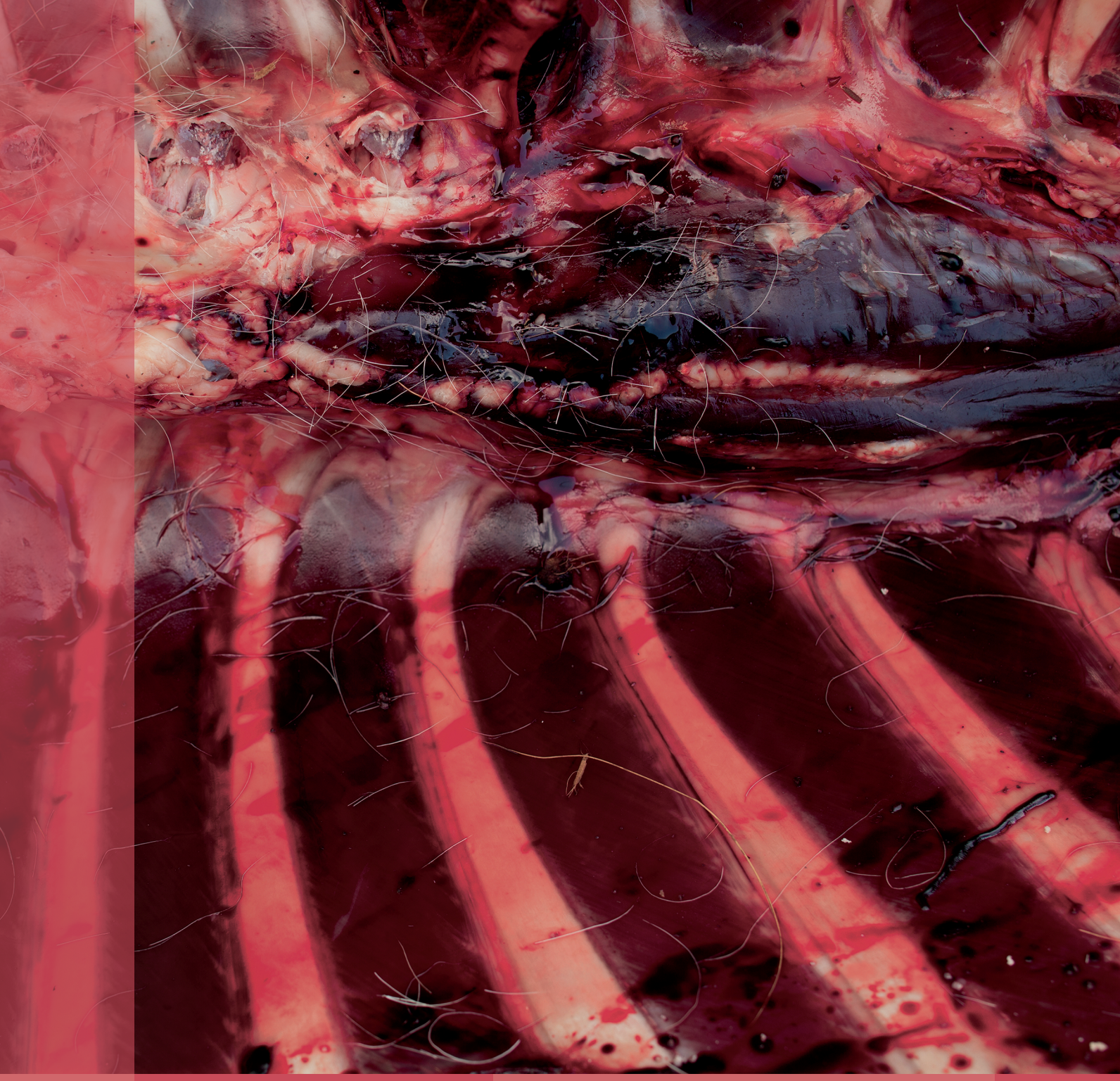

Sabine Gaudzinski-Windheuser · Olaf Jöris (Eds.)

The Beef behind all Possible Pasts

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

Volume 1

Römisch-Germanisches Zentralmuseum
Leibniz-Forschungsinstitut für Archäologie

R G Z M

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MONOGRAPHIEN

des Römisch-Germanischen Zentralmuseums

Band 157, 1

Römisch-Germanisches Zentralmuseum
Leibniz-Forschungsinstitut für Archäologie

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VOLUME 1

Verlag des Römisch-Germanischen Zentralmuseums Mainz 2021

Redaktion: Sabine Gaudzinski-Windheuser, Olaf Jöris, Geoffrey Carver,
Sophie Jørgensen-Rideout, Claudia Nickel, Marie Reiter (RGZM)
Satz: Nicole Viehöver (RGZM)
Grafische Ausstattung: Nicole Viehöver (RGZM)
Umschlaggestaltung: Nicole Viehöver (RGZM)

**Bibliografische Information
der Deutschen Nationalbibliothek**

Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über **http://dnb.d-nb.de** abrufbar.

**ISBN 978-3-88467-342-3
ISSN 0171-1474**

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Diese Publikation ist auf http://www.propylaeum.de dauerhaft frei verfügbar (Open Access).
DOI: https://doi.org/10.11588/propylaeum.868
eISBN: 978-3-96929-054-5
eISSN: 2629-673X
URN: urn:nbn:de:bsz:16-propylaeum-ebook-868-3

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Druck: johnen-druck GmbH & Co. KG, Bernkastel-Kues
Printed in Germany.

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Elaine and Martin at the Lower Palaeolithic site of Miesenheim I, 1984/85.


VERY WELL
DONE INDEED!

DEAR ELAINE AND DEAR MARTIN,

The Times They Are A-Changin' – despite being not that keen on Bob Dylan, and quoting here a song older than we are, we nonetheless use the song title to point to the recent changes that rather predictably befell our MONREPOS-team, as both of you went into retirement: Elaine already in 2019 and Martin in 2020. We guess you've seen these moments slowly approaching, too. And maybe you have even feared this situation, after having lived two long dyed-in-the-wool careers dedicated to archaeology and to archaeology at MONREPOS. Although you both have retired now, we are happy and proud that you decided to plough on in MONREPOS and continue with your research and your support for the institute.

As the institute owes you so much, we feel that we must give you at least something back and thus decided to honour your relentless commitment to Pleistocene Archaeology with this *Festschrift*. As you arrived together in Germany from the UK in the middle of the 1970s and since then your private and working lives were inextricably intertwined, it seemed a logical consequence to dedicate a *Festschrift* to both of you, thereby choosing the rather uncommon format of a tandem.

While we were in the very last stages preparing this *Festschrift*, which as everybody knows who ever edited a volume from top to bottom, is not in the least a rewarding task, we found a printout at the copy-machine in MONREPOS that Martin had not picked up. It was his reply to a Belgian colleague who probably had betrayed our surprise Tandem-*Festschrift* idea to Martin. In his reply, Martin was wondering whether the idea of secrecy is a valid concept in Belgium, as another Belgian colleague in an earlier mail had apparently already cryptically hinted at a *Festschrift*-in-the-making. Given this conspiracy we are happy that Mietje kept silent! In hindsight, it was surely rather naive to assume that such an endeavour involving so many of your close friends and colleagues could be kept secret for the lengthy time of the production of such a volume – and we all know that what Martin knows, Elaine also knows in a flash, and will be kept secret until their dying day. So likely you would never have told us that you knew!

←

Wobbly Business! Elaine and Martin at the Middle Palaeolithic site of Ariendorf, 1981/82.



Elaine and Martin at the Late Upper to Late Palaeolithic site of Andernach-Martinsberg, 1982.





Elaine and Martin at Solutré (France), 1995.



Elaine transcribing lists of site documentation, Jagdhaus Monrepos, ca. 1983.

So unfortunately, this Tandem-*Festschrif*t is not the surprise we had hoped to offer – although we managed to keep it secret almost until the publishing date. We were delighted to see how many colleagues from all over the world were prepared to contribute to the present publication. The result of all the input is a two-volume *Festschrift* with excellent and inspiring contributions that will surely be recognised in its own right in the future. We are relieved that some further 40 friends and colleagues of yours who initially promised additional contributions, were forced to decline as the pandemic situation had impacted too severely on their work schedules. To prepare a four-volume *Festschrift* would have stolen all our remaining energy. The present two volumes could only be published with help of many others. For the graphic design we thank the adept Nicole Viehöver who improved most the figures that were submitted. Under normal circumstances we would have approached you, Elaine and Martin, for proof-reading and if we would have been more aware of the conceptual differences in the perception of secrecy in neighbouring European countries, we could have spared all detours and could asked you directly. But Sophie Jørgensen-Rideout and Geoff Carver willingly stepped in with a lot of help in editing and proof-reading as native English speakers. We are grateful for their support, which sometimes included even repeated cross-reading and checking of numerous manuscripts that were written in all imaginable regional versions of what some people call English – including our own contributions. This concerns a very sensitive issue as both of you are perfectionists and will surely immediately and at first glance spot a mistaike!





Elaine visiting Coudolous (France) in 1995 (see the contribution by Brugal and Jaubert, this volume).

You, Elaine and Martin, and MONREPOS form an inseparable unit. You are dyed-in-the-wool MONREPOS-*Urgestein* even before MONREPOS was properly founded in the middle of the 1980s. Both of you worked behind the scenes when MONREPOS was in the making and made the institute what it is today. Your eminent expertise in research has been a guarantor for the path the institute took and for the high quality of MONREPOS-research over the decades. And without your jokes and British humor, our working lives would have been a great deal bleaker.

It was the scarcity of excavations in older archaeological periods and the limited perspectives in archaeology in the UK in the mid-1970s that drove you to look for opportunities across the channel. Both of you had been educated at Birmingham University and still keep in touch with your student friends. Once in Germany, you became interested and entangled in Gerhard Bosinski's research into the German Palaeolithic. But, at least for you, Elaine, we know that you were very much into Celtic Art when you came to Germany, which must have had something to do with certain animals being the central topics in the Celtic *Tierstile* ornaments.

After having initially inhabited the Gönnersdorf excavation-hut, life and research continued in the "*Forschungsstelle Altsteinzeit*" of Cologne University, located in the Hunting Lodge at Monrepos – a quite idyllic and romantic setting during summer. What sounds like a proper institution would never withstand modern workspace safety standards, with guaranteed frost-bite during winter,

Martin at the Late Upper to Late Palaeolithic site of Andernach-Martinsberg, 1982.



Elaine in 2013, inspecting the newly arrived taxidermy for the exhibition at MONREPOS.



Martin and Gabi Gräser, who was for numerous years the logistic backbone of MONREPOS during the Virchow-Lecture in 2015.

and, everything to do with the upkeep of the lodge – including chopping wood and catching mice (just to name the more pleasant tasks) – just part of the daily working schedule – *The Times They Are A-Changin'* indeed.

Research at MONREPOS during its infancy was very much determined by the large interdisciplinary research projects funded by the *Deutsche Forschungsgemeinschaft*, focussing on the East Eifel volcanic region which provided exceptional archives, spanning the last ~ 1.2 million years of the Palaeolithic. In one way or another everybody involved with MONREPOS had to pay tribute to this very large research adventure. Parallel excavations, numerous interdisciplinary working groups, involvement of long-time unemployed helpers, an entire student cohort, and a never ending stream of visitors very much determined the daily routine. Needless to say, you both were in the midst of it all, being excellent field-archaeologists – Elaine with her excavations at Ariendorf and Miesenheim I, and Martin with the excavations at the Martinsberg at Andernach and of an entire forest at Miesenheim II and other Late Glacial and early Holocene exposures. You were always prepared to help wherever needed and for many years you were – and still are – the institute's backbone. Both of you provided the social glue at an institute with a highly fluctuating personnel.

During the 1970-1980s German Pleistocene Archaeology was still very much occupied with the compilation of lithic tool catalogues, and the study of animal bones was basically restricted to species tables compiled by palaeontologists. You were familiar with animal bones and aware of the new perspectives zooarchaeological investigations had to offer for our perception of human behaviour. It is against this background that the development of the MONREPOS research perspective



Gerhard Bosinski explaining Niederbieber to colleagues, among them Joachim Hahn from Tübingen University. Elaine and Martin rather bored in the background.



particularly profited from your input. You provided the foundation for the Archaeozoology Laboratory at MONREPOS and for a long period of time were amongst the few Pleistocene Archaeologists in Germany familiar with this valuable source of knowledge. Here lies the foundation for an important research focus MONREPOS has dealt with over the years and continues to do so. This is true even though many of us were quite outspoken that you, Elaine, took it a bit far with your installation of a *Dermestes* population for bone maceration in what is now the MONREPOS elevator, as for years its stink vaguely wafted through the castle.

Until the late 1980s and early 1990s publishing in English was not considered a priority by our authorities, in fact the opposite was true. Money for translations was simply unavailable and with the new spirit that the "New Archaeology" had set free, it became imperative to communicate important findings to the wider English-speaking community. As a result, everybody who wanted to contribute just had to jump in at the deep end – a blessing in disguise. Nobody has probably ever counted the amount of *denglish* and occasionally *frenglish* manuscripts both of you copy-edited over the years for friends, colleagues within the Palaeolithic research community, and to certain degree for the entire Römisch-Germanisches Zentralmuseum, whenever it was required. Although it cannot be entirely excluded that you Martin – with your love for keeping lists – might even have kept an account of the thousands of pages you corrected during your career. There is no doubt that both of you are to be especially acknowledged as the trailblazers for the internationalisation of Pleistocene Archaeology in Germany. Being part of the editorial board of *Quartär* Martin, you even institutionalised these copy-editing activities for the sake of quality control. It was basically the never-ending patience and willingness of you both to help that did a great deal to make German Pleistocene Archaeology internationally visible.

Over the years you were engaged in numerous research projects from the Middle Pleistocene Lower Palaeolithic up to the early Holocene Mesolithic and you, Martin, even took a detour into medieval times. One can hardly find colleagues who were willing to involve themselves with such numerous and challenging tasks, as is reflected in the wide array of topics that have been submitted to this *Festschrif*t. In your research both of you always followed a very much down-to-earth approach, always looking for the most plausible of all possible explanations, always looking for the best of "all possible pasts". The most parsimonious explanation and the most solidly argued one has always been your priority, withstanding the *Zeitgeist* or trends to sell your scientific results best. What you always had on offer was sound and solid data one can chew on, data that will remain relevant for generations to come. Your publications present "the beef behind all possible pasts", based on the hard data that supports the most plausible of all possible explanations – independent of how long you have to chew on these data. Not surprisingly, little of what you have published since the start of your careers would require revision. It is this state of "beef" that structures the table of contents of this *Festschrift*. If you, Martin, would have been responsible for the editing, you would surely have come up with alternative suggestions for sorting of the papers according to e.g., methods, site-studies vs. studies focussing on periods, regions, etc. – just to avoid the simple chronological solution. We chose the latter, following the sequence from "well done" via "medium", "rare" and "freshly caught" to "alive and kicking", as the spectrum of topics was simply too diverse to come up with a more intellectually challenging structure.

The diversity of topics reflected by these contributions is due in large part to your rock-solid research, which is based on your exceptionally broad expertise and reflected in your highly interdisciplinary research projects. It is only with this background of knowledge and experience that enables one to evaluate all "possible pasts". Given this, one might even go as far as to say that



Cheers, Elaine and Martin!

you in a way, succeed Gottfried Wilhelm Leibniz (1646-1718) who argued that the actual world is to be perceived as "the best of all possible worlds". Although today, the scientific base for this argument would need revision, the basic attitude of how to do research is comparable to yours. You developed and followed this attitude independently since the beginning of your scientific careers, long before the Leibniz research association chose Leibniz's quote as its motto.
Research is never finished, and once you became interested in a specific topic, you immediately were committed. We thank you very much, Elaine and Martin, for everything you have done over the many years for MONREPOS and the RGZM and for Palaeolithic Archaeology in Germany and beyond. And for us, the people behind MONREPOS, and all your friends and colleagues, and we hope that we will be able to continue together for the foreseeable future. Very well done!

Sabine and Olaf

Note: We thank our numerous friends and colleagues who have followed Elaine and Martin over decades, and who have kindly and generously provided us with photos, documenting their careers. We have refrained from acknowledging every single contributor individually, as many remained anonymous or have been difficult to track down.


WELL DONE



Elaine and Martin at the Middle Palaeolithic site of Ariendorf, 1981/82.

A steak is "well done" when it has been fried for quite a while. It needs fire to cook it, as well as skill and experience in controlling the fire to not just let the steak become chewy. Basically, the same applies to "well done" in science, where it takes literacy, skill, experience, and commitment to turn the sometimes murky ingredients into a festival for different tastes.

The analogy is admittedly a bit clumsy but this is what you get when you let scientists deal with prose, and for once, we decided to devote ourselves freely to the metaphor for this Tandem-*Festschrift* which – as must have become apparent to the reader – is "meat", in different facets and approaches.

Studying "meat" provides an important ingredient to the understanding of our very deepest history and offers an entire universe of analogies, and Elaine and Martin can both be said to love "meat" (Martin being the only individual in MONREPOS able to turn a tick infested hind leg of a cervid into a gourmet experience), as well as both also being skilled zooarchaeologists.

Elaine and Martin definitely deserve a huge "well done" in science, as well as having worked with aspects of archaeological records that also deserve the label "well done", as being neither "fresh" nor "rare" nor "medium". In the 1980s and 1990s Elaine's and Martin's research contributed significantly to establishing the chronology and biostratigraphy of the Pleistocene in Europe and beyond, and their comprehensive excavations, analyses and publications of the Lower Palaeolithic sites at Miesenheim I, Kärlich, Schöningen and at the Middle Palaeolithic sites of Ariendorf and Hummerich must be mentioned here.

2021

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Elaine and Elisabeth Noack during UISPP in Paris, 2018.



Martin in Paläon, Schöningen 2014.

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Martin searching for the dwelling at the Middle Palaeolithic site of Ariendorf, 1981/82.



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Martin joining Nick Conard's excavations at the late Middle Palaeolithic site of Wallertheim, ca. 1992.



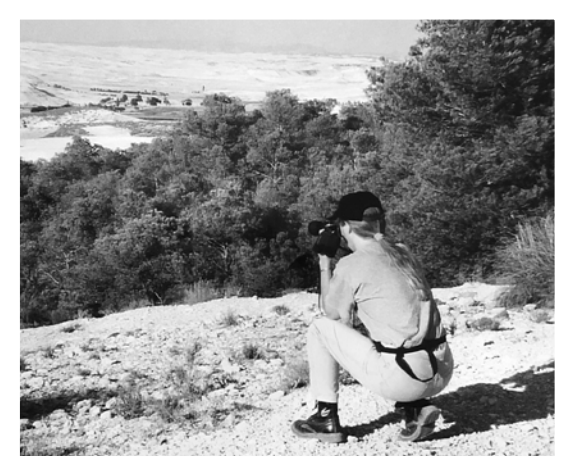


Quarrying alone. Martin in Ariendorf, 1981/82.





Martin giving a lecture on the dog remains from Bonn-Oberkassel in LVR LandesMuseum Bonn, 1995.



Elaine at Venta Micena during the Congreso internacional de paleontología humana, Orce (Spain) 1995.

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Elaine resting in Alhambra, Granada (Spain), 1995.



WIL ROEBROEKS · KATHARINE MACDONALD · FULCO SCHERJON

ESTABLISHING PATTERNS OF EARLY FIRE USE IN HUMAN EVOLUTION

Abstract

Studying the origins and development of the use of fire as a tool in deep prehistory is challenging, given the mostly ephemeral traces of fire use left behind by mobile hunter-gatherers and their preservation-determined low visibility in the archaeological record. Keeping in mind the incompleteness of that record, we attempt to reconstruct the spatio-temporal patterns of (Early and Middle) Pleistocene fire use in the Old World, building on a series of earlier studies. We briefly review the possible evidence for early fire use in Africa, discuss the evidence from the late Early and early Middle Pleistocene of Africa and Eurasia, and present the rich record of fire use from the second half of the Middle Pleistocene of the Old World. The strong signal for fire use since ~400,000 years ago does not imply that there was no fire use before that period, even though the record for earlier use is ambiguous at best. We infer that, at a minimum, the Middle Pleistocene signal suggests changes in the dynamics of fire use. Despite the fragility of traces of fire use, this change is still visible, hundreds of thousands of years later, in archaeological excavations over major parts of the Old World.

Keywords

Early and Middle Pleistocene, Africa, Eurasia, multi-method approaches, taphonomy

INTRODUCTION

Palaeolithic archaeologists work with notoriously incomplete datasets. The record is biased in many respects, through differential preservation, by visibility and accessibility issues as a result of burial processes, and by imbalances in research intensity between regions, to mention just a few. Despite these limitations, we use this biased record routinely to identify spatiotemporal patterns of hominin activities and to interpret these patterns in terms of former human behaviour. Evaluating the strength of identified patterns and developing testable interpretations that make predictions about what we are going to find in field and laboratory work is the bread and butter of our discipline. Pattern-interpretations generate hypotheses that make predictions that can be tested and can stimulate new work explicitly aimed at proving them wrong, and by doing so, advance our knowledge about the timeline of past behavioural developments.

Here, we will present data that we consider useful to establish patterns of Early and Middle Pleistocene fire use, a topic that has become a major palaeoanthropological research focus in the last decade. This focus is understandable, as systematic interaction with fire, including enhanced maintenance and production (Chazan, 2017), is one of the most important accomplishments within the cultural evolution of humankind. Fire afforded hominins protection against predators and the cold, broadened the range of edible foods and the amount of energy that could be extracted from them through cooking (Wrangham, 2009), allowed manipulation of materials (Mazza et al., 2006), extended the length of the day, impacted the character of human social interactions (Wiessner, 2014), and possibly also the biological adaptations of hominins (Aarts et al., 2016, 2020; Hubbard et al., 2016). Fire gave hominins a tool to increase the productivity of their habitats, over time, through repetitive burning, significantly transforming natural landscapes (Bliege Bird

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.868.c11305

et al., 2020; Scherjon et al., 2015). Fire also came with costs (Henry et al., 2018), as fire-using hominins had to collect fuel to be brought to a fireplace, possibly calling for forms of cooperation within a group common in humans today but rare in other primates (Twomey, 2014).

Tracking the development of the earliest uses of fire in time and space is challenging, as identifying traces of fire as anthropogenic is not a straightforward undertaking. One reason for this is the often ephemeral character of fire use by hunter-gatherers, illustrated in these quotes (Woodburn, 1968: 51):

"Vegetable food is collected almost every day by the women of the camp […] Whatever the type of vegetable food, a large proportion is eaten where it is collected. […] Roots are […] in most cases, lightly roasted on an open fire […] The men, like the women, satisfy their hunger at the place where food is obtained. A man on his own will normally light a fire, cook, and eat on the spot any small animal he kills".

This description of foraging and food processing activities by the East African Hadza highlights the short-lived and spatially dispersed use of fire by mobile foragers, who rarely invest in structures around hearths. Materials that have been exposed to heat make up the most common proxies for such fire use and include charcoal, heated lithics, charred bone, and the heat-altered sediments on which a fire was built (James, 1989; Roebroeks and Villa, 2011). In the open air, wind and water easily remove many of the fragile traces (particularly charcoal and ash) (Sergant et al., 2006), while once buried, post-depositional weathering can alter or remove any remaining traces of fire use (for a review, see: Aldeias, 2017). At the same time, natural fires are known to create a range of proxies that can mimic anthropogenic ones (Gowlett et al., 2017).

Given these challenges, many authors argue that the best evidence for anthropogenic fire use comes when several different fire proxies can be demonstrated to be in primary archaeological context (James, 1989; Roebroeks and Villa, 2011). Whether fire occurred where the residues are found can be clarified using micromorphological approaches (Mentzer, 2014). At the same micro-scale techniques can be applied to further understand the archaeological context (Mentzer, 2014), and are particularly effective in cave and rock shelter settings (Braadbaart et al., 2020). An important strand of recent research on the early prehistory of fire use has involved the development and application of new analytical methods to fire residues to deal with these issues, as described in two recent reviews (Mentzer, 2014; Sandgathe and Berna, 2017). This is strengthened by numerous experimental studies testing the effects of heat on wood, bone, and various types of artefacts as well as on sediments underlying fireplaces and the artefacts in those sediments (Reidsma et al., 2016; Aldeias, 2017; van Hoesel et al., 2019). In some cases, such multi-method approaches have shown that inferred traces of early fire use had been diagnosed incorrectly as resulting from heating. Prominent examples have refuted evidence from the South African "Cave of Hearths" (Herries and Latham, 2009) and the ~300 thousand years (ka) old site of Schöningen in Germany (Stahlschmidt et al., 2015).

Given the impact pyrotechnology must have had, understanding the origins and development of fire use is relevant for our understanding of the development of the human niche. Keeping in mind the challenges mentioned above, we will attempt to establish the spatiotemporal pattern of (Early and Middle) Pleistocene fire use in the Old World. We will do this building on a series of earlier studies (James, 1989; Rolland, 2004; Roebroeks and Villa, 2011; Gowlett and Wrangham, 2013) and expanding these with recently published data, profiting from the multi-method approaches mentioned above. We will first briefly review the possible evidence for early fire use in Africa, then discuss the evidence from the late Early and earlier Middle Pleistocene of Africa and Eurasia, and, finally, document the strong signal of fire use from the second half of the Middle Pleistocene of the Old World. We will make a brief attempt to interpret the established pattern in the discussion part of our contribution.

EARLIEST FIRES IN AFRICA?

In contrast to Richard Wrangham's well-known arguments in the fire debate for the role of cooking in the emergence of the *Homo erectus* Bauplan, there exists no archaeological evidence for hominin fire use until minimally half a million years *after* the emergence of the *Homo erectus* lineage (Herries et al., 2020). Even those earliest *possible* traces, dating to around 1.5 million years (Ma), are debated (Brain, 1993; Gowlett and Wrangham, 2013; Hlubik et al., 2017, 2019; Isaac, 1982; James, 1989). The open-air setting of all of these early sites continues to be a problem for interpreting the anthropogenic versus natural origin of the earliest fire evidence, as exemplified by possible fireplaces from the Koobi Fora area with reddened patches of sediment, the origin of which after four decades (!) is still under debate (Gowlett et al., 1981; Isaac, 1982; Clark and Harris, 1985; Hlubik et al., 2017, 2019).

The Wonderwerk Cave (South Africa) is often cited as having the earliest evidence for human knowledge and use of fire (Stahlschmidt et al., 2015: 182), around 1 Ma ago, but the evidence given in the available proxies might not be strong enough to support the significance for early fire given to this site. Peter Beaumont (2011) presented the potential evidence for the presence of anthropogenic fire at Wonderwerk Cave based on macroscopic observations as far back as Stratum 12 (Oldowan) of the cave, while Berna et al. (2012) identified microstratigraphic evidence of "*in situ* fire" from Stratum 10, in the form of heated bone and ashed plant remains. From this evidence, these authors inferred that fire was present during the early Acheulian occupation of the cave, and given the long distance from the present entrance (around 30 m), it was assumed that these fires were introduced by hominins (Berna et al., 2012). However, no data were presented that could confirm that the small materials were indeed heated on the location where they were retrieved. Analyses of new samples from the Wonderwerk sequence furthermore show that the micromorphological evidence published in 2012 "[…] is clouded by the fragments of micritic pseudomorphs of plant tissues", opening "[…] up the possibility that some of the ashes originally identified in a small area […] were in fact calcified plant fragments" (Goldberg et al., 2015: 641). All in all, the evidence for hominin-made fire(s) in the cave is possibly not as strong as originally presented by Berna and colleagues (2012).

Furthermore, and importantly, Chazan (2017) has contrasted the presence of traces of fire in the low-density cave site setting of Wonderwerk on the eastern slopes of the Kuruman Hills with the absence of any traces of fire in the Acheulian and Fauresmith sites of the Kathu complex on the hills' western fringes. The tens of millions of stone tools from these sites have not yielded any (macroscopically visibly) heated lithics. In Chazan's view, the presence of fire in a low-density cave site contemporaneous with the absence of fire traces on sites with massive accumulations of lithics suggests that during this period, aspects of hominin behaviour related to the use of fire and those related to the production and discard of large quantities of artefacts may have been spatially differentiated. In his view, such a spatial differentiation of the use of fire and the discard of stone tools at around 1 Ma is, at the least, difficult to reconcile with the important role of fire in human evolution, which Wrangham's cooking hypothesis suggests (Chazan, 2017).

The current data for early fire use in Africa suggests that the dispersal of early hominins into Eurasia, at around 2 Ma, was *not* associated with any type of archaeologically visible fire use. By this time, hominins were already distributed over major parts of the Old World. As far as the archaeological evidence goes, the Early Pleistocene hominin range expansion into Eurasia seems to have been carried out by hominins who were *not* dependent on the use of fire.

THE LATE EARLY AND EARLY MIDDLE PLEISTOCENE FIRE RECORD

The fire record from about 1.0 to 0.4 Ma might be expected to yield more convincing examples, given the much denser record of sites, wider geographical distribution, and cooler or otherwise more challenging conditions at some locations, but this does not seem to be the case. Roebroeks and Villa's (2011) review of the European evidence of a decade ago identified a distinct change in the European archaeological record around 350-400 ka ago, with the first half of the Middle Pleistocene and earlier periods seemingly devoid of any solid traces of anthropogenic fire use. Long archaeological karstic sequences such as the Atapuerca site complex in Spain or the Caune de l'Arago at Tautavel (France) did not yield any evidence for fires caused by hominins until ca. 350 ka, while fire traces are also absent from open-air sites dating to the late Early and first half of the Middle Pleistocene, including prolific sites such as Boxgrove in the UK (Roebroeks and Villa, 2011).

The Cueva Negra cave site in south-eastern Spain, however, constitutes a possible case of fire use at the very end of the Early Pleistocene. Here indications for anthropogenic fire in the form of very small pieces of heated chert, charred and calcined bone fragments, and heated microfaunal remains within an area of coloured sediment have been reported (Walker et al., 2016; Rhodes et al., 2016). Given the small number of lithics, their very small size (0.5 to 5 mm) and shattered condition, it seems possible that a key part of this evidence is based on a few heat-altered larger stones only. However, it remains open whether or not these stones were artefacts. Initially assigned to the later part of the Middle Pleistocene, the sequence has now been dated by magnetostratigraphy (Scott and Gibert, 2009) and faunal remains (Lopéz Jiménez et al., 2020) to the late Matuyama period (~ 1.0-0.8 Ma). However, some workers still prefer a late Middle Pleistocene age (e. g., Jimenez-Arenas et al., 2011).

The early Middle Pleistocene Levantine site of Gesher Benot Ya'aqov is often quoted as demonstrating recurrent fire use over tens of thousands of years, in the form of a series of "phantom hearths" with an age of ~ 780-700 ka. These are identified using maps of the distribution of heated flint (micro-) artefacts at the site. However, some of these "burned flint microartifacts" (Alperson-Afil and Goren-Inbar, 2010: Appendix 1; cf. Goren-Inbar et al., 2004: Suppl. Materials) may not be humanly modified pieces. Although it is difficult to evaluate this on basis of the published picture, certainly the artefactual status of objects b, c, j, and l in Appendix 1 of Goren-Inbar et al. (2004) needs further scrutiny (cf. Stahlschmidt et al., 2015: 183, for comments about the character of the Gesher Benot Ya'aqov evidence).

Absence of evidence is not evidence of absence, especially given the fact that proxies for anthropogenic fire use are generally very ephemeral and bound to easily disappear from the archaeological record. Lebreton et al. (2019) recently analysed micro-charcoal from Middle Pleistocene sediments from sites in the Molise region in southern Italy, where hominins were virtually continuously present. They focused on micro-charcoal to deal with the possibility that weathering, affecting charcoal preservation and fragmentation and dispersion of heated materials, may have destroyed potential proxies for anthropogenic fires. In their study, the authors compared sediments from geological and archaeological sites, focusing on data from 780-300 ka, the period before and after the inferred onset of regular fire use in Europe. Their study concludes that no evidence of anthropogenic fire is present for this whole time window in Molise, either in the form of hearths or high concentrations of micro-charcoal. In the view of Lebreton et al. (2019), the oldest evidence for fire use in Italy thus far documented dates from the Middle Palaeolithic site of Campitello Quarry, which has a minimum age of ~ 200 ka (Mazza et al., 2006).

Again, such a lack of evidence needs to be treated with caution, given the taphonomic issues with fire proxies mentioned above. This especially applies to the African record for this time trajectory, given the low density of observation points there. In that respect one interesting high altitude area without fire evidence

may be worth mentioning here. The Melka Kunturé open-air sites complex, situated in the Upper Awash valley in the northern Ethiopian highlands, is located at about 2,000 m a. s. l., documenting hominin adaptations to high altitude environments over a very long period, from ~ 1.7 Ma to the Late Stone Age. In the Pleistocene these high altitude environments were affected by severe cold periods, probably too cold for a continuous hominin presence, as suggested for the occupation signal from the 850-700 ka sequence of Gombore II (Mussi et al., 2016). Apart from a single possibly heated pebble from Garba 1, a late Acheulian site (Chavaillon and Berthelet, 2004), there is no evidence for the presence of fire until the Late Stone Age throughout the whole of the spatially extensive Melka Kunturé complex.

This absence (or extreme rarity) of traces of fire use in the late Early Pleistocene and the early Middle Pleistocene, in (high altitude) Africa and western Eurasia, raises important questions about hominin survival strategies. At the least, hominins, distributed over large parts of the Old World from around 2 Ma onward, did not use fire in the regular way suggested by the cooking hypothesis (or minimally: did not do so constantly, i. e., in an archaeologically visible way) for hundreds of thousands of years (MacDonald, 2017). However, as Gowlett and Wrangham (2013: 22) argue, "To postulate that they could manage without fire is to say that they had other strategies for preparing uncooked fat and meat, for maintaining warmth during the ice-age winter and avoiding predators."

Recent work may provide some alternatives for food processing and digestion. Zink and Lieberman (2016) point to the importance of simple food processing techniques like slicing meat and pounding vegetables, while Speth (2017) argues that fermentation of meat, fat and fish could have provided many of the benefits similar to cooking for Neanderthals, as well as a means of storing food and preserving vitamin C. Following Speth's studies, Dunn et al. (2020: 8) suggest that "[…] neither technical nor intellectual barriers would have prevented *H. erectus* or their relatives from fermenting at least some kinds of food". In support, they cite simple ethnographically documented methods of fermentation and examples of carnivores storing and fermenting meat, as well as the likelihood (still to be demonstrated) that a common ancestor of chimpanzees and humans possessed adaptations to tolerate sour tastes and digest alcohol. If they can be applied to early occupants of high altitude settings throughout the Old World, these suggestions help to explain how hominins could have met their nutritional needs without use of fire to cook food. Alternative physiological and cultural ways of controlling body temperature have also been suggested (MacDonald, 2018; Gilligan, 2010), including muscle insulation and a high level of metabolic up-regulation, a thin layer of winter fur, wearing simple clothes, or seasonal migration. Combinations of these strategies could have helped hominins to avoid hypothermia even in winter conditions at sites in North-Western Europe, assuming they got enough food (MacDonald, 2018). These scenarios would seem to make the absence or infrequent use of fire by the earliest occupants of Europe plausible but require testing in the archaeological record and ancient DNA. However, the subsequent strong fire signal change in the middle part of the Middle Pleistocene is beyond any doubt, as discussed in the following section.

A MIDDLE PLEISTOCENE CHANGE IN THE FIRE RECORD?

The later half of the Middle Pleistocene is characterised by a large number of sites with multiple proxies for fire use, in close to primary context, from ~ 400 ka onwards, with the frequency with which multiple traces of fire are present increasing (James, 1989; Rolland, 2004; Roebroeks and Villa, 2011; Gowlett and Wrangham, 2013). The Gruta da Aroeira cave site in Portugal provides a recent confirmation of this pattern in Europe, where fire proxies in the form of heated bones are found starting ~ 400 ka (Daura et al., 2017).

Shimelmitz et al. (2014) have tried to put an age estimate on the "emergence of habitual fire use" in the Levant, to a large degree based on the long and well-dated sequence of Tabun Cave, Israel, as well as a review of the evidence from a range of other cave sites (note that the site Gesher Benot Ya'aqov is not even mentioned in this review). In the case of Tabun, Shimelmitz et al. (2014) interpret increases in the frequencies of heated lithics as indicating the onset of "regular fire use" between 357 and 324 ka. The presence of very low numbers of heated lithics further down in the sequence, however, indicates that fire use did occur somewhat earlier at Tabun. Earlier fire use may simply not be reflected well in the excavated assemblages: rock shelters and caves evolve through time, with cliff faces and drip lines receding and the feature finally becoming unsuitable for human habitation. These changes in morphology have consequences for the placement of "site furniture", including fireplaces, in these locales and hence for their visibility in the archaeological record. Locations where fireplaces were positioned in the early phases of a rock shelter (i. e., most likely closer to the drip-line) may already have disappeared through lateral erosion when later occupations occurred (and the drip-line moved backwards), while small-scale excavations may only document specific parts of the former use of a rock shelter (Sorensen and Scherjon, 2018). Nevertheless, while the 324-357 ka date may underestimate the actual age of the onset of regular fire use in the Levant, the Levantine evidence as reviewed by Shimelmitz et al. (2014) strongly suggests that fire use was an integral part of the hominin technological repertoire here during the second part of the Middle Pleistocene.

Beyond the Levant, there is very limited evidence for fire use in the Middle Pleistocene of Asia (Dennell, 2008). Gao et al. (2017) discuss the history of fire research at the Zhoukoudian site in China, where evidence for *Homo erectus* fire use discovered in the 1930s became contested from the 1980s onward. Recent excavations have uncovered unambiguous traces of anthropogenic fires in a layer for which the age estimates obtained vary per dating technique used, but all point to the 500-250 ka range (Gao et al., 2017).

While we have focused thus far on Eurasian and Near Eastern evidence, a good African illustration of the Middle Pleistocene change in fire signal is provided by the occupation traces *Homo sapiens* left at Jebel Irhoud, Morocco, a locality with abundant evidence for anthropogenic fire use at ~ 300 ka, including numerous heated lithics and heated faunal remains (Richter et al., 2017). The Jebel Irhoud evidence fits very well into the pattern of abundant evidence for anthropogenic fire use also in the African MSA, particularly in South African caves, reflecting the amount of fieldwork done there. Bentsen's (2013) review of the various kinds of fire evidence shows that the regular use of fire was very important in the MSA, as it was in the European and Western Asian Middle Palaeolithic (Roebroeks and Villa, 2011; Shimelmitz et al., 2014; Sorensen, 2019).

In most western Eurasian Middle Palaeolithic sites fire proxies are present, in open-air as well as rock shelter sites (Roebroeks and Villa, 2011). Fire was used for the cooking of foods (Henry et al., 2011), production of pitches (Mazza et al., 2006) and to gain access to deep caves (Jaubert et al., 2016). There are sites at which such fire evidence is repeated many times, over long periods, in open-air contexts, such as at Biache-Saint-Vaast (France) (Hérisson et al., 2013), as well as in karstic settings. For example, at Bolomor Cave, Portugal, 14 hearths associated with heated materials have been excavated from multiple levels dating from 350-100 ka (Peris et al., 2012). Similarly, in the Near East, at Qesem Cave, there is evidence for extensive burning throughout the occupation history of the site, between 400 and 200 ka (Karkanas et al., 2007), and a very large central hearth dating to around 300 ka was used repeatedly (Shahack-Gross et al., 2014). Even though it is difficult to find evidence for fire *production* in this period (Sorensen et al., 2018), the evidence for fire use in the second half of the Middle Pleistocene is very strong.

DISCUSSION

Our review indicates that fire use was very probably a standard part of the hominin technological repertoire from the second half of the Middle Pleistocene onward. In this sense, our review supports suggestions made in previous reviews of the record from Europe and the Levant. We see plausible evidence for "fire at will" (Shimelmitz et al., 2014) in those parts of the Old World that have undergone some form of representative archaeological sampling – and comparable evidence is very probably also hidden in sediments in areas where we have seen far less archaeological fieldwork relative to the size of the regions (and perhaps also in the literature of these areas), such as the Indian subcontinent, China and Southeast Asia. The strong signal for fire use since ~400 ka does not imply that there was no fire use before that period, even if some of the early contested cases may indeed be the result of natural fires. As mentioned above, hominins were distributed over large parts of the Old World from around 2 Ma onward and were probably occasionally exposed to settings that are quite challenging in terms of thermoregulation and diet for present-day humans in our current interglacial, such as the loess plateau of Central China (Zhu et al., 2018). The few cases for which early Middle Pleistocene and Early Pleistocene fire use have been claimed (see above) may indeed testify to earlier use, possibly limited to specific periods and/or regions only: depending on the mode(s) of cultural transmission of knowledge, population density and ecological necessity, new inventions could have flourished for some time and petered out again. Early Pleistocene hominins at the northern edge of their range may have been occasional visitors, expanding their ranges during warm periods, possibly from a source population in a more temperate region, and staying only for the warmer parts of the year (Dennell, 2013). Even if groups or subpopulations on the northern edge of the range were using fire, these skills might have been lost due to local extinctions, and 'source' populations from warmer regions might have had less use for such skills. The costs associated with fire use, and benefits varying with environment, also make it more likely that fire use was patchy and temporary (Henry et al., 2018), at least in its early stages.

We cannot even rule out the possibility that fire use, despite its extreme rarity or complete absence over much of the archaeological record, was ubiquitous in the Old World, long before it became archaeologically visible in the middle part of the Middle Pleistocene. In such an interpretation, its traces simply did not survive or have not been picked up yet. Parker et al.'s (2016) pyrophilic primate hypothesis, for instance, suggests that long before fire use became visible at archaeological sites, where it was used to prepare food, hominins had been experiencing the foraging benefits of freshly burned landscapes and over time actively transported fire from burned to unburned areas, with virtually no traces left in the archaeological record. We have to envisage that the range of purposes for which fire was used broadened over time to incorporate e. g., food preparation and preservation activities and the production of new materials, such as pitches (Mazza et al., 2006), all possibly increasing the archaeological visibility of fire use. Such changes may have occurred at different periods in different regions and within different types of environments.

Also, changes in mobility and land-use strategies that involved longer stays at "base camps" versus an earlier "on the road" and shorter-term use of fire, may have increased the archaeological visibility of its usage and have generated the strong mid-Middle Pleistocene fire signal reported here (cf. Rolland, 2004). Kuhn and Stiner (2019) suggest that changes in social and spatial organisation are evident in the Near Eastern Middle Pleistocene record, reflected in a strong association between fire use and caves; this may be true in other regions as well. Or as Holdaway et al. (2017: S239) suggest, "What may have changed [in the European Middle Palaeolithic] was the locations where fires were created and therefore the probability of their survival in the archaeological record".

Whatever the correct interpretation of the pattern is (cf. MacDonald et al., in prep.), and no matter how "messy" the record for Pleistocene fire use seems to be, we do suggest that amid this taphonomical "noise"

the mid-Middle Pleistocene fire signal is a very strong signal: it indicates changes in the dynamics of fire use that despite the fragility of its traces are still visible, hundreds of thousands of years later, in archaeological excavations all over major parts of the Old World.

Acknowledgements

The authors are grateful to Margherita Mussi (Rome) and John Speth (Michigan) for fruitful discussions about aspects of this study. We thank Sabine Gaudzinski-Windheuser and Olaf Jöris (MONREPOS) for comments on the manuscript. When Martin Street published his 1994 *Archäologisches Korrespondenzblatt* paper on the "Absolute Chronologie des Späten Paläolithikums und des Frühmesolithikums im nördlichen Rheinland" (together with Michael Baales and Bernhard Weniger), his handwritten dedication on the offprint included the statement that now, with this paper, for the younger periods all problems had been solved. As our paper accomplishes very much the same for the thorny issue of fire use in the Lower Palaeolithic, we wish to dedicate our manuscript to Martin Street and to Elaine Turner, continuous sources of inspiration, scientific rigour and, last but not least, fun.

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THE WOOLLY RHINOCEROS FROM SEWECKENBERGE NEAR QUEDLINBURG (GERMANY)

Abstract

The locality Seweckenberge (near Quedlinburg) yielded, during the quarrying of gypsum, a large amount of Pleistocene fossils; remains that inspired Otto von Guericke in 1678 to reconstruct the famous *Magdeburger Einhorn* (i. e., "Magdeburg Unicorn") or *Guericke-Einhorn*. For his reconstruction he made use of skeletal parts of recent as well as fossil, Pleistocene material collected in 1663 at the locality Seweckenberge. The Pleistocene faunal assemblage is rather diverse and includes different species of the so-called Mammoth Steppe biome. One of these species is the Woolly rhinoceros. A skull fragment of a juvenile individual with an age of ca. 1.5 years, described in this paper, is stored in the collection of the *Museum für Naturkunde und Vorgeschichte Dessau* (Museum of Natural History and Prehistory Dessau) in Dessau-Roßlau.

Keywords

Guericke-Einhorn, mammoth steppe biome, Woolly rhinoceros, *Coelodonta antiquitatis*

INTRODUCTION

The locality Seweckenberge (Saxony-Anhalt, Germany) plays an important role in the history of the Unicorn myth; the legend of an animal that is nowadays often depicted as a horse with a large, pointed, spiralling horn projecting from its forehead, and in some cases with a goat's beard and cloven hooves. The legend goes far back in time and is geographically widespread; it originates most probably from India or south-east Asia inspired by the appearance of the Indian One-horned Rhinoceros (*Rhinoceros unicornis*) but also (fossils of) the Woolly rhinoceros (*Coelodonta antiquitatis*), the Woolly mammoth (*Mammuthus primigenius*) and the Aurochs (*Bos primigenius*) could have been a source of inspiration (Gröning and Brauckmann, 2011). However, the fossil Siberian Unicorn (*Elasmotherium sibiricum*) should not be excluded as base for the unicorn legend. Recent investigations indicated that the very large, Eurasian rhinoceros existed to at least 39,000 years ago, living at the same time as modern humans (Kosintsev et al., 2019; Kuitems et al., 2019).

There have been several attempts to reconstruct the mythical unicorn. Well known is the *Magdeburger Einhorn* (i. e., "Magdeburg Unicorn") or *Guericke-Einhorn* reconstruction undertaken in 1678 by the German inventor and scientist Otto von Guericke (**Fig. 1**), and among others mayor of the city of Magdeburg. Guericke's reconstruction got lost but fortunately, there are drawings of the creature he made: the oldest picture is published in 1714 by Valentini (see Oekentorp, 1994); well known is the drawing published by Leibniz (1749) (**Fig. 1: b**). These drawings form the base for 3D models of the *"Guericke-Einhorn"* (**Fig. 2**), for example the one that is on display in the *Museum für Naturkunde* (i. e., Natural History Museum) in Magdeburg (Germany) or the Otto von Guericke's unicorn skeleton, exhibited near the Zoo in Osnabrück (Germany).

The drawings, although not very detailed, show that Otto von Guericke made use of skeletal parts of recent as well as fossil animals for his reconstruction of the unicorn. The corn is most probably the "tusk" from a narwhale (*Monodon monoceros*), a medium-sized whale that lives in the Arctic waters around Greenland,

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.868.c11306

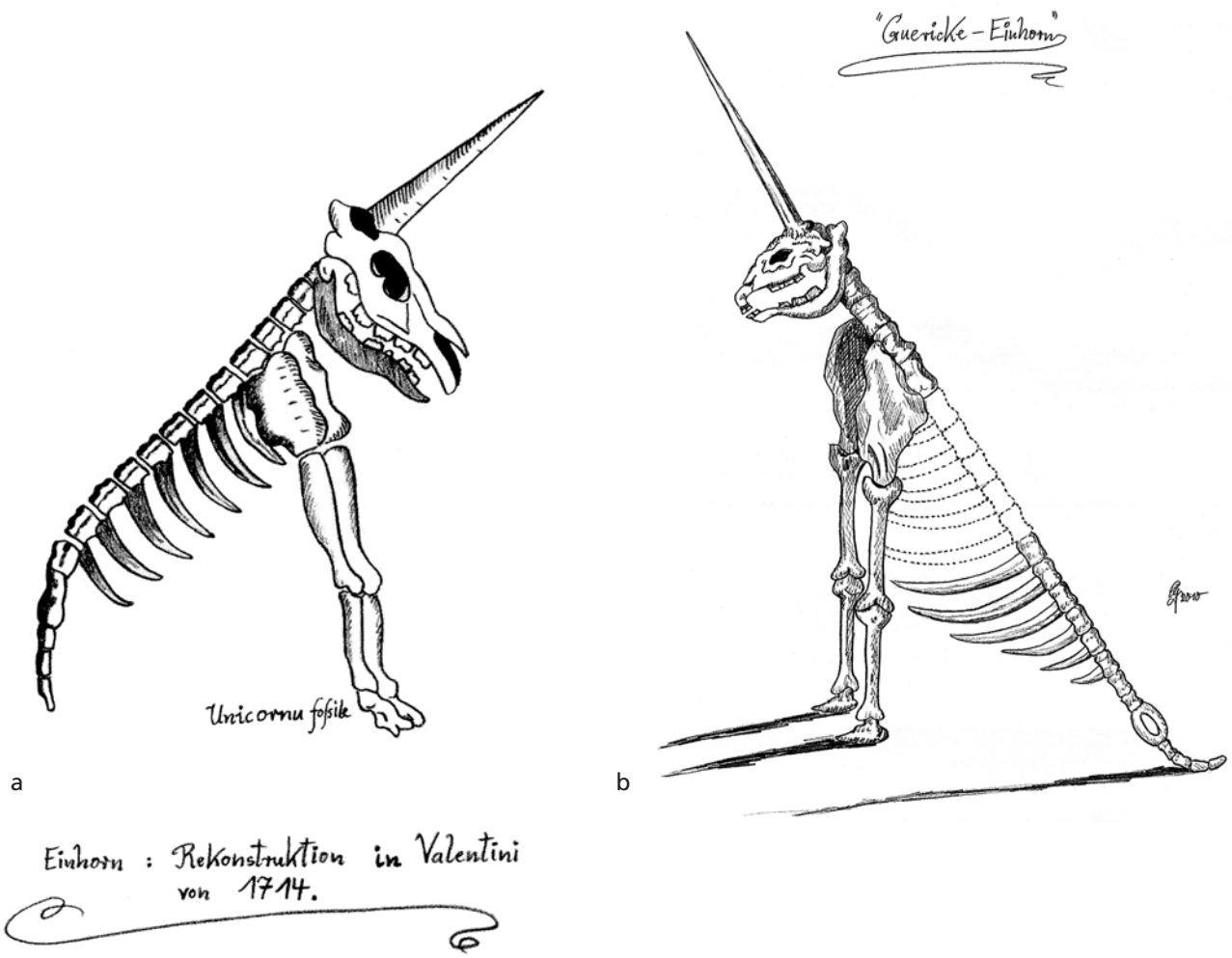

Fig. 1 Drawings of the *Guericke-Einhorn*. **a** after Valentini (1714) (redrawn by Elke Gröning after Oekentorp, 1994); **b** after Leibniz (1749) (redrawn by Elke Gröning). – (Drawings from Gröning and Brauckmann, 2011).

Canada, and Russia. The left upper canine of the narwhale males form a spirally twisted, long tusk with a length up to more than 3 m. The skull of the unicorn looks like a fossil skull of a Woolly rhinoceros and the shoulder blades and the bones of the two front legs are from the extinct Woolly mammoth. The original species of the other unicorn bones is/are unclear. The fossil material Otto von Guericke used for his reconstruction is Pleistocene in age and was collected at the locality Seweckenberge near Quedlinburg (Gröning and Brauckmann, 2011).

SEWECKENBERGE / SEWECKEN HILLS

The Seweckenberge (i. e., Sewecken Hills; 51° 47′ N; 11° 8′ E) are located in the eastern foreland of the Harz mountains ca. 4 km east-south-east of the city of Quedlinburg. The hills are a part of the Quedlinburg Anticline and are formed by the erosion-resistant beds of the mid-Triassic Muschelkalk series. The Middle Muschelkalk consists mainly of dolomitic marl and cellular limestone with embedded gypsum rocks formed by the evaporation of salt-water. Due to the weathering and dissolution of the Muschelkalk, karst



Fig. 2 3D model of the *Guericke-Einhorn* on display at the *Museum für Naturkunde* (Natural History Museum) in Magdeburg (Germany). – (Photo: Michael Buchwitz, *Museum für Naturkunde Magdeburg*).

phenomena such as sinkholes, pipes and dolines developed. These karst features formed traps where, in particular, Pleistocene animals accumulated. Quarries were made in the Muschelkalk layers to mine the valuable, extremely pure gypsum (Selenite) and in these quarries the dolines and other karst features, rich in Pleistocene fossils, got exposed. Flint artefacts and human remains indicate human presence at the site (Wüst, 1906).

Taxa	Common name	Taxonomic classification used by Nehring (1904)
AMPHIBIA		
Rana sp.	frog	*Rana* sp.
AVES		
Hirundo rustica	barn swallow	*Hirundo rustica* L. (*H. fossilis* Giebel)
Anser sp.	waterfowl	*Anser* sp.
Anas sp.	dabbling ducks	*Anas* sp. (*A. bochas* L.?)
Anas crecca	Eurasian teal	*Anas crecca* L.
Lagopus sp.	ptarmigan	*Lagopus* sp. (*Lagop. albus* Keys. U. Blas.?)
MAMMALIA		
Rodentia		
Hystrix sp.	porcupine	*Hystrix* sp. (*hisutirostris* Brdt?)
Spermophilus rufescens	russet ground squirrel	*Spermophilus rufescens* Keys. U. Blas.
Cricetus cricetus	hamster	*Cricetus vulgaris* Lesk
Dicrostonyx torquatus	Arctic lemming	*Myodus (Cuniculus) torquatus* Pall.
Lemmus lemmus	Norway lemming	*Myodes obensis* Pall. (*M. lemmus* Hensel)
Microtus gregalis	narrow-headed vole	*Arvicola (Microtus) gregalis* Pall.
Alactaga major	great jerboa	*Alactaga saliens fossilis* Nhrg.
Lagomorpha		
Ochotona sp.	pika	*Lagomys* sp. (*pusillus* Pall.?)
Lepus sp.	hare	*Lepus* sp. (*timidus* ant.?)
Carnivora		
Canis aureus	golden jackal	*Canis aureus* L. Var.
Vulpes lagopus	Arctic fox	*Canis (Vulpes) lagopus* L.
Vulpes vulpes	red fox	*Canis vulpes* L. *(Vulpes vulgaris)*
Mustela eversmanii	steppe polecat	*Foetorius Eversmanni* Lesson
Ursus sp.	bear	*Ursus* sp.
Crocuta crocuta spelaea	cave hyena	*Hyaena spelaea* Blumenb. *(H. crocuta foss.)*
Perissodactyla		
Coelodonta antiquitatis	woolly rhinoceros	*Rhinoceros tichorhinus* Cuv.
Equus sp.	horse	*Equus caballus ferus* Pall.
Artiodactyla		
Megaloceros giganteus	giant deer	*Cervus euryceros* Pohl.
Rangifer tarandus	reindeer	*Cervus tarandus* L.
Bison sp.	bison	*Bison* sp. (*priscus*?)

Tab. 1 Fauna list of the fossil vertebrate assemblage described by Nehring (1904) collected by Dr. Lampe (Quedlinburg) in 1903-1904 from a doline exposed in one of the quarries in the Sevecken Hills.



Fig. 3 The Seweckenberge rhinoceros skull fragment in the collection of the *Museum für Naturkunde und Vorgeschichte Dessau* (Museum of Natural History and Prehistory Dessau) in Dessau-Roßlau (MNVD-G 11.144). **a** occlusal view; **b** lingual view. – (Photo: Thijs van Kolfschoten).

THE SEWECKENBERGE PLEISTOCENE FOSSIL RECORD

The Pleistocene fossils Otto von Guericke used for his reconstruction, were found in 1663 (Gröning and Brauckmann, 2011). Carl-Andreas Bischof collected Pleistocene fossils in the period before 1863 (Ludwig, 2012) and part of his collection is nowadays stored in the *Museum fur Naturkunde und Vorgeschichte Dessau* (Museum of Natural History and Prehistory Dessau) in Dessau-Roßlau. Lampe (Quedlinburg) collected in 1903-1904 a large amount of Pleistocene vertebrate fossils from a doline exposed in one of the quarries in the Sewecken Hills; this collection is stored in the *Museum für Naturkunde* (Museum of Natural History) Berlin.
Alfred Nehring (1845-1904), a German zoologist and palaeontologist, published an extensive description of the Lampe collection (Nehring, 1904). Nehring identified 26 different species: amphibia, birds and small rodents as well as large mammals (**Tab. 1**). The fauna is diverse; rodents and carnivores are well represented with respectively seven and six species (Nehring, 1904). Remarkable is the absence in Nehring's list of the Woolly mammoth.
The Sewecken Hill fauna, listed by Nehring (1904) is dominated by smaller mammal species that inhabit a dry steppe environment. The occurrence of the Arctic lemming indicates rather cold climatic conditions. It is

a fauna that is characteristic for the Late Pleistocene Mammoth Steppe ecosystem (Markova and van Kolfschoten, 2008; Markova et al., 2019) and the small mammal assemblage shows similarities with for example the fauna from Villa Seckendorff at Stuttgart-Bad Cannstatt (von Koenigswald, 1985). H.-D. Kahlke (1975) mentions a fossil of a Saiga Antilope, *Saiga tartarica,* from the Sewecken Hills excavated in 1728. The find confirms the assumption that the Pleistocene fauna inhabited a steppe environment.
The Sewecken Hill Pleistocene fossils in the *Museum für Naturkunde und Vorgeschichte Dessau* in Dessau-Roßlau, collected by Carl-Andreas Bischof, is rather limited. It includes a mandible (MNVD-G 9237) and two vertebrae (MNVD-G 9203) of a hyena (*Crocuta crocuta spelaea*), a canine and a distal end of a femur (MNVD-G 9204) of a cave bear (*Ursus spelaeus*), a mandible fragment with a molar (MNVD-G 9235) of a bison (*Bison* sp.) and a mandible fragment and a molar (MNVD-G 9231) of a bovid (*Bos* sp.). A very special Sewecken Hill find in the Dessau collection, described in the paper, is a skull fragment (MNVD-G 11.144) of a juvenile rhinoceros obtained from Bischof in 1869.

THE RHINO SKULL FRAGMENT

The fossil remnant MNVD-G 11.144 consists of a fragmented part of the left side of a skull of a juvenile rhinoceros, embedded in fine grained sediment (**Fig. 3**). The specimen includes (fragments of) four dental elements: P2, DP3, DP4 and M1. The P2 is only represented by the anterior part of the ectoloph which shows a well-developed parastyle and a prominent paracone fold[1]. The parastyle is unworn and the upper part of the paracone fold is broken off. The DP3 is damaged; the outer side of the ectoloph as well as the inner side of the molar are (partly) missing. Hence, the possible occurrence of an internal cingulum is unknown. The DP3 shows a well-developed multiple crochet and a crista and a closed medifossette. The enamel is thin and the molar is only slightly worn. The DP4 is also damaged; the outer side of the ectoloph as well as the inner side of the molar are (partly) missing. The DP4 shows a well-developed single crochet and a crista and a closed medifossette. The enamel is thin and the molar is only slightly worn. The M1 is incomplete; only the anterior half of the ectoloph of the molar is clearly visible. It shows a well-developed parastyle and a prominent paracone fold. The molar is unerupted and hence, not worn.

SPECIES IDENTIFICATION

The morphology of the DP3 and DP4, and in particular the closed medifossette, indicate that the specimen should be attributed to the Woolly rhinoceros *(Coelodonta antiquitatis).* The medifossette of the upper milk molars of other possible Late Pleistocene species *Stephanorhinus kirchbergensis* and *Stephanorhinus hemitoechus* is open or very rarely closed whereas it is closed in the upper deciduous molars of *Coelodonta antiquitatis* (Guerin, 1980); a feature that is also visible in the Woolly rhinoceros deciduous upper molars from the Tomsk Priob'e area of southeast Western Siberia, published by Shpansky (2014).
Table 2 lists the dimensions of the Seweckenberge rhinoceros dental elements and **Table 3** shows that dimensions of the Seweckenberge rhinoceros milk molars are rather small compared to the size range of the *Coelodonta antiquitatis* milk molars from other European Pleistocene localities presented by Guerin (1980) (**Fig. 4**).

[1] The terminology used in the description is based on Guerin (1980) and Lacombat (2006).

THE INDIVIDUAL AGE

The most complete molars of the specimen are small in size, low crowned and the enamel is thin; features that indicate that we are dealing with deciduous/milk molars. Hillman-Smith et al. (1986) published age estimation criteria for the southern White rhinoceros (*Ceratotherium simum simum*) and defined for the molars ten different tooth eruption and wear stages as well as XVI different age classes. Assuming that the eruption sequence and the wear pattern of the White rhinoceros and the extinct Woolly rhinoceros are comparable, the Seweckenberge juvenile rhino skull fragment would fall at the transition of the age classes IV to V, indicating an age at death of ca. 1.5 years.

DISCUSSION AND CONCLUSION

The occurrence of a specimen of a Woolly rhinoceros in the Seweckenberge fossil assemblage is not new. Nehring (1904) mentions the presence of two individuals: three upper milk molars of a single young individual and limb bones of an older rhino. The fauna composition of the assemblage indicates a so-called Mammoth Steppe environment; conditions that were common in Central Europe during most of the Middle and Late Pleistocene. The Woolly rhinoceros, *Coelodonta antiquitatis*, is part of the Mammoth Steppe fauna association in Central Europe since the Elsterian (Marine Isotope Stage 12) when it immigrated from the east (Kahlke and Lacombat, 2008); the species occurred in Central Europe, with some interruptions, until ca. 11 ka BP (Stuart and Lister, 2012; Markova et al., 2013). The Woolly rhinoceros is rather common in the Middle and Late Pleistocene fossil record of Europe.

	P2	DP3	DP4	M1
lenght		30.5	43	
width		29.5	38	
height	31.5	26		44

Tab. 2 Dimensions (mm) of the dental elements of the Seweckenberge rhinoceros. Because of the poor preservation, most of the measurements are estimations.

	Seweckenberge	*Coelodonta antiquitatis*			
		N	min.	max.	mean
DP3					
lenght	30.5	27	31	45.5	41.96
width	29.5	28	31.5	42	37.11
height	26	7	25	33.5	29.79
DP4					
lenght	43	20	44	57	48.60
width	38	23	39	55	43.35
height		7	33.5	46	40.00

Tab. 3 The dimensions (mm) of the Seweckenberge rhinoceros milk molars compared to the size range of *Coelodonta antiquitatis* milk molars from other European Pleistocene localities presented by Guerin (1980).



Fig. 4 The Woolly rhinoceros *Coelodonta antiquitatis*. – (Drawing: Elke Gröning).

Due to the incomplete and poor conservation of the finds, it is unfortunately not possible to establish the cause of death of the young rhinoceros described in this paper. The flint artefacts and the human remains, found at the site (according to Wüst, 1906) might suggest the possibility that humans might have killed the animal. The fossil record of the localities Biache-Saint-Vaast (France) and Taubach (Germany) indicate the hunting/butchering of the two different rhinoceros species *Stephanorhinus kirchbergensis* and *Stephanorhinus hemitoechus* (Dusseldorp, 2009), the evidence of hominin/human hunting of the Woolly rhinoceros is, however, very limited or absent. The Middle Palaeolithic site Lingjing (Xuchang, Henan, China), yielded a large amount of (stone) artefacts as well as butchered larger mammal remains (van Kolfschoten et al., 2020). A large bovid (*Bos primigenius*) and an equid (*Equus przewalskii*) dominate the faunal assemblage. The age profile of both taxa shows the dominance of prime adults which suggests that both taxa were hunted by humans. The Lingjing fossils record also includes a large number of fossil Woolly rhinoceros remains of at least nine different individuals; the majority is juvenile. The difference in age profile, combined with the absence of butchering marks on the rhinoceros bones, suggests that the Woolly rhinoceros has not been hunted/killed by humans. They died, most probably, a natural death. And we assume that this is also the case with the juvenile rhinoceros from Seweckenberge.

The Seweckenberge rhinoceros is another confirmation of the occurrence of the Woolly rhinoceros in Central Europe during the Middle and Late Pleistocene. The rhinoceros skull fragment in the Dessau collection is, however, special because of its indirect link with the *Magdeburger Einhorn* or *Guericke-Einhorn*.

Acknowledgements

The authors would like to thank Oliver Hampe (*Museum für Naturkunde Berlin*) for tracing the Nehring collection in the museum archives in Berlin. We also thank Dr. Michael Buchwitz (*Museum für Naturkunde Magdeburg*) for providing us with the picture of the 3D model on display at the *Museum für Naturkunde Magdeburg* (Germany).

This paper is dedicated to Elaine Turner and Martin Street (RGZM, MONREPOS, Neuwied) to acknowledge their important contribution to the study of Quaternary mammals in Central Europe as well as in northern Africa and to honour their retirement.

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DANCING WITH WOLVES AT SCHÖNINGEN 13II-4

Abstract

The Schöningen 13II-4 site has produced a wealth of insight into the hunting and butchery activities of Middle Pleistocene hominins, highlighted by the famous Schöningen spears preserved with hundreds of cut-marked and broken horse bones. The bones of carnivores are rare at the site, but tooth pits, scores, and other markings that record their presence are abundant. Here we describe the carnivore remains from Schöningen 13II-4 and provide a detailed analysis of carnivore markings on different skeletal parts in the faunal assemblage and their spatial distribution. In studying carnivore activities at Schöningen, we aim to achieve a more comprehensive view of site taphonomy and, in turn, a better appreciation of the anthropogenic process that shaped the archaeological record. The placement and sequence of carnivore marks on the bones in relation to butchery marks indicates that carnivores scavenged from the remains of hominin kills. In the large horse bone assemblage, carnivore damage is more prevalent on limb bones of juveniles than adults. This pattern reveals that adult horse carcasses were fully butchered by hominins, but juvenile horse carcasses were abandoned earlier in the butchery process, leaving more consumable tissues that attracted scavenging carnivores. Tooth pits and scores on the Schöningen remains are very large and compare well with markings produced by wolves, especially those observed in a sample of modern wolf-gnawed bones we collected and analysed from *Adler- und Wolfspark* Kasteelburg. Clusters of carnivore-damaged bones appear around the periphery of dense concentrations of bones butchered by hominins, suggesting that wolves displaced some skeletal elements quickly after abandonment by hominins. Such a spatial pattern hints at the long-standing co-habitation of the Schöningen landscape by hominins and wolves during the Middle Pleistocene.

Keywords

Zooarchaeology, taphonomy, Middle Pleistocene, carnivores, wolf, cave lion

INTRODUCTION

The relationship between humans and carnivores is considered a major driving force in human evolution (Domínguez-Rodrigo, 2001). Hominin subsistence strategies increasingly focused on meat-eating have coincided with a reduced species richness in the African carnivore guild over the last two million years (Werdelin and Lewis, 2013), and it has been postulated that changes in the carnivore guild enabled early hominin dispersal into Eurasia (Lewis, 2017). Throughout the Middle and Upper Pleistocene, hominins and carnivores competed for similar resources, evidenced by the often alternating occupations of caves by either hominins or carnivores in archaeological contexts. Carnivores influenced the formation of many Pleistocene archaeological sites, either by contributing directly to the accumulation of faunal assemblages (Blumenschine, 1986; Bunn, 1989; Blumenschine and Selvaggio, 1991; Selvaggio, 1994; Stiner, 1994; Capaldo, 1995; Rosell and Blasco, 2009) or by scavenging the remains left behind by Palaeolithic hunters (Rosell and Blasco, 2009; Rosell et al., 2012). Humans were killed by large predators (Morel, 1998; Camarós et al., 2016; Daujeard et al., 2016), and sometimes their corpses were scavenged by carnivores (Stiner, 1991). On the other hand, carnivores were regularly hunted and exploited by humans (Kindler, 2012; Romandini et al., 2018; Cueto et al., 2020), for their fur (Auguste, 1995; Charles, 1997; Cueto et al., 2016), for their teeth to

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.868.c11307

use as personal ornaments (Wojtal et al., 2020), for bait (Street and Turner, 2013), or to domesticate them (Street et al., 1989; Chaix et al., 1997; Street et al., 2015). Consequently, an understanding of the evolving relationship between humans and carnivores helps to define the human niche and to evaluate the circumstances under which hominins proactively influenced and altered their position in the food web throughout the Pleistocene.

Especially for Middle Pleistocene contexts, accounting for the role carnivores played in the formation and preservation of archaeological sites can provide for a more holistic view of Palaeolithic hunter-gatherer subsistence strategies (Blasco and Rosell, 2009; Gaudzinski-Windheuser and Niven, 2009; Starkovich and Conard, 2020). In this context, it is of particular interest to interrogate key archaeological sites with outstanding preservation and in undisturbed contexts, such as the site of Schöningen 13II-4. The open-air, lakeshore site of Schöningen 13II-4, most famous for the wooden spears and butchered horses, also preserved the remains of several large carnivores and a significant number of ungulate bones showing traces of carnivore activity, such as tooth pits and other damage from gnawing (Thieme, 2005; Voormolen, 2008; van Kolfschoten, 2014; van Kolfschoten et al., 2015; Hutson et al., 2020). Schöningen 13II-4 has provided a wealth of information about Middle Pleistocene hominin lifeways and likewise has great potential to inform on the position of hominins within the carnivore community during the European Middle Pleistocene.

Here we present an analysis of the carnivore remains and other evidence for carnivore activity from Schöningen 13II-4. We contextualize our zooarchaeological and taphonomic analyses within the wider European Middle Pleistocene carnivore community in order to formulate a potential cast of carnivore actors present



Fig. 1 Map of Germany showing the location of Schöningen and other sites mentioned in the text with carnivore faunal remains.

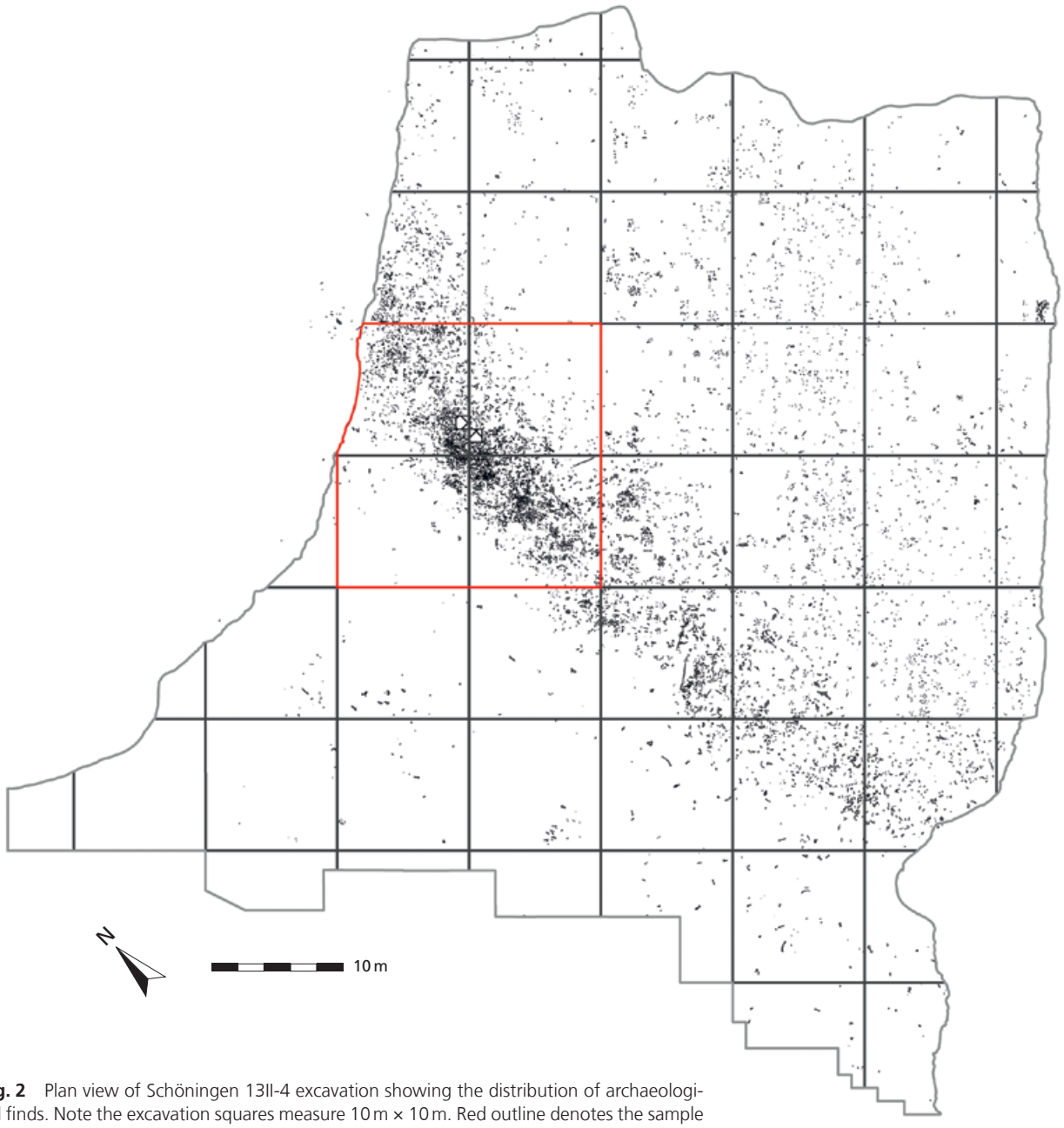


Fig. 2 Plan view of Schöningen 13II-4 excavation showing the distribution of archaeological finds. Note the excavation squares measure 10 m × 10 m. Red outline denotes the sample area for all measured carnivore tooth pits, punctures, and scores.

on the Schöningen landscape. Actualistic studies, in addition to a thorough review of known patterns of carnivore damage to ungulate bones, were employed to further identify the carnivore species involved in modifying the Schöningen faunal assemblage. Lastly, we introduce an in-depth spatial analysis to better understand the taphonomic history of the Schöningen deposit and temporal relationships between hominins and carnivores at the site. Altogether, our aim is to detail the role of carnivores in the formation of this important archaeological site, and more broadly, bring into focus the relationship between hominins and carnivores during the Middle Pleistocene.



Fig. 3 (Top) Wolf in one of the large wooded enclosures at the *Adler- und Wolfspark* Kasteelburg. (Bottom, left to right) *Bos taurus* radius, femur, and tibia gnawed by wolves from Wolfspark Kasteelburg.

SITE BACKGROUND

Open-cast mining activity near the town of Schöningen (Lower Saxony, Germany; **Fig. 1**) led to the discovery of a series of archaeological sites contained within a sequence of erosional 'channels' dating from the Middle Pleistocene (Serangeli et al., 2012). These 'channels' indicate the presence of a large paleo-lake. The site named Schöningen 13II-4 (site 13, channel II, level 4) became known worldwide in the 1990s as the 'Spear Horizon', due to the extraordinary discovery of several wooden spears (Thieme, 1997, 2007; Schoch et al., 2015) alongside an archaeological assemblage of around 15,000 faunal remains, 1,500 lithics, and a significant number of wooden and other macro-botanical remains (Serangeli and Böhner, 2012). Excavations by Hartmut Thieme from 1995 to 2008 extended over an area of 3,900 m^2. The exceptionally preserved faunal assemblage, mainly composed of horse bones, was originally interpreted as the remains of a mass-kill hunting event near the lakeshore and dated to around 400 ka (Thieme, 2005). However, both the interpretation and chronology of the site were challenged by later studies, which demonstrated that the site formed through the accumulation of several hunting events (Voormolen, 2008; van Kolfschoten, 2014; Julien et al., 2015b; van Kolfschoten et al., 2015; Hutson et al., 2020) during Marine Isotope Stage 9 (MIS 9; Richter and Krbetschek, 2015) or a later interglacial period.

Multiple geological and paleoenvironmental records (Lang et al., 2012, 2015; Stahlschmidt et al., 2015; Peters and van Kolfschoten, 2020; García-Moreno et al., 2021) indicate the Schöningen 13II-4 site formed in a delta lacustrine environment straddling the dryland, shoreline, and shallow water zones of the Schöningen paleo-lake. The lake was surrounded by a mosaic landscape, with aquatic plants at the lake margins surrounded by grassland and open forest (Urban and Bigga, 2015; Bigga, 2018). The 'Spear Horizon' was embedded in the uppermost 30-40 cm of the sedimentary sequence of Level 4. Most of the archaeological remains appeared in sublayer 4b, a dark brown laminated organic silt layer. Actualistic experiments revealed that black staining on many of the faunal remains was caused by decaying plant in waterlogged sediments (Turner et al., 2018). Consequently, the Schöningen 13II-4 site likely formed in the shallow waters of the lakeshore and nearby swampy areas. Roughly two-thirds of the archaeological assemblage is distributed along a 10 m wide by 60 m long strip extending north-to-south across the site (**Fig. 2**). This concentration is interpreted as a close approximation of the shoreline during major episodes of hominin activity (Böhner et al., 2015; García-Moreno et al., 2021), with permanently dry land to the west and the deeper portion of the lake basin to the east. Faunal remains are significantly more scattered throughout the eastern portion of the site, which may correspond to deposition during periods when the lake level was lower (Turner et al., 2018; García-Moreno et al., 2021). Based on sediment micromorphology, orientation of archaeological finds, and other taphonomic indicators, there is no evidence of significant post-depositional alterations of the assemblage (Böhner et al., 2015; Stahlschmidt et al., 2015; Turner et al., 2018; Hutson et al., 2020; Peters and van Kolfschoten, 2020; García-Moreno et al., 2021).

The Schöningen 13II-4 faunal assemblage consists of roughly 15,000 remains, nearly all of which is derived from the 'Spear Horizon' (García-Moreno et al., 2021). Horse (*Equus mosbachensis*) is overwhelmingly abundant, represented by 9,018 identifiable specimens (NISP – number of identified specimens). Red deer (*Cervus elaphus*) is the next most abundant taxon, yet only numbers 358 NISP. Two bovid species, the steppe bison (*Bison priscus*) and aurochs (*Bos primigenius*), are represented by a combined 289 NISP. Other ungulate species are present at Schöningen 13II-4 in low numbers, including the European wild ass (*Equus hydruntinus*), roe deer (*Capreolus capreolus*), giant deer (*Megaloceros giganteus*), straight-tusked elephant (*Palaeoloxodon antiquus*), and two rhinoceros species (Welker et al., 2017): narrow-nosed rhinoceros (*Stephanorhinus hemitoechus*) and Merck's rhinoceros (*Stephanorhinus kirchbergensis*). Other small mammals, birds, fish, and amphibians are present in the Schöningen 13II-4 faunal assemblage (Voormolen,

2008; Böhme, 2015; van Kolfschoten et al., 2015; Hutson et al., 2020; García-Moreno et al., 2021). The various carnivores and traces left by carnivores on the ungulate bones are reported in detail here.

MATERIALS AND METHODS

This account of the Schöningen carnivores constitutes part of an ongoing analysis of the complete faunal assemblage from the Schöningen 13II-4 deposit. A full account of our zooarchaeological and taphonomic methodology is provided in Hutson et al. (2020). Taxonomic identifications were made using the comparative collection housed at the MONREPOS Archaeological Research Centre and Museum for Human Behavioural Evolution. Identifications were made at the species level when possible, otherwise minimally identifiable specimens were categorized by size (e.g., red deer-sized, horse-sized, bison/aurochs-sized). Standardized anatomical measurements of individual carnivore skeletal parts were taken with digital callipers following von den Driesch (1978). Taxonomic and skeletal part abundances herein are based on number of identified specimens (NISP).

Taxon	ID #	Bone	Side	Portion
Canis lupus, Wolf	18835	Radius	Left	Complete
NISP = 7	11711	Innominate	Right	Incomplete
	20637	Innominate	Right	Ilium + acetabulum
	3781	Femur	Right	Shaft
	21099	Femur	Left	Proximal
	20330.1	Tibia	Left	Shaft
	15693	Lumbar vertebra	-	Dorsal
Vulpes vulpes, Red fox	11600	Maxilla (C, P1, P3, P4)	Left	Incomplete
NISP = 3	19099.1	Rib	Indet.	Shaft
	21098	Tibia	Left	Distal + shaft
Meles meles, European badger	11929	Ulna	Left	Complete
NISP = 5	15697	Cervical vertebra	-	Cranial
	15711	Rib	Indet.	Shaft
	19023	Ulna	Right	Proximal
	19574	Innominate	Left	Acetabulum
Mustela sp., Weasel	2243	Innominate	Right	Ischium + acetabulum
NISP = 5	2463	Caudal vertebra	-	Complete
	2463.1	Limb	Indet.	Shaft
	10190.2	Phalange	Indet.	Complete
	21162.7	Metapodial	Indet.	Complete
cf. *Panthera leo spelaea*, Cave lion	11440	Thoracic vertebra	-	Incomplete
NISP = 1				
Carnivora indet., Large carnivore	1279	Rib	Indet.	Shaft
NISP = 4	2834	Rib	Indet.	Shaft
	4159.3	Rib	Indet.	Shaft
	19691.1	Coprolite	-	Fragment

Tab. 1 Schöningen 13II-4 carnivore species list and description of skeletal remains.

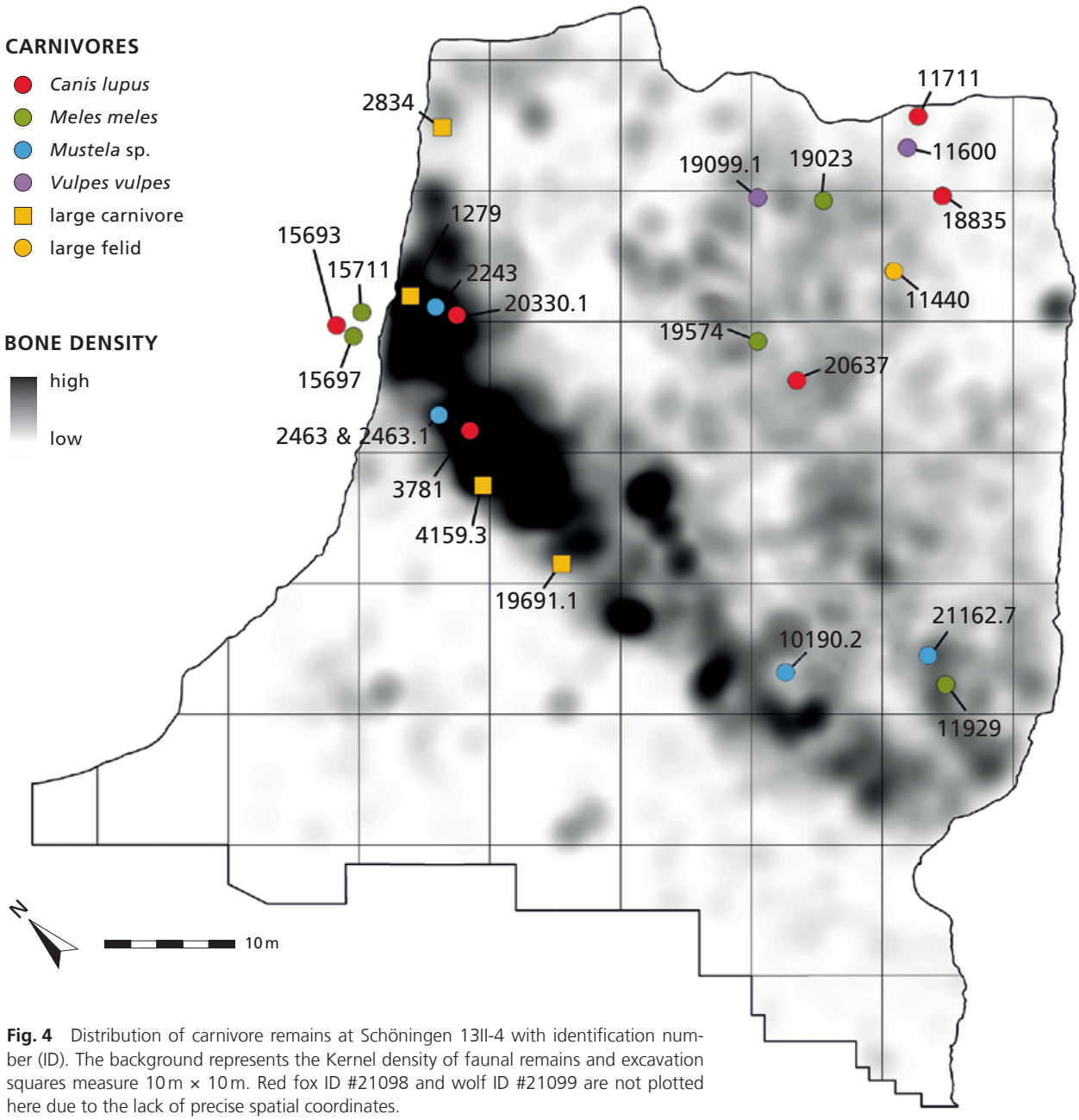


Fig. 4 Distribution of carnivore remains at Schöningen 13II-4 with identification number (ID). The background represents the Kernel density of faunal remains and excavation squares measure 10 m × 10 m. Red fox ID #21098 and wolf ID #21099 are not plotted here due to the lack of precise spatial coordinates.

All bones were examined under magnification with a 10x hand lens or 20-40x digital microscope for surface modifications. Of primary interest here is damage produced by carnivore teeth during feeding, and identifications of all carnivore traces, notably tooth pits, punctures, and scores, were based on descriptions and images provided by various taphonomic manuals (e. g., Lyman, 1994; Fisher, 1995; Fernández-Jalvo and Andrews, 2016; Gifford-Gonzalez, 2018), and specifically outlined in Lehnig et al. (2021). Importantly, pits were distinguished from punctures in that punctures penetrate the cortical surface, whereas pits do not; pits were distinguished from scores in that score length is greater than or equal to three times the breadth, whereas pit length is less than three times the breadth. The locations of carnivore modifications (also hominin butchery marks) were marked in digital templates of individual skeletal elements and compiled using a GIS approach (García-Moreno et al., 2015). Length and breadth measurements of pits, punctures, and

Site	Location	Age	Species	Radius	Femur		Reference
				Greatest length (GL)	Greatest breadth of proximal end (Bp)	Greatest depth of caput femoris (DC)	
Unter-maßfeld	Germany	~ 1 Ma	*Canis mosbachensis*	163.0-169.0 n = 4	34.7-39.5 n = 7		Sotnikova, 2001
Escale	France	800-700 ka	*Canis mosbachensis*	151.5-174.6 n = 20	32.4-41.0 n = 14	16.0-19.0 n = 14	Boudadi-Maligne, 2011
Igue des Rameaux	France	MIS 11/10	*Canis lupus*	155.4-174.6 n = 7	39.1-47.0 n = 9	17.9-23.0 n = 14	Boudadi-Maligne, 2011
Lunel Viel I	France	~ 400-350 ka	*Canis lupus*	171.0 n = 1			Boudadi-Maligne, 2011
Schöningen	**Germany**	**MIS 9**	***Canis lupus***	**190.9 n = 1**	**47.0 n = 1**	**21.3 n = 1**	**present study**
Coudou-lous I	France	MIS 7	*Canis lupus*	178.9 n = 1	44.0 n = 1	20.4-20.7 n = 3	Boudadi-Maligne, 2011
Malarnaud	France	MIS 5	*Canis lupus*	190.0-213.0 n = 3	46.0-53.5 n = 4	24.0-25.0 n = 4	Dufour, 1989
Aven de l'Arquet	France	MIS 3 (40 ka)	*Canis lupus*	183.3-207.9 n = 4	47.0-53.5 n = 5	23.0-26.2 n = 8	Boudadi-Maligne, 2011
Jaurens	France	MIS 3 (30 ka)	*Canis lupus*	217.3-218.8 n = 2	58.1 n = 1	27.2-27.2 n = 2	Boudadi-Maligne, 2011
Maldidier	France	MIS 3 (30 ka)	*Canis lupus*	212.6-222.6 n = 3			Boudadi-Maligne, 2011

Tab. 2 Anatomical comparison between wolf remains from Schöningen 13II-4 and other Pleistocene sites. All measurements (in mm) follow von den Driesch (1978).

scores from a sample of the Schöningen material were taken with digital callipers directly on the marks following Andrés et al. (2012).

The measured sample is drawn from the area of the site with the densest concentration of faunal remains, covering roughly 40 m^2 at the northern end of the main accumulation (see **Fig. 2**). The sample area includes a total 5,391 faunal remains (37.2 % of the overall assemblage); 71 limb bones and limb bone fragments of horse, red deer, and bison/aurochs from this sample preserved evidence of carnivore damage, and we measured 186 tooth pits and 179 tooth scores from the Schöningen sample.

Measurements of carnivore tooth pits and scores have been used with varying success to identify the species responsible for modifying faunal assemblages, and measurements of pits and scores on a sample of the Schöningen material were compared to similar marks on bones fed on by a number of carnivore species during actualistic or experimental studies, including wolf (*Canis lupus*), dog (*Canis familiaris*), coyote (*Canis latrans*), black-backed jackal (*Canis mesomelas*), red fox (*Vulpes vulpes*), brown bear (*Ursus arctos*), spotted hyena (*Crocuta Crocuta*), African lion (*Panthera leo*), mountain lion (*Felis concolor*), and bobcat (*Lynx rufus*) (see Domínguez-Rodrigo and Piqueras, 2003; Campmans and Beauval, 2008; Delaney-Rivera et al., 2009; Andrés et al., 2012; Sala, 2012; Saladié et al., 2013; Sala et al., 2014; Young et al., 2015; Yravedra et al., 2019). Individually, these published studies encompass a range of experimental methodologies, involving wild, captive, and domesticated animals feeding on large and small ungulate bones. Furthermore, most of



Fig. 5 Cranial view of a wolf (*Canis lupus*) left radius (ID #18835) from Schöningen 13II-4.



Fig. 6 Cranial view of an incomplete large felid (cf. *Panthera leo spelaea*, cave lion) thoracic vertebra (ID #11440) from Schöningen 13II-4.



Fig. 7 Horse (*Equus mosbachensis*) right innominate (ID #7191) gnawed by carnivore. Note the scalloped edge and multiple tooth punctures.

these studies differentiated between marks located on limb bone mid-shafts (diaphyses), near-epiphyses (metaphyses), and ends (epiphyses) because the dimensions of carnivore tooth pits and scores could be affected by bone density, i. e., carnivores impart longer and broader pits and scores on the less dense epiphysis portions of long bones. These divisions result in small sample sizes for some carnivore species. To increase sample sizes, we pooled all studies together by species using published data on mean, standard deviation, and individual sample size of the length and breadth measurements of tooth pits and scores, with no regard to the location of the marks (i. e., diaphysis, metaphysis, epiphysis). Punctures were also included with the measurements of pits. This greatly increased the sample sizes for nearly all species involved for comparison against the sample of pits and scores from the Schöningen assemblage.

To this, we add our own collection of wolf-modified bones gathered from *Adler- und Wolfspark* Kasteelburg (Germany; **Fig. 3**). *Adler- und Wolfspark* Kasteelburg hosts semi-wild 'arctic' and 'timber' wolves in two separate forested enclosures covering 20 ha. The pack of 'timber' wolves is fed portions of animal carcasses on a regular schedule and the discarded bones are generally left within the enclosure after feeding, perhaps for a period of up to several years. During a walking survey of the 'timber' wolf enclosure in June 2014, we gathered 167 bones (scapula, humerus, radius, ulna, femur, tibia, and metapodials), mostly from cow (*Bos taurus*), horse (*Equus caballus*), and sheep (*Ovis aries*), the occasional roe deer (*Capreolus capreolus*) and

wild boar (*Sus scrofa*), and possibly red deer (*Cervus elaphus*). All bones were well-preserved and unweathered when recovered owing to the protective cover of the forested environment. In total, we identified and measured 249 pits (including punctures) and 1,067 scores from the *Adler- und Wolfspark* collection, which is currently housed at the MONREPOS Archaeological Research Centre and Museum for Human Behavioural Evolution and available for study.

Differences in length and breadth measurements of pits and scores between the pooled carnivore samples and the Schöningen sample were calculated using independent t-tests.

As the foundation for spatial analysis, all faunal remains were plotted according to their three-dimensional coordinates based on the local reference system of the excavation grid. Of particular relevance here are the precise locations of carnivore remains and other faunal remains modified by carnivores and hominins. In cases where precise coordinates were not recorded during field excavations, artificial coordinates were given to those finds using the central point of the corresponding 1 × 1 m². Once plotted, the mean, minimum, and maximum distance between carnivore remains was calculated. In order to visualize the spatial patterning of the remains showing butchery traces and carnivore damage, Kernel density estimates were analysed. Based on this, areas showing densities of butchered bones higher than the mean density were defined; likewise, areas with densities of bones affected by carnivores higher than the mean were defined. Superimposing the high-density butchery areas with the high-density carnivore areas allows for the identification of zones where hominin and carnivore activities are spatially exclusive and where those activities overlap.

The distribution of butchered and carnivore-damaged bones is, in part, influenced by the overall spatial patterning of faunal remains across the site. Here we define and calculate a Carnivore/Butchery Index (CBI) to evaluate whether bones showing butchery marks or carnivore damage were more abundant per area unit. First, we used the Quadrat method to estimate the cell size of a regular grid that best fits the dimensions of the site and number of finds (Getis, 1964; Sánchez Romero, 2019). Based on that, we created an 'improved'



Fig. 8 Horse (*Equus mosbachensis*) left rib (ID #5534) gnawed by carnivore. Note the scalloped margin and tooth score at the distal end.



Fig. 9 Horse (*Equus mosbachensis*) right ulna (ID #1374) gnawed by carnivore. Note the scalloped edge on the proximal end.



Fig. 10 Subadult horse (*Equus mosbachensis*) left humerus (ID #5484) gnawed by carnivore. Proximal and distal ends have been completely gnawed, leaving bone cylinder.

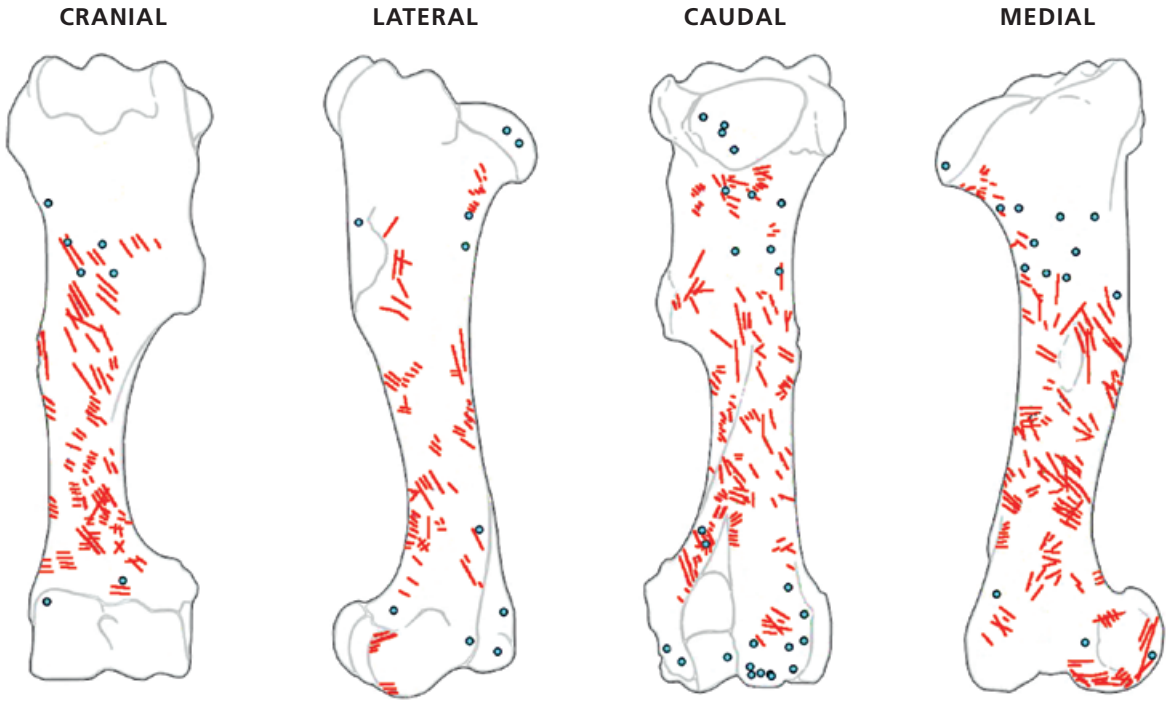


Fig. 11 Composite drawing of cut-mark (red lines) and carnivore tooth mark (cyan circles) locations on all identifiable adult horse (*Equus mosbachensis*) left humeri.

grid for the site and calculated the number of faunal remains showing butchery marks and carnivore damage appearing within each cell. In calculating the CBI, butchery marks include cut-marks, scraping marks, and impact marks; carnivore damage is wide-ranging, and includes all tooth pits, punctures, scores, furrowing, and other damage typical of carnivore feeding. These counts represent only the total number of bones with each modification and do not account for intensity of modification. Finally, the CBI was calculated for each cell of the grid: Carnivore/Butchery Index (CBI) = $(b_1 / [b_1 + c_1]) - (c_1 / [b_1 + c_1])$
where b_1 is the number of bones showing butchery marks in cell 1 and c_1 is the number of bones with carnivore damage in cell 1. Bones that included butchery marks and carnivore damage were counted once in each category. The resulting CBI ranged from 1 to -1, wherein a value of 1 indicates 100 % of the modified bones show traces of butchery and a value of -1 indicates 100 % of the modified bones show traces of carnivore damage.

RESULTS

Carnivore remains from Schöningen 13II-4

Overall, carnivore remains are rare in the Schöningen 13II-4 deposit, totalling only 25 specimens from five taxa (**Tab. 1**; **Fig. 4**), including wolf (*Canis lupus*), red fox (*Vulpes vulpes*), a large felid, possibly cave lion (cf. *Panthera leo spelaea*), badger (*Meles meles*), and a small weasel (*Mustela* sp.). Some of these specimens were originally reported by van Kolfschoten (2003, 2012, 2014; van Kolfschoten et al., 2015). Four additional remains could only be identified to large carnivore, approximately wolf-sized or larger.

Skeletal Part	Horse			Red deer			Bison/Aurochs		
	NISP	Cut	Carn	NISP	Cut	Carn	NISP	Cut	Carn
Tooth	933	-	-	59	-	-	17	-	-
Cranium	251	10	6	91	0	0	23	1	0
Hyoid	72	0	4	1	0	0	0	0	0
Mandible	487	72	12	9	0	0	13	6	0
Cervical	499	17	4	12	0	1	7	2	0
Thoracic	1,017	38	63	8	2	1	14	1	1
Rib	2,145	186	229	20	5	7	45	2	2
Sternum	3	0	0	0	0	0	0	0	0
Lumbar	317	10	11	9	0	1	4	0	0
Sacrum	66	2	3	1	0	1	3	0	0
Caudal	20	0	1	0	0	0	0	0	0
Scapula	152	8	16	8	0	2	1	0	0
Humerus	301	120	40	12	1	1	12	5	1
Radius	361	125	13	11	2	1	7	2	1
Ulna	96	16	21	7	0	1	11	0	2
Carpals	135	0	3	11	0	0	13	0	0
Metacarpal	137	27	8	13	3	1	9	2	0
Acc. metacarpal	63	3	4	-	-	-	-	-	-
Pelvis	205	28	26	12	0	4	2	0	0
Femur	351	122	30	5	1	2	20	8	1
Patella	25	0	3	2	0	1	1	0	0
Tibia	358	116	21	13	2	4	15	5	1
Fibula	7	0	0	2	0	0	4	0	0
Tarsals	173	7	15	8	1	0	18	0	0
Metatarsal	129	40	5	17	4	1	14	8	4
Acc. metatarsal	70	13	2	-	-	-	-	-	-
1st phalange	74	1	9	5	0	0	11	0	1
2nd phalange	66	0	3	6	0	0	7	0	0
3rd phalange	54	0	0	4	0	0	4	0	0
Sesamoid	81	0	0	8	0	0	13	0	0
Total	**8,648**	**961**	**552**	**354**	**21**	**29**	**288**	**42**	**14**
% NISP modified		**12.46**	**7.15**		**9.86**	**13.62**		**16.15**	**5.38**

Tab. 3 Skeletal part representation for horse (*Equus mosbachensis*), red deer (*Cervus elaphus*), and combined bison and aurochs (*Bison/Bos*) sample from Schöningen 13II-4 measured by number of identified specimens (NISP). Frequency of cut-marks (Cut) and carnivore marks (Carn) per skeletal element are tabulated by NISP and % NISP (excluding teeth).

	Horse		Red deer		Bison/Aurochs	
	Carnivore	Cut	Carnivore	Cut	Carnivore	Cut
Axial skeleton	333	335	11	7	3	12
Adult	298	291	10	6	3	10
Subadult	35	44	1	1	0	2
Appendicular skeleton	219	626	18	14	11	30
Adult	152	590	17	13	9	30
Subadult	67	36	1	1	2	0

Tab. 4 Frequency (NISP) of carnivore tooth marks and cut-marks on the axial and appendicular skeletons of the three primary ungulate taxa at Schöningen 13II-4. Data for adults and subadults are also presented individually. Some specimens may include carnivore tooth marks and cut-marks.

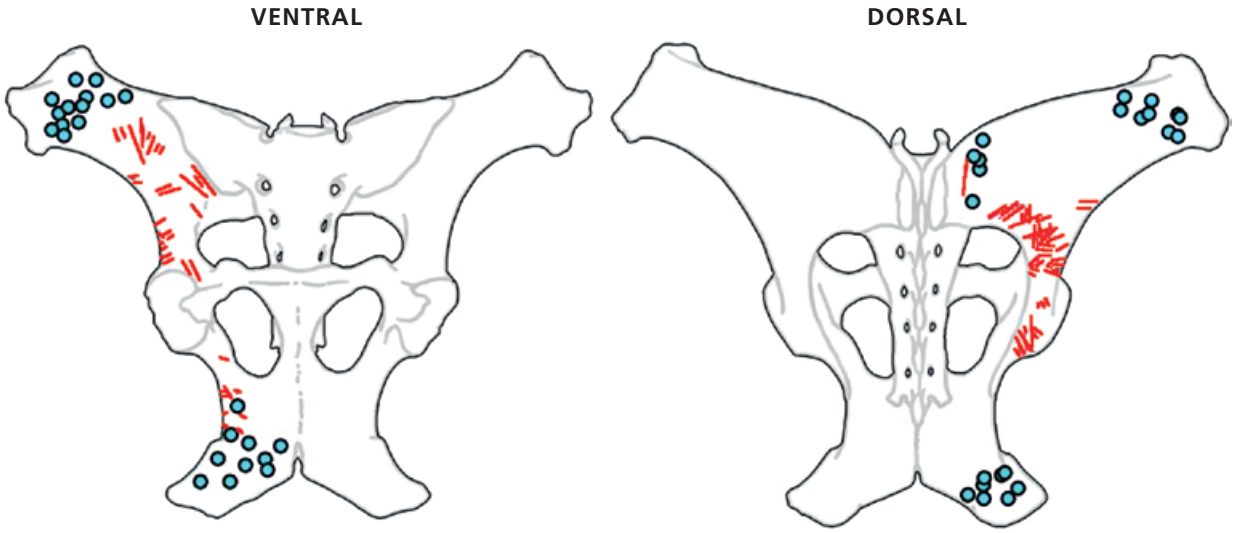


Fig. 12 Composite drawing of cut-mark (red lines) and carnivore tooth mark (cyan circles) locations on all identifiable adult horse (*Equus mosbachensis*) right innominates.

Wolf remains are the most numerous, with seven post-cranial elements (see **Tab. 1**). A minimum of two individuals is indicated by the presence of two innominates (one nearly-complete, one ilium fragment) from the right side. Based on a limited set of anatomical measurements, the Schöningen wolves appear to be of intermediate size for Pleistocene canids (**Tab. 2**). There is a well-established size gradient within the *Canis* genus in Western Europe, with increasing body size through time (Bonifay, 1971; Boudadi-Maligne, 2011; Brugal and Boudadi-Maligne, 2011). The complete radius (ID 18835; **Fig. 5**) from Schöningen is significantly longer than any example of *Canis mosbachensis* individuals from late Lower to early Middle Pleistocene sites in Germany and France. The size of the Schöningen radius closely approximates the range of *Canis lupus* remains from late Middle Pleistocene and some Upper Pleistocene contexts in France, and is substantially shorter than any more recent Upper Pleistocene individuals. The proximal femur (ID 21099) from Schöningen is also positioned in precisely the same position along the *Canis* temporal size gradient (see **Tab. 2**).

The red fox assemblage consists of a maxilla fragment, rib shaft, and distal tibia (see **Tab. 1**). The maxilla fragment preserves the canine, P1, P3, and P4, the combined morphology and dimensions of which overlap with modern *Vulpes vulpes* and Middle Pleistocene specimens from Escale and Lunel Viel (van Kolfschoten, 2003; van Kolfschoten et al., 2015).

A number of mustelid remains are present in the assemblage. The larger remains have been identified as badger, whereas the smaller skeletal material could only be identified to the genus *Mustela* (see **Tab. 1**). *Mustela erminea*, *Mustela nivalis*, and a specimen from the genus *Martes* were reported by van Kolfschoten (2012, 2014), but the material available for this study did not allow for precise taxonomic determinations.

A single bone from a large felid was identified in the Schöningen 13II-4 assemblage (see **Tab. 1**). The thoracic vertebra (**Fig. 6**) was submitted for zooarchaeology by mass spectroscopy (ZooMS) analysis and returned a signature consistent with cave lion (*Panthera leo spelaea*) (Frido Welker, personal communication, publication forthcoming). It should be noted that sabre-toothed cat (*Homotherium latidens*) has been reported from the Schöningen 13II-4 main excavation and from the nearby Obere Berme (Serangeli et al., 2015; Janssens et al., 2019). These remains were excavated after 2008 and are not directly associated with the Schöningen 13II-4 main excavation and are thus not part of the current study. Only postcranial remains of saber-toothed cat, which may not be readily distinguished from cave lion (Diedrich and McFarlane, 2017),

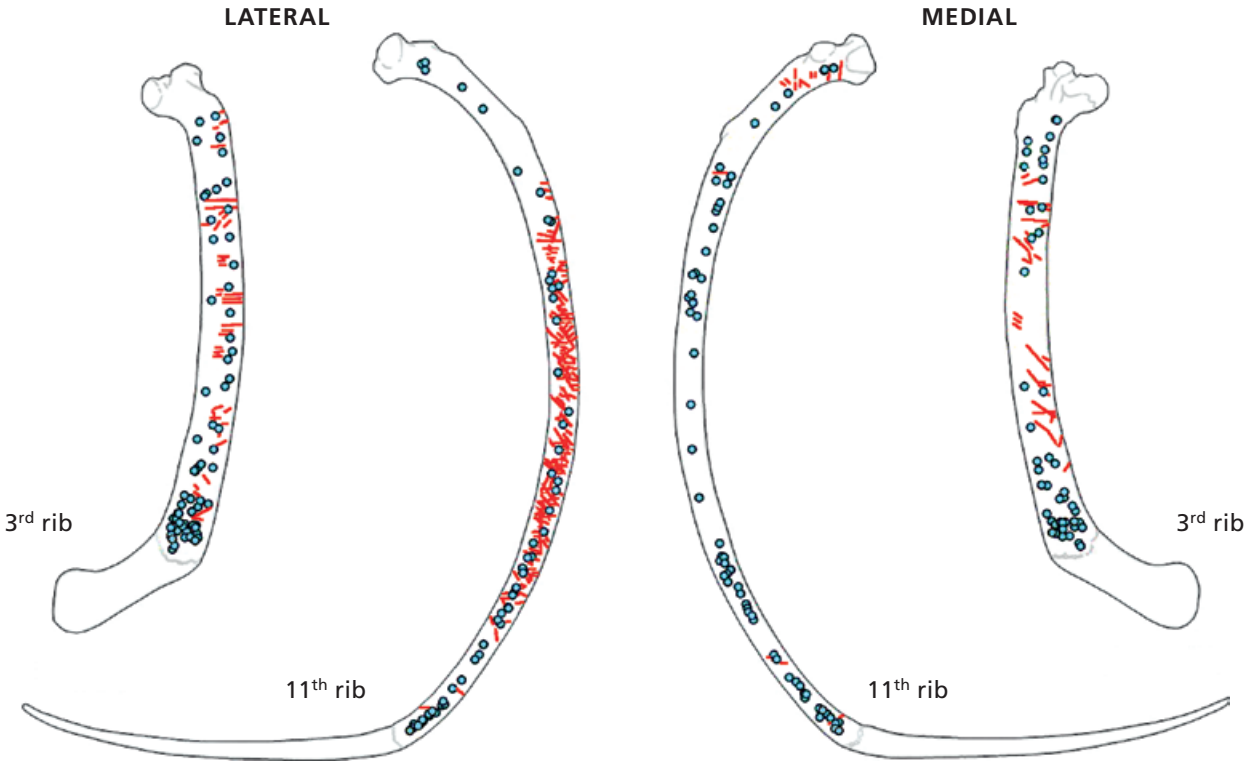


Fig. 13 Composite drawing of cut-mark (red lines) and carnivore tooth mark (cyan circles) locations on all identifiable adult horse (*Equus mosbachensis*) left ribs. '3rd rib' represents composite of ribs 1-6; '11th rib' represents composite of ribs 7-18.

originated from the Schöningen 13II-4 main excavation area; however, isolated saber-toothed cat dental material has been discovered within the Obere Berme deposit.

Three additional rib shaft fragments and a possible coprolite fragment were identified as large carnivore (see **Tab. 1**), wolf-sized or larger.

Carnivore remains at Schöningen 13II-4 are spatially dispersed (see **Fig. 4**), with no remains from a single species clustered together. The overall faunal assemblage is heavily concentrated along a narrow strip oriented north-south in the central portion of the site, which likely corresponds to the shoreline of the lake during a period of increased hominin activity. A number of carnivore remains were recovered within or near this central concentration, most in the northern portion of the site and few in the south. A smaller number of carnivore remains were recovered from the eastern portion of the site, likely corresponding to additional shorelines during times of lowered lake levels and reduced hominin activity (Turner et al., 2018; García-Moreno et al., 2021).

Traces of carnivores at Schöningen 13II-4

Whereas carnivore remains are relatively rare at Schöningen 13II-4, damage to ungulate bones in the form of carnivore tooth pits, punctures, scores, and the like (**Figs. 7-10**) is abundant. Across the three primary ungulate taxa (horse, red deer, bison/aurochs) a total of 595 remains (NISP) preserve carnivore damage (**Tab. 3**). In contrast, 1,024 of those remains show cut-marks. In the horse assemblage, cut-marks are substantially more abundant than carnivore damage on the meat-bearing bones of the appendicular skeleton

(**Tab. 4**), particularly the long bones, scapula, and innominate. On the other hand, cut-marks and carnivore damage are equally distributed on the axial skeleton, mostly ribs and vertebrae. A closer look at carnivore damage and cut-marks across the axial and appendicular skeletons reveals differences in the treatment of adult and juvenile carcasses (see **Tab. 4**). Carnivore marks slightly outnumber cut-marks (298 : 291) on adult axial skeletal parts; for the juvenile axial skeleton, the ratio of carnivore-damaged-to-cut-marked bones is 35 : 44. There is no significant difference between the frequencies of carnivore marks and cut-marks on adult and juvenile bones when considering the axial skeleton ($\chi^2 = 1.10$, $p = 0.29$). On adult appendicular remains there are far fewer carnivore marks than cut-marks (152 : 590); for juveniles, carnivore damage is nearly twice as frequent as cut-marks (67 : 36). This sharp contrast is statistically significant ($\chi^2 = 93.55$, $p < 0.00001$), suggesting that hominins processed the carcasses of adult and juvenile horses differently, thus leaving different portions of adult and juvenile horse carcasses to be scavenged by carnivores.

For the much smaller red deer assemblage, carnivore damage occurs more frequently than cut-marks on all portions of the skeleton (see **Tab. 3-4**). A higher frequency of carnivore-modified bones may indicate increased competition among scavengers for access to red deer carcasses abandoned by hominins. The opposite pattern is observed in the combined bison and aurochs assemblage, with cut-marks outnumbering carnivore damage on axial and appendicular skeletons. Overall, carnivore involvement with the bison/aurochs assemblage was minimal. There are too few juvenile red deer and bison/aurochs remains to determine if hominins treated the carcasses of adults and subadults differently.

The locations of cut-marks and carnivore tooth marks on horse bones are clearly differentiated. For long bones, cut-marks are concentrated on the mid-shafts, showing intensive filleting of meat from the bones. **Figure 11** shows this general trend in the humeri, which is replicated across most of the long bone elements. Fewer cut-marks are preserved toward the epiphyses, corresponding to disarticulation of long bones at the joints. It should be noted, however, that long bone shafts preserved more frequently than epiphyses, in general. In contrast to cut-mark locations, carnivore tooth marks occur at or near the epiphyses and are almost never found on mid-shafts. This is a well-recognized pattern among large carnivores, wherein defleshed bones are gnawed from the epiphyses and down the mid-shaft (e. g., Haynes, 1980, 1982, 1983), sometimes

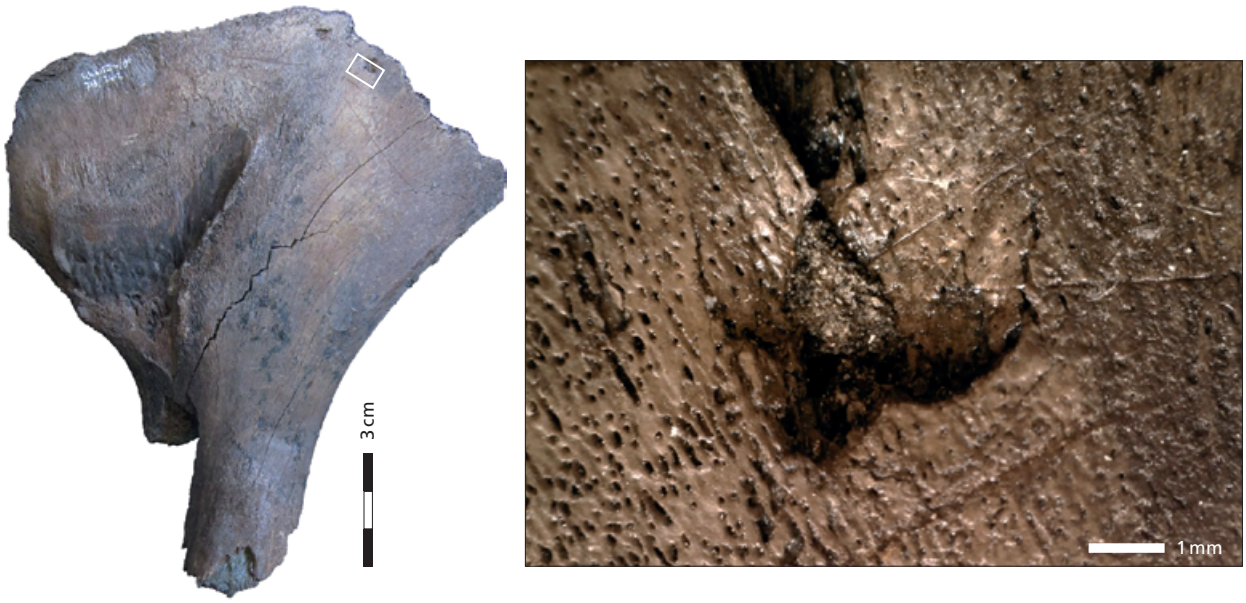


Fig. 14 Cut-marks beneath carnivore tooth puncture on horse (*Equus mosbachensis*) left ilium (ID #11820).

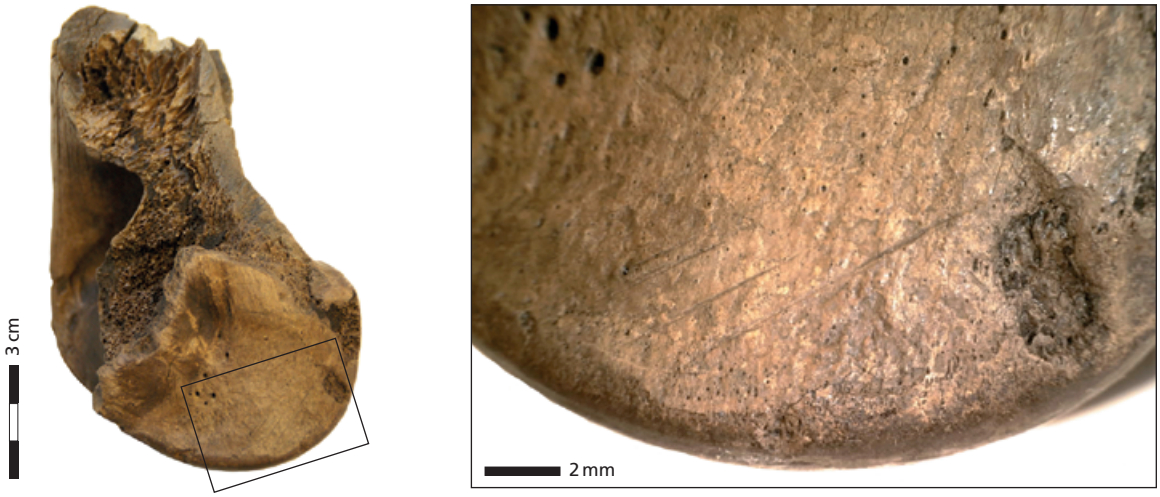


Fig. 15 Cut-marks beneath carnivore tooth pit on horse (*Equus mosbachensis*) left humerus (ID #5031).

resulting in long bone cylinders (see **Fig. 10**). The complete consumption of long bone epiphyses and other bone portions, which is common in the Schöningen assemblage, is a pattern more prevalent among hyena and canids rather than felids (Domínguez-Rodrigo et al., 2012). On innominates, cut-marks occur near the acetabulum and adjacent portions of the ilium and ischium (**Fig. 12**). The positions of these cut-marks relate to filleting and dismembering. There is little overlap with the locations of carnivore marks, which are mostly restricted to the prominent and easily accessible portions at the crest of the ilium and ischial tuberosity. Cut-marks on ribs are concentrated on the central portion of the rib shaft, whereas carnivore marks appear most frequently at the distal ends (**Fig. 13**). Often carnivores consumed some portion of the distal end of the rib, leaving tooth pits, punctures, and scores further toward the proximal ends of rib shafts; this is the likely cause of the carnivore damage to the shaft portions of the ribs depicted in **Figure 13**. Overall, it seems that gnawing from the proximal ends of ribs was less frequent that gnawing from the distal ends.

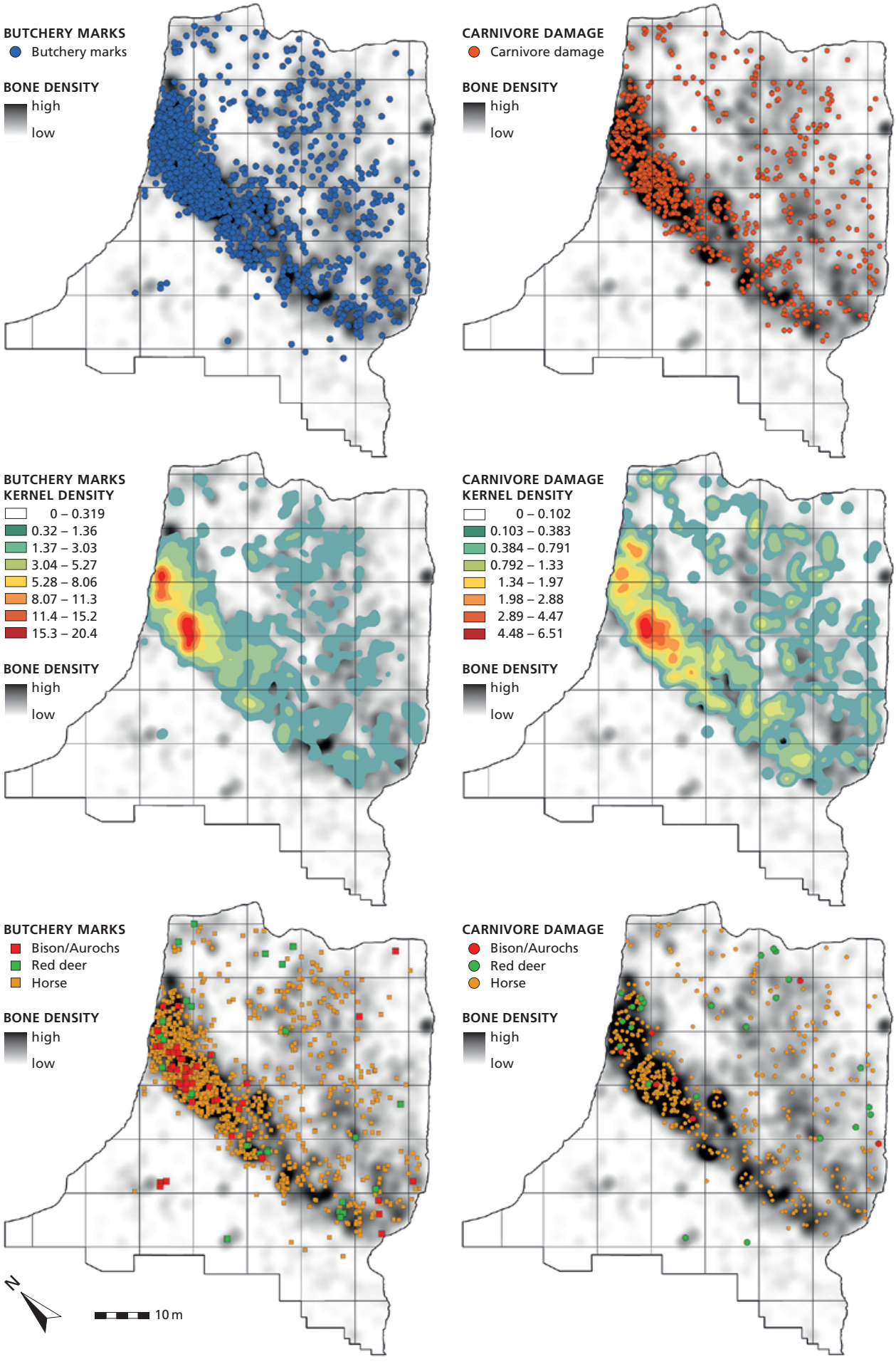
Carnivore tooth marks and cut-marks are far less frequent on red deer and bison/aurochs bones, but follow the same general pattern as observed in the horse assemblage.

In terms of overall frequency and placement of carnivore marks and cut-marks, all evidence indicates that carnivore damage to bones was secondary to hominin butchery. This sequence has been confirmed by an in-depth study on the relative timing of various markings on a sample of the most heavily-modified remains (Lehnig et al., 2021). Furthermore, nine bones preserve overlapping carnivore damage and cut-marks, and in all cases the cut-marks occur beneath the carnivore tooth damage (**Figs. 14-15**).

Spatial distribution of carnivore traces at Schöningen 13II-4

Faunal remains at Schöningen 13II-4 are concentrated along a narrow strip extending in a north-south direction across the central portion of the site. Bones with traces of carnivore activity and hominin activity (cut-marks, impact marks, scraping marks) mirror this overall pattern (**Fig. 16**), especially in the northernmost

Fig. 16 Overall distribution of faunal remains showing butchery marks (cut-marks, impact marks, and scrapping marks) (right) and carnivore damage (left), including Kernel density analysis (centre) and distribution by taxa (lower).


BUTCHERY MARKS
Butchery marks
BONE DENSITY
high
low
CARNIVORE DAMAGE
Carnivore damage
BONE DENSITY
high
low
BUTCHERY MARKS
KERNEL DENSITY
0 – 0.319
0.32 – 1.36
1.37 – 3.03
3.04 – 5.27
5.28 – 8.06
8.07 – 11.3
11.4 – 15.2
15.3 – 20.4
BONE DENSITY
high
low
CARNIVORE DAMAGE
KERNEL DENSITY
0 – 0.102
0.103 – 0.383
0.384 – 0.791
0.792 – 1.33
1.34 – 1.97
1.98 – 2.88
2.89 – 4.47
4.48 – 6.51
BONE DENSITY
high
low
BUTCHERY MARKS
Bison/Aurochs
Red deer
Horse
BONE DENSITY
high
low
CARNIVORE DAMAGE
Bison/Aurochs
Red deer
Horse
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high
low
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10 m

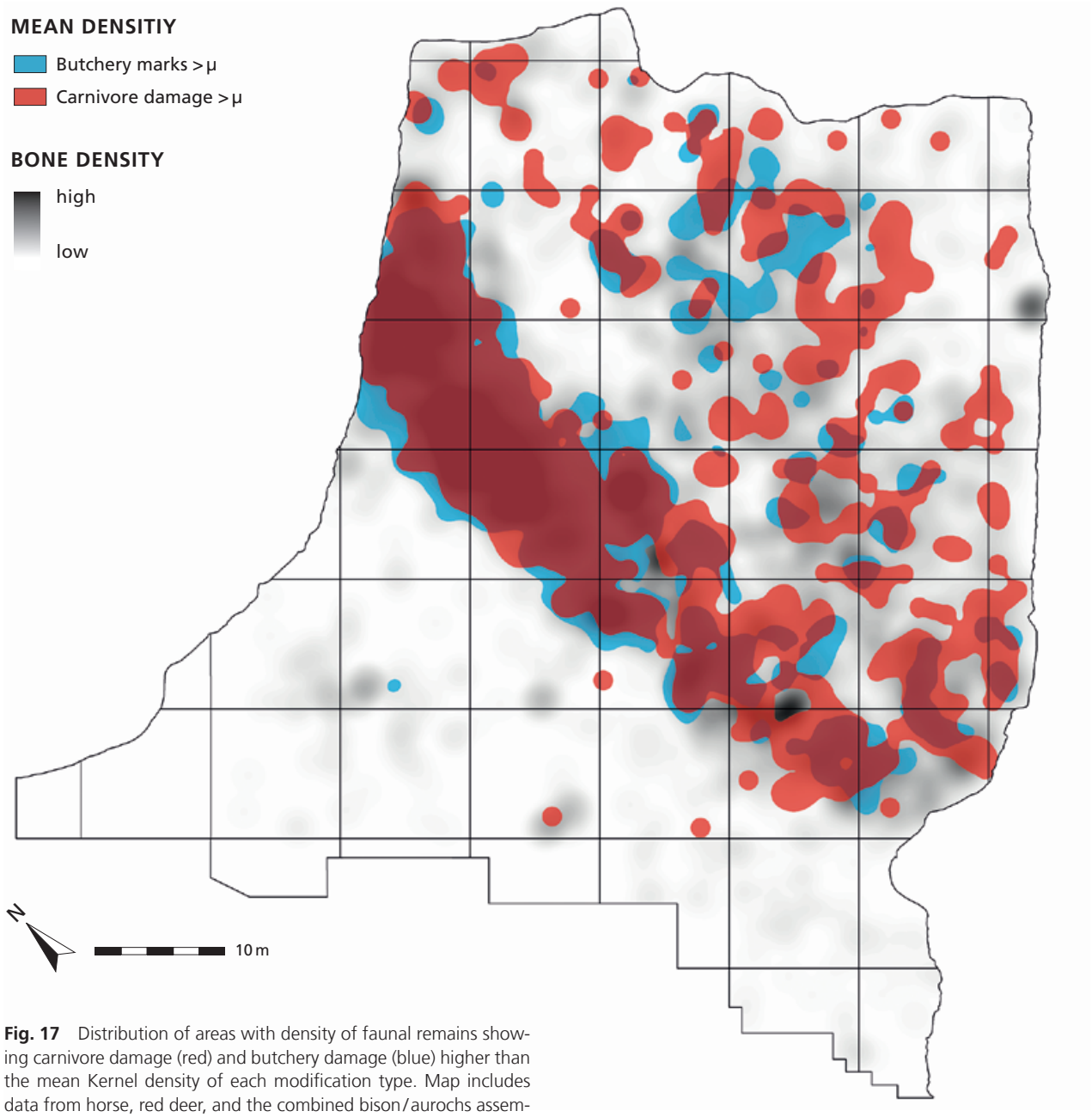

Fig. 17 Distribution of areas with density of faunal remains showing carnivore damage (red) and butchery damage (blue) higher than the mean Kernel density of each modification type. Map includes data from horse, red deer, and the combined bison/aurochs assemblage.

portion of the site where the densest concentration of bones were recovered. Fewer bones impacted by carnivores and hominins were found to the east of the main concentration and almost none were recovered to the west. Bones with carnivore damage are more dispersed than bones showing butchery marks (average distance: 0.72 m *vs.* 0.37 m) (see **Fig. 16**). For horse and the combined bison and aurochs samples, most of the modified bones occur within the main concentration. For the red deer, hominin-modified and carnivore-damaged bones are nearly as frequent in the eastern portion of the site as in the main concentration (see **Fig. 16**); this pattern mimics the distribution of red deer bones in the entire assemblage.

Figure 17 shows the areas where the density of faunal remains showing carnivore damage and butchery marks is higher than the estimated Kernel mean density for each type of bone surface modification. Carni-

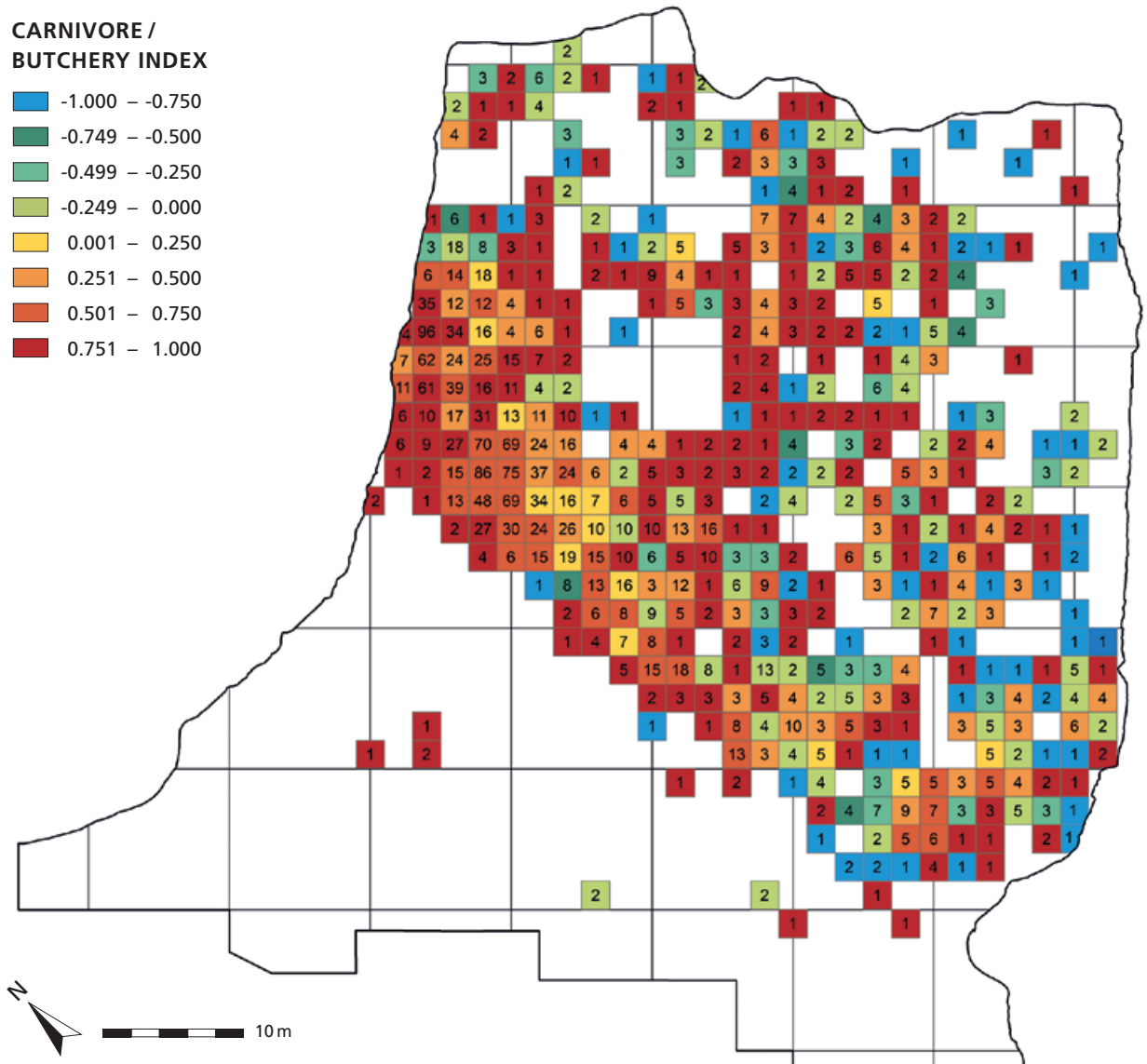

Fig. 18 Carnivore/Butchery Index for Schöningen 13II-4 based on the number of bones showing carnivore damage and butchery marks in each cell of a 2 m × 2 m grid created according to Quadrat method. Index value of -1 (blue) corresponds to 100 % of bones with carnivore damage, whereas an index value of 1 (red) corresponds to 100 % of bones showing butchery marks. The number inside each cell represents the total number of modified faunal remains in it.

vore damage and butchery marks overlap quite neatly within the main concentration, especially within the northern half. In contrast, the picture in the eastern portion of the site is different, with smaller patches of carnivore-damaged bones and hominin-modified bones barely overlapping. However, this difference may be a consequence of the different overall spatial patterning, since finds are less abundant and more scattered in the eastern portion of the site.

The CBI shows that butchery marks are clearly dominant in the northern part of the main concentration (**Fig. 18**), where the larger and densest clusters of faunal remains are located. In contrast, the southern part of the main concentration shows a patchier distribution, where cells containing bones with butchery marks alternate with cells with bone showing carnivore damage; however, the number of modified remains

Taxa		Europe 400-200 ka[1]	Europe 200-0 ka[1]	Bilzingsleben[2]	Schöningen 12II-1[3]	Schöningen 12B[4]	Schöningen 13II-2[4]	Schöningen 13II-3[4]	**Schöningen 13II-4**[5]	Schöningen Obere Berme[6]	Weimar-Ehringsdorf[7]	Neumark Nord 1 & 2[8]	Salzgitter-Lebenstedt[9]
Hyenids	*Pliocrocuta perrieri*		?										
	Crocuta crocuta	+	+	+							+	+	
	Hyaena prisca	+											
Canids	*Canis lupus*	+	+	+			+		**+**		+	+	+
	Cuon priscus	+											
	Cuon alpinus		+										
	Vulpes vulpes	+	+	+					**+**		+	+	
	Alopex lagopus		+										
Felids	*Panthera leo spelaea*	+	+	+	+	+			**+**		+	+	
	Homotherium latidens		?							+			
	Large felid											+	
	Lynx pardina/spelaea	+	+										
	Lynx lynx		+								+		
	Felis lunensis/silvestris	+	+	+									
Ursids	*Ursus arctos*	+	+								+		
	Ursus spelaeus	+	+			+					+		
	Ursus thibetanus	+	+			+					+		
	Ursus sp.			+	+						+	+	
Mustelids	*Meles meles*	+	+	+	+				**+**		+		
	Gulo gulo		+										
	Martes sp.		+	+				+			+		
	Mustela sp.	+	+					+	**+**		+		
	Lutra lutra	+	+	+							+*		

Tab. 5 Carnivore species present in late Middle Pleistocene Western and Central Europe, several Schöningen localities, and other key German sites. Archaeological sites are ordered approximately from oldest to youngest, left to right.

1 Croiter and Brugal, 2010
2 Müller and Pasda, 2011; all fauna from 1969-2003 excavations
3 Julien et al., 2015a
4 van Kolfschoten, 2014
5 Hutson et al., 2020, and this study
6 Starkovich and Conard, 2015
7 Schäfer et al., 2007; all levels
8 Kindler et al., 2020; all levels
9 Gaudzinski, 1999
+* *Cyrnaonyx antiqua* – Pleistocene otter

per cell is substantially lower than in the northern portion of the site. Cells containing bones with more carnivore damage occur along the edges of the main concentration, but the overall density of butchered bones in the main concentration is simply too high to discern any clear pattern in the spatial distribution of carnivore damage. These results suggest that carnivore activity can be better tracked in the eastern half of the site where the faunal remains are less abundant and more scattered. Here, cells containing bones with carnivore damage often appear at the periphery of cell clusters showing butchery. This pattern could indicate that portions of previously butchered animal carcasses were slightly displaced during scavenging events by one or more carnivores.

Which carnivores were active at Schöningen 13II-4?

Based on the evidence presented here, our assessment on the role of carnivores in the formation of the Schöningen 13II-4 deposit is that of scavengers. The carnivore remains themselves provide the most direct evidence for which carnivores species may have scavenged from the hominin kills along the Schöningen lakeshore (see Tab. 1). Because of the substantial carnivore damage to many of the bones, the largest species, namely wolf and lion, are potential scavenger candidates, but fox and badger cannot be discounted entirely. We also cannot restrict the range of potential scavenging carnivores to only those represented in the Schöningen 13II-4 assemblage. Other carnivore species were undoubtedly present on the landscape, but either none died at the small stretch of shoreline represented in Schöningen 13II-4 deposit or their bones did not preserve. Schöningen 13II-4 includes the richest carnivore assemblage of all the well-studied Schöningen sites, but contains relatively few carnivore species compared to all carnivores present in Pleistocene Europe from 400 ka onward (Tab. 5). Additional Schöningen localities and regional interglacial sites shed further light on the possible presence of different carnivore species on the landscape. Hyenids are absent from all Schöningen localities, but spotted hyena (*Crocuta crocuta*) does appear in the post-Elsterian (i. e., post-MIS 12) travertine deposits from Bilzingsleben, as well as at the interglacial sites of Weimar-Ehringsdorf (MIS 7) and Neumark-Nord (MIS 5e). Of the several canid species present in Europe during the late Middle Pleistocene, wolf (*Canis lupus*) and red fox (*Vulpes vulpes*) appear most consistently, including at Schöningen 13II-4. Lion (*Panthera leo spelaea*) is nearly as ubiquitous as wolf, persisting in Europe into the Late Pleistocene; ZooMS analysis confirms its presence at Schöningen 13II-4. The presence of sabre-toothed cat (*Homotherium latidens*) in main excavation at Schöningen 13II-4 is problematic and does not appear in any other post-Elsterian sites in the region. Smaller felids, such as the lynx (*Lynx lynx*) and wildcat (*Felis sylvestris*) were present but probably rare in open lakeshore habitats such as Schöningen, but lynx is present at Weimar-Ehringsdorf. Schöningen 13II-4 preserved no ursid remains, but cave bear (*Ursus spelaeus*) and Asian black bear (*Ursus thibetanus*) have been identified at Schöningen 12B from a level that likely corresponds to the peak of the locally-defined Reinsdorf Interglacial (Urban and Sierralta, 2012); however, the Asian black bear is primarily herbivorous and the isotopic composition of cave bear remains reveals a predominant herbivore signature (Bocherens, 2019). Ursid remains are also found at Bilzingsleben and Weimar-Ehringsdorf, including brown bear (*Ursus arctos*), which was likely more carnivorous than cave bear and Asian black bear. A variety of mustelid species are present at several Schöningen localities, including Schöningen 13II-4, and must have been frequent visitors to the Schöningen lakeshore, but were not likely to have been significant affecters of the Schöningen 13II-4 faunal assemblage. In reviewing the regional carnivore record, hyena and bear should be added to wolf and lion as potential scavengers of hominin kills at Schöningen 13II-4.

To narrow this list of possible scavenging carnivores, we look to traces of carnivore damage on the Schöningen bones, i. e., tooth pits and tooth scores, to determine if there is any measurable overlap with pit and score dimensions from modern carnivores. Mean pit length in the Schöningen sample is larger than any of the carnivore samples (Tab. 6; Fig. 19), falling closest to the pooled lion sample, but this is not statistically significant. For mean pit breadth, the Schöningen sample is again measurably larger than all of the pooled carnivore samples, except for lion (Tab. 7; Fig. 20); the difference between mean pit breadth for the Schöningen and pooled lion samples is not statistically significant. In terms of mean score length, the Schöningen sample shows statistical similarities with wolf, mountain lion, and bear (Tab. 8; Fig. 21). Finally, mean pit breadth at Schöningen is statistically similar to the bear sample (Tab. 9; Fig. 22).

In all respects, the dimensions of carnivore tooth pits and scores from the Schöningen sample are very large. Only the largest carnivores – wolf, lion, hyena, bear – could have made these marks on the Schöningen bones.

	Pit length [mm]					
Reference	N	Mean	Min	Max	SD	95 % CI
Fox						
Andrés et al., 2012	108	1.93	0.36	9.07	1.40	1.66-2.19
Delaney-Rivera et al., 2009	8	1.09	0.43	2.91	0.81	0.53-1.66
Young et al., 2014	442	1.66	0.15	6.10	0.96	1.57-1.75
Total fox	558	1.71	0.15	9.07	1.06	1.62-1.79
Dog						
Andrés et al., 2012	85	1.91	0.50	9.88	0.99	1.70-2.12
Delaney-Rivera et al., 2009	45	1.37	0.65	4.21	0.68	1.30-1.44
Young et al., 2014	15	3.11	1.97	4.81	0.97	2.62-3.60
Total dog	145	1.87	0.50	9.88	1.03	1.70-2.03
Coyote						
Delaney-Rivera et al., 2009	17	2.17	0.66	5.19	1.17	1.61-2.73
Jackal						
Domínguez-Rodrigo and Piqueras, 2003	80	2.48	-	-	1.26	-
Wolf						
Sala et al., 2014	512	2.85	0.76	7.41	1.16	2.75-2.95
Andrés et al., 2012	365	2.89	0.40	9.95	1.44	2.74-3.03
Campmas and Beauval, 2008	2,238	2.32	0.14	14.24	1.74	2.25-2.39
Wolfspark Kasteelberg, this study	249	6.58	1.49	22.48	3.14	6.19-6.97
Total wolf	3,364	2.78	0.14	22.48	2.10	2.71-2.85
Hyena						
Andrés et al., 2012	779	1.99	0.17	25.60	1.73	1.87-2.12
Delaney-Rivera et al., 2009	8	2.83	1.35	5.35	1.64	1.69-3.96
Sala, 2012	167	3.29	0.80	20.00	2.52	2.91-3.68
Total hyena	954	2.23	0.17	25.60	1.95	2.10-2.35
Bobcat						
Delaney-Rivera et al., 2009	75	1.84	0.35	5.72	1.16	1.58-2.10
Mountain lion						
Delaney-Rivera et al., 2009	86	2.05	0.41	5.96	1.36	1.76-2.33
Lion						
Andrés et al., 2012	206	5.72	0.98	23.30	3.51	5.24-6.20
Delaney-Rivera et al., 2009	47	2.24	0.78	8.16	1.69	1.76-2.72
Sala, 2012	190	4.79	1.77	10.18	1.85	4.53-5.06
Total lion	443	5.03	0.78	23.30	3.26	4.72-5.33
Bear						
Saladié et al., 2013	285	3.46	0.50	9.86	1.88	3.24-3.68
Domínguez-Rodrigo and Piqueras, 2003	58	4.68			2.70	3.98-5.37
Sala, 2012	36	4.90	2.36	10.13	1.74	4.33-5.47
Total bear	379	3.78	0.50	10.13	2.09	3.57-3.99
Schöningen, this study	186	5.68	1.56	25.89	3.29	5.21-6.15

Tab. 6 Reference data for carnivore tooth pit lengths (mm): sample size (N), mean, minimum (Min), maximum (Max), standard deviation (SD), 95 % confidence intervals (95 % CI). Dataset includes punctures if provided in original source.

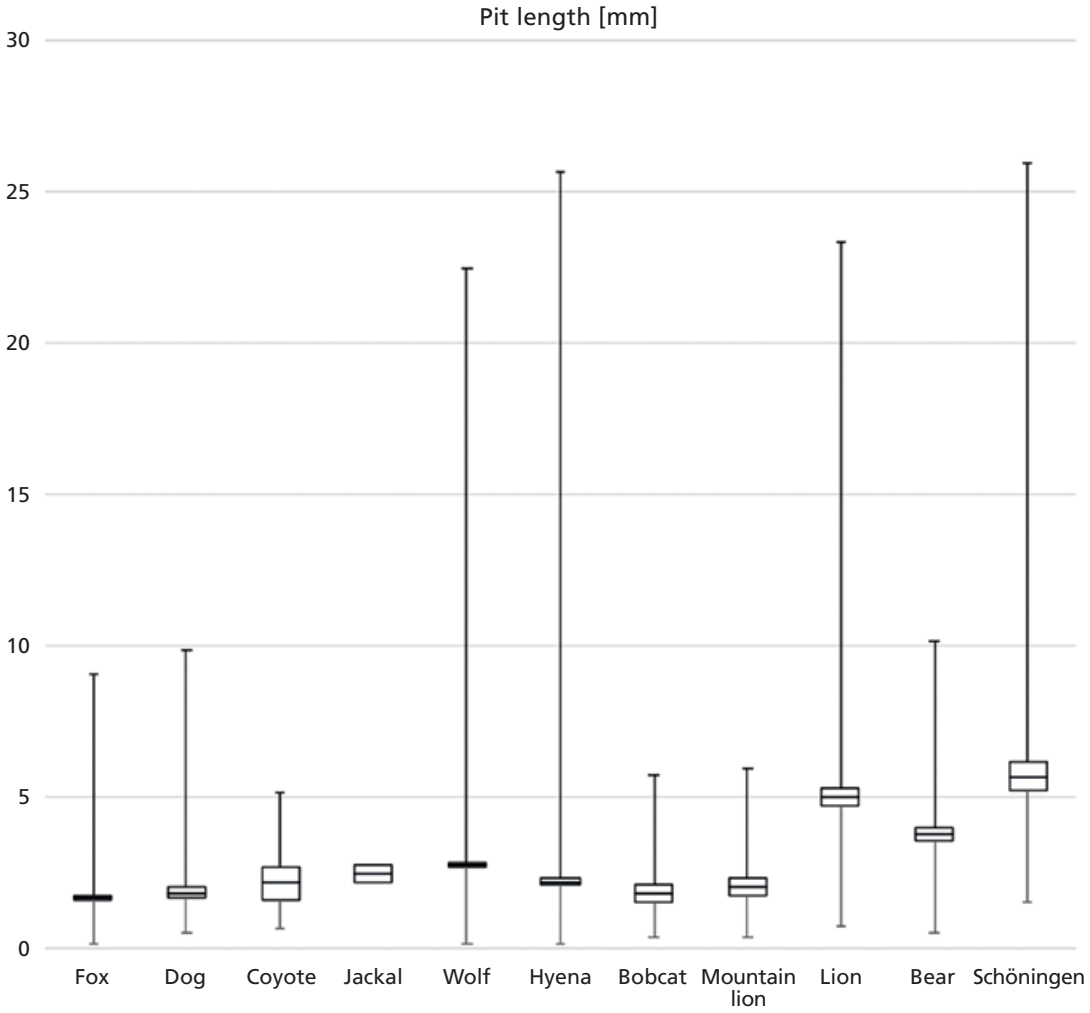

Fig. 19 Comparison of tooth pit lengths among several carnivore species and the Schöningen sample. Data represent median pit length with 95 % confidence intervals and minimum and maximum values from **Tab. 6.**

The hyena's reputation as a bone crunching carnivore is well deserved, but the individual marks imparted on bones by hyenas are quite small relative to other carnivores, and even sometimes superseded by smaller canid species. Considering the marks on the Schöningen sample are so large and their absence in all Schöningen faunal assemblages, hyenas likely did not scavenge from the animal carcasses abandoned by hominins at the Schöningen lakeshore.

Even the dimensions of pits made by wolves are much smaller than those recorded in the Schöningen sample, although score lengths are similar between the two datasets. Interestingly, dimensional data for the *Adler- und Wolfspark* Kasteelburg sample reported here is also quite high relative to other carnivores, even much higher than other wolf samples, and more closely approximates the sample from Schöningen 13II-4. This loose affinity with tooth mark dimensions supports the suggestion that wolves likely played a prominent role in scavenging at Schöningen 13II-4, which is also underscored by the presence of at least two wolf individuals in the Schöningen 13II-4 faunal assemblage. Voormolen (2008) and van Kolfschoten et al. (2015) also suggest the gnawing damage at Schöningen 13II-4 was inflicted by wolves, both citing the placement and intensity of damage observed by Haynes (1983).

	Pit breadth [mm]					
Reference	N	Mean	Min	Max	SD	95 % CI
Fox						
Andrés et al., 2012	108	1.33	0.19	5.91	1.04	1.13-1.52
Delaney-Rivera et al., 2009	8	0.78	0.32	1.80	0.54	0.40-1.15
Young et al., 2014	442	1.07	0.29	4.65	0.59	1.02-1.13
Yravedra et al., 2019	41	0.45	0.13	0.75	0.18	0.40-0.51
Total fox	599	1.07	0.13	5.91	0.70	1.02-1.13
Dog						
Andrés et al., 2012	85	1.48	0.50	7.93	0.72	1.33-1.63
Delaney-Rivera et al., 2009	45	0.86	0.39	1.42	0.27	0.78-0.93
Young et al., 2014	15	2.03	1.17	4.18	0.72	1.66-2.40
Yravedra et al., 2019	34	1.62	0.31	3.32	0.70	1.38-1.85
Total dog	179	1.40	0.39	7.93	0.71	1.29-1.50
Coyote						
Delaney-Rivera et al., 2009	17	1.48	0.43	3.51	0.84	1.08-1.88
Jackal						
Domínguez-Rodrigo and Piqueras, 2003	80	2.20	-	-	1.45	-
Wolf						
Sala et al., 2014	362	2.22	0.66	6.12	0.95	2.12-2.32
Andrés et al., 2012	365	2.12	0.16	7.48	1.11	2.01-2.23
Yravedra et al., 2019	28	3.37	1.99	4.86	0.80	3.07-3.66
Wolfspark Kasteelberg, this study	249	3.01	1.28	10.96	1.27	2.85-3.16
Total wolf	1,004	2.41	0.16	10.96	1.16	3.15-3.58
Hyena						
Andrés et al., 2012	779	1.40	0.11	14.00	1.08	1.32-1.47
Delaney-Rivera et al., 2009	8	1.50	0.70	2.07	0.50	1.15-1.84
Sala, 2012	7	5.50	3.00	10.00	2.29	3.80-7.20
Total hyena	794	1.44	0.11	14.00	1.16	1.36-1.52
Bobcat						
Delaney-Rivera et al., 2009	75	1.26	0.28	4.59	0.79	1.08-1.44
Mountain lion						
Delaney-Rivera et al., 2009	86	1.48	0.33	4.93	0.98	1.28-1.69
Lion						
Andrés et al., 2012	206	3.73	0.60	15.00	2.40	3.40-4.06
Delaney-Rivera et al., 2009	47	1.43	0.46	6.32	1.16	1.10-1.76
Sala, 2012	190	3.57	1.07	9.13	1.64	3.34-3.81
Total lion	443	3.42	0.46	15.00	2.11	3.22-3.62
Bear						
Saladié et al., 2013	285	2.31	0.12	7.38	1.39	2.15-2.47
Domínguez-Rodrigo and Piqueras, 2003	58	3.28	-	-	2.01	-
Sala, 2012	36	2.84	1.64	5.85	1.45	2.37-3.32
Total bear	379	2.51	0.12	7.38	1.54	2.36-2.67
Schöningen, this study	186	3.36	0.77	8.95	1.48	3.15-3.58

Tab. 7 Reference data for carnivore tooth pit breadths (mm): sample size (N), mean, minimum (Min), maximum (Max), standard deviation (SD), 95 % confidence intervals (95 % CI). Dataset includes punctures if provided in original source.

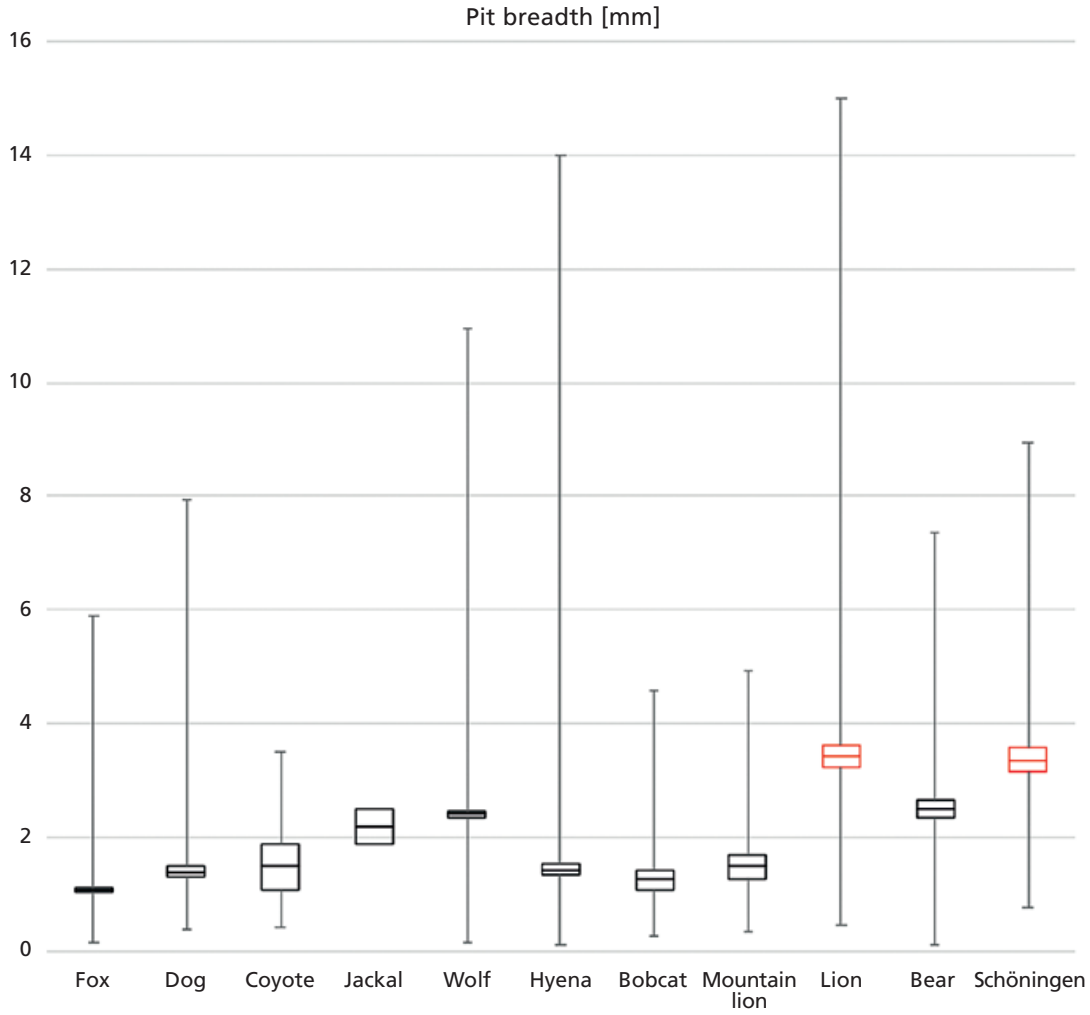

Fig. 20 Comparison of tooth pit breadths among several carnivore species and the Schöningen sample. Data represent median pit breadth with 95 % confidence intervals and minimum and maximum values from **Tab. 7.** Samples highlighted in red are not significantly different ($p \geq 0.05$) according to unpaired t-test.

Likewise, the presence of lion and some overlap with large felid tooth markings implicates lion as a potential scavenger at Schöningen 13II-4. Starkovich and Conard (2015) implicate wolf and a large felid in the modification of the Schöningen Obere Berme assemblage based on tooth pit dimensions. They identify sabre-toothed cat rather than lion as the large felid species. For Schöningen 13II-4, we argue for lion as the scavenger species due to its presence in the 13II-4 faunal assemblage, whereas the association of sabre-toothed cat with the Schöningen 13II-4 main excavation is less secure. Furthermore, Marean and Ehrhardt (1995) report that although tooth marks are common for *Homotherium*-gnawed bones, crushing and breakage is rare, features that are common in the Schöningen 13II-4 assemblage. Nevertheless, the presence of sabre-tooth cat is an intriguing possibility as Hemmer (2001) has suggested that *Homotherium* was at least partially reliant on scavenging.

Although not present in the faunal assemblage, the Schöningen sample shows similarities with bear, overlapping in score length and breadth. The ursid species identified at Schöningen 12B, cave bear and Asian black bear, are mostly herbivorous and unlikely primary modifiers of the Schöningen 13II-4 assemblage. However, supposed cave bear-scavenged bones from the Late Pleistocene site of Coro Tracito, Spain (Rabal-

Garcés et al., 2012), do show some dimensional similarities with the Schöningen sample, with a very large mean pit breadth of 5.32 mm (Schöningen: 5.68 mm) and a score breadth rarely exceeding 2.5 mm (Schöningen: 2.14 mm). Several bear species, including brown bear, are noted in the Lower Travertine at Weimar-Ehringsdorf, though the Lower Travertine fauna at Weimar-Ehringsdorf is younger than the Schöningen 13II-4 fauna by at least 70,000 years based on current age estimates. Nevertheless, it is possible that some large ursid species was actively scavenging the animal carcasses from Schöningen 13II-4.

	Score length [mm]					
Reference	N	Mean	Min	Max	SD	95 % CI
Fox						
Andrés et al., 2012	103	3.64	1.36	14.22	2.05	3.25- 4.04
Delaney-Rivera et al., 2009	2	3.28	2.87	3.69	0.58	2.48- 4.09
Young et al., 2014	90	6.89	1.94	14.09	3.12	6.25- 7.54
Total fox	195	5.14	1.36	14.22	3.05	4.71- 5.57
Dog						
Andrés et al., 2012	209	5.25	1.14	26.55	2.81	4.87- 5.63
Delaney-Rivera et al., 2009	18	4.74	2.06	9.97	1.66	3.98- 5.51
Young et al., 2014	25	9.29	2.67	18.19	4.21	7.64-10.94
Total dog	252	5.62	1.14	26.55	3.15	5.23- 6.00
Coyote						
Delaney-Rivera et al., 2009	1	3.78	-	-	-	-
Jackal						
Domínguez-Rodrigo and Piqueras, 2003	40	3.35	-	-	1.09	-
Wolf						
Andrés et al., 2012	384	9.05	1.00	32.03	4.53	8.60- 9.51
Wolfspark Kasteelberg, this study	1,067	12.83	3.96	42.46	5.40	12.50-13.20
Total wolf	1,451	11.83	1.00	42.46	5.44	11.60-12.10
Hyena						
Andrés et al., 2012	1,145	3.28	0.35	31.60	2.55	3.14- 3.43
Delaney-Rivera et al., 2009	19	8.50	3.00	20.28	4.22	6.61-10.40
Total hyena	1,164	3.37	0.35	31.60	2.67	3.22- 3.52
Bobcat						
Delaney-Rivera et al., 2009	11	4.89	1.53	8.98	2.63	3.98- 5.80
Mountain lion						
Delaney-Rivera et al., 2009	33	10.46	1.60	31.31	7.22	7.99-12.92
Lion						
Andrés et al., 2012	200	9.84	2.70	35.00	5.06	9.13-10.50
Delaney-Rivera et al., 2009	12	8.60	1.97	19.27	5.73	5.36-11.84
Total lion	212	9.77	1.97	35.00	5.10	9.08-10.50
Bear						
Domínguez-Rodrigo and Piqueras, 2003	18	10.86	-	-	5.04	-
Schöningen, this study	179	11.77	2.95	34.13	5.51	11.00-12.60

Tab. 8 Reference data for carnivore tooth score lengths (mm): sample size (N), mean, minimum (Min), maximum (Max), standard deviation (SD), 95 % confidence intervals (95 % CI).

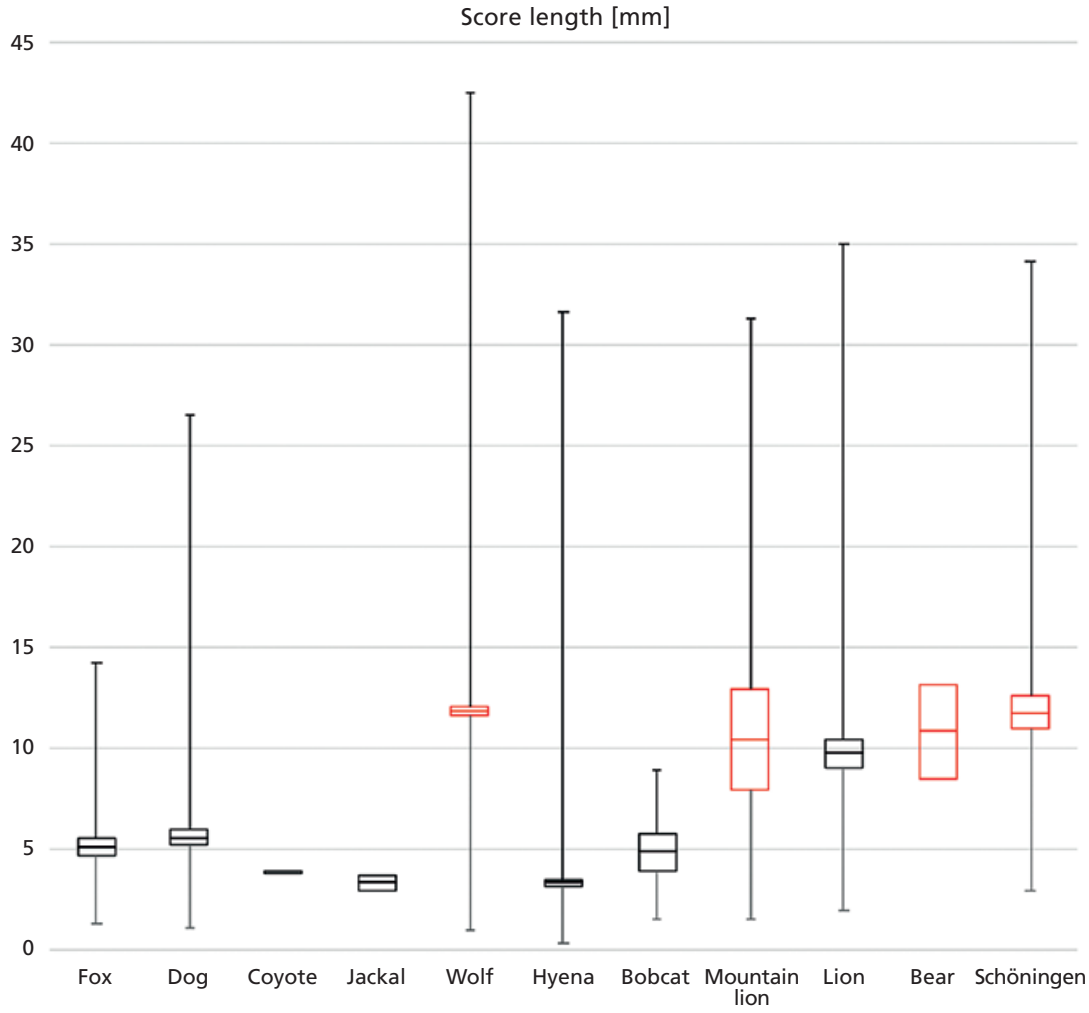

Fig. 21 Comparison of tooth score lengths among several carnivore species and the Schöningen sample. Data represent median score length with 95 % confidence intervals and minimum and maximum values from **Tab. 8**. Samples highlighted in red are not significantly different ($p \geq 0.05$) according to unpaired t-test.

CONCLUSIONS

From all available data, hominins are primarily responsible for the large accumulation of bones at Schöningen 13II-4 and the role of large carnivores in the formation of the site was as secondary scavengers. Cut-marks are far more prevalent than traces of carnivore activity and the locations of carnivore tooth pits and scores suggests secondary access to animal carcasses, at least for the large assemblage of horse bones. The nine bones with overlapping carnivore damage and butchery marks all show the carnivore tooth pits and scores on top of cut-marks, evidence for primary access by hominins and secondary scavenging by carnivores. Based on the faunal list and the large dimensions of tooth pits and scores observed on the gnawed ungulate bones, wolf and lion are suggested to be the primary scavengers of animal carcasses the Schöningen 13II-4. Between these two taxa, the heavy damage to many of the Schöningen bones and the consumption of some bone portions is more indicative of wolves than large felids.

A closer look at the finer details of the faunal assemblage reveals that carnivore marks are more prevalent on the appendicular skeletons of juvenile horses than adults. This pattern suggests that hominins fully

	Score breadth [mm]					
Reference	N	Mean	Min	Max	SD	95 % CI
Fox						
Andrés et al., 2012	103	0.44	0.11	2.02	0.33	0.37-0.50
Delaney-Rivera et al., 2009	2	0.50	0.46	0.53	0.05	0.43-0.57
Young et al., 2014	90	1.00	0.35	4.56	0.59	0.88-1.12
Total fox	195	0.70	0.11	4.56	0.55	0.62-0.77
Dog						
Andrés et al., 2012	209	0.69	0.14	4.58	0.32	0.65-0.74
Delaney-Rivera et al., 2009	18	0.72	0.20	1.46	0.34	0.57-0.88
Young et al., 2014	25	1.80	0.12	4.28	0.89	1.45-2.14
Total dog	252	0.80	0.12	4.58	0.53	0.74-0.87
Coyote						
Delaney-Rivera et al., 2009	1	1.09	-	-	-	-
Jackal						
Domínguez-Rodrigo and Piqueras, 2003	40	0.41	-	-	0.15	-
Wolf						
Sala et al., 2014	247	1.38	0.40	7.41	0.96	1.26-1.50
Campmas and Beauval, 2008	812	1.40	0.10	6.61	0.79	1.35-1.45
Andrés et al., 2012	384	1.93	0.12	7.91	1.34	1.80-2.07
Wolfspark Kasteelberg, this study	1,067	2.12	0.25	7.26	0.84	2.07-2.17
Total wolf	2,510	1.79	0.11	7.91	0.99	1.75-1.83
Hyena						
Andrés et al., 2012	1,145	0.63	0.10	9.00	0.68	0.59-0.67
Delaney-Rivera et al., 2009	19	1.37	0.81	2.28	0.47	1.16-1.58
Sala, 2012	105	2.84	0.50	25.00	3.41	1.84-3.83
Total hyena	1,269	0.82	0.10	25.00	1.32	0.75-0.90
Bobcat						
Delaney-Rivera et al., 2009	11	0.70	0.37	1.03	0.23	0.49-0.92
Mountain lion						
Delaney-Rivera et al., 2009	33	1.65	0.35	5.69	1.11	1.27-2.02
Lion						
Andrés et al., 2012	200	1.62	0.26	18.80	1.86	1.36-1.88
Delaney-Rivera et al., 2009	12	1.31	0.54	2.05	0.53	1.01-1.61
Sala, 2012	45	1.56	0.40	8.28	1.48	1.13-2.00
Total lion	257	1.60	0.26	18.80	1.75	1.38-1.81
Bear						
Domínguez-Rodrigo and Piqueras, 2003	18	1.77	-	-	1.29	-
Sala, 2012	21	1.88	0.40	4.70	0.95	1.48-2.29
Total bear	39	1.83	0.40	4.70	1.10	1.48-2.18
Schöningen, this study	179	2.14	0.62	7.61	1.13	1.98-2.31

Tab. 9 Reference data for carnivore tooth score breadths (mm): sample size (N), mean, minimum (Min), maximum (Max), standard deviation (SD), 95 % confidence intervals (95 % CI).

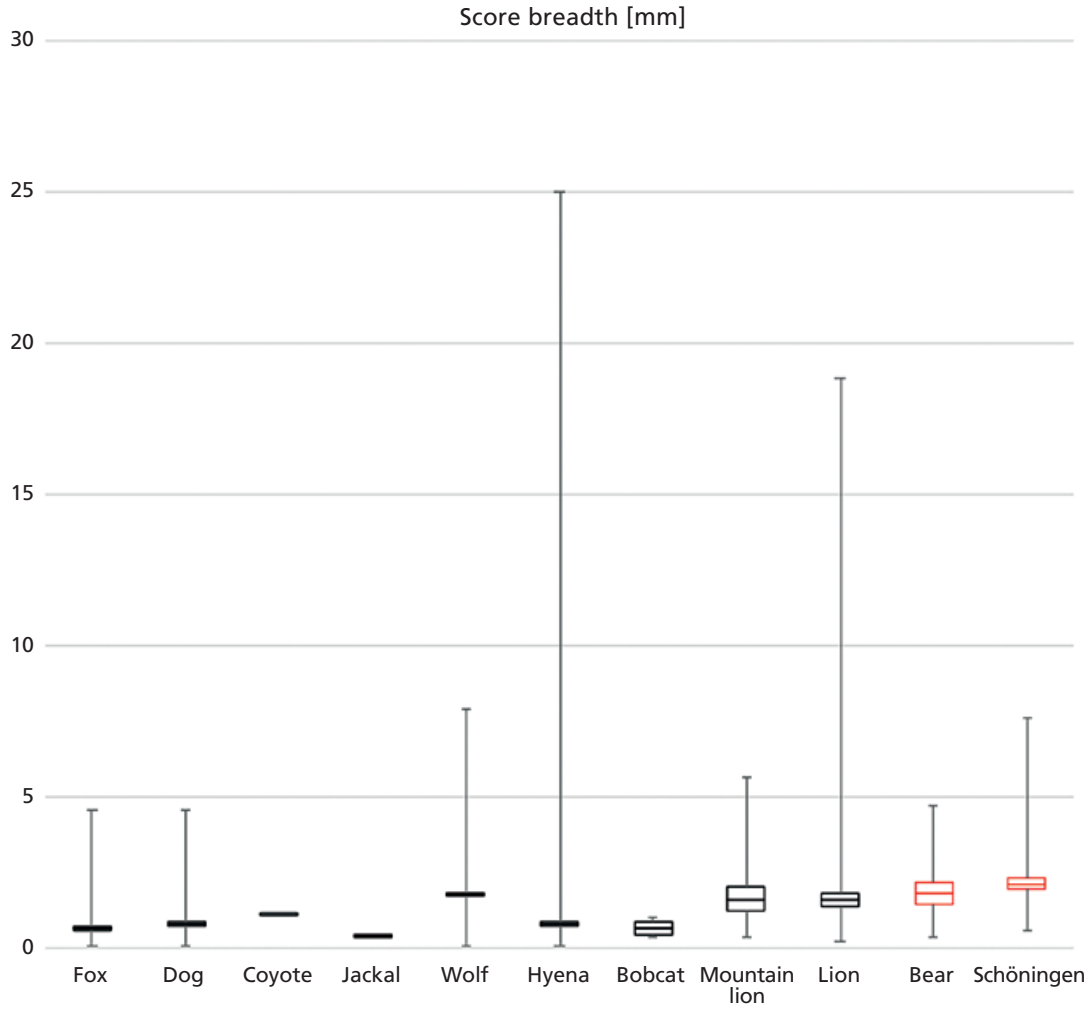

Fig. 22 Comparison of tooth score breadths among several carnivore species and the Schöningen sample. Data represent median score length with 95 % confidence intervals and minimum and maximum values from **Tab. 9**. Samples highlighted in red are not significantly different ($p \geq 0.05$) according to unpaired t-test.

processed adult horse limb bones for meat and marrow, but limbs of juveniles were discarded at an earlier stage of butchery, which may account for the greater incidence of carnivore damage to the appendicular skeleton of juvenile horses. Horse hunting at Schöningen appears to have targeted entire horse family groups; essentially, multiple horse individuals were killed at a time (Julien et al., 2015b; Hutson et al., 2020; García-Moreno et al., 2021). This echoes aspects of the "shoot first" and "adults only" hunting and butchery strategy noted at a number of Middle Pleistocene Neanderthal sites (Gaudzinski and Roebroeks, 2000; White et al., 2016), where prey mortality profiles include many prime-aged adults whose carcasses are extensively butchered, but the Neanderthals chose not to butcher the killed juveniles as thoroughly as the adults. In contrast to the horse assemblage, the much smaller red deer assemblage shows more carnivore damage than traces of hominin butchery. While red deer fall within the preferred prey size range of wolves in places where the two species co-occur (Newsome et al., 2016), we maintain that the red deer represented at Schöningen 13II-4 were hunted by hominins and subsequently scavenged by carnivores. Red deer form small social groups for most of the year and were likely killed individually rather than in entire family groups as reckoned for the horses. In consequence, there was less to scavenge from a solitary red

deer carcass than there was from a butchery event involving multiple horses. Increased competition for the leftovers from single butchered red deer likely led to more completely scavenged carcasses, and therefore more carnivore damage to the remaining bones, increased consumption of some bone portions, and possible removal of some skeletal elements from the kill site. As for the very small bison and aurochs assemblage, hominins were only rarely successful in killing one of these very large and potentially dangerous animals. Modern lion prey preferences do include animals of this size (Hayward and Kerley, 2005) and bison fall at the upper limit of potential prey size for wolves (Newsome et al., 2016), but carnivore involvement with these species is limited to tooth marks on only a few remains and is therefore reasoned to represent scavenging from hominin kills.

The site's vast area and high density of faunal remains within the main concentration pose complications for interpreting spatial aspects of hominin and carnivore activities (see Böhner et al., 2015; Peters and van Kolfschoten, 2020; García-Moreno, 2021). However, here we have noted that spatial relationships may be more apparent in the eastern portion of the site where the density of faunal remains is lower. Away from the main concentration, clusters with more carnivore-marked bones are slightly offset from those clusters with more cut-marks, scraping marks, and impact damage. Similarly, the Carnviore/Butchery Index reveals scatterings of carnivore-damaged bones around the periphery of denser clusters of hominin-damaged bones. This can be taken as further evidence of carnviores scaveneging and scattering of some bones from hominin kills. Dispersal of bones from large mammal carcasses by wolves is usually limited to less than 15 m (Haynes, 1982), although wolves may transport some bones greater distances, especially if single carcasses are scavenged multiple times (Yravedra et al., 2012). With future work, it may be possible to piece together individual kills from among these less-dense clusters of hominin- and carnviore-damaged bones. In turn, this would serve as a model for disentangling discreet hunting events within the main concentration at Schöningen 13II-4 and further afield at other sites across the broader Schöningen lakeshore environment.

We have argued here that hominins were the dominant predator on the Schöningen landscape. The impact of carnivores on the Schöningen 13II-4 faunal assemblage was secondary to that of hominins, and wolves were the primary scavengers of hominin kills. Based on the relatively undisturbed nature of the Schöningen 13II-4 deposit, wolf access to prey carcasses followed in quick succession after abandonment by hominins. Such events were probably commonplace during the Middle Pleistocene in Europe, but what is intriguing about the scenario at Schöningen is that wolves consistently scavenged from hominin kills at the same open-air lakeshore location. Hominins and wolves did not exist in isolation from one another, but rather they shared the Schöningen landscape. Wolves are not obligate scavengers, but high-ranking predators, and any encounters with hominins were likely to have been aggressive. Yet, these adversarial relationships between predators were built on mutual respect and caution born from generations of co-habitation, possibly involving some level of wolf habituation to hominins. Habituation is a key element of the commensal pathway toward domestication (Zeder, 2012), wherein wild species may become increasingly reliant upon human-mitigated landscapes for survival. We are not suggesting that Middle Pleistocene hominins at Schöningen domesticated wolves, but the primordial elements of this special relationship existed on the Schöningen landscape. Thousands of years of sustained habituation eventually drew humans and wolves ever closer into a mutually beneficial partnership that culminated in the appearance of domestic dogs by the Last Glacial Maximum.

Acknowledgements

Elaine Turner is fond of wolves, and other carnivores, too, but mostly she is fond of wolves. This trait was on full display during our visits to *Adler- und Wolfspark* Kasteelburg that she most eagerly coordinated. Under different circumstances, Elaine would be included as a co-author on this *Schrift*; instead, we offer this *Festschrift* in honour of Elaine and the work she holds so dear. Elaine has been deeply involved in the Schöningen project at MONREPOS from the beginning. She was the main driving force behind the practical organisation of research and continues to be a major asset in communication among everyone involved with Schöningen research at MONREPOS. In other words, Elaine is the glue that has kept this Schöningen project going for nearly a decade, always sharing knowledge, always practical, always reliable, and always gracious.

This research is part of the 'Hominin subsistence strategies during the Middle Pleistocene in Schöningen' project, funded by the *Deutsche Forschungsgemeinschaft* (GA 683/9-1). JH, AGM, and AV thank Elaine Turner for your tireless support for this project and your continuing friendship that began with our time as postdocs at MONREPOS.

And to Martin, thank you for always having an open door and being ever ready with helpful advice. We also thank the staff of *Adler- und Wolfspark* Kasteelburg for granting access to their wolf colony and general hospitality during our survey. We thank Frido Welker for performing ZooMS analysis on the Schöningen large felid specimen. Finally, we thank Piotr Wojtal and Adrian Marciszak for guidance on wolf skeletal measurements.

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NEANDERTHAL SUBSISTENCE STRATEGIES AT THE KARSTIC SITES OF COUDOULOUS IN THE QUERCY (SW FRANCE) – FROM MARGINAL SCAVENGING TO A KILL-BUTCHERY SITE, AND BACK

Abstract

This paper reports a long stratigraphic Pleistocene/Palaeolithic sequence from Marine Isotope Stage (MIS) (8)-7 to MIS 4-3, discovered in a karstic system in south-western France, where two chronologically complementary archaeo-palaeontological sites were uncovered. The sites provide a global overview of biological (*sensu lato)* events happening at the same locale over time, in which herbivores, carnivores and humans all played a role. Several multi-disciplinary studies have been conducted and a first synthesis is proposed, which greatly complements our knowledge about subsistence strategies in Early Neanderthal and in Neanderthal populations.

Keywords

Karstic sites, south-western France, natural trapping, predators, human subsistence, Neanderthal

INTRODUCTION

Karstic environments – caves and sinkholes – provide favored habitats for many vertebrate and invertebrate species. Predators in particular, both human and non-human, use these places on a regular basis, often for limited periods only, according to their seasonal cycles of activities. Their often-alternating occupations in the caves leaves waste, which tends to mix and form amalgams or palimpsests in the fossil record. It is therefore interesting to disentangle the succession of these occupations and their chronology, and to determine their modalities. The abundance, nature and condition of fossil remains, the presence of lithic artefacts and the completeness of their *chaîne opératoire* allows us to distinguish primary occupations from more marginal, secondary occupations.

In the study of fossil assemblages, taphonomic resolution is often low. Nevertheless, major events as well as accumulating agents can be identified. Caves (horizontal entrance) and sinkholes (vertical entrance) can record and also preserve long chrono-stratigraphic sequences and significant fossil records.

One such case is represented by the karst sites of Coudoulous I and II (Lot) located in the middle hilly region of the Quercy in south-western France. Two archeo-palaeontological sites from the same karstic complex enable us to follow a succession of various occupations in one locale during a long time period, from the end of the Middle Pleistocene to the Late Pleistocene, spanning the period of Marine Isotope Stages (MIS) (8)-7 to MIS 4-3.

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.868.c11308

THE QUERCY REGION

The two sites of Coudoulous are located in the center of a mid-elevated limestone area (named *Causse*, ca. 350-450 m a. s. l.) in the Quercy region, which is dissected by east-north / west-south running rivers (Dordogne, Lot, Célé, Aveyron rivers), coming down from the margin of the Massif Central to the Aquitaine Basin. The landscape is mainly characterized by plateaus and relatively narrow valleys bordered by limestone cliffs. This region yields numerous Palaeolithic and palaeontological sites, mostly located in caves and rock-shelter (Jarry et al., 2013). The hydrographic network and geological nature (mainly Jurassic) of the region explains the particularly high density of karstic cavities, composing of mostly caves and sinkholes (Brugal et al., 2006). Most of these sites yield a more or less large quantity of fossil material, especially bones of large ungulates which have fallen into these natural traps. Large Pleistocene animal populations (of ten or more individuals) of horse, bison, and occasionally cervids are well known from this type of setting. The palaeobiological data that can be extracted from these locales are important for our understanding of past climatic conditions and the dynamics of mammalian communities during the Pleistocene (Brugal et al., 2013a). Together with two other categories of sites, i. e., dens and human occupations, these locales provide high resolution biotic frames which are important to better understand the precise subsistence (acquisition, consumption) and behavioral traits (competition) of human and non-human predators. Finally, human occupation in this region seems relatively continuous from the end of Middle Pleistocene to the Late Pleistocene (Jaubert, 1999, 2010; Jaubert et al., 2013).

THE COUDOULOUS SITES

Coudoulous is located near the edge of a limestone plateau, overhanging two rivers (Lot and its tributary the Célé) (**Fig. 1**) with alluvial terraces and surrounded by prominent vertical cliffs. Some topographical incisions provide a connection between the two biotopes. The alluvial terraces served as the main source of lithic raw materials for humans.

This site complex basically functioned as a sinkhole for the most part of its depositional history. Discovered in 1966, rescue excavations conducted by J. Clottes and E. Bonifay (1978-1980; e. g., Bonifay and Clottes,

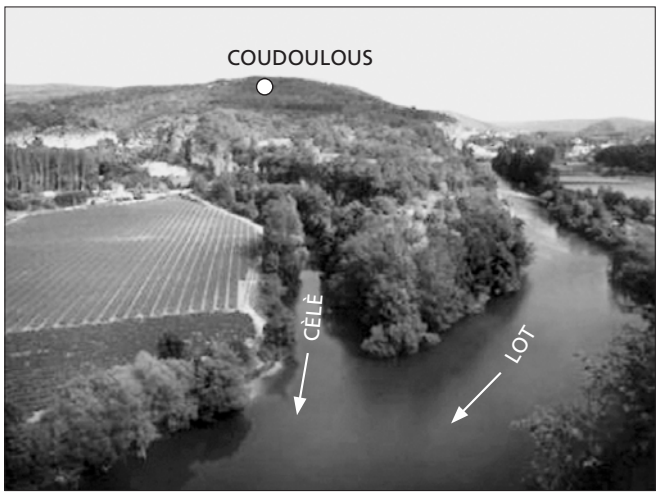

Fig. 1 Location of Coudoulous karstic sites on a plateau between the Lot and Celé rivers.

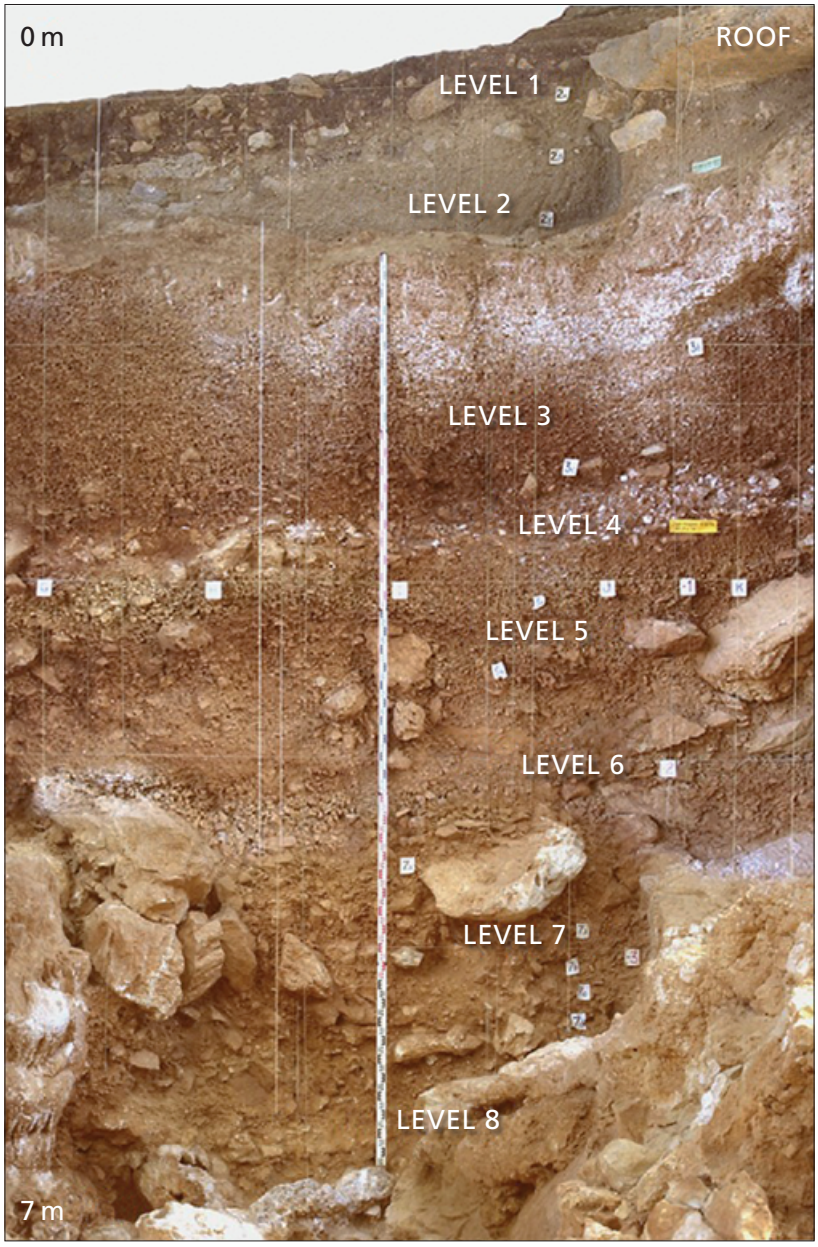

Fig. 2 Stratigraphic sequence of Coudoulous I.

1982) were followed by more intensive fieldworks (1993-2003) directed by the two authors of this paper. Interdisciplinary studies, undertaken during the field seasons, provided a general overview of the geological infilling and allowed us to determine the origins of the accumulations of bones and lithics, and their associations.

The combination of stratigraphic sequences from the two main deposits located in two distinct cavities provides a chrono-climatic record covering the time-span from ca. 300 ka to ca. 40 ka. The sequences yielded very rich and diversified faunal assemblages as well as different cultural layers that gave important new insights into both paleoenvironmental conditions and human subsistence strategies during at least MIS 7 to 3. Thus, Coudoulous provides the quite unique opportunity to follow the history of occupation of the locales in a diachronic perspective by studying the succession and interplay of biological and cultural agents.



Fig. 3 Example for bone (epiphysis) fragmentation with perpendicular fracture planes (Lower Unit – Coudoulous I).

Coudoulous I

Coudoulous I (see first synthesis in Jaubert et al., 2005) was partly destroyed by heavy quarry work. The geomorphology of the site, defined as a sinkhole resulting from the gradual collapse of the roof, constitutes a key-factor in explaining the occasional or more permanent occupations by carnivores and humans during the Middle Pleistocene. A complex sequence almost 8 m was subdivided into many strata and substrata representing four main units (**Fig. 2**): a basal part (levels 9-10) of karstic sterile clay; a complex lower part (levels 8 to 5) starting with a stalagmitic floor (basal sub-levels of level 8) and followed by detrital heterometric stones in clay-sandy matrix deposits (upper level 8 to level 5), a middle unit (levels 4 and 3) constituted of a rich assemblage of lithics and bones (level 4); and an upper unit starting with a thin stalagmitic layer and with levels 2 to 1. Only the lower and middle units yield diversified faunas and lithic artefacts. The chronostratigraphic scheme of this sequence is supported both by faunal remains (according to the degree of evolutive stage of some taxa, especially rodents) and radiometric dates (TL, ESR, TT-OSL and U/Th on speleothems of a stalagmite floor, and tooth enamel). The fossiliferous lower part of the sequence is bracketed between MIS 8-7 to 5, and level 4 clearly dates to MIS 6 (Jaubert et al., 2005; Couchoud, 2006; Hernandez et al., 2015; Fernandez et al., in press). The collapse of the limestone roof connected the endokarst with the outside, favoring sedimentation accompanied by the first evidence for animal and human activities (bottom of level 8). As the sinkhole became larger, making detrital sedimentation easier, the mid-part of level 8 to level 1 developed, until the complete filling of the cavity. The lower unit (levels 8 to 5) is characterized by the heavy impact of post-depositional processes (compaction, freeze-thaw action, flow-debris) as shown in the fauna by the low percentages of identifiable specimens (< 2,000), while more than 81,000 bones/teeth measuring less than 5 cm in length represent ca. 98 % of the total bone assemblage (levels 6b + 7abc yield the largest bone assemblages).

Bone breakage is very high and even epiphyses show perpendicular breakage patterns (**Fig. 3**). Micro fauna (studied by M. Jeannet, A. Louchart, O. LeGall) is very abundant (> 10,000 remains) and diversified (ca. 110

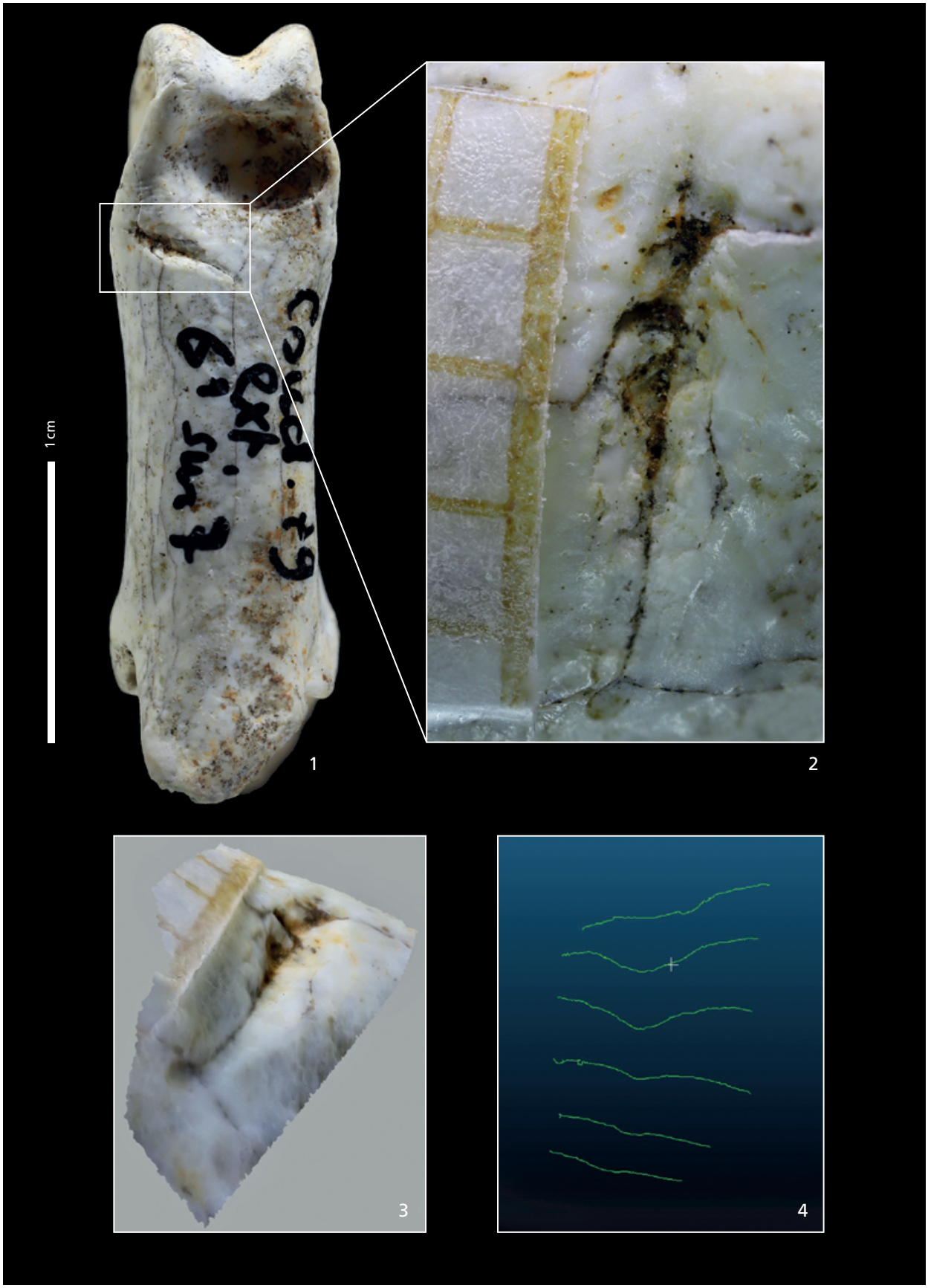

Fig. 4 Example for a cut-mark on a first phalanx of a raptor bird from Coudoulous I (level 6'/7).

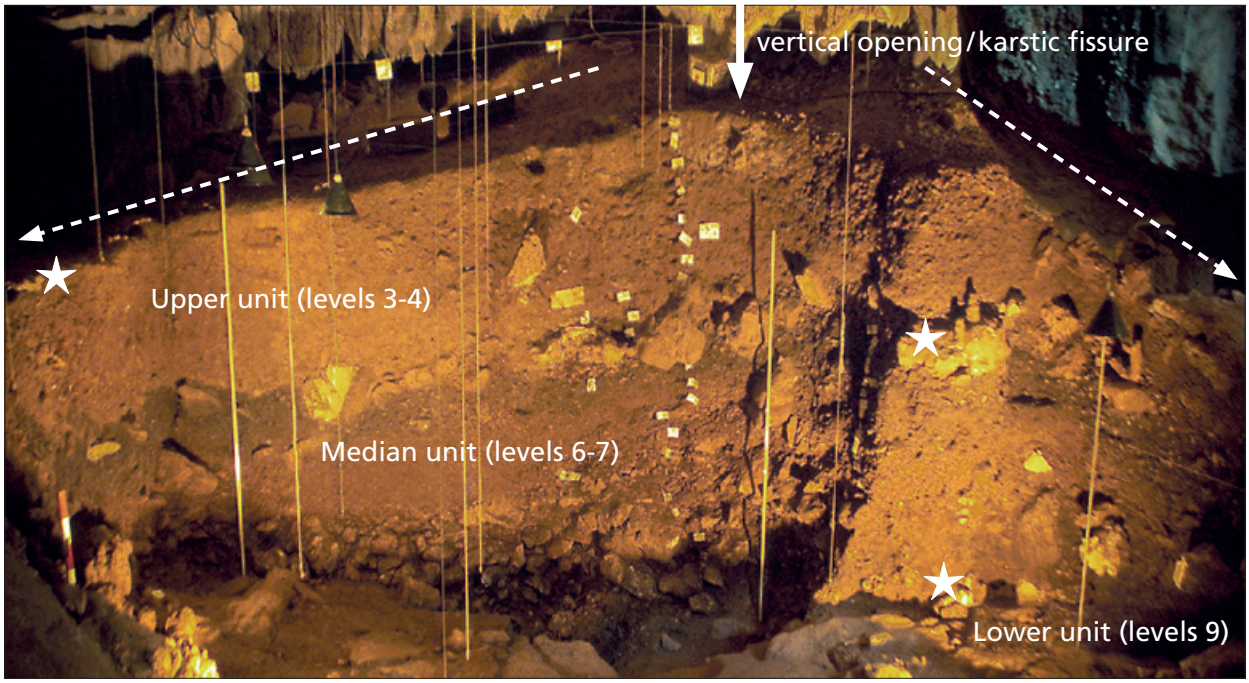

Fig. 5 Stratigraphic sequence of Coudoulous II. White star: Carbonate floor (from top to bottom = levels 2, 5 and 8).

rodent species, leporids, insectivores, chiropters, reptiles, amphibians, birds, fishes, mollusk). Ten herbivore species are represented, mainly comprising equids (*Equus c. mosbachensis*), bovines (*Bison priscus mediator*), cervids (*Cervus*, few *Capreolus* and *Dama*?) and caprids (*Hemitragus*, few *Rupicapra*), followed by a lower number of suid-, proboscid- (*Palaeoloxondon antiquus*) and rhinocerotid- (*Stephanorhinus*) remains. The main ungulates are represented by juveniles, adults and old adults. Of particular interest is the presence of fetus bones (especially from horse), indicating end of winter-early spring deaths. Twelve species of carnivores occurred, mainly represented by canid (*Canis l. lunellensis*: Boudadi-Maligne, 2010), *Cuon*, *Vulpes*] and Ursid (*U. deningeri*, very few *U. thibetanus*). Only rarely are felids (lion, leopard, lynx, wild cat) and mustelids (badger, polecat, weasel) documented. Some juvenile carnivores are present among the canids, ursids and felids (lion) and demonstrate use of the place during winter season for hibernation and reproduction. Coprolites have not been recorded, potentially due to taphonomic bias. Non-human predators are particularly abundant at the base of the sequence indicating a possible horizontal passage ('ghost' gallery) or at least easy entrance.

Both carnivores and humans occasionally left marks on the bone material. Few cut-marks were documented on bone shafts. Among these, a femoral condyle of a caprid (Brugal et al., 2006: Fig. 5) documents carcass dismemberment. A particularly deep cut-mark on a first phalanx of raptor bird (cf. *Bubo bubo*) also needs to be mentioned (**Fig. 4**). Only a few cases of bird exploitation have been reported for the Middle Pleistocene, becoming more frequent in later phases (e. g., Morin and Laroulandie, 2012; Romandini et al., 2014). Most of the bones are either complete, or show dry breakage. Green bone fracture and bone flakes are both rare, though their presence so far could indicate that humans interacted with the bones, as do few burnt black bones attesting to the use of fire (level 6b and 5). These data on faunal material reveals an opportunistic and discrete intervention by humans.

In the lower unit, lithic material is rare (around 100 pieces) and spatially dispersed. The strictly local and very diversified raw material used for lithic production (microgranite, quartz, quartzite, basalt, jasper, etc.)

derived from the alluvial terrace, 100 m down the valley. Among the lithics heavy-duty cutting tools produced on cobbles (hammers, cores, choppers, few flakes and one large cutting tool) are mostly represented. They can be attributed to the Acheulian of south-western France (Jaubert, 1995, 1999; Jaubert and Mourre, 1996; Mourre, 1996; Turq et al., 2010; Colonges et al., 2013). Predator dens and above all, natural deaths are responsible for the bioaccumulations. The stratigraphic sequence was interpreted to reflect a natural ungulate trap with only marginal scavenging.

Level 4 is the main anthropic level. The 30-50 cm thick deposit dates around 160 ± 20 ka and 148 ± 11 ka (MIS 6) and yielded a rich Early Middle Paleolithic (EMP) industry made on local quartz, quartzite (n > 3,000, discoid, bipolar on anvil) and flint (n = 108, Levallois) (Jaubert and Mourre, 1996; Faivre et al., 2013). Use wear analyses (n = 79 tools) demonstrated that the production of shape flakes mainly served butchering activities, but also woodworking and working of dry hide. Comparison with experimentally obtained data (Venditti, 2014) indicates that some of the pointed flakes were used as projectiles (spearheads). Some of these flakes show tip breakage that occurred together with localized, meat related use-wear.

Around 98 % of the associated fauna (plus a few remains of horse, wolf, red fox and beaver) represents steppe bison, with more than 230 individuals recorded in the 25 m^2 excavated. All parts of the skeleton are present (with a taphonomical bias toward axial and spongy parts such as cranials and horn-cores), and metric attributes show the presence of mostly female individuals. Bones in articulation are common and were especially represented by the distal parts of legs and dental series.

A catastrophic mortality pattern with a dominance of juveniles and young adults is evident (Brugal, 1999a; Brugal and David, 1993). Dental wear studies and skeletochronology (H. Martin, unpubl.) indicate recurrent late spring to early summer deaths. Finally, anthropic modifications are relatively numerous, with green bone fractures, cut-marked bones and few localized small burnt bones. This impressive evidence was analysed, with a combination of taphonomic and isotope data (Bernard et al., 2009) as well as studies of sex and age, with reference to eco-ethologic data as well as typo-technology and raw material studies (Bernard et al., 2009). Interpretation suggests several recurring seasonal hunting events on a single prey species by Early Neanderthal groups (Brugal, 1999b), by driving part of the herds into the pit-fall, which during this time period formed a wide opening, subsequently followed by focused exploitation. Such hunting events were part of organized planned activities of structured human groups.

Coudoulous II

Coudoulous II is a complex cavity, with a 3 m deposit showing a detrital cone (**Fig. 5**) coming from a vertical narrow opening, which is actually blocked (in comparison to Coudoulous I) (Brugal, 2006). Three main units are subdivided by three main speleothems: levels 2, 5 and 8 (from top to bottom) (Kervazo et al., 2008). They have been dated by U/Th series (Y. Quinif) and provide a chronological sequence bracketed between MIS 6 to the beginning of MIS 3. The middle part of the sequence contained a well-preserved interglacial deposit (MIS 5 *sensu lato*), with humic horizons, the presence of charcoal remains, as well as faunal and lithic material (see below). It is important to note that the Coudoulous II chronosequence completes and chronologically complements that of Coudoulous I.

The lower unit (level 9) represents a bone-bed with many complete bones, often found in semi-anatomical connection (Uzunidis and Brugal, 2018; Franch, 2020) (**Fig. 6**). Herbivores are dominant, and a morphometrical study and dental wear analyses were used to determine the precise evolutionary stage of several taxa as well as paleoenvironmental conditions. The ungulate species are *Bos primigenius trochoceros*, *Bison priscus*

mediator, *Equus* cf. *mosbachensis*, *Coelodonta antiquitatis*, *Stephanorhinus kirchbergensis*, *Mammuthus intermedius* (*sensu* Labe and Guerin, 2005), *Cervus elaphus* (of a large size), *Rangifer tarandus* and *Dama dama.* Carnivores are rare and mainly represented by wolf (bigger that the *lunellensis* form), red fox and steppe polecat (an almost complete articulated skeleton of *Mustela eversmanii*), with very few remains of bear, lion and cave hyena. Comparative analyses allowed us to infer the chronology of the level, attributed to the very end of the Middle Pleistocene. In this level, the large ungulates represent a faunal association with temperate and cold species indicating the transitional period between the Middle- (MIS 6) and Late Pleistocene (MIS 5e), a period still poorly known in the Quercy region and beyond. This level lacks evidence for hominid or carnivore activities and provides a clear picture for a natural bone deposit formed by carnivores and ungulates that had become trapped in the cavities.

The middle part of the sequence (levels 7 and 6) is attributed to MIS 5 (incl. its sub-stages), with temperate species dominating the bone assemblage, comprising of cervid species (red deer, fallow deer, roe deer), a few bovids, and suids. The material is dispersed and fragmented, with many juvenile specimens. With less than 5 %, carnivora are rare with canids (wolf, red fox), lynx and badger not known to accumulate bones. The natural presence of charcoal indicates a forested and mild environment with hornbeam (66 %), blackthorn (16.1 %), oak (9.4 %), and maple (7.1 %) (Théry-Parisot et al., 2008). All these bioaccumulations are interpreted as of non-anthropogenic origin. However, several lithic artefacts (n = 71) occurred in these levels, displaying a very diverse raw material spectrum with flint, quartz, metaquartzite, and granite. Some bones showing green fracture and scarce cut-marked bones (studies in progress), reveal a discrete human presence and minor carrion exploitation.



Fig. 6 Semi-articulated distal front leg (metapodials, phalanxes, sesamoids) from *Bison* from level 9 at Coudoulous I.

The upper unit (levels 4 and 3) forms a thick deposit of clay and clastic elements. The faunal analysis was based on the material from Brugal's excavations (NISP = 1,452, Costamagno, 1999). Herbivores represent 79.5 % NISP with ten species present. Among these cervids (*Cervus*, *Rangifer*, *Capreolus*), bovids, and caprids (*Rupicapra*) dominate, followed by Equids (mostly *E. hydruntinus*) and some suids. Juveniles are numerous (overall 17.9 %, including fetal bones). Carnivores are mainly represented by adults, and constitute 20.5 % NISP of the assemblage, comprising seven species: canids (*Canis*, *Vulpes*) and hyenids (*Crocuta*) are the most abundant species, then felids (*Panthera spelaea*), ursids (*U. arctos*) and Mustelids (*Meles*, *Putorius*). Such associations correspond to a cool and relatively dry environment (mosaic landscape) dated to MIS 4 and early MIS 3. During this period, the Quercy region is peculiar and during the Pleistocene the documented biocoenosis quite often shows a mixed picture (Brugal et al., 2013a). Taphonomical analysis demonstrates that the cavity was not used as a carnivore den even though around 18.3 % of the bones are tooth-marked (mainly deer and bovid bones and few bones of wolf and red fox). Less than 40 lithic artefacts of bad quality were documented and the fauna lacks clear evidence for human interference. The association of animals and artefacts could be purely accidental (cf. Villa and Soressi, 2000). Conclusions report a mainly natural accumulation formed by ungulates trapped in the cavity that attracted human- and non-human predators, which probably removed portions of meat from the cavity. For a more refined perspective complementary analyses are still needed to integrate material unearthed during fieldwork undertaken by Bonifay and Clottes.

DISCUSSION

Karst systems can yield bone- and/or lithic assemblages that reflect the use of the site by human groups for diverse purposes (base or seasonal camp, hunting place or bivouac). Carnivores equally use these systems, mostly for denning or hibernation. Moreover, some sites with vertical access/opening i. e., sinkholes or pitfalls are characterized by a huge amount of bone material originating from accidental deaths (trapping), particularly of ungulate individuals. Such natural accumulations are very common in limestone areas throughout the Neogene and the Pleistocene. They contain a huge number of individuals ('populations'), often well preserved, and thus are an important source for palaeontological studies. The Query region is particularly rich in karstic sites and many sinkholes, which are known to yield rich and diversified faunal records (e. g., Castel et al., 2018; Coumont et al., 2013).

Coudoulous (Coud I & II) are of particular importance as i) both sites represent sinkholes, with a wide (Coud I) or narrow opening (Coud II), ii) they display a long stratigraphic sequence (ca. 12 m cumulative thickness), iii) they cover the long chronological sequence from MIS 7 to MIS 3, iv) they yield abundant remains both of fauna and lithics, whose quantity and nature vary according to level. It is therefore possible to follow the biological dynamics (including humans) of these deposits over a long period of time at the same locality within a similar geomorphological context.

Table 1 summarizes the main characteristics of the material from the main levels at Coud I and II. Most of the bone assemblages are of natural origin with herbivores trapped in the pitfall. Five models for site use distinguished by different degrees of predator involvement have been postulated (Tab. 2). Level 4 - Coud I represents the only major archaeological layer with a predominance of a single prey species (bison), interpreted as a kill-butchery site. Complete or partial herds were driven into the sinkhole during repeated, unselective, but controlled communal and seasonal hunting episodes, and it might be possible that knowledge about site use was transmitted over several generations. Paleolithic large-Bovid assemblages are recognized throughout the Middle to Late Pleistocene (Jaubert and Brugal, 1990; Farizy et al., 1994; Gaudzinski, 1996,

		Coudoulous I				Coudoulous II		
		Layers 7+8	Layer 6	Layer 5	Layer 4	Layer 9	Layers 7-6	Layers 4-3
	MIS	(8)-7	7	7	6	6-5	5	4-(3)
	bones [n]*	12,500	6,000	3,500	> 10,000	3,500	2,500	11,000
	NISP [%]*	6	2	3	40	50-60	75	28
Carnivores	main species	canid + felid + ursid	canid	canid	(canid)	canid	canid (felid)	canid, hyenid
	gnawed bone	++	+	+	no	0	very few	18.3 % NISP
	coprolites	0?	0	0	0	0	0	4
Carnivore/ Human	green fracture	++	+	-	+++	no	very few	very few
Humans	lithics	50	20	34	> 3,200	0	71	35
	cut-marked bones	2	1	2	++	0	7	1?
	flaked bones	+	+	+	++	0	+	-
	burnt splinters	0	3	10	very few	0	3	0
Herbivores	main species	horse, bison, red deer, thar			bison	horse, bison, red deer	cervid	cervid, bovid
	main age structure	fetus + juv. + ad.			juv. to adults	adult	ad. (level 6) + juv. (level 7)	(fetus) + juv. + ad.

Tab. 1 Synthesis of main features from the main units at Coudoulous. MIS Marine Isotope Stage; NISP Number of Identified Specimens; juv. juvenile; ad. adult. * estimated value; canid = wolf, red fox.

2005; Brugal, 1999a, 1999b; Brugal et al., 1999), and Coud I probably accounts for one of the oldest testimonies of such monospecific game acquisition. The Quercy region is rich in Middle and Upper Paleolithic sites and bison seem to have been a regular and common prey-resource for various human groups and societies (Brugal et al., 2013b).

With the lower unit of Coud I and the median unit of Coud II, additional human site use patterns were documented. These levels yield very few lithic artefacts, and based on the analysis of the naturally accumulated bones, marginal and opportunistic scavenging is respectively suggested. Non-human predators were evidenced in the first case which implies higher risk and competition for humans whereas the other carnivore species were involved in opportunistic scavenging in the second case. Finally, two other hominid site use models are reported from Coud II. Layer 9 lacks any evidence for carnivore involvement, whereas in layers 4-3 several scavenging processes are visible. Hyenas were only documented in these levels, while mainly canids (wolves) typically play the major role in the remaining sequence. Canids are more regularly reported in the Middle and Upper Paleolithic sites in the Quercy region (Brugal et al., 2013a: tabl. 4).

This marginal exploitation strategy might relate to the frequent occurrence of herbivorous trapped in the karstic pitfall during different Pleistocene phases. With one sinkhole per 2 km² estimated, the density of sinkholes in the *Causse* limestone plateau bordering the French Massif Central is quite high (Brugal et al., 2006). Many of them contain fossil Pleistocene faunas. Human and non-human predators observed the regularly occurring accidental trapping of herbivores, which led to the primary exploitation of these karstic environments that were sometimes rich in well preserved carcasses. Compared to open-air sites where decay

is more rapid, these settings are favorable for scavenging, with their settings also allowing human groups to use these holes as traps to push and drive herds, as observed in the level 4 of Coud I.

Different pictures emerge, from marginal (and methodical) scavenging to active hunting (both in Coudoulous I), followed by the return to marginal scavenging (Coudoulous II) for Early Neanderthals/Neanderthal groups. We observe the co-occurrence of small lithic assemblages, comprising technologically simple stone tools made from local materials, and bones displaying few cut-marks (meat removal) and green bone breakage (marrow procurement) indicating potential food procurement. These lithics and bones are found in closed association with natural bone accumulations, and though a direct causality is difficult to demonstrate, the record at least shows the presence of humans around (and inside?) these sinkholes. But how can we explain this human presence? The numerous carcasses within the karstic traps may have been a discontinuous phenomenon, and were probably a seasonally occurring phenomenon. 'Occupations' by humans were probably very short, ephemeral and even discrete, without leaving clear trace of their activities. However, we think that these palaeontological sites with some lithic artefacts are relevant for assessing variabilities in hominid food-management and meat procurement by scavenging (for this hypothesis, cf. Brugal and Jaubert, 1991).

The adaptive framework of meat-eaters basically follows three strategies to exploit large ungulates (Houston, 1979: 265-266) 1) by predation: killing prey is often risky and requires time, energy, a strategy and hunting weapons; 2) by scavenging from a predator kill or predator accumulations (den): food is generally of low quality and it can be risky to frequent such places (higher interspecies competition); 3) by locating and scavenging from animals that died due to starvation, disease or accident (i.e., unconnected to predation), a strategy that introduces seasonal exploitation to this kind of mortality. Indeed, mortality is not uniform throughout the year. On the east African plains, two third of ungulate deaths fall into category 3, which delivers the main food supply for non-human predators during certain times of the year. Such a strategy can be applied to the modelled conditions prevailing at karstic systems on the European limestone landscape, with its combination of a high density of pitfalls and frequent incidents of animal trapping during the Palaeolithic/Pleistocene.

Such sites attracted all kind of predators, and in the case of the Quercy, large canids are the most common species and therefore an interdependence with human prehistoric groups could be assumed to some extent. These sites are concentrated in distinct areas and the risk of confronting other predators is highly possible (also called aggressive scavenging). An alternative view outlines the dynamics in these areas as an example for ecological interaction, expressed in the term *ecosystem service* for early humans (Moleon et al., 2014). The presence of canids around sinkholes where herbivores have been trapped helped to locate carcasses to benefit human groups (Moleon et al., 2014). In addition, these natural processes might have inspired humans to actively develop the use of these trap-sites within the frame of cooperative

	Coudoulous I		Coudoulous II		
	Layers 8-5	Layer 4	Layer 9	Layers 7-6	Layers 4-3
MIS	(8)-7	6	6-5	5	4-(3)
Origin	natural trap	hominid trap	natural trap	natural trap	natural trap
Hominid	low (scav.)	high (hunt)	0	low (scav.)	0
Carnivore	high (den + scav.)	0	0	0	high (scav.)

Tab. 2 Patterns recorded for the main units/layers at Coudoulous. MIS Marine Isotope Stage; scav. scavenging.

hunting (for a discussion on the origins of cooperation in hominins, cf. Smith et al., 2012). Among predators, the relationship between humans and wolves is very special, based on mutual fear and fascination. This relationship goes back to the "dawn of time", and might have begun with some extent from of commensalism and proto-domestication. 'Wolf' becoming 'dog' is one of the first and most ancient bonds between humans and animals.

CONCLUSION

The long Palaeolithic sequence of the two sites at Coudoulous constitutes a significant archive for our knowledge about the socio-economic dynamics of prehistoric groups and provides information about other non-human predators, mammal associations, and the paleoenvironment. Study of the main characteristics from the main units of the two chronologically complementary sites Coudoulous I and II, covering the long period between MIS 7 to 3, allows us to propose five distinct scenarios or patterns. These scenarios combine the origin of ungulate deaths (primarily natural) and two predators, carnivores and humans, against the context of the sites topography, i. e., cavities that functioned as pit-falls.

Geotopography is important when considering the location and accessibility of these features. This last point, accessibility, is especially relevant for quadruped and biped species. Humans are more easily able to ascent the vertical walls of a sinkhole. The mode and nature of bone accumulations is variable, with complete carcasses found in pits. Fragmented and dispersed material is expected in cave situations that are riskier due to the possibility of encountering other carnivores.

Finally, human involvement, in terms of degree of occupation and the resulting cultural debris, shows again a different picture. It can be assumed that the presence of humans in sinkholes would be short, encompassing just the necessary time to collect fresh portion of carcasses. Humans leave very few or no lithic artefacts or traces on bones. The examples given above supports the idea of discrete human involvement with some of the carcasses found in these natural accumulations. The chronology of the record from Coudoulous starts with some cases of marginal scavenging followed by an intense hunting event, with a later return to marginal scavenging. This evidence demonstrates the regular, non-exclusive use of these two strategies, with a significance of these strategies for the course of human evolution not evident.

Hominid food acquisitions using animals trapped in sinkholes could be considered as an original subsistence behavior, marked by the systematic monitoring of small karstic territories on a regular and seasonal basis. These sites with vertical entrances are hardly accessible to quadrupedal (carnivore) animals, while bipeds are more able of climbing and exploiting carcasses that have fallen into these wells. In addition, these cavities could function like fridges, promoting preservation and benefiting the body/nutrient conservation (Brugal et al., 2006: 8). These factors must be considered during food exploitation, especially when animal resources were scarce. However, for past human groups this opportunistic tactic does not serve as a reliable foraging strategy throughout the year, as humans adapt according to context, using various and complementary strategies (hunting, scavenging or simply collecting) to ensure their subsistence.

Acknowledgements

The multidisciplinary studies of the Coudoulous sites (excavations funded by Min. of Culture, Occitanie archaeological Service DRAC; Coud I: resp. J. Jaubert, Coud II: resp. J.P. Brugal) is object of an entire team of specialists and we would like to name here and warmly thank: A. Argant, J.J. Bahain, M. Boudadi-Maligne, I. Couchoud, M.P. Coumont, C. Falguères, P. Fernandez, C. Franch, M. Girard, M. Hernandez, M. Jeannet, B. Kervazo, B. Labe, F. Lacombat, V. Laroulandie, N. Lateur, O. Le Gall, C. Lécuyer, C. Lemorini, J.B. Mallye, H. Martin, N. Mercier, V. Mourre, Y. Quinif, I. Théry-Parisot, F. Venditti.

Finally, I (J.P.B.) would like to express an '*amical salut*' to my colleague E. Turner, and to thank S. Gaudzinski-Windheuser and O. Jöris to give us the opportunity to participate to this tribute and greatly improve the quality of a first draft of this paper.

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PAST HUMAN ADAPTATIONS IN CENTRAL ASIA AND THE PEOPLING OF EURASIA: INSIGHTS FROM A MULTIDISCIPLINARY INVESTIGATION OF THE OBI-RAKHMAT SITE (UZBEKISTAN)

Abstract

This article presents the results of a zooarchaeological study of the faunal remains from Obi-Rakhmat (Uzbekistan), a key Palaeolithic site in Central Asia, to understanding the peopling of Eurasia by Neanderthals and Modern Humans and the origins of the Upper Palaeolithic. The site is of particular interest for its peculiar lithic material associated with a long and well-dated multi-layered stratigraphy, which includes the Middle to Upper Palaeolithic transition. Due to the sedimentological and depositional context and harsh climatic conditions, bones are usually not preserved in Palaeolithic sites of this region. Thus, the preservation of animal and human remains at the site is remarkable.
This paper focuses on a taphonomic, zooarchaeological and typo-technological study of the osseous and lithic remains from layer 16 of Obi-Rakhmat. The study allows the reconstruction of the environment and subsistence behaviour of the populations that left the remains found in this layer. Several lines of evidence support the contemporaneity of the archaeological and human remains, which comprise of a fragmented young adulescent scull cap.
The implications of the site for the global understanding of Neanderthal/Modern Human interactions in their eastern-most habitats, as well as Neanderthal demise, are discussed. The apparently long and persistent presence of Neanderthals in Central Asia is considered in a broader perspective, and alternative scenarios concerning general current models on the peopling of Eurasia by Modern Humans and the origins of the Upper Palaeolithic are proposed.

Keywords

Central Asia, Obi-Rakhmat, Middle/Upper Palaeolithic, peopling

INTRODUCTION

The transition between the Middle and Upper Palaeolithic (hereafter MP/UP) takes place during the Weichselian Interpleniglacial (or MIS 3), with a generally fairly temperate and humid climate marked by three colder events known as Heinrich events. In the centre of the Eurasian continent, the MP/UP transition is characterised by the appearance of new lithic and bone industries called transitional industries (Chabai, 1998; Chabai et al., 2004; Derevianko, 2001; Derevianko et al., 2000; Marks, 1998; Zwyns and Viola, 2014) and by the presence of three human species: Neanderthals, Denisovans and the first Anatomically Modern Humans (hereafter AMH) (Krause et al., 2007; Trinkaus, 2005, 2006; Vishnyatsky, 2004). In this vast geographical area, the modalities of the arrival(s) and dispersal(s) of AMH and their associated cultural traditions are still relatively poorly known, as are their possible biological and cultural interactions with Neanderthals and/or Denisovans. Research on subsistence behaviour of the last Neanderthal societies of Eurasia has shown that some populations had a lasting stabilised relationship with their environment (i. e., persistency of territories and behaviour) (Chabai and Patou-Mathis, 2009; Patou-Mathis and Chabai, 2005; Patou-Mathis et al., 2020) while other populations underwent economic and socio-cultural changes (i. e., new *savoir faire* and

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.868.c11309

territories) (Derevianko, 2001; Hublin et al., 2020). Based on a diachronic and synchronic study of animal resource management modalities, both for dietary and non-dietary purposes, we attempt here to characterize the subsistence behaviour of potentially the easternmost Neanderthal populations in relation to those attributed to the first AMH, as well as between different so-called transitional techno-complexes. We will focus on the study of subsistence behaviour at one site in Uzbekistan: Obi-Rakhmat. Placed in their ecological and cultural contexts, we will discuss the contribution of data obtained to current animated scientific debates on the MP/UP transition in Central Asia that is still not comprehensively investigated.

STUDY SETTING

The Obi-Rakhmat site (thereafter O-R) is located in Central Asia, on the foothills of the Western Chatkal Mountains in North-Eastern Uzbekistan (**Fig. 1: a**). Located 1,200 m above sea level, the site is a collapsed cave which is now a small rock shelter (**Fig. 1: b-c**). The entrance faces south in the direction of a canyon drained by a river. The site is watered all year long by a natural spring. Archaeological investigations were performed during the 1960s by the Uzbek Institute of Archaeology and since the late 1990s by the Institute of Archaeology and Ethnography of the Siberian Branch of the Russian Academy of Sciences. Andrei Krivoshapkin directed the last excavation campaigns and research.

In this region the majority of Palaeolithic sites are represented by open-air sites with a single archaeological layer. Long stratigraphic sequences are very rare. In this context, O-R is an exception as here, an impressive sedimentary sequence composed of 22 archaeological layers, measuring 10 m in thickness, survived (Mallol et al., 2009) (**Fig. 1: c**; **Fig. 2: a-b**).

Different radiometric dating methods have been applied to investigate the chronology of the O-R deposits, including AMS, U-series, ESR and OSL. The chronology of the sequence is now well known (**Fig. 2: a**), with the top of the sequence (i. e., the top four layers) younger than 40,000 uncal BP, layers 5 to 14 dating between 40,000 and 50,000 uncal BP, and layers 15 to 22 older than 50,000 BP down to about 80,000 BP (Blackwell et al., 2006; Krivoshapkin et al., 2010; Skinner et al., 2007; Wrinn et al., 2004).

The lithic industry of the site is composed of a mix of Middle and Upper Palaeolithic tool types (**Fig. 2: c**), such as numerous points of different morphology (including elongated Levallois points or pointed blades), burins, and side-scrapers on blades. Core reduction demonstrates a combination of strategies characterizing the Middle and the Upper Palaeolithic, mostly aimed at blade and bladelet production (Krivoshapkin et al., 2006).

In addition, in layer 16, close to 150 human remains have been discovered together with faunal remains. The different studies performed on the specimen show that the cranial and dental remains belong to a juvenile individuum (Bailey et al., 2008; Glantz et al., 2004, 2008; Smith et al., 2011). The cranial remains present features more characteristic of Modern Humans, while the more archaic morphology of the teeth suggests the dentition is essentially Neanderthal. This mix of characters is usually found in juvenile Neanderthals, making the specimen one of the easternmost known Neanderthals.

MATERIAL AND METHODS

Faunal remains dominate within the archaeological assemblage uncovered from the site. A large part of the faunal collection was studied and partly published by P. Wrinn in his dissertation. Wrinn studied the material

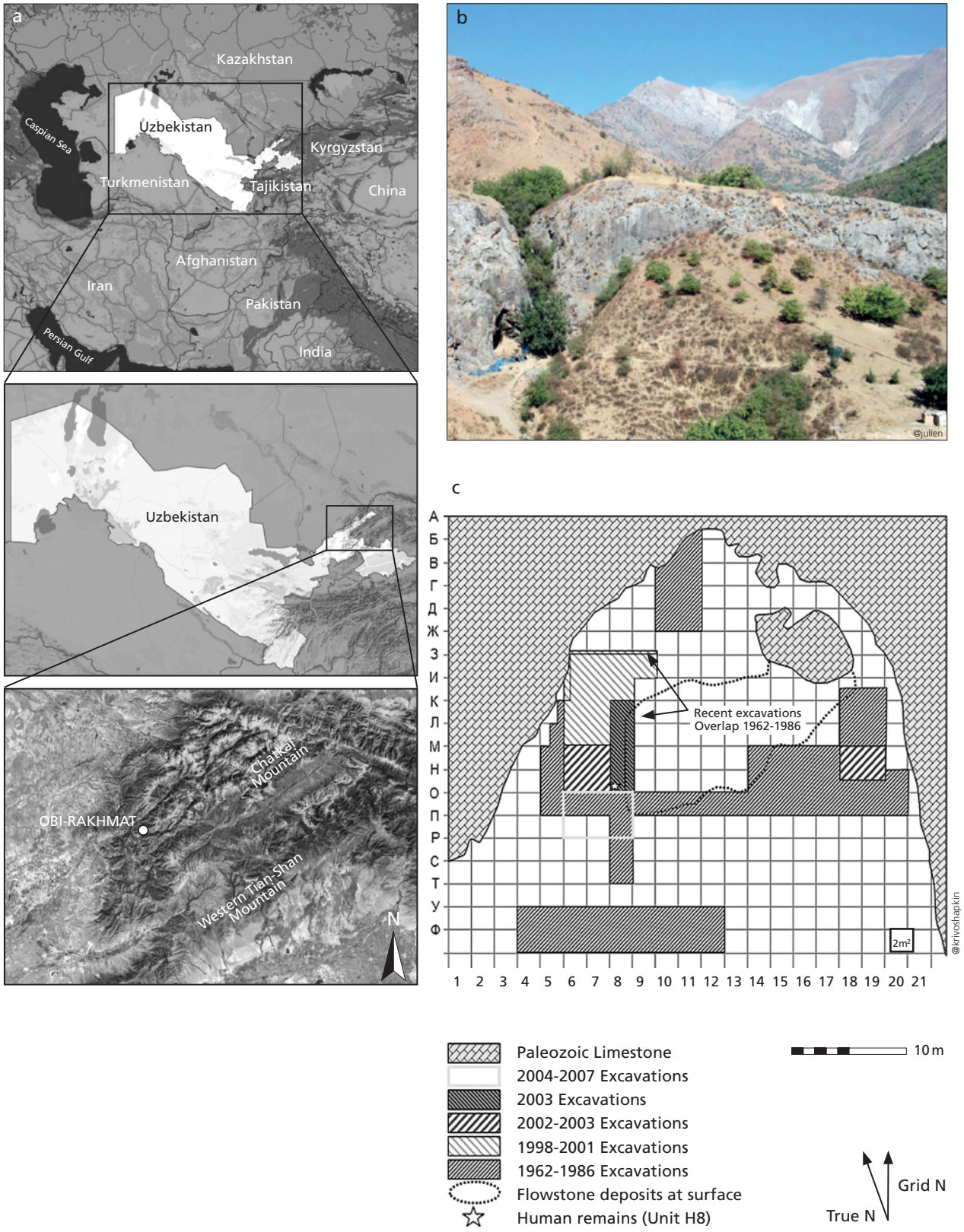

Fig. 1 Geographic location of Obi-Rakhmat rockshelter (Uzbekistan). **a** map location; **b** site view; **c** excavation plan in 2007. – (1a @wikipedia; 1b photo: M.A. Julien; 1c modified after Krivoshapkin).

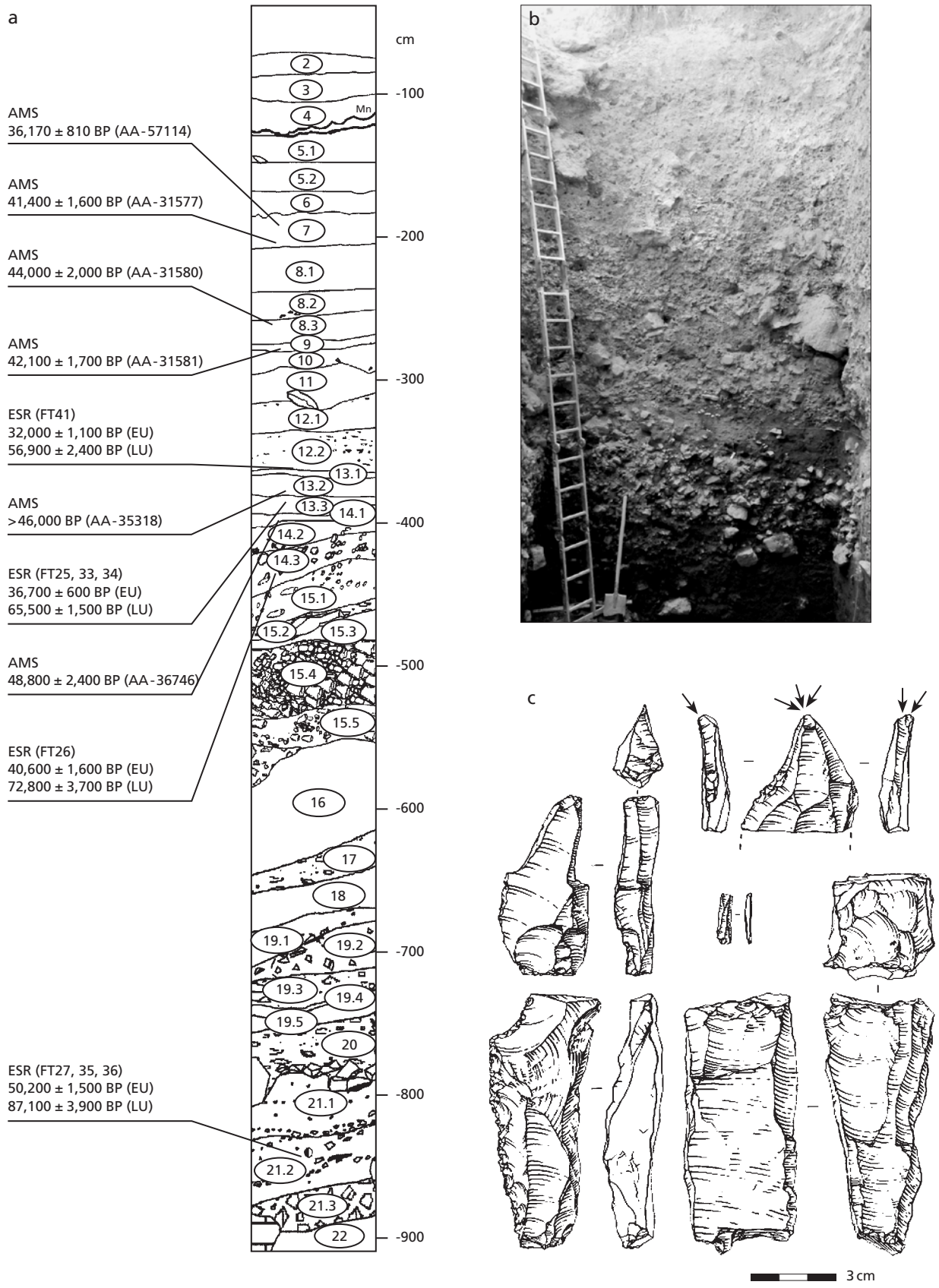

Fig. 2 Obi-Rakhmat. **a** synthetic chronostratigraphic sequence; **b** stratigraphy view; **c** examples of lithic artefacts. – (Modified after Krivoshapkin et al., 2006, 2010; Skinner et al., 2007).

from the first part of the excavation campaign (Wrinn, 2004). We analysed the material from the excavation performed by A. Krivoshapkin between 1998 and 2012 and our study can be considered to represent the first complete study of the faunal material from O-R.
In this paper we focus on the bone remains from layer 16, in which the human remains attributed to Neanderthals were found. Discovered in the summer 2003, these hominin remains represent the first additions to the human fossil record from Uzbekistan in over 65 years. We studied all faunal remains excavated in 1999 (Derevianko's excavations) and in 2000 - 2006 (Krivoshapkin's excavation campaigns).
No direct dating was performed on layer 16; however, dates from layer 14 gave an upper age limit of 48.8 ka uncal AMS ^{14}C, and a lower limit for layer 19 of between 50 and 80 ka by ESR (Blackwell et al., 2006; Skinner et al., 2007; Wrinn et al., 2004) (**Fig. 2: a**).
Taphonomic, paleoecological and archaeozoological approaches were applied to the study of the faunal material. Bones are described following standard parameters as the total Number of Remains (NR), the total Number of Identified Specimens (NISP) and the combined Minimal Number of Individuals (cMNI) (Brugal et al., 1984; Binford, 1981; Bunn, 1983; Lyman, 1994). Taphonomic analyses are based on the reading of alteration marks from climate-edaphic or biological (including anthropogenic) modifications. We used several archaeological, experimental and actualistic references to identify each kind of trace (Andrews and Cook, 1985; Behrensmeyer, 1978; Gifford, 1978; Lyman, 1994; Patou-Mathis, 1997; Shipman and Rose, 1988; Villa and Mahieu, 1991). Material was also determined by referencing the comparative faunal collection from the Institute of Archaeology of Novosibirsk.

RESULTS

Faunal spectrum

The faunal bone collection from the site is particularly rich, with almost 100,000 recorded remains (**Fig. 3**). Faunal remains are present in all layers, but 80 % of the material comes from the lower layers 12 to 21.
Very few species are present, with no major changes throughout the sequence (**Fig. 3**). Two species are omnipresent in all layers: *Capra sibirica*, the large Siberian ibex, and *Cervus* cf. *elaphus*, the Red deer. Siberian ibex and deer are always the most abundant species, both in NISP and cMNI (**Fig. 3**).
Other ungulates include roe deer and wild boar, present mostly in the lower part of the sequence, but only represented by a few remains. In addition, marmot and hare were also documented in the lower part of the sequence. Carnivore remains are very rare, the most common being the golden jackal and fox. Cave lion was only documented in layers 9 and 20; hyena, only in layer 21. A few bear remains were found in layers 19 and 21 (**Fig. 3**).
Layer 16 is relatively poor in bones: a total of 2,552 remains were unearthed from an excavated area of about 25 m². 2,363 bones (92,6 %) could not be attributed to species. Among the 189 bones determined to species (NISP), ibexes predominate (34,4 %) (**Tab. 1**). Red deer, roe deer, wild boar, golden jackal and hare were also identified, as well as four small bird bone fragments (**Tab. 1**). Forest taxa (red deer, roe deer and wild boar) were well represented.

Layer	NRT	NISP	cMNI
2	1,132	18	3
3	1,425	32	2
4	4,818	114	7
5	7,345	88	6
6	13	4	1
7	226	205	6
8	642	97	8
9	151	148	8
10	585	77	4
11	3,097	248	11
12	8,151	356	10
13	8,186	524	12
14	1,587	626	15
15	22,368	612	18
16	2,552	189	11
17	44	7	2
18	932	128	11
19	1,831	79	6
20	5,996	113	9
21	24,451	979	15
total	95,532	4,644	165

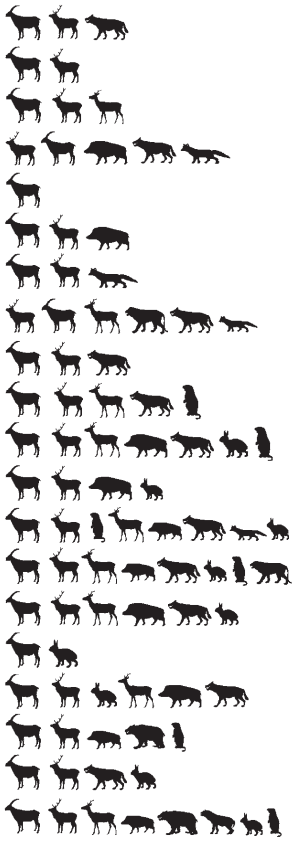



Fig. 3 Obi-Rakhmat. Stratigraphic quantification of the faunal spectrum. Total Number of Remains (NRT), Number of Identified Specimens (NISP) and combined Minimal Number of Individuals (cMNI). For each layer species are ordered from the most to the less frequent remains.

Taphonomy

The osseous material from Layer 16 is very fragmented: more than 88 % of the bones have a length of ≤ 2 cm. This fragmentation relates to weathering damage, mostly producing elongated bone fragments. Preservation of the bone surfaces is relatively good. Although climato-edaphic signals are scarce (0.7 % of the NR), they essentially occur due to percolation (mainly in the form of manganese deposition). We can therefore propose that climate was relatively temperate and humid after deposition. Moderate weathering indicates a regular and relatively quick sedimentation.

The action of plant roots is negligible, and traces of rodents and carnivores are absent. This may indicate that this level was not occupied by denning carnivores, and that they were probably not present at all. The relatively high percentage of bones with anthropogenic marks (10.01 % of the NR) results from the

numerous presence of burned bone(s) (242 remains, i. e., 94.5 %, distributed in all excavated squares). Six bone flakes and six bones with green bone fractures in form of percussion marks attest to the recovery of long bone marrow from ibex. Only two bones bear marks of butchery: an undetermined long bone diaphysis and a radius attributed to ibex. Corresponding to defleshing, they both come from square П7.

Skeletal representation

Ibex

Ibex is represented by 66 remains belonging to at least 5 individuals: 2 young, 1 sub-adult, 1 young adult and 1 elderly adult. The mortality pattern observed does not correspond to a natural profile. As carnivores did not play a role in the origin and taphonomic history of the bone assemblage from layer 16, the observed mortality could correspond to an anthropogenic hunting profile.

The majority of the bones belong to the cranial skeleton (NISP = 34) and to the autopodium (NISP = 28) (**Fig. 4**). The upper part of anterior limbs is represented by only four remains. The postcranial skeleton enables the calculation of an MNI of two: a young individual and an adult *sensu lato*.

A radius (**Fig. 5**) and a metapodial diaphysis, as well as two proximal phalanges show anthropic breakage. This suggests that the meat and marrow of long bones of at least two ibexes was consumed. Ibex remains were present in all squares excavated, without any clear spatial concentration.

Roe deer

Roe deer is represented by 15 bones, attributed to at least one adult individual *sensu lato*. Cranial remains are absent. The postcranial skeleton is represented by an element of the spine (head of the rib), a diaphysis of a humerus and 13 fragments of a total of eight bones of the autopodium. A distal end of a proximal phalanx is burned.

It is probable that this individual was brought into the cave as a complete carcass and subsequently consumed by humans. The roe deer bones mainly concentrated in squares H/M-6/7.

Medium size ungulates

According to their dimensions, 92 faunal remains that could not be attributed to species probably originate from ibex and/or roe deer. These bones mostly represent the axial skeleton (mainly fragments of ribs,

Layer 16	NISP	MNE	cMNI
Capra sibirica	66	38	5
Capreolus capreolus	15	10	1
Cervus elaphus	10	7	1
Medium-size ungulate	91	6	1
Sus scrofa	1	1	1
Canis cf. *aureus*	1	1	1
Lepus sp.	1	1	1
Small bird(s)	4	3	1
total	**189**	**67**	**12**

Tab. 1 Obi-Rakhmat. Faunal spectrum of layer 16 in Number of Identified Specimens (NISP), Minimal Number of Elements (MNE) and combined Minimal Number of Individuals (cMNI).

vertebrae and pelvis) and the autopodium. This relativizes the absence or the scarcity of these body parts observed for these two taxa.
Among the material, we identified a newborn from a germ of a decidual tooth and two long bone fragments. For this individual, death can be stipulated to the beginning of summer.

Other mammals
Among the remaining material, ten faunal remains correspond to at least one sub-adult deer: two teeth and eight bone fragments (corresponding to 5 bones) of the autopodium. A lower right incisor attests the presence of a wild boar, probably a female. A canid, tentatively attributed to the golden jackal, is represented by a first upper left premolar from an adult individual. Finally, a hare was identified by a cuboid fragment.

Human remains

Human remains from Layer 16 of Obi Rakhmat have been studied by different scholars (see Bailey et al., 2008; Glantz et al., 2008; Smith et al., 2011). They consist of six isolated (5 left and 1 right) permanent maxillary teeth (incisor, canine, two premolars and two molars) and over 121 cranial fragments (parietal, frontal, temporal, petrous, vault). All remains were recovered from layer 16 and they were found adjacent to the southern wall of the central 10 m deep trench (Bailey et al., 2008; Glantz et al., 2008; Smith et al., 2011) (**Fig. 1: c**). Their recovery, partially *in situ* and partially from the screening of the sediment, supports a strong spatial association of the remains in a single square meter (H8) (**Fig. 6**).
Anthropological analysis concluded that the most parsimonious interpretation of the O-R material is that it represents a single individual of roughly 9-12 years old (OR-1; Bailey et al., 2008). The highly fragmented

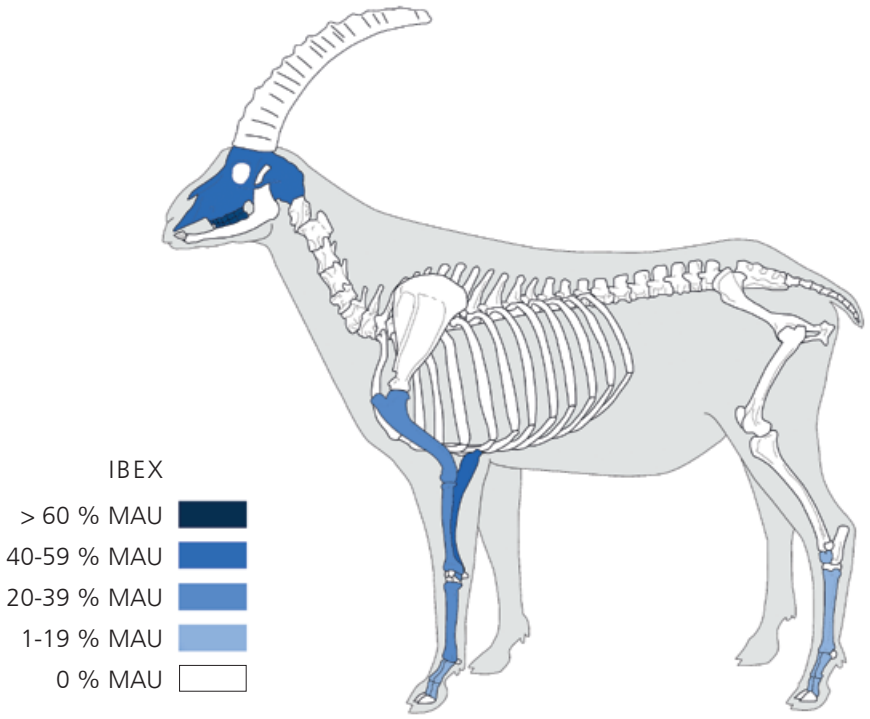

Fig. 4 Obi-Rakhmat. Skeletal representation of Siberian Ibex from layer 16 (in percentage of Minimal Animal Unit: MAU).



Fig. 5 Obi-Rakhmat. Fragment of a radius diaphysis (layer 16, square П7) of Siberian Ibex showing two cut-marks identified by the black arrows, and anthropic fracture. – (Photo: L. Crépin).

cranial pieces offer no clear indication for duplicate bones, in that they are distinct from the six isolated permanent maxillary teeth in terms of morphometrics or ontogenesis (Bailey et al., 2008; Glantz et al., 2008; Smith et al., 2011). Age estimates derived from an examination of relative root development and the degree of dental wear.

A mosaic of morphological patterns expresses a mix of archaic and modern features and the absence of key anatomical areas, like the mental symphysis, did not allow taxonomic identification. In summary, it is not clear whether OR-1 is a Modern Human (in the sense of Qafzeh and Skhul) or a Neanderthal (Bailey et al., 2008; Glantz et al., 2008; Smith et al., 2011).

Remarks on human remains taphonomy

The preservation of hominin cranial fragments is quite heterogeneous. Some fragments exhibit dark grey or black stains (possibly manganese deposits), but most bones are white or close to yellow (Glantz et al., 2009). The bone surface is relatively well preserved while in some cases the external surface is altered, as observed on the faunal remains. Most of the fracture angles resulted from post-depositional processes on dry bones, although few remains show curved bone edges. Some fragments display edge rounding (**Fig. 6**). Taphonomic variables observed on the human remains show the same characteristics as those found on the faunal remains. Thus, the taphonomic histories of both human and animal remains do not appear to have differed. The cranial remains display, however, slightly heterogeneous preservation. Several fragments showing very different preservation were refitted, with no evidence for duplicates. In this context, the absence of the



Fig. 6 Obi-Rakhmat. Parietal reconstruction of OR-1 composed of 27 cranial fragments. – (Modified after Glantz et al., 2008 and Krivoshapkin, pers. comm.).

mandible (as well as inferior teeth) is striking. This seems to indicate that the fragmentation of the cranium occurred shortly after deposition, and that some fragments were exposed to different sub-surface post-depositional influences despite their spatial proximity to one another. The absence of other human remains among the bones from layer 16 seems surprising, especially since a large area was opened up in the immediate vicinity of these remains during several excavation campaigns.

The human remains could derive from a secondary deposit of a young adolescent skull cap in a specific sector (square H8), that was subsequently affected by low fragmentation and limited alteration. This parsimonious hypothesis cannot be substantiated without a more complete excavation of Layer 16.

DISCUSSION AND CONCLUSION

The Obi-Rakhmat deposit is an exceptional archive of recurrent human occupations over several tens of thousands of years in a mid-mountain context. The quality, diversity and preservation of the remains make it an important site to understand how different waves of human populations developed and adapted in Central Asia.

Excavations at O-R have uncovered 22 archaeological layers. The upper part of the filling was dated between 36 ka and 41.4 ka uncal BP (layer 7) and 48.8 ka uncal BP (l.14) and the lower layers (layers 15 to 22) from > 50 ka BP up to about 80 ka BP (Blackwell et al., 2006; Krivoshapkin et al., 2010; Skinner et al., 2007; Wrinn et al., 2004).

The lithic assemblages of all layers of O-R show striking similarities with the so-called Early Middle Palaeolithic blade industries from the Near East (especially Hayonim cave – unit F, and Mysliya cave; Zaidner and Weinstein-Evron, 2020), from Tajikistan (Honako 3 site – PK2) and Uzbekistan (Pavlenok et al., 2016; Kolobova et al., 2018), which date back to more than 200 ka, while late Middle Palaeolithic/Transitional blade industries of the Altai Mountains in Siberia, date back to ~ 60 ka. This may reflect the long-lasting and gradual transition from the Middle to the Late Palaeolithic in the western part of Central Asia (Derevianko, 2001;

Krivoshapkin et al., 2010) or provide evidence of retention of the blade-based Early Middle Palaeolithic in Central Asia (Vishnyatsky, 2004).

The occurrence of forested species in the lower part of the O-R sequence documents forested biotopes in the vicinity of the site. Their absence in the middle and upper part of the sequence seems to result from a succeeding extension of steppe vegetation. The site of O-R records different depositional environments between the top and the bottom of the sequence, with colder and more arid conditions prevailing in the upper levels and more temperate climatic conditions in the lower layers. These levels are characterized by the development of soil horizons as reported by sedimentological and palynological studies (Mallol et al., 2009).

In the mountain areas of Central Asia, as well as for the O-R sequence, we do not observe any noticeable change in subsistence behaviour. Over several thousand years, an impressive resilience in subsistence is evident with only few and minor differences. Minor differences most likely reflect global climatic and environmental changes (which contributed to shorter occupations) rather than clear or abrupt cultural or traditional changes. In all likelihood, this shelter, at an altitude of 1,250 m, whose occupations appear to be mainly of short duration, has been used on numerous occasions as a hunting camp in the mountainous environment. The assemblage from layer 16 is not rich in faunal remains, but the assemblage attests to a classical subsistence behavior in that it reflects few activities mainly focusing on butchery during a short summer hunting camp targeting mid-size ungulates (mainly ibex and red deer).

A singularity of layer 16 is the presence of human remains showing a mixture of Neanderthal and modern traits, characteristic of juveniles (Bailey et al., 2008; Glantz et al., 2008; Smith et al., 2011). Moreover, a detailed understanding of the origin and history of that bone accumulation supports the hypothesis that the depositional association of human remains and archaeological remains seems not random and likely corresponds to the deposition of a human calvaria (without the mandible) in the living area.

On a large regional scale, around the site of O-R, different sub-contemporaneous human species have been recognized: Neanderthals at Teshik-Tash (Glantz et al., 2009), O-R and Aman-Kutan (presence of one human distal femur dated at about 50 ka) in Uzbekistan, Denisova, Okladnikov and Chagyrskaya in the Altai (associated with the Sibiryachikhian culture), and perhaps at Khudji (with a child incisor dated at 37-38 ka uncal BP) in Tadjikistan (Okladnikov, 1940; Ranov and Schafer, 2000; Trinkaus et al., 2000, Vishnyatsky, 1999). In addition, a few AMH remains were discovered at Anghilak in Uzbekistan (Glantz et al., 2003), and Denisovans at Denisova cave in the Altai (Buzhilova et al., 2017; Douka et al., 2017; Krause et al., 2010; Reich et al., 2010).

The mitochondrial DNA sequences of Teshik-Tash are similar to those of European Neanderthals, and seem to be more closely related to those of Scladina (Belgium) than to those of Okladnikov (Altai), which is geographically much closer. "Eastern" Neanderthals and European Neanderthals are thus said to have separated relatively late (Glantz et al., 2009). This observation could explain the late arrival of Neanderthals in Central Asia and Siberia, probably as late as in the Last Interglacial (Krause et al., 2007; Peyregne et al., 2019; Prüfer et al., 2013).

If, despite some Neanderthal characteristics, the fifth right metatarsal discovered in 2002 in the Anghilak cave in southern Uzbekistan does belong to a modern human, AMH were already present in this region between 43,000 and 39,000 years ago. This bone was associated with a 'Mousterian' lithic industry.

The mixed composition of the lithic industry at O-R points to a complex genesis of the Obirakhmatian, perhaps resulting from cultural interaction between different human populations. The absence of visible changes in behavioural patterns throughout the sequence, as indicated by the relative continuity in both the faunal and the lithic records, makes O-R of particular interest for our understanding of the MP-UP transition – or more accurately the absence of a clear transition – in Central Asia. It might however be possible that techno-economic characteristics relate to the specialized function of the site (hunting camp).

Various researchers have proposed that at least two major waves of AMH migration into Eurasia took place: a first wave of migration to the East about 70-80,000 years ago, with a probable cohabitation of different types of humans in Central Asia; and a second wave to the West that started some ~45,000 years ago, of populations possibly carrying Neanderthal genes, and indicative of a territorial cohabitation of Neanderthals and Denisovans (Buzhilova et al., 2017; Zwyns et al., 2019).

Recently a much earlier (>200 ka) dispersal of Modern Humans out of Africa was proposed, at least, within the territory of Southwest Asia (Hershkovitz et al., 2018). Moreover, this earlier migration wave was archaeologically associated with a lithic industry characterized by 'Levallois' blades (Zaidner and Weinstein-Evron, 2020) very similar, even though much earlier, to the industry of the O-R rock-shelter (Krivoshapkin et al., 2006, 2010). In some areas, the cultural traditions seem to have evolved independently of the different waves of migration, which could be due to the function of the sites in the specific habitat of the Tian-Chan mountain slope.

In any case, this part of Central Asia must be understood within the framework of a specific regional model of evolution and cannot directly be compared to other regions of Europe or the Middle East in terms of cultural traditions or peopling by different human species.

More work will be necessary to fully understand the human occupation at O-R and its significance in this key region for the peopling of Eurasia by Modern Humans and the emergence(s) of the Upper Palaeolithic. These questions remain open and our initial research shows the need to pursue studies in the region where several human species succeeded one another and probably coexisted at certain times and in certain habitats where they may have influenced each other.

Acknowledgements

We would like to thank our colleagues at the Institute of Archaeology who provided help and access to the archaeological collections and reference collections, especially S.K. Vasiliev. The research presented here has received the support from the Muséum National d'Histoire Naturelle (Paris) – ATM 'Relations Sociétés-Nature' (dir. S. Bahuchet, D. Couvet, M. Patou-Mathis), and the Carl Zeiss Foundation. The archaeological investigations of Obi-Rakhmat were supported by the Russian Foundation for Basic Research, project number 19-09-00453.

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LUTZ KINDLER

EVERY BONE CAN TELL ITS STORY. A REMARKABLE PATHOLOGICAL HORSE BONE FROM THE MIDDLE PALAEOLITHIC OF THE PFRIMM VALLEY IN PFEDDERSHEIM (RHINE-HESSE, GERMANY)

Abstract

The article presents the diagnosis and aetiology of an arthropathological horse (*Equus* sp.) radius from the Middle Palaeolithic site of Pfeddersheim (Rhine-Hesse, Germany). For the contextualisation of the results the chronological and archaeological frame of the site, the taphonomic history of the faunal assemblage and site formation are summarised. A fracture of the ulna caused a malposition of the humeroradial joint, that developed into a degenerative arthrosis with severe grooving of the articular surface of the radius, extension of the joint by new bone formation and exostosis around the epiphysis. The progression of the disease from the trauma to the final grade of arthrosis and how it affected the horse's life is portrayed. Eventually, the horse fell prey to a large carnivore. Finally, the palaeoecological significance of this very specific palaeopathological finding is discussed.

Keywords

Palaeopathology, arthropathology, osteoarthrosis, taphonomy, palaeoecology, Middle Palaeolithic

PREFACE

About 20 years ago, while desperately looking for a Master thesis topic in order to become a zooarchaeologist, the former head of MONREPOS, Prof. Dr. Gerhard Bosinski, told me that, if I want to study material from Mesolithic or Upper Palaeolithic contexts, then I would need Martin as a supervisor, and if I would prefer the Middle to Lower Palaeolithic, then I would need Elaine. So it was Elaine who escorted me through the study of Middle Palaeolithic bones from the Pfrimm valley in Rhine-Hesse (Kindler, 2001). Afterwards I could tap into her knowledge of cave bears for my PhD, and in the course of time we became colleagues in the same institute and shared responsibilities for the Taphonomical Zooarchaeology Lab in MONREPOS. What I immediately absorbed from Martin and Elaine in my first attempts at becoming a zooarchaeologist was – besides the interest of past human subsistence – their interest in the animals they study. I understood this perspective as their motivation for the detailed extraction of even the tiniest anectodical information from bones to reveal very specific stories of an animal's fate, which adds colour to our pictures of past lifeways. To quote: "every bone can tell its story", was my first and most important lesson. Now, what makes a better topic for their *Festschrift*, than my expression of gratitude for this lesson. When Elaine had a first look through the material I should study she just said "interesting material", which – for me, as a young student – provided enough motivation to hammer in the last nail in the coffin of the "hunter *vs*. scavenger debate" which had fought its last battles at the turn of the century. The result then deviated somewhat from it. Afterwards I learned that, whenever we screened faunal remains together, it was always "interesting material". But, there were different connotations of "interesting". Sometimes the whole material was worth

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.868.c11310

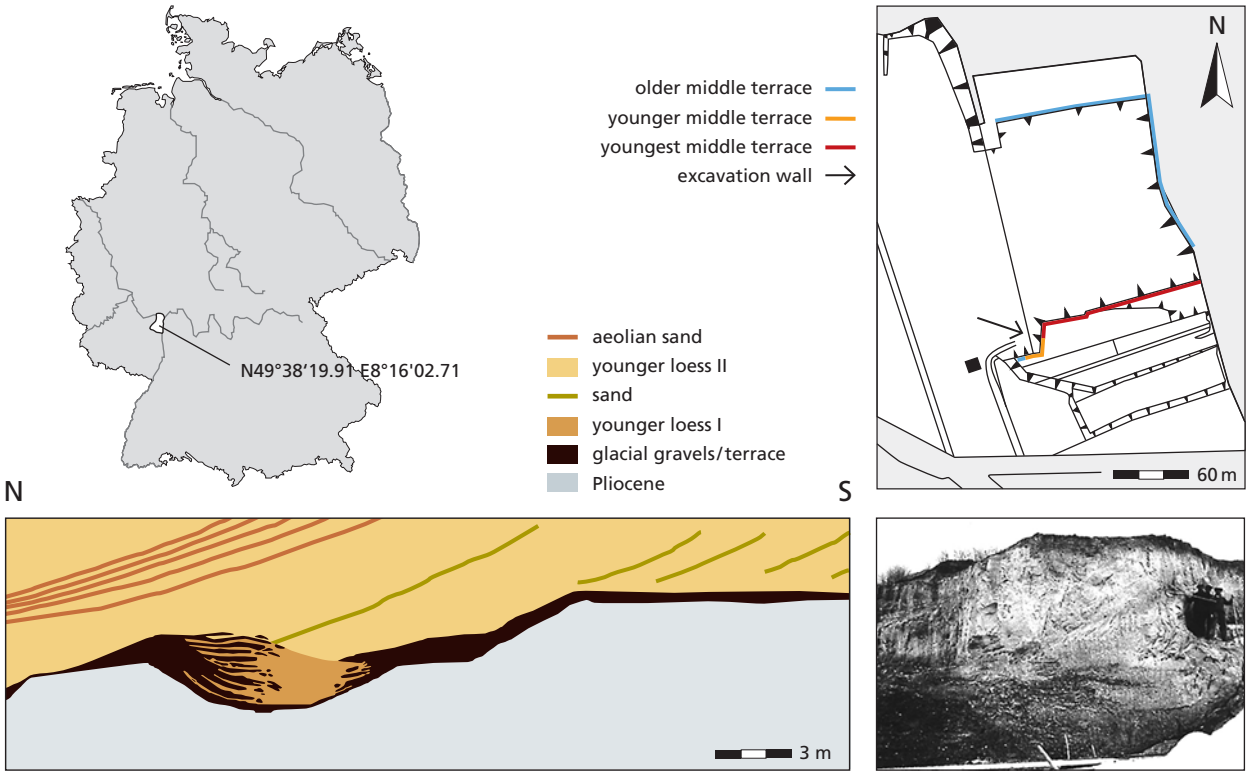

Fig. 1 Pfeddersheim. Top left: location of the Middle Palaeolithic site on the left banks of the Pfrimm in the Upper Rhine Graben (Image produced with Google maps). Top right: sketch of the sand quarry in Pfeddersheim. The arrow indicates the excavation wall (taken from Weiler, 1937). Bottom left: Profile of the excavation wall with gravel ridge and channel (redrawn from Weiler, 1937). Bottom right: historic photograph of the excavation wall with gravel ridge and channel, Eastern 1935 (from Weiler, 1937).

studying, sometimes a specific bone or some features grabbed her attention, and sometimes the material was interesting because there was nothing more to say about it besides the expectation that some bones will somehow "tell their stories". So, I browsed in my old Master thesis files in search of a bone that has a very unique story. It is a sad story of the discovery of a palaeopathological horse long bone, but a revealing story of my joyful first collaboration with Elaine: definitely interesting.

INTRODUCTION

Health and disease in past animal populations is rarely addressed in Pleistocene zooarchaeology. With the advent of animal husbandry, past societies would have had a self-interest in keeping their livestock healthy, well-nourished, and in finding ways and means to prevent and cure diseases. For hunter-gatherer societies there are almost no opportunities to counter diseases in wild game populations, apart from a general rule of "staying away from the sick". Animal palaeopathological studies in zooarchaeology therefore focus particularly on societies relying on animal husbandry (Baker and Brothwell, 1980; Davies et al., 2005; Thomas, 2012). In contrast, the knowledge obtained regarding veterinary considerations of wild game in Pleistocene forager contexts is more limited. In the taphonomic perspective we are dealing here, the fragmentation

of individual bones during food processing hampers the identification of lesions. Subsequent syn- and post-depositional attrition is an additional influence on the "survival" of *pre-mortem* lesions (Bartosiewicz, 2008). From an ecological perspective, bone diseases and fractures can pose a vital threat to an animal (e. g., individuals with a limb bone trauma are vulnerable prey); however, the prevalence of skeletal injuries and healed lesions in wild mammals is rarely recorded (Taylor, 1971; Bulstrode et al., 1986; Argyros and Roth, 2016). Thus, it is hard to estimate the rate of bone lesions to be expected in zooarchaeological assemblages. In a survey of more than 250,000 prehistoric and historic bones from North America, only 0.03 % of the specimens showed pathologies, with most of them without significant effects on the individual's life (Shaffer and Baker, 1997). In late Pleistocene cave bear assemblages, somewhat higher rates of bone pathologies are observed, with many of them being age-related (Germonpré and Sablin, 2001; Withalm, 2004). From this small amount of documented bone pathologies in the fossil record a portion might be considered as atavisms, which evolutionary paths can be traced back deep in time to ancestral taxa, exemplified by the lineages of horses (Rooney, 1997). Against this background, pathological bones in Pleistocene faunal assemblages are rare, and usually unrelated to typical zooarchaeological questions concerning human and animal behaviour. On the other hand, zooarchaeologists play with enormous numbers of bones in their careers und thus easily detect "abnormal" bones, but are usually not veterinarians, not trained in aetiology, nor in pathogenesis and disease symptoms. Especially locally restricted and "superficial" bone lesions might not be detected, biasing our awareness of the impact of especially infectious diseases on past animal populations. In wildlife conservation pathogens are recognised to facilitate extinction risk at least in already threatened species (Smith et al., 2006; Smith et al., 2009; Cunningham et al., 2017), but recent data is still sparse and historical evidence missing. However, in a study of late Pleistocene Mastodon bones, half of the individuals in the sample show lesions indicative of tuberculosis (Rothschild and Laub, 2006), and DNA of the respective pathogen *Mycobacterium tuberculosis* was detected in a late Pleistocene bison (Rothschild et al., 2001), nourishing the hypothesis of a pandemic disease contributing to faunal extinction at the Pleistocene-Holocene boundary in North America.

Apart from the question of the ecological significance of pathogens, injuries and diseases affect individuals directly. The most apparent question from a palaeopathological finding on a bone concerns its negative impact on the individual's life history. In conjunction with find context and additional ecological information, palaeopathology can help to identify processes and interactions in past biocoenoses. This contribution discusses the find context and pathological investigation of an adult horse radius from the Middle Palaeolithic site of Pfeddersheim (Rhine-Hesse, Germany) (Kindler, 2001).

THE MIDDLE PALAEOLITHIC SITE OF PFEDDERSHEIM

The village of Pfeddersheim is a district of Worms in the lower course of the river Pfrimm in the eastern part of the Upper Rhine Rift in southern Rhine-Hesse. The Pfrimm is a left tributary of the Rhine, approximately 40 km long, which originates in the Buntsandstein of the Palatinate Forest, passes in its middle course the limestone plateaus of the low, rolling hills of Alzey, and running through a slightly undulating landscape in its lower course. Although more a stream than a river today, the Pfrimm built up rather thick fluvial terraces during the Pleistocene. The natural history of the Pfrimm and the Pleistocene palaeontology in southern Rhine-Hesse was intensively studied by Wilhelm Weiler (Weiler, 1931, 1935, 1937, 1938a, 1938b, 1939, 1949/1950, 1953). Later, a revised terrace stratigraphy and history of landscape development of the Pfrimm was established by Leser (1967), which is still valid today (see Peters and van Balen, 2007).

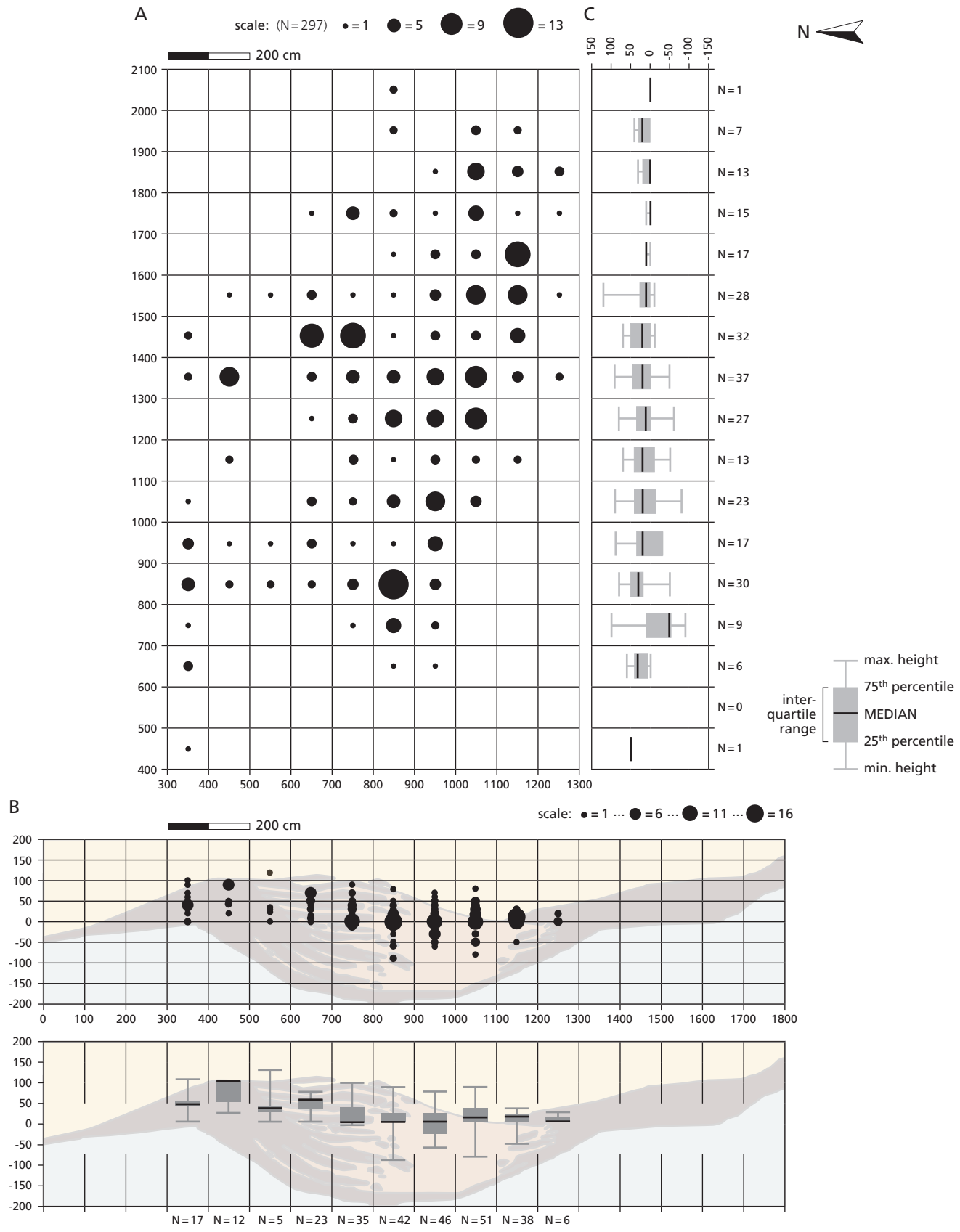

Fig. 2 Pfeddersheim. Horizontal distribution (A) (n = 297) and profile projections (B, C) (n = 276) of large mammal bones from the excavations in 1936 and 1937. In B the vertical distribution is projected on the profile of the excavation wall indicating the Pfrimm terrace and its remnants (grey) and the location of the channel (taken from Weiler, 1937 and modified by observations registered in Weiler's excavation diary).

	Pebbles with negative(s)	Cores	Flakes	artificial shatter	[n]
Porphyry	1		14	2	17
Devonian Quartzite, red	1		14		15
Devonian Quartzite, green		2	6		8
Lydite			1		1
Chalcedony			1		1
[n]	2	2	36	2	42

Tab. 1 Pfeddersheim. Raw material groups and lithic artefacts present in the Weiler collection in the Natural History Museum Mainz.

During his mapping of terraces in the former sand quarry of Pfeddersheim on the northern banks of the Pfrimm – the local football field is now located here – Weiler found bones and lithic artefacts on a gravel ridge and in an adjacent channel filled with reworked gravels and loess (**Fig. 1**). He excavated the site from 1935 to 1937, and originally separated a Middle (labelled "Pm") and early Upper Palaeolithic (labelled "Pa") find level. The associated herbivore bones – including mammoth, rhino, Bos/Bison, giant deer, red deer, reindeer, horse and wild ass – were interpreted as the remains of a hunted fauna (in sum 32-34 individuals were calculated); additional carnivore and small mammal bones were considered natural elements (Weiler, 1937, 1938a). The lithic material was typologically analysed by Bosinski (1967); according to this study, both find levels are Middle Palaeolithic. Leser (1967) described additional profiles nearby the site which also indicate a close temporal association of the two find horizons. According to Leser (1967), the gravel ridge is the remnant of an eroded younger middle terrace of the Pfrimm attributed to the late Riss. The reworking of the younger middle terrace can be observed over a wider area in other profiles along the Pfrimm valley and is attributed to the early Würm. The gravel ridge, the channelling and its filling should be considered as syngenetic processes, placing the finds also in an early Würm context (see also Kindler, 2001).

For my analyses of the find material I could take advantage of the excavation diaries of Wilhelm Weiler, which allow – at least for the campaigns in 1936 and 1937 – comprehensive insights into the depositional contexts and spatial distribution of the finds (Kindler, 2001). During the excavation Weiler and his team of excavators followed the west-east course of the gravel ridge and the adjacent channel, with fluctuations in the breadth of both features up to 1 m (see also Weiler, 1937). Beside observations of the progression and sedimentological features of the gravel ridge and channel, the diary includes in ideal cases three-dimensional recording of finds, partly with sketches and information on orientation and dipping. Height information of finds is relative to the upper or lower boundary of the channel. For the campaigns in 1936 and 1937, the find distribution covers an area of approximately 17 m × 10 m (**Fig. 2**). The recordings in the diary clearly suggest that the two find levels "Pa" and "Pm" indicate the embedding milieu of finds and not two stratigraphically separated find levels, with "Pa" embedded in loessic and "Pm" in gravelly material. The fluvial loess infill of the channel was interspersed with scraps of reworked terrace gravels, especially on the slope of the gravel ridge. Here, the heights of finds show an inversion of the find levels, finds attributed to "Pm" are above finds attributed to "Pa". In addition, several bones attributed to level "Pm" and "Pa" could be refitted, also invalidating the separation of these two find levels. Rather, it is to be assumed that during reworking of the terrace – with the gravel ridge as its remnant – finds were translocated from higher positions and became embedded during the filling up of the channel. This context suggests a palimpsest in a hydrodynamic milieu as important parameters in the site formation process and taphonomic history of the bone accumulation.

Species	NISP	%
Large mammals		
Canis lupus	1	0.3
Vulpes vulpes	6	1.8
Panthera leo cf. *spelaea*	1	0.3
Mammuthus primigenius	15	4.5
Equus sp.	218	65.1
Coelodonta antiquitatis	10	3.0
Megaloceros giganteus	5	1.5
Rangifer tarandus	28	8.4
Bos/Bison	51	15.2
[n]	335	100.0
Small mammals		
Lepus sp.	9	50.0
Marmott sp.	1	5.6
Dicronstonxy sp.	2	11.1
Rodentia indet.	6	33.3
[n]	18	100.0
Birds		
Aves sp.	1	100.0

Tab. 2 Pfeddersheim. Species representation in the Weiler collection in the Natural History Museum Mainz. NISP = number of identified specimens per taxon.

Lithics, fauna and taphonomic signatures

The find material from Pfeddersheim is stored in the Museum of Natural History in Mainz. A comprehensive presentation and discussion of the material can be found in Kindler (2001). The collection comprises 152 lithics, three larger blocks of fossilised wood and 354 bones and teeth; the overwhelming majority consists of larger specimens easily to identify. Comparisons with the excavation diary shows that almost all recovered small bone fragments (labelled "bone fragments" and even smaller pieces "bone splinters") are now missing. Presumably because of their lack of any taxonomic value, the "bone fragments/splinters" – half of the material originally present – were discarded soon after excavation or in the course of storage. Three lithic artefacts – a handaxe and two scrapers, which are illustrated in Bosinski (1967) – are also missing.

Of the 152 lithics present in the Weiler collection, only 42 pieces can be identified as artefacts. A total of 36 specimens represent simple flakes, two are simple cores, two pebbles with negatives and two artificial shatters. The artefacts are made of porphyry and a red and green variety of Devonian quartzite (**Tab. 1**; **Fig. 3**). Both raw materials – together with quartz – constitute the main components of the Pfrimm gravels. Two flakes are made of most likely non-local lydite and chalcedony, which may indicate connections to raw material sources outside the Pfrimm valley (Floss, 1994). The dimensions of the flakes range for most specimens between 20-40 mm. Smaller chips and debitage are missing, maybe because of the excavation technique or due to winnowing by hydrodynamic processes. In most of the cases the cores, flakes and striking platforms display larger areas covered with cortex. The cores and frequencies and distribution of dorsal negatives indicate predominantly unidirectional reduction. Thus, the small lithic ensemble represents an economic approach to obtain cutting edges rather than the realisation of distinct concepts of reduction and flake shape; but one must consider the possibility that the size of the river gravels used for lithic production may have prevented the implementation of a more sophisticated lithic technology at Pfeddersheim.

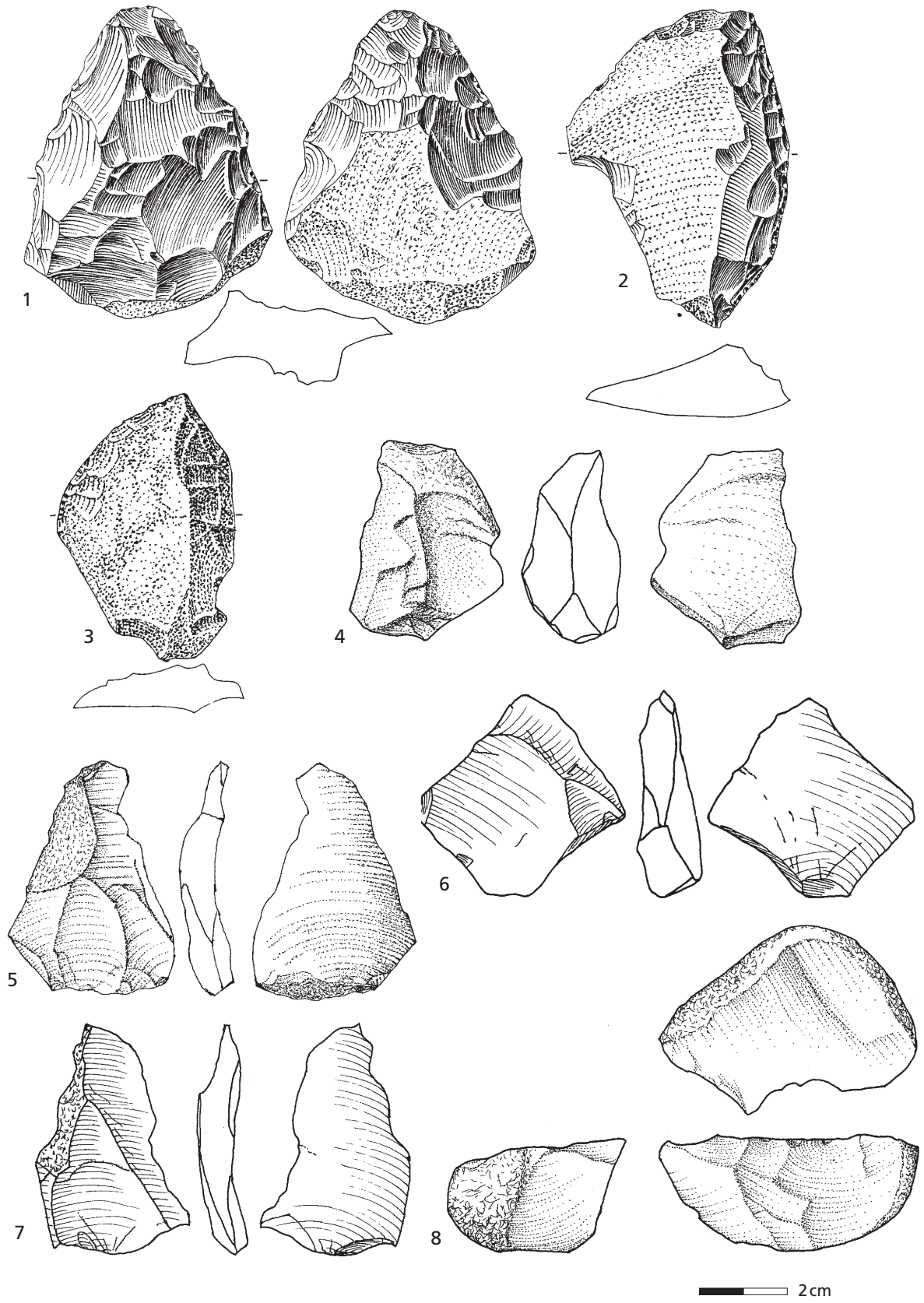

Fig. 3 Pfeddersheim. Examples for lithic artefacts from the sand quarry. **1** Biface (porphyry), **2** Scraper (porphyry), **3** Scraper (quartzite), **4** Flake (red quartzite), **5** Flake (green quartzite), **6-7** Flake (porphyry), **8** Core (green quartzite).

However, the small biface and two scrapers discussed in Bosinski (1967) may indicate modification of flakes and tool production at the site.

In addition to teeth, the 354 faunal specimens in the Weiler collection mainly consist of relatively complete long bone diaphyses and epiphyses, or larger fragments thereof. Horse dominates the species spectrum among the large mammals with a proportion of 65 %, followed by Bos/Bison (15 %) and reindeer (8 %). Additional herbivores are woolly mammoth, rhino and giant deer. Carnivores have a share of 2 % of the large mammal bones, with one bone belonging to each of wolf and lion. Fox bones are somewhat more frequent. The material of small mammals consists of several post-cranial bones from a hare, plus teeth from a marmot and a lemming. Additional teeth could not be assigned to a specific taxon. One bone belongs to an unidentified bird (**Tab. 2**). The species spectrum comprises the typical taxa of the "mammoth steppe" and indicate stadial steppic conditions during formation of the thanatocoenosis (Kahlke, 1999).

Syn- and postdepositional processes have led to both partly heavy and quite heterogeneous bone surface modifications. The faunal assemblage is "colourful": the bones display seven different colour schemes. Most bones show a grey colour, with gradients to a darker brown coloration and gradients to a lighter yellow coloration. Bone colour has a heterogeneous horizontal spatial distribution when plotted in the excavation grid; however, bones displaying a brownish gradient tend to be located higher in profile projections than the ones with a yellowish gradient. Thus, composition and changes in embedding milieu can be regarded as the most important aspect governing bone colour (Turner, 1990). In Pfeddersheim bone colour may also have an addition chronological aspect. Bones deposited in fluvial contexts are prone to become abraded and edge rounded. As a rule of thumb, the higher the hydrodynamic loading and coarser the material, the more severe the attrition of bones. Interestingly, only a minor fraction of the Pfeddersheim bones are edge rounded: this accounts for 29 bones out of 335 large mammal bones. In addition, 25 of these bones are labelled "Pa" and are associated with a more fine-grained loessic matrix. This may indicate that bones embedded in the loessic milieu were subjected to hydrodynamic processes for a longer time or for additional reworking cycles than bones embedded in a more gravelly matrix. A longer temporal succession of bones entering the thanatocoenosis and/or fluctuations in sedimentation rates can be discerned by differential rates of bone weathering (Behrensmeyer, 1978; Turner, 2000). Following the subdivision of climatic induced weathering by Behrensmeyer (1978) – from stage 0 (= fresh and unweathered) to stage 5 (= almost disintegrated *in situ*) – more than 90 % of the Pfeddersheim bones in both subsamples "Pm" and "Pa" display advanced stages of surface modification (stage 2 and 3). Only 2 bones can be attributed to stage 1, and 17 bones belong in stage 4. The bones must have stayed for a prolonged period on the ground before burial. Originally, Behrensmeyer (1978) links such patterns with natural death rates in animal populations due to starvation, dying of thirst and old age, disease and predation. The modest appearance of stage 4 and the lack of stage 5 bones indicate that climatic-induced weathering is not a significant factor for bone loss and destruction at Pfeddersheim.

Another significant taphonomic pattern of the faunal assemblage is root etching. More than 75 % of all bones display root etching; in most cases more than half of the bone surfaces are affected. Severe root etching and advanced stages of weathering in the Pfeddersheim assemblage limits the preservation of modifications of preceding biogenic and anthropogenic processes and actions. Shallow striations occur regularly on the bones, which may result from the movement of bones in gravelly to sandy sediments and/or trampling by other animals (Behrensmeyer et al., 1989). Undisputable cut-marks and hammerstone impacts are not present on the bones.

Quantitative and qualitative considerations of the identified bone specimens follow standard methods described in Lyman (1994). The biased nature of the Weiler collection is best illustrated by the minimum number of elements (MNE) present in the faunal assemblage, which largely correspond to the number of identified specimens (NISP) after refitting.

Element	NISP			MNE
	sin	indet	dex	
Cranium/Maxilla		1		1
Mandibula	1	1	2	4
teeth, mandibulary	4	4	10	18
teeth, maxillary	34	3	37	73
Vertebrae, cervical		7		3
Vertebrae, thoracic-lumbar		2		2
Costae				
Sacrum				
Pelvis	3		4	6
Scapula	2	1	4	5
Humerus	10		11	19
Radius	7		5	12
Ulna			2	2
Carpals				
Metacarpus III	6	2	3	11
Metacarpus II				
Metacarpus IV				
Phalanx 1	3		5	8
Phalanx 2		1		1
Phalanx 3		2		2
Femur	5			5
Tibia	5		3	8
Astragalus	3			3
Calcaneus	3		3	6
other tarsals				
Metatarsus III	5	1	7	12
Metatarsus II	1			1
Metatarsus IV	2		3	5
[n]	218			207

Tab. 3 Pfeddersheim. *Equus* sp., NISP (number of identified specimens per taxon) and MNE (minimum number of elements) of skeletal elements. In the case of the phalanges no differentiation was made between anterior and posterior phalanges. Ulnae were only counted when isolated from the radius.

Element	NISP			MNE
	sin	indet	dex	
Cranium/Maxilla				
Mandibula	1		1	2
teeth, mandibulary		1	1	2
teeth, maxillary	8		5	13
Vertebrae, cervical				
Vertebrae, thoracic-lumbar				
Costae				
Sacrum				
Pelvis	1		1	2
Scapula				
Humerus	1			1
Radius	5		2	2
Ulna				
Carpals	1			1
Metacarpus		4	1	4
Phalanx 1				
Phalanx 2				
Phalanx 3		1		1
Femur			1	1
Tibia	5		2	2
Astragalus				
Calcaneus	1			1
other tarsals	1		1	2
Metatarsus	4	1	1	4
[n]	51			38

Tab. 4 Pfeddersheim. Bos/Bison, NISP (number of identified specimens per taxon) and MNE (minimum number of elements) of skeletal elements. In the case of the phalanges no differentiation was made between anterior and posterior phalanges.

With 218 out of 335, horse dominate among the large mammal bones. The NISP and MNE is given in Table 3. Almost exclusively, teeth and appendicular bones are present. A discrepancy in the preservation of upper and lower teeth is striking. Bones of the fore leg are better represented than bones from the rear leg. Based on bone counts, a minimum number of individuals (MNI) of 10 is given by left humeri and 7 by left radii. A distal femur and radius still display the epiphyseal line, and in three metapodials the distal joints were not fused. Taking crown height and occlusal wear patterns of tooth rows and isolated teeth into account (Habermehl, 1975; Levine, 1979, 1982, 1983), an MNI of 12 for teeth can be calculated. Three individuals died as juveniles (one at an age of approximately one year, another at a maximal age of 2 years and the third between 1 ⅓ and 3 ½ years). Eight individuals are in the prime ages between 6 ½ and 11 ½ years. A senile individual is represented by a heavily worn and chewed down molar, giving a minimal age

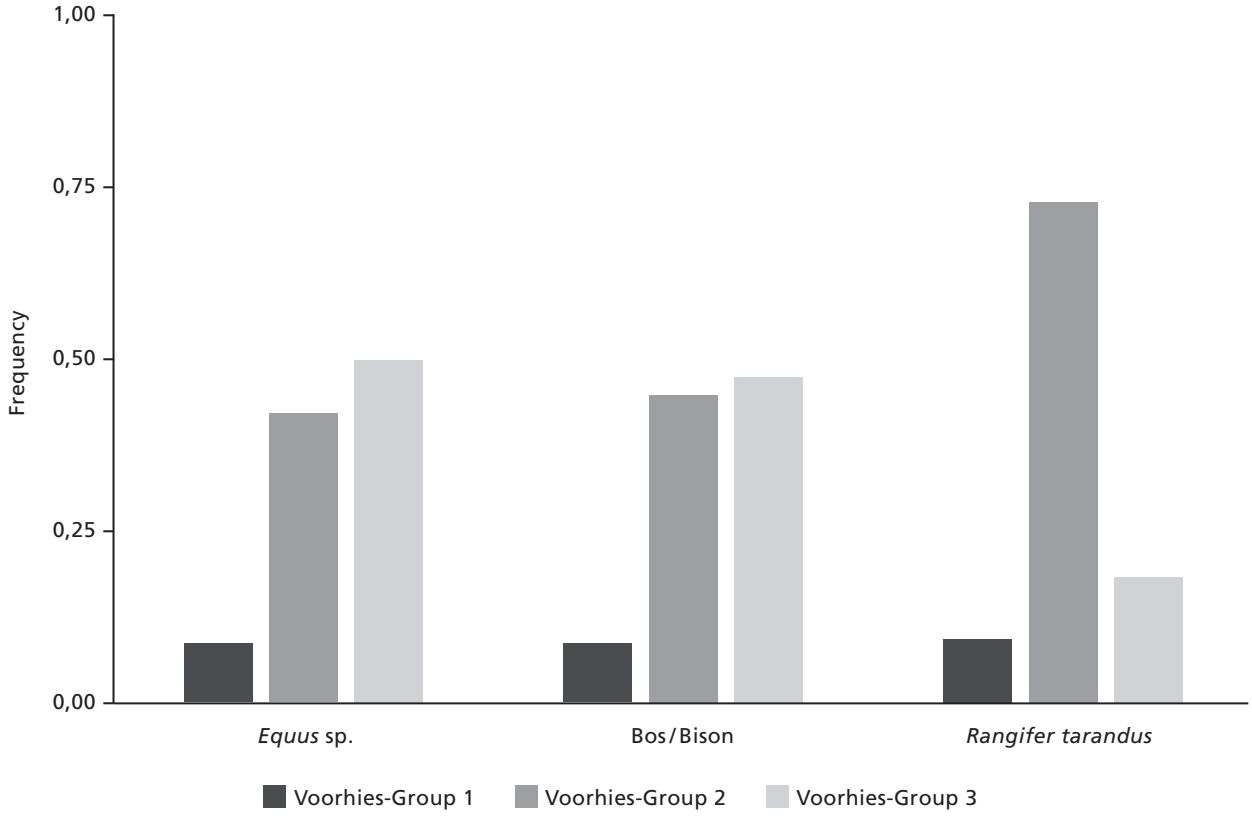

Fig. 4 Pfeddersheim. Frequencies of Voorhies-Groups (Voorhies, 1969; Behrensmeyer, 1975) based on the minimum number of identified specimens (NISP) of *Equus* sp., Bos/Bison and *Rangifer tarandus*.

of death of 15 years. Discounting the teeth, 15 % of the bones display traces of carnivore modifications, mainly at or near the proximal parts of the long bones.

Bones of large bovids (Bos/Bison) make of 15 % of the Pfeddersheim assemblage. The material lack clear diagnostic criteria to discriminate between *Bos* and *Bison*. Again, mainly teeth and appendicular bones are present (**Tab. 4**). Bones and teeth belong to a minimum of four prime age individuals, based on the upper molars. Seven bones show carnivore modification (20 % of all specimens, discounting teeth).

Reindeer is represented by 14 bones (2 scapula, 2 humeri, 4 radii, 1 calcaneus, 1 metatarsus and 4 metapodials), 11 antler fragments and 3 partly larger unshed antler fragments with attached skull parts. The MNI is 3, based on the antlers. Carnivore gnawing is present on both humeri and on one antler fragment.

Remains of giant deer include one antler fragment with pedicle, two isolated upper deciduous molars, a mandible fragment with two milk molars and three metatarsi. The MNI is two. No traces of carnivore modification could be observed.

The NISP for the woolly rhino is 15, and comprises fragments and larger portions of humerus, radius and tibia as well as three molars. Two teeth belong to an adult individual, a fragment of a third tooth represents an unerupted molar of a juvenile individual. The long bone remains also represent an adult and a juvenile. Hence, the MNI is two. A humerus shows carnivore gnawing near the proximal joint and a tibia fragment is gnawed on its proximal and distal break edges.

The NISP for woolly mammoth is also 15: tooth fragments, a vertebra and ribs as well as fragments of pelvis and long bones. An upper M2 and a lower dP2 belong to an adult and juvenile individual, with reconstructed

ages of 26 ½ and 3 years (Laws, 1966; Haynes, 1991). An additional adult may be represented by fragmentary tooth plates from a large and worn molar, presumably a lower M3. The post-cranial bones are also be attributed to one adult and one juvenile individual. No carnivore gnawing is present on the mammoth bones. A distal humerus can be designated to *Canis lupus*, and two mandible fragments with teeth, a distal tibia and three metapodials to *Vulpes vulpes.* The cave lion is present by an Ulna, but an association with the channel infill is not secured. The bones don't wear traces of carnivore modification.

Bone loss and survival are governed by successive processes in the taphonomic chain. As pointed out in the general characteristics of the Pfeddersheim assemblage, climatic-induced weathering can be considered as a minor contributor to bone destruction at the site. A general proxy for a bone's capability for preservation and susceptibility for destruction is its bone mineral density (BMD) (Brain, 1969; Lyman, 1994). Correlations of skeletal element frequencies and their respective BMD values are generally used to describe post-depositional or *in-situ* attrition, but biostratinomic process may also lead to density dependent bone preservation. As pointed out, the Pfeddersheim faunal assemblage is a biased assemblage and only horse bones occur in frequencies high enough to enable comparison with bone mineral density data. Using values obtained by Lam et al. (1999), the relative MNI for each survived bone element portion results in

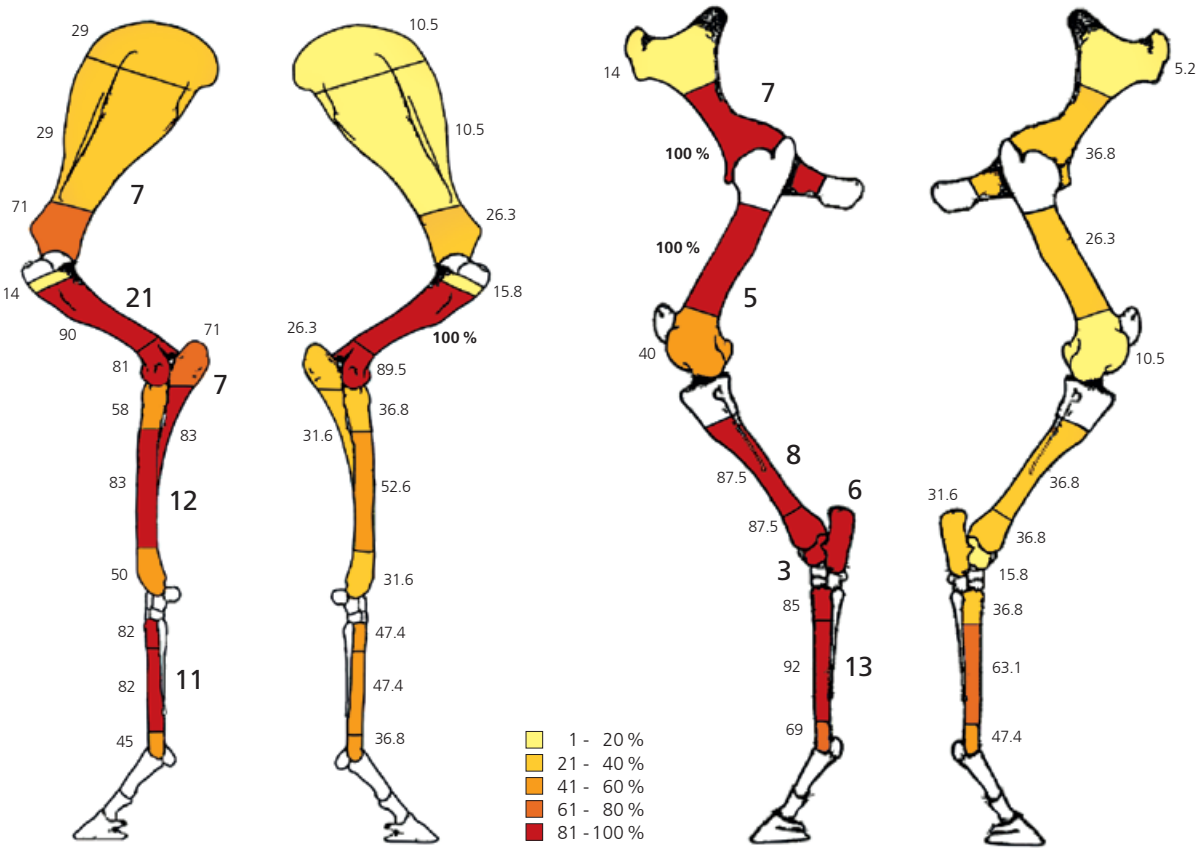

Fig. 5 Pfeddersheim. Skeletal intra-element representation of front leg (including scapula) and hind limb (including pelvis) of *Equus* sp. On the right side of the legs, the NISP for each skeletal element and the percentage of the proximal and distal parts and the diaphysis are given. The frequencies have been grouped and are shown in different colours. The left side of the legs display the proportions in relation to the most common bone area, the humerus diaphysis (= 100 %). Example: 83 % of the 12 radii are distributed in the diaphyses and 50 % in the distal epiphyses. The proportion related to the humeral diaphysis is 52.6 % for the radius diaphysis. The humeral diaphysis occurs almost twice as often as the radius diaphysis (see also Turner, 2002).

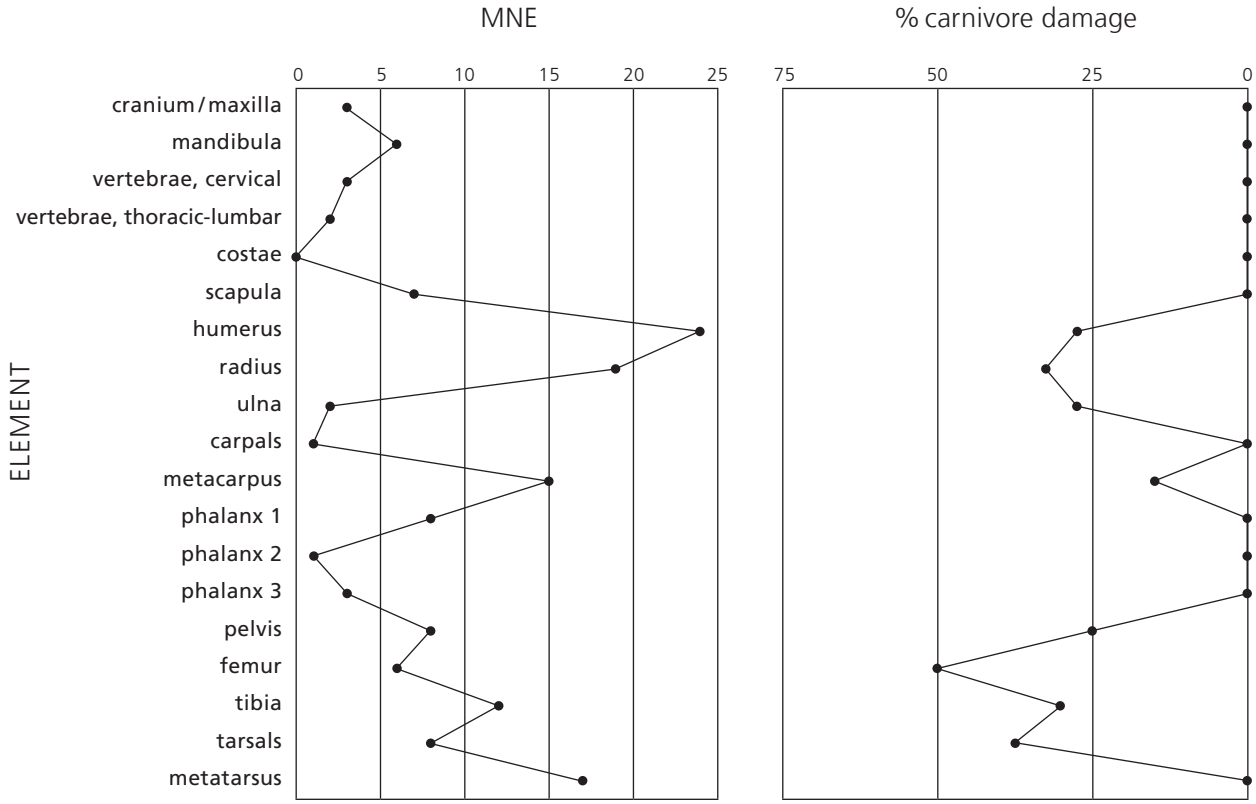

Fig. 6 Pfeddersheim. Left: Skeletal element representation of *Equus* sp., Bos/Bison, *Rangifer tarandus* and *Coelodonta antiquitatis* (MNE = 154). Right: Percentage of skeletal elements displaying carnivore damage.

a moderate relationship between both variables (R^2 = 35 %). Thus, taphonomic factors in addition to the preservation capacity of a skeletal element must be considered as important contributors influencing bone survival at Pfeddersheim. From the given sedimentary context, fluvial processes must be considered. Bone mineral content as an indicator for weight and the shape of skeletal parts are major properties influencing hydrodynamic bone transport. Sorting processes in water streams are investigated in experiments and simulated in models (Voorhies, 1969; Behrensmeyer, 1975, 1982; Hanson, 1980). In river streams with constant flow isolated bones of a skeleton can be separated in three groups (so-called Voorhies-Groups), representing different susceptibility for transport. In general, short and flat bones belong to group 1, group 2 consists mainly of the long bones, and group 3 of the cranium and mandible (Voorhies, 1969). The arrangement, frequency and/or lack of the individual groups give information of stream velocity and distance to the source assemblage of a transported fauna. All Voorhies-groups are present for the Pfeddersheim horses and the large bovids, but group 1 is only represented in low quantities. In contrast reindeer is almost exclusively represented by group 2 (**Fig. 4**), which indicates a longer distance to the source assemblage in comparison to horses and bovids (Behrensmeyer, 1975; Gaudzinski, 1992). Thus, fluvial transport can be considered as a major taphonomic process shaping bone representation at Pfeddersheim. However, initial sorting of bones may have occurred prior to fluvial transport. Carnivore damage is another major characteristic of Pfeddersheim faunal assemblage, and is present on horse, large bovid, reindeer and woolly rhino bones. 20 % of the bones of these four taxa show traces of carnivore gnawing. In general, bones of the front leg are more frequent than bones from the hind limb, as illustrated by the skeletal part

representation of the horse (**Fig. 5**). The intra-element representation corresponds mostly with mineral density. 42 % of all breaks have a helical outline and must have occurred in fresh condition (Lyman, 1994). In contrast to the skeletal representation, the relative frequency of carnivore damage is higher on the hind legs (**Fig. 6**). Most carnivore gnawing is located near the epiphyses. All these features, representation of the appendicular skeleton, breakage and loss of less dense epiphyseal parts are typical for assemblages generated and accumulated by carnivores (Haynes, 1980b, 1983a, 1983b; Binford, 1981; Brain, 1981; Blumenschine, 1986; Gifford-Gonzales, 1989; Hill, 1989; Marean and Spencer, 1991; Lyman, 1994; Marean, 1998; Marean and Kim, 1998).

Predation of ungulates along the Pfrimm, consumption, collection and transport of body parts by carnivores must be regarded as the most prominent process from which the Pfeddersheim faunal assemblage originated. The remaining carcasses parts were lying on the river banks for a prolonged period of time, as advanced stages of weathering show. From here, bones were repeatedly raised by the river, translocated downstream and (re-)deposited in the channel where the bones accumulated in their final position. Thus, the taphonomic chain at Pfeddersheim can bridge a considerable time depth. Against these major taphonomic processes and actors, a human contribution to the formation of the faunal assemblage – as suggested by the presence of lithic artefacts – becomes completely obscured by succeeding processes.

THE PATHOLOGICAL HORSE BONE

A right radius with attached ulna of an adult horse show multiple arthropathological features, traumatic as well as degenerative, which caused pain, restriction of motion and potentially joint stiffness during life (**Fig. 7**). Weiler (1936, 1937) already recognized the lesions on the bones and summarised them as an *Arthritis* (sic) *deformans*.

On the proximal radius the compact bone of the medial joint plate was almost completely removed by extensive erosion by deep parallel fissures. These fissures are accompanied in some areas by exostosis, in other areas the grooving exposed the underlying trabecular bone. Along the radial tuberosity to the medial face of the joint, the complete area is covered by extensive exostosis, extending the articular surface. Co-occurrence of grooving of the articular surface and its extension by new bone formation as well as exostosis around the joint and eburnation are diagnostic criteria for osteoarthritis (Baker and Brothwell, 1980). Osteoarthritis is synonymous with *Arthrosis deformans* and in most instances is a degenerative disease. The suffix *-arthritis* suggests the joint disorders originate from an inflammation of the soft tissue and cartilage of the joint, which may also affect the bone and subsequently cause a degenerative arthrosis. An acute inflammation and its pathogen are rarely found on bone, especially in archaeological ones. Thus, the term osteoarthrosis provides a more proper and neutral label for the disorders on the horse radius (O'Connor, 2008).

Osteoarthrosis proceeds in stages in which the space between the joint becomes lost by progressive degradation and destruction of cartilage and remodelling of bone. When the subchondral bone becomes exposed, sclerosis develops and osteophytes as well as bone cysts form (Arden et al., 2018). An age-related development of osteoarthrosis seems to be common in wild horse populations (Cantley et al., 1999). However, osteoarthrosis may occur in higher frequencies in populations maladapted to the environments they are placed in (Lyras et al., 2016). In the Pfeddersheim specimen the degree and magnitude of the bone modifications correspond to a final grade of severe and prolonged progress of osteoarthrosis. Especially the extend of joint surface erosion and the depth of the attendant fissures are remarkable, when compared

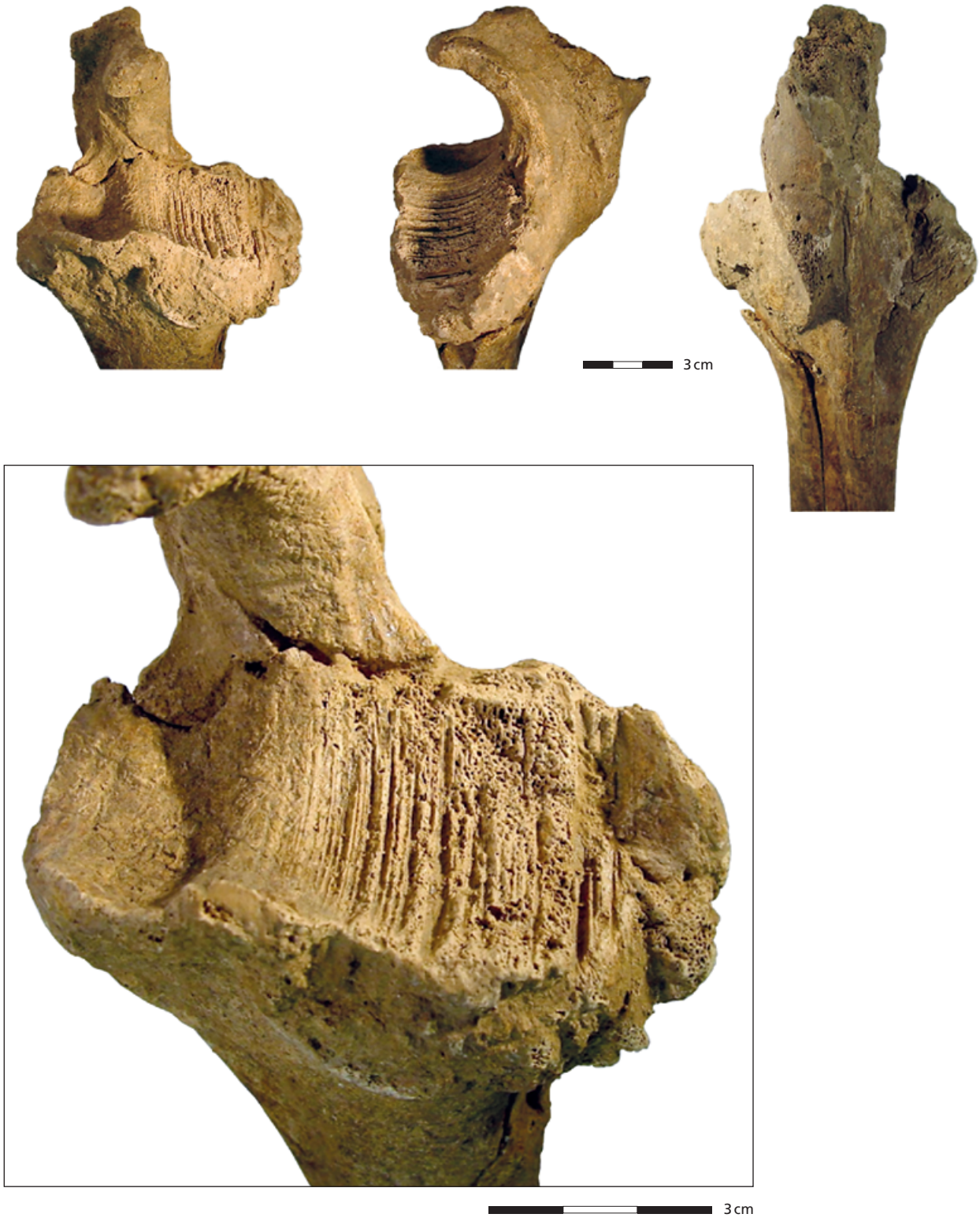

Fig. 7 Pfeddersheim. *Equus* sp., proximal epiphysis of the right Radioulnare with arthropathological features caused by trauma and subsequent degenerative osteoarthrosis/-itis. Top left: anterior aspect, the ulna shows abnormal position of the *Processus anconatus* and an ossified fissure on the trochlear notch. The radius joint displays deep anterior-posterior grooving, medial extension of the joint and exostosis along the medial periphery. Top centre, medial aspect of the joint showing grooving and exostosis of the proximal radius and on the ulna olecranon crenulated edges produced by a large carnivore. Top right, posterior aspect, showing abnormal S-shape bending of the ulna olecranon. Bottom, enlargement of the anterior aspect of the radius displaying severe osteoarthrosis.

to other zooarchaeological specimens diagnosed with osteoarthrosis (compare with figures in Baker and Brothwell, 1980; O'Connor, 2008). The cartilage between the joint must have been completely removed on the medial aspect of the joint, so that the trochlea of the humerus was in constant friction with the radius epiphysis.

The development of osteoarthrosis of the radius is not age-related but resulted from a posttraumatic malposition of the joint. The remaining distal part of the olecranon bends on the posterior face in a *S*-shape in lateral direction. The anconeal process is also displaced laterally. An ossified fissure proceeds diagonally along the trochlear notch. These features imply one or multiple fractures of the olecranon including the ulna joint. Ulna fractures are not uncommon among recent domesticated horses, with the majority of these fractures positioned similar to the ones reconstructed for the Pfeddersheim horse (Hertsch and Abdin-Bey, 1993). Young and still growing horses are often affected; many of these injuries are supposed to come from kicks during contentions of "pecking order" and fights for dominance. Apart from the overall dislocation of the ulna, no additional features of the healed fractures – such as callus formation and/or remnants of bone remodelling – are present. Thus, the trauma may have occurred early in the horse's life span. A still growing bone and less weight pressing on the joint facilitates wound closure and consolidation in young horses (Hertsch and Abdin-Bey, 1993). In any event, after healing of the trauma the joint deformity remained and developed in the course of time into a degenerative arthrosis, which must have progressively led to pain and lameness in the right front leg. In the end, the horse most likely died of predation. At least a large carnivore – presumably a wolf or hyena – has removed the missing parts of the olecranon below the apophysis and left typical crenulated edges.

DISCUSSION

Long bones with healed fractures are extremely rare in the archaeological record. For domesticated cattle and horses, it is suggested that individuals suffering such injuries were predominately and instantly slaughtered (Udrescu and van Neer, 2005). For wild game we can assume that animals suffering immobilisation of one leg due to a trauma will be vulnerable victims for carnivores and will also die quickly after occurrence of the long bone fracture. The healing process of a long bone fracture allows an estimation of time passed between the accident and the death of an animal. For instance, a diaphyses fracture with extensive callus formation is reported for a large and strong male bison from the lower Pleistocene site of Untermassfeld (Thuringia, Germany) (Kierdorf et al., 2012). Before death, this individual passed through an initial inflammatory response to the trauma: reorganisation of bone around the fracture to a phase of hard callus formation around the lesion. Hard callus formation around bone fractures peaks around two weeks after the injury (Marsell and Einhorn, 2011). The callus is remodelled in a subsequent absorption phase to restore the biomechanical properties of the bone. This phase initiates 3-4 weeks after the incidence and may take years to completion (Marsell and Einhorn, 2011). As the Untermassfeld tibia doesn't show any significant traces of remodelling, it is speculated that the bison died some weeks and up to some months after the fracture occurred, presumably by predation or – given the formation history of the Untermassfeld site – by drowning (Kierdorf et al., 2012).

The ulna fracture of the Pfeddersheim horse is completely healed. The good healing process could indicate that the fracture happened prior or during adolescence. Due to the remaining malposition of the elbow a degenerative arthrosis developed, which reached a severe stage in the adult horse. In general, the course of arthrosis progresses slowly, usually interrupted by phases of stabilisation. It takes many years to develop

the symptoms expressed in the Pfeddersheim specimen (Arden et al., 2018). Because of the posttraumatic origin, the erosion of the cartilage and grooving of the joint may have been accelerated compared to more common causes and progression of arthrosis. After a period of lameness during healing of the fracture, the horse may have been free of symptoms for a certain amount of time. But with the increase of symptoms in the course of arthrosis the horse will have faced increased pain, joint stiffness and, again, lameness. Only in the terminal stage of the disease the horse most likely fell prey to a large carnivore, as the bite marks suggest.

To survive the ulna fracture and a degenerative arthrosis to the grade the Pfeddersheim horse shows in a Pleistocene steppe environment is remarkable. The common progression of degenerative arthrosis suggests that the horse suffered from lameness not only during the time of the ulna fracture and the terminal stage of the disease, but also during episodes of exacerbations in between. The horse was a vulnerable prey during these repeated phases of impaired locomotion, but it survived for a long time. The taphonomic context illustrates the substantial role carnivores played in the formation of the Pfeddersheim assemblage. However, taphonomic signatures are not congruent with past ecological conditions. Although, recent bone assemblages can image their original biocoenosis with high fidelity (Behrensmeyer and Miller, 2012; Miller et al., 2014), deriving past environmental conditions from fossil faunas has limitations and is challenging, when patterns of ecological processes are addressed (Lyman, 2017). An additional problem is a quantitative approach to estimate the scales of past ecological processes or even just a relational consideration of processes in different past environments (Kindler et al., 2020). Predation is a typical process present in all ecosystems; it is also present in most Pleistocene faunal assemblages, but the systemic interrelations of predation is only seldomly addressed (e. g., Hemmer, 2001). The long survival of the Pfeddersheim horse can be indicative for reduced predation pressure in the early Weichselian stadial steppe of the Pfrimm valley and, thus, of low population densities of carnivores.

Since Guthrie's (1990) "frozen fauna of the mammoth steppe," the Ice Age stadial steppes in the northern latitudes are often depicted as self-organising, highly productive ecosystems. An essential element of this vanished ecosystem was an enormous ungulate biomass. Calculations of ungulate biomass derived from the fossil record of the mammoth steppe (Zimov et al., 2012) can reach values equivalent to ungulate productivity in African savanna ecosystems. However, taking the external factors that limit the carrying capacity of an ecosystem into account, ungulate biomass production in the mammoth steppe of the northern latitudes must have been relatively low, especially in relation to interglacial ecosystems (Rodríguez et al., 2014; Kindler et al., 2020). When ungulate biomass production is low, the population densities of their predators (including humans) must decrease and the size of their hunting grounds must increase correspondingly. Thus, the lack of any human signature in the Pfeddersheim faunal assemblage as well as the generally sparse evidence concerning human subsistence in faunal assemblages of similar chronological or ecological context in nearby regions like the central Rhineland (Bosinski et al., 1995; Gaudzinski et al., 1995) may simply reflect the minor role human hunting played in the respective ecosystems, compared to other more prevalent processes. When Martin and Elaine studied the faunal material from the Central Rhineland (Turner, 1990, 1997, 2000; Street, 2002), the big question was the role of early humans in the formation of faunal assemblages (Gaudzinski and Turner, 1999); we now have to question the role of early humans in past ecosystems.

Against this background, palaeopathological considerations may help us understand the magnitude of ecological processes in Pleistocene environments. Otherwise and as always, when considering "loners" in the Pleistocene record, the horse was just lucky – an anecdotal and interesting pathological discovery. Just another bone that tells its story.

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RECAPITULATING ZOOARCHAEOLOGY AT SALZGITTER-LEBENSTEDT: CURRENT STATE OF RESEARCH AND PERSPECTIVES

Abstract

This review article summarizes the state of research on zooarchaeology at the German Middle Palaeolithic site of Salzgitter-Lebenstedt. The site has become famous as analyses demonstrated mass hunting of reindeer in Middle Palaeolithic contexts and provided an up to now unparalleled assemblage of bone tools manufactured from mammoth bones.
Results of studies undertaken with a time-offset of almost 20 years on faunal material unearthed during the 1950s (Lebenstedt I) and the 1970s (Lebenstedt II) are compared, previously unpublished data from Lebenstedt I are additionally included, and the potential of the site for future research is outlined.

Keywords

Neanderthals, mass hunting, bone tools, mammoth, subsistence, reindeer

INTRODUCTION

The last 20 years have witnessed a paradigmatic change in our perception of Neanderthals. Neanderthals made it from our underachieving cousins, to popular mating partners, a perspective that trace back to interpretations of DNA studies of the Neanderthal genome (Prüfer et al., 2014; Vernot and Akey, 2014). Neanderthals, however, are very different from anatomically modern humans, especially in the way they behaved. Therefore, it is not astonishing that today a research focus re-emerges, aiming to more clearly define and understand the differences in behaviour between them and us or to phrase it better, between us then and now. It was in the mid 1990s that the discovery of wooden spears at the late Middle Pleistocene site of Schöningen (Germany) (Thieme, 1997; Schoch et al., 2015) fueled debates on Neanderthals' cognitive abilities, that ranged from scavengers hardly able to survive (Binford, 1985) to efficiently adapted daredevils (Trinkaus, 1995). Among the studies that at that time contributed to the rehabilitation of Neanderthals from a behavioural perspective was the zooarchaeological analysis of bones and bone tools from Salzgitter-Lebenstedt (Gaudzinski, 1998, 1999; Gaudzinski and Roebroeks, 2000). It suggested a specialization in the exploitation of Reindeer that could only be explained by intentional cooperative hunting encounters. Moreover, until today Salzgitter has provided the only large series of Middle Palaeolithic bone tools. The study of the faunal assemblage was a repeated focus of intense discourse (Munson and Marean, 2003; Gaudzinski and Roebroeks, 2003; White et al., 2016) illustrating the interpretative potential that lurks among the bone and bone tools discovered at the site.
Against the background of the paradigmatic shift in the perception of Neanderthals that has taken place since, there is hardly a better time to recapitulate the study and the results on Salzgitter-Lebenstedt, even if the study, though not the results obtained meanwhile, have become of age.
The particular studies reported here focus on material from the original 1952 excavation (Lebenstedt I) and were undertaken during the latter part of the 1990s (Gaudzinski, 1998). By that time, it was not possible

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.868.c11311

to additionally include material unearthed during a new excavation in 1977 (Lebenstedt II; Grote and Preul, 1978), as the study of the 1977-material was already underway when the analysis of the 1952-material started. The analysis of the 1977-material took some time and was not published until 2017 (Ludowici and Pöppelmann, 2017). By then the 1952-sample had been published for almost 20 years and the authors took the opportunity to draw on these results, considerably increasing the sample size and adding valuable in-depth information on the character of the species represented.
The current review article takes the opportunity to outline the similarities and differences between the different studies, starting from the analysis of the 1952 bone material. In addition, previously unpublished data from Lebenstedt I on the role of humans in the assemblage formation are added.
This compilation and evaluation of study results with its relatively narrow site-focus is far from the current research focus on tracing Neanderthals ecology. Though new research is currently underway at Salzgitter that focuses on traceological studies of the numerous bone-tools from the site, there is hardly a better moment for recapitulation of this particular site that is so very important for the understanding of human lifeways during the Middle Palaeolithic.

Geological and taphonomical parameters

Salzgitter-Lebenstedt looks back on two archaeological excavations – in 1952 (Lebenstedt I) and 1977 (Lebenstedt II). Both excavations unearthed material from fluvial deposits, i. e., fine sands and gravel of a small stream. Based on the two field campaigns, the accumulation of lithics and faunal remains extends over at least 30 m in NS direction and ca. 40 m in WE direction. Topographically, Salzgitter-Lebenstedt is located between the Central European low mountain ranges (*Mittelgebirge*) and the Northern German Plain, on the northern slope of the Krähenriedebach riverlet, where its formerly narrow and steep valley joined the wide, flat glacial valley of the Fuhse river. At the valley bottom ran a small, mostly dried up riverlet with intermittently changing water-level and meandering stream, with two backwater ponds not exceeding 1 m in depth that were occasionally silted up by strong water currents coming from north-eastern slopes (Tode et al., 1953; Kleinschmidt, 1953a). Lebenstedt I preserved especially the faunal material in the two backwater ponds (main find horizon) with concentrations of artefacts around these ponds (Tode, 1953).
To understand the depositional history of Lebenstedt I Kleinschmidt (1965) studied the stratinomy of small fluvial systems. He emphasized that the surfaces of the bones unearthed at Lebenstedt I mirrored their burial milieu. Bones deposited in sand were severely affected, their surface preservation contrasting that of bones deposited in humic environments, from which most of the finds were unearthed. Accordingly, the surface of a bone can display differing preservation according to the varying chemical composition of the burial milieus. The depositional history of the assemblage is complex and a homogeneous spatial pattern for the entire site was not observed. What can be outlined however is a para-autochthonous deposition of the bone assemblage, influenced by changes in the water regime and by cryoturbation, the latter leading to vertical transport of up to 1 meter and to the very local vertical arrangement of bones (Kleinschmidt, 1953a). Excavation plans (Tode, 1982: Taf. 131-136) as well as the photo documentation display animal body parts aligned still in anatomical order, among them complete feet from reindeer and *Bison*, isolated mammoth molars, reindeer antler and bone-fragments from *Esox* (Tode, 1953; Kleinschmidt, 1953a).
In contrast to such findings, the excavation plans also illustrate the presence of poly-specific bone concentrations with faunal remains that had accumulated around large, bulky skeletal elements stopping their leeward spatial scattering. Together with an analysis of the surrounding sediment matrix these bone concentrations allow an estimate on flow direction, velocity and water level (Kleinschmidt, 1965; Tode, 1982:

Taf. 131-136). In parts of the site, the spatial distribution of small bones ran parallel to the direction of the shoreline. Based on the presence of bones belonging to the same individual, Kleinschmidt reconstructs vertical bone transport with a distance of at least 8 m (Kleinschmidt, 1965). Other sections of Lebenstedt I survived completely unaffected by mechanisms which caused the spatial displacement of animal bones and teeth.
The depositional history of Lebenstedt II with the archaeological finds accumulated in a loose scatter, is also of complex nature though different from Lebenstedt I as it is characterized by the presence of three gullies that eroded and cut into the main find horizon (Preul, 1991, 2017: Fig. 10).

MATERIAL AND METHODS

The study of the faunal material from Salzgitter-Lebenstedt comprised a total of n = 3,056 faunal remains (Kleinschmidt, 1953a) unearthed during the excavation of the site in 1952 (Lebenstedt I). This material is stored at the Braunschweigisches Landesmuseum Wolfenbüttel (Germany). Numerous mammoth teeth which had originally been part of the faunal assemblage and published by Guenther in 1991 were not stored together with the rest of the material and could not be studied. Guenther's (1991) results, however, are considered in the present study. The sample unearthed in 1952 also included bone fragments, among them a huge amount of reindeer long-bones. A comparison with the bone sample unearthed during the more recent excavations in Salzgitter in 1977 (Lebenstedt II) illustrates that the 1952 sample suffered from a strong collection bias towards bone fragments. A strong collection bias is equally apparent for the lithic material (Gaudzinski, 1998). It was therefore decided to exclude these fragments altogether from the analysis.
In the following the methods that served the analysis of Lebenstedt I are listed:

Taxonomic determination, age and sex determination, and determination of season of death

Part of the faunal material was taxonomically determined by A. Kleinschmidt, this especially applied to skeletal remains from reindeer. Further in-depth determination for a variety of taxa as to skeletal elements were undertaken by the author.
The mammoth teeth had been studied by Guenther (1991). He provided information on the ages of the individuals represented. The mortality structure for mammoth was calculated based on data provided by Haynes (1993), Laws and Parker (1968) and Laws (1966).
For reindeer, determination of age is based on Habermehl (1985) and a comparative study with reindeer, aged between 2 months and 12.5 years, from West Greenland from the comparative collection of the MONREPOS Archaeological Research Center and Museum for Human Behavioural Evolution. For information on epiphyseal fusion Hufthammer's data (1995) were used. The seasonality of mortality based on reindeer antlers is based on Berke (1989) and Sturdy (1975).

Minimum Number of Individuals (MNI)

MNI calculation followed Binford (1978), but additionally took information on individual age into consideration. For reindeer the %-MNI (Minimum Number of Individuals) were calculated against the most frequent

postcranial element (i. e., the metatarsus) and were obtained by putting the proximal metatarsus at 100 %, calculating the other %-MNIs relative to this.

Weathering

Traces of weathering indicating the relative duration between the death of an individual and its final burial were documented based on information about climatically induced weathering provided by Behrensmeyer (1978).

Abrasion

As with traces of weathering, abrasion is another parameter that indicates the relative time between the death and the burial of an individual. Among other taphonomic variables, fluvial transport can lead to bone abrasion. The study of bone abrasion distinguishes between unrolled, heavily rolled and partially rolled skeletal elements as suggested by Shipman (1981).

Bone mineral density

Selective post-depositional bone destruction can be related to bone mineral density. In order to evaluate if the assemblage was affected by selective processes, skeletal element representations for reindeer, horse and bison were analysed using bone mineral density data (Lyman, 1994; Gaudzinski, 1998: Tab. 14) that were correlated with %-MNI for the individual species.

Bone loss due to fluvial transport

Fluvial dynamics can cause selective transport of bones. Documentation of presence/absence of particular bones of a carcass can help to evaluate if a bone assemblage was affected by these processes, as it leads to a loss of more easily transportable parts (Voorhies, 1969). The transport potential of different bones is known (Voorhies, 1969; Behrensmeyer, 1975). Bones with similar dispersal behaviour are combined into Dispersal-Groups, where bones of Dispersal-Group 1 (various vertebrae, carpals, tarsals) are very susceptible to fluvial transport whereas bones of Dispersal-Group 3 (elements of the skull) characterize lag deposits. Bone loss due to fluvial transport was checked for *Rangifer tarandus*, *Mammuthus primigenius*, *Equus ferus*, *Bison priscus* and *Coelodonta antiquitatis* (for a detailed definition of Dispersal-Groups for the individual species, cf. Gaudzinski, 1998).

Modification by carnivores and deer

For the identification of traces of carnivore modification, the zooarchaeological comparative collection of the MONREPOS Archaeological Research Centre and Museum for Human Behavioural Evolution was used. Identification followed Haynes (1983), Zapfe (1939) and Sutcliffe (1973).

	NISP 1952	MNI 1952	NISP incl. 1977	MNI incl. 1977
Rangifer tarandus	2130	86	4358	not specified
Mammuthus primigenius	410	17	478	not specified
Equus sp.	227	8	515	not specified
Bison priscus	79	3	128	3
Coelodonta antiquitatis	9	1	38	3
Canis lupus	1	1	8	2
Megaloceros giganteus	-	-	8	2
Panthera leo spelaea	-	-	2	2

Tab. 1 Salzgitter-Lebenstedt (Lebenstedt I and II). Qualitative and quantitative composition of the large mammal assemblage according to frequency. NISP includes Lebenstedt II, taken from Ludowici and Pöppelmann (2017). NISP = Number of Identified Specimens per taxon, MNI = Minimum Number of Individuals.

Bone surface modifications and fragmentation by humans

Bone surfaces were studied using a hand lens with a magnification of 32×. All traces were registered per bone and recorded by anatomical position. The taphonomic comparative collection of the MONREPOS Archaeological Research Centre and Museum for Human Behavioral Evolution and diagnostic criteria were used to identify hominin induced cut-marks and anthropogenic fractures (Binford, 1981; Blumenschine and Selvaggio, 1991).
For the visualisation of characteristics on bone retouchers and cut-marked bird-bones a Smartzoom 5 digital microscope was used, featuring a PlanApo D 1.6×/0.1 objective.

RESULTS FROM THE ANALYSIS OF LEBENSTEDT I, CONTEXTUALISED AGAINST LEBENSTEDT II

In the following results of the zooarchaeological analysis of Lebenstedt I are reported and evaluated against the results of new zooarchaeological analysis that also included the material from the 1977 excavation at Lebenstedt II (Ludowici and Pöppelmann, 2017). In parts, these studies followed a different methodological apparatus that cannot be replicated for the entire newly analysed assemblage. It is therefore not always possible to directly compare the results of both studies. The Ludowici and Pöppelmann (2017) study had strong focus on palaeontology, on species determination and demography and considerably enlarged sample size. It becomes apparent that results obtained from the extended sample supports the results obtained from the 1952 assemblage, while adding additional valuable information.
Bone preservation at Salzgitter is generally very good, as is shown for example by the survival of bones from neonate mammoths or the survival of numerous complete reindeer hemi-mandibles. Kleinschmidt's finding that the character of bone surface preservation can vary on a single bone, was repeatedly confirmed (cf. Gaudzinski, 1998: Tab. 9), however and therefore, for this assemblage weathering and abrasion do not serve as suitable indicators for the relative time between the death of an individual and its final burial.
Staesche (2017a) identified more than 30 bone-fragments exposed to fire. Whereas some of these show only slight traces of burning, others are completely calcinated. They were detected among bone-fragments

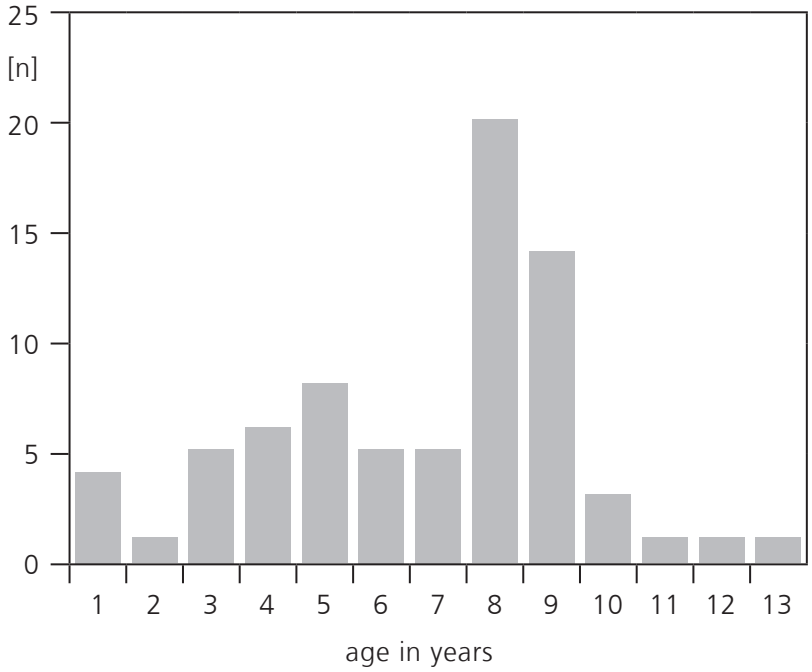

Fig. 1 Lebenstedt I. Age profile for *Rangifer tarandus* based on age estimates for complete hemi-mandibles [n].

from Lebenstedt I and II. Staesche interprets these bones to have been used as fuel. Hearths, however, were neither documented for Lebenstedt I (Tode, 1952) nor for Lebenstedt II.
The assemblage of large mammal species from Lebenstedt I comprised species listed in **Table 1**.
The new round of faunal studies Ludowici and Pöppelmann (2017) that included the Lebenstedt II material presented an enlarged species composition, in which *Megaloceros giganteus* (Staesche, 2017d) and *Panthera leo spelaea* (Staesche, 2017e) were additionally identified.

Rangifer tarandus

In total, 2,130 reindeer bones from Lebenstedt I were analysed, amounting to an MNI of 86. Age composition for Lebenstedt I indicates a stable presence of young individuals with a peak at 8 to 9 years (**Fig. 1**). A number of 74 more or less completely preserved hemi-mandibles were included in the study (Gaudzinski and Roebroeks, 2000).
For an estimate on the sex ratio represented in Lebenstedt I, measurements of antler bases were undertaken (Gaudzinski and Roebroeks, 2000) that reveal a clear bimodal distribution with a large group of adult males and a second group of sub-adult males, females and young individuals (**Fig. 2**). Season of death was stipulated for Lebenstedt I (Gaudzinski and Roebroeks, 2000) based on the dentition of young individuals, stages of epiphyseal fusion in young individuals, and the state of antler as late summer/autumn, leading to the interpretation of autumn-hunting of entire reindeer-herd(s), an interpretation later supported by studies on tooth-microwear analysis (Rivals et al., 2015).
The new zooarchaeological studies (Staesche, 2017b) which included Lebenstedt II, considerably enlarged the reindeer-sample to NISP = 4,358. However, MNIs were not calculated.This study puts particular empha-

sis on the determination of sex, age and season of death, underlining the relatively high amount of juvenile and subadult individuals and concluded a balanced gender ratio, possibly with a very slight prevalence of females, and resumed that age- and sex composition reflects the structure of a naturally occurring population (Staesche, 2017b). Histological analysis of root cementum annulations of two mandibular first molars stretched the season of death for the reindeer from late fall to winter, as both seasons were evidenced (Kirdorf and Witzel, 2017).

Skeletal element representation for reindeer in Lebenstedt I (**Tab. 2**) showed frequent survival of elements of the skull and distal parts of hind legs, a result consolidated by the new studies (Staesche, 2017b: Tab. 3). At Lebenstedt I the skeletal element representation was evaluated for bone selection by fluvial processes and density mediated attrition. For the latter, the correlation coefficient ($r = 0.63$) and the coefficient of determination (r^2) indicate that less than half of the observed variation can be attributed to the influence of the density-to-%MNI relationship (Gaudzinski and Roebroeks, 2000: 503, Fig. 3). Analysis of fluvial selection with the abundant presence of bones of all Dispersal-Groups indicates a relatively undisturbed faunal assemblage, with only little material loss (Gaudzinski, 1998; Gaudzinski and Roebroeks, 2000).

Equally, carnivores modified the Lebenstedt I bone assemblage to a minor degree, with only 16 bones displaying evidence for carnivore modification (Gaudzinski, 1998; Gaudzinski and Roebroeks, 2002: Tab. 1). The substantial extension of the reindeer sample achieved by including Lebenstedt II, further lowered this

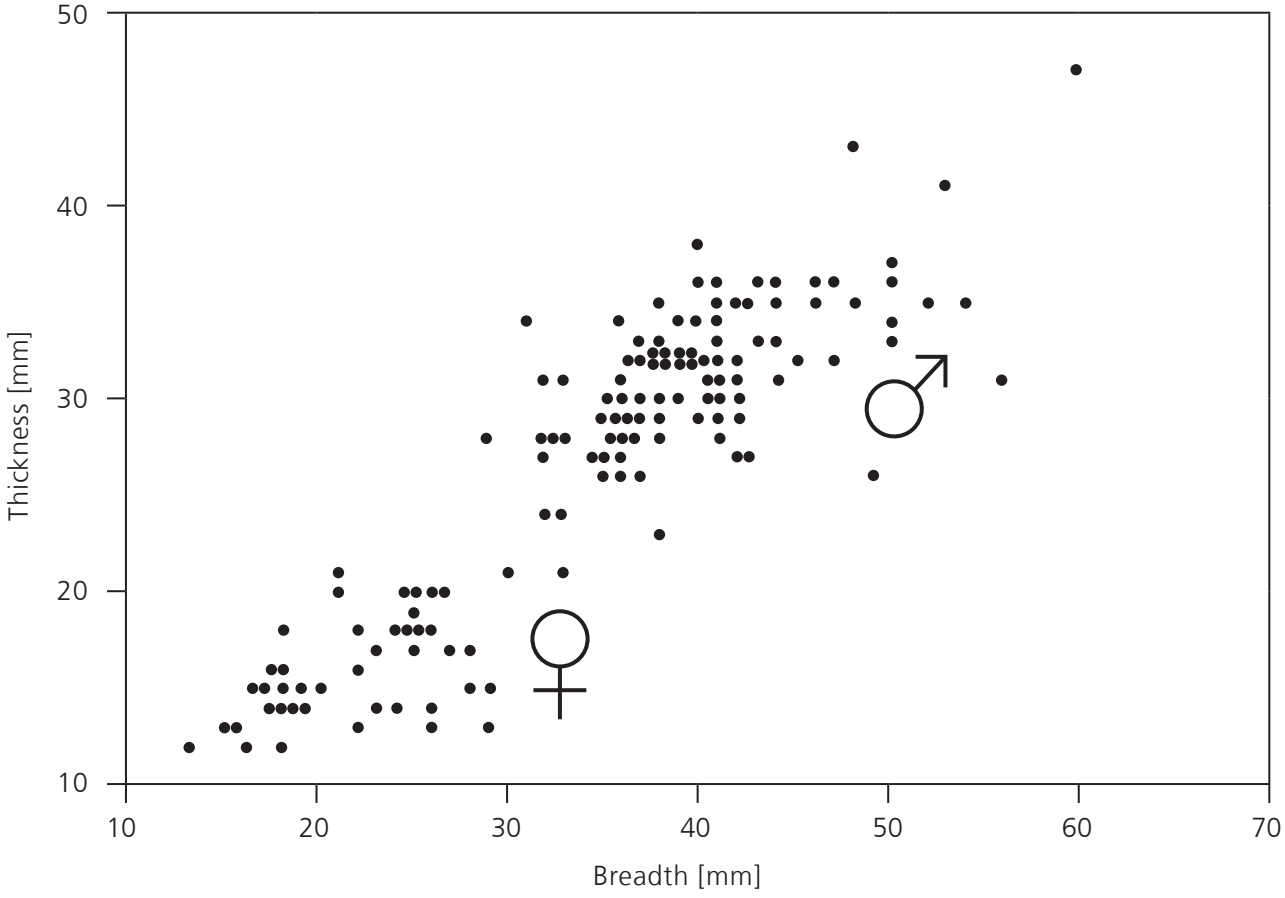

Fig. 2 Lebenstedt I. Thickness *vs.* breadth for antler beams (n = 135). For position of measurements taken see Sturdy (1975: Fig. 1, position 2).

	NISP	MNI sin	MNI sin./dext.	MNI dext.	MNI	MNI [%]
Antler	156	78	-	86	82	186.4
Maxilla	34	17	-	15	16	36.4
Mandible	83	48	-	33	41	93.2
Atlas	18	-	18	-	18	41.0
Epistropheus	15	-	15	-	15	34.1
Cervical	44	-	17	-	10	22.7
Thoracal	92	-	13	-	8	18.2
Lumbar	39	-	11	-	9	20.5
Sacral	8	-	8	-	8	18.2
Pelvis	52	27	-	25	26	59.1
Ribs	275	17	-	19	11	25.0
Scapula	49	28	-	21	25	56.8
Humerus prox.	18	15	-	3	9	20.5
Humerus dist	54	31	-	23	27	61.4
Radius prox.	55	20	-	35	27	61.4
Radius dist.	39	14	-	25	20	45.5
Ulna	36	16	-	20	18	40.9
Metacarpus prox.	38	23	-	15	19	43.2
Metacarpus dist.	41	20	7	14	17	38.6
Femur prox.	27	13	-	14	14	31.8
Femur dist.	50	30	-	20	25	56.8
Tibia prox.	67	31	-	36	34	77.3
Tibia dist.	83	49	-	34	42	95.4
Metatarsus prox.	87	45	-	42	44	100.0
Metatarsus dist.	97	34	-	41	38	86.4
Calcaneus	63	43	-	20	32	72.7
Astragalus	46	23	-	23	23	52.3
Phalange I	95	32	-	29	24	55.0
Phalange II	38	16	-	11	11	25.0
Phalange III	20	5	-	6	5	11.4

Tab. 2 Lebenstedt I, *Rangifer tarandus*. Qualitative and quantitative composition of skeletal elements. NISP = Number of Identified Specimens. MNI sin. = Minimum Number of Individuals (MNI) for the left body half, MNI dext. for the right body half.

already low ratio, as Staesche counts only 27 modified bones for the entire assemblage (Staesche, 2017a: 74, Tab. 1).

Apart from carnivores, herbivores additionally modified the thanatocoenosis and their traces can occasionally be documented on antler fragments in the form of forking of fragments or of flat, blunt, and broad grooves on antler beams (Gaudzinski, 1998: Tab. 7,3). Staesche considers faunal remains with these modifications intentionally modified tools (Staesche, 2017a: 81, Figs. 14-17).

Lebenstedt I gives evidence for numerous traces of hominin meat and marrow processing, in the form of cut-marked bones and bones with conchoidal impact fractures (**Tab. 3**; **Fig. 3**) (Gaudzinski and Roebroeks, 2003). The documented traces must be read as a quantitative minimum estimate, as a thin sedimentary film covered some of the bones and blurred traces. Cut-marks and impact fractures were documented on 512 skeletal elements or fragments thereof, with 222 skeletal elements displaying conically induced impacts. Bone fracture patterns point to a very standardized marrow exploitation (Gaudzinski and Roebroeks, 2000:

Figs. 11-13). The systematic and standardised way of marrow exploitation is particularly well illustrated by metatarsals. For opening the marrow cavity, the anterior face of the bone was taken off like a lid (Gaudzinski, 1998; Gaudzinski and Roebroeks, 2000: Fig. 13) (**Fig. 3**).
Staesche (2017a) also analysed traces of hominin meat and marrow exploitation but only documented part of these (Staesche, 2017a: 77, Tab. 3). In contrast to the documentation of cut- and fracture marks at Lebenstedt I, he documented the number of cuts, not the number of cut-marked bones, and additionally mentions that the assemblage yielded numerous additional unspecified cut-marked fragments. Though Staesches documentation of traces is knowingly incomplete, his observations on the occurrence of cut-marks adds valuable information. He primarily observed cuts on ribs, tibiae and metatarsi, a result already outlined for Lebenstedt I, consolidating the low abundance of traces on metacarpi and forelegs as well as on the upper part of hindlegs. This is quite remarkable as the inclusion of all shaft-fragments in the analysis did obviously not alter the general pattern observed in the analysis of Lebenstedt I only.
Staesche additionally observes conically induced impacts and, again in contrast to the analysis of Lebenstedt I, documents the number of impacts, not the number of elements on which these traces have been observed. Again, the highest number of impacts is observed on tibiae and metatarsi, as is also documented for Lebenstedt I. These results consolidate observations made for Lebenstedt I, showing that during the process of marrow exploitation a selection against subadult individuals, mandibles, metacarpi and phalanges occurred (Gaudzinski and Roebroeks, 2000: 508-509, Fig. 14).
Several long bone fragments show scars due to the fragments having been used for stone tool production. Some of the bone retouchers preserved tiny flint fragments embedded in their scar-fields (**Fig. 4**). Staesche (2017a) counted 67 scar-fields, most of them on fragments of tibiae (n = 37) and metatarsi (n = 21).
Reindeer-antler was also modified by humans. One of the best examples is an almost complete left antler beam, still attached to the skull, with distinct chopping marks on the brow-tine (Tode et al., 1953; Gaudzinski, 1998).

Mammuthus primigenius

A number of 410 remains from *M. primigenius* have been studied from Lebenstedt I. A MNI of 17 was calculated based on the abrasional pattern of the occlusal face of upper (n = 11) and lower (n = 10) molars (Guenther, 1991). Guenther (1991) additionally provides information on the age of death of these individuals. Even though the sample is small, thought on the mortality structure represented was given (Gaudzinski, 1998).
For the interpretation of mortality structures in elephants, Haynes (1991) suggested a subdivision of ages according to 12 year-intervals. Elephants reach the height of their reproductive career, i. e., their prime, at an age between ca. 37-45 years (Haynes, 1991). For the Salzgitter mammoths a clear dominance of juveniles and subadult individuals and noticeable under-representation of prime adults and old individuals becomes apparent (Gaudzinski, 1999). This result finds support in Krönneck's recent analysis of the mammoth age composition based on the epiphyseal state of the postcranial skeleton that included material from Lebenstedt I and II (Krönneck, 2017b).
The general skeletal element representation for mammoth (**Tab. 4**) from Lebenstedt I is clearly dominated by molars and fibulae. A number of 13 fibulae were recorded that represent a minimum of seven individuals. The abundance of fibulae does not correspond to the rather small number of skeletal elements that articulate with the fibula, i. e., the tibia or tarsal bones.
Moreover, 161 rib fragments of 10 cm to more than 1 m length were documented with the provison that no confusion with *Coelodonta antiquitatis* ribs occurred (especially for the smaller fragments) (cf. Wolsan,

	Impact fractures		Cut-marks		
	sin.	dext.	sin.	dext.	sin./ dext.
Mandible					
lateral			16	7	
medial			6	4	
medial and lateral			25	18	
Humerus Shaft					
cranial	0	0	2	1	
caudal	0	1	3	3	
lateral	3	3	1	3	1
medial	4	4	7	7	
lateral and medial			2		
Humerus distal					
caudal	0	0	0	3	
lateral	0	0	2	0	
medial	0	0	4	6	
Radius/Ulna prox.					
cranial	0	1	1	1	1
caudal	0	0	0	0	
lateral	0	1	1	3	1
medial	1	0	1	0	
Radius/Ulna Shaft					
cranial	7	11	10	12	
caudal	1	5	0	1	
lateral	0	0	1	0	
medial	1	0	1	0	
Radius/Ulna dist.					
caudal	0	0	0	1	
Metacarpus Shaft					
cranial	0	1	5	3	1
caudal	0	0	0	0	1
lateral	0	0	1	1	
medial	4	1	5	1	1
Metacarpus dist.					
cranial	0	0	0	1	
Femur prox.					
caudal	0	0	1	0	
lateral	0	0	1	0	
Femur Shaft					
cranial	6	2	7	8	
caudal	2	1	0	2	
lateral	1	1	1	1	2*
medial	7	5	1	2	
Femur dist.					
cranial	0	0	1	0	
lateral	0	0	1	0	
medial	0	0	0	1	

	Impact fractures		Cut-marks		
	sin.	dext.	sin.	dext.	sin./ dext.
Tibia Shaft					
cranial	4	1	3	2	
caudal	6	13	12	9	
lateral	0	1	4	2	
medial	19	18	8	9	
lateral and medial	1			2	
Tibia dist.					
cranial	0	0	1	0	
caudal	0	0	0	1	
Astragalus					
lateral			0	2	
medial			1	3	
lateral and medial			1	4	
Calcaneus			16	11	
Os cubo-naviculare			4	1	
Metatarsus prox.					
cranial	0	0	0	0	
caudal	0	0	0	0	
lateral	1	0	0	2	
medial	0	0	1	1	
medial and lateral	0	0	1	0	
Metatarsus Shaft					
cranial	0	0	1	1	
caudal	0	0	0	0	
lateral	25	9	13	14	
medial	10	16	12	10	
medial and lateral	18	6	4	8	8

Tab. 3 Lebenstedt I, *Rangifer tarandus*. Frequency of cut-marks, percussion marks and gnawing marks on skeletal elements.
The table presents the number of skeletal elements (or fragments thereof) on which one or more cut-marks and/or percussion marks have been observed. ant. = anterior; post. = posterior; lat. = lateral; med. = medial; sin. = left; dex. = right; * = lat. or med.

	Cut-marks		
	sin.	sin./ dext.	dext.
Skull			
Maxilla	10	2	11
Os Nasale	5	0	4
Os Zygom.	1	0	0
Os Frontale		16	
Os Hyoid.	5	1	3
Skull indet.		6	
Scapula	22	10	18
Vertebrae			
Atlas		15	
Epistropheus		5	
cerv 3		6	
cerC 4		0	
cerv 5		2	
cerv 6		3	
cerv 7		2	
th 1		9	
th 2		12	
th 3		7	
th 4		6	
th 5		5	
th 6		0	
th 7		2	
th 8		4	
th 9		2	
th 10		5	
th 11		4	
th 12		7	
th 13		3	
l 1		7	
l 2		10	
l 3		0	
l 4		5	
l 5		7	
Sacrum		3	
Ribs			
1. Rib	1		1
2. Rib	2		2
3. Rib	2		3
4. Rib	5		11
5. Rib	10		7
6. Rib	8		7
7. Rib	9		11
8. Rib	9		8
9. Rib	10		9
10. Rib	8		9
11. Rib	6		8
12. Rib	3		6

	Cut-marks		
	sin.	sin./ dext.	dext.
13. Rib	1		3
14. Rib	1		3
Rib-Fragments		48	
Sternum Segment			
1		3	
2			
3		1	
4			
5			
6		1	
7			
indet		1	
SterCum Segment 1-3		2	
Pelvis	18		7
Phalanx 1			
ant. sin. med		5	
ant. sin. lat.		6	
ant. dex. lat.		7	
post. dex. lat.		2	
post. dex. med.		2	
post. sin. lat.		4	
post. sin. med.		3	
Phalanx 2			
post. sin. lat.		1	
Phalanx 3			
post. sin. lat.		2	
post. sin. med.		2	

	gnawed	tooth marks	possible tooth marks
Mandible	2	2	2
Scapula	1	4	2
Pelvis	4	0	0
Humerus	1	0	1
Radius/Ulna	2	0	1
Femur prox.	2	0	1
Femur dist.	4	4	0
Metatarsus	0	2	2



Fig. 3 Lebenstedt I. Typical fracture patterns for (**a**) metatarsals from *Rangifer tarandus* and (**b**) Radius/Ulna with enlargements of three proximal locations with cut-marks.

1982). Only six of these ribs were complete, a number of 40 proximal ends survived as well as 14 distal ends. The sum of the length of all fragments is 75.55 m, and thus it could be pointed out that ribs represent a further dominant element within the prostcranial element representation for this species. The observed skeletal element representation clearly deviates from patterns generally observed in the archaeological and palaeontological record (cf. Haynes, 1991).

The faunal study from 2017 (Krönneck, 2017b) of Lebenstedt I and II excluded teeth from the analysis, but underlines the results obtained from Lebenstedt I, in that it also observes ribs to be among the most numerous skeletal elements. Due to a higher number of fragments of femora and acetabuli, the 2017 study highlights pelvis and femora as second most frequently represented in the comparative compilation of skeletal elements based on bone weight.

Lebenstedt I also yielded bones from neonate individuals. They are primarily represented by complete mandibles (n = 3) and pelves (n = 2). Additional three fragmented pelvis remains from juvenile individuals complete the assemblage, indicating a clearly biased skeletal element representation for juvenile/subadult mammoths (Gaudzinski, 1998).

The profile of mammoth body parts (**Tab. 4**) is characterized by an anecdotal presence of bones and bone loss by fluvial transport. However, bones of all Dispersal-Groups were present in relatively equal proportions (cf. Gaudzinski, 1998: 194, Fig. 14), with selective fluvial mechanisms seemingly having played no or only a minor role in the survival of skeletal elements of this species (Gaudzinski, 1998).

For Lebenstedt I, carnivore modification affected a high number of these skeletal elements, as 27.7 % show traces of gnawing. The damage pattern indicates hyena damage. A number of 93 small long bone fragments that could not be determined to skeletal element complete the assemblage. Among them are 45 bone fragments, again a very high ratio, with clear hyena modification (Gaudzinski, 1999). In contrast, Staesche (2017a) outlines a number of only 18 bones for Lebenstedt I and II modified by carnivores, mostly hyaenas.

The degree of hominin interaction with the mammoth remains judged from cut-mark frequencies is difficult to assess. Various surface modifications can be observed on ribs due to post-excavational conservatorial measures. Among bones from Lebenstedt I are six rib fragments with unambiguous cut-marks. As other presumable cut-marks have been observed associated with surface modifications that clearly originated from conservatorial measures, quali- and quantification of cut-marks was not undertaken for this assemblage.

Staesche (2017a) was able to increase this sample by including Lebenstedt II, with a further cut-marked rib as well as two fibulae and two pelvis fragments.

Hominin influence on the mammoth assemblage is also clearly indicated by modified ribs and fibulae. Within Lebenstedt I a total of 23 skeletal elements shows modifications made by humans. In addition, Tode mentions a further two ribs (Tode, 1953: Fig. 18 bottom; Tode, 1982: Taf. 124b.2) as well as a modified fibula (Tode, 1982: Taf. 124b.1) with modifications similar to those described below. These bones are not stored in Wolfenbüttel and were therefore not included in the analyses of bone-tools from Lebenstedt I. A comparison of 20 mammoth ribs with unmodified (cf. Gaudzinski, 1999: Fig. 5a), broken off (cf. Gaudzinski, 1999: Fig. 5b), carnivore gnawed (cf. Gaudzinski, 1999: Fig. 5c) or split-by-drying (cf. Gaudzinski, 1999: Fig. 5e) ends from Lebenstedt I clearly illustrates the morphological differences between these ribs and those modified by humans.

It can generally be outlined that the majority of ribs modified by humans are characterized by a spiral fracture resulting from the removal of the head. Due to the high degree of carnivore modification it is unclear whether hyaenas or humans were responsible for these damages. All modified ribs show a convex curvature corresponding to their natural bending.

Three modes of modification on the ribs can be distinguished. One way of modifying the ribs is characterized by the symmetrical or unsymmetrical tapering of the ribs' ends opposite the spiral fractured end from

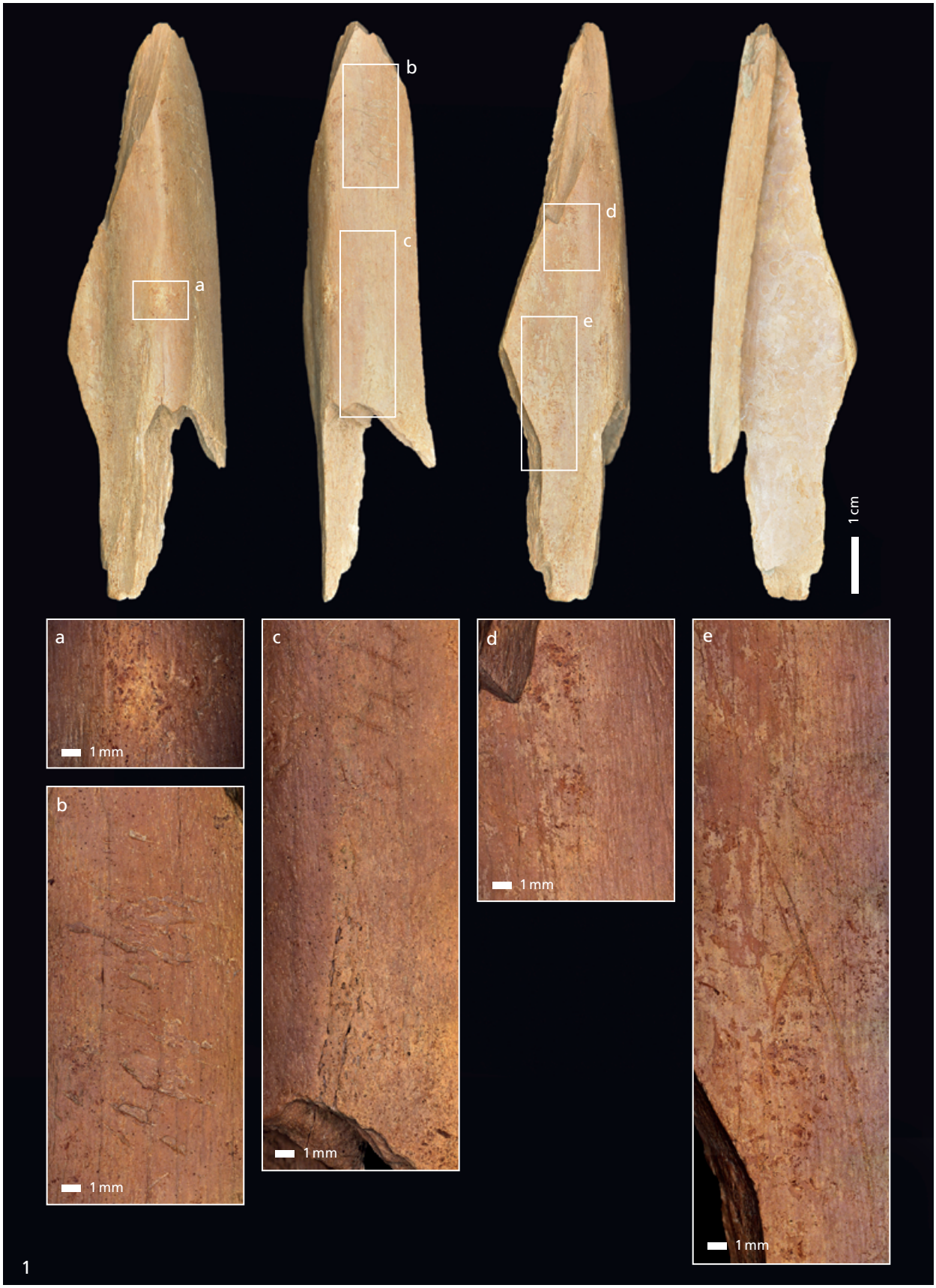

Fig. 4 **1** Lebenstedt I. Bone retoucher.



Fig. 4 **2** Lebenstedt I. Bone retoucher.



Fig. 4 **3** Lebenstedt I. Bone retoucher with flint fragments (indicated with an arrow) still embedded in the scar-fields.

	NISP	MNI sin.	MNI sin./dext.	MNI dext.	MNI [%]
Maxilla	8	5	-	3	57.1
Mandible	14	7	-	7	100.0
Cervical	2	-	1	-	2.3
Thoracal	17	-	3	-	2.5
Lumbar	3	-	1	-	2.0
indet.	25	-	1	-	-
Pelvis	4	-	2	-	14.2
Ribs	(161)				
Scapula	4	2	-	2	28.5
Humerus dist.	1	1	-	-	7.1
Radius prox.	6	3	-	2	35.7
Ulna	6	2	-	3	35.7
Os carpale	1	1	-	-	7.1
Os naviculare	1	1	-	-	7.1
Patella	1	-	-	1	7.1
Tibia prox.	3	1	1	1	21.4
Fibula	13	7	-	6	92.8
Talus	1	-	1	-	7.1
Phalanges	2	1	-	1	14.2

Tab. 4 Lebenstedt I, *Mammuthus primigenius*. Skeletal elements. NISP = Minimum Number of Identified Specimens. MNI sin. = Minimum Number of Individuals (MNI) for the left body half, MNI dext. for the right body half; MNI sin./dext. = body side indeterminate.

cranial and/or caudal direction. These modifications either affect or remove the compacta on the lateral face of the bone and produced short, flat points (compare Rib 1 and Rib 4; **Fig. 5** and **Fig. 8**; Note: modified ribs are addressed below in paragraphs of their own). It is striking that some of the ribs modified this way lack a clearly pointed tip (see Rib 1; **Fig. 5**) and it is unclear if the tip was intentionally broken off or broke off from functional stress.

A further modification of the ribs produced long and compact tips (compare Rib 2 and Rib 3; **Fig. 6** and **Fig. 7**). Tapering and pointing of the tip was either obtained by abrading the bone compacta while the convex curvature of the bone was retained by splitting off one half of the bone to reduce the tips circumference (see Rib 7; **Fig. 9**).

Furthermore, the morphology of ribs was altered by bone splitting (see Rib 1; **Fig. 5**). Numerous conical impacts on the bones' lateral and caudal edges attest to wedges, which were rammed into the caudal and lateral faces of the ribs in order to initiate the process of splitting. These impacts distinguish intentionally modified ribs from bones that disintegrated during storage due to drying. In order to reconstruct the work-stages necessary to produce the modifications observed in detail, traceological studies based on controlled experiments are necessary. These analyses are already initiated at the TraCEr Laboratory for Traceology and Controlled Experiments at the MONREPOS Archaeological Research Centre for Human Behavioural Evolution and will provide more insight into the quantification of the degree of functional stress as an additional variable in tool morphology.

All modified pieces have been described in detail in Gaudzinski (1998); therefore only a representative selection will be described below.

Rib 1 (**Fig. 5**)
(fragment, sin.; length: 60.3 cm, max. breadth: 3.7 cm, max. width: 2.5 cm)
The proximal end of the rib shows a spiral fracture 7.9 cm in length, indicating damage when the bone was still green. On its medial face the distal end was tapered by diagonal abrasion of the compacta from cranial, reducing the bone thickness from 1.8 cm (measured at the base of the modification) to 0.8 cm (measured at the tip) exposing the spongiosa. The modification also reduced the breadth of the bone (from 3.0 cm to 1.1 cm). The tip ends in a flat break.

Rib 2 (**Fig. 6**)
(fragment, sin.; length: 78.0 cm, max. breadth: 4.2 cm, max. width: 2.7 cm)
The proximal end of the rib shows a spiral fracture covering 11.4 cm and 3.4 cm of the cranial and caudal edges of the bone. At its distal end, the lateral face is modified by convergent abrasion of the bones' compacta from cranial and caudal resulting in a pointed tip, 10.4 cm in length. The bone was reduced in thickness from 1.6 cm (measured at the base of the modification) to 0.3 cm (measured at the tip) and breadth (from 3.5 cm to 0.9 cm), exposing the spongiosa at the end of the tip.

Rib 3 (**Fig. 7**)
(fragment, indet.; length: 37.6 cm, max. breadth: 3.3 cm, max. width: 2.2 cm)
Rib 3 is a fragment with a plain fracture. At the opposite end, the lateral face shows a tip similar to Rib 2. The unidirectional modification affected the compacta of the bone retaining the convex curvature of the bone surface. The tip measures 8.9 cm in length. At the tip, the bone was reduced in thickness from 1.2 cm (measured at the basis of the modification) to 0.3 cm (measured at the tip).

Rib 4 (**Fig. 8**)
(fragment, sin.; length: 63.3 cm, max. breadth: 3.9 cm, max. width: 2.4 cm)
The head of the rib was removed leaving a spiral fracture. At the distal end the lateral face was tapered from cranial and caudal to form a tip. The modification reduced the breadth of the bone from 1.3 cm (measured at the base of the modification) to 0.4 cm (measured at the tip) and exposed the spongiosa of the bone. In addition, the thickness was reduced from 3.4 cm to 0.6 cm by smoothing/abrading the lateral face.

Rib 7 (**Fig. 9**)
(fragment, indet.; length: 80.5 cm, max. breadth: 4.6 cm, max. width: 3.2 cm)
Rib 7 was equipped with a compact tip, 15.9 cm in length. On the lateral face, the compacta was modified retaining the concave curvature of the rib and probably subsequently additionally smoothed. The width of the tip was reduced by splitting off the medial half of the bone as shown by small conical impact fractures on the cranial and caudal edges of the bone. By producing a tip, the bones' breadth and width were reduced from 4.4 cm to 0.6 cm and from 3.3 to 0.5 cm.

Split rib 1 (**Fig. 10**)
(fragment, indet.; length: 72.5 cm, max. breadth: 5.1 cm, max. width: 2.4 cm)
The most striking feature that characterizes this bone fragment are numerous small conical impacts on the cranial and caudal side of the bone with a total of 18 impacts on one and 9 impacts on the opposite side. These damages result from the splitting of the bone. The proximal articular joint of the rib was broken off when the bone was still fresh, leaving a spiral fracture. The bone was equipped with a tip by tapering from

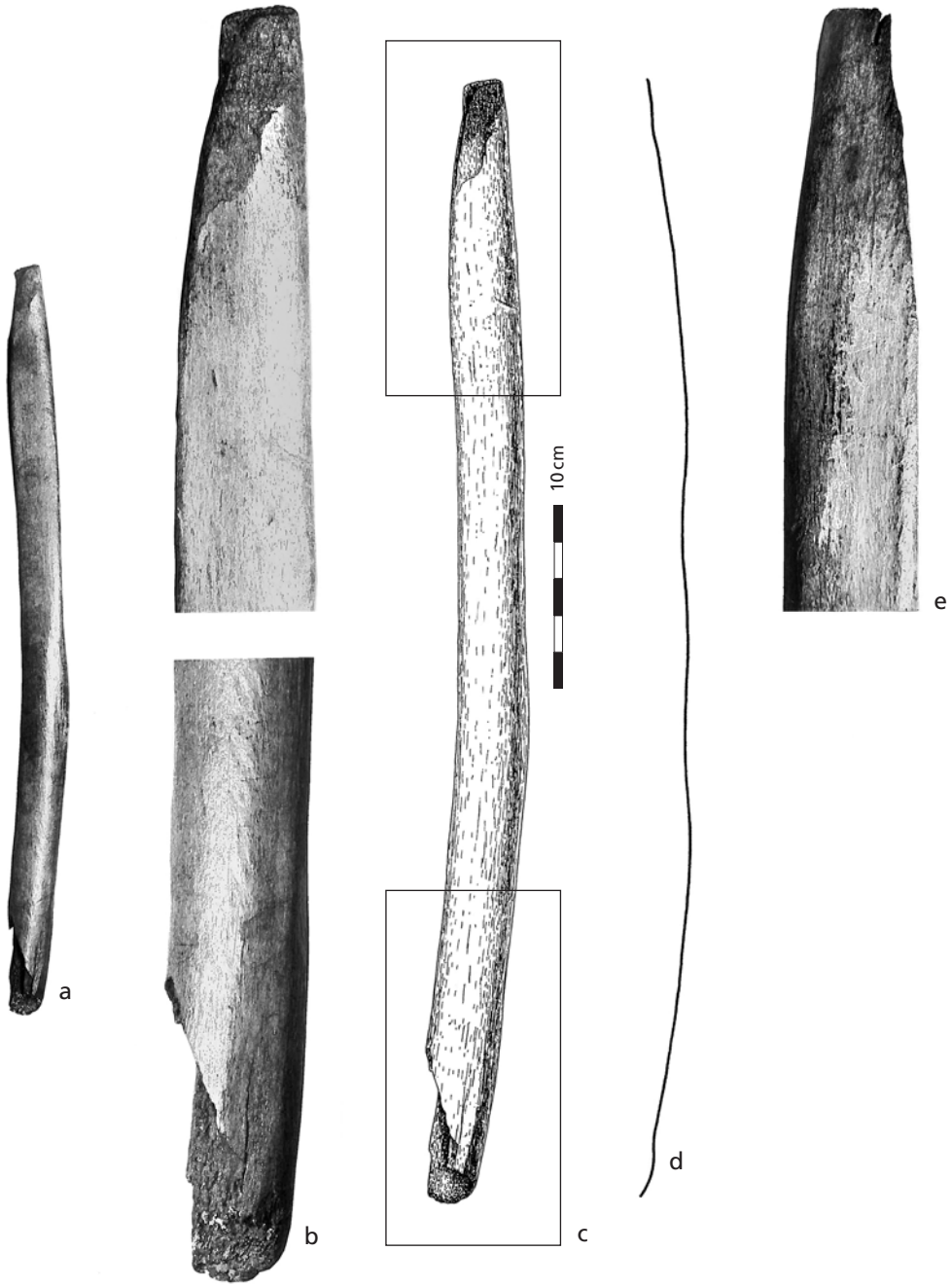

Fig. 5 Lebenstedt I. Modified Rib 1. **a-c** medial view; **d** caudal view; **e** lateral view.

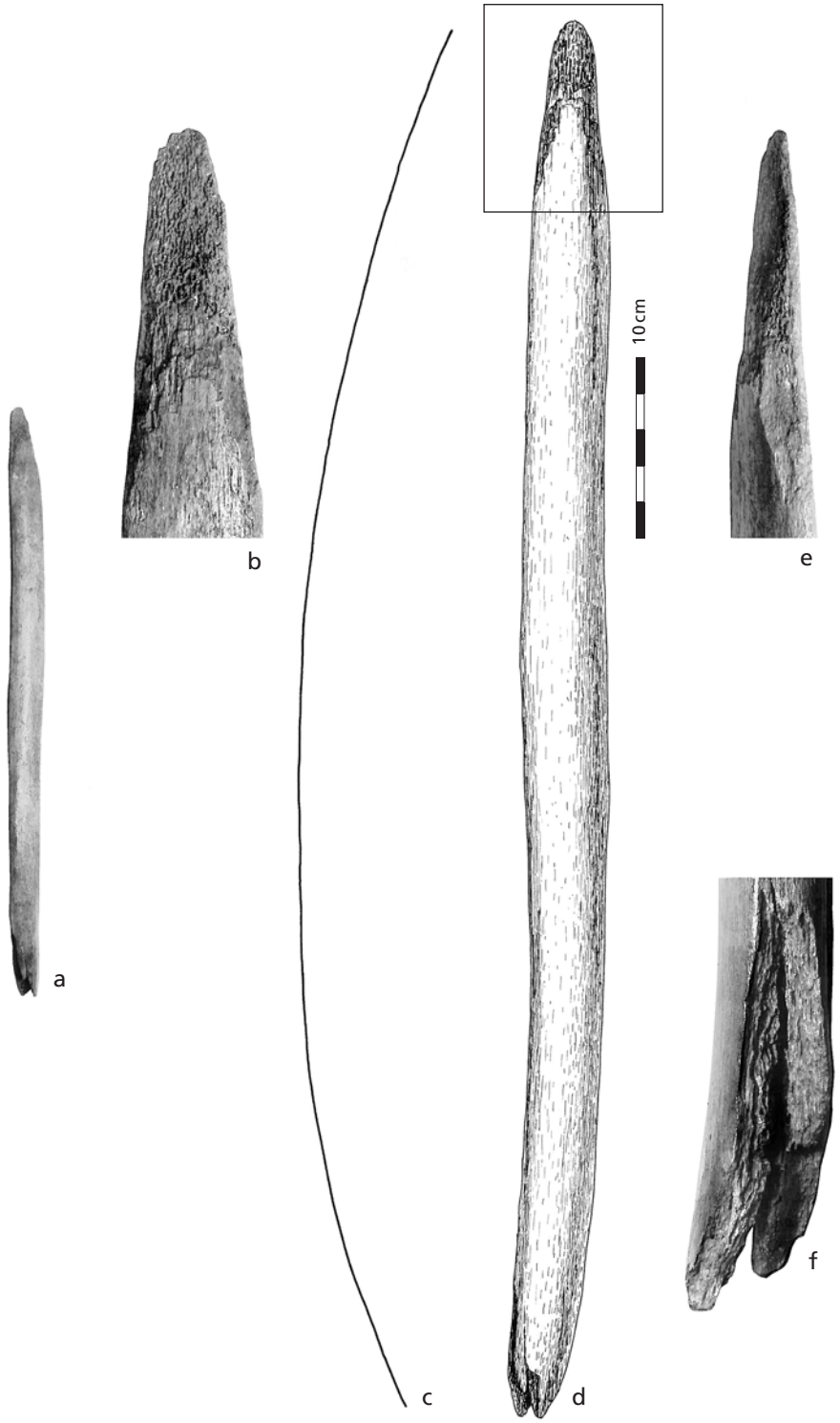

Fig. 6 Lebenstedt I. Modified Rib 2. **a-b, d** lateral view; **c** cranial/caudal view; **e-f** caudal/cranial view.

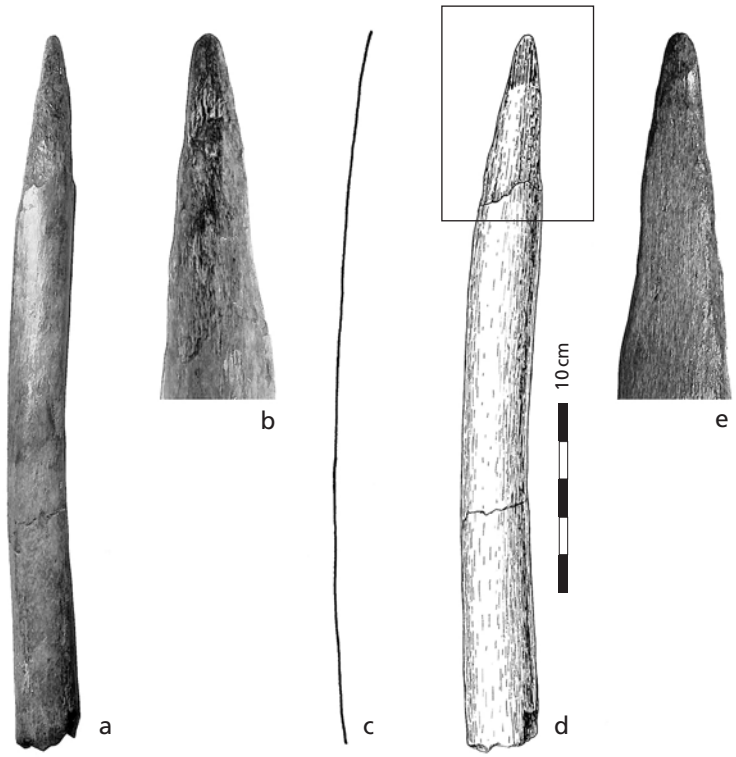

Fig. 7 Lebenstedt I. Modified Rib 3. **a-b, d** lateral view; **c** cranial/caudal view; **e** medial view.

cranial and caudal direction reducing the breadth of the bone from 3.5 cm to 1.4 cm. Both edges of the tip show rounding. The bones' thickness was reduced from 1.0 cm to 0.6 cm.
In addition to ribs, mammoth fibulae served as raw material for tool production. These bones show modifications comparable to the ones observed for the ribs. All modifications occurred proximal. The distal joint can be present (n = 2), absent (n = 1) or carnivore gnawed (n = 2). Fibula 1 (**Fig. 11**) serves as an example to illustrate the modifications observed.

Fibula 1 (**Fig. 11**)
(fibula, dext.; length: 50.2 cm, max. breadth: 5.0 cm, max. width: 4.0 cm)
Proximal, the bone was equipped with a point, 11.0 cm in length, by reducing the bones breadth (from 3.1 to 0.4 cm) and width (from 3.8 to 0.4 cm). The edges of the bone have been abraded and additionally smoothed. Distal, the bone bears traces of carnivore modification.

Bone point (**Fig. 12**)
An unequivocal piece of evidence for the manufacturing of tools is provided by a bone point, 6.3 cm in length. The bone fragment was shaped into a triangular form as shown by its abraded distal edges. Notching of the distal end occurred in order to produce a winged base. Proximally, a conical blunt tip indicates that the point was either used or manufactured to be used for drilling. The point was either produced from mammoth or rhino long-bone, judging from the surface properties of the winged base.
It has repeatedly been outlined that the bone point is probably intrusive to the assemblage, as according to Müller-Beck (1966), it indicates an unexpectedly evolved technique for the Middle Palaeolithic. Judging

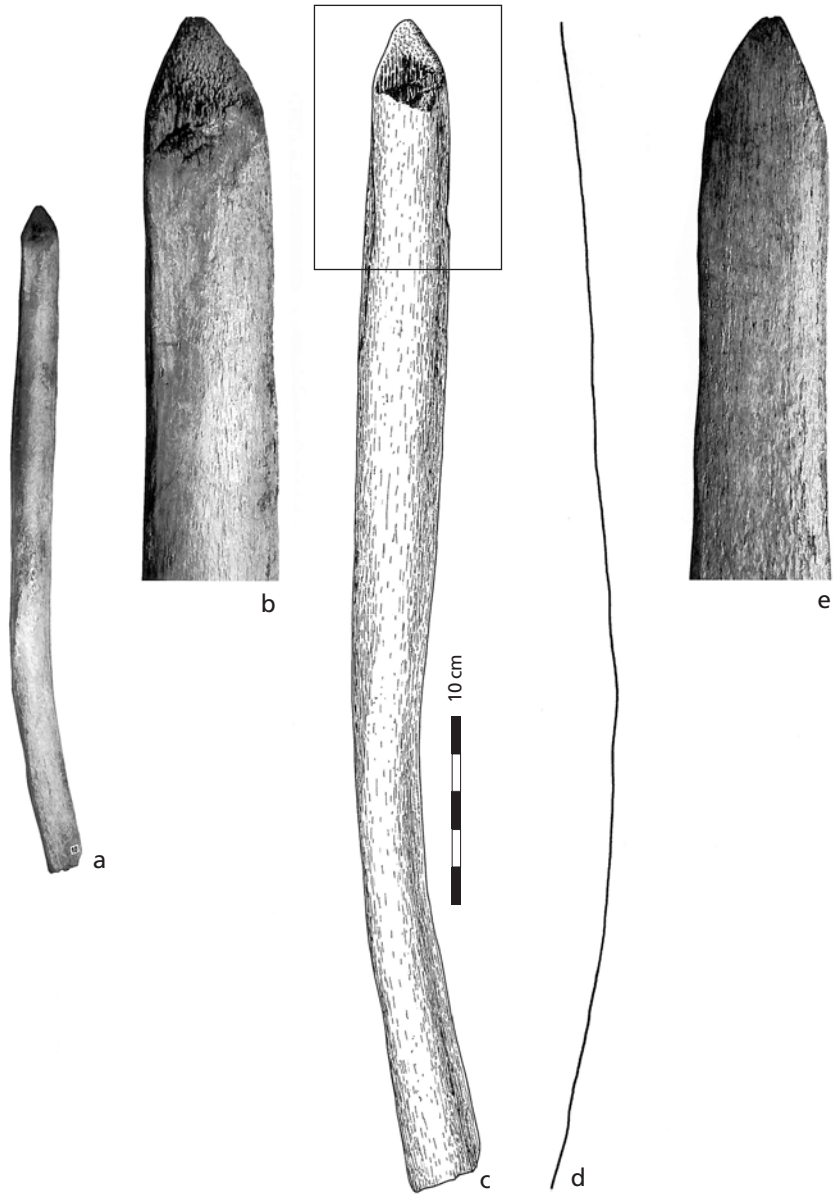

Fig. 8 Lebenstedt I. Modified Rib 4. **a-c** lateral view; **d** caudal view; **e** medial view.

from the depositional setting of the site there are no indications to support this suggestion (Preul, 1991). In his 1952 publication Tode mentions that the point was not found in primary position though definitely originates from Middle Palaeolithic substrate and quotes Kleinschmidt who considered the point to have been produced from a rib, probably of mammoth (Tode, 1953: 214).

According to Staesche (2017d, 2017a) who quotes unpublished documentation by Kleinschmidt, the tool was however found on the excavations soil heap and Staesche (2017a) outlines that Kleinschmidt himself doubted the contemporaneity of this tool with the worked ribs and fibulae. These doubts were based on results of x-ray analyses indicating that the raw-material used for the point was red deer antler, with red deer not being part of the Middle Palaeolithic faunal assemblage. Thus, further studies are currently underway, which will shed light on these differing perspectives.

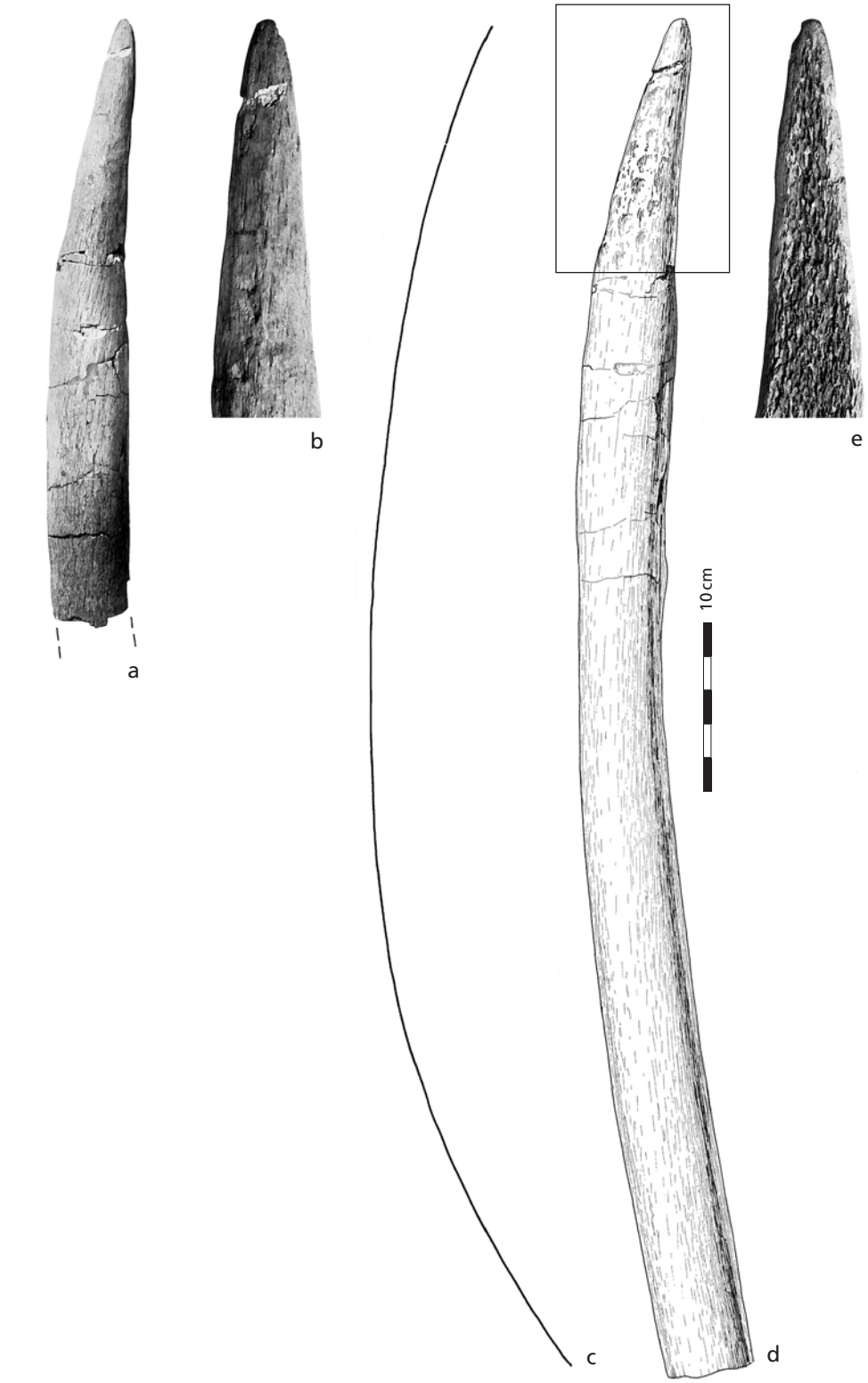

Fig. 9 Lebenstedt I. Modified Rib 7. **a-b, d** lateral view; **c** cranial/caudal view; **e** medial view.

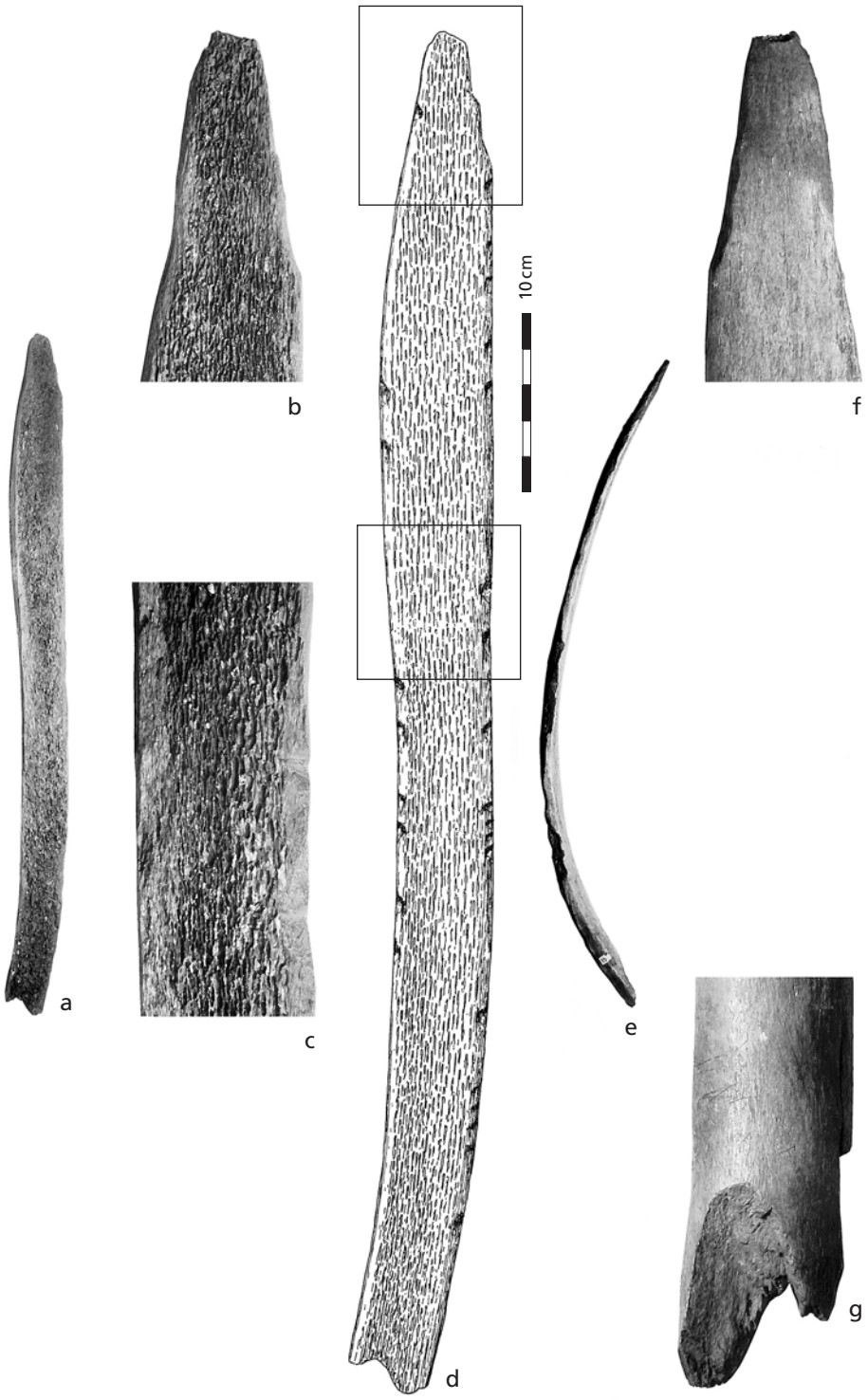

Fig. 10 Lebenstedt I. Split rib 1. **a-d** lateral view; **e** cranial/caudal view; **f-g** medial view.



Fig. 11 Lebenstedt I. Modified fibula 1. **a-b, e-f** lateral view; **c** medial view; **d** cranial view.

Equus sp.

Horse remains were numerously documented at Lebenstedt I. Based on a number of 228 bones and teeth, a MNI of 8 was calculated. During re-analysis of the material including bones from Lebenstedt II Cramer and Staesche (2017) identified 515 bones from this species, which they taxonomically classify as *Equus ferus*. It was outlined that the horses documented in Salzgitter were considerably smaller than the comparative population from Mosbach (Cramer and Staesche, 2017), a Middle Pleistocene context considerably older than Salzgitter.

Concerning age composition of the horse sample, Cramer and Staesche (2017) point out that 41 % of the sample represents bones and teeth from sub-adult to adult individuals, with only 6 % of the horse remains representing juveniles to subadults. The remaining bones and teeth do not allow an age estimate.



Fig. 12 Lebenstedt I. Bone point.

The skeletal element representation for Lebenstedt I horses (**Tab. 5**) is characterized by the presence of almost all body parts. Heads, scapulae and metatarsi dominate, while humeri, femura and phalanges are clearly under-represented, as are vertebrae. The assemblage is completed by rib fragments for which a minimum of at least three individuals could be calculated (Gaudzinski, 1998). The inclusion of Lebenstedt II by Cramer and Staesche (2017) consolidated these results in that it also emphasized the abundant presence of skull-elements, scapulae and metapodials (metacarpi being less well preserved than metatarsi) as well as an under-representation of phalanges and elements of the rump. However, it also modified the results in that the relatively equal survival of radius/ulnae and tibiae obvious for Lebenstedt I is deferred in favor of radius/ulnae. What is striking for Lebenstedt I is the high number of complete bones. For horse, the number of determinable postcranial elements amounts to 72, among which are 33 complete bones (45.8 %).

For an estimate if the differing bone preservation at the site depended on the burial environment impacting on the survival of horse bones, skeletal element representation for Lebenstedt I was matched against bone mineral density (Gaudzinski, 1998: Tab. 14, Fig. 12). A correlation could not be established indicating that the bone survival for horse was not, or only to a minor degree mediated by their density.

The same can be outlined for selective processes due to fluvial mechanisms that might have impacted the skeletal element representation. As for mammoth, again, bones of all Dispersal-Groups were present (cf. Gaudzinski, 1998: 194, Fig. 14).

Carnivore modification was documented for 16 bones, i. e., 22.2 % of the total sample. Fragments of tibiae showed conical impacts though it was not apparent if these traces originated from hominin or carnivore modification. Finally, for Lebenstedt I it could not be argued that humans were responsible for the bone accumulation as direct traces of interaction in the form of cut-marks could not be observed.

For Lebenstedt II, however, Staesche regularly observed cut-marks on a scapula, on ribs (n = 8), a pelvis, a femur, and on tibiae (n = 4) and metatarsi (n = 3) (Staesche, 2017a) and additionally reports conically induced impacts on three bones that he considers to have been induced by humans (Staesche, 2017: Tab. 2). Moreover, he reports three fragments of long-bones that were used as retouchers (Staesche, 2017a).

Bison priscus

The large mammal assemblage from Lebenstedt I yielded 79 skeletal remains identified as *Bison priscus.* A MNI of 3 was calculated based on the presence of three almost complete hemi-mandibles. The general pattern of skeletal element survival is characterized by a corresponding frequency of articulating bones. The axial skeleton in heavily under-represented, in contrast to the distal hind leg and elements of the skull.
To evaluate if the skeletal element representation is density mediated, body profiles were correlated with bone mineral densities, however no correlation was observed (Gaudzinski, 1998), and indications for a selective transport of bones by fluvial mechanisms were not shown as bones of all Dispersal-Groups, are represented despite the highly selective survival of body parts for *Bison* (Gaudzinski, 1998). The bones lacked modifications by carnivores and show indubitable butchering traces by hominins (Gaudzinski, 1998). The inclusion of faunal material from Lebenstedt II raised the NISP to 128 though the extension of the sample did not lead to an increase in MNI. The resulting skeletal-element representation is more or less congruent with Lebenstedt I. Larger differences occurred with the lower values for the survival of Metacarpi and elements of the skull (Krönneck, 2017a: 224, Fig. 1). These data were raised due to weight-proportions (Krönneck, 2017a). Staesche (2017a) observed a carnivore modification on a femur fragment, cut-marks on eight ribs and a humerus as well as retouching scars on a fragment of a radius/ulna.

	NISP	MNI sin.	MNI sin./dext.	MNI dext.	MNI [%]
Max.	18	5	8	5	66.6
Mandible	2	1	-	1	16.6
Thoracal	6	-	6	-	8.3
Lumbar	6	-	6	-	16.6
Sacral	2	-	2	-	8.3
Pelvis	5	4	-	1	41.6
Ribs	122	-	122	-	41.6
Scapula	10	4	-	6	83.3
Humerus prox.	2	1	-	1	16.6
Humerus dist.	3	1	-	2	25.0
Radius prox.	6	5	-	1	50.0
Radius dist.	6	5	-	1	50.0
Ulna	6	5	-	1	50.0
Metacarpus prox.	6	2	-	4	50.0
Metacarpus dist.	6	3	-	3	50.0
Femur prox.	3	2	-	1	25.0
Femur dist.	4	2	-	2	33.3
Tibia prox.	6	1	-	5	50.0
Tibia dist.	6	2	-	4	50.0
Metatarsus prox.	11	5	2	4	75.0
Metatarsus dist.	9	4	2	3	58.3
Calcaneus	4	3	-	1	33.3
Astragalus	1	1	-	-	8.3
Phalange III	3	-	3	-	8.3

Tab. 5 Lebenstedt I, *Equus* sp. Skeletal elements. NISP = Minimum Number of Identified Specimens. MNI sin. = Minimum Number of Individuals (MNI) for the left body half, MNI dext. for the right body half; MNI sin./dext. = body side indeterminate.

	NISP	NISP sin.	NISP sin./dext.	NISP dext.
Mandible	2	-	1	1
Cervical	1	-	1	-
Ribs	1	-	1	-
Scapula	1	-	-	1
Humerus prox.	1	-	1	-
Humerus dist.	1	-	1	-
Radius prox.	1	-	-	1
Radius dist.	1	-	-	1
Femur prox.	2	1	-	1
Femur dist.	2	1	-	1

Tab. 6 Lebenstedt I, *Coelodonta antiquitatis*. Skeletal elements. NISP = Minimum Number of Identified Specimens. MNI sin. = Minimum Number of Individuals (MNI) for the left body half, MNI dext. for the right body half; MNI sin./dext. = body side indeterminate.

Coelodonta antiquitatis

For woolly rhino Lebenstedt I only yielded nine skeletal elements (Tab. 6), representing at least one individual. The bones represent the rump and upper extremities. Staesche points out that a femur (Gaudzinski, 1998: Taf. 6.1) included in the recent study (Staesche, 1977), was unearthed from the Salzgitter-lake and not from the excavation itself. By including Lebenstedt II, material stored in the Landesmuseum Hannover and Museum Schloss Salder in Salzgitter, Staesche could considerably enlarge the sample to 39 bones and teeth. These additional bones and bone fragments also represent rump and upper extremities with the exception of one tibia. MNI could be raised to two adult and a neonate individual (Staesche, 2017c).
For Lebenstedt I it was evaluated if fluvial processes might have played a role in the survival of woolly rhino skeletal elements (Gaudzinski, 1998: Fig. 14) and it was outlined that due to the lack of bones belonging to Dispersal-Group I, bones winnowed first by fluvial dynamics, showing that the taphonomic history of *Coelodonta* in the Lebenstedt I assemblage differed from that of other species represented. The inclusion of the material from Lebenstedt II modify these results as the larger sample additionally included four vertebra fragments, i. e., bones belonging to Dispersal-Group I.
Most of the *Coelodonta* remains from Lebenstedt I (70 %) are heavily modified by hyaenas in that the proximal and distal epiphyses have been gnawed off, leaving characteristic funneling. Modifications by humans were not observed.
The compiled sample obviously yielded no additional bones or bone fragments with carnivore modifications (Staesche, 2017c) but did add a cut-marked fragmented scapula to the taphonomic history of the Lebenstedt I assemblage (Staesche, 2017a), originally interpreted as a non-anthropogenic faunal component based on grounds of (1) the relative completeness of the bones, (2) the almost 70 % amount of traces of carnivore-gnawing/funneling and (3) the absence of cut-marked specimens.

Canis lupus

Lebenstedt I yielded a left Metartasus-V from *Canis lupus*. The bone showed neither traces of biotic nor abiotic agents that would enable the reconstruction of its taphonomic history. Staesche additionally reports

seven skeletal elements from *Canis lupus* from Lebenstedt II, among them two tibia fragments which raise the MNI to two (Staesche, 2017f).

Megaloceros giganteus

Among the finds uncovered from Lebenstedt II was a shed antler Staesche (2017d) determined to belong to *Megaloceros giganteus*. It showed that six small bone fragments from Lebenstedt I and II of tibiae, mandible, femur and metatarsus and a further small antler fragment belong to the same species (Staesche, 2017d). Due to thickness of the fragments' bone compacta Staesche calculated an MNI of 2 individuals. According to Staesche (2017a) the femur-fragment showed traces of carnivore modification as well as cut-marks.



Fig. 13 Lebenstedt I. Velvet Scoter (*Melanitta fusca*). Cut-marked humerus.

Panthera leo spelaea

Staesche reports a complete canine and Metacarpus-III of *Panthera leo spealea* from Lebenstedt II. The size of the metacarpus indicates a female individual, whereas the canine belonged to a male, therefore a MNI of 2 was calculated (Staesche, 2017e).

Birds, fishes and small mammals

The faunal assemblage is completed by small mammals, fishes and birds.
Among the small mammals *Desmana moschata* and *Arvicola terrestris* were identified (Kleinschmidt, 1952; van Kolfschoten, 2017) in addition to *Allactaga major* (Staesche, 2017g). Remains taxonomically determined as *Esox lucius* and *Perca fluviatilis* testify the survival of fish-bones (Kleinschmidt, 1953a; Staesche, 2017h).
The most striking finding in the faunal assemblages is the occurrence of *Torgos tracheliotus*, the lappet-faced vulture published by Kleinschmidt (1953b) together with an extended discussion on how this species which today typically lives in Africa and on the Arabian Peninsula, can be explained in the context of the species composition documented at Salzgitter. From this huge vulture an almost completely preserved sternum, fragments of a left proximal tibiotarsus and a radius and a right ulna were identified among the Lebenstedt I bones (Kleinschmidt, 1952). *Torgos tracheliotus* is a typical scavenger, although its impact on the taphonomic history of the faunal assemblage at Salzgitter-Lebenstedt has yet to be demonstrated.
For two additional bird-species, handling by humans can be argued. A humerus from Lebenstedt I determined by Kleinschmidt to belong to *Melanitta fusca*, the velvet scoter. This bone survived in pristine condition and shows numerous cut-marks on its medial and distal diaphysis (**Fig. 13**). Wing bones are particularly low in meat, this being one of the reasons why it is assumed that Neanderthals targeted at feathers. The sustained processing of birds, raptors and corvids in particular, for their dark feathers has been shown to be a regular feature at sites across the western-mid latitude belt (Finlayson et al., 2012). Based on an ethnographic survey the authors indicate that use of feathers for adornment represents a human universal behaviour that might root in the Middle Palaeolithic (Finlayson et al., 2012).
It is not clear if the humerus of the velvet scoter from Salzgitter represents a male or a female specimen, but in this context it is quite interesting to note, that in velvet scoters males are all black with white only around their eyes, sporting a white speculum.
A phalanx prox. digit. III. ped. from *Cygnus* sp., the swan (Kleinschmidt, 1953a), provides further insight into the exploitation of birds as the bone also showed a cut-mark on its diaphysis (**Fig. 14**), a trace difficult to explain, though that might have been produced during recovery of the webbing.

DISCUSSION AND PERSPECTIVES

The reindeer sample from Lebenstedt I was the focus of particular interest as zooarchaeological analysis indicated mass death encounters of reindeer by humans with a subsequent bias in exploitation depending on the primeness of resources (Gaudzinski and Roebroeks, 2000). The implicit consequences of the results of this analysis was manyfold with regard to Neanderthals social interaction, as mass death encounters imply coordinated group hunting. Moreover, the cost/benefit-targeted exploitation of reindeer carcasses demonstrated the purposeful handling of resources by Neanderthals, at the same time – with evidence of mass



Fig. 14 Lebenstedt I. Swan (*Cygnus* sp.). Cut-marked phalanx.

death encounters – challenging the "optimum foraging paradigm" that has prevailed in interpretations of zooarchaeological analyses of that time. Finally, the study highlighted the parallels between Middle Palaeolithic and Upper Palaeolithic and especially Late Glacial exploitation of reindeer (Gaudzinski and Roebroeks, 2003).

New zooarchaeological studies at Salzgitter (Ludovici and Pöppelmann, 2017) consolidate the results obtained by earlier analysis that were based on the Lebenstedt I assemblage only. The new study considerably enlarged the sample size by the inclusion of material from Lebenstedt II, unearthed in 1977. Two additional species were identified: *Megaloceros giganteus* (Staesche, 2017d) and *Panthera leo spelaea* (Staesche, 2017e). Apart from these obvious additions, the new study adds more complexity to the taphonomic history of the assemblage, e. g., with the identification of burned and charred bones which had not been observed before (Ludowici and Pöppelmann, 2017). By generally adding more variables to the puzzle, our reading of elements that must be or had been considered as part of the natural background fauna changed as it now appears that species, which based on the study of Lebenstedt I lacked clear evidence for hominin interference, must be added to hominin prey as indicated e. g., for horse.

The equivalents in content observed between Lebenstedt I and II underline observations by geomorphological studies (Preul, 2017) that both samples sprang from the same original source and survived in separate, considerably different geomorphological contexts.

With the new studies, the classical zooarchaeological analysis of the Lebenstedt assemblage is finally completed. Why then is the site still an important research target for our understanding of the past?

The geochronological position of the site during a time period a few millennia before the onset of the Central European Upper Palaeolithic makes Salzgitter-Lebenstedt a valuable research target. This is also true because Salzgitter, with a relatively reasonable temporal resolution compared to contemporaneous cave sites, is surely still among the best-preserved Middle Palaeolithic open-air contexts known to date. The geological setting (Preul, 1991, 2017) suggests a chronological position in an early or mid-Weichselian Interstadial,

probably the Oerel-Interstadial (Behre and Lade, 1986; Behre and van der Plicht, 1992; Litt, 2007) as palynological comparison shows.
Analyses of pollen and macro-remains (Pfaffenberg, 1991; Schüttrumpf, 1991; Selle, 1991) draw the picture of a shrub-tundra with cold adapted species such as *Betula nana*, *Salix polaris* and *Salix herbacea*. Composition of micro- and macro-fauna underlines these results as do the habitat requirements of preserved fungi (Johannes and Schuh-Johannes, 1991), and it can be summarized that during the time of occupation, arctic/subarctic conditions with moderate, continental climate prevailed. Attempts to substantiate the chronology by reconstructions of the palaeotemperature by oxygen isotope studies on horse and reindeer bones and teeth, have however, come up with ambiguous results (Stephan, 2017). Attempts to directly date the site (Preul, 2017: Table 1 for a compilation of ^{14}C-ages) indicate an age of at least 55 ka.

Roughly between 110.000 and 50.000 years we witness an increasing complexity of social environments on the individual and group level that led to massive population growth, reflected in a sheer explosion in the number of sites, that turned the custom of neighbouring groups to share traditions into the implementation of sets of rules and regulations of the earliest societies of the Upper Palaeolithic. These processes can only be understood in detail by contextualisation of well-preserved records attributed to this particular time slice.

Moreover, analysis of Lebenstedt I outlined parallels in subsistence tactics to Late Glacial contexts (Gaudzinski and Roebroeks, 2000) at a time when results of many archaeological studies implied that Neanderthals' cognitive capacities were inferior to those of modern humans. Studies at Lebenstedt I concluded that subsistence tactics were either not suited to describe the behavioural differences between Middle and Upper Palaeolithic humans, or the tactics employed did simply not differ, at least when particular game such as reindeer was exploited.
Our perspective on the behavioural differences between Middle and Upper Palaeolithic humans has broadened over the decades and we have become increasingly aware of the social embedding of subsistence behaviour during the Upper Palaeolithic, where we see the effects of social rules and regulations imprinted on human's perceptions of prey species, as evidenced in Upper Palaeolithic depictions, mobile art, and personal ornaments (cf. Street and Turner, 2015).
Social consensus in the form of regional cultural entities has been reported many times for Middle Palaeolithic contexts (e. g., Jöris, 2004) but are difficult to identify when subsistence tactics are at stake. The fact that humans made use of ethological characteristics to target prey, as observed for reindeer in Middle and Upper Palaeolithic contexts, leads to similar patterns in the zooarchaeological record. The observation of these patterns is surely relevant for reconstructions of the hunting methods employed, but are probably rather useless for the reconstruction of the social dynamics behind subsistence practices. Given the complexity in social environments that is visible in the Upper Palaeolithic and are, in comparison, almost invisible in the Middle Palaeolithic, it seems rather unlikely that the social embedding of subsistence followed the same agenda. To disentangle and understand these social frameworks, again, we need to contextualise additional information from contemporaneous archaeological archives.
Over the years, many aspects from Salzgitter-Lebenstedt have been suggested that might provide insight into Neanderthal lifeways, apart from the obvious archaeological evidence revealed by studying lithics and bones. What was by research-standards of the 1990s rather on the speculative side, is still speculative today. Today though, some of these speculations can be contextualised. In recent years studies from other Neanderthal sites demonstrated non-utilitarian exploitation of bird feathers (e. g., Peresani et al., 2011). Although the Salzgitter duck humerus is only a singular find, it could indicate that the exploitation of dark

feathers for personal adornments during the Middle Paleolithic stretches geographically towards northern latitudes.

A further avenue concerns the consumption of medicinal plants by Neanderthals (Hardy et al., 2012). It is interesting to note that fungi were unearthed from altogether 11 find-spots at Lebenstedt I identified as *Bovista plumbea* and *Calvaria uteriformes* (the assemblage being completed by an additional find from Lebenstedt II). Johannes and Schuh-Johannes (1991) point out that only ripe specimens of the latter were represented, their find-spot not being equivalent to their natural local habitat. Due to the antibiotic character of the fungi, they speculate on whether these were particularly collected by humans (Johannes and Schuh-Johannes, 1991, compare Hardy et al., 2012). In a comparable line of argumentation Krönneck and Staesche (2017) highlight the discovery of tree-fungi (n = 15) from Lebenstedt II that might have been used as tinder.

Salzgitter can help us to further evaluate the potential of craftmanship during the Middle Palaeolithic. The use of heat/water/pressure for tool/glue engineering is long since known from Middle Palaeolithic contexts (e. g., Boeda et al., 1996; Grünberg, 2002; Mazza et al., 2006). This evidence is scarce, however, and it is therefore difficult to evaluate these observations, and to assign their consequences for our knowledge of the archaeological record. This is where controlled experiments and traceological studies can help us to understand tool function and the skills needed for manufacturing. Against the scarcity of evidence and the heterogeneity of tool morphology, results of traceological studies and controlled experiments help to define set skills in Middle Palaeolithic organic tool production, and therewith provide a more profound bracket for our understanding of Middle Palaeolithic organic industries.

Current interdisciplinary meta studies on the reconstruction of anthropic impacts on Middle Palaeolithic ecosystems, to evaluate human's ecological footprint, are focussing on the extensive (28 ha) Last Interglacial lake-landscape of Neumark-Nord (Kindler and Gaudzinski-Windheuser, in prep.). The site of Salzgitter-Lebenstedt with its excellent organic preservation is surely a suitable next candidate to finally evaluate to which degree hominin subsistence had emancipated from the 'dictate of nature' shortly before these strategies became embedded and steered by social rules and regulations in Upper Palaeolithic contexts.

Acknowledgements

I dedicate this contribution to Elaine Turner and Martin Street who have been my colleagues for the last 30 years. I would like to say thank you that I could participate in and profit from their endless and fundamental expertise on Pleistocene Archaeology and in zooarchaeology, as well as for quite a lot of fun we had over the years, and this is what counts and what we will all keep in mind.

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MAMMUTHUS-COELODONTA FAUNAL COMPLEX FROM SIEGSDORF (CHIEMGAU, GERMANY) – OVERVIEW AND NEW ANALYSES

Abstract

Remains of Pleistocene large mammals were discovered near the village of Siegsdorf, south-eastern Bavaria, in 1975 and 1985. New radiocarbon dates of some of these finds show that the Siegsdorf fauna can be assigned to two phases of the Würm Glacial. Among the Siegsdorf bones were those of a cave lion with cut-marks. According to radiometric dating, these marks must have been made by Neanderthals. The traces represent the first evidence of the presence of Neanderthals in the SE of the German Pre-Alps. Due to the rapid embedding in the clayey-silty sediments of a former waterhole, the bone finds are exceptionally well preserved. For this reason, bone samples from the mammoth and cave lion from Siegsdorf are also included in various important palaeogenetic analyzes.

Keywords

Mammoth, cave lion, cut-marks, radiometric dating, palaeogenetics

INTRODUCTION – HISTORY AND FINDS

The village of Siegsdorf is situated between Rosenheim and Salzburg in the local government of Traunstein, ca. 10 km from Lake Chiemsee (**Fig. 1**). The site itself is located in the Gerhartsreiter Graben, 1.5 km from the village centre (**Fig. 2**). Here, in the summer of 1975, two schoolboys found bones of a woolly mammoth (*Mammuthus primigenius*) in the clay beds of a creek.

Approximately half of the mammoth skeleton was unearthed after several weeks of amateur excavations. It was supposed that the missing half would be found beneath the gravel deposits of a steep slope, however, it was not possible to remove the sediment without special equipment. Accordingly, excavations in this area halted, and then later continued in 1985. The village of Siegsdorf took over the costs, while the scientific responsibility lay at the Institute of Palaeontology and Historical Geology at the Ludwig Maximilian University of Munich and the Bavarian State Collections of Palaeontology and Historical Geology. Besides the second half of the skeleton and three tusks, as well as the remains of other woolly mammoths, the site yielded a well-preserved, partial skeleton of a cave lion (*Panthera spelaea*), a right and left mandible from a wolf (*Canis lupus*), mandibles, skull fragments and postcranial bones from three woolly rhinoceroses (*Coelodonta antiquitatis*), a right scapula from an Irish elk (*Megaloceros giganteus*), and a right juvenile tibia fragment and a right radius fragment from a steppe bison (*Bison priscus*). Moreover, the presence of cave hyenas (*Crocuta crocuta spelaea*) is indirectly confirmed by coprolites (**Fig. 3**) and numerous gnawing marks on the bones of the mammoth and woolly rhinoceros.

The well-preserved partial skeletons of the *Mammuthus primigenius* and *Panthera spelaea* represent significant findings. A comparative osteological analysis of these findings was conducted by Ziegler (1994) and Gross (1992), respectively.

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.868.c11312

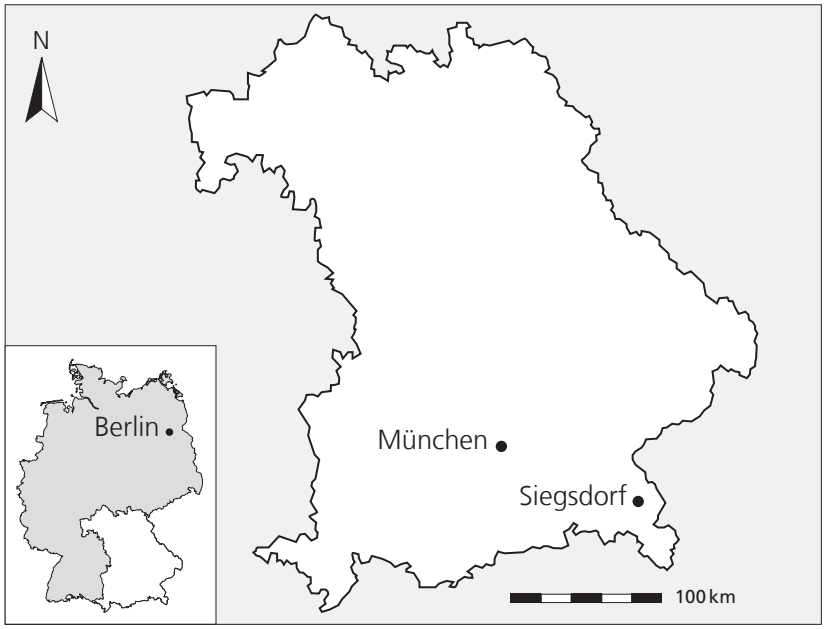


Fig. 1 Geographic location of Siegsdorf. – (Sketch: W. Rosendahl, *Reiss-Engelhorn-Museen* Mannheim).

In 2012, additional bones at the excavation area of the Siegsdorf mammoth were found. All belong to a horse and have the same color as the mammoth bones. Radiocarbon dating yielded an age of about 400 years for the horse remains (Darga, 2016).

The mammoth (**Fig. 4**) is identified as a bull, measuring 3.60 m at shoulder height. It represents one of the largest woolly mammoths known in Europe. The condition of its teeth indicates that it died at the age of around 50. Both last molars of the mandible were completely developed. The skeleton displayed only a few indications of arthritis, and no further signs of disease. The mammoth bones bear no traces of human impact as a result of either hunting or butchering. It is possible that the Siegsdorf mammoth simply became stuck in the clayey mire of the riverbed, and died there. Hyenas gnawed at significant portions of its cadaver, as evidenced by the gnawing marks on large bones such as pelvis, humerus and femur (**Fig. 4**). A probable explanation for the lack of cranial and facial bones of the mammoth could be the expansive force of grow-



Fig. 2 Aerial view of the site at which the Siegsdorf mammoth was found (top arrow), facing south toward the Alps. The road at the bottom left of the image is the Munich-Salzburg motorway. The Siegsdorf finds are displayed in the Southeast Bavarian Natural History and Mammoth Museum Siegsdorf (bottom arrow). – (Photo: Natural History and Mammoth Museum Siegsdorf).



Fig. 3 Hyena coprolites (maximum 3.5 cm in diameter). – (Photo: Natural History and Mammoth Museum Siegsdorf).

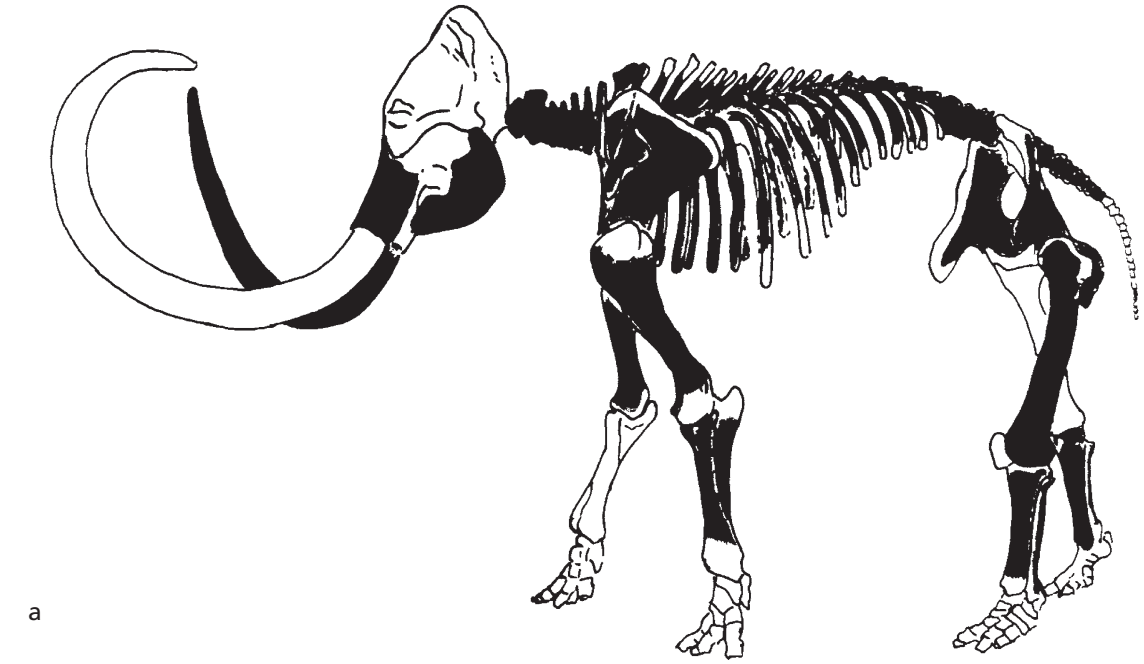
ing ice, which would have fragmented the perforated, spongy osseous mass of the skull into tiny pieces. The missing left tusk, like the tusk of another mammoth individual, probably decomposed in the weathering zone and was washed away down the creek.

The skeleton of the cave lion (**Fig. 5**) belongs to a senile individual, as evidenced by heavily worn teeth and the closed tooth sockets in the mandible, where teeth had already fallen out. It also appears that the Siegsdorf cave lion suffered from several or recurrent infections. This, at least, would explain the coarsely porous bone material found in a number of skull sections (Schouwenburg et al., 2009). It is fair to conclude that the animal may not have been particularly agile due to its age and infections, and its condition may even have rendered its continued survival impossible. It is a reasonable assumption that it did not seek an abode close to the waterhole or shallows in order to hunt, but instead, to feed on carrion.

ECOLOGY, CLIMATE AND CHRONOLOGY

The Siegsdorf fauna reveals a more temperate period within the Glacial, based on the ecological and climatic needs of the identified species. The presence of Irish elk *Megaloceros giganteus,* and the discovery of a snail belonging to the genus *Arianta arbustorum* (identified by R. Dehm in: Heissig and Bredow, 1987) contradict a high glacial climate. There are no traces of mixed fauna, e. g., due to redistribution processes, and the Siegsdorf fauna therefore can hence be considered homogeneous. Based on the size of the mammoth skeleton Ziegler (1994) ascribed the find into the Riss glaciation.

To clarify the chronostratigraphical position of the Siegsdorf Fauna an initial phase in reassessing the finds was started in 2001. Two bone samples, one from the mammoth and one from the cave lion, were dated by use of the radiocarbon method at the Leibniz Laboratory for AMS-^{14}C dating in Kiel (Germany). The cave lion sample (KIA 14406) revealed a radiocarbon age of 47,180 +1190 / -1040 ^{14}C BP and the mammoth sample (KIA 14407) an age of 45,180 +1130 / -990 ^{14}C BP. The age difference between these two samples is statistically insignificant. Most likely, both samples belong to the same period (**Tab. 1**).



a



b

Fig. 4 The Siegsdorf mammoth: **a** sketch of a mammoth skeleton (according to Abel, 1929) with the skeletal remains of the Siegsdorf mammoth highlighted in black. The bones in white are missing. The edges of the pelvis and many ends of joints and ribs were gnawed off by hyenas, as bite marks clearly show. – **b** cast of the skeleton of the Siegsdorf mammoth in the Natural History and Mammoth Museum Siegsdorf. – (a from Ziegler, 1994; b photo: Natural History and Mammoth Museum Siegsdorf).

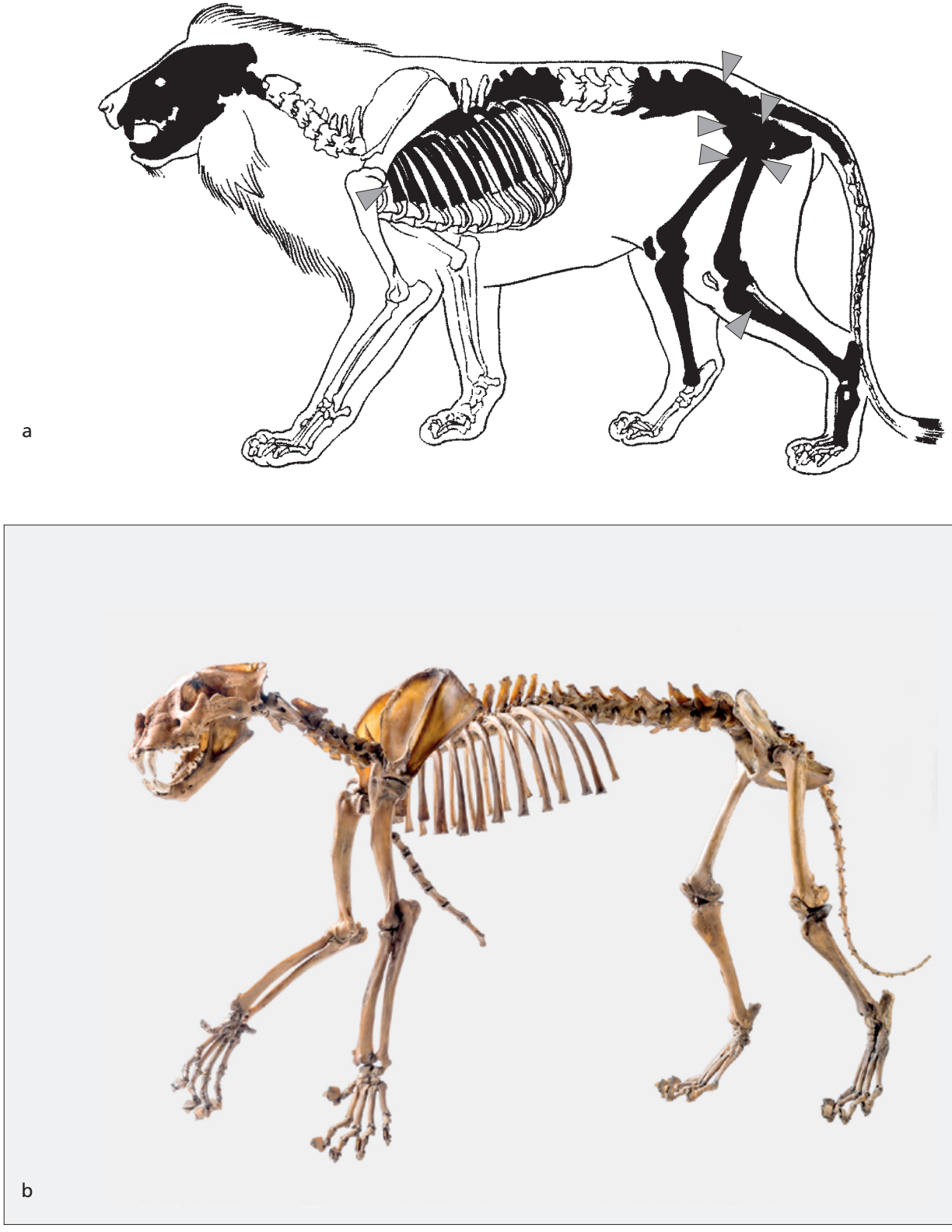


Fig. 5 The Siegsdorf cave lion: **a** sketch of a lion skeleton, with the skeletal remains of the Siegsdorf cave lion highlighted in black; arrows show the position of the cut-marks; **b** cast of the skeleton of the Siegsdorf cave lion. – (a sketch: W. Rosendahl, *Reiss-Engelhorn-Museen* Mannheim; b photo: T. Schwerdt, *Reiss-Engelhorn-Museen* Mannheim).



Fig. 6 Mandibles of two woolly rhinoceroses (to the left) and the mandible of a wolf (to the right). (Photo: Natural History and Mammoth Museum Siegsdorf).

In 2020 a second phase of reassesing faunal remains was started and bone samples from *Coelodonta antiquitatis, Megaloceros giganteus* und *Bison priscus* were dated with the radiocarbon method at the *Curt-Engelhorn-Zentrum für Archäometrie gGmbH* in the *Reiss-Engelhorn-Museen* in Mannheim. All dates obtained fall into Oxygen Isotope Stage (OIS) 3 and cluster between ~45,000 and ~50,000 cal BP; only the date obtained on the woolly rhinoceros (**Fig. 6**) turns out some 4,000-5,000 years younger than the majority of the Siegsdorf fauna (**Tab. 1**).

The recently produced AMS results confirm the dates obtained earlier from mammoth and cave lion. These results permit us to state that the majority of the mammal fauna from Siegsdorf is chronological homogenous and dates into a Middle Würmian period of OIS 3. In climatic-ecological terms, this period correlates with a more temperate climate in the middle part of the last Glacial. Vegetation in this period was typically characterized by open woodlands with pine trees (*Pinus*), spruce (*Picea*) and birch (*Betula*) (van Andel and Tzedakis, 1996). The annual average temperature was approximately 4 degrees Celsius below current levels (Guiot et al., 1989). The woolly rhinoceros, on the other hand, dates into a cooler period, close to the Heinrich 4 cold episode.

TAPHONOMY

The deposits in which the osseous remains were embedded consist of grey silt with a small proportion of clay, holding a few sharp pieces of carbonate stone and scree. The average granular diameter of the sediment is 0.020 mm (coarse mid-silt), and it is extremely well-sorted. The analyses were conducted on one kilogram of sediment taken from a reserve sample of material found at the site during the excavation in 1985.

The silt is a product of weathering in the Gerhartsreiter beds. These are clay-like, marly deposits from shallow waters belonging to the Helvetic Late Cretaceous period. These beds extend approximately 100 m southward around the Gerhartsreiter Graben, where they form the bedrock. A smaller expanse of stagnant water, fed by a minor tributary brook, emerged in the area of today's Gerhartsreiter Graben during the lifetime of the Siegsdorf fauna. Clay sludge from weathered Gerhartsreiter layers settled on its floor. Older, water-permeable quaternary sedimentation, for instance gompholite, formed the immediate vicinity around the pool. It is likely that the animals in the surrounding areas used the pool as a watering hole. It is possible that if one of these animals died and fell into the water or into the clay-like sludge, it would have become embedded in the material. Based on the large number of hyena bite marks, especially on the mammoth, it is clear that a part of the cadaver lay exposed, at least for a certain period. The extremely well-preserved bones in the find deposits nevertheless indicate that embedding must have taken place relatively quickly. The sediment, which tightly enclosed the bones, would also have contributed to the good state of preservation.

The skeletal remains found originate either from older (e. g., *Mammuthus primigenius*, *Panthera spelaea* and *Canis lupus*), or from juvenile individuals (*Coelodonta antiquitatis*, *Megaloceros giganteus* and *Bison priscus*).

After the bones were embedded, the waterhole was covered with thick layers of gravel (**Fig. 7**) that were deposited during the Last Glacial Maximum (LGM). During the LGM, the area was not directly affected by the advancing ice, as the Weißtraun glacier moving northward from the Alpine mountains did not reach the Gerhartsreiter Graben. Its northernmost Würmian moraine is located

Species	element	inv. no.	lab. no.	^{14}C-Age [BP]	± [BP]	Age [cal BP] *	C:N	C [%]	collagen [%]	references	original figures	endogenous DNA [%]	reference
Panthera spelaea	femur, dex.		KIA 14406	47,180	+1190 -1040	49,369-45,989			19.4	Rosendahl & Darga, 2002	Gross, 1992	3.3	Stanton et al., 2020
Mammuthus primigenius	bone		KIA 14407	45,180	+1130 -990	47,922-44,694			17.1	Rosendahl et al., 2005	Ziegler, 1994: Plate 7, Fig. 1		
Megaloceros giganteus	scapula	NKM522	MAMS 45184	42,260	390	45,914-45,208	3.3	42.9	7.6	this paper	Ziegler, 1994: Plate 9, Fig. 3		
Bison priscus	tibia	NKM523	MAMS 45185	43,270	450	46,921-45,953	3.3	42.9	4.1	this paper	Ziegler, 1994: Plate 9, Fig. 4		
Coelodonta antiquitatis	mandibula	NKM526/2	MAMS 45186	36,540	460	41,615-40,739	3.3	43.3	2.1	this paper	Ziegler, 1994: Plate 8, Fig. 2		

Tab. 1 Radiocarbon dates from the Siegsdorf fauna. * 1-sigma.

to the south of Eisenärzt near Neustadl, 2 km south of Siegsdorf (Ebers, 1939). It is due to this circumstance that the movement of ice did not strip off the find-bearing layers during the LGM.
During the Late Glacial and Holocene rivers eroded the glacial gravel deposits, and cut into the site.

ARCHAEOLOGY

Traces of cut-marks on several bones of the preserved cave lion skeleton were discovered as far back as its first analysis in 1992 (Gross, 1992). They are located on the insides of several ribs, on the pelvic bones, and on both femora (**Fig. 5**; **Fig. 8**). Comparisons undertaken during these investigations revealed that the cut-marks produced on the Siegsdorf lion remains were most certainly the work of humans. The find complex, however, has not yielded any stone artefacts or human bone remains, making these cut-marks the only indications for human presence at the site. Combined with the ^{14}C-date of the cave lion's right femur one has to conclude that (a) Neanderthal(s), *Homo neanderthalensis*, produced the cut-marks (Rosendahl et al., 2005). Hence, the Siegsdorf site provides the first confirmation for the presence of Neanderthals in the Alpine foothills of Upper Bavaria. At the same time, it is the earliest proof for the presence of humans in this region (Rosendahl and Darga, 2004).
Even if a general consensus exists on the fact that Neanderthals did not hunt cave lions to obtain their meat, the position of the cut-marks on the skeletal remains of the Siegsdorf cave lion (e. g., on the inside of several ribs and the pelvic bone) nevertheless show that the cadaver was gutted. It is doubtful that the animal was also skinned, as typical bones that would otherwise be missing (e. g., phalanges) are still present. Cut-marks that would clearly confirm that the animal was skinned are also missing (e. g., on the outside of the ribs). Neither the skeleton nor the location of the find provides any indication as to how or if the animal had been hunted.



Fig. 7 Excavators clear the soil and rocky material above the site in 1985. The dark grey clay of the bone bearing layer is cut at a depth of approximately 2 m below the person standing in the centre of the picture. – (Photo: Natural History and Mammoth Museum Siegsdorf).

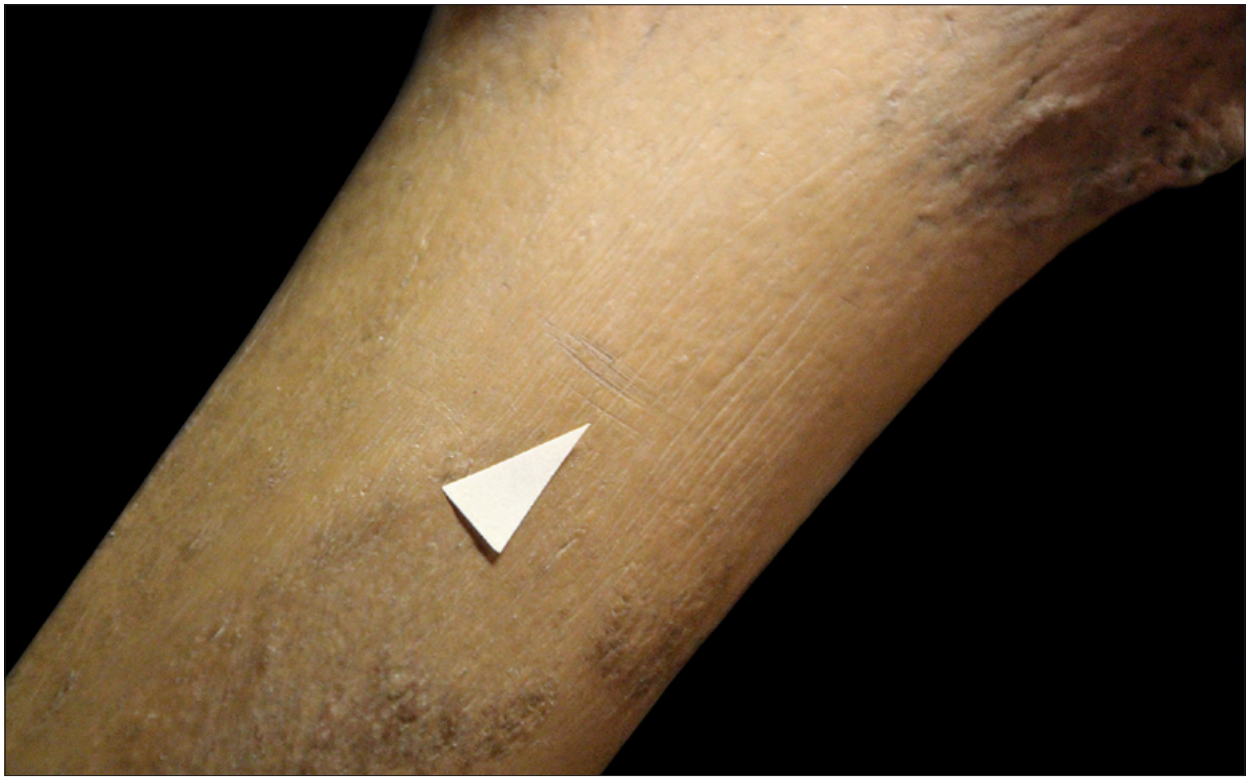


Fig. 8 Cut-marks (arrow) on the left femur of Siegsdorf cave lion. – (Photo: Natural History and Mammoth Museum Siegsdorf).

It is certain, however, that the lion's cadaver was very quickly embedded in the clay-like sludge of the waterhole, once the Neanderthals had used stone tools to eviscerate the lion carcass. This is confirmed by the extremely good preservation of the osseous substance, and the lack of any gnawing marks, such as those exhibited by numerous other bone remains found at the site (**Fig. 9**).

GENETIC ANALYSES

Due to the excellent depositional conditions the faunal remains of Siegsdorf are characterised by their outstanding bone preservation. This led to their suitability for various aDNA studies, which are summarized here. Relevant literature has discussed a variety of different variations, with respect to the taxonomic designation of Upper Pleistocene cave lions (Hemmer, 1974). Besides a sister species to *Panthera spelaea* (e. g., Barnett et al., 2009), the genus is also recorded as subspecies *Panthera leo spelaea* (e. g., Burger et al., 2004) or even as *Panthera tigris fossilis* or *Panthera tigris spelaea* (Groiss, 1996).
For the first molecular genetic analyses (Burger et al., 2004), a sample was taken from the left femur of the cave lion at the same time as the dating samples were taken; this sample was used to conduct aDNA analysis. A comparison with recent bones showed that the aDNA of the Siegsdorf lion is in extraordinarily good condition for preservation of aDNA and, in places, is of comparable preservation as with that of modern bones (Burger et al., 2004). A second aDNA sample of the Siegsdorf lion, taken from a tooth root, was compared with 31 mitochondrial genome sequences (Stanton et al., 2020). The results support previous hypotheses that at least two different subspecies of cave lions existed during the Pleistocene, and that lions



Fig. 9 The Siegsdorf ice age fauna ~45,000 to ~50,000 years ago in the Weißtraun valley south of Siegsdorf, Bavaria. This view from Rudhart (a hamlet near the contemporary place of discovery) to the west shows the ancient river Traun much less incised into the ground than today, the alpine foothills and the summit of the mountain Hochfelln on the horizon. The bones of the Siegsdorf ice age animals were preserved in a marshy depression similar to the waterhole in the foreground. – (Photo: Natural History and Mammoth Museum Siegsdorf).

and cave lions represent distinct species. The ca. 47,600 cal years-old Siegsdorf cave lion perfectly matches Clade C, the only lineage known from Europe (Stanton et al., 2020), that is continuously documented on the continent until the LGM.

A further molecular genetic study was conducted in 2005, using residue from a tibia, which until then had only been identified within the Siegsdorf fauna spectrum as *Bos vel Bison* (aurochs or wisent, i. e., European bison). The aDNA analysis conducted in the Institute of Anthropology at the University of Mainz (Palaeogenetic Research Group under Prof. Joachim Burger) resulted in its species attribution to the steppe wisent (*Bison priscus*) (Bollongino, 2006).

The mammoth was also sampled as part of a large-scale international study on the reconstruction of the gene pool of *Mammuthus primigenius* (Chang et al., 2017). One purpose of this study, among others, is to find out more about the genetic diversity found among mammoths. Near the end of the Pleistocene epoch, populations of woolly mammoth (*Mammuthus primigenius*) were distributed across parts of three continents, from Western Europe and northern Asia through Beringia to North America. The Eurasian range of the woolly mammoth confirms that the Late Pleistocene mammoth populations comprised three distinct mitochondrial lineages. The Siegsdorf mammoth matches to clade 3 (haplogroup B2), documented from European and Siberian sites (Chang et al., 2017).

The excellent depositional conditions of the faunal remains of Siegsdorf and their outstanding bone preservation led to their suitability for various aDNA studies. The Siegsdorf site provides also the first confirmation

for the presence of Neanderthals in the Alpine foothills of Upper Bavaria and it is the earliest proof for the presence of humans in this region. Therefore the Siegsdorf site is one of the best investigated *Mammuthus-Coelodonta* faunal complex in the SE of the German Pre-Alps.

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MEDIUM



Elaine's secret passion: excavating human burials at Taforalt (Morocco), ca. 2006.

A "medium" steak is in transition from "rare" to "well done", and in a metaphorical sense this also applies for the period from the Late Middle Palaeolithic to the Middle Upper Palaeolithic between ~ 100,000 until 25,000 years ago. The behaviours we see in the archaeological record from this time interval are neither archaic nor are they fully modern, and we can witness here the foreshadowing changes that finally lead to our "behavioural modernity".

Dealing with these "transitional" topics is a comparatively recent phenomenon in Elaine's and Martin's careers and both have addressed the issues involved from different points of view. While Elaine focused on human-carnivore relationships, Martin's interest lay in chronology. Both perspectives dramatically changed our anthropological record, as their revisions led to a considerable shortening of the list of fossil hominins in Germany. It turned out that some presumably late Neanderthals were just cave-bears and, quite frequently, presumed early modern humans had to be erased from fossil-lists when directly dated by radiocarbon, due to their much younger age. This is just one of the occasions proving that you should leave Elaine and Martin entirely out of the loop if you seek final confirmation for your research results – as they will always find something to grouse about. Moreover, Elaine and Martin also focused on relevant behavioural aspects when e. g., dealing with dynamics of cultural change and the origin and recognition of new categories indicative of "modern human behaviour", such as personal ornaments or weaponry.

World-class! Martin occupied 3rd on the world ranking list for Atlatl throwing during the 1990s.



Martin with Thomas Terberger and Jordi Serangeli at the Mid-Upper Palaeolithic site of Wiesbaden-Igstadt, 1992.

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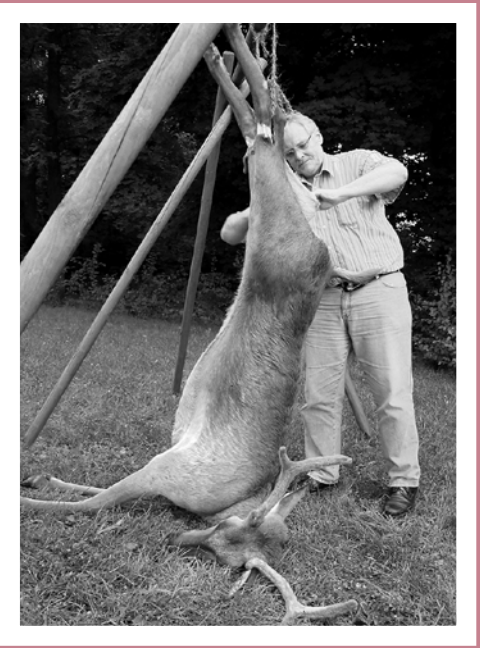
Elaine with Jalil Bouzouggar
in Morocco, ca. 2006.



Elaine in Morocco, ca. 2006.



Martin, the handyman, 2011.

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Martin preparing for competition during the 1990s.



Elaine in her usual posture.

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DICK STAPERT · MARCEL J.L.T. NIEKUS · LYKKE JOHANSEN

A BIJOU LEAF POINT OF THE MAUERN TYPE FROM VENRAY (THE NETHERLANDS); WITH REMARKS ON THE BONE RETOUCHERS FROM MAUERN

Abstract

This article highlights a special Neanderthal artefact: a Late Middle Palaeolithic leaf point. The piece was found in a field near Venray (prov. Limburg). Without any doubt it is one of the finest Dutch leaf points of the so-called 'Mauern' type, a celebratory treat that we are happy to present to Martin and Elaine in this *Festschrift*. We also briefly describe six bone retouchers from Mauern, which were ^{14}C-dated in Groningen.

Keywords

Leaf points, bone retouchers, Venray, Mauern, Neanderthal migration

THE FINDSPOT

In October 2018, the second author got to know about a beautiful leaf point of late Neanderthals from the outskirts of Venray. The finder was Roy Janssen of that town, who had picked up the artefact some twenty years previously in a field that at the time belonged to his family. This field of ca. 120 m × 60 m is now built over with housing. The coordinates of the centre of the field are: N 51°32'20.5" / E 5°57'59.2" (coordinates on the Dutch ordnance map: X = 195.186 / Y = 394.608). The findspot is on the southeastern brow of the valley of the Loobeek, a small tributary of the river Meuse. On the same edge two handaxes were found: 1. the 'Micoquian' handaxe of Venray, almost 2 km to the northeast, and 2. the cordiform handaxe from 'De Vliezen', some 3.5 km to the southwest (see **Fig. 1**, after: Stapert, 1979). From this we may conclude that the Loobeek was a popular hangout for Neanderthals, during multiple phases of their existence. They evidently were keen to sojourn on the edges of river valleys, including those of the small tributaries of major rivers like the Meuse.

We can observe the same pattern along some other smaller streams in the north of Limburg and the east of the adjacent province of Noord Brabant. Maps of this region (**Fig. 1**) show some Middle-Palaeolithic sites that we know about. Middle-Palaeolithic artefacts have been found also along the watercourses Lactariabeek, Groote Molenbeek (outside the map) and Oostrumsche Beek. Along the Lactariabeek, the handaxe of Overloon; along the Groote Molenbeek, the side-scraper of Blitterswijck; and along the Oostrumsche Beek, the chopping-tool of Oostrum and the two flakes of Hoogriebroek-Schoor (see **Tab. 1** for details of the various Middle Palaeolithic finds).

In fact, the picture in other parts of the country is quite similar. In the province of Drenthe, many Middle Palaeolithic sites have been identified on the edges of valleys including those of the Drentse Aa and the Oostervoortschediep and of their side valleys. The most important among these is the handaxe-rich site at Peest near Assen, the subject of earlier publications (Niekus et al., 2016, 2017).

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.868.c11314

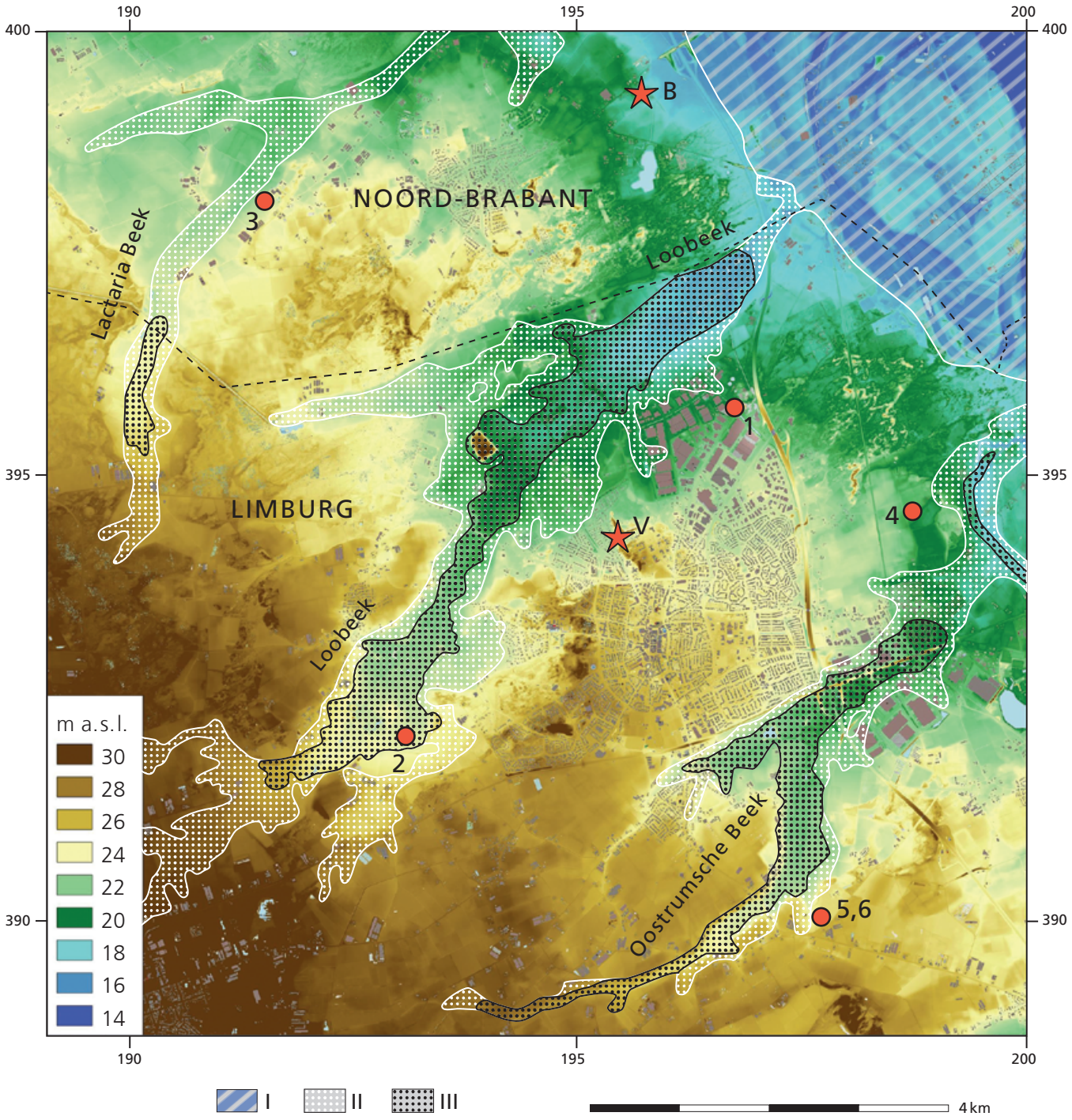


Fig. 1 Map of the region around Venray (the box in **Fig. 5**) with findspots of Middle Palaeolithic artefacts. Map based on 'AHN' relief map (by Jaap Bongers, De Steekproef bv, Zuidhorn) with superimposed geology. **I** deposits of the river Meuse, in the Kreftenheye Formation, dating mostly from the Weichselian (Devensian) glaciation; **II** coversand less than 2 m thick on fluvio-periglacial deposits of the Twente Formation; **III** Holocene peat on fluvio-periglacial deposits of the Twente Formation. Findspots: **V** findspot of the leaf point of Venray; **B** approximate location of the major Middle Palaeolithic concentration of 'De Biesplanken' (finder: W. Hoex). Earlier finds in the vicinity: **1** the handaxe of Venray; **2** the handaxe of 'De Vliezen'; **3** the handaxe of Overloon; **4** the chopping-tool of Oostrum; **5-6** the flakes of Hoogriebroek-Schoor. – (The geological information is based on the geological map of this area, Van den Toorn, 1967; map by Lykke Johansen and Dick Stapert, based on the map in Stapert, 1979).

The somewhat dated geological map of the region around Venray (Van den Toorn, 1967) indicates the following for the leaf-point findspot: coversand thinner than 2 m on fluvio-periglacial deposits of the 'Twente Formation'. Nowadays the former Twente Formation is subsumed under the Boxtel Formation (within which no fewer than nine 'deposit parcels' are distinguished; De Mulder et al., 2003: 346-350). The findspot lies close to a small area where Van den Toorn's map indicates less than 2 m of coversand on peat of the 'Asten Formation'. This peat dates from the Eemian (Ipswichian) interglacial (nowadays the former Asten Formation is part of the 'Woudenberg Formation'; see De Mulder et al., 2003). At the findspot of the Venray handaxe, Eemian peat was found at a depth of 210-250 m, which at any rate suggests that this handaxe dates from after the Eemian interglacial (Stapert, 1979: 116).
On the opposite bank of the Loobeek lies an important Middle Palaeolithic site, known as 'De Biesplanken', discovered by Mr Willem Hoex of Venray. This site lies not far from the southern edge of the Meuse valley, and in a somewhat different geological context from the above-mentioned sites on the brows of tributary valleys. According to the 1967 map, the Biesplanken site lies in an area with coversand less than 2 m thick on gravelly deposits of the 'Veghel Formation C': Meuse deposits of the final phase of the Saale (Wolstonian) glaciation. Nowadays the former 'Veghel Formation' is subsumed under the 'Beegden Formation' (De Mulder et al., 2003). So far, we have been able to examine 37 finds from the Biesplanken site; notable among them are a Mousterian point, a bifacial Quina scraper and some other scrapers, a Levallois core and at least one blade (Stapert and Johansen, 2019). It is a Late Middle Palaeolithic site from which we expect to see more splendid finds in the future.

THE VENRAY LEAF POINT

This is a complete, virtually undamaged leaf point of the 'Mauern' type (**Fig. 2**). It has two pointed ends, being a so-called bi-point or double-point. Mauern leaf points are bifacially worked, thin implements, with mostly two pointed ends, but sometimes just one. Use-wear analysis has shown them to have been used mainly as spearheads. Some dimensions of this piece: length: 5.8 cm (a very small piece of one of the tips is missing, but no more than 1 mm; the original length would have been 5.9 cm); width: 3.2 cm; maximum thickness: 0.8 cm (roughly midway along its length). Its weight is 12.8 g. The thickness index (100 × thick-

Findspots	geomorphological setting	object(s)	finder	Fig. 1	references
Biesplanken	south edge of Meuse valley	Middle-Pal. cluster	W. Hoex (Venray)	B	pers. comm.
Blitterswijck	east bank of Groote Molenbeek	side-scraper	G. van Ass (Venray)	outside the map	1, 2
De Vliezen	east bank of Loobeek	cordiform handaxe	J. van Meyel (Venray)	2	1, 2
Hoogriebroek-Schoor a & b	east bank of Oostrumsche Beek	flakes	a: J. Arts (Hoogriebroek); b: B.A.M. Kruysen (Venray)	5, 6	a: 1, 2; b: 2
Oostrum	west bank of Oostrumsche Beek	chopping-tool	B.A.M. Kruysen (Venray)	4	1, 2
Overloon	east bank of Lactariabeek	amygdaloid handaxe	E.J. Winter (Sonnega)	3	2, 3
Venray	east bank of Loobeek	Micoquian handaxe	P. Berg (Venray)	1	2
Venray	east bank of Loobeek	'Mauern' leaf point	R. Janssen (Venray)	V	this article

Tab. 1 Some Middle Palaeolithic findspots in the vicinity of Venray. References: 1 Van Haaren, 1968; 2 Stapert, 1979; 3 Dijkstra and Van der Lee, 1978.

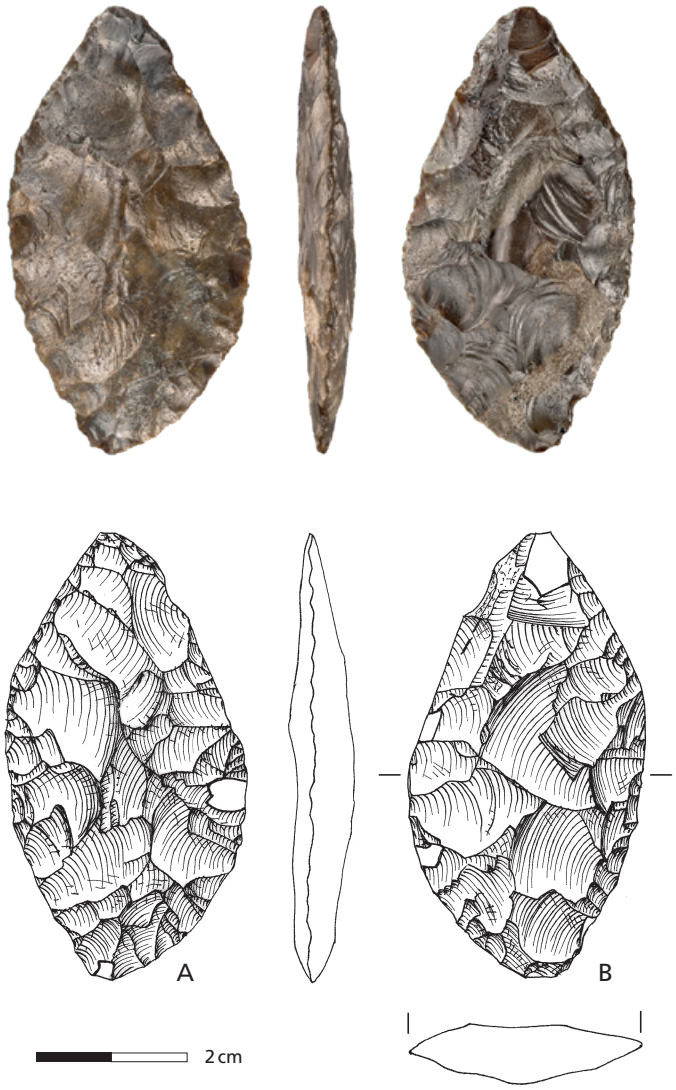


Fig. 2 The 'Mauern' leaf point of Venray. Key to the artefact drawings: blank: recent damage; irregular stippling or cross-hatching: cortex or other ancient surfaces, including primary frost split faces; open circle: point of percussion no longer present. – (Photo: Frans de Vries [Toon-Beeld, Oosterwolde]; drawing: Lykke Johansen).

ness divided by length) is 13.6, on the basis of the reconstructed length of 5.9 cm. The Venray leaf point is the smallest bifacial leaf point known from the Netherlands, at least among the (more-or-less) successful and also (more-or-less) complete specimens (cf. **Tab. 2**). The specimens from the Leusderheide and Eindhoven, very similar in shape, have lengths of 6.8 and 8.8 cm, respectively; the reconstructed length of the bi-point of Emmerschans (A) is 7.7 cm. The last-named still is the relatively thinnest Dutch leaf point, with a thickness index of 10.4.

The Venray leaf point was very skilfully made, by means of 'soft percussion', i. e., with a percussion tool of bone, antler or wood. The flaking scars are very shallow and mostly extend up to or just beyond the centreline of the point. Face B, close to the tip, on the left, still retains a small area of cortex, as well as what presumably is a remnant of an ancient surface. Otherwise both faces are entirely worked. Face B has on average somewhat larger scars than face A, which appears to be more intricately finished. In combination with the

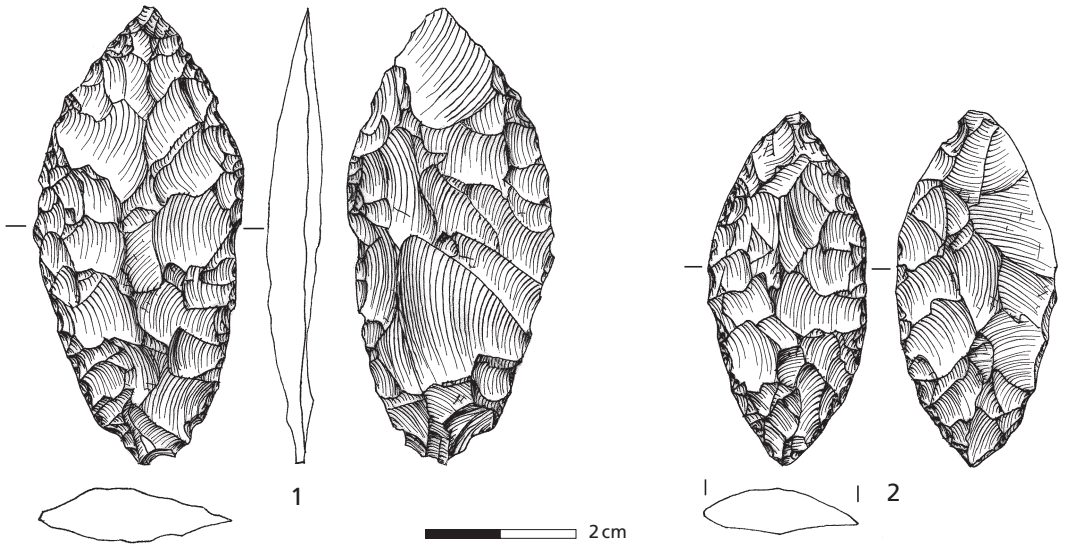


Fig. 3 Two small, bifacial leaf points from Mauern. The smaller has a maximum length of 4.7 cm. – (Drawings: Lykke Johansen, after Bohmers, 1951).

presence of a spot of cortex on face B, this might indicate that the point was made from a flake and that face B was the dorsal surface. In cross-section, the point is slightly plano-convex. Face B is fairly flat; face A, slightly convex (see the drawn cross section). Face A may well be the ventral surface of a flake, but this cannot be ascertained because of the total-surface working. The angles of the cutting edges are sharp, around 40 degrees. The outline of the Venray leaf point is slightly asymmetrical. This is not uncommon in Mauern leaf points; among the mostly beautifully finished specimens from the type-site near Mauern, too, there are asymmetrical ones (see Bohmers, 1951). This is unlikely to be a typologically relevant phenomenon. Manufacturing a symmetrical leaf point just happens to be quite difficult. Once the piece has become rather small in the course of production, one has to stop at some point, even if the shape still is less than perfect. Despite this asymmetry, it is not hard to tell which is the tip and which the base of this leaf point. The angle at which the edges meet is ca. 60 degrees at the tip and ca. 80 degrees at the base (see the drawing, **Fig. 2**). At a few (sub-) recent damaged spots on both edges and at the tip and base, it can be seen that the original flint was grey-brown. Small fossil inclusions are visible, but no distinct bryozoans (remains of moss animalcules that characterise flint of northern provenance). Hence the flint probably was of southern provenance. The flint is of a fine-grained texture, with pale patches and bands of a slightly coarser texture. Distinct windgloss with 'fine pitting' is evident on both faces (Stapert, 1976a); on face B this is somewhat more developed than on face A. The leaf point therefore must have spent a considerable length of time on the surface during a cold period. Most probably this was the Upper Pleniglacial of the final glaciation, the Weichselian (Devensian). No scratches or pressure cones were observed. The edges and ribs display slight rounding (due to solution processes in the soil, not to rolling in a riverbed), a little less so on face B than on face A. Maybe the piece has a brown patina (though the flint itself has a brownish colour), with a cast of white patina that appears slightly more developed on face B.

While this piece from Venray may be the smallest (successful) bifacial leaf point in the Netherlands, at Mauern an even smaller one was found which up to a point resembles the one from Venray, with a length of just 4.7 cm (**Fig. 3**, after: Bohmers, 1951: Taf. 26, no. 3). The Mauern leaf points can be divided by their lengths into three size classes: small, medium-sized and very large (**Fig. 4**; after Stapert, 2007; on the basis

of data from Bohmers, 1951 and Zotz, 1955). The 18 complete leaf points from Mauern in a histogram divide into two groups: small points with lengths between 4.5 cm and 8 cm, and medium-sized ones between 9 cm and 13 cm long. A third group, comprising 'giant' leaf points with lengths of ca. 20 cm or more, is represented by a single fragment (illustrated in Stapert, 2007: Fig. 1; after: Bohmers, 1951).

Another important leaf-point site in Germany is Ranis 2 (Hülle, 1977). Here, too, we see a comparable subdivision into three size classes. A few leaf points from Ranis 2 with lengths of around 20 cm are proper showpieces (one of them is shown in Stapert, 2007: Fig. 2). It is unclear whether, and if so to what extent the two most numerous groups of leaf points (the small and medium-sized) of Mauern and Ranis 2 differed in function. It should be noted that some of the medium-sized leaf points of Mauern, like the 'giant' leaf points, are splendidly worked artefacts (see also: Bosinski, 1967: 56). Some of these implements almost are true pieces of art! Such remarkable beauty is not, on the whole, observed among the small leaf points, which therefore must have been (primarily) functional items. The small ones, and the bulk of the medium-sized ones without doubt served as spearheads. The more-or-less complete bifacial leaf points from the Netherlands whose lengths we know or can reasonably assess, are between 5.9 and 8.8 cm long (**Tab. 2**). This means that they match the group of 'small leaf points' that we know from Mauern and Ranis 2. In part, the absence of larger leaf points in the Netherlands may be due to the lack of suitable raw materials (which *were* present at Mauern and Ranis). Indeed, the leaf point of Venray, although the smallest in the Netherlands, is also among the finest. In this respect it is comparable to the also beautifully made leaf points

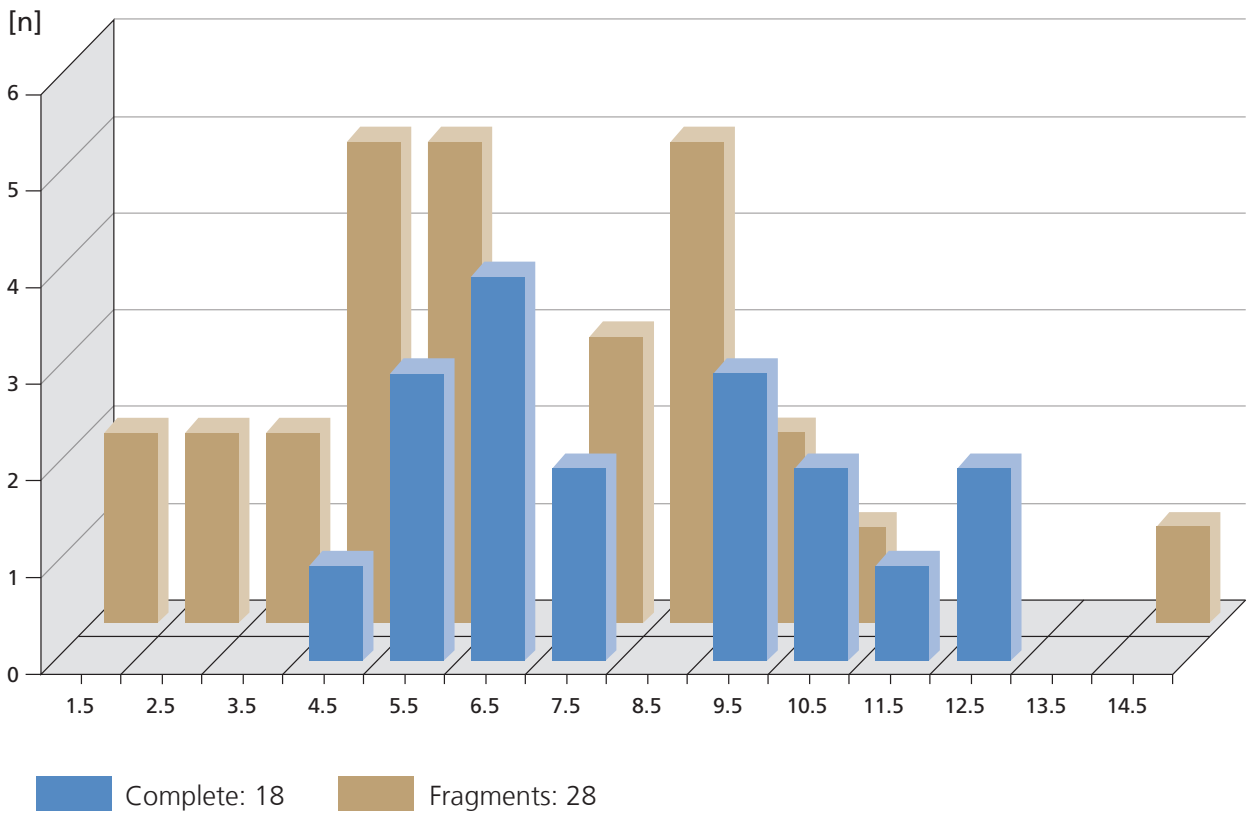


Fig. 4 Lengths (in cm: 1.1-2.0, 2.1-3.0, etc.) of leaf points from Mauern (based on Bohmers, 1951 and Zotz, 1955). Some unfinished items were excluded. Among the complete specimens two groups can be distinguished: smaller and larger pieces. A fragment with a length of 14.6 cm points to the existence of a third category: 'giant leaf points'. – (Graph: Dick Stapert and Lykke Johansen).

Findspots	Length [mm]	Width [mm]	Thickness [mm]	Th/L index	Weight [g]	References
A. Bifacial leaf points						
Venray	59*	32	8	13.6	12.8	this article
Maasvlakte 2	60*	37	12	20.0	28.0	4
Leusderheide	68	36	12	17.6	27.1	10, 11
Eeserveld	70*	35	9	12.9	20.7	9
Emmerschans (A)	77*	36	8	10.4	-	2, 5, 10
De Krim	81	33	13	16.0	-	2, 10
central Netherlands (?)	84	34	9	10.7	28.8	12
Eindhoven	88	44	13	14.8	-	6, 10
B. Leaf-point-like implements						
Eersel (*Faustkeilblatt*?)	119	64	21	17.6	147.1	7
Banholt (Quina side-scraper?)	100	58	19	19.0	87.0	17
C. Bifacial or unifacial leaf point						
Den Bosch	38**	35**	9**	-	14.0**	16
D. Certain or probable unifacial leaf points						
Aardjesberg	40**	21**	10**	-	-	8, 10
Maasvlakte 2	36**	30**	11**	-	12.2**	4
E. Possibly unfinished leaf points or failed attempts by learner flintknappers						
Zeijen-Oost (A)	73	45	16	21.9	-	10
Zeijen-Oost (B)	79	46	16	20.3	59.2	15
Woldberg	63	34	16	25.4	-	9
Zuidlaren	50	38	16	32.0	-	1, 3
Emmerschans (B)	72	44	16	22.2	-	2, 5
Balloo	67**	52	17	-	-	10
Emmen-Roswinkelerweg	46	40	10	21.7	19.4	5
Onna	48**	65**	10**	-	-	9
Meppel	96	57	17	17.7	88.0	1
Ameland	90*	45	16	17.8	57.2	13, 14

Tab. 2 Leaf points, leaf-point-like implements and possibly uncompleted leaf points or failed efforts by apprentice flintknappers. References: **1** Beuker et al., 2007; **2** Beuker and Niekus, 1994; **3** Johansen and Stapert, 2012; **4** Niekus et al., 2021; **5** Niekus et al., 2019; **6** Roebroeks, 1986; **7** Stapert, 1976b; **8** Stapert, 1992; **9** Stapert et al., 2008; **10** Stapert et al., 2007; **11** Stapert et al., 1993; **12** Stapert and Johansen, 2008; **13** Stapert et al., 2013a; **14** Stapert et al., 2013b; **15** Stapert et al., 2015; **16** Verpoorte, 2016; **17** Wouters, 1980a. * estimated complete dimensions; ** dimensions of fragments. Th/L index: 100 × thickness divided by length.

of Emmerschans (A) and Eeserveld. It is well-made but also functional – not an exceptional 'showpiece' like those from Mauern and Ranis 2; for this it is too small and also too thick.

A measure for the craftsmanship is the 'thickness index' mentioned above (100 x thickness divided by length). The larger a leaf point, the harder it is for the knapper to get it this thin along its full length. The Venray leaf point has a thickness index of 13.6, which is respectable but not astounding. The leaf points from Eeserveld and Emmerschans (A) both have lower scores: 12.9 and 10.4, respectively. The Emmerschans leaf point thereby holds the Dutch record in terms of this index. But even thinner pieces occur at Mauern and Ranis. At Ranis 2 the range is 5.7 to 15.9, with an average of 9.7. The Mauern leaf points have an average thickness index of 10.8 (range: 6.8-15.9). The eight more-or-less complete bifacial leaf points from the Netherlands (**Tab. 2**) have an average thickness index of 14.5 (range 10.4-20.0). That the values here

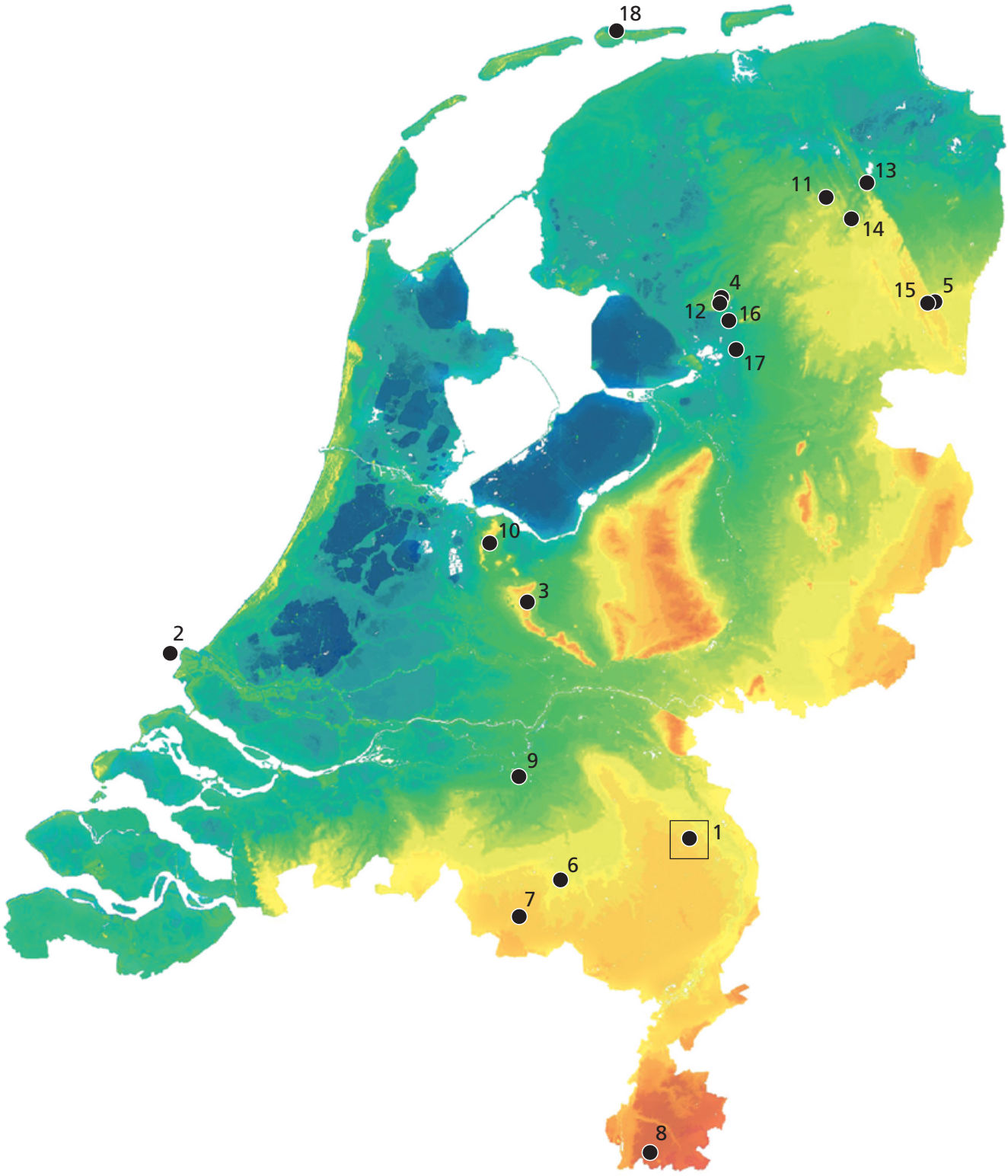


Fig. 5 'AHN' relief map showing the findspots of leaf points, leaf-point-like implements and possible unfinished leaf points in the Netherlands. Findspots: **1** Venray; **2** Maasvlakte 2; **3** Leusderheide; **4** Eeserveld; **5** Emmerschans; **6** Eindhoven; **7** Eersel; **8** Banholt; **9** Den Bosch; **10** Aardjesberg; **11** Zeijen-Oost; **12** Woldberg; **13** Zuidlaren; **14** Balloo; **15** Emmen-Roswinkelerweg; **16** Onna; **17** Meppel; **18** Ameland. The area around Venray is shown in a box (see **Fig. 1**). The finds from De Krim and 'central Netherlands' are not marked on the map because their original findspots are unknown. – (Map: Jaap Bongers [De Steekproef bv, Zuidhorn]).

are significantly higher than at Mauern and Ranis may be due to the often poor quality of the then available raw material in what is now the Netherlands.

OTHER LEAF POINTS IN THE NETHERLANDS

Table 2 (see also Fig. 5) lists 23 leaf points or leaf-point-like implements from the Netherlands, including unfinished ones and what probably are failed attempts by apprentice knappers (Figs. 6-7). The literature, however, mentions several further Dutch 'leaf points'. Some of these we have been able to examine, but in our opinion they are not Middle Palaeolithic leaf points. They are:

1. 'Venlo' (mentioned by Van der Lee, 2006). This piece was at one time exhibited in the Limburgs Museum at Venlo, but since it was a find from the isle of Texel it is nowadays on display at 'Ecomare' in Texel. In our opinion it is a not quite completed 'flint sickle' of the Bronze Age, definitely not a Middle Palaeolithic artefact.
2. Gerhegge or Neer-Boshei, Leudal valley near Roermond; finder: D. Beeren (see Wouters, 1980b). This piece is kept at the regional museum at Asselt, and we were granted permission to examine it microscopically at Groningen University. We do not believe it to be a Middle Palaeolithic flint, but a bifacially retouched, dagger-like tool of the Late Neolithic or Early Bronze Age. Possibly it is an unfinished piece.
3. Kessel; finder: W. Vossen (see Wouters, 1980b). This is a tool on a flake; the percussion bulb and a remnant of the striking platform are still partially present. The finder and Leo Verhart (of the Limburgs Museum) kindly allowed us to personally examine it. In our view it is a semimanufactured point-like implement of the Neolithic or the Bronze Age, but definitely not a Middle Palaeolithic tool; apart from a slight gloss patina, its surfaces have remained virtually fresh.

Unfortunately, there are several other pieces that we have been unable to inspect.

1. 'Eersel PA-3' (Fonteyn and Wouters, 1995/1996). This piece reportedly consists of quartzite – an unusual material for a leaf point.
2. Nunhem (Metsemakers and Wouters, 1993). This piece is said to come from the Leudal valley; the picture suggests that it might be a *blattförmiger Schaber*.
3. Hazeldonk-Noord (Peeters, 1989). The brief description does not rule out that this may be a Neolithic tool; despite several requests, we have not succeeded in examining the piece ourselves.
4. Sint Geertruid 'SG.15' (coll. W. Roebroeks-Janssens: see Wouters, 1980a). The item is described as a handaxe fragment, but the drawing suggests that it might in fact be part of an unfinished Mauern leaf point. We still hope for permission to examine this piece at some future date.

Recently (mid March 2021) the second author identified a preform of a 'Mauern' type leaf point in the collection of Mr Francois van Wessel (Tegelen). The preform was found in 2019 during dredging for a harbour at Grubbenvorst, approximately 15 km to the south of Venray (Fig. 5: 1). This piece, as well as a small handaxe and a few other finds from the same location, will be studied in the near future.

Table 2 shows that the Dutch finds include quite a few probable practice pieces of learner knappers. This is hardly surprising: in the Middle Palaeolithic, leaf points were technically the hardest tools to create. Indeed, it is interesting to note that also within the Mauern assemblage we spotted some pieces that we believe to be (more or less successful) practice pieces by apprentice knappers (see Fig. 8; after Johansen and Stapert, 2012).

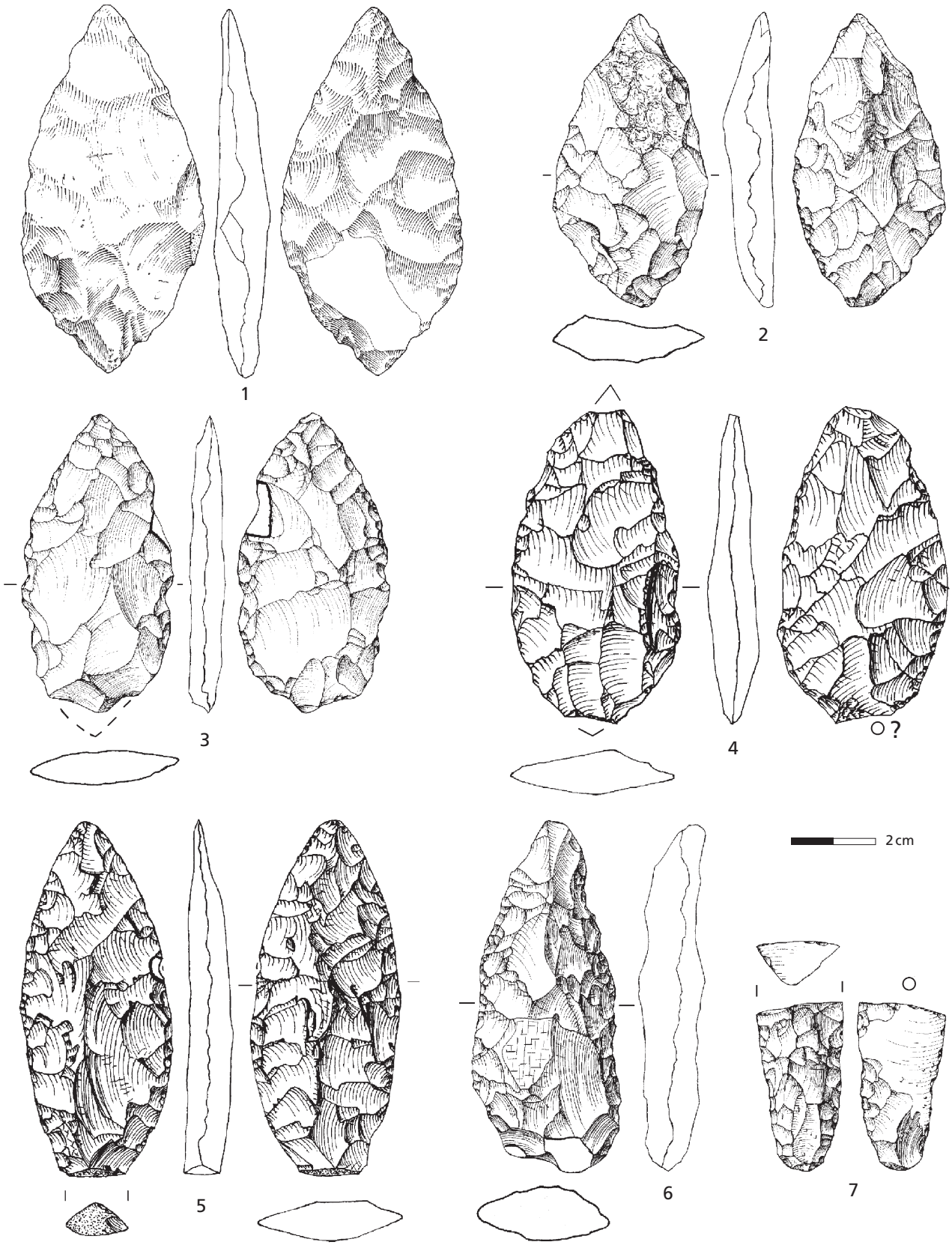
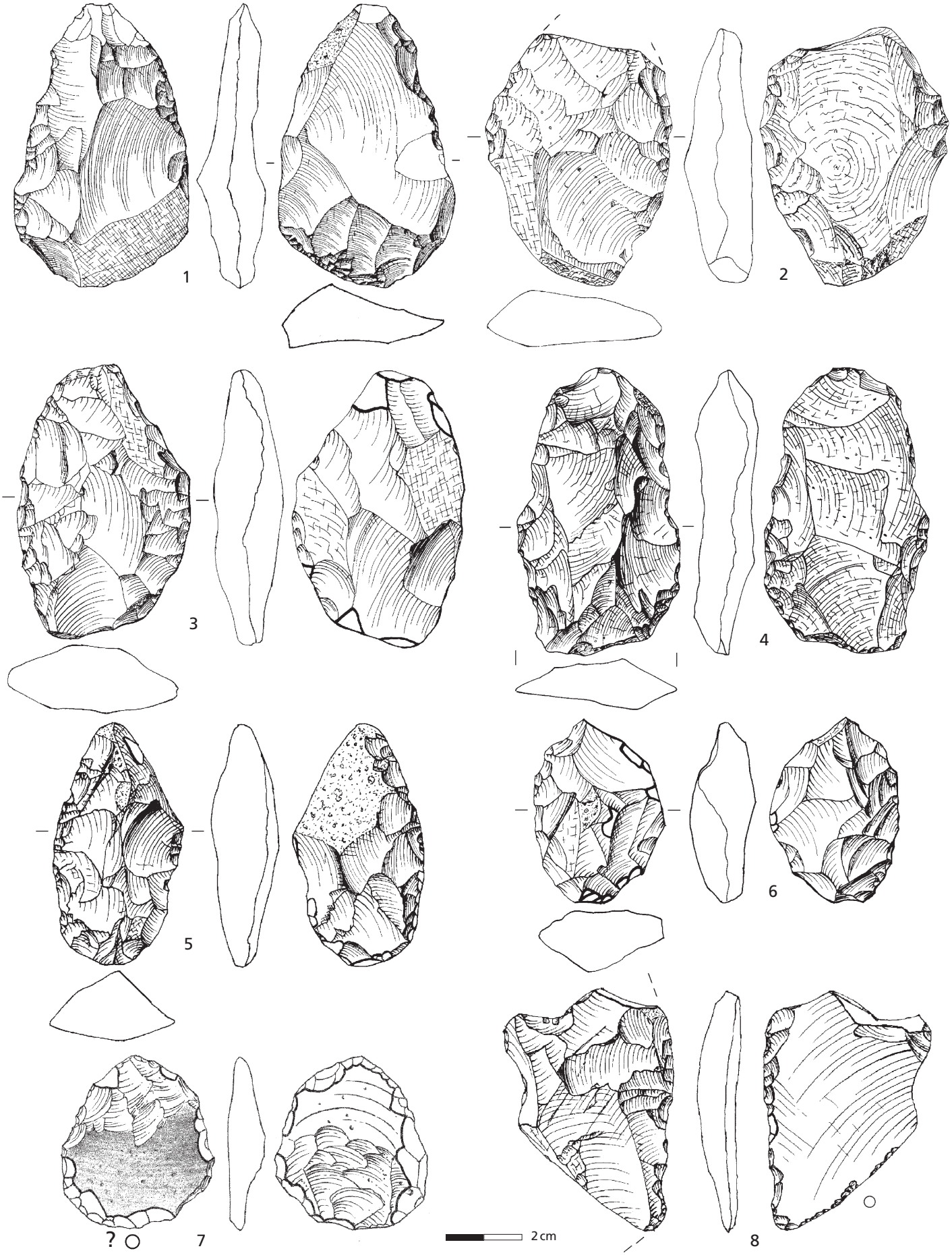


Fig. 6 Some leaf points from the Netherlands (nos. 1-6 'Mauern' type, 7 Jerzmanowice type): **1** Eindhoven; **2** Leusderheide; **3** Emmerschans (A); **4** Eeserveld; **5** central Netherlands (?); **6** De Krim; **7** Aardjesberg. See **Tab. 2** for references and **Fig. 5** for the location of the findspots. – (Drawings: Lykke Johansen).

Fig. 7 Some uncompleted leaf points or failed efforts probably made by apprentice flintknappers: **1** Emmerschans (B); **2** Balloo; **3** Zeijen-Oost (A); **4** Zeijen-Oost (B); **5** Woldberg; **6** Zuidlaren; **7** Emmen-Roswinkelerweg; **8** Onna. See **Tab. 2** for references and **Fig. 6** for the location of the findspots. – (Drawings: Lykke Johansen [nos. 1-6, 8] and H.R. Roelink [RUG/GIA, Groningen Institute of Archaeology]).


1
2
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? ○
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2 cm
8

Probably practice pieces by learners also occur at the somewhat younger site of Beedings in West Sussex (pers. comm. by the late Roger Jacobi to Stapert), which we shall return to below.

Table 2 also includes two or three 'unifacial leaf points' from the Netherlands. These were made from substantial blades, ventrally mostly worked with shallow retouch. The retouches, especially those at the proximal and distal ends, afforded the blades a straight lateral profile: an important feature in spearheads. Jacobi (2007) dubbed such leaf points on blades 'blade points'. They were made by the latest Neanderthals in northern and western Europe, not long before they went extinct. We call such leaf points 'Jerzmanowice leaf points', after the site of Jerzmanowice (the Nietoperzowa Cave) in Poland, where in 1961 they were first described by Chmielewski. He suggested that the tradition characterised by such leaf points be named 'Jerzmanowician', and we see no reason to do otherwise (*contra* e. g., Flas, 2011).

A 'GREAT WESTWARD MIGRATION'?

There are good reasons for assuming that in northern and western Europe this was the last Neanderthal 'culture'. Datings of this tradition fall around 36,000 ^{14}C BP in the radiocarbon chronology (uncalibrated: ^{14}C uncal. BP). Quite recently, such dates have been obtained from direct datings of multiple skeletal remains of Neanderthals excavated in the famous cave of Spy; comparable datings are known from Britain (see e. g., Jacobi et al., 2006; Jacobi, 2007; Semal et al., 2009; Crevecoeur et al., 2010). Possibly this tradition was just a short-lived one, maybe lasting no more than one or two thousand years. At Spy more than ten unifacial leaf points were recovered, perhaps as many as 25 if re-used fragments are included (Pirson et al., 2011; Rougier and Semal, 2013). The major site of Beedings in Sussex was already mentioned; here no fewer than 43 Jerzmanowice leaf points were recovered, most of them broken (Jacobi, 2007). In the Netherlands one certain find of this type is known, a fragment found on the Aardjesberg hill (Fig. 6: 7; Stapert, 1992; Stapert et al., 2007), as well as one or two possible further fragments (Maasvlakte 2, Den Bosch?).

It is an appealing hypothesis that the Neanderthals performed a 'Great Westward Migration' – away from the expanding Cro-Magnons, who even before 40,000 ^{14}C uncal. BP started spreading across Europe from

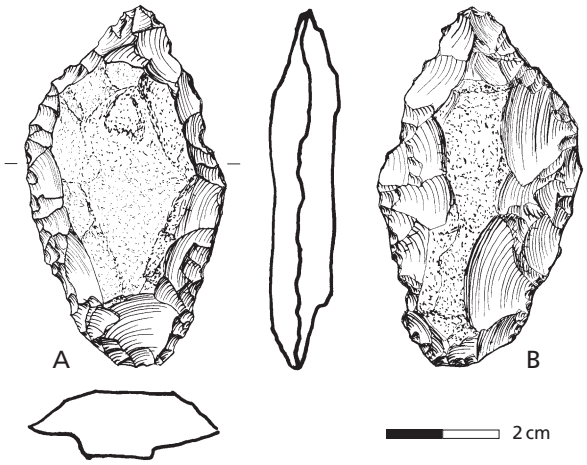

Fig. 8 A failed preform of a leaf point from Mauern, excavated by A. Bohmers. The point displays poor knapping skill, e. g., many steps. Drawing by Lykke Johansen. – (After Bohmers, 1951).

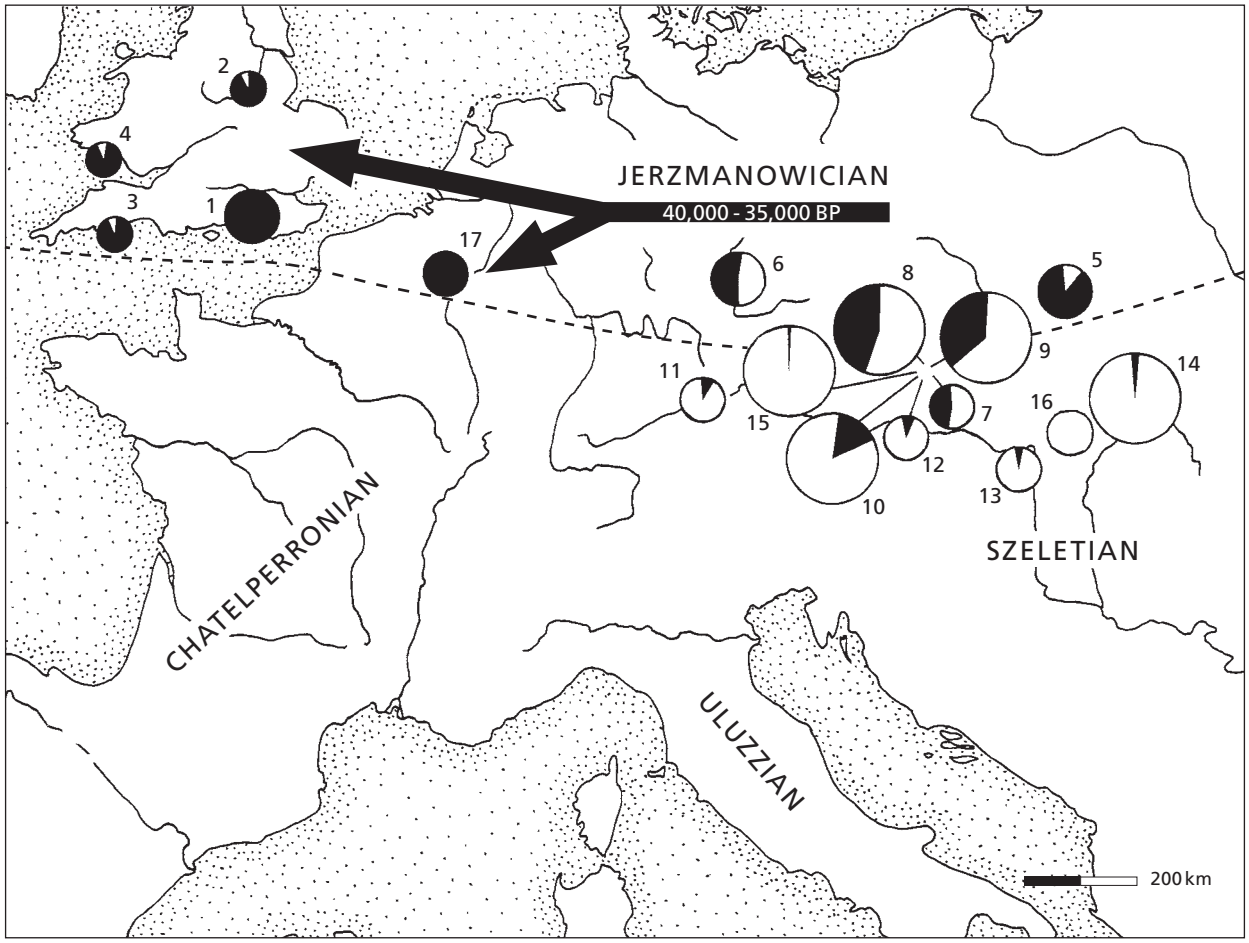

Fig. 9 Map showing selected findspots of the Leaf-point Group in central and northern Europe. Sites where Jerzmanowice leaf points predominate are labelled Jerzmanowician; sites with a predominance of bifacial leaf points, Szeletian (in the broad sense). The pie charts show the proportions of the two types: black: unifacial, blank: bifacial. The diameters of the pie charts roughly reflect the total number of leaf points per site. All English sites with over 10 leaf points; elsewhere a selection of sites with over 20 leaf points each (based on Allsworth-Jones, 1986, various publications by Jacobi (e. g., Jacobi, 1990, 2007) and other sources). The arrows illustrate the proposed Great Westward Migration of the last Neanderthals across the continent – away from the expanding Cro-Magnon territory. Findspots: **1** Beedings (Pulborough); **2** Robin Hood; **3** Kent's Cavern; **4** Paviland; **5** Jerzmanowice (Nietoperzowa); **6** Ranis (2) Ilsenhöhle; **7** Zelesice; **8** Lisen; **9** Ondratice (1, 3-7); **10** Neslovice; **11** Mauern; **12** Orechov (1); **13** Jankovich; **14** Szeleta (3-7); **15** Jerezany (1 and 2); **16** Balla (2); **17** Spy. – (Map: Dick Stapert and Lykke Johansen).

the southeast (for this hypothesis see Stapert, 2007). **Figure 9** is an illustration of this presumed Westward Migration, based on the assumption that Jerzmanowice points on average appeared later than the Mauern points. It is of interest to note that at Mauern five or six unifacial leaf points were present, in addition to 44 bifacial ones. The map in **Figure 9** seems to suggest that the Neanderthals were trying to avoid the Cro-Magnons by fleeing to the north and especially the west. One reason for believing that the users of leaf points (first bifacial, then unifacial ones) in southern England were migrants, is the fact that there was no local cultural substrate for these types. However, such a background *was* present in central Europe: in the Micoquian (*Keilmessergruppen*), leaf points or leaf-point-like tools had by then been produced for thousands of years. Although we now know through DNA analysis that the two (sub-) species interbred, this does not rule out violent confrontations. The possible causes or combinations of causes of the extinction of Neanderthals around 35,000 ^{14}C uncal. BP have since long been the subject of debate, on which the final word has not yet been spoken.



Fig. 10 The bone retoucher from Empel (prov. of Noord Brabant; see Stapert, 1977, 1981). It is a lengthwise split fragment of a long bone (probably a shinbone) of a large ungulate, with four clusters of 'stigmata' that derive from its use as a percussion tool in flintworking. Experiments have shown it to have been used by a left-handed Neanderthal. Length 11.2 cm; weight 92 g. – (Photo: Frans de Vries [Toonbeeld, Oosterwolde]).

BONE RETOUCHERS FROM MAUERN

Middle Palaeolithic leaf points were created by 'direct soft percussion', i. e., without a punch. No pressure flaking was applied, as often was the case in later Stone-Age (and Bronze-Age) periods. The flints were not heated prior to working to improve their workability, as was done with (part of) the leaf points of the Solutrean ca. 20,000 years ago (Bordes, 1969), and possibly also with some bifacial tools of later periods. Nonetheless the Neanderthals managed to create amazing leaf points while using only direct percussion. As said before, there are exceptionally fine and indeed very large leaf points which can hardly have been functional. They are true display pieces, demonstrating the makers' great skill as flint workers, and it has been suggested that these showpieces of the late Neanderthals were their equivalent of 'art' (Stapert, 2007: 17). As percussion tools, the Neanderthals used mostly bone hammers, made from long bones of large animals. These generally were ungulates, but the knappers were not too particular in this respect: even parts of Neanderthal bones (!) might be used (at Goyet; see Rougier et al., 2016). The finest Dutch example of such a bone percussion tool is from a suction-dredged gravel pit beside the Meuse, at Empel (**Fig. 10**; after Stapert, 1977, 1981). A remarkable aspect is that this tool had been used by a left-handed Neanderthal. Various kinds of research have shown that around 10 % of Neanderthals – like ourselves – were left-handed. Bone retouchers like this piece were without doubt used for producing a variety of tools: not just leaf points, but for instance also side-scrapers and handaxes. Although they were not always noted earlier by archaeologists (for instance, Lewis Binford in 1981 mistakenly described them as bones gnawed by hyenas, wolves, dogs, etc.), hundreds of such implements are now known, not just from Middle Palaeolithic, but also from Upper and Late Palaeolithic contexts. A couple of years ago, 2018 saw the appearance of an important book on

Fig. 11 The six bone retouchers from Mauern. No. 1951.804.A shows gnawing marks at the base. – (Drawings: Lykke Johansen).

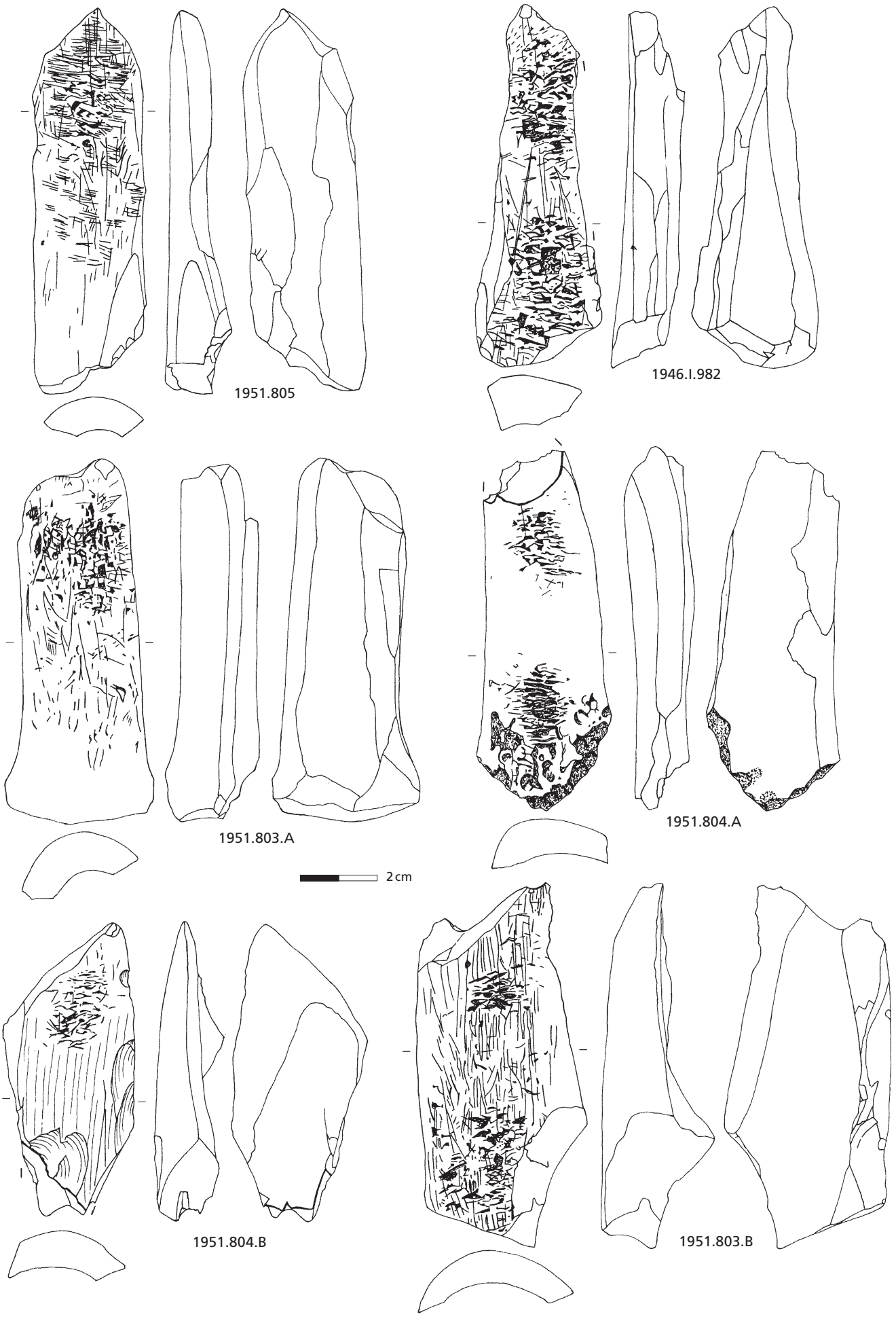
1951.805
1946.I.982
1951.803.A
1951.804.A
2 cm
1951.804.B
1951.803.B



Fig. 12 One of the bone retouchers from Mauern: No. 1946.I.982. – (Photo: Gert van Oortmerssen [RUG/GIA, Groningen Institute of Archaeology]).

bone technology in general and bone retouchers in particular (Hutson et al., 2018), which contains a lot of useful information.

The Mauern site was excavated by A. Bohmers in 1937-1939 for '*Das Ahnenerbe*'. Later investigators of the site included L.F. Zotz (1955, 1959) and W. von Koenigswald et al. (1974). Bohmers published his findings after the war, in the first issue of *Palaeohistoria*, the journal of the (then) Biological-Archaeological Institute of Groningen University (Bohmers, 1951). Recently the archaeologist/historian Arnold Carmiggelt published an extensive book on Bohmers' life and work, including the Mauern episode (Carmiggelt, 2019). Until recently, a small 'study collection' of some 50 items from Mauern was kept at the (present) Groningen Institute of Archaeology, including five leaf points and one bone retoucher (see Carmiggelt and Stapert, 2009; Stapert et al., 2010). In 2009 the first author and Carmiggelt re-united this collection with the rest of the excavated material in the *Archäologische Staatssammlung* in Munich. It transpired that five more bone retouchers were kept there, and we were granted permission to study these at Groningen (Stapert et al., 2010). Some information about the six pieces from Mauern (**Figs. 11-12**) can be found in **Table 3**. The five more-or-less complete specimens are on average 10.4 cm long and weigh on average 48.3 g. In general, the blanks are parts of long bones split lengthwise. Bone retouchers are very suitable for the purpose of dating, because it is certain that they belong to animals butchered by Neanderthals. Bone retouchers are especially useful in contexts such as caves, where many bones ended up without any human agency.

This at any rate applies to the majority of the bones recovered at Mauern, according to W. von Koenigswald (von Koenigswald et al., 1974). Moreover, it is only in a fresh condition that bones could have served as percussion tools (Martin, 1907-1910). This is underlined by the presence of fine, lengthwise scratches on three or four of the six studied bone retouchers from Mauern. These scratches precede their use as retouchers, and can be attributed to the bones being scraped to remove the periosteum.

The radiocarbon analyses of the six Mauern specimens were published by Van der Plicht (2012); they proved disappointing, probably because of contamination, which despite our best efforts could not in all cases be removed. One of the dates is clearly much too young: 20,490 ^{14}C uncal. BP. Moreover, this retoucher (no 1951.803.A) is of the lateral type (see Taute, 1965), a type that occurs especially in Upper/Late Palaeolithic contexts. The Gravettian level at Mauern produced radiocarbon dates of ca. 29,000 ^{14}C uncal. BP (von Koenigswald et al., 1974), still much older than 1951.803.A. According to Van der Plicht (2012), the oldest date

No.	species	anatomical part	lab.-nr.	^{14}C date [BP]	± [BP]	remarks
1951.804.B	cf. *Bos primigenius*	femur	GrA 46189	35,410	+280/-250	Fragment. Fine longitudinal scratches from bone-scraping.
1951.805	*Bos primigenius*	femur	GrA 46190	30,030	160	Besides stigmata from use as a retoucher, also small clusters of cut-marks.
1946.I.982	cf. *Bos primigenius*	cf. tibia	GrA 44676	36,180	+260/-240 *	From Cave A. Part of the Groningen 'Study collection'.
			GrA 46289	31,670	+350/-310	
1951.804.A	?	?	GrA 46186	37,150	+300/-270	With secondary gnawing marks.
1951.803.B	*Bos primigenius*	femur	GrA 46185	32,370	+200/-180	Used by a left-handed person. Fine longitudinal scratches.
1951.803.A	*Equus* sp.	metacarpal	Gra 46184	20,490	90	Lateral retoucher. Fine longitudinal scratches.

Tab. 3 Six bone retouchers from Mauern. Zoological determinations by R.J. Kosters and W. Prummel (RUG/GIA, Groningen Institute of Archaeology). Radiocarbon dates after Van der Plicht (2012: Tab. 1). – * unreliable radiocarbon date.

(of no 1946.I.982, which was dated twice) is unreliable (36,180 +260/-240 ^{14}C uncal. BP: GrA 44676). In fact, the present authors believe only one date to be a reasonable estimation of the true radiocarbon age of the leaf-point period: 37,150 +300/-270 ^{14}C uncal. BP (GrA 46186). It would make Mauern at least 1000 years older than Spy, which is not unreasonable. Van der Plicht (2012: 146) thinks that all dates are too young, partly because he believes that the retouchers date from the Micoquian. In our opinion, however, it is more likely that the majority date from the leaf-point period.

As for lateralisation, there is one specimen with clear left inclinations of the stigmata; most others are either unclear or show inclinations that are slightly to the right. So it seems that one of the users was left-handed. The bone retouchers of Mauern are fascinating tools in their own right, and certainly merit further study.

SUMMARY AND CONCLUSION

A beautiful bifacial leaf point of the 'Mauern' type is described and illustrated (**Fig. 2**). It was found some 20 years ago near Venray in the southern Netherlands by Roy Janssen, near his home. With its length of about 5.9 cm, it is the smallest successfully worked leaf point of this type found in the Netherlands so far. However, some failed preforms of leaf points, which were probably made by learners of the art of flintworking, are even smaller. The smallest piece in that group is the object from the Roswinkelerweg in Emmen: it measures only 4.6 cm (see **Tab. 2**). At the type-site of Mauern, the smallest bifacial leaf point – which is well-made – has a maximum length of 4.7 cm (illustrated in **Fig. 3**, after Bohmers, 1951).

We assume that this and other Dutch leaf points were made by members of one of the last groups of Neanderthals in northern Europe. Leaf points such as the specimen from Venray most probably served as spearheads. They were created by direct percussion, using bone retouchers. At least six of such bone percussion tools are known from Mauern, which are discussed briefly in the latter part of this paper. These tools were ^{14}C-dated in Groningen (Van der Plicht, 2012).

Many bifacial leaf points are very beautiful tools, and bear witness to the great flintworking skills of the Neanderthals. Elsewhere, for example at Mauern and Ranis 2, exceptional specimens are known – very large

and very thin – which can hardly have been functional as spearheads; they probably served as 'prestige' objects. Such pieces are as yet unknown in the Netherlands, probably because no suitable raw materials for their creation were available here.

Acknowledgements

First of all, we thank Roy Jansen (Venray) for the opportunity to examine and illustrate his find. Since then the leaf point has found its way into the Netherlands Collection of the Rijksmuseum van Oudheden (National Museum of Antiquities) in Leiden (accession number l 2019/12.1). We are grateful to Frans de Vries (Toonbeeld, Oosterwolde) for his as always brilliant photographs, and to Jaap Bongers (De Steekproef bv, Zuidhorn) for the AHN relief maps. Also, we are indebted to Willem Hoex (Venray) who kindly made available his finds from 'De Biesplanken' for us to study and to Francois van Wessel (Tegelen) for information on the finds from Grubbenvorst. Stapert and Johansen further wish to thank W. Hupperetz (at the time of the Limburgs Museum at Venlo), the staff of Ecomare in Texel, H. Jenniskens (curator of the Culture-Historical Museum at Asselt), Leo Verhart (at the time curator of the Limburgs Museum at Venlo), W. Vossen, and Hans Peeters (Groningen Institute of Archaeology) for their information and cooperation with regard to supposed Middle Palaeolithic leaf points. Also, we thank S. Hutschemakers (Banholt) for information on the findspot of his item at Banholt. Leo Verhart made arrangements for us (Johansen and Stapert) to draw and examine the leaf-point-like tool from Banholt at the Limburgs Museum, for which we thank him. As we thank our friend Xandra Bardet (Groningen), for preparing the English translation of this article, part of which first appeared in Dutch in *Grondboor & Hamer* (Stapert et al., 2020). We thank Robert Kosters and Wietske Prummel for their zoological determinations, Gert van Oortmerssen for the photograph of one of the Mauern retouchers, and Roelf Barkhuis and Hannie Steegstra for their help with assembling the figures. Finally, Dick Stapert and Lykke Johansen are happy to thank Martin Street and Elaine Turner for their warm hospitality and many years of comradeship.

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PETR NERUDA

DECONSTRUCTING THE MIDDLE / UPPER PALAEOLITHIC TRANSITION IN MORAVIA (CZECH REPUBLIC)

Abstract

Archaeological sites in Europe provide evidence for the interactions between local Neanderthal groups and newly arriving groups of Anatomically Modern Humans. Traditionally, the models targeted at solving the relation between the Middle Palaeolithic, the Bohunician, the Szeletian, and the Aurignacian. The limited number of stratified and well-dated sites and unknown bearers of the industries provides a major problem to these models. Moreover, genetic studies indicate a complicated interaction between local Neanderthal groups and arriving Anatomically Modern Humans. Moravia (Czech Republic) is one of the regions where this cultural mixture could be complicated. One way to revitalise the discussion on this topic is the implementation of assemblages that are not representative from the methodological point of view, but that contain mixed elements, which could reflect interaction between different groups of both Neanderthals and anatomically modern humans.

Keywords

Middle/Upper Palaeolithic transition, Micoquian, Mousterian, Szeletian, Bohunician, Aurignacian, Líšeň I/Podolí industry, Míškovice industry, Moravia

INTRODUCTION

For a long time, the Middle to Upper Palaeolithic transition has been an important archaeological research topic. The appearance of Anatomically Modern Humans (AMH) in Europe, their influence on local Neanderthal populations, and the associated changes in material cultures are very complex and are open to many interpretations. The Middle Danube region is one of the important areas crucial to this topic, with significant sites such as Willendorf II, Krems, Mladeč, Vedrovice, Brno-Bohunice, Stránská skála, Dzeravá skála, Szeleta and others (**Fig. 1**). One of the key spots within this area is the region of Moravia (the eastern part of the Czech Republic) where different technocomplexes have been recorded (**Fig. 2**) and where we can study the relationship among these, and consequently the relationship between Neanderthals and AMH.

Unfortunately, there is a limited number of human remains in the archaeological context, affecting the potential for reconstructions of the cultural developments. From the aforementioned area, Neanderthal remains have been reported from several sites, from Kůlna Cave (Jelínek, 1988), Švédův Stůl Cave (Jelínek, 1962), and Šipka Cave in Moravia (Maška, 1886; Vlček, 1969), Stajnia Cave (Picin et al., 2020) and Ciemna Cave in Poland (Willman et al., 2019), Šaľa in Slovakia (Jakab, 2005; Sládek et al., 2002), and Subalyuk in Hungary (Bartucz and Szabo, 1940). The presence of AMH is recorded in the Mladeč Caves in Moravia, where a number of skulls and postcranial bones were uncovered, within the context of an Aurignacian industry (Teschler-Nicola, 2006). For other technocomplexes however, such as the Bohunician, the Szeletian and the Jerzmanowician, we do not know who created these industries.

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.868.c11315

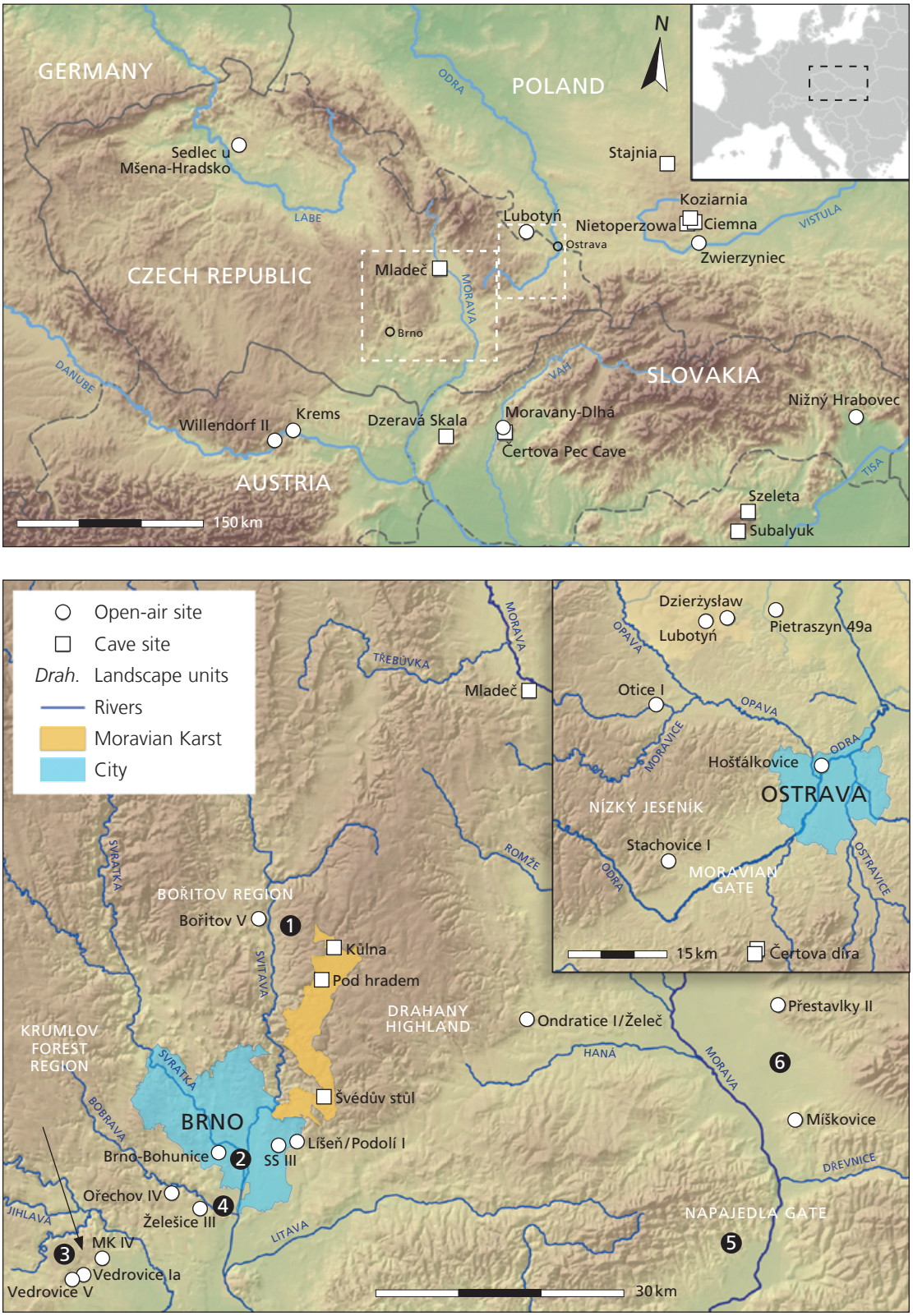

Fig. 1 Map of the eastern part of Central Europe with sites mentioned in the text. – (Model by P. Neruda).

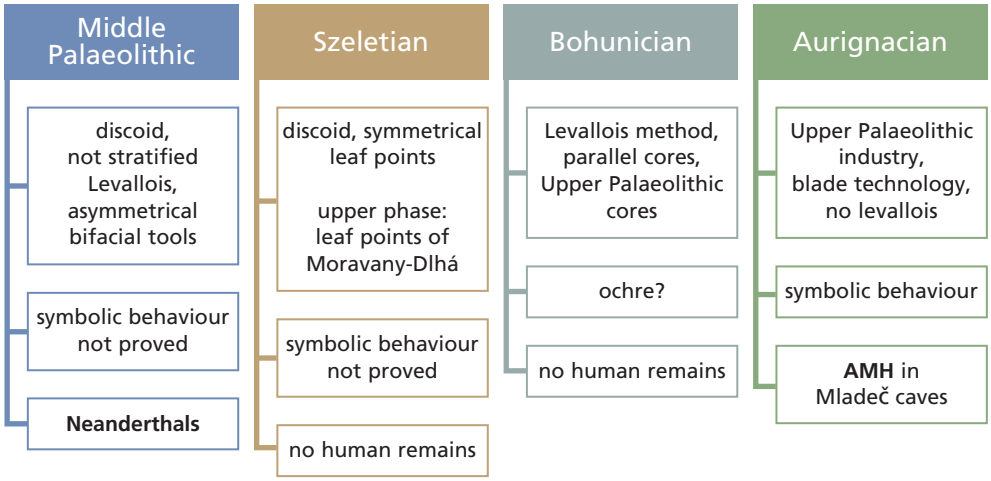

Fig. 2 Traditional technocomplexes identified in Moravia during the Middle/Upper Palaeolithic transition.

Considering the dating of sites, we see that Neanderthal populations persisted in the Middle Danube Region until at least 45 ka cal BP (**Fig. 3**)[1]. Their appearance overlaps partly with both the Szeletian and the Bohunician occupation of Moravia. Dated Aurignacian sites in Moravia are younger[2] however, AMH appeared in Austria, Slovakia, and likely Hungary earlier (Bolus and Conard, 2001; Conard and Bolus, 2003; Haesaerts and Teyssandier, 2003; Kaminská et al., 2005; Nigst et al., 2009).

Constructed models of cultural development are mostly based on stratified and dated sites. This is an obvious approach. Nevertheless, it should be mentioned that despite new archaeological analyses, excavation of new sites, and more accurate dating methods, research is somewhat stagnant. For a long period of time, we have been unable to find new sites with a superposition of individual Early Upper Palaeolithic (EUP) technocomplexes (except for the the Bohunician and Aurignacian in Stránská skála). In addition, for the majority of EUP cultures, it is still unknown whether Neanderthals or AMH were responsible.

In this context, the probability for the discovery of new human fossils is low, as the majority of caves have been explored, and conditions at open-air sites in the Middle Danube Region are not suitable for organic preservation as the records are located in fossil soils. Adding to this, genetic research often suggests that anthropogenesis was more complicated (Green et al., 2010; Peyrégne et al., 2019; Posth et al., 2017; Slatkin and Racimo, 2016) than indicated by osteological remains and archaeological finds. It is obvious that human evolution was significantly influenced by interbreeding (Fu et al., 2015; Sankararaman et al., 2012; Slon et al., 2018; Trinkaus, 2007), which must result from some form of co-existence of different populations (e. g., Neanderthals and AMH or Neanderthals and Denisovans), and we must ask how this process is reflected in the archaeological record. The problem is that well-dated and stratified sites represent only a small fraction of human imprint on the landscape. We cannot be sure that this evidence reflects the main characteristics of human behaviour. Moreover, we typically treat individual technocomplexes as isolated entities that developed more or less independently from each other, with processes of acculturation or copying of some features only occasionally taken into consideration[3]. It is clear, however, that even in a small area, e. g., Moravia, the interaction among different groups can be expected to be rather intensive and complex.

1 For earlier occupation of Europe by AMH see the problem of the Protoaurignacian (Conard and Bolus, 2015).

2 E. g., we should treat the radiocarbon data for the human fossils from Mladeč as being more precise than those obtained from carbonates.

3 Discussion about the relationship between the Châtelperronian (Roussel, 2014), the Szeletian and the Bohunician (Oliva, 2016, 2019).

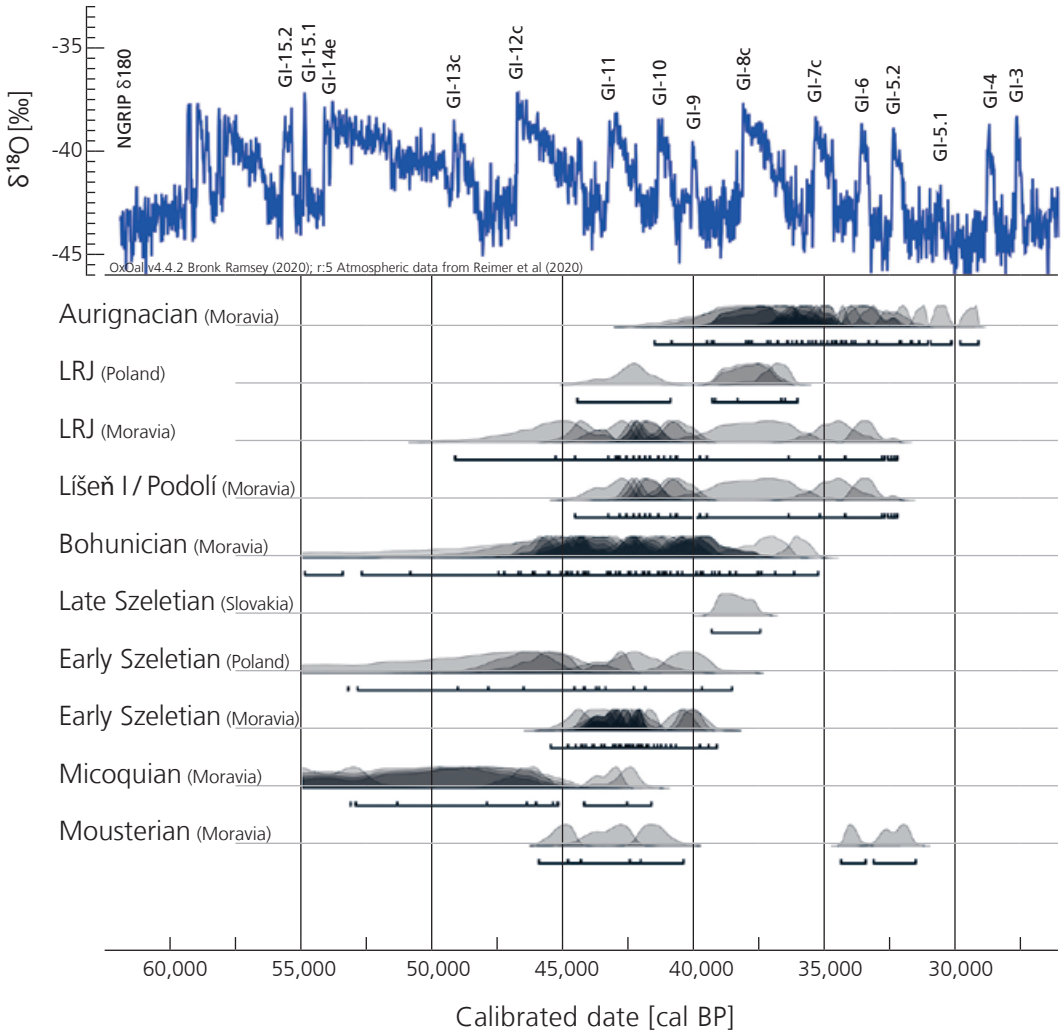

Fig. 3 Chronological position of individual technocomplexes using stacked data. Data for LRJ (Poland) according to (Kot et al., 2020), for Líšeň I/Podolí and LRJ (Moravia) two youngest data (Poz-76201 and Poz-76152) were removed. Modelled in OxCal 4.4., the calibration curve IntCal20 (Reimer et al., 2020).

Therefore, we should ask if the high-resolution data we usually prefer to use has an effect on our interpretative repertoire, and whether deconstruction of the subject with a special focus on "problematic" finds can open new research perspectives. Moravia and the surrounding areas provide evidence indicating that our current models could be more complex, to reflect the complexity of the archaeological record.

This contribution is focused on lesser-known finds from Moravia and the surrounding areas, which are not taken into consideration in current model building. The main aim is the identification of new possible relationships among individual technocomplexes in Moravia, focusing on broaching the following subjects:

- The Middle Palaeolithic substrate of the transition,
- The origin and chronological division of the Szeletian,
- Aurignacian features in the context of Middle and Early Upper Palaeolithic industries,
- The origin of the Bohunician and its relation to the Szeletian,
- The Líšeň/Podolí I type of industry,
- The problem of the Jerzmanowician in Moravia,
- And, the problem of the Míškovice type Industry.

DECONSTRUCTION

Middle Palaeolithic substrate of the transition

Within the time range under analysis, only one technocomplex is well documented – the Micoquian. This industry is represented in the upper part of the stratigraphic sequence at Kůlna Cave and is characterised by the presence of bifacial tools, and the use of the discoid method for blank production (Valoch, 1988). The Levallois method is absent. This same characteristic has also been noted at another dated site – Šipka Cave (Neruda, 2011).

Focussing on the Levallois method, which appears to have been significant for the Bohunician, an interesting question is related to its presence in a further Late Middle Palaeolithic technocomplex – the Mousterian. Rich and characteristic Mousterian sites directly dated to the period around 50 ka cal BP are absent in Moravia. Finds from Čertova díra Cave in northern Moravia probably date to this period (Neruda, 2011; Neruda and Nerudová, 2013; Valoch, 1965b), but the number of finds are limited, and the Levallois method seems not to have been applied. Industries from Švédův stůl Cave, where we have also found Neanderthal remains, are attributed to the Mousterian, though absolute dates are missing (Jelínek, 1962; Klíma et al., 1962). This also applies for evidence for the application of the Levallois method. It is apparent that sites with typical Levallois production have not been unearthed in Moravia[4]. Isolated pieces mostly collected from surface sites (Oliva, 2006) cannot be taken into account here because the presence of an isolated Levallois-like core does not automatically imply that the method was applied, and, without dating, we can hardly identify lithics from the time range under analysis.

Therefore, the possible existence of a Mousterian with Levallois production in Moravia is solely based on a surface collection from Hošťálkovice Ia. In addition to "Upper Palaeolithic" lithic components (see below) several Middle Palaeolithic side scrapers have been recorded, showing that the Levallois technology was applied for preferential flake production.

However, the lack of well-dated sites makes it impossible to substantiate if the Mousterian in Moravia during the transitional period is autochthonous or allochthones. Based on European analogies, we can expect Neanderthals to be the bearer of this industry.

Szeletian

The majority of contexts attributed to the Szeletian are known from surface collections, however Szeletian sites have also been found during excavations in Moravia relatively often. Due to the technological composition and presence of bifacial leaf points, the relation of the Szeletian to the Micoquian is broadly accepted (Allsworth-Jones, 1986; Kaminská et al., 2011; Oliva, 2005; Svoboda, 2005; Valoch, 2012)[5].

Several problems and questions are related to the Szeletian with significant consequences for model(s) of EUP developments. One key question is whether the Szeletian represents a late phase of the Micoquian, or a technocomplex that originated from the Micoquian and developed in parallel with the Micoquian during the EUP? Stemming from this, there is also the problem of how to consistently distinguish the Szeletian from the Micoquian.

4 Western Bohemia has provided better evidence for Levallois production in the Czech Republic, where such industries are related to outcrops orthoquarzite of Bečov type.

5 The probable genetic relation between the Szeletian and the Middle Palaeolithic (at that time i. e., Mousterian) was first proposed by František Prošek who defined the Szeletian (Prošek, 1953).

This problem recently appeared in the context of the classification of Layer 0 at Moravský Krumlov IV (MK IV), due to the discovery of unfinished leaf points, which are very similar to Micoquian bifacial backed knives. Both refitting (Neruda and Nerudová, 2019) and scar pattern analyses (Neruda and Kot, 2019) show that the main strategy for bifacial tool production was different at MK IV in comparison to the known Micoquian examples, e. g., Layer 7a at Kůlna Cave. The described technology from Layer 0 at MK IV shows leaf points (and their symmetry) to be the discriminatory tool type because they are not typical for the Moravian Micoquian. On the other hand, the technology of the Early Szeletian (Vedrovice V, Moravský Krumlov IV) is similar enough to the Micoquian (it proves a familial relation), and we can therefore understand the Szeletian as a late phase of the Micoquian.

However, some evidence indicates that the late Micoquian could be penecontemporaneous with the early phase of the Szeletian. This is supported by calibrated ^{14}C data that show a temporal overlap between the Micoquian and the Early Szeletian (an interval of calibrated dates of ~40-46 ka cal BP) (Haesaerts et al., 2013; Neruda and Nerudová, 2013). In this context, the wide data range and varying quality of dates for Kůlna Cave Layer 7a must be taken into account (**Fig. 2**). The first dates, obtained during the 1980s are generally younger than the new dates that were based on improved sample cleaning (Neruda and Nerudová, 2014). On the other hand, Layer 7a is not the last Micoquian layer at Kůlna Cave. The uppermost Layer 6a is stratigraphically younger and should date to the interval for the overlap between the Micoquian and Early Szeletian. However, the radiocarbon dataset for Layer 6a also contains dates comparable to the Upper Palaeolithic sequence (Neruda and Nerudová, 2014: Tab. 2) and one radiocarbon date is significantly older than data for Layer 7a (Neruda and Nerudová, 2013).

For these reasons, the assumption of overlapping of dates should be taken into consideration as it supports the hypothesis that the Szeletian occupation represents a new group (probably of Neanderthals), and is related to the Micoquian but including a specific discriminatory tool – the leaf point.

It is important to note that the settlement dynamics for both technocomplexes differ. With the exception of isolated leaf points in Rytířská (Valoch, 1965c) and Pod hradem caves (Valoch, 1965a), Szeletian occupations have not been located in caves, contrary to the Micoqiuan occupation[6]. Moreover, Szeletian open-air sites are situated in different regions compared to the Micoquian. A similar strategy can be identified in southern Poland. Here, the early Szeletian is also only known from open-air sites, e. g., at Lubotyń 11, a site penecontemporaneous with Vedrovice V and MK IV in Moravia (Bobak et al., 2016). Micoquian sites found in the same region as Lubotyń are older, and could rather represent a previous occupation phase on the Głubczyce Plateau. This hypothesis supports the dates from the site of Pietraszyn 49a, which can be correlated with Layer 9b at Kůlna Cave (Wiśniewski et al., 2017). Micoquian sites contemporaneous with the Early Szeletian are known from the caves of the Kraków-Częstochowa Upland.

Another important question is whether we are able to distinguish the internal development of the Szeletian. Due to the lack of well-dated archaeological sites and the superposition of Szeletian assemblages[7], answering this question is still a challenge, although research has focussed for quite a long time on the inner division of the Szeletian in Moravia, Slovakia or Hungary (e. g., Kaminská et al., 2011; Mester, 2010, 2018; Oliva, 2004, 2019; Ringer, 1990; Valoch, 1957)[8].

6 Base camps or hunting camps in caves are represented in the Szeleta Cave in Hungary, in Dzeravá skála (Prošek, 1951) and in Čertova Pec (Bárta, 1971) in Slovakia. Dzeravá skála is probably only one site were the Micoquian and the Szeletian could be in superposition. Unfortunately, the last excavation (Kaminská et al., 2005) did not locate the Szeletian layer and all bifacial items were related to the Micoquian (for this issue see also Valoch, 2012).

7 Only the Szeleta Cave in Hungary recorded a probable superposition, but both, stratigraphy and dating of horizons is very complex and the data should only be used with care (Adams, 2002; Mester, 2002; Ringer and Mester, 2000).

8 For this issue see Mester (2014).

The Early Szeletian (~46-40 ka cal BP) is relatively well documented at Vedrovice V (Valoch et al., 1993), Moravský Krumlov IV, Layer 0 (Neruda and Nerudová, 2009), and Želešice III (classified as Jerzmanowician in: Demidenko and Škrdla, 2020; classified as Szeletian in: Škrdla, 2017). The site of Lubotyń in Poland located near the border to the Czech Republic (**Fig. 1**) may also belong to this group of sites (Bobak et al., 2016). Younger phases of the Szeletian are difficult to establish due to the lack of dated sites and indications are given that later phases differ regionally. Oliva proposed techno-typological criteria for the identification of the Late Szeletian in the region of Moravia, based on collections from Drahany Highland (e. g., Ondratice Ia, Oliva, 2004). He saw the developed character of such industries in an increase of blade technology, a high proportion of imported raw materials (e. g., chert of Zdislavice-Troubky, **Fig. 1**), the presence of long-distance imports, the higher ratio of burins, and an increase of Aurignacian-like tools (mostly end scrapers). A high ratio of side scrapers is still present. Partly retouched leaf points (cf. Jerzmanowice) prevail over completely bifacially retouched pieces. He compares such industries with the Míškovice-type (Oliva, 1990; for more see the chapter below) which might represent the late (final?) phase of the Szeletian in the region of the eastern bank of the Morava river (Oliva, 2004).

The late phase of the Szeletian can also be represented by the Szeletian of the Moravany-Dlhá type typical for western Slovakia (for this issue see Kaminská, 2014). It is possible to date the leaf point with convex base group (Freund, 1952) to ca. 39 ka cal BP (Kaminská et al., 2011; Nemergut, 2010) based on a charcoal sample (Poz-29011; 33,600 ± 300 ^{14}C BP) from the eponymous site Moravany-Dlhá, excavated by L. Zotz (Zotz, 1943a, b), J. Bárta (Nemergut, 2010), K. Absolon (Nerudová and Valoch, 2009) and others.

In Hungary, the so-called Developed Szeletian is distinguished. However, there is no concurrence regarding the definition of this industry (for a summary see Mester, 2014). While we can identify some technological roots related to the Moravian Late Szeletian industries in the previous early phase, from the technological point of view, industries, e. g., of the Moravany-Dlhá type differ significantly, and the question remains if they represent the development of the same technocomplex (Oliva, 2016).

The discontinuity of cultural traditions between the Early and Late Szeletian (the Moravany-Dlhá Szeletian included) is supported by technological analyses from Hungary where the Early and the Developed Szeletian also differ significantly (Mester, 2010).

Behind these technological considerations is the question of who was responsible for the Szeletian. Due to the similarity with the Micoquian, we generally expect Neanderthals to be responsible for the Szeletian (Neruda and Nerudová, 2019; Oliva, 1991b; Svoboda, 2006; Škrdla, 2017). However, the possible independence of the Late Szeletian provokes the hypothesis that this younger phase could have been produced by AMH, given that AMH also produced leaf points (Oliva, 2019).

Besides the local independent development of the Szeletian from the Micoquian (Neruda and Nerudová, 2013; Oliva, 1991b) some scholars propose that the Szeletian developed in a process of acculturation from the Micoquian to the Aurignacian (Allsworth-Jones, 1986; Valoch, 1973, 1990a, 1990b). For the time being, this is problematic due to the dating of AMHs arrival to Moravia, which is later than the Early Szeletian. In concordance with the previously postulated hypothesis, Nigst (2012) also considers the Szeletian as the result of the acculturation of the Micoquian by the first wave of AMH, which are assigned to the Bohunician (Svoboda and Bar-Yosef, 2003; Tostevin, 2000a). Nigst based his hypothesis on attribute analysis, which showed a higher degree of similarity between the Szeletian and the Bohunician than between the Szeletian and the Micoquian. On the base of this analysis, he even attributed Layer II in Willendorf II to the Szeletian despite the fact that it contains no bifacial components. Controversies to this hypothesis arise as we lack proof to relate the Bohunician to AMH (see below as to whether the Bohunician is a truly independent technocomplex) and when we compare the complexity of the *chaine operatoires* we see different strategies for blank production in the well-defined Bohunician from Stránská skála compared to those identified for the

Szeletian (Neruda and Nerudová, 2005). Moreover, although there is overlap between the Micoquian and the Bohunician, we lack evidence for direct contact.
On the other hand, sites reflecting the Szeletian/Bohunician contact zone indicate interaction between these technocomplexes. Moreover, if we consider sites like Ondratice I, Ia, and Vincencov etc. to be homogeneous (e. g., Late Szeletian) their Aurignacian-like features and imported raw materials from Aurignacian zones (e. g., Napajedla Gate) support the assumption that the local population was in contact or directly acculturated by Aurignacian AMH.

Bohunician

Though many new stratified sites have been excavated during the last two decades, there are still many problems related to the Bohunician (definition: Oliva, 1979; Oliva, 1981; Svoboda, 1980). The "pure" Bohunician is known mostly from several locales on the outcrop of chert at Stránská skála (Svoboda and Bar-Yosef, 2003) and it is characterised by the coexistence (Valoch et al., 2000) or fusion (Škrdla, 1996) of both Levallois and Upper Palaeolithic blade production. Interestingly, the use of chert from Stránská skála decreases significantly with increasing distance from the outcrop. Moreover, bifacial leaf points appear in some assemblages, e. g., on the eponymous site Brno-Bohunice (Tostevin and Škrdla, 2006; Valoch, 1976). They are usually made from rock different from the Stránská skála chert, which is typical for the Bohunician. Such cases have been interpreted variably, as the Szeletian of Levallois facies (Valoch, 1956), an intrusion/contamination/imports into the Bohunician (Nerudová, 2002; Oliva, 2016; Škrdla, 2017), or an integral part of the Bohunician (Škrdla, 2014). We also note Levallois products in assemblages classified as Szeletian (e. g., Vedrovice V; Valoch et al., 1993). Sometimes, cultural classification of distinct assemblages varies (for this issue Oliva, 2016) between the Bohunician and the Szeletian and recently, reclassification of some sites to the Jerzmanowician (or LRJ) has been proposed (Demidenko and Škrdla, 2020). The situation is further complicated by the low number of Bohunician sites in the surrounding areas. Only lithic industries from Sedlec u Mšena-Hradsko (Neruda and Nerudová, 2000; Škrdla et al., 2013; Vencl, 1977) and Nižný Hrabovec (Kaminská et al., 2009) can be attributed to this technocomplex. Superposition of both the Bohunician and the Szeletian in Poland at Dzierżysław is revised and the presence of the Bohunician at this site is dubious (A. Wiśniewski, pers. comm.).
If we, for the argument of this contribution, accept the Bohunician as an independent technocomplex, the origin of the Bohunician and its creator becomes an important topic.
Traditionally, two theories have tried to explain the origin of the Bohunician. One group of scholars have pointed out the similarity of the Bohunician with some industries from the Near East, based on a typical example from Boker Tachtit (comparison with the Bohunician: Škrdla, 2003). Consequently, this group expects the bearers of the industry to be AMH. In this conception, the Bohunician is an intrusional (allochthonous) technocomplex that might represent the arrival of AMH before the Aurignacian (Demidenko and Škrdla, 2020; Nigst, 2012; cf., Richter et al., 2008; Svoboda and Bar-Yosef, 2003; Škrdla, 2014, 2017; Tostevin, 2000b).
The second theory is based on the lack of direct evidence for migration. Sites classified to the Bohunician are rare. If its origin is assumed in the Near East, we should expect to find raw materials from southern and south-eastern direction at the Moravian sites (Oliva, 2016). We also lack direct evidence that the industry of Boker Tachtit type was produced by AMH. Moreover, it should be stressed that there are very similar industries observed in Western Europe, of Middle Palaeolithic origin (e. g., Seclin, Rocourt, and Riencourt-les-Bapaume) that contain both the Levallois method and Upper Palaeolithic-like blade production (Valoch et al., 2009; Valoch et al., 2000). Migration of the creators of these industries from the west to Central

Europe also cannot be supported, due to the same reasons that support the rejection of a Near Eastern origin, namely no raw materials from Western Europe. Therefore, the autochthonous origin should also be considered. There is, however, no well-documented substrate for the Levallois method (see above).

Aurignacian features in other industries

The Aurignacian is the single technocomplex discussed here we know to have been created by AMH, because we have found typical lithic and organic industries associated with human remains at the Mladeč Caves (Teschler-Nicola, 2006). In Central Europe, the impact of the Aurignacian on EUP technocomplexes differed regionally. The oldest dates for the Middle Danube region (Adams and Ringer, 2004; Kaminská et al., 2005; Nigst et al., 2014) are recorded at Willendorf (~ 43-39 ka cal BP), Peskő (> 40 ka cal BP), and Dzeravá skala (~ 42-36 ka cal BP). If we take into account these dates from Moravia, we see, for now, that AMH entered Moravia later, at ca. 37 ka cal BP (Neruda and Nerudová, 2013). This is in concordance with the stratigraphy at Stránská skála, where the Aurignacian is stratigraphically located above the Bohunician (Svoboda, 2003) and it appears that the arrival of AMH terminated the development of the Bohunician.
The stratigraphic relation between the Aurignacian and other EUP and Middle Upper Palaeolithic technocomplexes is poorly documented. This stratigraphic relation is however documented for the Pod hradem Cave (Nerudová et al., 2012; Valoch, 1965a) where a layer containing a leaf point is stratigraphically located below Aurignacian horizons (Nejman et al., 2018; Nejman et al., 2013). Dzeravá skala preserved the stratigraphical superposition of Micoquian, Szeletian, and Aurignacian (Kaminská et al., 2005; Prošek, 1951), but due to the history of research at the site the relation between the technocomplexes, i. e., the Szeletian and Aurignacian, cannot be studied with modern methods (for this issue see Valoch, 2012). In this context it is interesting to note that for the Kumlov Forest region, superposition of Szeletian and Aurignacian was not documented, although both technocomplexes are represented at stratified sites.
The best example of the presence of UP (Aurignacian) features in other technocomplexes that has been noted so far, comes from the uppermost Micoquian Layer 6a at the southern entrance of Kůlna Cave, where K. Valoch discovered Aurignacian-like end scrapers on blades and another fragment of an end scraper (Valoch, 1988: Abb. 18). As this horizon at the southern entrance of the cave also contains Gravettian and Magdalenian finds, intrusion cannot be excluded (Neruda and Nerudová, 2014; Nerudová and Neruda, 2014). But, contrary to such an argument is the absence of an intact Aurignacian layer in Kůlna Cave and the lack of any significant assemblage related to the Aurignacian. The presence of a few blades was noted but blade technology was applied in the Micoqian Layer 7c. Except for one excellent Aurignacian-like blade core originating from Layer 7a, blades and cores are technologically imperfect and were not transformed into formal tools. We recorded mostly use-wear on edges[9]. Taking the dates for Layers 7c, 7a and 6a into account, all upper Micoquian layers predate the appearance of the Aurignacian in Moravia.
The presence of isolated Aurignacian-like elements in the Micoquian at Kůlna Cave is not an isolated example. In the region of the Svitava River Valley (Bořitov Region), near Kůlna Cave, we discovered a cluster of Middle Palaeolithic surface sites. Most of them contain typical Middle Palaeolithic tools, including side scrapers and bifacial backed knives associated to the Micoquian. Upper Palaeolithic elements such as blade cores, carinated end scrapers, and burins were also quite often associated with these surface sites (Oliva, 1987, 1991a; Oliva and Štrof, 1985; Valoch, 1978).

9 Only basic macroscopic observation was performed.

Scenario	Pros	Cons
Coincidence	e. g., end scrapers on a thick blank may resemble carinated end scrapers	repeated coincidence in many cases
Palimpsest	– for surface collections: probable – for Kůlna Cave: possible for Layer 6a, not probable for Layer 7a and older layers	missing technological stages indicative for the Upper Palaeolithic
Co-existence of Neanderthals and AMH	possible for undated surface collections if Neanderthals survived later than 35 ka cal BP (AMH in Moravia) or AMH in Moravia earlier than 35 ka cal BP	for stratified collections: not probable, because of appearance of AMH in Moravia
Independent innovation by Neanderthals	according to dating, blade technology before AMH in Moravia	does not explain Aurignacian-like tools in assemblages, individual appearance of same type of tools in two different technocomplexes created by different human groups?

Tab. 1 Explanation of Aurignacian-like features in Middle and Early Upper Palaeolithic assemblages.

A similar combination of Middle Palaeolithic industry with some Aurignacian elements was documented at several sites in northern Moravia and the Czech part of Silesia. The site of Hošťálkovice I – Dubiček represents a typical example, is where we not only discovered typical Middle Palaeolithic side scrapers, Levallois cores and flakes (therefore, the industry is dedicated rather to the Mousterian), but also carinated end scrapers and Upper Palaeolithic-like cores (Neruda, 1997). The site of Otice u Opavy (Klíma, 1974) yielded a similar industry, though Levallois elements and bifacial tools were absent. Upper Palaeolithic (Aurignacian) elements at the site are represented by a carinated end scraper (Neruda, 2018). More Upper Palaeolithic artefacts were documented at the site of Stachovice, showing a decrease in the proportion of Middle Palaeolithic components. Unfortunately, all of these sites are unstratified and undated (Neruda, 2018).
It is important to note that Aurignacian-like artefacts are also commonly represented in Szeletian and Bohunician assemblages. If we take this into account, these collections should be older than the appearance of the Aurignacian in Moravia. However, we confront the same problem as for the Middle Palaeolithic assemblages. Several explanations have been brought forward. The common explanation for these surface assemblages is the mixing of two individual occupational events. This cannot be excluded, but it is however important to point out that several sites in different regions exist where these particularly characterised assemblages have repeatedly been documented (for the issue of homogeneity see e. g., Oliva, 1987). Dating does not prove the parallel development of the Aurignacian and the above-mentioned technocomplexes. The problem is complex, and we can postulate several scenarios (**Tab. 1**).

Líšeň I / Podolí type of industry

The site of Líšeň I/Podolí near Brno provides an interesting contribution to the discussion. This stratified open-air site yielded an industry with Bohunician components (e. g., points), and Jerzmanowice points (Škrdla, 2017). The surface collection also contained Szeletian leaf points and Aurignacian-type end scrapers (Oliva, 1981). The importance of this site is related to 36 Tertiary mollusc shells and their fragments, representing different species and coming from two different geological formations. At least two of these shells were perforated and some have traces of hematite or manganese on their surface. Ochre lumps were also

noted at the site. The raw material for lithic production is the same as the raw-material used at the Bohunician site of Stránská skála (Škrdla, 2017). P. Škrdla classifies this industry as a specific new EUP industrial type. Radiocarbon dating of charcoal places the site within the time range ~40-42.5 ka cal BP, which is close to contemporaneous to dates for both the Szeletian and Bohunician.
The problematic classification of the industry from Líšeň I/Podolí was recently solved by re-classification to the Jerzmanowician (Demidenko and Škrdla, 2020).

Jerzmanowician

The assessment of Jerzmanowice points in Moravian assemblages is still a point of discussion. They appear in almost all assemblages but only prevail over bifacial forms at Ondratice I and Ia (Oliva, 1991b, 2004). This tool type specific to Moravia is generally attributed to the Szeletian.
Demidenko and Škrdla (2020) have recently proposed to assign some of the Moravian collections to the Jerzmanowician or more generally to the Lincombian-Ranisian-Jerzmanowician (LRJ). They point out that the current state of knowledge is affected by the lack of residential campsites. In their opinion, such sites are preserved in Moravia, at e. g., Želešice III (classified as Szeletian in: Škrdla, 2017), Líšeň I/Podolí (a distinct type of industry in: Škrdla, 2017), Líšeň I/Líšeň-Čtvrtě, and Tvarožná X/Tvarožná-Za školou (classified as Bohunician in: Škrdla, 2017).
In their conception, the Moravian LRJ toolkit features parameters typologically relevant for the UP (Upper Palaeolithic) and a lack or only occasional presence of MP tools. Bifacial leaf points are absent[10]. Finally, the appearance of personal ornaments, an important aspect of Moravian LRJ residential sites is exemplified by the coloured and perforated mollusc shells uncovered at Líšeň/Podolí I and Líšeň I/Líšeň-Čtvrtě.
If we accept the theory of Demidenko and Škrdla (2020), it follows that the Moravian Jerzmanowician overlaps with the Early Szeletian and the Bohunician in time and space. According to their definition, the beginning of LRJ can be dated to around ~46-42 ka cal BP (Demidenko and Škrdla, 2020)[11]. This technocomplex could have survived up to ~39-36 ka cal BP, based on new data from Jerzmanowician layers from Koziarnia Cave in Poland (Kot et al., 2020). This younger phase could be contemporaneous with collections from the Drahany Highland, especially with Ondratice I and Ia, traditionally attributed to the Late Szeletian. The question is if these sites represent the Late Szeletian or rather Jerzmanowician contexts, according to this new hypothesis.
The creator of the LRJ in southern Moravia and the relationship to other technocomplexes are topics that are rather controversially debated. Demidenko et al. relate the above-mentioned assemblages to the Bohunician-LRJ "evolution line" and attribute both the Bohunician (Initial UP) and LRJ (Late Initial UP) to AMH (Demidenko et al., 2020). They discuss a concept proposed by D. Flass, who understands the Lincombian-Ranisian-Jerzmanowician (LRJ) as an independent technocomplex that appears more likely to have been authored by Neanderthals and is unlikely to be the result of acculturation processes (Flas, 2011). According to Demidenko and Škrdla, the Neanderthal remains from the Belgian Spy Cave dated to ~41 ka cal BP are rather weak evidence for the argument that Neanderthals were responsible for the LRJ. Nevertheless, it should be mentioned that the relation between the Bohunician and AMH is equally hypothetical and still remains an assumption (see chapter: Bohunician).

10 The surface collection, for example, from Želešice III contains bifacial leaf point.

11 The Polish Jerzmanowician is newly dated (Kot et al., 2020).

Furthermore, they emphasize the presence of personal ornaments, in the form of a coloured and perforated shell, from the site of Líšeň I/Podolí I. It remains an open question if the presence of personal ornaments *per se* supports the attribution of industries to AMH. Use of personal ornaments is evident during the Aurignacian, and we can therefore consider them as typical for the behavioural repertoire of AMH, although the behaviour of Neanderthals was sometimes "modern", as application of ochre and/or use of shells or bird feathers was important for some groups (e. g., Hoffmann et al., 2018; Peresani et al., 2013).

Míškovice

Another specific technocomplex usually related to the EUP complex industries is called the Míškovice Type after the eponymous site Míškovice – Křemenná Hill. It contains Szeletian features (side scrapers and triangular bifacial leaf points), Aurignacian tools (carinated end scrapers and Aurignacian burins), and Gravettian tools (backed bladelets and points). This specific industry was recorded east of the Morava River (Oliva, 1990). These collections (Míškovice, Lhota near Lipník, Přestavlky, Pavlovice, and others) are not dated and it is therefore complicated to establish their relation to other EUP technocomplexes. Oliva assumes the Míškovice Type to represent a specific group within the Late Szeletian, with contacts to the Aurignacian and Gravettian. In his synthesis of the Moravian and Szeletian Palaeolithic, J. Svoboda assigned these industries to the Aurignacian though additionally assumes a relation to the Szeletian (Svoboda et al., 2002) or the so-called "Pomoravský" Aurignacian *sensu* B. Klíma (see the critical comment of the term: Klíma, 1978; Oliva, 2005). Unfortunately, we also have no evidence who was responsible of this industry. Due to the combination of features we can expect a rather autochthonous origin.

A HYPOTHETICAL MODEL

Against the context of the interpretations mentioned above, several possible scenarios can be constructed for the Middle to Upper Palaeolithic transition. **Figure 3** illustrates a hypothesis, explaining the cultural setup in Moravia and its surrounding areas.

Neanderthals survived in Moravia during the time of the EUP complex, and are represented by Late Micoquian, the Late Mousterian, and by the Szeletian industries. The Szeletian technocomplex was either autochthonous and penecontemporaneous with the Micoquian (parallel; this variant on **Fig. 4**), or represents a late development of the Micoquian (consecutive).

We cannot exclude the possibilities that both Micoquian and Mousterian Neanderthals experienced acculturation by AMH, and therefore copied UP tools and/or that Neanderthals and AMH lived together in some regions and created specific industries with both Middle and Aurignacian features. Given both these scenarios, we would have to assume an earlier arrival of AMH in Moravia (before 35 ka cal BP) or a longer persistence of Neanderthal groups (after 35 ka cal BP). Both possibilities (**Fig. 4:** dash line) are an option, as AMH appeared in the Danube region before 35 ka cal BP (Haesaerts et al., 2013; Nigst et al., 2008, 2009), and it might be possible that some of the Micoquian surface sites are younger. Moreover, it looks as if Szeletian Neanderthals persisted for a long time period (given they are bearers of the Szeletian) and they could have met with AMH (especially, if the Szeletian represents the Late Micoquian). If we accept the postulated contacts between the Late Szeletian and the Aurignacian, this late phase could have been created by both Neanderthals and AMH. This is in contrast to the Early Szeletian, which is attributed to Neanderthals.

It is most likely that Micoquian Neanderthal hunters had no contact with groups responsible for the Bohunician and it appears as if they respected their preferred landscapes. Nevertheless, if Neanderthals were creators of the Szeletian industry then we do expect contact between Szeletian Neanderthals and Bohunician groups due to industries with features of both Szeletian and Bohunician technocomplexes recorded in contact zones. If we accept the Bohunician as an allochthonous technocomplex (the applied Levallois method is unique in the area under study), then the main questions remaining relate to its origin, both in terms of responsible group and geographic origin. According to the preferred conception, the Bohunician came from the Near-East and could be produced by one of the first groups of AMH. Nevertheless, due to similar collections from Western Europe, we still cannot exclude the possibility that the Bohunician is a Neanderthal Late Middle Palaeolithic industry.

The traditional model for the EUP is complicated by the inclusion of a new type of industry (Líšeň), related to the problem of the co-existence of the Szeletian and Bohunician. It remains an open question if this industry results from the co-existence of EUP technocomplexes, as is the question of who created these industries. Again, AMH, Neanderthals, or both could be responsible here. A recent hypothesis proposes that this industry belongs to the LRJ complex (Jerzmanowician), leaving different options for interpretation.

While stratigraphic sequences at Stránská skála indicated that the Aurignacian ended the development of the Bohunician, evidence from the site of Sedlec u Mšena-Hradko suggests contact between the technocomplexes. The site is still an isolated example and the possibility that it represents a palimpsest has not yet been excluded.

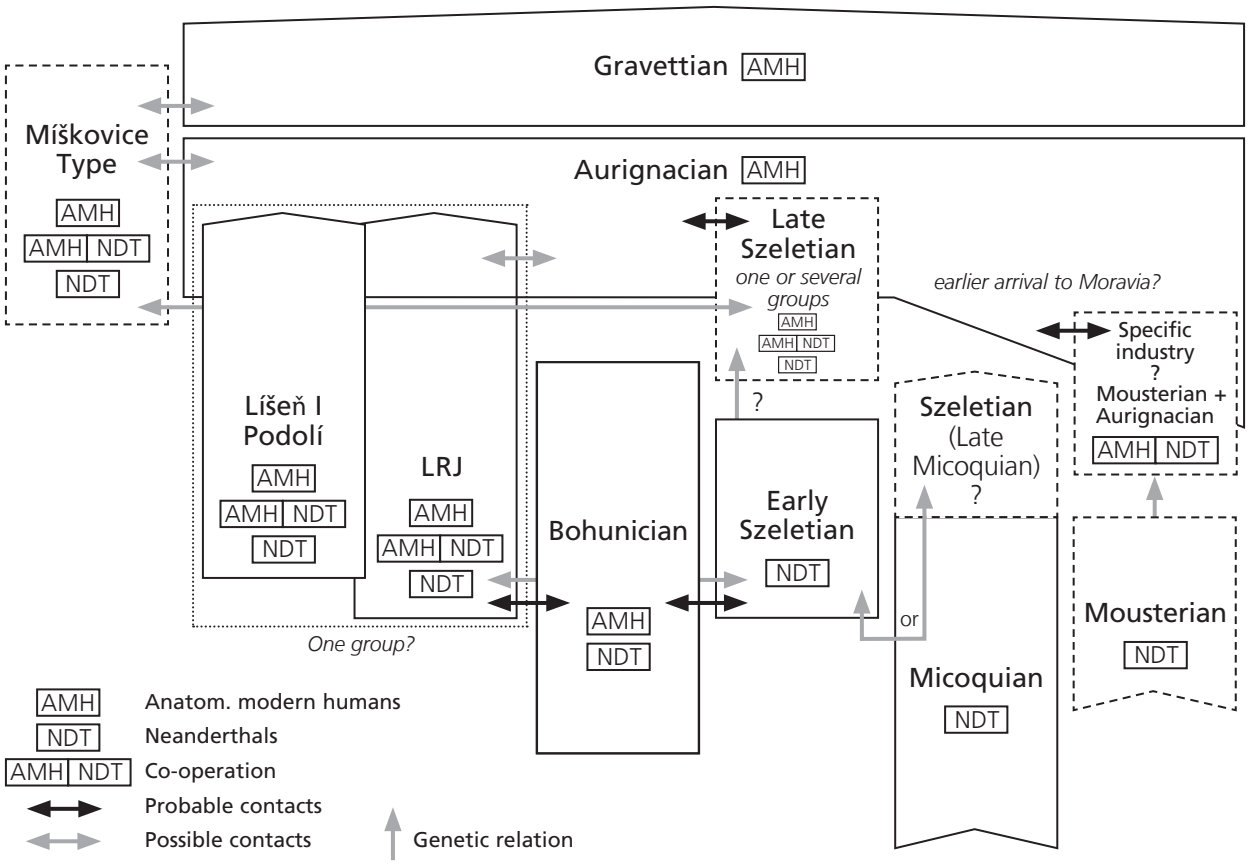

Fig. 4 Model for the Middle/Upper Palaeolithic transition in Moravia.

It is difficult to place the Míškovice Type of industry in this model because the homogeneity of its collections has not yet been definitively proven, and the industry is as yet not absolutely dated. We assume a later age, though this assumption is purely based on typological arguments. If the industry is autochthonous one would have to outline the long persistence of the leaf point tradition, at least until the transition from Aurignacien to Gravettian.

CONCLUSION

Given the hypothesis that all identified industries represent independent technocomplexes and that the mixed character of some industries results from the interaction between different groups of Neanderthals and AMH, the model explaining the Middle/Upper Palaeolithic transition and EUP technocomplexes appears to be very complicated, more complicated in fact than stratified and dated sites indicate. Nevertheless, the mixture of characters in some collections can reflect the physical interaction between Neanderthals and AMH, as indicated by ancient DNA studies. It seems our classificatory system and traditional terminology cannot reflect these complicated processes. Therefore, we should leave or rebuild our concept of independent cultures and, in future rather refer to techno-typological tendencies (Oliva, 2016).

Acknowledgement

This paper was financially supported by the Ministry of Culture of the Czech Republic through institutional financing of the long-term conceptual development of the research institution (the Moravian Museum, MK000094862) for the years 2019-2023.

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THE ORIGINS OF HUMAN VISUAL CULTURE: A THREE-STAGE HYPOTHESIS FROM BABBLE TO CONCORDANCY TO INCLUSIVITY

Abstract

Palaeolithic 'art' is usually characterised as reflecting the overwhelming importance of depictions of prey animals. This is true for the period < 30,000 BP, but it is now clear that a very long period of non-figurative imagery preceded this, created by both Neanderthals and Upper Palaeolithic *Homo sapiens.* While much discussion of 'cave' and 'portable' art has focussed on the emergence of symbolism, this has largely restricted our understanding of the emergence of art to a 'you either have it or you don't' conclusion. Here, I forward a three-stage hypothesis for the long-term emergence of human visual culture. Arising through body gesture and ornamentation, the first phase saw the use of colourants and personal ornamentation directly on the body; the second arose out of this, with extension of parts of the body onto the physical landscape and small objects held close to it by Neanderthals and probably the earliest *Homo sapiens* groups in Europe. Finally, figurative art emerged in or by the 37th millennium BP in Europe, possibly earlier in Indonesia, and drew on visual psychology for several of its characteristics.

Keywords

Palaeolithic art, Neanderthals, Upper Palaeolithic, visual culture, Gravettian

THE ANIMAL INSIDE US ALL

Palaeolithic visual culture is usually caricatured as reflecting the total dominance of representations of gregarious prey animals, at least on the basis of European Upper Palaeolithic rock and portable art. It certainly was for the last 30,000 years of the Pleistocene, to which our record of figurative art is currently restricted. It is easy to see why. Even our modern, urban visual worlds – at least those of imagination, entertainment, aesthetics, and more dubiously advertising – are dominated by animals and human-like animals, which, used in advertising, can sell things far better than their human counterparts (McCutchen, 2005; Spears and Germain, 2007). As much of our evolutionary history was spent as hunter-gatherers dependent on the procurement of animal prey, we can justifiably assume that our psychology has been shaped by the wild animals which we ate, which ate us, with which we competed for resources critical to survival as our brains evolved, and in some cases with which we evolved sympatric relationships that resulted in their (and our) domestication. We cannot escape our co-evolved animal origins.

Archaeologically, the centrality of animals to our visual worlds is apparent as soon as figurative art appeared among Upper Palaeolithic *Homo sapiens* hunter-gatherer groups by 40,000 years before present (henceforth BP) in Sulawesi, Indonesia (Aubert et al., 2014, 2019), and somewhere between the 39th and 37th millennia BP in Europe (Conard, 2009; Conard and Bolus, 2008; Kind et al., 2014, Floss, 2018). In Palaeolithic terms the appearance of figurative art was, however, apparently recent. On current evidence it seems that it was preceded by a long period of non-figurative visual culture, which is well documented from

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.868.c11316

~ 100,000 BP, but evident in places up to 400,000 years beforehand, revealing a long use of material adjuncts to visual culture among various archaic human and early *Homo sapiens* groups in Africa and Eurasia. Hence while is it understandable that when human groups sought to represent things fairly accurately they chose animals as their subjects, when we want to understand the *emergence* of human visual culture we need to look at another set of material entirely. I will explore this issue here, asking how and why non-figurative art emerged first, and why figurative representations of animals emerged, and why this was relatively late. Animals are central to such a task.

THE PROBLEM WITH 'MAN AND HIS SYMBOLS'

Unlike the zooarchaeology that Elaine and Martin have made such a strong contribution to, with its precise terminology and methodology, the study of Palaeolithic visual culture is replete with ambiguity (I myself will toggle here between the terms 'visual culture' and 'art'). This is not simply a semantic issue. Palaeoanthropologists have often equated 'visual culture' with 'symbolism', a poorly-defined component of perceived 'modern human' cognition, itself ill-defined and overly-broad. The search for a fully 'symbolic capacity' has become an integral part of research into the emergence of *Homo sapiens,* in a paradigm in which material culture has been seen as having become increasingly important as a means of storing and communicating information about the world. Surprisingly, the specific form and content of Palaeolithic art has often been overlooked in this 'tick box' approach to palaeoanthropology; instead, its presence is simply noted, as an indicator that its producers had a symbolic capacity from a certain point in Pleistocene time within a fundamentally progressivist approach to the archaeology of human origins.

Symbols – or a vague notion of them – have become the icons of the secular cult of progressivism that palaeoanthropology is to many people, particularly the media. From this viewpoint we are bound to judge Palaeolithic visual culture as either having been 'successful' (in that it was 'symbolic', and hence, 'modern' in hindsight) or not (in that it displays no signs of 'symbolism' that are obvious to us, and is, therefore, 'archaic'). Research into the emergence of visual culture has, therefore, too often been reduced to an 'either/or' test – you either have it or you don't – and with such perspectives there is very limited scope for nuance, particularly as to how variable forms of visual culture are in the animal world and how a more distinctly human visual culture might have emerged from that. As one primatologist succinctly observed "the human tendency to consider ourselves the 'crown of the evolutionary chain' has regularly prevented us from looking at animals in an unbiased way and has favoured simplistic criteria to define our own superiority" (Boesch, 2012: 21).

There is nothing fundamentally wrong with the observation that symbolism was a central aspect of the cognitive ability of *Homo sapiens,* or that its appearance seems to have been gradual rather than abrupt. For example, "Several scholars view the accumulation of *markers for modern behaviour* as gradual during at least the Upper Pleistocene, if not since earlier times" (Bar-Yosef, 2002: 365, my emphasis). But implicit in such observations is the notion that if 'modern behaviour' can be reduced to anything, it must be equated with symbolism: "We agree that modern behaviour has symbol use at its core" (Nowell, 2011: 20) and "symbolic actions such as burial of the dead, production of personal ornaments and 'art', and the use of ochre for decoration are further often cited traits for identifying *modern behaviour*" (Henshilwood and Marean, 2003: 628, my emphasis). More specifically, "the earliest figurative art […] is often seen as an important proxy for *advanced symbolic communication"* (Conard, 2009: 248, my emphasis). The problem lies in what is ignored in such treatments. At what point does visual gesture or material culture cease to

be 'advanced symbolic communication'? Does chimpanzee vocal communication about direction of travel which affects the behaviour of individuals out of sight of the vocaliser, the recognition of the skulls of their dead kin by elephants, the waggle dance of a bee to indicate the availability and location of water and food, or air rings blown by dolphins as part of complex play routines qualify as 'advanced symbolic communication'?

In fact, when we examine the vast evidence for communication in the animal world, it is evident that our use of Palaeolithic visual culture to make inferences about the origins of visual worlds and 'modern behaviour' has been simplistic in the extreme. If we find an object in the archaeological record that we can see functioning as part of complex systems in the present – shell jewellery for example – we tend simply to assume through some uniformitarian principle that the same complexity was at work in the past; "it is tempting to assign complex meaning to ornaments because of their universal connection to visual communication among recent cultures. Interpretations of Palaeolithic ornaments are greatly limited, however, by the disorder in which archaeologists normally find them" (Stiner et al., 2013: 396). As a result, our conclusions are so generalised they have little meaning. Archaeology is by its very nature almost entirely visual; if we were to focus on *audial* culture, however, the shared intra-pod calls (linguistic dialects), community-specific greeting rituals, and click-greetings learned by imitation in socially stable cetacean groups – "cultures that closely parallel those found in chimpanzees and humans" (Rendell and Whitehead, 2001: 320) – would lead us to conclude that several taxa of whales and dolphins were 'behaviourally modern', a somewhat pointless conclusion.

A further question arises as to what functions this 'symbolism' evolved for. Among palaeoanthropologists it is implicitly assumed to have been a means of social communication, facilitating the maintenance of larger, more widespread and more integrated social groups than could be maintained with non-symbolic communication. For example, engraved eggshell containers from Diepkloof rockshelter in South Africa "provide unequivocal evidence for the existence of *symbolically mediated social behaviour* and the development of a *behaviourally modern system* by 60,000 years ago" (Texier et al., 2010: 184, my emphasis). The potential pitfall is that acts which are potentially simple both conceptually and physically are taken to be indicative of some great cognitive achievement, hence the mere presence of pigments and simple pendants of shell, bone and teeth on an archaeological site are taken at face value to be complex symbols. Here is an example: "evidence […] suggests that some Neanderthals buried their dead with grave goods […] and developed personal symbols (including manganese oxide pigments and pendants made from animal teeth). They apparently also used plants with medicinal properties" (Stringer, 2013: last accessed 25.05.2021). None of this may be incorrect, but neither does it necessarily indicate that all Neanderthals were artists and physicians with beliefs in an afterlife.

Three decades ago, a physical anthropologist suggested that "palaeoanthropology should aim at increasing its theoretical content by reducing the list of qualitative human uniquenesses […] eliminating it altogether if possible" (Cartmill, 1990: 173). It is a shame that so few specialists have taken up this perceptive challenge. We do need to try to nuance our understanding of the earliest material examples of visual culture with such caveats in mind, and to take as broadly contextualised an approach as possible. After all, archaeological perspectives on visual culture should deal with the relationships between people, things and ideas, and not just images (Janik, 2020). I will now use data on the great apes to consider what aspects of visual culture might have been innate or at least unsurprising to early human groups, then proceed to explore the archaeological record for how early visual social worlds may have functioned. Beginning with the long phase of non-figurative art that preceded a relatively widespread and rapid adoption of figurative art by *Homo sapiens* during the Late Stone Age of Africa and Eurasian Upper Palaeolithic I finish with an examination of some of the characteristics of the earliest figurative art.



Fig. 1 La Pasiega cave, Spain. Non-figurative cave art of Pre-*Homo sapiens,* presumably Neanderthal manufacture: rectangular 'scalariform sign' created by linked finger dots. Images around this that are not dots were added much later, during the Upper Palaeolithic. U-Th dating indicated a minimum age of 65,000 BP obtained on flowstone sampled at the figured location. – (Photo: U-Th cave art dating team, Hoffmann et al., 2018).

PALAEOLITHIC VISUAL CULTURE

Humans evolved as visually-centric beings: 80-90 % of information about our surroundings derives from our eyes (Griefahn, 1996, cited in: Pastoors and Weniger, 2011: 381). We experience the world as an abundance of colour (in reality differing wavelengths of light), and the colour of the objects around us conveys information about them that can be considered to have been evolutionarily advantageous to humans who were evolving as diurnal animals (Foley, 1987). Without colour, for example, it is difficult to discern ripe from unripe fruit, edible leaves from dead ones, or prey animals from their background landscape. Although differences in illumination will affect the hue, saturation and brightness of colours, it does not prevent the identification of basic colours, which remain constant (Jameson and Hurvich, 1989: 7).

Visual culture functions not as sets of static images but as a dynamic form of action (Gell, 1998). Indeed, as it seems to have emerged on the human body, which by its very nature is a moving thing, and was then extended to small, movable objects associated with the body, and finally, to fixed points in the landscape where the fluctuating light available often animated it, we should begin with the perspective that visual culture emerged not as static material culture but as a moving, changing thing. I will return to this char-

acteristic below, but for now I want to focus not on its form, but on how random marking of the body evolved into an understandable means of cultural transmission in the visual sphere. As a working (and, I hope, falsifiable) hypothesis I conclude that a long phase of individually unique body gestures and markings, which I term *babble* (for reasons I explain below) preceded the social 'gathering up' of such markings into coherent group traditions by both Neanderthals and *Homo sapiens* from at least ~ 100,000 BP. I follow a basic hypothesis that visual culture originated as body decoration, became extended to small, portable objects associated with routine tasks close to the body some time prior to 500,000 BP (a peripersonal phase), and finally to the fixed, external landscape (extrapersonal phase), over the period by or around 100,000 BP (Hodgson and Pettitt, 2018).

Today, we have a broad understanding of how visual culture emerged and evolved during the Palaeolithic (e. g., Delluc and Delluc, 1991, 2009; Ripoll López et al., 1999: 73; Pettitt and Pike, 2007; Gárate, 2008; Pike et al., 2012). Earliest examples, dating to at least 64,000 BP and assumed to be the product of Neanderthals, consist of finger dots (**Fig. 1**), hand stencils (**Fig. 2**) and colour washes (**Fig. 3**) in deep caves, i. e., beyond the zone of natural light (Hoffmann et al., 2018). By at least 40,000 BP in Indonesia, and at least 37,000 BP in Europe, these markings of the body were first complemented and gradually replaced by figurative art. The earliest European Upper Palaeolithic (Evolved Aurignacian: ~ 37,000-31,000 BP) figurative art took the form of simple animal outlines possibly restricted to the walls of rockshelters rather than in deep caves, and of a small number of three-dimensional carvings of mammoth ivory and bone, particularly in southwest Germany (Floss, 2018). It is only with the Mid Upper Palaeolithic Gravettian: ~ 31,000-22,000 BP) that one can see both a numerical increase in the amount of figurative art, and the earliest convincing evidence of the creation of figurative art in deep caves. Among the latter, regional clusters that can be distinguished on the basis of style can be identified, such as the caves of the Quercy in southwest France including Pech-Merle and Cougnac (Lorblanchet, 2010). With the possible (and in my opinion unconvincing) exception of paintings in Leang Bulu' Sipong 4 cave in Indonesia (Aubert et al., 2019) it is only from this time that true compositional scenes and a high degree of naturalism are common, in which animal figures have risen to prominence. By the Late Upper Palaeolithic (Solutrean, Badegoulian and Early, Middle and Late Magdalenian: ~ 22,000-13,000 BP) – to which the majority of surviving Upper Palaeolithic art dates – considerable complexity of production, compositional scenes displaying perspective and movement, high-relief sculpture, and the great polychrome paintings of Lascaux, Altamira and elsewhere are evident. Surprisingly, the development follows closely the chronological schemes proposed by Breuil (1952) and Leroi-Gourhan (1968) on the basis of style and a limited amount of relative data (e. g., superimpositioning) and in the absence of absolute chronology.

THE ORIGINS OF VISUAL CULTURE: PERSONAL HABITS TO CONCORDANT VISUAL CULTURE; BABBLE TO CONCORDANCY

Whatever the specific terminology one uses, the cognitive evolution of *Homo sapiens* probably involved the development of an 'autobiographical self', in which individuals conducted an internal dialogue with themselves, and by so-doing numerous potential behavioural scenarios could be evaluated and contribute to the construction of their social persona (Damasio, 2010). Presumably, the scale to which such hypothetical dialogues occurred at and the complexity of factors within them evolved as brains grew in absolute size. On a sensory level, an engagement with the visual and physical world was a central part of this, and the

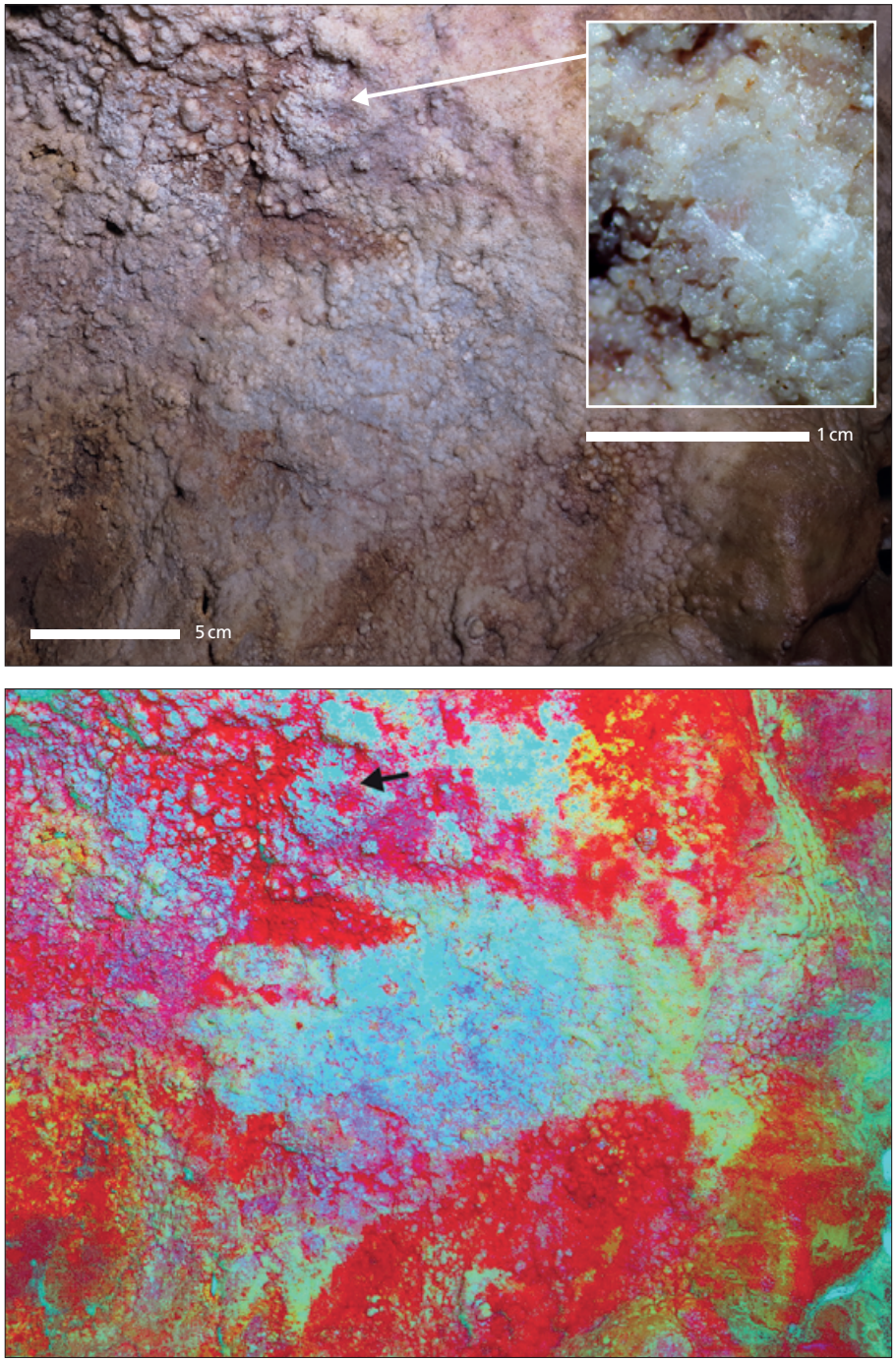

Fig. 2 Maltravieso cave, Spain. Non-figurative cave art of Pre-*Homo sapiens,* presumably Neanderthal manufacture: Hand stencil GS3b (top) and manipulated image using D-Stretch programme (below). U-Th dating indicated a minimum age of 65,000 BP obtained on flowstone sampled at the figured location. – (Photo: U-Th cave art dating team, Hoffmann et al., 2018).

way in which the 'self' blends into the external world in a complex set of relationships has been explored as 'technoetic awareness' and material engagement (e.g., Malafouris, 2007, 2008, 2014, 2015). Out of this, non-figurative, and later, figurative visual culture emerged first as an index of the human body and an extra-personal representation of the self; and by so-doing, material engagement became critical to visual evolution.

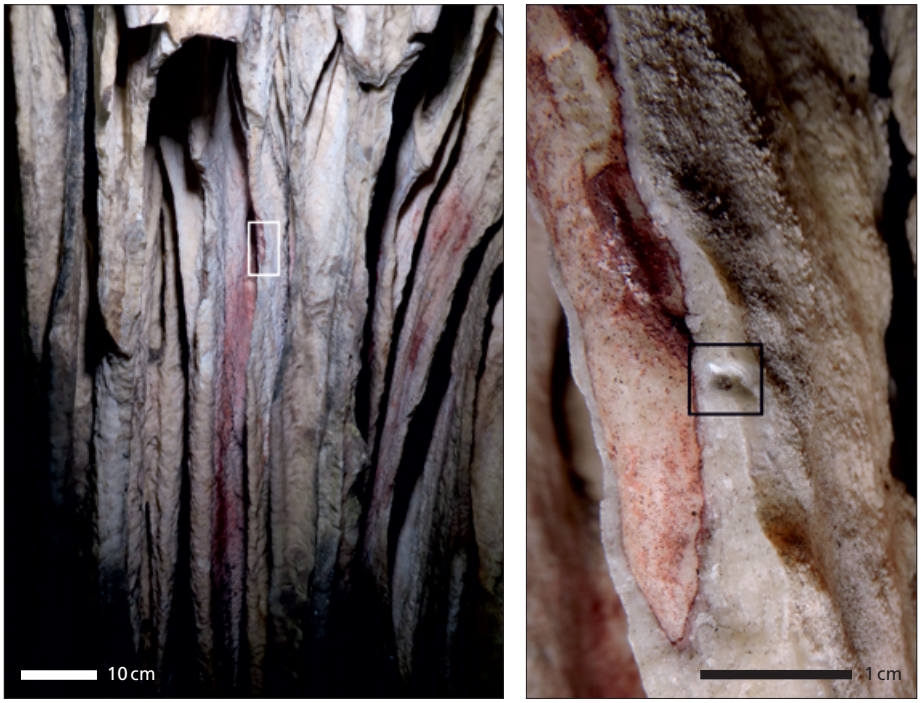

Fig. 3 Ardales cave, Spain. Non-figurative cave art of Pre-*Homo sapiens,* presumably Neanderthal manufacture: Red wash within the folds of a flowstone drapery (left) and detail of it (right). U-Th dating indicated a minimum age of 65,000 BP obtained on flowstone sampled at the figured location. – (Photo: U-Th cave art dating team, Hoffmann et al., 2018).

The question is how natural (or even inevitable) such an evolution might be. Humans do exhibit a propensity for visual communication. Even in the absence of spoken language, isolated groups of profoundly deaf children can create gestural systems which, if limited by the absence of language, can nevertheless efficiently communicate needs and feelings about people, objects and actions (Sachs, 1990). An idea of what we might expect of early hominin visual worlds *as a minimum* can be grasped through what is known about great apes. The use of signs is in itself nothing special: gorillas can memorise and deploy a vocabulary of ~650 signs in American Sign Language (Byrne, 1995). Modern children, chimpanzees and bonobos all develop a capacity for symbol use during ontogeny, during which gestural and facial interaction between infants and adults provides a social scaffolding that turns individual noises, gestures and expressions (babble) into contextually meaningful (concordant) shared communication (Gillespie-Lynch et al., 2011). Chimpanzees and bonobos, in fact, inhabit visual worlds that are fundamentally similar to humans in terms of colour and pattern perception (Matsuzawa, 1996). They are capable of self-recognition, and possess at least a rudimentary concept of the self (Gallup, 1970). They make use of visual symbols to communicate their perceptions of the world and to express desires and make requests (Savage-Rumbaugh and Lewin, 1994); they make statements about things (Lyn et al., 2011), express moral concepts (good and bad) in appropriate social contexts (Lyn et al., 2008), and also concepts of possession (Itakura, 1994). Their visual symbols can be combined into two (occasionally three) elements (e. g., numbers, colours, objects: Savage-Rumbaugh et al., 1986; Lyn et al., 2008, 2011; Itakura, 1994); they can express basic numeracy (including, cardinals, ordinals and the meaning of zero: Biro and Matsuzawa, 2001), and use arbitrary visual signs to indicate goal objects at locations currently observed up to 650 m distant (the vocal directional signs noted above: Menzel et al., 2002). They display delayed imitation (memory) in their use of signs (Allen

Gardner and Gardner, 1969), populational (cultural) variation in their gestural signals (Tomasello et al., 1989), and, like humans, can generate novel symbol combinations in conversational contexts. Looking at this list I wonder why palaeoanthropologists ever restricted themselves to a simple search for a presence of the vaguely defined concept of 'symbolism'. In simplistic terms this has in the past lead to the assumption that 'art and symbolism' appeared only with *Homo sapiens*, part of a 'cognitive revolution' that endowed our own species with our evolutionarily competitive edge predicated upon an ability to think 'symbolically' and to express symbols biologically (through language) and in visual culture (art). Although in recent years new discoveries pertaining to Neanderthal behaviour have considerably narrowed the erroneous perceptual gap between 'them' and 'us' in many aspects of their cultural and survivorship capabilities. Defined in such simple terms we would now have to admit that Neanderthals had a symbolic capacity; job done. But, like the 'cognitively modern cetaceans' this is hardly a useful conclusion for behavioural evolution. In fact, considerable degrees of behavioural sophistication are possible without a symbolic capacity. For example, chimpanzee behaviour around newly dead individuals, and the carrying of the corpses of dead infants by their mothers "highlight the interest of a comparative evolutionary perspective on death and dying in species *without symbolic representations* of death or death-related individuals" (Anderson et al., 2010: R350-1, my emphasis).

It is easy to envisage how symbolic thought could emerge relatively easily and require no great cognitive leap. "The capacity of chimpanzees for symbolic thought probably emerged as a result of the need for concept formation, for perceiving the relations between things. We can trace a pathway along which representations of, for example, a fig become progressively more distant from the fig itself. The value of a fig to a chimpanzee lies in eating it. It is important that he quickly learns to recognise, as fig, the fruit above his head in a tree (which he has already learned to know through taste). He also needs to learn that a certain characteristic odour is representative of fig, even though the fig itself is out of sight. Food calls made by other chimpanzees in the place where he remembers the fig tree to be located may also conjure up the concept of fig. Given the chimpanzees' proven learning ability, *there does not seem to be any great cognitive leap from these achievements to understanding that some quite new and different stimulus (a symbol) can also be representative of a fig*. Although chimpanzee calls are, for the most part, dictated by emotions, cognitive abilities are sometimes required to interpret them. And the interpretations themselves may be *precursors of symbolic thought*" (Goodall, 1986: 588-589, my emphases). The important question, therefore, is not *how* symbolic visual culture arose, but under what circumstances it came to be adaptively advantageous, i. e., *why* material culture served a useful mechanism for turning babble into concordant communication.

In the absence of any evidence to the contrary, most palaeoanthropologists assume that visual culture originated on the body as decoration (e. g., Morris-Kay, 2010: 160). As the body is the focus of social negotiation this seems the most parsimonious interpretation of the evidence that exists. There is no reason to assume that Neanderthals and early *Homo sapiens* didn't intuitively think of the self as occupying a physical location within the body, close to the eyes, as modern children and adults do (Starmans and Bloom, 2012), and we may, therefore, perhaps assume that the face was under particular selection for visual elaboration. Whatever the case, the earliest preserved visual culture relates to the actions of the body on small objects, among both Neanderthal and *Homo sapiens* groups (or some of them). If we assume that personal gestures and habits (babble) formed the raw materials for the early development of visual culture, these may be identified archaeologically by the presence of items which are unique (i. e., only a single example exists) or are present in very low numbers on one archaeological site. Imagine the possible archaeological record for the activities of the chimpanzee Viki, who "*scribbles,* cuts with shears, builds with blocks and tinker-toys, throws and catches balls, operates light switches and door latches, with about the same skill and enthusiasm as most



Fig. 4 Painting made by the chimpanzee Congo in 1957. Examples of Congo's artistic babble were bought by Pablo Picasso and Joan Miró among other artists. Note the similarity to the lines engraved on ochre from Blombos Cave. – (Courtesy of the Mayor Gallery, London).

three-year-old humans" (Hayes and Hayes, 1951: 106). Viki's scribbles, and the 'art' produced by several chimpanzees can be seen as examples of individual babble (**Fig. 4**).

I therefore interpret as material remains of babble those objects that appear unique to their Palaeolithic contexts; i. e., the evidence of individuals communicating to themselves (internally) via the media of the objects they have in hand (or to the objects themselves). These objects are found only sporadically from ~ 500,000 BP onwards, and are in some cases were strongly identified with the mechanical actions linked to quotidian tasks such as opening shells with stone tools, and in all cases represent minimal, even ephemeral, modifications, such as the markings possibly engraved on a mollusc shell ~ 500,000 BP at Trinil, Java assuming these are anthropogenic (Joordens et al., 2015). Examples of engraved lines on the cortex of stone flakes and tools are known across Europe and Western Eurasia between ~ 380,000 and ~ 35,000 BP (Majkić et al., 2018), produced by *Homo heidelbergensis* and *Homo neanderthalensis.* At the younger end of this range several sub-parallel marks were engraved in the centre of a patch of cortex of a flint flake of Neanderthal manufacture from Kiik-Koba (Crimea). While such examples often exhibit careful engraving, they are still rare and ephemeral objects which stand out among the many unmodified examples of these materials on each site.

Pierres figures – natural objects whose resemblance to the human body has been emphasised by minimal (if careful) engraving – are perhaps best interpreted as examples of individual babble. A small pebble from the Lower Palaeolithic of Berekhat Ram (Israel), probably ~ 250-280,000 BP in age, bears modifications made by a flint point (d'Errico and Nowell, 2000), and a similarly small example from Tan Tan (Morocco), probably



Fig. 5 The emergence of concordant visual culture: retouched, ground and scraped ochre slab with two sets of engraved, superimposed lines crossed and framed by three horizontal lines from Blombos Cave, South Africa. – (Courtesy of Christopher Henshilwood & Francesco d'Errico).

~ 400,000 BP in age, was grooved and coloured with red pigment. The babble these represent could either have been internal ('this looks to me like a human body') or interactive ('I think you look like the human body'). It is noticeable that they clearly represent natural materials that inspired their recognition as representations of the body, and they are of interest in terms of the social scaffolding (shared interaction) that bridges the development of language in human and higher primate infants. Are they the earliest examples of a material scaffold in the origins of concordancy in visual culture? Whether or not this is correct, there is no reason to see them as examples of a fully-formed and shared visual culture. Later examples of babble might include use of ochre by Neanderthals from at least 250,000 BP (Soressi and d'Errico, 2007; Zilhão et al., 2010; Roebroeks et al., 2012), occasionally in association with shell personal ornamentation (Peresani

et al., 2013), and possibly even an attempt to depict a human face on a natural object with minimal modifications (Marquet and Lorblanchet, 2003).

African *Homo sapiens* were processing ochre at least as early as 100,000 BP, and a tradition of shared motifs engraved onto ochre blocks had emerged by at least 75,000 BP (**Fig. 5**; Henshilwood et al., 2009, 2011). I use the term concordancy to reflect this point at which individual babble became shared and hence, socially meaningful. This need not imply any cognitively sophisticated symbolism: pigment and engraving can be used as simple decoration, primarily for visual effect, whether or not it carries any symbolic meaning. Marking can function to convey simple messages by way of enhancing existing natural clues (signs); it can function as relatively simple symbolism by nuancing natural messages, or can function as fully symbolic, i. e., to communicate an explicit statement (Pettitt, 2011). The problem for palaeoanthropology is how we distinguish between these different levels of function, at least before figurative images were commonly used. If we cannot do this, at least we can understand why material examples of visual culture became commonplace, presumably as it facilitated the maintenance of increasingly large and complex social groups: "what changed during the Palaeolithic was the character and extent of the social scale […] the materials needed to support extended networks within a social landscape led to the elaboration of culture to carry the novel social representations in symbolic form" (Gamble, 1998: 442). In such circumstances it makes sense for vision to be harnessed around concordant material culture: hominins have evolved technologies of separation and social extension would be impossible without harnessing the environment as a part of our cognitive architecture (Gamble, 2010). Hence it is the concordance that was important, irrespective of any perceived content.

FIGURATIVE ART: WHY ANIMALS, AND WHY SO LATE?

On the basis of current evidence, at least 25,000 years separate the emergence of non-figurative art > 65,000 BP and the earliest evidence of figurative art ~ 40,000 BP; although as the earliest dates are minimum ages the actual difference could be considerably more. Given this, one might justifiably conclude that non-figurative concordant visual culture adequately served the communicative purposes to which it was put for Neanderthals and early *Homo sapiens*: until at least 40,000 BP representing things seems to have been adaptively unimportant. Now that we know that a long period of non-figurative art preceded figurative art, our focus should no longer be simply on explaining an 'artistic explosion' of figurative images. If figurative art was so central to the emergence of visual culture in humans, *Homo sapiens* or otherwise, why did it emerge so late? This cannot be a biased picture caused by sampling issues; in Europe, there are no convincingly dated examples of figurative art predating ~ 37,000 BP and in Indonesia none earlier than ~ 42,000 BP, despite a wealth of archaeological sites on which other organic materials including shell and ivory jewellery survive in abundance. This suggests that as late as the Initial Upper Palaeolithic, most visual culture was still focussed on the body or, where it was extended onto other materials was used to *represent* the human body or parts of it by fragmentary signs (hand stencils and finger marks) in the wider landscape. If this is correct, representing other things would have been unnecessary, at least if visual culture served to make statements about oneself to others and little more. In this light the absence of depictions of humans in the earliest phases of figurative art is notable: marks involve solely the *connection* between an individual's body and the external landscape, or the use of the landscape as an intermediary to communicate from one individual to (an)other(s). These are not the depictions of *imaginary* individuals. In terms of my three-stage evolution of visual culture this represents the use of the landscape as an adjunct to concordant expression.

It is possible that hand stencils survived down to the Mid Upper Palaeolithic (or were re-invented then) although a critical examination of the available chronology suggests that most or all dated examples in Europe are earlier (Pettitt et al., 2015).

On present evidence the earliest creation of figurative art on fixed locations in the landscape occurred not only late relative to non-figurative art, but also significantly later than the arrival of *Homo sapiens* in Europe. While figurative carvings on objects presumably closely associated with the body appeared from ~37,000 BP in some (but not all) regions, examples of rock art in open-air situations, such as Portugal's Foz Côa and Spain's neighbouring Domingo García (Aubry et al., 2014; Baptista and Fernandes, 2007; Ripoll López and Municio González, 1999; Alcolea-González and de Balbín Behrmann, 2007) suggest that figurative art was widespread in the landscape from at least the Mid Upper Palaeolithic (early Gravettian ~30,000 BP) onwards. Once again, however, we should not think that art was everywhere from this time; some regions have little or no evidence of it (Ochoa et al., 2019). After all, when writing (another form of visual culture) emerged, it was restricted in two senses; first, to certain urbanising cultures such as early Dynastic Sumer, and secondly, to very restricted sets of literate people within these societies (Finkel and Taylor, 2015). There is no reason to believe why Palaeolithic 'art' was practised everywhere, by everyone, or to refer to everything; in fact, the regionality that characterises its early expression presumably is a reflection of the fact that concordant visual culture was only turning into figurative expression among *some* groups before ~30,000 BP, and perhaps that its meaning was limited.

Rockshelters with engraved, sculpted and/or painted friezes only became relatively common in the Late Upper Palaeolithic of Western Europe (Solutrean and Magdalenian, from ~20,000 BP: Leroi-Gourhan, 1968: 163; Lorblanchet, 1995: 25-28). From this time, the importance of light and shadow in the definition of volume on high-relief sculpture (Barrière, 1993) suggests that visual culture now involved not only a dialogue between the individual and the external landscape, but also a holistic integration of fixed (topography) and dynamic (light) elements, e.g., the Solutrean sculpted frieze of Roc de Sers (Charente, France: Tymula, 2002) or the Magdalenian frieze of the Roc aux Sorciers, L'Angles sur L'Anglin (Vienne, France: Iakovleva and Pinçon, 1997). In open-air locations one might assume that art became visible or invisible depending on the position of the sun, and in this sense its animated 'life' was connected with the diurnal cycle. In caves, however, the contrast between light and dark, particularly gradations from daylight to twilight to darkness, is the most profound of a number of sensory experiences that were exploited from around the same time (Arias and Ontañon, 2012). In terms of 'decorated' caves, artistic effort was occasionally focused in outer chambers where daylight penetrated, and as such these may be considered to be transitional in a luminary sense, and include the painted bison, horses and deer of the famous Middle Magdalenian 'polychrome ceiling' of Altamira, which was intended to be viewed from the chamber's entrance. The artist would have worked with their back to natural light (Pérez-Seoane, 1999) which would nevertheless have required some artificial light, probably provided by the marrowfat bone lamps that were recovered from beneath the painted panels (Pérez-Seoane, 1999: 68). Similarly, it has been suggested that Lascaux's Great Hall of the Bulls would have been bathed in a crepuscular light at dawn and dusk but deeper chambers required artificial light (Geneste et al., 2004).

Clearly, the lack of natural light did not preclude activities in deep caves from a similar point in time[1]. These perpetually dark areas can only be explored with the use of mobile artificial light, which took the form either of simple torches or brands – bundles of branches for which indirect evidence occurs in the form of torch

[1] If the figurative drawings of Chauvet Cave are genuinely > 30,000 cal BP in age (e.g., Quiles et al., 2006) evidence of cave art would clearly pre-date portable art, but this is contestable (cf. Jouve et al., 2020) and in my opinion there is no convincing evidence of any cave art in Europe prior to the early Gravettian.



Fig. 6 Painting as shadow.
a the author with hands positioned over a pair of hand stencils on the Panel of Hands in El Castillo Cave, Cantabria, Spain. Note the association of the stencils with natural cracks in the cave ceiling, and the extension of arms in the form of shadows. – **b** positive prints of left and right hands/arm in Ardales Cave (Malaga, Spain). – (a photo: Becky Harrison, and courtesy of Gobierno de Cantabria; b photo: P. Pettitt, and courtesy Pedro Cantalejo & Ardales Cave).

wipes (*mouchage du torche* – charcoal stubbings on cave walls) from the early Mid Upper Palaeolithic – and simple stone 'bowl' lamps for which there is some evidence from the Early Upper Palaeolithic, although most examples derive from Mid and Late Upper Palaeolithic contexts (de Beaune, 1987a, 1987b). In Ardales cave (Málaga, Spain) lamps were made from concavities in small, broken blocks of stalactite and stone as well as atop stalagmite columns (Cantalejo et al., 2014). In each case these small light sources give off about 10 watts/1850 kelvin of light, the equivalent of a small candle or sunset/sunrise, or even lower (Delluc and Delluc, 2009).

The nature of lighting available to Palaeolithic 'artists' is instructive in understanding why humans should go to the dangerous extent of creating art in dangerous areas beyond the zone of natural light. In the nineteenth century, with the introduction of gas and subsequently electric lighting, shadows for the first time stopped flickering in the streets and houses of the world. The introduction of a static component – a chip heated to incandescence by gas flame or a filament by electricity – introduced light that was stable for the first time (Casati, 2003: 14). We should remember that "until just a few generations ago, shadows were always moving" (Casati, 2003: 14), and in some respects, "painting is the shadow of sculpture" (Casati, 2003: 179). It is well known that animal images in cave art are often associated with features of the natural topography of cave walls that 'suggest' or stand for anatomical features of the animals (e. g., Clottes, 1993; Groenen, 2000; Lejeune, 2004; Pigeaud, 2004; Vialou, 2004; Bahn, 2016). The enhancement of the cave surface through lighting will turn a two dimensional depiction into a three dimensional one – effectively an art conceptually between sculpture and painting. Shadow forms the critical component of this optical illusion, combining with surfaces to provide a moving, natural line which along with concavities and convexities of the surface of the wall will change the morphology of images according to variations in the viewer's position. It seems reasonable to conclude that this was installation art (Sakamoto et al., 2020), but it seems that not only was the artist/viewer installed in the dynamic scene, but his/her shadow was too. The suggestive environments of deep caves therefore offer an example of concordancy *par excellence:* the individual is installed in a dynamic and moving scene; his/her shadow forms an intermediary between their physical body and the moving walls of the cave; the interplay of topography and shadow suggests animal shapes to the participant; and the participant finally brings these out by engraving, drawing or painting (**Fig. 6**). At this stage, the individual (babble) and group (concordant) visual culture has extended to include animals and the landscape. In social terms, not only human individuals and groups but also animals and things have become part of a meaningful whole. Only when humans began thinking of animals and things in similar ways to themselves did the notion of representing one on the other come about. In this sense Upper Palaeolithic figurative art represents a third stage in the development of visual culture, when the wider world, including animals, became integrated into a conceptual whole.

If this is correct, it might explain why the observable themes of humanity's earliest figurative art do not correspond to what one might predict based on modern cross-cultural surveys of humans' 'ideal' concepts of what figurative art should be. Such surveys reveal a preference for irregular (broken) landscapes containing water and hills, and a predominance of the colour blue (i. e., sky and water), which some have suggested reflect a cognitive memory of our evolution on the African savannah (Orians and Heerwagen, 1992; Dutton, 2009)[2]. Upper Palaeolithic figurative art could hardly be more different. Its subjects are almost entirely animals, of which large gregarious herbivorous prey are overwhelmingly dominant. The animal depictions are often singular, and where they are integrated into wider 'scenes' in which several interact, these do not occur against a natural background but float on the canvas of the cave wall in the case of parietal art or in

[2] Although if that were the case we presumably forgot it for tens of thousands of years!

the viewer's hand in the case of portable art. They form restricted theatrical tableaux without scenery. Aside from a very few questionable claims that curvilinear lines represent rivers, or that a few clusters of dots represent star constellations (or, more believably, that one engraved stone object represents a map of the environs of a camp site: Utrilla et al., 2009), the depiction of landscape features is entirely absent from Palaeolithic art. The animals float, 'un-anchored' in normal space, and thus while some Palaeolithic art does constitute 'scenes', these are not 'landscapes' in the sense that art historians generally mean by the term.

In terms of interpretation, prehistorians have recently arrived at the opposite extreme to the generalising umbrella theories that characterised the twentieth century. Dutton (2009: 64-84) noted how the anthropology of the 1960s-1980s over-exaggerated the regional uniqueness of the art of small-scale societies, as part of a wider 'postmodern' trend that emphasised the regionally unique and culturally contingent nature of human behaviour. At the same time, the notion that however culturally contingent art was, it should still comply with universal functions over large geographical areas, became as unfashionable as Darwinian explanations for culture and cultural change. It has become fashionable to believe that Palaeolithic art is so distant from us chronologically, and was produced by societies so alien to us, that we can never recapture *any* of its meaning of function. Hence we no longer place any reliance on unsupported theories that its 'function' was, to quote the most pervasive interpretations, aesthetics ('art for art's sake'), sympathetic (hunting or fertility) magic, pedagogy, or the reproduction of visions experienced in altered states of consciousness. Its chronological and contextual distance from us cannot be denied, and while we will never (or very rarely) be able to recapture *specific* meanings about the images and their associations, prehistorians are skilled enough to identify patterning in theme, technique and context and to make *some* generalisations from this. To suggest that we cannot understand any of it is therefore unfair and unproductive; unlike cave art we are not completely in the dark. The important point is that considerable investment of time could be made into depicting prey animals in deep caves where there was otherwise no quotidian reason to be. The act often drew inspiration from the cave walls themselves, in a way in which the dynamics of light and viewpoint played an active role in what was perceived and depicted, which was itself created according to relatively tight thematic and stylistic convention. This is a clear link between the individual, group, landscape and prey animal worlds.

CONCLUSIONS

I have suggested that human visual culture emerged out of personal babble, which crystallised into concordant symbolism among Neanderthal and *Homo sapiens* by or shortly after 100,000 BP. If it is justifiable to reduce the origins of visual culture to three distinct phases, I suggest these progressed through two phases that seem to focus exclusively on the human body (which I have focussed on here), towards a third which incorporated the bodies of prey animals. The earliest phase, dating to at least 40,000 BP in Indonesia and at least 65,000 BP in Europe, which I have termed peripersonal, drew inspiration from parts of the human body itself. Where it is preserved in the landscape it already refers to the natural shape of materials (e.g., *pierres figures* and placing of hand stencils in association with topographic features on rock surfaces). It was a visual culture used by individuals to elaborate and place marks (signs) of their own bodies. In the second phase, dating to at least 75,000 BP in Africa, concordancy developed among signs that originated in or drew inspiration from bodily gestures (Blombos and other South African engravings) or from the body parts of other animals used peripersonally (Neanderthal personal ornamentation). Only with the third phase (~40,000 or younger), did figurative depictions (of animal bodies) emerge, which clearly drew inspiration

from the morphology of the external landscape on which they were created (notably the shape of lithic and organic objects on which the art was formed, or that of the rock surfaces that came to be engraved and marked by pigments). This latter phase represents a major restructuring of the earliest human visual culture, which took form, I suggest, only when previously-anthropocentric culture came to incorporate cultural meaning about the wider, non-human world. At which of these stages one places the marker of 'cognitive modernity' so beloved of palaeoanthropologists is irrelevant.

Thus I suggest a three-stage development of Palaeolithic visual culture:

1. Individuals babble to themselves; reassuring and otherwise habitual vocalisations and gestural actions become meaningful to individuals and are not – or are rarely shared. Doodling – by which I mean any tangible interaction between babble and the material world – arises from time to time, out of gestural actions or perhaps pareidolia.
2. Through a process of social scaffolding – perhaps originally between mothers and infants – individual babble becomes repeated between individuals and takes meaning as concordant traditions, probably to communicate about human individuals to other human individuals. At some point the landscape comes to be used as a medium for carrying this communication.
3. The wider landscape – particularly the animals within it – becomes acculturated, i. e., the conceptual world now refers not only to human individuals and group norms but to the wider animate and inanimate world. Animals are depicted on meaningful parts of the physical landscape in an interactive and dynamic whole that incorporates (installs) the human within the whole.

Acknowledgements

It is a pleasure to contribute to this *Festschrift* in honour of Elaine Turner and Martin Street. I first met them as an undergraduate student in 1989. I was reading Ancient History and Archaeology at Birmingham University; they had read the same degree and had taken their PhDs at Birmingham too. I participated in my tutor, Lawrence Barfield's excavations in northern Italy that summer, and as Elaine and Martin had kept in touch with him we all broke our journey at Monrepos overnight. I was immediately impressed with the Palaeolithic research being conducted there, and slowly came to specialise in the Palaeolithic myself. I kept in touch, and over the years I've made numerous visits to Monrepos, always enjoying the support and friendship of Elaine, Martin, Sabine, Olaf, Lutz and their colleagues. Our collaborations continue to this day, and really, Elaine and Martin are at the very heart of that. Long may we all continue!

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THE CHRONOLOGY OF EARLY MODERN HUMANS IN EASTERN EUROPE, SIBERIA AND EAST ASIA: RESULTS AND PROBLEMS

Abstract

This article presents an analytical review of the direct radiocarbon dating evidence of anatomically modern human fossil remains (early *Homo sapiens*) from Palaeolithic contexts in Eastern Europe, Siberia and East Asia, with a brief mention of other regions in Eurasia. One of the most ancient finds for entire Eurasia, which provided a direct radiocarbon date, is Ust'-Ishim in Western Siberia (ca. 45,000 years ago); in Eastern Europe, the earliest directly-dated *H. sapiens* fossils are Kostenki 14 and Kostenki 1 (ca. 35,500-37,400 years ago). For a number of finds (such as Kostenki 18, and human fossils from the site of Sungir), there are serious problems that need to be solved with help of new data. This is particularly clear for Sungir where 21 radiocarbon dates were obtained on different collagen fractions (bulk collagen; ultrafiltered collagen; and hydroxyproline), and dates, even of the same skeleton, often contradict each other. Prevailing methodological issues of radiocarbon dating bones, and the importance of possibilities to assess independently the results obtained, are also considered. When preservation of collagen (which can be controlled using a number of parameters) is good, dating of the bulk collagen fraction appears to be reliable. Claims that only specific amino acids (such as hydroxyproline) give accurate radiocarbon dates for bone are not strictly proven.

Keywords

Radiocarbon dating, anatomically modern human fossils, Palaeolithic, Eastern Europe, Siberia, East Asia

INTRODUCTION

Establishing a reliable chronology is an essential part of Palaeolithic research. The most common way to determine the age of ancient sites is the radiocarbon (^{14}C) dating method. At present, this method has been used to understand the main temporal patterns of the Upper Palaeolithic cultural complexes in northern Eurasia (e. g., Kuzmin, 2007; Anikovich et al., 2007; Kuzmin et al., 2011; Qu et al., 2013; Pitulko and Pavlova, 2016, 2020; Keates et al., 2019; Dinnis et al., 2019; Pavlova and Pitulko, 2020).

One of the directions in the study of the Upper Palaeolithic concerns the chronology of human fossils. Starting from about 40,000 calendar years ago (cal BP), practically only one species of hominin was distributed throughout Eurasia – anatomically modern humans (early modern *Homo sapiens*, *H. sapiens*; hereafter: EMHS). According to direct ^{14}C dating of Neanderthal fossils, they survived in Europe until ca. 35,400-38,800 cal BP (Kuzmin and Keates, 2014: 756) and possibly to ca. 40,600-44,200 cal BP only (see Devièse et al., 2021), and therefore Neanderthals for some time coexisted with modern humans.

The most reliable estimate for the antiquity of human fossils is their direct (i. e., obtained on bones and teeth of ancient humans) ^{14}C age determination; these data and their analysis are the focus of this article. A seminal paper by Street et al. (2006) clearly demonstrated the importance of such direction in Palaeolithic research. By acknowledging the pioneering role of Dr. Martin Street in this respect, here the main attention is given to Eastern Europe, Siberia, and East Asia, with a brief discussion of EMHS chronology for other parts

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.868.c11317

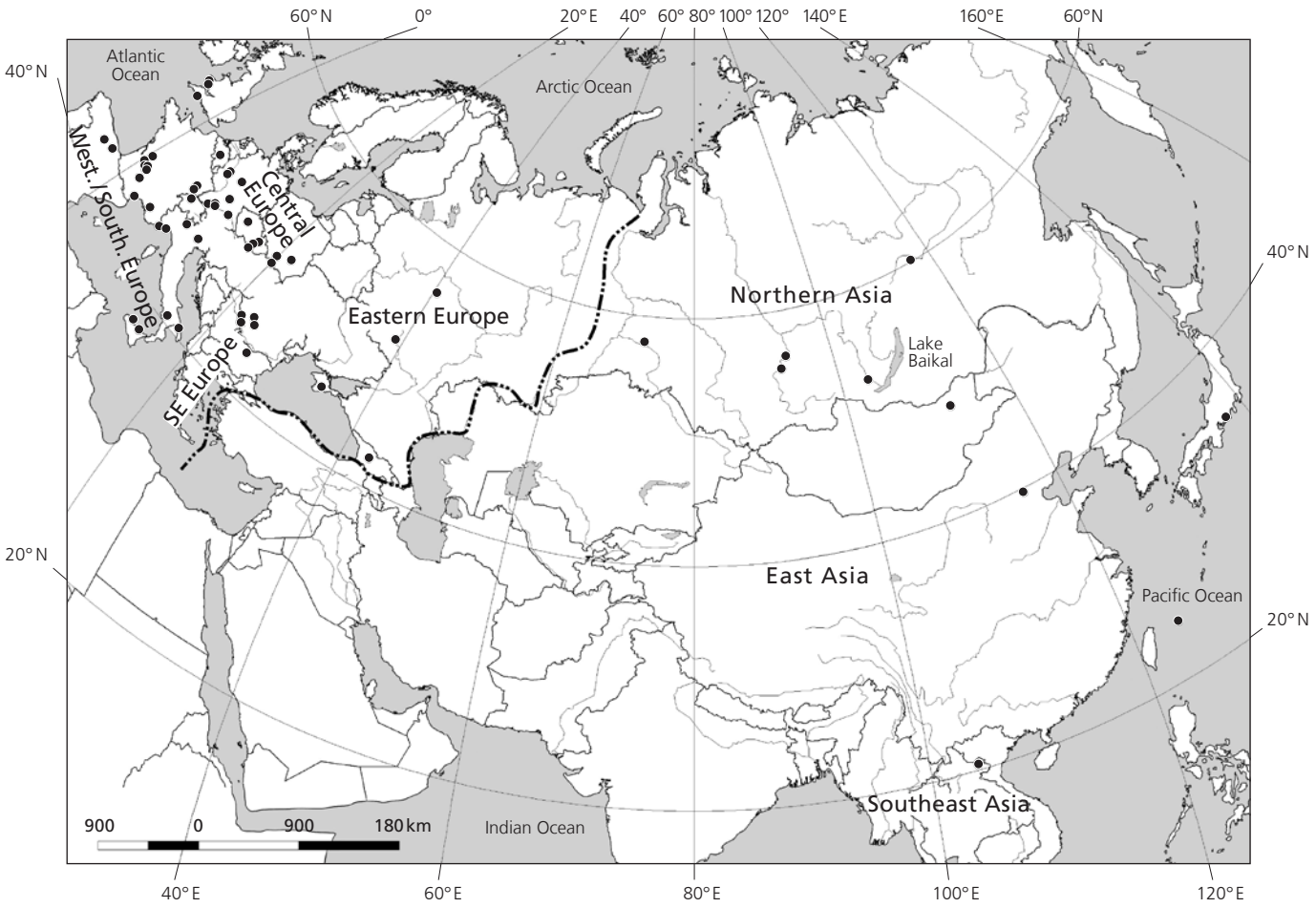


Fig. 1 Geographic distribution of early modern *H. sapiens* (EMHS) finds in Eurasia with direct ^{14}C dates (according to the data as of January 2021); names of locations are indicated in Kuzmin and Keates (2014).

of Eurasia. The importance of reliable age determination for EMHS fossils increased significantly after the accumulation of the initial "critical mass" of information on DNA of ancient hominins (see reviews: Nielsen et al., 2017; Skoglund and Mathieson, 2018; Yang and Fu, 2018).

MATERIALS AND METHODS

Currently (as of January 2021), about 120 direct ^{14}C dates have been published for EMHS fossils from Eurasia (**Fig. 1**; Kuzmin and Keates, 2014; see also: Formicola et al., 2005; Krause et al., 2007; Craig et al., 2010; Marom et al., 2012; Gazzoni et al., 2013; Fu et al., 2014, 2016; Kuzmin et al., 2014; Reynolds et al., 2017; Garralda et al., 2019; Devièse et al., 2019; Hublin et al., 2020; Kılınç et al., 2021). The geographical distribution of dated finds is not even (**Fig. 2**): Europe accounts for 88 % of the total (Western, Southern, Central and Southeastern Europe: 84 %; Eastern Europe: 4 %), and Asia for 12 %. Thus, Eastern Europe, Siberia and the neighbouring regions of Asia constitute 16 % of the ^{14}C-dated EMHS.

Until now, there has been no clear explanation for the phenomenon of the small number of EMHS fossils in Siberia and Eastern Europe; this problem is specifically discussed by Turner et al. (2013: 386-390). Reference

to the insufficient degree of Palaeolithic research in Siberia compared to Western/Central Europe does not look convincing, because in southern Siberia systematic studies of the Palaeolithic have been carried out since 1871 when the very first Russian Palaeolithic site of 'Military Hospital' was discovered in the city of Irkutsk (Larichev et al., 1990).

Since the 1970s, collagen – the major organic part of the bone – has been used for ^{14}C dating of animal and human remains. Several methods are now employed to extract collagen from the raw bones/teeth/tusks: 1) dissolution of small pieces (up to 2-3 cm long) in a weak solution of hydrochloric acid (HCl) (e.g., Arslanov and Svezhentsev, 1993); the resulting material is often assigned as "bulk collagen"; 2) dissolution of powdered material in HCl (Longin, 1971); with a certain reservation, such material can also be called "bulk collagen"; 3) ultrafiltration, with extracted collagen passed through a filter with the size of holes small enough to allow only molecules with an atomic weight of less than 30,000 Daltons (atomic weight units) to go through; the remaining material with a weight greater than 30,000 Daltons is the subject of ^{14}C dating (Higham et al., 2006a; Brock et al., 2010); this can be classified as "ultrafiltered collagen"; 4) extraction of specific amino acids from collagen, mainly hydroxyproline (HYP) (McCullagh et al., 2010; Marom et al., 2012); this may be called "individual amino acids"; and 5) extraction of collagen using absorbent resins of the XAD-2 type (Stafford et al., 1988); this can be defined as "resin-purified collagen". The most widespread methods at present are numbers 1-3; in some cases, methods numbers 4-5 are used.

One of the most important aspects of ^{14}C dating Palaeolithic human bones and Late Pleistocene mammals is the quality assessment for the material dated. At present, certain criteria to estimate the suitability of extracted collagen have been developed (van Klinken, 1999; Brock et al., 2012): 1) the collagen content should ideally be more than 1 % weight (sometimes 0.5-1 % weight is sufficient); 2) the carbon content in collagen should be about 20-35 %, and the nitrogen content about 11-16 %; these values are approximate; 3) the atomic ratio of carbon to nitrogen (C:N) in collagen should be in the range of 2.9-3.6, and in some cases no more than 3.2-3.3; and 4) the ratios of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotopes in

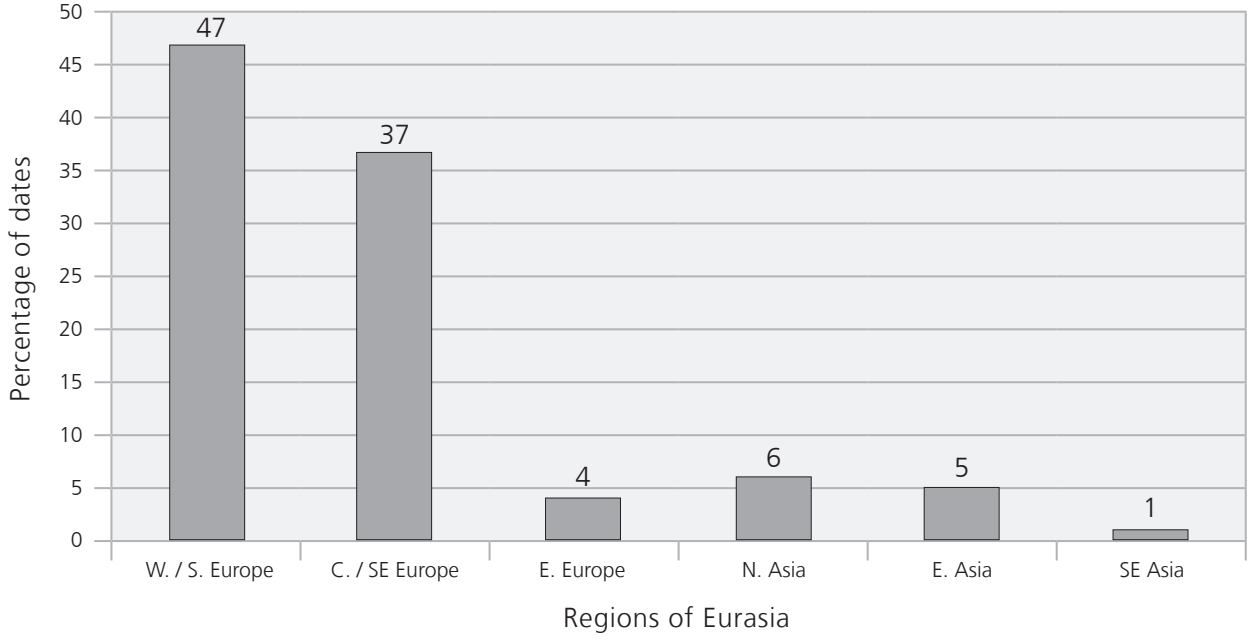


Fig. 2 Distribution of early modern *H. sapiens* (EMHS) ^{14}C dates by main regions of Eurasia (according to the data as of January 2021).

collagen for terrestrial organisms and humans should generally be within the ranges of -19‰ ÷ -22‰ (for $\delta^{13}C$), and +2‰ ÷ +12‰ (sometimes up to +17‰) (for $\delta^{15}N$). In cases when at least one of these criteria is not met, the ^{14}C date cannot be considered as reliable.

To compare the ^{14}C dates with the palaeoclimatic events of the Late Pleistocene – in particular, with the global climate fluctuations based on the Greenland ice core records – it is necessary to convert the ^{14}C ages into the calendar (astronomical) time scale. In order to do so, calibration software Calib Rev 7.0.4 (available at: http://calib.org/calib/), based on international standards (Reimer, 2020; Reimer et al., 2013), is used here. When performing the calibration, certain rules should be followed: 1) use a standard deviation of ± 2 sigma (σ); 2) round off the calibration results to the next 10 years; and 3) combine all the possible calendar intervals together. In this paper, mostly calibrated ^{14}C dates (expressed as "cal BP") are used; sometimes, uncalibrated ^{14}C ages (given as "BP") are also applied.

RESULTS

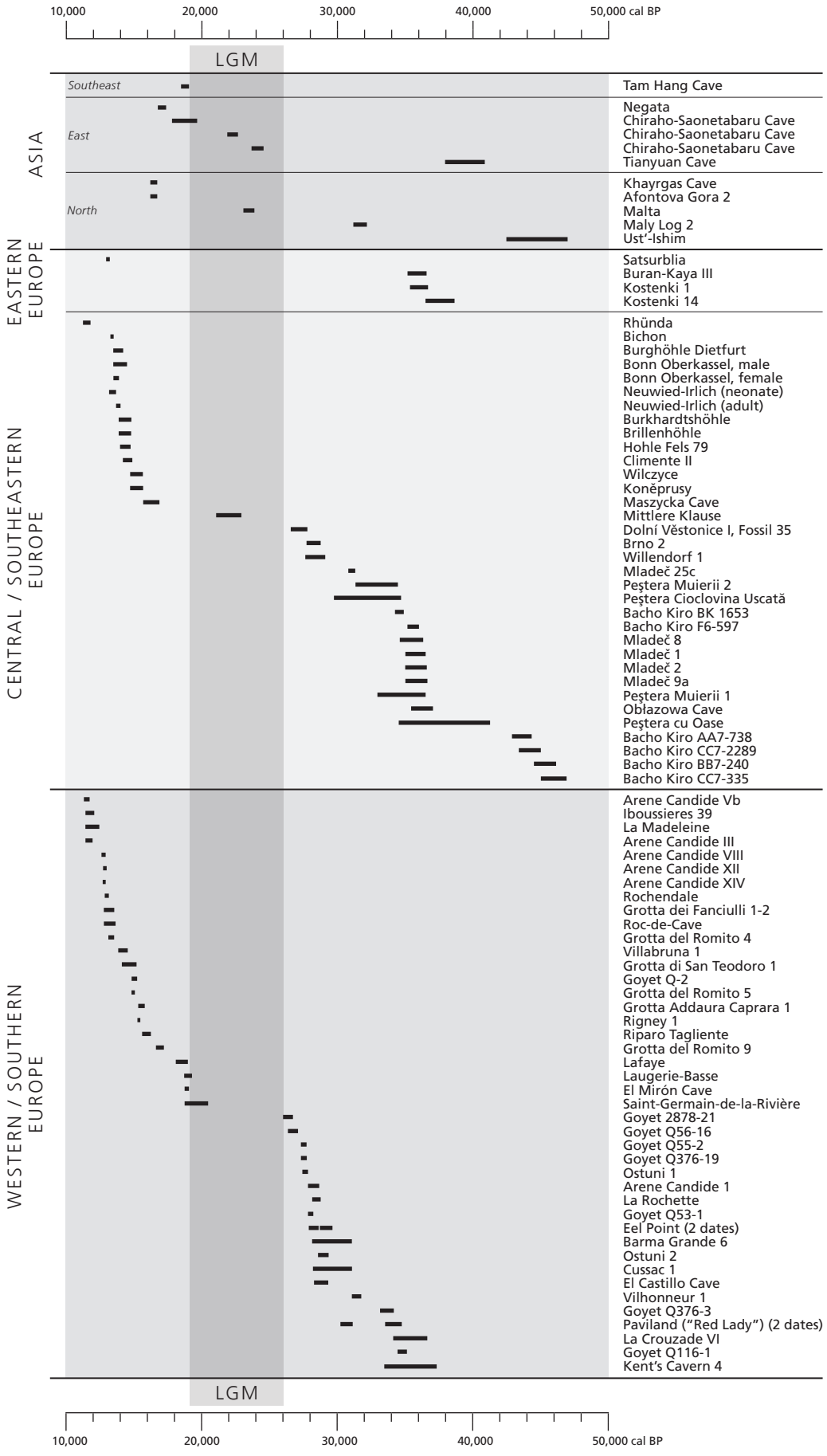
General chronology of early modern humans in Eurasia: a brief overview

The overall chronology of Pleistocene modern humans in Eurasia, based on direct ^{14}C age determinations, is shown in **Figure 3**. The oldest in Asia is the Ust'-Ishim human from West Siberia, dated to ca. 45,000 years ago (y. a.; hereafter "y. a." is the average value of the age intervals of calibrated ^{14}C dates). Another very early date for East Asia is Tianyuan Cave (northern China), about 39,500 y. a. In Europe, the oldest finds of early modern humans are dated to ca. 44,800 y. a. (Bacho Kiro, south-eastern Europe); ca. 37,800 y. a. (Kostenki 14, Eastern Europe); and ca. 35,400 y. a. (Kent's Cavern, Western/Southern Europe) (Kuzmin and Keates, 2014; Fu et al., 2014; Hublin et al., 2020).

As for the chronological relationship between EMHS in Eurasia and palaeoclimatic events of the second half of the Late Pleistocene (Seierstad et al., 2014; Rasmussen et al., 2014), the following patterns can be noted. Only a small number of EMHS finds corresponds to the time of the Last Glacial Maximum (LGM) (**Fig. 3**), currently dated to ca. 24,000-28,000 cal BP (Seierstad et al., 2014), or in a somewhat wider range to ca. 22,900-27,300 cal BP (Kuzmin and Keates, 2018). This undoubtedly reflects the fact that the Palaeolithic populations of Eurasia declined during the coldest and driest climatic conditions for the last 130,000 years. However, there is evidence of human habitation in the periglacial zone of Eastern Europe and southern Siberia during the LGM (Kuzmin, 2008; Kuzmin and Keates, 2005, 2013, 2018; Pitulko and Pavlova, 2020). In addition, a number of EMHS finds corresponds to other cold stages of the second half of the Late Pleistocene. For example, the Kostenki 1 skeleton dated to ca. 35,950 y. a. (mean calendar value of two ^{14}C dates) corresponds to the Greenland GS-8 cold interval (ca. 36,000 cal BP) (Kuzmin, 2019). Thus, Upper Palaeolithic people possessed a sufficient set of tools (dwellings; complex clothes made from sewn pieces of skin; cf. Gilligan, 2019), which allowed them to survive even in high latitudes.

In addition to the ^{14}C method, there are also direct age determinations of EMHS obtained by other techniques with a wider dating range (cf. Walker, 2005). The most reliable is the Uranium series (U-series) method, sometimes used in conjunction with Electron Spin Resonance dating (ESR). The oldest find of

Fig. 3 General chronology of early modern *H. sapiens* (EMHS) in Eurasia based on direct ^{14}C dates (LGM Last Glacial Maximum); names of finds are indicated to the right. Data compiled after Kuzmin and Keates (2014), with additions.


10,000
20,000
30,000
40,000
50,000 cal BP
LGM
ASIA
Southeast
East
North
EASTERN EUROPE
CENTRAL / SOUTHEASTERN EUROPE
WESTERN / SOUTHERN EUROPE
Tam Hang Cave
Negata
Chiraho-Saonetabaru Cave
Chiraho-Saonetabaru Cave
Chiraho-Saonetabaru Cave
Tianyuan Cave
Khayrgas Cave
Afontova Gora 2
Malta
Maly Log 2
Ust'-Ishim
Satsurblia
Buran-Kaya III
Kostenki 1
Kostenki 14
Rhünda
Bichon
Burghöhle Dietfurt
Bonn Oberkassel, male
Bonn Oberkassel, female
Neuwied-Irlich (neonate)
Neuwied-Irlich (adult)
Burkhardtshöhle
Brillenhöhle
Hohle Fels 79
Climente II
Wilczyce
Koněprusy
Maszycka Cave
Mittlere Klause
Dolní Věstonice I, Fossil 35
Brno 2
Willendorf 1
Mladeč 25c
Peştera Muierii 2
Peştera Cioclovina Uscată
Bacho Kiro BK 1653
Bacho Kiro F6-597
Mladeč 8
Mladeč 1
Mladeč 2
Mladeč 9a
Peştera Muierii 1
Obłazowa Cave
Peştera cu Oase
Bacho Kiro AA7-738
Bacho Kiro CC7-2289
Bacho Kiro BB7-240
Bacho Kiro CC7-335
Arene Candide Vb
Iboussieres 39
La Madeleine
Arene Candide III
Arene Candide VIII
Arene Candide XII
Arene Candide XIV
Rochendale
Grotta dei Fanciulli 1-2
Roc-de-Cave
Grotta del Romito 4
Villabruna 1
Grotta di San Teodoro 1
Goyet Q-2
Grotta del Romito 5
Grotta Addaura Caprara 1
Rigney 1
Riparo Tagliente
Grotta del Romito 9
Lafaye
Laugerie-Basse
El Mirón Cave
Saint-Germain-de-la-Rivière
Goyet 2878-21
Goyet Q56-16
Goyet Q55-2
Goyet Q376-19
Ostuni 1
Arene Candide 1
La Rochette
Goyet Q53-1
Eel Point (2 dates)
Barma Grande 6
Ostuni 2
Cussac 1
El Castillo Cave
Vilhonneur 1
Goyet Q376-3
Paviland ("Red Lady") (2 dates)
La Crouzade VI
Goyet Q116-1
Kent's Cavern 4
LGM
10,000
20,000
30,000
40,000
50,000 cal BP

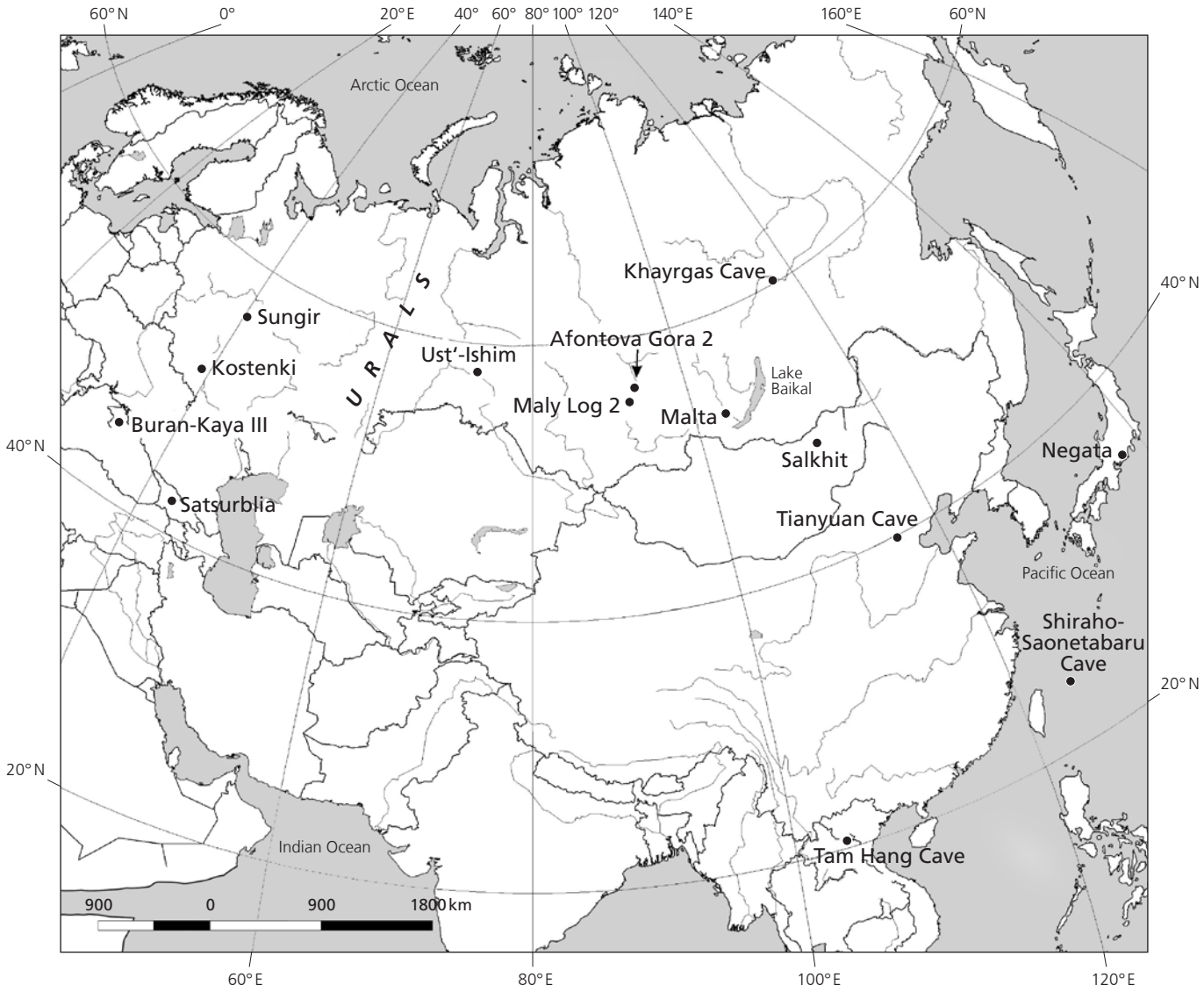


Fig. 4 Geographic distribution of early modern *H. sapiens* (EMHS) with direct ^{14}C dates in Eastern Europe and Asia (according to the data as of January 2021).

Pleistocene *H. sapiens* in Eurasia comes from the Misliya Cave in the Levant; the combined age by the U-series and ESR methods is 174,000 ± 20,000 (calendar) years ago (Hershkovitz et al., 2018). For South-east Asia, the earliest date is from the Niah Cave dating to 35,200 ± 2,600 years ago; for Tabon Cave dates in the range of ca. 16,500-47,000 years ago are less reliable (cf. Keates et al., 2012: 343-346).

Reviews of other direct dates using the U-series method for EMHS in Eurasia are presented in our works (Keates et al., 2012; Kuzmin and Keates, 2014). It should be emphasized that the early dates for the Skhul II and Skhul IX in the Levant, in the range of ca. 121,000-131,000 years ago, are quite problematic (cf. Grün, 2006: 31-34). The issue of the age for modern human remains in Tam Pa Ling Cave in Laos, ca. 46,000 years ago or older (Demeter et al., 2012), needs further confirmation (cf. Pierret et al., 2012).

Radiocarbon chronology of early modern humans in Eastern Europe, Siberia and East Asia

For Eastern Europe, Siberia, and East Asia, relatively few ^{14}C dates have been obtained on EMHS fossils (**Figs. 4-5**; **Tab. 1**). As it was already noted, the earliest finds are Ust'-Ishim and Kostenki 14 (**Fig. 5**). It is of some interest that the Ust'-Ishim specimen in West Siberia, along with Bacho Kiro in south-eastern Europe (**Fig. 3**), have provided some of the oldest direct ^{14}C dates for EMHS in entire territory of Eurasia.

An important aspect of determining the ^{14}C age is the ability to control the results obtained using independent information – for example, stratigraphic markers such as layers of volcanic ash (tephra) with a known age. Unfortunately, in most cases such verification is impossible. However, for two sites of the Kostenki site cluster in Eastern Europe stratigraphic age confirmation is given.

For the Kostenki 1 skeleton (Layer 3), two ^{14}C dates were generated resulting in ca. 35,520 y. a. (collagen without ultrafiltration) and ca. 36,360 y. a. (ultrafiltered collagen, **Tab. 1**). These calendar ages correspond well to the chronology of Layer 3, for which a series of ^{14}C dates was obtained on charcoal with the earliest one of ca. 35,500 cal BP. It also fits well the general stratigraphy of the site where Layer 3 is very likely to be located above the tephra layer known as the Campanian Ignimbrite (CI) dated to ca. 39,000-40,000 cal BP (Holliday et al., 2007; cf. Muscheler et al., 2020). The CI tephra is also present at the Kostenki 14 site, where the age of a human burial dated using HYP is ca. 37,400 y. a. (Marom et al., 2012; **Tab. 1**). The well-preserved modern human skeleton here is associated with Layer 3, and it was found in a shallow pit which cuts through the CI tephra. Other ^{14}C dates from Layer 3 of Kostenki 14 are in the range of ca. 32,300-35,700 cal BP (Holliday et al., 2007); according to the latest information, the age of Layer 3 is younger than ca. 37,300-38,900 cal BP (Dinnis et al., 2019).

Difficulties with ^{14}C dating of some EMHS fossils (Kostenki 18, Sungir, and Salkhit), as well as with the ^{14}C age of finds with unclear species determination (Tuyana and Okladnikov Cave) should be considered separately.

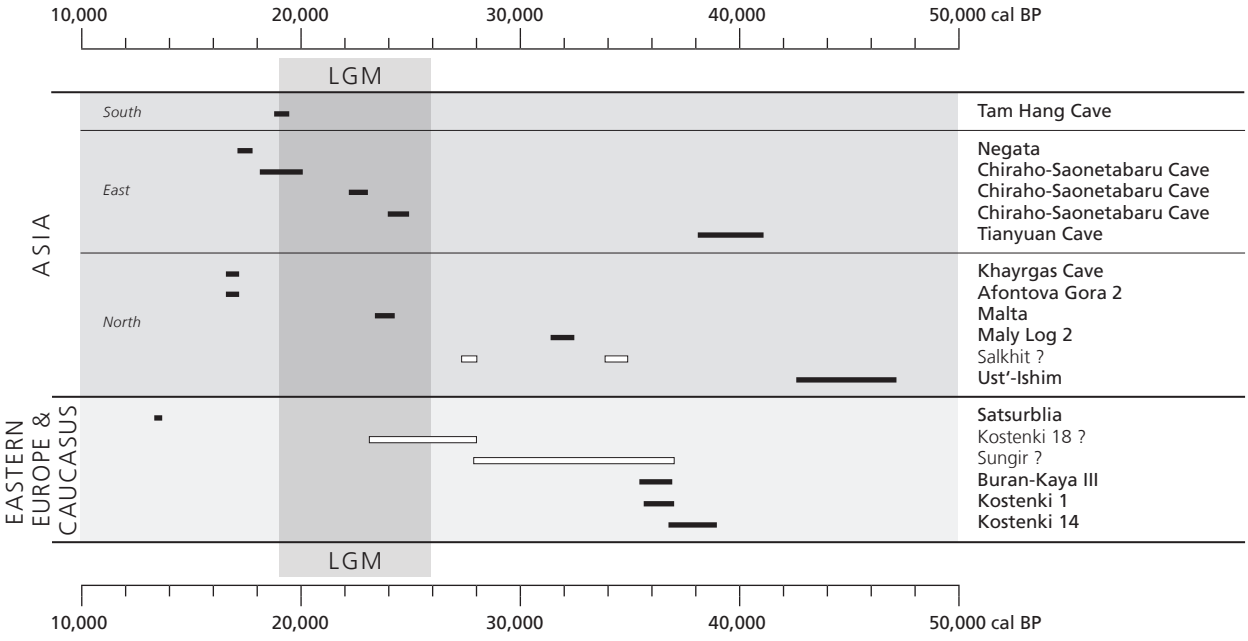


Fig. 5 Chronology of early modern *H. sapiens* (EMHS) in Eastern Europe and Asia (cf. **Tab. 1**; ages of problematic finds are shown by non-filled rectangles); LGM Last Glacial Maximum.

For Kostenki 18, several ^{14}C dates (**Fig. 6**) were obtained on mammoth and human bones (Reynolds et al., 2017). The discrepancy between the age of the burial based on ^{14}C-dated HYP fraction and the overlying mammoth bones which are clearly younger than the human bones is noteworthy, although it is assumed that the skeleton and overlaying mammoth bones were simultaneously placed in the ground (Reynolds et al., 2017: 1439). Also, the ^{14}C dates for human bones run on bulk collagen and HYP differ significantly from each other (**Fig. 6**). The reasons for these discrepancies remain unclear. Therefore, it is not possible to accept the conclusion by Reynolds et al. (2017) about the age of the Kostenki 18 modern human as ca. 27,600 y. a. Further work is required, including new ^{14}C dates on animal bones from this site.

The situation with the ^{14}C age of the Sungir burials looks even more complicated; this issue was discussed several times (cf. Kuzmin et al., 2014; Reynolds et al., 2017; Kuzmin, 2019; Higham, 2019; Pettitt, 2019). By February 2020, a total of 21 ^{14}C values had been generated for five EMHS fossils from this site (**Fig. 7**). Their ages range from ca. 23,000-31,800 y. a. (Kuzmin et al., 2014; Sikora et al., 2017) to ca. 34,000-34,100 y. a. (Marom et al., 2012; Nalawade-Chavan et al., 2014). Because there is no independent stratigraphic marker for the Sungir site that could help to establish the upper or lower limit for the antiquity of human bones, the only indirect way to assess the reliability of their ^{14}C dates is to compare them with the age of animal bones from the same site.

The age of the reindeer bones is ca. 30,700-31,500 y. a.; and the ^{14}C date of horse bones collected from a relatively large area is ca. 29,900 y. a. In addition, the ^{14}C values of the woolly mammoth (*Mammuthus primigenius*) bone from a clear stratigraphic context (horizons 3 and 4, i. e., the lower part of the cultural layer) are ca. 30,400-32,000 y. a. (non-ultrafiltered bulk collagen). It should be noted that the ^{14}C dates of ca. 33,600-34,200 y. a., generated for the mammoth bone using ultrafiltered collagen and HYP (Marom et al., 2012; cf. Kuzmin, 2019), are clearly older than the bulk collagen ^{14}C age of ca. 31,400 y. a. for the same specimen. The reason for this is still not clear. Most of the other mammoth bones from Sungir have a ^{14}C age similar to the value generated on non-ultrafiltered collagen from horizons 3-4: ca. 30,700-

Locality	Laboratory code	^{14}C date [BP]	Calendar age [cal BP]	Reference
Ust'-Ishim	OxA-25516	41,400 ± 1,300	43,210-46,880	Fu et al., 2014
Tianyuan Cave	BA-03222	34,430 ± 510	38,120-40,940	Shang et al., 2007
Kostenki 14	OxA-X-2395-15	33,250 ± 500	36,690-38,980	Marom et al., 2012
Kostenki 1	OxA-15055	32,070 ± 190	35,710-37,000	Higham et al., 2006a
Buran-Kaya III	GrA-37938	31,900 + 240/-200	35,510-36,890	Prat et al., 2011
Maly Log 2 (Pokrovka 2)	OxA-19850	27,740 ± 150	31,420-32,440	Akimova et al., 2010
Shiraho-Saonetabaru Cave	MTC-12820	20,415 ± 115	23,930-24,780	Nakagawa et al., 2010
	MTC-13228	18,750 ± 100	22,060-22,900	Nakagawa et al., 2010
	MTC-12818	15,750 ± 420	18,000-19,840	Nakagawa et al., 2010
Malta (Mal'ta)	UCIAMS-79666	20,240 ± 60	23,890-24,420	Raghavan et al., 2013
	OxA-7129	19,880 ± 160	23,330-24,260	Richards et al., 2001
Tam Hang Cave	GrA-10952	15,740 ± 80	18,670-19,280	Demeter et al., 2009
Negata	Beta-160572	14,200 ± 50	16,970-17,580	Kondo and Matsu'ura, 2005
Afontova Gora 2	UCIAMS-79661	13,810 ± 35	16,750-17,080	Raghavan et al., 2013
Khayrgas Cave	Beta-453115	13,790 ± 40	16,550-16,940	Kılınç et al., 2021
Satsurblia	OxA-34632	11,415 ± 50	13,130-13,380	Fu et al., 2016

Tab. 1 Direct ^{14}C dates of early modern *H. sapiens* (EMHS) in Eastern Europe, Siberia and Asia (as of January 2021). Calibration performed using Calib Rev 7.0.4 software (available at http://calib.org/calib/), with ± 2 sigma.

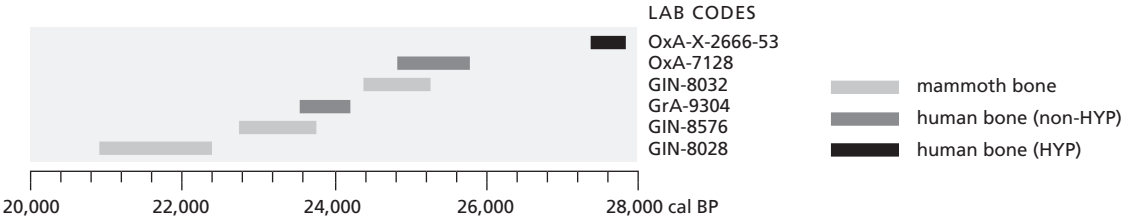


Fig. 6 The calibrated ^{14}C dates of early modern *H. sapiens* (EMHS) and mammoth bones at the Kostenki 18 site (Reynolds et al., 2017; Kuzmin, 2019); lab codes for ^{14}C dates are shown to the right.

32,000 y. a. (Trinkaus et al., 2015). It can be concluded that the ^{14}C dates of human bones obtained using HYP, when compared to the ^{14}C age of the reindeer and horse bones, as well as the majority of mammoth ^{14}C values, seem to be clearly older. Given this, the "true" age of the Sungir EMHS, however, remains unknown (Kuzmin, 2019; Kuzmin et al., 2014).

As for the EMHS skull cap found in northern Mongolia, in the area of Salkhit within a gold placer field, two ^{14}C dates were obtained: ca. 27,700 y. a. on ultrafiltered collagen; and ca. 34,000 y. a. on HYP (Devièse et al., 2019) (**Fig. 5**). Since there is no additional information about the age of what is essentially a surface find, such a significant difference between the ^{14}C dates of the two collagen fractions generates the question which age should be accepted as the valid one? Devièse et al. (2019) believe that the HYP ^{14}C value looks more reliable because the skull cap from which the sample was taken had been treated with conservants. This conclusion is part of a more general approach *sensu* Higham (2011, 2019) who considers the oldest ^{14}C values as the most reliable ones because younger ^{14}C dates reflect contamination which was not removed prior to dating (see also Discussion). In my opinion, the question of Salkhit's age remains entirely unresolved.

For one of the hominin bones found at Okladnikov Cave in the Altai Mountains of southern Siberia (a fragment of an adult humerus; Krause et al., 2007), a ^{14}C date of ca. 28,300 y. a. was obtained. Because DNA was not retrieved from this sample (Krause et al., 2007: SI, p. 4), it is impossible to establish its taxonomic affiliation, whether it is a Neanderthal or a modern human. The age of the latest Neanderthals in Eurasia is ca. 35,400-38,800 y. a. (Kuzmin and Keates, 2014). Thus, the adult humerus from Okladnikov Cave most likely belongs to a EMHS. In this case, again, the question arises about the degree of disturbance of the site's stratigraphy as suggested by Turner et al. (2013: 220; cf. Kuzmin and Keates, 2020).

More recently, data on hominin fossils from the Tuyana site in the Cis-Baikal region of southern Siberia were published (Vasiliev et al., 2017; Shchetnikov et al., 2019). For two human bones, ^{14}C dates of ca. 31,100 y. a. and ca. 52,800 y. a. were generated. Because it is impossible to determine unequivocally the hominin species to which the Tuyana finds belong, the question remains open until the results of ancient DNA analysis will be available (Vasiliev et al., 2017: 159). Based on the general chronology of EMHS in Eurasia (**Fig. 3**), it can be assumed that a bone with a date of ca. 31,100 y. a. belongs to a modern human.

Errors in radiocarbon dating of early modern humans in Eurasia

In rare cases, errors in the ^{14}C dating of EMHS have occurred, and were subsequently corrected. The human talus bone found at the Baigara locality in central West Siberia was originally ^{14}C dated to > 44,300 BP (Kuzmin et al., 2009). When the DNA was extracted from this bone at the Institute for Evolutionary Anthropology of the Max Planck Society (Leipzig, Germany), it turned out that the DNA structure is atypical for the

Palaeolithic (B. Viola, personal communication 2011). Repeated ^{14}C dating in three laboratories (University of Arizona, Tucson, AZ, USA; University of Groningen, Groningen, the Netherlands; and Klaus-Tschira Laboratory, Mannheim, Germany) showed that the age of the bone is much younger, ca. 10,300-10,440 y. a. (Kuzmin, 2016). Upon additional investigation, it was found that this happened as a result of the unintentional misplacement of two samples at the AMS Laboratory of the University of Arizona in 2008: at some stage, the bone of a fossil elk (*Alces latifrons* or *A. alces*) was mislabelled as a human bone. Initially, the elk bone was ^{14}C-dated to ca. 10,100 cal BP (Kuzmin et al., 2009). The subsequent re-dating of the elk gave the age of > 44,000 BP (G.W.L. Hodgins, personal communication 2013). However, this was a single error in this laboratory in the dating of about 1000 samples submitted by me in 1997-2014. Thus, Baigara should be excluded from the list of EMHS localities in Siberia (Kuzmin and Keates, 2014: 760).

DISCUSSION

Nowadays, it seems obvious that ^{14}C dating of materials (presumably) associated with human remains (for example, animal bones or charcoal from the layer in which human bones are found) does not always give a reliable result. A clear case is the Vogelherd Cave in southern Germany, where *H. sapiens* remains were dug into an early Upper Palaeolithic (Aurignacian) cultural layer. The directly ^{14}C-dated human bones transpired to be much younger, ca. 5500-5750 y. a. (Conard et al., 2004), than the animal bones from the Aurignacian, dating to ca. 35,700-40,300 y. a. (Conard and Bolus, 2003), indicating a Neolithic burial context for the human remains (Conard et al., 2004). Ironically, for many years the presumed "undisturbed" stratigraphy of the Vogelherd Cave did not raise any doubts among Palaeolithic experts on the context of these finds. Another example is the estimated age of an EMHS child burial at the Hungsugul Cave of the Turubong (Durubong) cave complex in South Korea (Nelson, 1993: 43; Norton, 2000). This burial, excavated in 1982, had always been associated with the Palaeolithic (e. g., Lee, 1997). Direct ^{14}C dating of this skeleton, finally conducted in the mid-2000s (de Lumley et al., 2011: 286), generated a very late age that falls into the seventeenth to nineteenth centuries AD.

To these cases one can add the unexpectedly late, Holocene ^{14}C dates for a number of presumed Pleistocene EMHS finds in Germany, including even skeletal remains that were previously directly ^{14}C-dated to ca. 40,800 y. a. (Hahnöfersand), 29,800-31,700 y. a. (Paderborn-Sande), ca. 25,500 y. a. (Binshof-Speyer), and ca. 35,200 y. a. (Kelsterbach) (Street et al., 2006). Also, some human fossils from Germany initially associated with the Palaeolithic, like Urdhöhle Cave, Weißenthurm, and Niedermendig, turned out to be of the Holocene age after direct ^{14}C dating (Street and Terberger, 2004: 288-289).

The studies by Street et al. (2006), and Street and Terberger (2004) serve as excellent examples of how additional research fundamentally changed the view of the archaeological record. It can be added that by direct ^{14}C dating of some surface finds of modern humans, which were considered to be of Late Pleistocene age, it was possible to establish their antiquity towards a much younger date, like in the case of a femur from the Ordos region in northern China (Keates et al., 2007).

There are considerable more examples of conflicting dating results of EMHS based on *indirect* dates, and here I discuss one of them in order to illustrate the danger of uncritical acceptance of such ages. Liu et al. (2015) dated the geological contexts of modern human teeth in Fuyan Cave in southern China by the U-series method to ca. 80,000-120,000 years ago. From Layer 1, overlying the human fossils, a U-series date of ca. 80,000 years ago was obtained on carbonates (speleothems, in this case flowstone and stalagmites). From Layer 2, containing the teeth of EMHS, U-series dates on carbonates have resulted in a large scatter of

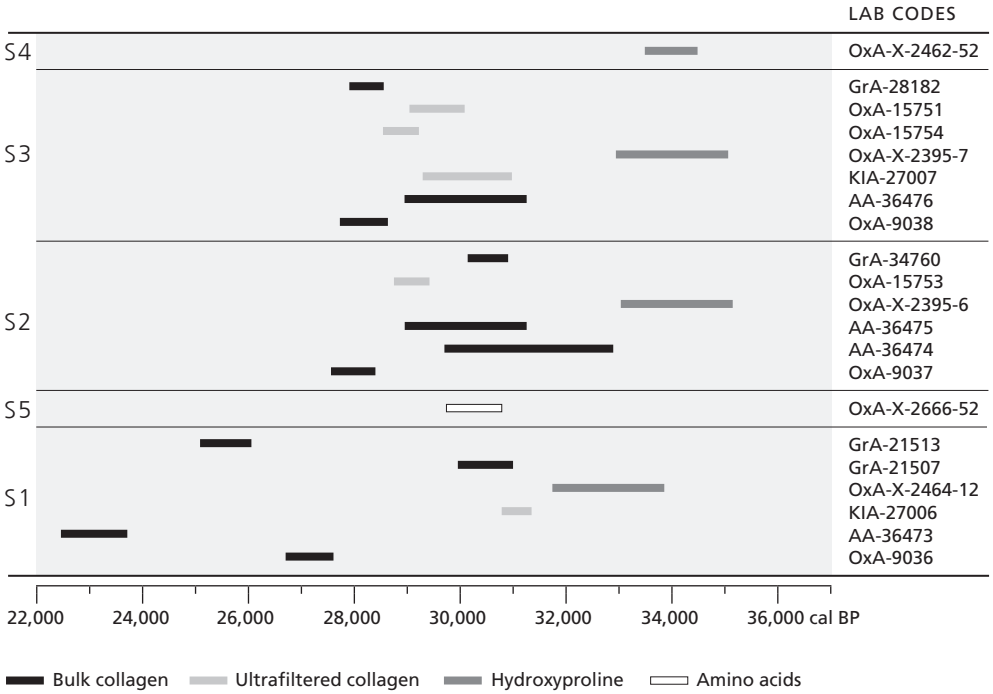


Fig. 7 The calibrated ^{14}C dates of early modern *H. sapiens* (EMHS) at the Sungir site (Kuzmin, 2019; Kuzmin et al., 2014; Sikora et al., 2017). S 1 - S 5 are skeleton and bone numbers (cf. Trinkaus et al., 2014); lab codes for ^{14}C dates are shown to the right.

dates, ranging from ca. 121,000 years ago to ca. 556,000 years ago. This allows me to suggest that the material in Layer 2 is mixed, and explains why it has such a wide age range. For Layer 2, the ^{14}C date on animal bones of ca. 43,000 y. a. (uncalibrated ^{14}C value: 39,150 ± 270 BP, lab code: BA-14021; produced at the AMS Center, School of Physics, Peking University) was also generated. This information is presented only in the electronic Supplement to Liu et al. (2015: SI, p. 4). Liu et al. (2015: SI, p. 4) consider this value as beyond the range of the ^{14}C dating method and therefore omit it: "This is close to the organic material background of AMS radiocarbon dating in Peking University (PKU) lab. Thus, 39150 ± 270 BP is beyond the limits of the radiocarbon technique at the lab." This, in my opinion, is an attempt to justify the incorrect standpoint. Realising the importance of the Fuyan Cave human fossils, it should not be difficult to measure the ^{14}C age of animal bones in AMS laboratories where the background of bone material is about 50,000 BP. Somehow, this was not done, and one can wonder what the reason for that may have been.

It is obvious that all the bones in Layer 2 of Fuyan Cave are not *in situ*; Liu et al. (2015) reluctantly admitted that the position of the bones was distorted after deposition in the cave, but, again, only in the electronic Supplement (see Liu et al., 2015: SI, pp. 2-3). Therefore, the lack of a direct determination of the age of the human teeth – for example, using the Uranium-Thorium method of dating tooth enamel (e. g., Walker, 2005) – makes the conclusions by Liu et al. (2015) highly questionable (cf. Michel et al., 2016).

Nevertheless, there are also examples of careful (albeit indirect) determinations of the age of EMHS. Westaway et al. (2017) dated modern human fossils from the Lida Ajer Cave on Sumatra Island (Indonesia). Several methods applied regularly in Quaternary geochronology were used to produce a reliable age estimate: 1) coupled U-series and ESR dating of orangutan and gibbon teeth located next to the human remains because the curators of the museum in Leiden (the Netherlands), where the human fossils are stored, did not give permission for direct dating of the latter (K. Westaway, personal communication 2018); 2) determina-

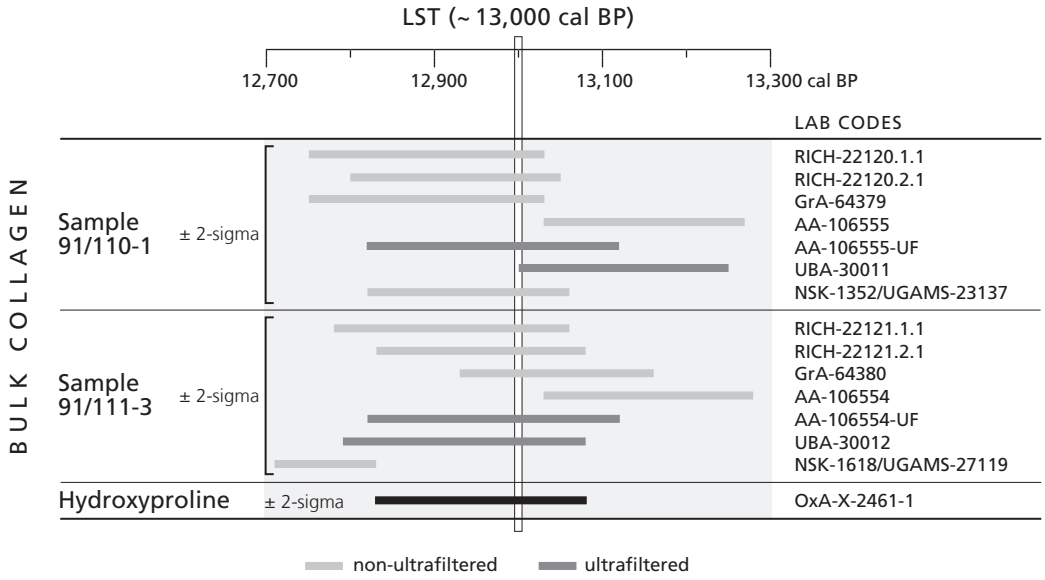


Fig. 8 The calibrated ^{14}C dates of the elk bone from the Miesenheim IV locality and the time of eruption of the Laacher See Tephra (Kuzmin et al., 2018); lab codes for ^{14}C dates are shown to the right.

tion of the age of carbonate flowstone by the U-series method; and 3) luminescent dating of quartz grains in the bone-bearing breccia. It should be noted that the work was carried out at an updated methodological level, with the selection of samples of fauna and cave deposits from *in situ* conditions. Combining all dating results and Bayesian age modelling for the layer in which the human teeth were found made it possible to establish the time of this EMHS's presence in central Sumatra at 68,000 ± 5,000 years ago.

In the recent debate about direct ^{14}C dating of human fossils (Kuzmin, 2019; Higham, 2019; Pettitt, 2019), some authors accept *a priori* that the oldest dates are the most reliable ones (Higham, 2011; Reynolds et al., 2017). However, one should bear in mind that at many Upper Palaeolithic sites the bones of two species of the extinct Pleistocene megafauna are often dated – the woolly mammoth and the woolly rhinoceros (*Coelodonta antiquitatis*). The dates of these bones do not necessarily correspond to the time of human habitation, since it is well known that Upper Palaeolithic people collected large subfossil bones and tusks of animals, which died naturally, for various purposes (e. g., Soffer, 2003). In this case, the ^{14}C dates obtained from megafaunal bones may well be older than the time of human presence. More reliable ages can be determined by ^{14}C dating of materials such as charcoal and bones of other animals that were probably hunted, such as Pleistocene bison (*Bison priscus*) and horse (*Equus caballus*), or other ungulates. Therefore, it is methodologically incorrect to simply accept the oldest ^{14}C dates as the reliable ones *sensu* Higham (2011). That such a view may be too simplistic, was proven for Upper Palaeolithic sites in the central Russian Plain (Praslov and Sulerzhitski, 1999).

Concerning the issue which organic fraction of the bone – bulk collagen, ultrafiltered collagen, or HYP – is the most reliable material for ^{14}C dating, there is still no consensus (see discussion in: Kuzmin, 2019; Higham, 2019). Since the "true" age (i. e., supported by independent data, as in the case of the skeletons of Kostenki 1 and Kostenki 14) of the human fossils in most of cases is unknown, this kind of discussion without the possibility to evaluate the ^{14}C dates by independent means is essentially fruitless. As an example, there were three ^{14}C dating campaigns for bones of Neanderthals from the Vindija Cave in Croatia. The first ^{14}C values on bulk collagen were in the range of ca. 32,000-33,000 y. a. (Smith et al., 1999). Later, they were

replaced by older ^{14}C dates run on ultrafiltered collagen of ca. 36,600-36,800 y. a. (Higham et al., 2006b). Finally, all these dates were declared as too young, and the HYP ^{14}C values of ca. 46,300-47,000 y. a. were accepted (Devièse et al., 2017). It is still not clear: which series of dates is the most reliable one? Probably, none of them, because at Vindija Cave there are no age markers which can be used as independent criteria to test the validity of the produced ^{14}C dates.

Some researchers (e. g., Higham, 2019) believe that HYP is the most reliable material for ^{14}C dating of bones. This, however, has not been supported by the measurement of the ^{14}C age for a sample with a known upper age limit. The skeleton of an elk (*A. alces*), found at the locality of Miesenheim IV in the German Rhineland, was selected for cross-dating in several laboratories, applying different collagen extraction methods. At Miesenheim IV, elk bones were buried below the Laacher See Tephra (LST), the eruption of which is reliably dated to ca.13,000 cal BP (Fiedel et al., 2013; Kuzmin et al., 2018). Parallel ^{14}C dating in five laboratories of bulk collagen and ultrafiltered collagen, followed by comparison with the HYP ^{14}C value, showed that all dates are almost contemporaneous (**Fig. 8**) and do not contradict the age of the tephra (Kuzmin et al., 2018). Thus, the "superiority" of HYP compared to other collagen fractions *sensu* Higham (2019) has not been proven in this particular case.

When bones were treated with conservants (mainly synthetic substances made of fossil carbon compounds, e. g., natural oil, such as the most commonly used polyvinyl acetate glue: PVA), the question of which collagen fraction is the most reliable for ^{14}C dating is a complicated issue. Our limited experience in cleaning the elk bones from the Miesenheim IV locality shows that solvent treatment (by hexane, acetone, and ethanol) can be successful in removing the PVA glue (Kuzmin et al., 2018: 11-13).

CONCLUSIONS

An overview of the state-of-the-art for direct ^{14}C dating of EMHS from Eastern Europe, Siberia and Asia indicates that there is still little information available for these regions compared to Western, Southern, Central and south-eastern Europe. Nevertheless, it is possible to draw some conclusions. The oldest directly ^{14}C-dated EMHS in Eastern Europe and Asia is Ust'-Ishim from West Siberia, with an age of ca. 45,000 y. a. In East Asia, the oldest EMHS from Tianyuan Cave is dated to ca. 39,500 y. a. In Eastern Europe, the oldest EMHS fossils come from the Kostenki 14 and Kostenki 1 localities, and dated to ca. 35,500-37,400 y. a. The presence of humans in Siberia (Malta site) and East Asia (Shiraho-Saonetabaru Cave on Ryukyu Islands, Japan) at the height of the last glaciation (LGM) is noteworthy.

In most cases, it is impossible to assess the reliability of the ^{14}C dates due to the lack of independent age markers, although for Kostenki 1 and Kostenki 14 there is a good correspondence between the ^{14}C dates and the tephrochronology. In some cases (e. g., Kostenki 18 and Sungir), there are obvious contradictions that can be resolved only after generating new data, preferably using non-conserved samples. The degree of collagen preservation can be controlled by generally accepted parameters (collagen content in bone; carbon and nitrogen contents in collagen; atomic ratio of carbon to nitrogen; and carbon and nitrogen stable isotopes' ratios). When a sample satisfies these requirements, the ^{14}C date of bulk collagen seems to be reliable. The conclusion that HYP is the most reliable collagen fraction for ^{14}C dating of bones has not been strictly proven.

Acknowledgements

I am indebted to Prof. Dr. Sabine Gaudzinski-Windheuser and Dr. Olaf Jöris for inviting me to prepare a paper for this *Festschrift*. Discussions of the results obtained were carried out with a number of colleagues, including L.D. Sulerzhitsky (deceased), A.A. Sinitsyn, K.N. Gavrilov, S.V. Vasiliev, A.A. Bessudnov, P.A. Kosintsev, D.I. Razhev, M. Boudin, S.G. Keates, J. van der Plicht, K. Westaway, G.S. Burr, A.J.T. Jull, S. Talamo, and G.W.L. Hodgins. I express my gratitude to all of them for the opportunity to communicate and exchange opinions.

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THE IMPACT OF ABRUPT ENVIRONMENTAL TRANSITIONS ON HUMAN DISPERSALS AND ADAPTATION

Abstract

This paper sets out new methodologies for analysing the effects of Abrupt Environmental Transitions (AETs) on cultural change in the late Middle and Upper Palaeolithic. Archaeologists need to conceive the Palaeolithic record as a series of dynamic and often asynchronous social processes, rather than as a succession of essentialist epochs, before they can evaluate the effects (causal, or neutrally contemporaneous?) of evidence of AETs found in archaeological deposits and elsewhere. New scales of analysis, from modifications in tool-forms, to substitution of artefact types by others, to replacement of one culture with another, need to be explored before dispersals of groups across the landscape, and social and economic responses to AETs, can be assessed.

Keywords

Essentialism, Abrupt Environmental Transitions, tephrochronology, hominin dispersal, Neanderthals, modern humans, cultural change, asynchronicity

INTRODUCTION

The demonstration from both ice and marine isotope records that climate change was abrupt has been one of the most significant findings of recent Quaternary science. As a result, the gradual model of changes in ice mass and sea level has been supplemented with one of rapid transitions (e. g., Alley et al., 1993; Siddall et al., 2003). These Abrupt Environmental Transitions (AETs) also impacted on floral and faunal biota, resulting in shifts in temperature of up to 6-7 °C in Late Glacial Europe over the course of a few human generations (e. g., Poland: Goslar et al., 1995; Germany: Brauer et al., 1999). Archaeologists have been keen to exploit AETs as the explanation for changes in aspects of Palaeolithic technology and economy, cultural behaviour and settlement history (e. g., d'Errico et al., 2001; Blockley et al., 2006; Bar-Yosef and Belfer-Cohen, 2002; Baillie, 2000; Weninger et al., 2009). However, the relationship can only be established if a chronological framework exists that combines information on abrupt change from marine, terrestrial and archaeological archives at comparable levels of precision.

The importance of chronological precision is well shown by a recent study dating to the early phases of the Holocene (Blockley et al., 2018), and where temperature shifts on a centennial scale of 4 °C characterise four AETs at 8.2, 9.3, 11.1 and 11.4 ka. The conclusion, however, of this high-resolution study using a suite of environmental indicators from Star Carr, Yorkshire, is that continuity and resilience dominated the human response. Change was not precipitated by external climate drivers as recorded in ice or deep sea cores. Rather, significant changes in behaviour at this site corresponded to local environmental conditions (Blockley et al., 2018: 816).

From the outset we need to distinguish between AETs, and environmental disasters (*sensu* Riede, 2014), with the latter being intense but short-lived. While AETs show a persistent shift from one set of conditions to another, environmental disasters are marked by short-term perturbations (e. g., tsunamis, extreme weather

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.868.c11318

conditions and volcanic eruptions), which, according to Riede (2014: 354) exposed "specific systemic weaknesses and vulnerabilities amongst European communities at each time slice." In this contribution, however, we argue that temporal persistence and spatial extent are key in distinguishing AETs from environmental disasters. Rather than identifying catastrophes our approach uses recent advances in tephrochronology to provide a framework for examining human adaptations to environmental change at both a local and continental scale. This work builds on a research strategy exemplified by Martin Street through his investigation, with Elaine Turner, of the key sites of Gönnersdorf and Andernach (Jöris et al., 2011) and his overviews of the European Upper Palaeolithic (Gaudzinski-Windheuser et al., 2011).

Martin has been at the forefront of research refining the chronologies of the Late Glacial and the Early Holocene. In 1997 he was part of the group that used AMS dates from Central and Northwest Europe to model the expansion northwards of humans from the refuges of Southern Europe (Housley et al., 1997). Then with Thomas Terberger he refined this model through the excavation and dating of Wiesbaden-Igstadt in the Rhineland (Street and Terberger, 1999), and later expanded to an analysis of the entire German Upper Palaeolithic (Street and Terberger, 2000). The importance of the Badegoulian outlier, Wiesbaden-Igstadt, is that it contradicted the model of abandonment during the Last Glacial Maximum (LGM) of Central Europe. What Martin uncovered was evidence for a continuing, if small, presence under the harshest conditions; a situation reminiscent of the British Upper Palaeolithic at sites such as Paviland (Jacobi and Higham, 2008) and King Arthur's Cave (ApSimon et al., 1992) in the lead-up to full glacial conditions. Continuity and resilience, albeit at low population numbers, would appear to have been the norm in Late Palaeolithic Europe.

The potential of tephrochronology

In this paper we examine further another of the dating projects with which Martin was associated. RESET (RESponse of humans to abrupt Environmental Transitions) was a five-year (2008-2012) Consortium funded by the UK's Natural Environment Research Council (NERC). Using the potential of cryptic tephras (Davies, 2015) it sought to produce an independent framework to enhance the precision and accuracy of radiocarbon dates (Lowe et al., 2012, 2015). Here we explore the theoretical implications of the RESET tephrochronological lattice for how we analyse the Palaeolithic archaeological record. The lattice enables us to

- evaluate appropriate spatio-temporal scales for analysing change,
- assess similarities and/or differences in cultural records connected by the same tephrochronological marker,
- establish how "universal" or localised and/or contingent changes in human behaviour were across continents and their varied environmental zones.

The success of RESET in identifying new cryptotephra records in archaeological sites (Housley et al., 2012, 2015; Davies et al., 2015; Ramsey et al., 2015) encourages us to reconsider our basic approaches to the Palaeolithic, in particular how we conceive and model drivers of cultural change. Did processes of *selection* (whether social or environmental) operate on the generation of cultural innovations, or did environmental *needs* and stimuli catalyse sudden cultural transitions (with intervening 'epochs' of cultural stability)? The latter model is perhaps easier to falsify, as it is largely dependent on external, large-scale stimuli, such as AETs, to instigate change in the record. The ability to match tephrochronological lattices to increased precision in the dating of diagnostic archaeological artefacts enables us to assess the degree of environmental cause and effect in the instigation of cultural change.

The demonstrable AETs recorded in ice and marine cores do not describe all the rates of change. Indeed, it is important to emphasize that much of what happened in the Pleistocene cannot be described as abrupt. But in the last 48 ka, in the region influenced by the North Atlantic climate system, the palaeo-environmental record identifies several AETs that ushered in both warmer and colder conditions (Blockley et al., 2012; Lowe et al., 2008). The evidence consists of the relatively short-lived D-O cycles and Heinrich events, as well as the longer Greenland GI-1 Interstadial, GS-1 Younger Dryas and Holocene, within which there are significant environmental 'spikes' (Blockley et al., 2018). Whilst there were periods of prolonged relative warm and cold climates, it is the speed of the switch between these states, their onset and ending, which rightly impresses (Steffensen et al., 2008), and which earns them the status of AET. The rapidity of these environmental changes poses a challenge to the analysis of other forms of archaeological data where temporal precision has been less detailed.

Whilst environmental and climate studies increasingly focus on high resolution records, archaeologists struggle to link human behavioural change to observed abrupt climate change. The improvement of archaeological chronologies is the key, for knowledge of the order of events gives insight into possible consequences, and explanations are reliant on an accurate understanding of cause and effect. At the moment high resolution environmental records tend to 'hook' or 'suck in' less well-dated cultural developments. Too often an epochal change in the archaeology is observed and an AET or environmental disaster is sought to match and correlate to it. Soon correlation becomes causality for the observed cultural change and an 'explanation' is developed. Given the mismatch in the dating resolutions, such a procedure cannot be described as satisfactory. But is there a better approach? Can the chronology of the archaeology be improved so that the correct sequence of steps may be discerned and we become more confident of distinguishing cause from effect?

THE IMPACT OF ABRUPT ENVIRONMENTAL TRANSITIONS

Many researchers see tephrochronology as the key to improving chronological resolution (Davies et al., 2002; Turney et al., 2006; Davies, 2015). Lasting hours, days or weeks, volcanic eruptions provide almost instantaneous (in geological terms) marker horizons to link spatially-separated sedimentary archives (Westgate and Gorton, 1981; Sarna-Wojcicki, 2000; Lowe, 2011). Additionally, when of sufficient magnitude, eruptions are believed to have the potential to trigger rapid environmental change and produce a corresponding human response. The 39.3 ka super-eruption in the Campi Flegrei, Naples, and the production of 105-300 km^3 of ash (Pyle et al., 2006; Fedele et al., 2008; Oppenheimer, 2011: 209) that fell in a northeast direction across South-East Europe and Russia, has been interpreted as the cause of the demise of European Neanderthals, thus allowing anatomically modern humans into the continent (e. g., Golovanova et al., 2010); an interpretation not however shared by all (e. g., Lowe et al., 2012; Fedele et al., 2008). The Laacher See Eruption (LSE) in Germany at 12.92 ka has been used to explain the distribution of certain Late Glacial hunters on the North European Plain, and is seen as the cause of a major re-organisation of technology and subsistence at the end of the Allerød (Riede, 2007, 2008, 2009). But how convincing are such hypotheses? Abrupt 'Pompeii-like' volcanic-induced catastrophic environmental change could have impacted very significantly on individual human groups, leading to local extinction or abandonment of specific areas (Grattan, 2006). Magnifying the impact to larger regions does call for more careful evaluation. Fisher-gatherer-hunter (FGH) groups differ from agriculturalists in having much larger territories and higher rates of mobility; they have more scope to avoid volcanically-impacted areas without suffering population con-

sequences. Binford's (2001) observation that FGH groups do not exploit all productive niches in their territories, but rather keep back favourable resource centres for times of stress, warns against assuming depopulation of one area necessarily had adverse long-term consequences. Thus Eriksen's (1996) suggestion of a regional occupation hiatus in the Thuringian Basin in the late Allerød and early Younger Dryas, and Riede's (2008: 594) documentation of the same phenomenon in a number of stratified Federmesser-Gruppen sites on the margins of the Central European Uplands are interesting, but need not have been particularly detrimental to the groups affected. Low population levels, large territories and high mobility would allow FGHs to buffer against such adverse AETs. One needs to look for more direct evidence of adverse consequences. Attempts to 'test' the causal relationship between volcanic events and environmental response (e. g., Lotter and Birks, 1993; Riede and Wheeler, 2009) are to be welcomed, though Riede (2014: 347, Tab. 5) has so far been unable to obtain a significant correlation between cultural change and any perturbation caused by LSE tephra fallout.

Whether volcanic-induced catastrophic environmental changes were of a magnitude and frequency to elicit an observable cultural response from European FGH groups is uncertain. Given the low population densities and large territories proposed, for example, for Western Europe in this period by Bocquet-Appel (et al., 2005), we contend that the influence of volcanoes as drivers of cultural change on human populations at a continental scale remains to be demonstrated. Using ethnographic estimates from the Arctic and Sub-Arctic, Bocquet-Appel et al. (2005) put forward population estimates for the Aquitaine region in France of 9000 persons at the LGM. If Iberia and the other intermittently occupied areas of the refugium are included, a meta-population estimate of 17,000 persons in GS-2 is obtained, rising to 64,000 in GI-1 (Gamble et al., 2005: 201); the increase being ascribed to an expansion in the settled area and a demographic response to richer resource conditions in the Interstadial. Like Sørensen (2010), we are sceptical however that patterns of summed probability distributions for Federmesser-Gruppen, Bromme and Perstunian ^{14}C dates necessarily reflect the impact of the LSE (Riede, 2007, 2008). Given the sometimes poor resolution of the ^{14}C data sets and the variable analytical quality of the age determinations, we believe changes consequent with the onset of GS-1 (ca. 200 years later) are responsible for the observed patterns. The suggestion that the impact of the LSE can be observed in the British Isles (Riede, 2008: 594), a region where Laacher See Tephra has never been unequivocally confirmed geochemically, is perhaps another symptom of the lure of AETs and environmental disasters.

This is not to deny the role of volcanic events as correlation points and chronological age markers (isochrons). The presence of such reference markers in natural sedimentary archives has long been recognised (e. g., Lowe, 2001; Lowe et al., 2001; Mangerud et al., 1984; Turney and Lowe, 2001; Vernet and Raynal, 2001). Methodological developments in the recognition of non-visible ash horizons (cryptotephra) have significantly extended the geographical area where tephra may be detected (Blockley et al., 2005; Turney, 1998; Turney et al., 2004). In recent years the resolution of natural environment proxy records has improved very significantly due to the application of tephrostratigraphy with high precision AMS ^{14}C dating of well-characterised molecular fractions, Bayesian age modelling, and the analysis of laminated (sometimes annually-varved) sediments (Blackwell and Buck, 2003; Blockley et al., 2004, 2007, 2008a, 2008b; Lane et al., 2013; Wulf et al., 2013). Extending such developments to archaeological settings is a priority but as we will now discuss, cultural layers have their own concerns.

QUANTIFYING ASYNCHRONICITY IN THE ARCHAEOLOGICAL RECORD

Scales and drivers of change

Scales of analysis in our analyses of asynchronicity (also known as time-transgression) in hominin behaviour comprise our second theme. Since the nineteenth century, it has been customary among archaeologists to consider cultural change as 'epochal' and essentialist, i.e., that change moves in short bursts ('transitions') between one stable phase (a 'culture' or 'industry') and its successor. Essentialism is here used to describe the concept that particular artefact combinations arise quickly, and then remain stable in form and composition ('epochs') until replacement by another. The short periods of transition are often explained by population replacement, by environmental stimuli, or by a combination of both factors. Such models of change are Lamarckian, relying either on ill-defined 'migrations' of peoples, or on changing environments, causing the rupture of stable adaptations through 'urges' or 'needs' to change (Cullen, 2000). Absolute dates, inasmuch as they are used in such essentialist analytical frameworks, exist only to provide 'range-finder' ages for particular cultures or epochs, and are seldom used in a dynamic sense to measure changing artefact morphologies and combinations across time and space. Despite the advances of archaeological theory since Binford (1962), many archaeologists prefer to retain lightly-sketched 19th and early 20th century conceptions of 'culture', in which artefacts respond to changing environments almost irrespectively of human agency (e.g., Djindjian, 1993; Banks et al., 2009) and realistically-conceived social interactions (e.g., Powell et al., 2009).
This section will explore the potential of tephrochronological frameworks (lattices) for measuring archaeological change across time and space, evaluating not only scales and levels of synchronicity between similarities, differences and changes across regions, but also the spatio-temporal relationships of hominin behavioural changes to environmental shifts. "Catastrophic" AETs and environmental disasters, such as the Campanian Ignimbrite eruption and Heinrich Events, are frequently held to have significantly affected hominin economies and survival patterns (Fedele et al., 2002, 2003, 2008; Giaccio et al., 2006; Golovanova et al., 2010; Banks et al., 2013). Among records of such AETs, tephras have distinct advantages: the principal one being that visible and cryptic tephras can be found in archaeological contexts. This evidence of major environmental events within or between archaeological assemblages allows much easier consideration of hominin responses to them than when we try to infer the effects of Heinrich Events, for example, on patterns of behaviour and regional occupation.
In order to assess the supposed deleterious effects of Heinrich Events (for which direct evidence is not found in terrestrial contexts, such as archaeological sites) on the lives of past hominins, radiometric dates were needed to connect spatio-temporal variation in archaeological site distributions to the environmental proxy records (e.g., Banks et al., 2006). Although tephras (whether visible or cryptic) are not found in every archaeological context, and vary in their frequencies of occurrence (Housley et al., 2015), they do occur in archaeological sites, and sometimes more than one eruption is archived in site deposits (e.g., Karkanas et al., 2015). Using these lattices, hypotheses of cultural phasing and asynchronicity can be tested. Change or stasis in the archaeological record can be tested against climatic and environmental conditions, including those created by abrupt events.

Inter-site cultural comparisons

Archaeological stratigraphic analyses are still founded on insights made in the seventeenth century that vertical sequences of layers can be characterised by particular fossil forms, and that these strata can span

large geographic areas. Since the mid-nineteenth century, Palaeolithic archaeologists have identified cultural 'phases' at key sites and extrapolated these sequences to all other sites dug subsequently (e. g., Banks et al., 2013; Dinnis et al., 2019). Thus, the stratigraphic sequence of Aurignacian assemblages from "key" SW French sites has been taken as the diagnostic diachronic framework for that technocomplex (culture), for example, despite the absence of some of those 'phases' anywhere else (e. g., Aurignacian IV) (Peyrony, 1933: 559; Djindjian, 1986: 101; Dinnis et al., 2019).

Figure 1a adopts a schematic rendering of a hypothetical cultural sequence within a region, whose sites have been geographically-ordered by longitude. Three out of the five sites have the same four archaeological industries in the same stratigraphic order, while the remaining two show the absence of one or two industries in their sequences. The provision of absolute dates for many archaeological assemblages has encouraged archaeologists to search for proof of penecontemporaneous phasing of industries over large areas, with each phase being treated as a diagnostic fossil assemblage (*sensu* Hooke [1705] and Steno [1916 (1669)]): each archaeological assemblage is seen as identical in its *essentials* to those attributed to the same phase found elsewhere (e. g., Dinnis et al., 2019). There is assumed to be no change in artefactual morphologies and combinations between the initiation and extinction of a phase, and little consideration of parallel/independent evolution. Figure 1b is the result of such assumptions: each industrial 'phase' can be fitted into a discrete period (A, B, C or D), even if some sites have apparently 'incomplete' occupation sequences. The latter 'gaps' at these sites are explained as occupational hiatuses, with a 'missing' industry failing to utilise these locations during its epoch. Each archaeological industrial phase is assumed to have spread consistently across space from its source (Fig. 1: c) in a spatio-temporal gradient, and it is thought to be homogeneous in its composition, with no discernible change in its essential aspects (tool types, morphologies and combinations). Transitional change only occurs when one industrial phase is replaced by another. These essentialist views of change assume landscapes of uniform affordances and resistances ('table-top models') for industries to spread rapidly across; little attention is given to environmental variation (topography, biomass and ecotones), and the role it might have played in facilitating or impeding hominin mobility. Isochronic markers within a chronological lattice allow us to evaluate these universalist and essentialist models of change with more confidence. We cannot assume that cultural successions happened as universal phases across large areas, and lattices enable us to identify the spatio-temporal scales of hominin behavioural mosaics with more confidence. Unravelling the variation in hominin behavioural patterns across time and space enables us to ask the more interesting questions about what might explain such patterning (environmental affordances?, social choices?, movements of individuals and groups?). The culture-historical approach of Dinnis et al. (2019) makes some effort to link typological epochs to a single tephra, but their approach cannot be said to use a tephrochronological lattice. In addition, their epochal treatment of the Aurignacian, with modelled penecontemporaneous diachronic phases, has no evident framework to explain such changes. It is not clear where each phase of the Aurignacian originated (all in SW France?), or what drove their claimed rapid and universal spread over several thousand kilometres: climatic/environmental forcing (assuming no significant time-transgression in AETs across Europe), population turnover (demic replacement), and/or rapid acculturation (social selection at different scales, from artefact forms or types to assemblage replacement)?

Figure 1d shows how isochronic markers can connect together archaeological sites at different spatial and temporal scales. Sites containing just one such isochron can be connected to others with more than one tephrochronological marker, and crytotephras vastly increase the spatial coverage and detail of our comparisons by augmenting the number of locations with such records. In addition, artefacts diagnostic of particular archaeological industries can be fitted into this lattice, ideally using direct (radiocarbon) dates, and their morphological variation over space and time measured to test dynamic (rather than essentialist) hypotheses

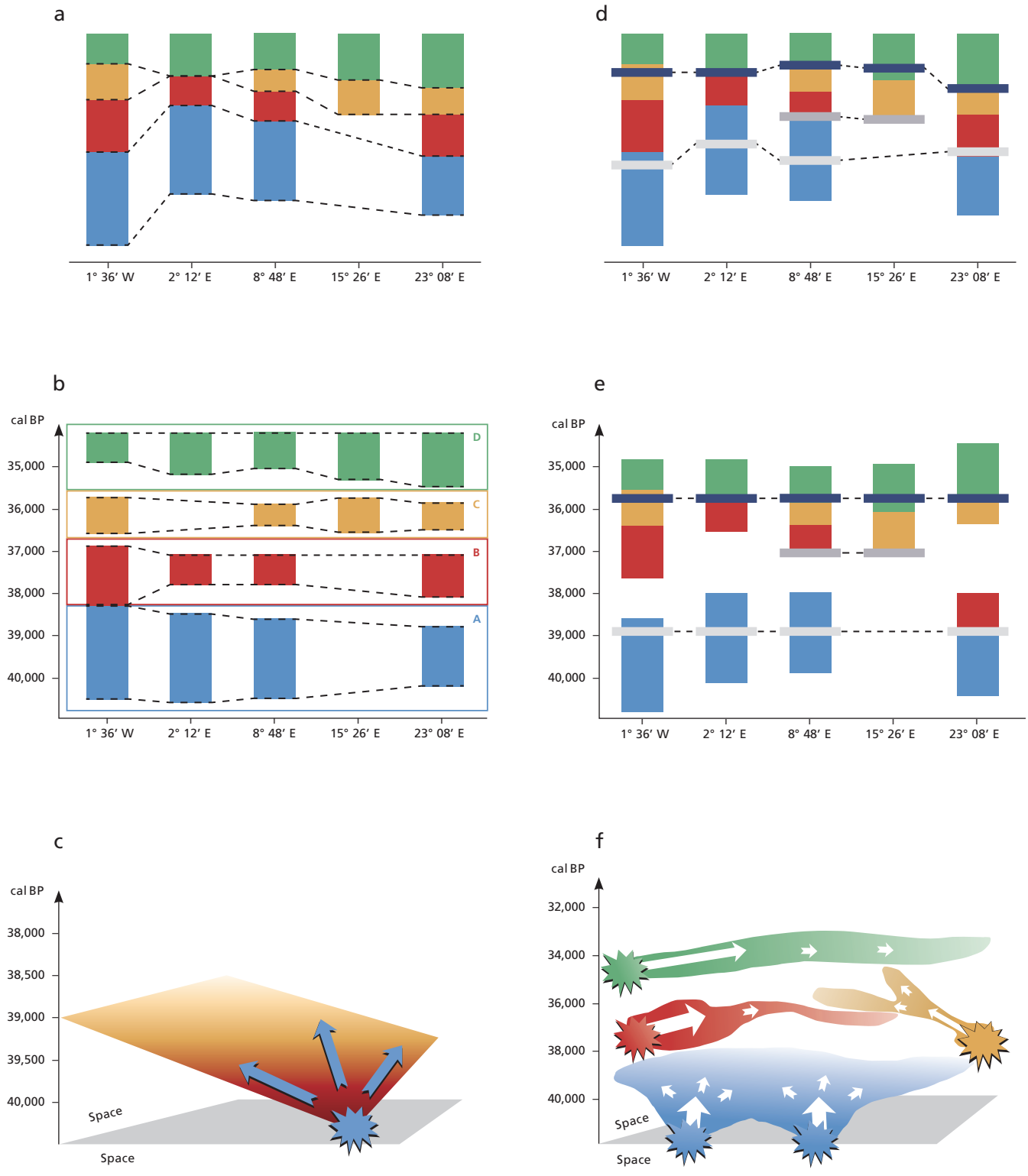

Fig. 1 Schematic depiction of archaeological approaches to behavioural change over time and space. **a-c** 'epochal' views of archaeological cultural successions; **d-f** dynamic and time-transgressive views of cultural change and diversity in the archaeological record.

about hominin responses to environmental conditions. Isochronic markers encourage the re-evaluation of hypotheses of dynamic change in the archaeological record, rather than the presupposition of essentialist phases/epochs of hominin behaviour. Such ideas can be further tested by incorporating morphometric studies of (directly-dated) diagnostic artefact types, to identify any spatio-temporal patterning in behavioural changes and hominin responses to environmental conditions. Not only can independent invention of similar artefact types in different places at different times be addressed, but the *nature* of technological variation across assemblages from the 'same' industries can be evaluated, allowing us the opportunity of dating morphological variation in diagnostic tool types. Ideas of localism and contingency in hominin behaviour, rather than generalising and universalist ones, can be made the main focus of our analyses.

Figure 1e clarifies the different durations and timings of hominin industries at different sites, showing how the spatio-temporal scales of behavioural mosaics might be identified. Reasons other than AETs must be sought to explain 'universal' changes and transitions in Palaeolithic societies and hominin species. Thus, we are evaluating different spatio-temporal behavioural mosaics, with different lead and lag times in their patterns of change (Fig. 1: f). More subtle and inflected conceptualisations of mobility in Palaeolithic populations are thus needed, ranging from daily migrations to trans-generational dispersals (Baker, 1978: 23; Davies, 2012). The reconstruction of different scales of mobility (from tethered movements/return migrations to long-distance displacements) allows us to model the likely effects of varying scales of environmental change (e.g., the proximal and distal effects of volcanic eruptions) on hominin movements. Mobility scales for each region need to be identified, which can then be scaled chronologically within our lattices, and related to assemblage characteristics and resources exploited. This increased spatio-temporal confidence in identifying localised characteristics will allow us to restore perspectives of contingency to our analyses of the archaeological record, rather than in assuming large-scale, universalist 'phases.'

Achieving scales of contingency in archaeology

A combination of direct dating of diagnostic artefacts and the use of tephrochronological lattices allows, for the first time, the potential to measure artefactual changes over time and space. At what spatio-temporal scales do similar behaviours occur? Are they contemporary, spatio-temporally restricted, or apparently unconnected? These questions need to be addressed before we can ask questions about causality of such behaviours and their changes. If we believe that abrupt environmental transitions, such as volcanic eruptions, caused cultural change, then the ecological effects of such transitions need to be clearly modelled (Fedele et al., 2008). Archaeological sites close to an eruption might be expected to display different responses (e.g., extinction/displacement, adaptive change) from those further away (in the distal zone). However, even if tephras are found at the base of an archaeological cultural level, they cannot be assumed *a priori* to have caused that change. Instead, careful evaluation must be made of all sites containing the same tephra marker, and the different stratigraphic positions of the event (at the base of, within or overlying one or more types of archaeological industry: see Fig. 1e) at all available spatial distribution scales (ranging from adjoining sites, to ones hundreds of kilometres apart). If, for example, a tephra marker event is found in various stratigraphic positions, within different archaeological industries, then Lamarckian assumptions of abrupt environmental transitions creating the need/urge for universalist cultural change can be falsified. Universalist assertions of cultural change, such as the transition from Proto-Aurignacian to Early Aurignacian industries as a result of environmental deteriorations attributable to Heinrich Event 4 (Banks et al., 2013), can thus be tested using tephrochronological lattices and direct dating of diagnostic Aurignacian osseous points.

ARCHAEOLOGICAL SIGNATURES FOR DISPERSAL

Culture-people-language signatures and archaeogenetics

Our final theme deals with the spatial and temporal scales of human and hominin dispersal. Among archaeologists it is a long-established tenet that population movements can be distinguished by changes in archaeological cultures. Childe's (1929) famous formulation that a 'people' could be identified by their cultural materials that recurred in space and persisted through time was driven by an interest in the movement of population. As this culture-people model was inspired by an *ethnos*, its full formulation should include a linguistic component. The culture-people-language signature for the analysis of past population movements remains popular among archaeologists, for example Bellwood's (2005) early farming hypothesis and Renfrew's (1987) study of archaeology and language.

Thanks to archaeogenetics, Childe's 'peoples' have now become haplogroup populations, or 'clans', traced predominantly through mitochondrial DNA (mtDNA) (Forster, 2004) and the male specific segment of the Y chromosome (MSY) (Underhill et al., 2001). Increasingly full genome data as well as information from the HLA immune system are extending the power of archaeogenetic techniques (Green et al., 2010; Krause et al., 2010; Thorsby, 2012). Archaeogeneticists have favoured the linkage to culture-population-language signatures (Cavalli-Sforza, 1991; Oppenheimer, 2006), and have developed a phylogeography of genetic dispersal calibrated from language trees. However, the time depth for these population movement signatures extends only as far back as the Neolithic; a limit imposed by the assumed non-survival of Palaeolithic languages.

This important time limit has not stopped the basic culture-people-language model being widely applied to the investigation of prehistoric hunters and gatherers. In particular, the material culture signatures for the Middle and Upper Palaeolithic of Europe have been used as markers not only for peoples but for differentiating hominin species, *H. neanderthalensis* and *H. sapiens*. The use of traits found in the European Upper Palaeolithic (Klein, 1995) has been criticised when applied to a universal human revolution (McBrearty, 2007). Yet despite this vigorous and well-made critique, the same traits (ornaments, Mode 4 lithic blades*, burials, art, settlement, etc.) are widely used as a match of archaeological to archaeogenetic data when studying human dispersal out of Africa and into the rest of the world (Powell et al., 2009; Mellars et al., 2013).

Our concern is that the correlation of culture-people-language (clans) is misplaced. It lacks the chronostratigraphic control, for example the tephra-lattice established through RESET, that would allow an independent test of the culture-people assumption. Without robust chronostratigraphic frameworks, the environmental context for dispersal and the impact, or not, that abrupt environmental transitions may have had on the process, remain conjectural. The process of data-fitting, for example in the correlations drawn between pots, languages and phylogeography in the Neolithic dispersals, or matching small pieces of scratched ochre and projectile point typologies to the various haplogroup 'clans' of the preceding Palaeolithic, is no substitute for a rigorous critique of independently-dated lines of evidence.

While archaeogenetics has revolutionised the field of population history, we are in danger of minimising those advances by applying outmoded archaeological taxonomies to their results. For all the sophistication that archaeogenetics has brought to population history, the expectation still exists for the correspondence

* Clark (1961, 1969) defined five Modes of stone tool production, of which Modes 2, 3 and 4 are used here. Mode 2 encompasses bifacial (handaxe) technologies of the Acheulean and later periods, where a nodule is flaked on both surfaces to produce a cutting tool. Mode 3 is defined by careful preparation of the stone core, allowing flakes of predictable dimensions and shape to be removed; a key example of Mode 3 is Levallois technology. Mode 4 is also dependent on careful core preparation, in this case to produce elongated, consistently-shaped products – called *blades* – significantly longer than they are wide, with straight, parallel margins.

Archaeological evidence	Weak	Strong
Human remains	None or very few	Many
Geographically and temporally distinctive stone and organic artefacts (projectile points, bifacial hand-held tools, boats, houses, ways-of-making)	None or few. Poorly-defined hronological spans. Reductive technologies with an instrument focus. Some additive ways of making.	Present, sometimes in quantity. Composite, additive and container-based technologies, as shown by tools, dwellings and transport. Well-defined chronological spans.
Geographically and temporally distinctive display objects (body, dress ornament, materials which change surface colour and texture, e. g., ochre)	None or few. Poorly-defined chronological spans.	Present, sometimes in quantity. Well-defined chronological spans.
Accumulation of distinctive artefacts	Rare, and only as sets of similar objects and materials	Common as sets of similar and diverse objects and materials
Enchainment through materials and artefacts	Short distances and rare occurrences	Longer distances and common occurrence
Domestic resources (plants, animals, food and power)	None or rare	Present, and usually essential for population dispersal

Tab. 1 Two archaeological signatures for population dispersal.

with culture-people-language signatures. This is clearly seen with the claims for a rapid Clovis expansion (Martin, 1973), which is of interest from the perspective of spatial and chronological scales. It operates at a continental scale and over comparatively short Late Glacial timescales. A robust audit of the available radiocarbon dates has undermined the likelihood of a Clovis population movement, pointing instead to the existence of a pre-Clovis population through which the distinctive projectile points spread like a virus (Waters and Stafford, 2007). The interest in Clovis is no longer one of culture-people as a signature of dispersal but instead an analysis of how demographic frameworks govern the transmission of novel information (Richerson and Boyd, 2005). A contrasting example is the case of Late Glacial Europe, where a similar robust analysis of the available radiocarbon dates confirms Dolukhanov's (1979) original model that human populations dispersed northwards from a south western refuge (Housley et al., 1997; Gamble et al., 2005); a pattern subsequently supported by archaeogenetics (Pala et al., 2012; Torroni et al., 1998).

Strong and weak signatures: importance of archaeological visibility

From these examples we generalise that the evidence for population movement comes in two forms: weak and strong archaeological signatures. The expectations are set out in Table 1 and are confined to archaeological evidence alone. In Table 2 some examples are provided. One obvious, but important, distinction between the Clovis and the Magdalenian/Epigravettian studies is the demonstration for the latter that they moved into unoccupied territory (the Badegoulian outlier excepted). Both are strong, highly visible signatures based on similarity among artefact types that are well constrained by the chronological evidence. But they represent two different processes: cultural diffusion vs. the physical movement of people.
These examples sharpen the focus on another strong signature, the appearance of the Upper Palaeolithic in Europe. As we have discussed this presents an extreme case of the culture-people-species assumption. The

power of the assumption overrides the scanty evidence prior to 40 ka for any stratigraphic association between anatomically modern human skeletal evidence and the traits of the Upper Palaeolithic (Zilhão, 2007; Hublin et al., 2020). Yet when found, blades and beads are instantly regarded as evidence for the arrival of a new species and the start of the demise of the existing Neanderthals. The impossible coincidence that Neanderthals could have decided to become modern at the moment *H. sapiens* arrived in Europe (Mellars, 2005) needs to be rephrased to consider the lack of evidence linking the Upper Palaeolithic to *H. sapiens* in the first place. Debates concerning the contemporaneity of Neanderthals and anatomically modern humans in north-western Croatia (Karavanic, 1995; Karavanic and Smith, 1998), south-western France (Hublin et al., 1996), and Hungary and Moravia (Allsworth-Jones, 1986, 2000) question the assumption that acculturation may not be an agent.

Such data-fitting is also evident in the debate surrounding the dispersal of modern humans from Africa. Currently two models are on offer. An older dispersal, that occurs on stratigraphic grounds before the Toba ash and the onset of MIS 4 at 71 ka (Petraglia et al., 2007), is contrasted with a more recent dispersal ~ 60-50 ka (Mellars et al., 2013). Both interpretations have their problems. The long chronology relies on a weak signature based on the lithic data. Because moderns, as they passed eastwards through South Asia, did not have a European-style Upper Palaeolithic they are archaeologically invisible. This is not due to lack of evidence but to the character of the lithic assemblages they made (Mode 3 *). Rather than seeing a European-style signature with new items made in a distinctive way, we are instead left searching for hints from a Mode 3 technology that passed through an existing Mode 3 technology (Foley and Lahr, 1997; Armitage et al., 2011).

Supporters of the later chronology have similar procedural difficulties. They subscribe to the view that modern humans will be distinguished archaeologically by a strong signature; a view derived from the European record. This leads them to draw comparisons between artefact types in South Africa and Sri Lanka and present the similarities in backed segment forms as evidence for people on the move (Mellars et al., 2013: Fig. 3). This analysis does not consider the demographic framework for the transmission of culture (see the Clovis example above) or the possibility of convergence in cultural innovation. Instead it belies a

	Weak	Strong
Population dispersal into unoccupied land		Humans first arrival in Australia, the western hemisphere, Late Glacial northern Europe and remote Oceania
Population dispersal and displacement within a previously inhabited continent	Repeated *Homo* dispersals in the Old World that involve Modes 1 and 2 technology; Movement of Mode 3 using humans from Arabia to Sunda pre-Toba ash	Modern humans into Neanderthal occupied Europe and southern Siberia; Neolithic farmers into Mesolithic Europe; Bantu migrations within Africa
Transmission of cultural material and information within an inhabited continent that involves no population movement or displacement	Mode 2 Acheulean bifaces; Mode 3 Levallois technology	*Nassarius* shell ornaments in south and north Africa; Clovis bifaces throughout the western hemisphere

Tab. 2 Examples of weak and strong signatures for population movement. Modes refer to Clark's (1961, 1969) technological divisions *.

rather outmoded view of how population movement is to be traced archaeologically; one, moreover, that is subservient to the non-radiometric dating used by archaeogeneticists.

Potential impact of a chronological lattice

This debate is set to run for a long time. It could of course be truncated if a chronological lattice existed through which competing claims could be evaluated. But even at this stage of lattice development we can see that archaeologists urgently need to revise their traditional notions of what constitutes a signature of dispersal (Gamble, 2013). It is not enough to be told by archaeogeneticists (whose molecular chronologies are, in the absence of a tie-in with archaeological data, unverified by independent means) that a dispersal took place and then search for its signature. The challenge for supporters of the pre-Toba chronology is to devise further ways to boost the weak signature while adherents to the post-Toba timing need to abandon the idea inherited from Childe's European data that a strong signature *must* exist to mark the passing-through a region of a people and a species.

The experience from RESET, which built a continental-wide lattice, is that an issue such as the timing of the transition between two strong signatures – the Middle and Upper Palaeolithic of Europe – can be resolved. Moreover, the role that AETs might, or might not have played can then be established (Lowe et al., 2012). In this example (**Fig. 2**), the presence of a distinctive major tephra horizon (CI or Campanian Ignimbrite) demonstrated cold/arid conditions associated with Heinrich Event 4 (HE4) were not the primary driver of cultural changes, population dispersals or regional Neanderthal extinction in Northern and Eastern Europe over this period. Moreover, the eruption was not in itself responsible for the demise of hunter-gatherer groups except for those in proximity to the eruptive centre. However, the RESET example is still some way from providing understanding of such a major transition in terms of the most popular explanation – the incoming *movement* of a new species with a Mode 4 technology into the continent occupied by a hominin with a Mode 3 technology. Whilst a searchlight can be shone on the weaknesses in current archaeological approaches to culture change, chronology is only part of the equation.

CONCLUSIONS

This paper has largely been critical of established archaeological methods of correlating behavioural change in the Palaeolithic with specific environmental events (AETs and environmental disasters). Many of our analytical techniques and units were defined in the nineteenth century, and have not been seriously re-evaluated for the twenty-first century; they are incompatible with population models created by archaeogeneticists (phylogeographers). We now have more refined and detailed models of environmental change over time and space, created by tephrochronological lattices and direct dates on diagnostic artefacts, which allow us to address time-transgression and localised responses to environmental change. We argue that our chronological frameworks need to serve the evaluation of archaeological models emphasising social interactions and mobility strategies in response to fluctuations in environmental resources, rather than to calibrate the transitions of epochs.

We need more subtle methodologies to differentiate the archaeological signatures of diffusion of ideas and concepts within established groups from those left by dispersing populations. Key to this methodological advance is the recognition of different scales of change within archaeological contexts, from (1) morpho-

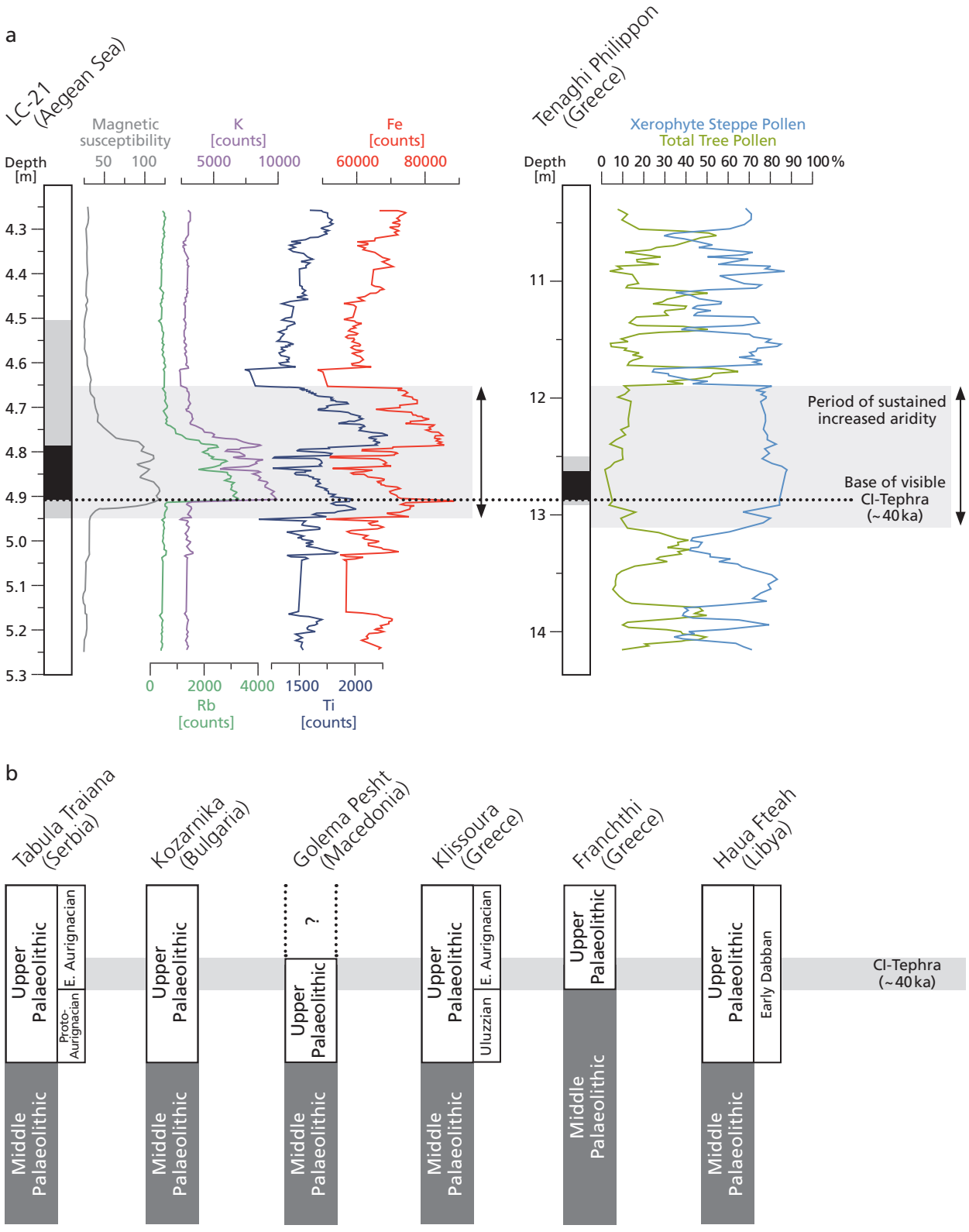

Fig. 2 **a** Position of the Campagnian Ignimbrite (CI): (black, visible glass shards; grey, cryptotephra) with respect to proxy evidence for a period of dry conditions in the eastern Mediterranean considered to approximate Heinrich Event 4 (HE 4). In core LC21, peaks in concentrations of magnetic susceptibility, Rb, and K correspond to peak CI tephra influx, whereas the longer-lasting high values for Ti and Fe reflect higher atmospheric dust influx. The marked reduction in tree pollen percentages in the Tenaghi Philippon sequence is also considered to reflect adversely dry conditions. The CI occurs early in this dry phase, which dates it to the lower part of HE 4. – **b** Schematic representation of the position of the CI with respect to the Middle Palaeolithic (MP) to the Upper Palaeolithic (UP) transition in six of the archaeological sequences investigated within the RESET Project. – (from Lowe et al., 2012: Fig. 4).

logical modifications of particular artefact forms, to (2) replacement of one artefact type with another, to (3) complete replacement of one industry with another (Davies, 2012). Scale (1) is one of the hardest to analyse in Palaeolithic archaeology, unless clear choices in form can be identified in different regions and/or at different times, because its speed is too fast for the precision and accuracy of most radiometric dating techniques. If, however, morphological variation in artefact forms can be dated across a region using an isochron, then at least we have a chance of identifying some (moderately time-averaged) variation in assemblages where there is a tephra marker. Scale (2) also benefits from being fixed within a tephrochronological lattice, ideally in conjunction with direct dating on the artefact if it is organic. Scale (3), in theory, could have occurred as fast as scale (2), marking the arrival of new cultural practices or ideas as an abrupt cultural event. This complete turnover in cultural practice might be attributable to the sudden wholesale replacement of socially-desirable technologies and techniques by an established population, or – perhaps more likely if it appears to have been sudden – the arrival of groups with new behaviours in a region. Careful evaluation of economies (resources used, and in what fashion, as exemplified by the work of Elaine Turner and Martin Street), as well as of the surviving artefacts, throughout site sequences is needed to provide a social context of assemblage and artefactual turnover for the assessment of scales of change. In addition, scales of environmental alteration by disasters can be modelled for volcanic eruptions: archaeological sites located in the proximal zone (defined largely by visible tephra deposits within stratigraphic sequences) contrasted against those found in the distal zone (largely cryptic tephra markers). We argue that regions in the distal zones would have been less affected (if at all) by eruptions; in these cases, the tephra primarily allows us to construct spatio-temporal lattices, rather than forcing us to model scales of environmental deterioration.
The task for future analyses is to integrate and test/cross-reference different chronometric records. Sites with both directly-dateable diagnostic artefacts *and* tephra isochrons need to be identified, so that the two chronological frameworks can be more tightly meshed. Direct evidence of AETs and environmental disasters in archaeological sites, such as tephra isochrons, can then be matched with direct evidence of hominin responses to their environments (as represented by dateable organic artefacts, including different forms of projectile tip). Only by taking such a multi-aspectual approach can archaeologists grasp something of the dynamism of past FGH responses to environmental variation, and thus overhaul their causal explanations for cultural change. A firmer understanding of *speeds* of change, both environmental and archaeological, will be essential for new explanations of Palaeolithic variation in time and space.

Acknowledgements

Funding for this paper came from grants NE/E/015905/1 and NE/E01531X/1 awarded to RESET by the UK's Natural Environment Research Council (NERC). This publication forms RHOXTOR contribution number RHOX/038.

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INTEGRATING ANTHROPOLOGICAL THEORY AND COMPUTATIONAL ARCHAEOLOGY

Abstract

Reconstructing human population dynamics in the past is a key aspect of archaeological research. The archaeological and palaeontological records contain important demographic clues but, whereas the temporal and spatial distribution of morphologically distinct taxa may be relatively easy to establish, identifying the presence of discrete human populations is fraught with difficulty. Drawing a link between patterns in the archaeological record and the existence of *specific* human populations at a given point in time is a major hurdle. It is surprisingly difficult to establish whether archaeologically recognised entities represent discrete biological and social entities. Estimating the size of these entities at a given moment in time is complicated by a combination of chronological uncertainty and relatively small sample sizes. Furthermore, a given population's size, distribution and rate of growth affects its archaeological visibility. This has obvious implications for our ability to interpret patterns in the material culture record in terms of past population dynamics.

Keywords

Hunter-gatherers, foragers, ethnography, computational archaeology, modelling, demography

INTRODUCTION

The size, spatial distribution and chronology of archaeological sites are our only proxies for estimating key demographic parameters of archaeologically recognised groups, or "cultures", in Prehistory. Numerical models have been used to estimate the size and density of Palaeolithic populations on the basis of these data (e.g., Bocquet-Appel et al., 2005; Bocquet-Appel, 2008; Sørensen, 2011; Bocquet-Appel and Degioanni, 2013; Crema et al., 2016). Ecological modelling techniques are increasingly used in archaeology to define and map the distribution of human habitats and, thus, populations in the past (e.g., Banks et al., 2006; Banks et al., 2008; Banks et al., 2011; Gautney and Holliday, 2015; Burke et al., 2017; Ludwig et al., 2018; Tallavaara et al., 2018) and to study the impact of population dynamics on gene flow and patterns of cultural transmission (e.g., Henrich, 2004; Collard et al., 2005; Derex et al., 2013; Derex and Boyd, 2016; Creanza et al., 2017; Wren and Burke, 2019; Sterelny, 2020). Underpinning much of this research, often implicitly rather than explicitly, is a body of anthropological theory and ethnographic observation that should not go unexamined. Questionable stereotypes about the social organisation of foragers persist and continue to colour our interpretation of the Palaeolithic archaeological record. The goal of this paper is to identify some of these stereotypes in the hopes that, if archaeological modellers chose to use them, they will not do so uncritically. Finally, the advantages of a dynamic model of foraging social structure is highlighted.

Most researchers today would agree with Isaac (1968) who points out that direct analogy between historically known hunter-gatherers and prehistoric people is an oversimplification that has no place in archaeological research. Direct analogy has also been criticized for its implicitly racist undertones. In addition, many historically documented foragers were not "pristine" and contemporary foraging societies often occupy

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.868.c11319

the margins of what were once richer and far bigger territories (e.g., Leacock, 1978; Clemmer, 2009; Kelly, 2013). However, anthropology has a well-developed body of theory that addresses these problems, as we will see (and as Sahlins points out) even "acculturated" groups provide useful insights into the social mechanisms of foraging societies (Sahlins, 1993).

In what follows, I use the term "forager" to designate people whose subsistence economies are based on the extraction of natural resources, as opposed to people who are engaged in food production. Other terms that have been used to designate foragers include hunter-gatherers, or hunter-gatherer-fishers, or hunter-collectors. I use the term "forager" fully aware that the distinction between foragers and farmers, i.e., between food extraction and food production, is a gross oversimplification of the full spectrum of human/environment interactions implicated in human subsistence practices both past and present. I also skirt the issue of complexity mostly because my focus is on the Palaeolithic and, although complex hunter-gatherer adaptations may have arisen during the Palaeolithic, they did not become widespread until the Mesolithic (Hayden, 2014).

IS THERE A SINGLE MODEL OF THE SOCIAL STRUCTURE OF FORAGING PEOPLE?

Over the years, different "models" (here, the term does not designate a formal model but rather a conceptual model) of foraging social organisation have been proposed. It is worth gaining some historical perspective before reflecting on what these models tell us about identifying cultural entities in the archaeological record and how we can use this knowledge to explore population dynamics in the past using a modelling approach. By the mid 20th century several normative models of band society had been proposed based on ethnographic data. Identifying which model reflected a "pristine" social structure which could serve as a conceptual framework for the evolutionary study of past foraging groups was an active pursuit for many social anthropologists and archaeologists at the time.

Service (1962) proposed that the patrilocal band, which he found evidence for on all continents, was the simplest and therefore oldest form of social structure. Patrilocal bands, as defined by Service, are characterised by low population density (1-50 sq. miles, or ~130 km^2 per person) and small group size (30 to ~100 individuals), male leadership and weakly developed non-kin associations. The key attributes of the patrilocal band, however, are: reciprocal band exogamy, patrilocality and territoriality (Service, 1962).

Birdsell's "dialectical tribe" (Birdsell, 1953; Birdsell et al., 1973), based on the ethnographic record of Australia, adopted many aspects of the patrilocal model. Birdsell promoted the dialectical tribe as the basic demographic unit for "economically simple" groups, which he describes as numbering 500 individuals united by a common dialect (Birdsell et al., 1973: 337). The dialectical tribe, in turn, is composed of one or more "hordes", i.e., local groups equivalent to extended families and numbering roughly 40 individuals each. Hordes are exogamous, patrilineal and patrilocal and are the primary land-owning units. The tribe is assumed to be territorial and the area it occupies is determined by climate conditions (e.g., rainfall) which drive productivity (Birdsell, 1953). It should be pointed out, however, that Birdsell's "optimum number" of 500 individuals glosses over considerable variability in the ethnographic record of Australia, considerably weakening the case for its universality (see Hiatt, 1968: "Discussions, Part V"). Birdsell excluded from analysis smaller or "fragmented" tribes (which he considered to be in a state of disequilibrium as a result of social upheaval) and much larger social units, or "confederacies of tribes" (which numbered in the thousands), which had matrilineal descent systems.

Wobst (1974) uses numerical models, life tables and mating rules to calculate the minimum equilibrium size of "mating networks", or maximum bands, which he equates with Service's patrilocal bands, Birdsell's dialectical tribe and Steward's maximum band (Wobst, 1974: 49). Again, a patrilocal model is explicitly embraced. The rationale behind Wobst's work is that group size should ensure that upon reaching sexual maturity, an individual will find a suitable mate within the network. Wobst assumed that maximum bands are bounded (territorial) and composed of smaller social units, or "minimum bands". Wobst's models suggest maximum band sizes of between 250 to 500 individuals (the upper size limit is similar to Birdsell's empirical calculations) and a minimum band size of roughly 25 people. He also predicted the emergence of network-specific styles as expressions of the social boundaries that were assumed to exist between maximum bands. As Gamble (2000) points out, however, a mating network is not a society; Wobst's approach, which equates the social with the demographic and only deals with the territorial and residential aspects of social organisation, is reductive (Gamble, 2000: 24).

Steward (1955) proposed the composite band model, which he believes results from two factors: the presence of gregarious herd species and the introduction of unrelated families into patrilineal bands (Steward, 1955: 149) – which implies that it was not in contention to be a model for Palaeolithic band structure. The composite band is composed of a group of biologically unrelated families whose constant association results in a level of social integration. In other words, spatial proximity is the mechanism by which these bands are socially integrated, rather than patrilineal descent and a shared language. Other key features of the composite band, according to Steward, are low population density, relatively large band size, the absence of exogamy and post-marriage residence rules, political autonomy and the control of access to resources within a band's territory without implying boundary defense.

The first "Man the Hunter" conference, which gave rise to an ongoing series of international conferences (the Conference on Hunting and Gathering Societies, or "CHAGS" conferences), was held in Chicago in 1966. The conference brought ethnographers, archaeologists, linguists and demographers together to conduct a "state of the art" survey of foraging societies and debate its implications (Lee and DeVore, 1968). By then, Service's patrilocal band (Service, 1962) based on earlier work by Radcliffe-Brown (1931), had already faced several challenges (e. g., contributors to Damas, 1965). The "Man the Hunter" conference would seriously weaken its claim for universality in addition to challenging its core assumptions (see contributions to Lee and DeVore, 1968).

The assumption of linguistic and cultural homogeneity, which would potentially have made the patrilocal band visible in the archaeological record, was also challenged by several ethnographers (e. g., Leacock,1969; Owen, 1965; Hiatt, 1968; Lee and DeVore, 1968; and contributors to Damas, 1965). Owen, for example, argued that in ecologically diverse settings with low population densities exogamy would result in the movement of individuals between culturally and linguistically differentiated bands, creating "culturally hybrid" social units (Damas, 1965: 683). The assumed adaptive advantage of virilocality was challenged by Lee (1962) and by Yellen and Harpending (1972). Discussants at the Man the Hunter conference (Lee and DeVore, 1968: Chapter 17) and later publications further argued that patrilocality was maladaptive as it would hinder a group's ability to smooth out demographic variation (e. g., sex ratios), tailor group size to available resources or resolve conflict through fission (Lee and DeVore, 1968; cf. Lee, 1972: 126). As a result of these criticisms and with increased awareness of the diversity of the ethnographic record, the prevailing model of foraging social organisation that would emerge during the second half of the 20th century, which owes a lot to Lee's work in the Kalahari (described below) rejects many of the previous assumptions and features relatively open social groups occupying overlapping shared territories.

THE FLUIDITY OF FORAGING SOCIAL ORGANISATION

Lee's seminal work in the Kalahari among the Ju/'hoansi (previously, and erroneously, labelled the !Kung) describes a flexible social system capable of adapting to fluctuations in the distribution of resources on the landscape at various temporal and spatial scales (Lee, 1968, 1972, 1979). The Ju/'hoansi live in small, highly mobile groups (or "camps") that form part of a larger social unit (Lee, 1972). The "camp" is a noncorporate, bilaterally organised group of individuals living and moving together for at least part of the year. Seasonal rainfall patterns are a limiting feature of life in the Kalahari, and groups aggregate around permanent waterholes during the winter dry season, or when seasonally aggregated resources (such as the mongongo nut) are present. A resident group is composed of a core group of kin (siblings and/or cousins) "generally acknowledged to be owners of the waterhole" (Lee, 1979: 77). The land around the waterhole (the *n!ore*) contains the basic subsistence resources for the group, but access to a larger territory is essential for the survival of the group in order to adjust to long-term patterns of resource scarcity. Associations between specific people and waterholes vary from several years to several decades and Lee estimates the "half-life" of a group's tenure to be between 30 and 50 years (Lee, 1979).

Seasonal mobility and a cycle of population aggregation and dispersal is a central aspect of Lee's concept of the social and spatial organisation of foraging bands. This cycle is driven by resource availability and governed by "rules and practices for allowing reciprocal access to, or joint exploitation of, key resources" (Lee, 1979: 91). Lee emphasises the fluidity of Ju/'hoansi spatial and social boundaries in his ethnography. Both kinship and access to resources are negotiable, and this fluidity ensures that a group's subsistence requirements are satisfied with minimal friction. For example, individuals inherit a *n!ore* from either or both parents, but gain access to other *n!ore* through marriage and "visiting", creating a state of flux in the composition of groups. As Lee notes, this allows for higher population densities than could otherwise be supported under existing conditions of environmental instability. Although Lee describes foragers as finding "a social solution to an environmental problem" his focus is on the adaptiveness of the social system as he invites the reader to "consider a more dynamic model in which interlocking aggregations of persons undergo continual reshuffling of groups in response to short- and long-term environmental fluctuations and to changes in population density." (Lee, 1972: 142).

Myers' ethnography of the Pintupi (Myers, 1982, 1986, 1988) also reflects the dynamic approach to foraging society that developed in the 20th century. Unlike Lee, however, who emphasised the adaptive rationale underlying forager social organisation, Myers describes the Pintupi social system as primarily oriented towards reproducing relations between individuals, i.e., towards social reproduction. The production of "social persons" is described as culturally important to the Pintupi and social networks are inclusive. Individual networks of dyadic relationships are viewed as *constitutive* of social structure at all levels of integration. Finally, Myers emphasises that the formation of groups is a social accomplishment, rather than a given (Myers, 1986: 72).

Pintupi land ownership is the materialisation of social relations rather than the reverse, and land encodes the history of relatedness of people and is a marker of social identity. Ownership does not imply territoriality, rather the "content of ownership […] is the right to be asked." (Myers, 1986: 99) and the emphasis on relatedness makes it difficult to refuse access. Mobility is not only regulated by the distribution of resources but also by the "organizational requirements of a complex regional system of social relations" (Myers 2002: 1). Myers' emphasis on social reproduction does not mean that he negates the importance of the resource base, however, but he cautions against reifying the group:

> "It seems sensible to characterize Pintupi bands as hypothetical entities moving through an optimal pattern of resource-scheduling, with different individuals affiliating themselves to these groups as they move place to place […]. The size of this abstract band may remain relatively constant while the actual composition may vary greatly. The important requirement is that individuals must affiliate with the residential group to use the land. The state of resources determines where people may be, but not necessarily where they actually are, or precisely who is where" (Myers, 1986: 97).

The last point, that groups are not static entities, is important for archaeologists seeking evidence for the existence of distinct "cultures" in the archaeological record. The level of social integration that would be required to create a recurring pattern in the archaeological record cannot be *assumed* to emerge, especially at the regional level where stable networks of social relations are the most difficult to maintain due to social and geographical distance.

THE CASE FOR DIVERSITY AND A NON-PRESCRIPTIVE MODEL

The archaeological vision of foraging society that emerged during the 20th century was largely based on the small-scale, egalitarian society described by Lee, dubbed the "original affluent society", or OAS, by Rowley-Conwy (2001). The OAS incorporates familiar concepts, such as: 1) little personal property and an egalitarian social system; 2) a pattern of fission/fusion; 3) a high level of individual mobility between bands; 4) fluid organisation involving no territorial rights; 5) no strong attachment of a group to a particular area, and 6) a lack of storage technology (Rowley-Conwy, 2001: 40). Explicitly or implicitly, this model was and, to a certain extent still is, widely adopted in archaeology as what Gamble (2000) qualifies as convenient "mental shorthand" for describing the social structure of Palaeolithic groups. The inherent fluidity of the OAS offers a satisfactory explanation for the long-term resilience of human foraging groups but it ignores the power of historical contingency and, more importantly, does not address the diversity of either the ethnographic or archaeological records. Finally, it reifies the group, generating assumptions about group size, mobility, social integration, and the emergence of linguistic and cultural homogeneity that the archaeological record is at pains to support. Clearly, the OAS should be discarded or at least updated to include current anthropological thinking.

The weight of ethnographic evidence accumulated over the course of the 20th century lead anthropologists to emphasise the diversity of social forms among foraging groups (e.g., contributors in Kent, 1996; Kelly, 2013). Settlement patterns vary within linguistic groups, different adaptive strategies are used within the same ecological and social environments, and the social structures of foraging groups vary from forms similar to the one Lee described for the Ju/'hoansi to its diametrical opposite (Guenther, 1996: 71). Clearly, proposing a single normative model of forager band structure is difficult to defend (Guenther, 1996). The emphasis in anthropology shifted accordingly to a more dynamic, agent-centered approach, such as the one adopted by Myers (Lourandos, 1997) and described above. This approach provides an over-arching conceptual structure that can accommodate the diversity of the ethnographic record because it does not prescribe a particular social structure. As Guenther (1996) points out, it is the inherent fluidity and the nested structure of foraging bands that allows them to take on various forms.

IMPLICATIONS FOR THE STUDY OF THE ARCHAEOLOGICAL RECORD

Does a dynamic model of social structure, which considers forager groups to be open with respect to territorial and group affiliation, loosely corporate with respect to land ownership and non-hierarchical, explain the diversity of the archaeological record? What are the archaeological implications of adopting this model?

Firstly, let us consider whether there is archaeological support for the proposed model. Archaeological data suggest that foraging groups share resources, either through trade mechanisms or simply through the existence of overlapping territories. Loring (2002), for example, identifies several different prehistoric groups in Labrador (Canada) who exploited the same chert source, implying overlapping patterns of land use. He suggests that trade in Ramah chert was an important tool for regional integration among early Late Prehistoric communities along Quebec's North Shore and the Straight of Belle Isle, noting that: "the information that accompanied the raw material would serve to define relationships between groups and prevent rigid social and territorial boundaries from forming" (Loring, 2002: 183). Loring's analysis, therefore, supports the proposition that foraging groups would have had mechanisms to limit territoriality. Archaeological modellers have tested some of the key assumptions of the proposed dynamic model. For example, Pearce (2014) created an agent-based model (ABM) designed to test whether foragers carrying out subsistence activities were able to "inadvertently" maintain social integration (contact between groups) without conducting special "visits" or exchanging tokens. The first null hypothesis, i.e., that maintaining social relations is a trivial task, is conclusively rejected. So, too, is the hypothesis that increasing mobility in regions where population density is low counterbalances the "handicap" imposed by physical distance. In other words, as Myers would have predicted, the maintenance of social networks is work and the work increases with distance.

Indeed, as Myers (1986) notes, social integration should be viewed as an achievement rather than a given. The sum total of individual networks of social relations forms the backbone of foraging social groups and the frequency of interaction determines a sense of common identity and belonging (Bird-David, 2017). Because people find it difficult to maintain social relations over longer distances, the upper-tier of social organisation (the "tribe" or "regional band") is predicted to drop in and out of usage under the influence of interacting variables such as historical contingency, population size, density and the structure of the environment. Cultural differences can be expected to emerge between groups with higher levels of social integration and those without (e.g., Steward, 1938). These differences may or may not include the emergence of archaeologically recognisable expressions of shared culture, although it seems likely that a regionally integrated group has a greater chance of producing a distinct archaeological signature.

Attempts to estimate population size on the basis of site frequencies and radiocarbon dates (Bocquet-Appel et al., 2005; Bocquet-Appel, 2008; Bocquet-Appel and Degioanni, 2013) indicate that Palaeolithic populations in Europe were likely small and highly dispersed. It is quite conceivable that these populations weren't always able to maintain stable social structures at a spatial and temporal scale that would leave a readily discernable pattern in the archaeological record, compounding the problems inherent in cultural taxonomies (Reynolds and Riede, 2019; Sauer and Riede, 2019). Long periods of apparent cultural stasis, for example during the Lower and Middle Palaeolithic in various regions, may well be explained on this basis. Finally, archaeologists encounter difficulties calculating group size when cultural affiliation is unknown or unknowable, but the structure of a population may be just as relevant to the way foragers conducted their lives as its size.

There is not enough space to develop the extensive literature on cumulative culture theory here, but it predicts that connectivity between spatially segregated groups is one of the mechanisms of cultural transformation (Derex and Boyd, 2016). Spatial segregation, especially if groups are poorly integrated at the upper

tier of social organisation, could conceivably produce cultural variants through a process of drift. A dynamic model of social organisation, which places a premium on fluidity, explains why connectivity exists. It also predicts that potential linguistic and cultural barriers arising through a process of differentiation should be permeable, although permeability will decrease with distance and the loosening of social bonds that accompanies it. In other words, the process of cultural differentiation is counter-balanced by an emphasis on permeability and connectivity in foraging societies. The spatial and social limits imposed on this balancing act can be explored in a variety of contexts using a modeling approach.

We can predict one instance when these two processes might have combined to produce cultural change. The archaeological record spans several timeframes when human populations were under significant ecological stress, e.g., during the Last Glacial Maximum (LGM). Ethnographically known foraging groups adopt a more inclusive, open social system when facing ecological risk (Leacock, 1969), allowing people and critical information about resource availability to circulate (Whallon, 2006). On one hand, the archaeological record suggests that climate conditions during the LGM resulted in the creation of spatially segregated refugia. On the other hand, our model suggests that creating connectivity would have been a priority during this event. The creation of cultural variants in spatially separated groups, therefore, would have been counterbalanced by the efforts of people striving to maintain connectivity, resulting in the appearance of new forms of cultural expression at a regional level (the Solutrean).

CONCLUSION

What conclusions can we draw from this brief account of the anthropological theory of foraging social structure? It suggests that, however ingrained they may be in archaeological practice, many of the assumptions inherent in the OAS should be abandoned – or at the very least, they should not be used uncritically. It also suggests that the adoption of a more dynamic approach to social organisation provides a more secure conceptual framework that recognises the role of the individual in building social networks among foraging people and warns us that groups should not be treated as immutable, culturally homogeneous, bounded entities. The dynamic, agent-centred approach described above, with its emphasis on fluidity and a multi-tiered social structure, is adaptive, makes room for the kind of diversity that is present in the archaeological record and has already been successfully integrated (if not always entirely) into computational models aimed at solving important questions regarding the social structure of past human populations (e. g., Grove et al., 2012; Pearce, 2014; Grove and Dunbar, 2015; Wren and Burke, 2019). Further developing this approach in Palaeolithic archaeology should shed light on some of the more puzzling aspects of the material culture record, such as the relatively long periods of apparent cultural "stasis" that have been observed.

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RARE



Elaine and Martin during excavations at the Late Upper to Late Palaeolithic site of Andernach-Martinsberg, when dungarees were at the height of fashion, 1982.

Translated into German, "rare" means "bloody" and as we are all aware "bloody" comes with a *lot* of possible connotations.

Elaine and Martin probably cursed more than once when they took up the enormous challenge of dealing with the research at sites such as Gönnersdorf, Andernach-Martinsberg, Solutré or Taforalt – comprising mega-archives indicating new, more effective and sustainable survival strategies since the post-LGM. Each of these archives can occupy you for a lifetime (which is in fact what we can observe looking at both their scientific careeres) and finding a way through the labyrinth of evidence requires a lot of discipline to not get lost. Elaine and Martin mastered this task brilliantly and trying to summarise all their findings in this context in a few sentences provides us in turn with a challenge that makes us curse.

Just so you know – it was very "rare" that making a living was easily mastered in the past, as numerous rules and regulations had to be taken into consideration. Our personal favourite contribution in this instance refers to their "feather in one's cap" publication where they provide us with a very black and white perspective on fashion during Magdalenian times (Street and Turner, 2016).



The Andernach Team, ca. 1981/82, Martin in the background, looking sceptical.

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Elaine in Solutré (France), ca. 1995.



Martin with Dan Adler in Oerlinghausen, 1997.



Elaine at Solutré (France) with another table of horse bones to be analysed, 1995.

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Carrying capacities! Martin excavating Andernach, 1982.





Coffee Break in Solutré, 1995. Elaine with Dagmar Savelsberg.

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Elaine with Sonja Grimm, Daniela Holst, Lutz Kindler, Michael Baales and Martin during another MONREPOS-Pentecost happening wearing a teeth-collier.



Elaine and Sabine in Solutré, 1995.

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Martin as usual looking sceptical in the background, Elaine in the foreground next to Michael Bolus, ca. 1981/82.



ESTEBAN ÁLVAREZ-FERNÁNDEZ · SERGIO MARTÍN-JARQUE · ANTONIO TARRIÑO

FLINT & SHELL: RAW MATERIALS AS EVIDENCE OF LONG-DISTANCE CONTACTS IN CANTABRIAN SPAIN DURING THE MAGDALENIAN

Abstract

Two types of raw material used by Magdalenian hunter-gatherers are studied here. Based on the archaeological record of five Magdalenian assemblages of northern Spain, flint is first examined with a focus on its provenance before objects of adornment made of marine gastropods from the Mediterranean Sea are analysed. Also modifications of the materials have been studied, providing information of where, how and when these modifications were made. Regional Magdalenian mobility is discussed through the study of these artefacts.

Keywords

Raw materials, flint, malacofauna, hunter-gatherers, Cantabrian Magdalenian

INTRODUCTION

Studies documenting long-distance contacts between Magdalenian hunter-gatherer groups enjoy a long tradition of research in northern Spain. This research has been based on the presence of different kinds of lithic and osseous tools, such as different types of weaponry (e. g., Vega del Sella, 1917; Obermaier, 1925; González Echegaray, 1960; González Sainz, 1989; Utrilla, 1981, 2007) and particular representations in parietal and portable art (e. g., Alcalde del Río et al., 1911; Breuil and Obermaier, 1935; Leroi-Gourhan, 1965; Barandiarán, 1973; Corchón, 1986; González Sainz, 2004; Arias and Ontañón, 2005; Fritz et al., 2007; Utrilla, 2007; Rivero, 2015), including some types of adornment, like *contours découpés*, rondelles and reindeer teeth sawn off at the height of their alveoli (e. g., Fortea, 1983; Álvarez-Fernández, 2006; Corchón et al., 2012). The presence of this evidence in northern Spanish sites is explained by contacts between the hunter-gatherers of this region and those inhabiting other regions of south-western Europe, especially in the French Pyrenees.

Research on the identification of raw materials used in Palaeolithic artefact production (in the Magdalenian in particular), and the determination of their places of provenance have advanced greatly over the last two decades. These studies have concentrated on the flint types used in stone tool production, and some objects of adornment, particularly those made from the shells of marine molluscs.

Studies on the availability and use of flint began to develop in the 1980s, by addressing their sources in archaeological contexts of the Cantabrian region. Other studies were published in the 1990s for Asturias and Cantabria (e. g., Arias, 1990, 1991; Sarabia, 1990a, 1990b, 1999) and by Tarriño and Aguirre (1997) for the Basque Country. Since the start of this century, following the methodological approaches proposed in the doctoral thesis of one of the present authors (Tarriño, 2001), it has been made possible to draw a detailed map of outcrops of siliceous rocks to be found in the eastern part of the Cantabrian region and in the western Pyrenees. Based on this map, a first model of how these resources were used – especially

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.868.c11322

during the Palaeolithic – has been created (Tarriño et al., 2015, 2016; Elorrieta, 2016). At present, these studies are being completed by research ongoing in central Cantabrian Spain (Herrero-Alonso, 2018). All this information indicates extensive mobility of flint in the north of the Iberian Peninsula during the late Upper Pleistocene and early Holocene.

The presence of marine molluscs that originate in the Mediterranean Sea at Upper Pleistocene sites of northern Spain was cited for the first time by H. Fischer (1923-1924: 321-323), who identified a pierced specimen of *Tritia mutabilis* in the Azilian level of El Castillo Cave, excavated by Breuil and Obermaier in 1910-1914. One of the present authors reviewed the collections of shells that were transformed into objects of adornment in his doctoral thesis (Álvarez-Fernández, 2006), in which he documented specimens from Palaeolithic sites in Asturias, Cantabria and the Basque Country. In recent years, the amount of evidence of shell ornaments has increased considerably (Álvarez-Fernández, 2016; Álvarez-Fernández et al., 2019). As a result, shells from the Mediterranean Sea are now known from all periods of the Cantabrian Upper Palaeolithic.

Here, the available information on long-distance contacts in northern Spain during the Magdalenian is compiled, presenting the material of five archaeological assemblages that produced artefacts made of exogenous flint types that originate in the Basque-Cantabrian Basin in the Western Pyrenees and in the Sud-Aquitanian Basin, as well as shells of Mediterranean marine gastropods. The archaeological contexts studied are: Level 1 in the Dwelling Area of the cave of Tito Bustillo, Level 1 in the cave of Coímbre B in Asturias, Level 6 in El Juyo, Level 1 in El Horno, and Level 17 in El Mirón; the latter three caves are located in Cantabria (**Fig. 1**).

METHODOLOGY

Allochthonous flint

Studies of the procurement and use of lithic raw materials at archaeological sites allow the reconstruction of land-use strategies employed by Palaeolithic hunter-gatherers to supply and satisfy their technological needs. Specifically, flint is an ideal material owing to certain characteristics that allow varieties to be identified and discriminated according to their origin, as well as representing one of the material categories that is best preserved in the archaeological record. Its characterisation by textural analysis with a stereoscopic microscope and occasionally with a petrographic microscope in studying thin sections is well-advanced and regularly applied by different research groups. This is possible because of the methods petrologists apply when characterising rocks in order to determine their sources. Such studies allow us to reach conclusions that can be interpreted throughout Prehistoric archaeology (Tarriño, 2001). Within this framework, flint and its outcrops can be classified depending on their distance from the archaeological site where the artefacts have been recorded. In this way, different models have been established for the management of each of the flint types (Tarriño et al., 2015, 2016):

- Local
  Flint types located within a radius that it is calculated as the distance a person can walk in half a day, i. e., < 30 km. This model can be sub-divided into *Near Local* (< 15 km) and *Distant Local* (15-30 km).
- Regional
  Also, sub-divided into *Near Regional* flint transported in a distance equivalent to a day and a half's walk, i. e., 30-60 km, and *Distant Regional*, when the flint is transported over a distance that can be covered within three days, i. e., 60-120 km.

- Tracer
  Flint that can be transported in a journey that a person can make on foot between three days and a week, i. e., ~ 120-250 km.
- Super-tracer
  Flint from distances that require a journey longer than a week, i. e., > 250 km distance.

The distances are calculated *grosso modo*, with 25 km as the average distance that at a person can walk at about 4 or 5 km/h in half a day (ca. 4-6 hours). The flint types classified as tracer and super-tracer that have been documented in the sites studied in this chapter are:

Pyrenean Flysch Flint

Upper Cretaceous Pyrenean Flysch Flint originates in turbiditic geological formations deposited in deep-water environments at the foot of the slopes connecting the marine platforms with the pelagic ocean bottoms (Tarriño, 2006). In general, the rocks containing the silicifications are formed by alternating bioclastic calcarenites with fragments of molluscs and sponge spicules. Inclusions of detritic quartz and organic matter are equally common, together with the occasional remains of planktonic foraminifera (Globigerinidae) (Tarriño, 2006).
The varieties of Upper Cretaceous Pyrenean Flysch Flint identified in the archaeological assemblages studied here are:

- Kurtzia Flysch Flint
  Described by A. Tarriño (2006) for the coastal site of Barrika (Bizkaia). This flint generally displays a translucent matrix characterised by turbiditic laminations. In the microscopic texture it can be identified by its bioclastic content with sponge spicules, detritic quartz, inclusions of organic matter and dolomite crystals.

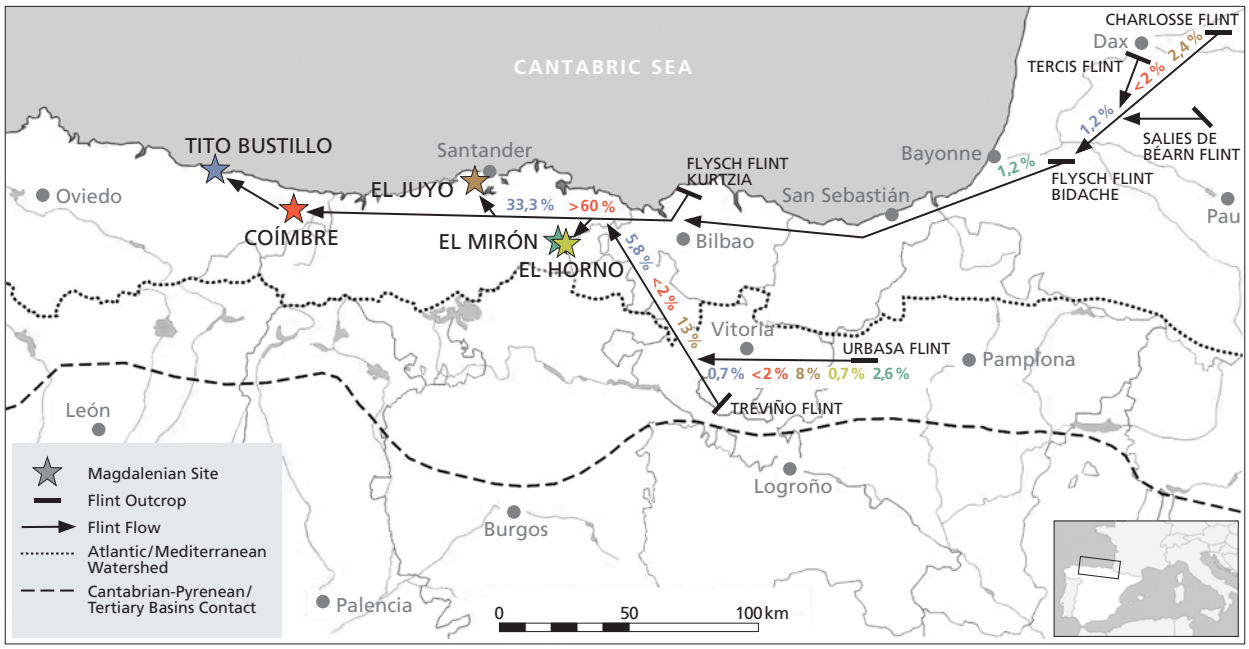

Fig. 1 Map showing the provenance of tracer and super-tracer flint varieties used at the five Magdalenian sites of northern Spain studied here. Percentages of flint flow are colour-coded, referring to the specific sites to which the raw materials have been transported.

- Bidache Flysch Flint
  Described by C. Normand (2002) for the area around the mouth of the River Adour, between Biarritz and the Bidache area (Pyrénées-Atlantiques, France). This material is greyish; one of its most noticeable macroscopic characteristics is the presence of parallel turbiditic laminations, which are quite obvious in case of intensive patination.

Treviño Flint

Continental flint from lacustrine-palustrine environments originating in outcrops located in the Miranda-Treviño Depression. Its silicifications are of Miocene age and appear in the hills of the Sierra de Araico (Treviño-Álava) and its prolongation towards the northern Cucho-Busto Hills (Treviño). Its microscopic texture is usually characterised by silcretes (siliceous layers of stratiform morphology) and micrites (homogeneous carbonate masses). Fossils indictive of continental environments (gastropods, ostracods, pedotubules, etc.) predominate (Tarriño, 2006). The four microfacies differentiated by A. Tarriño (2006) and identified in some of the archaeological assemblages studied here are:

- Bioclastic micrites
  Dark matt flint that usually displays liesegang rings, which are most visible in case of intensive patination. It is accompanied by abundant ostracods and gastropods.
- Clotted silcretes with fenestral porosity
  Dark flint from outcrops in limestone and calcareous dolomite containing stratiform silcretes formed by an accumulation of peloids.
- Brecciated silcretes
  Dark and even blackish flint from a palustrine environment. It has a macroscopic ooidal texture, with abundant moulds of roots and porosity with vadose cementations.
- Micrites with algae lamination
  Banded flint with a certain organic matter content parallel to the lamination, and occasional presence of ostracod valves.

Urbasa Flint

Palaeocene flint found in the Sierra de Urbasa (Navarre). Its silicifications, formed in the external marine platform, have been defined and dated by benthonic foraminifera: Discocyclinidae (*D. seunesi*) and Nummulitidae (*N. heberti*) (Baceta, 1996). This flint – of nodular shape and quite dark colour – contains microscopic relicts of macroforaminifera and echinoderms, and is characterised by significant incipient micro-dolomitization with idiomorphic crystals of 10-20 mm length (Tarriño et al., 2007).

Tercis Flint

From a deep marine environment in the Upper Cretaceous. Its silicifications are found in the area of Tercis-les-Bains, near Dax (Landes, France). It is generally translucent, dark, and with a high macroforaminifera content, comprising both planktonic and benthonic species (Normand, 2002; Normand et al., 2001).

Salies-de-Béarn Flint

Salies-de-Béarn Flint originates from Upper Cretaceous deep marine environments. The silicifications are located in the area surrounding the town of Salies-de-Béarn (Pyrénées-Atlantiques, France). It is a greyish flint with fossils of planktonic foraminifera that is very characteristic due to the abundancy of bioturbations, resulting in a zonal appearance (Normand, 2002).

Chalosse Flint

The Upper Cretaceous Chalosse Flint formed at the outer marine platform. Outcrops are located in the Audignon-Montaut anticline and marginally around the Bastennes-Gaujacq Diapir (Landes, France) (Chalard et al., 2010). It is a bioclastic flint with of nodular shape, translucent and varying in colour from blackish to grey. When patinated, the material acquires more or less zoned white or yellowish tones. At microscopic level it displays high contents of bioclastic inclusions, particularly of bryozoans and macroforaminifera (Lepidorbitoides) (Bon et al., 1996).

Mediterranean shell

Archaeomalacological studies of the last two decades have enabled the identification of the shells of Mediterranean gastropod species at several Upper Palaeolithic sites of northern Spain. The Mediterranean Sea is more than 200 km distant from the Magdalenian of the Bay of Biscay. The shells that derive form archaeological assemblages studied here have been classified by use of reference collections like that of the Archaeozoology Laboratory at the University of Salamanca. The studies are underpinned by both general and dedicated studies (e. g., Borja and Muxica, 2001; Dantart and Luque, 1994; Consolado et al., 1999; Galindo et al., 2016; Gianuzzi-Savelli et al., 2003; Gofas et al., 2011; Hidalgo, 1917; Ortea Rato, 1977; Palacios and Vega, 1997; Poppe and Gotto, 1991; Rolán, 1992; Sauriau, 1991; WoRMS, 2021), providing details about the description, habitat and distribution of the species and information of whether or not they are edible. The origin of the shell is determined by the present-day distribution of the species. The presence of Mediterranean species at Magdalenian sites in Cantabrian Spain, in the interior of the Iberian Peninsula, and north of the Pyrenees (and also in other parts of the centre of Europe) indicates long-distance contacts between hunter-gatherers groups and explains their presence at archaeological sites hundreds of kilometres distant from the shores (Álvarez-Fernández, 2006).
Archaeomalacological studies also involve the study of remains of organisms that populate shell surfaces (i. e., the epifauna, such as the exoskeletons of balanoids) or of alterations caused by them (perforations and incrustations), of evidence of abrasion caused by wave action in a sandy environment (which shows that the shells were picked up on the beach when the animal was dead), of anthropic modifications (scrapings, incisions and perforations; gloss, deformations and fractures by use; intentional staining with dyes), and of post-depositional alterations (precipitation of carbonates or decalcification). These studies also take into account spatial information (e. g., if they are associated with grave goods, or a concentration indicating a possible workshop where ornaments were produced) to determine if their presence in the assemblage is to be explained by deliberate human activity or if they represent objects that were simply lost during the occupation of a site (Álvarez-Fernández, 2006, 2013, 2017).

RESULTS: IDENTIFICATION OF FLINT AND SHELL IN THE MAGDALENIAN SITES OF THE CANTABRIAN REGION

The Living Area (Área de Estancia) in Tito Bustillo Cave (Ribadesella, Asturias)

The Living Area (Área de Estancia) of the cave of Tito Bustillo – today ~300 m from the Sella Estuary and 1 km from the modern coastline – was excavated in the 1970s and 1980s (García Guinea, 1975; Moure Romanillo, 1990, 1997; Álvarez-Fernández et al., 2018). Two levels were documented: Levels 1 and 2. The upper level, Level 1, was in turn divided into two complexes (Upper and Lower Complex), comprising different stratigraphical sub-levels. Level 1 is considered to represent a palimpsest of several Magdalenian occupations. The lower level, Level 2, corresponds to a period of increased sedimentation; its few archaeological remains date into the Lower Magdalenian (Álvarez-Fernández et al., 2018).

The first study of lithic raw materials from the Living Area (Área de Estancia) of Tito Bustillo was carried out by J.A. Moure Romanillo (1990). Here, a minor predominance of flint over quartzite is observed in the Upper Complex of Level 1 (52.3 % and 47.7 %, respectively), whereas in the Lower Complex quartzite was more abundant than flint (53.6 % and 46.4 %, respectively). It was also noted that flint predominates among the tools in both complexes. However, some larger variations in frequencies occur in the sub-levels within both complexes. The sub-level for which most information on worked flint is available is sub-level 1c2 in the Lower Complex of Level 1, dated to ca. 18,200 cal BP (in the Lower Magdalenian). In this assemblage (n = 2,161) flint represents 50.4 % and quartzite 49.4 %. Rock crystal appears in minor amounts (0.2 %). Tracer and super-tracer types of lithics amount to a significant 41 % of all the flint varieties, with Pyrenean Flysch by far the most common siliceous resource (including Kurtzia Flysch), followed at a distance by Treviño and – in much smaller proportions – Urbasa and the Upper Cretaceous pelagic varieties from the South-Aquitanian Basin (Tercis and Salies-de-Béarn). The flint assemblage of this level represents quite progressed stages within the *chaîne opératoire*, including rejuvenations and resharpening, but also display some initial stages of core preparation. Blade and micro-blade blanks are most frequently made on tracer and regional flint types, and a high percentage of retouched tools was made on those blanks, mostly of Pyrenean Flysch and Treviño Flint. The Urbasa and Tercis/Salies-de-Béarn Flint types only appear as blanks and finished tools, and are not represented in cores and preparational flakes; the functional study of these items is still in progress (**Fig. 2**).

The first Mediterranean molluscs in Tito Bustillo were recognized at the start of this century (Álvarez-Fernández, 2002a, 2006). A later review of archaeomalacological remains (Álvarez-Fernández, 2013), together with other biotic material (Álvarez-Fernández et al., 2015, 2018), enabled the classification of further Mediterranean shells and determined the exact stratigraphic provenience of each one. These finds come from both, the Upper (nine specimens of *T. pellucida*, one of *T. mutabilis* and one *of H. sanguineum*) and Lower Complexes (eight *H. sanguineum*) of Level 1. The use-wear on the shell's outer surfaces indicated that they had been used as objects of adornment (**Fig. 3**).

Coímbre B (Peñamellera Alta, Asturias)

Coímbre Cave is located in the middle valley of the River Cares, a tributary of the River Deva. Following their downstream courses, the site lies about 19 km south of the present-day coastline. Zone B in the cave was excavated from 2008 to 2012. Seven Gravettian and Upper Magdalenian levels were documented.

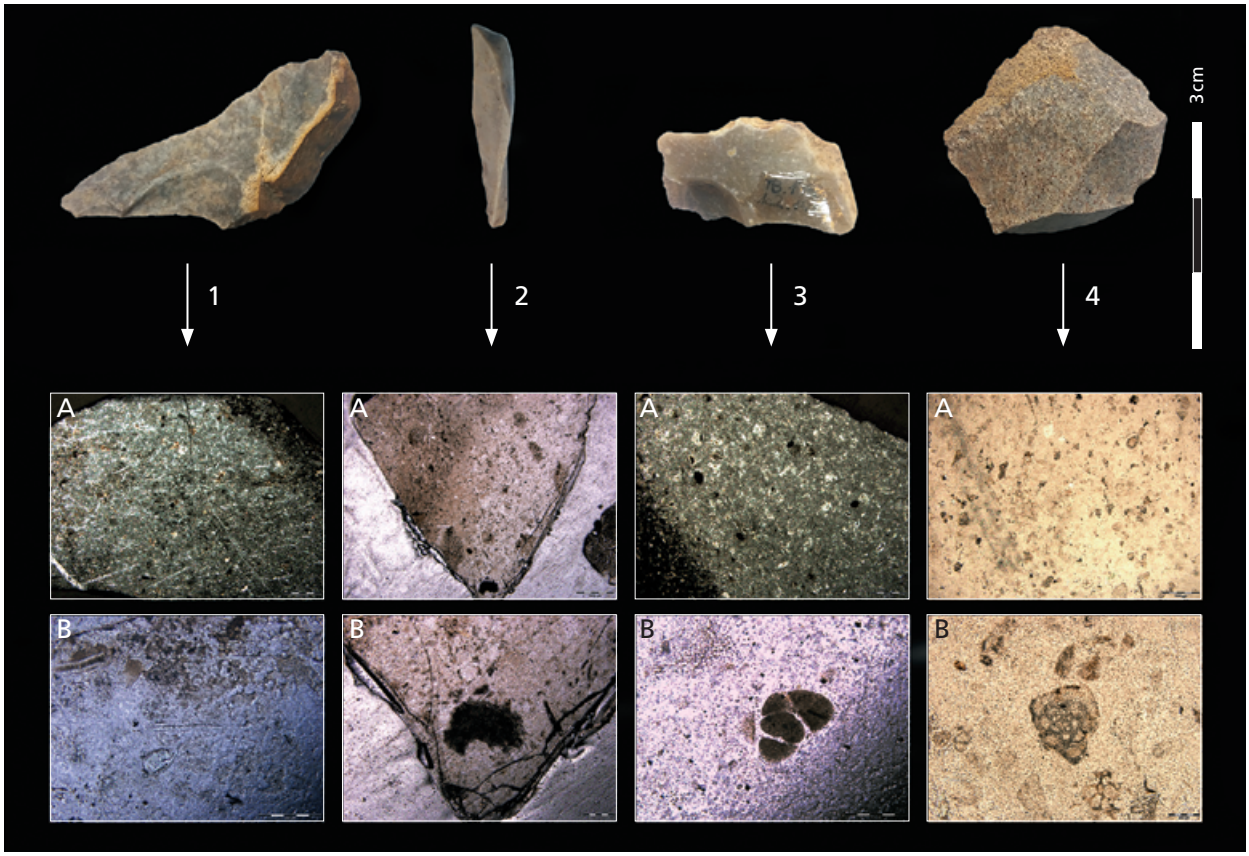

Fig. 2 Examples of the tracer and super-tracer flint varieties found in sub-Level 1c2 in the Dwelling Area in Tito Bustillo Cave. **1** Pyrenean Flysch Flint; **1A** crypto- (< 5 µm) to microcrystalline (5-20 µm) mosaic with multiple bioclast inclusions (× 25 XPL, crossed-polarized light). **1B** detail of longitudinal sections of sponge spicules (× 200 PPL, plane-polarized light). – **2** Urbasa Flint; **2A** crypto- (< 5 µm) to microcrystalline (5-20 µm) mosaic with multiple fragments of foraminifera, bryozoans and echinoderms (× 25 PPL); **2B** detail of an echinoderm relict (sea urchin plate) about 0.4 mm in diameter (× 100 PPL). – **3** Upper Cretaceous pelagic flint, probably of Tercis type; **3A** crypto- (< 5 µm) to microcrystalline (5-20 µm) mosaic, with bioclasts and opalized patination zoning (× 25 XPL); **3B** detail of a planktonic foraminifera (Globigerinidae) about 0.3 mm in diameter, with opalized internal chambers and idiomorphic ferruginised dolomite crystals with an average size of about 0.02 mm (× 200 PPL). – **4** Marine platform bioclast flint (unknown source); **4A** crypto- (< 5 µm) to microcrystalline (5-20 µm) mosaic, totally bioclastic (× 25 PPL); **4B** detail of a benthonic foraminifera (Miliolidae) about 0.4 mm in diameter (× 100 PPL).

The topmost Level 1 is dated to ca. 15,000 cal BP, i. e., into the Upper Magdalenian (Álvarez-Alonso and Yravedra, 2017).

Published studies of the Level 1 lithic raw materials (n = 7,653) indicate a predominance of quartzite (57.3 %) over other resources (40.4 % flint, 2.2 % rock crystal, 0.1 % other undetermined materials). A sample of about 200 flint artefacts, including blade blanks, retouched objects and cores, determined that about 66 % came from a distant source, as they consisted almost exclusively of Pyrenean Flysch Flint (> 60 %), whereas the Treviño, Urbasa and Chalosse Flint varieties were infrequent (< 2 % each). Significant differences are seen in the lithic *chaînes opératoires*, between those items made of quartzite – which represent quite complete *chaînes opératoires* spanning from the initial stages (mainly targeted at the production of flakes) – to those made of flint (Álvarez-Alonso et al., 2017; Tarriño and Elorrieta, 2017).

All the Mediterranean mollusc shells found in Coímbre Cave came from Level 1, comprising eight *T. pellucida* specimens, of which six displayed anthropic perforations around which use-wear was identified (Álvarez-Fernández, 2017; Álvarez-Fernández and Aparicio Alonso, 2017).

El Juyo (Camargo, Cantabria)

The cave of El Juyo is located about 4 km south of the Bay of Santander. Excavations at the site were first carried out by P. Janssens, J. González Echegaray and P. Azpeitia from 1955 to 1957, documenting Lower Magdalenian and Bronze Age occupations. L.G. Freeman and González Echegaray re-excavated the site between 1978 and the 1990s and, in general terms, confirmed the archaeological sequence that was recognized earlier (Janssens et al., 1958; Barandiarán et al., 1987; González Echegaray and Freeman, 1992-1993, 2000). Radiocarbon dates and the lithic assemblages indicate a Lower Magdalenian occupation at ~ 17,500 cal BP.

Studies of the lithic assemblage of Level 6 (n = 3,511) indicate the predominance of flint (about 66 %) over other raw materials. The latter were not differentiated at further detail and include quartzite and lutite. Regarding the flint assemblage (n = 2,317), the tracer varieties identified are the Treviño (13 %) and Urbasa Flint types (8 %) (Fontes et al., 2016). The flint *chaîne opératoire* shows a strong focus on the production of micro-blade blanks used to produce backed elements (González Echegaray and Freeman, 1992-1993).

A single specimen of *T. mutabilis* was recorded from Level 6, without any information about possible anthropic modifications being provided (Madariaga de la Campa and Fernández Pato, 1987).

El Horno (Ramales de la Victoria, Cantabria)

This cave is located in the Asón valley, some 20 km south of the present-day coastline. It was excavated by M. Fano in four field seasons (1999, 2000, 2001 and 2004). Beneath a superficial layer, a Late Upper Palaeolithic level (Level 0) and three levels dated to the Final to Upper Magdalenian (Levels 1-3) were documented. Level 1 dates to ~ 14,800 cal BP (Fano, 2005).

The information available about Level 1 (n = 146) raw materials emphasises an almost exclusive use of flint, whereas the proportions of quartzite and rock crystal are very small (1.4 % and 2.7 %, respectively). Among the flint (95.9 %), the only tracer type is Urbasa Flint (0.7 %). The lithic assemblage – mainly in Pyrenean Flysch Flint – represents a quite late stage within the *chaîne opératoire*, with clear evidence of core rejuvenation and resharpening, indicating that knapping took place *in situ*, and mostly focussed on the production of micro-blade blanks for backed artefacts. The functional analysis carried out on a sample of tools (with different types of taphonomic alterations), indicates they were used in activities connected with hunting and working fresh hides (Fano et al., 2016).

A single broken shell of *T mutabilis* was found in Level 1. No signs of anthropic modification were recognised (Fano and Álvarez-Fernández, 2010).

El Mirón (Ramales de la Victoria, Cantabria)

This cave lies near El Horno Cave in the vicinity of the confluence of the Rivers Gándara and Calera in the Asón valley. It is located about 20 km distant from the present-day coast. Between 1996 and 2013, M. González Morales and L.G. Straus excavated the cave deposit systematically. Three areas were excavated: the rear vestibule or 'Corral' (inside the cave), the mid-vestibule (in the centre) and the outer vestibule or 'Cabin' near the cave entrance. They documented occupations from the Mousterian to the Bronze Age. Level 17 in the outer vestibule or 'Cabin', dated to ca. 18,500 cal BP, is attributed to the Lower Magdalenian (González Morales and Straus, 2014).



Fig. 3 Mediterranean marine gastropod species documented in Level 1 of Tito Bustillo Cave. **1** *Tritia mutabilis*; **2** *Tritia pellucida*; **3** *Homalopoma sanguineum*.

The Level 17 assemblage (n = 33,718) is characterized by the predominance of flint, while the percentages of quartzite is 14.2 %, and of quartz and calcite amount only 1.2 %. Limestone, lutite and other undetermined raw materials sum up to a total of 23.1 %. The tracer and super-tracer varieties in the flint assemblage (61.6 %) are Urbasa (2.4 %), Bidache Flysch (1.2 %) and Chalosse Flint (2.2 %) (Fontes et al., 2018). The lithic *chaîne opératoire*, based on the use of Kurtzia Flysch Flint and another two regional varieties, is quite complete with plentiful evidence of core preparation, rejuvenation and resharpening, as well as abundant micro-waste, which shows that reduction took place *in situ*. The *chaîne opératoire* principally aimed at micro-blade production for backed elements. Bidache Flysch and the Urbasa and Chalosse Flint types appear in the form of cores, with evidence of their preparation on the spot, as well as various kinds of blanks and finished tools. The functional analysis performed on a sample of 'nucleiform endscrapers' showed that these cores were used to produce bladelets and only occasionally served other purposes (Straus et al., 2016).

A single pierced specimen of *H. sanguineum* was found in Level 17 in the outer vestibule (Álvarez-Fernández, 2006).

Site and layer	Local quartzite	Other local	Regional	Tracer/ Super-tracer	Indeterminate	Other
Tito Bustillo 1c2 (n = 2,161)	49.4 %	15.5 %	11.4 %	20.7 %	3.0 %	-
Coímbre B 1 (n = 7,653)	57.3 %	> 2.5 %	> 0.4 %	> 1.9 %	> 0.3 %	0.1 %
El Juyo 6 (n = 3,511)	no data	> 2.8 %	49.2 %	13.9 %	-	-
El Horno 1 (n = 146)	1.4 %	2.7 %	82.2 %	0.7 %	13.0 %	-
El Mirón 17 (n = 33,718)	14.2 %	32.8 %	29.4 %	3.8 %	14.8 %	5.0 %

Tab. 1 Lithic raw material management in the five Magdalenian assemblages of northern Spain studied here. The percentages are calculated over the total number of lithic artefacts for each of the assemblages.

DISCUSSION

In northern Spain, the Magdalenian assemblages in which both tracer or super-tracer flint varieties and Mediterranean shells have been found are: Level 1 in the Living Area (Área de Estancia) in Tito Bustillo Cave, Level 1 in the cave of Coímbre B, Level 6 in El Juyo, Level 1 in El Horno and Level 17 in El Mirón.

Lithic raw material studies at these sites have identified flint varieties from the Basque-Cantabrian Basin (Kurtzia Flysch, Treviño and Urbasa). Other varieties from outside this area that originate in the Western Pyrenees (Bidache Flysch) and the Sud-Aquitanian Basin (Tercis, Salies-de-Béarn and Chalosse) are present in at least three Magdalenian assemblages, albeit in much smaller proportions (Tito Bustillo, Coímbre B and El Mirón). This allows the reconstruction of Magdalenian land-use patterns for the management of lithic resources (Fig. 1; Tabs. 1-2).

However, because of the varying distances from the flint outcrops in the Basque-Cantabrian Basin to the archaeological sites studied, it needs to be emphasized that not all flint types can be considered as tracer types. Thus, the westernmost sites studied here (Tito Bustillo and Coímbre B, both in Asturias) possess higher percentages of tracer and super-tracer types than those in the centre of the Cantabrian region (El Juyo, El Horno and El Mirón, all in Cantabria), because the latter are located closer to the main sources of lithic raw materials (Tab. 3).

Flint types from outcrops ≥ 120 km distant have also been found, in some cases reaching 300 km for the Urbasa Flint at Tito Bustillo and ~ 350 km for Chalosse Flint at Coímbre B. These super-tracer flint types amount to larger percentages only at Tito Bustillo and El Juyo (ca. 21 % and 14 %, respectively), contrasting with El Mirón (ca. 4 %), Coímbre B (ca. 2 %) and El Horno (< 1 %).

The case of Tito Bustillo Cave is particularly interesting because tracer and super-tracer flint types amount to 20.7 % of the total raw materials. However, it should be noted that Pyrenean Flysch Flint makes up a third of the total flint assemblage and represents the main siliceous resource used. Flint varieties from Upper Cretaceous pelagic environments, equivalent to the Tercis and Salies de Béarn Flint types in the Sud-Aquitanian Basin, have also been documented; however, a more precise discrimination between the different varieties has not yet been possible due to taphonomic processes that affected most of the artefacts and hinder their straight-forward differentiation. Instead, an *ad hoc* category has been applied for their recording. Furthermore, another siliceous variety has been recorded which still remains of unknown geographic and

Site and layer	Flysch	Treviño	Urbasa	Upper Cretaceous pelagic flint	Chalosse	Other	Indeterminate
Tito Bustillo 1c2 (n = 1,089)	41 %				-	53.0 %	6.0 %
Coímbre B 1 (n = 200)	> 60 %	< 2 %	< 2 %	-	< 2 %	> 27.0 %	< 10.0 %
El Juyo 6 (n = 2,317)	17.9 %	13.0 %	8.0 %	-	-	60.9 %	-
El Horno 1 (n = 140)	80.0 %	2.1 %	0.7 %	-	-	3.6 %	13.6 %
El Mirón 17 (n = 20,770)	31.0 %	1.8 %	2.6 %	-	2.4 %	50.0 %	12.2 %

Tab. 2 Flint types documented in the five Magdalenian assemblages of northern Spain studied here. The percentages are calculated over the total number of lithic artefacts for each of the assemblages.

geological origin; from its characteristics it is likely that it formed in a marine platform on the northern side of the Pyrenees, but at present it is impossible to be more precise.

Except for the assemblages of Level 17 of El Mirón and of sub-Level 1c2 of Tito Bustillo, information about the raw material related differentiation of the *chaîne opératoire* is still very imprecise, especially with regard to the tracer and super-tracer varieties. For both assemblages, it has been emphasised that most of the reduction took place at the sites, since cores, evidence of preparation and different kinds of blanks and finished tools have been documented. This accounts for the Bidache Flysch, Urbasa and Chalosse Flint types at the former site and for the Pyrenean Flysch and Treviño Flint at the latter, suggesting that the raw material was distributed from the outcrops in the form of cores. Different types of finished tools were probably distributed, too, but this needs to be tested in the future; for example, by more detailed functional studies. Some siliceous raw material types from the Basque-Cantabrian Basin have been found at Magdalenian sites in other regions, comparable to exogenous flint types from outside northern Spain that have been documented at the sites studied here. Thus, for example, Treviño and Urbasa Flint have been found in the Middle Magdalenian at Isturitz and Berroberria and in the Middle to Upper Magdalenian at Zatoya (Elorrieta, 2016). It has also been suggested that Treviño Flint forms part of the Middle and Upper Magdalenian assemblages at Laa 2, in an area between the eastern and central Pyrenees (Sánchez de la Torre, 2015).

A total of 28 marine gastropod shells from the Mediterranean have been recorded in the levels at the five sites presented here. They belong to the species *Homalopoma sanguineum*, *Tritia pellucida*/*Tritia neritea* and *Tritia mutabilis*. At present-day *T. pellucida* and *T. mutabilis* do not exist on the coasts of northern Spain, so it needs to be considered that in colder periods (in the present case, at the end of the last glaciation), these species they would have been restricted to the Mediterranean, just as they are today. The other species found in Magdalenian deposits would have colonised these coasts in the course of the Holocene for which the timing of the colonisation is known with greater (*T. neritea)* or lesser precision (*H. sanguineum*) (**Fig. 3**, cf. **Tab. 4**). All the shells classified as *T. pellucida*/*neritea* are small and preserve hardly any of their original colouring. They are all thought to belong to the smaller species, *T. pellucida*.

26 of the studied shells preserve intentionally pierced holes (in Level 1 at Tito Bustillo, Level 1 at Coímbre B and Level 17 at El Mirón). We do not know if the other two were also pierced (one each in Level 6 at El Juyo and Level 1 at El Horno). *H. sanguineum* and *T. pellucida* are characterised by their small size and lack of nutritional value. Additionally, evidence of marine abrasion can be observed on the shells, and it is therefore

Site and layer	Flysch	Treviño	Urbasa	Upper Cretaceous pelagic flint	Chalosse
Tito Bustillo 1c2	200 km	250 km	300 km	350 km	-
Coímbre B 1	150 km	200 km	250 km	-	350 km
El Juyo 6	reg.	120 km	155 km	-	-
El Horno 1	reg.	reg.	120 km	-	-
El Mirón 17	170 km	reg.	120 km	-	250 km

Tab. 3 Approximate distances in kilometres, as the bird flies, between the main outcrops of tracer and super-tracer flint types and in the five Magdalenian sites of northern Spain studied here. In some cases, when the distance is < 120 km, the type forms part of a regional raw material management mode (reg.).

clear that they were picked up on a beach after the animal had died. Although *T. mutabilis* is currently fished in the Adriatic for consumption (Poppe and Gotto, 1991: 156), the shells that have been found were not gathered as food, as they are equally eroded by sea water in a sandy environment.

Polish caused by their use can be observed around the orifices of the well-conserved shells. This suggests that these objects were probably picked up on the Mediterranean shore, where they were pierced, and probably joined into some form of more complex ornamentation, either stitched to garments or threaded to form a bracelet or necklace, etc. They were then handed from person to person until they reached the sites in northern Spain studied here (Álvarez-Fernández 2002a, 2002b, 2006). Tito Bustillo, about 600 km from the Mediterranean Sea in a straight line, is currently the most distant site where shells from this source have been recorded.

Finds of objects of adornment from the Mediterranean at Magdalenian sites midway between the Mediterranean and Atlantic shores, on both sides of the Pyrenees, allow us to follow the routes of the contacts along valleys and rivers. Thus, for example, to the north of the Pyrenees, *H. sanguineum* has been reported from the Middle Magdalenian at Espélugues, Le Mas d'Azil (Chambre Piette), Enlène (Salle des Morts) and

Taxa	Recent distribution	Bathymetry	Substrate	Colour	Size
Homalopoma sanguineum (Linnaeus, 1758)	Mediterranean, Strait of Gibraltar, W. Portugal, Asturias	from the intertidal zone down to 50 m	rocky	red/pink	6-7 mm in diameter
Tritia pellucida (Risso, 1826)	S. Portugal, Gulf of Cadiz, Mediterranean	15-1,200 m	sandy	yellowish with clear reticule; brown suture; white callosity	6-8 mm in diameter
Tritia neritea (Linnaeus, 1758)	Mediterranean, Gulf of Cadiz, S. Portugal, N. Atlantic coast of Spain (since early 1900s)	lower intertidal zone and low shore	muddy	yellowish with brown reticule; yellowish or brown callosity	12-20 mm in diameter
Tritia mutabilis (Linnaeus, 1758)	Mediterranean, Gulf of Cadiz, S. Portugal	intertidal zone	sandy	yellowish pale to darker	up to 25 mm in length

Tab. 4 Characteristics of the different marine gastropod species that are represented in the five Magdalenian assemblages of northern Spain studied here.

Canecaude I, and in the Upper Magdalenian at La Vache and Tournal. *T. neritea*/*T. pellucida* (= *Cyclope* sp. in the original publication of Y. Taborin, 1993) has been found in the Middle Magdalenian at Tournal and Canecaude I and in the Upper Magdalenian at La Vache and Rhodes II. *T. mutabilis* has been documented in the Upper Magdalenian at La Crouzade, Le Mas d'Azil and Montfort (Taborin, 1993). To the south of the Pyrenees and closely related to the tributaries of the River Ebro, the latter two species have been cited in the Lower (Montlleó) and in the Middle to Upper Magdalenian (El Parco) (Mangado et al., 2014), and in the transition from the Upper Palaeolithic to the Holocene at Balma Guilanyà (Martínez and Mora, 2009) and Balma Margineda (Guilaine et al., 2007). Pierced specimens of *H. sanguineum* have also been documented at sites in the interior of the Iberian Peninsula, in the Badegoulian at El Gatos (Classification EAF) and in the Middle Magdalenian at Buendía (Torre et al., 2015), and of Cyclope in the Upper Magdalenian levels at Estebanvela (Avezuela, 2013).

Most of the pierced gastropod shells found in these five Cantabrian Magdalenian assemblages studied here came from the coasts on the Bay of Biscay, rather than from the Mediterranean. In the case of Level 1 at Tito Bustillo, Level 1 at Coímbre B and Level 17 at El Mirón, Atlantic molluscs represent ca. 80-87 % of the gastropods made into adornments. These percentages would be maintained in Level 6 at El Juyo and Level 1 at El Horno, if we suppose that the *T. mutabilis* form those levels were also objects of adornment (there is no information regarding the former site, as the preserved fragment was strongly decalcified). If we suppose that shells of the Atlantic species were picked up on the shore near the site, this would have been a local raw material acquisition in the Magdalenian as even the most inland of the five sites would not have been further than 30 km from the Bay of Biscay at that time. However, this does not mean that they could not have been collected on more distant Atlantic coasts, up to several hundreds of kilometres (i. e., ca. 300-400 km) further away.

CONCLUSIONS

Evidence of long-distance contacts between northern Spain and other parts of south-western Europe during the Magdalenian has been documented over recent decades, mainly through objects of adornment and portable art objects. This evidence is based on the use of identical raw materials (e. g., reindeer teeth), formal analogies (e. g., *contours découpés*, rondels, engraved or sculpted representations of herbivore legs, etc.), similar *chaînes opératoires* for their fabrication (e. g., scraping in the case of pointed horse teeth), in decoration (e. g., chevrons) and functionality (e. g., reindeer teeth used as ornamentation and pointed horse teeth as awls). Similarly, in the case of parietal art, thematic and technical similarity is observed in the use of certain conventions in the depictions of some animal figures (e. g., hind's heads with striated engraving or ibex depicted as frontal views), in anthropomorphs (e. g., more or less schematic female figures of 'Gönnersdorf' type), and in signs (e. g., claviforms). The presence of a larger number of a particular type of adornment, a portable art object, or a certain engraved or painted morpho-type in portable and parietal art have been used to reconstruct the territories in which they must have been 'created' and from where they were later 'distributed'. Thus, for instance, the schematic depictions of ibex in frontal views would have originated in northern Spain, whereas the *contours découpés* representing horse heads would come from the Pyrenees (see e. g., Taborin, 2004; Fritz et al., 2007). However, it is currently not possible to provide unambiguous proof of these origins.

The study of different flint types and marine mollusc shells enables greater precision in the documentation of long-distance contacts in Prehistory. The analysis of these raw materials from five Magdalenian assem-

blages at sites located in Cantabrian Spain has enabled us to determine not only their place of origin but also to characterize where they were procured and where and how they were modified; in particular, in the case of the flint from sub-Level 1c2 at Tito Bustillo, the geological areas where the materials have been procured have been identified. After acquisition of the material, the raw material was transported to the sites in the form of cores from which different types of artefacts were produced at the sites. Similarly, we can establish whether a shell originated in the Atlantic or the Mediterranean and if it reached a site as raw material or as a finished (and used) object of adornment. In the latter case, the shells arrived as pierced objects (that had been used as adornments) and not as raw material for their fabrication.

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THE LATE MAGDALENIAN OF GÖNNERSDORF AND ITS HEADLESS ANTHROPOMORPHIC DEPICTIONS. ON SOCIAL COHERENCE AND THE LATE UPPER PALAEOLITHIC COLONIZATION OF CENTRAL EUROPE

Abstract

This paper presents a brief review of the present state of research on the Late Magdalenian site of Gönnersdorf. It attempts to provide an improved, synthetic and 'holistic' interpretation of the site, with a focus on its spatial data and the rich body of its 'artistic' expression. The 'Gönnersdorf-type' headless anthropomorphic depictions serve as the backbone of a diachronic and supra-regional comparison of Late Upper Palaeolithic anthropomorphic depictions. Between ~19,000 and 14,000 cal BP "headlessness" appears to have been an important subject that was shared between different Late Upper Palaeolithic societies of Europe and its neighbours. The geographic and diachronic variability and the cultural contexts of these depictions, however, imply that different worldviews and/or belief systems are reflected in the different styles of anthropomorphic representations. The observed homogenisation that accounts for the Late Magdalenian 'Gönnersdorf-type' headless anthropomorphic depictions is argued to have enhanced social interconnectedness and cohesion on supra-regional scale and that the establishment of newly organized social-cultural systems has supported the successful colonization of central Europe from ~16,000 cal BP onwards.

Keywords

Palaeolithic art, headless anthropomorphic depictions, Late Magdalenian, socio-cultural rules and regulations, base camp

PREFACE

When I first visited what is today the MONREPOS Archaeological Research Centre and Museum for Human Behavioural Evolution, I got to know Elaine and Martin, who welcomed me in the castle's *Jagdhaus*. It didn't take me long to realize that both of them were essentially humanized reference books of Prehistoric archaeology, and I probably learned more from each of them than I did from university. Over the course of the past decades Elaine and Martin were deeply engaged in numerous research projects in which they addressed a plethora of topics within Pleistocene and Early Holocene archaeology. But they were always united in their joint interest in zooarchaeology and its contributions to understanding how past human groups coped with the challenges of their everyday lives and consequently managed to survive. Probably, one of the most impressive analyses Elaine and Martin jointly published is the monographic presentation of their research on "The Faunal Remains from Gönnersdorf" (Street and Turner, 2013), in which they present the results of their in-depth study of a material they began to work with shortly after they arrived in Germany. The results of this comprehensive work provide not only the raw data for an improved understanding of Late Magdalenian adaptations and lifeways, but also shed fresh light on a synthetical interpretation of the Gönnerdorf open-air site (**Fig. 1**), which is more in line with all the other evidence the site has provided us with.

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.868.c11323



Fig. 1 Gönnersdorf, showing excavated areas and trenches (grey) between modern buildings (black). Within the excavated area, arrangements of larger stones and artefical pits allow to distinguish the different concentrations (from south to north: concentrations K-I, K-SW, K-IIa, K-IIb; K-III, K-IV). Elevations are given in metres above sea-level. – (Modified from: Jöris et al., 2011; Jöris and Moseler, 2021a).

WHY GÖNNERSDORF?

The present contribution attempts to bring together the different topics the site of Gönnersdorf, excavated by Gerhard Bosinski between 1968 and 1976 over a total area of 687 m² (Bosinski, 1979), has touched upon since its discovery (Bosinski, 1969, 1975). Over the last 50 years, a number of 'core questions' the site seemed appropriate for addressing, have been repeatedly explored and continuously updated, corrected and refined in numerous monographs and articles.

(1) The first of these questions relates to understanding the sites' spatial organisation and structure. At the time of its discovery, much of the research into this period was still dominated by excavations in caves and rock-shelters, and, consequently, little focus was spent on the spatial structures and features that high-resolution open-air sites could provide. But new excavation methods and standards now allowed for a new quality of documentation and analytical resolution. Bosinski's work at Gönnersdorf was strongly influenced and guided by the methods developed and implemented during the excavation of the Magdalenian site of Pincevent in France (Leroi-Gourhan and Brézillon, 1966, 1972) that began shortly before and continued in parallel to Bosinski's work. These efforts were targeted at understanding the socio-economic and socio-spatial organisation of Late Upper Palaeolithic hunter-gatherer lifeways and so to provide a better understanding of their "ethnologie préhistorique" (Leroi-Gourhan, 1936; cf. Valentin, 2015). Similarily, Bosinski's work at Gönnersdorf targeted the identification of spatial units and their understanding as areas of differing activities, including potential habitation structures (Bosinski, 1969, 1979, 1981, 1988, 2007). The site's large and artefact-dense concentrations were interpreted as ground plans of differently sized dwelling structures (e. g., Bosinski, 1979, 1981, 1988, 2007). Over the last decades, the interpretation of these structures and their temporal interrelations have repeatedly been addressed and changed; the present state of analyses and interpretation will be summarized below.

(2) The second question concerns the understanding of the rich record of 'artistic' expressions that Gönnersdorf has become famous for. No other Magdalenian open-air site has produced 'artistic' expressions in anything like a comparable amount (Bosinski and Fischer, 1974, 1980; Bosinski et al., 2001; Bosinski, 2008).

(3) The third question concerns the sites' chronostratigraphic position and, consequently, its place within the Magdalenian demographic expansion from south-western into central Europe. Initially thought to have commenced with the beginning of the period of Late Glacial warming, i. e., the "Bölling" interstadial[1] (Brunnacker et al., 1978; Bosinski, 1981), subsequent radiocarbon dates and the ability to calibrate the radiocarbon time scale over the Glacial period that emerged in the 1990s, showed that the sustainable post-Last Glacial Maximum (LGM) re-occupation of central Europe actually commenced long before the "Bölling" interstadial (Street et al., 1994; cf. Housley et al., 1997; Stevens et al., 2009). Gönnersdorf took a prominent position in this process.

Each of these questions, however, is closely interlinked with the others and cannot be answered from studying in isolation the site's spatial structure, 'artistic' record, or radiocarbon chronology. Instead, answering each of the questions requires a much deeper, more comprehensive and synthetical approach, as the site's function(s) can only be assessed through a combination of these lines of research, and through their discussion within a widened contextual framework into which other lines of evidence from Late Upper Palaeo-

[1] With the term "Bölling" Arlette Leroi-Gourhan referred to the beginning of the Late Glacial interstadial (Brunnacker et al., 1978). In the northern half of central Europe, where the Bølling had been defined (cf. discussion in Jöris and Álvarez-Fernández, 2003), the beginning of the Late Glacial interstadial, i. e., Greenland Interstadial GI 1e (cf. Rasmussen et al., 2014), is defined as the Meiendorf interstadial (cf. Street et al., 2002).

lithic contexts will need to be included and discussed. Until now, such a holistic perspective has not been attempted for the site.

Closely connected to such a broadened contextual framework is the question to which degree the observations and interpretations made at one site can be accounted as representative, 'typical' or 'characteristic' for the entire time interval and geographical area in focus, and to which degree data from one site may be extrapolated to add to the understanding of others (e. g., Pasda, 2012; Leesch and Bullinger, 2012). Major shifts in the frames of reference and in the perspectives taken that came with the *New Archaeology* (e. g., Binford, 1983) opened up the possibility of alternative interpretations of site organisation and function, strongly focussing on the understanding of daily routines of Magdalenian hunter-gatherers in their socio-economic contexts (cf. e. g., Audouse, 1987; Valentin, 2015). Together with the observation that most of the activities at Magdalenian sites apparently took place in the immediate proximity to hearths (cf. Bullinger at al., 2006; Leesch and Bullinger, 2012; Leesch et al., 2004; Julien and Karlin, 2014; Zubrow at al., 2010; cf. Moseler, 2020) and the argument that the archaeological remains at (most) Palaeolithic sites would result from the 'palimpsest' accumulation of (distinct) "intermittent episodes of deposition resulting from high residential mobility" (Galanidou, 1997: 1), a widespread view of Magdalenian lifeways emerged that placed great emphasis on repetitition of the same or similar activities which are documented at many Magdalenian sites and which, therefore, are seen to reflect culturally learned activities undertaken by the members of a certain social entity (cf. Pasda, 2012). Such patterns can appear quite alike, especially in reindeer-based economies, even between sites, and show certain analogies with the enthnographic record (cf. e. g., Julien and Karlin, 2014 and references therein). Major distinctions between different sites would in this case be less likely to be based on the natural environment and site function than they were on group size, season of occupation, and frequency and duration of each of the occupations of a specific locale. This perspective closely follows Leroi-Gourhan's "palaeo-ethnological" approach (Leroi-Gourhan, 1936; cf. Valentin, 2015), and through it, one can argue for the existence of a well-defined Magdalenian behavioural canon, which could serve as a further argument for the general applicability of conclusions made from individual sites.

The interpretation of Gönnersdorf, however, stands in stark contrast to such a 'monolithic' view of the Magdalenian, and the long time period that is covered by as the concept of the "Magdalenian" (ca. 17,500-12,000 ^{14}C BP; i. e., ~21,000-14,000 cal BP[2]) and its wide geographical distribution from the Iberian Peninsula to eastern central Europe (cf. Maier, 2015), add considerable variability and complexity to this perspective. Inter-site similarities and differences can be found at varying analytical levels and at varying levels of resolution, addressing different aspects of Magdalenian lifeways that allow us to go beyond the reconstruction of domestic activities. The following synthetical approach will therefore focus not only on answering the three central questions linked to the Gönnersdorf site, i. e., its spatial interpretation, 'artistic' record, and chronology. Instead, the frame of reference will be widened by the comparative study of the Late Upper Palaeolithic headless anthropomorphous depictions at the supra-regional level, and it will dive deeper into the 'cultural history' that preceeds the Late Magdalenian of Gönnersdorf to address the origins, formation and development of Late Upper Palaeolithic worldviews and belief systems as they are of relevance for understanding Gönnersdorf's site function.

[2] Radiocarbon dates were calibrated with the CalPal software (Weninger, 2021), using the IntCAL20 "Northern Hemisphere Radiocarbon Age Calibration Curve (0-55 cal kBP)" of Reimer et al. (2020). As the focus of this contribution is not on a detailed chronology, calibrated dates are rounded. A more detailed discussion of chronological issues is largely based on uncalibrated radiocarbon dates.

GÖNNERSDORF RE-INTERPRETED

Elaine's and Martin's joint study of "The Faunal Remains from Gönnersdorf" reveals that the locality was used over an extended period of the year, during which at least 53 horses and numerous other animals were consumed (Street and Turner, 2013). An almost complete absence of carnivore or small mammal gnawing not only implies that the site was buried shortly after it was abandoned, but also that humans were likely present at the locale more or less continuously over the time that is represented by seasonal faunal data, i. e., disencouraging these animals to scavenge from the site (Street and Turner, 2013). With regard to its main occupation phase, dating to between ~ 15,600 and ~ 16,000 cal BP (cf. Stevens et al., 2013), these data may best be read in favour of a possibly even singular, but lengthy (probably much more than half-year long) period of use. These data also match well with the results from intensive refitting studies (including knapped lithics and rocks) that were initially aimed at disentangling different phases of occupation of the site and at establishing an internal chronology for the site's different material concentrations (e. g., Eickhoff, 1989, 1990; Eickhoff and Lindenbeck, 1989; Veil, 1990; Terberger, 1997). All of the established relative-chronological sequences for the site have pointed to the more-or-less simultaneous use of these distinct zones (Sensburg, 2007, 2008, 2011; cf. Terberger, 1997), in contrast to many other broadly contemporary sites which are interpreted as palimpsests of repeated but short occupational phases, where refits document the sequential movement of material starting at one point and ending at another (e. g., Bullinger et al., 2006). At Gönnersdorf the different concentrations frequently interconnect by large number of long-distance refits. The outcome of comprehensive refitting efforts of different rock types, undertaken by David Batchelor in the 1970s and 1980s, is plotted on detailed plans archived in MONREPOS, and documents hundreds of refitted complexes. Among these are numerous cases in which refits span long distances between the concentrations, showing movement of materials repeatedly running back and forth, i. e., in two directions (Terberger, 1997). These data provide evidence for activities that were interconnected and took place in parallel, and differ from the evidence provided by most other sites that are interpreted as the result of more ephemeral, short-term and seasonally frequented locales at which a restricted range of activities were practiced, mostly focussed on the procurement of animal resources (e. g., Debout et al., 2012; Julien and Karlin, 2014; cf. Turner, 2002).

The relative degree of ("limited") "sedentism" proposed for Gönnersdorf (Street and Turner, 2013: 250) complements these observations, and explains to a large degree the site's richness (e. g., Franken and Veil, 1983) and the broad spectrum of activities that have been documented at it. Clearly, a temporally extended period of occupation of the site justified greater investment into the organisation of space and in architectural structures that the site provides (e. g., Bosinski, 1979, 2007; Terberger, 1997; Jöris and Terberger, 2001; Sensburg, 2007, 2008; Moseler, 2008, 2011; Jöris et al., 2011, 2021; Jöris and Moseler, 2021a, 2021b; Street and Turner, 2013). Evidence of periodic cleaning (Jöris and Moseler, 2021a) highlights the maintenance of the Gönnersdorf concentration K-IV light rectangular tent structure in the north of the excavated area that was composed of a structural frame of some of the largest schist plaquettes documented at the site, laid out as more-or-less even pacing (**Fig. 2**; Jöris and Terberger, 2001; Moseler, 2008, 2011). It is noteworthy that in contrast to the refit-patterns of the other concentrations – none of the plaquettes forming the rectangular frame of the K-IV construction could be refitted (which would imply transport of the material); as such these rocks appear to have been of static constructional importance, i. e., to provide structural stability: all rocks > 15 cm in maximum dimension appear to have been placed there deliberately. The area so enclosed was kept free of waste generated by the processing of fauna, and inside the tent's ~ 16 m² large rectangular ground plan, no large faunal elements were found at all (Jöris and Moseler, 2021a). In terms of its low density of finds, distinct architectural components, lack of pits and virtual absence of distinct find

categories, the K-IV structure differs from the site's largest and densest concentrations (K-I, K-II, K-III), the latter of which are made up of tons of gravel and rocks transported to the site (mostly from a nearby small creek) that accumulated over the entire duration of occupation.

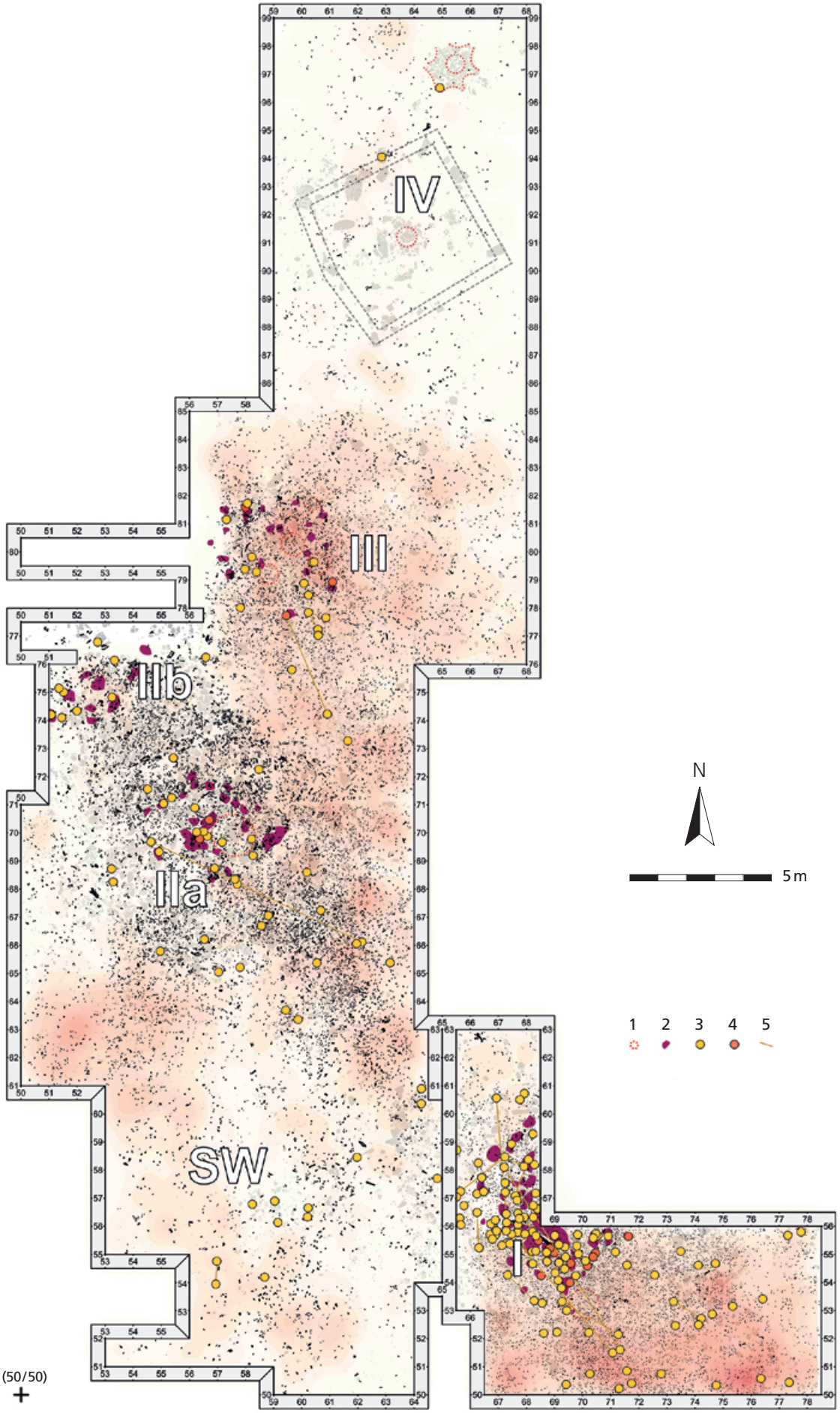
Today, the large concentrations can no longer be understood as enclosed, roof-topped constructions as they once were, but rather as areas of outdoor activities that were systematically organised spatially (Jöris et al., 2021; Sensburg, 2008). This was characterised by the constant accumulation and – over the course of occupation – re-arrangement of material over a lengthy period of time (cf. Jöris and Moseler, 2021b; Sensburg, 2007). Refits, particularly for K-II and K-III, closely link these clusters to the K-IV tent structure (Terberger, 1997). If one follows the interpretation of K-IV as a tent dedicated to resting and sleeping (hence the need to keep it clean: Jöris and Moseler, 2021a) and if one considers the immense amount of material that the large outdoor activity areas of the denser concentrations have produced, one may predict that other K-IV-like structures must have existed at the site, but which the excavations did not locate. Test *sondages* designed to establish the spatial extent of the site within the area covered by modern buildings were undertaken during the 1970s in parallel to the excavation, assessing large areas to the east and north of K-IV (Bosinski, 1979; cf. **Fig. 1**). As most of the test squares contained few artefacts only, excavations were never extended into these areas. However, the low densities of finds there show that the settlement area continued over a surface of at least ~400 m² or even more. The fact that no dense find scatters have been detected there, allows us to assume that at least no dense concentrations like those of K-I, K-II or K-III would be expected there. But this projection does not imply that there were no further light structures characterised by low find densities that could resemble (a) K-IV-like structure(s). Future fieldwork could target this question and test this hypothesis.

The complex spatial patterns of refitted materials at Gönnersdorf are most suggestive of activities that were sequentially linked and which accumulated in parallel over a long period of time, ultimately forming dense concentrations of material (Sensburg, 2011), rather than repetitive but temporally disconnected short-term activities that spanned a longer period (several years) of repeated but discontinuous site use, also involving the regular use of fire (Moseler, 2020). As many of the individual quotidian activities that took place at Gönnersdorf were of quite ephemeral character; we are therefore presented with palimpsests of such short-term activities. Refitting, raw-material and size-sorting studies have, however, shown that these palimpsests did not lead to a horizontal disturbance (i. e., spreading-out) of materials; instead they remained more-or-less in place, where they were constantly re-arranged and re-cycled in subsequent activities (e. g., Jöris and Moseler, 2021b; cf. Terberger, 1997). There is probably no other site of this period that reveals an equally broad spectrum of activities and/or equally intense traces of them; these include the intensive use of (non-knapped) schist, quartzite, quartz, and occasionally basalt (e. g., Batchelor, 1979; Terberger, 1997), partly as architectural elements used to structure and organise the space used (Jöris et al., 2011), or as ground stone tools used as supports or anvils for numerous tasks, including hammering, battering, chiselling, drilling, and others. Most of these traces have not yet been studied exhaustively. However, use-

Fig. 2 Composite Gönnersdorf excavation plan (modified from: Jöris and Moseler, 2021a) highlighting the different concentrations (from south to north: K-I, K-SW, K-IIa, K-IIb; K-III, K-IV with the reconstructed, ~16 m² covering quadratic ground plan of a presumably light tent-like dwelling structure). Scale: 1:200.

The plan comprises (a) distribution of delibrately placed manuports (rocks and plaquettes) shown in grey in the background of the figure, overlain by (b) the relative density of small tooth fragments from the sieving remains recorded per ¼ square metre (the more intense the red, the higher the tooth fragment density; Jöris and Moseler, 2021a) and (c) faunal remains recorded as single finds (black). Hearth structures/fireplaces (**1**; modified from: Moseler, 2020) and artifical pits are also shown (**2**).

Additionally, plaquettes engraved with 'Gönnersdorf-type' depictions found in occupation level (**3**) and within pits (**4**) are plotted (modified from: Bosinski et al., 2001); refit-lines (**5**) between plaquette fragments that display 'Gönnersdorf-type' depictions are also included.


IV
III
IIb
IIa
SW
I
N
5 m
1 2 3 4 5
(50/50)

wear studies on flint artefacts (Sano, 2012a, 2012b, 2021) not only reveal a broad spectrum of activities within the largest concentration (K-II), but emphasise the partly intensive and long-term use of some of the tools that were used in this area alongside numerous organic implements (Tinnes, 1994; 2001). The results of use-wear studies on Gönnersdorf K-II so-called 'Western European' Meuse flint show clear differences to the results from use-wear studies of the same raw material on other Late Magdalenian sites (in terms of the activities performed and especially of the intensities of these performances), which have been interpreted as characterized by more restricted task spectra than at Gönnersdorf (Sano, 2012a, 2012b). A high degree of reduction and re-cycling of the lithic material enforces this picture (cf. Franken and Veil, 1983; Veil, 1983).

At Gönnersdorf the large concentrations were apparently areas that were communally used for most of the daily activities of the groups that came together here (Jöris et al., 2021; Sensburg, 2007, 2008, 2011; cf. Moseler, 2020). According to the exogenous raw materials that dominate the Gönnersdorf lithic assem-

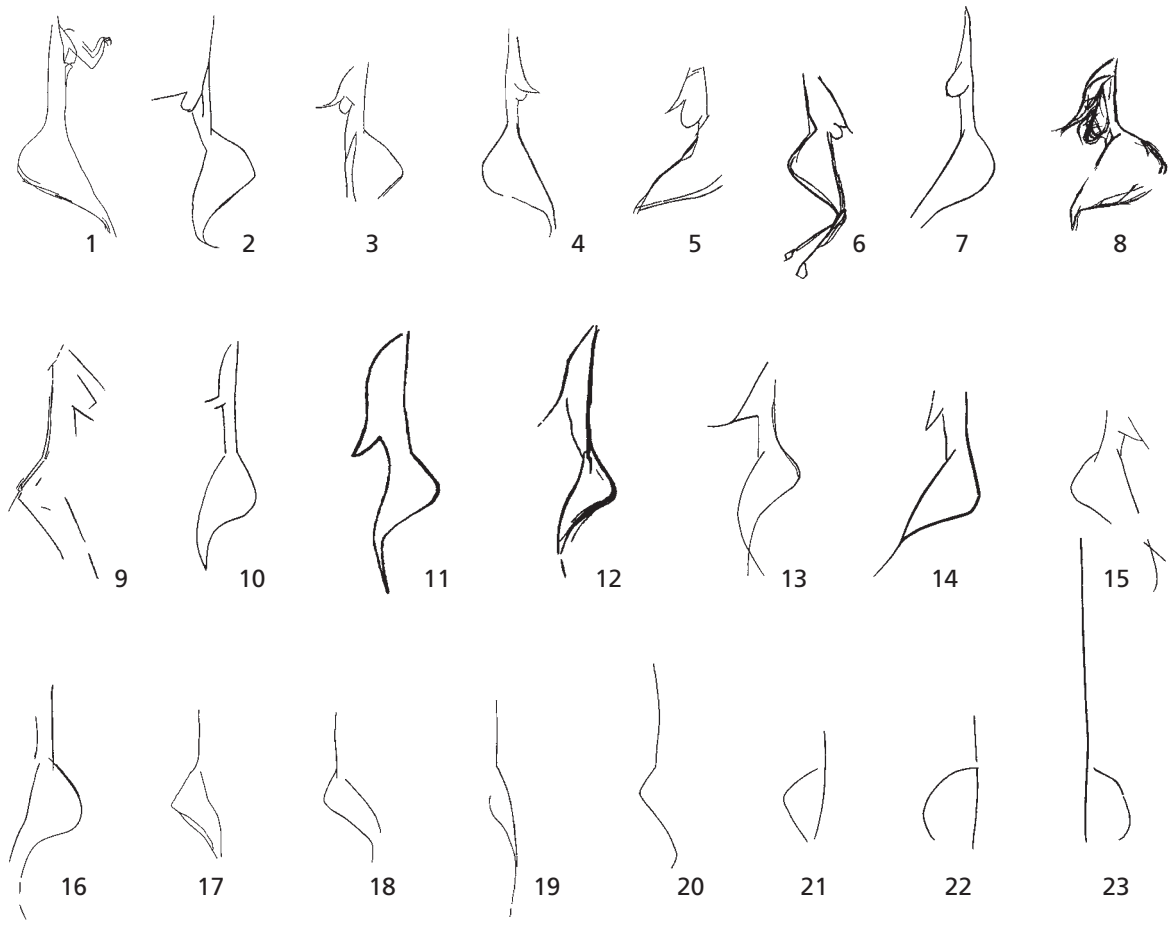


Fig. 3 Different levels of abstraction of the 'Gönnersdorf-type' engravings from the open-air site of Gönnersdorf (not to scale, but for better comparability adjusted to similar torso size; after: Gaudzinski-Windheuser and Jöris, 2015; cf. Bosinski et al. 2001). – Top row: the most complete depictions with arms and breasts (**1-6, 8**) and breasts only (**7**). Figure no. after: Bosinski et al. (2001): **1** 59.1; **2** no. 80.1; **3** no. 1.1; **4** no. 206.1; **5** no. 184.2; **6** no. 73.2; **7** no. 206.2; **8** no. 203. – Middle row: more simplified depictions with arms only (**9-15**). Figure no. after: Bosinski et al. (2001): **9** no. 204.2; **10** no. 65.1; **11** no. 65.3; **12** no. 180.2; **13** no. 205A.1; **14** no. 86.1; **15** no. 46. – Bottom row: extremely simplified depictions without arms or breasts (**16-23**). Figure no. after: Bosinski et al. (2001): **16** no. 202.1; **17** no. 43.1; **18** no. 68.5; **19** no. 72.6; **20** no. 72.7; **21** no. 72.5; **22** no. 53.3; **23** no. 213.2.



Fig. 4 Gönnersdorf. Headless anthropomorphic engravings of four hatched figures of 'Gönnersdorf-type', all facing towards the right and in alignment. Note: the second figure from the right seems to carry a smaller figure on its back. – (Photo: Volker Iserhardt, RGZM; after: Gaudzinski-Windheuser and Jöris, 2015; cf. Bosinski et al., 2001: plaquette no. 87, the so called "*Strickvenüsse*"). – Width = 8.5 cm.

blage (Floss, 1994), different groups from different regions, each about a hundred kilometres or more distant, met here, and spent a lengthy part of the year together (Street et al., 2006; Jöris et al., 2011): "Taken together, all this evidence reinforces an interpretation of Gönnersdorf as a base camp at which the full range of domestic and social activities was carried out" (Street and Turner, 2013: 250), as was previously proposed by Gerhard Bosinski (1975, 1988). However, not "all people would necessarily have been present [at Gönnerdorf] all the time or at the same time" (Street and Turner, 2013: 250). The large, communally used concentrations are also those places where almost all of the depicted animals and anthropomorphs cluster (**Figs. 2-4**). The site's rich body of such 'artistic' expressions underlines its particular importance among the Late Magdalenian sites of the wider region. The numerous (n ≈ 249) naturalistic depictions of animals (Bosinski and Fischer, 1980; Bosinski and Bosinski, 1991; Bosinski, 2008) and the schematic representations of 'Gönnersdorf-type' anthropomorphic depictions (n ≈ 423), generally interpreted to represent females (Bosinski and Fischer, 1974; Höck, 1995; Bosinski et al., 2001; Bosinski, 2011a, 2011b), may have played a significant role in Late Magdalenian communication networks (Gamble, 1982; cf. Gaudzinski-Windheuser and Jöris, 2015). The 'artistic' expressions at Gönnersdorf are spatially embedded within the remains of quotidian activities. Whatever the specific messages communicated *via* these depictions was, the transferal of information involving them appears to have taken place in communally used, 'public' areas of quotidian use (cf. Gaudzinski-Windheuser, 2015, 2021). The recognition of such communal or public areas is of great relevance in the context of the spatial organisation of sites such as Gönnersdorf, as they define the socio-spatial (built) environments in which a society's sets of rules and regulations do not only become most

visible through constant re-iteration through practice, but likely where the validity of these sets of rules and regulations are also questioned, newly negotiated, altered or conserved when agreed upon; in short, where the rules and regulations that underpin societies are negotiated.

Overall, the combined Gönnersdorf data highlight the site's importance as a meeting point at supra-regional scale (Street et al., 2006). This is further indicated by the presence of other materials imported to the site over large distances, e. g., personal ornaments made of Mediterranean shells (Álvarez-Fernández, 2009), presumably indicative of social networks that spanned distances of hundreds of kilometres (e. g., Bosinski, 2007). Some of the highly dynamic and naturalistic depictions of animals include species which most likely no longer lived in the region at the time the site was occupied (cf. Stevens et al., 2009; Street et al., 2012), such as mammoths and several taxa of seals (Bosinski and Bosinski, 1991). This implies that at least a few individuals with detailed knowledge of such animals must have travelled over long distances to reach the German central Rhineland, where they shared information on those animals.

Comparable finds and features have been recorded from the Magdalenian site of Andernach-Martinsberg [3], at about 2 km distance to the south-west and just in sight of Gönnersdorf, on the opposite bank of the River Rhine (Bosinski, 2007; Street et al., 2006). As at Gönnersdorf, evidence for long-distance imports of materials to the site is abundant, including, among other examples, a whale bone, probably a projectile foreshaft which hints at parallels with Late Magdalenian sites in the Pyrenees (Langley and Street, 2013). The Andernach specimen may have been exchanged over this long distance, just as may has been the case with the shell ornaments of "49 specimens of *Homalopoma sanguineum,* a Mediterranean marine gastropod" (Street, 2021), found next to the whale bone in a small pit. The close spatial association with an engraved schist plaquette depicting a seal (Street, 2021) may, on the other hand, suggest that the whale bone artefact and the gastropod ornaments were brought to Andernach by (an) individual(s) travelling this long distance, who were familiar with these animals.

The accumulated evidence of Gönnersdorf and Andernach-Martinsberg emphasises the sites' central position within Late Magdalenian supra-regional social networks (Street et al., 2006). Dating to ca. 15,600-16,000 cal BP (cf. Stevens et al., 2013), i. e., within Greenland Stadial GS 2.1a (cf. Rasmussen et al., 2014), the two sites are statistically indistinguishable in age, with most plausible radiocarbon dates ranging from ca. 12,990 ± 55 ^{14}C BP (OxA-V-2223-42) to 13,270 ± 55 ^{14}C BP (OxA-V-2223-39) (Stevens et al., 2013). Technologically and typologically they are indistinguishable, placing them into an Early Upper Magdalenian according to recent French terminology (cf. Langlais et al., 2015b, 2017; ~ "Magdalenian V"). The sites display many more extremely close similarities, e. g., their organic tool types (Bosinski, 2007; Tinnes, 1994) and in the technical details that characterize the reduction of so-called "Palaeozoic Quartzite" (Heuschen, 1997; cf. Street et al., 2006). In fact, both sites appear so alike that one may easily argue that at one point during the Magdalenian Gönnersdorf was chosen as a meeting point of Late Magdalenian communities, but shortly – probably only a few years – thereafter Andernach took on the same purpose, or the other way around. But the great number of 'artistic' depictions – particularly at Gönnersdorf – highlights the sites' special position in the Late Magdalenian oikumene, which is further mirrored in their incomparably high frequency of personal ornamentation (cf. Schwendler, 2012). In fact, in comparison to other Magdalenian sites, the rich Gönnersdorf body of depictions is paralleled only by the famous rock- and cave-art sites, rather than by any other open-air locality.

[3] The Late Magdalenian site of Andernach-Martinsberg is in many ways much like Gönnersdorf (Bosinski, 2007). The differences in the numbers and frequencies of certain find categories (i.e. quantitative data) are best explained by the much more fragmented and discontinouos areas of excavation at the Martinsberg site, rather than to a qualitatively different archaeological record.

LATE UPPER PALAEOLITHIC HEADLESS ANTHROPOMORPHIC DEPICTIONS

In the Late Upper Palaeolithic of Europe and north-eastern Africa, headless anthropomorphic depictions comprise a rich category of the 'artistic' record. In Europe they outnumber by far other more realistic (or complete) anthropomorphic/human depictions (e.g., Duhard, 1993, 1996). In their overall design they strongly contrast with the depictions of the preceding Mid-Upper Palaeolithic "Willendorf-style" which often possess heads, occasionally faces, and frequently hairstyles/hats and other details that can be interpreted as depictions of specific individuals (Gaudzinski-Windheuser and Jöris, 2015; cf. Bourrillon et al., 2012). Beginning ~ 19,000-18,000 cal BP, and continuing until ~ 14,000 cal BP, "headlessness" appears as a prominent characteristic of European anthropomorphic/human depictions (**Fig. 5**; cf. **Tab. 1**), and one may ask whether or not their penecontemporaneous continental-wide appearance may be (1) simply coincidental, (2) interpreted as a reflection of similar or convergent worldviews or belief systems and/or (3) best explained by high levels of supra-regional interconnectedness and the related transmission of ideas. In

	L. Basse and Abri Bourdois	**Gö-type engravings**	**Gö-type figurines**	**Mezin female figurines (dwelling 2)**	**Mezin female figurines (dwelling 3)**	**Mezin male figurines (dwelling 2)**	**Mezhyrich female figurines**
functions in ... view							
	frontal	profile	profile (frontal)	(profile) frontal	(profile) frontal	(profile) frontal	frontal
HEAD							
	no	no	no	no	no	no	no
UPPER TORSO							
front neck	no	no	no	vertical lines	vertical lines (n = 1)	vertical lines	no
front thoracic cage	no	no	no	chevrons	chevrons	chevrons	horizontal lines
front arms	no	frequently	no	no	no	no	no
front breasts	no	occasionally	occasionally (sometimes pairs of breasts)	no	no	no	no
side	no	rarely geometrically ornamented (n = 2)	rarely geometrically ornamented (n = 1)	geometrically ornamented	geometrically ornamented	geometrically ornamented	no
back	no	–	no	geometrically ornamented	geometrically ornamented	geometrically ornamented	no
LOWER TORSO							
front hips/buttocks	no	pronounced	pronounced	pronounced	pronounced	weak	no
front pubic region	pubic triangle engraved	no	no	pubic triangle engraved	pubic triangle engraved	no	pubic triangle engraved
side	no	rarely geometrically ornamented (n = 2)	no	geometrically ornamented	geometrically ornamented	no	no
back	no	–	no	geometrically ornamented	geometrically ornamented	no	no
FEET							
	no	n = 2	no	no	no	no	no

Tab. 1 Major stylistic characteristics of Late Upper Palaeolithic headless anthropomorphic respresentations.

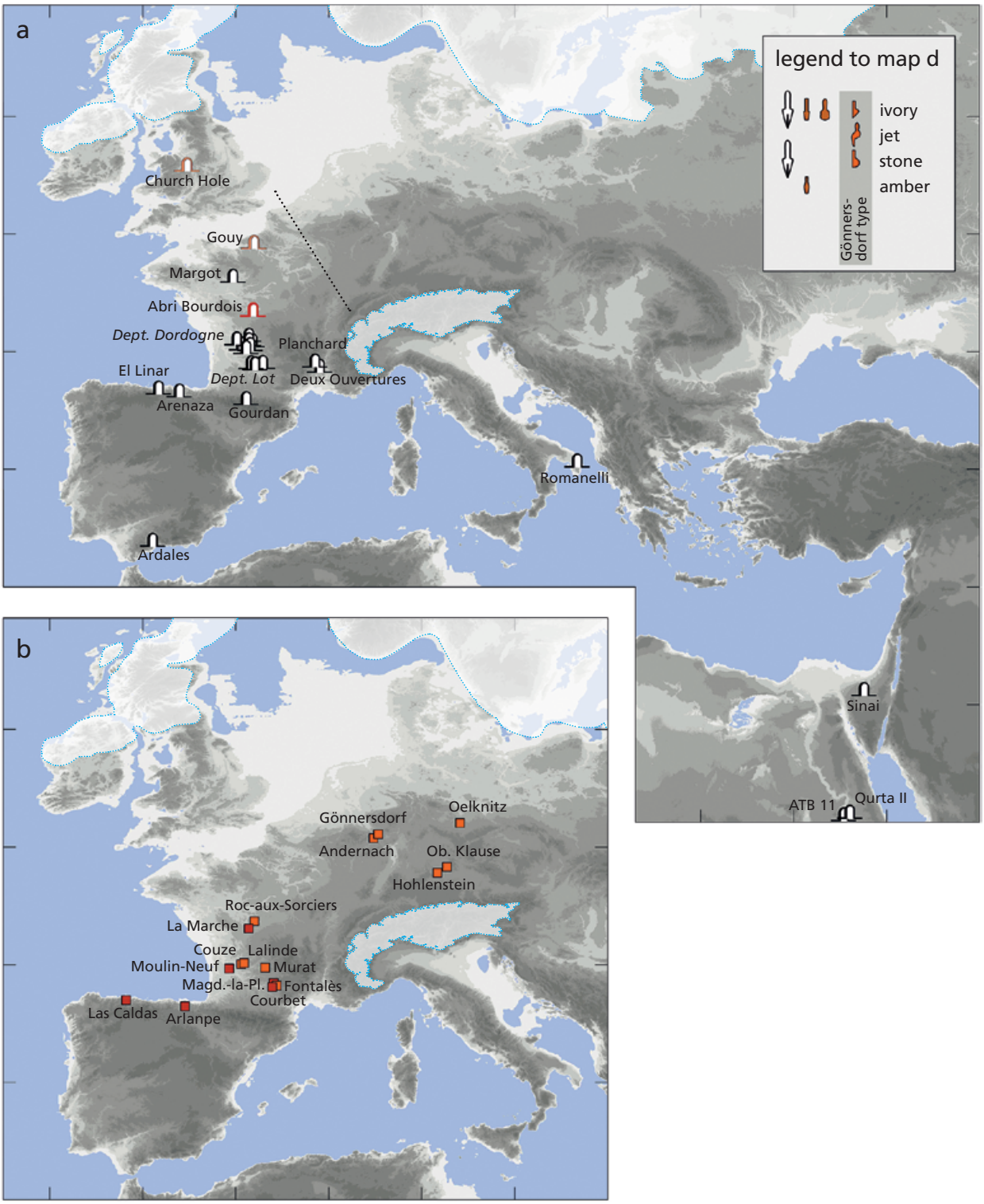


Fig. 5 Spatio-temporal context of Late Upper Palaeolithic headless anthropomorphic depictions, dating between ~ 19,000-13,000 cal BP. **a** depictions in rock art (mostly engraved, but in few cases engraved and painted); **b** engravings on stone palquettes and blocks; **c** engravings on pebbles (**c-1**: quadrats) and bones (**c-2**: circles); **d**) figurines (plastically sculpted).
Maps (modified from Gaudzinski-Windheuser and Jöris, 2015), showing coastlines, lowered for ca. -60 m compared to present-day sea level, the Northern European ice sheets at ca. 16,000 cal BP (after Hughes et al., 2016) and the Alpine ice shield at around the Last Glacial Maximum (LGM). Site references: see appendix.


d
Eliseevichi
Mezin
Dobranichivka
Mezhyrich
Wilczyce
Pekárna
Nebra
Gönners-
dorf
Mégarnie
Oelknitz
Garsitz
Andernach
Waldstetten
Petersfels
Monruz
Laugerie-
Basse
Enval
Fontalès
Courbet
c
Teufelsbrücke
Niederbieber
Felsställe
Bycí Skála
Petersfels
Roffat
Rochereil
Rond-du-Barry
Faustin
Las Caldas
~14,000 – 15,000 cal BP
~15,000 – 16,000 cal BP
~16,000 – 18,500 cal BP
~17,000 – 18,500 cal BP

order to better understand the contexts of 'Gönnersdorf-type' headless anthropomorphic depictions, which make up the largest amount of Late Upper Palaeolithic anthropomorphic representations, this record will be reviewed and discussed below.

The 'Gönnersdorf-type' headless anthropomorphic depictions

'Gönnersdorf-type' depictions (Gaudzinski-Windheuser and Jöris, 2015), as they were named by Gerhard Bosinski (Bosinski, 2007: *Gönnersdorf-Typ*), are highly schematic, abstract and, in a way, standardised anthropomorphic representations that are generally interpreted as depicting females (cf. Lorblanchet and Welté, 1987, 1990: *Lalinde/Gönnersdorf type*; Delluc and Delluc, 1995: *figurations féminines schématiques*; cf. Bourrillon et al., 2012: *Groupe A*). Although mostly engraved they also appear frequently as 3-dimensionally carved figurines. Engravings are to be found on plaquettes and pebbles, on bone and in parietal art (**Fig. 5**).
The basic shape of 'Gönnersdorf-type' depictions resembles the human body in profile view or in sagittal section (cf. Rosenfeld, 1977). The primary elements shared in these depictions form the trunk, composed of the lower body which is depicted in more-or-less triangular shape, interpreted as representing pronounced buttocks or wide hips, and the upper body which, in the case of the engravings, is usually indicated by one or two more-or-less parallel lines only (**Fig. 3**). In varying levels of detail other attributes may add to the primary shape of the torso: arms are the next-most frequently shown trait (depicted mainly by converging lines), and – in even fewer cases – breasts (mostly round) that may be depicted below the arms (Bosinski et al., 2001). Some of the 'Gönnersdorf-type' depictions take the form of carved ivory statuettes, a few of which possess pairs of breasts (Höck, 1995). The combination of buttocks and breasts makes it clear that females are depicted, although in a very generic and abbreviated manner. Although this interpretation seems to apply to the majority of 'Gönnersdorf-type' anthropomorphic representations, it is unclear whether it can be extended to depictions that lack clear female attributes (cf. discussion in: Floss et al., 2021).
The general absence of the head is most characteristic of all 'Gönnersdorf-type' depictions (e. g., Bosinski, 2011a, 2011b; Bosinski et al., 2001; Cluzel and Cleyet-Merle, 2011; Höck, 1995). Additionally, only a very few depictions at Gönnersdorf include feet (Bosinski et al., 2001: plaquette 73). Given that most of the 'Gönnersdorf-type' depictions are in fact engravings, any such details as heads and feet could easily have been added, if they were desired; we can therefore conclude that their omission was deliberate. In terms of the characteristics listed above, 'Gönnersdorf-type' depictions can, therefore, be clearly distinguished from other styles of Upper Palaeolithic (female) anthropomorphic representations (Bourrillon et al., 2012; cf. Duhard, 1993; Gaudzinski-Windheuser and Jöris, 2015).
Gönnersdorf alone has produced a total of almost 450 anthropomorphic representations of this type, of which some 423 are engraved on schist plaquettes (with 'Gönnersdorf-type' depictions being presented on ~ 185 plaquette surfaces), sometimes in scenic arrangement in pairs or in small groups (Bosinski and Fischer, 1974; Bosinski et al., 2001; Bosinski, 2011a). In one case amounting to 22 figures, they have been arranged successively in different groups, with the largest group in this arrangement composed of 17 figures (Bosinski et al., 2001: plaquette 65). About 20 'Gönnersdorf-type' depictions are known from Andernach-Martinsberg (Bosinski, 1994), and in addition to these a number of figurines were made on ivory, schist or other stones (Höck, 1995). It should be emphasised that these numbers are approximations only, given that a certain number of the simplest and most abstract depictions may or may not be included in this category; when depictions possess all stylistic elements, i. e., hips, arms and breasts, the depicted motif appears beyond any doubt to represent a 'Gönnersdorf-type' depiction, but especially when extreme schematic depictions (alike **Fig. 3: bottom line**) are overlain or underlain by other engraved lines, their recognition and interpretation

is difficult. Some of the simplest depictions attributed to the 'Gönnersdorf-type' (e. g., **Fig. 3: 21-23**) are almost indistinguishable from the 'claviform signs' of franco-cantabrian cave art (e. g., Fuentes et al., 2019) – the latter, however, are usually viewed upside-down when compared to 'Gönnersdorf-type' depictions. In some of the 'Gönnersdorf-type' depictions, it seems that the engraver's tool slipped somewhat, resulting in body proportions that diverge from the 'standard', e. g., hip-to-back angles (Bosinski et al., 2001), and which, therefore, makes it unclear whether they are attributable to the canon.

The same difficulties arise when such simple and schematic motifs are composed of a few lines only, including a certain amount of depictions at several other sites where depictions appear restricted to the torso, which is engraved as a (sometimes elongated) double S-shaped figure. With this in mind, one has to acknowledge that the evidence at some sites that are often referred to for comparison (cf. Bosinski et al., 2001; Bosinski, 2011a, 2011b; Gaudzinski-Windheuser and Jöris, 2015; Rios-Garaizar et al., 2015), may not be as clear as is usually assumed. This is more problematic when unambiguous 'Gönnersdorf-type' anthropomorphic depictions are otherwise not present at such sites where similar examples have been said to exist (e. g., Pettitt, 2007; Mussi and De Marco, 2008).

Even though a few depictions may have been over-interpreted, therefore, their uniquely high number at Gönnersdorf (cf. Schwendler, 2012) and their spatial 'omnipresence' in the site's larger concentrations (**Fig. 2**; Bosinski et al., 2001) enhances the interpretation that the site may have served, among other functions (see above), as a meeting point for different foraging groups: a context in which the 'Gönnersdorf-type' anthropomorphic representations may have had a particular importance for social scaffolding (Gaudzinski-Windheuser and Jöris, 2015) and the implementation of rules and regulations. Here, they appear to have been embedded into quotidian activities within communally-used space, from which one can infer that 'Gönnersdorf-type' depictions played a role in the public, everyday transmission of social rules and regulations. The existence of some scenic depictions, interpreted as reflecting dance (Bosinski et al., 2001; cf. Gaudzinski-Windheuser and Jöris, 2015), may hint at their use in festival and/or ritual contexts.

Chronology and context of the 'Gönnersdorf-type' headless anthropomorphic depictions in central Europe

The degree of abstraction and schematisation and the relative standardisation of 'Gönnersdorf-type' anthropomorphic representations suggests that they functioned as symbols of (a) socially shared idea(s) (Gaudzinski-Windheuser and Jöris, 2015; cf. Bourrillon et al., 2012). The complete lack of any obvious individual traits on the 'Gönnersdorf-type' anthropomorphic representations, in particular their "headlessness", reinforces the notion that this symbol carried no information on specific individuals, but rather concerned the gender-related role(s) of females in Late Magdalenian societies (cf. Gaudzinski-Windheuser and Jöris, 2015). Given this degree of abstraction, one may infer that the full meaning of this symbol could only be discerned by those individuals who were socialized within the Magdalenian groups that employed this symbol. Beginning with this assumption, one may further infer that 'Gönnersdorf-type' anthropomorphic representations may have served their purpose(s) only within a relatively short period of time, i. e., while the symbol was 'current' and socially transmitted from one generation to the next through teaching and social learning (cf. Nishiaki and Jöris, 2019; Jöris, 2018). Such transmission forms the baseline for the establishment and implementation of rules and regulations that derive from socio-cultural contexts.

Interestingly, within central Europe, 'Gönnersdorf-type' anthropomorphic representations are closely linked with the Late Magdalenian (e. g., Bosinski et al., 2001; Fiedorczuk et al., 2007; Leesch et al., 2004) which equates to the Early Upper Magdalenian of south-western France (Langlais et al., 2015b, 2017), within which

they correlate specifically to a phase during which *Lacan* type burins were produced across central Europe (Street et al., 2012; cf. Połtowicz-Bobak, 2012). When radiocarbon dates are available for these sites, they compare closely to the dates established for Gönnersdorf and Andernach or date slightly younger (Street et al., 2012; Stevens et al., 2013; cf. e. g., Fiedorczuk et al., 2007), falling into the major phase of the Late Glacial population expansion that commenced ~ 16,000 cal BP or shortly before (cf. **Fig. 10**). At this time, central Europe was rapidly and more sustainably re-occupied after sporadic earlier attempts (e. g., Street and Terberger, 1999; Terberger and Street, 2002; Street et al., 2009; Miller, 2012; Bobak and Połtowicz-Bobak, 2014; Maier, 2015, 2017; Pasda, 2017; Wiśniewski et al., 2017; Maier et al., 2020; Jöris and Street, 2021). Even in the eastern extremity of central Europe the south-eastern Polish site of Wilczyce produced 'Gönnersdorf-type' anthropomorphic flint figurines that had been intentionally shaped by retouch (Fiedorczuk et al., 2007), dated at its oldest to 13,180 ± 60 ^{14}C BP (OxA-16728; on a tooth pendant derived from a perinatal baby burial: Irish et al., 2008); the chronology is similar to that of Gönnersdorf and Andernach.

As direct dates for 'Gönnersdorf-type' anthropomorphic representations do not exist, more precise age estimates of the length of time during which these symbols were implemented are difficult to establish. In the south-western part of Gönnersdorf, a few 'Gönnersdorf-type' anthropomorphic representations were associated with a small cluster of schist plaquettes, labelled Gönnersdorf-SW (**Fig. 2**; cf. Buschkämper, 1993). Here, atypical narrow-backed points and *Lacan* type burins, all made of Baltic flint, were found in close spatial association with red deer and elk bones, indicating a younger occupation of the site at a time when the region was beginning to reforest at the onset of the Late Glacial interstadial complex (Street and Turner, 2013: Plan 40). A radiocarbon date measured on one of the elk remains (Street and Terberger, 2004; cf. Street et al., 2012) places this younger occupation into the very beginning of Greenland Interstadial (GI) 1e, roughly 14,700-14,500 cal BP (cf. **Fig. 10**; Rasmussen et al., 2014). Although the presence of 'Gönnersdorf-type' anthropomorphic representations at Gönnersdorf-SW could be explained as due to potential re-use of material from other (and older) concentrations of the site, such an age would be roughly in accordance with age estimates for depictions of "Birds/Ladies" from Church Hole Cave in Creswell Crags (UK) further to the north-west, that – although not corresponding absolutely – are broadly similar to the 'Gönnersdorf-type' depictions (Pettitt, 2007; Pike et al., 2007). Similarily, several engravings in the Grotte de Gouy in northern France resemble the 'Gönnersdorf type' depictions (Martin, 2007). The lithic industry of this site, which includes bi-points and other backed points (Bordes et al., 1974), hints at a Final Magdalenian/Azilian/*Federmesser* context, matching a radiocarbon date from the site very closely (~ 14,000 cal BP: Martin, 2007), chronologically close to the age of several 'Gönnersdorf type' figurines (and a potential engraving) from the Final Magdalenian/Azilian of the Petersfels in southern Germany (Bosinski, 2011b, Bosinski et al., 2001). The age estimates available for Gönnersdorf-SW, Church Hole and Gouy (representing the north-westernmost appearances of this type of depiction) and those of the Petersfels all fall into the transition to and early phases of the Late Glacial interstadial complex (from shortly before GI 1e until GI 1d or, possibly, early GI 1c$_3$). This is of interest, as it is to the same period that several of the Late/Final Magdalenian sites of the Paris Basin belong, which have so far provided no convincing evidence for 'Gönnersdorf-type' anthropomorphic representations at all (cf. Debout et al., 2012). This may account for the comparably scarce archaeological evidence from the earlier stage of the Late Magdalenian (i. e., ~ 16,000-15,000 cal BP) in the Paris region.

Of even younger age is a sandstone arrow shaft smoother from the Late Palaeolithic *Federmesser* site of Neuwied-Niederbieber, only a few kilometres to the north-east of Gönnersdorf (Gelhausen, 2011). A series of more-or-less parallel incisions on one side of the object appears to resemble a series of 'Gönnersdorf-type' depictions (Loftus, 1982). Consequently, the find has been interpreted as reflecting a certain regional continuity from the Late Magdalenian to the Curved-Backed Point industries (*Federmessergruppen*)

of the Late Glacial Allerød interstadial (GI 1c-b; i. e., ~ 14,000-13,000 cal BP). However, assuming that such shaft smoothers were used in pairs, as is implied from younger contexts (Henry, 1976; Meier-Arendt, 1975), the incisions could – in an alternative interpretation – relate to marks made when fixing a twine around a pair of shaft smoothers to facilitate their use.

To summarise the chronological evidence from central and north-western Europe, one has to conclude that 'Gönnersdorf-type' anthropomorphic representations date within the range ~ 16,000-14,000 cal BP, and probably persisted until shortly thereafter. Despite the questionable evidence from the Niederbieber shaft smoother that may hint at a certain cultural continuity from the Magdalenian to the succeeding *Federmessergruppen*, the period of 'Gönnersdorf-type' anthropomorphic representations ends ~ 14,000 cal BP, roughly at a time that ancient DNA studies signal a major population-turnover in Europe (Posth et al., 2016; cf. Bortolini et al., 2020, for discussion).

'Gönnersdorf-type' headless anthropomorphic depictions of south-western Europe

Search for the 'stylistic predecessors' and (socio-cultural) origins of 'Gönnersdorf-type' anthropomorphic depictions requires a closer look into the record of the Magdalenian 'homeland' of south-western Europe. Unless one assumes an extremely rapid, *quasi* simultaneous spread of this type of depiction (which would lie beyond the chronometric resolution of the radiocarbon dating method), one would assume to find evidence in the south-west of Europe predating the central European record.

The south-west of Europe provides, on one hand, numerous Late Pleistocene sites that are listed as possessing headless anthropomorphic depictions (Duhard, 1993), most of which have been assigned to the 'Gönnersdorf-type' (**Fig. 5**; cf. Bosinski et al., 2001; Bosinski, 2011a, 2011b; Duhard, 1993; Ladier et al., 2005; Mussi and De Marco, 2008; Rios-Garaizar et al., 2015; Sentis, 2005). On the other hand have most of these sites produced far fewer depictions than are known from central Europe, and many of the specimens discussed do not convincingly represent anthropomorphs. Due to their simplistic style or representation, the latter accounts for several engravings in parietal art contexts (e. g., Garate, 2004; cf. Mussi and De Marco, 2008).

By contrast, more convincing examples are the engraved plaquettes or blocks found in rock-shelters or near to cave entrances, such as those reported from La Roche de Lalinde (Leroi-Gourhan, 1971; Bosinski et al., 2001), Gare de la Couze (Bordes et al., 1963), Abri Fontalès (Lorblanchet and Welté, 1987), Abri Murat (Lorblanchet and Welté, 1987) and Grotte du Courbet near Bruniquel (Alaux, 1972; Welté and Cook, 1993); these are the closest parallels to 'Gönnersdorf-type' depictions. Stratigraphically, and on the basis of the typology of associated finds, the engraved plaquettes or blocks from these sites can be dated to the later phases of the Magdalenian ("*Magdalénien supérieur / recent / final*"; cf. Cluzel and Cleyet-Merle, 2011), or, if more specific information is available, to the onset of the Late Upper Magdalenian (Langlais et al., 2015b, 2017; i. e., ~ "Magdalenian VI"; cf. Bordes et al., 1963; Alaux, 1972; Bosinski et al., 2011), chronologically a little younger than Gönnersdorf and Andernach. Radiocarbon samples from Fontalès, Abri Murat, Care de la Couze, and Abri Faustin produced dates between 13,140 ± 120 ^{14}C BP (GifA 96327) and ~ 12,300 ^{14}C BP (Langlais et al., 2012; Drucker et al., 2011; Barashay-Szmidt et al., 2016) for layers that have provided 'Gönnersdorf-type' anthropomorphic depictions, corresponding to the second half of GS-2.1a, ~ 15,900-14,500 cal BP, i. e., of roughly equal age to the central European evidence (**Fig. 10**).

Nevertheless, radiocarbon dates from the Middle to Late Magdalenian of Courbet appear a little older, ranging between 13,380 ± 120 ^{14}C BP and 13,490 ± 260 ^{14}C BP (Ladier and Welté, 1999; Ladier et al., 2005), but these statistically overlap with the oldest radiocarbon dates for horse remains from Gönnersdorf (OxA-V-2223-39: 13,270 ± 55 ^{14}C BP) and Andernach-Martinsberg (OxA-10651: 13,270 ± 180 ^{14}C BP and

OxA-10492: 13,500 ± 90 ^{14}C BP; cf. Stevens et al., 2009). A further engraving quite similar to 'Gönnersdorf-type' depictions is reported from La Magdeleine-la-Plaine (Ladier, 2001), the Middle Magdalenian archaeological context of which is dated to 13,680 ± 130 ^{14}C BP (GifA 96345: Ladier et al., 2005). In northern Spain, the Middle Magdalenian levels of Las Caldas Cave in Asturias yielded a plaquette (level VI) and a bone (level VII) on which each a 'Gönnersdorf-type' anthropomorphic depiction was engraved (Corchón Rodríguez, 1990; Fortea et al., 1990; cf. Corchón Rodríguez and Ortega Martínez, 2017; Corchón Rodríguez and Rivero Vilá, 2017). The radiocarbon chronology of the sequence indicates an age of ~ 13,650 ^{14}C BP for these finds (Corchón Rodríguez, 1995, 2017) similar to the proposed age of La Magdeleine-la-Plaine. As with Gönnersdorf and Andernach, all of these contexts also contain harpoons (for the chronology of Magdalenian organic projectiles, cf. Pétillon, 2016).

This is not the case for the large engraved limestone-"venuses block" from the cave of Arlanpe in northern Spain (Rios-Garaizar et al., 2015). Although at first sight this block seems to include a 'Gönnersdorf-type' depiction, similarities are difficult to establish due to the relatively few lines of which the double S-shaped motif is composed. The situation is even further complicated as the block was not discovered entirely *in situ*, as a Roman pit had been excavated into the cave sediments and exposed the "venuses block" and we do not know if by so-doing they disturbed its original position. Establishment of a solid age estimate for the presumable Middle Magdalenian context of the Arlanpe "venuses block" appears, therefore, fairly difficult (Rios-Garaizar et al., 2015). Of the two radiocarbon dates available for level I to which the "venuses block" most likely should be assigned, the younger, obtained from an anthropogenically-fractured herbivore bone and which is closest linked to the archaeology, comes from the base of level I and dated to 14,150 ± 60 ^{14}C BP (Beta-287336); the other measurement, derived from a bone that displays no human modification, dated to 15,100 ± 60 ^{14}C BP (Beta-316472: Rios-Garaizar et al., 2015). The top of level I may, however, be much younger than this.

The engraved plaquette from the Early Middle Magdalenian site of Moulin-Neuf in the Gironde may be of roughly comparable age or older (Sécher and Caux, 2017; Langlais et al., 2015b, 2017). This is also included among the headless anthropomorphic depictions of the Late Upper Palaeolithic (Ladier et al., 2005). In this case it remains unclear whether or not an anthropomorph is depicted at all; the figure is of a 'compressed' double S-shape, and, if it is justifiable to compare it to 'Gönnersdorf-type' anthropomorphic depictions at all, one may interpret it as representing the lower part of the torso only. Radiocarbon dates for it range from ~ 14,200 ^{14}C BP (Ladier et al., 2005) to ~ 15,400 ^{14}C BP (Barshay-Szmidt et al., 2016).

The Middle Magdalenian site of La Marche, famous for its highly naturalistic and often caricature-like depictions of humans (Pales and Tassin de Saint Péreuse, 1976; Airvaux and Pradel, 1984; Mélard, 2008) also provides a few examples of anthropomorphic depictions that closely resemble the 'Gönnersdorf-type' (Mélard, 2008: planche 12; planche 35). Dating to around 14,250 ^{14}C BP (Orsay-3780: 14,240 ± 85 ^{14}C BP; and: Ly 2100: 14,280 ± 160 ^{14}C BP; Pradel, 1980; cf. Barshay-Szmidt et al., 2016) the site belongs to the same age range as Arlanpe and overlaps with the younger age estimates for Moulin-Neuf. The greater majority of the female depictions from La Marche are engraved on limestone blocks in profile view (Pales and Tassin de Saint Péreuse, 1976; Mélard, 2008), a perspective in which the outline of the body closely resembles the shape of the female torso that is also captured in engravings of 'Gönnersdorf-type' headless anthropomorphs. In this context, therefore, one may view the complete depictions of females at the site as potential blue-prints – probably stylistic predecessors – for the more abstract 'Gönnersdorf-type' depictions that developed later.

With regard to parietal examples of 'Gönnersdorf-type' anthropomorphic depictions, one such, in the cave of Gourdan in the Pyrenees, "has been attributed to the Middle or Upper Magdalenian by stylistic comparison […] and the associated archaeological context has yielded two dates between 14,400 and 13,200

[^{14}C] BP […], that is, within the temporal range of the Middle Magdalenian" (Rios-Garaizar et al., 2015: 334). Age estimates for parietal examples can only be ascertained indirectly, as the rock-art may – at best – be linked on stylistic grounds to archaeological layers that contain radiocarbon-dated material. The oldest radiocarbon date from the lowest (Mid-) Magdalenian level at the site of Les Combarelles in the Dordogne, a cave which also produced a series of 'Gönnersdorf-type' parietal engravings (Archambeau and Archambeau, 1991), dates to 13,680 ± 210 ^{14}C BP (Ly 3202), but most other dates from the site are significantly younger (cf. Cluzel and Cleyet-Merle, 2011). Furthermore, in both Gourdan and in Les Combarelles the precise relationship between the parietal engravings and the dated archaeological levels remains unclear, but at least in the case of Les Combarelles its age ranges are in accord with the age estimates for other south-western European sites that have produced 'Gönnersdorf-type' headless anthropomorphic depictions and that post-date ca. 13,650-13,680 ^{14}C BP (~ 16,500 cal BP).

To summarise, 'Gönnersdorf-type' anthropomorphic depictions can occasionally be found in south-western Europe probably from as early as ca. 16,500 cal BP onwards, but more solid evidence for the appearance of the 'Gönnersdorf-type' depictions which are stylistically almost identical to the depictions at the eponymous site in the German central Rhineland is only available from ca. 16,000 cal BP onwards, i. e., quasi simultaneous with the central European evidence. Considering the finds from Arlanpe, Moulin-Neuf and La Marche, potential double S-shaped 'predecessors' of the 'Gönnersdorf-type' headless anthropomorphic depictions may even date as old as ~ 17,000-18,000 cal BP (Rios-Garaizar et al., 2015). However, the poor contextual dating evidence for these south-western European examples must be viewed with some caution, given the contextual problems these often multi-layered stratigraphic sequences of caves and rock-shelters with much more complicated site formation processes have in comparison to single-layered open-air sites. It should furthermore be emphasised that 'Gönnersdorf-type' depictions are comparably rare in number among south-western European sites, where the possibly early candidates are mostly depicted in a very rudimentary style – often reduced to a double S-shape of the torso. Finally, their occasional appearance in rock-art, sometimes engraved deep in caves on the cave walls, emphasises the different contexts into which the south-western European depictions seem to be embedded (Bosinski et al., 2001).

Late Upper Palaeolithic ('Gönnersdorf-type') headless anthropomorphic depictions outside Europe

Geographically distinct from the European record of 'Gönnersdorf-type' headless anthropomorphic depictions , a small series of rock-shelters in Egypt have yielded engraved depictions of anthropomorphs (Huyge, 2015). Of special interest here are several headless specimens from the rock-shelter of Qurta II in Upper Egypt, that very closely resemble 'Gönnersdorf-type' depictions (Ucko and Rosenfeld, 1972; Huyge, 2009, 2015). The panel QII.3.1 at Qurta comprises two clusters of depictions: one cluster of four (QII.3.1.6-9), and another of two (QII.3.1.4-5) 'Gönnersdorf-type' depictions, all facing to the right (**Fig. 6: 2**). The one furthest to the right in the cluster of four (QII.3.1.9) seems to depict "rudimentary arms and/or breasts", similar to the more detailled 'Gönnersdorf-type' depictions (Huyge, 2015: 420; cf. Ucko and Rosenfeld, 1972). Other anthropomorphic, potentially "human" depictions come from Qurta I (QI.1.1.16) and Abu Tanqura Bahari 11 at el-Hosh (ATB11.4.6-7) on the other side of the River Nile. These depictions differ in their body proportions from the 'Gönnersdorf-type' depictions of Qurta II due to their more elongated upper torsos. Whereas the Qurta I specimen seems to display a head, the two anthropomorphic depictions in panel ATB11.4 at el-Hosh do not preserve heads (**Fig. 6: 1**). It may be the case, however, that heads were originally depicted but were subsequently removed by the picked depiction of a bovid superimposed on the



Fig. 6 Upper Egypt. Depictions of bovids superimposed upon headless anthropomorphous depictions from the rock-shelters of Qurta II (**2**) and Abu Tanqura Bahari (ATB) 11 at el-Hosh (**1**). – (Redrawn and modified by G. Rutkowski and N. Viehöver from: Huyge, 2015).

anthropomorphic depictions (Huyge, 2015). Two further headless depictions have been published from a rock-shelter further north on the Sinai peninsula, where, due to an emphasis on large, round breasts and strongly protruding buttocks these have been interpreted as female (Zboray, 2012).

The age of these depictions is difficult to establish. In general it is believed that the Upper Egyptian depictions can be tied to the so-called Ballanan-Silsilian industry which is represented by several sites in the region (Huyge, 2015). Radiometric age estimates for this, however, are highly inconsistent and rely on a few available dates only. In general, an age of roughly 19,000-18,000 cal BP is expected for the industry (i. e., ~ 16,000-15,000 ^{14}C BP; cf. Schild and Wendorf, 2010), but considerably younger dates also exist (cf. Vermeersch, 1992). At Qurta II, panel QII.3.1, an engraving of a bovid is superimposed upon the 'Gönnersdorf-type' headless depictions; this also occurs to the anthropomorphic depictions of ATB11.4.6-7 at el-Hosh. Therefore, at both sites the anthropomorphic depictions pre-date the engraving of bovids. Assuming that the bovids were depicted in the same period, which one may argue for, the OSL dating evidence from panel QII.4.2 at Qurta would be of relevance, as, here, the engraving of a bovid was buried below eolian sands. The OSL dates calculated from these sands provide a *terminus ante quem* of 16 ± 2 ka BP and 17 ± 2 ka BP for immediately below or near the base of the buried depiction, and 13 ± 1 ka BP and 10 ± 1 ka BP for its top, i. e., the back line of the engraved bovid (Huyge et al., 2011, 2012), implying an age of at least 13 ka BP, but likely closer to 16 ka BP. Radiocarbon dated faunal remains from the 16 ± 2 ka BP OSL-dated level, i. e.,

the base of the panel, result in calibrated ages of ~ 14,000 cal BP (KIA-41532: 12,130 ± 45 ^{14}C BP) for a bird bone sample and some (not reservoir-corrected) 12,750-12,600 cal BP (KIA-40546: 10,585 ± 50 ^{14}C BP) for fishbone sampled from the same layer (Dee et al., 2010).
Taking the dating evidence from the Qurta II rock-shelter overall, an age of around 14,000 cal BP or slightly older seems to be most plausible for the site's 'Gönnersdorf-type' depictions (cf. **Fig. 10**), which is of interest given that it is in agreement with the younger range of dates for 'Gönnersdorf-type' depictions in north- and south-western Europe (see above). Claims that state that the headless anthropomorphic depictions of Upper Egypt could pre-date the European record of 'Gönnersdorf-type' depictions (Huyge, 2015), however, require more solid data and are currently premature; their relation to the European headless anthropomorphic depictions of 'Gönnersdorf-type' remains unanswered.

Headless anthropomorphic depictions in the Late Upper Palaeolithic of eastern Europe

Further to the east of the easternmost appearance of 'Gönnersdorf-type' depictions (i. e., Wilczyce in south-eastern Poland; Fiedorczuk et al., 2007), headless anthropomorphic depictions are found in the eastern European steppes of modern Ukraine and western Russia. Notably, these include several ivory figurines and fragments of potential figurines from the Epigravettian site of Mezin in Ukraine (Iakovleva, 2009; Bosinski, 2011b), some of which closely resemble the 'Gönnersdorf-type' figurines (**Fig. 5**). But other headless anthropomorphic ivory figurines of different shapes are additionally reported from Mezin (Chovkoplass, 1965) and Mezhyrich (Pidoplichko, 1976; Abramova, 1995), which – together with several other sites such as Dobranichivka, classified as Epigravettian – are well-known for their mammoth bone concentrations which are most often interpreted as dwelling structures (e. g., Pidoplichko, 1998; Gladkih et al., 1984; Iakovleva, 2015; for a counter-position cf. Khlopachev and Gavrilov, 2019).
The site of Mezin produced a total of 18 headless anthropomorphic figurines of ivory (**Fig. 7**; Chovkoplass, 1965; cf. Iakovleva, 2009, 2015), of which 16 are interpreted as female representations and two that are of a more elongated phallic shape (**Fig. 8**). At least three headless female figurines derive from Mezhyrich, of which one is made on a flat bone (**Fig. 9**; Abramova, 1966; cf.; Iakovleva, 2009, 2015). Although these depictions share their "headlessness" and abstractness and to a certain degree, their overall shapes (at least in case of representations interpreted as female) differ from those of 'Gönnersdorf-type' in several details (**Table 1**). The Mezin and Mezhyrich figurines are in fact of great morphological diversity, and it appears that different styles of representations relate to different concentrations/dwellings (**Figs. 7-8**; Chovkoplass, 1965; Iakovleva, 2009, 2015).

Schematised and anonymized anatomy

As with 'Gönnersdorf-type' depictions, the headless female figurines of Mezin are characterised by pronounced buttocks/hips opposite to a relatively flat-fronted torso. With this shape and viewed from the side, they resemble 'Gönnersdorf-type' depictions, and, more specifically, the 'Gönnersdorf-type' figurines (Iakovleva, 2009). Whereas the latter were designed to function in side/sagittal view (Gaudzinski-Windheuser and Jöris, 2015), the Mezin figurines display most relevant details on their front (Chovkoplass, 1965; Iakovleva, 2009, 2015): among these, the lower part of the torso displays on its flat frontal face an engraved triangle, interpreted as the female pubic triangle (**Fig. 7**). The upper part of the figurines' torso is also engraved on the frontal aspect. It is on this frontal aspect that most differences appear between the figurines

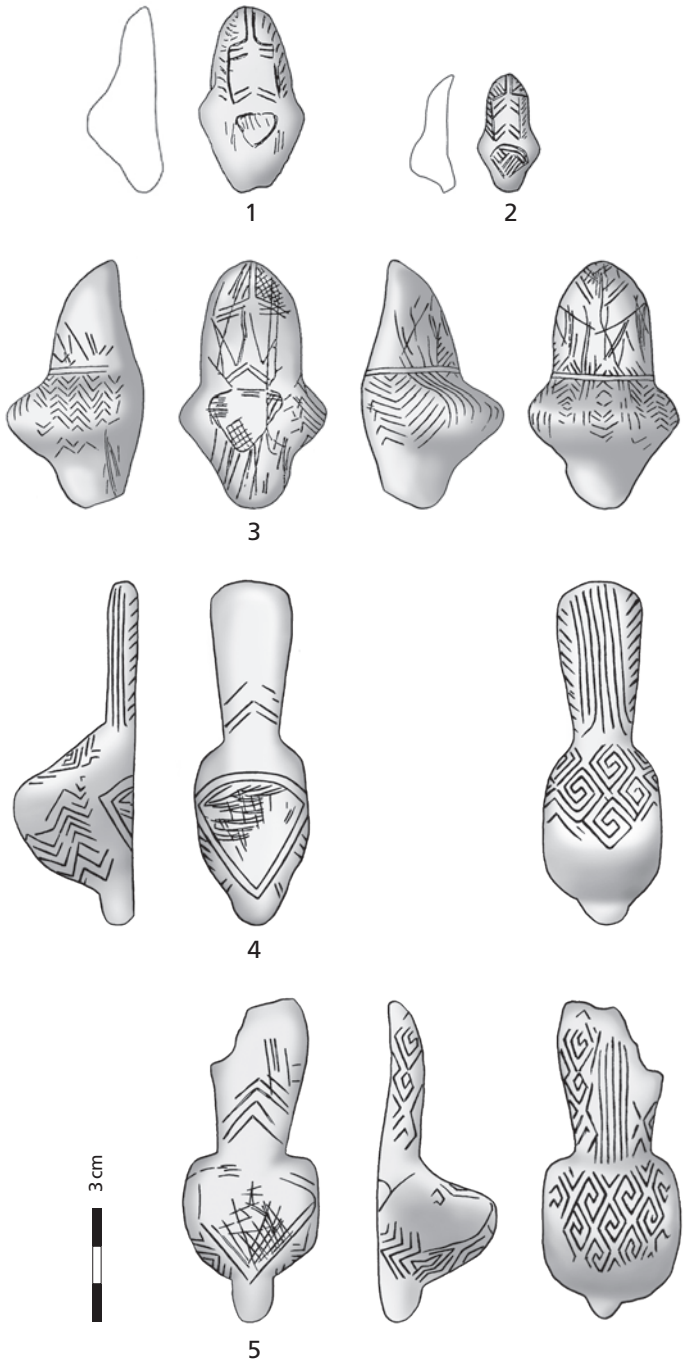


Fig. 7 Mezin. Headless anthropomorphous ivory figurines, interpreted as female, from dwelling 2 (**1-3**) and dwelling 3 (**4-5**). – (Redrawn and modified by G. Rutkowski and N. Viehöver from: Chovkoplass, 1965).

from the different dwellings; those from dwelling 2 possess engravings that form an elongated trapezoidal box, filled with pairs of chevrons, which seem to represent the thoracic cage. This impression is enhanced by two vertical lines on top of this box, most likely to be interpreted as the neck, ending at the top of the figurine where the head would be placed if the figurines weren't depicted headless. Given this, the front of the headless female figurines from Mezin-dwelling 2, appear to display – although in strongly schematized form – detailed human anatomy; breasts, however, are lacking. The slightly larger female figurines from Mezin's dwelling 3 are quite similar to those from dwelling 2 (Chovkoplass, 1965); their upper torso, however, is shown in a more simple and abstract manner, displaying sets of chevrons (i. e., 'ribs'), with additional lines that may resemble the neck, displayed on a single figure only. The rear side of the upper torso of the

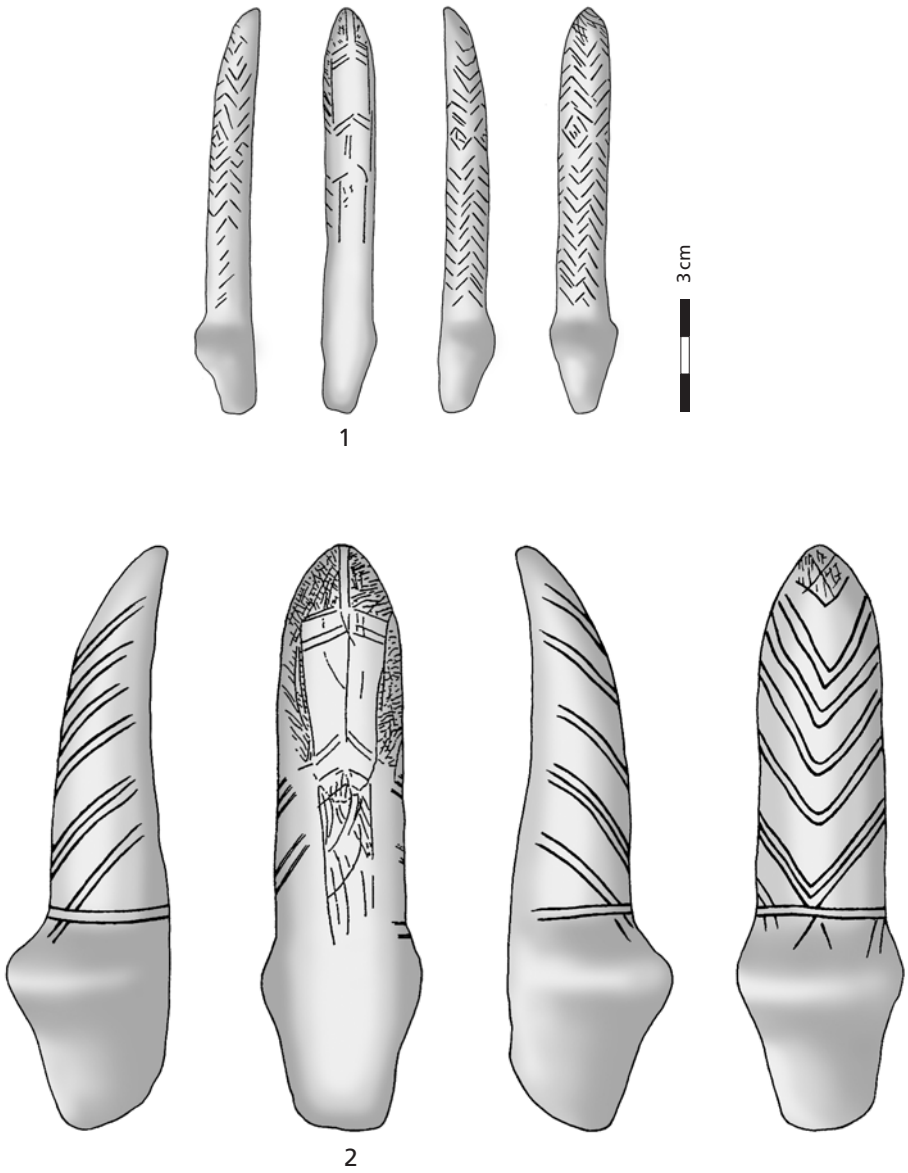


Fig. 8 Mezin. Headless anthropomorphous ivory figurines, interpreted as male, from dwelling 2. – (Redrawn and modified by G. Rutkowski and N. Viehöver from: Chovkoplass, 1965).

two larger figurines from dwelling 3 display long, parallel and vertically running engravings: perhaps they depict long hair or the spinal column? Aside from these details, the back and sides of the dwelling 2 and 3 figurines are ornamented with geometrical patterns (zig-zag lines and 'angular meanders'; Chovkoplass, 1965; Iakovleva, 2009, 2015).

The Mezhyrich headless female figurines appear to be much more schematic in form (**Fig. 9**; Abramova, 1995; cf. Iakovleva, 2009). Most characteristic is the pubic triangle engraved on their flat front in the lowest part of the lower torso. Additionally, a specimen from dwelling 2 displays sets of parallel lines running horizontally across its upper torso. The site of Dobranichivka produced a few amber figurines and possible fragments of such that are of a shape that resembles that of the headless anthropomorphic ivory figurines from

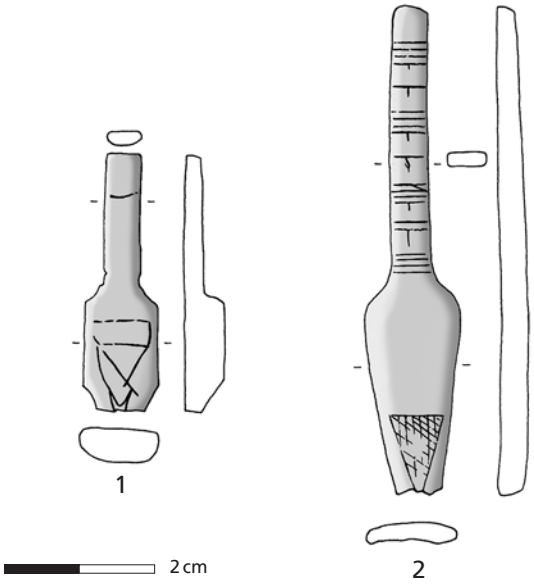


Fig. 9 Mezhyrich. Headless anthropomorphous figurines, interpreted as female, from dwelling 1 (**1**) and dwelling 2 (**2**). – (Redrawn and modified by G. Rutkowski and N. Viehöver from: Abramova, 1995; Iakovleva, 2009).

Mezhyrich (Iakovleva, 2009). Due to their poor surface preservation, however, it cannot be said whether or not they once bore engraved ornamentation. In addition to the headless depictions, Mezhyrich also produced at least one highly schematic anthropomorphic figurine that possesses a small face (Abramova, 1995; Iakovleva, 2015). The examples from Mezhyrich are particularly flat, and other attributes that characterize the Mezin figurines and/or 'Gönnersdorf-type' depictions, like pronounced buttock, are absent (Iakovleva, 2009, 2015).

Mezin-dwelling 2 also produced two headless anthropomorphic figurines of generally more phallic shape (Fig. 8; Chovkoplass, 1965). Both are characterised by a more elongated upper torso, but display the same stylistic design of the thoracic cage and the indication of the neck as the female figurines from the same dwelling structure (Table 1). Their hips are, however, less pronounced, and their pubic regions remain blank. With their overall phallic shape and the absence of any female characteristics, i.e., less pronounced hips and absence of the pubic triangle, it is likely that these represent male counterparts (Iakovleva, 2009, 2015). Their backs and sides are ornamented with zig-zag or double-zig-zag patterns.

Interpretation and age

Similar to the 'Gönnersdorf-type' anthropomorphic representations, the headless anthropomorphic figurines of Late Upper Palaeolithic eastern Europe are also highly schematic and abstract, although – by their stylistical conventions of representation – depict far more anatomical detail, allowing the viewer to clearly distinguish between female and male figurines. A similar distinction cannot be made amongst the 'Gönnersdorf-type' depictions, as sexual attributes are largely absent. With these, aside from the depictions with breasts, only the shape of the hips indicate that in the overwhelming majority of cases it is females that are represented (see above). Another difference between the eastern and central European examples lies in the

comparably large stylistic diversity of the headless anthropomorphic figurines of the Late Epigravettian of eastern Europe that differ in the proportion of the torso and in ornamentation between sites and dwellings, as described above (cf. Iakovleva, 2009, 2015).

Given the characteristic features of the anthropomorphic figurines of the Late Epigravettian of eastern Europe, the lack of clear individual traits and especially their "headlessness", one may conclude by analogy with the interpretation of 'Gönnersdorf-type' depictions that the eastern European figurines also served as symbols, probably encoding gender-differentiated social roles in the Epigravettian of the region. The comparably large variability between the figurines from different sites and dwellings implies that other levels of social differentiation, such as e. g., household, lineage or kin, may additionally be encoded.

The similarities between the eastern European headless anthropomorphic figurines and the 'Gönnersdorf-type' depictions are all the more interesting as the eastern European examples seem to pre-date the latter (Iakovleva, 2005; Iakovleva and Djindjian, 2005; Haesaerts et al., 2015; Gavrilov, 2021; cf. Marquer et al., 2012). Combined radiometric and stratigraphic evidence (Haesaerts et al., 2015), indicates an age of ~ 18,300-17,400 cal BP (~ 15,050-14,300 ^{14}C BP) for the multiple occupation phases of the site of Mezhyrich (cf. Soffer et al., 1997). This interval is in agreement with the radiocarbon dating evidence for other Epigravettian sites from this period in the Dnepr and Desna region of Ukraine and western Russia that produced mammoth bone concentrations (Iakovleva, 2005; Iakovleva and Djindjian, 2005; Gavrilov, 2021). This includes the site of Mezin, which produced dates of 15,100 ± 200 ^{14}C BP (OxA-719; Iakovleva and Djindjian, 2005) and 14,560 ± 90 ^{14}C BP (GrA-22499; Haesaerts et al., 2015). The site of Dobranichivka may be slightly younger, with dates of ~ 14,100 ^{14}C BP (GrA-22472: 14,355 ± 90 ^{14}C BP, and OxA-12108: 13,990 ± 90 ^{14}C BP, on the same bone; Haesaerts et al., 2015) and 12,700 ± 200 ^{14}C BP (OxA-700; Iakovleva and Djindjian, 2005). From the archaeological contexts provided by these sites, however, age estimates based on radiocarbon dates significantly younger than ~ 14,000 ^{14}C BP should be viewed with scepticism (Iakovleva and Djindjian, 2005). On the other hand, the few dates available from Mezin that fit into the above interval may still overestimate the age of the archaeological occupation as the dated bones derive from bone concentrations that consist of collected subfossil material that has been piled up at the site.

"HEADLESSNESS" IN THE EUROPEAN LATE UPPER PALAEOLITHIC ANTHROPOMORPHIC DEPICTIONS: CHRONOLOGICAL TRENDS AND GEOGRAPHIC SCALES

The headless anthropomorphic depictions of 'Gönnersdorf-type' and those of the eastern European Late Epigravettian can be compared with a few further anthropomorphic depictions from the Late Upper Palaeolithic of south-western Europe. Viewed in chronological order, such comparison sheds new light on the understanding of the supra-regional homogeneity of 'Gönnersdorf-type' depictions, and contributes to the overall interpretation of the eponymous site.

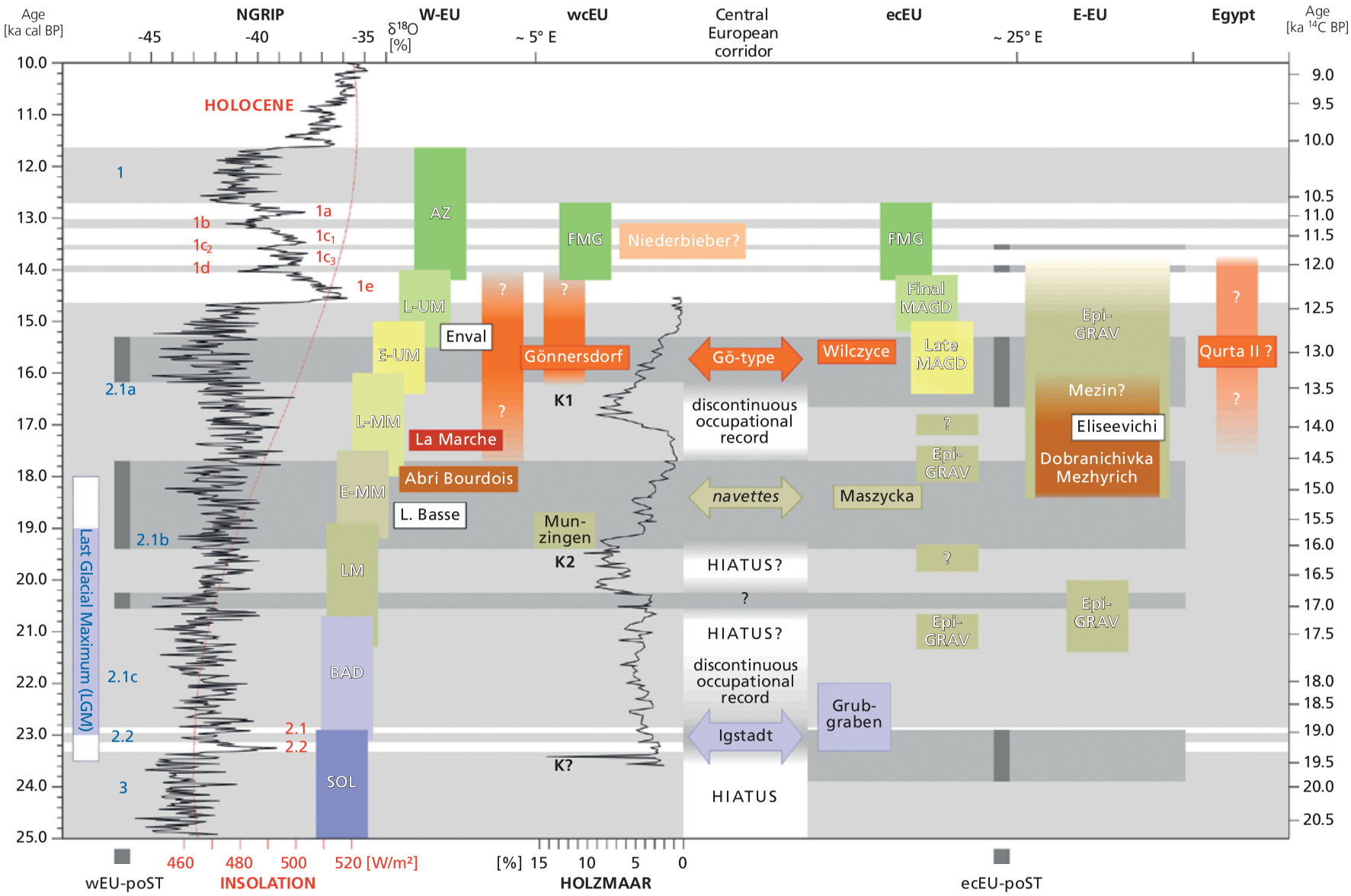
East-west temporary interconnectedness ~ 19,000-17,500 cal BP

Due to its early discovery in 1864 the most famous Palaeolithic human depiction is the *Vénus impudique* ('immodest Venus'), a headless ivory figurine from Laugerie Basse in the Dordogne (e. g., Delporte, 1979, 1993a, 1993b), that dates to the Middle Magdalenian (**Fig. 10**). The figurine's head appears to have been

broken off; its feet are also lacking, the latter at least probably broken off during their archaeological discovery. Additionally, its arms and breasts are missing, but in this case as they were never carved as elements of the figurine's design. The figurine is meant to be viewed from the front, where its deeply incised vaginal opening is visible. Another small figurine depicting a female torso, made of stone, is reported from the Late Magdalenian of the site of Enval (Bourdelle et al., 1971). The figure's head has been broken off; but, similar to the Laugerie Basse figurine, the missing breasts, arms and feet were never carved in the first place. Radiocarbon dates obtained on samples from the layers below (Delpech, 1998), suggest an age of ~ 15,500 cal BP or slightly younger can be assumed for the Enval figurine. Of similar style when compared with Laugerie-Basse and Enval, but of Early Middle Magdalenian age is the monumental "*panneau des Vénus*" bas-relief of Abri Bourdois at Roc-aux-Sorciers in L'Angles-sur-l'Anglin (Vienne), composed of at least three female torsos and a forth one aside, all of which lack heads, breasts, arms and feet, but which display deeply incised vaginal openings (de Saint-Mathurin and Garrod, 1949; Iakovleva and Pinçon, 1996, 1997, 1999). This is an interesting parallel to the more-or-less contemporaneous headless anthropomorphic figurines of Mezhyrich discussed above (**Fig. 9**); they were also intended to be viewed from the front, lack heads, breasts, arms and feet, but show engraved pubic triangles. The Dobranichivka amber figurines closely match the overall shape of the headless figurines from Mezhyrich (Iakovleva, 2009). The Mezin figurines are very similar to those from Mezhyrich, but they are much more strongly ornamented, and more strongly emphasise the typical profile characteristic of 'Gönnersdorf-type' depictions that appeared in central Europe from ~ 16,000 cal BP on.

It is surely unlikely that similarities in the appearance and amount of principle stylistic elements shared by the *Vénus impudique*, the plastically sculptured females in the frieze at Abri Bourdois ("*Panneau des Vénus*") and the headless anthropomorphic figurines of Mezhyrich is simply coincidence. The same principle – designed to be viewed from the front, lacking heads, breasts, arms and feet, but showing the female pubic region – is realised also at a small series of six Middle Magdalenian sites of south-western France, most of them assigned to the *Magdalénien à pointes de Lussac-Angles* facies (Abri Bourdois, les Fadets, Montgaudier, l'Abri Gaudry, Grottes du Chaffaud, La Marche), where horse incisors were also found engraved with a pubic triangle (Mazière and Buret, 2010; Airvaux, J., 2011). Their overall shape is similar to that of the ivory

Fig. 10 Chronology of Late Upper Palaeolithic headless anthropomorphic depictions (orange; Gö = Gönnersdorf) in the context of different palaeoclimate and archaeological records for western Europe (W-EU), western central Europe (wcEU: ~ 5-15° E), eastern central Europe (ecEU: ~ 15-25° E), eastern Europe (E-EU), and Egypt (left timescale: ka cal BP; right timescale: approx. ka ^{14}C uncal BP; cf. Reimer et al., 2020).
Greenland NGRIP δ^{18}O [‰] isotope record (Rasmussen et al., 2014) with Greenland Stadials (GS: blue) and Greenland Interstadials (GI: red); summer insolation [W/m²] in June at 60° N (Berger and Loutre, 1991); the Last Glacial Maximum (LGM) follows the definitaion of Mix et al. (2001) as the period of maximum global ice volume and lowest sea levels during the last Glacial cycle, i. e., ~ 23,000 - 19,000 cal BP (LGM light-blue), and spanning from the northern hemispheric summer insolation minimum at ca. 23,500 cal BP (Berger and Loutre, 1991) and the timing of Heinrich Event H2 until ca. 18,000 cal BP (LGM white), when the Fennoscandian Ice Shield started to slowly retreat after its maximum advance during the Brandenburg glacial stage (Hughes et al., 2016). Holzmaar carbonate contents [%] in lacustrine clastic varves with carbonate peaks K1, K2 and K? (data from Brauer, 1994; Zolitschka et al., 2000, modifed), indicative of calcareous dust flux and increasead eaolian activity (i. e., loess deposition) in western central Europe (Zolitschka et al., 2015); periods of the presence of saiga antilopes (poSt: dark grey) in western Europe (wEU-poSt) and eastern central Europe (ecEU-poSt) with wEU-poSt data compiled from Langlais et al. (2015a), Barashay-Szmidt et al. (2016) and Nadachowski et al. (2016) for directly ^{14}C-dated samples of *Saiga tatarica* and Bosinski (2009) for contextual age-estimates from the 'artistic' record, and ecEU-poSt data compiled from Nadachowski et al. (2016) for directly ^{14}C-dated samples of *Saiga tatarica* and Kozłowski et al. (2017) for contextual age-estimates from Maszycka cave.
The archaeostratigraphic record is shown schematically for France, central and eastern Europe, covering the Solutrean (SOL), Badegoulian (BAD), Lower Magdalenian (LM), Early Middle Magdalenian (E-MM), Late Middle Magdalenian (L-MM), Early Upper Magdalenian (E-UM)/ Late Mgadalenian (Late MAGD), Late Upper Magdalenian (L-UM)/Final Magdalenian (Final MAGD) to the Azilian (AZ)/*Federmessergruppen* (FMG), following data compilations from Ducasse et al. (2021; cf. Ducasse, 2012) for the SOL to BAD, from BAD to E-MM (Ducasse and Langlais, 2007) and from Langlais et al. (2015a, 2015b) for the E-MM to L-UM sequences, and from Wiśniewski et al. (2017) and Nerudová et al. (2019) for the Epigravettian (Epi-GRAV) of eastern central and from Gavrilov (2021) for eastern Europe. For further references: see text.


Age [ka cal BP]
NGRIP
-45
-40
-35
δ18O [‰]
W-EU
wcEU
~ 5° E
Central European corridor
ecEU
~ 25° E
E-EU
Egypt
Age [ka 14C BP]
HOLOCENE
1
1a
1b
1c2
1c1
1c3
1d
1e
2.1a
2.1b
2.1c
2.2
2.1
2.2
3
Last Glacial Maximum (LGM)
AZ
L-UM
E-UM
L-MM
E-MM
LM
BAD
SOL
Enval
La Marche
Abri Bourdois
L. Basse
FMG
Niederbieber?
Gönnersdorf
K1
Mun-zingen
K2
K?
Gö-type
navettes
discontinuous occupational record
HIATUS?
HIATUS?
discontinuous occupational record
Igstadt
HIATUS
FMG
Final MAGD
Late MAGD
Wilczyce
Maszycka
Grub-graben
Epi-GRAV
Mezin?
Eliseevichi
Dobranichivka
Mezhyrich
Qurta II ?
460
480
500
520 [W/m²]
INSOLATION
wEU-poST
[‰] 15
10
5
0
HOLZMAAR
ecEU-poST

figurines from Mezhyrich (see above; cf. Chovkoplass, 1965; Iakovleva, 2009, 2015). In their overall characteristics the engraved horse incisors seem to represent a 'special' regional variant (cf. Fuentes et al., 2019) of a theme that appeared at this time in western and in eastern Europe. During this time interval, however, in western Europe spanned by the Lower and Middle Magdalenian, there is limited evidence for human presence in central Europe and hence, to bridge the east and the west, a topic currently discussed intensively (**Fig. 10**; cf. e. g., Maier et al., 2020; Maier, 2017; Pasda, 2017; Wiśniewski et al., 2017). Particularly prominent in this discussion is the cave of Maszycka in southern Poland, dated to ~ 18,600-18,000 cal BP (Kozłowski et al., 2012, 2017), with an industry that is characteristic of the *Magdalénien à navettes* comparing in many details to French sites attributed to this 'facies' (Allain et al., 1985; Bourdier et al., 2017a). The lithic raw materials used at Maszycka do, indeed, not only link ~ 600 km to the west to southern Germany ("*Plattensilex*"), i. e., half way towards France, but also some 300-400 km to the sources of so-called Volhynian flint in western Ukraine (Kozłowski et al., 2017), showing that central Europe at this time must have formed a corridor for the long-distance transmission of people and ideas.

Given the paucity of archaeological sites in central Europe that correspond to the Lower and Middle Magdalenian and which could, therefore, provide evidence for the interconnectedness of western and eastern European populations, the presence of saiga antelope (*Saiga tatarica*) could serve as a useful proxy for punctuated or comparably short periods of presence in western Europe, during oscillations of extremely dry climate when saiga habitats expanded from western central Asia to the Atlantic costs of France (Nadachowski et al., 2016). The presence of saiga in the hunted fauna (e. g., Maier et al., 2020), at best directly dated by radiocarbon (e. g., Nadachowski et al., 2016; Barashay-Szmidt et al., 2016; Langlais et al., 2015a) or its presence in the 'artistic' record (Bosinski, 2009) during the period discussed, help to compile a record of pulses of saiga antelopes' westward expansions in periods in which central Europe was (principally) habitable (cf. Maier et al., 2020). Interestingly, the period ~ 19,000-18,000 cal BP represents such a period of saiga expansion (**Fig. 10**), with evidence in eastern central Europe at Maszycka, although not directly dated (Kozłowski et al., 2017), and at a series of Early and Middle Magdalenian sites in the west (Costamagno, 2000; Barashay-Szmidt et al., 2016; Nadachowski et al., 2016) among which the site of Moulin-Neuf, discussed above (Costamagno, 2000), is most relevant here.

In France, the Middle Magdalenian record appears as a complex 'mosaic' which – amongst other aspects that led to the distinction of the two facies named above, i. e., the *Magdalénien à pointes de Lussac-Angles* and the *Magdalénian à navettes* – is comprised of a rich 'artistic' record of fascinating diversity (see Bourdier et al., 2017a). In terms of 'artistic' expression, the *Magdalénien à pointes de Lussac-Angles* is largely characterized by numerous, mainly realistic depictions of animals and humans, whereas figurative art remains scarce in the *Magdalénian à navettes* sites, the few examples that do exist being of highly schematised style (e. g., Bourdier et al., 2017b; Fuentes et al., 2017, 2019). Much of the current discussion of the two facies, in which human / anthropomorphic depictions also figure (Fuentes et al., 2017), centres on understanding their spatio-temporal relationship (e. g., Langlais et al., 2017) and the question whether or not, and if so to what degree, they represent different "graphic traditions" (Bourdier et al., 2017b: 103) and have to be interpreted as expressions of regionally differentiated socio-cultural (group) identities (e. g., Fuentes, 2013).

Without the need to dive deeper into this discussion, it is worth noting that the great diversity observed within the Early Middle Magdalenian of south-western Europe, including that of 'artistic' expressions, is paralleled in the technological diversity of the Epigravettian of eastern Europe (e. g., Gavrilov, 2021), including the stylistic diversity of headless anthropomorphic depictions visible at Mezhyrich and Mezin. As has already been described, besides the similarities of the headless anthropomorphic depictions of the latter two sites, strong stylistic dissimilarities exist in terms of the overall design of the figurines and their

level of abstractness, although the sites are assumed to be of comparable age and are located in certain regional proximity. Even at an intra-site level, stylistic differences have been highlighted between different dwellings and between the different themes addressed (Tab. 1; Fig. 7; Fig. 9; Chovkoplass, 1965; Iakovleva, 2009, 2015): only dwelling 2 of Mezin, for example, provided presumably male ivory figurines (Fig. 8), whereas potential gender-related distinctions do not otherwise manifest at the site. At the same time, the variability between individual figurines remains comparably high in terms of body proportions and details of ornamentation. To a certain degree this diversity seems to correspond to the variability among Middle Magdalenian depictions of humans (and human body parts) and anthropomorphic depictions which represent humans at different levels of completeness and abstraction, although individual elements remain visible (cf. Fuentes et al., 2017). For the ~18,500-17,500 cal BP interval, this may be read in a way that comparably high levels of probably household-, lineage- or kin- (i.e., dwelling-related) and regional-based identities were expressed in human and anthropomorphic representations that were depicted 'atop of' a general worldview expressed in abstract, often fragmented and – and especially in the east of Europe – headless, illustrations, representing potential common denominators within supra-regionally interconnected worldviews or belief systems. The establishment of such supra-regional interconnections seems to relate to a period immediately following the *Magdalénian à navettes* in a later half or a phase during which saiga antelopes expanded from the east to the west, indicative for on 'active' central European corridor.

Anthropomorphic depictions ~17,500-16,000 cal BP

With the end of the saiga phase, i.e., after ~18,000 cal BP, the cultural developments of western and eastern Europe appear to have become markedly disconnected. This seems to relate to the discontinuous archaeological record of much of central Europe (Jöris and Street, 2021; cf. recent discussions in Maier et al., 2020; Wiśniewski et al., 2017; cf. Nerudová et al., 2019), and it is likely that the area was totally abandoned by humans – at least gradually over the course of several phases (Fig. 10).

Whereas the trend of geometric ornamentation that characterises the Epigravettian of Ukraine and western Russia, seems to have continued (e.g., Iakovleva, 2016; cf. Borić and Cristiani, 2016; Mărgărit, 2010, for the Balkans), (headless) anthropomorphic depictions, however, seemed to have ceased after ~17,000 cal BP (cf. Iakovleva, 2009, 2015, Iakovleva and Djindjian, 2005). But, as noted above, the site of Mezin could even be much younger than generally assumed, given its poor state of dating, and the overall stylistic 'habitus' of headless anthropomorphic depictions that appear stylistically 'intermediate' (Tab. 1), as they show similarities to both, the Mezhyrich figurines and those of the 'Gönnersdorf-type'.

There is only one more eastern European site of relevance here for the period ~17,500-16,000 cal BP: Eliseevichi 1 in the upper Desna valley in the Bryansk province of Russia. This produced a ~15 cm large headless ivory figurine with large breasts and massive legs, yet lacking arms. Its chest is ornamented by horizontal lines (Abramova, 1966, 1995), resembling the ornamentation of one of the headless anthropomorphic figurines from Mezhyrich. The figure's head has been broken off, but was present when the figure was carved. It was found together with other small, three-dimensionally carved limestone figurines depicting animals, which have otherwise no parallels in the Desna region (Sablin and Khlopachev, 2002, and references therein).

In France, at around the same time, the site of La Marche, attributed to the *Magdalénien à pointes de Lussac-Angles*, is key to this discussion (see above). Many of the human depictions engraved on its limestone blocks possess heads, which are depicted in a level of detail that one can be sure that specific individuals

are depicted in 'portrait' style (Pales and Tassin de Saint Péreuse, 1976; Mélard, 2008). Some of the depictions lack heads or are broken at the point where the heads would be expected; it cannot be said for sure whether or not the part of the plaquette that once displayed the head was broken off intentionally, as has been argued for many of the figurines assigned to the preceding Mid-Upper Palaeolithic "Willendorf-style" (e. g., Guthrie, 2005; Verpoorte, 2001; cf. Gaudzinski-Windheuser and Jöris, 2015). As argued above, the depiction of females in lateral view at La Marche closely resembles the double S-shape of the female torso in lateral view. Given this, a few female body outlines of headless depictions from La Marche (Mélard, 2008: planche 12; planche 35) appear quite similar to some of the pre-16,000 cal BP headless anthropomorphic depictions from Middle Magdalenian contexts (e. g., Moulin-Neuf, Arlanpe; cf. discussion above) that are frequently attributed to the 'Gönnersdorf-type'. This interpretation can be questioned, however, on the grounds of the rudimentary level of detail in their creation, and one can alternatively interpret those double S-shaped depictions of presumable female torsos as potential stylistic predecessors of the succeeding, more schematised depictions of 'Gönnersdorf-type' that appeared ~ 16,500 cal BP and which had become dominant from ~ 16,000 cal BP onwards.

New standards on supra-regional scale ~ 16,000-15,000 cal BP

From around the Late Middle Magdalenian to the Early Late Magdalenian transition around ~ 16,500 cal BP, there is growing evidence in south-western Europe for headless anthropomorphic depictions of 'Gönnersdorf-type', and from ~ 16,000 cal BP 'Gönnersdorf-type' headless anthropomorphic depictions became more standardised (Bosinski et al., 2001). With this "formal homogenization" the typical 'Gönnersdorf-type' of headless anthropomorphic depictions spread rapidly across Europe (cf. Bourrillon et al., 2012; Fuentes et al., 2019), reaching as far as eastern central Europe (**Fig. 10**; Wilczyce in south-eastern Poland: Fiedorczuk et al., 2007).

This eastward dispersal of headless anthropomorphic depictions of 'Gönnersdorf-type' appears to have been extremely rapid, and seems to have been linked, once again, to the re-opening of a corridor through central Europe through which saiga antelope habitats expanded in the opposite direction towards the west (Bosinski, 2009; cf. Maier et al., 2020; Nadachowski et al., 2016). Additional arguments for the re-activation of this corridor have been forwarded on the basis of stylistic reasoning (Bosinski et al., 2001) as some of the central European 'Gönnersdorf-type' headless anthropomorphic depictions are decorated with geometric patterns (e. g., Gönnersdorf plaquette no. 87: **Fig. 4**; and a pair of angles, or chevrons, engraved into the side of the large 'Gönnersdorf-type' ivory sculpture no. An2/11 from Andernach-Martinsberg: Höck, 1995), a design that resembles ornaments typical for the eastern European Epigravettian and reminds us, more specifically, of the geometrically decorated figurines from Mezin (Chovkoplass, 1965; Iakovleva, 2009).

The potential stylistic influences from the east also seem to be reflected in the decision to carve three-dimensional figurines, mostly in ivory. The Mezin sculptures also appear technically, and in terms of their profile view, as potential predecessors for 'Gönnersdorf-type' figurines (cf. Iakovleva, 2009). This, again, hints at the idea outlined above, that present age estimates for the site of Mezin may overestimate its real age. From around ~ 16,000 cal BP onwards, the combined evidence hints at strong levels of supra-regional interconnectedness between the west and the east of Europe. It seems that during this time the idea to carve female figurines spreads westwards, while the idea of engraving depictions of comparable profile view, spreads eastwards. In central Europe both these trends overlaped and merged (**Fig. 5: d**), and it is here that 'Gönnersdorf-type' depictions appear to have become most standardized.

'GÖNNERSDORF-TYPE' DEPICTIONS AND THE SOCIAL FOUNDATIONS OF THE LATE GLACIAL EXPANSION

In central Europe, the geographical spread of 'Gönnersdorf-type' anthropomorphic representations ~ 16,000-14,000 cal BP coincides with the most dynamic and unprecedently-rapid phase of Late Glacial human range expansion into the northerly parts of Europe which appears to be linked with the beginning of the Late Magdalenian (Street et al., 2009; cf. Housley et al., 1997). Besides the required adaptive demands (cf. Burke et al., 2017; cf. Baales and Jöris, 2006), on a meta-population level, the greatest challenge had been the establishment of a population size viable enough to survive in the newly occupied regions of central Europe, involving the constant founding and establishment of new social entities and associated networks ensuring successful interconnection of individuals and groups over large distances. With regard to the latter, and for the Late Magdalenian expansion to succeed, it has been argued that newly established supra-regional social (and communication) networks were further required to inter-connect the (presumably small) 'pioneering' groups at the front of the expansion with the populations in the Magdalenian 'homelands' of south-western Europe (for further details see: Gaudzinski-Windheuser and Jöris, 2015). Such supra-regional large-scale social networks would have been required to connect individuals over much larger geographical scales than would have been the case within the seasonal migration ranges of specific foraging groups. Only through the implementation of sets of socio-cultural rules and regulations that – among other issues – organised partnership, kin and – above all – residence would have facilitated the establishment of such networks and enabled the relocation of at least some individuals over large distances between different groups. Such supra-regional and large-scale social networks must have focussed intently on the mandatory functioning of certain individuals. "Thus, the individual sphere must have been subordinate for the group and was presumably reflected in the absence of depictions of individuals" (Gaudzinski-Windheuser and Jöris, 2015: 312). It may have been the case that the establishment and maintenance of such large-scale social networks belonged to the realm of the 'female sphere', for which 'Gönnersdorf-type' anthropomorphic depictions may have served as symbols in support of a communal identity or of communal worldviews, which could be communicated over large distances across Europe (Gaudzinski-Windheuser and Jöris, 2015; cf. Wobst 1977). Following these arguments, it was most likely due to the implementation of such sets of rules and regulations and a concept of communal identity underlying Late Magdalenian social organization that this phase of the Late Glacial Expansion finally succeeded. The resulting social networks would not only have established a viable meta-population over central Europe, but also reduced Magdalenian population densities and potentially associated population pressures within the 'homeland' regions, where groups had lived for several millennia in an Ice Age refugium at levels probably close to the limits of the region's carrying capacity (cf. Burke et al., 2017). Following this line of argument, one could furthermore conclude that the Late Magdalenian expansion succeeded due to the 'culturally planned' spread of humans over such a vast area; it is, therefore, the result of a planned, rule-driven 'colonization' governed by social rules on partnership, kin and residence, rather than a gradual and comparably slow 'dispersal' of a population due to its more-or-less continuous adaptation to new environmental conditions. The latter mode of dispersal may have applied to earlier (i. e., pre-16,000 cal BP) attempts to re-settle central Europe after the LGM which had, however, failed to establish viable populations over the longer term (Street et al., 2009; cf. e. g., Street and Terberger, 1999; Terberger and Street, 2002; Maier et al., 2020; Wiśniewski et al., 2017).

In parallel with the Late Magdalenian dispersal, 'Gönnersdorf-type' depictions left the context of deep caves (Bosinski et al., 2001) and came mostly to be found in both open-air sites, and if in rock-shelters in or near the daylight zone (e. g., La Roche de Lalinde: Leroi-Gourhan, 1971; Bosinski et al., 2001; Gare de la Couze:

Bordes et al., 1963; Abri Fontalès: Lorblanchet and Welté, 1987; Abri Murat: Lorblanchet and Welté, 1987). These observations support the notion that the transmission of the 'Gönnersdorf-type' symbol's content(s) took place in the public (rather than a personal of private; cf. Gaudzinski-Windheuser, 2015) sphere, and, according to the spatial data available (Bosinski et al., 2001), was embedded within everyday activities. This overall 'presence' and 'publicity', and the increased stylistical formalisation of 'Gönnersdorf-type' depictions, enhanced their saliency and recognisability at a supra-regional scale, fostered the understanding and acceptance of the symbol's content and, in combination, may have been beneficial for the establishment of large-scale networks which resulted in the enhancement of social cohesion spanning large geographical areas by interlinking different groups (that otherwise relied on different regional economies) and individuals from far distant regions. Spanning large distances, the supra-regional social webs established during this time led to increased frequencies of human-human interactions, which are seen as a motor for the development of common identity and a sense of belonging (Bird-David, 2017). Associated mating systems and residence rules in support of densly woven geographically well-interconnected social webs would have allowed the successful establishment of a viable meta-population that – from ~ 16,000 cal BP onward – built the base for the more sustainable resettlement of central – and susequently, northern – Europe (e. g., Street et al., 2009).

GÖNNERSDORF SITE FUNCTION

A low-level persistence of regional stylistic variability reveals, however, that regional social networks were not replaced, but instead that a social ('ideological': see below) super-structure was added on top of these. Whereas 'Gönnersdorf-type' ivory figurines are to be found predominantly at the northern margin of the Magdalenian oikumene, similar figurines made of jet, for example, are restricted to a few sites in southern central Europe, i. e., Monruz and Petersfels (**Fig. 5: d**). The latter type of figurine has a more double S-shaped outline, similar to an ivory statuette from Pekárna Cave in Moravia. Such regional patterns (which are to certain degree also reflected in lithic raw material provisioning patterns; e. g., Floss, 1994; Street et al., 2006; Maier, 2015, 2017) indicate the maintenance of regional social networks, styles and, likely, identities. These may have functioned on subordinate levels under the umbrella of an overarching 'metaphysical' or 'ideological' system of beliefs that served to enhance social cohesion. Transmission of the 'ideological' underpinnings of this social super-structure presumably required regular meetings or aggregations (*sensu* Conkey et al., 1980) at places where different – most likely neighbouring – foraging groups would have met to spend a certain and possibly extended time of the year together and to which a certain number of individuals from far distant regions would have joined (Langley and Street, 2013; Street and Turner, 2013). In this context 'Gönnersdorf-type' female depictions may have served as a symbol that was implemented to support the social inter-connectedness of Late Magdalenian groups and individuals. The reason why a symbol for the social role of females had been chosen for this task may be because women had been largely constituting and maintaining the supra-regional Late Magdalenian social web (Gaudzinski-Windheuser and Jöris, 2015). Implementation of rites, rituals and festivals would have fuelled the establishment and maintainance of such supra-regional social webs, reiterating the shared rules, regulations and concepts on which the 'ideological' super-structure was built upon. From the discussion above, the site of Gönnersdorf provides all the evidence in favour of an interpretation of the site as exactly such a nexus point. At the same time, this contextualisation emphasises that Gönnersdorf cannot be considered as an "average" Magdalenian site (*contra* discussion in Pasda, 2012), but that it complements to the majority of Magdalenian sites of different function by serving, amongst others, aspects of the social structuring of Late Magdalenian societies.

With the implementation of an 'ideological' super-structure and its associated rules and regulations on top of the regional social networks on which the economies of foraging groups were regularly running, this super-structure tier of social ties would have allowed for more complex land-use strategies, including supra-regional alliances which were based on increased levels of interdependencies and systems of support that allowed for increased levels of inter-group reciprocity and insured against periodic scarcities (cf. Minc and Smith, 1989). In this context, the 'ideological' umbrella that is most likely expressed in 'Gönnersdorf-type' depictions would have not only enhanced new levels of social interconnectedness and coherence but would have additionally been of immediate economic benefit, allowing the establisment of a viable meta-population in central Europe from the Late Magdalenian onwards (cf. Kretschmer, 2015; Tallavaara et al., 2015). This is not only evidenced by the significant increase of Late Magdalenian sites in central Europe (Street et al., 2009; Maier, 2015), but also by the Gönnersdorf seasonal zooarchaeological evidence (Street and Turner, 2013) that shows that Late Magdalenians had established economic sytems which allowed not only to overcome the glacial winters with reduced levels of biomass production (cf. Burke et al., 2017), but also to sustain year-round economies in central Europe, with the latter feeding positively back to the persistency of established social webs and to the successful colonisation of central Europe.

DISCUSSION

The Late Upper Palaeolithic non-naturalistic record of depictions, including 'signs' and 'symbols' and other abstract forms of 'artistic' expressions, is most generally interpreted in relation to the reconstruction or definition of regional ([palaeo-]"ethnic") identities (Leroi-Gourhan, 1981) or (their) "symbolic territories" (Fuentes et al., 2019). Conclusions of wider relevance for the understanding of the social and 'ideological' changes or changes in mentalities, worldviews and belief systems underlying the Late Upper Palaeolithic record of artistic expressions have rarely been considered (e. g., Leroi-Gourhan, 1971; Lorblanchet, 1989). On the contrary, the present interpretative trends for this rich (but poorly dated) record (see papers in Lorblanchet and Bahn, 1993) focus less on stylistic tendencies and their implications than on the recognition of geographical differences (cf. discussion in Pigeaud, 2007).

However, in an attempt to widen the perspective from the Late Upper Palaeolithic anthropomorphic depictions discussed above, a range of observations and inferences may be made in comparison to other themes present in Late Upper Palaeolithic art. Such comparison may not only highlight, but also help to contextualise and partly explain some of the major differences in the spatio-temporal and stylistic patterning of cultural changes observed in Late Upper Palaeolithic 'art history'. The coarse-grained view taken here attempts to go beyond highly focussed evidence and benefits from the wide geographical scope and the diachronic perspective that has been addressed above.

The interval of ~ 16,000 to 15,000 cal BP, i. e., the Late Magdalenian period during which 'Gönnersdorf-type' headless anthropomorphic depictions spread across much of Europe, can be understood further by considering wider data. Besides representations of 'Gönnersdorf-type', only few human or anthropomorphic illustrations are known from the period, as is the case for the entire Late Upper Palaeolithic (e. g., Duhard, 1993, 1996; Cohen, 2003; Bourrillon et al., 2012; Gaudzinski-Windheuser and Jöris, 2015). This stands in stark contrast to the far richer body of animal depictions. In the Middle Magdalenian facies *à pointes de Lussac-Angles* and in Upper/Late Magdalenian contexts, animals are depicted in high degrees of detail (e. g., Bourdier et al., 2017b; Bosinski and Fischer, 1980; Bosinski, 2008; Pigeaud, 2007). When depictions were engraved, in particular when they do not cover very large surfaces, they often appear highly naturalis-

tic or realistic, and in some cases at Gönnersdorf and many other sites dating to the ~16,000-15,000 cal BP interval, they reveal a particular concern with highlighting the animals' individuality in an extremely dynamic manner, including their individual expressions and behaviours (cf. Bosinski, 2007, 2008).

Thanks to the great numbers of schematic anthropomorphic (Bosinski and Fischer, 1974; Höck, 1995; Bosinski et al., 2001; Bosinski, 2011a, 2011b) and naturalistic animal depictions (Bosinski and Fischer, 1980; Bosinski, 2008), the Gönnersdorf site exemplifies the strong dichotomic separation of the way humans (or symbols of their social roles) were depicted on the one hand, and how animals were represented on the other. Whatever the underpinning worldviews or belief systems underlying this stylistic distinction contained in detail (cf. discussion in Lorblanchet, 1989), the notable dichotomy most likely reflects a conceptual or ideological differentiation between the animal world and the human sphere. In contrast to the depictions of animals, Late Magdalenian representations of humans/anthropomorphs generally lack individual traits. Within the human realm, the scarcity of representations interpreted as male, highlights another dualism – likely at a different conceptual level. Those concepts that placed little emphasis on the individual's sphere may probably have been beneficial in enhancing social coherence on a supra-regional scale (Gaudzinski-Windheuser and Jöris, 2015: 312), which is possibly reflected in the comparably high levels of standardisation and the restricted Late Magdalenian canon of objects of personal adornment (Álvarez Fernandez, 2006); in short, signalling coherence and membership of a certain group or entity was more important than displaying any form of individuality. The general scarcity of burials known from this period may be interpreted likewise (Pettitt, 2010).

Appendix: Site reference list to Fig. 5

Note: Asterixes in the site reference lists below refer to sites that have yielded potential anthropomorphic depictions. The attribution of some of them to the 'Gönnersdorf-type', however, is regarded here as probable, but unclear (*) or doubtful (**).

a *Spain*: Cueva de Ardales* (Malaga; Ramos Muños et al., 2002), Cueva del Linar* (Cantabria; Muños Fernandez and San Miquel Llamosas, 1991), Arenaza* (Basque; Garate, 2004); *France*: Gourdan (Haute-Garonne; Fritz et al., 1996), Grotte de Pestillac (Lot; Sentis, 2000), Grotte Carriot (Lot; Lorblanchet and Welté, 1987), Abri Lagrave* (Lot; Ipiens et al., 2000), Les Combarelles (Dordogne; Capitan et al., 1924; Archambeau and Archambeau, 1991), Grotte Saint-Cirq* (Dordogne; Delluc and Delluc, 1982), Grotte de Commarque (Dordogne; Delluc and Delluc, 1981), Vielmouly II* (Dordogne; Delluc and Delluc, 1987), Grotte de Fronsac (Dordogne; Delluc et al., 1994), La Font-Bargeix* (Dordogne; Barrière et al., 1990), Villars* (Dordogne; Delluc and Delluc, 1991), Grotte du Planchard (Ardèche; Bosinski et al., 2001), Grotte des Deux-Ouvertures* (Ardèche; Gély and Porte, 1996), Abri Bourdois, Angles-sur-l'Anglin (Vienne; de Saint-Mathurin and Garrod, 1949), Grotte Margot* (Mayenne; Pigeaud et al., 2010), Grotte de Gouy (Seine-Maritime; Martin, 2007); *British Isles*: Church Hole* (Nottinghamshire; Pettitt, 2007); *Italy*: Grotta Romanelli** (Apulia; Mussi and De Marco, 2008); *Egypt*: Sinai shelter (Sinai; Zboray, 2012); Abu Tanqura Bahari (ATB) 11 at el-Hosh* (Upper Egypt; Huyge, 2015), Qurta II (Upper Egypt; Huyge, 2015).

b *Spain*: Las Caldas (Asturias; Corchón Rodríguez, 1990), Arlanpe (Basque, Rios-Garaizar et al., 2015); *France*: Grotte du Courbet near Bruniquel (Tarn; Alaux, 1972; Welté and Cook, 1993), Abri Fontalès (Tarn-et-Garonne; Lorblanchet and Welté, 1987), Magdeleine-la-Plaine* (Tarn; Ladier, 2001), Abri Murat (Lot; Lorblanchet and Welté, 1987), La Roche de Lalinde (Dordogne; Leroi-Gourhan, 1971, Bosinski et al., 2001), Gare de Couze (Dordogne; Bordes et al., 1963), Moulin-Neuf* (Gironde; Ladier et al., 2005), La Marche (Vienne; Pales and Tassin de Saint Péreuse, 1976; Mélard, 2008), Roc-aux-Sorciers (Vienne; Sentis, 2005); *Germany*: And. Andernach-Martinsberg (Rheinland-Pfalz; Bosinski, 1994), Gö. Gönnersdorf (Rheinland-Pfalz; Bosinski et al., 2001), Hohlenstein near Ederheim (Bayern; Bosinski, 1982), Obere Klause (Bayern; Floss et al., 2015), Oelknitz (Thüringen; Gaudzinski-Windheuser, 2013).

c-1 engravings on pebbles (quadrats). *France*: La Goutte Roffat near Villerest (Loire; Bosinski et al., 2001; cf. Larue et al., 1955, 1956); *Germany*: Niederbieber* (Rheinland-Pfalz; Loftus, 1982), Felsställe near Mühlen* (Baden-Württemberg; Kind, 1987), Teufelsbrücke near Saalfeld (Thüringen; Wüst, 1998); *Czech Republic*: Býčí Skála* (Moravia; Valoch, 1978).

c-2 engravings on bones (circles). *Spain*: Las Caldas (Asturias;

Corchón Rodríguez, 1990; Fortea et al., 1990); *France*: Abri Faustin (Gironde; Lenoir, 1995), Grotte Rochereil* (Dordogne; Delluc and Delluc, 1991), Rond du Barry* (Haute-Loire; de Bayle de Hermens, 1972); *Germany*: Petersfels* (Baden-Württemberg; Albrecht and Berke, 1980; Bosinski, 2011b).

d *France*: Grotte du Courbet* (Tarn; Ladier, 1987), Abri Fontalès (Tarn-et-Garonne; Lorblanchet and Welté, 1987), Laugerie-Basse (Dordogne; Delporte, 1979), Enval (Puy-de-Dôme; Bourdelle et al., 1971); *Belgium*: Mégarnie (Höck, 1995); *Switzerland*: Monruz (canton de Neuchâtel; Bullinger, 2006); *Germany*: And. Andernach-Martinsberg (Rheinland-Pfalz; Höck, 1995), Gö. Gönnersdorf (Rheinland- Pfalz; Bosinski et al., 2001; Höck, 1995), Petersfels near Bittelbrunn (Baden-Württemberg; Bosinski, 1982; Höck, 1995), Waldstetten (Baden-Württemberg; Floss et al., 2021), Nebra (Sachsen-Anhalt; Mania, 1999), Garsitz, Bärenkeller** (Thüringen; Bosinski, 1982), Oelknitz (Thüringen; Gaudzinski-Windheuser, 2013); *Czech Republic*: Pekárna (Moravia; Absolon, 1949); *Poland*: Wilczyce (Fiedorczuk et al., 2007); *Ukraine*: Mezhyrich (Pidoplichko, 1976; Abramova, 1995; Iakovleva, 2009), Dobranichivka (Iakovleva, 2009), Mezin (Chovkoplass, 1965; Iakovleva, 2009); *Russia*: Eliseevichi 1 (Bryansk; Abramova, 1966; Iakovleva, 2009).

Acknowledgements

My thanks go to Martin and Elaine: needless to emphasize this in a *Festschrift* dedicated to the two of them. But in this case, I want to add further thanks, as their research so significantly shaped the MONREPOS research topic "Rules and Regulations in context" within our research field of "Becoming Human". Many of Elaine's and Martin's different projects related, in one way or another, back to Gönnersdorf. Similar questions of "increased sedentism" Elaine recently addressed in Taforalt (cf. Barton et al., 2019).

This contribution was a much welcome opportunity to present a wrap-up of the contents of this research topic. It combines the contents of presentations I gave in 2015 at a meeting organised by the Eurasian Department of the DAI in Berlin on "Prehistoric Networks in the longue durée: Palaeolithic Innovations enabling the Neolithic Revolution" and in 2017 at an international workshop and conference in Ekaterinburg on the "Great Shigir idol in the context of North Eurasia Stone Age art". It is also meant as a contribution to the Top-level Research Area "40.000 Years of Human Challenges: Perception, Conceptualization and Coping in Premodern Societies (Challenges)" at Johannes-Gutenberg University Mainz.

My thanks go to Sabine Gaudzinski-Windheuser for valuable comments on an earlier version of this contribution. I am very grateful to Paul Pettitt, Durham University (UK), for significant improvements to the English text at different stages of its production, and to Gabriele Rutkowski and Nicole Viehöver for all the energy, patience and care with the artworks.

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BLADE UTILIZATION STRATEGIES AT GÖNNERSDORF AND BOIS LAITERIE: FROM THE LATE TO FINAL MAGDALENIAN

Abstract

At the Magdalenian site of Gönnersdorf (dated to ca. 15,800 cal BP) a large number of flint tools made on long blades were unearthed. These blades are comparably long and curved in profile, which is characteristic for the Late Magdalenian. In contrast, at the slightly younger cave site of Bois Laiterie in Belgium (dated at ca. 15,100 cal BP), the typical Late Magdalenian long blades were found, as well as shorter, straight blades, which prevail throughout the succeeding Late Palaeolithic. To better understand the differences in blade utilization strategies between Gönnersdorf and Bois Laiterie, the results of use-wear analysis of flint tools from the two sites are compared and discussed. While the blade tools from Gönnersdorf were exhaustively used, none of them shows traces that resulted from hunting activities. Instead, backed bladelets were predominantly used as hunting armatures. This is due to the fact that while the extremely long Late Magdalenian blades are ideal for repeated use and long reduction sequences on the one hand, the great length and curved profile make them unsuitable for use as a projectile. In contrast, at Bois Laiterie a considerable number of backed points were made on shorter, straight blades, many of which show impact fractures. The change of blade utilization strategies would have been the first sign of the gradual techno-functional transformations underlying transition from the Late Magdalenian to the Late Palaeolithic in North-western Europe.

Keywords

Use-wear analysis, hunting weapons, Late Pleniglacial, Late Glacial Interstadial, North-western Europe

INTRODUCTION

Few archaeological sites that date into the Last Glacial Maximum (LGM) are known in North-western and Central Europe. Due to the extremely cold climatic conditions of the LGM, large portions of the hunter-gatherer population abandoned North-western and Central Europe, and survived in the Mediterranean region (Gamble, 1986; Bosinski, 1995; Housley et al., 1997). Although the climate gradually recovered and the ice sheets of Northern Europe retreated further north, North-western and Central Europe remained uninhabited until 16,500 years ago – except for a couple of Middle Magdalenian sites in southern Germany and southern Poland (Jöris and Street, 2014). Nevertheless, between 16,500 and 15,000 years ago, Late Magdalenian hunter-gatherers probably followed the Pleistocene fauna that migrated from South-western Europe to the north. These hunter-gatherers eventually re-colonized North-western and Central Europe (Jöris et al., 2011; Jöris and Street, 2014).

The Late Magdalenian of North-western and Central Europe shows functional variability across different geographic areas (Sano, 2012a, 2012b). The vast amounts of finds, comprising lithic artefacts, faunal remains, figurative art, and architectural remains, at the sites of Gönnersdorf and Andernach-Martinsberg in the Neuwied Basin of the Central Rhineland (**Fig. 1**), suggest that these had been used as base camps (Bosinski, 1981, 1987, 2007). The Neuwied Basin was probably an optimal location, where Magdalenian people were able to hunt a wide variety of prey animals (Street et al., 2012). The abundant and diverse faunal remains preserved at Gönnersdorf indicate that this locality has been repeatedly occupied over multiple seasons

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.868.c11324

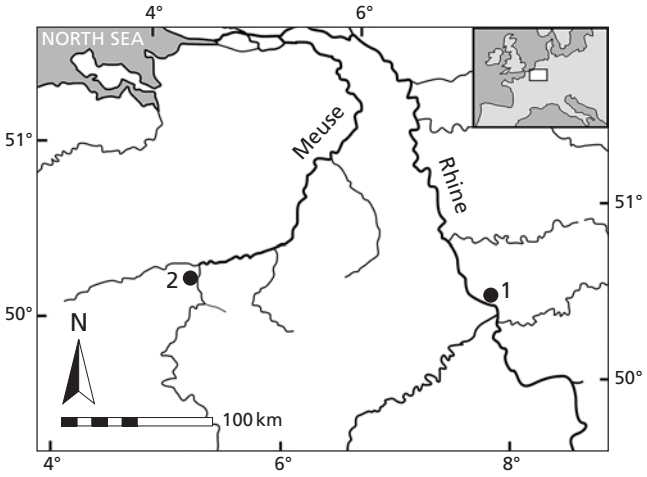

Fig. 1 Map showing the locations of Gönnersdorf (**1**) and the cave of Bois Laiterie (**2**).

(Jöris et al., 2011; Street and Turner, 2013). Another distinctive feature of the sites of Gönnersdorf and Andernach-Martinsberg is the variety of lithic raw materials, which were imported from different regions. Three different types of high-quality exogenous lithic raw materials were transported to the sites. These include chalcedony from south-eastern sources, located at distances of around 80 to 120 km, and two Upper Cretaceous flint types, i. e., Baltic Flint and Meuse Flint, which originated from sources at a distance of more than 100 km (Floss, 1994; Jöris et al., 2011). The former came from the northern glacier-pushed tills, the latter from the chalk formation in the Meuse catchment area.

At Gönnersdorf, concentration II (K-II) yielded numerous Meuse flint artefacts. Their surfaces show little to no patination, compared with other flints. Use-wear analysis was undertaken for K-II Meuse flint artefacts. The results indicated that a series of activities, including hunting, butchery, processing of carcass remains, and stone-working had been performed at the site (Sano, 2012a, 2012b).

Meuse flint is also often found at the Late/Final Magdalenian cave sites in the Ardennes Massif in Belgium (Straus and Orphal, 1997), demonstrating that the Magdalenian hunter-gatherers moved with this type of raw material to the cave-rich area along the Meuse River (Straus and Otte, 1998). While huge amounts of debitage and laminar blanks were recovered at Magdalenian open-air sites in the Meuse flint provenance area (Rensink, 1993), cortical debitage and blade cores are almost absent at the cave sites in the Ardennes Massif (Straus and Orphal, 1997). On the other hand, backed bladelets are abundant at the caves, such as Chaleux and Bois Laiterie (**Fig. 1**). In addition to numerous backed bladelets, several lithic and antler points were also found at Bois Laiterie. Due to the limited habitation area and the northward-facing entrance, the Bois Laiterie cave is unsuitable as a residential locality. Conversely, it is highly suitable for more specific activities such as hunting (Straus and Otte, 1998). A use-wear analysis undertaken on flint artefacts from Bois Laiterie demonstrated the validity of the hypothesis (Sano, 2009; Sano et al., 2011).

A series of radiocarbon dates from Magdalenian sites in Germany and Belgium has been accumulated over the last few decades. In particular, samples of anthropogenically-modified remains of horses and reindeer – the dominant species at the site of Gönnersdorf (Street and Turner, 2013) – were submitted for AMS radiocarbon age determination. The dating of megafauna, including mammoths and woolly rhinoceros, yielded older results than those from horses and reindeer. Such findings suggest that Magdalenians collected sub-fossil mammoth and woolly rhinoceros bones and teeth for use as constructional elements or art (Street and Terberger, 2004). A sample of elk bone from the south-western area of the Gönnersdorf site (SW) shows that this area was also occupied at a later period, which had already been inferred based on the remains of faunal elements adopted to (boreal) forested environments, such as red deer (Street et al., 2006),

and a lithic assemblage that includes backed points (Buschkämper, 1993). The most reliable AMS radiocarbon dates (ca. 13,270-12,990 ^{14}C BP) (Stevens et al., 2009; cf. Housley et al., 1997; Street and Terberger, 2004;), excluding dates from the large mammal fauna in Gönnersdorf SW, indicate that the main period of occupation at Gönnersdorf took place at around 15,800 cal BP (Street et al., 2012) – corresponding to the second half of the Greenland Stadial (GS) 2a cold phase.

Radiocarbon dates from Magdalenian cave sites in the Belgian Ardennes Massif fall within a tight chronological frame, ranging from ca. 13,000 to 12,500 ^{14}C BP (Charles, 1993, 1994, 1996), although there are some exceptions. Based on the radiocarbon dates from Bois Laiterie the Magdalenian occupation of the cave is dated to ~ 15,100 cal BP (ca. 12,650 ^{14}C BP) (Sano et al., 2011), and seems to have been occupied during a phase that is slightly younger than the western German Late Magdalenian, slightly predating the Late Glacial Interstadial. A techno-morphological analysis of the Bois Laiterie assemblage indicates that the site should not be assigned to a specific archaeological culture. Rather, it falls into a transitional period that forms the substrate from which the Final Magdalenian, the Hamburgian and the Creswellian affiliate as techno-typological affinities indicate (Sano et al., 2011). For instance, the presence of backed points made of blades is a striking distinction in the Bois Laiterie assemblage, which differs from the Gönnersdorf material. Hence, the blade utilization strategies may have changed from the Late Magdalenian to the subsequent chronological phase.

In the following research, the differences in blade utilization strategies between Gönnersdorf and Bois Laiterie are shown, with the significance of this change discussed in the context of the cultural evolution from the Late Pleniglacial to the Late Glacial Interstadial (cf. Grimm, 2019). The details of the use-wear analysis have been published elsewhere (Sano, 2009, 2012a, 2012b; Sano et al., 2011). Here, the author focuses on typical Magdalenian blade tools, such as end-scrapers and burins, blades, backed bladelets, and backed points. The use-wear analysis was undertaken based on the Low-Power Approach (LPA) (Tringham et al., 1974; Odell and Odell-Vereecken, 1980; Odell, 1981; Akoshima, 1987) and the High-Power Approach (HPA) (Keeley, 1980; Plisson, 1985; Vaughan, 1985a; Gijn, 1990). Use-wear traces were analyzed using a metallographic microscope Leitz Metallux II, at magnifications ranging from 100× to 400×. A stereomicroscope Leica M420 at magnifications ranging from 6.3× to 32× was likewise used. The microphotography was carried out with a Canon EOS 40D SLR digital camera attached to the microscopes.

	bBLL	BL	BU	BUsp	ES	PE	PE/BU	ES/BU	BU_{sp}	ES_{sp}	SP	Total
Hard		2		1		11					11	25
Hard/hard-medium	1				5				2			8
Stone	1	3	1	1	9	2	1	1	1	1	1	22
Shell or tooth		2				1						3
Antler, bone, or ivory		4	6	4	6			1	5	6	8	40
Hide	1	5	5	3	14			3	1	4	1	37
Butchery		1	3		2							6
Projectile	27											27
No usewear	2	4	4	5	2	1						18
Uncertain	35	6	2	7	3	6						59
Total*	**67**	**27**	**21**	**21**	**41**	**21**	**1**	**5**	**9**	**11**	**21**	**245**

Tab. 1 Results of the use-wear analysis of flint artefacts from Gönnersdorf K-II. – *Several artefacts show more than one worked material. bBLL backed bladelet; BL blade; BU burin; BUsp burin spall; ES endscraper; PE perforator; PE/BU perforator-burin combination tool; ES/BU endscraper-burin combination tool; BU_{sp} splintered burin; ES_{sp} splintered endscraper; SP splintered piece.

LATE MAGDALENIAN LITHIC UTILIZATION STRATEGY AT GÖNNERSDORF

To reveal the spectrum of use of the Upper Cretaceous Meuse flints, all the Meuse flints artefacts excavated from Gönnersdorf K-II were scanned. Among them, unpatinated or less patinated specimens were selected for use-wear analysis. A total of 203 flint artefacts were microscopically analyzed, with a large number of them showing discernible use-wear traces. While 18 pieces showed no clear use-wear traces and 56 exhibit uncertain traces, 134 items bear use-wear traces (**Tab. 1**).

Interestingly, a large number of unretouched or marginally retouched blades show clear use-wear traces that indicate a series of activities, such as butchery, hide-processing, antler-, bone-, or ivory (ABI) processing, shell- or tooth-processing, and stone-processing (**Tab. 2**). Although some blades were employed for tasks using the distal end, most blades were used with their lateral edges involved in longitudinal motions, including cutting and sawing motions. A typical Magdalenian long blade with a curved profile retains very fresh surfaces and exhibits multiple use-wear traces (**Fig. 2**). The right lateral edge of the distal portion of the blade presents unifacial micro-flaking on the dorsal face (**Fig. 2: a**), and polish from hide-working on the ventral face. Such features demonstrate that this edge was used for hide-scraping. The left lateral edge of the proximal part shows alternate edge damage and polish that formed bifacially and that results from ABI processing on both sides (**Fig. 2: b**). These traces indicate its use for sawing of hard organic materials.

High power approach									
	Bu	Hi-TM	Hi-LM	Hi-Wo	ABI-LM	ST-LM	St-LM	St-TM	St-Gr
distal end				1				1	3
broken end								1	
lateral sides	2	4	4		4	2	1		
Low power approach									
	HM-LM	HM-TM	unc.-TM						
lateral sides	1	1	1						
Total number of IUZs									**26**

Tab. 2 Functions by the independent use zone (IUZ) of blades (n = 24) from Gönnersdorf K-II. – Bu butchering; Hi hide; ABI antler, bone, or ivory; ST shell or tooth; St stone; HM hard material; unc. uncertain; TM transverse motion; LM longitudinal motion; Gr grooving; Wo motion is uncertain.

High power approach								
	Bu	Hi-TM	Hi-LM	ABI-LM	ABI-TM	St-Wo	St-TM	St-We
end-scraper edge		16			3		6	1
proximal end						1		
proximal/distal ends					1			
lateral sides	2	2	5	7			2	
Low power approach								
	H/MM-LM							
lateral sides	6							
Total number of IUZs								**52**

Tab. 3 Functions by the independent use zone (IUZ) of endscrapers (n = 24) from Gönnersdorf K-II. – Bu butchering; Hi hide; ABI antler, bone, or ivory; St stone; H/MM hard or medium hard material; TM transverse motion; LM longitudinal motion; We wedging; Wo motion is uncertain.

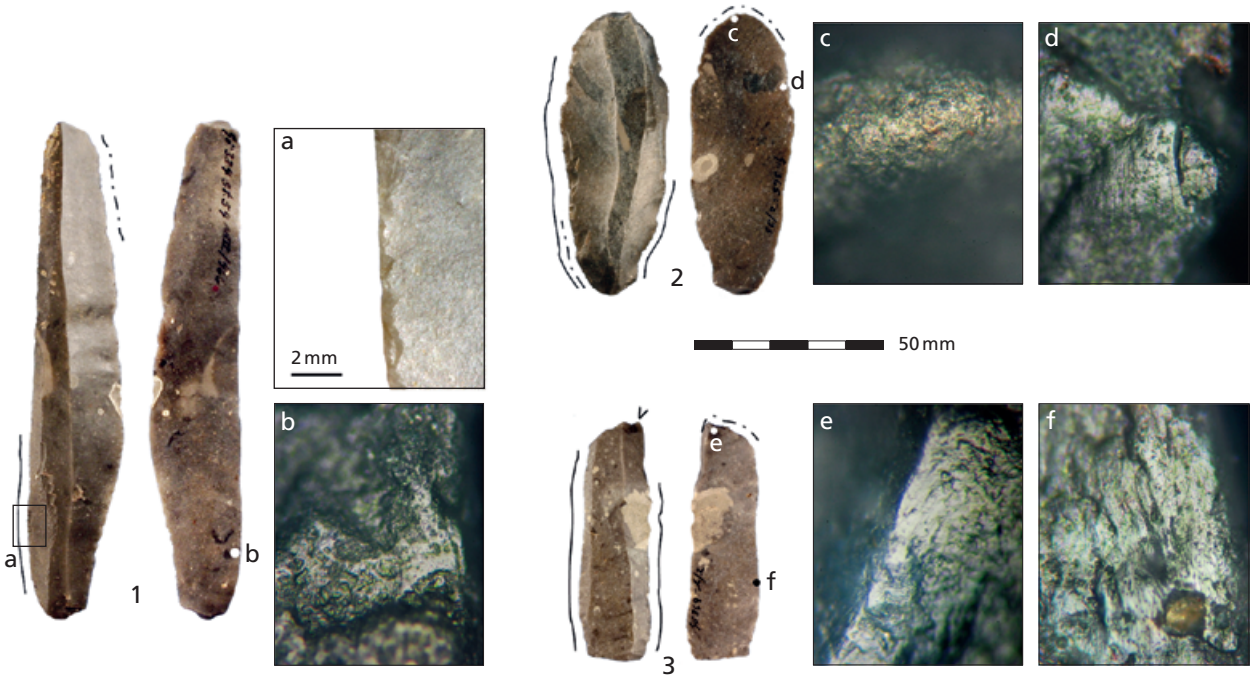

Fig. 2 Blade tools from Gönnersdorf showing use-wear traces. **1** blade; **2** end-scraper; **3** burin. **a** edge damage; **b** polish from ABI-sawing; **c** polish from hide-scraping; **d** polish and striation from ABI-sawing; **e** polish from ABI-grooving; **f** polish from hide-cutting. – b-f magnifications are at 200 ×. Solid lines show edges worked with longitudinal actions, dashed lines show edges worked with transverse actions, and v shows traces of grooving.

Most of the end-scrapers from Gönnersdorf show traces linked to hide-working, as is typical for end-scrapers from other Late Magdalenian sites (Audouze et al., 1981; Moss, 1983; Vaughan, 1985b, 2002; Plisson and Vaughan, 2002; Gosselin, 2005). In particular, distal scraper edges were used primarily for hide-scraping (**Fig. 2: c**; **Tab. 3**). Out of 29 scraper edges, 16 edges were used for hide-scraping, six edges for stone-scraping, and three edges for ABI-scraping. On the other hand, their lateral edges were used for diverse purposes, including butchery, hide-working, ABI-sawing (**Fig. 2: d**), and stone-processing.

While more than 70 % of the scraper edges show clear use-wear traces, burins exhibit a low frequency of utilization of their "working" edges, such as burin bits (23.8 %) and burin facets (14.3 %) (**Tab. 4**). Despite the low frequency of use, burin bits provide evidence for ABI-grooving (**Fig. 2: e**), as the pointed tip is

High power approach								
	Bu	Hi-TM	Hi-LM	Hi-Wo	ABI-LM	ABI-TM	ABI-Gr	St-TM
burin bit				1			4	
burin facet				2		1		1
truncation edge		3				1		
broken edge								1
lateral sides	3		3		3			
Total number of IUZs								23

Tab. 4 Functions by the independent use zone (IUZ) of burins (n = 16) from Gönnersdorf. – Bu butchering; Hi hide; ABI antler, bone, or ivory; St stone; TM transverse motion; LM longitudinal motion; Gr grooving; Wo motion is uncertain.

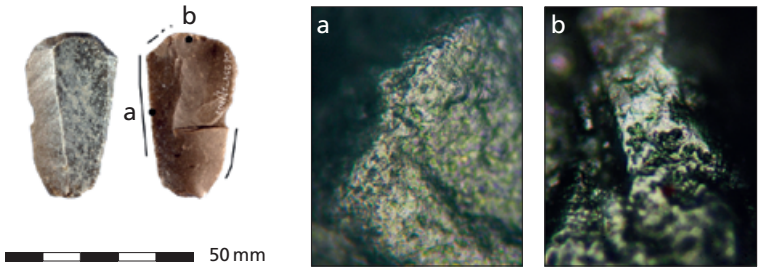

Fig. 3 A splintered endscraper from Gönnersdorf showing use-wear traces. **a** polish from hide-cutting; **b** polish from ABI-working. – a-b magnifications are at 200×. Solid lines show edges worked with longitudinal actions, dashed line shows edges worked with transverse actions, and arrow shows the direction of wedging.

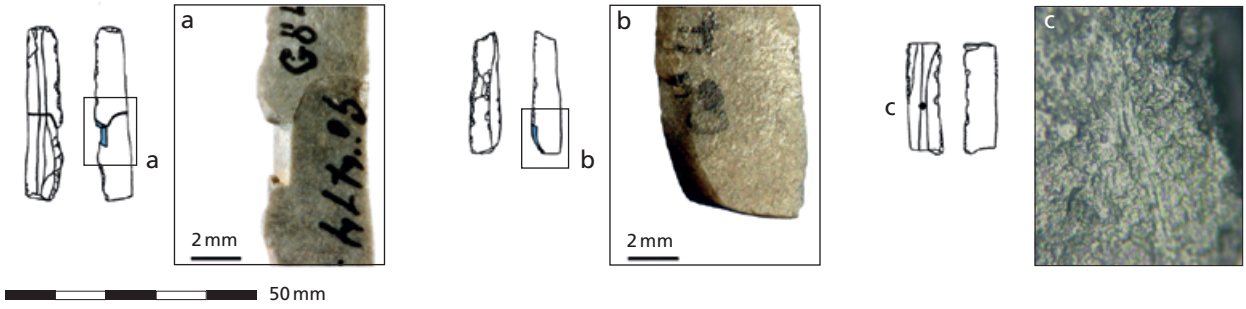

Fig. 4 Backed bladelets from Gönnersdorf showing evidence of hunting. **a-b** impact fractures (burin-like fractures); **c** microscopic linear impact traces (200×).

assumed to be effective for the grooving of hard material. In contrast to our expectations, the lateral edges of the burins were used more frequently (**Fig. 2: f**). The functions of the lateral edges of burins match more or less those of blades and end-scrapers. Multiple utilization of the lateral edges of burins was confirmed at other Late Magdalenian sites (Vaughan, 1985b, 1985c, 2002; Plisson and Vaughan, 2002). As use-wear traces are more often found on adjacent edges to burin facets compared to on burin facets or burin bits themselves, it is suggested that the burin-blow was a technique not only for the preparation of a working edge, but also for the production of bladelets, the rejuvenation of worn edges, and preparation for hafting (Vaughan, 1985c; Barton et al., 1996; Tomášková, 2005).

At Gönnersdorf, a substantial number of end-scrapers and burins demonstrate massive splintering on both ends. The lateral edges of these tools also show diverse functions (**Fig. 3: a**; **Tabs. 5-6**). Experiments have demonstrated that large splintered scars seen on pieces from Gönnersdorf could only have formed if these items were used as wedges against hard materials, such as antlers, bones, or stones (Sano, 2012b). As this wedging induces fracturing of the working edges during use, microwear traces are hardly retained. Nevertheless, some splintered end-scrapers and burins show polish from ABI-working on the ridges between flake scars (**Fig. 3: b**), demonstrating that the pieces were used for wedging against ABI-materials.

Backed points made on blades are absent at Gönnersdorf, except for the younger occupation remains at Gönnersdorf SW. No flint artefacts made on blades were used for hunting (**Tab. 2**). In contrast, numerous backed bladelets show evidence that they were used for hunting (**Tab. 4**). Of the 67 backed bladelets analyzed, 27 specimen bear diagnostic impact fractures (DIFs) (**Fig. 4: a-b**) and four pieces exhibit microscopic linear impact traces (MLITs) (**Fig. 4: c**). In contrast, only three backed bladelets yield other use-wear traces, such as hide-scraping, stone-grooving, and cutting/sawing of hard or medium-hard materials. The high

Splintered end-scrapers								
High power approach								
	Hi-TM	Hi-LM	ABI-LM	ABI-We	St-LM	St-TM	St-TM	St-Gr
proximal and distal ends				6			1	3
end-scraper edge	4					1	1	
lateral sides	1	2	3		1			
Total number of IUZs								18

Tab. 5 Functions by the independent use zone (IUZ) of splintered end-scrapers (n = 6) from Gönnersdorf. – Hi hide; ABI antler, bone, or ivory; St stone; H/MM hard or medium hard material; TM transverse motion; LM longitudinal motion; Gr grooving; We wedging.

Splintered burins			
High power approach			
	Hi-TM	ABI-We	St-Gr
proximal and distal ends		5	
distal end	1		
burin bit			1
Low power approach			
	H/MM-LM		
lateral sides	3		
Total number of IUZs			10

Tab. 6 Functions by the independent use zone (IUZ) and splintered burins (n = 5) from Gönnersdorf. – Hi hide; ABI antler, bone, or ivory; St stone; H/MM hard or medium hard material; TM transverse motion; LM longitudinal motion; Gr grooving; We wedging.

ratio of burin-like fractures to other types of impact fractures suggest that these backed bladelets were laterally hafted, as is evidenced at the cave of Lascaux and the site of Pincevent in France, where backed bladelets were found laterally attached to an osseous point (Leroi-Gourhan and Allain, 1979; Pétillon et al., 2011).

LATE / FINAL MAGDALENIAN LITHIC UTILIZATION STRATEGY AT BOIS LAITERIE

All of the excavated lithic artefacts from Bois Laiterie cave, excluding collections for the permanent exhibition and micro-debitage, were scanned. A total of 256 samples were selected for use-wear analysis. Unfortunately, the microscopic analysis on most of the materials from the Bois Laiterie cave is hindered by the heavy patination of flints. Therefore, it was impossible to identify a polish type on most artefacts based on HPA; those pieces were analyzed based on LPA only (**Tab. 7**).

Similar to the Gönnersdorf assemblage, many burins and several end-scrapers from Bois Laiterie show use-wear traces on their lateral edges (**Tabs. 8-9**). The lateral edges exhibit alternate micro-flaking on the dorsal and ventral faces, indicating that these edges were used for longitudinal motions, such as cutting or sawing. The contact material for these tools is still uncertain. An end-scraper made on a typical Magdalenian long blade retains relatively fresh surfaces, allowing the identification of micro-wear traces. A developed polish band from hide-scraping was observed along the scraper edge (**Fig. 5: a**). Both lateral edges bear alternate micro-flaking and complex micro-wear traces, consisting of generic weak polish, hide-polish, and partially

	bBLL	FR	FL	BL	BP	BU	BUsp	ES*[1]	PE	TR	SP+ NO+ DE	Total
Hard			1	4		5		3	2			15
Hard/hard-medium			2	9		6						17
Stone						1						1
Shell or tooth												0
Antler, bone or ivory				1				1				2
Hide								1		1		2
Butchery								1				1
Projectile	24	3		10	13							50
No usewear				2								2
Uncertain	52	34	4	40	10	3	5	6	10	3	3	170
Total*[2]	**76**	**37**	**7**	**66**	**23**	**15**	**5**	**12**	**12**	**4**	**3**	**260**

Tab. 7 Results of the use-wear analysis of flint artefacts from Bois Laiterie. – *[1] Two endscrapers have splintering and both the splitered endscrapes show traces from hard material working; *[2] Several artefacts show more than one worked material. – bBLL backed bladelet; FR fragment; FL flake; BL blade; BP backed point; BU burin; BUsp burin spall; ES endscraper; PE perforator; TR truncation; SP+NO+DE includes one splintered piece, one notch, and one denticulate.

High power approach			
	Bu	Hi-TM	ABI-LM
end-scraper edge		1	
lateral sides	2		1
Low power approach			
	HM-We	HM-LM	
end-scraper edge	2		
lateral sides		3	
Total number of IUZs			**9**

Tab. 8 Functions by the independent use zone (IUZ) of endscrapers (n = 10) from Bois Laiterie. – Bu butchering; Hi hide; ABI antler, bone, or ivory; HM hard material; TM transverse motion; LM longitudinal motion; We wedging.

High power approach				
	St-TM	St-Gr		
burin bit		1		
burin facet	1			
Low power approach				
	HM-TM	HM-Gr	HM-LM	H/MM-LM
burin bit		5		
burin facet	1			
lateral sides			4	6
Total number of IUZs				**18**

Tab. 9 Functions by the independent use zone (IUZ) of burins (n = 13) from Bois Laiterie. – St stone; HM hard material; H/MM hard or medium hard material; TM transverse motion; LM longitudinal motion; Gr grooving.

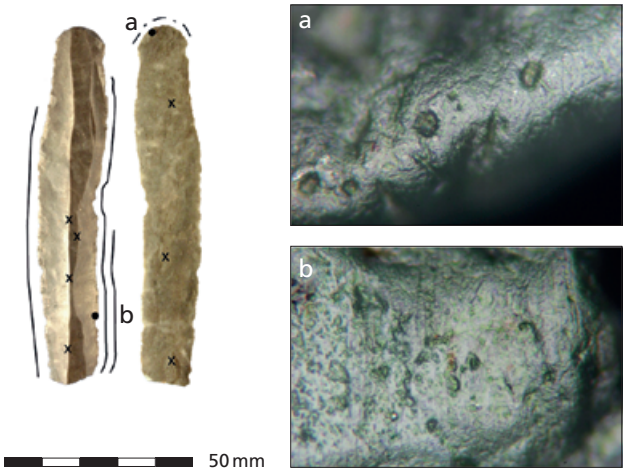

Fig. 5 An end-scraper from the Bois Laiterie cave showing use-wear traces. **a** polish from hide-scraping; **b** polish from ABI-sawing. a-b: magnifications are at 200×. Solid lines show edges worked for longitudinal actions, dashed lines show edges worked for transverse actions, and x shows traces of hafting.

formed linear ABI-polish. The combination of these traces suggests that both edges were used for butchery. The proximal half of the right edge was probably also used for ABI-sawing as this zone shows well-developed ABI-polish, which is an uncharacteristic feature for butchery (**Fig. 5: b**).

Backed bladelets were abundant at Bois Laiterie, and a high ratio of the backed bladelets show DIFs (**Fig. 6: a-b**). No other use-wear traces were observed on the backed bladelets. Due to heavy patination none of them allowed the analysis of micro-wear traces. Nevertheless, the highly-frequent occurrence of impact scars on backed bladelets demonstrates that they were basically used as hunting armatures. In contrast to Gönnersdorf, a considerable number of backed points were found at Bois Laiterie (Sano et al., 2011). Out of 23 backed points, 13 backed points show evidence for projectile usage (**Tab. 7**). Moreover, no other use-wear traces were observed on backed points. The large dimension of the impact fractures (**Fig. 6: c-e**) suggests that they were delivered with high impact velocity.

The backed points from Bois Laiterie were made on blades. However, the blade production technique differs from that documented at Gönnersdorf. The typical Magdalenian long and curved blades are knapped by use of an organic hammer after a specific preparation of the core's striking platform(s), referred to as *en éperon* preparation (Weiner, 1989). The *en éperon* preparation is also present in blades from Bois Laiterie. However, this technique is practiced much less frequently (< 10 %) at this cave than at other typical Late Magdalenian sites (Sano et al., 2011). At Bois Laiterie, blade tools show approximately straight profiles, with curved blades rather rare. Using a soft stone hammer is favorable when seeking to obtain straight profiled blades (Pelegrin, 2000). Technological scars for the use of soft stone hammers (Pelegrin, 2000), comprising a marked striking impact scar, an *en esquillment du bulbe*, and a platform remnant that is ≤ 5 mm^2, were often observed on blade tools from Bois Laiterie (~ 40 %). Although the striking platform of backed points is missing due to retouch, their straight profile implies that the blanks were detached using a soft stone hammer, in order to obtain a preferential straight profile that is ideal for use as a projectile tip.

DISCUSSION AND CONCLUSIONS

The high frequency of impact scars on backed bladelets has also been observed at other Magdalenian sites in Western Europe, including Pincevent (Moss, 1983) and Étiolles (Christensen and Valentin, 2004) in the Paris Basin, and Champréveyres (Plisson and Vaughan, 2002) at Lake Neuchâtel. Although other use traces

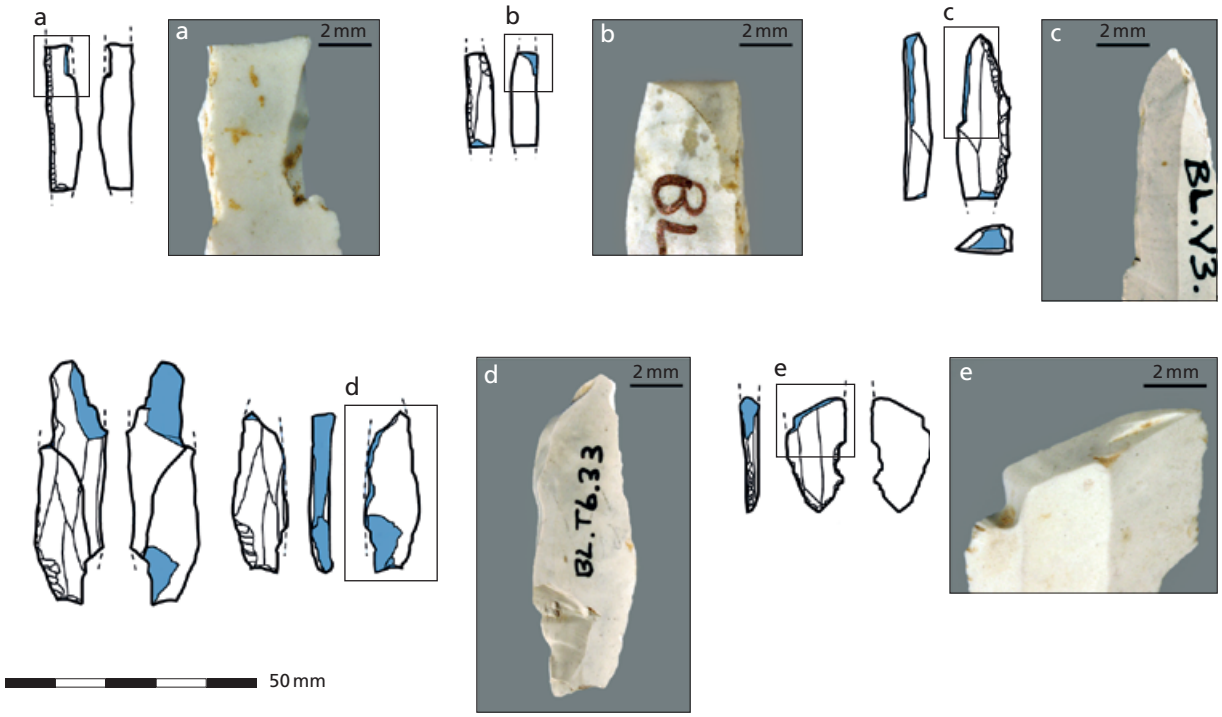

Fig. 6 Backed bladelets and backed points from the Bois Laiterie cave showing impact fractures. **a-c** burin-like fractures; **d** burin-like (s-shaped) and flute-like fractures; **e** burin-like (s-shaped) fracture.

were also found on backed bladelets from these sites, their otherwise low frequency suggests that the utilization of these artefacts for other purposes was rather opportunistic. Consequently, we may conclude that Magdalenian backed bladelets were produced specifically as hunting weapons (**Fig. 6**).

While scraper edges and burin bits were used for a relatively specific task with transverse motions, the lateral edges of end-scrapers and burins were employed for multiple tasks, with mostly longitudinal motions. The temporal relationship between the distal ends and lateral edges is challenging to elucidate. However, while hafting traces on the Gönnersdorf flints were ambiguous due to the overlap of developed use-wear traces and possible hafting traces, Magdalenian end-scrapers were probably hafted for their use (Rots, 2005). The lateral edges of end-scrapers and burins were not usable during the task using the distal end. Hence, the functional disconnection between the distal ends and lateral edges suggests reduction sequences from blades to end-scrapers and burins.

The lateral edges of typical long, standardized Late Magdalenian blades from Gönnersdorf were used for multiple tasks (**Fig. 7**). Some of them were even given scraper edges and were used for hide-scraping. Some were continuously utilized, and worn edges were rejuvenated by retouch or burin-blows. They are then used again after repair. Several blades may have obtained burin-blows, particularly in order to use the burin bits for grooving of hard materials. Moreover, burin-blows were probably performed to attain bladelets. However, the process was also performed in the course of modification for hafting as well. Considerable numbers of end-scrapers and burins show massive splintering on both ends, suggesting that many blade tools were also used as wedges after repeated use, and they have finally finished their "life-cycle" when discarded.

While blades from Gönnersdorf were exhaustively used, none of them were used as a hunting weapon. This is not surprising, since the curved longitudinal profile and the great length of the typical Magdalenian

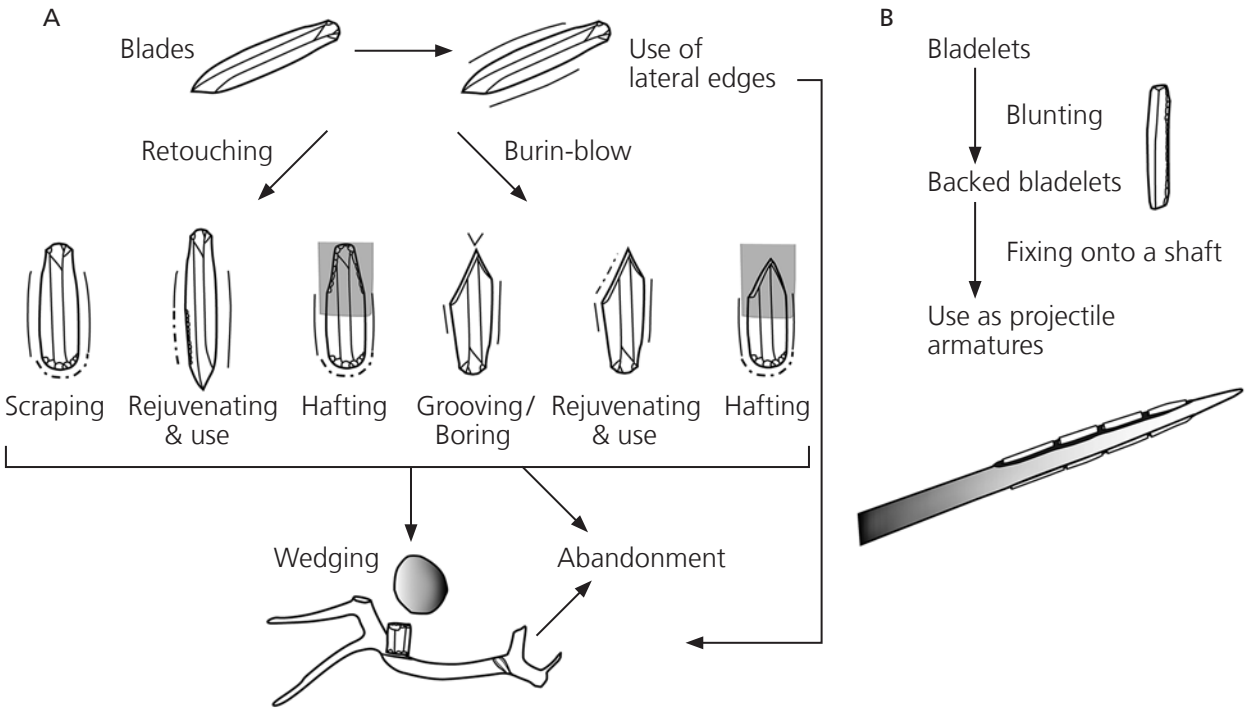

Fig. 7 Utilization sequences for Magdalenian blades (**A**) and bladelets (**B**). Solid lines show edges worked for longitudinal actions, dashed lines show edges worked for transverse actions, and v shows traces of grooving.

blades render it unsuitable as a projectile point. The extremely long Magdalenian blades are optimal for repeated use. Reduction by retouch or burin-blows allowed Magdalenian people to rejuvenate their blades. Therefore, the great length of the blades is especially well-suited for longer utilization.

We can therefore consider that while, on the one hand, Magdalenian blades became longer to maximize durable blade utilization, on the other hand, this would have made them unsuitable as a projectile tip. Instead, backed bladelets are used as projectile tips for hunting. The more significant number of backed bladelets in Magdalenian assemblages compared to in preceeding European Upper Palaeolithic technocomplexes, including the Solutrean and the Gravettian, in which lithic points are also abundant, may reflect the more critical role of Magdalenian backed bladelets as hunting weaponry.

The straight, short blades at Bois Laiterie, probably detached using a soft stone hammer, might stem from the somewhat younger Magdalenian phase of this site (ca. 15,100 cal BP, compared to the age of Gönnersdorf at ca. 15,800 cal BP). The production method for such straight, short blades is more frequently attested in Final Magdalenian and Azilian assemblages (Valentin, 2006; Weber, 2006; Grimm, 2019). A typological comparison of backed points recovered from Bois Laiterie with those found in the succeeding Late Glacial assemblages indicate a similarity with the angle-backed points of the Creswellian, as well as the curve-backed points found in Azilian and *Federmessergruppen* contexts (Sano et al., 2011). The radiocarbon dates of the Bois Laiterie cave slightly predate the Late Glacial assemblages, and partially overlap temporally with the earliest chronological phase of the classic Hamburgian on the North European Plain (Weber and Grimm, 2009). While the Hamburgian shares a long, curved blade production method with Late Magdalenian, using *en éperon* preparation, new technological trends also appear within the former (Weber, 2006, 2012). The coexistence of Magdalenian and Late Glacial technologies is also seen in the Creswellian, which chronologically coincides with the Hamburgian, but is distributed through the Benelux and the south British Isles

(Barton et al., 2003). The change of blade utilization strategy from Gönnersdorf to Bois Laiterie indicates the first step of the gradual techno-functional transformation from the Late Magdalenian to the Late Palaeolithic in North-western Europe.

Acknowledgements

The paper is based on my PhD study undertaken at the University of Cologne and at MONREPOS, "a little bit of a long time ago" and profited much from studies on Magdalenian and Late Palaeolithic sites in the Neuwied Basin by Martin Street and Elaine Turner. I thank Martin and Elaine for their contributions to this field. Their help and friendship during my stay in Neuwied supported me very much. My family shares great memories in Leutesdorf with Martin that are now our treasures. I thank Andreas Maier and Stephan Heidenreich for their techno-typological analysis of the Bois Laiterie assemblage. I am grateful to Sabine Gaudzinski-Windheuser (University of Mainz, RGZM), Rebecca Miller † and Marcel Otte (Université de Liège), Laurence Guy Straus (The University of New Mexico), and Jürgen Richter (University of Cologne) for their permission and support for the study of the Gönnersdorf and Bois Laiterie assemblages. Special thanks are due to Olaf Jöris for his help with the study of Gönnersdorf and with this paper.

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A FIGURINE OF THE GÖNNERSDORF TYPE FROM THE MAGDALENIAN OPEN-AIR SITE WALDSTETTEN-SCHLATT AND BI-GENDERED REPRESENTATIONS IN PALAEOLITHIC ART

Abstract

Besides more than 2,000 lithic artefacts, a female figurine of the Gönnersdorf type, made of an imported quartzite pebble was discovered at the Middle and Upper Palaeolithic open-air site Waldstetten-Schlatt. The figurine was found in a Magdalenian find concentration. Its anthropogenic impression is emphasized by several partly circumferential engravings. This is the first time a figurine of the Gönnersdorf type was identified in the context of a Palaeolithic open-air site in Southwest Germany. The general shape of the piece as well as a conspicuously engraved constriction at its end has given reason to consider this figurine to be of two sexes.

Keywords

Female figurine, Gönnersdorf type female depiction, Magdalenian, poly-gendered representations

INTRODUCTION

Waldstetten is located in the Ostalbkreis, Baden-Württemberg, Germany, about 2 km south of Schwäbisch Gmünd and situated between the Rems valley and the Swabian Jura (**Fig. 1**). Southeast of Waldstetten lie extensive fields. The so-called Schlattäcker (416 m a. s. l.) is topographically considered to be a plateau (**Fig. 2**), preceding the north-westerly egde of the Swabian Jura. The site forms a spur with a wide view over the Alb foothills and the Rems valley. The Waldstetter Bach to the west and the Bettringer Bach to the east are two river valleys that divide the area into several plateaus. Geologically, a loess-bearing colluvium overlays lower Jurassic sandstone formations (Black Jura α 2-3; Kind, 2012).

Since 1988 the site has been regularly surveyed by Adolf Regen of the *Arbeitskreis Steinzeit Schwäbisch Gmünd.* Consequently, more than 2,000 prehistoric finds have been recovered from the site's surface. For visualization of the find distribution the location of each artefact was mapped. Waldstetten is relevant to our project on Palaeolithic open-air sites in Baden-Württemberg, as it constitutes the richest Palaeolithic open-air site in the region. The Magdalenian find concentration in the southwestern part of the site (**Fig. 2**) yielded an outstanding object discovered by Adolf Regen, in the form of a figurine of the Gönnersdorf type (Regen et al., 2019), which is the subject of this contribution.

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.868.c11325

THE ARCHAEOLOGICAL CONTEXT

The surface scatter at Waldstetten comprises finds from post-glacial periods, which are spatially separated from Palaeolithic finds. These lithics differ in the raw materials used, their general technological features, and the degree of patination. As far as the Palaeolithic discoveries are concerned, the Middle Palaeolithic and Magdalenian periods are particularly relevant in terms of quantity and diversity.

The use of local raw materials characterises the Palaeolithic assemblages from Waldstetten. Keuper chert is exposed on the slopes of the Waldstetter Bach, (e. g., Burkert, 2012: 72) and most of the lithics collected by A. Regen – especially those originating from Middle Palaeolithic contexts – are made from local Keuper chert. The spectrum of raw materials in the Magdalenian context is more diversified. While local raw materials are still present, exogenous material such as tabular chert from Bavaria, probably originating from the Abensberg region is documented, as is Tertiary chert, most likely from the Randeck Maar. This chert also characterizes the raw material spectra of other Palaeolithic sites in the region, e. g., Hohle Fels (Taller, 2014), the Kleine Scheuer in the Rosenstein massif (Wettengl, 2013), in the Burkhardtshöhle (Simon, 1993), and the open-air site Sand near Heubach (Wettengl, 2016; Floss et al., 2017).

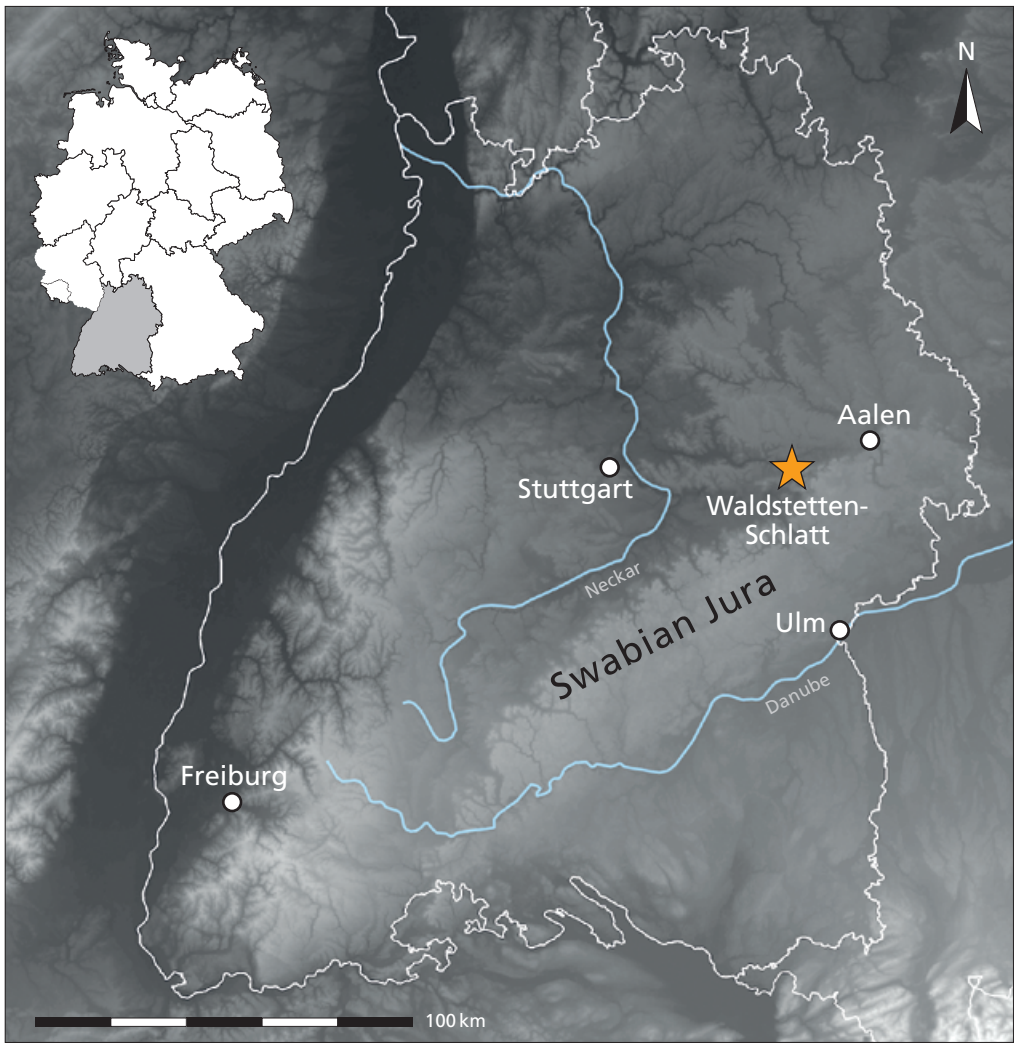

Fig. 1 Geographic situation of Waldstetten. – (Map: S. Fröhle, S. Wettengl).

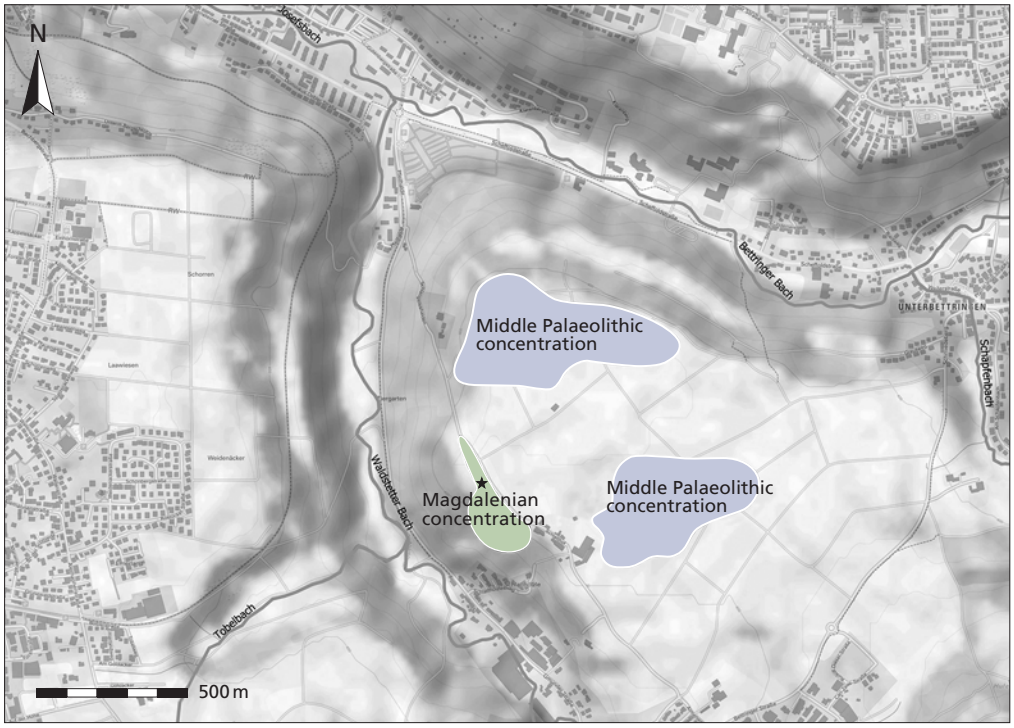

Fig. 2 Overview of the open-air site Waldstetten-Schlattäcker. Marked in blue are the Middle Palaeolithic surface find concentrations, in green, the Magdalenian concentration with the provenance of the figurine (black star). West of the spur, in the small valley of the Waldstetter Bach, a Keuper chert outcrop is situated. – (Map: S. Fröhle, S. Wettengl).

From an archaeological point of view, the occupation of the Schlattäcker starts during the Middle Palaeolithic, to which more than 100 stone artefacts can be attributed. In the Levallois-oriented inventory there is a strong unifacial component with many side scrapers (n = 46). With the Kombewa-concept a further reduction strategy was also observed. Additionally, there are several artefacts that can be assigned to the *Keilmesser* concept.

In chronological terms, a further important assemblage of the site can be attributed to the Magdalenian. It is characterized by borers, different types of burins, end scrapers and backed bladelets (**Fig. 3**). The majority of finds attributed to the Late Upper Palaeolithic originate from a concentration in the southwestern part of the site (**Fig. 2**). Compared to the Magdalenian site Heubach-Sand (Wettengl, 2016; Floss et al., 2017), situated 7 km to the north-east, blank production in Waldstetten-Schlatt is not often observed. Siliceous limestone (*Kieselkalk*), which dominates the raw-material spectrum within the Sand assemblage, is also present at Waldstetten, represented in form of a blade core. The most important Magdalenian site in the region is the Kleine Scheuer cave in the Rosenstein massif in Heubach (Wettengl, 2019).

THE FIGURINE

The object presented here (**Figs. 4-5**) was found by A. Regen in the center of the Magdalenian find concentration (**Fig. 2**). It is made of a conspicuously naturally shaped quartzite pebble, which originates from lower Pleistocene river deposits, which can be found in a distance of at least 10 km to the east of Waldstetten. The

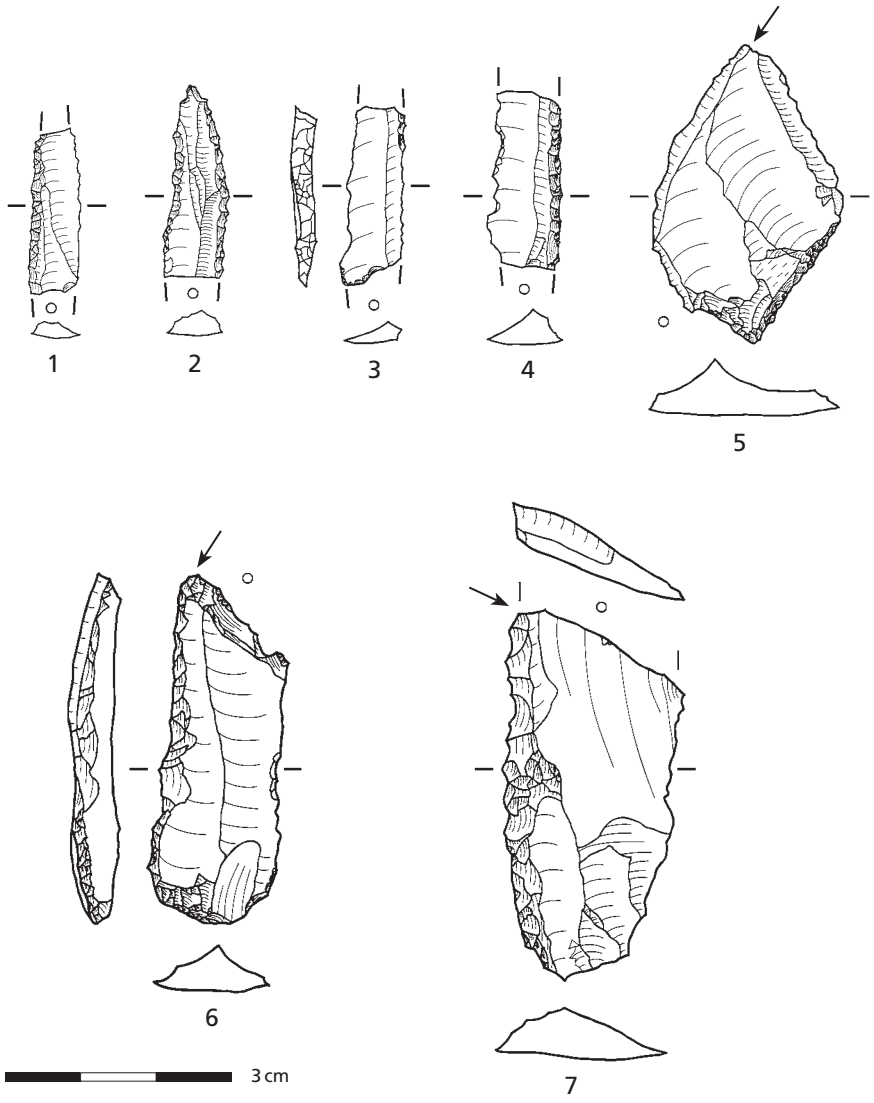

Fig. 3 Magdalenian artefacts: **1, 4** simple backed bladelets; **2** bilaterally retouched, pointed backed bladelet; **3** ventrally retouched backed bladelet; **5** combination tool of burin on natural face and borer; **6** combination tool of burin on truncation and end scraper; **7** laterally retouched transversal burin (1-2 tabular chert; 3, 5-7 Jurassic chert, 4 tertiary chert). – (Drawings: S. Wettengl).

object measures 5.8 cm in length, with a maximum width of 1.9 cm (**Fig. 7**). The piece is 2.5 cm thick and weighs 25.3 gr. Apart from a few modern grooves, the surface of the object is intact.

One of the decisive factors for the object's definition as an example of portable art is its form, which can be recognized in female figurines of the Gönnersdorf type, named after the Magdalenian site Feldkirchen-Gönnersdorf on the northern edge of the Neuwied Basin (Bosinski, 1979). The fact that the object originates from the centre of the Magdalenian find concentration underlines the above attribution. Nevertheless, we are aware that the find comes from a surface scatter. Its anthropogenic character would certainly have remained doubtful without its archaeological context. Moreover, the object clearly displays anthropogenic modification in the form of engravings. The object is homogeneous in patina and surface texture, underlining the anthropic origin of the engravings which are significantly different from modern modifications or damages, an observation that strengthens our argument.



Fig. 4 Views of the Waldstetten figurine. – (Photos: S. Fröhle).

Some of the engravings (**Figs. 4-6**) are completely circumferential, emphasizing the already peculiar natural form of the quartzite pebble. As described in detail by Bosinski (Bosinski et al., 2001) and Höck (1993), figurines of the Gönnersdorf type are subject to a tripartite structure of the body, representing the upper part of the body without head, the dominant middle part with buttocks and the lower part of the body, which is also shortened (Bosinski, 2011).

The medial part of the Waldstetten figurine can be read to represent chest area, abdomen-back and hips. The chest area is unmodified, though the irregular surface structure of the pebble reads in terms of breasts. There are two additional engravings on both lateral sides of the object (**Figs. 5-6**). The engraving on the left side extends towards the back and in a semicircle redirects towards where the abdomen would be. On the right side, only 3 mm below the circumferential incision, there is an engraved line, 6 mm in length that follows the separating neck-line. A further 6 mm below this, where the lumbar region would be assumed, a fine incision, 11 mm in length is pointing towards the abdomen. Where the pebble widens, the hip area would be located, and consequently, the lower back, belly and genitals would clearly retract, with rounded and protruding buttocks. On the left side the object shows a small incision 4 mm in length. Towards distal, the object tapers and thins out at around where the thigh area would be expected. In this reading of the object, the legs are only partially shown as would be expected considering the regular design concept of Gönnersdorf type figurines (Bosinski, 2011). Following Bosinski and Fischer (1974), defined measurements enable comparability of proportions (**Fig. 7**).

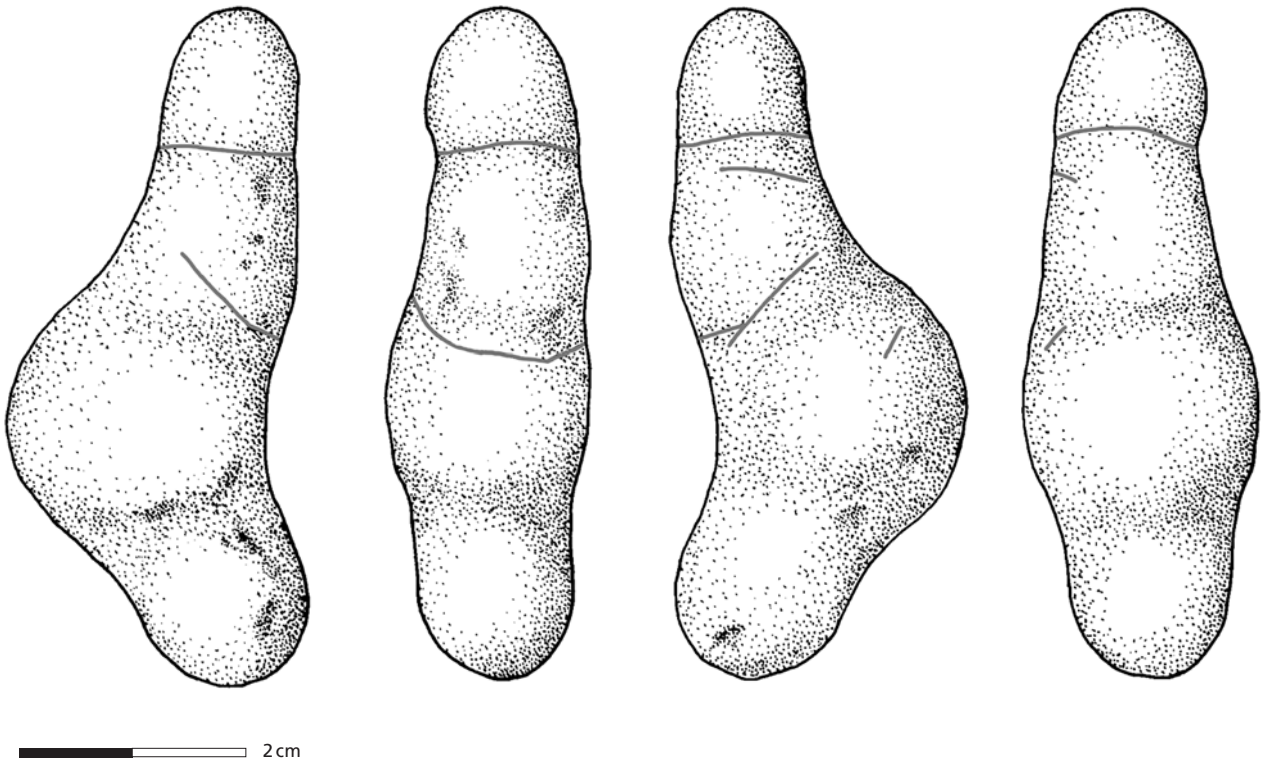

Fig. 5 Drawing of the figurine, with the anthropogenic engravings marked in grey. – (Drawing: S. Wettengl).

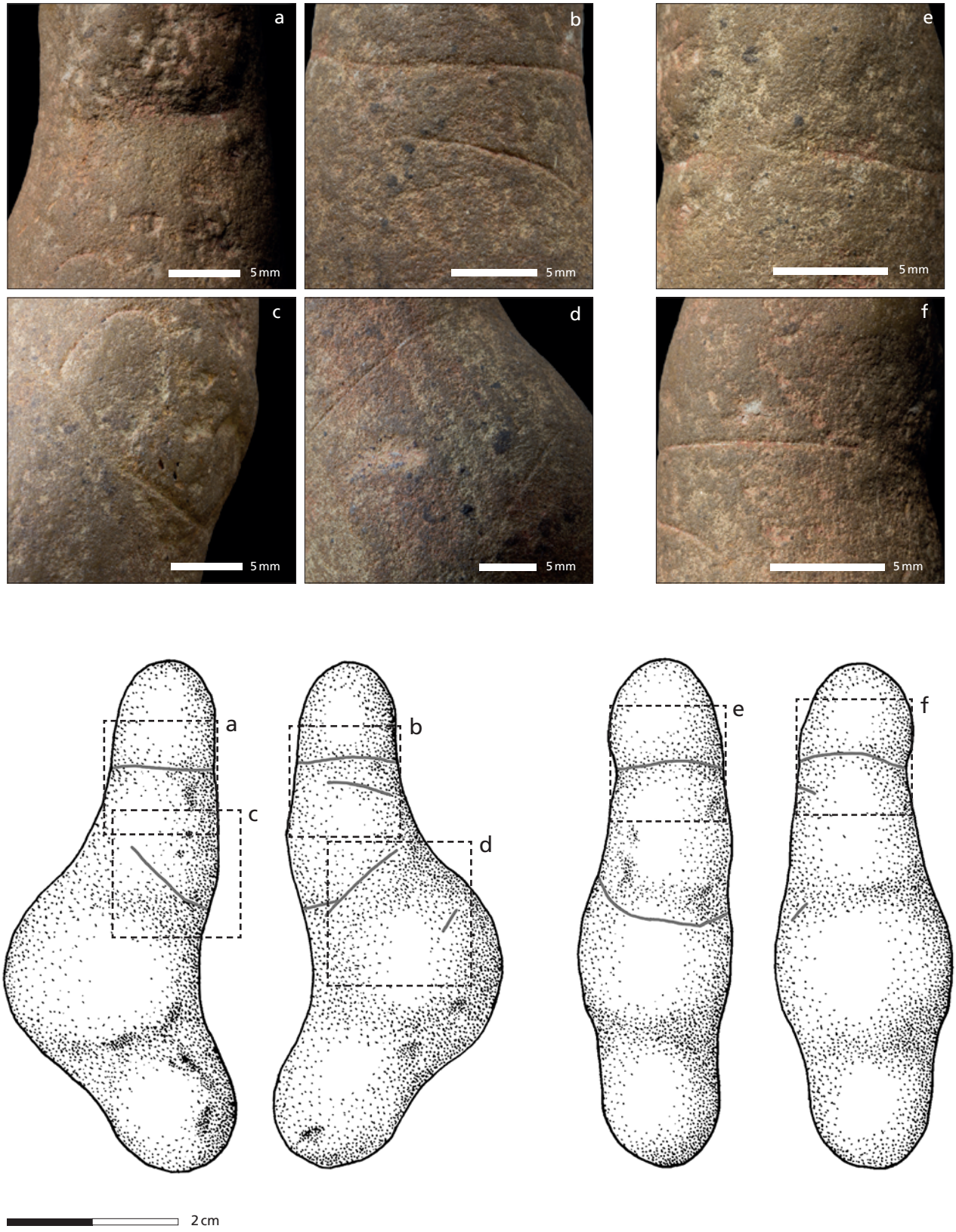

Fig. 6 Macro-Photos of the engravings. – (Photos: S. Fröhle, drawings: S. Wettengl).

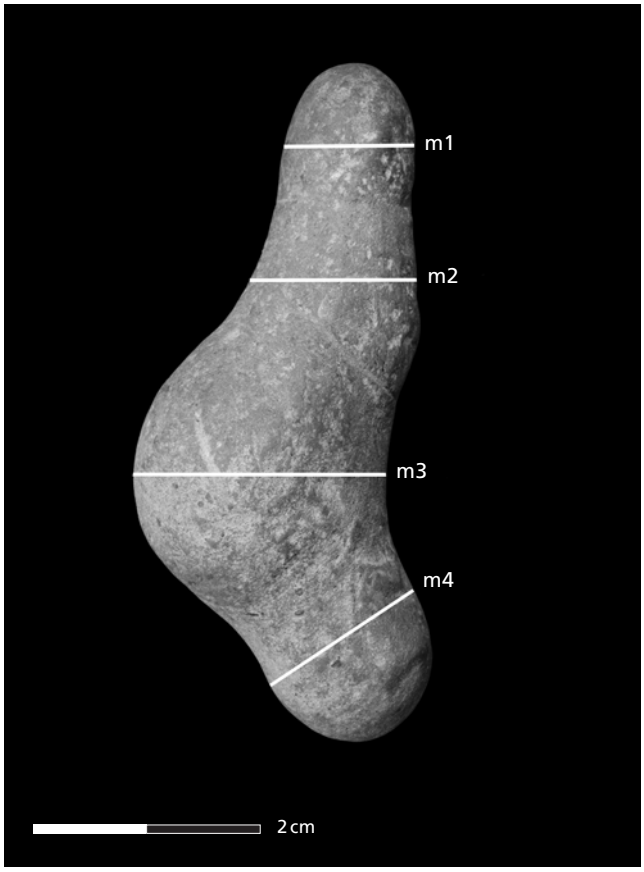

Fig. 7 Measurements of the Waldstetten figurine. Upper Body H 1.2 cm (m1: B × T = 1.3 × 1.1 cm); Torso H 3.1 cm, chest (m2: B × T = 1.4 × 1.5 cm), Buttocks, Abdomen-Waist (m3: B × T = 1.9 × 2.1 cm); Lower Body H 1.5 cm (m4: B × T = 1.3 × 1.4 cm). – (Graphic: S. Wettengl).

COMPARISONS

Female figurines are a common feature in Palaeolithic art (Gaudzinski-Windheuser and Jöris, 2015). Gönnersdorf type figurines and depictions are geographically widespread and have been repeatedly reviewed in recent decades (Bosinski, 1982, 2011; Höck, 1993). This typical Magdalenian design type appears in parietal and mobile art, mainly in the form of engravings and sculptures, more rarely also in the form of paintings. Recently, two engravings of such figurines were identified in the assemblage of the Bavarian cave site of Obere Klause (Floss et al., 2015). There are figurines that have been manufactured, i. e., the typical shape exclusively results from human intervention as exemplified by ivory figurines from the Magdalenian sites of Gönnersdorf (Bosinski and Fischer, 1974), Andernach (Veil, 1982), Nebra (Mania et al., 1999) and Oelknitz (Gaudzinski-Windheuser, 2013), as well as the figurines made of jet from Petersfels (Peters, 1930; Mauser, 1970; Müller-Beck and Albrecht, 1987) and Monruz (Cattin, 2018). On the other hand, there are also a number of figurines of this type that are based on natural forms that functioned as pareidolia with only minor anthropogenic alterations. Such figurines, which are usually made of stone, are found e. g., in larger numbers in Oelknitz (Bosinski, 1982, 2011; Feustel, 1970; Gaudzinski-Windheuser, 2013).

BI-GENDERED REPRESENTATIONS IN PALAEOLITHIC ART

Multi-sex representations are quite numerous in Palaeolithic art. A first group consists of anthropomorphic depictions, which can equally be interpreted as being phallic in character. In this context, the anthropomorphic figurine from Vogelherd or representations from La Combe, Abri Blanchard and Trou Magrite are often mentioned (Hahn, 2020: 17).

A second group are figurines with female and/or male sexual characteristics. This group includes, for example, the so-called hermaphrodite from the Balzi Rossi caves (Piette, 1902). The steatite sculpture is about 5 cm tall. The complex discussion about this figure revolves mainly around the question of how to address a distinct bulge in the genital area (Hahn, 2020: 19-21). Another figure belonging to this group is the so-called figurine à la ceinture from Brassempouy (Piette, 1895; White, 2006). This figurine was found in 1894 in the Grotte du Pape in a level of the Gravettian.

Another group of bi-gender representations are female depictions with a phallic upper body. One of these representations is the so-called Venus of Milandes, found in 1980 near the castle of Les Milandes (White, 2002). Perhaps the most famous figure in this category is the so-called Rote von Mauern, which was found in 1948 during excavations led by Lothar Zotz (Zotz, 1951, 1955; Mussi, 1997) in the Weinberghöhlen near Mauern. The figurine, made of limestone, has a size of 7.2 cm. Another figure belonging to this group is the so-called Venus of Tursac, which was found in 1959 in the Abri du Facteur in the Dordogne (Delporte, 1959). The 8 cm high figure was made of amber-colored calcite. Two other figures in this group, originating from Italy, are the so-called Venus of Savignano, which was found by chance in 1925 (Graziosi, 1925), and the figure of Trasimeno (Graziosi, 1939, 1960), which was discovered by chance in 1938 in a 19th century archaeological collection. While the Venus of Savignano is made of serpentine, the figure of Trasimeno is made of grey-green steatite. Finally, some figurines from the Ukrainian site of Mezin, which come very close to the representation principle of the Gönnersdorf type (Iakovleva, 2009), also belong to this group.

A final group is represented by figurines that combine female and male primary and secondary sexual characteristics. Above all, numerous representations from Dolní Věstonice must be mentioned here, some of which are described as Venus figurines, others as pendants. These figurines combine breasts and phallic projections (Svoboda, 2008). Two objects from the Grotte du Placard in the Charente can also be assigned to this type of representation (de Mortillet, 1906).

THEORETICAL IMPLICATIONS

The discovery of the figurine from Waldstetten sheds new light on the understanding of gender in Palaeolithic societies. The meaning of gender in this context is in the broadest sense of the word. Gender is defined as "the physical and/or social condition of being male or female" (Cambridge Dictionary). In this context the meaning includes the biological gender (sex) and the existence of genders beyond "male" and "female". Through certain features the figurine can be attributed to both the modern socially constructed categories of "male" and "female". The androgynous and ambiguous character of the figurine questions the attribution to a binary classification of gender. In this context "androgynous" is used without connotations of modern day discussions. The definition here is solely "having both male and female features" (Cambridge Dictionary). When analyzing and interpreting Palaeolithic figurines with androgynous characteristics, background knowledge from Gender Theory and Gender Archaeology is necessary to understand to what extent our understanding of gender is socially constructed. Only then can one understand why it should not

be directly transferred to other societies. Our current understanding of gender is based on "binary binds", which are defined by the sex/gender system as well as the "two-sex/two-gender" model (Ghisleni et al., 2016). The sex/gender system describes the division of sex, referring to the biological differences between males and females, and gender, which is a complex term, generally describing the gender role or gender identity of a person. A clear distinction of those two terms is not possible as they are dependent on each other. An important concept of gender theory regarding the sex/gender system is "Doing gender", which points out just how much gender is socially constructed and how little it is actually based on physical or biological differences (West and Zimmerman, 1987). Furthermore, the "two-sex/two-gender" model describes the assumption of only two gender identities – either male or female – which derive from biological differences. This belief is fundamental to western society, as current binary gender roles of male and female, as well as behavior and thought patterns are perceived and described as inevitable and natural. This, among other things, is based on the inaccurate belief that the binary system is a constant characteristic of all societies and deviations from it only describe individual cases (Moen, 2019). However, there are numerous ethnological and archaeological studies showing that this binary division of sex/gender cannot be observed in all societies (Hamilton, 2000).

Another particularly important topic of gender archaeology, especially for the interpretation of androgynous representations, is intersexuality. Numerous scientists note that even in basic biology an absolute dimorphism does not exist, meaning that internal and external sexual characteristics vary more often than most people are aware of (Brandt et al., 1998; Fausto-Sterling, 2000). When examining evidence for intersexuality, transsexuality or transgender individuals, the term "third gender" is often used as an analytical category. However, this term only insufficiently shows that gender is variable and fluid and cannot be divided into rigid categories (Moral, 2016). There is considerable variation in the perception and number of gender identities throughout history (Nanda, 2014), which shows that our modern and western understanding of gender cannot be transferred to other past societies. An important point is that conclusions about gender in the respective societies are additionally difficult, as androgynous figurines only show sex characteristics, without indications of gender.

Nevertheless, the fact that sex characteristics were in fact depicted shows that they were of importance for the "artists", or were at least consciously used as an artistic expression in order to illustrate the meaning of the object.

In summary it can be said that conclusions and presumptions about the gender of androgynous figurines from the Palaeolithic must be made very carefully. The analysis of the figurine from Waldstetten and other androgynous figurines suggests that modern binary classification of gender might not be sufficient to account for the ambiguous character of the figurines.

CONCLUSIONS

The figurine from Waldstetten-Schlatt is the first representation of the Gönnersdorf type to be identified in southwestern Germany in the context of an open-air site. Even if one might object that the find originates from an unstratified surface context, several arguments speak for its authenticity. In addition to the absolutely typical morphology of the Gönnersdorf representation principle (Bosinski et al., 2001), the position of the figurine in the middle of a Magdalenian find concentration and the anthropogenic imprinting in the form of several engravings, speak for a Magdalenian dating of the find. The circumferential engraving in the upper part suggests an at least bi-gendered character of the figurine as a female representation and

as a phallus, as repeatedly discussed for Upper Palaeolithic female figurines. A complete presentation of the Palaeolithic finds from Waldstetten-Schlatt is part of the ongoing project "Palaeolithic open-air sites in Baden-Württemberg".

Acknowledgements

We would like to thank Adolf Regen and Wolfgang Naak from the *Arbeitskreis Steinzeit Schwäbisch Gmünd*. Without the fruitful cooperation with the *AK Steinzeit* our research in the Ostalbkreis would never have been possible. We would like to thank Adolf Regen in particular who has been surveying the Waldstetten site for several decades and discovered the female figurine described here.

The investigations in Waldstetten are part of our archaeological project "Palaeolithic open-air sites in Baden-Württemberg".
We would like to thank the *Landesamt für Denkmalpflege*, the *Archäologisches Landesmuseum* and the *Förderstiftung Archäologie*, all Baden-Württemberg, for their support.

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WE TEND TO TENT – REFLECTIONS ON A GROUP OF FEATURES AT THE MAGDALENIAN SITE OF BAD KÖSEN-LENGEFELD, SAXONY-ANHALT

Abstract

At Bad Kösen-Lengefeld, a well-preserved Magdalenian camp site with a large variety of features, such as hearths, paved areas, and pits has been excavated during the last years. Judging from the spatial distribution of finds and features, we propose a tent structure enclosing a massive hearth construction as well as an adjacent open-air activity zone as a plausible interpretation, although the possible contemporaneity in the use of both areas needs further investigation. We discuss this finding against comparable structures at other Magdalenian sites as well as the ethnographic record.

Keywords

Tent structures, postholes, hearth, paving, ethnography

INTRODUCTION: INSIDE OR OUTSIDE?

There seems to be little dissent that dwelling features were regularly constructed by Upper Palaeolithic hunter-gatherers. How these objects can be detected in the archaeological record, how they were constructed, what shape they had, and what functions they served is, however, still a topic of considerable debate. Circular features of mammoth bones usually interpreted as remains of buildings have been described early on in Palaeolithic research for Eastern and eastern Central Europe (Gladkih et al., 1984). In Western and western Central Europe, in contrast, architectural objects seem to have been less massive and have taken the more ephemeral form of tents. Leaving no tangible remains themselves, these buildings have to be inferred from features created by their constructive elements and the observable imprint they impose on the spatial patterning of objects in their environment. The first detailed analysis of this kind was performed by A. Leroi-Gourhan at Pincevent, where he analyzed border effects in the distribution of different find categories to infer activity zones and the shape and location of a potential dwelling structure (Leroi-Gourhan and Brézillon, 1966, 1972; Leroi-Gourhan, 1984). Since these works, the criteria used to infer ephemeral buildings in the archaeological record have not changed significantly and usually include spatial information on hearths, postholes, paving, lithic and organic tools, production waste, faunal remains, colourants (e. g., such as hematite), and refittings. None of these criteria alone a necessary condition for a tent, and therefore the absence of any of them is no argument against the former presence of a tent at a site. There is also no single sufficient condition for inferring a former tent dwelling. Therefore, repeated observations of the same spatial boundary pattern in different categories of observations are usually considered the best argument for postulating the former presence of a tent at a site and inferring its location and shape. There is, however, debate about the argumentative capacities of each criterion and how its spatial patterning has to be structured to be considered convincing evidence for former dwelling features. Further complicating matters are

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.868.c11326

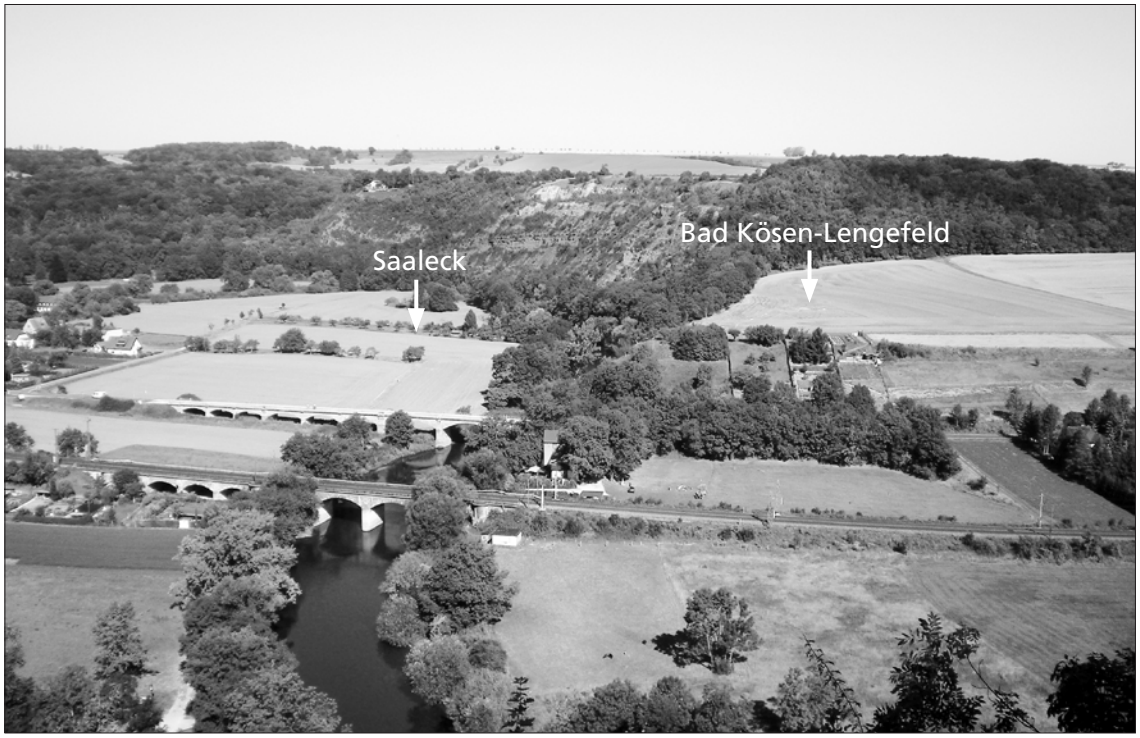

Fig. 1 View from south to the Magdalenian sites of Bad Kösen-Lengefeld and Saaleck.

palimpsest situations, where objects have been recycled and the organization of activity zones has changed several times (Leesch and Bullinger, 2012).

As a consequence, and despite substantial agreement on the general existence of tents, it is often difficult to decide whether specific features at specific sites are the remnants of tent structures and inside-activities or open-air structures and outside activities. In the following, we present features from the Magdalenian site of Bad Kösen-Lengefeld in Saxony-Anhalt and discuss the pros and cons of their interpretation as being the leftovers of a former tent.

MATERIAL AND METHODS

The site

The open-air site of Bad Kösen-Lengefeld (**Fig. 1**) is situated immediately north of the riverbank of the Saale river, approximately 6 km downstream from the city of Naumburg (Burgenlandkreis) in the eastern part of the Federal Republic of Germany. On a regional scale, the site is part of a cluster of Magdalenian sites within the Saale-Unstrut region, which includes the well-known localities of Saaleck (Bock et al., 2013), Oelknitz (Gaudzinski-Windheuser, 2013; Bock et al., 2015), Bad Frankenhausen (Feustel, 1989), and Nebra (Mania et al., 1999), among others (Küßner, 2009, 2010; Küßner and Jäger, 2015). Topographically, the site is located on an elevated terrace 35 m above the left bank of the Saale River, which – according to the preservation of the Magdalenian site of Saaleck in the extant oxbow of the Saale – did not change its course since

the end of the Late Pleistocene. While the area of the Magdalenian occupation itself is nearly horizontal, the immediate surrounding is characterized by a pronounced relief, with a steep slope towards the riverbed and another, higher terrace in the back of the site (Fig. 1). Together with a south-facing exposure, this provides both prevention from wind chill and long exposure time to sunlight. In addition, a pronounced narrowing of the river valley accompanied by steep slopes on the northern bank and almost vertical undercut banks on the opposite shore (which starts near the site and proceeds for about two kilometers in direction to Bad Kösen) provides numerous promising topographical positions for hunting of animals moving to the water source and/or along the river valley.

After its discovery in 1954 by V. Toepfer, W. Matthias, and F. Waih, the site was systematically surveyed, also by D. Mania, and investigated with a small test trench in 1966 (Adaileh, 2020). From 2008 onwards, the find area has been investigated by the Universities of Cologne and Erlangen-Nürnberg in close cooperation with the Landesamt für Denkmalpflege und Archäologie Sachsen-Anhalt (Uthmeier and Richter, 2012; Uthmeier et al., 2017). The multi-disciplinary field work involves systematic surveying, geophysical prospection, geo-archaeological drilling, excavation, the search for micro-tephra, micro-morphological analysis, and a dating program. The geological sequence comprises at least 9 m of loess, with two archaeological horizons in the upper 0.6 m of the sequence. While the lower archaeological layer seems to be embedded within *in situ* aeolian deposits, the upper (main) archaeological layer is located about 0,3 to 0,4 m above the lower layer and shows interlacing with a series of thin solifluction horizons.

Surveys and coring indicate a total settlement area in the upper archaeological layer of about 420 m² (Fig. 2). Excavations so far uncovered 91 m² of comparatively dense remains of settlement activities. Wet sieving, 3D-measurements and photogrammetry warrant precise documentation of the numerous finds and features. To date, 3,455 lithic artefacts from the surface collections and the lithic finds, faunal remains and features of the northern part of the site have been analyzed and are published (Adaileh, 2020) or await publication (Richter et al., in press).

The archaeological remnants of the upper layer largely appear to be conserved in primary position, with hundreds of manually transported limestone slabs, representing former settlement features. However, there is also evidence that small items may be under-represented in certain areas as a result of low-energy sheet flow events. A longer exposure of the palaeo-surface is indicated by the sometimes strongly weathered faunal remains or areas where only teeth were preserved.

The lower horizon has been documented during the 2017 field season and is restricted to the central part of the site. It has been recognized by the position of the artefacts, not by any technological or typological differences. However, the lithic raw material of the lower layer is of much better quality than that of the upper layer. We think that Saalian moraines, to be found some kilometers northeast of the site, were the source of this raw material, whereas the occupants of the upper layer seem to have relied on materiel obtained from the Elsterian tills accessible at the nearby plateau only some hundred meters distant. Up to now, the lower layer only yielded a few hundred artefacts, and three small pits can be related to this archaeological horizon.

Cornerstones of tent identification

In the following, we briefly present general aspects usually invoked in discussions about the identification of architectural objects and evaluate their argumentative capacities. Where applicable, these aspects are included in the analysis of the different features of the site. Eventually, we compare our findings with the ethnographic record as well as with other Magdalenian sites.

Hearths

Hearths are often considered important for understanding the spatial structure of a site (e. g., Leesch and Bullinger, 2012) and therefore feature prominently in some methods of intra-site spatial analysis (Stapert, 1989). However, it can be difficult to infer the location of hearths even if the preservation of other features is good (e. g., Vencl, 1995). Moreover, there is no general rule as to whether hearths are located outside, at the center, or rather at the threshold of tents (cf. Vermeersch et al., 1984; Wenzel, 2011).

Postholes

Postholes are usually considered a convincing case for remains of dwelling features. However, there are a number of imponderables connected to them. First, it needs to be demonstrated that small pits are related to architecture and thus can be considered postholes. Second, (at least) in the case of palimpsests, postholes can be too numerous or erratically distributed to form a pattern that can be meaningfully connected to a tent (Gaudzinski-Windheuser, 2013). Third, postholes can be the remnants of scaffoldings and other structures not related to tents.

Paving and weight stones

Areas covered with larger stone slabs or cobbles are often referred to as paving and are not unusual for Upper Palaeolithic sites. However, by themselves they are not sufficient to indicate the location or shape of former tents, since they could also have been constructed in non-sheltered places or covered only a part of the dwelling. Moreover, some of these structures seem to be the result of covered hearths (Bullinger et al., 2006). Larger slabs or cobbles could have served as weight stones on tent covers and thus are sometimes used to trace their potential outlines (Jöris and Terberger, 2001). Depending on the number and distribution of larger items at the site, reconstructions of outlines can vary considerably between authors (e. g., Vermeersch et al., 1984; Wenzel, 2011). There is also the danger of circular reasoning if reconstructions of outlines try to fit certain shapes, which are deemed most likely for tents (pentagons, hexagons, circles), to a find distribution that allows for multiple readings.

Find densities

Changes and discontinuities in the densities of finds can yield valuable information about the spatial organization of a site (Hietala, 1984; Kind, 1985). Different techniques of mapping are applied, such as excavation plans, mapping of quantities per area, or interpolated isolines of equal densities (Stapert, 1989; Gelhausen et al., 2004; Wenzel, 2009). An inspection of the spatial patterning identifies boundary situations occurring repeatedly at similar locations in different materials. These reoccurring boundaries are then argued to represent evidence of former dwelling features. There seems to be a consensus that a local increase in an otherwise decreasing density distribution (referred to as bimodal distribution or wall effect) is good evidence of a former spatial barrier, often interpreted as tent walls (Leroi-Gourhan, 1984; Stapert, 1989). It is,

however, debated whether a sharp drop in find density is an equally sufficient criterion to assume a barrier situation (Gelhausen et al., 2004). Often, high densities of tools are frequently considered a good indicator for the interior part of a dwelling, while the density of production waste and faunal remains should be low (Leroi-Gourhan and Brézillon, 1966; Wenzel, 2009). However, opinions differ on whether areas of high or, conversely, areas of low find densities should be considered the location of a former dwelling (Bolus, 1992; Gelhausen et al., 2004), or if both can occur simultaneously in the interior of a dwelling (Leroi-Gourhan and Brézillon, 1966; Vermeersch et al., 1987; Jöris and Terberger, 2001).

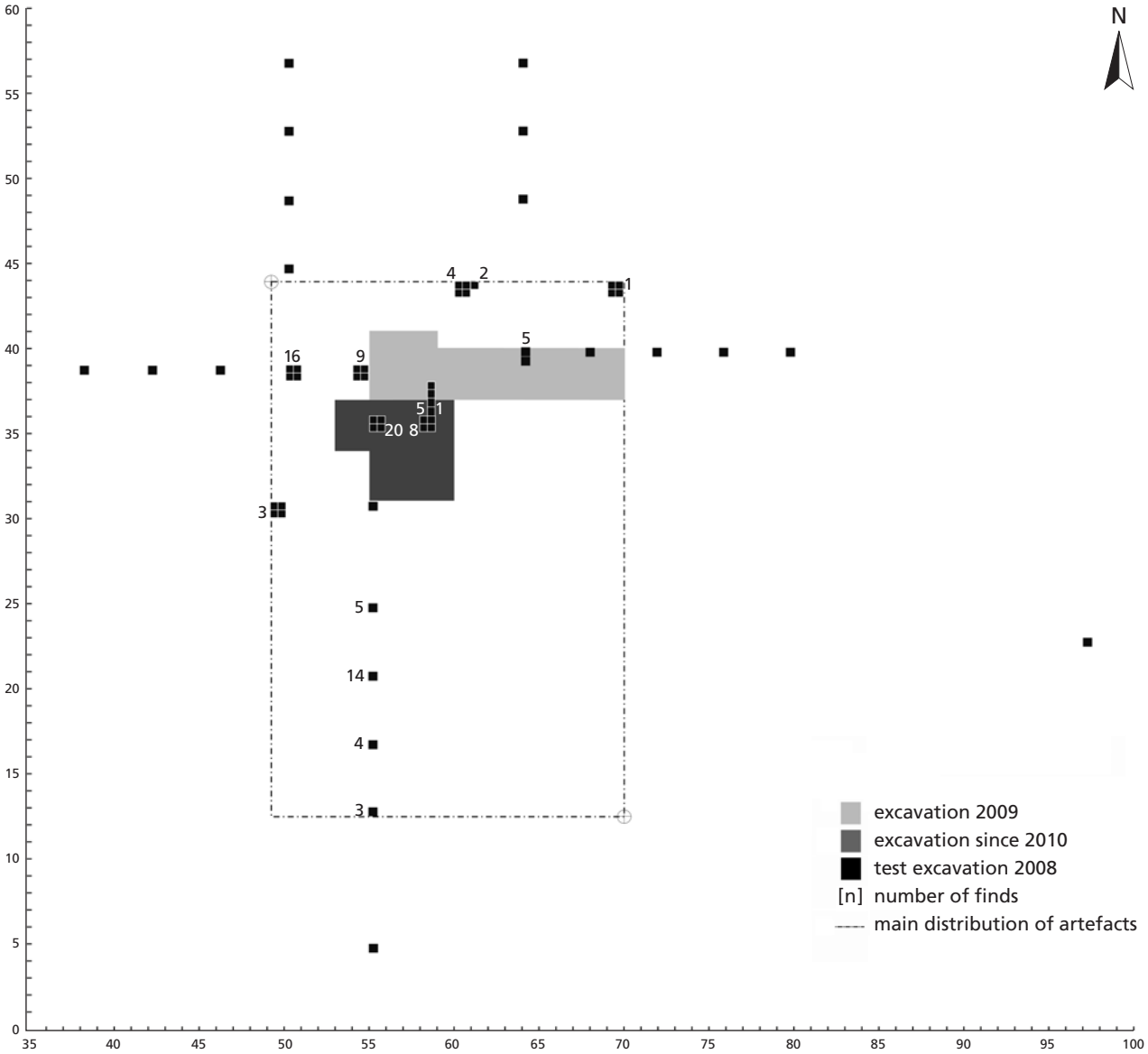

Fig. 2 Bad Kösen-Lengefeld. Overview of the excavated areas of field seasons in 2008, 2009, and since 2010.

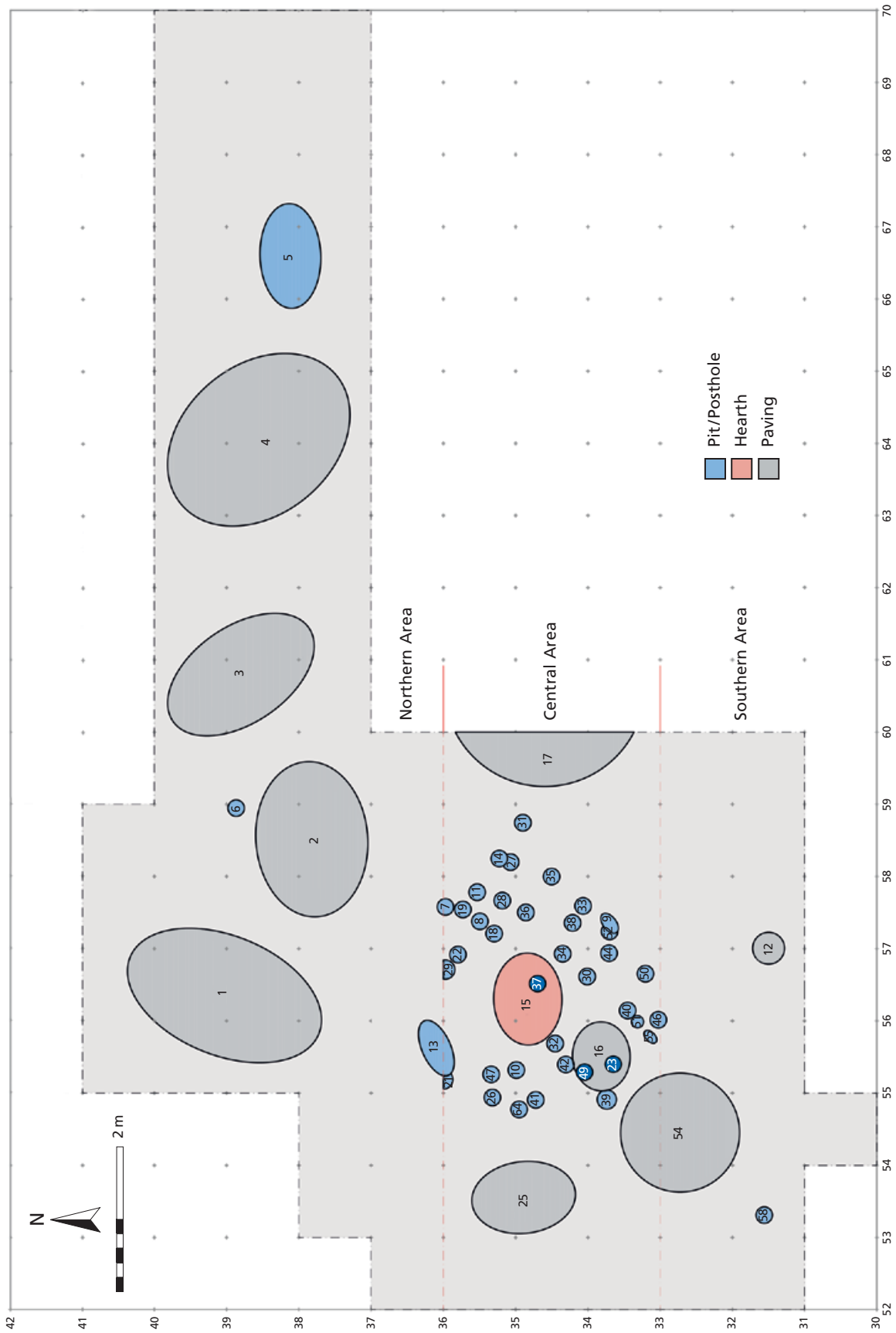

Fig. 3 The northern, central, and southern areas of Bad Kösen-Lengefeld with the main evident features. The light blue color indicates the 33 possible "postholes", surrounding feature 15. Pits 23, 37, and 49 in dark blue are linked to the lower archaeological horizon.

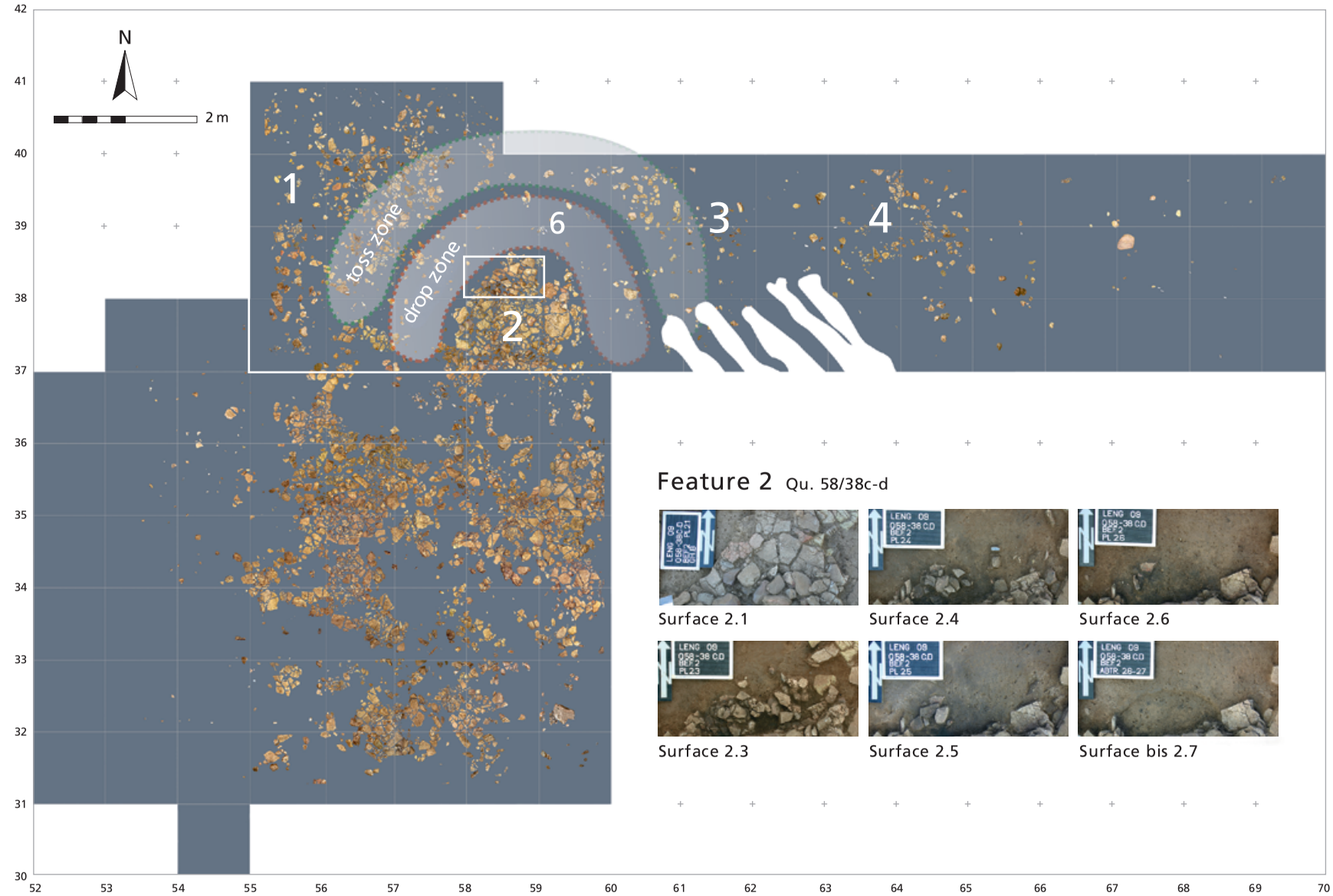

Fig. 4 Bad Kösen-Lengefeld, upper layer. Photogrammetric plan of limestone slabs with indication of the evident features of the northern area and their interpretation as remnants of open air activities (feature 1, feature 3, feature 4: concentration of limestone slabs; feature 2: combustion feature; figure 6: small pit filled with artifacts; brown: traces of ploughing; to note: feature 5 is a geological feature and therefore not depicted). The pictures in the inserted box illustrate different phases of excavation of feature 2.

Refittings

The spatial pattern of refitted objects is also used to infer former architectural objects. Connection lines not crossing certain boundaries are considered to support arguments for the existence of a former barrier (Leroi-Gourhan and Brézillon, 1966; Wenzel, 2011).

Ochre

The spatial distribution of pigments as indicators of domestic zones is also used to identify the interior parts of former dwellings (Leroi-Gourhan and Brézillon, 1966; Bosinski, 1979). It needs to be stressed that post-depositional movements of finds and periglacial phenomena such as patterned soil can arrange objects in curves and straight lines and can sort objects according to size-classes (Bertrand et al., 2010). Taphonomic processes therefore can create circular and polygonal structures and mimic boundary effects and have thus be taken into consideration for the spatial analysis of Palaeolithic sites.

RESULTS

The following discussion only concerns the upper find horizon. The excavation area can be divided into three areas, called the northern, central and southern area, which differ in both the characteristics of their evident features and the composition of the faunal remains (**Fig. 3**). For the question at hand, only the northern and central area will be discussed in detail.

The northern area: features related to open-air activities

The northern part of the excavation area measures 61.5 m² (**Fig. 4**). Among the faunal remains in this area, horse is by far the dominant species and is represented by remains from all skeletal parts, some of which in anatomical order, and indicate on-site killing and dismembering of the animals (Meindel, in press). The most prominent evident feature (labelled "feature 2") is a hexagonal structure made from more or less horizontally positioned stone slabs. It covers a surface of approximately 2 m² and has conspicuous straight and rectangular limits on three sides, two of which are oriented in a northeast-southwest direction and the other in a northwest-southeast direction. Further towards the south (i. e., towards the central area), the density of stone slabs decreases rapidly, but does not form a clear boundary line. Feature 2 consists of several layers of flat and often broken stone slabs with a maximum length of ~ 0.5 m and a thickness of a few centimeters. By excavating each layer separately, it became clear that the slabs lay on top of each other with almost no sediment but low numbers of lithic artefacts, burnt quartz pebbles, and faunal remains between them. Direct evidence for fire was found immediately below the basal layer of stone slabs, where sediments showed a sooty component and were sampled for the analysis of molecular proxies, and on top of the uppermost layer, where small portions of burnt sediment were located. In a first and only preliminary reconstruction of the use history of feature 2, several steps can be distinguished that indicate an area of intense domestic activity related to fire.

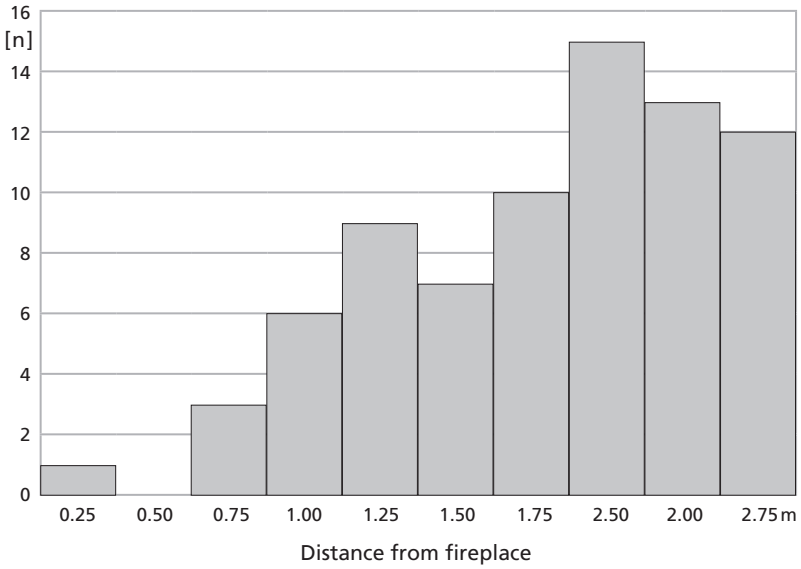

Fig. 5 Bad Kösen-Lengefeld, upper layer. Frequency (n) of lithic artefacts in concentric rings around feature 2, subdivided in steps of 0.25 m; the unimodal distribution is interpreted as indicating open air activities.

1.) The sooty sediment at the base may originate from an *in situ* fireplace covered with stone slabs as it has been described for Monruz (Bullinger et al., 2006). However, it is also possible that the accumulated soot has been washed down from a fire burning on top of a stone paving or even has been washed in from a nearby fireplace.
2.) The middle section of the feature – where faunal remains, artefacts, and heat-splintered quartz pebbles have been found between the stone slabs – may be the result of intensive and continued use of the feature as a (stone-covered) fireplace. However, it cannot be excluded that objects from previously used fireplaces were taken to construct feature 2, thereby mimicking intensive reuse of the feature.
3.) The last phase of use is represented by the uppermost layer of stone slabs, which seems to have been covered by a thin layer of burnt sediment, indicating that a fire had been burning on top of feature 2.

To the west of feature 2, an area of approximately 14 m² labelled "feature 1" was covered by a sparse scatter of limestone slabs (**Fig. 4**). Differences in the find densities of both slabs and artefacts allow a distinction to be made between a semi-circular zone almost void of finds west of feature 2 and a second, similarly oriented zone with more finds. The excavated area east of feature 2 is characterized by a generally low density of finds that decreases evenly towards the borders of the excavation. Evidence for ploughing may point to a modern destruction of possible features, but the lack of finds in the ploughing horizon in this part of the excavation and a test trench to the north without any finds more convincingly points to an actual border of the Magdalenian activities.
To answer the question of the use, context, and setting of feature 2, a ring-and-sector analysis (following Stapert, 1989, 1990; Albert, in press) was conducted. The unimodal distribution of find frequencies in the rings and sectors around feature 2 (**Fig. 5**) argues against the presence of a tent-like structure. An interpretation as an open-air working area around a fireplace with a close drop-zone and a more distant toss-zone (*sensu* Binford, 1978) currently seems more plausible. The activities were mainly dedicated to retooling and rehafting of backed implements, probably accompanied by hide working (due to the presence of numerous end scrapers).
This interpretation, if accepted, has also consequences for the interpretation of feature 1. Since the scatter of artefacts attributed to activities carried out around feature 2 are superimposed on (and do not spatially

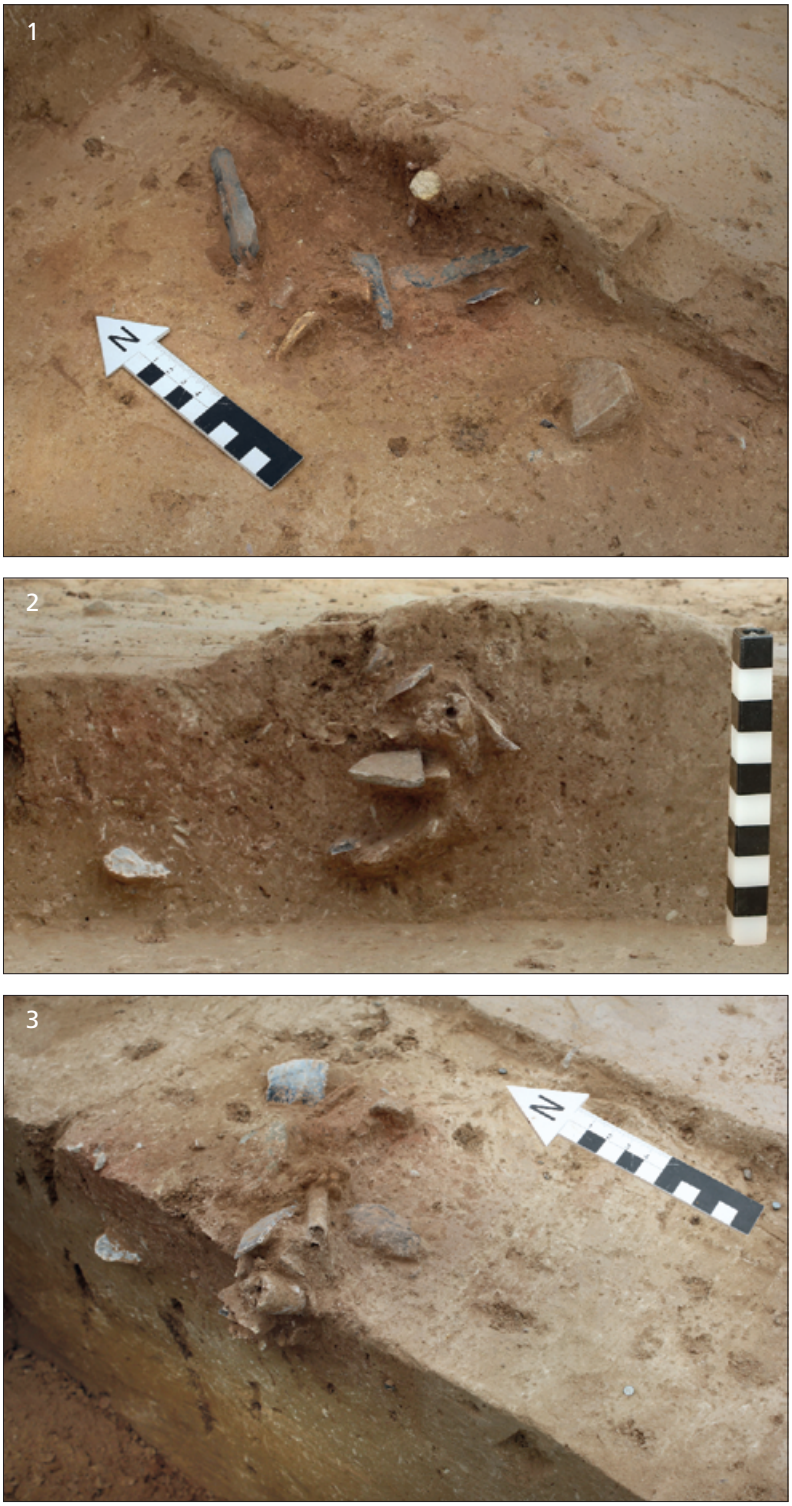

Fig. 6 Bad Kösen-Lengefeld, upper layer – excavation of feature 19. Example of a small shallow pit without stone wedges. **1** Bird's view showing both the occupation surface in the eastern half, no colouration visible in planum view and the next excavation level in the western half with lithics, bones, and red colour; **2** South-North section, view to east, of feature 19 showing the findings mostly scattered in the southern part with steep southern limit and shallow northern limit of the pit; **3** The next excavation stage with next spit removed in the eastern half and deepening of the western half continued. The feature displays a round planum shape and an asymmetric section shape with asymmetric distribution of filling.

respect) feature 1, the latter seems to be a remnant of an earlier site use. Similar explanations apply for two additional stone scatters found east of feature 2 (**Fig. 4**: "feature 3" and "feature 4"). The results of the ring-and-sector analysis suggest that feature 3 was part of the drop and toss zones of lithic artefacts in the vicinity of feature 2. However, at the present state of investigation, it proved difficult to decide whether the discard of waste in the area of feature 3 was restricted to artefacts deposited on an already existing feature of stone slabs, or if the tossing also included stone materials from feature 2. The distance between feature 4 on the one hand and feature 2 and feature 3 on the other makes a contemporaneous functional relation less plausible. Therefore, at least feature 4 at the northernmost periphery of the site most probably originates in an earlier occupation phase, and the stone paving was exploited by later occupants in order to set up the much better preserved feature 2. Unaware of the results of future analysis of the precise chronological and functional relation between each of the features, the different states of preservation of the stone scatters or structures clearly show that we are dealing with at least two subsequent occupation events within the upper archaeological horizon.

Central area: features related to a tent-like architectural object

To the south of the features described above and in the central area of the known find scatter, 36 small pits have been recorded (**Fig. 3**). These features are restricted to a comparatively small area of the excavation, and comparable features have not been documented elsewhere at the site. The pits are usually between ~15-20 cm in diameter and ~10-30 cm deep (**Figs. 6-8**). They are distinguishable by their infill consisting of red pigments, artefacts, bone fragments, and smaller stone slabs. Some part of the infill, such as small limestone slabs at the bottom of the pits, had presumably been installed intentionally, while others probably fell in by chance from the settlement surface. However, in most cases, it has not been possible to determine the shape of the pits exactly, because the sediment infill is mostly indistinguishable in colour and grainsize from the adjacent sediment, and the pigments tend to fade out and blend into the sediment rather than highlighting clear boundary lines. The fact that sediment infill and surrounding sediments are identical except for the anthropogenic remains indicates the absence of any soil formation processes during both the occupational event itself and later, until the site had been covered by loessic material. The upper part of some pits appears eroded and covered by an overlying solifluidal sediment layer with mixed particles of loess, coarse sand, fine gravel, and humic components. The processes that led to the deposition of the solifluidal sediments in these parts of the site thus also eroded the former loess cover, but its remnants have been trapped in the respective pits. Consequently, the depths of part of the pits must be considered minimum depths. Reconstructions of the shape of the pits are not yet available. Because the outlines of the pits were often only vaguely detectible at the top-planum level, and in order to record their possible oblique and asymmetrical shape (potentially invisible in arbitrarily located profiles), the spatial recording of the artefacts and reddish colourings of the infill will be used to create 3D-reconstructions of the pits for further inspection (**Fig. 6: 3**).

The pits enclose the up to now most complex stone feature found at the site of Bad Kösen-Lengefeld, labelled "feature 15" (**Fig. 3**). It consists of a large, oval limestone slab which covered a large, shallow pit filled by some globular quartz river pebbles. The overlying oval limestone slab displays patches of blackish colouring (ash particles?). About a dozen globular quartz river pebbles (originally complete, but some now partially fragmented *in situ*) were found scattered in the center on top of the large limestone slab. Craquelée and reddish colour indicate that these quartz pebbles had been exposed to heat. The whole construction – shallow pit – round pebbles – oval slab – round pebbles – was completely preserved until



Fig. 7 Bad Kösen-Lengefeld, upper layer – excavation of feature 36. Example of a small shallow pit with layered stone wedges. **1** Bird's view of top planum (western half): limestone slabs protruding from the occupation layer, eastern half stone fragments and debris used stuffed under top limestone slabs; **2** Western half: top limestone slabs cleaned and eastern half: stuffing debris removed down to pure loess.

the moment of excavation. The entire hearth construction was probably covered by a number of additional limestone slabs uncovered on top of the upper quartz pebble layer; however, in contrast to the large oval limestone slab below, the uppermost limestone slabs are badly preserved and incomplete. At present, we interpret this construction as the central fireplace of the last occupation phase of the site. Further investigation will tackle the history of the fireplace including its architecture, raw materials, and functional components.

The outline resulting from the small pits (**Figs. 6-8**) described above is indicated by a circle of limestone slabs. Between theses pits and the central fireplace of feature 15, a circular corridor of 0.5 to 1 m width remained partially free of small pits. We interpret at least the majority of the small pits as postholes, in the sense of positioning traces of pole bases either intentionally dug or unintentionally imprinted into the occupation surface. The postholes form a polygonal structure that encloses the central fireplace (feature 15) in a roughly constant distance of 1 to 1.5 m and are absent in other parts of the site. To date, with analytic studies of the site just beginning, we cautiously assume that the cluster of postholes surrounding feature 15 is indicative of a former architectural construction at the site, most likely a tent-like dwelling. The dwelling would have had a polygonal to sub-circular outline with a maximum diameter of the substructure (indicated by the small pits) of about 3.5 m and a circular corridor of 0.5 to 1 m around a central fireplace. Up to 36 posts could have constituted the dwelling, or, alternatively, a dwelling of 18 posts was erected twice (three settlement phases: 12 postholes each; 4 settlement phases: 9 postholes each). If the dwelling would have been rebuilt several times, the diameter of its substructure would have been smaller than the maximum diameter estimated above and well below 3.5 m. However, the total area roofed by the dwelling might have been larger, depending on the way it was constructed (see discussion below).

In the future, these findings need to be contrasted with the results from refits (not yet available), as well as more in-depth analyses of the distribution of other find categories, for example the faunal material.

DISCUSSION

Leroi-Gourhan referred to his analysis at Pincevent as "ethnological presentation of habitation 1", highlighting the fact that from its inception, ethnographic reflections were part of the analysis of dwelling structures at Palaeolithic sites (e. g., Hahn and Rousselot, 1975). The ethnographic record, however, is quite varied with regard to tent architecture (Faegre, 1980). Interestingly, their archaeological reflections seem to follow a temporal trend. Earlier reconstructions of Magdalenian dwellings are dominated by rounded shapes (Leroi-Gourhan and Brézillon, 1966, 1972; Bosinski, 1979; Vermeersch et al., 1984; Audouze, 1987; Pigeot, 1987; Olive, 1988). During the 1990s, polygonal reconstructions emerged (Gaussen, 1992, 1994) and were discussed alongside rounded shapes (Schmider, 1992; Terberger, 1997) also in the early 2000s (Jöris and Terberger, 2001; Stapert, 2003; Pigeot, 2004). In recent years, polygonal shapes seem to have become the dominant way of reconstruction outlines (e. g., Gelhausen et al., 2004; Sensburg, 2007), partly "reshaping" some of earlier interpretations (e. g., Wenzel, 2009), although rounded shapes are still described (Bodu et al., 2006). Other studies identified the location of a tent without reconstructing its precise shape (Holzkämper, 2006). Instead of being grounded in opposing methodical and conceptual paradigms, these two views rather seem to reflect different degrees of abstraction (or attention to detail) and are thus not really in conflict with each other. If tents were build using posts and skin-cover, then a truly round shape is impossible to achieve. So, as a matter of fact, all tents are necessarily polygonal in shape, but may vary with regard to the number of exterior surfaces and thus approximation to a circle.

Given the apparent imponderables with regard to structural details, these differences seem, by and large, to be of minor importance, since the noise may outweigh the signal. However, they can become relevant for questions about the construction (e. g., Faegre, 1980) or calculations of the area covered by the tent, which, in turn, has consequences for reflections on group sizes. The shape and size of tent structures can also provide hints about their function. Not all tents are necessarily dwellings and alternative options for use have recently also been discussed for the circular structures of mammoth bones in Eastern Europe (Pryor et al., 2020).

General characteristics of conical tents

To approach the question which type of ethnographically documented dwelling would match our excavation results, we need criteria to evaluate the structural elements, including the posthole attributes and positions. As a base for discussion, we list a selection of possible criteria based on the descriptions of Torvald Faegre (1980) of hunter-gatherer tents (**Tab. 1**). The tent types selected for comparisons are those that share basic features with the dwelling structure of Bad Kösen-Lengefeld and are listed in Table 2: poles as construction elements for the tent walls which follow a sub-circular to polygonal outline. These constructions either involve long inclined poles leaning against each other (conical longitudinal section) or a scaffold of shorter poles with additional poles for the roof resting on top (vertical walls and inclined roof). To be sure, it cannot be expected that Magdalenian dwellings are in complete accordance with ethnographic examples. Instead of looking for 1:1 matches, it thus seems more instructive to search for general characteristics of tent-like dwellings from environments poor in trees. **Table 1** summarizes a list of constructional features of conical tents taken from the ethnographic literature (Faegre, 1980) and complemented by data from case studies of Magdalenian key sites, such as Gönnersdorf (Sensburg, 2007; Street et al., 2012), Nebra (Mania et al., 1999), and Oelknitz (Gaudzinski-Windheuser, 2013), and evaluates possible archaeological evidence for the listed constructional features.

Dwelling features dug into the sediment or fixed with larger objects located on the occupation surface are comparatively well-documented in the Palaeolithic record and were, for example, documented in larger numbers at the Magdalenian site of Nebra (Mania et al., 1999). From a methodical point of view, inferences to interpret the excavated features as postholes are based on historical, ethnographical, and/or modern analogies. The ethnographic record includes much more elusive constrcution elements that do not leave traces in or on the ground. Among these is a removable supplementary wooden construction with a small number of poles, which are erected to enhance the installation of the actual skeleton frame of the tent, but removed before the dwelling is used. Such lightweight constructions are not supposed to take heavy loads, because the main weight of the outer cover of the tent is installed only after their removal. Hence, they will not leave much trace on the surface of the inner part of the dwelling or are easily wiped out by later activities. The same applies for ring beams made from ropes, which guarantee the cohesion of the poles despite the centrifugal load caused by the weight of the tarpaulins. Regarding the load management in conical tent constructions on poles, it is useful to have a more detailed look at possible measures taken to fix the poles. In the next section, we first look for evidence of features from **Table 1** in the archaeological record of Bad Kösen-Lengefeld. This will allow a better understanding of some of the basic constructional elements deduced from the outline shape and the mounting of the tent frame at its base. In a second step, we will compare these features with those from tents documented in the ethnographical record in order to reduce the number of possible matches.



Fig. 8 Bad Kösen-Lengefeld, upper layer – excavation of feature 38. Example of a steep, deep pit with massive lateral stone wedges and a supporting horizontal slab at the base. **1** Bird's view showing both the surface of the upper archaeological horizon in the SW half, with no colouration visible in planum view, and the following excavation level in the NE half, with lithics, bones, and red colouring; **2** oblique view with unchanged surface and extended section yielding a massive limestone slab at the base; **3** SE-NW section displaying the bag-shaped outline with debris filling to the SE and a massive, horizontal slab in the center of the bottom.

Construction elements inferred at Bad Kösen-Lengefeld

The analysis of evident and latent features of Bad Kösen-Lengefeld is just beginning. Therefore, only preliminary hypotheses can be developed here, which are mainly based on the documentation of the field work, e. g., drawings of surfaces and sections as well as 3D-models of features. In the future, these hypotheses need to be tested with more sophisticated spatial analysis. For example, the spatial proximity of some of the features interpreted as postholes points to a repositioning and/or replacement of individual poles during the use of the structure, or to two or more reinstallations of the entire construction. Given the density of the stone paving, it is also possible that not all poles were installed in postholes but fixed between larger slabs. This is also possible for the inner part of the structure, where no posthole features have been observed. If the very general table of features typical for ethnographically known conical tents (Tab. 1) is used to identify basis structural components at Bad Kösen-Lengefeld, then these would be the following:

- The basic construction was that of a frame built from poles.
- The contour line described by the corresponding postholes is sub-circular to polygonal. The diameter of the contour line of ~ 3.5 m corresponds to a covered ground area of ~ 10 m².
- The investment in the excavation of the postholes and examples of stone wedges to better fix the poles indicate that the poles themselves carried the vertical load. This is supported by the small distances between the poles. As a consequence of fixing the poles in the postholes, additional ropes to connect poles were probably not necessary.
- The fact that the central part is void of postholes, and the lack of additional postholes near those of the contour line, implies a simple frame without additional constructional elements to carry the roof.
- If the poles fixed in the postholes were the only vertical constructional elements, then the tent must have been of conical shape.
- The restricted number of construction elements point to a mobile dwelling construction.
- The ring of limestones surrounding the postholes is indicative of a mounting of cover of the tent on the ground from the outside. The covering therefore most probably consisted of tarpaulins made from animal skin.

Possible analogies in the ethnographical record

Against this background it is possible to discuss the degree of similarity between features of the dwelling of Bad Kösen-Lengefeld and ethnographically documented examples selected for a similar ground shape (Tab. 2). The problem of far-reaching conclusions from ethnographical comparisons, which have to rely on the analogy of a small number of features selected by preservation, has already been mentioned above. It follows that any ethnographical analogy proposed for Bad Kösen-Lengefeld is nothing more than a working hypothesis supposed to guide further analysis.

Conical tent types usually involve a central structure in order to reduce the roof load of the marginal poles. However, in the case of Bad Kösen-Lengefeld, there seems to be no convincing evidence for a massive central structure. Any central construction – if it existed – must have been made from a small number of poles only. This corresponds well to the rather large fireplace in the center (feature 15). Nevertheless, the use of a temporary sub-construction that helped to erect the outer skeleton, but was removed after completion of the tent, cannot be excluded. Furthermore, conical structures always rely on inclined poles. This is also true for a scaffold of tripods carrying a roof construction, and has consequences for the shape of the postholes and their contents. At Bad Kösen-Lengefeld, the shape of the postholes is still subject to ongoing research

Part of the construction of mobile tent-like dwellings	Constructional purpose	Direction of load controlled by the constructional item	Constructional elements	Possible archaeological evidence
Removable supplementary construction	Installation of the main frame	No loads	Poles erected in the centre or near to the outer walls	Removed prior to use of the dwelling, no postholes (or intentionally refilled, therefore no sink for finds)
Central pole construction	Support for the roof in addition to the marginal pole structure		Small number of poles (potentially with larger diameter then those of the marginal structure)	Postholes in the central part; eccentric position of the fireplace
Connection near the floor between upright/inclined lateral elements of the marginal frame	Reduction of centrifugal forces at the base of the poles due to pressure from the roof/ the wall cover		Ropes connecting diametrically opposed poles; ring beam	Impossible unless preservation of organic materials (e. g., bog sites)
Securing poles in postholes			Excavation of a posthole; if the pole is vertically inclined, the posthole has to be sufficiently larger than the radius of the pole to enable inclination	Evident feature most reliably identifiable when refill is different from surrounding sediment (e. g., mixed with ochre, charcoal or humus) and/or if indicated by finds in the refill
Securing poles without posthole by wedging with stones			Spatially isolated larger (e. g., thicker) stones forming a triangle, circle or rectangle	Identification of isolated stones and/or slabs along the circumference of the assumed dwelling in the course of detailed spatial analysis
Unilateral support of the position of poles from outside of the structure			Spatially isolated larger (e. g., thicker) stones at the circumference of the assumed dwelling	
Prevention from subsidence into soft ground			Spatially isolated thin slab or spatially isolated group of several thin slabs	

Tab. 1 A tentative list of basic constructional elements of conical tents (compiled with data from Faegre, 1980; Mania et al., 1999; Gaudzinski-Windheuser, 2013; Jöris and Terberger, 2001; Street et al., 2012).

and we cannot present a conclusive answer as to the inclination of former poles. If the preliminarily reconstructed diameter of approximately 3.5 m and the presumed lack of a central construction is taken into consideration, then the best agreement would be a dwelling construction that shares numerous elements of the domes of the arctic Inuit. However, the construction of the Inuit dome largely depends on bending elastic wooden poles made from willow, which are interconnected in the center of the roof. To work against energy in an upward direction resulting from the bending of elastic organic material, it is necessary to put additional weight on the roof, which in case of the Inuit dome is snow. If the combination of the estimated

size and the presence of a central fireplace is considered, then the Northern European Kata would offer good parallels for most of the features of the dwelling at Bad Kösen-Lengefeld. This is even more so as the relatively small number of postholes in the marginal structure would be in good agreement with the hypothesis that the postholes in Bad Kösen-Lengefeld may result from two subsequent installations of the same tent (or at least the same tent type). To the contrary, the northern American Tipi as well as the Siberian Cone and Jaranga are different with regard to their marginal pole structures and/or their size. In sum, according to their dimensions and number of poles involved, at the present moment, the Inuit dome and the Kata would yield the first working models to be tested against the above indicated attributes.

Some thoughts about the availability of wood

Tents as discussed in this article rely on wooden construction elements. In a glacial environment, this immediately raises the question of the availability of wood and the potential presence of trees in the surrounding landscape (Uthmeier, 2017: 297). Pollen analyses indicate that during the Oldest Dryas (i.e., Greenland Stadial GS 2a, ~ 16.9-14.7 ka; Björck et al., 1998; Rasmussen et al., 2006), Central Europe was divided into three larger vegetation zones (Maier, 2015). Steppe elements prevailed in the north-western part, while tundra elements were dominant in the south-western part. In both regions, trees and larger shrubs seem to have been very sparse and even absent in some areas. East of the Hercynian Forest, however, the situation appears to have been different. In the pollen spectra from Aschersleben See (former Gaterslebener See, Müller, 1953), values of arboreal pollen are significantly higher than in pollen archives located further west. This region thus apparently marks the westernmost extent of a vegetation zone that spans over the Bohemian Forest up to the valleys of the San and Vistula rivers as well as the lowlands of Masuria in the east and is characterized by comparatively high values of arboreal pollen (cf. Kaplan et al., 2016: Fig. 1). These high values cannot be convincingly explained by wind dispersal alone, given that the dominant wind direction has been from west to east (Meyer and Kottmeier, 1989). Rather, it seems that changing precipitation patterns hampered tree-growth in the western and fostered it in the eastern part of Central Europe (Florineth and Schlüchter, 2000). Macroscopic remains are rare. A piece of pine charcoal from the site of Wilczyce in Poland was ^{14}C-dated to 15,220 ± 200 cal BP (12,770 ± 120 ^{14}C BP; Poz-14892; Fiedorczuk and Schild, 2002), and another from the site of Putim in Bohemia dated to 15,560 ± 130 cal BP (13,010 ± 60 ^{14}C BP; GrA-36010; Verpoorte and Šída, 2009), indicate the presence of pine during the occupation of Bad Kösen-Lengefeld within the catchment area of the Elbe River. Although direct evidence of the presence of trees in the surrounding of Bad Kösen-Lengefeld is lacking, the potential for scattered stands of pines and birches seems not unlikely.

Relation between the northern and the central area of Bad Kösen-Lengefeld

The relation between the features of the northern and central part of the excavation area is difficult to assess as long as detailed analyses concerning the spatial distribution of lithic artefacts and faunal remains, the death season of the prey species, and the refitting of artefacts are not completed. For now, the precise temporal relation between the features found in the upper layer, although spatially immediately adjacent, remains to be investigated. While the hypothesis that at least major parts of these features belong to the same occupation and in combination represent a system of site use with a tent and an outer activity area seems a plausible reading, the difference in prey species in each of the two parts call for caution.

	Fireplace	Central pole structure	Marginal pole structure	Diameter	Position of pole base	Positioning devices
Tipi (N.-America) * 153	excentric	3-4 posts, rope fixed to ground. Backwards skewness, windward	15 tent poles of pinewood	~ 4 m	inclined towards centre (i. e., centripetal)	floor stop to reduce centrifugal tension?
Inuit-Dome (Arctic) * 138	excentric	no central poles. Always snow covered to stabilize dwelling	30 bent willow poles connected to the centre	~ 3 × 2.7 m	straight	floor stop to reduce centrifugal tension?
Kata (N.-Europe) * 123	central	3 straight poles or 10 benched poles	20-30 poles, stone weights	~ 3-3.8 m	inclined, centripetal	floor stop to reduce centrifugal tension?
Cone (Siberia) * 117	central	3 frame poles and 2 cross sticks	30-50 poles	~ 4-5 m? (estimated from drawing)	inclined, centripetal	not necessary
Jaranga (Siberia) * 108	central	tripod stand of ~ 3-5 m long poles	7-8 tripods supporting conical roof (i. e., 21-24 pole imprints), stone weights	~ 5-10 m	inclined, multiple directions	not necessary
Attributes of the assumed dwelling at Bad Kösen-Lengefeld, upper layer						
Bad Kösen-Lengefeld	central	no traces of central postholes	36 postholes	~ 3.5 m	no information	no information

Tab. 2 A selection of possible criteria derived from the descriptions of Torvald Faegre (1980) of hunter-gatherer tent types (* no. refers to Faegre, 1980), compared with the situation at Bad Kösen-Lengefeld (green: good agreement, orange: poor agreement).

The faunal composition and potential recycling of stone slabs from the northern part support the assumption of at least two occupations. A potential re-use of the tent area in the southern part is also in line with this observation. However, it remains difficult to state which of the features documented in the northern area are contemporaneous to the dwelling of the central area and the fireplace inside it. At the moment, the only argument for the hypothesis that the northern and the central part constitute functionally different areas of the same occupation is the northward orientation of a gap in the otherwise more or less dense line of postholes in the southern part. If this would be identified as the entrance of the dwelling, e. g., by the direction and distances of refits, then Bad Kösen-Lengefeld would combine two different, yet much-debated models of Magdalenian site use in one and the same occupation:

- the construction of a complex, recurrently used fireplace covered by stone elements in the northern area as found, for example, in Monruz-Neuchâtel and Monruz-Champrevères (Bullinger et al., 2006), and
- a tent-like dwelling with a complex fireplace in the centre, as discussed for the concentrations of Gönnersdorf (Sensburg, 2007; Terberger, 1997; Street et al., 2012; Jöris and Terberger, 2001; Mania et al., 1999).

Admittedly, contemporaneity between the features of the northern and central part is the most parsimonious hypothesis at the moment. However, it is still possible that further analyses will show a temporal gap between (some of) the activities of the northern and central part. Unaware of these uncertainties, the claim of functional differences between open-air activities in the northern area and activities in a dwelling in the central area are based on the absence of evidence for dwelling features in the nothern aera, notwithstanding comparable preservation.

CONCLUSION

Over the course of the excavation of the northern area during the early campaigns between 2009 and 2012, attempts to interpret the site focused on concentrations of stone slabs. Given the almost total absence of other kinds of evident structures, such as pits and postholes, the excavation team worked on the assumption that settlement activities at Bad Kösen-Lengefeld took place mostly in the open and that dwellings were less important than frequently claimed by archaeologists. Consequently – and in line with observations at other Magdalenian sites with similar findings – it was assumed that dwellings might have been of ephemeral nature and of limited use (as a mere shelter for sleeping) with no visible traces to be preserved. Unconnected to artefact scatters and activity zones, it was expected that the shelters were placed in the empty spaces of the settlement areas.

First and foremost, potential activity zones were identified by the presence of features related to the use of fire, such as feature 2 (the geometric multi-layered paving) or feature 15 (the central hearth). Both the range of different components and the stacked stone slabs appeared as complex architectural constructs rather than just simple stone scatters, and – with all caution – can be interpreted as stoves rather than conventional "fireplaces" (Bullinger et al., 2006; Leesch and Bullinger, 2012; Moseler 2012). The differences already observed in this early stage of investigation between feature 2 and feature 15 need further analysis. Possible explanations range from differences in the duration of use (including intensive re-use, rebuilding and recycling in the case of feature 2) to differences in function.

While the interpretation of these features still stands, the hypothesis about the presence of elaborated dwellings changed when in 2014 the excavation team commenced to unearth a large number of small pits (now 33 belonging to the main occupation horizon) in what is now called the central part of the site. Provisionally interpreted as "postholes", these features turned out to clearly surround feature 15. The diameter of the resulting contour of ~3.5 m does not only fit the range found in ethnographically documented dwellings. At the same time, it leaves enough interspace between the fireplace of feature 15 in the center and the assumed walls along the contour line. Finally, a gap in the line of "postholes" would be in good agreement with the presence of an entrance.

We expect that future analysis of the "postholes" will enable the addition of further arguments for testing the above developed working hypothesis concerning the construction of the dwelling. The chosen excavation technique will facilitate complete 3D reconstructions of the outlines of the pits, based on the positions of the filling elements (artefacts, bones, rocks, etc.). According to the information yielded by ethnographic records and experiences derived from other Magdalenian excavations, we will apply the following criteria to future analysis of the "postholes":

- Planigraphic *outline*: symmetric or asymmetric (indicating an oblique or straight position of the pole)?
- *Size of outline*: similar or different (to identify the presence of initial larger poles and supplementary smaller poles)?

- *Direction of elongated outlines*: are they directed to the center or not?
- *Distribution of stone wedges* and their position within a posthole: do wedges allow a possible inclination of the pole to be identified?
- *Depths*: do postholes of different depths exist, and is it possible to identify a pattern?
- *Infill*: is it possible to identify a regular pattern concerning the infill processes, or are they different (and thus allow a temporal differentiation)?
- *Stratigraphic relation*: do postholes exhibit information about relative chonological relations, e. g., one or more postholes cutting into older postholes?
- *Refits*: do refits exist between objects from the infill of postholes?

Future analysis must compare all features uncovered at the Magdalenian site of Bad Kösen-Lengefeld in order to establish an intra-site chronology. It already seems highly probable that the northern area of the site was used in the course of two occupations within the upper archaeological horizon, with the later using parts of the existing paving of the first. The same applies to the central area, where immediately neighboring "postholes" are best explained by a repeated installation of a tent-like dwelling at a more or less identical place of the site in order to make use of the fireplace structure of feature 15. At present, there are no convincing arguments against a contemporaneity of parts of the evident and latent features observed in the northern and the central area. Therefore, Bad Kösen-Lengefeld combines two models of Magdalenian settlement features often seen as contradicting each other, i. e., open-air activities related to complex structures made from flat stones and related to the use of fire on the one hand, and the classical perception of activities inside a robust dwelling with an internal fire place on the other.

Acknowledgements

The authors would like to thank the Landesamt für Denkmalpflege und Archäologie Sachsen-Anhalt, and especially Prof. Dr. Harald Meller and his team, for more than a decade of organisational, scientific, and financial support. Corresponding financial support came from the Universität zu Köln and additional support – for two field seasons – from the Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU). For many years, Joel Orrin (excavation engeneer/Cologne) has now supervised our annual fieldwork and he also developed (with Florian Sauer/Cologne) the digital (3D-)documentation. Some of the general data presented here is based on a number of bachelor and master theses at the Universities of Cologne and Erlangen (S. Szyja, Th. Albert, A. Adaileh, H. Decker, A. Puskar, P. Meindl), with special thanks to Th. Albert, whose results concerned the northern excavation areas, particularly reported in this paper. Fieldwork would not have been possible without local support (U. Zeidler and many other helping hands from Bad Kösen/Naumburg and Bad Sulza) and without the many students, most of them from the two mentioned universities. Finally, the authors would like to thank Sabine Gaudzinski-Windheuser and Olaf Jöris for inviting us to contribute to the *Festschrift* for Elaine Turner and Martin Street, as well as for their corrections and helpful comments on a first draft of this article. We hope that Elaine and Martin will luckily proceed in adding meet to the naked bones and scattered lithics uncovered from the deserted camp sites of remote times.

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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.