, placing their deposition towards the end of the Last Glacial Maximum. From these determinations it suggests that the occupation of the site dated to the first half of the Late Glacial (Windermere) interstadial, roughly equivalent to the Late Bølling oscillation in the North European terminology (Naudinot et al., 2019).

Typological and technological attributes of the flint assemblage identify it as belonging to an early facies of the *Federmessergruppen* (or Azilian). This is based partly on the retouched tools (n = 263) which include a curve-backed blade pointed at both ends (bi-point) (**Fig. 4: 1**) and several broken, backed points. There is a notable scarcity of backed bladelets (5 fragments) and absence of trapezoidal backed forms (Cheddar points) typical of the Magdalenian and British Creswellian facies, respectively. Amongst the end-scrapers are shorter examples typical of the *Federmessergruppen* (**Fig. 4: 2-3**), and the burins include a relatively equal representation of dihedral and thicker truncation types. One of the most diagnostic tool forms are seven blades with invasive stepped and scaled retouch (knife blades or *lames à retouche rasante*) (**Fig. 4: 4-5**). Such blades with *rasante* retouch are regarded as an important typological marker of the Azilian in mainland Europe (Bodu and Mevel, 2008); they are uncommon in the Late Magdalenian. Technologically, the assemblage is characterised by regular blades, straight or slightly curved in profile, often from a single preferred flaking direction. The use of soft stone hammer percussion (as opposed to organic hammer percussion) to produce them is a feature shared with *Federmessergruppen* and Azilian assemblages on the European mainland (Naudinot et al., 2019).

Flint scatters and refitting evidence

Two dense flint concentrations were identified within the excavated scatter of flint artefacts: Concentration 1 (C1) in the north-western part of the site, and Concentration 2 (C2) in the south-eastern part. Both concentrations were about 2 m^2 in size and were separated by a gap of about 4-5 m. Most of the rest of the flint assemblage recovered from the site was in the area between and to the east of the two concentrations (see **Fig. 2**). Both concentrations consisted of large quantities of knapping debris including cores, crested pieces, core tablets and other rejuvenation products, and refitting has shown that they were foci for blade manufacture. They also contained more than half of the assemblage debitage with a high proportion of artefacts with cortical surfaces implying prime knapping areas where cores were reduced from raw nodules. Where cortex survives on artefacts it usually has the characteristics of slightly weathered flint nodules derived from the Chalk (rather than river gravel flint). It is therefore presumed that the nodules were brought from a nearby chalk outcrop to the site for working.

The knapping strategies reconstructed from refitting revealed a very similar pattern of reduction in each of the concentrations which involved the production of long regular blades, straight or slightly curved in profile, and often from a single preferred flaking direction. The elaborate shaping of cores included the careful preparation of butts for the longer blades, and the frequent use of faceting and platform abrasion. One other consistent feature of C1 and C2 was the relatively low incidence of bladelets and the fact that in their final stages, the cores show the preferential production of short, straight blades generally made with soft stone hammer percussion. From refitting it also became clear that each of the concentrations had many internal refits, and also refits with material from elsewhere on the site, but that there were few inter-connecting conjoins between C1 and C2. There are only two main instances of artefacts refitting between the two concentrations and these were both examples where a tool knapped in one concentration was found in the

Fig. 5 Photograph of refitting group RG-6. – (© Institute of Archaeology Oxford University).

area of the other: refit groups RG-2 (n = 15) and RG-10 (n = 11). There are two other instances but in both cases the refitting groups are too small to allow interpretation: refit groups RG-23 (n = 5) and RG-29 (n = 4). Despite similarities in the overall quality and standard of blade production in C1 and C2, there are subtle variations in the knapping techniques that would indicate the actions of different experienced individual flintknappers. For example, a method similar to the *en éperon* technique for isolating platforms prior to blade removal occurs more frequently in C2 and its related refitting groups, while there is a slightly higher proportion of plain butts, often with the bulb of percussion located precisely at the edge of the platform, in C1 and related groups. These variances perhaps suggest differences in technical ability between the individual knappers responsible for the main concentrations. Alternatively, since there are well-made blades in both clusters, then it may simply be a question of divergent styles of flintknapping. Either way, the differences in knapping style seem to indicate the presence on site of at least two knappers skilled in blade production.

The only refitting group that does not seem to be entirely the product of skilled flint working is refit group 6 (RG-6; n = 8) (**Fig. 5**), which we hypothesize was the work of an inexpert, possibly novice, knapper. This group consists mainly of laminar flakes with large plain butts removed from a single platform cortically-backed core (c.1908). The flint is of good quality and originated from a river cobble; a different source from the other cores at the site. The removals were apparently by soft stone percussion and are reasonably well-executed although generally lacking the precise technical skill shown on debitage from other refitting groups. These flakes and the core were all found near each other about 1 - 1.5 m to the west of C1 (**Fig. 2**), at the edge of the excavated site. The core appears to have been abandoned before it was exhausted, most

Fig. 5 (continued)

likely as the platform was damaged by the lack of care with which the final 2-3 removals were executed. These final removals were not recovered during the excavation, but the negative scars on the core show that they were uncontrolled and apparently either hard hammer struck and/or detached with considerable force. These combined factors regarding RG-6 would seem to fulfill the main criteria for identifying the activity of a relatively unskilled 'novice' flint knapper: i.e., recovery of a near complete debitage cluster from a small area; lack of technical precision in knapping compared to the rest of the assemblage; early abandonment of a core; proximity to activity of a skilled knapper; and activity at the periphery of a site/activity area. Further support for this interpretation is provided by two other artefacts in this refitting group, both of which were found away from the main RG-6 scatter. One is a successful platform rejuvenation flake (c.1908) that had been removed immediately prior to the start of the series of laminar flake removals. Dorsal features and refitting show that before this flake was detached the entire core platform had been crushed by repeated unsuccessful blows. The rejuvenation flake had been detached efficiently by soft stone percussion and was found within C1. Its presence there is hard to explain other than by hypothesizing a connection between the skilled knapper in C1 and the nearby 'novice' knapper. Perhaps this simple repair to the core could be seen as an 'educational interaction' with the novice of the type proposed by Johansen and Stapert, in this case possibly demonstrating how to refresh a core platform. In this light it is interesting to note that the flake that subsequently removed the remaining part of the damaged platform (c.879, from the main RG-6 scatter) had been knapped by the same characteristic method of delivering a blow precisely at the edge of a plain platform that is most frequently seen in C1 and related refitting groups. This perhaps is another indicator of a skilled knapper instructing or guiding the novice.

The other refitting artefact in RG-6 is a well-made blade (c.2403) with an *en éperon*-type isolated butt and features of soft-stone percussion. It was found about 3 m to the east of the main group of 'novice' refits, and about 2 m north east of C1 in an area where some tool using activity seems to have occurred. Refitting shows that this blade relates to an earlier phase of use of the RG-6 core when the volume of the block was larger and the main working platform higher. The blade is clearly the product of skilled blade manufacture, and it perhaps represents the final phase of the use of the core for that purpose before it was passed to a novice for knapping practice. As no further refits have been found it cannot be determined if earlier blade manufacture took place onsite or whether the core was brought in from another location. The presence of this blade in the refit group does demonstrate at least two phases of use of this core, originally for skilled blade manufacture, and later as raw material for a novice to use for knapping practice. This is consistent with Grimm's observation that novices often reuse material discarded by more expert knappers.

Refitting of other material found close to the RG-6 scatter provides further potentially relevant information regarding interaction between the novice and the skilled C1 flintknapper. Several large thick debitage elements from C1 refit groups (four from RG-1: n = 71; two from RG-2: n = 15; and one from RG-4: n = 11) were found closely clustered together with elements of the RG-6 novice group (see **Fig. 2**). The distribution of these large debitage pieces does not appear to have been by chance as the artefacts must have been moved there up to 1.5 m from where they were knapped. In our view it is plausible that they had been deliberately placed there together – possibly for reference or for future use in knapping practice by the novice. In addition, the only tool associated with the main RG-6 novice group is a broken edge-damaged flake, that was originally knapped as part of RG-1 in Concentration 1.

DISCUSSION

Refitting data and technological observations of the *chaîne opératoire* demonstrates a spatial connection between the C1 knapping concentration and the adjacent smaller RG-6 scatter. One of the main questions however concerns the nature of that connection. Based on our analysis we would argue that RG-6 represents the work of a novice, lying adjacent to a concentration of more expertly knapped material near the edge of the known site and thus fulfilling the criteria set out by Grimm (2000). In addition, the reduction method of RG-6 was not particularly skillful in its execution, the resulting products were simple laminar flakes, most of the artefacts were abandoned close to the core, and the flint used had already been discarded by a more expert knapper. Although not conclusive, it is therefore tempting to interpret the evidence from the Guildford site as that of a novice sitting alongside an expert knapper, observing the process and products of the skilled work, as part of a learning experience. This is not too dissimilar to the scenario envisaged at Trollesgave in which an inexperienced novice is described seated next to and receiving instruction from a highly skilled knapping teacher (Fischer, 1989).

Of the potential counter-arguments to this interpretation, it could be suggested that the core simply represented an expedient use of locally available lithic raw material that came from the bed of the nearby river Wey. This contention, while possible, seems unlikely to us because none of the flakes from this core showed any signs of use-wear and they lay in a small cluster, more or less as they had been knapped. This interpretation also does not take sufficiently into account the extended 'life-cycle' of the RG-6 core which at an earlier stage seems to have been worked by a more expert knapper. Nor does it explain the skilled repair of the original damaged platform, or the connections with C1 that can be demonstrated by refitting.

Taking a broader view of human activity in southeast Britain during the Late Upper Palaeolithic, it is interesting to note that another example of novice knapping has been described at the nearby site of Wey Manor Farm, Surrey (Jones and Cooper, 2013). This site is believed to be of similar age to the Guildford Fire Station site and lies just 11 miles downstream on the River Wey (**Fig. 1**). Although the assemblage is not as extensive as at Guildford there are many similarities between the two sites, including that they were both probably short-term occupations made by a small group of people. The possible presence of a novice flintknapper on both sites might be another significant parallel. The diagnostic indicator in the Wey Manor Farm assemblage was a fragment of a well-made blade core that had broken along a natural fracture plane and had subsequently undergone a final phase of poorly executed reduction (Jones and Cooper, 2013: 21). This final phase of working had resulted in a series of stepped fractures and apparently failed attempts at platform rejuvenation (Jones and Cooper, 2013: Fig. 2.14). The end-product was interpreted as being the work of a child, and the report speculates that the child might have been present either as an apprentice with a hunting-task group or possibly as a member of a family group (Jones and Cooper, 2013: 49). The same might possibly also be true of the Guildford site. It suggests the importance of finding further examples of high-resolution sites of such kind to explore whether such patterns were more widespread.

Acknowledgements

The Guildford Fire Station project has involved many people from different specialisms working together over the past few years, and we would like to thank them all for their contributions. In particular we would like to thank Oxford Archaeology South and Christopher Hayden for permission to publish data and figures ahead of the full results of the excavations at the site (Barton et al., submitted). We are also grateful to Sophie Lamb (drawings), Gary Jones (spatial diagrams), and Ian Cartwright (photographs) for the figures. Surrey County Council is thanked for funding the excavation. Surrey County Council and Historic England are thanked for funding the post-excavation analysis and publication. It should also be mentioned that Martin Street was the first European Palaeolithic specialist to examine the assemblage with us, and we are grateful for his comments and observations. We apologise to Elaine Turner that no bone was found at the site.

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PAULE COUDRET · JEAN-PIERRE FAGNART

LATE GACIAL SETTLEMENT AT THE SITE OF SALEUX (SOMME, FRANCE)

Abstract

The site of Saleux, situated in the Selle valley 6 km southwest of Amiens, was excavated from 1993 to 2011. Some ten find concentrations (*loci*) attributable to the *Federmesser* tradition (*Azilien*) have been studied over an area of about one hectare. They are dispersed over three distinct excavation sectors, spatially separated by relatively large sterile areas (100 to 200 m). Given this, the site cannot be considered a single Late Palaeolithic camp, but rather a series of diachronic settlements, documented within each area by one or more concentrations of remains.

The different settlements appear to have been small residential camps, each of which was only occupied once, over a limited time period, by a small or extended family unit, as demonstrated by the diverse range of activities observed at the different *loci*. If we consider all the data available for the Somme basin, the settlement mode in the region during the Allerød oscillation appears to have been based on the residential mobility of human groups, whose subsistence was derived from non-migratory game (e. g., red deer and aurochs), which represented a stable, regular resource over time and space.

Almost all the settlements at the site represent a recent phase of the *Federmesser* tradition (*Azilien récent*), which can be placed into the end of the Allerød oscillation at around ~11,000 ^{14}C BP (i. e., ca. 12,900 cal BP). An initial occupation of the site, attributable to the early phase of the *Federmesser* tradition has been identified, but could not be precisely dated, due to the absence of associated organic remains. This very characteristic lithic industry is comparable with that of the lower level in Quarry III.1 in Hangest-sur-Somme, located in the Somme valley, between Amiens and Abbeville.

Keywords

Late Glacial, Allerød oscillation, Final Palaeolithic, *Federmesser*, Somme basin, camps and territories, land-use

INTRODUCTION

The site of Saleux was discovered in August 1990 during exploratory surveys prior to the construction of the A16 motorway connecting northern Paris and the Franco-Belgian border (Coudret, 1992). In 1993, the positive appraisal of the site led to a series of rescue excavations over an area of ~760 m^2 (Coudret, 1995, 1997). From 1993 onward, an excavation programme was carried out over the course of several years alongside the motorway limits in order to obtain more comprehensive archaeological information about the Late Glacial human occupation of the region. This programme was the subject of 19 different excavation campaigns over the summer periods. As a result, around ten find concentrations (*loci*) attributable to the *Federmesser* tradition were identified between 1993 and 2011, over an area of about 1 ha.

The site of Saleux lies on Cretaceous bedrock in the northwest of the Paris Basin. It is located in the Selle river valley, one of the main tributaries on the left banks of the Somme, less than 6 km southwest of Amiens, near the town of Saleux, in a place known as *La Vierge Catherine* and *Les Baquets* (**Fig. 1**). The site is situated on the edge of the Selle floodplain, at the bottom of a gentle loamy slope (**Fig. 2**). This geomorphological position is comparable with that of most Late Glacial sites of the region (Fagnart, 1993, 1997).

In: S. Gaudzinski-Windheuser · O. Jöris (Eds.), The Beef behind all Possible Pasts. The Tandem-*Festschrift* in Honour of Elaine Turner and Martin Street. Monographien des RGZM 157 (Mainz 2021). DOI: 10.11588/propylaeum.950.c12579

In this region, the Selle river valley shows the classic asymmetry frequently observed in the valleys of the Picardy and northern France (Demangeon, 1905; Antoine, 1990). The gentle, loamy western slope contrasts with a much steeper, chalky eastern slope. Flint outcrops from the Coniacian stage are present at different altitudes on both sides of the valley.

In this part of the valley the main Late Glacial palaeochannel, identified during surveying, is located in the immediate vicinity of the sites, just along the edge of the lowest terrace (**Fig. 3**). During the Allerød oscillation, the archaeological settlements overlooked the active river channel, 2-3 m above the valley bottom (Antoine in: Coudret, 1995).

GEOMORPHOLOGICAL AND STRATIGRAPHIC CONTEXT

The first stratigraphic surveys carried out along the planned route of the A16 motorway were performed by P. Antoine (Antoine in: Coudret, 1995). Over the following years, the different excavation trenches were laid out by the excavation teams. Finally, a major transect through the Selle valley was carried out by Antoine with a hydraulic auger over a distance of about 600 m. This operation made it possible to obtain a complete cross-section of the valley down to the chalky top of the bedrock (Antoine in: Coudret, 1995).

The sectors investigated are located at the contact between the slope deposits and the fluvial formations of the present floodplain. The archaeological settlements are located on a loamy bluff, which is slightly inclined towards the southeast, forming a 20-metre-wide bench on the edge of the floodplain. This landform is related to the existence of a strip of fluvial gravel beneath the silt, which has been preserved along the valley edge. The height of the gravel relative to the deepest incision of the valley allows it to be attributed to the lowest terrace of the Somme. The fluvial gravel formation is about 1.5 to 2 m thick and lies on the chalk at an altitude of 30 m above sea-level (a.s.l.). This fluvial formation at the edge of the present floodplain is

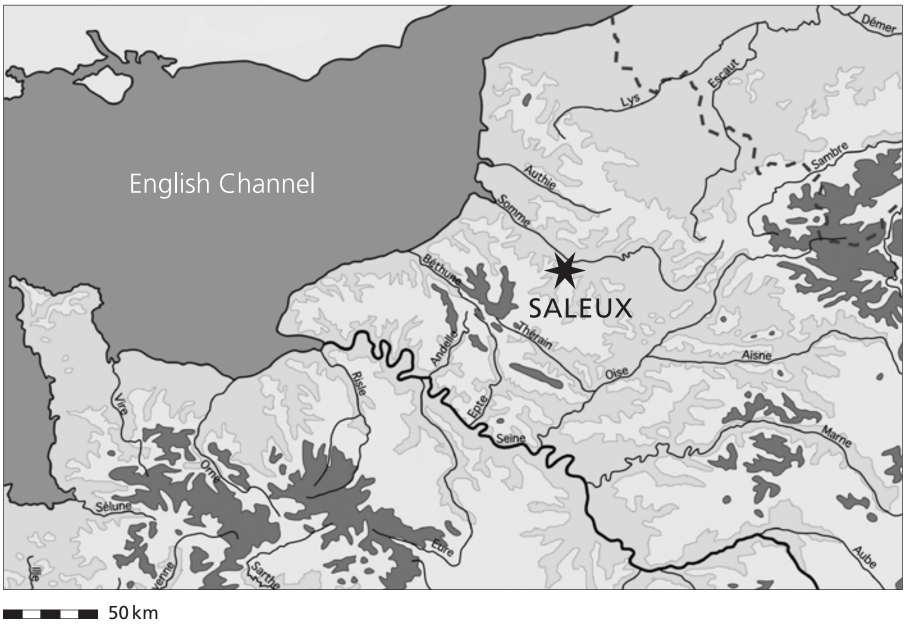


Fig. 1 Saleux, *La Vierge Catherine* and *Les Baquets* (Somme). Geographical location of the site.

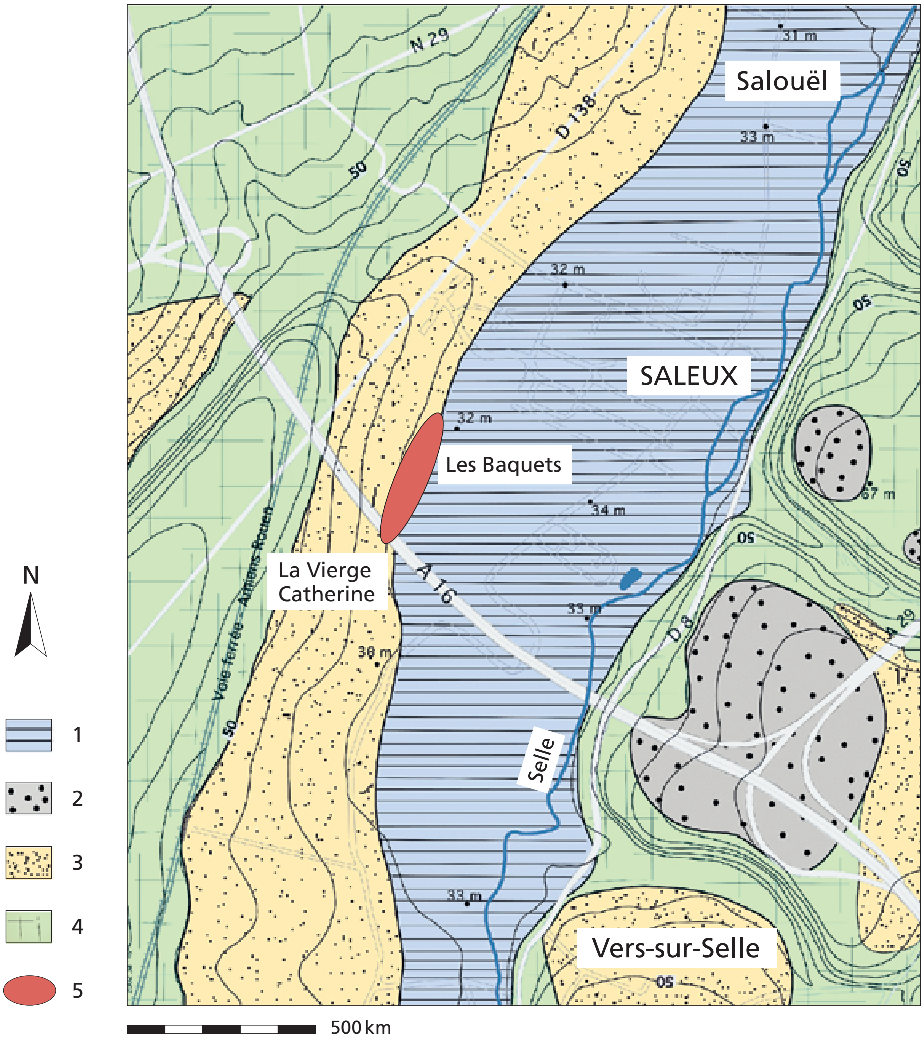


Fig. 2 Saleux, *La Vierge Catherine* and *Les Baquets* (Somme). Geomorphological and topographical context of the site. **1** floodplain; **2** alluvial gravel; **3** loess and colluvial loam; **4** chalk; **5** extent of the site on the edge of the floodplain.

the *Nappe d'Étouvie* (Antoine, 1990, 1993), which is prevalent in the Amiens region. This gravel layer corresponds to the most recent stage of the Low Terrace Complex of the Somme (i.e., of late Saalian age) with a basal level of 24.5m a.s.l. A Weichselian gravel layer was subsequently deposited in the valley bottom during an early phase of the last glacial period.

The fluvial gravel formations of the lowest terrace and the valley bottom are covered by a thin layer of loessic colluvial deposits. The different lithostratigraphic observations made in the Somme basin have allowed these deposits to be attributed to the end of the Upper Pleniglacial of the Weichselian (Antoine, 1990, 1993; Fagnart, 1993) or to an early phase of the Late Glacial (Limondin, 1995; Limondin-Lozouet, 1997).

An organic loam with or without chalk granules and varying from greyish brown to greenish grey in colour (depending on waterlogging) formed at the top of the loessic colluvial deposits. This loam corresponds to a prominent phase of soil formation and relative geomorphological stability. It is this organic horizon that provides the evidence of Final Palaeolithic occupations (*Federmesser* tradition) and that is correlated on lithostratigraphic and pedostratigraphic grounds with the *Belloy-sur-Somme* soil, which has been attributed

Sector	Locus	Material	Laboratory code	^{14}C Age [BP]	Age [cal BP]
1	114	*Bos primigenius*	OxA-4932 (Lyon-81)	11,010 ± 80	12,813-13,035
1	114	*Bos primigenius*	OxA-4933 (Lyon-82)	10,800 ± 140	12,641-12,922
2	234	*Bos primigenius* (femur)	GrA-15945 (Lyon-1141)	11,200 ± 70	12,978-13,216
2	234	*Bos primigenius* (M2 inf.)	GrA-15946 (Lyon-1142)	11,160 ± 70	12,937-13,192
2	244	*Bos primigenius* (metapodial)	GrA-18832 (Lyon-1566)	11,640 ± 70	13,387-13,670
3	284	diaphysis (non determined)	Lyon-4303 (GrA)	11,440 ± 50	13,233-13,480
3	294	*Cervus elaphus* (diaphysis)	Beta-170949	11,180 ± 50	12,968-13,200

Tab. 1 Radiocarbon dates for the *Federmesser* settlements at the site of Saleux (Somme). Calibration was performed with CalPal (quickcal2007 vers.1.6: www.calpal.de), using the calibration curve CalPal2007_Hulu.

to the Allerød oscillation (Fagnart, 1993; Antoine, 1997; Antoine et al., 2000, 2003). This attribution is confirmed by the palynological analyses carried out by A.-V. Munaut and A. Defgnée (1997) and by radiocarbon dates obtained from the different archaeological concentrations excavated from this horizon (**Tab. 1**).

Younger Dryas deposits are missing from the bluff of the lowest terrace and are only observed below the present floodplain. In the area of the archaeological excavations, the peodogenesis of the Allerød is directly masked by Holocene slope formations, preserving settlements attributed to the Middle Mesolithic (Boreal). A large part of the site is then covered by peat and calcareous tufa deposits that formed during the filling of the floodplain. Finally, loamy colluvial sediments from the cultivation on the slopes in historical periods have masked the old topography, leading to the present stable landscape.

In parallel with the research carried out at Saleux, a multidisciplinary study of the site of Conty, located a little less than 15 km upstream of the valley, has made it possible to reconstruct the history of the Selle river system in close relation to the climatic changes that took place between the end of the Weichselian Pleniglacial and the beginning of the Holocene (Antoine, 1997; Antoine et al., 2000, 2003, 2012).

THE ARCHAEOLOGICAL SETTLEMENTS

Three particularly dense areas of Late Glacial remains have been studied (**Fig. 3**). Between these different areas, systematic test trenches have indicated the absence or extreme rarity of any remains.

Sector 1 is located in the southern part of the site, along the current route of the A16 motorway; Sector 2 is located 200 m to the north, and remains of a human skull (*Homo sapiens sapiens*) were documented there in 1998; Sector 3 is located almost a further hundred meters to the north. The different *loci* investigated in these excavation areas (**Tab. 2**) cover a strip of land about 20-30 m wide, over a distance of about 400 m, corresponding to the flat bench of the lowest terrace. The site therefore covers an area of around 1 ha.

Sectors 1 and 2 at Saleux

In Sectors 1 and 2 at Saleux, six *loci* have been identified that have been attributed to the *Federmesser* tradition (*Azilian*). *Loci 114* and *109* (Sector 1) are located on the route of the A16 motorway and were excavated as part of a rescue operation in 1993 and 1994. *Locus 234*, and the three *loci* in area 244 (and

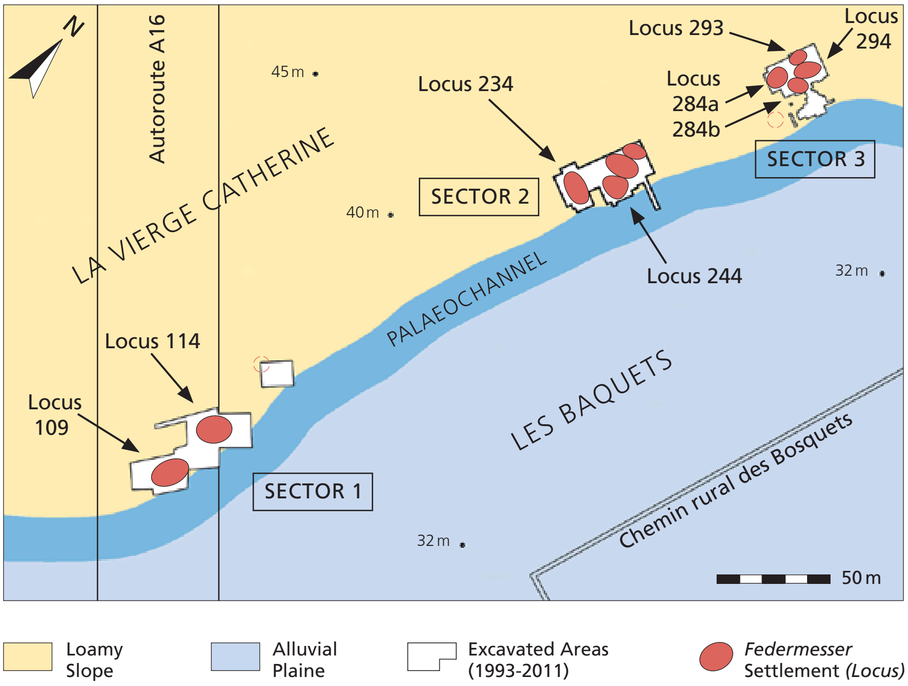


Fig. 3 Saleux, *La Vierge Catherine* and *Les Baquets* (Somme). Location of the three excavation sectors and the principle areas of investigations into the Final Palaeolithic on the edge of the Late Glacial palaeochannel.

254) (Sector 2), were explored as part of a long-term excavation programme between 1996 and 2002, with an additional field campaign in 2011. Sector 1 was excavated entirely manually over an area of 760 m^2, and Sector 2 over an area of 696 m^2.

Locus 234 is a good example of the spatial organization of the Palaeolithic camps at Saleux. The remains were found over an oval-shaped area, about 60 m^2 in size. A little more than 6,500 lithic and bone remains have been collected, not including fragments and chips < 1 cm in size. The general organization of the *locus* is based around a hearth, where most of the activity was concentrated, as shown in find distribution plans (**Figs. 4-5**). Evidence of the combustion structure is provided by a small collection of heated flints, concentrated in a small area. It involves a flat hearth, which is quite typical of most Azilian and *Federmesser* sites (Leesch et al., 2004; Baales and Street, 1996). According to initial counts, 262 blanks transformed into tools have been documented in this concentration. The lithic industry is divided into three main categories of tools: backed points, burins, and retouched backed knives (**Fig. 6**). Backed bladelets are present in relatively modest percentages, as at most of the *loci* within Sectors 1 and 2. The scarcity of end-scrapers in *Locus 234* is also noteworthy in comparison with the neighbouring *loci*. The diversity of the toolkit (projectile points and tools for domestic use, such as retouched backed knives and burins) shows that domestic activities were just as important as hunting activities.

The projectile points were very often found fragmented at their site of manufacture and involve single pointed curve-backed pieces made on small blades. No bipoints have been found. The breakage types clearly indicate that most specimens were fractured during shaping. Only a very small number of projectile points have been found with impact marks, and very few complete examples have been found. This situation reflects the state of abandonment of the site, where objects no longer of great use were left discarded on the ground. In *Locus 234*, the remains of a human skull were found during the 1998 excavation cam-

Sector	Area [m²]	*Locus* no.
1	760	109 114
2	696	234 244 (3 *loci*)
3	375	284a 284b 293 294
Total	1,831	10 *loci*

Tab. 2 Saleux, *La Vierge Catherine* and *Les Baquets* (Somme). Excavation sectors and concentrations (*loci*) of Final Palaeolithic settlement.

paign (**Fig. 7**). Their unique location on the edge of the camp is related to the presence of a dump zone where flint slabs and heated blocks have also been found (Coudret and Fagnart, 2004). The specimen was resting with its base on the base of the Allerød layer. The condition of the cranial sutures indicates that the skull represents a young adult aged between 18 and 25.

The three *loci* in area 244 are situated about 20 m north of *Locus 234* (**Fig. 5**). The remains are more loosely distributed and are organized around four small, flat hearths, one of which probably served for domestic use (R10). The others are further away from the denser concentrated remains and were probably related to satellite activities (B13, L8 and H10). The abundance of end-scrapers in *Locus 244* could indicate its functional complementarity with *Locus 234*, unless it involved an occupation at a different time, during another season.

In Sector 1, *Loci 114* and *109*, which are located at about 15 m distance, occupy a markedly different stratigraphic position, suggesting that these camps do not correspond to the same time period (**Fig. 3**). These two domestic units, which are spatially relatively isolated, thus appear to have functioned individually and autonomously (Coudret, 1995, 1997).

As at most of the Late Glacial *loci* at Saleux, the state of bone conservation in Sectors 1 and 2 is relatively poor. Several dozen bone remains have nonetheless been collected, but they have not yet been the subject of an in-depth zooarchaeological study. We can note, however, the presence of red deer (*Cervus elaphus*), aurochs (*Bos primigenius*) and most likely horse (*Equus* sp.) in the hunted prey of the Palaeolithic groups.

The typological and technological characteristics of the lithic assemblages allow to the camps in Sectors 1 and 2 at Saleux to be attributed to the recent phase of the *Federmesser* tradition or the *Azilian récent* (Fagnart and Coudret, 2000a, 2000b; Coudret and Fagnart, 2004, 2006; Valentin, 2005, 2008; Naudinot et al., 2019). These industries are characterized by relatively simple technical processes aimed at extracting straight blades of medium size using a soft stone hammer. The best comparisons with the Seine basin have been made with the "intermediate level" at the site of Le Closeau, excavated by P. Bodu in Rueil-Malmaison (Bodu, 1995, 1998, 2000; Bodu and Valentin, 1997) and with *Locus 33* at the site of Ambenay, in the Eure valley (Valentin et al., 2004). According to the stratigraphic position of the *Federmesser* industry in Sectors 1 and 2 at Saleux, the available radiocarbon dates (ca. 11,640-10,800 ^{14}C BP, i. e., ~13,530-12,780 cal BP; **Tab. 1**) and the palynological data, the occupations can be placed into the second half of the Allerød oscillation (i. e., Greenland Interstadial GI 1a-1c$_1$; cf. Rasmussen et al., 2014).

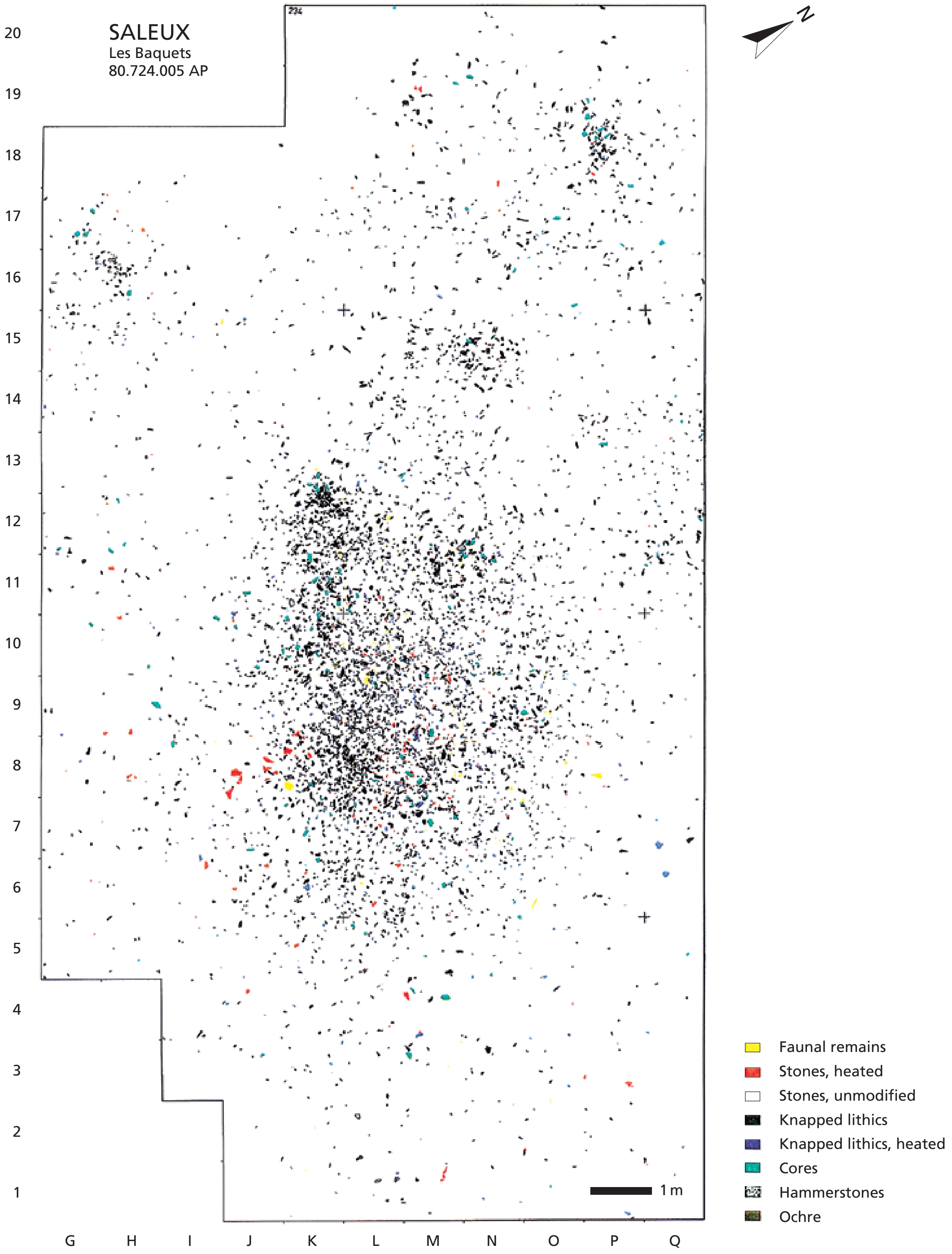


Fig. 4 Saleux, *Les Baquets* (Somme). Distribution of the archaeological material in *Locus 234*.

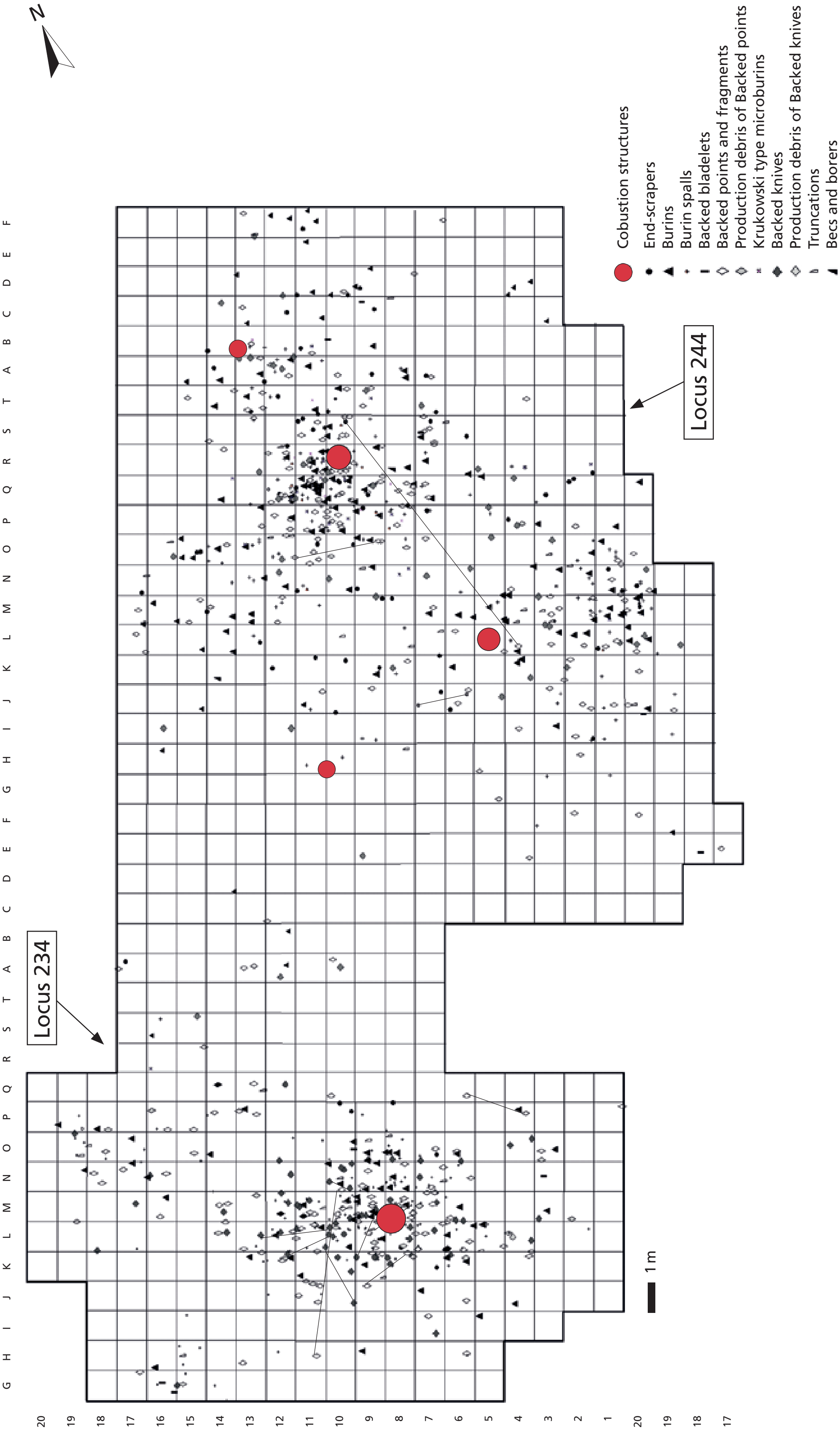


Fig. 5 Saleux, *Les Baquets* (Somme). Sector 2. Distribution of the main tool categories in the *Federmesser* concentrations (*Loci 234* and *244*).

Sector 3 at Saleux

Sector 3 has been only partially studied covering some 479 m^2 (of which 375 m^2 are attributed to Final Palaeolithic *loci*). A zone adjoining the excavated area, approximately 400 m^2 in size, has been preserved as archaeological evidence for future research. In this third sector, the typological and technical characteristics and the physical aspects of the lithic remains have made it possible to distinguish two assemblages pertaining to the Final Palaeolithic; however, the site's stratigraphy makes it difficult to distinguish between them altimetrically.

A first – largely predominant – assemblage with a white or greyish white matt patina consists of artefacts in Coniacian flint (Zone B according to Monciardini). It is distinguished by original technical processes which characterize the recent phase of the *Federmesser* tradition. This occupation, which is very widely represented in most of the *loci* of Sectors 1 and 2 at Saleux, has been attributed to the second half of the Allerød oscillation or its end. The second assemblage, which has a bluish or greyish patina which is sometimes slightly vermiculated and very soft to the touch, is mainly composed of flints from the base of the Coniacian (Zone A according to Monciardini) which is not present in the immediate environment of the site. This occupation presents knapping methods identical to those of the lower level at Hangest-sur-Somme, which has been attributed to the end of the Bølling oscillation or an early phase of the Allerød oscillation (Fagnart, 1997; Valentin et al., 2006).

The main occupation in Sector 3 at Saleux: the white, matt patina assemblage

The main occupation in Sector 3 produced ~ 12,000 bones and lithic artefacts as well as several thousand fragments and chips < 1 cm in size, which have not yet been the subject of a detailed inventory. At this stage of the study, the lithic material from Sector 3 has been treated as a whole, given the close proximity and occasional overlapping of the different *loci*. In a subsequent stage of the analysis, the counts will be established concentration by concentration (*Loci 293, 294, 284a, 284b*). From a typological perspective, a total of 803 tools have been identified in Sector 3. The inventory includes 119 cores and around 30 fragments or other debris. A dozen un-knapped blocks and two stone hammers complete this assemblage as well as several hundred pieces of heated flint and resulting fragments.

The raw material used by the Palaeolithic groups during the main occupation of Sector 3 involves flint from local Coniacian chalk, which is present on both slopes of the valley. The industry discovered presents a fairly homogeneous patina that is white or a matt greyish white in colour, but sometimes also bluish white.

Knapping is focused on the production of straight, relatively short or medium-sized blades (generally < 14 cm in length). There is a fairly good preparation and relative regularity involved in the blank manufacture during the phase of blade production (*plein debitage*). The initial phase of blade production is much less standardized, however. Various morpho-technical indications (Pelegrin, 2000) suggest that the blade preparation and extraction phases were carried out with a soft stone hammer.

As the analysis of the industry is still in its preliminary stages, the results presented here are provisional and could evolve at a later date. Four main categories of tools dominate the lithic industry as a whole (**Figs. 8-9**): backed bladelets, burins, backed points and retouched backed knives. End-scrapers and truncated pieces are a little less frequent, and only a few examples of other tool types have been found. It is noteworthy, however, that in Sector 3, backed bladelets represent over 30 % of the finds, which is far more than is the case in Sectors 1 and 2 (between 2 % and 10 %). The typological and technological characteristics of the industry make it possible to attribute the main occupation of Sector 3 at Saleux to the recent phase of the

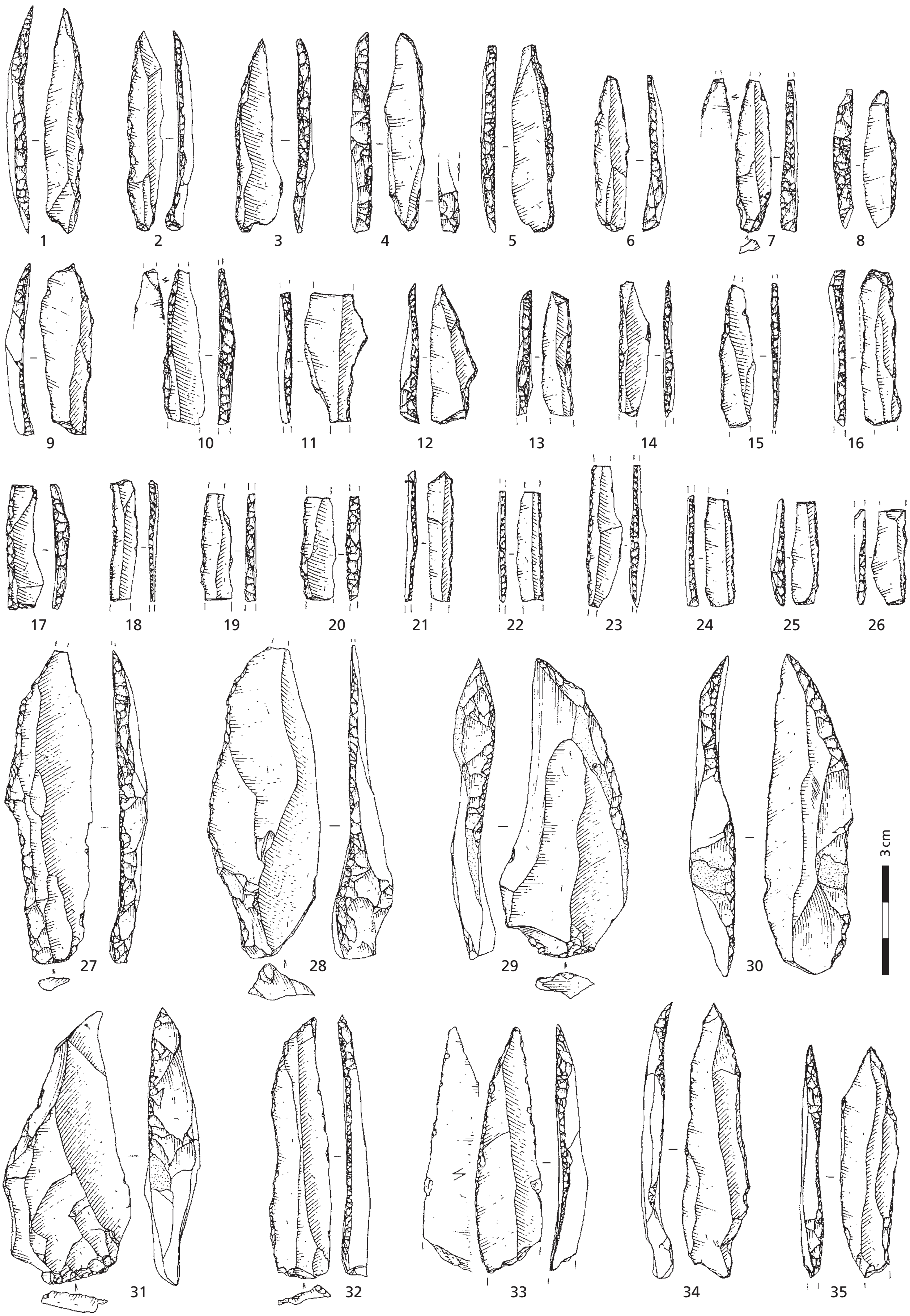


Fig. 6 Saleux, *Les Baquets* (Somme). Lithic industry from *Locus 244*. **1-26** backed points (*Federmesser*) and backed bladelets, **27-35** retouched backed knives. – (Drawings: P. Alix).

Federmesser tradition (Fagnart, 1997; Coudret and Fagnart, 1997, 2004, 2006, 2015; Fagnart and Coudret, 2000a, 2000b).

As with the *loci* in Sectors 1 and 2 at Saleux, few bone remains have been documented in Sector 3. So far, the species that have been identified are red deer (*Cervus elaphus*) and aurochs (*Bos primigenius*).

In Sector 3, the 12,000 remains were spread over an area of 375 m^2. At least five flat hearths have been found in the occupied area (**Fig. 10**). Hearths S12, C16 and L10 all have a similar layout and organization, involving sub-circular combustion structures approximately 60 cm in diameter, evidenced by heated flint nodules from the gravel of the lowest terrace (**Fig. 11**). However, no ashy or reddened zones could be identified within these structures. The location of the other hearths is much more discreet, the initial location of the combustion structures only being evidenced by a small scattered group of heated flints (structures J1 and L16).

Fig. 7 Saleux, *Les Baquets* (Somme). Human skull from *Locus 234*. – (Photo: S. Jousse).

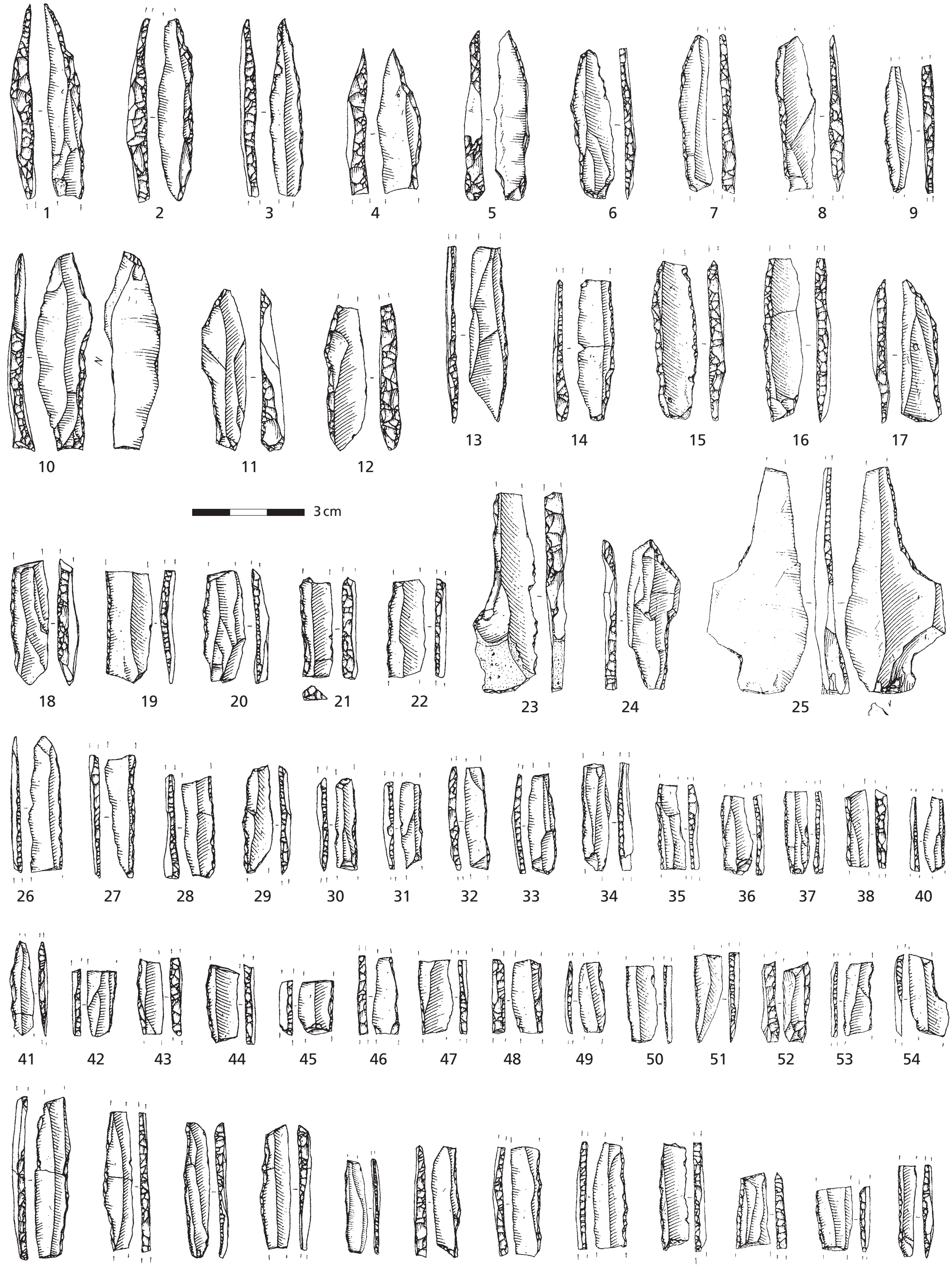


Fig. 8 Saleux, *Les Baquets* (Somme). *Federmesser* lithic industry from Sector 3 (matt, white patinated assemblage). **1-17** backed points, **18-22, 27-66** backed bladelets, **24-26** technical pieces related to the manufacture of backed points. – (Drawings: P. Alix).

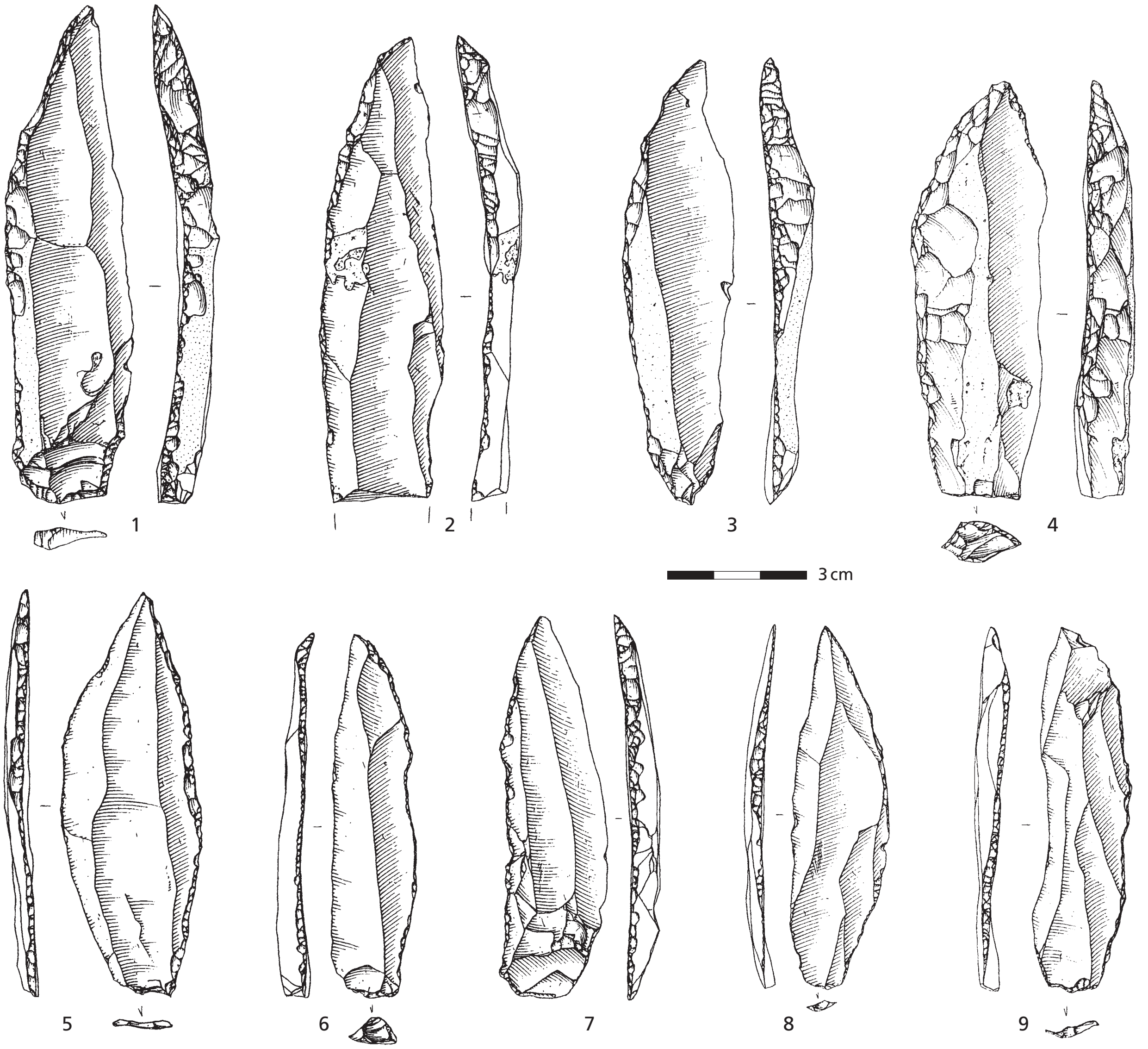


Fig. 9 Saleux, *Les Baquets* (Somme). *Federmesser* lithic industry from Sector 3 (matt, white patinated assemblage). **1-9** retouched backed knives. – (Drawings: P. Alix).

Within the *loci*, the lithic and bone remains are generally found around the combustion structures (**Fig. 10**). This observation is particularly true of the spatial distribution of the backed bladelets, backed points, and to some extent for the burins. No functional specialization could be identified, each *locus* presenting a diverse spectrum of activities (**Fig. 12**). As at most of the *loci* studied at Saleux, the cores are often found in the periphery of the find-rich areas. This phenomenon is related to the discarding of exhausted cores towards the margins of the occupied space.

An initial proposal has been put forward, marking out the limits of the *loci* excavated in Sector 3 (**Fig. 10**). Four *loci*, which are all relatively close to each other, appear quite distinct on the distribution plans of the remains. They have been labelled according to their location on the excavation grid: *Loci 293, 294, 284a* and *284b*. The remains delineate sub-circular or oval surfaces with an average diameter of 8 m. The area of each unit covers about 60 m^2. Most of the *loci* are organized around a single hearth which generally occupies a central position (hearths S12, C16 and L16). However, other combustion structures are located at clearly peripheral position in relation to the different *loci* (hearths J1 and L10).

The occupied area in Sector 3 is therefore characterized by the close proximity of several concentrated zones of activity. In Sectors 1 and 2 at Saleux, the distance between the different *loci* is generally greater and ranges around 15-20 m. In Sector 3, the spatial limits and thus the distinction between the *loci* is more difficult to establish, given the presence of overlapping areas in the periphery of the different occupation zones.

The assemblage of bluish-white patina on "Turonian" flint of Sector 3 at Saleux

The analysis of the archaeological material in Sector 3 has made it possible to isolate an assemblage of lithic remains with very distinctive characteristics. This assemblage is distinguished by its use of a very specific raw material, its unique physical appearance, and its original techno-typological characteristics. This industry is also present, but much more sporadically, in trenches *234* and *244* at Saleux.

The raw material from this assemblage has not yet been entirely sorted. Only the cores and tools have thus far been documented. It will be necessary to sort all the material in Sector 3 in order to group together all the lithic remains from this level, which were difficult to distinguish during excavations due to limited sedimentation, indicating that a comparably short time elapsed between the two periods. The assemblage currently includes 57 tools and 4 cores.

The raw material used by the Palaeolithic groups exclusively involves a very fine-grained homogenous flint with a thick yellowish-white, beige-white or rose-coloured cortex. It is the flint that is found at the top of the Turonian sequence or the base of the Coniacian (Zone A according to Monciardini).

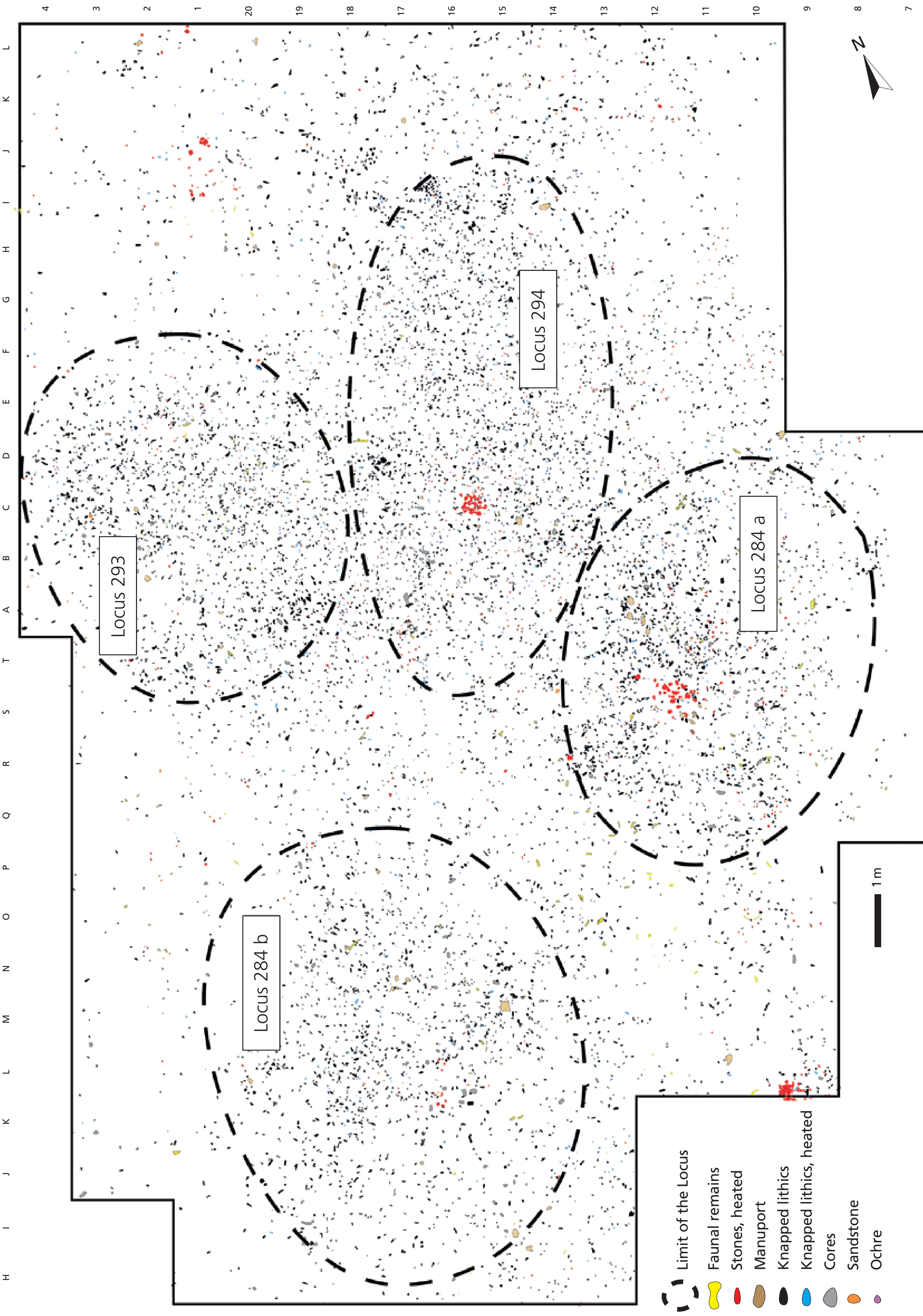
Knapping in this assemblage primarily involved the manufacture of regular blades and bladelet blanks, which tend to be well-prepared and generally straight or, sometimes, slightly curved. In some cases, the butts of the artefacts, which have generally been well prepared and finely abraded, have a small lip at the junction with the ventral face. The blades were produced by percussion with a soft stone hammer used in a tangential movement (Pelegrin, 2000). The rare cores associated with this level demonstrate elaborate preparation and management, which is absent in the other Late Glacial settlements at Saleux.

The proportions of the different categories of tools are provided here. The lithic industry can be divided into five major classes of tools: burins (37 %), backed bladelets (21 %), backed (or *Federmesser*) points (14 %), retouched backed knives (14 %) and end-scrapers (3 %). The rest of the industry is made up of a few fragments of retouched blades.

The backed or *Federmesser* points (8 artefacts) essentially resemble relatively elongated curve-backed points that have been made from small blades. A single fragmented piece could be classified as a real bipoint. The other armatures are all monopoints and often have a small transverse or oblique truncation at the base.

The typological and technical characteristics of the "Turonian" flint industry at Saleux allow comparisons to be drawn with the lower level of Quarry III.1 at Hangest-sur-Somme, which has been attributed to the early phase of the *Federmesser* tradition (Fagnart, 1997; Fagnart and Coudret, 2000a, 2000b; Coudret and Fagnart, 2015).

Fig. 10 Saleux, *Les Baquets* (Somme). Distribution of the archaeological material in Sector 3 (matt, white patinated assemblage) and proposed spatial limits of the different *loci*.


Locus 293
Locus 294
Locus 284 a
Locus 284 b
N
1 m
Limit of the Locus
Faunal remains
Stones, heated
Manuport
Knapped lithics
Knapped lithics, heated
Cores
Sandstone
Ochre
4
3
2
1
20
19
18
17
16
15
14
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The archaeological material made from "Turonian" flint appears relatively uniformly and loosely distributed over the entire excavated area. The slight degree of wear on the ridges of the artefacts suggests that some pieces have been slightly displaced on the slope by erosional processes and that the industry may not be in its original position, which could explain the spatial distribution of the lithic material.

GENERAL REMARKS AND CONCLUSIONS ABOUT THE LATE GLACIAL CAMPS AT SALEUX

The extent of the site of Saleux, which covers a distance of about 400 m along the edge of the Selle floodplain, and the presence of three spatially distinct and well-separated sectors of archaeological material, means that the site cannot be considered as a single large campsite. While certain *loci* appear to have been functionally complementary, the large areas documented through extensive excavations appear above all to have been the result of repeated occupations of the site over different time periods. The numerous lithic refits weave a dense network of links within the different *loci*, but aside from a few rare exceptions, they do not draw links between the main concentrations. The relative abundance of lithic remains (4,000 to 6,000 artefacts > 1 cm in size for each of the *loci*) and the use of a relatively homogeneous and poorly distinguishable raw material do not facilitate refits over longer distances.

Overall, the areas occupied by the Palaeolithic groups at Saleux present fairly consistent characteristics for the different *loci*. The lithic and bone remains are often dispersed within a clearly limited radius, giving the impression that the sites were only occupied once, during residential occupations that took place over a relatively limited time. Given the diversity of activities represented in the different *loci*, it appears that an entire small or extended family unit was present at the site, each time. A few refits demonstrate poorly skilled knapping, suggesting the presence of children.

The archaeological material collected for each *locus* is scattered over an oval or circular area of 40 to 60 m^2. The domestic space is generally organized around a single hearth, where most of the activities took place. The combustion structures are generally flat hearths evidenced by small heated or fire cracked flints. The number of blanks that have been transformed into tools is ~ 150-250 for each of the *loci*, and the diversity of tools (projectile points, end-scrapers, burins and retouched backed knives) suggests that domestic activities were as important as hunting activities. No real functional specialization is observed in the different *loci*, which tend to display a wide range of activities. In Sectors 1 and 2, groups of two or three *loci* are separated by large sterile areas in between. In Sector 3, the different *loci* are much closer together, and the empty spaces between the different areas of activity or camps are much smaller. The dynamic analysis of these *loci* sometimes suggests that they had possible functional complementarities, as seems to be the case between *Locus 234* and the *loci* in trench 244 in Area 2.

In general, the Saleux find concentrations appear to be fairly similar to those identified at various sites attributed to the recent phase of the *Federmesser* tradition (*Azilian récent*), in particular to the sites in the Neuwied Basin (Street, 1998; Street and Baales, 1997, 1999; Street et al., 2002, 2006; Baales, 2002, 2006; Baales and Street, 1996, 1999; Wenzel, 2009; Gelhausen, 2011), the Meuse (De Bie, 1998; De Bie and Caspar, 2000), the Seine (Bodu, 1998, 2000, 2011; Bodu et al., 2012; Mevel and Bodu, 2018), and the Loire valleys (Marchand et al., 2004, 2009, 2011).

The Late Glacial *loci* studied, can be attributed to the *Federmesser* tradition of the Final Palaeolithic. From a chrono-stratigraphic perspective they can be placed in the second half of the Allerød oscillation (i.e.,

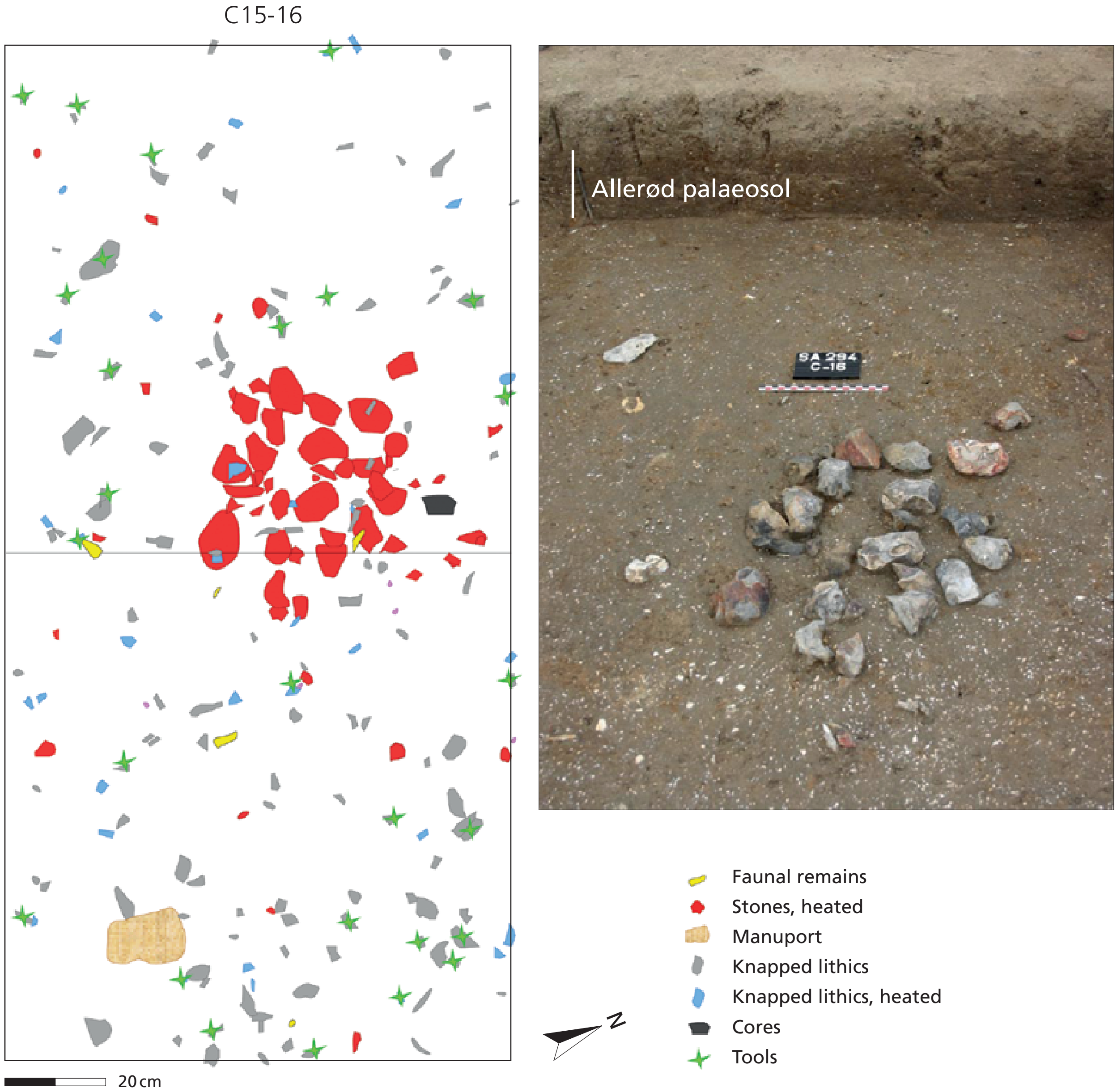

Fig. 11 Saleux, *Les Baquets* (Somme), Sector 3. Left: plan of hearth C16 and the associated lithic and bone remains; right: views of hearth C16 under excavation.

~ GI 1a-1c$_1$), but an assemblage made on "Turonian" flint also testifies to an earlier occupation of the site around the end of the Bølling or the beginning of the Allerød interstadial.

The territory in which human groups were present in the Somme basin during the Allerød oscillation can only be partially identified by studying the origin of the siliceous materials, due to the omnipresence of chalk flint and a certain homogeneity of its facies. At Saleux, the very local acquisition of flint – flint imports from the Conty region to the southeast, in the upper Selle valley, as well as from the region of Amiens region to the northeast, at the confluence between the Selle and the Somme rivers – nevertheless suggests some limited movement within a very small radius (not exceeding 15 km within the Selle basin. At the site of Prouzel in the Selle valley, less than 5 km upstream of Saleux, rescue excavations lead by T. Ducrocq prior to

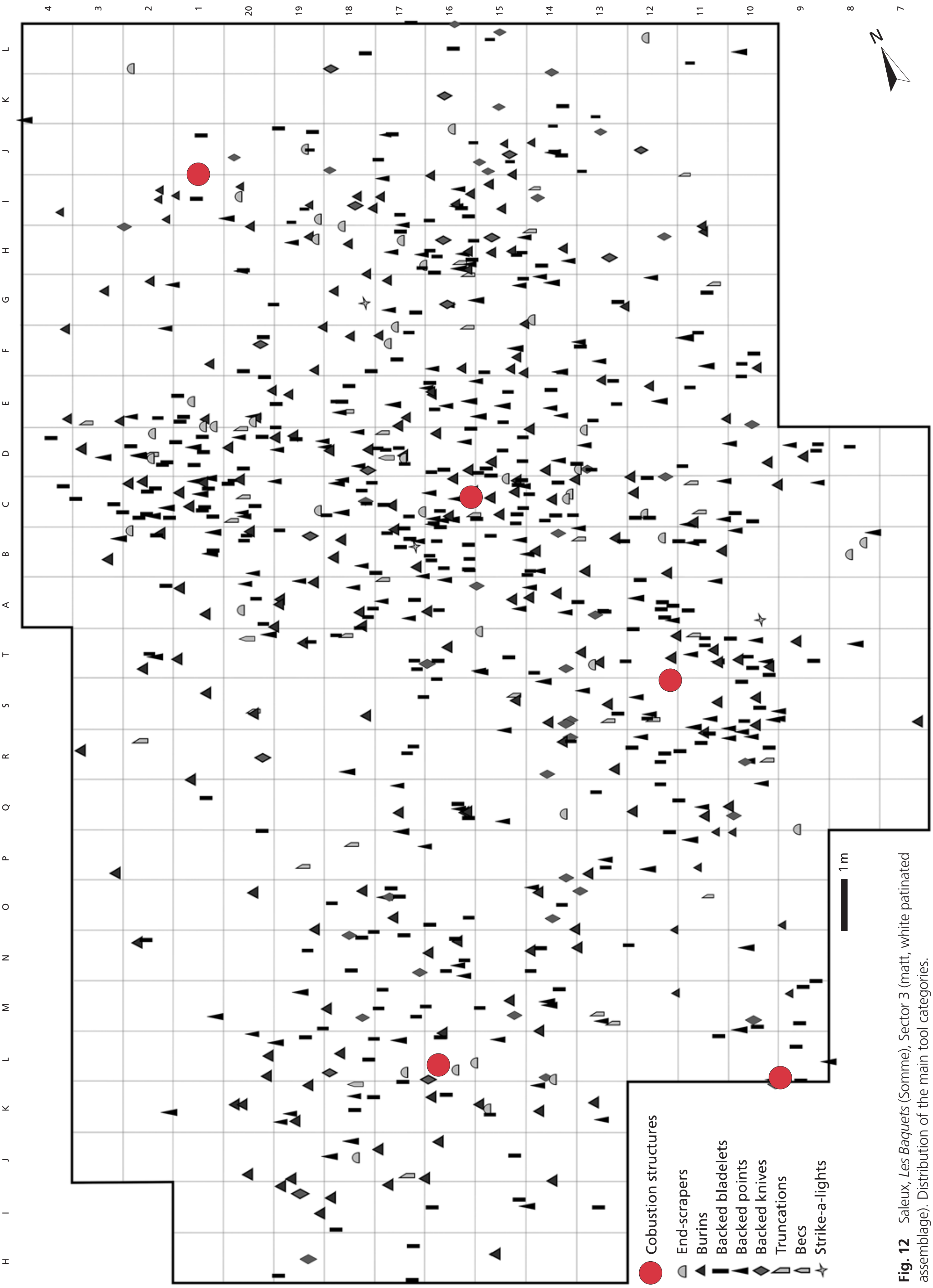

Fig. 12 Saleux, *Les Baquets* (Somme), Sector 3 (matt, white patinated assemblage). Distribution of the main tool categories.

the construction of a housing estate have revealed a backed point and two Bartonian tertiary flint debitage products at a settlement attributed to the *Federmesser* tradition (Bostyn, 2019). At the current point of research, this is the only example in the Somme basin for importing non-local exogenous flint from the tertiary plateaus of the Île-de-France around 60 km further south.

The abundance of hunting armatures amongst the common tools makes it possible to interpret the settlements from the recent phase at Saleux as small hunting camps, involving small groups, which were probably very mobile within a limited territory. According to the activities documented in these *loci*, the mode of land exploitation appears to have involved residential mobility of the groups, whose subsistence came from non-migratory game (red deer and aurochs). As such, animal food resources during the Allerød oscillation appear to have been stably and evenly distributed over space and time.

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THE LITHIC ASSEMBLAGE OF “ANDERNACH 2” FROM THE LATE PALAEOLITHIC LEVELS ON THE MARTINSBERG IN ANDERNACH, RHINELAND-PALATINATE (EXCAVATIONS 1979-1983)

Abstract

During excavations in the years 1979-1983, the site of Andernach 2 in the German central Rhineland produced two find layers: an older one dating to the Magdalenian period with extensive settlement structures and an overlying Late Palaeolithic one with a rather loose find scatter that can be assigned to the *Federmessergruppen*. This article concentrates on the lithic artefacts of this late Palaeolithic find layer, which has an age of ~ 14-13 ka cal BP, and dates into the Allerød interstadial. 13 different raw materials or raw material varieties could be distinguished, whereby the vast majority of the pieces are made of different flints and quartzites. In the tool spectrum, artefacts with blunt backs dominate by far, i. e., backed points and backed knives. Short end-scrapers are also well represented. The burins are usually not worked very carefully. Truncated tools, splintered pieces, non-blunted tips and laterally retouched pieces also occur.

Keywords

Backed points, backed bladelets, short end-scrapers, *Federmessergruppen*, lithic raw materials

INTRODUCTION

The following text is largely based on a heavily revised, unpublished version of the author’s Master’s thesis, which focused on the Late Palaeolithic artefact inventory of the 1979-1983 excavations on the Martinsberg in Andernach and was submitted to the University of Cologne in 1984 (Bolus, 1984). Martin Street analysed the faunal material from these excavations as part of his PhD on the Late Upper Palaeolithic, Late Palaeolithic and Mesolithic faunal inventories in the northern Rhineland which was submitted to the University of Birmingham (Street, 1993). However, since neither the lithic nor the faunal material from the 1979-1983 excavations – in which Martin Street participated as field technician (**Fig. 1**) – were published comprehensively but were only considered within the context of thematic overviews, and despite the time lag since the submission of my Master’s thesis, this *Festschrift* provides a wonderful opportunity to finally present the results of the lithic analysis. The main focus of this contribution will be the retouched forms, which will be illustrated in their entirety.

In recent decades, countless new works on the Late Palaeolithic have appeared in Germany and abroad, and new Late Palaeolithic finds and features have been excavated on the Martinsberg itself (excavations 1994-1996), studied by Jan Kegler as part of another Master’s thesis at the University of Cologne (Kegler, 1999, 2002). However, contextualization of the Andernach-Martinsberg finds in light of the extensive new research and the results obtained over the last few years is not intended here, and more recent literature has only been considered on occasion.

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SITE LOCATION

The Neuwied Basin, together with the Maifeld and the Pellenz to the west, forms a geomorphological basin of about 20 km × 30 km in the centre of the Middle Rhine region in Rhineland-Palatinate. The town of Andernach lies on the north-eastern edge of the basin, on the left side of the Rhine, just before the so-called Andernach Gate (*Andernacher Pforte*), with the town of Neuwied in sight on the opposite bank (cf. Bolus, 1992). Both towns are widely known through Prehistoric research on the two significant and well-comparable Magdalenian sites of Martinsberg (Andernach) and Gönnersdorf (district of Neuwied-Feldkirchen) (in summary: Bosinski, 2008). The Martinsberg in Andernach also provided the remains of a younger occupation, attributed to the Late Palaeolithic *Federmessergruppen* (curved-backed point industries). The lithic material from this upper level at the Martinsberg is the subject of this article. The material has good parallels to the nearby *Federmesser* site in the Neuwied district of Niederbieber (Bolus, 1992; Baales, 2003; Gelhausen, 2011).

Fig. 1 Martin Street, in 1982, during photographic documentation of the excavations at the site of Andernach-Martinsberg. – (Photo: M. Bolus).

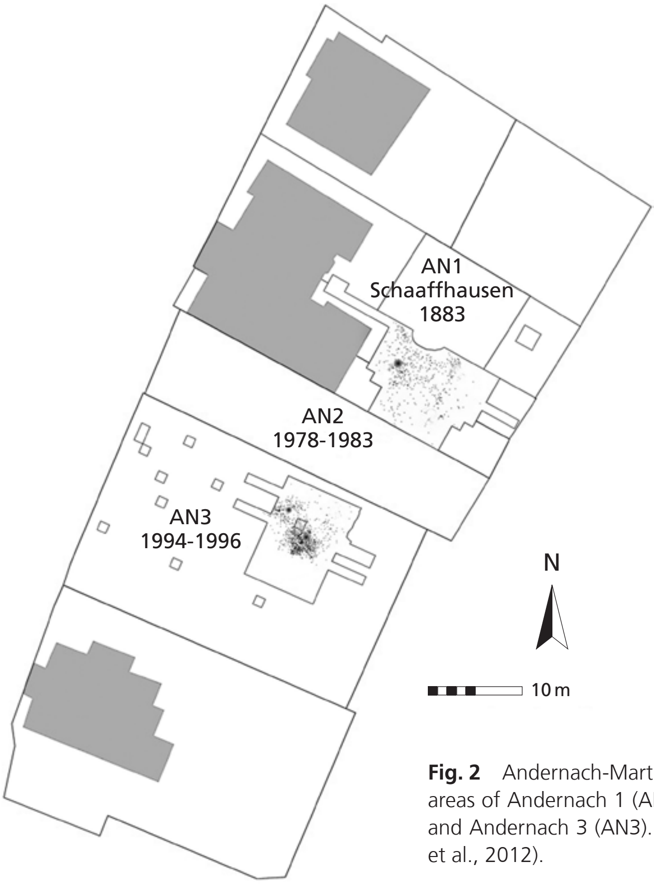

Fig. 2 Andernach-Martinsberg. The excavation areas of Andernach 1 (AN1), Andernach 2 (AN2) and Andernach 3 (AN3). – (Modified from Street et al., 2012).

RESEARCH HISTORY

In the following, the research history of the Martinsberg site is only considered to the extent that is relevant for the Late Palaeolithic finds. The Martinsberg site was discovered at the beginning of February 1883 through the extraction of pumice from the Laacher See eruption, some 13,000 years ago.

Immediately after being notified by Constantin Koenen, the Bonn anthropology professor Hermann Schaaffhausen initiated an excavation at the Martinsberg (Schaaffhausen, 1888), during which he unearthed the assemblage "Andernach 1" (most of which is now stored in the LVR-LandesMuseum Bonn), which mostly consists of Magdalenian finds, but which further includes seven (Late Palaeolithic) backed points that were, however, not referred to as such. Hans Hofer first associated backed points with the Andernach site in 1941 (Hofer, 1941: 25, Fig. 2, 28.30). However, the backed points he referred to did not come from Schaaffhausen's excavations, but belong to the small series of so-called *Neuwieder Federmesser*, comprising some 20 backed artefacts and three blades. These artefacts were made from a chocolate-coloured flint which is not known from the wider region, and purchased by the Neuwied Regional Museum (*Kreismuseum*) at an auction in Düsseldorf in 1912. Being unaware of this, the backed points (especially the *Neuwieder Federmesser*) led Hermann Schwabedissen in his fundamental work on the *Federmessergruppen* in the north-western European lowlands (Schwabedissen, 1954) to link his Rissen group (i.e., *Rissener Gruppe*), into which he placed the Andernach-Martinsberg finds, with the Magdalenian, since the rest of the assemblage – namely the types of burins, end-scrapers and the bone and antler industry – are clearly of Magdalenian character. In their restudy of the material from Schaaffhausen's excavation, Gerhard Bosinski and Joachim Hahn were able to prove that the *Neuwieder Federmesser* were not part of the Martinsberg assemblage (Bosinski and

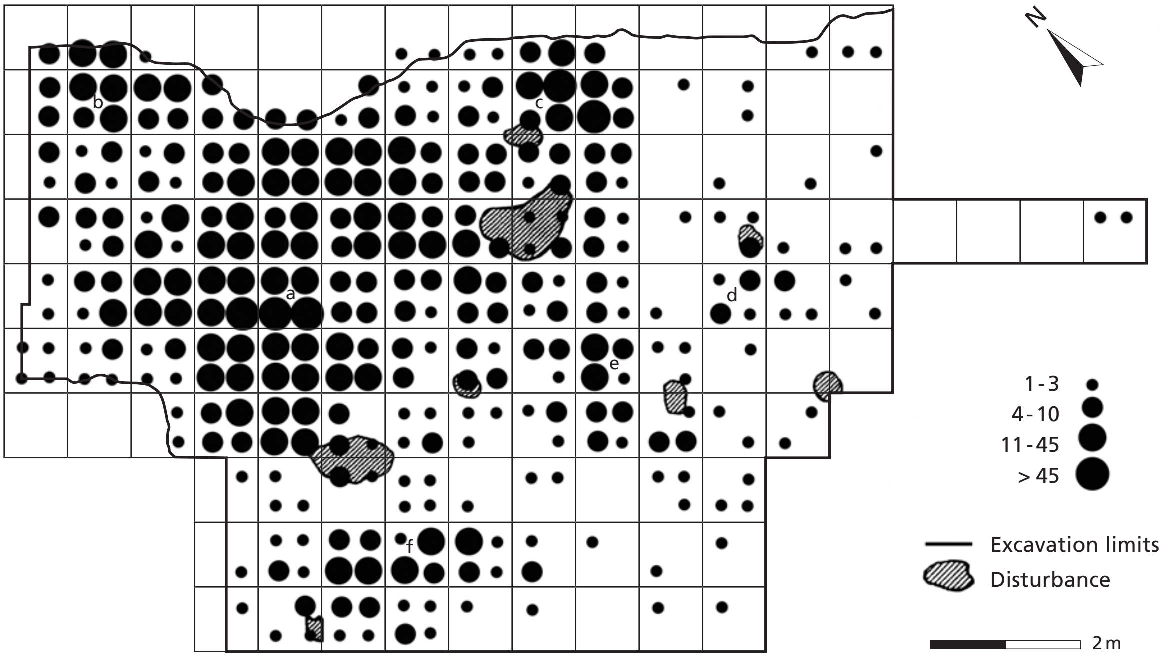

Fig. 3 Andernach-Martinsberg, Late Palaeolithic find horizon of Andernach 2: Distribution of all lithic artefacts (**a-f** concentrations within the general distribution). – (Modified from Bolus, 1991; basic plan drawn by W. Willingstorfer).

Hahn, 1972). The Late Palaeolithic types that remained part of Schaaffhausen's inventory were the seven backed points mentioned above.

New research under the direction of Stephan Veil shed new light on the backed point problem, and it became clear that the seven specimens of the 1883 excavation do not belong to the Magdalenian, but to a younger, Late Palaeolithic find layer. In 1977 Stephan Veil began preliminary investigations with coring on the Martinsberg, during which Late Glacial sediments were found. A preliminary, two-week exploratory follow-up excavation in 1978 also provided Late Glacial sediments, including layers of Allerød age buried below the Laacher See pumice, as well as a number of unclassified but probably Upper Palaeolithic finds (Veil, 1977/1978). A small excavation carried out in 1979 and situated further to the southwest partially uncovered a Magdalenian artefact concentration and additional finds of probably more recent age, including a short end-scraper (**Fig. 7: 13**), which gave a first concrete indication of the presence of a Late Palaeolithic find horizon atop of the main – Magdalenian – occupation layer (Veil, 1979). The succeeding excavations of the years 1981-1983 (Veil, 1982, 1984) provided the final proof of a separate, Late Palaeolithic occupation that produced lithic artefacts, animal bones, charcoal and latent features. With this discovery the seven backed points found in 1883 appear in a new light and can most likely be associated with this Late Palaeolithic occupation of the Martinsberg. The fact that the excavation area of 1979-1983 (Andernach 2) (**Fig. 2**) is directly adjacent to Schaaffhausen's excavation is evidenced not only by the trench boundary of 1883 – recognized as a disturbance during the new excavations (**Fig. 3**) – but also by a number of refits linking artefacts and bones from the new excavations with finds from Schaaffhausen's field work (Bolus and Street, 1985). In the years 1981-1983 an area southwest of the continuous excavation was examined by a number of small *sondage* squares. One of these squares (square 20/64) proved to be very rich in finds. The excavations of 1994-1996 (Andernach 3) should show that it lies on the northern edge of another find concentration (Kegler, 2002; cf. Veil, 1982) (**Fig. 2**).

ARCHAEOLOGICAL HORIZONS AND DATING

As mentioned above, the Palaeolithic site on the Martinsberg in Andernach has provided two culturally and chronologically clearly distinguishable find horizons: an upper archaeological layer of Late Palaeolithic age that dates between ca. 14,000 and 13,000 cal BP into the Late Glacial Allerød interstadial lies atop of a Magdalenian settlement horizon, very rich in finds, dated to ca. 15,600 cal BP (Stevens et al., 2009). The Magdalenian level, on the other hand, deposited on a Mid-Pleistocene basalt lava stream, which is crossed by several elongated crevices that may have likely formed when the lava cooled (cf. Veil, 1982). The Late Palaeolithic horizon is characterized by its relatively sparse distribution of finds, which mainly consists of knapped lithic artefacts (**Fig. 3**) and the remains of the hunted prey. In addition, quartz, fish remains and charcoal were among the archaeological finds. There is minor evidence of finds being relocated from the lower layer upwards, and less often from the upper layer downwards. Such relocation processes can be explained, among other things, by settlement activities, bioturbation by animals and plants as well as by freezing and thawing processes.

THE LATE PALAEOLITHIC LITHIC ASSEMBLAGE OF ANDERNACH 2

On the basis of various criteria such as stratigraphic position, raw material, techno-typological aspects and refits, a total of 2,793 stone artefacts from the 1979-1983 excavations (including some *sondages*) were recognized as Late Palaeolithic. 1,377 of these artefacts measure ≥ 1 cm, 1,416 artefacts are small-scale debitage (< 1 cm, but > 3 mm). The total weight of the Late Palaeolithic lithic assemblage from Andernach 2 is 2,126 grams. Their spatial distribution covers practically the entire excavated area, but shows six more or less distinct concentrations (**Fig. 3: a-f**), with the main distribution being in the north-western and central

Raw material	Weight [g]	Portion of the total weight [%]	Number [n]	Portion of the total assemblage [%]	≥ 1 cm [n]	Portion [%]	< 1 cm [n]	Portion [%]
R1	199	9.4	64	2.3	56	87.5	8	12.5
R2	131	6.2	259	9.3	98	37.8	161	62.2
R3	589	27.7	1,020	36.5	463	45.4	557	54.6
R4	20	0.9	7	0.3	6	85.7	1	14.3
R5	114	5.4	193	6.9	71	36.8	122	63.2
R6	226	10.6	245	8.8	136	55.5	109	44.5
R7	395	18.6	388	13.9	190	49.0	198	51.0
R8	134	6.3	217	7.8	118	54.4	99	45.6
R9	99	4.7	69	2.5	58	84.1	11	15.9
R10	78	3.7	146	5.2	70	48.0	76	52.0
R11	81	3.8	111	4.0	67	60.4	44	39.6
R12	43	2.0	57	2.0	29	50.9	28	49.1
R13	17	0.8	17	0.6	15	88.2	2	11.8
Total	2,126		2,793		1,377		1,416	

Tab. 1 Andernach-Martinsberg, Late Palaeolithic find horizon: Lithic raw materials from Andernach 2 after amounts and weight relative to the size of the total assemblage. For the characterisation of the raw materials and raw material variants R1-R13, see the text.

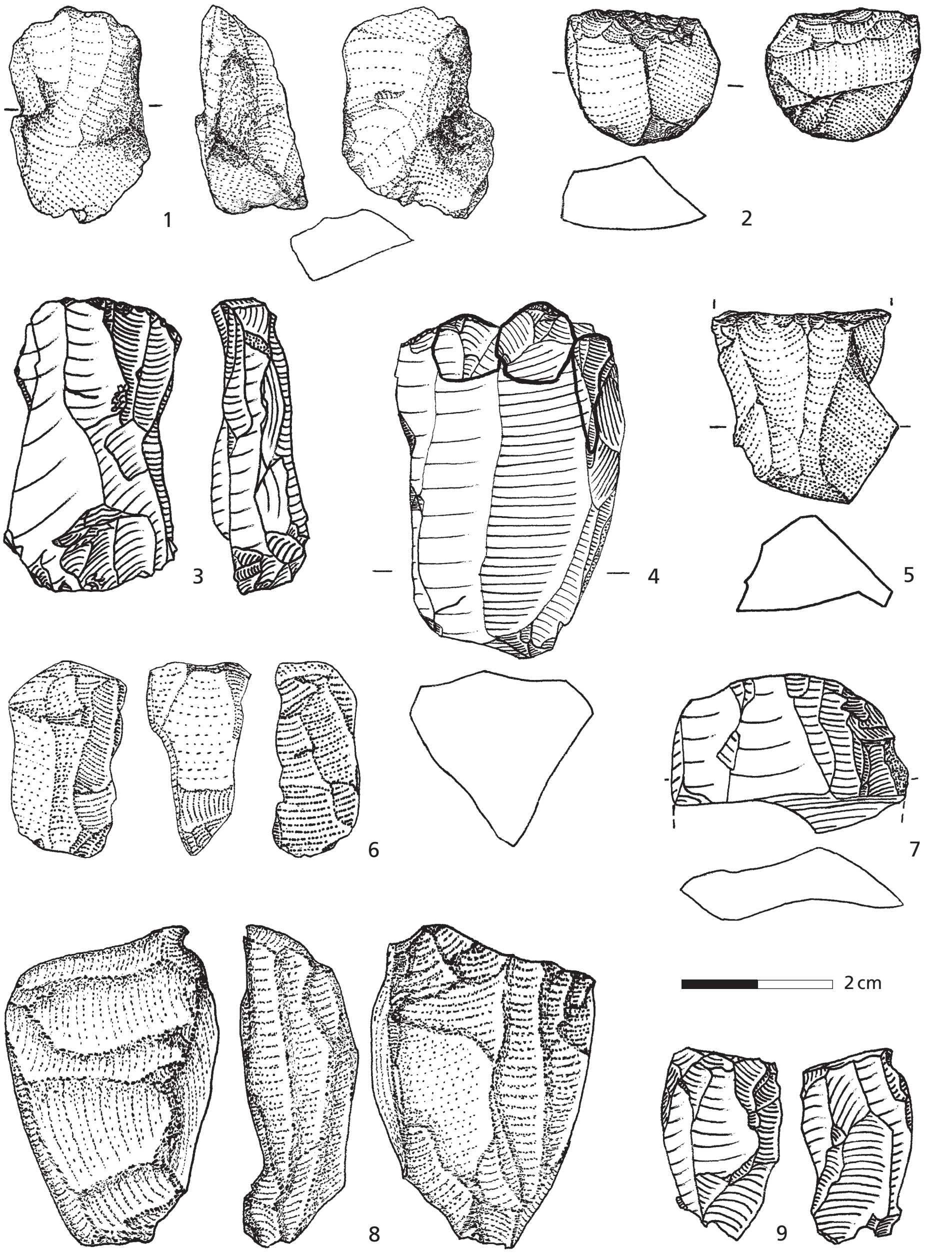

Fig. 4 Andernach-Martinsberg, Late Palaeolithic find horizon: Selection of cores from Andernach 2. – (Line drawings: G. Rutkowski).

part of the area (**Fig. 3**). Reference should be made to spatial analysis of these finds by Dick Stapert and Martin Street (Stapert and Street, 1997) with regard to the potential existence of a dwelling structure. Since the density of Late Palaeolithic finds directly at the disturbance along the edge of Schaaffhausen's excavation is still relatively high, while only a few of his finds may be attributed to the upper occupation horizon, it can be assumed that a not inconsiderable proportion of Late Palaeolithic finds were lost in 1883.

Detailed studies of the horizontal and vertical distribution of finds, including the frequencies of the different raw materials, seem to reveal two to three different consecutive and brief phases of occupation within the Allerød settlement that followed shortly after each other (Bolus, 1984). New dating results appear to be in support of these data (Stevens et al., 2009).

Lithic raw materials

A total of 13 different raw materials or raw material varieties have been distinguished in the Late Palaeolithic material of the Martinsberg:

- Pebble slate (i.e., *Kieselschiefer*: Raw material R1)
- Coarse-grained grey quartzite with larger quartz inclusions (Raw material R2)
- Light grey to light brown fine-grained tertiary quartzite ("fresh water quartzite"), partly with rounded quartz inclusions (i.e., *Süßwasserquarzit*: Raw material R3)
- silicious limestone (i.e., *Verkieselter Kalk*: Raw material R4)
- brown silicate tuff with black bands (Raw material R5)
- Chalcedony (Raw material R6)
- Greenish opaque Meuse gravel flint with reddish and bluish areas (Raw material R7)
- Greenish eluvial Meuse flint with diffuse bright spots (Raw material R8)
- Grey-blackish Meuse flint of the "Vetschau" type with chalk cortex (Raw material R9)
- Black Meuse flint with chalk cortex (Raw material R10)
- Meuse "egg" flint nodules (i.e., *Maaseifeuerstein*: Raw material R11)
- Beige silica Oolites (i.e., *Kieseloolith*: Raw material R12)
- Baltic flint (Raw material R13)

Some of these raw materials (pebble slate R1, silicious limestone R4, and tertiary quartzite R3) could be found in the vicinity of the site itself or at short distances, while others had to be procured from 50km (chalcedony R6, some flint varieties?) or 75km (silica tuff R5?); others from up to 100km away or more (other flint varieties): For details on the individual raw materials and their origins, see Floss (Floss, 1994: 271-283).
Represented with 1,020 pieces, the light grey fine-grained tertiary quartzite (R3) dominates with a percentage of ~36% of the total inventory. In contrast to this, the next frequent raw materials, the greenish opaque Meuse gravel flint (R7: 388 pieces, ~14% of the inventory) and the coarse-grained grey quartzite (R2: 259 pieces, almost 9% of the inventory) fall significantly. Weights and percentages of all raw materials are listed in **Table 1**.

Blank production, knapping technique and assemblage composition

The Late Palaeolithic inventory of the Martinsberg Andernach 2 assemblage comprises 17 cores and core fragments (**Fig. 4**), made of a total of seven raw material varieties, without any of them showing particular dominance. However, it is noteworthy that only four cores (i.e., 23.5% of the cores) consist of coarse-grained grey quartzite, which accounts for only 9.3% of all artefacts, and two cores (11.8% of the cores) are made of silica tuff, which is represented in the total inventory with only 6.9% of all artefacts. Eight cores and core fragments were reduced along a single surface, seven on two and two cores display more than two surfaces exploited for the production of blanks. Intensive core preparation, as is the case in the Magdalenian, is missing from the Andernach 2 Late Palaeolithic.
In addition to the cores, the assemblage contains 119 complete and 455 fragments (with medial fragments predominating, followed by proximal and finally distal fragments) of blades and bladelets that are in most cases not very elaborately produced, applying almost exclusively hard percussion. Only a few blades of relative high quality that form part of a refitted sequence, are made of light grey tertiary quartzite, and seem to have been produced by direct soft percussion. The remaining artefacts are made up of flakes and small-

Tool type	Number	Portion of tool assemblage [%]
Backed point	28	19.45
Backed bladelet	27	18.75
End-scraper	23	15.97
Burin	22	15.28
Truncation	9	6.25
Other pointed tool	7	4.86
Splintered piece	7	4.86
Assorted modified artefacts	21	14.58
Total	**144**	

Tab. 2 Andernach-Martinsberg, Late Palaeolithic find horizon. Spectrum of tool types in Andernach 2.

Tool type	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13
Backed point	1	1	9	-	-	3	5	3	4	-	-	1	1
Backed bladelet	-	3	10	-	1	1	5	3	1	-	-	-	3
End-scraper	-	2	3	-	*	2	10	2	-	-	-	-	4
Burin	1	1	6	-	*	5	6	*	1	2	-	*	*
Truncation	-	1	-	-	-	-	2	1	1	2	1	-	1
Other pointed tool	-	1	2	-	-	-	-	1	-	2	-	-	1
Splintered piece	-	-	1	-	-	*?	*?	1	1	2	2	-	-
Assorted modified artefacts	2	1	4	-	1	2	4	1	2	1	3	-	-
Total	**4**	**10**	**35**	**-**	**2**	**13**	**32**	**12**	**10**	**9**	**6**	**1**	**10**

Tab. 3 Andernach-Martinsberg, Late Palaeolithic find horizon. Raw material spectrum of tools and tool spectrum of raw materials in Andernach 2. For the characterisation of the raw materials and raw material variants R1-R13, see the text. * tool-type only indirectly evidenced by production waste debitage.

sized debitage. Cortical flakes are numerous, with proportions varying from raw material to raw material. However, the coarse-grained grey quartzite and the light grey tertiary quartzite do not naturally display cortical surfaces, as they are layered materials that have been naturally broken into angular slabs and plates. In addition, it is difficult to determine the cortex portion of the silicate tuff and the chalcedony, since their cortical areas cannot always be reliably distinguished from fracture surfaces within the material.

With the exception of the Baltic flint, refits were made for all raw materials. In 20.4 % of the refits, the refitted items were found less than 0.5 m apart. By far the most common, in 56.8 % of cases, refitted items were between 0.5 m and 1.9 m apart. Distances between 2.0 m and 4.0 m are represented with 11.8 % and distances > 4 m with 10.1 % between refitted artefacts.

Most frequently artefacts made of opaque Meuse gravel flint were refitted. A cobble of this material could be refitted to more than 50 %, whereby many cortical preparation flakes were also involved, so that this cobble was probably complete when it reached the site, where reduction begun. Considering the large number of artefacts, only relatively few refits could be established between artefacts made of the light grey tertiary quartzite. The refit rate in the latter material is almost only a quarter of that of the opaque Meuse gravel flint. But in one area of the excavation, several comparably 'good' blades found near each other almost represent on the spot serial blade production.

The modified forms and their production debris

Here, all blanks that have been intentionally modified by humans after their removal from the core are ascribed as "modified forms". For this classification it is irrelevant, whether this modification was caused from percussion (i.e., as is the case with "splintered pieces") or from retouch. However, here, only artefacts in which the modification resulted in the formation of a functional end or of a functional edge are considered. Following this definition, 144 tools or tool fragments (**Tab. 2**) with a total of 155 functional ends/edges were identified in the Andernach 2 Late Palaeolithic assemblage. This corresponds to a tool share of 5.2 % in relation to the total inventory and a proportion of 10.5 % in relation to the pieces of at least 1 cm size.

Backed points

Particularly characteristic and decisive for the cultural assignment to the Late Glacial *Federmessergruppen* are 28 backed points (19.5 % of all tools; **Fig. 5**). These are bladelets or narrow blades with a bluntly backed longitudinal edge and a clear tip. In the case of medial and proximal fragments of such backed tools, it is sometimes difficult – sometimes even impossible – to decide whether it is a fragment of a backed bladelet or of a backed point. Here, only those specimens are classified as backed points for which this assignment can be clearly and reasonably argued. Raw material variability is quite high for the backed points: the backed points of the Andernach 2 assemblage were made from nine of the 13 raw material varieties present at the site (**Tab. 3**), with nine specimens made of the most frequent material, i.e., light grey tertiary quartzite, and with five specimens made of the next frequent material, i.e., opaque Meuse flint. A total of 18 backed points display a clearly convex back, so they are to be addressed as typical *Federmesser* (i.e., pen-knife points). Six backed points have a slightly curved back. In one complete specimen and in two fragments, the most curved part of the back is located in the upper part of the point; in another complete specimen in the middle and in an additional fragment approximately in the lower part of the point. Four backed points, including three fragments, have a straight back. However, two of these fragments could also be fragments of curved-backed points. Nine backed points are complete, in eight cases they are proximal or distal and in three they are medial fragments. If the point is oriented to the top, 17 backed points are retouched at the left lateral edge and eleven on the right. Two specimens are retouched bi-laterally in their distal parts; both display slight basal retouch. In 22 cases the retouched functional end was located at the blank's distal end, compared to six pointed proximal ends. Three backed points display fracturing at the tip (once on the dorsal surface, twice on the ventral surface), which may have been caused from use as projectiles (Fischer et al., 1984). Two of these pieces are very small distal fragments, and it is quite likely that the pieces broke off during use. Complementary to this picture, just such a distal end is missing from another backed point, which displays a burin scar-like facet on the upper part of the backing, similar to those R. N. E. Barton and C. A. Bergman (1982) were able to document for artefacts that were used as projectiles. In terms of their size, the backed points of the Martinsberg Andernach 2 assemblage display an astonishing range of variations. The shortest complete piece is only 2.1 cm long, while the longest complete specimen measures 5.2 cm. With a width of only 0.6 cm the shortest complete backed point is also the narrowest. This is contrasted by a 2.2 cm wide point which is fragmentary in its length. The complete backed points have a length-width ratio of ~3:1, which indicates a certain degree of standardization. Surprisingly, the five complete backed points from the Schaaffhausen collection also fit to these proportions. Worth mentioning is a backed point made of eluvial Meuse flint, which is composed of three refitting fragments (**Fig. 5: 25**). This specimen also represents the longest complete backed point of the inventory. After the distal tip had been broken of (probably

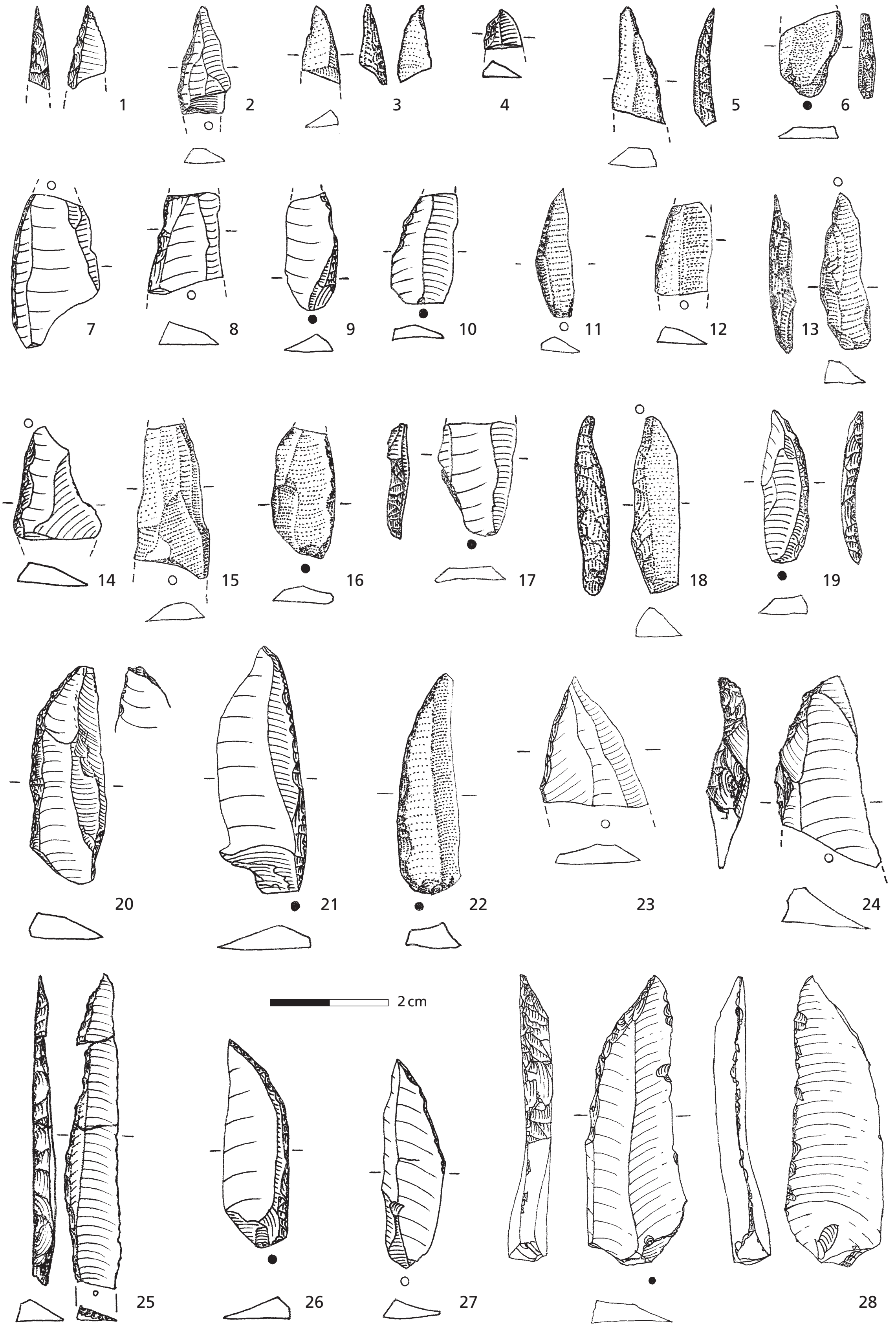

Fig. 5 Andernach-Martinsberg, Late Palaeolithic find horizon: Backed points from Andernach 2. – (Line drawings: G. Rutkowski).

during use) an attempt was made to create a new tip by retouch. Probably during this effort, the piece was broken right through the middle and was therefore discarded.

Backed bladelets

In addition to the 28 backed points, 27 backed bladelets and fragments of bladelets were identified (18.8 % of all tools; **Fig. 6**). Their raw material spectrum is similarly variable as for the backed points, as eight different raw material varieties are represented amongst the backed bladelets (**Tab. 3**). Again, the light grey tertiary quartzite dominates by far with ten pieces alone, followed here by the opaque Meuse gravel flint with five examples. Two backed bladelets display bi-lateral longitudinal retouch; all other pieces are simple backed bladelets; end-retouched specimens do not occur. In two cases, burin spalls had been backed. The blank is

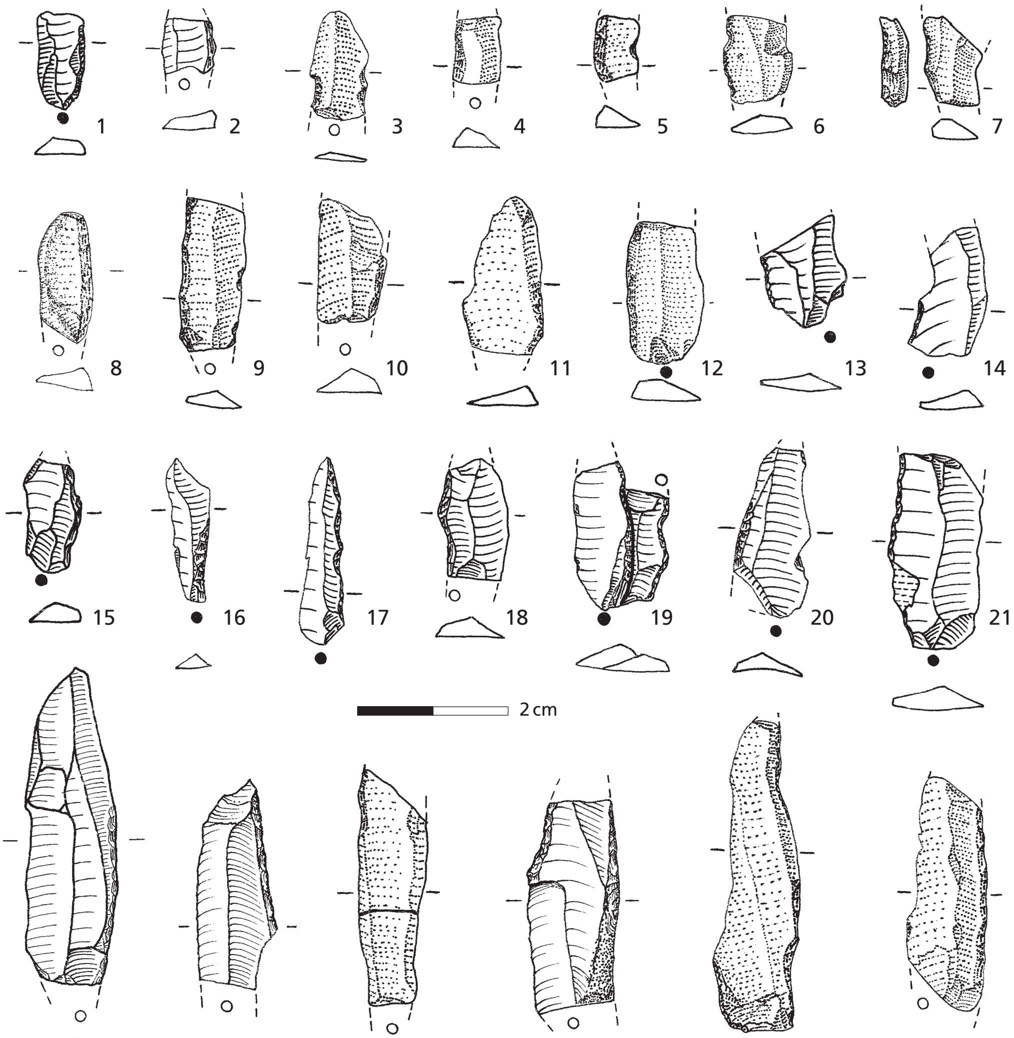

Fig. 6 Andernach-Martinsberg, Late Palaeolithic find horizon: Backed bladelets from Andernach 2. – (Line drawings: G. Rutkowski).

completely preserved on just three backed bladelets. Ten pieces are medial fragments; with nine pieces, proximal fragments are almost as common. Distal fragments, on the other hand, are rarer, with only five pieces.

End-scrapers

End-scrapers, i.e., tools with at least one more or less convex retouched end perpendicular to the blank's longitudinal axis, are represented in Andernach with 23 pieces (16.0 % of all tools; **Fig. 7**); they display a total of 26 functional ends, i.e., end-scraper caps. In contrast to the backed tools, only six raw material varieties are represented in end-scrapers (**Tab. 3**). Ten end-scrapers are made of opaque Meuse flint, while – unlike the backed tools – the light grey tertiary quartzite is represented only three times. Instead, Baltic flint is represented in the scrapers with four specimens. As expected, the end-scrapers were made almost exclusively on flakes, represented by 22 pieces, outnumbering the single specimen made on a blade. Twelve end-scrapers are complete, eleven are broken. All end-scrapers are retouched at the blank's distal end, two double scrapers additionally at the proximal end; one scraper is retouched along its entire perimeter. Nine specimens display light edge retouch. A small simple end-scraper displays a kind of burin scar at its distal end; this specimen may be classified as a combined tool (**Fig. 7: 12**). It is the only such item in the entire Late Palaeolithic inventory of Andernach 2. A size comparison of the lengths and widths of the complete end-scrapers shows that most pieces have a length-width ratio of ~1:1 (i.e., the end-scrapers are "short"). Such short end-scrapers are typical of inventories of the *Federmessergruppen*. A complete end-scraper made on a core tablet (**Fig. 7: 20**) is almost twice as long as wide. Similar proportions also apply to the single blade end-scraper (**Fig. 7: 23**). The broken end-scrapers are usually slightly wider than long.

In addition to the end-scrapers, 166 chips were identified that relate to the retouch of end-scraper caps. However, the actual number is likely to be even higher. In the case of a double end-scraper made of opaque Meuse gravel flint, it was possible to fit three retouching chips, found in the immediate vicinity, onto the tool (**Fig. 7: 22**). In this case, we can assume that the piece was also made or at least sharpened at the place of use and then abandoned. In contrast to this, some retouching chips of end-scraper caps from silicated tuff prove the production or re-sharpening of at least one end-scraper on the site, whereas no end-scraper made of this raw material was found.

Burins

Burins did not seem to play a major role in the Late Palaeolithic of the Martinsberg, as is often the case with comparable sites. The 22 pieces found in the Andernach 2 assemblage (15.3 % of all tools; **Fig. 8**) are almost all manufactured in a non-elaborate manner. Here, too, the raw material spectrum is somewhat less variable than with the backed tools, but in some raw material varieties burins are evidenced indirectly by burin spalls (**Tab. 3**). Among the six raw materials used for burins, light grey tertiary quartzite and opaque Meuse gravel flint dominate with six specimens each, followed by five burins made from chalcedony. Overall, it does not appear that a single raw material has been given as much preference for burins as for other tool classes. In the case of two burins made of opaque Meuse gravel flint, onto which the spalls could be

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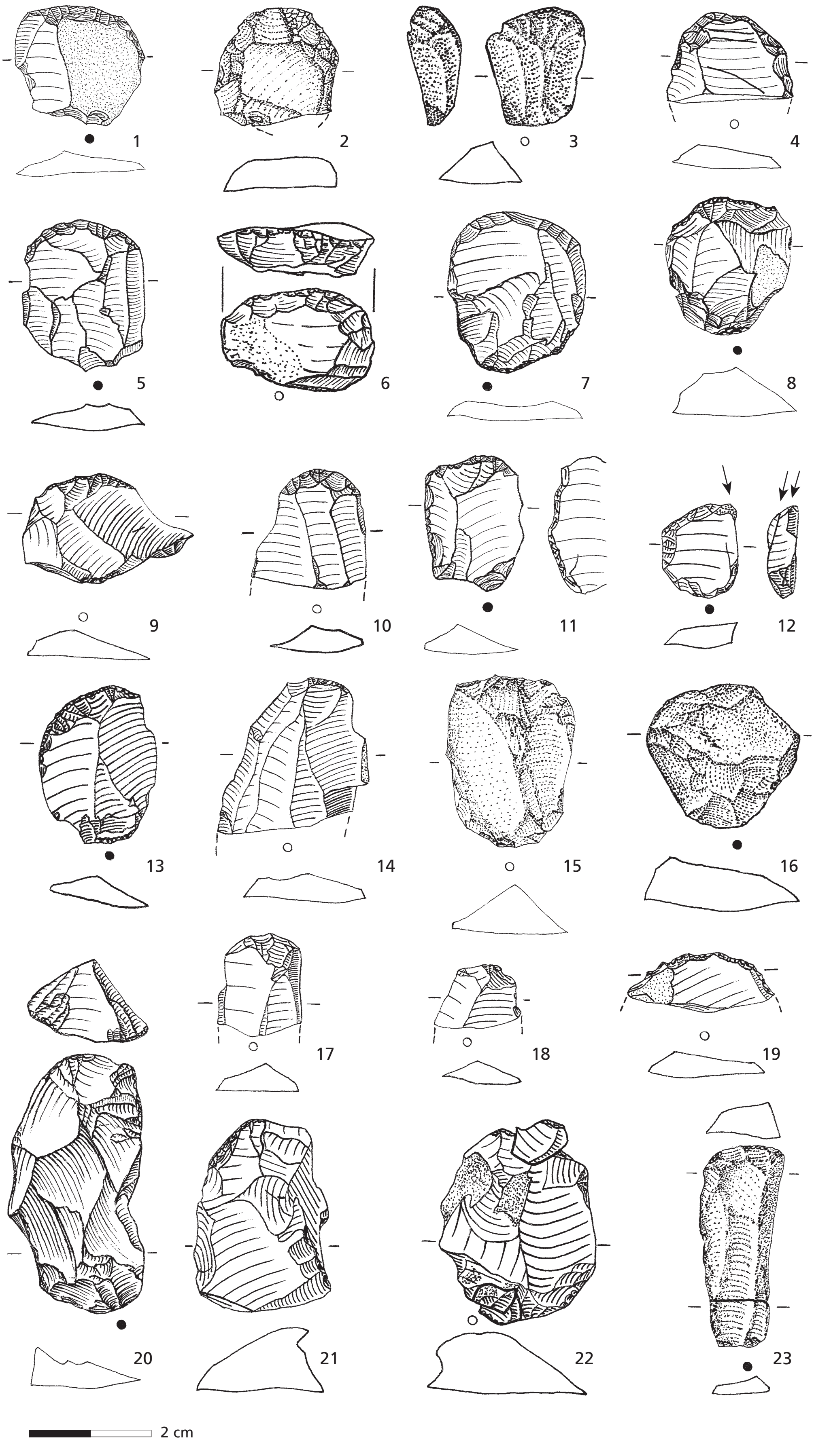
Fig. 7 Andernach-Martinsberg, Late Palaeolithic find horizon: End-scrapers from Andernach 2. – (Line drawings: G. Rutkowski, D. Apel and E. Turner).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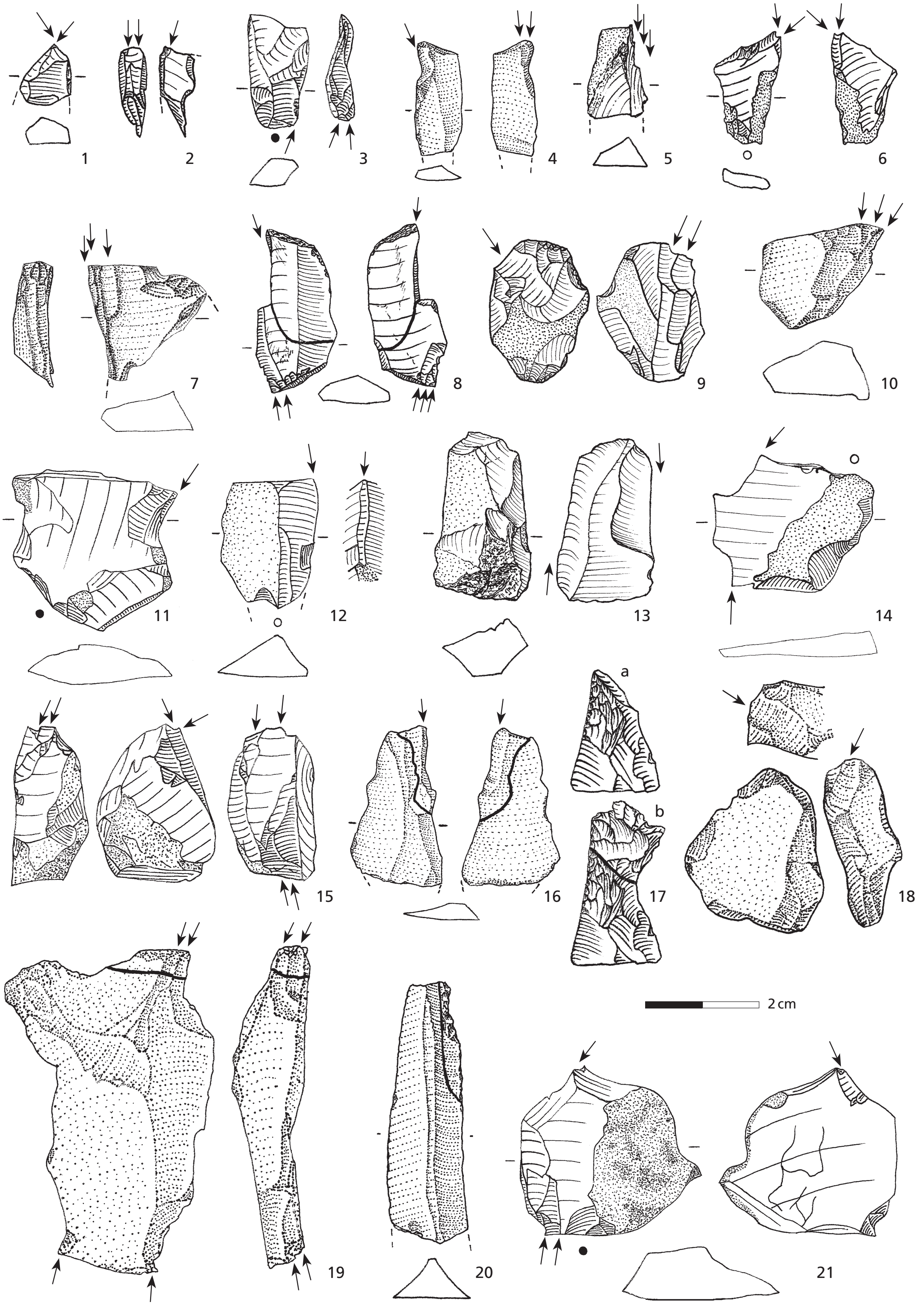

Fig. 8 Andernach-Martinsberg, Late Palaeolithic find horizon: Burins from Andernach 2. – (Line drawings: G. Rutkowski).

refitted, the spalls lay in one case directly next to the tool, and in the other almost 6 m away. In two burins made of light grey tertiary quartzite to which burin spalls have been refitted, the tool and the waste were each less than 1 m apart. Remarkable is the concentration of five burins (22.7 % of all burins) within the *sondage* square 20/64 mentioned above. Among them were some of the most carefully worked burins from the entire assemblage.

A total of 20 fragmented burins is contrasted with only two complete ones. In three cases, the modification was applied to cores (the difficulty in clearly distinguishing between core burins and bladelet cores is only mentioned here). In 16 cases, flakes served as burin blanks, in two cases blades and in one a bladelet. A total of 17 burins display a single functional end only; four are double burins, one is a triple burin. In total 29 functional burin ends are present, if the burin modification on the short end-scraper mentioned above (**Fig. 7: 12**) is also taken into account. In 15 specimens the modifications typical for burins are located at the distal tool ends and in eleven cases at their proximal ends. No decision can be made in three cases. In contrast to the end-scrapers, the high proportion of modified proximal ends is noticeable. This is usually the thickest part of a flake. This end of a blank displays the bulb of percussion and is highly unsuitable for transformation by retouch into an end-scraper cap. For the production of a burin, however, directing the burin blow to the thicker proximal end just makes sense, because it could create a reasonably wide working edge. In 15 cases, a breakage surface, in three cases a terminal retouch and in two cases a different burin scar or a natural surface served as a platform from which the burin spall was struck. Other burin platforms (e. g., knapped surfaces or end-scraper caps) occur seven times. In the entire assemblage there is only one typical dihedral burin. Fifteen times the modification was generated by a single stroke only, in four cases the tools display two burin scars, and in ten specimens three or more scars per functional end. Marginal lateral retouch occurs only in two burins, in one case on the ventral surface. On average, the length-width ratio for burins is slightly higher than for the end-scrapers, i. e., slightly more elongated blanks were selected for the production of burins than were for end-scrapers. In addition to the burins, 108 burin spalls of their production (including 42 primary burin spalls) were identified. Refits between burins and burin spalls have already been briefly discussed; in addition, two burin spalls from fine-grained tertiary quartzite that were found near each other have been refitted.

Truncations

In contrast to the convex retouched end-scraper caps, truncations refer to tools that are modified at their narrow proximal or distal ends by straight or slightly concave retouch which lies usually oblique to the longitudinal axis of the blank. Nine artefacts from the Andernach 2 assemblage meet these criteria (6.3 % of all tools; **Fig. 9: 15-23**). Compared to the relatively small number of pieces, it is somewhat surprising that they are made of seven different raw material varieties, which are almost exclusively non-local materials (**Tab. 3**). Two blades, two bladelets and five flakes served as blanks. Eight truncations are located at the distal, one at the proximal end. Whether (some of the) truncations may have served as half-fabricates for the production of other tools, for example of burins, cannot be decided and will therefore not to be discussed further here.

Other pointed tools

In addition to the backed points, seven pointedly retouched artefacts that lack back blunting (4.9 % of all tools; **Fig. 9: 1-7**) are part of the Late Palaeolithic Andernach 2 assemblage. Some of these items were

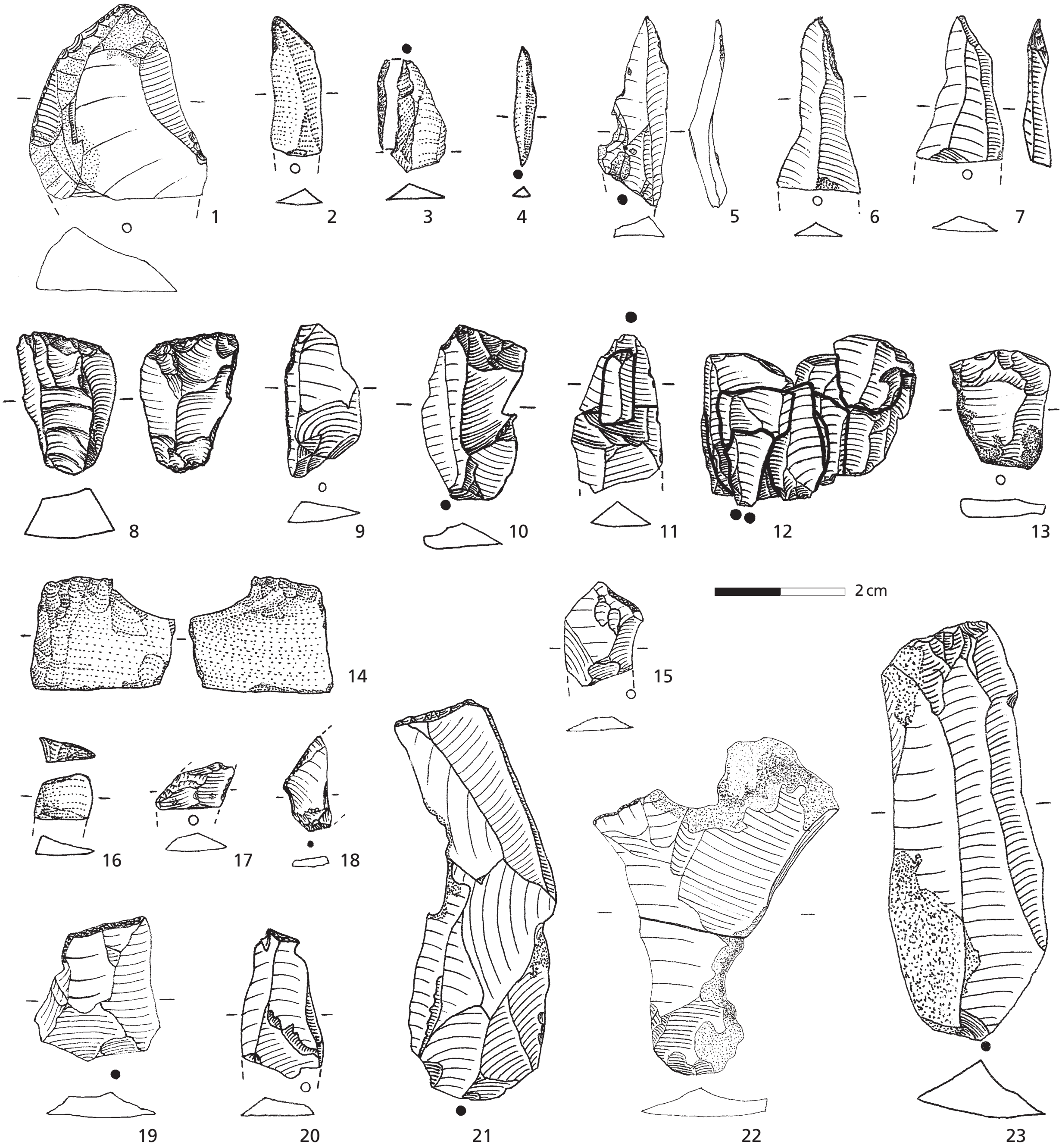

Fig. 9 Andernach-Martinsberg, Late Palaeolithic find horizon: **1-7** other pointed tools; **8-14** splintered pieces; **15-23** truncations from Andernach 2. – (Line drawings: G. Rutkowski).

retouched similarly to truncated pieces, but should be discussed separately, since they show some similarities with simple points from Mesolithic contexts. Raw material preferences were not observed (**Tab. 3**). Bladelets and narrow blades, and in one case a flake, served as blanks. The retouch by which the tip was generated is always found on only one lateral edge at the end of the blank and can be straight, convex or concave. Typologically, these items cannot be characterized as perforators, which are, moreover, missing from the Martinsberg Late Palaeolithic.

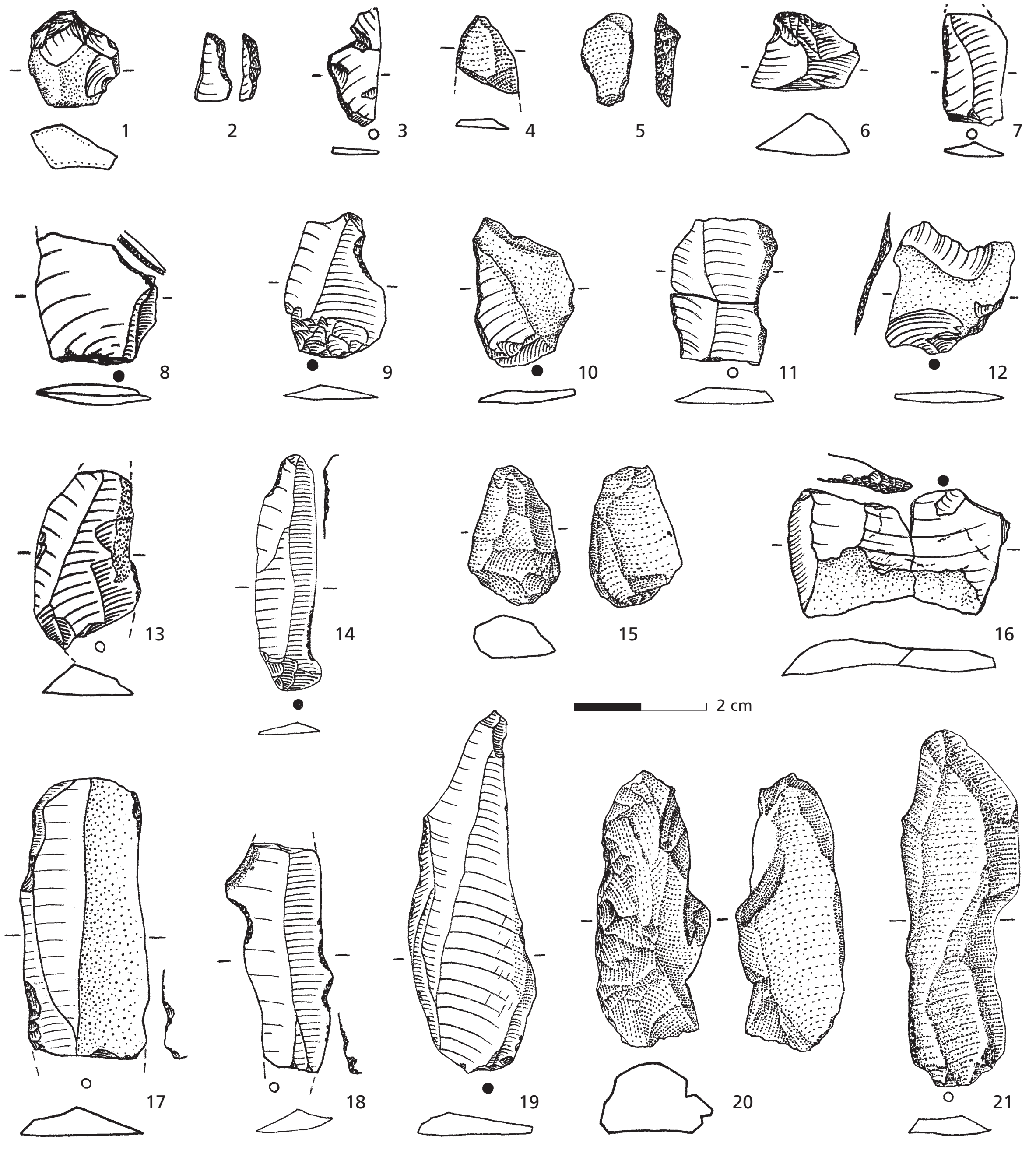

Fig. 10 Andernach-Martinsberg, Late Palaeolithic find horizon: Retouched flakes and blades and other modified artefacts from Andernach 2. – (Line drawings: G. Rutkowski).

Splintered pieces

Splintered pieces, i.e., chisel-like used artefacts, which – depending on the intensity of use – are more or less strongly fractured on their dorsal and/or ventral surfaces, only play a minor role in the Late Palaeolithic inventory, with just seven specimens presented in the assemblage (4.9 % of all tools; **Fig. 9: 8-14**). Similar to the truncations, however, it is interesting to note that five different raw material varieties are represented, namely four flint varieties and one type of quartzite (**Tab. 3**). In five cases, the typical splintering is on flakes, in two cases on blades. With five splintered pieces, dorsal and ventral surfaces are splintered, with two pieces it is only the dorsal surface.

In addition to the splintered pieces, a total of 27 characteristic splintering chips could be identified with some certainty. Such splinter chips could be refitted onto two splintered pieces made of Meuse gravel flint.

Retouched flakes and blades and other modified artefacts

A final group comprises tools that cannot be assigned to any of the tool types described thus far. These are (often partially) laterally retouched blades and bladelets, retouched flakes and tool fragments that cannot be classified further. With 21 pieces, 14.6 % of all tools fall into this category (**Fig. 10**). According to the lack of homogeneity in this group, the raw material spectrum is also wide: only three of the 13 raw material varieties are not represented (**Tab. 3**). Because of their low uniformity, these tools will not be discussed further.

Raw material spectrum of tools and tool spectrum of raw materials

Finally, to conclude these considerations, it can be said that the raw material spectrum of the tools or the tool spectrum of the raw materials reveals some clear preferences (**Tab. 3**). This is especially true for the backed tools, which are more often made of light grey tertiary quartzite, while this raw material plays only a minor role amongst end-scrapers. The latter are mainly made of various flint varieties, especially from opaque Meuse gravel flint; truncations were even made exclusively from flint varieties. Otherwise, it can be noted that by far the most common raw materials, i. e., the light grey tertiary quartzite and the opaque Meuse gravel flint, also supplied most tools with 35 and 32 specimens respectively.

OTHER LATE PALAEOLITHIC FINDS

In addition to the knapped lithic artefacts, the Late Palaeolithic horizon of the Martinsberg in Andernach was distinguished above all by a scatter of faunal remains, in most cases probably the remains of hunted prey (Street, 1993). In addition, in the course of the analysis of all quartz pebbles and fragments, a number of these pieces could almost certainly be identified as belonging to the Late Palaeolithic horizon (own unpublished data). Since almost all of these quartz fragments are reddened, most of them are interpreted to be fragments of so-called cooking stones and not constructional elements of hearths. However, the presence of fireplaces can be reconstructed by heat-altered materials as burnt artefacts, burnt bone, charcoal and reddened quartzes, with occasional overlapping concentrations. The few special finds from the Late Palaeolithic inventory comprise a retoucher made of claystone, a grooved grinding stone (arrow shaft smoother; Bolus, 2012) made of sandstone found in the immediate vicinity of the retoucher, the fragment of a possible bone awl (Baales and Street, 1996) and a red deer incisor decorated at its root with scored lines (Baales and Street, 1996).

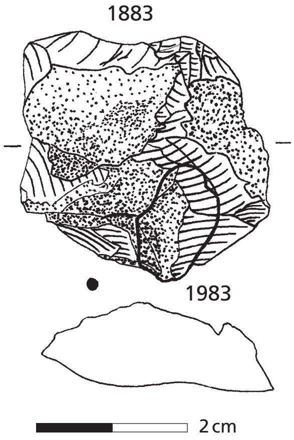

Fig. 11 Andernach-Martinsberg, Late Palaeolithic find horizon: Refit of a small flake from the 1983 excavation onto a larger flake from the 1883 excavae tion, connecting Andernach 2 with Andernach 1. – (Line drawing: G. Rutkowski).

CONCLUSIONS

The lithic artefacts from the Late Palaeolithic horizon of the Martinsberg in Andernach (Andernach 2: excavations 1979-1983) represent a typical inventory of the *Federmessergruppen* that date into the Late Glacial Allerød interstadial. Of the total of 13 raw materials or raw material varieties, some could be obtained within the nearer region of the site, whereas others were procured at distances of 50-75 km, and a few others at even greater distance of just over 100 km. The refitting of a flake from the excavation in 1983 onto a flake from Schaaffhausen's 1883 collection (**Fig. 11**) shows that the disturbance at the northeast boundary of the 1979-1983 excavation area is indeed identical to the southwestern limit of Schaffhausen's 1883 trench, and that Hermann Schaaffhausen probably found a Late Palaeolithic layer in addition to the Magdalenian remains without being aware of it. The technological analysis of the knapped lithic material shows that hardly any core preparation was used in advance of blank extraction, and that the production of high-quality blades was of insignificant relevance. The spectrum of retouched forms is dominated by backed points and bladelets which comprise almost half of the total tool inventory, followed by (often short) end-scrapers and usually poorly worked burins. A hearth, which probably belongs to the oldest phase of the Late Palaeolithic occupation of the site, can be recognized as a latent feature (see black dot in **Fig. 2**). All in all, a typical picture for Late Palaeolithic sites emerges at the Martinsberg: not a settlement site inhabited over a long period of time, but rather a place of several repetitive short-term (hunting?) occupations. For the uture, it would be desirable to comprehensively present all categories of finds of this important site together, including those materials from the 1994-1996 excavations.

PERSONAL CLOSING REMARKS

For the two colleagues and friends honoured with this *Festschrift*, I wish all the best and continued successful research in their retirement. Martin and Elaine were the first I met when I joined the excavations at Andernach in 1981, when they greeted me with a hearty dinner upon my arrival in our accommodation in the former Gönnersdorf dig house. During the coming years, and after moving to the hunting lodge in Neuwied-Monrepos and during my fieldwork at the site of Niederbieber, I was always able to enjoy Martin and Elaine's warm hospitality. At this point, I would like once again to extend to both of them my gratitude in all its forms.

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CHANGING ENVIRONMENT AT THE LATE UPPER PALAEOLITHIC SITE OF LYNX CAVE, NORTH WALES

Abstract

Lynx Cave is one of a handful of locations in North Wales that provide evidence of Late Upper Palaeolithic hunter-gatherers at the end of the last ice-age. With the region being recolonized at a time of rapid environmental change there is a need to develop on-site palaeoenvironmental records that are directly linked to the archaeology in order to further understanding of the environments and landscapes that these hunter-gatherer groups experienced. Through carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$) and sulphur ($\delta^{34}S$) stable isotope analysis of animal bones we explore the environmental conditions during the human occupation of Lynx Cave. Analysis of the data indicates the faunal isotope results cluster into three distinct groupings, which when considered in light of the species composition, radiocarbon dates, sample layer provenance and known temporal patterns in herbivore isotope data from Northern Europe, are likely to relate to GI-1cba (the Allerød period) around 13,700-13,000 cal BP, GI-1cba/GS-1 (the Late Allerød/early Younger Dryas period) around 13,100-12,800 cal BP, and the Bronze Age. The isotope data indicates that the Late Upper Palaeolithic or Late Palaeolithic occupations occurred in an open landscape in which soils were undergoing changing hydrological conditions linked to ice sheet melt and permafrost thaw process and subsequent recovery. The evidence of butchery marks on the faunal remains from both Late Glacial isotope clusters, along with the disparate radiocarbon dates and the presence of three hearths, support the idea of very short-term episodic use of the cave over an extended time period.

Keywords

Bone, collagen, stable isotopes, permafrost thaw, sulphur, Creswellian

INTRODUCTION

The repopulation of the British Isles after the retreat of the Last Glacial Maximum ice sheets occurred immediately prior to, or at the very onset of, the Late Glacial Interstadial (i.e., GS-2 to GI-1 boundary on the NGRIP GICC05 time scale: Rasmussen et al., 2014) (Jacobi and Higham, 2011). These Late Upper Palaeolithic occupations are mostly associated with Final Magdalenian style lithic artefacts, known locally as the Creswellian, although some shouldered and large bi-points from the region are of Hamburgian form (Jacobi and Higham, 2011; Pettitt and White, 2012). The earliest Late Upper Palaeolithic archaeological assemblages are found at King Arthur's Cave (Wye Valley) and in Cheddar Gorge, Somerset (Gough's Cave and Sun Hole Cave), while reoccupation of other areas, such as Devon (Kent's Cavern) and the east Midlands (Creswell Crags), appears to have been somewhat delayed (Jacobi and Higham, 2009a, 2009b, 2011). Later in the Late Glacial Interstadial (Greenland Interstadial GI-1), the Late Upper Palaeolithic was replaced by Final Palaeolithic technologies, including *Federmesser* technologies including penknife points (Pettitt and White, 2012). This broadly coincided with a shift towards the woodland phase of the Late Glacial Interstadial (GI-1d/1c), greater use of open air locations, and a diversification in fauna targeted as prey, with evidence of reindeer, red deer, large bovids and hares being hunted alongside horse (Jacobi and Higham,

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Fig. 1 Position of Lynx Cave in North Wales (red square), shown alongside location of other archaeological sites mentioned in the text (red circles): **1** Kendrick's Cave; **2** Raven Scar Cave; **3** Fox Hole Cave; **4** Dead Man's Cave; **5** Creswell Crags; **6** King Arthur's Cave; **7** Priory Farm; **8** Aveline's Hole; **9** Gough's Cave; **10** Kent's Cavern; **11** Bob's Cave.

2009a, 2009b, 2011; Pettitt and White, 2012). Although the broad relationship between the British Late Upper and Final Palaeolithic human presence and climate change is known, with such rapid rates of climatic and environmental change occurring across the Late Glacial Interstadial, the landscapes that these hunter-gatherer groups experienced are likely to have varied considerably across the region. Obtaining detailed on-site palaeoenvironmental and palaeoecological information directly from archaeological material allows the reconstruction of local conditions experienced by these populations and complements regional and global records. Here we explore the archaeological record at Lynx Cave in Denbighshire, North Wales (**Fig. 1**) through carbon, nitrogen and sulphur isotope analysis of animal bones, with the aim of reconstructing the environmental conditions during the Late Upper Palaeolithic (hereafter LUP) occupation of the cave and furthering understanding of the archaeological sequence represented at the site.

The stable isotope composition of herbivore bones reflects the local environment and ecology at the time the animal lived. After death the *in vivo* isotope compositions are preserved and through analysis of the archaeological bone remains these records can be used to reconstruct dietary ecology, animal behaviour and local environmental conditions during periods when humans were active within the landscape. Herbivore carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$), and sulphur ($\delta^{34}S$) isotope ratios reflect those of the plants they consume (Gannes et al., 1998). Plant $\delta^{13}C$ and $\delta^{15}N$ values are determined by underlying environmental conditions

(Kohn, 2010; Amundson et al., 2003; Craine et al., 2015). Thus, faunal $\delta^{13}C$ and $\delta^{15}N$ values represent an environmental signal, mediated by species-specific dietary behaviours. Environmental parameters that have been shown to influence herbivore $\delta^{13}C$ values include temperature, water availability, relative humidity, atmospheric carbon dioxide concentrations and the canopy effect (Heaton, 1999; Kohn, 2010). For herbivore $\delta^{15}N$ values, parameters include temperature and precipitation, mediated through soil processes (Stevens and Hedges, 2004; Stevens et al., 2008). Of particular relevance to this study is the observation that the $\delta^{15}N$ values of herbivores in Northwest Europe were likely strongly influenced by permafrost thaw processes during the Pleniglacial – Late Glacial (Stevens and Hedges, 2004; Stevens et al., 2008; Drucker et al., 2011b, 2012; Reade et al., 2020b, 2021). Herbivore $\delta^{34}S$ values are influenced by underlying lithology, soil-bedrock interactions, mineral weathering and soil environment (e.g., microbial activity, water and oxygen content) (Thode, 1991; Nehlich, 2015; Nitsch et al., 2019; Reade et al., 2020a, 2020b). It has been suggested that across the Pleniglacial – Late Glacial transition environmentally driven parameters potentially linked to soil and permafrost conditions may have had a greater influence on animal bone $\delta^{34}S$ values than underlying lithology (Reade et al., 2020b, 2021).

SITE BACKGROUND

Located close to Llanarmon-yn-lal in Denbighshire, North Wales, Lynx Cave is situated between the twin peaks of Bryn Alyn, at the base of a small limestone outcrop, on the south side of a small valley (**Fig. 1**; Blore, 2012). Discovered in 1962 by J. Blore and B. Nuttall, the small cave was excavated primarily by Blore over the subsequent 50 years. The cave is one of a handful in North Wales that provide evidence of LUP hunter-gatherers at the end of the last ice-age. The LUP lithic assemblage solely contains abruptly modified blades and bladelets, some of which have been described as resembling Creswellian or Hamburgian types (Blore, 2012; Pettitt and White, 2012). Similar cave assemblages that also do not contain any other retouched tool forms such as burins or scrapers have been found at Aveline's Hole in Somerset, Bob's Cave in Devon, Priory Farm Cave in Pembrokeshire, Fox Hole in Derbyshire, and Dead Man's Cave and Raven Scar Cave in Yorkshire (Jacobi, 2005). The shoulder-backed points are likely to be later examples of their forms which, when found in association with straight-backed blades and bladelets and curve-backed points, suggest a late Hamburgian tradition (Pettitt and White, 2012). When found in the British Isles such assemblages have been called 'Hengistbury-type' assemblages (Conneller and Ellis, 2007). The suggested age of such assemblages is typically considered to be around the interface between the Older Dryas (GI-1d) and the start of the Allerød (GI-1cba) (Conneller and Ellis, 2007; Jacobi and Higham, 2011; Pettitt and White, 2012). Conneller and Ellis (2007) and Jacobi and Higham (2011) use a different terminology from Pettitt and White, calling this an early variant of the *Federmesser*. The later part of the *Federmesser* industries were dominated by the penknife point; a mono-point with curve-backing, leading edge retouch with a proximal oblique termination resulting in the tool having an off-set tang (Jacobi and Higham, 2011). The absence of penknife points amongst the Lynx Cave assemblage would therefore suggest that the Lynx Cave assemblage may be contemporaneous with the earlier variant of the *Federmesser* in the British Isles, as defined by Conneller and Ellis (2007) and Jacobi and Higham (2011). A further observation of the Lynx Cave lithic assemblage relates to the use of the tools. The two shoulder-backed points and one of the curve-backed bi-points display impact fractures. All the straight-backed blades and bladelets are also fragmentary with fractures consistent with their use. This small assemblage would fit a task-site where a limited range of activities, dominated by hunting, were taking place.

Sample number	Layer	Lab Code	^{14}C age [BP]	Age [cal BP]*	Late Glacial climatic phase	Species	Element	Comment	Reference
940	D	OxA-16854	11,015 ± 50	13,090-12,820	GI-1cba/GS-1	*Rangifer tarandus*	Humerus	Smashed when fresh for marrow extraction	Blore, 2012
621	C/D	OxA-7993	11,145 ± 80	13,230-12,840	GI-1cba/GS-1	*Rangifer tarandus*	Humerus	Smashed when fresh for marrow extraction	Blore, 2012
620	C/D	OxA-12884	11,245 ± 65	13,300-13,075	GI-1cba	*Bos primigenius*	Left femur	Smashed when fresh for marrow extraction	Currant and Jacobi, 2011
622	C/D	OxA-19206	11,640 ± 45	13,600-13,370	GI-1cba	*Cervus elaphus*	Left astragalus		Jacobi and Higham, 2011
704	D	OxA-19207	11,680 ± 45	13,735-13,445	GI-1cba	*Cervus elaphus*	Left tibia		Jacobi and Higham, 2011
NW2 Artefact 6	C?	OxA-8164	11,700 ± 90	13,770-13,355	GI-1cba	most likely *Cervus elaphus*	Bone point	Magdalenian in style	Bronk Ramsey et al., 2002

Tab. 1 Late Glacial radiocarbon dates from Lynx Cave.
* Calibrated age range in cal BP at 95 % confidence (INTCAL20), using OxCal v4.4.2 (Bronk Ramsey, 2020).

At Lynx Cave, radiocarbon (^{14}C) dates from butchered mammal bones from the same sedimentary context as the LUP lithic assemblage date this occupation to the second part of the Late Glacial Interstadial (Allerød, i. e., GI-1cba) (**Tab. 1**; **Fig. 2**). Occupations at the site appear to have occurred throughout GI-1cba, coinciding with some of the dated LUP human remains and cultural artefacts recovered at Kendrick's Cave, some 50 km away on the Creuddyn peninsula on the North Wales coast (Richards et al., 2005; Jacobi et al., 2009; cf. https://www.britishmuseum.org/collection/object/H_Palart-900). Therefore, although the LUP assemblages in North Wales are small in size and few in number, the radiocarbon dates suggest human presence in the region was sustained over a significant period of time, even if visits to the area were fleeting.

The deposits at Lynx Cave have suffered from some disturbance particularly in the upper layers, but some LUP archaeology was recovered from undisturbed levels. Layers A and B contained disturbed deposits and artefacts from the Late Bronze Age, Romano-British and historic periods, along with fauna typical of both late Pleistocene and Holocene environments. Layer C was also disturbed but to much less extent than Layers A and B. Layer C contained human remains, some of which were located within a burial mound, together with a range of artefacts including a worked antler, horse cheek piece and a shale bracelet, which are likely to date to either the Bronze or the early Iron Age. Fauna from this layer included typical Holocene domesticates, such as sheep, goat, bovids, and horse in addition to roe deer and a single red deer, the latter of which may have been disturbed from its original context (Blore, 2012). Unlike the other animals, some bovid bones show evidence of cut-marks, but these are few in number. A radiocarbon age of 2,945 ± 35 uncal BP (OxA-8070) from a black stork (*Ciconia nigra*) humerus found in Layer C confirms attribution of these deposits to the British Bronze Age. The few lithic artefacts found in this layer are likely to have been disturbed from the layers below. Two non-conjoining mesial fragments of what is considered to be a single bone point were recovered from the perimeter of the burial mound in Layer C in an area of disturbed sediments (Blore, 2012: Fig. 26, p58). These point fragments have been described as resembling fluted spear-points typical of the Magdalenian (Wymer in Blore, 2012). Both fragments have one ancient and one recent break and both have a groove that may represent the remnant of the medullary cavity. On one piece this runs the whole length of the dorsal face, whereas on the other it is only partial. Both are fragments close to each end, as both pieces taper towards a point. They may originate from a long bone of red deer. The pieces are both clearly worked, except within the groove. One of these point fragments (Specimen A6 AC-NMW acc. no. 83.98H/1) has produced a direct radiocarbon age of 11,700 ± 90 uncal BP (OxA-8164) confirming its LUP origin (Aldhouse-Green, 2000; Blore, 2012). Carbon isotope measurements made on the sample during

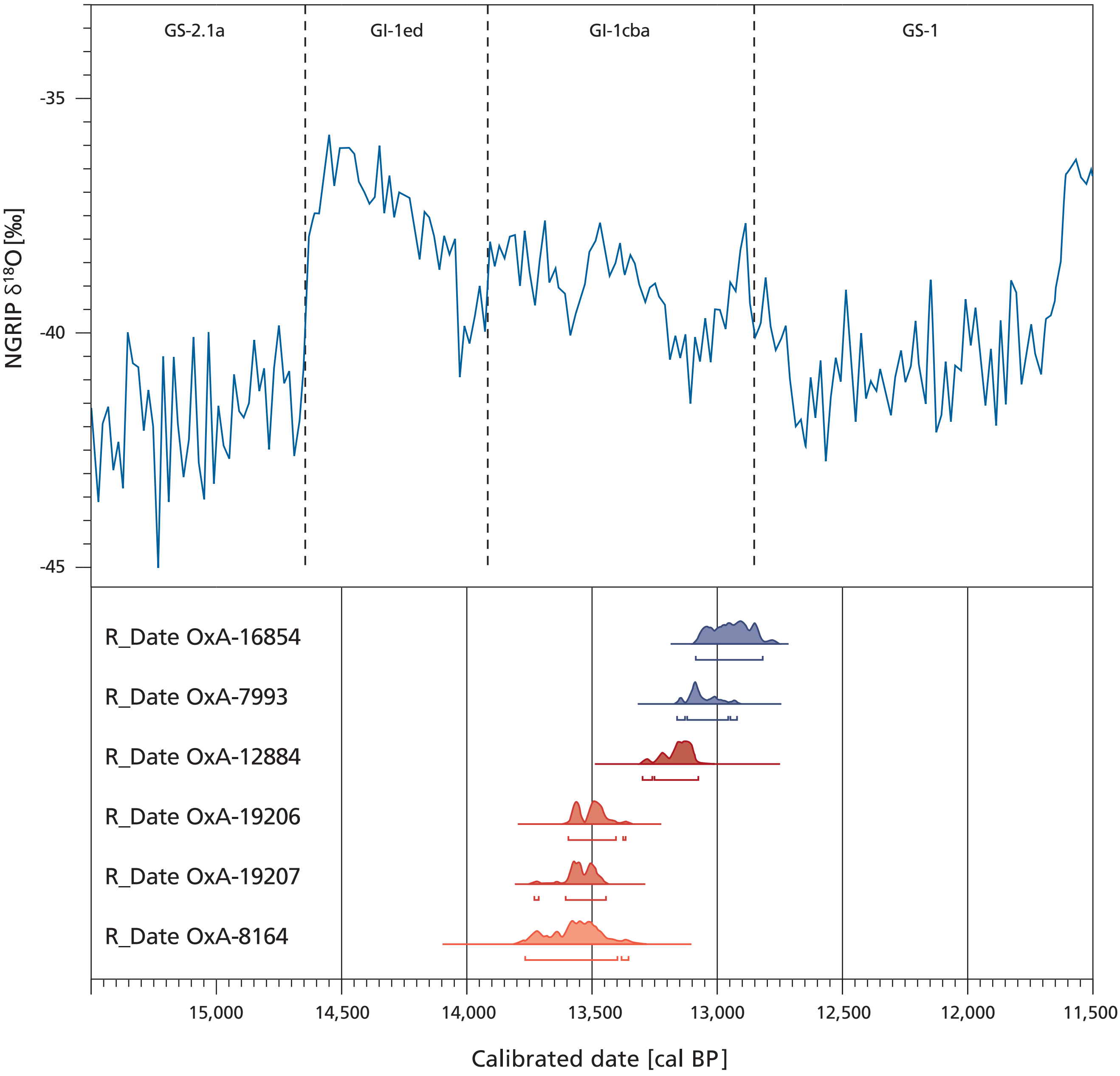

Fig. 2 Calibrated radiocarbon dates for Late Upper Palaeolithic occupation of Lynx Cave (cf. **Tab. 1**) plotted against the NGRIP isotope record. *Rangifer tarandus* = blue (OxA-16854, OxA-7993); *Bos primigenius* = dark red (OxA-12884); *Cervus elaphus* = medium red (OxA-19206, OxA-19207); Bone point (most likely of *Cervus elaphus*) = light red (OxA-8164); Calibration using OxCal v4.4.2 (Bronk Ramsey, 2020); NGRIP atmospheric data from Reimer et al. (2020).

radiocarbon dating gave isotope values consistent with the red deer analysed in this study, thus supporting the potential species identification (Bronk Ramsey et al., 2002). A comparable point, dated to 11,210 ± 90 uncal BP (OxA-2847) was found at Coniston Dib, Derbyshire (Hedges et al., 1992; Blore, 2012). The lack of Mesolithic and Neolithic deposits in the cave is thought to be due to a huge rock-fall event that inundated the cave entrance at the end of the Pleistocene.

Layer D contained relatively undisturbed deposits which extended throughout the cave and was underlain by Layer D1 in the back section of the cave only. Within Layer D three hearths were found near the entrance to the cave, along with LUP lithic artefacts spread throughout the cave, bone artefacts and butchered animal remains. The lithic assemblage contained nine abruptly modified blades and bladelets; comprising six straight-backed blades, two curve-backed blades and one shoulder-backed point (Jacobi, 2005; Blore, 2012). One bone point was recovered from the lower levels of Layer D, this is undated and is not of a form that would enable its dating on stylistic grounds alone. An antler point was also recovered from a small void within the back of the chamber, attached to the side wall 10 cm above layer D1. The position of recovery of these points and the complexity of cave deposits suggest they may have found their way from layer C as despite their recorded findspots they are unlikely to be older than those described from the layer C/D interface. The faunal assemblage recovered from Layer D was small but included elk (*Alces alces*), aurochs (*Bos primigenius*) red deer (*Cervus elaphus*) and reindeer *(Rangifer tarandus*) (Blore, 2012). Most of the large herbivores display evidence of butchery, including for marrow extraction. Five radiocarbon dates from fauna from Layers D and C/D securely place their formation into GI-1cba and to the GI-1a/GS-1 transition (**Tab. 1**; **Fig. 2**). The red deer ^{14}C dates (likely to be from a single individual) are similar to that of the bone point recovered from the perimeter of the burial mound in Layer C in a disturbed area (**Tab. 1**; **Fig. 2**). The aurochs and reindeer ^{14}C dates are younger, towards the end of GI-1cba, and for the reindeer, potentially the start of GS-1 (Younger Dryas) (**Tab. 1**; **Fig. 2**). Analysis of charcoal from the hearths showed the wood for fuel was sourced from Scots pine (*Pinus sylvestris*), willow (*Salix* sp.) or birch (*Betula* sp.) and oak (*Quercus sp.*) (P. Thomas in: Blore, 2012). A single left humerus of a child aged around 10-years-old was also recovered from Layer D. However, this bone is assumed to be out of context, as it is similar in colour and preservation to the human bones found in the upper layers, and dissimilar to the faunal bones recovered from Layer D. Furthermore, it is of similar developmental stage as the child mandible found higher in the cave stratigraphy, however, the specimen has not been radiocarbon dated.

Layer E is thought to contain Late Glacial aeolian deposits, although no radiocarbon dating has been undertaken from this layer. The layer was devoid of archaeology except for a small number of bones that were found at the top of the layer. They are thought to have originated from Layer D and became compressed into the uppermost part of Layer E as people and animals used the cave (Blore, 2012).

METHODOLOGY

A total of 35 bone samples were selected for stable isotope analysis (**Tab. 2**). Three reindeer bones from Layers A/B were sampled despite being from a mixed deposit. This was because their physical appearance and condition was comparable to the reindeer assemblage from Layer D and two of the bones had been fractured when fresh, and therefore could provide environmental information linked to human activity at the site.

Four *Bos* and one horse bones were sampled from the burial mound in Layer C, with three of the former displaying cut-marks, two of which were described as being "*by a heavy instrument*" and one having

Sample No.	Museum/ Excavation Sample No.	W/mark	Spit No.	Additional excav. info	Layer Group	Layer	Bone (Humanly modified?)	Species
UPN-804	83.98H/9	7	2M	150	Disturbed (Layer A/B)	A/B	Metacarpal (**1**)	*Rangifer tarandus*
UPN-824	83.98H/11	14	1M	401	Disturbed (Layer A/B)	A/B	Phalanx 1st	*Rangifer tarandus*
UPN-805	83.98H/10	23	2M	427	Disturbed (Layer A/B)	A/B	Metacarpal (**2**)	*Rangifer tarandus*
UPN-786	2015.11H/88.1	-5	5	831	Holocene (Layer C)	C	Rib	*Bos primigenius*
UPN-785	2015.11H/88.2	-5	5	832	Holocene (Layer C)	C	Vertebra	*Bos primigenius*
UPN-794	2015.11H/88.6	-4	6	759	Holocene (Layer C)	C	Vertebra	*Bos primigenius*
UPN-835	2015.11H/79	-4	5	803	Holocene (Layer C)	C	Tibia	*Equus*
UPN-797	83.98H/12	23	4	702	Holocene (Layer C)	C (burial mound)	Rib (**3**)	*Bos primigenius*
UPN-803	2015.11H/88.3	27	4	639	Holocene (Layer C)	C (burial mound)	Rib (**4**)	*Bos primigenius*
UPN-795	2015.11H/88.4	27	4	640	Holocene (Layer C)	C (burial mound)	Rib (**5**)	*Bos primigenius*
UPN-791	2015.11H/88.5	27	4	635	Holocene (Layer C)	C (burial mound)	Cuboid tarsal	*Bos primigenius*
UPN-798	2015.11H/101	27	4	641	Holocene (Layer C)	C (burial mound)	Axis Vertebra	*Equus*
UPN-829	83.98H/13/B	28	6	620	Pleistocene (Layer D/D1/E)	C/D	Femur	*Bos primigenius*
UPN-808	2015.11H/126	28	6	621	Pleistocene (Layer D/D1/E)	D	Humerus (**6**)	*Rangifer tarandus*
UPN-807	2015.11H/103.2	-14	10	944	Pleistocene (Layer D/D1/E)	D	Radius	*Rangifer tarandus*
UPN-833	2015.11H/106.7	1	7	925	Pleistocene (Layer D/D1/E)	D	Phalanx	*Alces*
UPN-790	2015.11H/89.1	4	5	623	Pleistocene (Layer D/D1/E)	D	Humerus	*Bos primigenius*
UPN-827	2015.11H/106.5	4	4	622	Pleistocene (Layer D/D1/E)	D	Astragalus	*Cervus elaphus*
UPN-801	2015.11H/103.4	5	5	633	Pleistocene (Layer D/D1/E)	D	Metacarpal	*Rangifer tarandus*
UPN-796	2015.11H/103.6	8	4	626B	Pleistocene (Layer D/D1/E)	D	Metacarpal	*Rangifer tarandus*
UPN-800	2015.11H/103.1	8	4	626A	Pleistocene (Layer D/D1/E)	D	Metacarpal	*Rangifer tarandus*
UPN-830	2015.11H/106.3	21	6	704	Pleistocene (Layer D/D1/E)	D	Tibia	*Cervus elaphus*
UPN-906	OxA-16854	24	11	940	Pleistocene (Layer D/D1/E)	D	Humerus	*Rangifer tarandus*
UPN-792	2015.11H/106.2	25	9	630	Pleistocene (Layer D/D1/E)	D	Tibia	*Cervus elaphus*
UPN-784	2015.11H/106.4	29	9	631	Pleistocene (Layer D/D1/E)	D	Radius	*Rangifer tarandus*
UPN-799	2015.11H/103.3	29	5	632	Pleistocene (Layer D/D1/E)	D	Radius	*Rangifer tarandus*
UPN-802	2015.11H/103.5	spoil B/C		936	Pleistocene (Layer D/D1/E)	D	Ulna	*Rangifer tarandus*
UPN-793	2015.11H/106.8	-15	17	951	Pleistocene (Layer D/D1/E)	D (presumed)	Antler burr (**7**)	*Cervus elaphus*
UPN-806	2015.11H/106.6	3	5	656	Pleistocene (Layer D/D1/E)	D-E	Metatarsal	*Cervus elaphus*
UPN-783	2015.11H/106.1	8	6	629	Pleistocene (Layer D/D1/E)	D-E	Tibia, shaft	*Cervus elaphus*
UPN-825	2015.11H/104.1	19	11	1045	Pleistocene (Layer D/D1/E)	D1	2nd phalange	*Rangifer tarandus*
UPN-789	2015.11H/107.2	27	12	1059	Pleistocene (Layer D/D1/E)	D1	premolar	*Rangifer tarandus*
UPN-832	2015.11H/89.2	29	12	1047	Pleistocene (Layer D/D1/E)	D1	Phalanx	*Bos primigenius*
UPN-787	2015.11H/107.3	30	12	1053	Pleistocene (Layer D/D1/E)	D1	molar	*Rangifer tarandus*
UPN-788	2015.11H/107.1	30	12	1054	Pleistocene (Layer D/D1/E)	D1	premolar	*Rangifer tarandus*

Tab. 2 Details of sample provenance and species identification. (1) Proximal end broken when fresh; (2) Proximal end broken when fresh, charcoal end; (3) Cut-marked; (4) Cut with heavy tool; (5) Cut with heavy tool, plus some marks made with flint?; (6) Shattered when fresh; (7) Found away from main passage in layer assumed to be continuation of Layer D.

Sample No.	Species	^{14}C Lab Code*	N [%]	C [%]	S [%]	C:N	C:S	N:S	δ^{13}C [‰]	δ^{15}N [‰]	δ^{34}S [‰]	Inferred age
UPN-804	*Rangifer tarandus*		14.4	40.3	0.2	3.3	682	209	-19.8	2.0	14.7	intrusive (likely Late Glacial)
UPN-824	*Rangifer tarandus*		15.6	44.5	0.2	3.3	738	222	-19.4	1.5	15.8	intrusive (likely Late Glacial)
UPN-805	*Rangifer tarandus*		15.0	43.4	0.2	3.4	687	204	-19.1	1.3	13.1	intrusive (likely Late Glacial)
UPN-786	*Bos primigenius*		14.9	43.8	0.2	3.4	686	200	-21.8	4.7	13.7	Late Holocene
UPN-785	*Bos primigenius*		15.4	44.8	0.2	3.4	713	210	-23.2	6.4	16.8	Late Holocene
UPN-794	*Bos primigenius*		15.6	44.3	0.2	3.3	691	209	-23.2	7.0	17.1	Late Holocene
UPN-835	*Equus*		15.8	44.6	0.2	3.3	722	219	-22.1	2.9	14.0	Late Holocene
UPN-797	*Bos primigenius*		15.2	42.9	0.2	3.3	698	212	-22.0	5.4	13.7	Late Holocene
UPN-803	*Bos primigenius*		14.6	41.7	0.2	3.3	679	204	-22.4	5.9	14.0	Late Holocene
UPN-795	*Bos primigenius*		15.1	43.2	0.2	3.3	716	215	-22.0	5.2	14.1	Late Holocene
UPN-791	*Bos primigenius*		14.6	42.0	0.2	3.4	683	204	-23.3	6.5	16.7	Late Holocene
UPN-798	*Equus*		14.8	42.0	0.2	3.3	671	203	-22.4	5.2	13.7	Late Holocene
UPN-829	*Bos primigenius*	OxA-12884	14.8	42.5	0.2	3.4	654	195	-20.3	3.4	7.4	Allerød
UPN-808	*Rangifer tarandus*	OxA-7993	13.2	38.3	0.2	3.4	665	197	-19.0	1.5	13.7	late Allerød/Younger Dryas
UPN-807	*Rangifer tarandus*		13.9	40.3	0.1	3.4	716	213	-20.0	2.0	14.6	late Allerød/Younger Dryas
UPN-833	*Alces*		15.0	44.0	0.2	3.4	653	191	-20.4	2.2	10.0	late Allerød/Younger Dryas
UPN-790	*Bos primigenius*		15.2	44.1	0.2	3.4	674	200	-22.3	5.7	13.6	intrusive (likely Late Holocene)
UPN-827	*Cervus elaphus*	OxA-19206	14.1	40.0	0.2	3.3	695	210	-20.5	2.2	8.1	Allerød
UPN-801	*Rangifer tarandus*		14.4	40.6	0.2	3.3	673	205	-19.6	1.6	14.3	late Allerød/Younger Dryas
UPN-796	*Rangifer tarandus*		16.0	44.9	0.2	3.3	723	221	-19.6	1.5	13.5	late Allerød/Younger Dryas
UPN-800	*Rangifer tarandus*		15.7	44.3	0.2	3.3	698	212	-19.5	1.3	13.9	late Allerød/Younger Dryas
UPN-830	*Cervus elaphus*	OxA-19207	15.3	43.8	0.2	3.3	692	208	-20.8	2.7	7.5	Allerød
UPN-906	*Rangifer tarandus*	OxA-16854	14.3	41.0	0.2	3.4	657	196	-19.6	2.5	13.8	late Allerød/Younger Dryas
UPN-792	*Cervus elaphus*		13.3	39.0	0.2	3.4	663	194	-21.3	2.9	8.6	Allerød
UPN-784	*Rangifer tarandus*		13.8	40.1	0.2	3.4	668	197	-18.9	1.3	15.3	late Allerød/Younger Dryas
UPN-799	*Rangifer tarandus*		13.8	39.8	0.2	3.4	688	205	-19.1	1.8	15.3	late Allerød/Younger Dryas
UPN-802	*Rangifer tarandus*		14.1	40.0	0.2	3.3	695	211	-19.0	1.3	14.2	late Allerød/Younger Dryas
UPN-793	*Cervus elaphus*		13.9	40.1	0.2	3.4	675	200	-23.1	6.5	16.6	intrusive (likely Late Holocene)
UPN-806	*Cervus elaphus*		13.5	38.9	0.1	3.3	694	207	-21.1	1.8	8.4	Allerød
UPN-783	*Cervus elaphus*		15.0	42.3	0.2	3.3	731	222	-20.7	1.3	8.5	Allerød
UPN-825	*Rangifer tarandus*		15.4	44.0	0.2	3.3	762	229	-18.9	1.5	14.0	late Allerød/Younger Dryas
UPN-789	*Rangifer tarandus*		14.8	43.1	0.2	3.4	721	212	-17.9	2.8	16.3	late Allerød/Younger Dryas
UPN-832	*Bos primigenius*		14.6	42.7	0.2	3.4	703	207	-20.7	4.3	11.5	late Allerød/Younger Dryas
UPN-787	*Rangifer tarandus*		15.4	45.3	0.2	3.4	674	197	-18.4	3.5	15.0	late Allerød/Younger Dryas
UPN-788	*Rangifer tarandus*		15.4	45.6	0.2	3.5	662	192	-18.5	3.0	15.7	late Allerød/Younger Dryas

Tab. 3 Results of stable isotope analysis. * cf. **Tab. 1**.

“*some marks made with flint*” (Blore, 2012). A further three Bos and one horse bones were sampled from Layer C. Due to the presence of the LUP bone point in the Layer C disturbed deposits, we sampled fauna from this level to explore whether any might represent Late Glacial specimens disturbed from their original context.

From the interface of Layer C/D two specimens that had been previously radiocarbon dated to the later part of the GI-1cba were sampled; the aurochs radiocarbon dated to 11,245 ± 65 uncal BP (OxA-12884) and the reindeer, which was fractured when fresh, to 11,145 ± 45 uncal BP (OxA-7993) (**Tab. 1**; **Tab. 3**; **Fig. 2**) (Currant and Jacobi, 2011; Blore, 2012).

From layer D, one elk, one Bos, four red deer and eight reindeer were sampled for analysis. Of these, two of the red deer bones are thought to belong to the same individual as they were a tibia and astragalus that had similar preservation and when put together articulated well. Both bones had been previously radiocarbon dated to 11,680 ± 45 uncal BP (OxA-19207) and 11,640 ± 45 uncal BP (OxA-19206) (**Tab. 1**; **Tab. 3**; **Fig. 2**) (Jacobi and Higham, 2011). A further aurochs was sampled from layer D1 along with four reindeer, and two red deer from layer D/E.

Samples were taken at the National Museum of Wales. A dental drill with either a small cutting wheel or tungsten burr drill bit was used to take a small sample of bone or tooth dentine (0.2 to 1.1 g) from each specimen. Samples were prepared at University College London (UCL) using a modified version of the Oxford Radiocarbon Accelerator Unit (ORAU) collagen extraction procedures (AG method; Brock et al., 2010), which is based on a modified version of the Longin (1971) method. All samples were treated with 0.5 M hydrochloric acid (HCl) at 4 °C until fully demineralised and then thoroughly rinsed with ultrapure

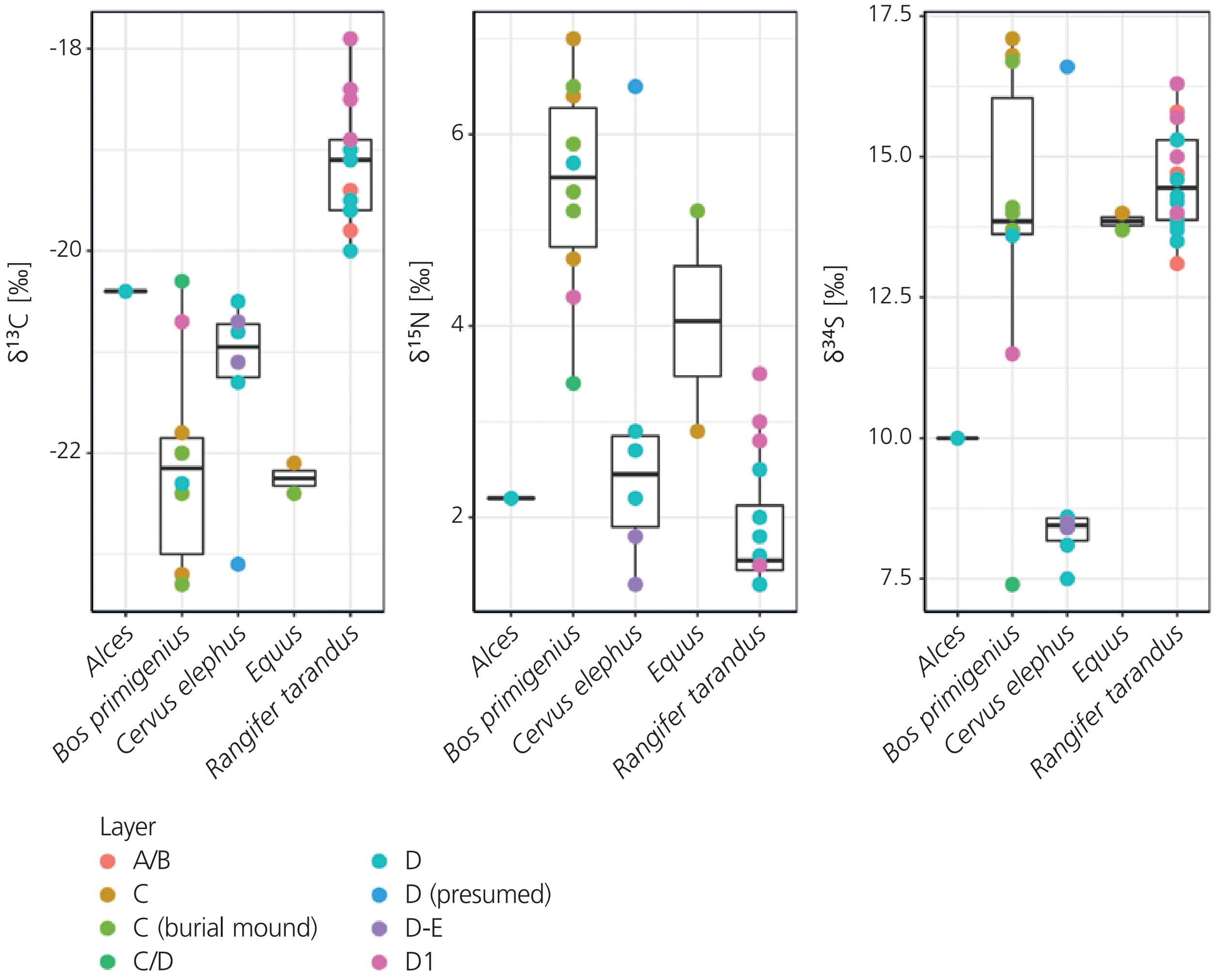

Fig. 3 Box plot of faunal collagen carbon, nitrogen and sulphur isotope data (with all data points shown) plotted by species with sample layer provenance shown in different colours.

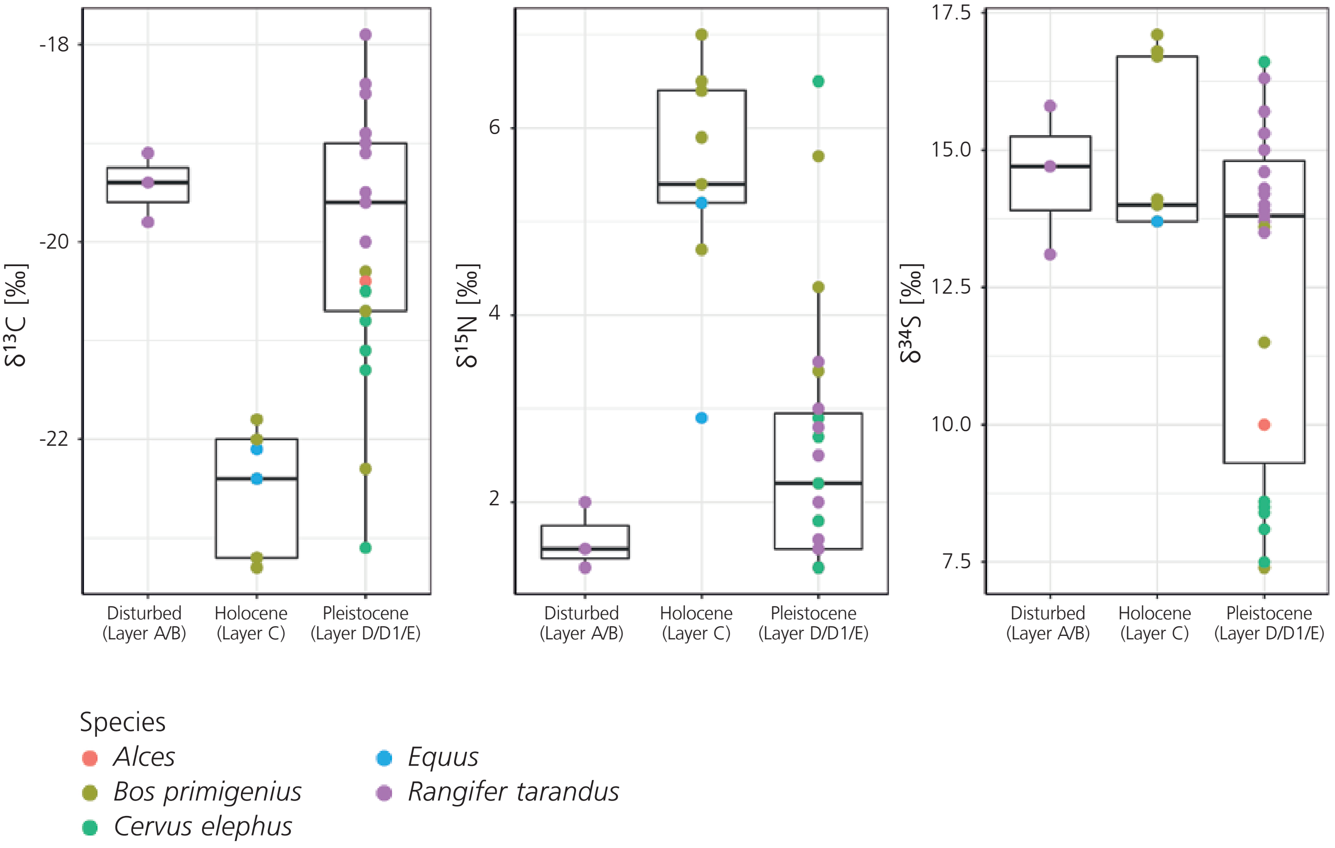

Fig. 4 Box plot of faunal collagen carbon, nitrogen and sulphur isotope data (with all data points shown) plotted by layers with species shown in different colours.

water. Samples were then treated with 0.1 M sodium hydroxide (30 mins), and 0.5 M HCl (1 hr) to remove humic contaminants (Szpak et al., 2017), again being thoroughly rinsed with ultrapure water between reagents. Samples were then heated in pH3 HCl solution at 75° C for 48 hrs and filtered using a pre-cleaned Ezee-filter, with the supernatant being retained and freeze dried. Between 1.2 and 1.5 mg aliquots of freeze-dried collagen were weighed into tin capsules and analysed using a Delta V Advantage continuous-flow isotope ratio mass spectrometer coupled via a ConfloIV to an EA IsoLink elemental analyser (Thermo Fisher Scientific, Bremen) at the Scottish Universities Environmental Research Centre (SUERC). For every ten unknown samples, three in-house standards that are calibrated to the International Atomic Energy Agency (IAEA) reference materials USGS40 (L-glutamic acid, $\delta^{13}C_{VPDB}$ = -26.4 ‰, $\delta^{15}N_{AIR}$ = -4.5 ‰), USGS41 (L-glutamic acid, $\delta^{13}C_{VPDB}$ = +37.6 ‰, $\delta^{15}N_{AIR}$ = -47.6 ‰), USGS43 (Indian Human hair: $\delta^{15}N_{AIR}$ = +8.44 ‰, $\delta^{13}C_{VPDB}$ = -21.28 ‰, $\delta^{34}S_{VCDT}$ = +10.46 ‰), IAEA-S-2 (silver sulfide, $\delta^{34}S_{VCTD}$ = +22.7 ‰), and IAEA-S-3 (silver sulfide, $\delta^{34}S_{VCTD}$ = -32.3 ‰) were analysed (Sayle et al., 2019). Results are reported as per mil (‰) relative to the internationally accepted standards VPDB, AIR and VCDT. Measurement uncertainty was determined to be ±0.1 ‰ for $\delta^{13}C$, ±0.2 ‰ for $\delta^{15}N$, and ±0.3 ‰ for $\delta^{34}S$ on the basis of repeated measurements of an in-house bone collagen standard and a certified fish gelatin standard (Elemental Microanalysis, UK). Each sample was analysed in duplicate with the exception of two samples (UPN-802 and UPN-804) and reproducibility was better than ±0.1 ‰ for $\delta^{13}C$, ±0.2 ‰ for $\delta^{15}N$ and ±0.3 ‰ for $\delta^{34}S$.

RESULTS

All samples (n = 35) produced sufficient collagen for isotopic analysis (collagen yields ranged from 3.1 to 16.3 %, 12.6 to 138.4 mg) (**Tab. 3**). All analysed samples returned C:N, C:S and N:S atomic ratios in the range of 3.2-3.5, 590-798 and 172-243, respectively, and %C, %N and %S in the range of 36-45 %, 12-16 %, 0.13-0.20 %, indicating good bone collagen preservation (**Tab. 3**) (DeNiro, 1985; Ambrose, 1990; Nehlich and Richards, 2009). Across the analysed samples δ^{13}C values ranged from -23.3 to -17.9 ‰ (mean = -20.6 ± 1.6 ‰), δ^{15}N values ranged from 1.3 to 7.0 ‰ (mean = 3.2 ± 1.9 ‰), and δ^{34}S

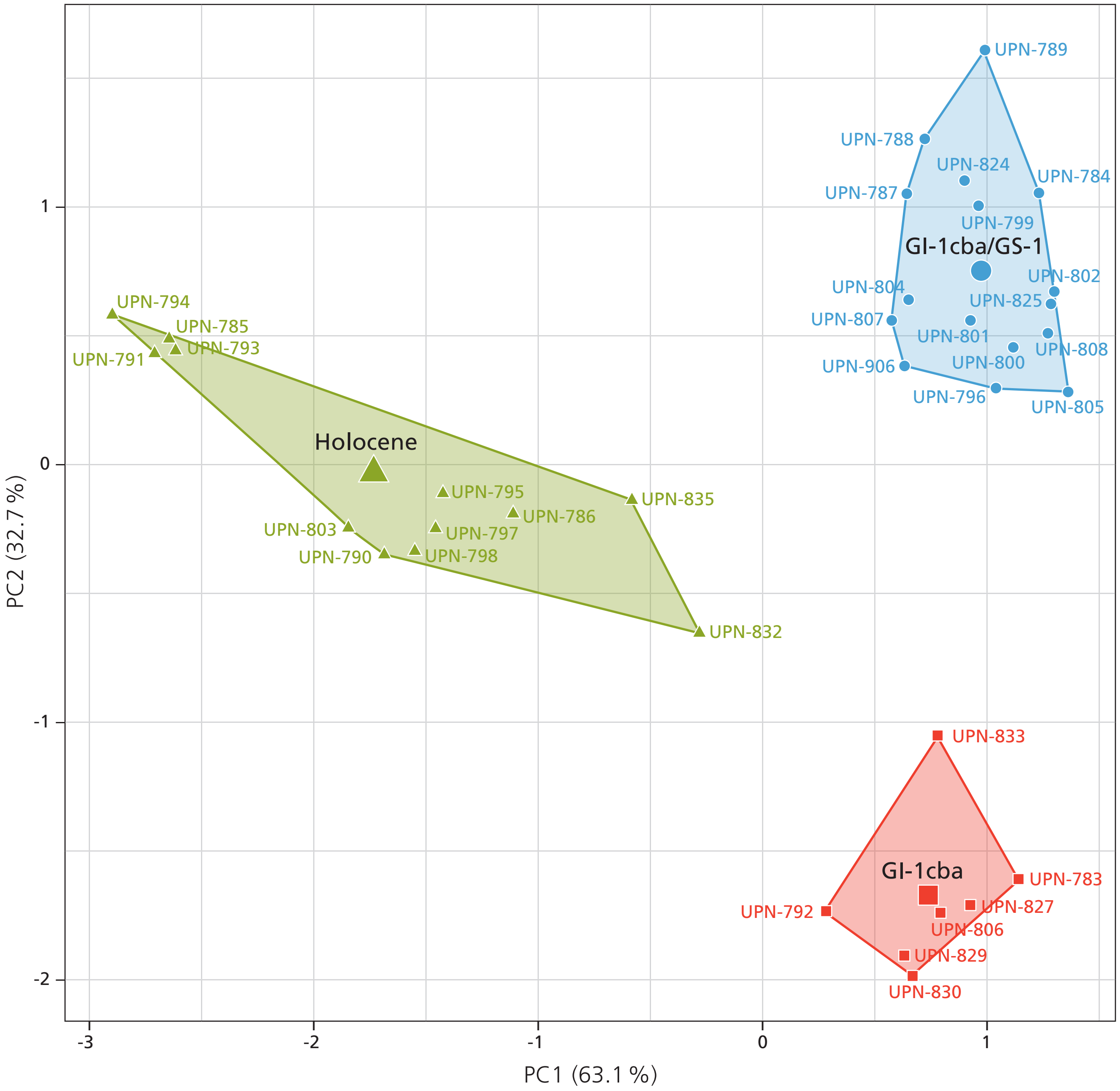

Fig. 5 Results of cluster analysis. Cluster 1 (red) = GI-1cba (Allerød), Cluster 2 (green) = Holocene, Cluster 3 (blue) = GI1cba/GS1 (Allerød / early Younger Dryas).

values ranged from 7.4 to 17.1‰ (mean = 13.4 ± 2.8‰) (**Fig. 3**). Significant species-based differences are identified in the $\delta^{13}C$ and $\delta^{15}N$ values (Kruskall-Wallis rank sum test, $\chi^2(4) = 26.84\,p < 0.05$ for $\delta^{13}C$ and $\chi^2(4) = 20.80\,p < 0.05$ for $\delta^{15}N$), but not in $\delta^{34}S$ values ($\chi^2(4) = 8.53\,p = 0.07$). Significant differences also occur between samples associated with Holocene (Layer C/burial mound) sediments and those excavated from Pleistocene contexts (Layer D/D-E/D1) for $\delta^{13}C$ (Mann-Whitney U test, $U = 10\,p < 0.05$) and $\delta^{15}N$ ($U = 190\,p < 0.05$), but not for $\delta^{34}S$ ($U = 141\,p = 0.12$) (**Fig. 4**).

Hierarchal cluster analysis of combined $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ values identify 3 distinct groups in the data (**Fig. 5**; Ward's minimum variance, coefficient = 0.963). The first cluster contains all but one red deer sample (n = 5), one aurochs and the elk sample. The cluster is characterised by intermediary $\delta^{13}C$ values, and comparatively low $\delta^{15}N$ and $\delta^{34}S$ values (**Tab. 4**). All samples in this cluster come from Layer D, or the interface of Layer C/D or D/E. Three samples in this cluster have been radiocarbon dated, producing a combined date range of ca. 13,735 to 13,000 cal BP (OxA-12884, OxA-19206, OxA-19207), placing this cluster within GI-1cba.

The second cluster is composed of all reindeer samples (n = 16) and contains no other species. It is characterised by comparatively high $\delta^{13}C$, low $\delta^{15}N$, and high $\delta^{34}S$ values (**Tab. 4**). Within this cluster, the reindeer samples from the Layer A/B disturbed sediments fall within the range of $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ values obtained from the Layer D samples. Samples from Layer D1 display higher $\delta^{13}C$ values (-18.9 to -17.9‰) compared to the other reindeer samples (-20.0 to -18.9‰), but all samples overlap in $\delta^{15}N$ and $\delta^{34}S$ values (**Fig. 5**) Samples in this cluster have been radiocarbon dated to ca. 13,230 to 12,820 cal BP (OxA-7993 and OxA-16854), situating this group within late GI-1cba and early GS-1.

The third cluster of results consists of all but one aurochs samples (n = 9), both horse samples and one red deer sample. It is characterised by comparatively low $\delta^{13}C$, high $\delta^{15}N$ and high $\delta^{34}S$ values (**Tab. 4**). All samples from Layer C and the Layer C burial mound are contained in this cluster, as well as one sample from Layer D, one from D1, and one that was found away from the main passage and area of excavation but presumed to be associated with Layer D. No samples analysed in this cluster have been radiocarbon dated, but a different bone from Layer C was dated between 3,215 and 2,965 cal BP (OxA-8070), placing this group in the Holocene.

DISCUSSION

Previous work on faunal $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ values across the Pleniglacial, Late Glacial and Holocene period in Northern Europe have recorded broadly consistent trends, albeit with species specific and regional variation in absolute values, and the timing and magnitude of changes. During the transition from the late Pleniglacial to the Late Glacial, herbivore $\delta^{15}N$ and $\delta^{34}S$ values are particularly low, and $\delta^{13}C$ values are consistent with previous periods (Stevens and Hedges, 2004; Stevens et al., 2008; Drucker et al., 2003, 2009, 2011a, 2011b, 2012; Reade et al., 2020b, 2021). $\delta^{34}S$ values appear to increase rapidly early in the Late Glacial interstadial, whilst an increase in herbivore $\delta^{15}N$ values occurs more gradually through the Late Glacial interstadial, with higher values generally observed in the Holocene (Stevens and Hedges, 2004; Stevens et al., 2008; Drucker et al., 2009, 2011a, 2011b, 2012; Reade et al., 2020b, 2021). $\delta^{13}C$ values initially begin to fall during the latter half of the Late Glacial interstadial (GI-1cba) and more significantly at the start of the Holocene due to changes in atmospheric CO_2 concentrations and potentially also due to expansion of woodlands (Drucker et al., 2003, 2008, 2011a; Stevens et al., 2014). Given the range of radiocarbon dates available from the different layers in Lynx Cave and the species found within these layers it seems

	$\delta^{13}C$ [‰]			$\delta^{15}N$ [‰]			$\delta^{34}S$ [‰]		
Cluster	Mean ± std	Min.	Max.	Mean ± std	Min.	Max.	Mean ± std	Min.	Max.
1 (GI-1cba)	-20.7 ± 0.4	-21.3	-20.3	2.4 ± 0.7	1.3	2.3	8.4 ± 0.9	7.4	10.0
2 (GI-1cba/GS-1)	-19.1 ± 0.6	-20.0	-17.9	1.9 ± 0.7	1.3	1.5	14.6 ± 0.9	13.1	16.3
3 (Holocene)	-22.4 ± 0.8	-23.3	-20.7	5.5 ± 0.8	2.9	7.0	14.6 ± 0.8	11.5	17.1

Tab. 4 Mean and standard deviation (std) of isotope data from each cluster identified with cluster analysis.

likely that the samples taken for isotope analysis represent a chronological sequence through time, with material sampled from the Late Glacial and the Holocene. Thus, we might expect the broad isotope trends seen in the wider regions to be detected through the layers at Lynx Cave, but some noise may be present in the signal due to some disturbance particularly in the upper layers. Cluster analysis has identified 3 clear groups in the data which when considered in light of the species composition, radiocarbon dates, sample layer provenance and known temporal patterns in herbivore isotope data from Northern Europe, are likely to relate to distinct chronological groupings. However, it is clear that some of the sampled material in certain layers is likely intrusive.

Layer A/B

Layer A/B is reported to be a highly disturbed deposit potentially containing material of varying ages from the Late Pleistocene to the Holocene (Blore, 2012). Three reindeer were analysed from this layer. Although not directly radiocarbon dated, it is highly unlikely that these are of Holocene age, as the species became extinct in the British Isles either at the end of the Pleistocene or very early in the Holocene (Coard and Chamberlain, 1999). Furthermore, the reindeer have δ^{15}N values that are lower than other wild cervids from Holocene contexts in the British Isles (Stevens et al., 2014). The reindeer δ^{13}C, δ^{15}N and δ^{34}S values are entirely consistent with those of reindeer from Layer D (**Figs. 3-4**) and cluster analysis groups them together (Cluster 1, **Fig. 5**). Taken together, these lines of evidence suggest that the reindeer sampled from layer A/B were intrusive material from (an) older deposit(s) and are likely to be of the same age as the reindeer recovered from Layer D (**Fig. 6**).

Layer C

Layer C has been attributed mainly to the Bronze Age, although there is some evidence of disturbance and intrusive material (Blore, 2012). Seven aurochs and two horses were analysed from Layer C. All but one sample have relatively high δ^{15}N, high δ^{34}S and low δ^{13}C values (**Figs. 3-4**), and cluster together away from all samples in layers A/B and the majority of samples from layers D/D1/D-E (Cluster 2, **Fig. 5**). One horse (UPN-835) had a relatively low δ^{15}N value, but its δ^{13}C and δ^{34}S values were comparable to those of the other horse (UPN-798) and the rest of the Cluster 2 fauna (**Fig. 5**). The Cluster 2 δ^{13}C and δ^{15}N isotope data are comparable to those of the same species from Holocene site in the British Isles (Lynch et al., 2008; Stevens and Hedges, 2004). Interestingly the Cluster 2 data appear to separate into two groups due to

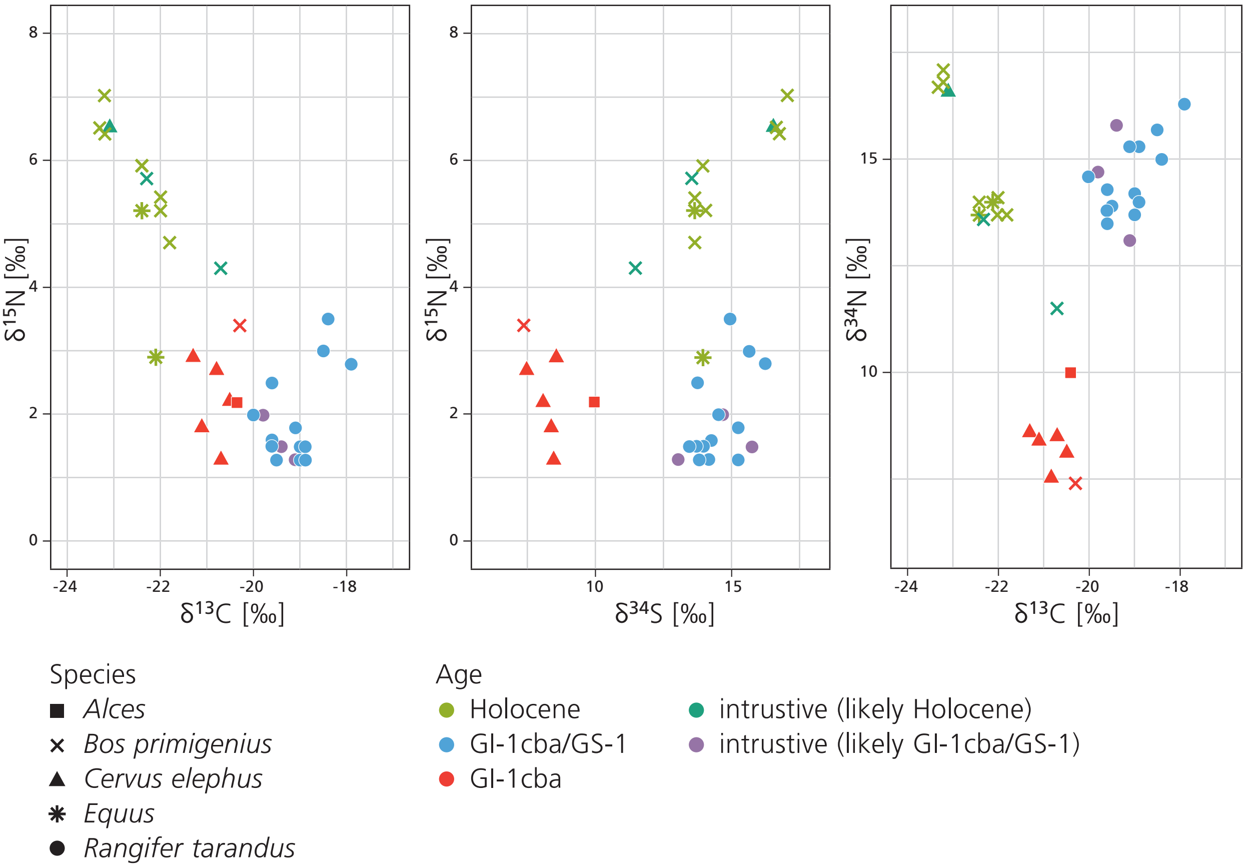

Fig. 6 Faunal collagen carbon, nitrogen and sulphur isotope data plotted by species and inferred chronological age.

their δ^{13}C values, however, this is based on visual inspection of the data and the cluster analysis views the data as a single group (**Fig. 5**). The low δ^{13}C values seen for two of the aurochs potentially indicate these individuals lived in a woodland environment, where their δ^{13}C values were affected by the canopy effect. By contrast, the aurochs and horse with slightly higher δ^{13}C values likely indicate an open environment. These differences could represent animals using different parts of the landscape. Alternatively, they could be linked to chronology, with some animals living in the area at a time when the landscape was more forested and other living in the area when the environment was more open. Without applying direct ^{14}C dating it is not possible to say which scenario is more likely.

Layers D/D1/D-E

The majority of the Lynx Cave LUP archaeology was recovered from Layer D/D1 and as the bones found in the top of sterile layer E are thought to have originated from Layer D, the analyses from these layers are considered collectively. A total of 23 samples (elk: n = 1; aurochs: n = 3; red deer: n = 6, reindeer: n = 13) were analysed from layers D/D1/D-E (**Fig. 3**).

A group of seven samples (red deer: n = 5; aurochs: n = 1; elk: n = 1) clearly cluster on their δ^{34}S values (Cluster 3), which are low (7.4‰ to 8.6‰) relative to the range of values in layers D/D1/D-E (7.4‰ to 16‰) and layers A/B/C (13.1‰ to 17.1‰) (**Figs. 3-4**). Three of these samples (UPN-829, UPN-827, UPN-

830) have been radiocarbon dated (two on the same individual) giving GI-1cba dates of ca. 13,735-13,075 cal BP. Notably none of these samples are reindeer. The $\delta^{13}C$ values are comparable to those seen in other European archaeological sites that date to GI-1cba and indicate an open environment (Drucker et al., 2003; Mannino et al., 2011; Stevens et al., 2014). Yet the identification of charcoal from birch, willow, oak and pine species in the hearths from layers D/D1/D-E show that even if the environment was open, wooded areas must have existed in the vicinity of the site during this period (Blore, 2012). The low $\delta^{15}N$ and low $\delta^{34}S$ values are typical of Late Glacial environments and the isotope data does not suggest significantly warm conditions or mature soils. This data along with the evidence that some of the bones were shattered when fresh indicates the presence of an early phase of human occupation associated with 'temperate' species during GI-1cba (**Fig. 6**).

A second group of 13 samples, all reindeer, group together (Cluster 1, **Fig. 5**), with relatively low $\delta^{15}N$, high $\delta^{34}S$ and high $\delta^{13}C$ values (**Figs. 3-4**). Two species from this group (UPN-808, UPN-906) are radiocarbon dated to ca. 13,170-12,820 cal BP, corresponding to the latter part of GI1-cba/early part of GS-1. Three of the four reindeer samples (UPN-787, -788, and -789) from layer D1 have slightly higher $\delta^{13}C$ and $\delta^{15}N$ values than the reindeer from Layer D (**Fig. 3**), but it should be noted that these samples were taken from teeth whereas the fourth sample and all others from layer D were taken from bones. This difference may be due to the tooth sample representing a shorter time snapshot of diet in early life which is likely for at least two of the specimens and corresponds with the consumption of milk as a calf. Reindeer are typically considered a cold climate species whose presence indicates cool environmental conditions. The reindeer $\delta^{13}C$ values are substantially higher than those of all other species at the site (**Fig. 4**; **Fig. 6**), which is a pattern often observed in Late Pleistocene contexts (e.g., Fizet et al., 1995; Drucker et al., 2003; Stevens et al., 2009). This is because reindeer eat lichen which exhibit higher $\delta^{13}C$ values than sympatric C_3 plants (Park and Epstein, 1960; Maguas and Brugnoli, 1996; Drucker et al., 2001). The reindeer's specific diet largely explains the difference in $\delta^{13}C$ values between GI-1cba and GI-1cba/GS-1 groups (Clusters 1 and 3, **Fig. 5**). The low reindeer $\delta^{15}N$ values, comparable to those in Cluster 3, are typical of Late Glacial environments, and suggest soil maturity and nitrogen cycling was similar during the GI-1cba and the late GI-1cba to early GS-1 periods. By contrast, substantially higher $\delta^{34}S$ values are seen for individuals in Cluster 1 relative to those in Cluster 3. Given the species composition disparities between the two clusters, one argument could be that the differing $\delta^{34}S$ values are linked to the species-based differences in landscape use due to ecological preference. This argument is unsatisfactory as it would rely on the late GI-1cba/GS-1 reindeer and the Holocene aurochs and horses using lithologically similar landscapes that are distinct to those being used by the GI-1cba aurochs, red deer and elk. The radiocarbon dates do, however, indicate the reindeer are slightly later in date than the other GI-1cba species, and a similar transition from lower to higher faunal $\delta^{34}S$ values at approximately this time has been observed in other areas of Northern Europe (Drucker et al., 2012; Reade et al., 2020b, 2021). In these contexts, it has been argued that herbivore $\delta^{34}S$ values track changes in soil redox conditions (that control microorganism-mediated isotopic fractionations), which are responding to ice sheet melt and permafrost thaw (Reade et al., 2020b). Another possibility is the higher $\delta^{34}S$ values could be linked to increased input of sulphur from the sea as proximity to the coast reduced due to sea level rise. Yet the amount of sea level rise along the North Wales coastline during the Late Glacial was nowhere near as great as between GS-1 and the mid-Holocene (Roberts et al., 2011), thus it seems unlikely that sea level change is driving the shift in $\delta^{34}S$ values. Furthermore, a similar trend in herbivore $\delta^{34}S$ values is seen in archaeological sites in eastern France, Switzerland and the Czech Republic (Drucker et al., 2012; Reade et al., 2020b, 2021), which are too far from the coast for sea level change to have had an impact. Thus, soil redox and hydrological changes linked to ice sheet melt and/or permafrost thaw offer a more parsimonious explanation for the observed change in herbivore $\delta^{34}S$ values.

Finally, three samples (red deer: n = 1, i.e., UPN-793, aurochs: n = 2, i.e., UPN-790, UPN-832) from Layer D/D1/D-E are clear outliers from the rest of the data from Layer D/D1/D-E, but cluster with the isotope data from Layer C (Cluster 2, **Fig. 5**), which is thought to relate to the Bronze Age/Holocene. Furthermore, their results are consistent with isotope values observed for the same species at Holocene archaeological sites in the British Isles (Lynch et al., 2008; Stevens et al., 2014). The red deer (UPN-793) $\delta^{13}C$ value potentially indicates the animal lived in a wooded environment. This specimen was found away from the main passage in a layer assumed to be continuation of Layer D, but this assumption appears to be speculative. It seems likely that all three specimens represent Holocene intrusive material (**Fig. 6**), although for the aurochs samples, the excavation records do not provide more conclusive support for this.

CONCLUSIONS

Analysis of the data from Lynx Cave indicates the faunal isotope results clusters into three, or potentially four, distinct groupings, which when considered in light of the species composition, radiocarbon dates, sample layer provenance and known temporal patterns in herbivore isotope data from Northern Europe, are likely to relate to distinct chronological periods. One group (Cluster 2) has rather different isotope values compared to the clusters attributed to the Late Glacial, and when combined with the archaeological and radiocarbon evidence appears to relate to the Bronze Age (Holocene). However, the possibility of two distinct groups within Cluster 2, one indicating an open environment and the other indicating a woodland environment could potentially suggest that the material belongs two time periods (e.g., Early Holocene and Late Holocene) when woodland development within the region likely differed. Alternatively, the potentially distinct groups could indicate contemporary animals using different parts of the landscape.

The second grouping (Cluster 1) seems to relate to GI-1cba (the Allerød period) ~13,700-13,000 cal BP. The temperate species composition (red deer, elk and aurochs) and isotope data indicate an open environment and not particularly mature soil conditions that are likely being impacted by permafrost thaw processes or affected by conditions created as a legacy of ice sheet melt and permafrost thaw. The second grouping seems to relate to GI-1cba/GS-1 (the Late Allerød/early Younger Dryas period) ~13,100-12,800 cal BP, when the presence of tundra-steppe species (reindeer) and isotope data indicate cool environmental conditions with relatively immature soil conditions, but which appear to be recovering from the impact of changing soil and hydrological conditions linked to ice sheet melt and permafrost thaw. The evidence of butchery on the faunal remains from both isotope Cluster 1 (Allerød) and Cluster 2 (Late Allerød/early Younger Dryas), along with the disparate radiocarbon dates and the presence of three hearths support the idea of very short-term episodic use of the cave over an extended time period (Blore, 2012). The Late Upper Palaeolithic lithic assemblage from Lynx Cave is small, but does contain elements typically found at continental Late Magdalenian, Hamburgian and Azilian/*Federmesser* archaeological sites (Blore, 2012; Pettitt and White, 2012). It is not possible from the current evidence to link any particular technocomplex to the radiocarbon dated material at the site. However, from the Lynx Cave data, together with the evidence from Kendrick's Cave (Richards et al., 2005; Jacobi et al., 2009; Cook, 2013), it is clear that people were present in North Wales during the early, middle and Late Allerød and early Younger Dryas periods, even if visits to the area were fleeting. Given that ancient DNA indicates this time period witnessed a major population turnover, and archaeological evidence from across Northern Europe indicate changes in mobility patterns, settlement structure, subsistence economy, technology and social organisation, further work is needed to establish which human groups were present in North Wales at this time (Posth et al., 2016; Amkreutz et al., 2018). The numerous small caves of similar size to Lynx Cave present through the whole limestone region of North Wales provide the opportunity for such work, along with the human remains from Kendrick's Cave which could be targeted for ancient DNA analysis.

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MICHAEL BAALES

TRACKING THE REINDEER: THE UPPER AND FINAL PLEISTOCENE RECORD OF REINDEER IN THE NORTHERN UPLANDS AND ITS SEASONAL IMPLICATIONS

Abstract

This contribution compiles the findings of antler assemblages of female / subadult reindeer in the northern uplands that I have come across, starting from the three Ahrensburgian sites with faunal remains located on the northern edge of the central European uplands and their clear evidence for reindeer hunting during spring season. In my opinion, the presented record proves for major parts of the Upper and Final Pleistocene – and even after interruptions due to climate and environmental changes – a regular pattern of reindeer herds migrating between their winter pastures in the north-western European lowlands and their summer pastures in the northern uplands to the south. This describes a complementary scenario to the Ahrensburgian model I developed some 30 years ago. However, no matching evidence is at hand for the Neuwied Basin Late Magdalenian.

Keywords

Central Europe, Upper and Final Palaeolithic, pleniglacial, Younger Dryas, spring migration

AN INTENSE WEEKEND

After spending the winter term 1986/1987 at what was called at that time *Institut für Jägerische Archäologie* (Archaeology of early Hunter-Gatherers) at the Eberhard Karls University of Tübingen, Gerhard Bosinski suggested that I could study the Ahrensburgian assemblage excavated below the so-called *Kartstein Felswand* (i. e., Kartstein rock-shelter) in the northern Eifel uplands for my Master's thesis at Cologne University (Baales, 1989). As a teenager, in 1977, I read about the Kartstein excavations in the newspapers, but despite my general interest in the history of my home region and beyond, I did not visit the site to witness the field work that was conducted at this time, even though my hometown was located in the near vicinity of the *Kakushöhle*[1] (used synonymously to the Kartstein; cf. Baales, 1996: 12), which I had known since childhood. However, if I had visited the excavations supervised by Hartwig Löhr, I could have met Elaine Turner and Martin Street, who worked at the site (Löhr, 1978). Instead, it was seven years later that I met them in Neuwied-Monrepos while I attended my first excavation at the Plaidter Hummerich volcano under supervision of Karl Kröger. During fieldwork, I stayed in the famous "Jagdhaus" at Monrepos for four weeks. Many years later, Martin published the results of the Plaidter Hummerich excavations (Street, 2002), while Elaine had already analysed some Hummerich animal remains as part of her PhD (Turner, 1995).

I got to know the two of them, and especially Martin, better, when I started to work on my Master's thesis after having returned to Cologne University from Tübingen in early 1987. Since the Final Palaeolithic assemblage of the Kartstein excavation mainly consisted of faunal remains, I had to learn zooarchaeological

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[1] "Cave of the Cacus giant" in Roman mythology, transferred in the mid-19th century to the northern Eifel region.

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Fig. 1 Crécy, northern France: Martin overlooking the battle field north of Abbeville[2]. – (Photo: M. Baales, August 1991).

methods. This was why and when Martin came into play, because Gerhard Bosinski suggested that I should meet with him in order to learn the basics. So we sat in Martin's office together for "a long, intense weekend" and surveyed the small-sized animal remains, mainly of reindeer and *Lagopus* that Martin and Elaine had unearthed ten years earlier during their Kartstein campaign. Of course, Martin was very interested in the material that he partly excavated as a student. This "long weekend" was essential to my early scientific work. It laid the ground work for becoming proficient in faunal studies, which I needed a lot in succeeding projects to come (cf. Baales, 2002).

While I worked more or less continuously in Monrepos from 1990 to 2002, a close and friendly relationship with Martin and Elaine, who both belong to the *Monrepos Urgestein* (i.e., 'Monrepos veterans'), developed. But above all, I have many memories of Martin and great gratitude for him in particular, because he published the first articles with me as a co-author in the English language, and translated several of my manuscripts – efforts that always resulted in significant and important improvements. But he also introduced me

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[2] During a trip to Belgium and northern France, in 1991 Martin and I also passed by the famous Crécy fields (Dép. Somme), where on August 26th in 1346 during the early phase of the Hundred Years' War, the English met the French and their allies for battle. Here, Martin explained to me where the English troops, with the famous teenage Black Prince in their rows, were positioned, how they attacked and how the French finally flew from the battleground. In this moment, I got the impression that Martin "saw" the battle turmoil from the lookout tower where we stood in front of his "spiritual eye" – and was very pleased we had made the little detour. Back then, in contrast to my English companion (because after all, at least his countrymen had won this fight, although not the war), I was not very familiar with the Hundred Years' War and the Battle of Crécy.

to many colleagues both at home and abroad. I still vividly remember one of our trips in 1991 that led to Liège and northern France (**Fig. 1**), visiting sites and ongoing excavations, meeting colleagues with whom we developed long-term scientific and friendly relations, and where we studied some important Palaeolithic collections.

AHRENSBURGIAN REINDEER HUNTERS IN THE NORTHERN UPLANDS

The cave of Remouchamps in the northern Belgian Ardennes was excavated as early as 1902, providing a rich archaeological assemblage – including numerous faunal remains, albeit mixed with some more recent material – that was later attributed to what has since been defined as Ahrensburgian. This accounts similarly for the Hohler Stein cave near Kallenhardt in the northern Westphalian *Sauerland* uplands that was excavated between 1928 and 1934, and for the early and quite unsystematic excavation at the Kartstein in 1913 which only provided a restricted number of objects later recognised as of Ahrensburgian age (Baales, 1996). But it would have not been possible to correctly contextualise these early finds without the innovative work of Alfred Rust (1900-1983), who excavated a site of reindeer hunters near Gut Stellmoor northeast of Hamburg from 1934 until 1936. His voluminous and detailed publication of the site defined the Ahrensburgian as a Final Palaeolithic "culture" of the northern central European lowlands (Rust, 1943).

Compared to the Stellmoor site, the sites of Remouchamps, Kartstein, and the Hohler Stein near Kallenhardt – all situated in the northern upland ranges (i.e., *Mittelgebirge*) – were clearly exceptional. Only thanks to new field campaigns at Remouchamps in 1969/1970 (Dewez, 1974) and at the Kartstein in 1977 could this picture be corrected, showing that the northern *Mittelgebirge* were also part of the Ahrensburgian economy (Baales, 1992, 1993, 1996, 1999).

Whereas Rust (1943) provided evidence for seasonal hunting at Stellmoor during autumn, data for the seasonality of Ahrensburgian presence in the uplands were scarce. When presenting the Ahrensburgian assemblages from Vessem, west of Eindhoven in the southern Netherlands, Nico Arts and Jos Deeben (1981: Fig. 53) forwarded a model that postulated north-south migrations (and *vice versa*) of prey and humans during the Final Palaeolithic. Hunter-gatherers at that time would have "hibernated" together with their prey in the adjacent southern uplands. This simple model, however, had already been rejected by the seasonal data available from Remouchamps in 1974, when Jean Bouchud (1974: 126) described two reindeer milk teeth which, due to their wear, indicated the *période estivale* (summer half year) as the hunting season. This estimation was later clarified by Bryan C. Gordon (1988: 215) who argued in favour of hunting during spring, based on his interpretation of annual cement increment analysis of eight reindeer teeth from the site.

My studies of the three most important Ahrensburgian faunal assemblages in the northern upland ranges in the early 1990s supported Gordon's seasonal interpretation of Remouchamps. Based on the presence of female/subadult reindeer antlers (mostly shed antlers and a few *bois de massacre,* which feature evidence of bone resorption at the junction of the antler and the pedicle), the evidence for dentition changes from milk to permanent teeth in young reindeer, and on the analysis of annual cement increments (available only for the Kartstein), plus comparative considerations on recent reindeer and caribou ethology and migration patterns, it was possible to argue for the interception of reindeer herds by Ahrensburgian hunters during the animals' spring migration into the northern uplands (Baales, 1996, 1999). In consequence, this implied that the Arts and Deeben model that postulated migration between the Eifel/Ardennes and the adjacent lowlands to the north, was "upside down", and that this pattern extended to Westphalia and most likely even further east. Since there are no other Ahrensburgian sites that preserved faunal remains in the region, this model has not yet been contradicted. However, it remains to be seen whether new sites uncovered in the future and/or modern analyses of the known material (e. g., isotope studies of reindeer teeth; cf. Price et al., 2017) will open new perspectives on this topic.

PRESENCE OF UPPER PLEISTOCENE REINDEER IN THE NORTHERN UPLANDS AND THEIR SEASONAL IMPLICATIONS

In my now almost 30 year old Cologne PhD (from late 1992; Baales, 1993, 1996), I already discussed some particular findings of Upper/Late Pleistocene reindeer in the northern uplands, the accumulation of shed antlers of female/subadult animals and their importance for the reconstruction of reindeer seasonality (Baales, 1996: 97-100, 303-306). Since then several more finds came to light or could be substantiated. In the following, I will give an updated overview of this evidence (**Fig. 2**), although this compilation cannot claim for completeness at all.

The Ardennes (Belgium)

Numerous caves, some of which were frequently visited by Palaeolithic hunter-gatherers, are known from the northern slope of the Ardennes in southern Belgium (Dewez, 1987). In these caves several archaeological and/or palaeontological find horizons have produced large quantities of shed antlers of female/subadult reindeer, which has been stated expressly and repeatedly (Dewez, 1980: 93: "Le problème des bois de chute de renne femelle amassés sur les sites […]"). This applies similarly to the caves of Trou des Blaireaux à Vaucelles (Bellier and Cattelain, 1986, 1987; Charles, 1994: 34-38; Cattelain, 2001; **Fig. 3**), Trou des Nutons (Furfooz: Dewez, 1987: 190; Charles, 1994: 223-224), Trou de l'Ossuaire/Presle (Aiseau) (recent excavations: Léotard and Otte, 1988: 192-193; **Fig. 4** and older finds from smaller caves located there: Dewez, 1980: 93, 1987: 28) and the Grotte du Coléoptère (Bomal-sur-Ourthe: Dewez, 1980, 1987: 404; Gordon, 1988: 93; Charles, 1994: 315; **Fig. 5**). The famous cave of Spy also produced numerous reindeer antlers, but also one shed antler of a reindeer bull exhibiting gnawing marks (Germonpré et al., 2013: 308, 319), while the Grotte de Sy Verlaine, a cave some 3 km north of the Grotte du Coléoptère, produced only a few reindeer antler fragments, but at least one with a shed base of a juvenile/subadult individual dated to the Late Magdalenian (Charles, 1994: 330-331). During my visit to the Prehistoric collections of the University of Liège in 1992 and our joint visit there one year before, Martin and I were able to study some of these finds first-hand.

The relevant finds are generally dated to the later Upper Pleistocene and often associated with the Late Upper Palaeolithic Magdalenian techno-complex (cf. Miller and Noiret, 2009: 40-41). The two find horizons II and III of Trou des Blaireaux, for example, each "caractérisent par l'abondance de fragments de bois de rennes femelles" (Cattelain, 2001: 36), date ~ 14-12.5 kyr cal BC according to the available radiocarbon dates. The basal layer, which likewise produced many slender reindeer antlers, gave even older ages of ca. 17 kyr cal BC, which are believed to date a non-anthropogenic accumulation of faunal remains in the cave, which accumulated over a longer period of time (Voeltzel, pers. comm. 18.03.2020). Basically, all the antler collections in Trou des Blaireaux are expected to be of natural origin (Cattelain, 2001; Cattelain and Voeltzel, 2000; Voeltzel, pers. comm. 18.03.2020), while potential human modifications (Bellier and Cattelain,

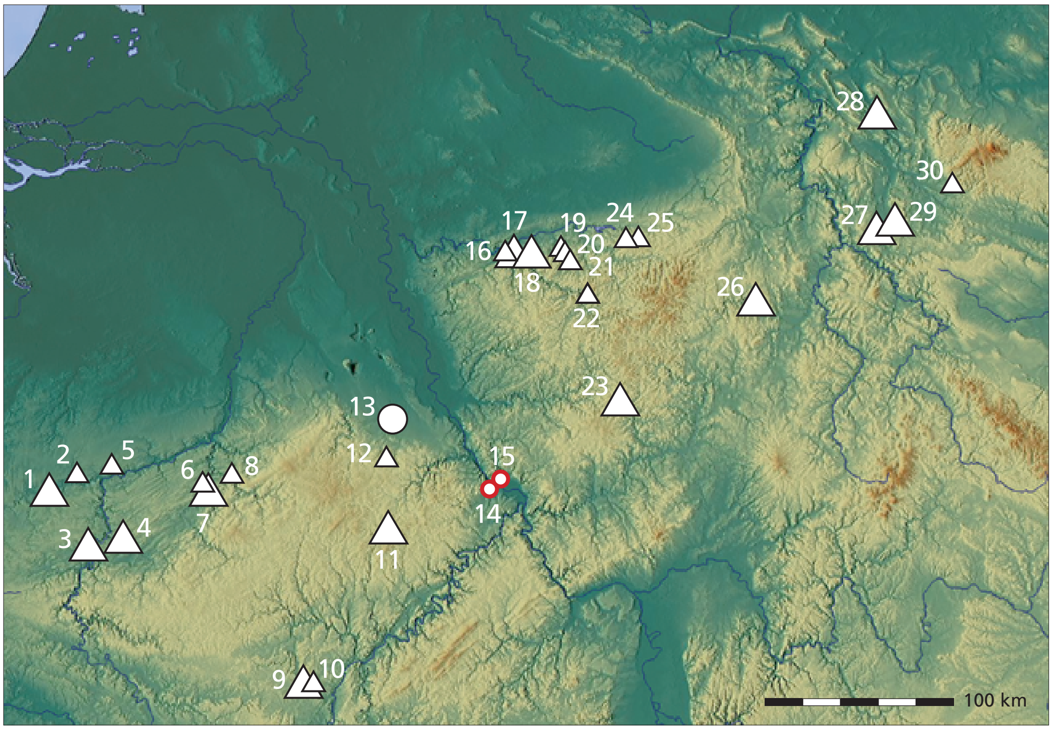

Fig. 2 The northern upland ranges (*Mittelgebirge*) between the Ardennes and the Harz with sites discussed in the text. Large triangles represent major collections of slender shed reindeer antlers, small triangles show sites that produced single specimens; large dot: Lommersum located just north of the upland edge; small dots: Late Magdalenian sites of Andernach-Martinsberg and Gönnersdorf in the Neuwied Basin. **1** Trou de l'Ossuaire/Presle near Aiseau (B); **2** Grotte de Spy near Jemeppe-sur-Sambre (B); **3** Trou des Blaireaux near Vaucelles (B); **4** Trou des Nutons near Furfooz (B); **5** Grotte Princess Pauline near Marche-Les-Dames (B); **6** Grotte de Sy Verlaine near Tohogne (B); **7** Grotte du Coléoptère near Bomal-sur-Ourthe (B); **8** Grotte du Remouchamps near Aywaille (B); **9** Schlaed/Schléd near Oetringen/Oetrange (LUX); **10** Kakert near Oetringen/Oetrange (LUX); **11** Magdalenahöhle and Buchenloch near Gerolstein (D); **12** Kartstein near Mechernich-Weyer (D); **13** Lommersum near Weilerswist (D); **14** Andernach-Martinsberg (D); **15** Gönnersdorf near Neuwied (D); **16** Hünenpforte near Hagen-Hohenlimburg (D); **17** Oeger Höhle near Hagen-Hohenlimburg (D); **18** Martinshöhle or Grürmannshöhle near Iserlohn-Oestrich (D); **19** Feldhofhöhle (questionable, see text) near Balve (D); **20** Volkringhauser Höhle near Balve (D); **21** Balver Höhle near Balve (D); **22** Fretter Höhle near Finnentrop (D); **23** Wildweiberhäuschen near Haiger-Langenaubach (D); **24** Bilsteinhöhle near Warstein (D); **25** Hohler Stein near Rüthen-Kallenhardt (D); **26** Edertal-Buhlen near Waldeck (D); **27** Abri Stendel XVIII near Friedland-Groß Schneen (D); **28** Aschenstein near Freden (D); **29** two abris in the Garte valley near Gleichen-Benniehausen (D); **30** Steinkirche near Herzberg am Harz-Scharzfeld (D). – (Map: M. Baales and M. Röring, Olpe; basis https://maps-for-free.com).

1987: 252) are today argued to result from natural processes (Charles, 1994: 36; Cattelain and Voeltzel, 2000). Altogether, the finds are proof of the recurrent presence of reindeer herds (or at least numerous female/subadult animals) during their spring migration into the Ardennes.

Other seasonal indicators on reindeer remains from Upper Palaeolithic sites of the Ardennes tend to give a more heterogeneous picture. The teeth of very young animals from the Magdalenian YSS assemblage of the Grotte du Bois Laiterie show no or only weak wear which "suggest occupation in the warmer period of the year, during the calving season of reindeer or shortly thereafter" (Gautier, 1997: 191). This interpretation is more or less supported by the analysis of the annual cement increments of reindeer teeth from Bois de Laiterie and further sites in the Ardennes (Stutz, 1997: 201; cf. Gordon, 1988, who defines the Ardennes as an Upper Pleistocene reindeer "calving ground" based on his results of annual cementum layers). The same method, applied on reindeer teeth from the Aurignacian at Trou Magrite near Dinant, however, points

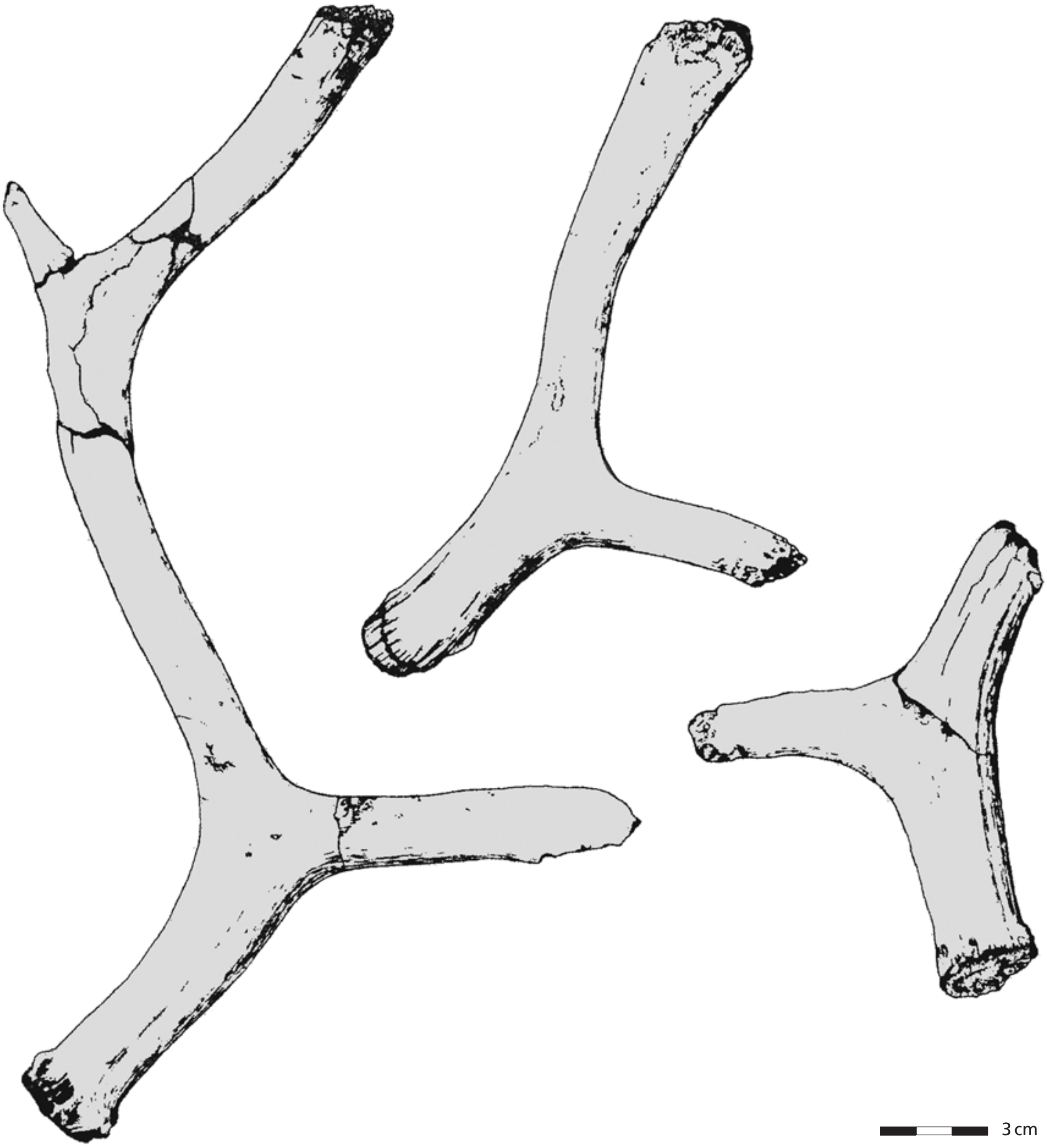

Fig. 3 Trou des Blaireaux near Vaucelles (southern Belgium). Three fragments of shed slender reindeer antlers. – (Drawing: H. Menne, Olpe, modified from Bellier and Cattelain, 1986).

to reindeer hunting during the cold season (Gautier, 1995: 149) or – more specifically – in late winter/early spring (Stutz et al., 1995: Tab. 9.2). Other Upper Pleistocene reindeer teeth from the region also indicate (late) winter/early spring as the time of death, although other seasons are occasionally indicated (Stutz et al., 1995: Tab. 9.3, 9.4). The not fully developed reindeer antler from the Aurignacian of the Grotte Princess Pauline (Marche-Les-Dames), on the other hand, is again considered to indicate hunting of reindeer during late spring/summer (Gautier, 1995: 150).

Those rather heterogeneous seasonal findings are sometimes interpreted as evidence for the "year-round" reindeer hunting in the Ardennes during the Upper Pleistocene. By reading the discussions of the annual cement increments in the cited studies, to me it seems, however, that the referred findings in reindeer tooth sections were not easy to interpret or do not always provide an unambiguous interpretation. Using improved analytical methods, future research could perhaps provide a clearer picture (cf. Stutz et al., 1995: 181). Although the annual cement increments analysis give evidence for the presence of reindeer herds in the Ardennes upland during their bi-seasonal migration periods, at present, the collections of shed reindeer antlers of female/subadult individuals represent the most significant seasonal evidence (Germonpré, 1993: 292) for the presence of reindeer herds in the Ardennes. They refer to multiple spring migrations of large herds with many female and young individuals on their way to their summer pastures in the higher Ardennes during the Upper/Late Pleistocene.

The Gutland (central and southern parts of the Grand Duchy of Luxembourg)

Similar findings as for the Belgian caves can be demonstrated for the Luxembourg Gutland further southeast. Decades ago, in a cave-diaclase in the Triassic sandstone near the village of Schlaed/Schléd (Oetringen/Oetrange), roughly 250 fragments of shed antler of female/subadult reindeer were recovered (**Fig. 6**) in addition to numerous other Upper/Late Pleistocene animal remains (Heuertz, 1969: 104, Fig. 44). In 1969, a bulked antler sample was dated by radiocarbon (Heuertz, 1969: 135) to ~17.5 kyr cal BC. The site of interest is located some 150 km south of the northern upland edge and is thus situated significantly further south than the cave sites in the Belgian Ardennes.

From a neighbouring cave-diaclase named Kakert, in 2008 a reindeer tooth was AMS-dated to ~19 kyr cal BC (Fabre, 2010: 324); nine reindeer shed antler fragments and one *bois de massacre* were identified from there, most likely coming from female/subadult individuals (Fabre, 2010: 327, 330). However, other

Fig. 4 Presle near Aiseau (southern Belgium). Fragments of reindeer antlers, among them three with shed bases. – (Photo: M. Baales, 1991). – Scale approx. 1:2.

seasons of death are also discussed based on a few diagnostic reindeer teeth and unfused bones (Fabre, 2010: 329-331).

Apparently, the collections of reindeer antlers found near Oetrange might have been analogous to those found in the Oeger Höhle in Westphalia (see below), accumulated over many millennia. I interpret this as evidence of countless reindeer migrations into the region where the antlers were found. It should be noted here that, even some ~100 km further south-west, numerous shed antler of female/subadult reindeer were excavated at the site of Roche Plate near Saint-Mihiel in the Meuse valley in north-eastern France, dating to the Late Upper Palaeolithic and estimated to be of a natural origin (cf. Cattelain and Voeltzel, 2000; Patou-Mathis et al., 2005: 34; Stocker et al., 2006: 36).

West and North Eifel

Around 100 km to the northeast from Oetrange near Gerolstein (West Eifel, Rhineland-Palatinate), between 1969 and 1972 a hobby archaeologist uncovered numerous shed antlers of female/subadult reindeer (**Figs. 7-8**) in front of a small cave, known as the Magdalenahöhle (Magdalena Cave; Weiß, 2002). When I was working in Monrepos I had the opportunity to have a closer look at this material, which was published much later (Probst, 2012). In 1971 a bulked sample of reindeer antler fragments was radiometrically dated to ~29 kyr cal BC (BONN-1658). However, this date is to be assessed critically, since the archaeological material was recently connected to the Solutrean (Probst, 2012: 61-62).

From the nearby Buchenloch cave, situated in the same limestone cliff (named Munterley), Löhr reported further examples of slender shed reindeer antlers (Baales, 1996: 98-99). At any rate, it can be agreed that

Fig. 5 Grotte du Coléoptère near Bomal-sur-Ourthe (southern Belgium). Fragments of shed antlers of female/subadult reindeers. – (Photo: M. Baales, 1992).

Fig. 6 Schlaed/Schléd near Oetringen/Oetrange (Luxembourg). Collection of shed antlers of female/subadult reindeers. – (From Heuertz, 1969). – Scale approx. 1:3.

during the late Upper Pleistocene, female/subadult reindeer repeatedly shed their antlers in the Gerolstein area on their southward migration through the western Eifel uplands.

The seasonal indications for the Ahrensburgian layer uncovered in 1977 beneath the Kartstein Felswand in the North Eifel, barely 60 km southwest of Cologne and at about 400 m a. s. l., have already been mentioned above (Baales, 1996). Since the beginning of the last century the Middle Pleistocene Kartstein travertine with its various caves and rock shelter situations was frequently the target of archaeological surveys and excavations, which repeatedly revealed reindeer remains. Most of the finds uncovered during the quite often relatively unsystematic surveys have been lost. A reindeer antler fragment published as a sketch drawing

Fig. 7 Magdalenahöhle near Gerolstein (Rhineland-Palatinate, western Germany). Large fragments of three shed antlers of female reindeers. – (Photo: M. Baales, ca. 2000).

(Rademacher, 1916) was among the objects recovered in 1913 during the second field campaign at the Kartstein undertaken by Carl Rademacher (1859-1935). Due to its assumed anthropogenic status of an artefact the item was re-published much later by Karl Josef Narr (1952: 5). However, this basal antler fragment was certainly no artefact, but just a shed antler of a female/subadult reindeer, as the illustration reveals. This example can basically be used to suggest that reindeer were present around the Kartstein not only during the Younger Dryas, as Löhr's filed work documented, but regularly during Upper Pleistocene spring seasons. In addition to the upland sites with reindeer remains, presented above, the Aurignacian site of Lommersum near Weilerswist (distr. Euskirchen; Hahn, 1989) located some 30 km north of the Kartstein (thus, just north of the Eifel upland edge), is of relevance here. The Early Upper Palaeolithic find horizons are mainly characterised by the remains of reindeer (Matthies, 2013), while horse was less frequent. The zooarchaeological study by Hubert Berke (1989) demonstrated that reindeer were killed in the vicinity during their spring migration. Is it not obvious that the herds intercepted near Lommersum were on their way southwards into the Eifel uplands, that could have served as summer pastures? The fact that the same season for reindeer hunting is argued for at the Final Palaeolithic Ahrensburgian site at the Kartstein a little further south but dating some 25 kyr younger, is of interest here.

Westphalian uplands (*Sauerland*) and northern Hessia

At the beginning of the 1930s, the Oeger Höhle in the Lenne valley near Hagen-Hohenlimburg (at the "gate to the *Sauerland* uplands"), was partially destroyed during road construction. From the remnant cave sediments, Josef Spiegel (1901-1984), founder of the later *Ruhrtalmuseum* in Schwerte, collected numerous slender reindeer antler fragments, including many basal parts of shed examples (**Fig. 9**). Many more specimens were collected over the coming years, sometimes during illegal excavations (cf. Niemeyer, 1992: 86-87; Baales, 1996: 99-100). About two decades ago, I was able to date two bulked samples of these antlers in the first radiocarbon facility at the University of Cologne. To my surprise, these measurements resulted in two completely different ages of around 13 and 30 kyr cal BC (Baales and Blank, 2013). Even though the chronostratigraphic value of the two age determinations is low, it is clear that the reindeer antlers were deposited over a longer period of time, spanning many millennia (similar observations have been made in a completely different region; see below; cf. Murray et al., 1993: 7).

Fig. 8 Magdalenahöhle near Gerolstein (Rhineland-Palatinate, western Germany). Further basal fragments of slender shed reindeer antlers. – (Photo: M. Baales, ca. 2000).

Unfortunately, the fragment of a barbed point found at Oeger Höhle, made from the split beam of a thin reindeer antler (**Fig. 10**), could not be dated by AMS-^{14}C due to low collagen content. The specimen, however, indicates that humans were present in the cave at roughly the time represented by the younger of the two conventional ^{14}C age determinations mentioned above. Interestingly, there are no further finds of Late Upper Palaeolithic age known from this locality.

In 1992, while studying the reindeer antlers from the Oeger Höhle in the former museum Hohenlimburg in Hagen, I recognized a further singular slender shed antler fragment from another former cave once located not far from the former Oeger Höhle within the same valley: the Hünenpforte (Baales, 1996: 284).

Since June 2002 (when I started my work in Olpe in Southern Westphalia), I have become aware of a whole series of cave sites in the *Sauerland* uplands, which produced shed antlers of female/subadult reindeer, sometimes in large quantities. These sites currently describe the region with the highest amount of finds of this kind in the Central European northern uplands.

In this region, the oldest record may even date back to the late Middle Palaeolithic (cf. Voeltzel, 2015), if one assumes that synchronicity of the reindeer antlers and the lithic artefacts found in the small Volkringhauser Höhle cave in the Hönne valley near Balve (Märkischer Kreis; Tafelmaier, 2011, 2013). The Hönne river runs south-north, contributing to the Ruhr about 25 km further north, and could be interpreted as a Pleistocene reindeer migration route on the way south into the Westphalian uplands.

Fig. 9 Oeger Höhle near Hagen-Hohenlimburg (southern Westphalia, western Germany). Collection of basal fragments of slender shed reindeer antlers. – (Photo: M. Baales, 1992).

Fig. 10 Oeger Höhle near Hagen-Hohenlimburg (southern Westphalia, western Germany). Fragment of a barbed point of reindeer antler. – (Photo: O. Jöris, MONREPOS, drawing: A. Müller, Olpe).

Furthermore, there is a series of yet undated collections of shed antlers of female/subadult reindeer. Many basal parts of shed antlers were found during early excavations in the Martinshöhle cave near Iserlohn-Letmathe east of Hagen. The cave, which was largely destroyed through quarrying in 1911, was located high up in the cliff, just where the valley of the Lenne bends southeast towards the southern *Sauerland*. Among others, the famous Bonn-based scholar Hermann Schaaffhausen (1816-1893) supervised the most extensive excavations in the Martinshöhle between 1875 and 1877 (Niggemann, 2018: 72-75) that revealed a large collection of Final Palaeolithic *Federmesser* material (Baales et al., 2013: 126). Given the Allerød interstadial age of the *Federmesser* industries within the wider region, the numerous reindeer antlers from the Martinshöhle should either pre- (Upper/Late Pleistocene) or postdate (Younger Dryas) the *Federmesser* occupation[3]. A collection of them (mostly labelled as "Schmitz, Letmathe 1889") is kept in the Geological-Palaeontological collection of the University of Münster together with a much more recent handwritten note about these finds coming from the Martinshöhle (**Fig. 11**).

In this context, it is worth noting, that in 1992, several skeletal remains of a female reindeer dated to > 46 kyr cal BC were found in the neighbouring Bunker Cave, below a sinkhole or a crack in the ceiling (Rosendahl and Tietgen, 1996). The skull displays both pedicles with adhering antler bases (**Fig. 12**). Due to its osteologi-

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[3] The label "SCHMITZ, LETMATHE 1889" sticking on these antlers points to the pharmacist Schmitz from Iserlohn-Letmathe who supervised the Schaaffhausen excavations in the Martinshöhle during the 1870s, where reindeer antlers were found (Niggemann, 2018: 72-73). However, it cannot be ruled out whether or not the antlers stored in Münster actually came from another cave, the nearby Grürmannshöhle (Grürmann's Cave), where early excavations apparently exposed a huge amount of animal remains (Ziegler, 1973: 2). A larger collection of animal remains (mainly from Grürmannshöhle?) compiled by the pharmacist Schmitz was later given to the University of Münster (Niggemann, 2018: 77). A few of the antlers labelled "SCHMITZ, LETMATHE 1889" are on display in the Deutsches Höhlenmuseum near the famous Dechenhöhle in Iserlohn and have been assigned to come from the Grürmannshöhle.

Fig. 11 Martinshöhle (or Grürmannshöhle; cf. footnote 3) near Iserlohn-Oestrich (southern Westphalia, western Germany). Several basal fragments of slender shed reindeer antlers (Münster University collection). – (Photo: M. Baales, 2007). – Scale approx. 1:2.5.

cally reconstructed individual age of 30-36 months (Tietgen and Rosendahl, 1999), this animal died during winter or spring. The assigned anthropogenic manipulations on a tibia, however, need to be confirmed.

There are other caves in the *Sauerland* that produced accumulations of slender reindeer antlers worth mentioning. Several collections contain reindeer remains from the famous Balve Höhle cave in the Hönne valley. Again: this material subsumes numerous shed antlers of females/subadults, as is the case of the collection stored in the University of Münster (**Fig. 13**). These specimens have not been dated directly and might be considerably younger than the rich Late Middle Palaeolithic lithic and most of the remaining faunal assemblages of the Balver Höhle. However, these layers also provided a shed reindeer antler of a female/subadult animal (Kindler, pers. comm. 13.03.2020) with anthropogenic traces (Kindler, 2012: 201).

Slender antlers, recovered during the 19th century from a side chamber of the Bilsteinhöhle cave system near Warstein remain undated, too. Several typical shed antler bases of female/subadult reindeer have been preserved and are kept in the regional museum in Warstein (**Fig. 14**) and in the Münster University collections (**Fig. 15**).

In 2014, the *Südsauerland Museum* in Arnsberg in southern Westphalia handed over its archaeological collection (which was not to be displayed in the newly designed exhibition) to the magazine of my department in Münster-Coerde. When inspecting these finds, two slender antler fragments caught my attention.

Unfortunately, their labels indicated their origin from (a) *Sauerland* cave(s), without, however, specifying the cave name(s). The finds comprise a basal shed antler fragment and a small fragment of a *bois de massacre* with obvious features of bone resorption at the junction between antler and pedicle (**Fig. 16**). It is possible that these antlers come from one of the Hönne valley caves, perhaps the Balver Höhle, or from the equally large Feldhoferhöhle cave a bit further down the Hönne, which is situated high up in the valley cliff where early excavations and earthwork destroyed an important archaeological archive. In old descriptions, reindeer is mentioned as being part of the site's Late Middle Palaeolithic faunal list (Andree, 1928: 76-77). The basal fragment of a slender *sagaie* can be taken as an indication of a Late Magdalenian occupation in the cave (Baales et al., 2013: 111-112; **Fig. 17**).

Finally, decades ago, another small cave, the so-called Fretter Höhle near Finnentrop, fell victim to quarrying. The Fretter Höhle marks the southernmost Westphalian site of interest here, located in a valley that contributed to the Lenne river at Fretter. Years ago, I was able to survey a small collection of faunal remains from this cave (Baales et al., 2017: 22). Among the remains of woolly rhino and cave bear, there were also two antler specimens: a very slim shed one and a significantly larger *bois de massacre* (**Fig. 18**). While the former suggests the presence of reindeer during spring, the latter can be interpreted as an indication of a reindeer sojourn in the region during (late) summer/autumn. Due to its seasonality, the latter specimen is of special interest as it represents a different season from all the other antler remains in the region.

Just south of Westphalia' southern border in northern Hessia, countless fragments of slender shed reindeer antler were excavated from sediments below the Wildweiberhaus/Wildweiberhäuschen cliff (**Fig. 19**) south of Haiger and near Langenaubach (Behlen, 1905: 292: "unzählige Bruchstücke von Rentiergeweihen,

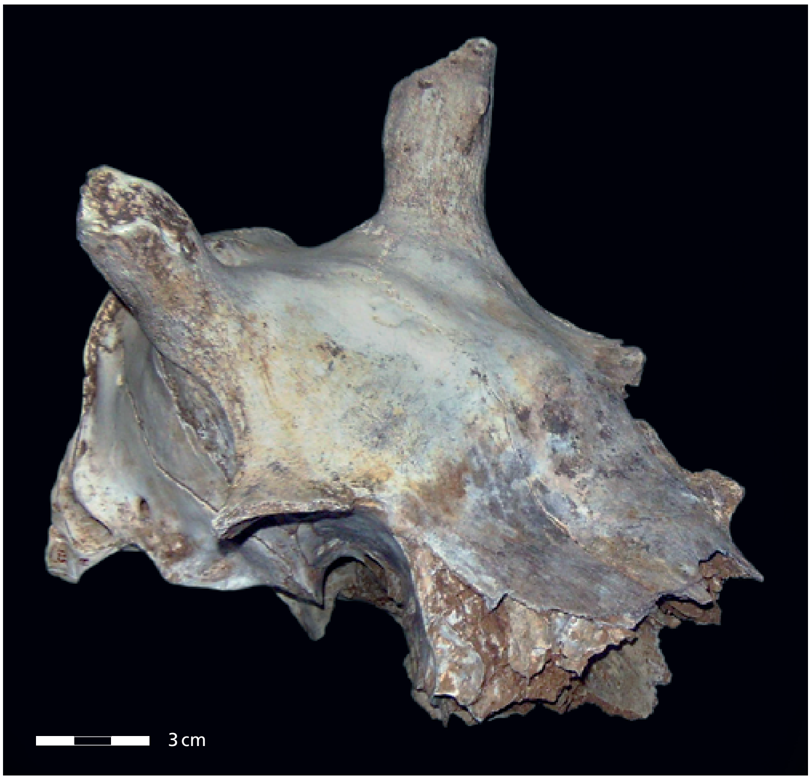

Fig. 12 Bunkerhöhle near Iserlohn (southern Westphalia, western Germany). Female reindeer skull cap. – (Photo: M. Baales, 2008).

Fig. 13 Balver Höhle near Balve (southern Westphalia, western Germany). Slender reindeer antler fragments (Münster University collection). – (Photo: M. Baales, 2007). – Scale approx. 1:2.

und zwar fast ausschliesslich abgeworfene Stangen jugendlicher Tiere"; cf. Jacobshagen, 1955: 38). The reindeer remains were found underneath a layer of Laacher See-Tephra (Jacobshagen, 1955: 41) dated to roughly 11 kyr cal BC (Reinig et al., 2020), and should hence belong to the late Greenland Stadial (GS) 2 time frame (cf. Rasmussen et al., 2014), a period for which as yet no human presence is known from the site or its vicinity. The Wildweiberhäuschen represents a remarkable parallel to the findings from the Aschenstein cliff around 200 km to the north-east in the uplands of Lower Saxony (see below).
The well-known Late Middle Palaeolithic site of Buhlen is situated About 100 km to the northeast of Haiger in the district Waldeck-Frankenberg in north-eastern Hessia. Here, the Upper Site (*Oberes Felsdach*) produced altogether 43 shed bases of slender reindeer antlers mainly assigned to the "Mousterian" *Fundkomplex Bu-II*. Further antler remains are present as well (Jöris, 2001: 115, 163-164). This site fills the gap between the Westphalian and Lower Saxon site-clusters.

Southern Lower Saxony: Leine Valley and Göttingen Forest

The unusual finding at the Aschenstein rock formation near in the Leine Valley has been known for a long time. Initially animal remains, particularly reindeer antlers, were discovered in 1959 in a dolomite quarry at the Aschenstein cliff, and many more were excavated together with lithic stone artefacts over the succeeding years. In 1999, there were 342 basal antler remains available (Terberger et al., 2009: Fig. 11), while I was able to record 127 basal shed antler fragments in the regional Alfeld/Leine Museum in 1992 (Baales, 1996: 305-306; **Fig. 20**).

In addition to the lithic artefacts that suggest human presence at the site during the Upper Palaeolithic (Terberger et al., 2009: 99), some antler fragments provide further proof of human activity (Terberger et al., 2009: 97). One of these artefacts has been dated to ~ 12.7 kyr cal BC and indicates a Late Upper Palaeolithic age. Two more radiocarbon dates – a conventional from 1981 (Cologne; bulk sample of reindeer bones and antlers) and another from the Kiel AMS facility – confirm the presence of reindeer in the region during a later stage of the Last Glacial Maximum (ca. 21 kyr cal BC; Terberger et al., 2009: 100).

When combined, these results compare well with the evidence from the Oeger Höhle and with the findings from the Wildweiberhäuschen in northern Hessia (see above), leading to the assumption that, at least for some millennia during the late Upper Pleistocene, reindeer herds moved up the northwest-southeast oriented Leine valley to spend their summers in the uplands of southern Lower Saxony and neighbouring

Fig. 14 Bilsteinhöhle near Warstein (southern Westphalia, western Germany). Three fragments of shed slender reindeer antlers (Warstein Museum collection). – (Photo: M. Baales, 2008).

regions. Despite the small number of artefacts from the Aschenstein site, they nevertheless can be taken as evidence that, most likely, hunter-gatherers repeatedly made use of this behaviour.

The Aschenstein findings are no isolated case in this region which, at first, was emphasized by an unexpected finding uncovered in 1997 in front of the Buntsandstein rock-shelter Stendel XVIII located in a small valley at an eastern tributary to the Leine river near Groß Schneen near Friedland south of Göttingen (Grote, 1998, 1999: 226-229, 2014: 20-23). After a geological survey, a trench was cut through the valley, uncovering some faunal remains from a sandy loess layer some 0.75 m below the late Allerød Laacher See-Tephra. Besides a typical Late Pleistocene faunal assemblage, the small-scale excavation uncovered around 220 fragments of reindeer antlers, which comprised several basal specimens of shed antlers of female/subadult animals (**Fig. 21**). Some of these are claimed to display traces of human manipulation (**Fig. 22**). Radiometric measurements indicate

Fig. 15 Bilsteinhöhle near Warstein (southern Westphalia, western Germany). Further fragments of shed slender reindeer antlers (Münster University collection). – (Photo: M. Baales, 2007). – Scale approx. 1:2.

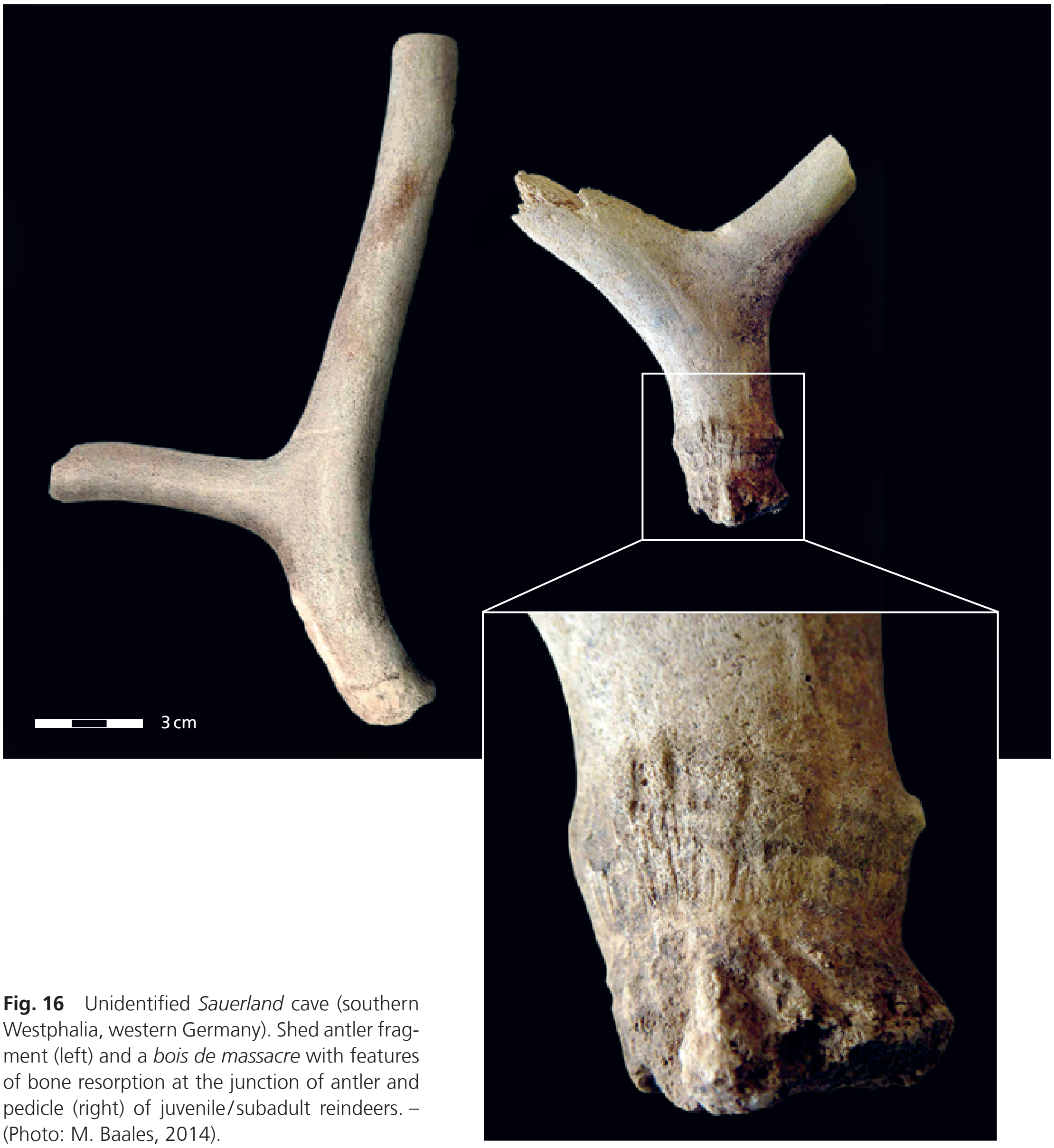

Fig. 16 Unidentified *Sauerland* cave (southern Westphalia, western Germany). Shed antler fragment (left) and a *bois de massacre* with features of bone resorption at the junction of antler and pedicle (right) of juvenile/subadult reindeers. – (Photo: M. Baales, 2014).

human habitation of the shelter during the Late Magdalenian ~ 13.2 kyr cal BC, apparently on the occasion of the spring migration of reindeer herds (Grote, 2014: 22; Terberger et al., 2009: 101).

By evaluating these and other comparable finds – there are two rock-shelters in the Garte valley near Benniehausen near Gleichen a few kilometers northeast of Friedland which also yielded collections of slender reindeer antlers (Grote, 1994: 326) and of a neonate reindeer calf uncovered below the Allerberg abri near Reinhausen (Grote, 1994: 326) – it can be assumed that, at least during the late Upper Pleistocene, reindeer herds took advantage of the Leine river valley and its tributaries during their spring migration on their way to their summer pastures in the southern Lower Saxony uplands. On their way south, the migrating herds were repeatedly intercepted by groups of hunters, as is further indicated by additional finds excavated below other rock-shelters in the Göttingen area (Grote, 1994, 1998, 1999, 2014; Staesche, 1994).

A little further to the east, slender shed reindeer antler fragments from a cave located on the south-western foothills of the Harz mountain should be mentioned here as well (Veil, 1988: 218).

Fig. 17 Feldhofhöhle near Balve (southern Westphalia, western Germany). Basal fragment of a slender *sagaie*. – (Photo: M. Baales, 2010).

GENERAL INTERPRETATION AND RESULTS

In the area considered here, from the Ardennes in the west to the southern Lower Saxony uplands to the east, there is a large amount of evidence of comparably large collections of shed antlers of female / subadult reindeer of Upper to Final Pleistocene age (**Fig. 2**). These finds are evidence for the presence of reindeer in the northern uplands during their spring migration and the warm season of the year. This seasonal pattern has been indicated even further to the east, where antlers of very young and female reindeer were reported from the Kniegrotte (Musil, 1974: 34, 44) as well as from the Teufelsbrücke (Musil, 1980: 5-6) near Saalfeld, both Magdalenian sites located in the valley system of the Saale on the northern edge of the Thuringian Forest. However, new seasonal studies for the regional Magdalenian would be of great interest[4], since the present evidence does not seem to be conclusive (cf. Höck, 2000: 35-36; Küßner 2009: 172).

The summarized evidence points towards a remarkable and diachronically rather stable migration pattern of reindeer herds between the upland summer pastures to the south and the winter pastures within the North-West European Plain to the north. This pattern seems to account for at least the Upper / Final Pleistocene of the region, i. e., over a period of tens of thousands of years. This furthermore indicates that the northern edge of the uplands can be regarded as reindeer calving grounds (cf. Murray et al., 1993). I find it highly interesting that this behaviour was re-established even after large time-gaps caused by major climatic and

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[4] In this context it would have been interesting to know whether there are any seasonal indications at hand for the Bärenkeller near Garsitz where Late Magdalenian reindeer antlers have recently been re-studied (Müller et al., 2020). Mario Küßner (2009: 30) claims that shed reindeer antlers were generally collected in the landscape by Magdalenian humans to be used as raw material. However, they are nevertheless indicative of reindeer presence during distinct seasons and should be described in more detail than has yet been done for the region. For Nebra there are indications on reindeer teeth that Magdalenian humans lived there during fall (Mania, 1999: 164).

environmental changes: As summarized above, the adaptation of people to migrating reindeer herds on their way to the northern uplands during spring season has been documented adequately for the Younger Dryas Ahrensburgian ~ 10 kyr cal BC (Baales, 1996). Similarly, this pattern appears to be applicable (at least for the Ardennes and the Lower Saxony upland ranges) for the Late Magdalenian ~ pre-12.5 kyr cal BC. But during the intermediate period, i. e., the moderate Late Glacial GI 1 which includes the Allerød Interstadial, completely different forested environments developed within the region considered here, followed by major changes in wildlife species composition (cf. Street and Baales, 1999; Baales, 2002). With the end of GI 1 the boreal forests collapsed (apparently very rapidly), and with the initial GS 1 populations of reindeer again expanded their habitats significantly to the south (including the northern upland ranges), resuming their earlier migration patterns.

Other seasonal data, particularly discussed for the Ardennes (see above), seems to be weakly supported or problematic at some points. They might also refer to scattered reindeer presence in the area during other seasons of the year or to animals gathering again to move northwards during the approaching autumn.

Fig. 18 Fretterhöhle near Finnentrop (southern Westphalia, western Germany). Basal fragments of shed female/subadult reindeer antler (left) and a *bois des massacre* of an adult male reindeer (right). – (Photo: M. Baales, 2010).

Fig. 19 Wildweiberhäuschen near Haiger-Langenaubach (northern Hessia, western Germany). View across the broad Aubach valley to the rock cliff in the back situated on the eastern side of the valley high above a small eastern tributary to the Aubach. – (Photo: M. Baales, 2020).

However, the evidence for seasons other than spring/early summer are by far less apparent than the numerous assemblages of female/subadult reindeer antlers recovered in the region mentioned here.

There are no comparable collections of antlers from reindeer bulls at all known from the region reviewed. For the northern uplands, no or only singular finds have been described or are known to me (see above), which might refer to reindeer herds that were present during the (late) summer or were on their way back northwards in autumn (or they represent artefacts). It could be argued that the large antlers of reindeer bulls, an important raw material for organic artefacts, were frequently used in the Upper Palaeolithic. However, unused bull antlers could not be found in Middle Palaeolithic horizons, nor are there any Upper Palaeolithic sites known in the area with considerable accumulations of waste remains from bull antler processing (cf. Dewez, 1987). Only very few, individual finds are available, if any at all (in the case of Trou des Blaireux: cf. Bellier and Cattelain, 1986: 56: "livré […] aucun fragment de bois de mâle adulte"; cf. Dewez, 1987: 190; Charles, 1994: 153).

When reindeer bulls shed their antlers after their rut (Germonpré, 1993: 292), the large autumn herds had already migrated from their upland summer pastures to the adjacent lowlands to the north. However, for the Central European lowlands adjoining the northern uplands, no detailed record of reindeer remains is available. In the case of the Westphalian lowlands, however, reindeer remains have repeatedly been described by palaeontologists (see 1980/1990s volumes of *Ausgrabungen und Funde in Westfalen-Lippe*), listing some *bois de massacre* and shed antlers, which were sometimes described as a representation of young adults. Besides a male antler frontlet from Greven-Bockholt dated to more than 45 kyr (Baales et al., 2019: Tab. 1) the only radiocarbon-dated example (~ 12.2 kyr cal BC) is a shed antler from a male reindeer

Fig. 20 Aschenstein near Freden (Lower Saxony, northern Germany). Pile of slender reindeer antler fragments (Alfeld/Leine Museum collection). – (Photo: M. Baales, 1992). – Scale approx. 1:2.

modified by humans from Castrop-Rauxel located some 20 km north of the Ruhr river and the northern edge of the uplands (Baales et al., 2019: 140-141). Two more examples of bull antlers could be identified as Lyngby axes, generally ascribed to the Ahrensburgian, but, unfortunately, it was impossible to date them directly by radiocarbon (Baales et al., 2019: 148-149).

Further information is available from the Flemish valley in northern Belgium, roughly 80 km north of the Ardennes. Here, reindeer remains were found, and among them were several *bois de massacre* interpreted as remains of bulls that died there after their autumn rut (Germonpré 1993, 292); some shed antlers extended the evidence for the presence of reindeer in the region into winter. A few shed antlers of females/subadult (males) are seen as a proof for the presence of young males during the winter or female animals during spring, in advance of their spring migration (Germonpré, 1993: 292). Altogether, there is evidence at hand that Upper and Final Pleistocene reindeer herds were present in the North European lowlands during the cold part of the year. This region could even have extended into what is today the southern North Sea region, which was dry land during that period (Glimmerveen et al., 2006; cf. Peeters and Momber, 2014).

When considering the topography of sites containing assemblages of female/subadult reindeer antlers, it is interesting to note that, apart from caves or abris close to the valley floor, others are located high up in the cliffs. This applies, for example, to the former Martinshöhle cave near Iserlohn-Letmathe, the Magdalenahöhle cave near Gerolstein, and the Buhlen II rock shelter. In such geomorphological settings, the presence of reindeer would normally not be expected. This leads to the question how such assemblages may have formed.

Fig. 21 Abri Stendel XVIII near Groß Schneen (Lower Saxony, northern Germany). Overview on the basal fragments of female/subadult reindeer antlers. – (Photo: K. Grote, Göttingen).

However, there are currently no new aspects available beyond what I already compiled from literature in 1996 (Baales, 1996: 100), as Klaus Grote already had done in 1994 (Grote, 1994: 326) and Thomas Terberger and colleagues in 2009 (Terberger et al., 2009: 98-99). Even if the latter favour the dominant influence of carnivores on the collections, there is, as far as I know, only one taphonomic study at hand – which was only published as a summary and is currently part of a PhD research project (Voeltzel pers. comm. 18.03.2020) – which discusses the influence of carnivore activities on some of the antler collections in depth. However, several authors (e.g., Cattelain and Voeltzel, 2000; and: Voeltzel pers. comm. 18.03.2020) claim that carnivore influence was, at best, only minimal (cf. Germonpré et al., 2013: 308). At the same time anthropogenic influence on these antler accumulations was either low or cannot be proven at all. Furthermore, I also was not able to find bite marks on the antlers I examined. On the material I have seen, the human impact was generally low (with few exceptions only: cf. Oeger Höhle or Aschenstein), although it might have been slightly higher at Abri Stendel XVIII.

This picture corresponds well with the situation at the famous Reindeer Cave in Scotland (Creag nan Uamh caves), located high above a valley. Here, a remarkable collection of slender reindeer antlers has piled up over thousands of years, but any human interference on the formation process can be ruled out completely (Murray et al., 1993). We therefore have to consider this situation as a potential kind of "blueprint" for explaining the accumulation of reindeer antler at many of the sites described above. But a satisfying model that could explain the formation of these antler accumulations remains is still lacking (cf. Cattelain and Voeltzel, 2000; Voeltzel pers. comm. 18.03.2020; this is also true for further European findings of this kind located outside of the region considered here; cf. Patou-Mathis et al., 2005; Voeltzel, 2015).

REINDEER IN THE NEUWIED BASIN

The so far oldest remain of a reindeer found in the Central Rhineland – the basal fragment of a shed antler, most likely of a female – was excavated from a rather unexpected context, the late Middle Pleistocene interglacial sediments of the so-called Kärlich *Seeufer* site (Gaudzinski, 1998: 118-119; Gaudzinski et al., 1996: 326). At that time, reindeer generally were less adjusted to cold climate than to open landscapes, which were quite common during Central European Middle Pleistocene interglacials (cf. the presence of reindeer in the late Middle Pleistocene site of Vérteszöllös in Hungary; Kretzoi and Dobosi, 1990). In the

Fig. 22 Abri Stendel XVIII near Groß Schneen (Lower Saxony, northern Germany). Reindeer fragments exhibiting possible anthropogenic marks. – (Photo: K. Grote, Göttingen).

following period, reindeer remains hardly play any role in late Middle to Upper Pleistocene find horizons containing Middle Palaeolithic lithic and faunal assemblages excavated on the East Eifel volcanoes (Turner, 1995: 309-312). Contrarily, major assemblages of red deer antlers, mainly shed specimens, were uncovered in some of the crater fillings (Turner, 1995: 286-287), which have also been described as having been arisen from natural processes, but have not yet been explained conclusively (Conard, 1992: 97-105; Turner, 1995: 290; Street, 2002: 69; cf. Vollbrecht, 2000; Wenzel, 2007). Red deer were also mentioned for both of the Neuwied Basin Gravettian sites Rhens and Koblenz-Metternich, but – if the information available is correct – reindeer, again, were of no importance (Guenther and Musil, 1993).

The picture is, on the other hand, somewhat different at the famous Late Upper Palaeolithic Magdalenian sites of Andernach-Martinsberg and Gönnersdorf, although the presence of reindeer was nowhere near as significant as the presence of horses, which was the main prey in the regional Late Magdalenian. This mirrors a major difference to the Magdalenian in south-western Germany and adjacent regions, where reindeer were far more common, if not dominant in the excavated faunal assemblages (Maier, 2015: 73). The Gönnersdorf faunal record was described in depth by Martin and Elaine (Street and Turner, 2013). According to them, only seven individual reindeer could be reconstructed; most of the finds came to light in concentration I, mostly in the form of antler fragments/artefacts and teeth jewellery. Depending on their state of wear, three teeth of young reindeer indicate an age of death of around 20-24 months; this corresponds to the reconstructed time of occupation of concentration I (Street and Turner, 2013: 129, 249). Three skull fragments still have antlers attached, but no gender distinction has been discussed (Street and Turner, 2013: 121).

Some more information on the reindeer antlers from these sites is available in Johann Tinnes' PhD (Tinnes, 1994: 47). As far as can be seen, the processed antlers at both sites are mainly shed examples (Tinnes, 1994: 223). Tinnes notes that the antler rods from Andernach tend to be weaker than those of Gönnersdorf. The width/thickness ratio for both sites ranges from 2/2.5 cm to 4/4.5 cm. For Gönnersdorf Tinnes (1994: Pl. 2) was able to reconstruct a complete antler from several fragments. Bosinski (2007: 98-99) states that the Gönnersdorf concentration I antlers were shed examples from reindeer bulls, and the weaker *bois de massacre* represent female animals. On the other hand, he assigned the latter to sub-concentration IIa as "thick *bois de massacre* from male animals killed during autumn" (*schädelechte dicke Geweihstangen von im Herbst erlegten männlichen Tieren*). The most recent excavations in Andernach (1994-1996), which uncovered the Magdalenian concentration IV, revealed the fragment of a shed antler tentatively assigned to a female/subadult reindeer. The cranial fragment with preserved pedicle belonged to a reindeer without antlers; unfortunately, the sex of this individual could not be determined (Holzkämper, 2006: 148). Based on these finds, the season of occupation for concentration IV in Andernach has been assigned to the warmer half of the year (Holzkämper, 2006: 167).

Slightly contradictory, Martin and Elaine (Street and Turner, 2013: 249) proposed a "regional absence of prey" during summer and autumn for Gönnersdorf; people therefore must have hunted reindeer elsewhere. Due to the major amount of exogenous lithic raw materials (present at both Magdalenian sites), the hunting grounds regularly visited by these bands may have been located north of the upland range. Accordingly, it could be speculated that, beside lithic raw materials, people also transported male reindeer antler rods, mostly shed antlers, as raw material supplies to the Central Rhineland.

Even though the Neuwied Basin is part of the northern Rhenish upland ranges, there is little evidence of reindeer presence during the warm season of the year and none at all for spring hunting of migrating reindeer herds, although Gönnersdorf and probably Andernach were inhabited at that season. We can only speculate about the reasons for this: were there enough food supplies from regional horse hunting available? Or did reindeer in the broad Rhine valley as well as in the area of the Central Rhine (Neuwied) Basin behave differently than further west and east in the upland ranges? Could the Lower Rhine Embayment (as a southern extension of the North European Plain) have influenced reindeer behaviour in any way? Ultimately, with the Magdalena Cave in the West Eifel and Oetrange in Luxembourg, two sites with numerous shed antlers of female/subadult reindeer are located even further south – and thus significantly deeper within the northern upland ranges – than the Neuwied Basin is.

In this context, it would be interesting to examine seasonal indicators from the Palaeolithic layers of the Lahn valley caves, located less than 50 km to the east of the Newied Basin. In the Lahn valley caves the presence of reindeer has been recorded from the Aurignacian until the Magdalenian. Among the material, shed antlers and skeletal elements of young animals are present (Terberger, 1993: 80-81, 114, 140). Or did the Late Magdalenian hunters in the Neuwied Basin simply miss or ignore the migrating herds because hunting horses in the surroundings was sufficient? We'll most probably never know.

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ÉVA DAVID · BERIT VALENTIN ERIKSEN

ANTLER TOOL'S BIOGRAPHY SHORTENS TIME FRAME OF *LYNGBY-AXES* TO THE LAST STAGE OF THE LATE GLACIAL

Abstract

The topic of this research paper is a discussion on the relevance of the sole use of absolute dating for the cultural attribution of bone artefacts. *Lyngby-axes* are an artefact-type indicative of a single culture of the Late Glacial, though radiometric dates suggest that a wider time period can be represented. It is discussed whether the direct dating of the utilised animal-based material always accurately reflects the age of the technology used to implement the artefact as a relevant cultural item. The technological approach used here points to the gathering of sub-fossil antler, targeted as a convenient raw material for this tool.

Keywords

Late Glacial, fossil antler, tool, technology, Hamburgian, Ahrensburgian, object biography

INTRODUCTION

The first Danish specimen recovered at Nørre Lyngby of a so-called *Lyngby-axe* (Fisher et al., 2013; Jessen and Nordmann, 1915; Stensager, 2004; see Degerbøl and Krog, 1959: 19, in particular "h", "i" and "p" for other possible *Lyngby-axes* from there), from the moment of discovery, served to define a new *fossil directeur* for the Late Glacial of the European Stone Age (Müller, 1901: n°1-2; Mathiassen, 1948: n°143 and 144). Perceived as bearing cultural value (Clark, 1936; Baales, 1996), this artefact-type was considered typically relevant of the Ahrensburgian archaeological culture when similarly worked antler pieces were discovered during excavations at the Stellmoor site in Germany (Rust, 1943). The original Stellmoor-publication records 46 Ahrensburgian *Lyngby-axes* from the upper horizon that date into the Younger Dryas. Only 18 specimens from this context were found again, and examined by us in the Schleswig-Holstein State Museums Schloss Gottorf. Tools made from reindeer antler resembling *Lyngby-axes* have also been reported from several Central-Eastern European settlement sites. Unfortunately, none of these tools from Eastern Europe are directly dated.

Some of the most recently published radiocarbon dates from *Lyngby-axes* (Clausen, 2004; Girininkas et al., 2016) suggest that this tool-type belongs to a chronological phase of the Late Glacial pre-dating the Younger Dryas. This contrasts with other dates from England (Gowlett et al., 1986; Jacobi et al., 2009), Southern Scandinavia (Hedges et al., 1993 and 1995; Stensager, 2006) and the South of the Baltic Sea regions (Goslar et al., 2006; Zagorska, 2012). Some of these dates are more reliable (AMS), indicating that these tools were particularly used during this r stage of the Late Glacial. The lower, i.e., Hamburgian cultural horizon of Stellmoor that dates into an earlier stage of the Late Glacial (Fisher and Tauber, 1986), provided a wide spectrum of cultural organic remains (Rust, 1943), casting doubts on the idea that *Lyngby-axes* are chronologically restricted to the Ahrensburgian, a perspective we would like to pursue in the following.

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Fig. 1 Side views of the complete *Lyngby-axe* from Ahrensburg (Rust, 1943: Fig. 56-1). – (Photo: @ Schleswig-Holsteinische Landesmuseen). – Length: 51 cm; length from back-side to bez tine's active end: 11,2 cm; thickness to the shaft: 2,9 cm; angle between the bez tine and the shaft: 89°; maximal diameter of the medallion: 4 cm.

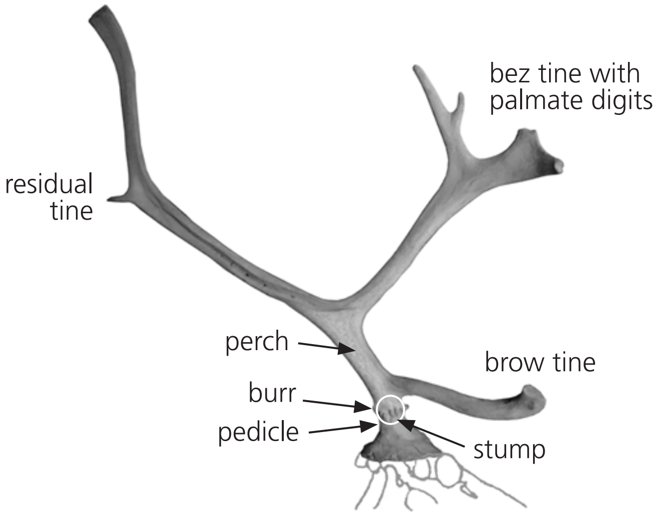

Fig. 2 Terminology used in the text on a worked frontal appendix of reindeer (unshed stag antler) in velvet from Stellmoor (Germany). – (Photo: É. David).

RESEARCH TOPIC AND METHOD

Although being used as *a fossil directeur*, *Lyngby-axes* were never properly defined as a tool-type. From the specimens we studied, the artefacts appear diverse in morphology and surface aspects, possibly due to the use of different types of antler materials or as a result of diverse uses. A recent study on marginally modified antler suggests that the relative chronological interpretation of surface modifications allows reconstruction of the artefact's biography (David and Ducrocq, in press). A comparative analysis conducted for these tools from the youngest and the oldest Late Glacial contexts was therefore considered, to test if differences in shape and/or the physical appearance of the surface (hereafter: *aspect*) would be relevant to any particular heuristic scenario. Due to the specificity of this artefact type, we assumed that the use of *Lyngby-axes* would have been either common or specific given the archaeological cultural context. We performed a 'biographical' analysis for three *Lyngby-axes.* The following specimens were studied: a tool from the Ahrensburgian from Stellmoor (Rust, 1943: Fig. 56-1), and two older specimens from the sites of Klappholz in Schleswig-Holstein in northern Germany (Clausen, 2004) and Parupé in Lithuania (Girininkas et al., 2016), both dated to the Allerød interstadial. The analysis of the latter artefacts is based on published high quality images, while the first tool was examined in person (Clausen, 2004; Girininkas et al., 2016).

The technological approach used here aims to reconstruct the tool's biography by studying how the raw-material was naturally modified and/or deliberately transformed into a tool. Therefore, taphonomical and histological variables must be taken into account when studying the shape, surface and structure of antler material to assess its initial *aspect*. Antler tool stigmata are usually examined with low magnification (from 4× up to 80×) and compared to reference collections for identification. Reconstruction of the artefact's biography takes the localisation, orientation, distribution, arrangement, and relation of observed stigmata into consideration as well as how these are patterned, contributing to the transformation of the antler in a certain order of time. The natural *aspect* of antler as raw-material for antler-tool production is known. This provides a starting point for the reconstruction of the successive "chronological events" (i.e., the palimpsest of observed taphonomical and technical patterns) as the osteological state of the animal-part can be mature or immature, fossil or fresh-collected or represent an extracted part of the

Fig. 3 Basal end of the Ahrensburgian *Lyngby-axe* viewed in cross-section. – (Photo: É. David).

raw-material: in this context antler (level 0). The observed anthropogenic-originated surfaces and traces that overlap on the recorded primary *aspect* constitute a succession of patterns ordered in steps (levels 1 to n). As mentioned above, recognised steps do not refer to human modification only, but include any other feature that characterises the object and thus, the object provides its own grid of analysis. In this way, the technological approach enables comparative analyses between the *Lyngby-axes* from the Ahrensburgian and the two older *Lyngby-axes* similar in appearance not in analogical (between comparable stigmata) but analytical terms (between comparable scenarios), on the conditions under which the osseous material modified in the course of use.

THE *LYNGBY-AXE* N°56-1 FROM THE AHRENSBURG LAYER OF STELLMOOR (GERMANY)

The piece is made of an unshed stag reindeer antler (**Fig. 1**). Antler morphology corresponds to reindeer antler uncovered at Stellmoor, described as quite large and circular (Gripp in Rust, 1943: 109, Fig. 3 and Fig. 2e) based on analyses of complete crania from the site. The antler surface of the tool is remarkably well preserved showing sinuous grooves of former blood vessels deeply imprinted on the surface, and with a remaining tuberous appearance for its highly pearled burr circle around the stump (**Fig. 2**).

The antler perch was chopped-off using the *nicking technique* and then straight-detached there from the palm in a *flexion break* (David, 2004). In transverse section, the outer antler layer is not clearly separated from the spongy inner core. In mature antler the compacta should make up about two thirds of the entire antler diameter, but seems to be missing here (**Fig. 3**). There is no other noticeable change in porosity or colour between the two different tissues constitutive of the antler. Even if the piece was obviously restored, no form of chemical modification (hypothetically from a low pH in burial conditions) can be thought of to explain that the external compacta would otherwise appear so alveolar.

This eventually attest to the fact that the antler material was not entirely calcified when the antler piece was worked, regardless of whether the antler derived from a male or female (Bouchud, 1954: 341). As the surface *aspect* of the antler appear quite alveolar even in the stump area where the antler appendix merges with the bone material from the pedicle, the complete unshed antler piece was in the process of ossification (in velvet) when the animal was butchered. This stage of growth corresponds to when the frontal appendix is heavily irrigated with blood venules and arterioles crossing from around and through the various osseous tissues (**Fig. 4**). This is before the hormonal-based yearly cycle continues with ischemia leading to necrosis and final shedding of the antler (Bouchud, 1966: 79, Fig. 39). The vascularisation through the anterogenic periosteum originally located under the velvet skin must have been still in progress, at the time the animal died.

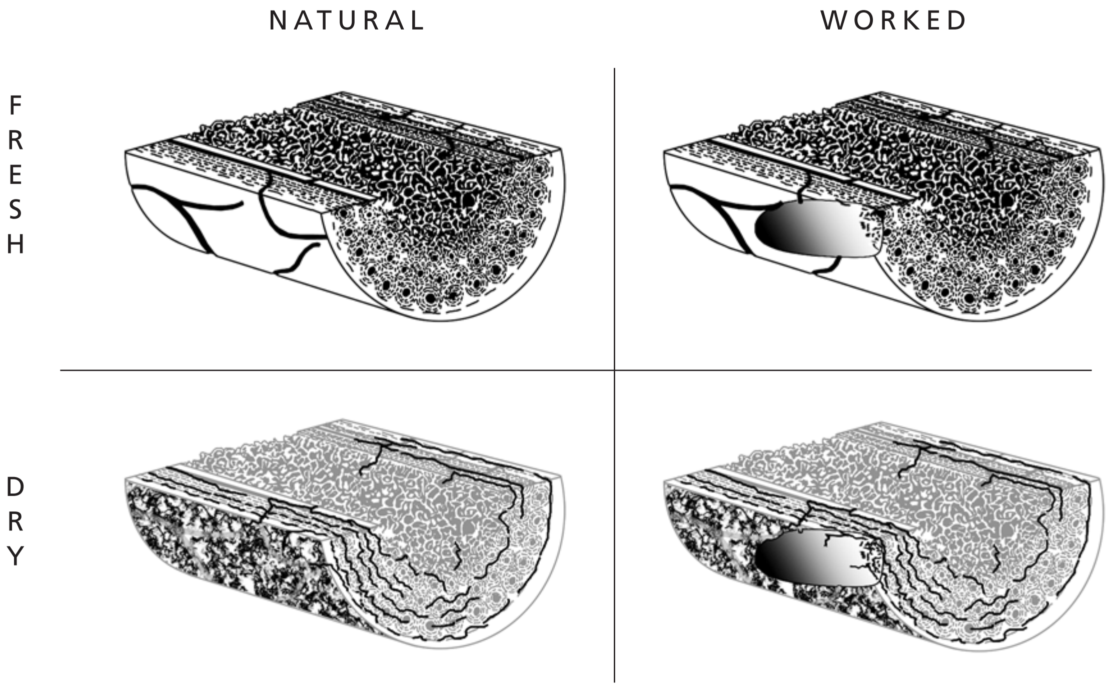

Fig. 4 The osseous (bone or antler) material consists of ${}^{1}/_{3}{}^{rd}$ trabecular hard tissue of spongy bone or spongy core that develops centrally (antler, flat bones) and at the extremities (limb and short bones). ${}^{2}/_{3}{}^{rd}$ of the material is represented by cortex or cortical hard tissue of compact bone or compacta initially protected with cellular derma and infra-derma periosteum (Bouchoud, 1966: 76). Once calcified, the compact bone is marked with prints (thick black outer lines) of former foramen and blood vessels and natural grooves through its numerous layers of *osteons* or *Haversian systems* – concentric nests of *lamellae* structures each constituted of *lacunae* and *canaliculi* (dotted circles) that encloses the central axial *Haversian canal* (central black hole) with its transverse-perforating *Volkmann's canals* (black deriving lines) – (Barone, 1986). The organic fraction of the bone reduces once the antler is shed or the animal is dead. Depending on burial and preservation conditions, desiccation lines may rapidly develop guided by the lamellar and alveolar structure of the two histological tissues, notably through their degraded interstitial (between the osteons) and circumferential parts (outer lamellae layer above the large dotted line). When worked (patch), the initial aspect of the osseous tissues used in artefact production remains in their most well-preserved surfaces, in how the distinct material precisely reflects the effects of mechanical constraints entailed in technical action. – (Drawing of mature bone viewed in axial and cross sections: É. David).

Fig. 5 Pedicle of the Ahrensburgian *Lyngby-axe* viewed from above, whose hard bone (circle), appearing as diversely vascularised (above and below dotted line), is marked from processing the frontal appendix with lithics (arrows). – (Photo: É. David).

The histology of the velvet skin differs from the cranial skin (Bouchud, 1966: 76), explaining why the pedicle appears subdivided into two zones: an upper zone with calcified bone patches (**Fig. 5**: circles) and a lower definitely ossified zone (Bouchud, 1954). The alveolar pattern is still discernable on the surface between the patches, clearly indicating that the antler including the upper zone of the pedicle was still covered in velvet skin to where it joins the cranial skin in a diffuse line almost at the bottom of the pedicle (**Fig. 5**: separation in zones with a dotted line).

This histological bi-partition of the pedicle surface is probably responsible for the different degree in which anthropogenic-originated impacts genuinely affected the bone material during working of the reindeer crania to remove the half-cranial carcass or 'trophy' (**Fig. 5**: some illustrated with arrows). In the upper (under velvet) part of the pedicle, impact marks appear torn and sunken, and as ripped into scars, whereas

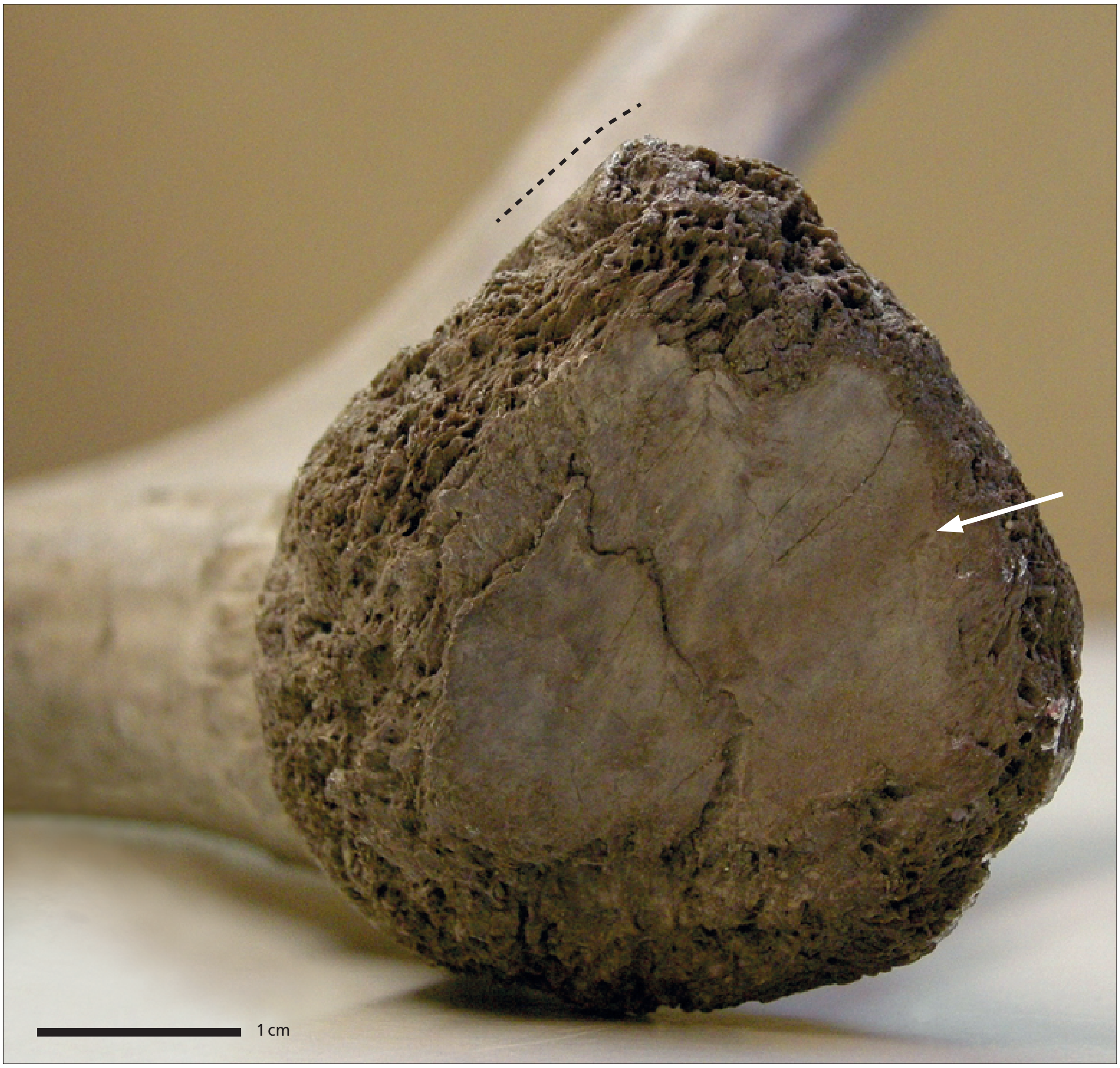

Fig. 6 Medallion-shaped skull cap of the Ahrensburgian *Lyngby-axe* viewed from its inner side, whose edge got partly smoothened (dotted line) with patinated cupule-shaped marks (one marked with an arrow) deriving from dog-gnawing. – (Photo: É. David).

in the lower zone of the pedicle impact marks are shallow and sometimes more sharply defined. Numerously observed spots with short incisions crossing each other arranged in two main rows along the edge at the bottom of the pedicle indicate similar repeated gestures, with which the front-parietal suture line had been modified. The slightly chipped-margin located below the straight-cut plane resulted from working the reindeer head or the cranium using the *nicking technique*: a lithic tool employed in direct percussion was used from the side with some precision, so that bone chips eventually detached in a mostly regular manner. The shape of these detachments developed in a row with no other distinction between worked and unworked bone parts, indicating the reindeer head was processed in fresh state (**Fig. 5**: front edge). The difference observed in the types of impacts (sunken *versus* sharp) might therefore not have been caused only by the histology of the bone matrix. It seems plausible to suggest that anatomy also determined the way the lithic

Fig. 7 Upper part of the Ahrensburgian *Lyngby-axe* viewed from a side marked with patinated cupule-shape mark (arrow) deriving from dog-gnawing. – (Photo: É. David).

cutting-edge marked the bone, where it had to be applied differently to work a narrower area of the pedicle towards the reindeer cranium. The straight-cut bone part is characterised by parallel lines and a column form, with incisions and scars above. This pattern resulted from the repeated incidental marking of the pedicle, while the front-parietal suture line was precisely aimed at, and was processed by direct percussion. Direct percussion was applied at various possible angles during repeated actions. All attest to processing for extracting the trophy rather than e.g., skinning, and perhaps also for gathering the rich proteinaceous substances from this opening of the reindeer head.

On the other side of the pedicle, the aspect of the trophy medallion suggests that the *nicking technique* was used, to shape the edge of the cranium into a regular disk-shape (**Fig. 6**). The processing was mainly from the side towards the inside of the skull cap, as shown by several occurrences of compact bone being partly torn off from the trabecular tissue. The shaped edge appears mainly brittle and with a brownish colour in the various occurring planes, all cutting through the whitish inner side of the skull cap but not always with a strict boundary.

In some places, the white patina overlaps broken parts and spongy bone parts close to where it is filled with some residual material. These cut-planes were otherwise not intensely modified. It might even be possible that their modification occurred incidentally and then were smoothed on a side (**Fig. 6**: dotted line) or crushed-in locally, as probably linked to using the piece as a tool. In their main aspect, the brownish planes appear evenly brittle as if fresh cut due to a recent damage of the skull cap from excavation or restoration techniques. However, the edge of the bone disk is genuinely ancient.

The residual material that still fills the trabecular tissue possibly acted as a protective deposit in some areas, and prevented irreversible damage to this particularly fragile edge of the disk before it eventually mostly dissolved during burial. This is indicated by the outline and colour of the un-damaged spongy bone situated in sharply indented reliefs, which would have changed colour or profile if recently altered and/or cleaned. Not altered so far with time, the regularised edge indicates the unshed antler piece was probably buried quite rapidly after the tool was used. As a consequence, the whitish "patina" on the unmodified inner side of the skull cap developed between the processing of the half-cranial carcass and when the antler was employed as a *Lyngby-axe*, most probably just after the shaping of the frontal appendix into a disk-shape. As a freshly extracted raw material, the utilisation of the piece as a *Lyngby-axe* before burial was anyway quite brief.

Gnawing marks inside the skull cap are rather white-patinated (**Fig. 6**: the largest one is marked with an arrow) as is the antler appendix of the piece (**Fig. 7**). Based on this observation, it can be argued that the white patina, as resulting here from an exposure to certain open-air conditions during a limited period of time, might have developed on the inside of the skull contemporaneously with the patina which had formed on the antler. This might have been even though scratching marks incidentally scattered across the antler surface in bands (**Fig. 8**: right side) show that one or two white-patinated layers already developed before scratching was performed by the carnivorous agent (the morphology of the gnawing marks suggests that reindeer or rodent were not the perpetrators – see Binford, 1981). Underneath the heavily damaged area the appearance of the scratches randomly changes from using the back-side of the tool depending on anatomy. Reduction in thickness due to repeated percussions by humans caused the brownish appearance of the impacted area on the back-side of the antler. Delimited towards the stump, the percussion marks

Fig. 8 Upper part of the Ahrensburgian *Lyngby-axe* viewed from the back (stump area towards the left). – (Photo: É. David).

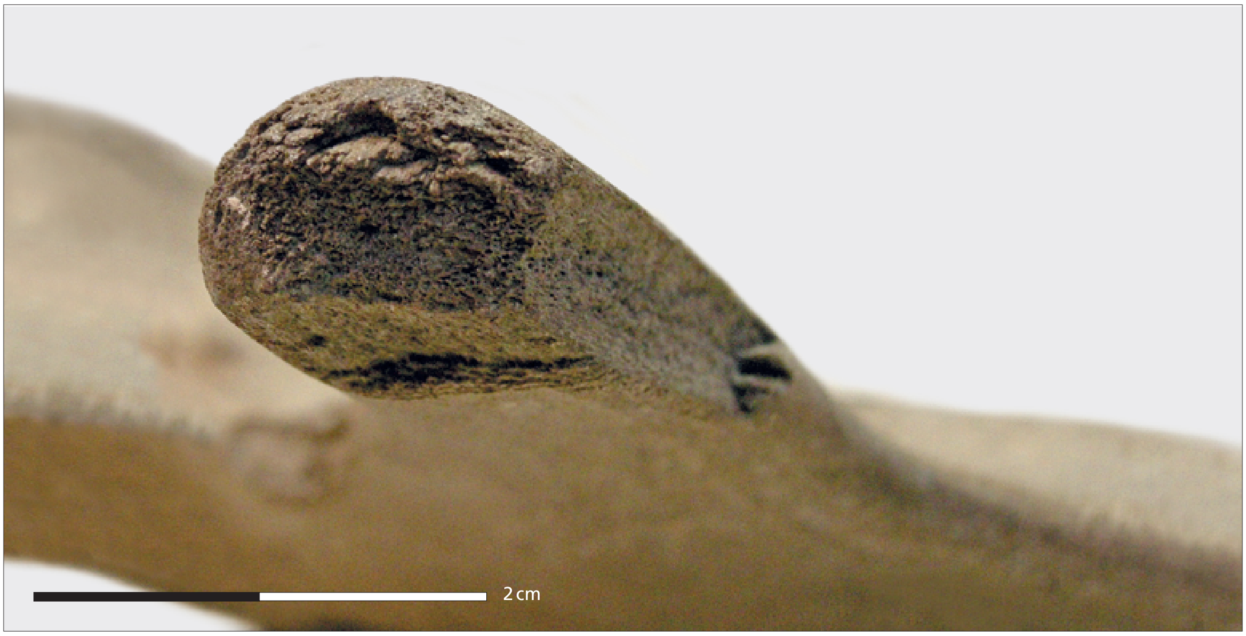

Fig. 9 Active part on the bez tine extremity of the Ahrensburgian *Lyngby-axe* viewed from above. – (Photo: É. David).

are shallower and on the impacted zone the white-patinated surface had completely been erased. This underlines that the patina must have been quite superficial, even though it probably developed in several successive planes over the antler surface (**Fig. 8**: left side).

If we agree that both the bone and the antler were anthropogenically-impacted during the same time slice, and gnawing occurred in equal patterning, the last white-patina developed on bone and antler during a short-term event, after the cranium was regularised and before the tool was last used.

The back-side of the tool, i. e., the posterior face of the antler, was subsequently transformed into a large though irregularly hatched area of randomly distributed blunt and "shiny" reliefs, sometimes sharply iterated, mainly orientated obliquely if not transversally (**Fig. 8**: middle). The deepest parts of the reliefs show a few scars singly attached to a percussion mark, regardless of their size or depth.

Sharp impacted reliefs overlay blunt or "shiny" reliefs and vice versa. These stigmata indicate that the area hatched by modifications was treated in an alternate manner using the sharp edge of a lithic tool (impacted-reliefs) and organic material ("shiny" reliefs) also as soft-hammer (club). As this off-white "shiny" use-wear pattern strictly overlaps earlier white-patinated surfaces also scratched and gnawed by the animal, it seems highly plausible that the antler was already de-velveted and in almost fully-grown condition, while partly immature in its osseous structure, when the trophy was extracted and used for a short slice of time, suggesting an interval of extraction during late summer (Bouchud, 1966: Fig. 37). The carnivorous animal was also involved in scratching the antler surface where the tool is blunt-hatched above and below percussion marks, suggesting that a dog as a companion to the hunter modified the piece in the duration of using the *Lyngby-axe*.

Repeated percussion of soft materials led to a drastic modification on the active area, which is located extending onto the bez tine (**Fig. 9**: see, the smooth reclining and crushed-in trabecular planes). Located at almost a right-angle to the main axis of the piece, the bez tine was heavily transformed, if not from the transverse removing of its digits (although this would have left no visible mark here as the bez tine may ini-

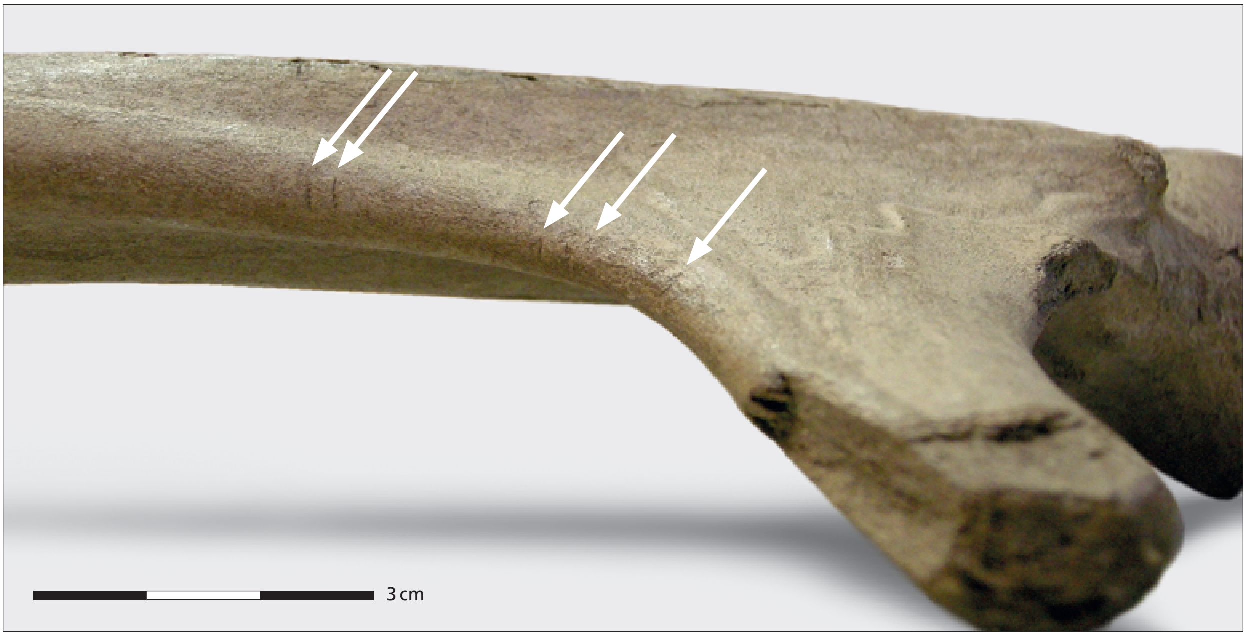

Fig. 10 Anatomical edge between the bez tine and the perch of the Ahrensburgian *Lyngby-axe* viewed from a side, with incised marks (arrow). – (Photo: É. David).

tially have been broken naturally), from using the reduced-bez tine directly as an active-part. As suggested from several long and deep damages occurring around its circumference and along both internal and upper faces, the active area was heavily peeled-off from use. These damages are slightly sinuous in their transverse profile (similar to the ventral side of a lithic blade from its prominent bulb area) and, in the lengthwise profile, their rough indented delineation indicates that a lithic artefact (the cutting-edge of a knapped blade or flake) has cut through in the axis of the alveolar tissue. Several percussion marks on the antler's natural curvature are otherwise located below, between the bez tine and the perch (**Fig. 10**).

These marks resemble one another, despite being independent in their location or orientation on this antler curvature. Thus, they probably result from a repetition of the same technical action. The reduced-bez tine was potentially used as a kind of club with a sharp lithic edge placed aplomb to the tine's main axis as an un-socketed active-end. These actions left these peeled-off damages on the tine edges as well as the below located impact marks when the percussion caused the lithic artefact to dislodge to one side.

Several differently angled scars, including the last ones, somehow truncated the active area from the side, indicating that the tool was last used in this uncontrolled manner. This is also evident from the active-area when viewed from above (see **Fig. 9**). The central area of the active-part is partially straight-split, resulting in blunt or "shiny" polish in most of its other parts where the alveolar tissue remained prominent. It seems that the two sharp sides constitutive of a lithic blade or flake had been used as a wedge on one side of the reduced-antler tine to split the worked soft materials with its other side, before hammering on the antler tool's back-side with another (wooden or antler) club. This could have led to the peeling of the bez tine, i. e., the split of soft materials leaving severe damages in return on the antler tine impacted surface. Due to the sideways sliding of the antler tool, in adjacent areas, repeated percussion led to the blunt crushing with incidental truncations and other scars on the antler curvature.

Needless to say, this heavy-duty work would have required craftsmen to perform together (there is no evidence that the lithic edge was firmly socketed to the tine). It is possible that the opposite working surfaces –

chronological events		Ahrensburgian *Lyngby-axe* n° 56-1 of Stellmoor
youngest	Level 8	antler buried as not-decayed material in cultural layer
	Level 7	antler used in direct percussion mainly (bez tine)
		antler used in direct percussion (back-side)
	Level 6	antler roughly reduced (nicking/flexion break)
		frontal appendix medaillon shaped (nicking)
	Level 5	bone/antler slightly patinated (short event)
	Level 4	bone/antler impacted (gnawing)
	Level 3	half-cranial carcasse (partly with nicking)
	Level 2	slaughtered reindeer
	Level 1	antler patinated/polished by reindeer's own action (de-velvet)
oldest	Level 0	immature fully grown antler in velvet (late summer)

▨ human agent
☐ non human agent

Tab. 1 Reconstructed biography of the *Lyngby-axe* from Ahrensburg (Rust, 1943: Fig. 56-1).

i. e., the back-side and the straight-cut bez tine – were used in the same way, though perhaps for different tasks, as the back-side offered a larger surface than the bez tine.

The damage patterns on the antler surface with impact marks and blunt or "shiny" areas are similar. These damages resulted from percussion of soft materials with a lithic cutting edge. The "shiny" convex areas are not planar as would be expected if caused by a smooth action. The soft materials worked with the *Lyngby-axe* must have been less dense (on the Mohs scale rating) than the osseous material, and it is most probable that wood was involved here. The same "shiny" appearance is evident for similarly worked planes on the pedicle. It is assumed that these modifications are caused by humans, although it is possible that these modifications are related to the reindeer scratching the antler velvet during the final period of antler growth, which may also result in some shiny polished zones on this material (Jin and Shipman, 2010). During use in percussion, the brow tine eventually snapped off, leaving a rough and familiar "shiny" area on the tool's edge, where the residual back tine would have otherwise remained.

Concerning the dynamics of use, two opposed working-ends can be recognized. The working-ends were probably in concomitant use to process soft materials (split wood) with a sharp lithic product used as an

Site	Country	Lab No.	^{14}C Age [BP]	Reference	Cal Age [cal BC]
Klappholz LA 63	Germany	AAR-2785	11,560 ± 110	Clausen, 2004	11,781 - 11,229
Parupé	Lithuania	Beta-403383*	11,170 ± 40	Girininkas et al., 2016	11,221 - 11,048
Mickelsmossen	Sweden	OxA-2791*	10,980 ± 110	Hedges et al., 1995	11,144 - 10,799
Odensee Kanal	Denmark	AAR-9298	10,815 ± 65	Stensager, 2006	10,940 - 10,750
Arreskov	Denmark	OxA-3173*	10,600 ± 100	Hedges et al., 1993	10,806 - 10,155
Mellupite	Latvia	KIA-42245*	10,399 ± 47	Zagorska, 2012	10,637 - 10,055
Earl's Barton	England	OxA-803*	10,320 ± 150	Gowlett et al., 1986	10,725 - 9,461
Murowana Goślina	Poland	Poz-15118	9,890 ± 50	Goslar et al., 2006	9,654 - 9,252
Nørre Lyngby, 7 *princeps* piece	Denmark	AAR-8919	9,110 ± 65	Stensager, 2004	8,542 - 8,233
Bara Lilla Mosse	Sweden	OxA 2793 (LUHM A)	9,090 ± 90	Larsson, 1996	8,560 - 7,966

Tab. 2 List of available AMS (*) and conventional radiocarbon dates directly obtained from *Lyngby-axes*.

intermediate piece. The back-side was used as club or soft-hammer (even to drive socket the lithic product in the bez tine of another *Lyngby-axe*). The bez tine was involved in driving the percussion. Further experiments using microscopic surface analyses are required to assign a more precise functional attribution. This is particularly true with regard to the development of the mentioned "shiny" aspect considering the relatively short duration of use (on/with frozen materials?).

As summarized in **Table 1**, the biography of the Ahrensburgian *Lyngby-axe* n°56-1 indicates that an almost fully-grown unshed stag antler was transformed when used with a lithic sharp edge as intermediate piece to work soft materials, soon after the reindeer was butchered. The tool was used as a heavy-duty tool and was then discarded and buried still in fresh state after having been used a further time.

THE "ALLERØD"-RELATED *LYNGBY-AXE* OF KLAPPHOLZ LA 63 (GERMANY), AS AFTER CLAUSEN, 2004

The *Lyngby-axe* from Klappholz is from shed stag antler that resembles the so-called "in sword" antler's natural morphology in reindeer species (Bouchud, 1966: Fig. 2-d). The piece is thought to attest to the oldest use of *Lyngby-axes* in the Late Glacial (Clausen, 2004, 152). However, this is difficult to confirm as according to our analysis, it was used as fossil antler.

The published photographs are very informative, showing that the worked parts of the antler are usually characterised by the same dark brownish colour, which distinguishes these areas from the overall white-greyish colour of the original surface (Clausen, 2004, 150). The different shades of colour derive from burial in a particular context, where weathering of the antler resulted in white-greyish colouring, and the crusted aspect of the antler surface was most evident for unworked areas. Since the marks related to the manufacture clearly overlap with the weathered natural areas of the antler in the observed intersecting planes, it seems that the osseous material was substantially degraded before the antler was used as a *Lyngby-axe*.

At the transverse-cut extremity of the perch for instance, cut-marks occur on the white-greyish upper portion of the hard tissue, resulting in scaling of the antler, and where similar cut-marks reach the underneath darker portion also made of the same hard bone tissue, resulting in shaving instead (Clausen, 2004: Fig. 6-1). This means that one technical action had different effects on the antler material depending on the stage of decay.

The overlapping of the different patterns on this single-action transverse-cut antler extremity – scaling/patinated/white-greyish turning to shaving/un-patinated/dark brownish – suggests that an extended period of time occurred between when the antler naturally decayed as a shed material, and when it was collected as a patinated antler piece to be used as a *Lyngby-axe*. Once used, the tool was buried, possibly quite rapidly. Otherwise the transverse-cut edge would also have had time to become changed and/or patinated. The hard tissue is thus either dark brown in its lower portion or white-greyish in its upper portion, with a strict boundary that precisely follows the circumferential lamellae structure of the compacta (see **Fig. 4**: fresh). The weathering effect only altered part of the piece, dependent on the differences in the otherwise unnoticeable histological composition between the outer lamellar and the inner osteonal/trabecular tissues. It is probable that the dark shade developed last, where the osseous structure was less mineralised than the discarded antler material and was subsequently discoloured in the peaty environment it was later excavated from (Clausen, 2004: 147).

The dark colouring is particularly developed in areas modified by the lengthwise- and/or sideways use of the bez tine; used surfaces occur dark only around the long blade-like edge with local striations caused by using this part of the tool in a smooth action (Clausen, 2004: Fig. 6-4). Considering the various orientations of the successive planes which constitute the long blade-like edge, which eventually merged into a single active-end, the same abrasion or repeated smooth action that was used to smooth the rough antler edges could have also been used here. Judging from the genuine white-greyish colour of the antler surface and apparent spongy core, it appears that when the antler was collected for use, the bez tine was originally truncated, having been broken in quite a straight manner in the natural state. The working-edge is therefore derived from using the antler, not from processing the antler tine as suggested in the original publication (Clausen, 2004: 149). Numerous specimens display a broken bez tine with a similar pseudo-blade shape as representing ordinary/unmodified reindeer antler material available in the Late Glacial natural environment (Degerbøl and Krog, 1959: Plate I, second row, fourth piece; Plate 1, last row, fourth & fifth pieces; Plate II, first row, first & fifth pieces; Plate II, second row, second piece; Plate II, third row, middle piece; Plate IV, last

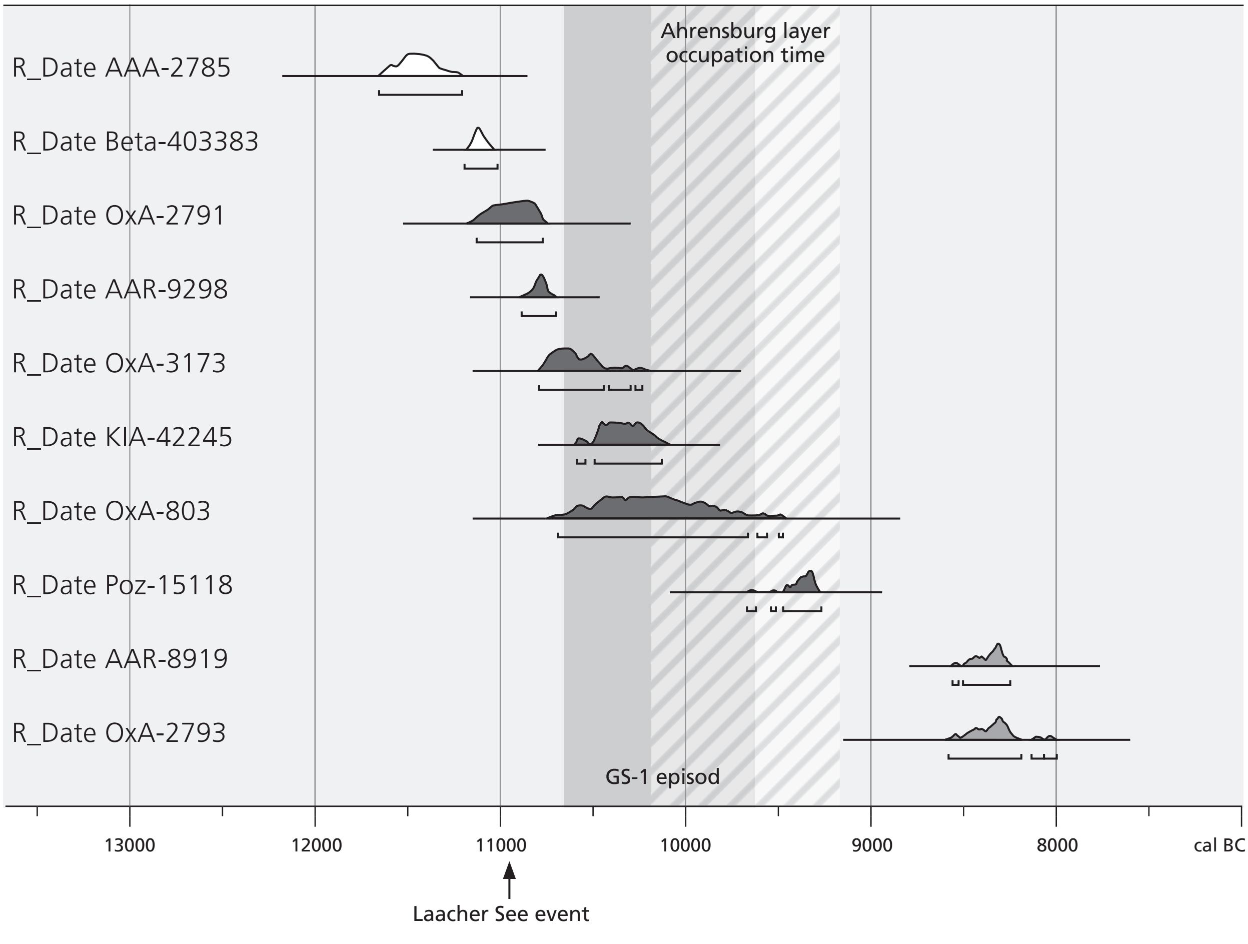

Fig. 11 Plotted available AMS (*) and conventional radiocarbon dates directly obtained from *Lyngby-axes* with presently (white) and anciently (grey) refuted range in age, which shortens time frame of *Lyngby-axes* from the Laacher See event (Baales et al., 2002) to the Ahrensburgian occupations from the Stellmoor site (Germany), mainly in the last cold GS-1 episode (grey column) from 10,750 to 9,620 cal BC (Weber et al., 2011). To plot the Ahrensburgian occupation duration at this site (hatched area), we used the nine published dates obtained from collagen material, discussed as representative in Fisher and Tauber, 1986: 11 (**Tab. 2**), dating to around 10,000 BP or 9,500 cal BC. Calibration (2σ: 95.4 %) using OxCal program v.4.4 with IntCal20 atmospheric curve (Reimer et al., 2020).

row, middle). The hunter possibly took advantage by collecting fossil antler pieces *in situ*, whose shape was close to that expected for the *Lyngby-axe*.

Although recently altered, a major scar located at the extremity of the truncation towards the perch is obviously contemporary with the use of the piece as a *Lyngby-axe*. Where smooth, the colour of the scar turns brown and is marked with three deep and short oblique scores towards a deeper and even darker area. In this precise zone, which is also the highest side of the long blade-like edge, the deepest part of the scar still displays a smooth aspect in line with the above successive planes, which are all constitutive of the long blade-like working-edge. This scored-smooth aspect might have derived from using the tool in a more radial motion, which caused the scores to develop where possibly the antler edge was less regular, with the effect of pulling out some indented part, and where the consequent scar was eventually smoothed from continuous use of the tool. Opposite the slanting smooth side, the chipped side of the scar detached, leaving a plate-like edge morphology typical for the desiccation cracks that commonly occur in dry antler. That this steep chipped edge derived from when the antler was used as a tool is evident from the white-greyish upper front, which is similarly smooth and weathered as other parts of the external surface of the piece here. This aspect of the desiccation-related plate shows that the antler desquamated during working and use. The active-edge was not altered further, excluding recent chipping on the margin of the scar, as shown by the lack of weathering in the particular deep and rough area developed in the length of the scar. So far, it was not important for the hunter to work with a fragile or dry antler raw material, as the bez tine was used for smooth actions, rather than for percussive actions. The arguments presented above show that two distinct consecutive taphonomic episodes can be reconstructed, with genuine technical events only associated with the later episode. The *Lyngby-axe* would be of a younger age than the date given by the radiometric dating of the shed antler material, as this must have starting fossilising some time before it was used. In consequence, the published radiocarbon date for the age of the *Lyngby-axe* is refuted, as it provides an age for the fossil antler only, not for its use by humans.

THE "ALLERØD"-RELATED *LYNGBY-AXE* OF PARUPÉ (LITHUANIA) AS AFTER GIRININKAS ET AL., 2016

The Parupé piece would attest to the oldest use of *Lyngby-axes* if it, too, was not directly used as a fossil antler material. This is apparent from the original publication with relevant pictures (Girininkas et al., 2016) illustrating that numerous inner desiccation lines had already occurred in the osseous structure of the shed antler when the piece was used as a tool; cracks have changed forms and/or size, and have somehow vanished locally, below the striations resulting from regularisation of the antler surface where the active-part is situated on the bez tine (Girininkas et al., 2016: Fig. 16, 21 and 22). In the case where the antler would have been shed "just" before use, e. g., in the form of sub-fossil material, worked planes and "shiny" areas on the truncated-edge (together with all the other natural surfaces of the piece) would have been altered evenly after a while. Here instead, two alteration phases can be distinguished. In phase one, the antler piece underwent a natural desiccation process and, in phase two, the anthropogenic-originated planes modified these decayed surfaces and were again affected by a further natural desiccation process. These processes affected the natural surface of the antler piece leaving two distinct patterns, that originated before and after the antler was collected including for the latter when it served as a *Lyngby-axe*. As already mentioned the first phase can be distinguished by cortical reliefs enclosing naturally developed inner splits which incidentally went downward, which then experienced flattening or surface-crushing in the second phase, regardless of their orientation or location due to working (Girininkas et al., 2016: Fig. 16, see the transverse crack). Histological canals structure the antler material and are visible in the form of tiny holes (see **Fig. 4**: fresh). These holes became inflected or obliterated by regularisation of the bez tine, causing striations which overlapped in surface and affected '*Haversian canal*' pits (if the illustrations in Girininkas et al., 2016: Fig. 14 refers instead to a close-up view of grid 1A, rather than of grid 1B; and Fig. 12 and 16, of grid 1B, rather than 1A or 2 respectively). Ultimately, black potentially manganese dots, which are distributed quite naturally on the unworked surface, look as if they have been erased, although are in fact still lightly remnant on the surface where the antler has been precisely transformed into the "blade-edge" (Girininkas et al., 2016: Fig. 13). This indicates that dots can be used to acknowledge with the un-erased ones on the original shape of the antler piece used as a collected material item. Dots form a regular pattern on the similarly slanted planes, which are all partly striated, indicating a working-edge (Girininkas et al., 2016: Fig. 12). Since these dots were not erased on the unworked panel below and laterally-located broken planes, versus erased from the above and centrally-placed worked panel, it indicates that this side of the bez tine was regularised, to form a single working-edge from a former (evenly black dotted) truncated broken bez tine. On the reverse side, the bez tine also shows that it was roughly regularised (perhaps only smoothed by use). Here, the antler tine was not shaped as a true bevelled-end tool; the inner and outer sides was planned to only converge for the use of this truncation in smooth action. It therefore seems that the shed antler piece was already provided with a singular broken bez tine when it was collected (for numerous occurrences of this kind in the Late Glacial see Degerbøl and Krog, 1959). More recently, large desiccation splits continued to develop, in parallel lines, cracking the antler material by lifting up most fragile cortical parts, including remnants of the formerly used worked plane (see Girininkas et al., 2016: Fig. 25 and 26). Based on these discussed taphonomic arguments which indicate a high degree of damage before the antler was implemented as a tool, the assumed age of the *Lyngby-axe* is refuted, with a younger age likely. This provides a useful reminder that radiocarbon dates show the age of the dead animal material, not the age of the tool.

CONCLUSION

This analysis shows that fossil antler was used as for tool production. Although taphonomic experiments that evaluate the decaying or patination time of antler have not been undertaken, the biography of the antler pieces presented here refutes the oldest time horizon proposed for tool use, and therefore restricts the time frame of dated *Lyngby-axes* to the last stage of the Late Glacial only (**Table 2**, **Fig. 11**). The consideration of other *Lyngby-axes* should be conducted in the same way, as the origin of the antler material might give new insights into human behaviour, with inference on later Late Glacial mobility patterning.

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ERWIN CZIESLA

THE LATE PALAEOLITHIC AND EARLIEST MESOLITHIC IN BERLIN-BRANDENBURG: STATE OF RESEARCH 2020

Abstract

This contribution compiles and reviews the Late Palaeolithic to earliest Mesolithic record in Berlin-Brandenburg. Emphasis is put on the extreme richness of the region in sites and finds, notably the abundancy of the – frequently – extremely well-preserved organic artefacts, which have been of significant influence on the history of research in the region. However, after decades of research, knowledge on the precise chronology of this period still remains rudimentary, given the scarcity of directly-dated objects. The potential, however, to use this material is of greatest value to establish a more data-driven chronological framework for understanding the cultural transformations from the Late Palaeolithic to the earliest Mesolithic in this region, and in surrounding areas.

Keywords

Late Glacial, early Holocene, lithic artefacts, organic artefacts, cultural continuity

PRELIMINARY REMARKS

Martin and I have maintained a friendly scientific exchange for decades. There was much discussion at the Cologne Institute, especially when evaluating Bedburg-Königshoven, when he presented initial ideas in the seminar with Wolfgang Taute. Martin has always endeavoured to record and structure the Palaeolithic to Mesolithic record from the German Rhineland, to present facts transparently and clearly in publications as in "Final Palaeolithic and Mesolithic Research in reunified Germany", which was published in the *Journal of World Prehistory,* and in which he coordinated the contributions of a total of ten authors (Street et al., 2002), and made them widely available by publishing in English – a French version of this article was published a year later (Street et al., 2003). Hardly anyone else could have done this like Martin, who also organized two meetings of the "Mesolithic Working Group" (*AG Mesolithikum*) in 1997 and 2002 in MONREPOS (cf. Cziesla, 2017a: Fig. 2). More recently, he provided an overview of the Late Palaeolithic and Early Mesolithic in the Rhineland (Street et al., 2019). Although he also referred to sites from the neighbouring regions, the focus was clearly on the area on both sides of the Rhine. Since research into this time period has also made significant progress in Berlin-Brandenburg, I take the opportunity here to provide a brief overview (**Fig. 1**; cf. **Tab. 1**) and to link this to Martin's most recent compilation (Street et al., 2019).

RESEARCH HISTORY

Research into the Late Palaeolithic of Berlin-Brandenburg has a long tradition, since – in 1844 – the Golßen pharmacist Carl Rudolph Schumann published lithic artefacts from the *Gehmlitz* (Schumann, 1844), a line

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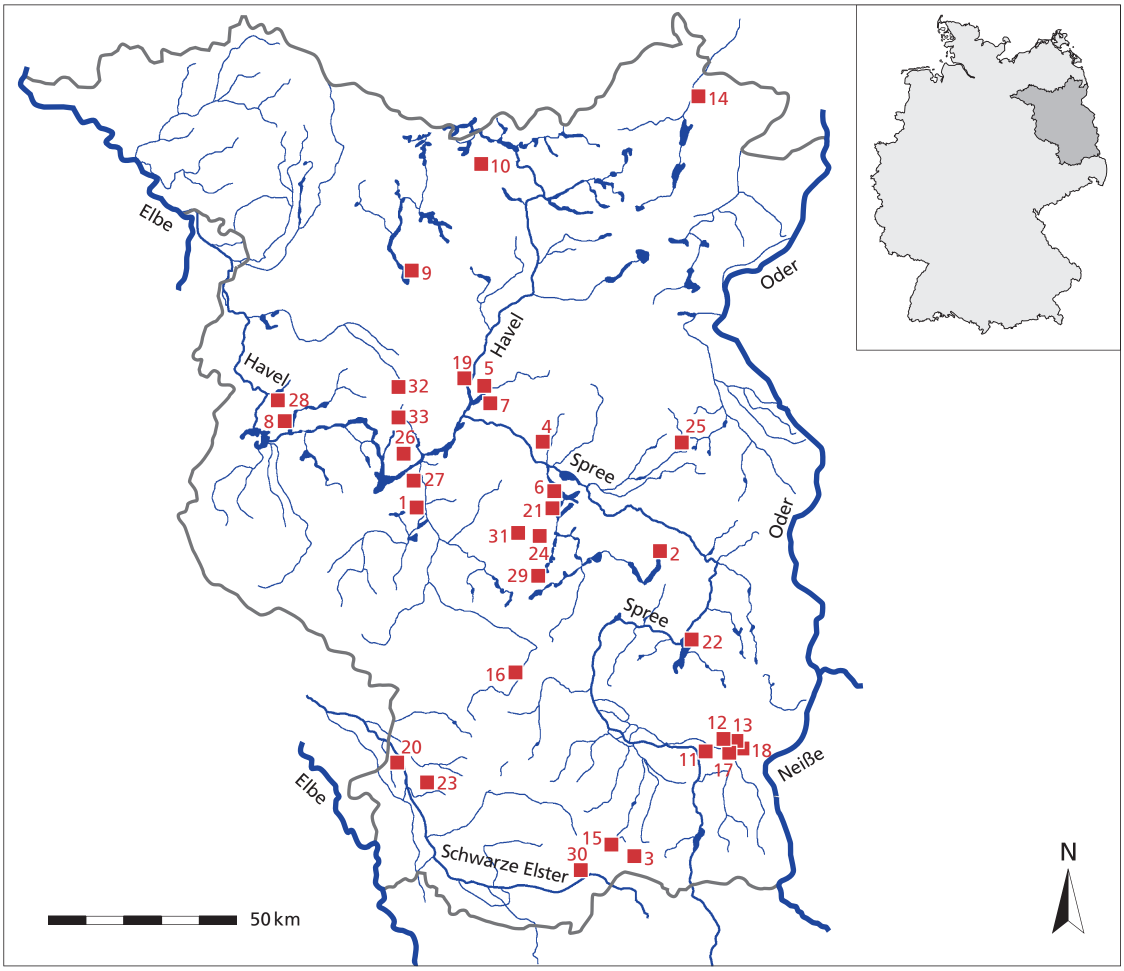

Fig. 1 The Berlin-Brandenburg region with the locations of the 33 sites listed in **Tab. 1** (stray finds were omitted due to spatial constraints).

of dunes north of Golßen (Gramsch, 2006a; **Fig. 1: 16**). As early as 1887 Albert Voß, director of *Königliches Museum für Völkerkunde zu Berlin*, and Gustav Stimming, merchant in Brandenburg ad Havel, published a splendid volume, displaying finds from the region, e.g., single and double-rowed barbed points from the *Ziegelerden* (brick earth) (Voss and Stimming, 1887: Taf. 4). This splendid publication contained a foreword by Rudolf Virchow, stating: "Prehistoric antiquities appear in large numbers, widespread across the entire Brandenburg region". Until today, no other region in Central Europe has produced a comparably high number of Late Palaeolithic and Mesolithic bone and antler artefacts, characterized by their large typological diversity and their – in most cases – excellent preservation. That so many organic finds could be secured was due to the fact that the clay used in bricks for building metropolitan Berlin was extracted by hand. The Havel and Spree rivers were also widened, which led to numerous finds. Collections were emerging everywhere, and one of those busily collecting was the physician Richard Stimming, son of the aforementioned merchant (research history in: Cziesla, 2000), who also published finds (Stimming, 1917, 1928). In this context, Eduard Krause's study of prehistoric fishing equipment is of relevance, because he saw the use of most Palaeolithic projectile points based on ethnological comparisons in connection with aquatic hunting (Krause, 1904: 31 ff.; cf. Kozłowski, 1981; cf. Cziesla, 2007a, 2018 regarding seasonal seal hunting).

The Late Palaeolithic region of Berlin-Brandenburg is not only characterized by individual finds of bone and antler, but also by extensive sites with lithic artefacts. The area south of the Tegeler Fließ riverlet in particular has produced Late Palaeolithic lithic artefacts since 1953. In Berlin-Tegel (**Fig. 1: 7**) an area of more than 3,000 m^2 was excavated, unfortunately applying less profound excavation techniques than would be used today. In 1955/1956, 21-year-old Wolfgang Taute, a student in Kiel, took a look around at the site, finding two tanged points. He also drew two tanged points from Berlin-Biesdorf (**Fig. 1: 4**) for an article by

No.	Period	Site	References
1	CBP/TP	Ahrensdorf	Pratsch, 2006
2	CBP/TP	Bad Saarow, Seestr.	Beran and Hensel, 1999
3	?	Bergheide, Tagebau Klettwitz	Cziesla, 2008b
4	TP	Berlin-Biesdorf	Reinbacher, 1957; Taute, 1968
5	CBP	Berlin-Lübars	Mey, 1967a
6	TP	Berlin-Schmöckwitz	Mey, 1961
7	CBP/TP	Berlin-Tegel	Taute, 1957; Mey, 1958, 1962; Taute, 1963; Sembach, 1973; Probst, 1989; Gelhausen et al., 2004, 2005
8	e-MESOL	Brandenburg-Mauseberg	Rothert, 1941; Cziesla, 2008a
9	TP/e-MESOL	Bützsee (near Altfriesack)	Cziesla, 1999a, 1999b, 2000, 2018; Cziesla and Pettitt, 2003
10	CBP/TP	Burow bei Gransee	Gramsch, 1973; Heußner, 1988
11	CBP/TP	Cottbus – Dissenchen 11	Kayser, 1999
12	TP	Cottbus – Groß Lieskow	Pasda, 1999; 2002a
13	CBP	Cottbus – Klein Lieskow 120	Pasda, 2001; 2002b; Neubeck, 2019
14	TP	Dauer II	Cziesla, 2019
15	?	Finsterwalde, Tagebau Klettwitz	Wechler, 1988
16	CBP	Golßen "Düne Gehmlitz"	Gramsch, 1969, 2006a; Winkler, 2010; Cziesla, 2012
17	TP	Grötsch 8	Stapel, 1997, 2000, 2001
18	TP	Heinersbrück 45 (Malxe-Tal)	Alves, 2001; Steinmann, 2003; Cziesla, 2008b
19	CBP	Hennigsdorf	Kloss and Wechler, 1987; de Klerk, 2006
20	TP	Herzberg, Apitz collection	Geupel, 1971, 1987
21	CBP	Königs Wusterhausen, harbour	Cziesla, 2002b
22	CBP/TP	Leißnitz-Sarkow, Schwielochsee	Barthel, 1975; Christl, 1988
23	e-MESOL	Malitschkendorf	Geupel, 1987; Cziesla, 2009
24	CBP	Mittenwalde	Mey, 1967b
25	TP	Münchehofe	Hohmann, 1927; Gramsch, 1957, 2003
26	CBP/TP	Potsdam-Bornim, Gutsdomäne	Hensel, 2019
27	ini-MESOL	Potsdam-Schlaatz	Benecke et al., 2002
28	TP	Pritzerber See	Cziesla, 2001a, 2002a
29	CBP/TP	Rehagen, Am Mellensee, Fdpl. 13	Winkler and Breest, 2016
30	CBP	Senftenberg "Bärengasse"	Cziesla, 2008b
31	TP	Telz, Fdpl. 9	Taute, 1968; unpublished collection of family Berger
32	ini-MESOL	Wustermark 22	Beran, 2001; Beran and Kurzhals, 2002; Hanik and Jahns, 2006; Hanik, 2009; Gramsch and Beran 2010; Gramsch et al., 2013
33	TP	Zeestow 4	Schwarzländer, 2009; Eickhoff, 2009; Cziesla and Pratsch, 2017

Tab. 1 List of the sites shown on the map in **Fig. 1**. The abbreviations in the second column refer to: CBP Curved backed point industries; CBP/TP assemblages with curved backed points and tanged points; TP Ahrensburgian tanged point industries; e-MESOL earliest Mesolithic with large blades; ini-MESOL initial Mesolithic without characteristic tools; ? unclear age.

Erwin Reinbacher (Reinbacher, 1957). In the same year a short contribution on Berlin-Tegel followed (Taute, 1957).

The excavations at Berlin-Tegel were likely the reason Wolfgang Taute became interested into the Late Palaeolithic. It took, however, around three decades for the location to be published. In her monograph, Barbara Probst was able to analyse ten camp sites of the backed point groups and at least three concentrations with tanged points (Probst, 1989). She suspected that the find concentrations resulted from open-air activities, but Frank Gelhausen, Jan F. Kegler and Stefan Wenzel (Gelhausen et al., 2004, 2005) now consider it possible that at least the "Berlin-Tegel IX" concentration was covered with a tent, given the compact find scatter limited by a barrier or wall effect. The site is of fundamental importance for research on the Late Palaeolithic period in the Berlin-Brandenburg area, even if questions regarding site formation remain unanswered. Why the site was not even mentioned in a recent compilation of the Late Palaeolithic in North-eastern Germany (Groß et al., 2019) remains incomprehensible.

Wolfgang Taute remained devoted to this region and to this period, and continued working on the *Federmessergruppen* (curved backed point industries; Taute, 1963) and *Stielspitzengruppen* assemblages (tanged point industries; Taute, 1968), as well as on a summary in the "Historical Hand Atlas of Brandenburg and Berlin" (Taute, 1980). Prior to this, Werner Mey – who also published on Berlin-Tegel and conducted several excavations on this site (Mey, 1958, 1962) – summarized the finds from Brandenburg, drawing attention following a contribution which appeared in "Quartär" (Mey, 1960). In the years that followed, Bernhard Gramsch published compilations of the Late Palaeolithic record of the region (Gramsch, 1981, 1987, 1988, 1989, 2004) and, later, I also contributed, by discussing the beginnings of regional history, and presenting the first distribution maps for sites of the *Federmessergruppen* (Cziesla, 2001a) and of the *Stielspitzengruppen* (Cziesla, 2001d). Numerous new finds resulting from the extensive excavation of Late Palaeolithic sites, in particular in the Lusatian lignite mining areas looked after by Eberhard Bönisch, made updating my two maps necessary.

The site of Heinersbrück 45 (**Fig. 1: 18**), for example, produced half a dozen concentrations and alleged pit features (Poppschötz, 2001; Poppschötz and Steinmann, 2001), as were also assumed to have existed at Berlin-Tegel, however their interpretation as resulting from tree windthrow features appears more likely (detailed in: Cziesla, 2017b: 77-82). Also of relevance are publications on site preservation and dune formation within the region (Bittmann and Pasda, 1999; Krauskopf and Pasda, 1999; Kühner et al., 1999; Pasda, 2003, 2007) and the uncovering and exploration of a Late Palaeolithic forest in the Cottbus-North opencast lignite mine (Gautier, 1999, 2001).

THE BEGINNING OF THE REGIONAL HISTORY OF NORTH-EASTERN GERMANY

The beginning of the region's history was often discussed, referring to alleged finds attributed to the Hamburgian (e. g., Terberger and Lübke, 2005), but so far none of the discoveries have been convincing (Cziesla, 2004a; detailed discussion in: Cziesla, 2019: 76-80; most recently: Winkler and Breest, 2016: 58). The lowland region of North-eastern Germany was probably uninhabitable for animals and humans for a long time after the glacial maximum (Tromnau, 2006).

The situation might be different in Upper Lusatia, where two lithic workshops near Finsterwalde were identified (**Fig. 1: 15**; Wechler, 1988), although lacking characteristic tool types. These may point to the south,

Fig. 2 Selected organic artefacts, of which numbers 1-3 have already been published by Voß and Stimmig in 1887 as line drawings, shown here for the first time in a single photo together with other organic artefacts form:
1 Gortz; **2, 4** Pritzerber See; **3** Göttin near Töplitz; **5** Deetz.

Fig. 3 Particularly striking objects from Brandenburg. **1** Gortz; **2** Pritzerber See; **3-4** stray finds from Havelland, west of Berlin (cf. Cziesla, 2004a); **5** Wustermark; **6** Ferchesar. The unusual bone knife with hafting grooves on the base (5) may be of Late Palaeolithic age, however, lacks a direct date.

Fig. 4 Heinersbrück 45. Lithic find scatters of the 2000/2001 excavation of the site, with what appear to be alleged pit features of Late Palaeolithic age. – (Modified from Steinmann, 2003).

where, at 65 km distance, at Burk near Bautzen a Magdalénien site is known (Brandt, 1960). The same problem applies to the flint mining site of Bergheide (**Fig. 1: 3**; Cziesla, 2008b). In addition, a very thin projectile point made of antler(?) from Bützsee (**Fig. 1: 9**) closely resembles Magdalenian points (Cziesla, 2001c). However, none of these finds give definitive proof for an early occupation within the region. We therefore have to conclude, that Brandenburg, together with Berlin and Mecklenburg-Vorpommern, probably has the shortest history compared to the other federal states of Germany. Recolonization after the last glacial maximum only took place as late as the second half of the Allerød interstadial warming period (from approx. ~ 11,700/11,500 cal BC; Cziesla, 2019: Abb. 87; cf. Maier et al., 2020), when Brandenburg became a kind of "paradise" for hunters and gatherers. Hardly any other region in Germany has produced so many sites, and nowhere in Europe are there organic finds of comparable quality (**Figs. 2-3**).

THE LATE PALAEOLITHIC IN BERLIN-BRANDENBURG

Numerous sites of the late Allerød *Federmessergruppen* are known from the region. Among these, the 360 m² excavation area of Cottbus-Klein Lieskow 120 (**Fig. 1: 13**) with three artefact concentrations and a preserved fishing hook (Pasda, 1999; Neubeck, 2019) is worth mentioning, as are the aforementioned sites of Berlin-Tegel (**Fig. 1: 7**) and the site of Golßen, excavated by Bernhard Gramsch in 1968 (published by: Winkler, 2010). What is particularly striking are the assemblages that contain both *Federmesser* (curved backed points) and tanged points. It is easy to argue for a later intermixing of materials ("palimpsests"). However, the combination of these two tool types on the same locality is so common in Brandenburg (compilation in: Cziesla, 2008b: Tab. 1) that I stated a few years ago that such assemblages are presumably to be placed at the beginning of the Ahrensburgian (cf. Gerken, 2000: 44), contribution to the accumulating evidence for more than three millennia (!) of cultural continuity in Lusatia, that is rooted in the Magdalenian and continued through the backed and tanged point industries into the Mesolithic (Cziesla, 2008b).

Sites with tanged points that date into the subsequent Younger Dryas cold period (~ 11,800-9,600 cal BC) are also frequent, and here the site Heinersbrück 45 (**Fig. 1: 18**) – where in 2000/2001 at least four lithic artefact concentrations (**Fig. 4**) and a dozen tanged points (photo in: Cziesla, 2008b: Fig. 47) were screened out of an area of approximately 450 m² – deserves mention.

In addition to these sites, it is undoubtedly the organic finds that characterize the Late Palaeolithic in Berlin-Brandenburg and make the region in Europe – this superlative can be applied without hesitation – unique! The latest extensive discoveries of Late-Palaeolithic and Mesolithic organic artefacts resulted from the so-called Wublitz-Rinne northwest of Potsdam, including – amongst many others – finds from Wustermark, Buchow-Karpzow and Hoppenrade (Schütrumpf, 1939; Hoffmann, 1941; Gramsch, 1965). Then, for decades, new discoveries became rare (Cziesla, 1999b). This changed abruptly with the discovery of three new sites at Bützsee (**Fig. 1: 9**) south of Neuruppin in 1995, at Wustermark 22 (**Fig. 1: 32**) in 1998/1999, and at Zeestow 4 (**Fig. 1: 33**), where a total of 722 m² were extensively examined under groundwater-level in 2006/2007.

Site	Sample Material	Lab-Code	^{14}C date [BP]	Age [cal BC]	Reference
Wustermark 22	wild pig, upper forelimb	KIA-32463	11,719 ± 45	11,620 ± 140	Gramsch and Beran, 2010
Bützsee	double-rowed barbed point	OxA-8742	10,480 ± 75	10,519 ± 218	Cziesla and Pettitt, 2003
Wustermark 22	wood fragment	Bln-5646	10,389 ± 57	10,280 ± 280	Gramsch and Beran, 2010
Wustermark 22	bone fishhooks	Ua-24701	10,370 ± 75	10,240 ± 240	Gramsch and Beran, 2010
Bützsee	Type-2 Duvensee point	OxA-8743	10,185 ± 65	9,901 ± 223	Cziesla and Pettitt, 2003
Wustermark 22	wood fragments	Bln-5645	10,050 ± 80	9,605 ± 285	Gramsch and Beran, 2010
Bützsee	double-rowed barbed point	OxA-8841	10,020 ± 60	9,549 ± 166	Cziesla and Pettitt, 2003
Wustermark 22	decorated elk antler tool	UA-20962	10,005 ± 70	9,575 ± 285	Gramsch and Beran, 2010
Potsdam-Schlaatz	partial aurochs skeleton	KIA-9562	9,979 ± 57	9,455 ± 155	Benecke et al., 2002
Potsdam-Schlaatz	wild pig ulna	KIA-9563	9,956 ± 54	9,440 ± 160	Benecke et al., 2002
Potsdam-Schlaatz	partial aurochs skeleton	KIA-5665	9,936 ± 40	9,440 ± 160	Benecke et al., 2002
Potsdam-Schlaatz	wild horse, mandible	KIA-9565	9,903 ± 52	9,320 ± 70	Benecke et al., 2002
Potsdam-Schlaatz	red deer metacarpal	KIA-9564	9,601 ± 639	8,990 ± 180	Benecke et al., 2002
Wustermark 22	wild horse bones	Ua-24799	9,135 ± 75	8,400 ± 160	Gramsch and Beran, 2010

Tab. 2 List of Late Palaeolithic and earliest Mesolithic ^{14}C dates from Brandenburg.

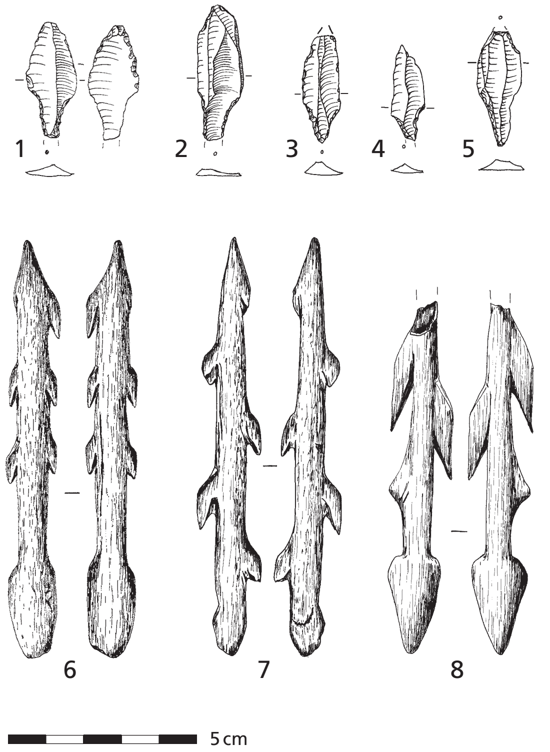

Fig. 5 Ahrensburgian tanged points (**1-5**) and biserially barbed harpoons (**6-8**) from Bützsee near Neuruppin. The biserially barbed point with small barbs (6) was directly dated to 10,519 ± 218 cal BC (OxA-8742); the harpoon head with shield-shaped base (8) was dated to 9,549 ± 166 cal BC (OxA-8841). – (After Cziesla and Pettitt, 2003).

During the mechanical deepening of a channel of Lake Bützsee south of Neuruppin, lake sediment was pumped onto rinsing fields laid parallel to the lake. Employees of the *Untere Denkmalschutzbehörde* (Local Monument Protection Authority) secured numerous finds from the northern rinsing field (Schmidt and Schwanz, 1996). More systematic find recovery was carried out by the "Wurzel Archaeological Company" and later by the district authorities. Since the numerous organic finds were to be dated, Paul Pettitt and I submitted an application to the NERC (Natural Environment Research Council in Swindon, UK) to cover the costs of dating an initial selection of eight samples at the Oxford University Radiocarbon Accelerator Unit (Cziesla and Pettitt, 2003). Due to the excellent preservation of the finds, dating efforts expanded to the measurement of several dozens of further samples at the Oxford laboratory, but authorities from the *Brandenburgisches Landesamt für Denkmalpflege*, responsible for the collections in Brandenburg, and from the *Museum für Vor- und Frühgeschichte* in Berlin denied access to sample the organic materials. This decision has set back research on the Late Palaeolithic and Mesolithic in north-east Germany by decades, and to this day the age of all organic finds of this time exhibited in Berlin-Brandenburg museums – apart from finds from Bützsee and Wustermark 22 (**Tab. 2**) – remains entirely unknown. Of the eight dated Bützsee finds, three are of Late Palaeolithic age, suggesting that the early Mesolithic points of the "Duvensee type 2" originates from the Late Palaeolithic (for criticism of this view, cf. Groß et al., 2019: 471). In addition to organic projectiles, typical Ahrensburgian tanged points were also found at Bützsee (**Fig. 5**), for the first time associated with the biserially barbed harpoons that have generally been attributed to the Ahrensburgian (Taute, 1968).

As in Bützsee, unusually well-preserved projectiles were recovered at Zeestow 4, located directly on the River Havel, including a biserially barbed point with a length of 21 cm and 21 (!) barbs (Schwarzländer, 2009: Fig. 35). Not only are the numerous organic projectile points awaiting direct dating, but there are also dozens of wooden stakes, which have been interpreted as the remains of fish weirs.

And, in addition to the organic equipment and the hunting fauna from Wustermark 22, an elk antler decorated with zigzag engraving was also found (**Fig. 6**), dated to around 9,575 cal BC, at the Palaeolithic/Mesolithic transition (Beran, 2001). The lithic artefacts from this site, however, cannot be assigned to a specific technocomplex.

The importance of direct dating of individual finds is highlighted by the early dates for wild boar bones (**Tab. 2**) from Wustermark 22 and Potsdam-Schlaatz (Hanik, 2009). Notably in order to improve our knowledge of the age of organic finds, of course, many more samples should be dated. Despite these problems, the systematic recording of organic finds from Berlin-Brandenburg has been continued. In the meantime, all thrusting lances (Cziesla, 2000), fish hooks (Cziesla, 2001b; Pasda, 2001; Gramsch et al., 2013), spindle-shaped bone points (Gramsch, 2006b), reindeer antler hoes (Cziesla, 2007a, 2018), biserially barbed harpoons (Cziesla, 2007a, 2007b, 2018) and part of the uniserially barbed harpoons (Cziesla, 2002a, 2004b) were recorded without knowledge of their age. Given this state of research, a large-scale dating project is needed (cf. Cziesla and Pratsch, 2017). Neither should the lithic artefacts be forgotten. They also may

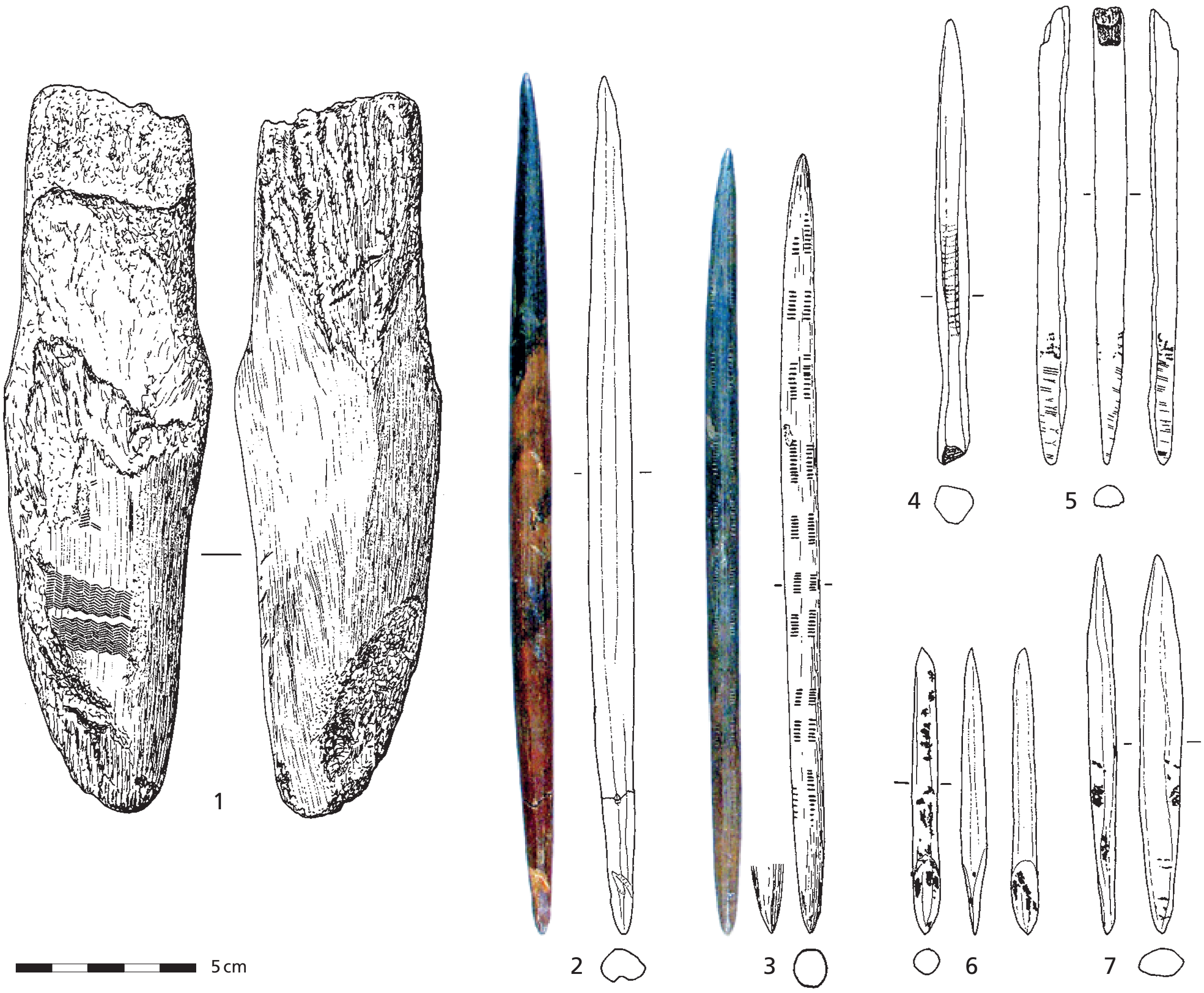

Fig. 6 Wustermark 22. **1** decorated elk antler tool; **2-5** bone points marked by line bundles; **6-7** bone points with hafting tar residues. – (After Gramsch and Beran, 2010).

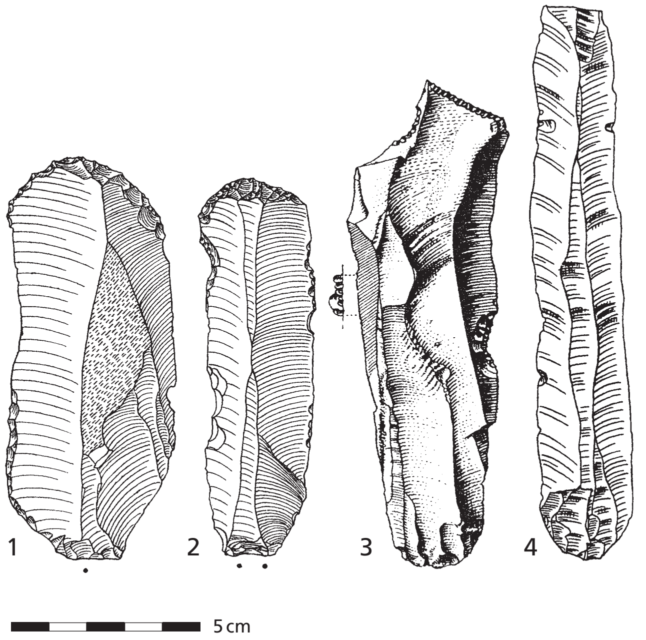

Fig. 7 Long blades from the Brandenburg region which may belong to the "Long Blade technocomplex". **1-2** Malischkendorf; **3** Mauseberg, Brandenburg city; **4** Golßen. – (1-2 after Geupel, 1987; 3 after Rothert, 1941; 4 after Gramsch, 2006a).

point at a long-lasting continuity from the Late Palaeolithic to the earliest Mesolithic. Large blades from Malischkendorf (**Fig. 1: 23**; **Fig. 7: 1-2**; cf. Geupel, 1987) of 100 mm and 97 mm length, from the Mauseberg in the city of Brandenburg (**Fig. 1: 8**; **Fig. 7: 3**; cf. Rothert, 1941) with a length of 120 mm, and from the Golßen site (**Fig. 7: 4**; cf. Gramsch, 2006a) with a length of 138 mm, could belong to the "Long Blade technocomplex" that dates at around the Pleistocene-Holocene boundary at around 9,600 cal BC. And this not only indicates a certain continuity from the Late Palaeolithic, but would also expand the spread of this technocomplex ("giant blades") – located more in the northern French and southern English region – considerably to the east (cf. Cziesla, 2015: 32 f.).

Despite all the progress in the years since the compilation by Martin Street and colleagues (Street et al., 2002), a sentence of Werner Mey still applies, especially in view of the lack of dating of the organic tools, with numbers going into the thousands, and which are largely published in preliminary reports only (only Golßen and Klein Lieskow 120 have finally been published): "Until today, research into the Late Palaeolithic and Mesolithic cultures of the Mark Brandenburg has not yet reached much beyond an initial stage, even though the area between the Elbe and the Oder rivers […] delivered a wealth of artefacts of all kinds" (Mey 1960: 1).

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THE MESOLITHIC “MULTIPLE BURIAL” OF GROSS FREDENWALDE REVISITED

Abstract

Palaeolithic and Mesolithic burials are rare discoveries in the archaeological record, and frequently receive special attention. As seen for the Late Palaeolithic burial(s) from Bonn-Oberkassel, reconstruction of the burial context can be difficult when they have been unearthed during old excavations, due to differing documentation standards. Here we present results from new investigations at the Mesolithic burial(s) from Groß Fredenwalde, which were poorly documented after their accidental discovery in 1962. New evidence from archival research combined with results from anthropological studies and ^{14}C-dating provided a new perspective on the original burial context. The results show that re-examination of old finds offer new perspectives, but these come paired with methodological pitfalls in the interpretation of double and multiple interments.

Keywords

Mesolithic, Groß Fredenwalde, multiple burial, double burial

OF DOGS AND MEN – INTRODUCTION

Burials are among the most fascinating features of Palaeolithic and Mesolithic archaeology. Martin Street has participated in and organised important excavations at Palaeolithic and early Mesolithic sites in the Rhineland, including Gönnersdorf, Andernach, and Bedburg-Königshoven. These Magdalenian and *Federmesser* sites allowed essential new insights into Late Glacial settlement structures and lifeways. However, burials were not preserved at these sites (Street et al., 2006). The search for the “Mann unter dem Bims”, an idiom for a potential skeleton preserved under the tephra of the Laacher See eruption (ca. 10,950 cal BC), became a never-ending quest for all colleagues working in the Neuwied Basin.

Martin, with his expertise in faunal analyses, gained scientific access to the famous burial of Bonn-Oberkassel found in 1914, where he re-analysed the dog remains. His study contributed to a better understanding of the double burial (e. g., Street, 1995, 2002; Henke et al., 2006; Street and Jöris, 2015; Street et al., 2015). Based on the revised chronology the burial, formerly associated to Magdalenian contexts (e. g., Bosinski, 1982; Wüller, 1999), added insight to the Late Glacial cultural sphere of Central Europe. Today, the burial is assigned to ca. 12,000 cal BC and thus to the early *Federmessergruppen*.

The dog remains are a valuable testimonial, illustrating the special relationship between humans and dogs that already existed at that time. Today, the grave good of a carving of a cervid represents an important contribution to the record of Late Palaeolithic art (e. g., Giemsch et al., 2015; Veil et al., 2012).

Because of the poor initial documentation of the burial, the original find situation in 1914 is not entirely clear. According to Orschiedt (2018: 2) “it has to remain unclear whether Bonn-Oberkassel was a double burial or two single burials in close proximity to each other”. The red-stained bones of both individuals indicate that both individuals had undergone the same ritual during inhumation and hence might signal a double burial.

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Another Late Palaeolithic "burial" was found in Neuwied-Irlich. In 1953, human bones probably belonging to four individuals (one adult, two children and a newborn) were collected from a secondary context. The bones were also dated to the Late Glacial period (ca. 12,500-11,900 cal BC). As their original find context is unknown, the number of Late Palaeolithic burials destroyed at Neuwied-Irlich remains unclear (Orschiedt et al., 2017).

The same problem applies to a number of Mesolithic burials in the region considered here (**Fig. 1**). It was a great surprise when Erik Brinch Petersen published a new burial from Strøby Egede on Zealand (Denmark) dating to the middle Ertebølle period (ca. 4,800 cal BC) (**Figs. 1-2**; Brinch Petersen, 1988, 1990). This unique late Mesolithic burial comprised no less than eight skeletons in a pit measuring ca. 2 m × 1 m.

Fig. 1 Map of Mesolithic burial sites. – (After Terberger et al., 2015).

Fig. 2 The multiple burial of Strøby Egede, Zealand (Denmark). – (Photo: Danish National Museum Copenhagen).

The cause of death of these individuals remained unclear. The skeletons were closely arranged in various postures. Sex determination, though not always possible, showed that males and females were oriented in opposite directions with the heads of males towards the North and the heads of the females towards the South. There is little doubt that the two adults (male and female) and the six children belong to the same context, and according to Brinch Petersen (1988: 124) they had died and were buried at the same time. But is this really the case?

Brinch Petersen compares the record from Strøby Egede to a supposedly similar burial in Germany, burial I at Groß Fredenwalde, Brandenburg, where in 1962 several individuals were found. An ongoing research project funded by the German Research Council[1] sheds new light on this unusual Mesolithic burial site within its Stone Age networks and traditions. The project adds new information on the problematic identification of multiple burials, which is the focus of the current contribution.

THE MESOLITHIC CEMETERY OF GROSS FREDENWALDE

The site of Groß Fredenwalde is located on a morainic hill in the Uckermark district, NE Germany (**Fig. 1**; **Fig. 3**). In 1962, the prominent position of the Weinberg hill was chosen to erect a sign post, and during construction works, human skeletal remains were detected (Schoknecht, 1963; Gramsch and Schoknecht, 2003). Animal tooth pedants attached to one of the skulls suggested a prehistoric context for the skeletons (**Fig. 4**). Local policemen documented the find situation in a few photos. On the same day, the local ama-

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Fig. 3 Aerial view of the Weinberg Hill at Groß Fredenwalde, Uckermark (NE Germany), with the site in the center and one of the nearby lakes in the background. – (Photo: Sebastian Lorenz).

teur archaeologist H. Zimmerling collected the material (complex I), and on the next day, archaeologist U. Schoknecht excavated two further individuals (complex II). A sketch drawing of complex II shows an adult individual together with the skeleton of a child lying on the adult's belly.

In his first publication, U. Schoknecht interpreted the ochre-stained skeletons and the few animal tooth pendants as the remains of Neolithic multiple burials. In his publication of the burial of Strøby Egede Brinch Petersen (1988) for the first time suggested a Mesolithic association for this find assemblage. Some years later, two radiocarbon dates confirmed the Mesolithic association, assigning the individuals to an early Atlantic context (ca. 6,500/6,300 cal BC; Hedges et al., 1995). A comprehensive report on the finds including the grave goods was published by Gramsch and Schoknecht (2003), in which the authors interpreted the entire feature (complex I+II) as one multiple burial.

In 2012, new archaeological field work started at Groß Fredenwalde, and in subsequent years the construction pit of 1962 was re-excavated. In the course of these works, new previously unknown burials were detected, among them a disturbed infant burial (feature 9), a baby burial (feature 8), and the unusual burial of a young man most probably buried in an upright position (feature 1/4) (**Fig. 5**; Terberger et al., 2015; Jungklaus and Terberger, 2016). Work in progress now is documenting further burials, and to date, twelve individuals have been reported from the site. According to systematic radiocarbon dating, the burial site was in use mainly from ca. 6,400-5,800 cal BC (**Tab. 1**). Due to possible aquatic reservoir effects in AMS dates on human bones, we might have to shift the dates to some decades later. Thus, the actual use period of the burial ground might have been shorter than indicated by the AMS dates. The burial of the young man (feature 1/4), however, clearly represents a younger phase around ca. 4,900 cal BC (**Fig. 6**).

Groß Fredenwalde is the only larger Mesolithic cemetery known in northern Central Europe. A decorated slotted dagger found in complex I shows parallels to southern Scandinavian sites of the Kongemose techno-complex (Gramsch and Schoknecht, 2003). On the burial site of Tågerup (burial 5), for example, a slotted bone dagger accompanied a male individual dated to ca. 6,100 cal BC (Karsten and Knarrström, 2001; see also Kotula et al., 2020).

Ongoing research aims to improve the understanding of the environmental context of the Groß Fredenwalde site and the land use pattern that prevailed during that time. To date, no Mesolithic settlement site has been identified in the direct vicinity of the burial ground on top of the hill, and we assume that camps and stations were located at the shores of the neighboring lakes in a distance of some hundred meters (**Fig. 3**). There is little doubt that this water rich area has been an attractive environment for hunter-gatherer-fishers during the Atlantic period, and isotope studies underline the contribution of aquatic resources to their life ways and subsistence economy (Terberger et al., 2015, 2018). *Linearbandkeramik* (LBK; i.e., Linear Pottery Culture) finds and settlements a few kilometers away from the Weinberg hill show that fertile soils also attracted early farming communinties towards the end of the use of the cemetery. From ca. 5,200 cal BC onwards we can expect local hunter-gatherer-fishers living side by side with colonizing farmers in this region (Weber, 2017), and it is likely that the unusually buried young man (**Fig. 5**; feature 1/4) would personally have met with early farmers during his life time. The Uckermark provides an important test case for interdisciplinary studies on the relationship of late Mesolithic groups and early farming communities.

Fig. 4 Groß Fredenwalde. Skull of a Mesolithic child found in 1962 with animal tooth pendants still attached. – (After Gramsch and Schoknecht, 2003).

THE "MULTIPLE BURIAL" – NEW RESULTS

For a long time, the "multiple burial" of Groß Fredenwalde remained a blackbox, and it was not even clear whether in 1962 one (Gramsch and Schoknecht, 2003) or two burials (Schoknecht, 1963; Brinch Petersen, 1988) had been detected. Following the discovery, a mere preliminary inspection of the human remains was conducted by anthropologist H. Grimm, and only hand and foot bones were studied in more detail (Grimm and Blume, 2003). Based on this analysis, six individuals were identified. A recent detailed study by one of the authors (B.J.) confirmed this number of individuals (Jungklaus et al., 2016). Because the skeletal remains were mixed up in the course of the rescue excavation, only part of the bones could be reliably assigned to specific individuals. Altogether, two male and one female adult (individuals nos 1-3) and three children (individuals nos 4-6) were identified (**Tab. 2**).

Unexpected but valuable new information is now provided by additional photos from the 1962 rescue excavation that were discovered in the archive of *Brandenburgisches Landesamt für Denkmalpflege*. Based on these pictures, the different individuals and their context can be better addressed. The photo provided in the initial publications shows a somewhat disturbed find situation with two skulls and long bones from different individuals, most of them apparently in original position. Now, a second photo of poor quality that had never been published provides additional information (**Fig. 7: a**). Furthermore, by identifiying the location of a photo showing a compass, the orientation of both complex I and complex II, the burial excavated on the second day, can be assessed. In conclusion, we can now presume that a minimum of two burials with differing orientations were found in 1962 that were probably located at a distance of ca. 1 m from each other (**Fig. 8**).

Closer inspection of the photos of complex I provides further new information (**Fig. 7: b**). In the lower part of the image, the skull (more or less complete), the arm bones, part of the spine, the pelvis and two femora of an adult individual are located *in situ*. Because the two adult individuals nos 2 and 3 are represented by other remains, these bones can reliably be assigned to individual no. 1, a man who died at the age of 30-39 years.

Alongside individual no. 1, a further adult individual is lying on the left side with the leg bones in an extremely crouched position (**Fig. 7: b**). Only part of the skeleton is visible, including the left humerus as well as an ulna and a radius of the left arm. The skull is not present on the photo, it is likely that it had already been removed in the course of the excavation. On this image, the femora visible are unusually bent, and according to osteoanthropological analysis only individual no. 2, a man who died in the age of 40-49 years, shows this pathology. It is very likely that the deformed femora of this individual were caused by rachitis during childhood (Jungklaus et al., 2016).

Interestingly, a skull of another individual has been lying next to the chest of individual no. 2 (**Fig. 7: b**). Close inspection of the image shows four animal tooth pendants attached to this skull. Additional photos showing this skull and tooth pedants exist. The breakage pattern of the bone leaves no doubt that we are dealing with individual no. 6, probably a 3-4 year-old male child (Terberger et al., 2015; Jungklaus et al., 2016; identification in contrast to Gramsch and Schoknecht, 2003). Other bones belonging to this child are not *in situ,* thus making the reconstruction of the exact position of the child's body difficult. There is little doubt, however, that the child was buried with/on top of the mature man (indiviual no. 2). The bones of the child are stained red, in contrast to the bones of the man which show less ochre staining. The reason for this variation remains unclear.

The photo taken on the first day of the excavation in 1962 only allows a reliable identification of grave goods (tooth pendants) for the child (individual no. 6) (**Fig. 4**). On the basis of parallels in the archaeological record (see below) we can only suggest that the slotted bone dagger was associated with one of the

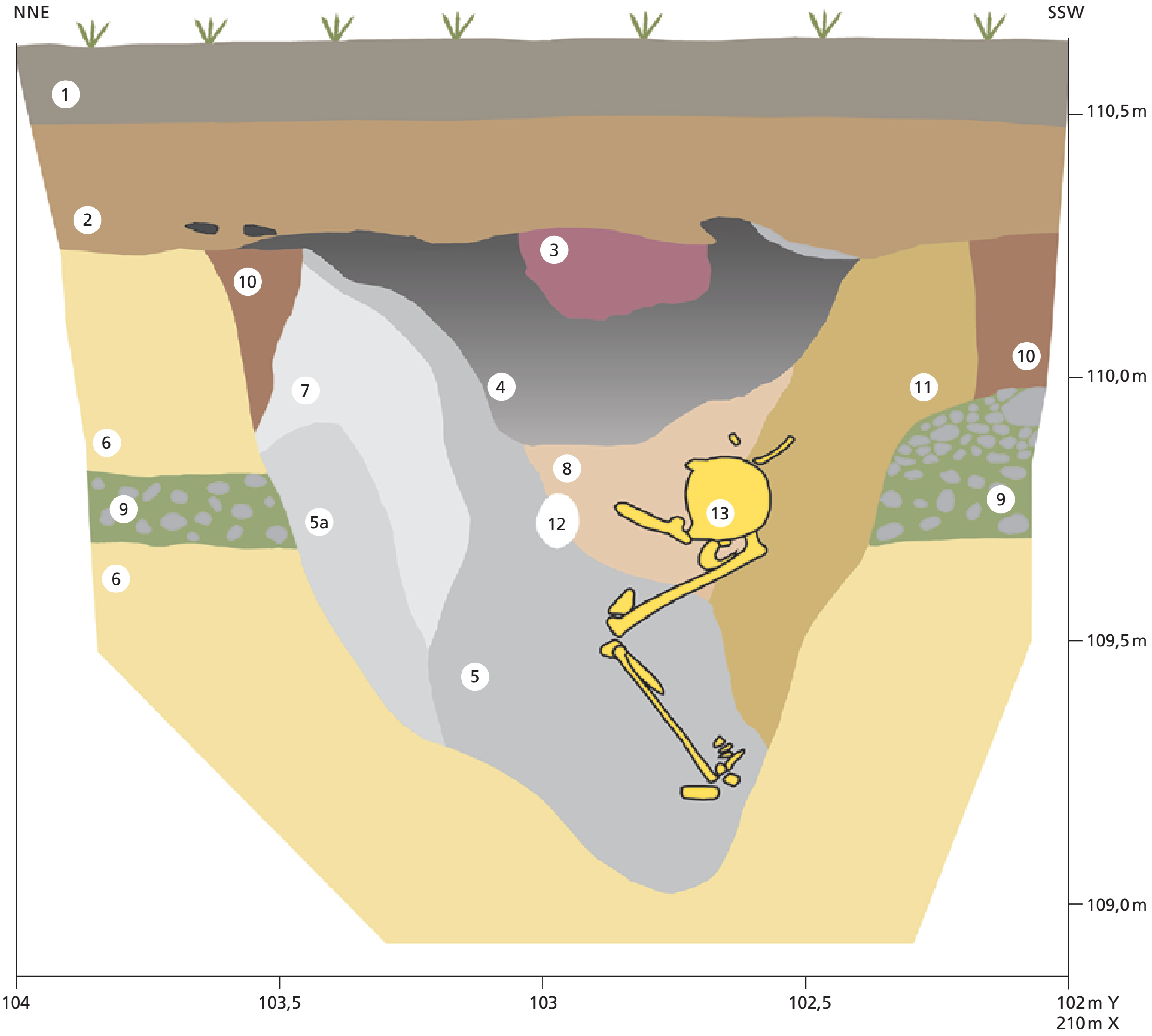

Fig. 5 Groß Fredenwalde. Profile of the burial pit of a young man probably buried in upright position (feature 1/4): **1** humic topsoil; **2** plough horizon; **3** hearth fill, cambic horizon; **4** fill, charred horizon rich in charcoals; **5** fill, sand with gravels, dark stained; **5a** fill, sand with gravels, dark stained, with charcoal flecks; **6** undisturbed sand; **7** fill, sand with gravels; **8** fill, slightly loamy and humic sand; **9** gravel bed; **10** cambic horizon; **11** fill, sand with gravels; **12** bioturbation. – (After Terberger et al., 2015).

adult (male) individuals (no. 1 or 2). The same can probably be said for ca. 39 flint blades/flakes and two transverse arrow heads (**Fig. 9: 13-14**). They too were probably associated with one or both men (Jungklaus et al., 2016). The assignment of a total of 86 animal tooth pendants is more difficult (**Fig. 9: 1-10**). A considerable number of the pendants are stained red, and it is possible that some of these pendants were also part of the head dress of the small child (individual no. 6; **Fig. 4**). The red colouring of bones from the child (individual no. 5) and the adult male (individual no. 1) might indicate that these individuals were also decorated with tooth pendants, as is the case with the female individual (no. 3) found on the second day of excavation (see below).

On the second day of the rescue excavation in 1962, an adult individual and a child (complex II) was more carefully unearthed (**Fig. 8**; **Fig. 10**). The quality of excavation is reflected in the good preservation of the skull and the postcranial skeleton, belonging to a female indivdual who died at the age of 40-49 years (individual no. 3). The bones of the woman show little ochre staining. The same is true for the 4-5 year-old child (individual no. 4), their bones showing better preservation than the remains from complex I. Concerning the position of the bodies in this grave, we are dealing with the burial of a mature woman with a child lying on her belly. The sketch plan does not allow for a more detailed reconstruction of the position of the child. Schoknecht (1963) mentions three tooth pendants at the skull as well as four tooth pendants and a bone pin close to the leg bones of the female individual (no. 3). Because of the position of the child's bones, an association of the latter pendants (and the bone pin) with the child might also to be an option. These finds demonstrate that adults were also furnished with animal tooth pendants. In summary, pendants were placed on different parts of the body and they are associated with individuals of different sex and age.

In addition, the skeleton of a 7-8 year-old child (individual no. 5) was uncovered. According to information found associated with the bones stored in the archive, this individual was found on the first day of the excavation (complex I). It remains unclear whether this child was located close to the adult males (no. 1 or 2) or whether it represents a separate burial. The latter situation would parallel two single child burials found during recent field work at the site (features 8 and 9; Terberger et al., 2015; Jungklaus and Terberger, 2016).

In contrast to Gramsch and Schoknecht (2003), who suggested a single multiple burial, the re-assessment of the available information favors a more complex interpretation. A minimum of two burials is evident. Taking evidence from radiocarbon dating (**Tab. 1**) into consideration, up to four interments or burial events might have originally been preserved in the trench uncovered in 1962:

(1) We can reliably identify the double burial of a man with crouched legs (individual no. 2) and a young child lying on his upper body (individual no. 6), dated to ca. 6,220-6,010 cal BC[2].

(2) A slightly later context is indicated for individual no. 1, the man buried in supine position, by a direct date of ca. 5,880-5,760 cal BC. Alternatively, the later date might be explained by a dating error (or methodological problems related to differing reservoir effects in comparison with the dates obtained for individuals nos 2 and 6).

(3) An additional 7-8 year-old child (individual no. 5) could also belong to this setting. In this case, the evidence would originally have represented a triple burial. However, it is equally possible to postulate a separate child burial dated to ca. 6,060-6,000 cal BC.

(4) About 1 m to the east of "complex I" the interment of a woman with a child was found (individuals nos 3-4; complex II). Together with direct dates of ca. 6,070-6,020 (individual no. 3) and 5,990-5,890 (individual no. 4) cal BC the different orientation indicates a potentially slightly later context for this double burial.

If we follow this interpretation, which is based on the range of AMS dates and on the different type of body position of individuals nos 1 and 2 (**Fig. 7: b**), the spatial association of skeletons alone does not necessarily indicate a simultaneous burial. It is possible that the burial pit of individual no. 1 was located next to individual no. 2 following the same orientation but with a temporal offset. We would have to assume that the

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[2] Data is displayed at 1σ range and rounded up to decade in the text. We have to expect some reservoir effects for the AMS dates of human bones and therefore only estimates can be given here for the dating. Most reliably were AMS dates of two animal tooth pedants providing almost identical dates of 6,010-5,918 cal BC and 6,012-5,922 cal BC (Terberger et al., 2015). For a discussion of reservoir effects in human bone dates from northern Germany see e. g., Olsen et al., 2010; Fernandes et al., 2015.

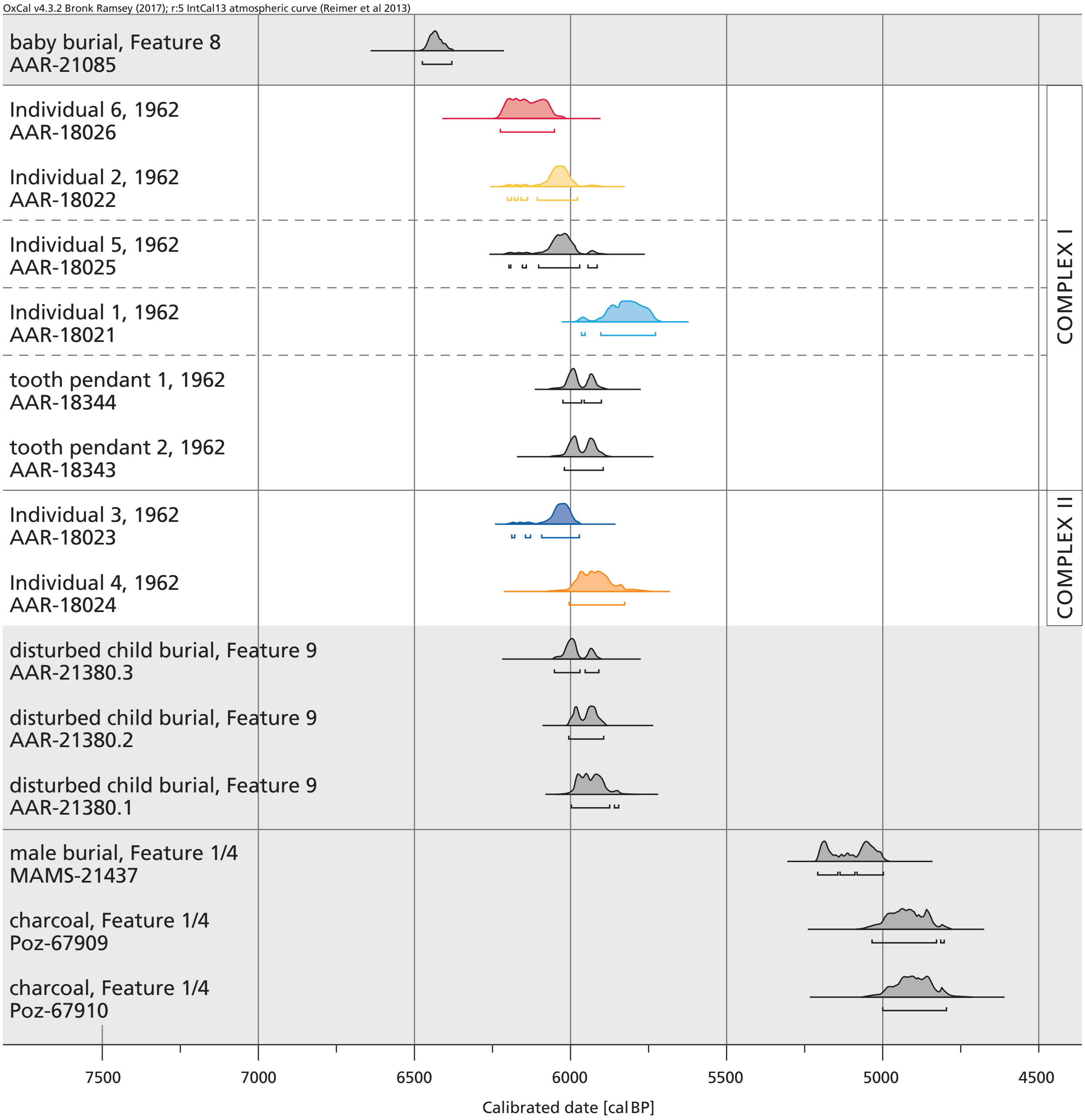

Fig. 6 Groß Fredenwalde. Calibrated radiocarbon dates. Note: colours refer to different individuals (cf. **Figs. 7-8**; **Fig. 10**). – (Graph: A. Kotula; calibration OxCal 4.3.2 with IntCal13 atmospheric curve: Bronk Ramsey, 2017; Reimer et al., 2013).

burial pit was still visible when individual no. 2 was interred. It is possible that even after generations people still have been aware of persons buried in the pits.

The new interpretation of the record uncovered in the 1962 trench as several burials is underlined by evidence from new excavations that uncovered additional burials in close vicinity. Burials dating to the first phase respect each other, and only the much later burial of the upstanding man (**Fig. 5**; **Fig. 8**; feature 1/4) spatially interfered with and almost completely destroyed an earlier burial pit of a child.

Context		Material	Lab. no.	Collagen Yield	C:N ratio	^{14}C [BP]	Calendar Age [cal BC] 68.3 % prob.	Calendar Age [cal BC] 95.4 % prob.	$\delta^{15}N$ [‰]	$\delta^{13}C$ [‰] (CF-CN)	$\delta^{13}C$ [‰] (dual-inlet)
Individual 1, c. I	excavation 1962	Human bone	AAR-18021	2.4	3.21 ± 0.18	6,944 ± 37	5,881-5,756	5,968-5,732	11.37 ± 0.29	-19.58 ± 0.14	
Individual 2, c. I	excavation 1962	Human bone	AAR-18022	1.6	3.19 ± 0.32	7,177 ± 40	6,070-6,012	6,209-5,924	11.25 ± 0.17	-20.48 ± 0.10	
Individual 5, c. I	excavation 1962	Human bone	AAR-18025	2.2	3.18 ± 0.23	7,161 ± 44	6,063-5,996	6,087-5,917	11.25 ± 0.29	-19.42 ± 0.14	
Individual 6, c. I	excavation 1962	Human bone	AAR-18026	1.1	3.18 ± 0.16	7,272 ± 42	6,218-6,073	6,230-6,034	11.74 ± 0.17	-20.02 ± 0.10	
multiple burial, c. I	Feature 3 re-excavation	Deer tooth pendant	AAR-18343	1.4	3.19 ± 0.17	7,085 ± 32	6,010-5,918	6,026-5,888	6.11 ± 0.17	-22.50 ± 0.10	
multiple burial, c. I	Feature 3 re-excavation	Deer tooth pendant	AAR-18344	3.0	3.19 ± 0.14	7,094 ± 28	6,012-5,922	6,026-5,895	5.05 ± 0.17	-20.76 ± 0.10	
Individual 3, c. II	excavation 1962	Human bone	AAR-18023	2.7	3.25 ± 0.22	7,187 ± 35	6,069-6,020	6,209-5,984	11.37 ± 0.29	-19.73 ± 0.14	
Individual 4, c. II	excavation 1962	Human bone	AAR-18024	2.0	3.20 ± 0.22	7,051 ± 45	5,987-5,892	6,022-5,832	11.62 ± 0.29	-19.33 ± 0.14	
hearth on top of burial	Feature 1/4	Charcoal	Poz-67909			6,030 ± 40	4,990-4,849	5,036-4,799			
hearth on top of burial	Feature 1/4	Charcoal	Poz-67910			6,010 ± 40	4,951-4,839	5,002-4,793			
young man burial	Feature 1/4	Human bone	SID-23897		2.7				11.30	-19.90	
young man burial	Feature 1/4	Human bone	MAMS-21437	6.7	3.1	6,137 ± 22	5,206-5,003	5,210-4,996		-20.10	
baby burial	Feature 8	Human bone	AAR-21095	4.5		7,569 ± 37	6,458-6,413	6,476-6,274		-21.75 ± 0.61	
baby burial	Feature 8	Human bone	AAR-21095 isotopes		2.7				12.30	-21.10	
disturbed child burial	Feature 9 (no UF)	Human bone	AAR-21380.1	7.3		7,040 ± 28	5,982-5,892	5,991-5,842			-19.47 ± 0.05
disturbed child burial	Feature 9 (UF > 30 kDa)	Human bone	AAR-21380.2	3.8		7,067 ± 28	5,990-5,908	6,016-5,851			-20.82 ± 0.57
disturbed child burial	Feature 9 (UF < 30 kDa)	Human bone	AAR-21380.3			7,108 ± 31	6,018-5,925	6,061-5,912			-20.92 ± 0.64

Tab. 1 Groß Fredenwalde. Radiocarbon dates of different individuals and contexts (c. I = complex I; c. II = complex II) (calibration OxCal 4.3.2 with IntCal13 atmospheric curve: Bronk Ramsey, 2017; Reimer et al., 2013). UF = ultrafiltration (with reference to molecule fraction).

Individual	anthropological assessment
1	Bones strong red discolouration, male, 30-39 years old, 161.0 ± 4.0 cm (Pearson, 1899)/ 166.9 ± 5.0 cm (Trotter and Gleser, 1952), no evidence of disease
2	Bones slight reddish discolouration, male, 40-49 years old, 161.8 ± 4.0 cm (Pearson, 1899)/ 168.1 ± 5.0 cm (Trotter and Gleser, 1952), femur and shafts of radius and ulna bent outwards (suspected Osteomalacia)
3	Bones slight red discolouration, female, 40-49 years old, 152.0 ± 4.0 cm (Pearson, 1899)/ 156.4 ± 4.3 cm (Trotter and Gleser, 1952), medium severe arthritis of the right elbow, severe tooth attrition, parodontosis
4	Bones slight red discolouration, probably male, 4-5 years old, height not determinable, no evidence of disease
5	Bones strong red discolouration, probably female, 7-8 years old, height not determinable, no evidence of disease
6	Bones strong red discolouration, probably male, 3-4 years old, height not determinable, porosity of teeth at gum edge, and some evidence of cribra orbitalia (suspected scurvy)

Tab. 2 Groß Fredenwalde. Results of the anthropological assessment of individuals nos 1-6 found during excavation in 1962. – (After Jungklaus et al., 2016).

DISCUSSION – LESSONS TO LEARN FROM GROSS FREDENWALDE

The critical re-assessment of the evidence from the "multiple burial" of Groß Fredenwalde exemplifies that care is needed with the identification and interpretation of "multiple burials" from early, and/or – by modern standards – inadequately documented excavations. Plural burials can shed light on funerary practices and rites, on underlying social structures, but also on the histories of individuals and communities. In the archaeological record, the (apparent) presence of remains of two or more individuals in the same structure or context can result from several different practices and processes: (1) The grave represents a burial of several individuals deposited either simultaneously, or successively over a short period of time (= multiple burial); or (2) The grave or context represents a multi-episode, successive deposit of individuals over a longer time period (= collective burial) (Tõrv, 2018: 49). A second important factor concerns the nature of the burial, whether it is (1) a primary burial, with fresh corpses buried soon after death, or (2) a secondary burial or deposit with human remains manipulated at least two times (e. g., decomposition at one location, followed by burial at another location; Tõrv, 2018: 45). Taphonomic variables (e. g., soil type, later disturbances, etc.), quality of documentation, and post-excavation analysis are also crucial for recognition and interpretation; as is the question whether the individual records allow the secure distinction between true plural burials and separate burials in spatial proximity.

At Groß Fredenwalde, the re-evaluation of the 1962 findings based on new archival and dating evidence suggests a minimum of two double burials, as opposed to one multiple burial suggested by Gramsch and Schoknecht (2003). It is however possible to reconstruct more burial events from the available record, with 3 or even 4 plausible. The two evident double burials comprise an adult and a child positioned on top of the adult's body (complex I: individuals nos 2 and 6, complex II: individuals nos 3 and 4) (**Figs. 7-8**; **Fig. 10**). The male individual no. 1 provided a slightly later date than the other individuals from the same complex (I). The body of this man is in close spatial association with the crouched-leged adult no. 2 and associated with child no. 6 (**Fig. 7: b**). The evident archaeological record can be read in terms of a simultaneous burial but

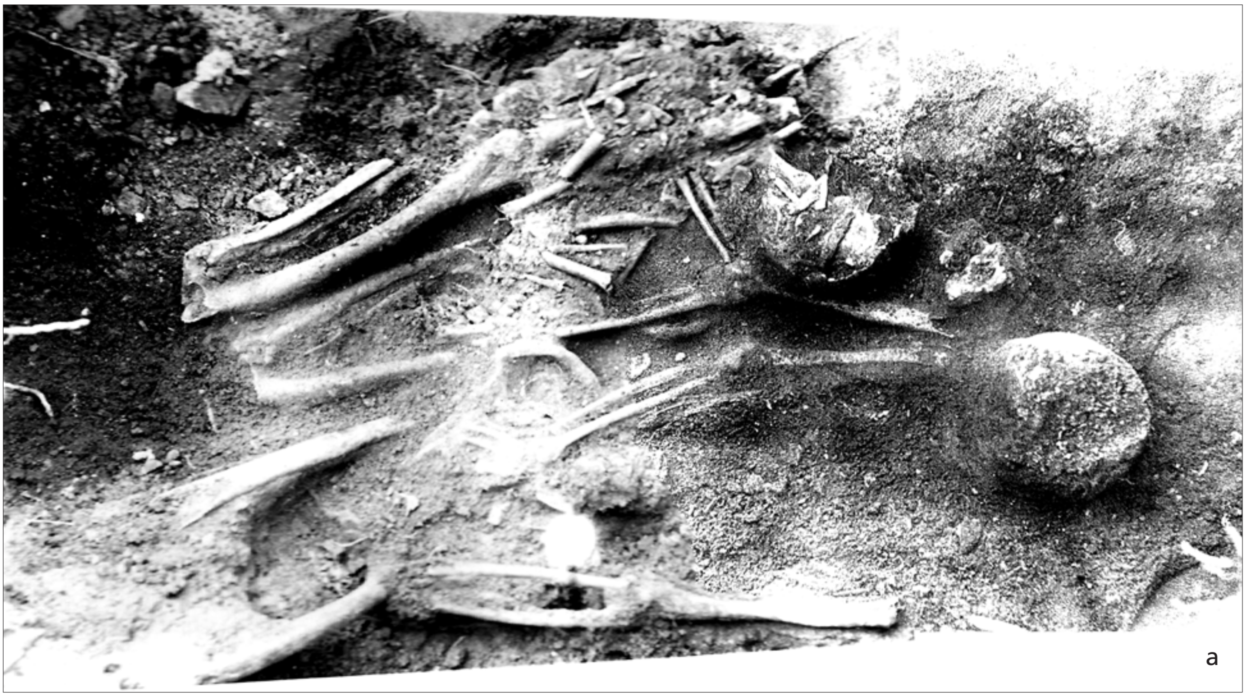

Fig. 7a Groß Fredenwalde. Refitted photos of the situation of 1962 excavated on the first day (complex I). – (Graph: A. Kotula).

the AMS dates indicate a temporal offset. If the younger date indeed reflects a younger interment, then this new burial respected the already-existing one. This scenario has to be tested by further radiocarbon samples.

New excavations at the site show that children were also individually buried from the age of ca. one year (feature 8). Red ochre and animal tooth pendants associated with a 3-4 year-old child (individual no. 6) indicate that in the early Atlantic Mesolithic, small children were already treated similar to older members of the community, with respect to the adornment of the clothes or body with tooth pendants, and the use of ochre as magical or ritual grave components.

Mesolithic double and multiple burials are not very frequent, but are nonetheless regularly observed both at cemeteries and as isolated burials (Grünberg, 1996; Tõrv, 2018: 214-222). The simultaneous interment of several corpses is signaled by the close, often carefully arranged, spatial relation of individuals, sometimes even expressed in physical gestures such as an arm put around another person's head (e.g., at Tamula XI and XII; Tõrv 2018: 221). Well-preserved evidence of a single, undisturbed burial pit would also be an indication for a simultaneous burial.

The death of two or more persons at the same time is an exceptional event, and several reasons might be responsible: Bone trauma or lesions due to weaponry are a strong indicator for the simultaneous violent death of individuals and would thus signal a double or multiple burial. Examples come from the Mesolithic head burials at Große Ofnet cave (e.g., Orschiedt, 2015; Terberger and Lidke, 2015; Terberger, 2006). More prominent evidence is known from later periods e.g., from the early Neolithic LBK site of Schöneck-Kilianstädten (Meyer et al., 2015), or the Bronze Age multiple burial from Wassenaar (Louwe-Kooijmans, 1993). Another reason for the need to simultaneously bury two or more persons are accidents with several casualties, e.g., with boats, or hunting accidents, identifiable due to the presence of skeletal trauma.

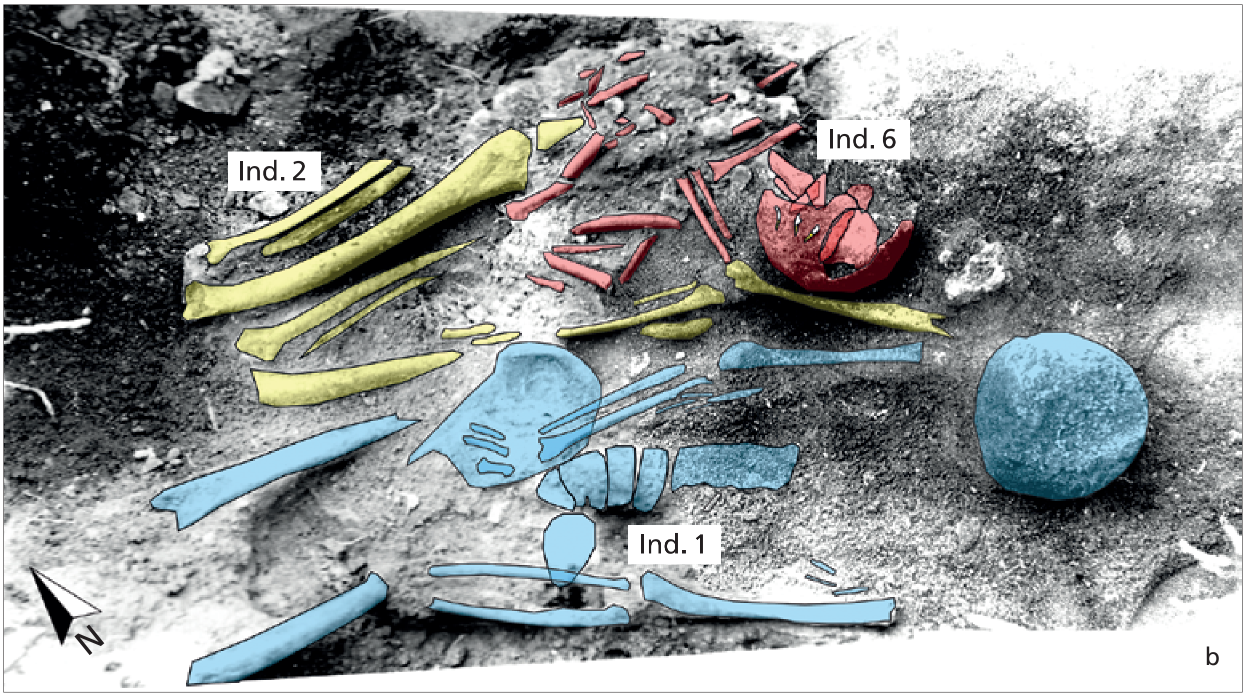

Fig. 7b Groß Fredenwalde. Complex I with identified individual no. 1 (blue, male adult), no. 2 (yellow, male adult) and no. 6 (red, 3-4 year-old child) (cf. **Tabs. 1-2**). Note: colours refer to different individuals (cf. **Fig. 6**; **Fig. 8**; **Fig. 10**). – (Graph: A. Kotula).

More numerous are double and multiple burials where anthropological analysis cannot detect any cause of death. Infectious diseases can be responsible for the simultaneous death of individuals (e.g., Grupe et al., 2015: 110), but generally do not leave traces on bones. Analysis of ancient DNA for detection of pathogens has not been widely applied to Mesolithic contexts. Multiple burials of adults and children, as represented at Groß Fredenwalde, could result from outbreaks in a family or community. Starvation is another reason for multiple deaths within a short period of time.

An unusual example of a hunter-gatherer multiple burial with 18 individuals was recorded at Sakhtysh 2 (Russia) (Kostyleva and Utkin, 2010: 20-21, 79-80). This Late Stone Age burial shows characteristics of a mass grave, with particularly dense packing of bodies and alternating body positions with heads pointing in opposite directions. Here, too, the skeletons lack evidence for the cause of death which must have been a catastrophic event. The excavators suggest a two-staged burial event, with a lower layer of already slightly decomposed carcasses on top of which an upper layer of carcasses was deposited, filling in the burial pit.

Re-use of burial pits is an additional option to explain burials with two or more individuals lacking evidence for simultaneous death. Re-opening of burial pits can only be detected during excavation if soil conditions and the documentation technique allows observation of these details. At the Mesolithic burial site of Oleni Ostrov in Russia (cf. **Fig. 1**) 16 double and three triple burials were found, most of them are regarded as simultaneous, multiple interments (Gurina, 1956: 50-55). However, for some burials, successive inhumations into a single burial pit have been suggested. Bone scatters or the partly removal of parts of a skeleton are interpreted as a result of re-opening of a pit, and in one case even a repeated re-opening of a pit is suggested (Grünberg, 2000: 61; Gurina, 1956: 40). In Zvejnieki, Latvia, several graves show stratigraphical separation of individuals in multiple burials (Grünberg, 2000: 87), probably indicating chronological depth and separated interments. An exceptionally complex situation with numerous multiple and sequential burials of several individuals, including inhumations as well as cremated remains, has been documented at the Late Mesolithic/"Para-Neolithic" cemeteries at Dudka and Szczepanki in northeast Poland (Guminski and Bugajska, 2016). In contrast, Nilsson Stutz (2003: 304 ff.) rejected the interpretation of successive deposition of bodies at the burial sites of Skateholm and Vedbaek-Bögebakken as suggested by the excavators.

The importance of taphonomy and ritual for identification of the internal chronology of a Mesolithic multiple burial is well illustrated by more recent findings from Campu Stefanu, Corsica (France) (Courtaud et al., 2016). While some bones of several individuals were found in close proximity to each other and appeared in anatomical order, others were not in anatomical order, or were completely missing. The authors argue for a primary burial situation here, but cannot reconstruct the internal chronology of the burial(s). They suggest bone preservation and post-mortem manipulation as possible agents that prevent straight forward interpretation.

Finally, we come back to the Strøby Egede burial with eight individuals (**Fig. 2**), lacking indication for simultaneous death. One of the children (skeleton E) and an adult individual (D) were found in slightly elevated

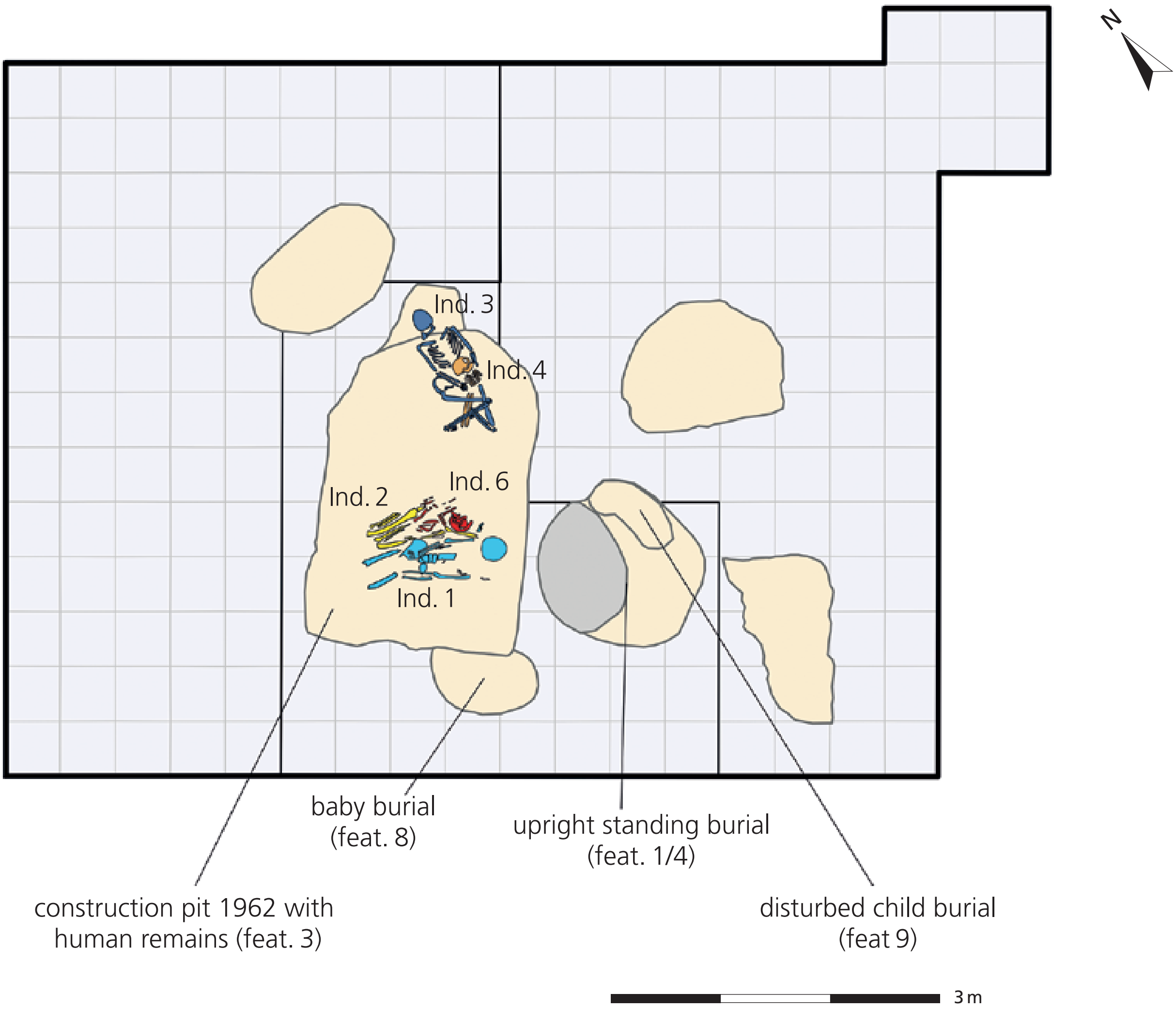

Fig. 8 Groß Fredenwalde. Location of Mesolithic features on the site and reconstruction of position and orientation of Mesolithic burials found in 1962 (complex I: individuals nos 1, 2, 6; complex II: individuals nos 3, 4). Note: colours refer to different individuals (cf. **Figs. 6-7**; **Fig. 10**). – (Graph: A. Kotula).

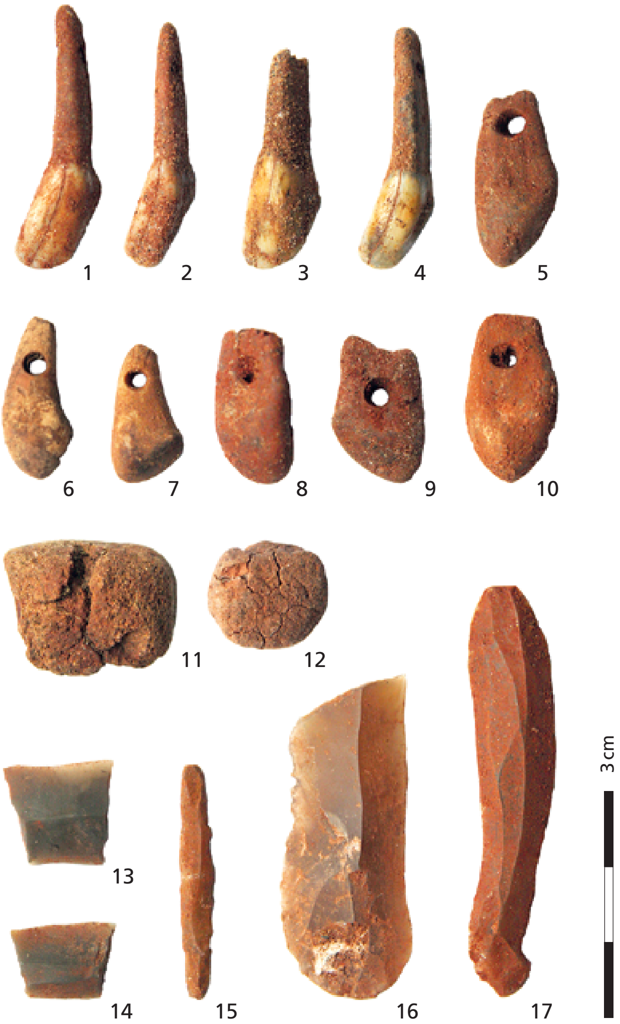

Fig. 9 Groß Fredenwalde. Selection of burial goods found in the re-excavated trench of 1962. **1-10** animal tooth pendants; **11-12** pieces of loan of unknown function; **13-14** transverse flint arrow heads; **15-17** flint bladelette and blades. – (Graph: A. Kotula).

positions that might indicate later deposition of these individuals in the same pit. However, Brinch Petersen (1988) suggests here a baby (individual G) lying in the arms of the male individual (D). We do not want to rule out that even such a well documented burial might be the result of more than one event.

Re-evaluation of multiple burials in Palaeolithic and Mesolithic contexts remains an interesting challenge for future research. Our investigation at Groß Fredenwalde calls for caution when interpreting the "double" and "multiple" burials of Bonn-Oberkassel and Neuwied-Irlich mentioned above. The complexity of these records can only be addressed by detailed observations during excavation and a thorough post-excavation assessment of the entire evidence and – where possible – by systematic and reliable radiocarbon dating of all individuals in a burial and preferably also of additional grave goods and other associated samples. It can be said with certainty that Martin Street as a critical scientist is always aware of such pitfalls!
For Groß Fredenwalde we were able to show that the situation discovered in 1962 results from different burial events and the use of the site for a longer period of time. We have to be aware, however, that only certain individuals were buried at these "cemeteries" and that many other deaths remain invisible in the archaeological record. The considerable number of children and individuals in double/multiple burials might have resulted from unusual events.

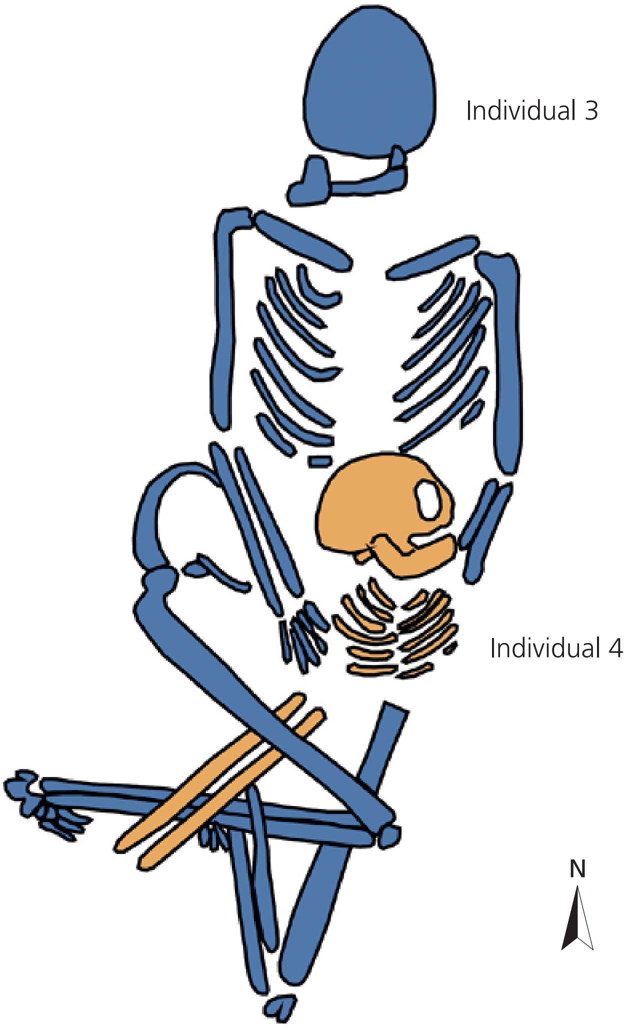

Fig. 10 Groß Fredenwalde. Sketch drawing of the burial found in 1962 on the second day (complex II) with individuals no. 3 (female adult) and no. 4 (child) (see **Tabs. 1-2**). Note: colours refer to different individuals (cf. **Figs. 6-8**). – (After Gramsch and Schoknecht, 2003).

Combining the evidence from the initial investigation in 1962 with the re-assessment of the record and evidence from the new, ongoing excavations since 2012, we can state that Groß Fredenwalde is an exceptional hunter-gatherer burial site in the vast North European Plain, although it does share characteristics with other Mesolithic burial grounds in the wider region from Scandinavia to the Baltic and Russia. Even though so far only twelve individuals have been discovered, already a wide spectrum of ritual and social practices is reflected in body positions (including an upstanding individual), the presence of single as well as double/multiple burials, and varying orientations of the bodies. However, a larger variety of burial rites seems to be typical for the Atlantic Mesolithic. Perhaps it is already legitimate to regard the burial site with its prominent topographical setting on the Weinberg hill at Groß Fredenwalde, as one of those nodes in the cultural landscape that might have developed as cosmological transition places between worlds, reflecting the entangled lifeways of local hunter-gather groups, as has been suggested e.g., for Oleni Ostrov and Skateholm (cf. Nilsson Stutz, 2014: 720-721).

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ANNABELL ZANDER

EUROPEAN MESOLITHIC SITES WITH ANTLER HEADDRESSES: A BRIEF OVERVIEW

Abstract

The discovery of 21 red deer antler headdresses by Grahame Clark at Star Carr has focused this site at the centre of debate of Mesolithic research in Britain for more than half a century. Despite these special artefacts, Star Carr is often presented as an Early Mesolithic "type site". However, recent excavations at Star Carr have revealed the complex history of the site which only finds parallels in a small number of Mesolithic sites in northern Europe. In investigating these sites, this chapter moves beyond the antler frontlets as proposed common artefacts. It focuses on the faunal and lithic assemblages in order to establish further similarities between the sites while evaluating the significance of each site in its respective regional context.

Keywords

Early Mesolithic, antler frontlets, faunal and lithic investigation

INTRODUCTION

The Early Mesolithic site of Star Carr has been at the centre of debate of Mesolithic research in Britain for more than half a century (Clark, 1954; Noe-Nyaard, 1975; Legge and Rowley-Conwy, 1988). The special character of Star Carr is often associated with the discovery of 21 red deer crania in the 1950s (Clark, 1954), which Grahame Clark interpreted as antler headdresses. This discovery had a significant impact on Mesolithic research in Europe: in the subsequent decade after Clark's (1954) publication several artefacts from the German sites of Hohen Viecheln, Berlin-Biesdorf and Plau were interpreted as possible antler headdresses (Schuldt, 1961; Reinbacher, 1956: 148; Schoknecht, 1961: 173). Moreover, in the late 1980s Martin Street (1989) referred to Clark's interpretation of the artefacts, when he uncovered two antler headdresses at the early Mesolithic site of Bedburg-Königshoven (**Fig. 1**).

However, the majority of published material and site reports of these finds were written in German exacerbating any detailed comparison between the sites (cf. Reinbacher, 1956; Schuldt, 1961; Schoknecht, 1961). In the 1990s Street published various international papers on Bedburg-Königshoven which therefore enabled a meaningful exchange of these important sites (Street, 1991; 1998). The recent investigations at Star Carr (Milner et al., 2018a, 2018b) and the re-evaluation of the Hohen Viecheln assemblage (Groß et al., 2019) both with detailed international publications allow a more extensive discussion of the Mesolithic sites with antler headdresses. The aim of this paper is to move beyond the antler frontlets as proposed common artefacts by investigating the assemblages of the sites. For the scope of this paper, the focus will lie on the faunal and lithic assemblages in order to establish further similarities between the sites while evaluating the significance of each site in its respective regional context.

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INTRODUCING THE SITES

Star Carr

Star Carr is arguably the most famous and most investigated Early Mesolithic site in north-western Europe (Clark, 1954; Milner et al., 2018a). The site was located at the north-western shore of a palaeolake, Lake Flixton, in the Vale of Pickering, North Yorkshire. After the discovery of the site by John Moore in the late 1940s, Grahame Clark excavated Star Carr over three seasons between 1949 and 1951. The results of Clark's excavations were magnificent: the waterlogged areas yielded an unusual assemblage, including 220 finished antler artefacts, over 100 fragments of discarded red deer antler and 191 barbed points. Furthermore, the organic deposits were associated with a large flint assemblage, including burins, scrapers and over 14,000 waste flakes (Clark, 1954).

The quality of the archaeological remains encouraged the re-excavation and re-interpretation of the site. Since the mid-1980s several research projects have been conducted in the Vale of Pickering, leading to the identification of 24 additional (mostly Early Mesolithic) sites around Lake Flixton, including Seamer Carr to the north of Star Carr and the island sites of Flixton Island and No Name Hill (Conneller and Overton, 2018). Between 2004 and 2015 Star Carr was further investigated leading to the discovery of 12 additional red deer antler frontlets, a further 36 barbed points and a large flint assemblage of more than 24,000 pieces (**Fig. 2**) (Milner et al., 2018b). The excavations also demonstrated that this was a much larger site than previously assumed where people repeatedly returned and invested a significant amount of time and labour in building timber platforms and dwelling structures (Taylor et al., 2010).

Hohen Viecheln

Another Mesolithic site which shows parallels to Star Carr is situated on a sandy terrace in the north bay of the Lake of Schwerin, in Mecklenburg-Vorpommern (Gehl, 1961a: 9). In 1952 a barbed point was discovered on the edge of the *Wallensteingraben*, the artificial northern drainage of the Lake of Schwerin which

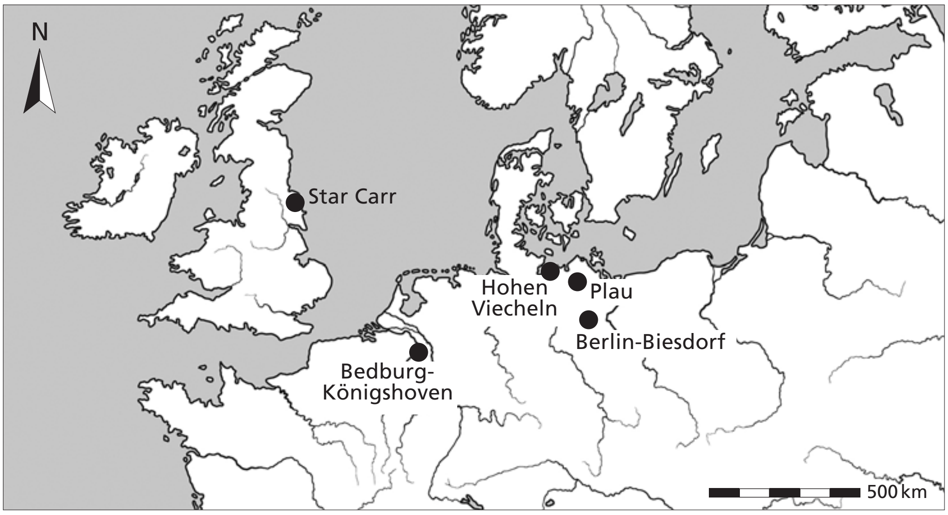

Fig. 1 Location of the Mesolithic sites with antler "frontlets" discussed in this work.

was created in the 16th century AD (Schuldt, 1961: 76). The subsequent excavation of the site during 1953-1955 yielded an extraordinary amount of organic material, including a total of 316 bone points and 680 deer bone fragments. However, it soon became clear that the site had suffered several disturbances during the millennia. The density of finds revealed that the *Wallensteingraben* with its sluice had destroyed the main occupational area of the site.

According to Schuldt (1961) the stratigraphy of the site suggests a repeated occupation. Among the finds of the early occupation were two well-preserved red deer crania with fragments of the antlers still attached (**Fig. 3**). Schuldt interpreted these artefacts as antler frontlets due to their resemblance with the examples from Star Carr (Schuldt, 1961: 28-29). However, Schuldt's investigations of the site have been subject to criticism since shortly after the publication of his monograph, including his coarse excavation methods and his suggested chronology (Schüle, 1962; Gramsch, 1964; Pratsch, 2006). The complex stratigraphy of the site has recently been re-evaluated with a focus on providing an absolute chronological framework for individual artefacts (Groß et al., 2019) (see: Chronology of the sites).

Bedburg-Königshoven

A further site with antler frontlets is situated at Bedburg-Königshoven. The site lay in the valley of the River Erft, approximately 20 km to the south-east of Mönchengladbach, near Düsseldorf (Street, 1989). Here, in the centre of the opencast lignite mine of Garzweiler a small "island" was left intact by quarrying which produced numerous Early Holocene finds, including antler tines and parts of a cranium *in situ* (**Fig. 4**). Street identified this find as an antler frontlet due to its similarities with the Star Carr and Hohen Viecheln specimens.

The excavation in 1988 produced well-preserved organic material, including one bone point, a bone chisel and red deer and aurochs bones. Among the finds another well-preserved red deer antler frontlet was discovered (Street, 1989: 17). Environmental investigations revealed that the site was originally situated within the northern end of a former meander of the River Erft. The excavation of such a large area could demonstrate that the excavated parts represent a peripheral zone of the site where the remains had been deposited into the water and that the terrestrial deposits which probably comprised the main settlement area suffered destruction.

Additional finds of antler frontlets

Besides these three Mesolithic sites, a possible antler frontlet was discovered at Berlin-Biesdorf. In spring 1953 a worked red deer antler skull was taken to the Department of Prehistory at the Deutsche Akademie der Wissenschaften in Berlin. The find derived from mechanical digging works by the River Wuhle. After the publication of Clark (1954), Erwin Reinbacher could identify certain similarities between the antler frontlets at Star Carr and the red deer skull from Berlin-Biesdorf (Reinbacher, 1956: 148). Unfortunately, the area of discovery had already been backfilled when the archaeologists arrived at the site preventing any additional investigations.

A further possible antler frontlet was discovered at Plau, in Mecklenburg-Western Pomerania. In 1933 a collection of antler, bone and lithic artefacts were taken to the Museum of Waren (Schoknecht, 1961: 169-170). The finds were uncovered during mechanical digging works to straighten the course of the River Elde near the village Plau. However, due to the circumstances of their discovery the context of the artefacts

Fig. 2 One of the 12 antler headdresses recovered from the recent excavations at Star Carr. – (Copyright: Neil Gevaux, CC BY-NC 4.0; Elliott et al., 2018. Material is available under Public License: https://universitypress.whiterose.ac.uk/site/books/e/10.22599/book1/).

Fig. 3 One of the antler headdresses from Hohen Viecheln. – (Photo: M. Wild; Wild, 2019).

remains unknown (Schoknecht, 1961: 169-170). Among the finds was a red deer cranium with parts of the antlers still attached (Schoknecht, 1961: 169-170). This cranium was only recognised as a possible antler frontlet by Ulrich Schoknecht following the publications of Clark (1954), Schuldt (1961) and Reinbacher (1956). Unfortunately, all the artefacts of the assemblage were damaged during a fire at the end of World War II and the flint artefacts were lost (Schoknecht, 1961: 172). Due to the lack of context of the finds from Berlin-Biesdorf and Plau the sites are excluded from the discussions in this paper.

THE ANTLER HEADDRESSES

Defining the headdresses

When discussing the antler headdresses it is important to ask: What sets the proposed antler frontlets apart from mere deer skulls? Potential key defining criteria for the headdresses have been discussed in recent publications and will only be mentioned briefly (cf. Street and Wild, 2015; Elliott et al., 2018).
Two different approaches to define the headdresses have come into focus:

1.) Street and Wild (2015) argue that the presence of artificial perforations through the parietal bone should be seen as the key to define Mesolithic headdresses. Only 9 of the 33 antler frontlets from Star Carr, one example from Hohen Viecheln and both frontlets from Bedburg-Königshoven feature these lateral perforations.
2.) On the basis of the excellent preservation conditions and contextual data at Star Carr, Elliott and colleagues (2018; see also Little et al., 2016) were able to analyse the frontlets using a technological approach. The results reveal a similar *chaîne opératoire* of the artefacts at Star Carr characterising them as a distinct group of artefacts. This broader definition of the frontlets based on technological studies therefore includes a much larger number of artefacts into this group than the single typological feature of the perforations.

The function of the headdresses

Since their discoveries, the antler headdresses have sparked numerous debates among scholars, specifically revolving around their function. Clark had offered two interpretations for the use of these unusual artefacts: Citing ethnographic studies from the Eskimos, he argued the antler frontlets were either used as hunting aids, allowing the hunters to stalk the prey at a close range, or as head-dresses during "ritual dances" (Clark, 1954: 170). Furthermore, Clark used Nicholas Witsen's (1705: 693) depiction of a Siberian Tungus shaman wearing a reindeer antler head-dress as a modern analogy to explain the Mesolithic antler frontlets (**Fig. 5**) (Clark, 1954: 171). The majority of subsequent interpretations of the antler headdresses remain within the realm of Clark's "either/or" argument with the German terminology for the antler frontlets (*Hirschgeweihmasken; Deer antler masks*) already assuming an interpretation due to its clear connotation of disguise (Reinbacher, 1956: 149-150; Schuldt, 1961: 130; Schoknecht, 1961: 172-173).
In more recent years, Chantal Conneller (2004: 37) has pointed at the impasse Clark's dichotomous interpretations of the antler frontlets have produced. She argues that Clark's interpretations of the frontlet as a form of disguise are based on several general dichotomies of the Western world. In contrast to Clark's division between an "economic" or "ritual" function of the frontlets, in modern hunter-gatherer societies economic

activities and cosmological beliefs are rarely separated (Ingold, 1987: 153). The more recent interpretations are within the realms of this more holistic perspective on the use of the headdresses. This includes the association of the frontlets with modern ethnographic analogies of Northern Europe, thereby suggesting they were probably used in ritual dances and ceremonies (cf. Street, 1989: 49; Elliott et al., 2018; Wild, 2019) or, more specifically, as part of Shamanic costumes (cf. Little et al., 2016).

THE FAUNAL ASSEMBLAGES

Comparing the faunal assemblages

An investigation of the faunal assemblages of Star Carr, Bedburg-Königshoven and Hohen Viecheln reveals further similarities beyond the antler frontlets as a common artefact group. All three sites feature a wide range of identified species (**Tab. 1**; **Fig. 6**). At Star Carr, the vast majority of the faunal assemblage consists of red deer remains, followed by an abundant representation of elk, aurochs and roe deer. Besides these large mammals, the faunal assemblage of Star Carr comprises of smaller mammals, including domesticated dog, fox, beaver and wild pig (Fraser and King, 1954; Knight et al., 2018). In addition, several bird remains were discovered, such as the red-breasted merganser and the great crested grebe (Fraser and King, 1954;

Fig. 4 One of the antler headdresses found during the excavations between 1987 and 1988. – (Photo: M. Street).

Fig. 5 Witsen's depiction of a *Tungus* Shaman wearing a reindeer antler head-dress from 1692.

Knight et al., 2018). The recent investigations at Star Carr have also recovered 21 fish remains, including northern pike and European perch (Knight et al., 2018).

Legge and Rowley-Conwy (1988) convincingly argue that red deer and roe deer antlers should be excluded from the count of the minimum number of individuals (MNI) as they may not represent killed animals but collected antlers (see also Knight et al., 2018). Despite the exclusion of antlers from the count, red deer remains the dominant species with an MNI of 35, followed by roe deer with 23 and aurochs with 19 (**Fig. 6**).

At Bedburg-Königshoven 29 species were identified, consisting mainly of large mammals but also smaller mammals, birds and fish were recovered from the site. The assemblage mainly consists of aurochs remains, followed by an abundant representation of roe deer, red deer and horse (**Tab. 1**; **Fig. 6**). This abundant record of aurochs in the Bedburg assemblage stands in contrast to the focus on red deer at Star Carr. The faunal assemblage of Hohen Viecheln comprises large quantities of animal remains of various different species, in sum 41 species. The majority of remains could be identified as roe deer and red deer remains (**Tab. 1**; **Fig. 6**). In addition, the assemblage consists of elk, aurochs and domesticated dog bones and smaller mammal remains, such as fox, badger and bear (Gehl, 1961b).

The regional context

The quality and size of the faunal assemblage at Star Carr stands in strong contrast to the fragmentary nature and small size of the faunal assemblages of the surrounding sites which appear to represent small-scale activities. The assemblages of sites Seamer K and C consist of approximately 100 bone fragments, including red deer, elk, aurochs and horse (Schadla-Hall, 1989; Conneller and Overton, 2018). The record of horse is particularly interesting considering its complete absence from Star Carr.

Species	**Star Carr**	**Bedburg-Königshoven**	**Hohen Viecheln**
Horse		×	×
Dog	×	×	×
Wild boar	×	×	×
Elk	×		×
Red deer	×	×	×
Roe deer	×	×	×
Aurochs	×	×	×
Bear	×		×
Beaver	×	×	×
Badger	×	×	×
Σ N species	26	29	41
Source	Knight et al., 2018	Street, 1989	Schuldt, 1961

Tab. 1 Representations of the main identified species from Star Carr, Bedburg-Königshoven and Hohen Viecheln.

Unfortunately, it is difficult to assess the faunal assemblage of Bedburg-Königshoven in its regional context since only few organic finds were discovered at other Preboreal sites, marking Bedburg as a special site concerning its preservation. The recently excavated Preboreal site of Mönchengladbach-Geneicken which lay approximately 20 km north of Bedburg-Königshoven produced 150 well-preserved bones of a single aurochs (Heinen, 2015: 300). The discovery of this skeleton represents almost 80 % of the entire skeleton marking this find as the most complete archaeological skeleton of an aurochs in Germany. It is difficult to determine the importance of the faunal assemblage of Hohen Viecheln in its regional context as no other Mesolithic organic finds were discovered around the Lake of Schwerin, characterising Hohen Viecheln as a unique site concerning its preservation.

Issues with seasonality and site function

According to Milner (1999: 51) one of the major problems concerning studies of seasonality is the "lack of understanding" of animal behaviour, as can be seen, for example, in the various interpretations of the seasonality of Star Carr. Clark (1954: 10-17) initially interpreted Star Carr as a seasonal home base of a community of hunter-fishers. Furthermore, he suggested a winter and possible spring occupation of the site according to the regular annual cycle of the growth and shedding of antlers. Subsequent seasonal interpretations of Star Carr ranged from the proposal that the site had been used as a "specialised industrial complex" (Pitts, 1979: 33); a hunting and butchering site which was used throughout most of the year (Legge and Rowley-Conwy, 1988); and a base camp which was repeatedly occupied for more than one season (Price, 1982: 4-7). However, the large number of re-interpretations of Star Carr probably rather reflect the long-term repeated use of the site which may represent different activities throughout the centuries of occupation. The recent investigations at Star Carr have also revealed that there is now evidence for animals that have been killed in all four seasons (Knight et al., 2018). According to Conneller and colleagues (2009: 80) Star Carr is one element of an entire system that should be fitted into its wider regional context and should not be reduced to "a single component of an idealised yearly round".

It is difficult to assess the assemblage of Bedburg-Königshoven since it only represents the peripheral parts of a larger site. Street investigated the representation of anatomical elements of aurochs at the site and concluded that the assemblage represents the majority of body parts suggesting that the animals were killed in the immediate vicinity of the site (**Fig. 7**). According to Street the entire butchering process was then carried out at the site (Street, 1990: 31-32). On the basis of the discovery of three aurochs which were killed in spring and the presence of white stork which is a summer visitor to Europe Street argues for a potential spring or summer occupation of the site (Street, 1991).

At Hohen Viecheln, Gehl (1961b: 44) suggests a spring or early summer use of the site on the basis of roe deer mandibles with erupting teeth. When comparing the faunal assemblage of Hohen Viecheln with the assemblage of Star Carr and Bedburg-Königshoven several similarities can be observed. The majority of anatomical elements were found at the site indicating that animals were probably butchered and processed at or near the site.

Bone and antler points

Besides the antler frontlets, the most distinctive artefacts of the three Mesolithic sites are the bone and antler points which were probably hafted as hunting weapons. No other sites in the regional context of Bedburg-Königshoven and Hohen Viecheln produced these points and only two more barbed antler points were found in the Vale of Pickering, on the shores of the island of No Name Hill and at Flixton Island I (Clark, 1954; Elliott and Milner, 2010). In sum 227 uniserial barbed points have been recovered from Star Carr, which represents 92 % of the total number of bone and antler uniserial barbed points associated with the British Mesolithic (Elliott and Little, 2018).

The selection of the material for the point production appears to have been crucial: of the 191 barbed points recovered from Clark's excavation at Star Carr, 189 were made of red deer antler (Clark, 1954; Elliott and Milner, 2010). The 2004-2015 excavations produced evidence for the use of animal bone for the production of a very small number of barbed points (cf. Elliott and Little, 2018: see point <116710>). In terms of production technique, the Star Carr barbed points show a "high level of typological variation, but a low level of technological variation" meaning the points were produced using a similar *chaîne opératoire* to manufacture a variety of different forms (Elliott and Little, 2018). The Bedburg-Königshoven and Hohen Viecheln points were made of bone rather than antler. In the case of Bedburg, the single example of a smooth bone point was made of metapodial bone from aurochs (Street, 1989: 38). Similar to Star Carr, at Hohen Viecheln the selection of raw material for the production of the points seems to have been important: The majority of the 316 bone points at Hohen Viecheln were produced from metapodials of red deer (Schuldt, 1955: 113-125).

THE LITHIC ASSEMBLAGES

Comparing the lithic assemblages

Star Carr comprises a very large flint assemblage of 41,820 pieces (combined sums of Clark, 1954; Conneller et al., 2018a, 2018b). The majority of artefacts were made of local/regional till flint of varying quality, mostly obtained as beach pebbles. The predominant use of this flint source limited the possibilities for the types of reduction sequences. The majority of cores were single platform cores reduced part way round (34.1 %), followed by opposed platform cores (27.5 %). Debitage was focused on the manufacture of

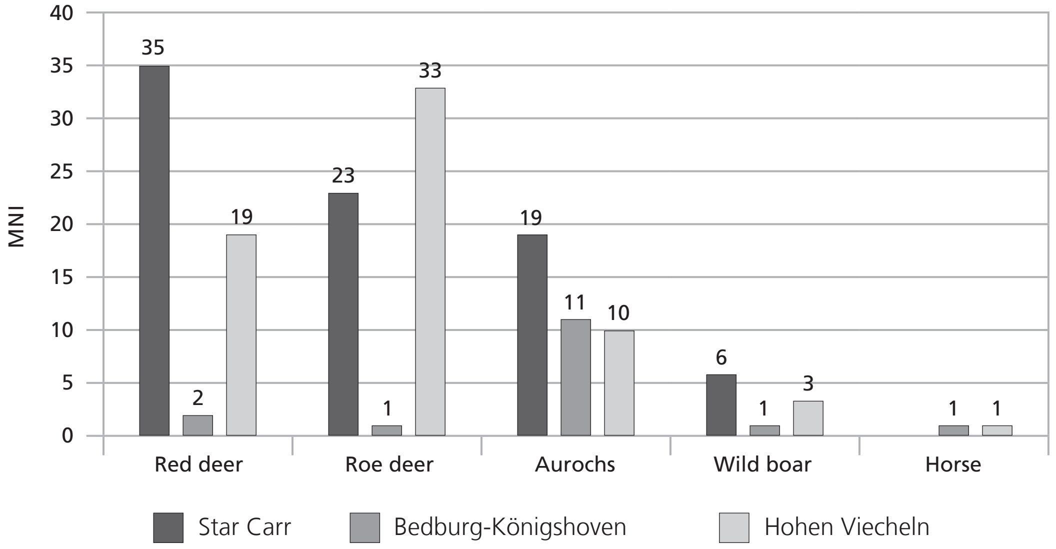

Fig. 6 Comparison of Minimal Number of Individuals (MNI) of large mammal species from Star Carr, Bedburg-Königshoven and Hohen Viecheln. MNI of Star Carr large mammals based on the bone assemblage and excluding antler remains (cf. Legge and Rowley-Conwy, 1988). – (Data: Knight et al., 2018; Street, 1989; Gehl, 1961b).

bladelets and narrows flakes. 3,690 artefacts show evidence of retouch, including 668 scrapers, 566 burins, 560 microliths and 28 axes (**Tab. 2**). Since the Star Carr assemblage represents a palimpsest of repeated occupation over centuries it is difficult to assess any meaningful tool ratios or frequencies.

The recent investigations of the site could reveal spatial patterning at the site. As such, there is a distinct contrast between lithics from the dryland and wetland areas of the site. On the dryland activities were very varied with evidence of different flint knapping scatters, frequently focused on hearths. In contrast in the wetland area the majority of lithic materials consisted of used and discarded tools with a high tool frequency of between 16.95 - 49.8 % (Conneller et al., 2018a).

Only a fraction of the lithic assemblage of Bedburg could be recovered with 196 stone artefacts which had been discarded into the water (Street, 1998: 167). In accordance with studies on lithic distribution on other Mesolithic sites, the major part of the lithic assemblage of the site would have been located on the drier parts to the north of the surviving section (Henriksen, 1976: 26-27). Despite the small size of the assemblage 15 different raw materials could be identified, including a fine-grained quartzite and two different *Kieselschiefer* (lydite) (Street, 1989: 33; Street, 1998: 167).

45 of the 196 lithic artefacts show evidence of retouch while eight tools of the assemblage (4.1 %) can be defined typologically. These tools consist of five scrapers and three oblique-retouched microlithic points made on narrow bladelets. The large proportion of cortex flakes in combination with 15 cores suggests the primary production of artefacts at the site. The flint-knapping technology at Bedburg seems to have been focused on the production of large laminar forms (Street, 1989, pers. comm.).

The relatively small number of waste flakes should not be surprising considering the proposed nature of the excavated area as a peripheral zone of the site (Street, 1998: 172). According to Street the entire butchering process was carried out at Bedburg-Königshoven (Street, 1990: 31-32). Besides the metapodia, phalanges and mandibles, the bones of the meat-bearing upper-limbs were also exploited for their marrow. This emphasis may suggest that the lithic items were deliberately selected from the debitage to conduct butchering tasks near the water's edge. Flakes and blades used in butchering do not need to exhibit any common features beyond a certain size and stability.

Hohen Viecheln comprises a large lithic assemblage of almost 11,000 lithics which is comparable to the assemblage of Star Carr (Schuldt, 1961: 102). All artefacts were made of a local grey flint from the shores. Of the 10,809 lithics 659 (6.1 %) artefacts can be classified as tools (Schuldt, 1961: 102). The presence of such a large amount of debris suggests that flint-knapping was carried out on the actual site. Like Star Carr and Bedburg, the lithic technology at Hohen Viecheln appears to have been focused on the production of blades with a sum of 2,247 blade forms of which only a few were worked into tools, including 10 microliths and 151 core and flake axes (Schuldt, 1961: 91). The relatively low number of microliths is not surprising given the coarse excavation methods in the 1950s.

The regional context

The scatters in the Vale of Pickering surrounding Star Carr are highly variable in terms of source and quality of raw material and in terms of scale, intensity and nature of flint-knapping activities at the sites. Compared to Star Carr, the other sites in the Vale of Pickering seem to represent short-term activity areas which were either abandoned or re-occupied for different activities. Star Carr therefore emerges as a unique site in its regional context due to its repeated re-occupation for a similar purpose (Conneller and Overton, 2018).

No comparable assemblages were found near the site of Bedburg which may be due to the history of mining in this region. An extensive accumulation of flint scatters was found on the north-east shore of the Lake of Schwerin, approximately 2 km from Hohen Viecheln, close to the village of Flessenow (Schuldt, 1959: 7). Of the 12,159 lithic artefacts recovered from the site 541 (4.4 %) lithics can be classified as tools, including core axes, borers and microliths. The 116 microliths are a predominant feature of the assemblage, making up 21.4 % of the tools and thereby contrasting the lithic assemblage of Hohen Viecheln (Schuldt, 1959: 9-10).

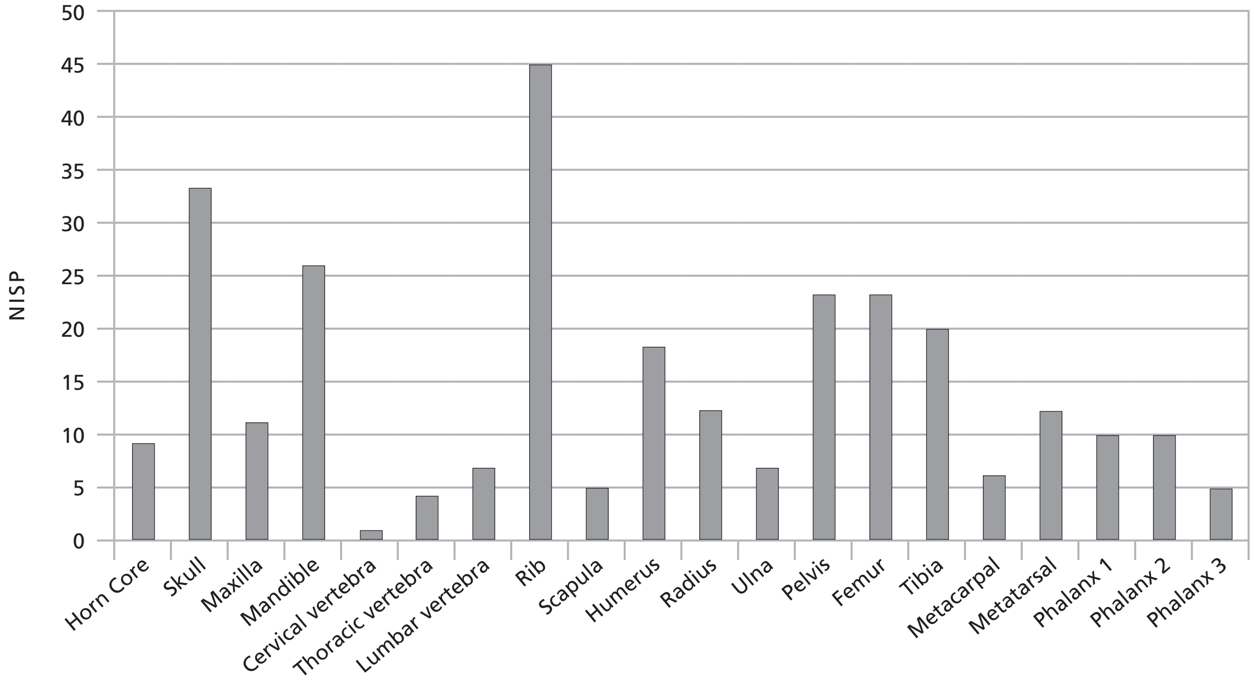

Fig. 7 Representation of the anatomical elements (NISP Number of Identified Specimens) of aurochs in the Bedburg-Königshoven assemblage. – (Data: Street, 1989).

Lithic category	Star Carr	Bedburg-Königshoven	Hohen Viecheln
cores	541	15	NA
tools	3,690	45	659
microliths	560	3	10
core/flake axes	28	0	151
scrapers	668	5	72
burins	566	0	23
Σ N lithic artefacts	41,820	196	10,809
Source	Clark, 1954; Conneller et al., 2018b	Street, 1989; Street, pers. comm.	Schuldt, 1961

Tab. 2 Representation of the main lithic artefact categories of the assemblages from Star Carr, Bedburg-Königshoven and Hohen Viecheln.

CHRONOLOGY OF THE SITES

All three sites discussed in this paper have recently been re-evaluated regarding their chronology. It is beyond the scope of this paper to include a list of all available radiocarbon dates which can be found in other publications (Star Carr: Milner et al., 2018a, 2018b; Bedburg-Königshoven: Street et al., 2019; Hohen Viecheln: Groß et al., 2019). In the following part the general chronology of the sites will be discussed to allow a comparison between the sites.

Star Carr and Bedburg-Königshoven represent some of the oldest Mesolithic sites in Europe. Bedburg was initially dated to the Middle Preboreal (Street, 1991). However, recent radiocarbon dates on aurochs remains confirm an early Mesolithic date for this site at the Younger Dryas/early Preboreal transition between 9,500-9,700 cal BC (Street et al., 2019). For the complex occupation at Star Carr, a total of 223 radiocarbon dates are available (Milner et al., 2018b: chapter 17). This site represents a persistent place in a rapidly fluctuating environment. According to Blockley et al. (2018) the hunter-gatherers at Star Carr demonstrated a significant degree of resilience to the climate change of the early Holocene with a repeated occupation of the site for over 800 years starting in circa 9,300 cal BC. The recent re-evaluation of the Hohen Viecheln chronology revealed that the first occupation at the site dates to the late Preboreal while the main find layers date to the Boreal. This indicates that Schuldt's original chronological classification was generally correct, although he had "simplified the chronological range" (Groß et al., 2019: 59).

A ritual deposition of artefacts?

The recent investigations at Star Carr have identified the complex history of the site where Mesolithic hunter-gatherers continuously deposited worked wood, bone and flint tools into the waters of the lake, often in similar ways over centuries (Milner et al., 2018a). During the main phase of occupation large timber platforms were built on the lake edge, dwelling-structures were erected on the dryland and the deposition of bones, antler frontlets and other artefacts was continued in the wetland areas of the site. According to Elliott and Little (2018) the fragmentary nature of the barbed point assemblage from Star Carr and evidence that a number of barbed points had been de-hafted after their use, potentially elsewhere in the landscape, suggests that the barbed points seem to have been returned to Star Carr for deposition. The results of the recent investigations at Star Carr also demonstrate the *ad hoc* loss of material alongside a potential ritual deposition of artefacts. As discussed in the previous section on the antler headdresses, this suggests that ritual behaviour was part of the daily lives of the people at Star Carr (Taylor et al., 2017).

The peripheral nature of the Bedburg assemblage makes it difficult to analyse any spatial patterning. According to Street the bones recovered from the excavated area at Bedburg probably reflect the importance of butchering activities near the water's edge. The coarse excavation methods at Hohen Viecheln (for a discussion see Groß et al., 2019) and the complex stratigraphy do not allow a detailed investigation of the spatial patterning of the finds. Therefore, the question of a potential ritual deposition of artefacts remains unanswered for this site.

DISCUSSION

The apparent similarities between the faunal and lithic assemblages of Star Carr, Bedburg-Königshoven and Hohen Viecheln demonstrate that Britain should not be viewed as isolated from the rest of Europe. During the occupation of Star Carr Britain was connected to the continental mainland by a stretch of lowland which now lies under the North Sea and the English Channel. Clark (1954: 179) already noted a "cultural homogeneity" across Early Mesolithic northern Europe which has been termed the "Maglemose Culture". The technological equipment of these Maglemosian communities comprised a developed bone and antler industry and a new lithic tool type, the stone axe (Zvelebil, 2008: 27). Similar to the assemblages discussed in this chapter, several Maglemosian sites show selective treatment and deposition of animal remains (cf. David, 2005).

Hunter-gatherer groups across north-western Europe clearly shared common ideas regarding the deposition and shape of their hunting equipment. However, these groups seem to have made different choices regarding the materials used for the production of the points as well as the production processes which varied considerably (Elliott et al., 2018). As demonstrated in this chapter we cannot assume simplistic interpretations for the Mesolithic sites with antler headdresses. These sites represent special places in their respective landscapes which have yielded unusually large and well-preserved assemblages reflecting repeated occupations of a larger group of people. The assemblage from Bedburg represents this on a smaller scale as it probably reflects only the peripheral zone of a much larger site.

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I would like to thank Dr Martin Street for many inspiring discussions revolving around the sites mentioned in this paper. As demonstrated in this chapter, his contributions have opened up an international exchange about the complex topic of human responses to climate change during the Pleistocene-Holocene transition. Martin has been a source of invaluable support and guidance to me over the last eight years and has helped to inspire my path in investigating this transition. I would also like to thank Dr Elaine Turner for her valuable feedback on my research and for her and Martin's warm welcome when I visited MONREPOS on several occasions.

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DANIELA HOLST

EQUIPPING THE LANDSCAPE:
THE USE OF STATIONARY STONES IN THE EARLY MESOLITHIC

Abstract

Among the "Ground Stone Tools" assemblages of the Mesolithic sites of Duvensee, Friesack 4 and Rothenklempenow 17, a small group of large stones stand out. Designated as "*stationary stones*", these display use-wear traces on their wide working surfaces, which speak in favour of a use as anvils. In comparison to a recently used nut cracking stone from a mangetti nut groove in Namibia, use wear on the archaeological samples only formed weakly to moderately. Remarkably, most of the "*stationary stones*" analysed have been detected at Duvensee, *Wohnplatz 8*, a late Preboreal camp for hazelnut processing. Following ethnographic examples, an installation of these stones in the landscape is assumed. This supports the notion of Mesolithic land use strategies as being effective and provident.

Keywords

Land use, ground stone tools, early Holocene, archaeology of recent hunter-gatherers

INTRODUCTION

When we consider stone artefacts, we usually think about sharp-edged implements of siliceous raw materials that were more or less carefully shaped for hand-held or hafted use. This is especially true during the Mesolithic, where stone artefacts are typically tiny, ephemeral, follow distinctive typologies and technologies, and are mobile, leaving certain relics of the artefacts use life at different places in the landscape. This allows archaeologists to trace movements; for example, by raw material procurement strategies, retooling of removed weapons, or the distribution of technological traditions.

The type of ground stones tools presented here stands in stark contrast to this common notion of stone artefacts as carefully shaped, fast-moving tools. *Stationary stones* are neither mobile, nor modified, but bulky blocks, supposed to have been positioned in the landscape for long-term, passive *in situ* usage. Therefore, they contain important hints on land use strategies. Still, these inconspicuous stones have rarely been intensively studied, at least for the Mesolithic. A total of 13 stationary stones at the sites Duvensee, Friesack 4 and Rothenklempenow 17 have been macroscopically investigated. To gain an idea of the ways these stones have been used, and their land use contexts, an ethnographic example is described beforehand.

Drawing attention to immobile stone implements instead of small fast-moving tools might also change our views on Mesolithic land use strategies: whereas these people have historically been regarded as following an exclusively highly mobile lifeway, newer investigations provide more evidence that supports an interpretation of reduced mobility in restricted and well-maintained territories. Here, Mesolithic groups made their living on the large-scale exploitation of stationary resources like nuts or fish (cf. Holst, 2010; Boethius, 2017).

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GROUND STONE TOOLS

"Ground Stone Tools" (GST) or macro-lithic tools are stones that are modified using motions like abrasion, percussion, polishing, grinding, pounding or pecking (Adams et al., 2009: 43; Dubreuil et al., 2015: 106). For these tasks more granular stone types – which are tougher and less brittle – are usually chosen. As this definition covers a wide range of stones, it includes carefully polished bifacial axes, as well as unmodified hammer stones, grinding plates or mortars. Beyond their function as tools these stones have also been used as heat conductors (e. g., cooking stones, roasting plates) and as settlement equipment, including construction stones, wall supports, seats or weights. Macrolithic tools were often used *ad hoc*, in a versatile and multi-functional way over the long-term. Considering this, a single stone could accumulate information regarding all different aspects of life. GST are among the oldest tools humans used and produced and are therefore important for understanding the evolution of our species. These earliest stone inventories also include large and heavy stones, probably used as anvils (Arroyo and de la Torre, 2020, with references therein). A well-known example from early prehistory are the pitted stones from Gesher Benot Ya'aqov, which were found in different forms and sizes, including large blocks and flat anvils (Goren-Inbar et al., 2002, 2015), and presumably used for nut cracking. In the late Pleistocene/early Holocene GST inventories tend to become larger and more varied (Dubreuil et al., 2015; Spivak and Nadel, 2016). This is probably related to the intensified processing of local resources – especially plants – into storable food supplies (cf. Wright, 1994; Dubreuil and Nadel, 2015).

Furthermore, in the Mesolithic the first polished and drilled tools, like mace-heads or axes, were produced. However, in general Mesolithic GST tend to be unhandsome, unmodified, and with infrequent traces of macroscopic use-wear, making their functions difficult to decode. A long and versatile life of use might additionally complicate their understanding: GST may have been used over long periods of time, with ethnographic records documenting the use of some GST over generations (Dubreuil et al., 2015: 112, with further references therein).

To gain more insight in Mesolithic land use traditions and subsistence strategies, GST from the sites of Duvensee, Friesack 4 and Rothenklempenow 17 (all Northern Germany) are investigated within the project "Functional analyses of Mesolithic ground stone tools", funded by the Deutsche Forschungsgemeinschaft (DFG) (project number 415158854). Within these assemblages a group of large, heavy and compact stones with larger working surfaces stands out (**Fig. 1**). Because of their weight (> 1 kg) and based on ethnographic analogy, we suggest an interpretation of permanent installation in the landscape at the places of use. This is why they have been named "stationary stones". Such large compact stones or boulders are occasionally recorded for Mesolithic settlements and burials. In the context of burials they have been placed as grave stones, construction elements of tombs, and grave goods (examples in: Grünberg, 2000: 98 ff.); some seem to weigh down the deceased like in grave A129 in Nivå (DK) (Lass Jensen, 2016) or grave HB:10 in Vedbæk (DK) (Brinch Petersen, 2016). The few stationary stones mentioned in publications for settlement contexts have been interpreted tentatively after their find contexts beneath fire places, huts or bark mats, often associated with flint waste, as anvils, seats, or construction elements of fire places. They have been detected in Barmose (DK) (Johansson, 1990: 15), Holmegaards Mose (DK) (Becker, 1945: 63), Sværdborg I (DK)

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Fig. 1 Selection of stationary anvils from Duvensee (**1-5**), Friesack (**6**) and Rothenklempenow (**7-8**). – **1** ID SH1978-35.**8**; **2** ID MfV1925. 119:012; **3** ID SH1978-35.**9**; upper and lower surface; **4** ID SH2017-27.**47**; **5** ID SH1978-35.**10**; upper and lower surface; **6** Friesack (ID **F72**); **7** Rothenklempenow (ID 99/77, **36**); upper and lower surface; **8** Rothenklempenow (ID 99/77, **46**); for IDs cf. **Tabs. 1-3**. Images after 3D scans compiled in GOM 2019.

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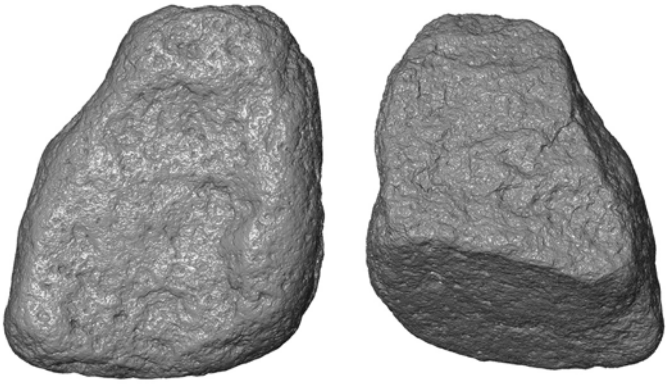

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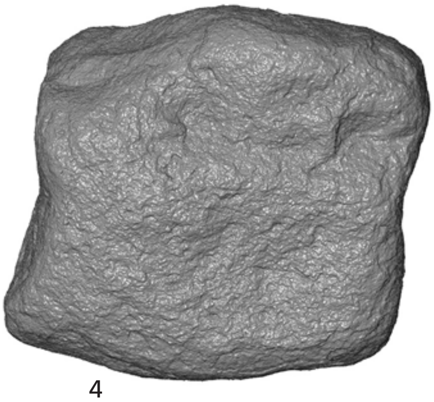

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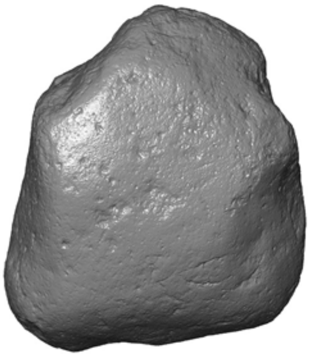

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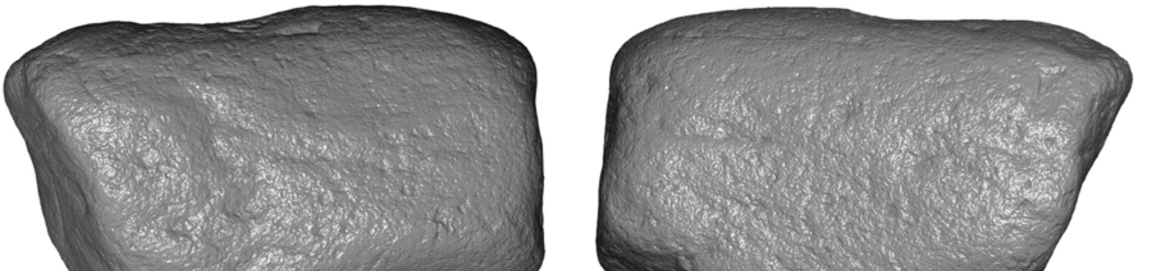

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(Henriksen et al., 1976: 34), Rottenburg-Siebenlinden (DE) (Kind, 2003: 73-74) or Star Carr (Clark, 1954: 97). Until now Mesolithic "stationary stones" have not been investigated in-depth.

THE USE OF STATIONARY STONES BY HUNTER-GATHERERS: AN EXAMPLE FROM NAMIBIA

The use of heavy stone blocks is still practiced in some parts of the world. Most common are examples of anvils used for cracking marula (*Sclerocarya birrea*) (Boshier, 1965; Marlowe, 2010) and mangetti nuts (*Schinziophyton rautanenii*; also called Mongongo) (Widlok, 1999) in Africa or Quandong (*Santalum acuminatum* R. Br.) in Australia (Pardoe et al., 2019). These nuts provide a rich staple food; their flesh and kernels are consumed either raw, roasted, or fermented as alcohol, and are also exchanged. Large rocks were used as seats (and anvils) and determine site selection in Hadza groups (Marlowe, 2010: 79).

There seem to be some common traits in the provision of these stones and their use: stones were picked up for future use, when the opportunity arose and suitable stones were at hand. Particularly large and heavy stones were often left behind for future use at locations for plant processing, where they were commonly used for many years (e.g., Yellen, 1976; Widlok, 1999; Marlowe, 2010: 79). So stones were not moved away once they reached the place of use, but instead "installed" in the landscape. This is true for hammer stones as well as anvils. The long-term placement of stones in the landscape meant that people did not have to search for new suitable tools every time they are going to process fruits, but instead choose to furnish their harvesting spots. The stones were usually not exclusively used for nut cracking and plant processing, but are typically multi-functional tools, especially in regions where such rocks are scarce (Widlok, 2017; Pardoe, 2019). However, investigations on stone use among Australian Aborigines also provide an example of the exclusive use of specialised anvil stones for cracking quandong nuts (Pardoe et al., 2019).

While the economy of mangetti or marula use is sufficiently described (Yellen, 1976; Widlok, 1999; Marlowe, 2010), nut cracking stones themselves have rarely been further documented (but see Pardoe et al., 2019). Thomas Widlok (University Cologne) kindly allowed investigation of two stones he brought from a mangetti grove in Northeast Namibia (Mangetti West, Farm 6) (Widlok, 2016) and provided me with information about their use context: stones are a rare and valuable commodity in Mangetti. For this reason, their use was long-term and multi-functional. When the opportunity arises, stones are brought from a river bed at about 20 km distance to the nut grove in anticipation of a future use for nut cracking there. They are habitually deposited along the paths within the groves for future use as a common good. As a result, with time the number of stones within the groves increases, as they are rarely taken away or exhausted. Stones of different use-lives and unused stones lie mixed together. The nut-cracking stones are not prepared or modified before use, simply selected for appropriate qualities and "improved" by use. The two stones taken from Mangetti West, Farm 6 consist of a larger compact stone block used as an anvil and a complementary smaller stone used as a hand hammer. The focus of this paper is on the larger compact stone used as an anvil.

The larger stone block consists of a medium grained granite and has an irregular prismatic form (**Fig. 2**). With a volume of 1,738 cm^3 and a weight of nearly 4.5 kg, this block is comparatively large, as most nut-cracking stones in Mangetti tend to be smaller (according to Widlok, 2017: Fig. 4.5, sized like a man's fist). However, for cracking of marula nuts anvils with a weight of up to nearly 23 kg have been recorded (Boshier, 1965).

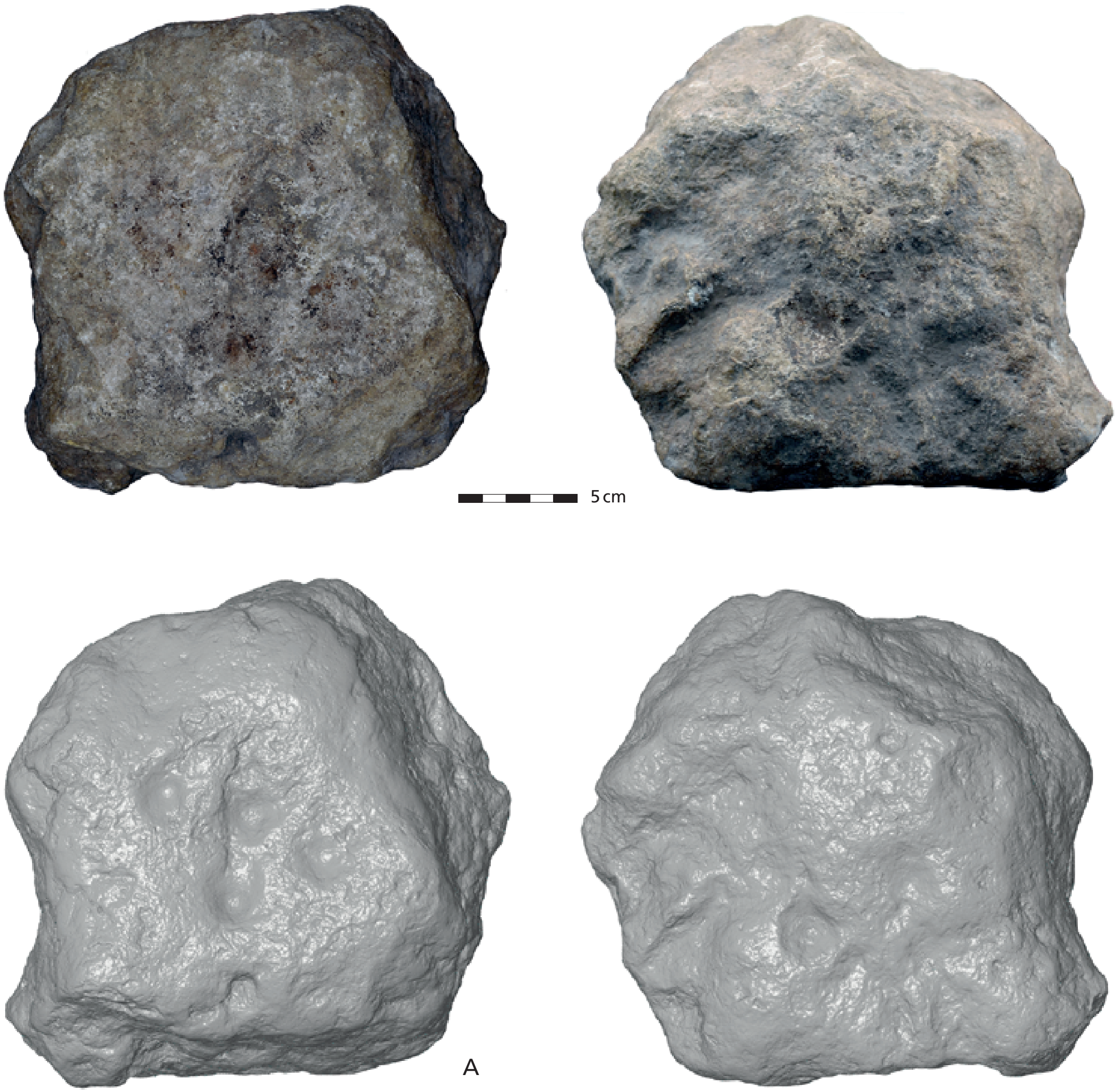

Fig. 2 Recent nut cracking stone from Mangetti West (Namibia), photo and 3D-scan. Clearly visible are the four pits on the upper side (**A**) and two beneath some unregular depressions on the bottom side (**B**), the abraded areas (whitish). Dark and reddish spots are residues, deposited in and around the pits.

Accordingly, the stone surface seems to be quite heavily worn. It has two horizontally opposed working surfaces, each covering a surface of more than 200 cm^2. These surfaces are characterized by several circular pits, each around 1.5 cm in diameter, with a depth of 0.5 cm. Interestingly, the pits have not been formed by intentional modification but developed over time by the use of natural depressions in the initial morphology of the stone (personal communication Thomas Widlok, December 2020). This is also evident on the bottom side of the stone: it was obviously less intensively used and accordingly shows just two circular pits and a few vaguely developed natural depressions towards the margins of the uneven surface (Fig. 2).

At the presumed top side of the mangetti stone, four of these depressions are grouped in the centre of the working surface. The inner faces of these pits feel mostly even and smooth with smoothed border areas, as if steadily abraded. While the natural surface of the stone is uneven, the area around the pits is extensively levelled by abrasion. These parts appear whitish and slightly rough. Within these areas and scattered beneath the pits are single percussion marks with an elongated triangular outline. Furthermore, there are two fields of parallel striations beside the pit group. The nuts were obviously cracked open by a pounding action, a combination of hitting and dragging. Of course, the stone could also have been used for alternative purposes that may have caused the fields of striations.

Elevations and the edges of the stone are partly worn and glossy like a polish, caused by the repeated handling of nuts, which are hand-held while cracked open. The partial polishing of surfaces of nut cracking stones in the mangetti groves by repeated handling and touching over a long time was already observed by Thomas Widlok during his field work (2017: 108), and was also noticed on nut cracking stones elsewhere (Boshier, 1965; Pardoe et al., 2019).

The most obvious use wear on the nut cracking anvil described here are the pits. Similar pits related to nut cracking have also been recorded on stones from Australia. These pits start as percussion marks, which develop into shallow indentations and then deepen into a steep-sided hole with a depth of up to 2 cm and a diameter of 2-3 cm (Pardoe et al., 2019). In contrast to this are observations during nut cracking experiments (e. g., Roda Gilabert et al., 2012) and descriptions of stones used for cracking of marula nuts, where the anvil surfaces became smoother and more even during use, due to the impact from the hammer stone (Boshier, 1965: 131-132), but without the development of pits.

FIND CONTEXTS OF THE STATIONARY STONES: THE SITES DUVENSEE, ROTHENKLEMPENOW AND FRIESACK

As the use of stationary stones can be regarded as part of a landscape that people modified to suit their needs, the settlement contexts of the stones are important for their understanding. All sites involved are distinguished by excellent organic preservation, which provides a sufficient background on varied subsistence activities. These sites were specifically selected for investigation due to their different functions and occupation times, in order to improve our understanding of diverse find contexts for stationary stones.

Duvensee

At the former Duvensee (Schleswig-Holstein, Germany), islets at the Western lake shore were repeatedly and seasonally used as short-term special task camps from the late Preboreal to the early Atlantic (Holst, 2014; Groß et al., 2018). These camps mainly served for the processing of large amounts of hazelnuts, as well as other subsistence and crafting activities (e. g., retooling of arrows). Enormous amounts of hazelnuts, stones (including heavy GST), sand, and wood for the roasting facilities have been brought to the sites (Holst, 2014). The transport of these items could have been provided by boats, as indicated by the find of a wooden paddle at the *Wohnplatz 2* site.

In total, 9 heavy stationary stones were detected in the find material of the sites (“*Wohnplätze*”) 5, 8 and 13 (**Tab. 1**).

The majority of the GST derive from site *Wohnplatz 8* (LA 18), a late Preboreal site (**Fig. 3**). Directly on the lakeshore, enormous amounts of hazelnuts were processed in roasting hearths of sand or bark mats (Bokel-

Site	inventory number (ID)	preser-vation [%]	weight [g]	length [mm]	width [mm]	thickness [mm]	volume [cm^3]	density [g/cm^3]	raw material	distance to settlement structures
Duvensee 5	MfV1925.119:012	100	1,109	128	100	88	435	2.55	sandstone	unknown
Duvensee 8	SH1978-35.**6**	~50	1,650	125	103	95	642	2.57	granite	2 m to central hearth
Duvensee 8	SH1978-35.**7**	~70	2,422	185	119	86	953	2.54	granite	1.5 m to central hearth
Duvensee 8	SH1978-35.**8**	100	1,800	132	115	83	696	2.59	granite	2.5 m to central hearth
Duvensee 8	SH1978-35.**9**	100	2,143	160	126	84	831	2.58	granite	6 m to central hearth
Duvensee 8	SH1978-35.**10**	100	4,263	195	131	116	1,644	2.59	granite	1 m to central hearth
Duvensee 13	SH2017-27.**4**	85	1,681	135	117	80	653	2.57	granite	11 m to central hearth, 14 m to bark mat
Duvensee 13	SH2017-27.**9**	~50	1,479	134	94	90	595	2.49	granite	4 m to central hearth, 3.5 m to bark mat
Duvensee 13	SH2017-27.**47**	100	4,767	180	165	104	1,884	2.53	granite	directly at centre of pine bark mat; 4 m from central hearth
Friesack 4		100	3,137	172	152	94	1,201	2.61	granite/ gneiss	
Rothenklempenow 17	99/77, **1603**	50	2,062	164	147	73	848	2.43	granite	~70 m to settlement/burial A, 20 m to settlement B
Rothenklempenow 17	99/77, **599**	100	2,723	220	124	95	1,047	2.60	quartzite	~70 m to settlement/burial A, 20 m to settlement B
Rothenklempenow 17	99/77, **603**	100	7,600	240	151	106	2,634	2.88	porphyry	~70 m to settlement/burial A, 20 m to settlement B

Tab. 1 Origin, morphology and raw materials of stationary anvils under investigation.

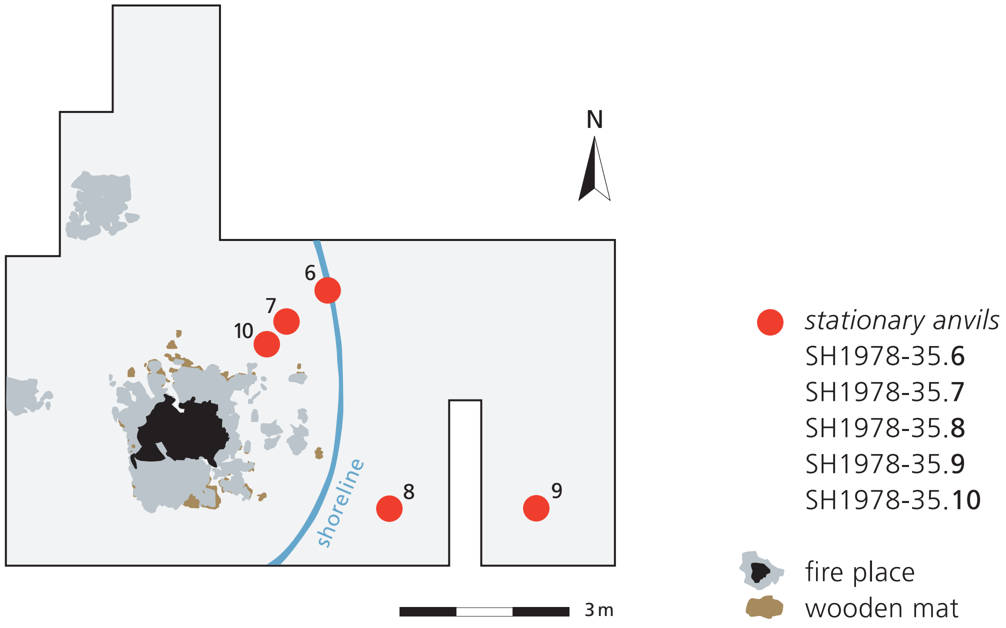

Fig. 3 Duvensee, *Wohnplatz* 8 (LA 18). Excavation area with roasting hearths and position of stationary anvils (cf. **Tab. 1**).

mann et al., 1981; Holst, 2010, 2014). During nut roasting stone artefacts were produced or repaired, with a particular focus on arrow heads (Holst, 2008, 2014). Microliths and microburins were found almost exclusively in the central hearth area. Larger stones and primary production waste, in contrast, have mostly been found beyond the shoreline, imbedded in *gyttja* layers. They had either been tossed into the low water or this area of the lake was used as a workshop for primary flint preparation during seasonal dry periods (Holst, 2014). The stationary stones seem to be an exception, however. With one exception, they derive from the settlement's peat layers, close to the central roasting hearth (< 2.5 m distance, cf. **Tab. 1**), regardless of their size and weight.

The site *Wohnplatz 13* (LA 19) comprises the remains of at least two distinct settlement events. In the central excavation area, a hearth was discovered in close proximity to a possible pine bark mat (**Fig. 4**). It was located directly adjacent to the lakeshore, and associated with a few hazelnut shells and thousands of silex artefacts (Bokelmann et al., 1985). To the east of this a further pine bark mat (190 cm × 70 cm) with a hearth on top was excavated (Bokelmann, 1989). Radiocarbon (^{14}C) dating of the bark assign it to a later settlement, dating to the end of the Boreal / early Atlantic. No lithics or other find materials have been associated with this settlement structure.

In the northern parts of *Wohnplatz 13* a small birch bark mat and a possible hearth have been recovered, associated with a few silex artefacts and hazelnut shells (Bokelmann, 1986).

Three stationary stones have been detected at *Wohnplatz 13*. One stone (ID[1] SH2017-27.**47**) was placed in direct contact with the eastern, younger pine bark mat (**Fig. 3**). The bark mat was partly destroyed in the centre next to the hearth, possibly the result of a former deposit (Bokelmann, 1989: 17). The GST shows

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[1] ID refers to individual inventory numbers given in **Tabs. 1-3.**

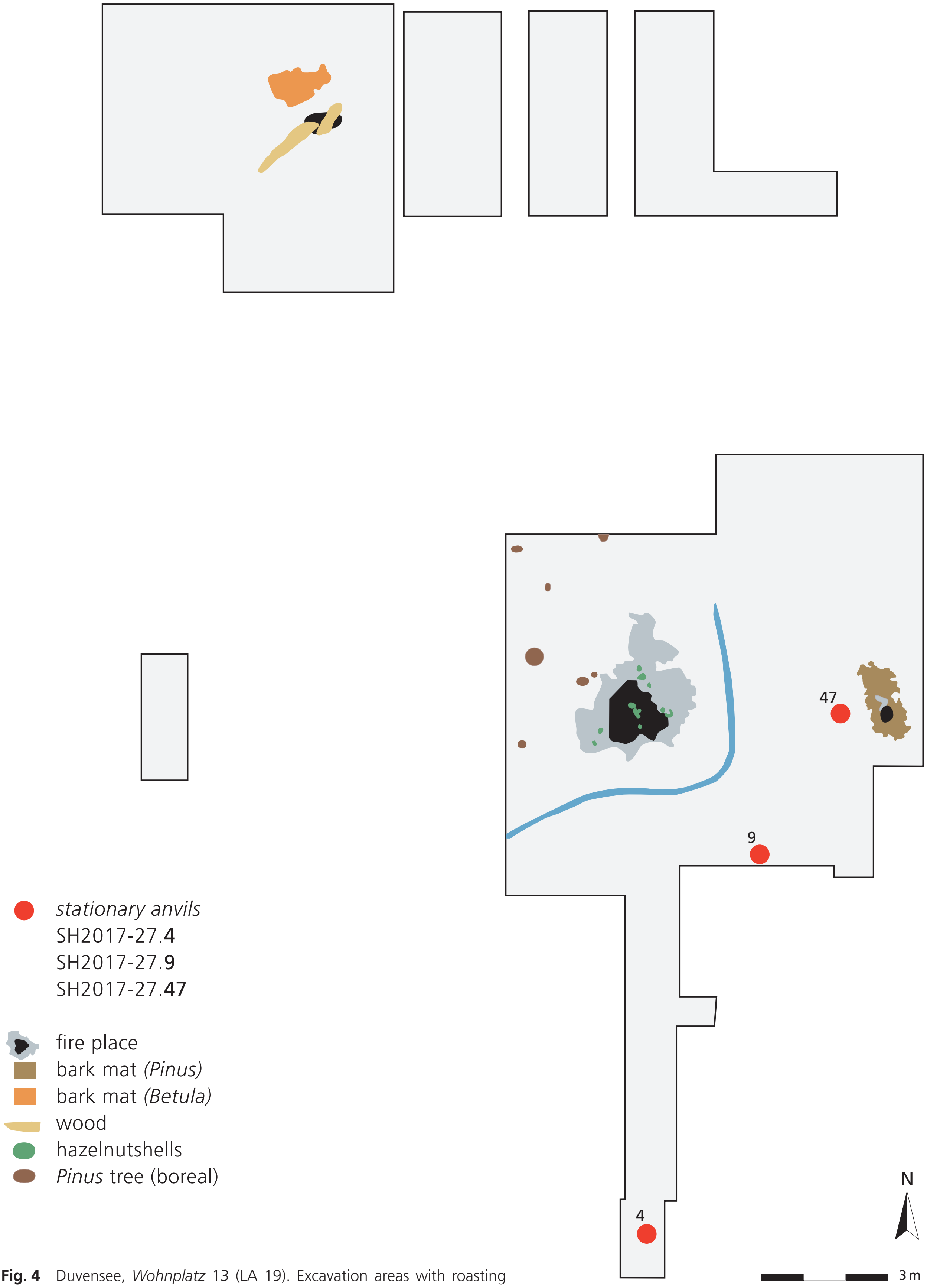

Fig. 4 Duvensee, *Wohnplatz* 13 (LA 19). Excavation areas with roasting hearths, bark mats and position of stationary anvils (cf. **Tab. 1**). – (Modified from Bokelmann, 1995: Fig. 1).

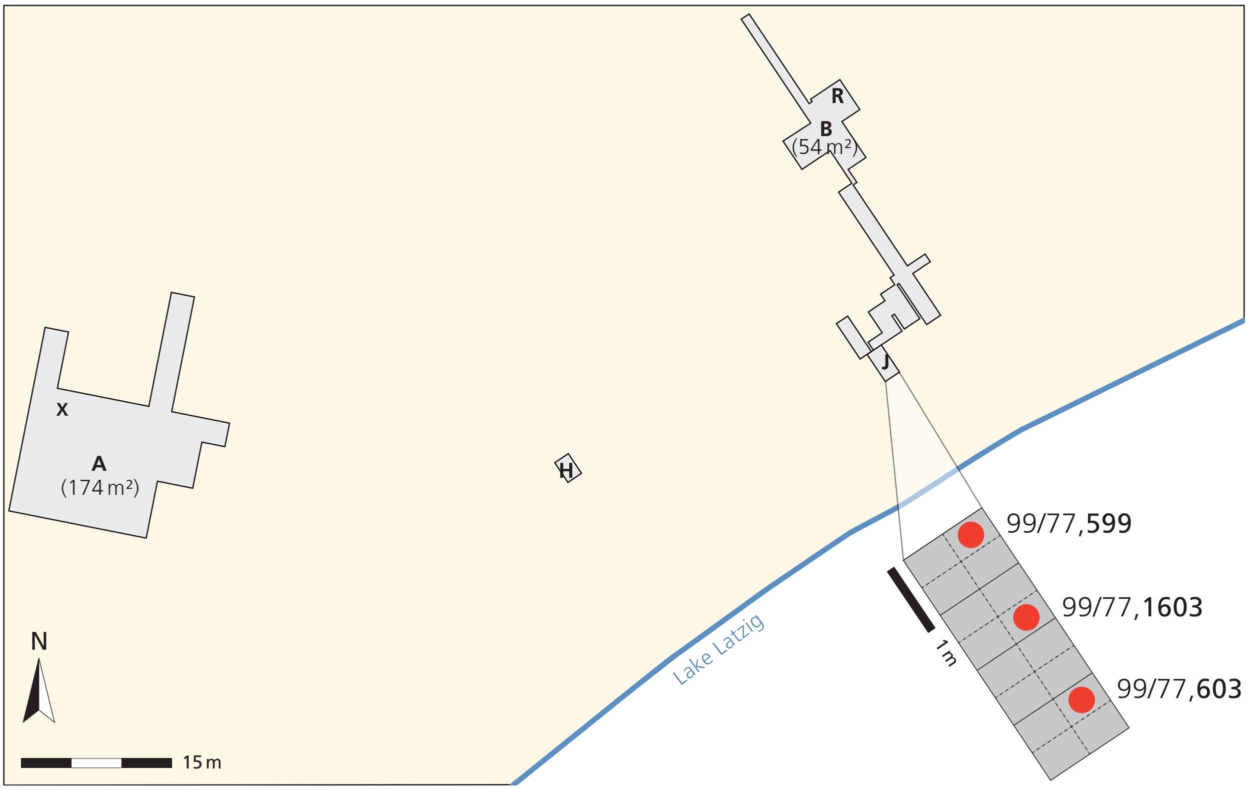

Fig. 5 Rothenklempenow 17. Excavation areas (A, B, H, J, R). Younger Mesolithic settlements have been detected in areas A and B, a burial in area A (marked by x). Dark grey: magnification of area J with excavation grid and position of stationary anvils (cf. **Tab. 1**; excavation plan modified from Elisabeth Noack).

heat damage, which may suggest that the large GST was originally placed in the damaged mat area next to the hearth.

The other two large GST have no close spatial relation to the hearths or bark mats (**Tab. 1**), and it remains unclear how these stones relate spatially to the settlement activities.

Duvensee, *Wohnplatz 5* was excavated in 1925. It differs from the before mentioned sites as five birch and pine bark mats of several settlement events were stacked vertically, separated by layers of hazelnut shells ("*Nussmull*") with peat (Schwantes et al., 1925; Bokelmann, 1971; Jenke, 2011). Several hearths of sand, loam, and charcoal were placed on the bark mats. Concentrations of micro-debitage and percussive stones mark areas of tool production on the bark mats (Jenke, 2011). GST have not been individually documented, but as the excavation area (~ 30 m^2) was confined to the uncovering of the bark mats, they are spatially directly associated with the mats and hearths.

Rothenklempenow

The Mesolithic site Rothenklempenow 17 (Mecklenburg-West Pomerania) is situated on the North-western lakeshore of the Latzigsee. Several areas have been excavated, covering 242 m^2 in total (**Fig. 5**). The lake shore was repeatedly visited from the mid-Preboreal to the Subboreal (early Neolithic), with the most intensive visiting period occurring in the mid-Boreal (Schacht and Bogen, 2001). Two settlements (A and B), designated by evident settlement structures like pits or hearths, have been excavated at the shore terrace. They date to a younger Mesolithic period (Schacht and Bogen, 2001). Furthermore, the burial of a woman in a sitting position, stratigraphically assigned to the mid-6th millennium BC (Bach and Bruchhaus, 1995: 28), was discovered at the north-western edge of area A (Schacht, 1993).

Even though the rich find material has yet to be studied in detail, hunting of large ungulates and fishing are regarded as the most important activities at Rothenklempenow (Schacht and Bogen, 2001), based on the quantity of animal bones and remains of fishing gear recovered at the site.

Three stationary anvil stones were detected in trench J (4 m^2) in the accretion zone of Latzigsee, at some distance from the settlement structures A and B (**Tab. 1**). No obvious settlement remains have been detected here, despite numerous well-preserved lithic and organic finds. This part of the settlement was interpreted as an area for accessing the lake and as a toss zone (Schacht and Bogen, 2001). The stationary stones may have been tossed here or used *in situ* during regression phases of the lake. One anvil stone (ID 99/77, **603**) was directly associated with a dated sample from the Preboreal. The other two have been detected in Boreal layers (ID 99/77, **1603** from layer 5b: pollen zone Vc; ID 99/77, **599** from layer 7: pollen zone Va).

Friesack 4

The Mesolithic settlement of Friesack is located on a sandy hill on an island of about 6,000-9,000 m^2, situated at a lakeshore within the Elbe-Oder ice-margin valley (Gramsch, 2001). The settlement itself was destroyed; excavations correspond to the former lakeshore area, where settlement material has been tossed, in some cases possibly deposited, but mostly rearranged by human-induced erosion. The complex stratigraphy of sand, humic sand, and *gyttja* layers corresponds to more than 100 episodic occupations that were grouped into chronologically sequential Complexes I to IV (Mesolithic) and V (Neolithic) (Gramsch, 2001, 2016). They date from the Preboreal to the mid-Atlantic (Gramsch, 2016: Tab. 1), documenting a Mesolithic settlement history of more than 3,600 years. Considering the quantity and diversity of find material and activities documented, Friesack 4 served as a residential site that was occupied for longer times (weeks or months), although not permanently (Gramsch, 2016: 22). According to zooarchaeological investigations of the early Mesolithic inventories, the site was visited in spring and summer (Schmölcke, 2016). Remains of boats and paddles attest the use of waterways for logistics and travelling to the site.

There is just one heavy stationary stone among more than 250 GST. It was detected in trench Z (Quadrant F6), in layer 8b, dating to the Preboreal (cf. Jahns et al., 2016: Tab. 1).

METHODS OF MACROSCOPIC INVESTIGATIONS

Within the case study the GST inventories are analysed macroscopically and microscopically, with focus on the selection criteria for the stones, ways of use, the materials processed, and the relation to fire. Macroscopic analyses included the recording of the morphologies and metrics, raw material, surface qualities, preservation conditions, and possible modifications. The surfaces have been examined by the naked eye and have been screened at low magnification (0.63×/0.116 objective with 10× oculars) by stereo-microscope (*Zeiss SteREO Discovery V8*), using a ringlight and LED swan-neck as light sources, optical zoom 1x-8x.

Furthermore, all stationary stones have been 3D-scanned using an AICON smart SCAN-HE R8 with the M-450 objective (field of view 355 × 265 × 220 mm, point-to-point distance 108 µm). The 3D models have been edited with the GOM Inspect 2019 (Hotfix 8) software package (**Fig. 1**); volumes and surface areas (**Tab. 1**) were computed from the 3D models in GOM. Lab analyses were conducted at the TraCEr Laboratory for Traceology and Controlled Experiments in the MONREPOS Archaeological Research Centre and Museum for Human Behavioural Evolution in Neuwied (DE). Ongoing lab analyses include high-resolution microscopy of surface alterations and sampling for possible residues.

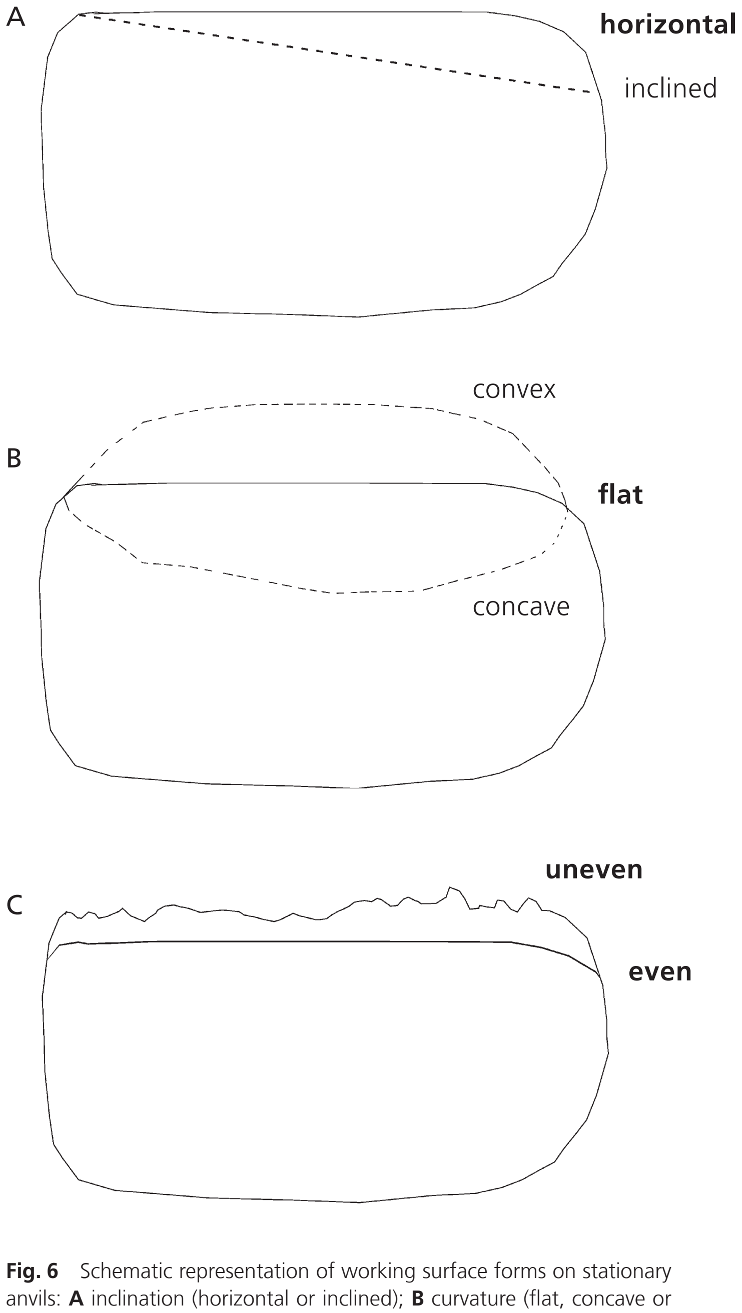

Fig. 6 Schematic representation of working surface forms on stationary anvils: **A** inclination (horizontal or inclined); **B** curvature (flat, concave or convex); **C** topographic relief (even or uneven). Micro-topography (rough or smooth) as fourth criterion is not presentable.

Site	inventory number (ID)	working surfaces [n]	surface preservation	surface area(s) [cm²]	surface orientation	surface curvature (upper/ lower face)	surface relief	surface roughness
Duvensee 5	MfV1925.119:012	1	good	89	slightly inclined	flat	slightly uneven	rough
Duvensee 8	SH1978-35.**6**	1	good	>98 (fragmented)	fragmented	fragmented	fragmented & used	smooth(ed)
Duvensee 8	SH1978-35.**7**	1	badly weathered	138	horizontal	flat	even (weathered or used)	rough
Duvensee 8	SH1978-35.**8**	1	ok	123	horizontal	irregular concave/ level	~even/~even	rough/rough
Duvensee 8	SH1978-35.**9**	1	good	195	slightly inclined/ slightly inclined	slightly concave/ level	slightly uneven/ uneven	rough
Duvensee 8	SH1978-35.**10**	2	good	225/164	slightly inclined/horizontal	sinuous/flat	uneven/even	rough/rough
Duvensee 13	SH2017-27.**4**	2	heat fractured	not measured	horizontal	flat	slightly uneven (weathered or used)	smooth
Duvensee 13	SH2017-27.**9**	1	badly weathered & heat damaged	(fragmented)	horizontal/horizontal	flat/flat	even	rough
Duvensee 13	SH2017-27.**47**	1	weathered	340	horizontal	flat	partly uneven	rough
Friesack 4		2	good	206/178	horizontal/horizontal	slightly convex/ level	even/~even	smooth/ ~smooth
Rothenklempenow 17	99/77, **1603**	1	lower surface split by heat	329	horizontal	unregular sinuous	uneven	smooth
Rothenklempenow 17	99/77, **599**	4	good	179/184 173/131	horizontal/horizontal slightly inclined/horizontal	flat/flat flat/slightly convex	even/even/ uneven/uneven	smooth/smooth smooth/smooth
Rothenklempenow 17	99/77, **603**	2	good	351/331	horizontal/horizontal	flat/flat	~even/~even	rough/rough

Tab. 2 Surface qualities of stationary anvils (cf. **Fig. 6**).

CHARACTERISTICS OF “STATIONARY STONES” IN DUVENSEE, FRIESACK, ROTHENKLEMPENOW

The majority (77 %) of the heavy stones consists of different varieties of granite. These are easy to procure from the tills close to the sites. Single stationary stones consist of sandstone, quartzite and porphyry (**Tab. 1**). Weathering has faded the colour of most of the stones to a greyish-white. This might also offer an explanation as to why the softer mica minerals on the granite surfaces are often underrepresented or totally missing. The humic acids and the increasing oxygenation of the peats led to the more or less severe degradation of stones, particularly in Duvensee. This is also evident in the comparatively low densities of the stones: granite usually has a density of 2.6-2.7 g/cm^3; here it is generally less (**Tab. 1**).

None of the stones bears evidence of being intentionally prepared for use, e.g., by cracking them into appropriate sizes, slicing them into slabs, or by shaping them laterally; nor are there any hints of intentional maintenance of the stones during use.

Weighing between 1,109 g and 7,600 g (mean weight 2,834 g or 3,442 g, if just compete stones are considered), with a volume between 435 cm^3 and 2,634 cm^3 (mean 1,170 cm^3 or 1,282 cm^3, cf. **Tab. 2**), the stones are clearly set apart from the other GST.

All stones have a compact, more or less prismatic form (except for the fragmented pieces) (**Fig. 1**), with one or two opposed surfaces. Only the “stationary stone” from Friesack shows four surfaces. Altogether 21 potential working surfaces that have been studied here. Their sizes range from 89 cm^2 to 351 cm^2 (**Tab. 2**). To describe the qualities of the presumed working surfaces, four levels of augmenting resolution are used (**Tab. 2**). They include the inclination of the working surfaces (horizontal or inclined) when the stone is placed on the ground, its curvature (flat, concave or convex), the topographic relief (even or uneven), and the micro-topography or roughness (which is mainly dependent on the granularity of the surface: roughness or smoothness) (**Fig. 6**). Most surfaces are oriented horizontally when the stone is placed on the ground, or are at most slightly inclined in single cases, depending also on the underground the stone is positioned. The surfaces of the respective stones are mostly level (76 %), though not necessarily perfectly even (55 %), but show disparities in the form of small depressions or elevations in 9 cases (45 %), resulting either from use or naturally occuring. About half of the surfaces feel rough, while the other half feel more or less smooth. Roughness depends mostly on the rocks natural granularity, and may therefore reflect selection for specific purposes (rough surfaces for grinding and frictional activities). But surface topography also results from use, heating, or weathering. In one case (**Fig. 7**) the surface was clearly smoothed by use. Weathering and heating have damaged the surfaces and increased the roughness of five stones (**Tab. 2**).

FUNCTION OF “STATIONARY STONES”: USE-WEAR RESULTS

Macroscopic and low magnification analyses reveal surface alterations on nearly all the stones, which seem to be related to use (**Tab. 3**). Depressions dominate; these seldom form pronounced and regular pits, or single percussion marks on the flat working surfaces. Only three stones show no or only obscure traces, due to their poor surface preservation. Based on this evidence, it is clear that most of the stones have been used passively as anvils for percussive activities. Additionally, three of the stones show percussion marks on the marginal ends, which must result from an alternative use as an active handheld heavy percussion tool. Here, scaled and stepped impact marks form crushed areas that have reduced the ends of the stones.

Site	inventory number (ID)	macro traces	location/arrangement
Duvensee 5	MfV1925.119:012	irregular shallow depression	centre of upper side
Duvensee 8	SH1978-35.**6**	very smoothly abraded/polished with fine striations; groove with deep triations; single impact scars; potential remnant of pit at breaking edge	upper side
Duvensee 8	SH1978-35.**7**	obscure flat depression; obscure impact marks	centre lower side next to breaking edge; scattered over lower and upper side
Duvensee 8	SH1978-35.**8**	long triangular scars/depressions; concentration of impact marks	centre of upper side; upper marginal end
Duvensee 8	SH1978-35.**9**	flat depressions in large-area abrasion? obscure small irregular depressions (low.); crushed areas with scale impact marks	nearly whole upper side; densely scattered on lower surface; marginal ends
Duvensee 8	SH1978-35.**10**	deep notched pit and parallel striations (up.); shallow irregular pits; impact marks; stepped flat flake negatives (low.)	centre of upper side; scattered over lower side and edges
Duvensee 13	SH2017-27.**4**	obscure circular and triangular pits (heat damage?)	scattered over upper and lower side
Duvensee 13	SH2017-27.**9**	not visible	
Duvensee 13	SH2017-27.**47**	large circular pits	on fringe of upper side
Friesack 4		shallow depression; short striation; single impact marks; crushed areas with stepped impacts; deep triangular scars	centre of upper side; marginal ends of short edges
Rothenklempenow 17	99/77, **1603**	obscure striations	centre of upper side
Rothenklempenow 17	99/77, **599**	shallow depression with triangular ection; single notches; parallel triations; scaly detachments	central on upper side; short edge
Rothenklempenow 17	99/77, **603**	shallow pits, circular with rough bottom and irregular with scale bottom; triangular impact marks; half-moon shaped notches	loosely scattered on both flat surfaces, two round pits side by side on lower surface; isolated marks on long edges

Tab. 3 Character and location of use wear on stationary anvils after macroscopic analyses.

Percussion marks on the flat surfaces appear as single cavities or cluster in distinctive, mostly shallow "pits", better described as depressions. These take different shapes and sizes, from a coarse roughening of the surface to deeper triangular notches. However, distinct circular pits with regular abraded surfaces that resemble those on the Mangetti stone described above are rare. Probably the best example (Duvensee 13: ID SH2017-27.**47**) is not appropriate for microscopic analyses, due to its heavily weathered surface. Furthermore, a few surfaces show striations (Duvensee 8: ID SH1978-35.**6**, ID SH1978-35.**10**; Rothenklempenow; ID 99/77, **599**) or short grooves (Friesack) in the immediate vicinities of the pits. Most are very fine,

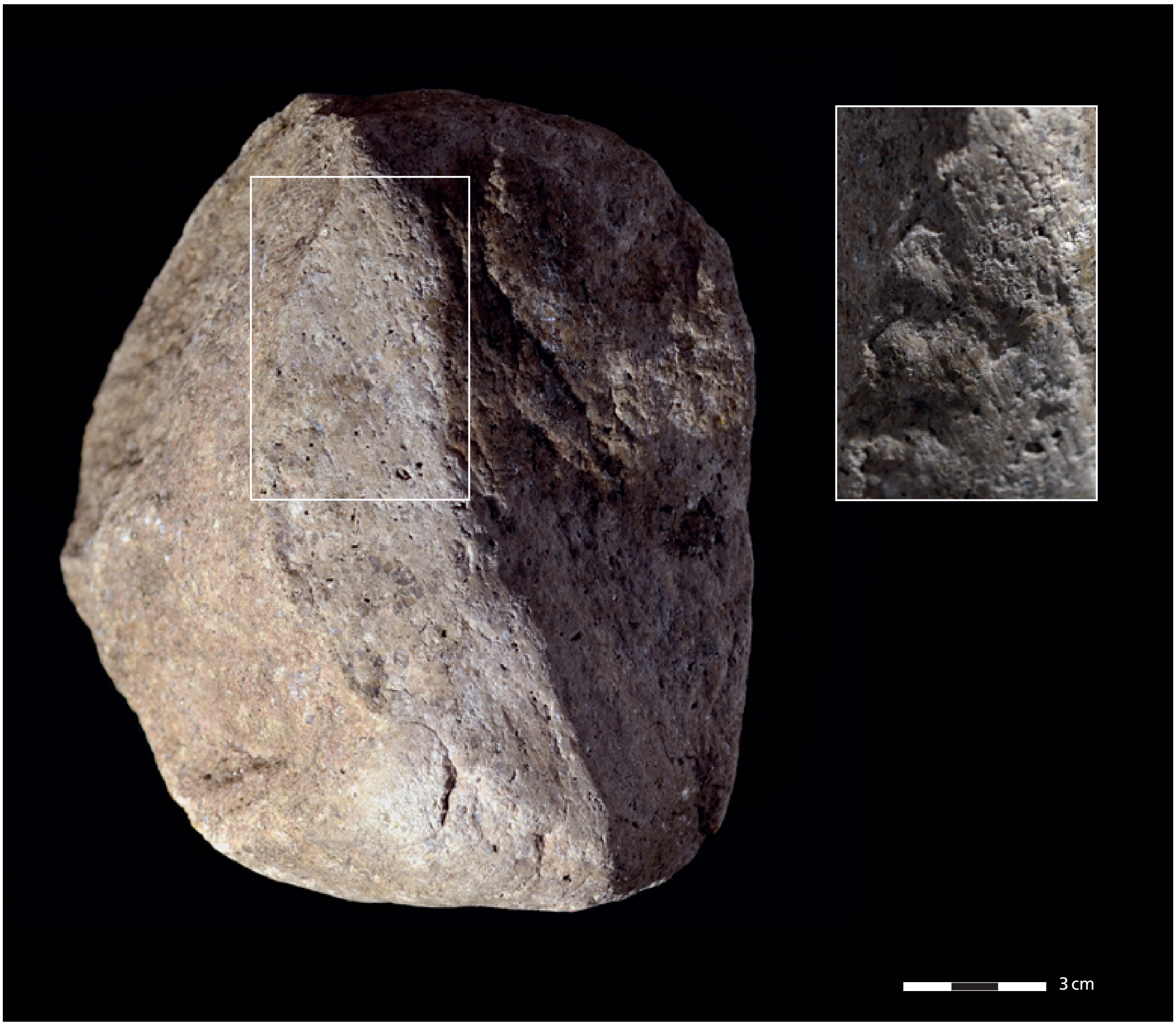

Fig. 7 Duvensee site 8, ID SH1978-35.6. Upper surface with abraded working surface, that probably broke during use. Magnification with parallel striations that indicate motion of use.

macroscopically visible only under grazing light. These striations might document the use of the surfaces for pounding as a combined movement of hitting and dragging. But the stationary stones were occasionally also used for grinding or polishing activities, as is evident on stone ID SH1978-35.6 from Duvensee 8 (**Fig. 7**). The stone broke into two halves across a working surface, that based on the presence of numerous parallel striations was totally smoothed by abrasion. Beneath the smoothed surface is an irregular groove that may have formed naturally but clearly shows some use-related deep striations inside.

If we compare the macroscopic evidence for use wear, especially the development of pits with those on the Mangetti stones from Namibia, they seem to be only weakly developed. This may have been induced by a variety of factors: the formation of use wear is a product of the raw materials of the stones and of the contact materials, namely the hammer and matter processed. A soft percussion tool like a wooden club or the processing of softer or more pliable organic materials like nuts, seeds, or fresh bone will produce less pronounced impact marks, but can still cause abrasion (de la Torre et al., 2013). On the other hand, there is no shock absorption during such knapping activities as bipolar knapping; this increases the force on the anvil, leading to surface fatigue and fractures, or the loss of grains (cf. Adams, 2014; Dubreuil et al., 2015: 135). Such damage has also been observed during preliminary microscopic investigations on percussion marks on the stones under consideration.

The duration and intensity of use play a prime role in the formation of use wear. This was also observed for the Quandong stones in Australia, where pits start as single percussion marks but deepen with use over time (Pardoe et al., 2019). In this regard it seems likely that the stones under consideration did not have a long and intensive use life. This is further supported by the fact that use wear traces are not densely distributed, but are instead loosely scattered and do not overlap.

CONCLUSIONS

Stationary stones form a distinctive artefact group within GST. These heavy and compact blocks are interpreted as having not been moved around, but instead installed as anvils at places of use. As such they are indicative of land use patterns and subsistence strategies. These changed dramatically – worldwide – at the end of the Pleistocene and the beginning of the Holocene, making the study of these stones particularly interesting for the Mesolithic. To date, little is known about the use of stationary stones in the Mesolithic.

Macroscopic analyses of the stationary stones from Duvensee, Friesack and Rothenklempenow reveal use-wear on nearly all stones, attesting to their use as anvils, but also in abrasive activities and as hammer stones. Other functions (for example, as seats or weights) are of course possible, but would not have left any traces of use. Percussion marks or flat depressions are most common, but all the stones are different, with a lack of use-wear patterns that can be interpreted in terms of repetitive activities. This might point to the versatile function of the stones, or be due to the length of time they were used: the traces are relatively weakly developed, indicating a less intensive use of the stones. However, macroscopic surface analyses are often ambiguous, and so far do not reveal anything about the materials processed on the stones. This requires further verification by microscopic analyses and comparative studies on experimentally used stones as well as on a natural reference collection. On this basis, a quantitative evaluation of use-wear in combination with residue analyses will allow for a reconstruction of the use history and economy of the stones. First microscopic analyses are promising. They document the damage of single grains in the relevant areas, like scars, fractures or even the total crushing of grains, resulting in a frosted appearance (e. g., Adams, 2014).

The find frequencies and settlement contexts of the stones are revealing. By far the majority of heavy stones have been detected at Duvensee *Wohnplatz 8*. In contrast to Friesack and Rothenklempenow, where the whole spectrum of subsistence and crafting activities is documented by an enormous amount of find material, Duvensee *Wohnplatz 8* was just an ephemeral camp, mainly used for hazelnut processing. This speaks in favour of the close connection of these stones to nut processing, among other functions. The Duvensee area was repeatedly occupied and, even though not all sites show the same bulk of nutshells, hazelnut processing was one of the main tasks here, after flint knapping. People returned year after year in a long and stable land use tradition, settling the same places (sites 5, 11) repeatedly, or more frequently chosing a location just a few meters from the previous one. In contrast to the situation in Mangetti described above, stones were abundant in the tills around Duvensee (and at Friesack and Rothenklempenow as well), and their transport could have been facilitated by boats. In this way, people seem to have gradually equipped the lakeshore area with working materials. It remains unclear, of course, whether people reused the stones from previous stays for nut cracking and grinding.

Final remark

My interest on the function of GST was sparked by my former work on the Duvensee sites, the subject matter of my PhD project. At that time, Martin helped with words and deeds, or better still, with data, knowledge, literature, and all his competence and experience. Thank you, Martin, for sharing this with me, and for the inspiring discussions that deepened my fascination for the Mesolithic.

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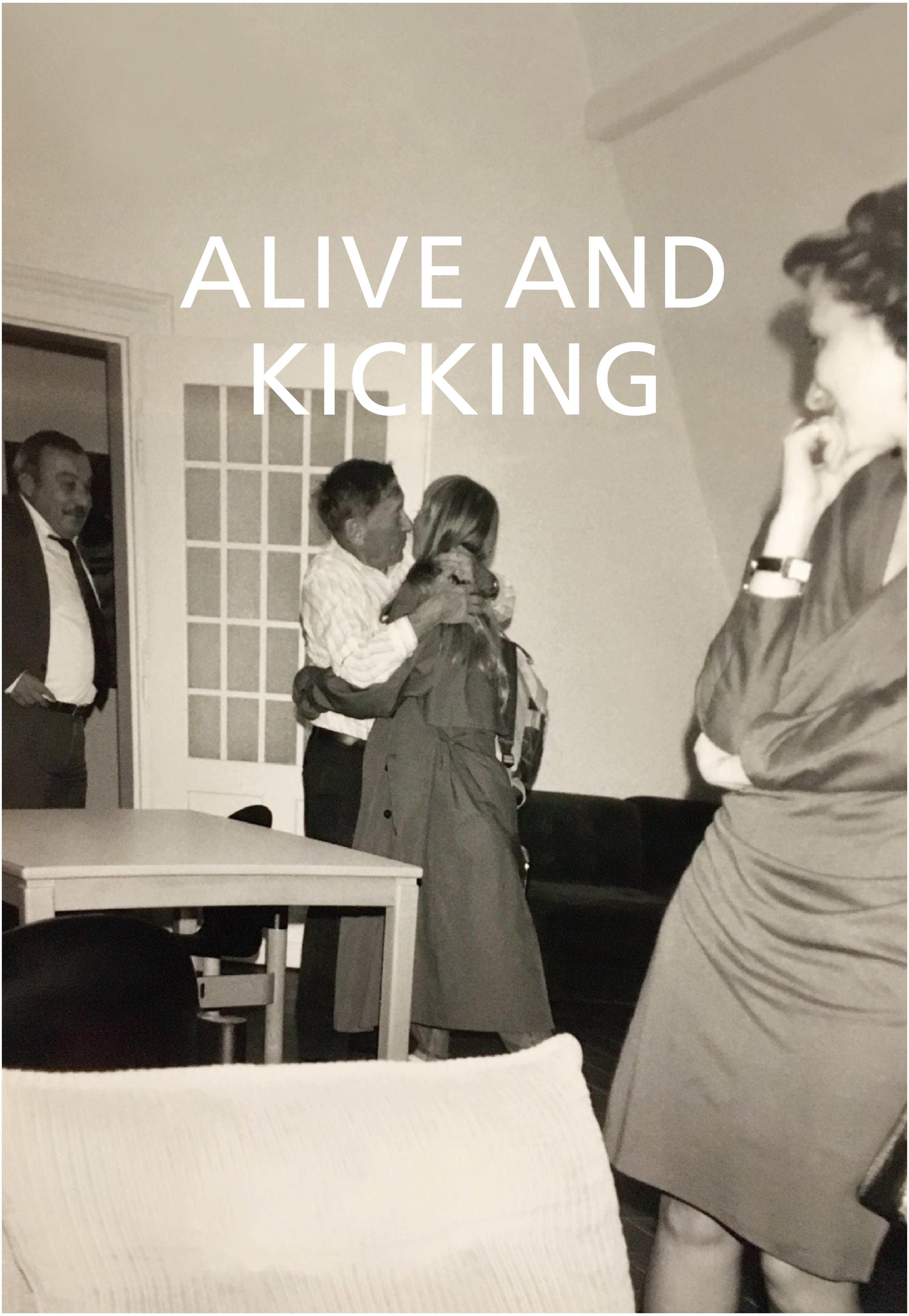
ALIVE AND KICKING



Martin with computer in his favourite closet, 1990.

Elaine and Martin are specialised in the archaeology of the Palaeolithic and Mesolithic, so there is hardly any ammunition that can be fired when the archaeology of younger – i. e., "alive and kicking" – periods is concerned. What only some know, however, is that Martin studied faunal remains found in the ditch of a Medieval Castle and Martin, being Martin, immediately became a specialist in medieval zooarchaeology! Unfortunately, this "Epi-Palaeolithic" record is still unpublished for years.
What can also be mentioned in this context is that the German police regularly visited MONREPOS in previous years presenting plastic bags to Elaine and Martin with mouldering contents that was almost "alive and kicking", hoping the contents would fail to fall under their responsibility – which gladly mostly it did!

2001

Terberger, T., Street, M., 2001. Neue Forschungen zum „jungpaläolithischen" Menschenschädel von Binshof bei Speyer, Rheinland-Pfalz. *Archäologisches Korrespondenzblatt* 31, 33-38.

←

MONREPOS 1989. Elaine being kissed by Vadim Ranov. In the background: V.N. Gladilin; Sabine in the foreground.

PIOTR WOJTAL · MICHAŁ WOJENKA · KRZYSZTOF WERTZ
LEMBI LÕUGAS · WOJCIECH ODACHOWSKI

ANIMAL REMAINS FROM OJCÓW MEDIEVAL CASTLE (SOUTHERN POLAND)

Abstract

The castle of Ojców belongs to the most impressive defensive fortifications of the Polish Middle Ages. The earliest stages of human occupation of the castle hill are dated to the Early Iron Age corresponding to the open-air settlement of the Lusatian Culture. After the fall of this settlement the castle hill was uninhabited until the early castle building works in the 14th century. The castle was a foundation of King Kasimir III the Great. In the 16th century the castle was ruled by Queen Bona Sforza, among others. At the end of the 18th century the castle lost its tenurial status for a while, and since it was not any longer profitable, at the early 19th century it was abandoned

The excavations in trenches I and II of Ojców castle yielded > 7,500 fish, bird and mammal remains. During the entire history of Ojców castle, from the beginning of the 14th to the 19th century, the main food resources for residents were domestic animals, especially mammals (cattle, pig, sheep and goat). However, birds (chickens and geese) were important dietary supplements. Fish remains are rare in the material studied. However, there is a noteworthy presence of sturgeon remains in the medieval cultural layers. Apart from the sturgeon, the high social position of the castle's residents is also reflected in the presence of exotic bird species (peacock), dated to the post-medieval period.

Keywords

Zooarchaeology, Middle Ages, castle, sturgeon, peacock

INTRODUCTION

The castle of Ojców (Skała commune, Krakow district), located in the scenic landscape of the Ojców National Park in the Krakow Upland (Gilewska, 1972), belongs to the most impressive defensive fortifications of the Polish Middle Ages. The castle – now for the most part in variable states of decay – sits on the flat crest of a limestone hill on the right bank of Prądnik creek (**Fig. 1**); its advantageous natural and strategic position clearly contributed to its prominent past.

Due to the castle's poor state of repair and the scarcity of written accounts, archaeological excavations are needed to preserve its history and answer the question of how it developed and changed through time. The castle has been the subject of several archaeological campaigns (1991, 2006-2020) which have shed light on both its development and the material culture of its inhabitants. Given the castle's ruination and the large size of the castle hill (around 63 acres or 0.63 hectare), detailed reconstruction of the multiple settlement phases is still in progress (Olszacki, 2011; Wojenka, 2008, 2016, 2018).

The purpose of this paper is to describe the animal remains from Ojców castle, a set of information that is seldom a focus of castle archaeology in south-eastern Poland. We hope this publication will fill a gap in our current state of knowledge and will provide, at least up to a point, a significant benchmark for understanding the role of animals at castles in this part of the country.

In: S. Gaudzinski-Windheuser · O. Jöris (Eds.), The Beef behind all Possible Pasts. The Tandem-*Festschrift* in Honour of Elaine Turner and Martin Street. Monographien des RGZM 157 (Mainz 2021). DOI: 10.11588/propylaeum.950.c12589

This paper is based on faunal assemblages unearthed in excavated trenches I-II, which were set out in 2006-2007 and 2011 (**Fig. 2**). The large collection of animal bones recovered from the castle site has been divided into five main phases of occupation that range from the prehistoric period (Phase I) up to medieval and modern times (Phases II-V).

CASTLE OJCÓW – HISTORICAL BACKGROUND

The scope of this paper includes both prehistoric and historic periods. We begin by providing a brief overview of the site's pre-castle occupation phases, traces of which were unearthed during the excavations. The earliest stages of human occupation are represented by finds in a cultural layer overlying the sterile natural loess strata. Apart from several flint scrapers of probable Neolithic age, this layer yielded hundreds of everyday artefacts dated to the Early Iron Age and corresponding to the open air settlement of the Lusatian Culture from Hallstatt HaC - HaD. In light of archaeological evidence, it is likely that the fall of this settlement was linked with a Scythian attack at the end of the 7th or in the first half of the 6th century BC (Wojenka, 2016: 222). According to the present-day state of research, from that time onward the castle hill was uninhabited until the early castle building works in the 14th century.

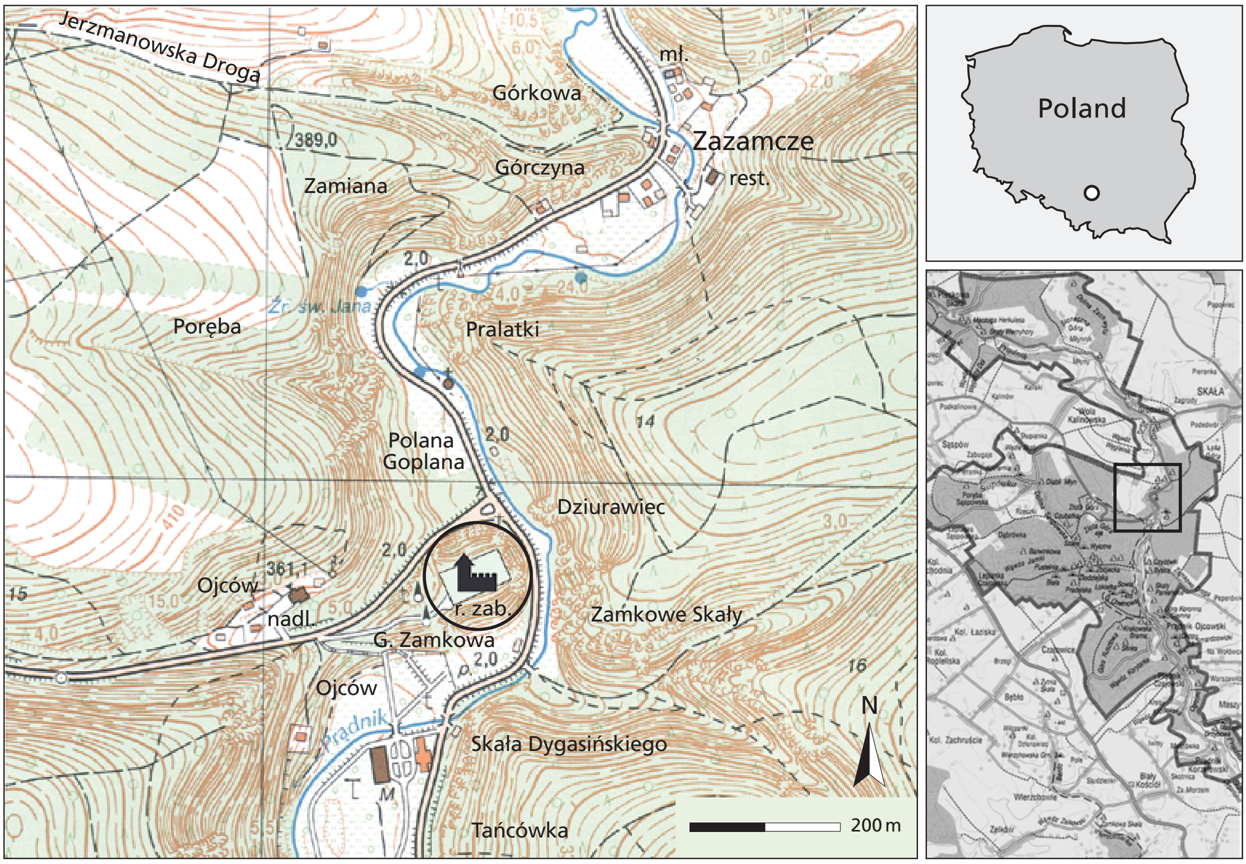


Fig. 1 Map showing the location of Ojców castle.

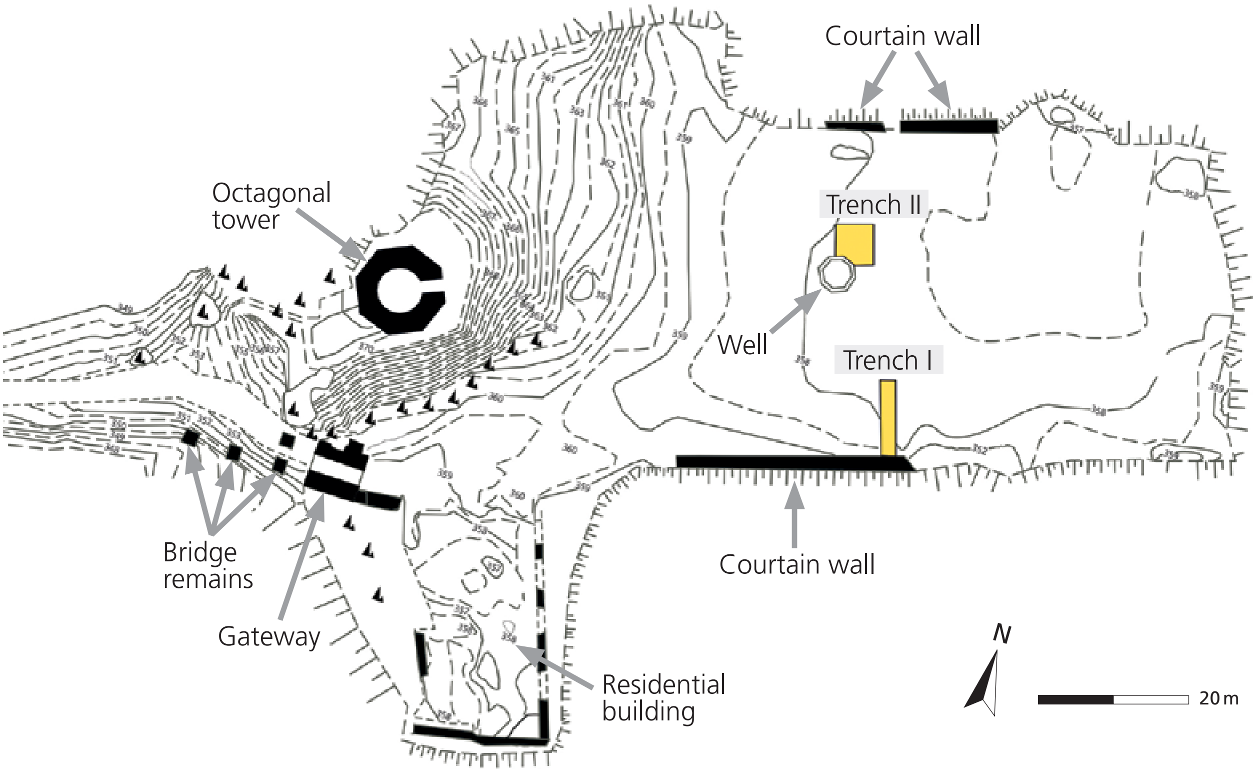


Fig. 2 Map of Ojców castle and location of trenches.

There is no doubt that the castle was a foundation of King Kasimir III the Great. The earliest written evidence on the castle dates from May 16th 1370, when *Zaclica burgrauio de Oczecz* was mentioned in a royal document, while slightly later, an anonymous text called *Quomodo regebat regnum et populum* mentioned the site in the index of foundations of the King († 1370; see Wojenka 2018, with further literature). The story of this fortified site started possibly soon after 1354, when the King incorporated the nearby village Smardzowice into the royal lands by a land exchange with the bishop of Krakow, Bodzanta. There are strong indications that the area of present day Ojców primarily belonged to this settlement (Laberschek, 1996: 270), and thus the beginning of building works at the Ojców castle is hereinafter assigned to 1354-1370. This assumption corresponds with archaeological data: the earliest assemblages representing medieval phases of the castle are not earlier than the 14th century.

It is commonly regarded that the castle was built as a commemorative realisation, given to honour the memory of Władysław the Elbow-high, the father of King Kasimir. According to the local tradition, Władysław the Elbow-high, early in the 14th century found a refuge in a cave located nearby (note the castle's name: Oczecz – later Ojców – in Polish means "father") (Wojenka, 2018).

Before 1385 the castle was given as a tenure (for 500 marks of silver) to Jan from Korzkiew, and since then, albeit still formally a royal site, it was managed by noblemen and regularly changed hands (Falniowska-Gradowska, 1999). In the 16th century the castle was ruled by Queen Bona Sforza (1536-1556), among others. In the following century (from 1619 until 1676) it became a seat of the Koryciński family, Topór house, who rebuilt it in a modern style. Later on, it was held by several noble families, but due to the political conditions at the end of the 18th century the castle for a while lost its tenurial status, and since it was not any longer profitable, at the early 19th century it was abandoned by the last governor, Teofil Załuski. Since it was uninhabited, the castle's state of repair inevitably went from bad to worse. In 1815, it passed to the Kingdom of Poland (Congress Poland) but in 1829 it was bought by Konstanty Wolicki, who started to dismantle its walls for building materials (Falniowska-Gradowska,1995, 1999; Ziarkowski, 2015).

TRENCHES I AND II – GENERAL REMARKS

Archaeological excavations in the south and central parts of the Ojców castle hill were made in 2006-2007 and 2011, led by Michał Wojenka (Institute of Archaeology, Jagiellonian University). Two main trenches were set out to examine the stratigraphy. Trench I (2.5 m × 10 m in size) was located near the south curtain wall, and trench II (5 m × 5 m and 2.5-6.5 m in size) was placed in the middle part of the courtyard by the castle's well (**Fig. 2**). The depth in both trenches was terminated where an undisturbed soil (a yellow clayey loess) appeared. The recorded stratigraphic evidence in trenches I and II is presented in **Tables 1** and **2** and in the cross-sections (**Figs. 3-4**) (for more detailed description of the stratigraphic sequence see Wojenka, 2016).

THE MAIN OCCUPATION PHASES OF THE CASTLE HILL

The archaeological examination of the stratigraphic sequences in trenches I and II provided a detailed insight into the occupation of the castle hill. Thanks to the analysis of archaeological sources combined with historical evidence on the castle (Laberschek, 2016; Falniowska-Gradowska, 1995, 1999) it was possible to distinguish five main phases of settlement, as follows:

Phase I

This is the Early Iron Age open air settlement of the Lusatian Culture communities, which covered the whole castle hill (Kruczek, 2001; Wojenka, 2016). The evidence so far indicates that the settlement may have been destroyed late in the Iron Age, in the 7th century or first half of the 6th century BC (Wojenka, 2016: 222) by a Scythian attack. This is evidenced by finds of a Scythian bone arrowhead found in trench I and – indirectly – by readable traces of fire in the stratigraphic sequence (Wojenka, 2016). We note that after the 2018 excavations, the collection of Scythian arrowheads has grown and currently includes five objects – four made of bronze and one made from a bone (**Fig. 5: 1**). Stratigraphically, Phase I is associated with the lowermost cultural layer of the castle hill (layer 27 in trench I and layer 12 in trench II), as well as with several sunken features representing the settlement's internal infrastructure (Wojenka, 2016). Phase I is dated broadly to Hallstatt HaC - HaD (in this respect, from mid-8th to the 7th or the first half of the 6th century BC).

Phase II

This marks the beginnings of the castle and the earliest medieval settlement on the castle hill. In the light of more recent excavations, human activity during Phase II may be associated with the earliest masonry buildings at the castle: the octagonal dwelling tower (Wojenka, 2018), the castle's gateway, and the curtain wall. It is likely that slightly later in Phase II the castle was given a rock-cut well. The area adjacent to the curtain

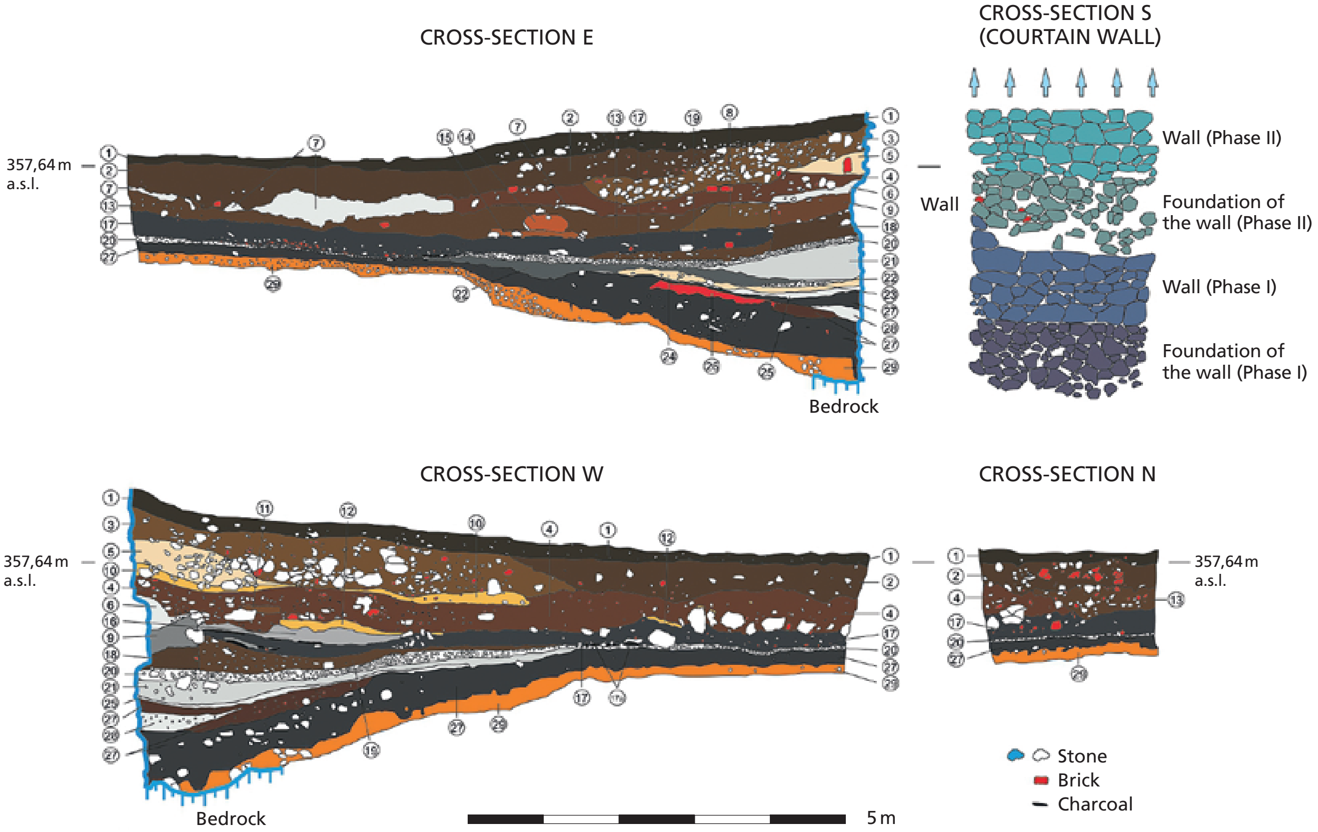


Fig. 3 Stratigraphic profiles of trench I, Ojców castle.

wall in this phase was built up by wooden buildings, but their number and spatial range are unknown. The end of Phase II we synchronise with the completion of essential building works, cutting the well, and cobbling of the courtyard, which was apparently done around the turn of the 15th century. This is confirmed by a find of the Jagiellonian coin issued in 1387-1396 at the top of layer 9 in trench II (the coin was used shortly up to the very early 15th century). The chronological range of Phase II is limited basically to the second half of the 14th century (from 1354-1370 to the turn of the 15th century).

Phase III

This is the period of late medieval occupation of the castle, associated with the deposition of layers 17 and 19 in trench I. These layers must be seen in a context of cultural strata formed inside an undefined building adjacent to the curtain wall. Phase III may be dated to the 15th century.

Phase IV

This is the time of the early Post-medieval (Renaissance) castle, which in a stratigraphic sequence is associated with layers 8, 13-15 in trench I, and layer 8 in trench II. The end of Phase IV can be synchronised with extensive restoration works carried out at the southern line of the curtain wall. Although in most previous

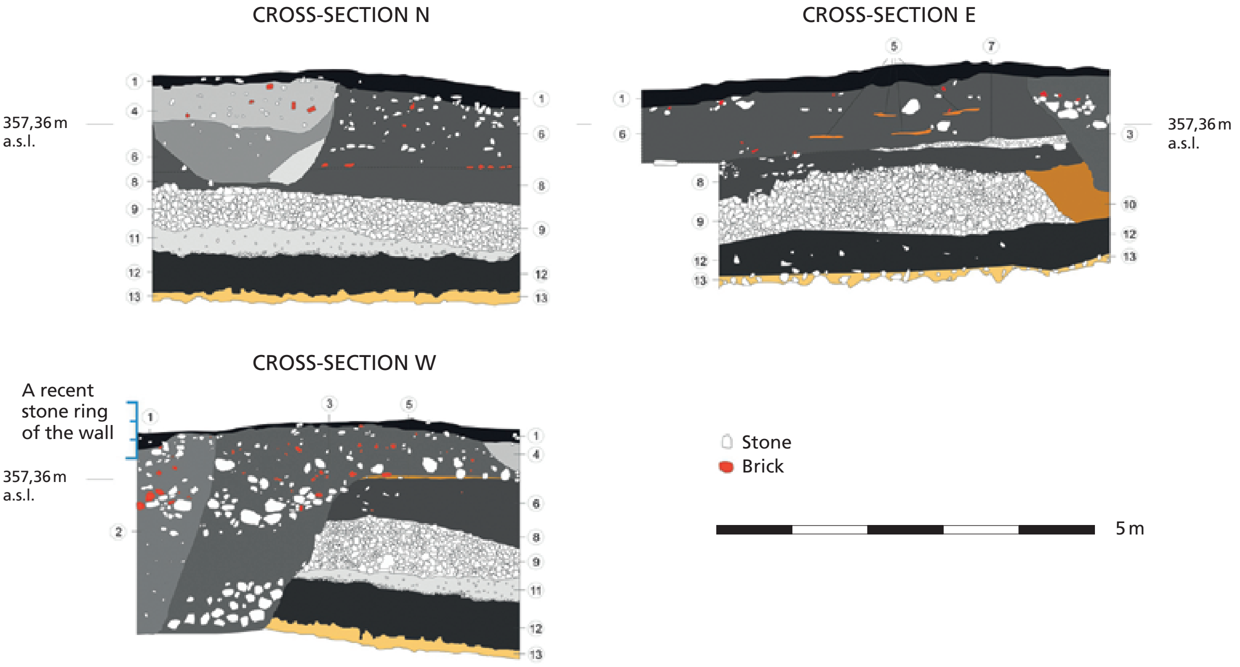


Fig. 4 Stratigraphic profiles of trench II, Ojców castle.

works on the castle the restoration of the wall was conditionally linked with the Koryciński family in 1619-1660 (Wojenka, 2008, 2016), in the light of recently published building registers from 1539-1540 it is not certain whether this restoration started earlier, at the end of the first half of the 16th century (Laberschek, 2016). Given the aforementioned circumstances, the dating of Phase IV may be the 16th century. However, a broader timespan is still tentatively assumed, even up to the first half of the 17th century.

Phase V

This marks the later stages of the castle's history in the Post-medieval period, represented by mostly mixed strata, found above layers 6 and 7 in trench I and over layer 7 in trench II. In light of archaeological finds (numerous pottery vessels, stove-tiles, metal objects including coins) the chronology of Phase V is limited to the period from the 17th to the turn of the 19th century (Wojenka, 2016). It must be stated, however, that archaeological assemblages from this phase hold some redeposited objects from the earlier periods of castle occupation, especially from the 16th century (this refers mostly to layer 4 in trench I).

MATERIAL AND METHODS

The studied osteological materials were recovered during excavations in the courtyard of the castle. We were able to study animal remains from the two trenches (**Fig. 2**). All osteological materials discovered during excavations are stored in the Institute of Systematics and Evolution of Animals, Polish Academy of Sciences in Krakow (ISEA PAS).

A few thousand bone remains from various animal classes (fish, birds, and mammals) were collected from trenches I and II. However, a complete set of zooarchaeological analyses were carried out only on mammal remains. Fish and bird remains were taxonomically identified. Zooarchaeological studies of bird remains are in progress and results are in preparation.

In trenches I and II animal bone remains were discovered in the sediments which cover both the prehistoric stage of castle hill occupation and the period between the second half of the 14th century to the turn of the 19th century.

All collected mammal remains were subjected to standard procedures used in zooarchaeological studies. In the first step, the bones were identified to element and assigned to species on the basis of comparative material from osteological collections held at ISEA PAS, bone atlases (e. g., Erbersdobler, 1968; Gromova, 1950; Kraft, 1972; Pales and García, 1981a, 1981b; Tomek and Bochenski, 2009), and online digital collections.

Layer number	Layer description	Phase
1	Recent humus, with admixture of limestone gravel and small pieces of brick.	–
2, 3, 4, 5, 11	Mixed layers, for the most part containing large quantities of limestone and smaller pieces of brick, with numerous Post-medieval artefacts including pottery fragments, stove-tiles and metal objects. Generally, the finds may be broadly dated to the 17th-18th/19th c.	V
6, 16	Light-grey mortar layer corresponding to the building of phase II curtain wall, likely during the 1st half of the 17th c. or a century earlier – in 1539-1540.	IV/V
7	Concentration of poured lime, possibly for paving (after the erection of phase II curtain wall).	IV/V
8, 13, 14, 15	Mixed layers with limestone gravel and brick fragments, with numerous everyday artefacts dated to the 16th c.	IV
9, 18	Layers in the foundation ditch of the Phase II curtain wall, containing a few pieces of Post-medieval pottery (the 16th-17th c.?).	IV
10	Yellow clayey layer (possibly an earthen floor), with low levels of admixture of Post-medieval pottery fragments and pieces of stove-tiles.	V
12	Yellow clayey layer (possibly an earthen floor), with low levels of admixture of 16th c. pottery fragments.	IV
17, 17A	Late medieval cultural layer, with numerous pieces of pottery vessels and metal objects, including weaponry (bolt-heads, a falchion handle) and riding gear (spur fragments).	III
19	Dark brown layer with small quantity of stones and numerous medieval artefacts, mostly pottery vessels.	III
20	Limestone cobble of the courtyard.	II/III
21, 23, 25	Building layer with several dozen fragments of medieval pottery.	II
22	Grey cultural layer below the cobble, with a few medieval pottery fragments.	II
24	Pale yellow-greyish layer with mortar below the cobble, with large quantities of medieval pottery fragments.	II
26	Remnant of a clay hearth corresponding to the remains of a wooden building adjacent to the curtain wall. In the area of the hearth few medieval pottery fragments were noted.	II
27	Prehistoric cultural layer, although with several dozens of medieval artefacts in the upper parts and hundreds of the Early Iron Age finds in the lower parts. These include pottery vessels, flint artefacts, bronze objects and a Scythian arrowhead.	I (I/II)
28	Building layer corresponding to phase I curtain wall.	II
29	Sterile loess with sharp-edged limestone.	–

Tab. 1 The stratigraphic sequence recorded in trench I (cf. **Fig. 3**).

Layer number	Layer description	Phase
1	Recent humus.	–
2	Younger repair trench by the well, dated by a Russian coin after 1895. The trench yielded numerous redeposited artefacts from all phases of occupation.	V-I
3	Older repair trench by the well, dated by an Austrian coin after 1791. The trench yielded numerous redeposited artefacts from all phases of occupation.	V-I
4	Loose, mixed layer with limestone gravel and brick fragments – a filling of a late Post-medieval pit.	V
5	Sterile yellow clayey layer in the NE part of the trench.	V
6	Dark grey, loamy layer with several pieces of brick and admixture of limestone gravel. This layer contained numerous artefacts dated to the 17th- and 18th c.	V
7	Limestone cobble with several pieces of 17th-18th c. pottery and a copper coin of king John II Kasimir (second half of the 17th c.) on top. The cobble was adjacent to the remains of a stone foundation of an undefined building, unearthed in the NE corner of the trench.	V
8	Dark grey loamy layer with several dozen fragments of Post-medieval pottery, mostly dated to the 16th c. Due to the analysis of the stratigraphic sequence on the castle hill as a whole, the accumulation of this layer may be linked to a period before the building of the phase II wall in trench I. It is most likely that this layer mainly corresponds to phase IV.	IV
9	Thick (50-90 cm) sterile layer of sharp-edged limestone. Formation of this strata is linked to cutting of the bedrock for a well. Layer 9 served as cobbles and it is important to note that its medieval chronology is beyond doubt – the surface of layer 9 yielded several medieval artefacts, including 5 small Jagiellonian coins: of Kings Władysław II Jagiełło and Jadwiga (issued in 1387-1396), Władysław II Jagiełło (after 1406), two coins of Władysław III of Poland (1434-1444) and one undefined coin. It is worth noting that medieval finds were also discovered below layer 9.	II/III
10	Yellow clayey loess without archaeological content.	II/III
11	Mortar layer, possibly a remnant of the earliest building works at the castle hill during the 14th c.	I
12	Prehistoric cultural layer, with several dozen of medieval artefacts in the upper part, and hundreds of the Early Iron Age finds in the lower part.	I (I/II)
13	Sterile loess with weathered limestone.	–

Tab. 2 The stratigraphic sequence recorded in trench II (cf. **Fig. 4**).

Fish bones were identified by comparing archaeological samples with the recent bones in the reference collection of the Archaeological Research Collection of Tallinn University. Both the taxon and anatomical part the bones represent were identified.

In the next step for mammalian and avian remains, standard zooarchaeological quantifications were calculated, namely Number of Identified Specimens (NISP) and Minimal Number of Individuals (MNI). These values were calculated on the basis of the definitions in Klein and Cruz-Uribe (1984) and Lyman (1994). The MNI was calculated by counting right and left elements and dividing by two, without trying to match pairs of bones with similar sizes and shapes.

In the next step of analyses all mammal remains were carefully inspected under strong oblique light to discover possible signs of human activity such as marks made by knives (cut-marks), percussion marks made by butchers' axes, and fire traces.

In addition to the evidence for human activity signs of dog activity, namely gnawing marks and digested bones were additionally recorded.

RESULTS

During the excavations of the Ojców castle trenches I and II, the following numbers of remains were collected: 7,653 mammalian bones, 307 bird bones, and 11 fish remains (**Tabs. 3-4**). Among the mammals only ~23.3 % (NISP = 1,783) of all osteological materials could be identified to taxon and skeletal element. Only part (NISP = 4,544; ~59.3 % of all mammal remains) of the osteological material could be connected to specific phases of castle development. In the assemblage remains of domestic mammals dominate (NISP = 1,737). Only 46 taxon identified bones represent wild animals, which is about 1 % of all identified mammalian remains. Excavations in trenches I and II yielded bones from hare (*Lepus europaeus*), red fox (*Vulpes Vulpes*), wolf (*Canis lupus*), roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), and wild boar (*Sus scrofa*). Among these taxa only hare (NISP = 32) and red deer (NISP = 7) are represented by more than two bones. Among domestic mammals three taxa dominate: cattle (*Bos taurus*; NISP = 811), pig (*Sus domesticus*; NISP = 580) and goat/sheep (*Capra hircus / Ovis aries*; NISP = 308). Horse (*Equus caballus*) and dog (*Canis familiaris*) are represented by only 18 remains each.

Similarly to the mammalian pattern, bird remains are dominated by domestic species (**Tab. 4**). The largest number of remains (NISP = 166; MNI = 11) belongs to domestic fowl (*Gallus domesticus*). Geese (*Anser* sp.) are also very well represented (NISP = 60; MNI = 5). Other bird taxa, both domestic and wild, are represented by single specimens.

Fish remains were represented by very low numbers (n = 11). Single bones were found in sediments from all phases. Only trench II yielded just two bones. The number of fish remains is too low to reconstruct the preferred fish species in the castle's faunal material; pike (*Esox lucius*), common bream (*Abramis brama*), and Atlantic sturgeon (*Acipenser oxyrinchus*) are all represented.

Phase I (The Early Iron Age)

Phase I is represented by nearly 600 mammal remains from the middle and lower parts of the earliest cultural layer (layer 27 in trench I and layer 12 in trench II), and is clearly associated with the archaeological context of the Lusatian Culture (Early Iron Age). Only ~21.7 % of the faunal remains (NISP = 130) could be identified to taxon. The osteological material is strongly dominated by remains of domestic animals; only two bones belong to wild animals, hare and red deer. Remains of cattle (NISP = 48; MNI = 4) are most numerous among domesticated mammals, followed in numbers by pig and goat/sheep (**Tab. 3**). We note that the largest number of horse remains (NISP = 9, MNI = 2) was found in this phase.

Signs of meat processing (dismembering and filleting cut-marks) were recorded on 71 mammal bones from this phase (**Tab. 5**). However, only 5 bones with cut-marks and 11 with percussion marks could be identified to taxon. It should be noted that there were cut-marks on a dog metacarpus bone, assigned to skinning. Also, a percussion mark is visible on a horse pelvis. Percussion marks are present on a fragment of red deer antler, probably created during preparation of the antler for making a tool or an ornament. Only four burnt bone fragments were recovered, with none identifiable to element or taxon.

A Scythian bone arrowhead (see Chmielewska, 1956) (**Fig. 5: 1**) was found in trench I. Beside this find another fragment of polished bone was also discovered (**Fig. 5: 2**), but its possible function could not be identified.

Dog gnawing marks were found on 58 mammal bones in the sediments of Phase I, with 11 located on identified bones of domestic animals, and the rest on unidentifiable bone fragments which were also probably from domestic species (**Tab. 6**). Notably, a dog scapula has a gnawing mark.

Taxon	Chronology											Total	
	Phase I		Phase II		Phase III		Phase IV		Phase V		Mixed layers		
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	NISP	MNI
Rabbit (*Oryctolagus cuniculus*)									1	1	1	2	1
Hare (*Lepus europaeus*)	1	1			5	1	1	1	7	2	18	32	5
Red fox (*Vulpes vulpes*)					2	1						2	1
Wolf (*Canis lupus*)					2	1						2	1
Dog (*Canis familiaris*)	7	2							1	1	10	18	3
Horse (*Equus caballus*)	9	2			1	1			5	1	3	18	4
Roe deer (*Capreolus capreolus*)									1	1	1	2	1
Red deer (*Cervus eleaphus*)	1	1			4	1					2	7	2
Goat/sheep (*Capra hircus*/*Ovis aries*)	23	3			42	2	36	3	58	3	149	308	11
Cattle (*Bos taurus*)	48	4	5	1	215	8	92	8	120	6	331	811	27
Pig (*Sus domesticus*)	41	1	5	1	148	5	70	6	76	4	240	580	17
Wild boar (*Sus scrofa*)					1	1						1	1
Identifiable total	**130**	**14**	**10**	**2**	**420**	**21**	**199**	**18**	**269**	**19**	**755**	**1,783**	**74**
Small sized mammals	7		2		8		52		33		85	187	
Medium sized mammals	80		3		194		149		189		485	1,100	
Large sized mammals	130		6		452		193		281		760	1,822	
Unidentifiable	251		5		760		393		328		1,024	2,761	
Unidentifiable total	**468**		**16**		**1,414**		**787**		**831**		**2,354**	**5,870**	
Total NISP/MNI	**598**	**14**	**26**	**2**	**1,834**	**21**	**986**	**18**	**1,100**	**19**	**3,109**	**7,653**	**74**

Tab. 3 NISP (Number of Identified Specimens), % NISP and MNI (Minimum Number of Individuals) of mammal remains from trenches I and II, Ojców castle.

Taxon	Chronology																		Total	
	Phase I		Phase II		Phase I-II		Phase III		Phase IV		Phase III-IV		Phase V		Phase IV-V		Phase I-V			
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP		NISP	MNI	NISP		NISP		NISP	MNI
Goose *Anser* sp.	4	1					3	1	1	1	1		29	2	13		9		60	5
cf. *Anser* sp.															1				1	
Mallard *Anas platyrhynchos*											1		1	1	1		4		7	2
cf. *Anas platyrhynchos*							1	1							2				3	1
Indian Peafowl *Pavo cristatus*															2	1			2	1
cf. Galliformes (small size)													1						1	1
Domestic fowl *Gallus domesticus*	35	5	3	1	8		5	1	17	2	1		22	2	31		44		166	11
cf. *Gallus domesticus*	1						1		4				6		5		12		29	
Capercaillie *Tetrao urogallus*							1	1											1	1
Hazel grouse *Tetrastes bonasia*	1	1																	1	1
Eurasian sparrowhawk *Accipiter nisus*											1								1	1
Rock pigeon *Columba livia*	1	1																	1	1
Columba livia/oenas							1	1											1	1
Jackdaw *Corvus monedula*													2	1					2	1
Magpie *Pica pica*													1	1					1	1
Aves indet.	3		1				1		1				2		2		2		12	
Aves indet. (big size)											1		3				1		5	
cf. Aves indet.							2						2		9				13	
Total NISP/MNI	**45**	**8**	**4**	**1**	**8**		**15**	**5**	**23**	**3**	**5**		**69**	**8**	**66**		**72**		**307**	**28**

Tab. 4 NISP (Number of Identified Specimens), % NISP and MNI (Minimum Number of Individuals) of bird remains from trenches I and II, Ojców castle.

Bird bones were also collected from this phase. The majority of them belong to the domestic fowl (*Gallus domesticus*) (**Tab. 4**), which were evidently reared at the site, as evidenced by the presence of immature specimens (four bones from juvenile specimens and two bones from subadult individuals), as well as adult females that died during the egg-laying period (eight remains have a structure called medullary bone that develops during that period; see Serjeantson, 2009). Almost half of the chicken bones were cut-marked which confirms the bird was heavily exploited for meat. Goose bones were found in much lesser quantity but they may also have originated from domesticated specimens.

An interesting case is the early presence of the rock pigeon (*Columba livia*). Poland is beyond the bird's natural occurrence (Voous, 1960) but there are questions about whether the species was introduced to the region by humans or if it had expanded its range to Poland by gradual colonisation of human settlements (Tomiałojć and Stawarczyk, 2003). Lasota-Moskalewska (2005) mentions that the pigeon was willingly already bred by Slavs in the Early Middle Age, but it is unknown when that began to happen. Its bones were recovered at a few Polish sites from that period (Bocheński et al., 2012, Lasota-Moskalewska, 2005) but there are doubts whether they come from domesticated / feral or colonising specimens. The recovered bone at Ojców Castle (*tarsometatarsus*) has a cut-mark on its proximal end suggesting portioning of the bird.

The bones of the hazel grouse (*Tetrastes bonasia*) surely come from wild living specimen; the bird is a known game bird. Methods for its hunting were described in the 16th century by a Polish nobleman, Mateusz Cygański (1584).

In this phase, only one fish costa coming from the family Cyprinidae was found. This family includes a group of freshwater fishes, the carp-like fishes, and is widely distributed in European freshwater bodies.

Phase I-II (Early Iron Age or first half of the 14th century)

The topmost part of the earliest cultural layer in trench I (i.e., layer 27) yielded an interesting fragment (~7 cm long) of a red deer antler, with visible percussion marks made by a metal tool (**Fig. 5: 3**). We think it is likely an initially processed raw material rather than a finished product. Due to the stratigraphic position of the find its chronology must remain uncertain prior to radiocarbon dating.

Phase II (second half of the 14th century)

Sediments of Phase II are dated to the turn of the 14th and 15th century. In this phase the smallest number of mammal remains were found (NISP = 26), which were collected from trenches I and II. Only bones of cattle (NISP = 5) and pig (NISP = 5) were identified. The other 16 bone fragments could not be identified (**Tab. 3**). Signs of human activity were found on six remains: two cut-marks, three percussion marks, and burning of fragments (**Tab. 5**). One percussion mark was found on a cattle tibia shaft.

Despite the very small number of animal remains, a fragment of bone was found that had been modified by human action. It is a fragment of the spinous process of a thoracic vertebra, belonging probably to cattle. Part of the bone is intentionally polished, which is not connected with food consumption (**Fig. 5: 4**).

Dog gnawing marks were also found on a very small number (n = 4) of bone fragments, and only one cattle bone has these marks (**Tab. 6**).

The only identified bird species from sediments of this phase is the domestic fowl (*Gallus domesticus*) (**Tab. 4**). In trench I one dental bone and four pieces of bony plates (scutes) of sturgeon (*Acipenser* sp.) were found.

All remains come from a very large individual about 2.5 m long. According to Desse-Berset (2011), the dental bone is attributed to the Atlantic sturgeon (*Acipenser oxyrinchus*) (**Fig. 5: 5**).

Phase III (15th century)

The largest number of remains belongs to Phase III, which is dated to the 15th century. In these sediments were found 1,834 mammal remains, but only 22.9 % of them could be identified to taxon. The remains of domestic mammals dominate the osteological material from this phase. Cattle and pig clearly dominate both in NISP and MNI (**Tab. 3**). These two taxa comprise more than 86 % of all remains discovered in this phase. Goat/sheep remains are only 10 % of total osteological material (NISP = 42; MNI = 2). It should be noted that also in this phase the largest number of wild mammal bones (NISP = 14) and taxa (n = 5) were discovered. Included are remains of hare, red fox, wolf, red deer, and wild boar. Remains of wolf, red fox, and wild boar were only discovered in this phase. The remains of wild mammals are only about 3.3 % of all identifiable mammalian remains from Phase III.

Although 452 bone fragments lacked characteristic landmarks and could not be identified to taxon of animal, the thickness of their cortical bone indicates they are from large (cattle/horse sized) animals. Because sediments of this phase contained only one bone fragment identified as from horse, we assume that the unidentified fragments are from cattle.

The most numerous taxon, cattle (NISP = 215), is represented by all parts of the skeleton. The axial bones from the cattle material include 29 teeth, horn, and mandible fragments, and eight vertebral fragments. Appendicular bones are dominated by long limb bones, most of them fragmented, and 25 having percussion marks made during the dismembering of carcasses (**Fig. 5: 6**). The appendicular materials include 26 fragments of scapulas and pelves. Eight scapulas and three pelves have visible percussion marks. It should be noted that the only complete bones are metacarpals and metatarsals (n = 89). Cattle feet are represented by 63 bones.

Pig (NISP = 148) is also represented by both axial and appendicular elements. In trenches I and II 60 fragments of skulls, mandibles, and isolated teeth, and seven vertebrae were recorded. Of the 39 long limb bones identified, only two with unfused epiphysis were complete. Percussion marks were found on three long limb bones. Pig foot bones are represented by 16 specimens, and no carpals bones were found.

The goat/sheep are represented by a much smaller numbers of bones and teeth (NISP = 42) than cattle and pig. The remains consisted of mainly head fragments (n = 20): isolated teeth (n = 12), skull and horn fragments (n = 4), and mandible fragments with teeth (n = 4). There were only two vertebral fragments found, an atlas and an axis. Limb bones are represented by 20 elements, including only long limb bones (none complete) and no foot bones (carpals, tarsals, phalanges).

The sediments of Phase III yielded the largest number of signs of human activity. Percussion marks were on 110 bones, 22 bones had cut-marks, and 14 specimens were burned. Of the cattle bones 45 had percussion marks, with 27 of these on long limb bones, 11 on scapulas and pelves, four on vertebra, and three were on astragalus bones. Percussion marks were also observed on five bones of pig and five bones of goat/sheep. We note that red deer remains (NISP = 4) were also collected from the sediments of this phase; a percussion mark is located on a fragment of red deer pelvis, and percussion marks are also visible on unidentifiable bone fragments. The largest number of percussion marks in the Phase III assemblage (n = 39) was on remains whose dimensions suggest that they are from large sized mammals. In the sediments of this phase > 200 cattle remains were collected and only four red deer bones, so we assume that most or all of the unidentified percussion-marked fragments belong to cattle.

Taxon	Chronology																		Total		
	Phase I			Phase II			Phase III			Phase IV			Phase V			Mixed layers					
	Cut-marks	Percussion marks	Burned bones	Cut-marks	Percussion marks	Burned bones	Cut-marks	Percussion marks	Burned bones	Cut-marks	Percussion marks	Burned bones	Cut-marks	Percussion marks	Burned bones	Cut-marks	Percussion marks	Burned bones	Cut-marks	Percussion marks	Burned bones
Rabbit (*Oryctolagus cuniculus*)																		1			1
Hare (*Lepus europaeus*)														1						1	
Red fox (*Vulpes vulpes*)																					
Wolf (*Canis lupus*)																					
Dog (*Canis familiaris*)	1																		1		
Horse (*Equus caballus*)		1																		1	
Roe deer (*Capreolus capreolus*)																					
Red deer (*Cervus eleaphus*)		1						2												3	
Goat/sheep (*Capra hircus/Ovis aries*)		2						5			5		2	1		1	7	3	3	20	3
Cattle (*Bos taurus*)	1	4			1		3	45	4		26	1		36		4	80	4	8	192	9
Pig (*Sus domesticus*)	3	3				1		5	4		4	2	2	4		1	20	8	6	36	15
Wild boar (*Sus scrofa*)																					
Identifiable total	**5**	**11**			**1**	**1**	**3**	**57**	**8**	**0**	**35**	**3**	**4**	**42**	**0**	**6**	**107**	**16**	**18**	**253**	**28**
Small sized mammals	3									2			1	1		7		1	13	1	1
Medium sized mammals	11	1	2	1			2	7	1	4		1	8	4	1	21	6	7	47	18	12
Large sized mammals	19	13	1	1	2		15	39	5	16	19		24	45	3	80	61	11	155	179	20
Unidentifiable	3	5	1				2	7		3	9			8		11	17	22	19	46	23
Unidentifiable total	**36**	**19**	**4**	**2**	**2**	**0**	**19**	**53**	**6**	**25**	**28**	**1**	**33**	**58**	**4**	**119**	**84**	**41**	**234**	**244**	**56**
TOTAL NISP/MNI	**41**	**30**	**4**	**2**	**3**	**1**	**22**	**110**	**14**	**25**	**63**	**4**	**37**	**100**	**4**	**125**	**191**	**57**	**252**	**497**	**84**

Tab. 5 Number of mammal bones with signs of human activity (cut-marks, percussion marks, burnt bones) discovered in trenches I and II, Ojców castle.

Taxon	Chronology												Total	
	Phase I		Phase II		Phase III		Phase IV		Phase V		Mixed layers			
	Gnawing marks	Digested bones	Gnawing marks	Digested bones	Gnawing marks	Digested bones	Gnawing marks	Digested bones	Gnawing marks	Digested bones	Gnawing marks	Digested bones	Gnawing marks	Digested bones
Hare (*Lepus europaeus*)									1	1		1	1	2
Dog (*Canis familiaris*)	1											1	1	1
Goat/sheep (*Capra hircus*/*Ovis aries*)	4				13		7	2	7	4	29	2	60	8
Cattle (*Bos taurus*)	4		1		66		27		20		69		187	
Pig (*Sus domesticus*)	2				36	1	12	1	11		38		99	2
Wild boar (*Sus scrofa*)					1								1	
Identifiable total	**11**		**1**		**116**	**1**	**46**	**3**	**39**	**5**	**136**	**4**	**349**	**13**
Small sized mammals			1				7		1		12		21	0
Medium sized mammals	14		1		76		58		65		118		332	0
Large sized mammals	9		1		103		59		50		135		357	0
Unidentifiable	24				139	7	44	1	39		89		335	8
Unidentifiable total	**47**		**3**		**318**	**7**	**168**	**1**	**155**		**354**		**1,045**	**8**
TOTAL	**58**		**4**		**434**	**8**	**214**	**4**	**194**	**5**	**490**	**4**	**1,394**	**21**

Tab. 6 Number of mammal bones with signs of dog activity (gnawing marks, digested bones) discovered in trenches I and II, Ojców castle.

Despite the large number of animal remains only two bone artefacts were discovered. One is a fragment of a heavily modified, polished, and ornamented bone fragment, possibly depicting an eagle (?) (**Fig. 6: 1**). Due to the fragmentation of the find its function is uncertain, although there is a strong possibility it is a bone ornamental plaque, possibly from a belt, sword shield, or saddle (see Marek, 2016: 306, Fig. 3). The second item is a pig 4th metatarsus with a drilled hole (**Fig. 6: 2**), which may be interpreted as a bone fastening device (see Jaworski, 2012: 167, Fig. 2.d-k).

A small number of bird bones (NISP = 15) attributed to this phase, which (**Tab. 4**) weakens our ability to generalise about the potential economic importance of different taxa. Even so, we think there is a shift in the pattern of human utilisation of birds; the number of goose bones in proportion to that of the chicken is higher than in the earlier phases. The duck and pigeon might have been caught in the wild or kept in captivity, which is suggested by the presence of medullary bone structure within the pigeon's bone. The capercaillie (*Tetrao urogallus*) was a highly regarded game bird (Cygański, 1584; Samsonowicz, 2011), with the recovered bone belonging to a male.

From Phase III, a dental bone was recorded from the cyprinid fish, the Common bream (*Abramis brama*), a common species in central and north-eastern Europe.

Phase III-IV (15th-16th century)

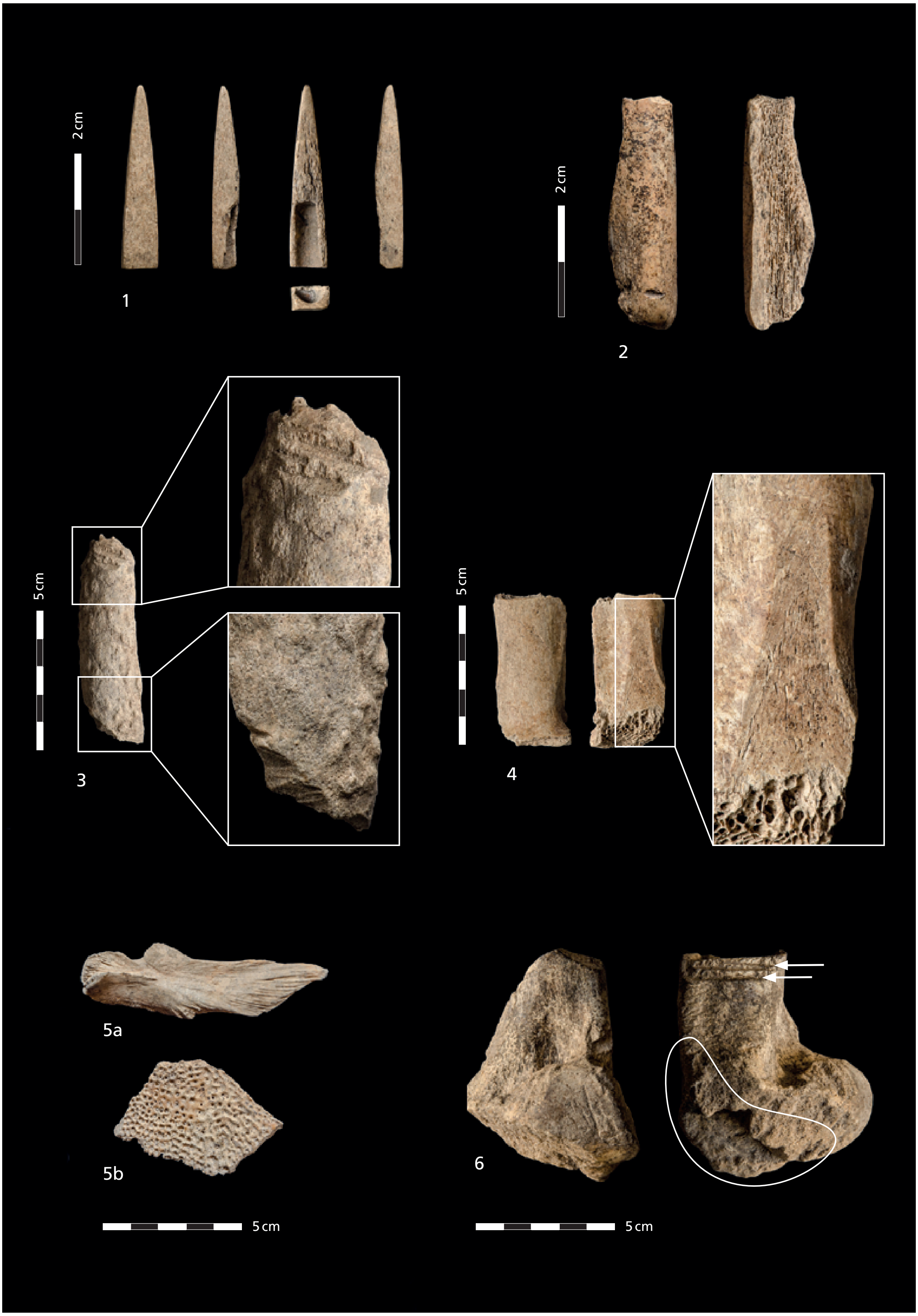
An important bird remain lacking clear stratigraphical position was found in mixed sediments of Phase III-IV (**Tab. 4**). A bone of the Eurasian sparrowhawk (*Accipiter nisus*) was recovered within a context of 15th and 16th century pottery sources. Wild-living sparrowhawks, due to their feeding and nesting behaviour, do not occur in human dwellings; their presence may be rather connected with hawking because of the popularity of the sparrowhawk in that activity (Bochenski et al., 2018). The suggestion of hawking is further supported by the fact the bone belonged to a female. Hawking was enormously popular sport for the upper ranks of society in Europe and Asia (Serjeantson, 2009).

Phase IV (16th to mid-17th century)

In sediments from Phase IV, 986 mammal bones and teeth were collected. Cattle remains (NISP = 92; MNI = 8) dominate the osteological material, followed by pig (NISP = 70; MNI = 6), and goat/sheep (NISP = 36; MNI = 3) (**Tab. 3**). Only one other bone could be identified to taxon, belonging to a hare. For the other mammal remains only a relative size of animal could be determined (small, medium, large mammals). Cattle remains (NISP = 92) are represented by head elements (NISP = 14), mainly upper and lower teeth. Only one mandible fragment was found and no other skull fragments. Among vertebrae only two separate axis bones were discovered. Long limb bones (NISP = 35) clearly dominate the osteological material identi-

→

Fig. 5 Ojców castle. **1** Scythian bone arrowhead (Phase I: Early Iron Age); **2** fragment of polished bone (Phase I: Early Iron Age); **3** Red deer (*Cervus elaphus*) antler, with visible percussion marks made by a metal tool (Phase I-II: Early Iron Age or first half of the 14th c.); **4** fragment of the spinous process of a thoracic vertebra of large mammal with part intentionally polished (Phase II: second half of the 14th c.); **5 a** dental bone of Atlantic sturgeon (*Acipenser oxyrinchus*), **b** fragment of bony plate (scuta) of sturgeon (*Acipenser* sp.) (Phase II: second half of the 14th c.); **6** cattle (*Bos taurus*) distal part of right humerus with gnawing marks and percussion marks (Phase III: 15th c.).


2 cm
1
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fied as belonging to cattle. Most of them are only fragments; only four complete bones were collected, two metacarpals and two metatarsals. Percussion marks were seen on 11 discovered limb bones, which is about one-third of the total number of limb bones. These marks explain the extreme fragmentation of these bones. Also, foot bones (carpals, tarsals and phalanges) are numerous (n = 29), with a high number of calcaneus bones (n = 10) were found.

The second-best represented taxon in this phase is pig (NISP = 70). Head elements (teeth, skull fragments, mandibles) are the most numerous (n = 49). Only one vertebra (atlas) was discovered. Also collected were six scapula and pelvis fragments. Long limb bones are the next most numerous pig remains (n = 10). Pig feet are represented by four bones.

Goat/sheep head elements are represented by 11 teeth and bone fragments. Also found were two vertebrae (an atlas and another cervical vertebra), and four fragments of scapulas and pelves. Long limb bones are represented by 11 specimens; no complete bones were discovered. Seven foot bones were also recovered.

Signs of human activity on mammal bones from Phase IV consist of mainly percussion marks (n = 63) and cut-marks (n = 25) (**Tab. 5**). Only four burned mammal bones were collected. Percussion marks were found mainly on cattle bones (n = 26) (**Fig. 6: 3**); pig and goat/sheep bones had only single marks (four and five respectively). Cut-marks were found only on unidentifiable bone fragments. The unidentifiable fragments belonging to large sized mammals included 19 specimens with percussion marks and 16 with cut-marks. It is assumed that these remains of large sized mammals belong to cattle.

In sediments of Phase IV three bone artefacts were discovered. One is likely a board game piece (see Blazevičius, 2013: 147, Fig. 8; Haak et al., 2012: 316, Fig. 18). It is very well preserved, very carefully modified and prepared (**Fig. 6: 4**). Another is a fragment of an inlaid adorned with floral motive, possibly from a wheel-lock firearm (**Fig. 6: 5**) (see Haak et al., 2012: 313, Fig. 15.3-4). The third is a fragment of furniture cladding (wardrobe, chest) or mirror frame (**Fig. 6: 6**).

Marks made by gnawing dogs were also found on mammal bones. The largest number of gnawed specimens were from cattle (n = 27) (**Fig. 7: 1**); another 59 specimens with dog gnawing marks are from large-sized mammals which also are probably cattle. Such marks were also noted on 58 bones of medium sized mammals which probably belong to pig or goat/sheep.

The bird assemblage from Phase IV is dominated by chicken bones (NISP = 17) (**Tab. 4**). Almost half of them come from immature specimens. A few bones have cut-marks. At least one bone has been gnawed, probably by a dog; the bone also appears partially digested. A few other bones were gnawed by rodents, which means they were thrown either onto a garbage heap or exposed on the ground and not buried in a pit.

Phase IV-V (16th to the turn of the 19th century)

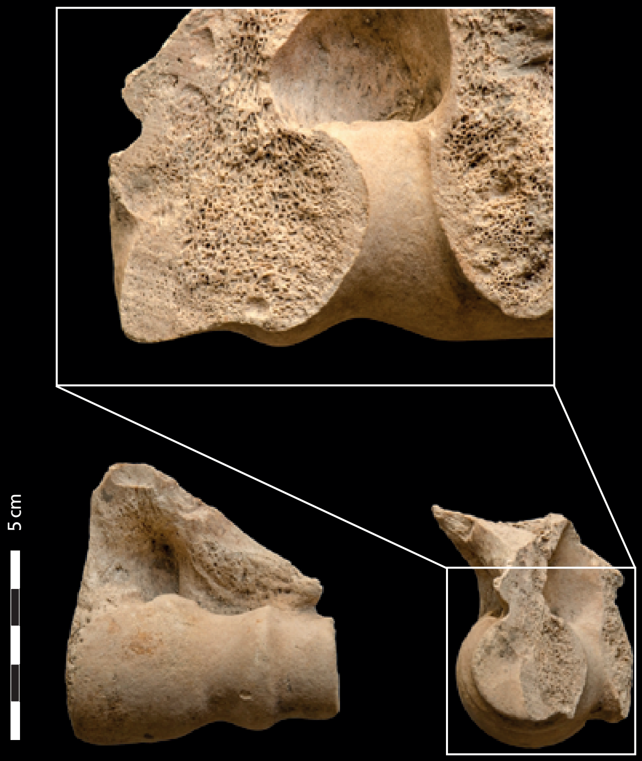
In mixed sediments of Phase IV-V the avian assemblage is mostly made up of chicken and geese remains. A few bones of mallard duck were also recovered. The unique finds in this phase are two bones of peacock

→

Fig. 6 Ojców castle. **1** fragment of a heavily modified, polished, and ornamented bone, possibly depicting an eagle (?) (Phase III: 15th c.); **2** pig (*Sus scrofa*) 4th metatarsus with a drilled hole, which may be interpreted as a bone fastening device (Phase III: 15th century); **3** cattle (*Bos taurus*) distal part of right humerus with percussion marks (Phase IV: 16th to mid-17th c.); **4** bone board game piece (Phase IV: 16th to mid-17th c.); **5** fragment of an inlaid adorned with floral motive, possibly from a wheel-lock firearm (Phase IV: 16th to mid-17th c.); **6** fragment of furniture cladding (wardrobe, chest) or mirror frame (Phase IV: 16th to mid-17th c.).

1

2



3

4

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6

(*Pavo cristatus*), a tibiotarsus and femur (**Fig. 7: 2**). The latter bone was radiocarbon dated, which confirmed its post-medieval chronology (1484-1648 cal AD; 95.4 % probability), supposedly the first half of the 17th century, i. e., the period in which the Koryciński family managed the castle (Wojenka and Wertz, 2018). The peacock is rarely found at archeological sites in Poland, although the oldest find occurred as early as in the 11th century at Ostrów Lednicki, a place related with the Piasts, i. e., the ruling dynasty of Poland (Makowiecki et al., 2014; Wojenka and Wertz, 2018). The bird had a great value in the past and its presence surely communicates the high status of the Castle's owner.

Phase V (17th to the turn of the 19th century)

The composition and the number of mammal remains is similar to that of the other phases. Remains of domestic mammals dominate the osteological material. The largest number of remains are cattle (NISP = 120, MNI = 6), following by pig (NISP = 76, MNI = 4) and goat / sheep (NISP = 58, MNI = 3). Also single bones of domestic mammals were found, specifically horse, dog, and rabbit (**Tab. 3**). Besides the domestic mammals, single bones were found of wild taxa, hare and roe deer. As with the assemblages from other phases, most of the remains from Phase V could not be identified to taxon (n = 831). However more than 500 bone fragments could be ordered into size group: small mammals (NISP = 33), medium sized mammals (NISP = 189) and large sized mammals (NISP = 281).

Cattle is represented by all parts of skeleton. From the head (n = 24), teeth (n = 11), horn fragments (n = 2), fragments of maxilla (n = 2) and mandible (n = 7), as well as skull fragments (n = 2) were collected. Only four vertebral fragments were discovered. Long limb bones are represented by 43 specimens. Similar to in other phases, only metapodials are complete in Phase V; other long bones were found broken, as mainly proximal or distal fragments. Small compact foot bones (carpals, tarsals, phalanges) are well represented (n = 36).

Pig head fragments were found in large numbers, including parts of skull (including maxillae and mandibles with teeth) and isolated teeth (n = 28). Long limb bones are represented mainly by shaft fragments (n = 16), and only one complete tibia was found. Also discovered were 21 foot bones (carpals, tarsals, metapodials and phalanges).

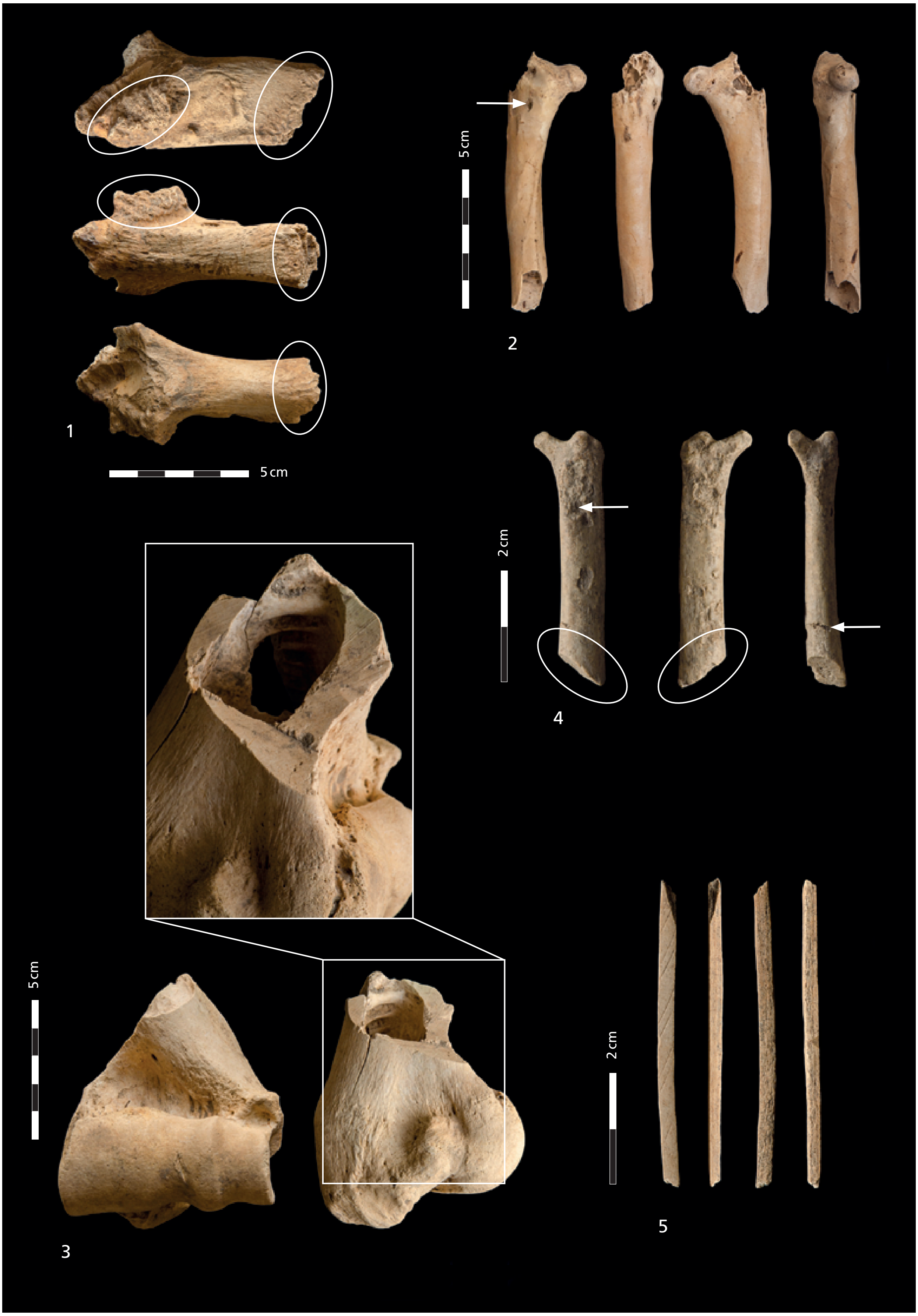
Goat / sheep remains are represented mainly by head fragments (teeth, skull fragments) (n = 6), long limb bones (n = 16), phalanges (n = 34), one fragment of pelvis, and one tarsal bone (astragalus).

As in other phases, the signs of human activity (n = 141) consist mostly of percussion-marked specimens (n = 100) (**Fig. 7: 3**), followed by cut-marked (n = 37) and burned bones (n = 4). Most of the identified bones with human modifications belong to cattle (**Tab. 5**). Only isolated bones of pig (**Fig. 7: 4**) and goat / sheep with percussion and cut-marks were found. As in other phases most of the signs of human activity were found on unidentifiable bone fragments (**Tab. 5**).

In this phase only one modified bone fragment was discovered, a polished fragment rectangular in cross section with a surface ornamented by cuts (**Fig. 7: 5**).

→

Fig. 7 Ojców castle. **1** cattle (*Bos taurus*) right calcaneus with dog gnawing marks (Phase IV: 16th to mid-17th c.); **2** femur of peacock (*Pavo cristatus*) with dog gnawing marks (Phase IV-V: 16th to the turn of the 19th c.); **3** Cattle (*Bos taurus*) distal part of left humerus with percussion marks (Phase V: 17th to the turn of the 19th c.); **4** pig (*Sus scrofa*) 5th metatarsus with percussion marks and dog gnawing marks (Phase V: 17th to the turn of the 19th c.); **5** polished fragment rectangular in cross section with a surface ornamented by cuts (Phase V: 17th to the turn of the 19th c.).


5 cm
2
1
5 cm
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5 cm
3
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5

Noticeable in this phase is the high proportion of goose bones in the avian assemblage (**Tab. 4**); the NISP of goose (NISP = 29) exceeds even that of the domestic fowl (NISP = 22). What is also noteworthy is that many chicken and goose bones are recorded as shafts, and since these elements were virtually omitted from calculations of MNI (because bones were not matched), the obtained MNI values are probably very underestimated. Bones of the domestic goose are hard to differentiate from the bones of its wild form, the greylag goose (*Anser anser*) as well as from the bean goose (*Anser fabalis*); nevertheless it is reasonable to assume that most of the recovered bones belonged to the domesticated form. The duck bone might have belonged to either a domesticated specimen or a wild mallard. Both discovered corvids, the magpie and jackdaw, are common synanthropic birds in the region and might have entered the sediment without human assistance. The bone identified as "cf. Galliformes (small size)" is a distal part of a tibiotarsus that resembles in overall morphology the same elements of grey partridge (*Perdix perdix*) and common quail (*Coturnix coturnix*). Its size, however, is too small for the grey partridge (Kraft, 1972), and apparently too big for the quail (perhaps due to limitations of the comparative collection).

Four fish bones were found in sediments of Phase V. These are two vertebrae of pike (*Exos lucius*) and two costae from fish of family Cyprinidae.

DISCUSSION AND CONCLUSION

During the excavations in trenches I and II of Ojców Castle > 7,500 mammal remains were collected. Unfortunately, ~ 40 % (NISP = 3,109) were discovered in mixed cultural layers and could not be assigned to one of the five phases of sediment accumulation. The osteological materials of all of the five phases are clearly dominated by domestic mammals, and wild taxa are represented only by single bones. Thus, it is apparent that even from beginning of the castle's existence (dating to Phase II) the residents derived their main food resources from breeding livestock. Cattle dominate in all phases, even in Phase I, when the site was an open settlement of the Lusatian Culture.

Small differences are evident in NISP and MNI percentages over time. Analytical results from Phase II are not considered here because of the very low number of collected remains from it (NISP = 26). In all other phases, cattle dominate both in NISP and MNI values. In Phase I (Lusatian Culture occupation) the MNI of goat/sheep exceeds that of pig, which is the only case of that situation from the castle. In other phases pig NISP and MNI have higher values. In Phase V (dated 17th to turn of the 19th century) the number of remains and individuals of cattle and pig decrease in comparison to Phase IV (dated to the 16th-17th century). In the same Phases IV and V, the goat/sheep NISP and MNI increase which could be connected with the lesser importance of the castle in the 18th century, and subsequent fewer residents. Wild mammals (hare, red deer, roe deer, wild boar) are rare in the osteological material, suggesting that this group of animals was not important as a dietary supplement.

Although the fish remains are few in our studied material, there is a noteworthy presence of sturgeon in the sediments of the second half of the 14th century when the castle began to be built. Most of the sturgeon remains known in the territory of medieval Poland come from the area of Szczecin Pomerania and Gdańsk Pomerania, i. e., they come from sites located in the Bay of Gdańsk, near today's Gdańsk, Sopot, and Pruszcz Gdański, which historically belong to Eastern Pomerania. Fewer such sites are known in Western Pomerania and they are situated within the Szczecin Bay or by the waters of the Odra estuary, examples being Szczecin and Wolin, and in Kołobrzeg; these were locales with several castles not having direct access to the sea (Makowiecki, 2003, 2008).

In the Middle Ages, the sturgeon was rather abundant in the Baltic Sea and due to its ability to live also in freshwaters, it would have appeared also in rivers during the spawning season. According to recent aDNA studies, the European sturgeon (*Acipenser sturio*) in the Baltic Sea was replaced by the Atlantic sturgeon (*Acipenser oxyrinchus*) by the Middle Ages (see e. g., Popović et al., 2014).

The sturgeon was enthusiastically fished because of its high nutritional value. Meat of this fish is practically boneless, tender, and tasty. This fish is difficult to breed because its reproduction takes place at long intervals and the females reach sexual maturity quite late, making it very expensive to buy today and also highly valued in the past. The remains of the sturgeon from the Ojców castle excavations came from a very large specimen. Based on the size of the dental bone, the body size is estimated to be about 250 cm. As shown by the data from the site in Staraya Ladoga (Berg, 1962), the Ojców castle specimen was a mature individual whose weight could range from 100 to 180 kg. This sturgeon was bigger than most of specimens from the Gulf of Gdańsk and Zatoka Szczecińska, but it should be emphasized that juveniles were also caught there, measuring about 50 cm (Makowiecki, 2003, 2008).

During the entire history of Ojców castle, from the beginning of the 14th to the 19th century, the main food resources for residents were domestic animals, especially mammals (cattle, pigs, sheep and goats). However, birds (chickens and geese) were important dietary supplements to livestock meat. The high social position of the castle's residents is reflected in the presence of rare fish remains (sturgeon) and an exotic bird species (peacock).

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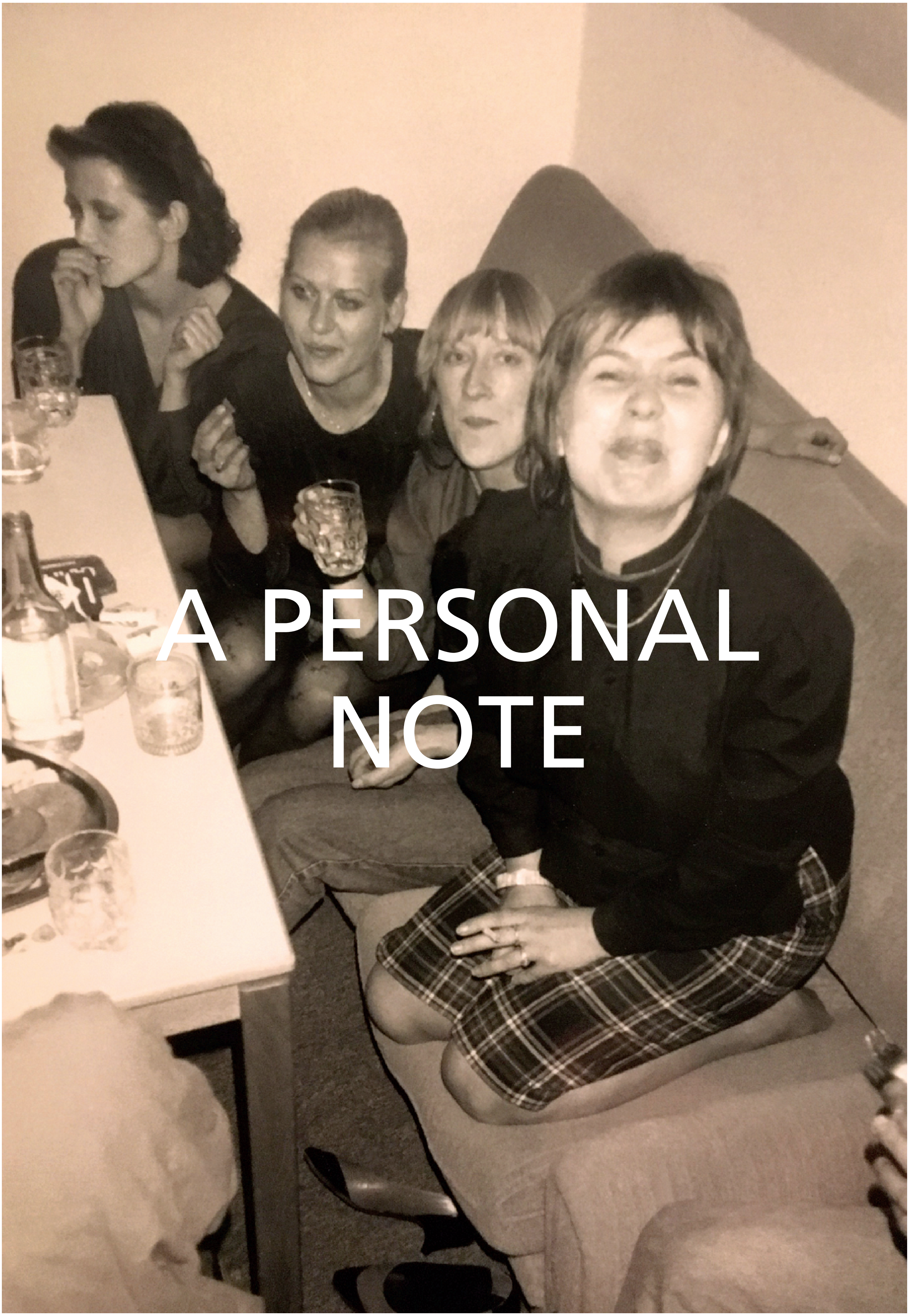


A PERSONAL NOTE

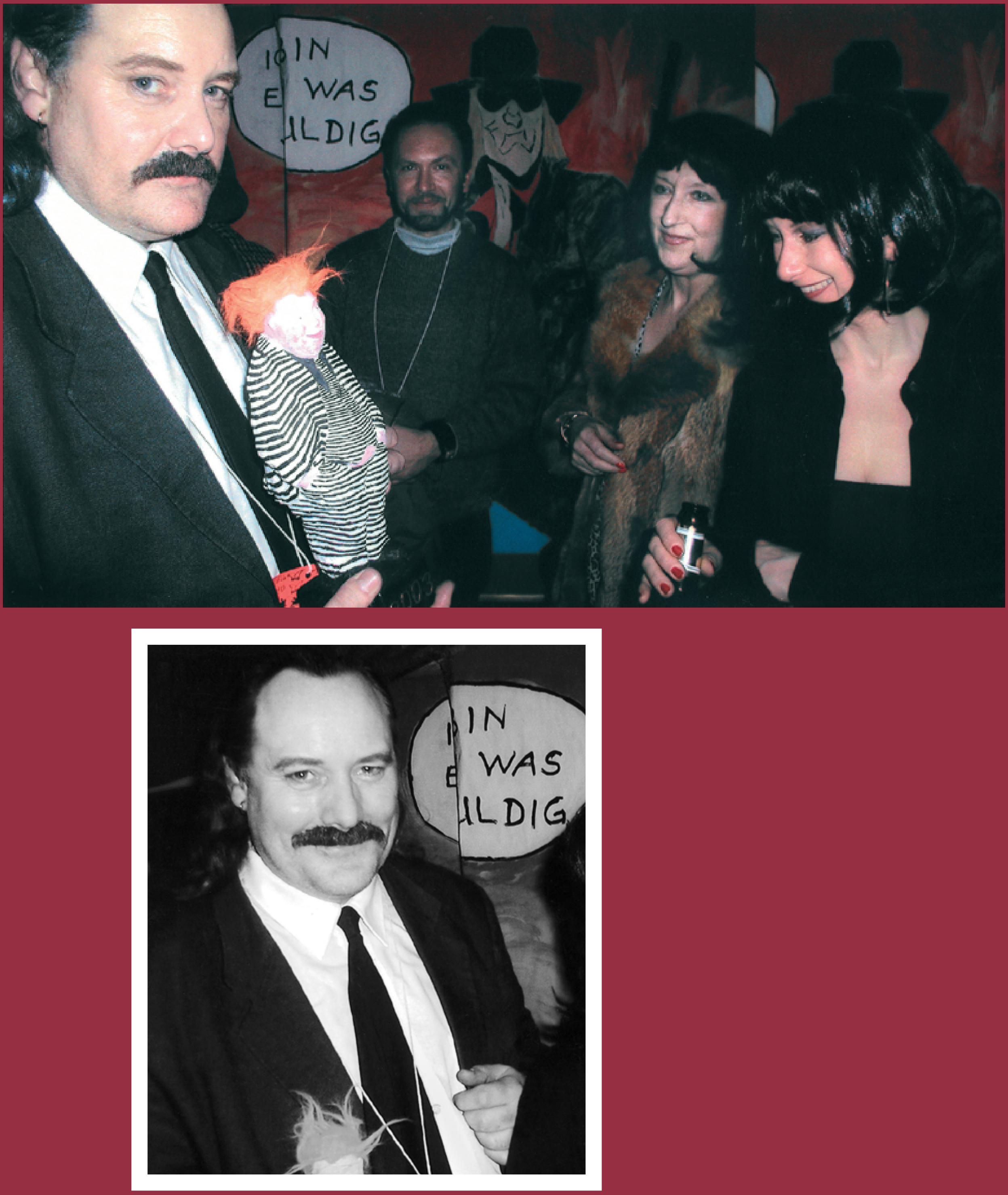
Martin on his way to home country – ferry on English channel, 2008.

Through both our scientific careers Elaine and Martin have been at our sides, and a professional life without them seems rather unthinkable. We have been together through the thick and thin of our institute, MONREPOS, and are glad that both decided to take the opportunity to stay on, even after retirement.

What feels, looking back, almost like a professional marriage, was in fact for years a very close collaboration and friendship, although sometimes, especially in recent years, our research interests diverged in parts. The reason for it being that on top of individual research projects, the overarching focus of MONREPOS increasingly gained centre stage, concentrating on theory building to understand human behavioural evolution. We feel that these discourses serve to highlight the relevance of Pleistocene Archaeology and position the discipline among the canon of scientific disciplines dealing with humans. But as this was and still is only part of what we are focussing on, we were always in very close collaboration, as no theory works without beef to the bone – the beef that very often could be found in Elaine's and Martin's projects.

MONREPOS 1989. Not a hen party – Larissa Kulakovskaja, Elaine, Antje Justus and Sabine.

In: S. Gaudzinski-Windheuser · O. Jöris (Eds.), The Beef behind all Possible Pasts. The Tandem-*Festschrift* in Honour of Elaine Turner and Martin Street. Monographien des RGZM 157 (Mainz 2021). DOI: 10.11588/propylaeum.950.c12590



MONREPOS goes Mafia. Carnival in the Rhineland is always a big issue. Above Elaine, Martin and Sabine with trophy for best costume.

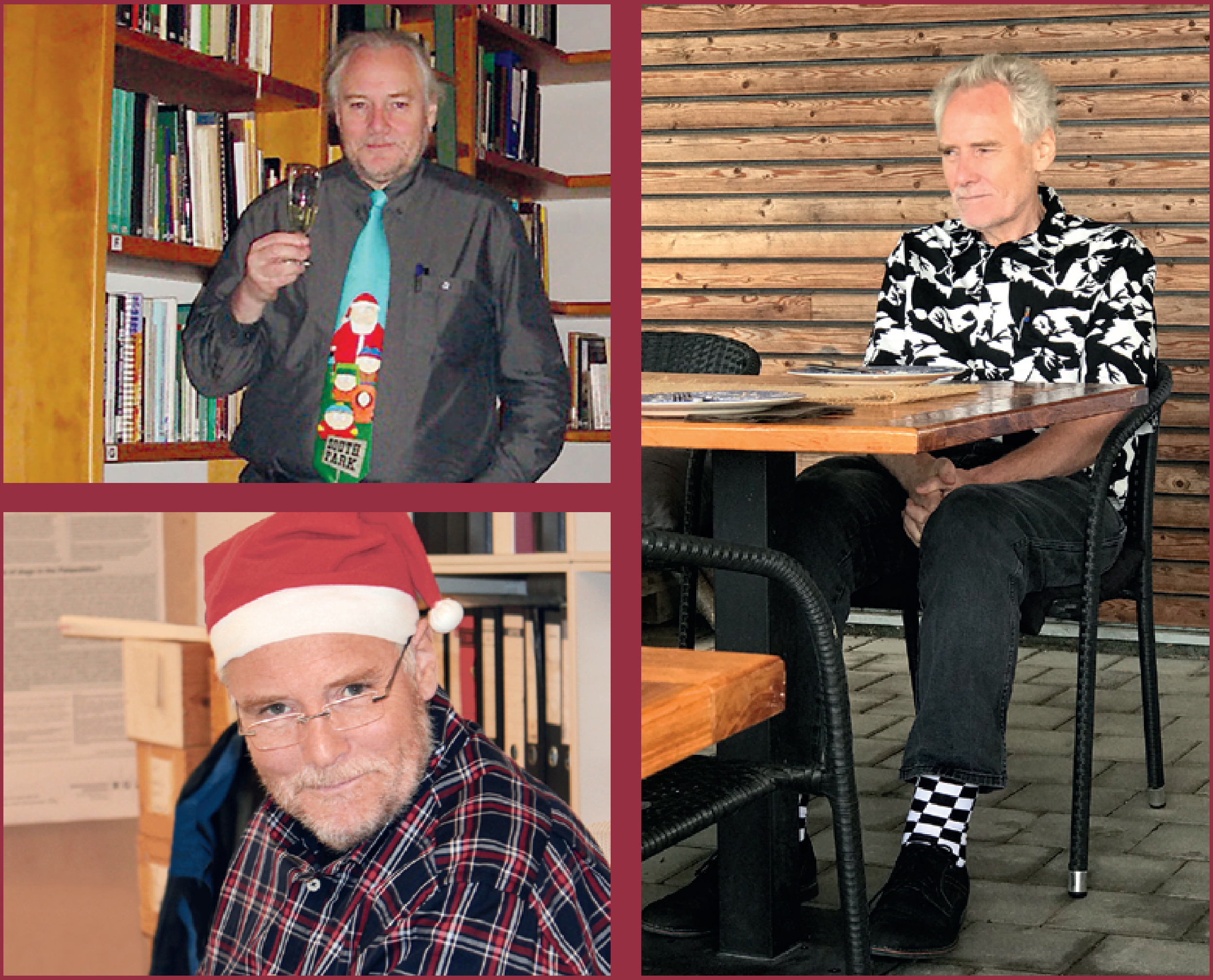
We do not know where this photo was taken but the motto must have had something to do with water.

Elaine is probably among the best organisers on earth, and apart from other skills, Martin is equipped with the rare talent that enables him to smell orthographic mistakes at a distance. While Elaine is very much down to earth in what she is doing – a talent that is very important for discussions when ideas become too aloof –, Martin is the personification of general knowledge, ranging from quantum physics to the latest Netflix-hype.

We vividly remember the numerous coffee breaks and dinners we spent together during conferences over the years in different combinations of us, chatting, laughing and gossiping away, with a lot of British humour involved.

Amongst all those experiences, we particularly recall a Hugo-Obermaier meeting in Mikulov (Czech Republic) at the end of the 1990s, with an after-conference tutorial that involved the trying of original Absint – a bodily experience that kept our olfactory senses actively and passively occupied for days, without even mentioning its consciousness-expanding or psychedelic effects, which probably explains some of our more strange/weird ideas.

What should also be mentioned is that Elaine and Martin are trailblazers of what today is called re-enactment. Both are particularly gifted with practical skills and over the years, more than once



Martin always dressed for the occasion.

we had to demonstrate hunting techniques using atlatls, bows, and arrows for the visitors of our Museum. Even though there was always somebody rough and ready to demonstrate how to use these weapons, the real professionals were always Elaine and Martin. Elaine is a very skilled archeress and Martin scored third on the world-ranking list for atlatl competitions. No wonder that whenever humans are needed for experiments in MONREPOS Elaine and Martin have to bite the bullet!

Finally, we have to acknowledge our institute the Römisch-Germanisches Zentralmuseum, Leibniz Research Institute for Archaeology, which provided us with the opportunity, the infrastructure and the finances not just to work together for decades, but also to produce this Tandem-*Festschrift* for Elaine and Martin. We felt we had to give back, to honour and recognise their lifelong service for and devotion to Pleistocene Archaeology!

Elaine and Patricia Anconettani,
Ferrara (Italy), 1996.

Cheers! MONREPOS, May 2019 with Sabine.

Martin and Clive Gamble during Virchow-Lecture in Schlosstheater Neuwied in 2016.

Martin and Elaine in 2020, during the "Roaring 1920s Gala" in Römisch-Germanisches Zentralmuseum, Mainz.

This Tandem-*Festschrift* pays tribute to Elaine Turner and Martin Street, to celebrate all you have both contributed to the MONREPOS Archaeological Research Centre and Museum for Human Behavioural Evolution of the Römisch-Germanisches Zentralmuseum, in ensuring high research standards, and for your contributions to Palaeolithic Archaeology in Germany and beyond. It should be understood as a big "CHEERS" from the MONREPOS staff and many other friends and colleagues from all over the world, who contributed to this *Festschrift*.

The double volume comprises a broad spectrum of topics from the Lower Palaeolithic to the early Holocene and even to the Medieval period – touching upon the vast array of topics Elaine and Martin have dealt with over the last more than 30 years. It starts with the discussion of the oldest evidence for fire and addresses many other key-topics of scientific debate at fascinating levels of detail.