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Schöningen: a reference site for the Middle Pleistocene

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ABSTRACT - Due to the exceptional preservation conditions, as well as the number and significance of the finds discovered, Schöningen in northern Germany stands out as a uniquely informative Middle Pleistocene site-complex. More than 20 archeological and 10 paleontological sites embedded in the shoreline sediments of a paleolake have preserved natural and anthropogenically modified wood, bones, and stones. A combination of data acquired from geological, stratigraphic, palynological, and faunal analysis, coupled with various direct dating methods, have indicated an age of ca. 300,000 years BP, corresponding to MIS 9. The lithic technology corresponds to the late Lower Paleolithic and is therefore consistent with these dates. This article gives an overview of the site-complex, of the most important discoveries at Schöningen, and describes the discovery of a nearly complete straight-tusked elephant skeleton (*Palaeoloxodon antiquus*) in an archeological context. Contextualized among contemporaneous archeological discoveries, the finds at Schöningen contribute significantly to our understanding of the late Lower Paleolithic in Europe.

Keywords: Late Lower Paleolithic; Middle Pleistocene; MIS 9; straight-tusked elephant; *Palaeoloxodon antiquus*; hunting.

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1. SCHÖNINGEN: AN OVERVIEW

The Middle Pleistocene site complex of Schöningen in northern Germany (Fig. 1) is exceptional for both the quality and quantity of its finds. Since 1994, ongoing fieldwork has documented more than 20 archeological and 10 paleontological sites attributed to the Reinsdorf interglacial and post-interglacial sequence dated to around 300,000 years ago and correlated with the Marine Isotope Stage (MIS) 9 (e.g., Tucci et al., 2021). Cycles of limnic and telmatic sediments (peat, organic mud, coarse detritus mud, calcareous mud, and clayey mud with varying proportions of sand, clay, or silt) situated on the shoreline of a paleolake have preserved natural and anthropogenically modified wood, bones, and stones.

The most important localities are Schöningen 13 I, 12 II and 13 II (Figs. 1 and 2).

The exceptional preservation on site is the consequence of rapid but mostly low-energy sedimentation, calcareous, organic rich, and fine grained paleolake-shore deposits sediments and of anaerobic conditions of the depositional environment (Krahn et al., 2021; Urban et al., 2023a).

Nearly 30 years of intensive paleoecological analyses, involving pollen, plant remains, and both macro- and microfauna, have allowed for the reconstruction of a diverse and evolving environment at Schöningen during MIS 9 (Serangeli et al., 2018; Urban et al., 2023a, 2023b). This dynamic ecological portrait has broadened our understanding of the environmental and climatic challenges faced by late Lower Paleolithic hominins living in northern Europe.

Fig. 1 - Satellite picture of the region around the limestone ridge of the Elm and the opencast mine with the site Schöningen 13 II. Image: Vijay Diaz and Utz Böhner.

Included among the archeological remains of Schöningen are some of the world's oldest, in some cases complete and best-preserved, wooden weapons: nine throwing spears, two or probably three throwing sticks, and one thrusting lance (Schoch et al., 2015; Bigga 2018; Milks et al., 2023). Numerous stone tools indicate different activities such as cutting and scraping. Use-wear traces on the lithic artifacts suggest woodworking and activities related to the skinning and butchering of animals (Rots et al., 2015; Venditti et al., 2022).

A large number of recovered bones display cut marks and impact scars for marrow extraction, showing intensive exploitation of the carcasses of large mammals. More than one hundred expedient and modified bone tools produced from the long bones of various large mammals (e.g., van Kolfschoten et al., 2015b; Lehnig et al., 2021) as well as the foot and hand bones of cave bear with cut marks (Verheijen et al., 2023) deserve a special mention. The presence of some large mammalians are remarkable discoveries too: some of the oldest fossil finds of aurochs and water buffalo in Europe (Serangeli et al., 2015, 2023; Serangeli, 2022), the remains of saber-toothed cats (Verheijen et al., 2022), and the isolated remains of ten individual elephants (Thieme, 2007; Serangeli, 2016). In addition, fossil footprints of large mammals and hominins were documented in the stratigraphic sequence (Altamura et al., 2023; Altamura and Serangeli, 2023, this volume).

Botanical, microfaunal, and other organic remains are equally important, with pinecones, seeds, leaves, eggshells, ostracods, chironomids, diatoms, and insect elytrons (Serangeli et al., 2015; Bigga, 2018; Krahn et al., 2021), each providing further paleoecological insights. Cycle 13 II-1 and the lowermost part of cycle 13 II-2 belong to the Reinsdorf Interglacial characterized by a warmth-loving flora with *Quercus*, *Corylus, Tilia, Acer tataricum, Fraxinus*, and *Taxus, Carpinus, Abies, Pinus*, and *Picea* during late temperate phases (Urban, 1995; Urban and Bigga, 2015). The upper layers in the cycles 13 II-2, II-3 and II-4 of the Reinsdorf sequence are representing two post-interglacial grass- and herb-rich steppe (open-woodland) phases and two intercalated moister woodland phases with *Pinus* and *Betula*, few *Alnus* and very few *Picea* and *Larix* prevailing in a grass-rich landscape (Urban et al., 2023a).

Furthermore, in the years 2017-2020, the nearly complete and very well-preserved skeleton of a straight-tusked elephant (*Palaeoloxodon antiquus*) was excavated in Schöningen 13-II (Serangeli et al., 2018).

Here we report for on the ongoing analysis of the find context of the elephant skeleton (Serangeli et al., 2020). The discovery of this almost complete elephant in Schöningen constitutes an important contribution to the discussion of the relationship between humans and elephants during this period. This study is not yet concluded, as the excavation of this area continues, and the restoration of the recovered bones is still in progress.

In sum, the Schöningen site-complex offers a unique window into the development of capacities and mechanisms involved in resource exploitation and settlement dynamics during the Middle Pleistocene in Europe.

1.1. LANDSCAPE AND GEOLOGY

The town of Schöningen (52°08' North, 10°57' East), in the district of Helmstedt, Lower Saxony, is in a transitional landscape with rolling hills between the Harz Mountains to the south, and the North German Plain to the north. The Elm, a 25 km long and up to 8 km wide limestone ridge, dominates this region. Its maximum altitude is 323 m above sea level. The surrounding lowlands have an average height of just ca. 100 m above sea level.

The town of Schöningen lies between 105 and 175 meters above sea level on the southeastern flank of the

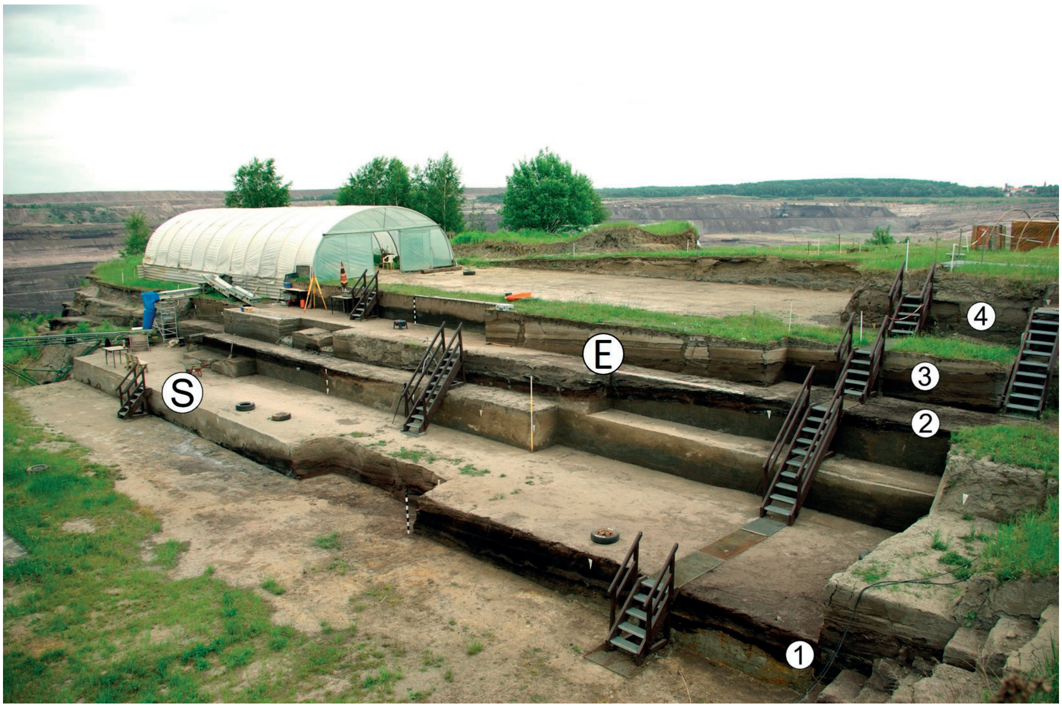

Fig. 2 - Locality Schöningen 13 II. The numbers 1 to 4 indicate the different silting events of limnic and telmatic sediments reflecting repeated changes in the level of a paleo-lake. The whole stratigraphic sequence in Schöningen 13 II has a thickness of up to 7.5 m. The nearly complete elephant skeleton has been recovered on the transition between cycles 2 and 3, indicated with the letter E. The isolated elephant rib and tusk have been recovered in the layer 2c, indicated with the letter S. The Spear Horizon, which has almost been completely excavated at this locality, was on the top of cycle 4. Photo: Jordi Serangeli.

Elm. The present-day climate of the Helmstedt region is continental with an average temperature of 9.5 °C. The average mean temperature of the coldest month, January, is around 1.1 °C while that of the warmest month, July, is on average 18.6 °C (DWD, 1996-2014, in Bigga, 2018).

Geologically significant in this area are the salt layers dating from the Late Permian (ca. 255 Ma) underlying the Buntsandstein (ca. 250 Ma) and the Muschelkalk (ca. 245 Ma). While the hard layers of the Muschelkalk at the Elm come to the surface through geological folding, the flanks of the Elm are marked by clay layers of the Keuper (ca. 235 Ma). Rainwater on the Elm seeps through the Muschelkalk and contributes to the erosion of the underlying strata. This has created hundreds of dolines on the Elm, none of which has yet been archeologically investigated. Due to the clay layers of the Keuper around the Elm, the water, now rich in lime, is forced to rise again, emerging at the layer change between Muschelkalk and Keuper in the form of overflow springs. The same sequence, Keuper, Muschelkalk, and Buntsandstein, is present in the open-cast mine (Fig. 3), but as a result of the aforementioned folding, is more developed and lies several hundred meters deep. The economically important geological layers in the open-cast mine are the Tertiary layers. Here, at the end of the Paleocene and the beginning of the Eocene (approximately 53 to 43 million years ago), thick layers of organic material were formed in the tropical climate of the Tertiary period. From 1979 until the 30th of September 2016, ten lignite seams have been the goal of the mining operations (Riegel et al., 2012; Wilde et al., 2021).

Furthermore, the region plays a key role in the study of the glacial and interglacial sequences of continental Europe (e.g., Litt et al., 2007; Laurer and Weiss, 2018). During the Quaternary the region was repeatedly covered by glaciers, including the Elsterian and the Saalian (early Saalian, Drenthian, MIS 8). The glacial advance occurred from the north and the ice carried stones from Scandinavia including Baltic flint (Hoffmann and Meyer, 1997). The glaciers of the late Saalian glaciation (Warthian, MIS 6) and the glaciers of the Weichselian glaciation (MIS 4 and 2) did not reach this region during their maximal extension. However, during the cold periods of the Weichselian, several meters of loess were deposited in Schöningen (Kunz et al., 2016). This calcareous material accounts for the richness of the soils and therefore the agricultural use of land in this region from the Neolithic until the present day.

The archeologically relevant layers are discordantly overlying the Elsterian till and meltwater sediments and are covered by Saalian till (Mania and Altermann, 2015). Therefore, the geology and stratigraphy already indicate an age within MIS 9 around 300,000 years ago. The biostratigraphy and the radiometric dating including thermoluminescence and U/Th underline and support these findings (Behre, 2012; Conard et al., 2015; Tucci et al., 2021; Urban et al., 2023a).

Fig. 3 - Bucket-wheel excavator Nr. 45 in the open-cast mine. Photo: Jordi Serangeli.

1.2. RESEARCH HISTORY

Since 1981 archeological excavations have taken place every year in an open-cast lignite mine just east of the town of Schöningen. From the start, the excavations and correlated research program were planned as a long-term, multidisciplinary, and international project. Furthermore, the scientific activities took place parallel with the active exploitation of the open-cast mine, which ceased in 2016. Since then, a new phase of reducing the overly steep slopes and renaturation of the entire mine is ongoing. The mine reached a depth of up to 130 m and covers an elongated, approximately rectangular area of about 1 km in width and is nearly 6 km in length.

Hartmut Thieme from the State Heritage Office of Lower Saxony in Hanover managed the project from 1983 until 2008. From 2008 onwards, the project received a new impulse under the direction of Nicholas Conard (project director) and Jordi Serangeli (excavation director), both from the University of Tübingen. At present, approximately 80 researchers from ca. 30 different institutions around the world are collaborating on this project.

Between 2011 and 2013 a museum as research and experience center named "paläon" (Fig. 4), which is only 300 m away from the main excavation site, was built in order to present the finds from the excavation and the results from the research to the general public.

Currently, the museum is operating as "Forschungsmuseum Schöningen" (Research Museum Schöningen) by the State Heritage Office of Lower Saxony. In 2021, this institute, together with the University of Tübingen, initiated the application for Schöningen to be a UNESCO World Heritage Site.

2. MAJOR DISCOVERIES

In this paper we give an overview of the most important discoveries unearthed in Schöningen and demonstrate how these finds have expanded our understanding of life in the late Lower Paleolithic. An extensive list of literature will supplement the necessary brevity of this summary with additional specific information.

2.1. THE WOODEN ARTIFACTS

The Schöningen site complex has become world-famous due to the numerous wooden artifacts (Tab. 1; Fig. 5) recovered from Schöningen 13 II, layers 4b, 4 bc, and 4c (Thieme, 1997). Collectively these archeological layers have yielded nine throwing spears, one thrusting lance, at least two throwing sticks, and one worked wooden stick showing burn marks at the point (Tab. 1).

Comparative analysis of these wooden artifacts has indicated the following:

1) Nearly all the artifacts were manufactured from the trunks of spruce trees (*Picea* sp.). Only spear IV was produced from pinewood (*Pinus sylvestris*). This might indicate a preference for conifers in general and spruce in particular as a source of raw organic material and may suggest some form of learned tradition. However, if one considers the small spectrum of wood species among all the wood found in the Spear Horizon and wood

Fig. 4 - Forschungsmuseum Schöningen (Research Museum Schöningen). Photo: Jordi Serangeli.

Tab. 1 - Schöningen 13 II-4: Information about the published wooden artifacts from the Spear Horizon (after Thieme, 1997, 2007; Schoch et al., 2015; Bigga, 2018; Böhner, 2018; Conard et al., 2020). The total length measured in different moments seems to have slightly changed over time, in particular before and after the restoration.

Object	Year of recovery	Preservation	Total length (cm)	Diameter max. (mm)	Wood species	Age of the tree at felling	Felling time	No. of fragments
Spear I	1995	Complete	221.0	47	Spruce (*Picea* sp.)	Min. 53	No indication	5
Spear II	1995	Almost complete	228.8	37	Spruce (*Picea* sp.)	Between 45-55	Early summer	4
Spear III	1995	Complete	184.1	29	Spruce (*Picea* sp.)	Min. 33	Summer	6
Spear IV	1996	Incomplete	118.5	31	Pine (*Pinus sylvestris*)	Min. 18	No indication	5
Spear V	1997	Complete	206.0	30	Spruce (*Picea* sp.)	Min. 49	Probably summer	4
Spear VI/ thrusting lance	1997	Almost complete	253.1	40	Spruce (*Picea* sp.)	Min. 57	Late summer	3
Spear VII	1997	Incomplete	202.8	30	Spruce (*Picea* sp.)	Min. 31	Summer	4
Spear VIII	1999	Incomplete	58.3	26	Spruce (*Picea* sp.)	Min. 21		2
Spear IX	1998	Incomplete	25.6	22	Spruce (*Picea* sp.)	No Indication	No indication	4
Spear X	1996	Incomplete	141.5	24	Spruce (*Picea* sp.)	Ca. 60	No indication	4
Throwing stick I	1994	Complete	78.0	30	Spruce (*Picea* sp.)		No indication	1
Throwing stick II	2016	Complete/ Damaged	64.5	29	Spruce (*Picea* sp.)		No indication	2
Worked burnt stick	1995	Complete	88.0	36	Spruce (*Picea* sp.)		No indication	2

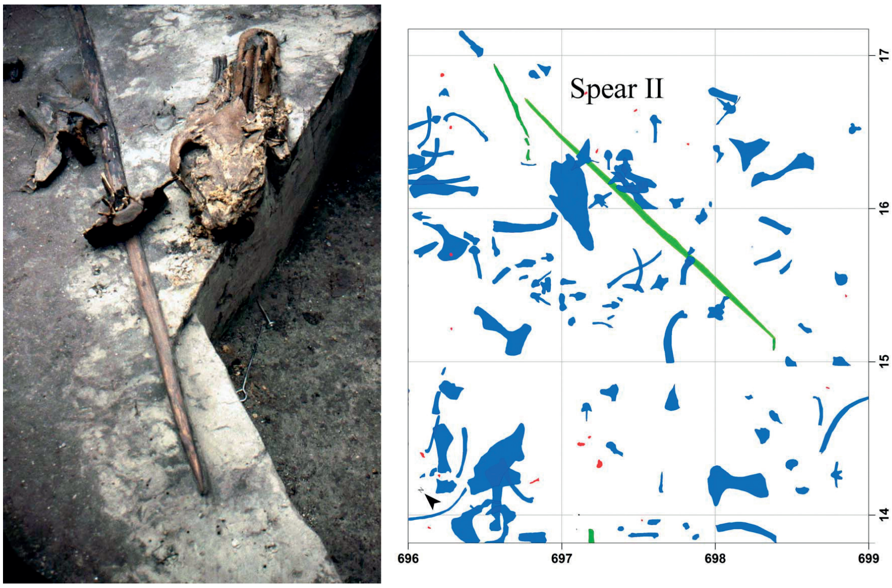

Fig. 5 - Schöningen 13 II-4. Spear II and horse bones. The photo was taken when the new finds were presented on November 1, 1995. Photo: Nicholas Conard. GIS-Map: Utz Böhner.

species reconstructed from botanical remains, a lack of alternative wood species for this use is also a possible explanation (Bigga, 2018; Urban and Bigga, 2015).

2) The parent trees of the various wooden artifacts, especially the spears, were most likely not felled in the same year and month (Schoch et al., 2015), indicating the recurrent presence of hominins in different seasons throughout the year. This is consistent with the stable isotope analysis performed on the third molars of 23 horses, which suggests that the horses from Schöningen 13 II-4 correspond to a cluster of multiple death events (Julien et al., 2015a).

3) The coniferous wood used for the artifacts was no more than 5 cm thick but had up to sixty narrow annual rings, often only 0.5-1 mm in width, indicating growth under suboptimal environmental conditions (Schoch et al., 2015). Extremely narrow annual rings consisting of only two cells are also present. There is strong evidence that slow wood growth is indicative of a colder climate. Traces of late spring frosts and the lack of hardwoods underline this (Thieme, 2007; Schoch et al., 2015; Krahn et al., 2021; Urban et al., 2023a). The wood of conifers with very narrow annual rings is correspondingly harder because the thick-walled latewood cells are present in a higher proportion than in fast-growing coniferous wood. The fact that the hominins used the best raw material available testifies to their empirical knowledge.

4) The shafts of the spears and lance included the innermost soft pith, the heartwood, and the outer growth rings of the tree trunks. Rather than fashioning the tip in the center, which would utilize the innermost soft layers, the tips are at a slight angle from the center line of the shafts in order to access the more durable heartwood and growth rings of the tree. This trick allowed for the tip to remain sharp for a longer period of time (Schoch et al., 2015). This once again indicates experience and standardization in production techniques coherent with learned tradition.

5) The largest diameter and thus the center of gravity of all except one of the Schöningen spears is located in the front third of the wooden shafts. The diameter of each of the shafts tapers off continuously towards the end, in some cases to a length of 60 cm. These features suggest that the artifacts were intended as javelins or throwing spears rather than thrusting spears (Thieme, 2007).

6) Spear VI differs from the rest of the Schöningen spears in having a center of gravity closer to the middle of the wooden shaft. In addition, the original stem has a natural bend that would be an obstacle to projectile flight. This natural kink is an old fracture, the stem continued to grow and completely covered the wound. With a length of 253.1 cm, spear VI is also the longest of the Schöningen spears. It is therefore interpreted as a thrusting lance rather than a throwing spear (Schoch et al., 2015).

7) The Schöningen spears (javelins and the one thrusting lance) are perfectly formed and balanced, as demonstrated through several experiments conducted with modern reproductions manufactured with stone tools by javelin thrower, coach and sports scientist Hermann Rieder and by the Paleolithic archeologist Annemieke Milks (e.g. Rieder, 2000, 2001, 2003, 2007; Milks et al., 2016, 2019; Milks, 2020). The length (184.1-228 cm), diameter (29-47 mm), and assumed weight (ca. 500-600 g; the weight can change significantly when the wood is very fresh or rather dry) of the spears are comparable with contemporary Olympic javelins for women. Spears heavier than 800 g can cause injuries to the elbow when thrown, at least to untrained people. Spears that are too light, too short (below 160 cm), or too long (over 320 cm) reduce the effectiveness of the throw

and counteract power and penetration (Rieder, 2003). In various performance tests utilizing the Schöningen spears, three key questions have been investigated:

a) How accurate are the throwing spears over various distances? Optimal performance was achieved within 15 m, though distances between 15 m and 25 m continued to produce respectable results. The impact speed by a replica of such a spear reached 23.7 m/sec. Beyond 25 m the accuracy of the throwing spears dropped rapidly, although a professional javelin thrower was able to hit targets up to a distance of 35 m with a reasonable degree of accuracy (Rieder, 2000, 2007).

b) What is the penetration depth of the throwing spears? Experiments using gelatin blocks resulted in penetration depths between 20 cm and 25 cm by an energy of 140.4 Joule at a range of 5 m (Rieder, 2000, 2007), while experiments utilizing animal carcasses indicated a penetration depth between 15 cm and 30 cm (Milks, 2018).

c) How far can one throw these spears? This last question is primarily of athletic interest, as long-distance throws with lower impact energy are unlikely to have been beneficial in a hunting context. Nonetheless, with a replica of the Schöningen spears a trained adult can reach a thrown distance between 60 and 70 m (Rieder, 2000). Ethnological comparisons are difficult, as spears produced in other regions using varied local materials can perform quite differently (Milks, 2018).

8) The two throwing sticks (Fig. 6) recovered in Schöningen (Conard et al., 2020; Milks et al., 2023; Thieme, 2007) are comparable in length (78 cm and 64.5 cm), diameter (3 cm and 29 mm), raw material (spruce wood), and manufacture. Their tips are formed slightly askew of the central pith, in precisely the same manner as those of the Schöningen spears. Unlike the spears, both ends of the two throwing sticks are clearly less pointed (Schoch et al., 2015; Conard et al., 2020; Milks et al., 2023), indicative of their intended use. While javelins are thrown over the shoulder with the point forward, transferring its acquired energy into one single penetration point, throwing sticks, in contrast, are thrown using a lateral rotation, like a non-returning boomerang. The throw is horizontal, parallel to the ground or to the surface of a lake, or even vertical when thrown into a flock of birds. Throwing sticks have a much larger impact area but possess much less impact force than throwing spears.

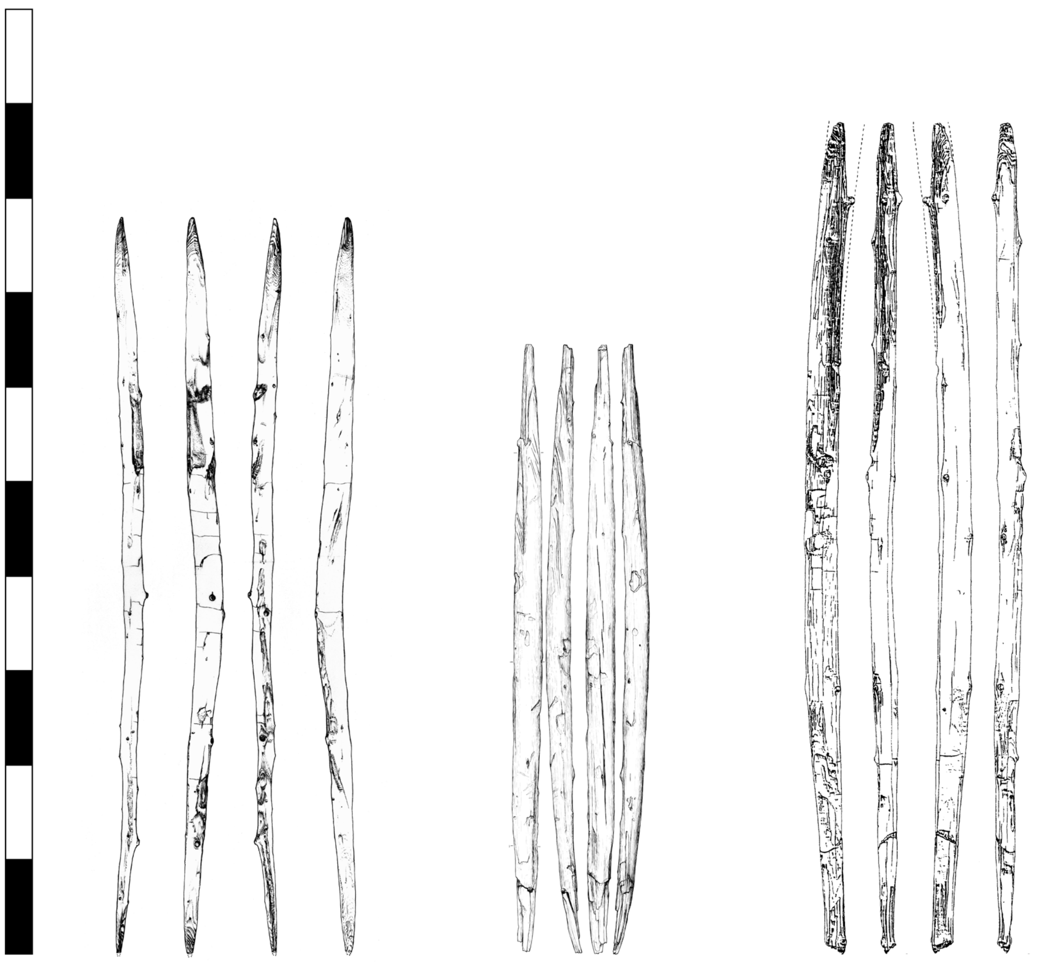

Fig. 6 - Throwing stick 1, excavated in 1994, length ca. 78 cm; throwing stick 2, excavated in 2016, length 64.5 cm; burnt worked stick, excavated in 1995, length ca. 88 cm. Drawing: Monika Schmidt Neubert, Ralf Ehmann, Arno Bojar.

This force is, however, sufficient to injure smaller animals or to bring down birds in flight.

9) The single worked stick with a burnt tip (Thieme, 2007) is ca. 88 cm long, has a diameter of 36 mm, and is made from spruce. It is manufactured in the same manner as the throwing sticks. Due to a small branch that was not completely cut off near the burnt end, as well as the object's proximity to a supposed "hearth" recorded during excavation, it has been interpreted as a "fire poker" or "roasting spit" which could have been used for food preparation (Thieme, 2007). The interpretation of possible hearths has been reassessed, with the reddish sediments in question now being attributed to post-depositional enrichment of iron-oxides rather than the result of burning (Stahlschmidt et al., 2015). If we compare Schöningen with other Paleolithic European sites, we see that fire was used during the Paleolithic as a tool for woodworking (e.g. Aranguren et al., 2018). The uncut branch situated in close proximity to the burnt end of the artifact may be evidence of a work in progress, perhaps suggestive of an unfinished third throwing stick. Additionally, an object intended for activities as e.g. for smoking or roasting meat on an open fire or maintaining a fireplace, would by no means have required the degree of intensive working observed on the stick in question, as already suggested by Thieme (2007). We therefore suggest that this object might be a third throwing stick.

10) If we consider the complete range of weapon technologies recovered from Schöningen 13 II-4, we can clearly see that specific tools were being produced for the various activities. This proves that the hominins of ca. 300,000 years ago were already skilled and competent hunters.

Some other wooden objects can only be briefly mentioned here, as they have not yet been studied or published in detail. They are the so-called ten or more "clamp shafts", and one digging stick (Thieme, 2007; Bigga, 2018).

2.2. THE STONE ARTIFACTS

The characteristics of the stone artifacts (Fig. 7) found in Schöningen indicate a late Lower Paleolithic technology. The composition of the lithic assemblages is determined by the availability of raw materials, the subsistence strategies, and the activities carried out at the lakeshore. The amount as well as density of stone artifacts vary in each site, as do some of their attributes. However, they share some general aspects that are illustrated schematically here:

1) Over 90% of the lithic raw material used by hominins in Schöningen is Senonian flint (which has a Scandinavian/Baltic origin) of very good, sometimes excellent, quality.

2) Hominins selected mainly cobbles to be used as blanks (most of the time fragmented preserving natural surfaces since the presence of cortex is quite low), but also frost spalls.

3) "Classic" cores are almost absent. Core-like pieces are often indeterminate exploited artifacts with a low number of detachments, tested pieces, or blanks with preparation surfaces.

4) The scar patterns on the debitage and on the scarce cores (core-like pieces) show that the Levallois technology is lacking.

5) Handaxes as well as bifacial objects are missing in the lithic assemblages in Schöningen.

6) The reduction sequences to produce flakes are short.

7) Flakes differ in shape and size.

8) Even though most of the recovered flakes show marked bulbs, the presence of very thin flakes with diffuse bulbs and lips on the ventral surface indicates the use of soft hammer percussion as well.

9) The retouched artifacts, which are few (<10%) in comparison with the rest of the lithic assemblage, were mainly produced on flakes. However, hominins also selected natural fragments and frost spalls as blanks for creating tools.

10) The retouch of some of the tools and worked edges call to mind tools from the Middle Paleolithic.

11) The production of scrapers and indeterminate retouched pieces dominates the tool spectrum of the Schöningen lithic assemblage, which is completed by the production of notches, denticulates, points, and double tools (two types of retouched edges).

12) Hybrid pieces (artifacts fulfilling two functions on the same blanks) also appear in lithic record along the sequence. They combine the presence of a few detachments and some sort of retouch, a duality between exploitation and configuration.

13) A large amount of the tools was introduced to the site in an almost finished form. Others, the smallest tools, were produced locally. In addition, some flakes or natural fragments with sharp edges were directly used without retouching the margins.

14) Use-wear and residue analysis on the stone artifacts recovered in Schöningen demonstrated that they were used for working wood, hides, and for cutting meat (Rots et al., 2015; Venditti et al., 2022).

2.3. THE BONE ARTIFACTS

There is a wide variety of bone artifacts in Schöningen from which the majority can be divided into knapping tools and bones with smoothened tips.

Present in the category of knapping tools are retouchers, hammers, and anvils. A detailed analysis of remains within this category has already been carried out for the site Schöningen 13 II-4, the Spear Horizon (van Kolfschoten et al., 2015b). Several of these finds have also been recovered in other layers, e.g. within the context of the nearly complete elephant skeleton in Schöningen 13 II-3 or in Schöningen 12 II-4 (Julien et al., 2015b). The bones used as knapping tools are mostly from horses (*Equus mosbachensis*), often from bovids (in Schöningen the bovids are mostly *Bos primigenius* or *Bison priscus*), sometimes from red deer (*Cervus elaphus*), and in one case from a saber-toothed cat (*Homotherium latidens*)

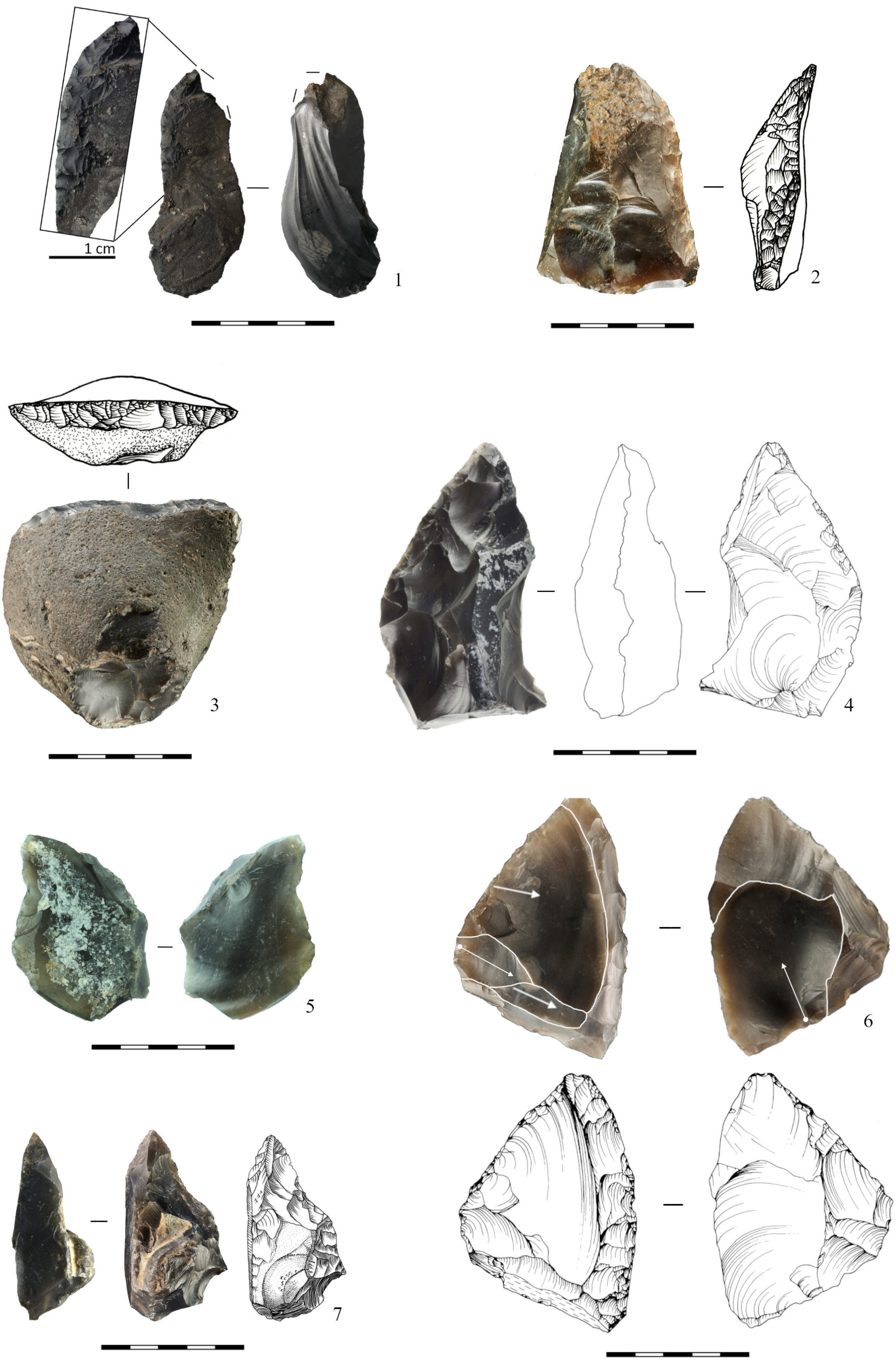

Fig. 7 - 1) Retouched artifact on frost spall (ID 17047); 2-3) Scrapers on flakes (ID 15798, ID 12703); 4) Scraper on a natural fragment partially broken by frost (ID 17961); 5) Notch on a flake (ID 29957); 6) Hybrid artifact on a piece of debris (ID 25975); 7) Double tool: point and scraper (ID 26983). Photos: Volker Minkus (2, 3, 6, 7); Bárbara Rodríguez-Álvarez (1, 4, 5, 7). Drawings: Sabine Boos (4, 6); Roxane Rocca (7), Heike Würschem (2, 3). Scale bar = 5 cm.

(van Kolfschoten et al., 2015b). The anatomical parts that are mostly used as knapping tools are the thicker sections of long bones (humerus, femur, tibia, radius-ulna, and metapodials). Other skeletal parts, such as ribs, have also been utilized, but only on rare occasions. Numerous bones have also been prepared before their use by scraping off the periosteum. The activity of knapping in Schöningen was mostly a very intensive, repeated activity, which will not only leave numerous deep scars behind, but sometimes also embedded flint splinters in the bone surface. Often only fragments of bones were used for these purposes, but in some instances, complete bones are also encountered.

In one case a nearly complete innominate bone from a horse has also been used, not as a retoucher or hammer, but as an anvil (van Kolfschoten et al., 2015b). However, other knapping tools described in the category of percussor probably functioned as anvils as well.

Several metapodia, mostly of horses, were used as hammers. This is evidenced by the distal ends, which show clear battering and flaking (e.g. Voormolen, 2008; van Kolfschoten et al., 2015b). Experimental analysis has shown that these bones can be used to fracture other marrow-bearing horse bones (Hutson et al., 2018; Bonhof and van Kolfschoten, 2021). In general, metapodials were often used for several tasks, as retouchers, anvils and hammers (van Kolfschoten et al., 2015b).

The choice of specific bones showing similar characteristics for similar activities, the removal of the periosteum, and the presence of numerous impact scars in precise areas of the bones, indicate a standardized chaîne opératoire which implies a clear conception of working steps.

Bones with signs of polishing indicate another potential category of bone tools. Although there is no evidence of any deliberate shaping to produce these rounded edges, this rounding could be the result of intensive and repeated use, potential qualifying them as expedient bone tools. On the other hand, natural processes such as sand abrasion through wind or underwater erosion can cause similarly polished edges. The potential bone tools were recovered from layers with a sandy component which was deposited underwater. These are "c-layers", e.g., Schö 12 II-4c and Schö 13 II-2c, 13 II-2b/c. Abrasion caused by sand and water has been documented and published several times in Schöningen (e.g., Tucci et al., 2021). Such potential tools with polished tips are mostly from long bone fragments. Some of the earlier described knapping tools also possess polished edges. Scraping marks show that the periosteum has been removed and impact scars show that they were used (Julien et al., 2015b; Lehmann and Serangeli, 2018). These "c-layers" also contain other, unequivocal bone and stone artifacts. One polished area on one tip of a smoothed tusk fragment suggests contact with sediment, either through use as a digging tool, or through erosion in water (Fig. 8; Julien et al., 2015b). The so-called wooden "digging stick", with polishing evidence (Bigga, 2018; Schoch, 2012) comes from a "b/c-layer", this is an intermediate layer with a sand component too (13 II-3b/c). At least one bone with a strong rounded end is certainly a bone tool, with both the periosteum removed and the impact scars documenting its use (Lehmann and Serangeli, 2018). Further research is required to verify if these rounded tips are actual bone tools or products of natural abrasion.

2.4. BONES WITH CUT MARKS AND IMPACT SCARS

A very large number of bones in Schöningen, circa 2,000 from the more than 20,000 bones recovered, show impact scars, or cut marks. Long bones have often been broken to obtain the marrow which shows an intensive exploitation of the carcasses of large mammals (Voormolen, 2008; van Kolfschoten et al., 2015b).

Numerous cut marks on the ribs of horses show that the horses were skinned. The presence of cut marks on the metatarsal and phalanx of a cave bear suggests that hominins started using bear skins to protect themselves from cold weather at least 300,000 years ago (Verheijen et al., 2023).

2.5. THE NATURAL ENVIRONMENT

The analysis of faunal remains (small and large mammals, birds, eggshells, fish, reptiles, amphibians, mollusks, ostracods, and chironomids; Voormolen, 2008; Böhme, 2015; van Kolfschoten et al., 2015a; Turner et al., 2017; Serangeli et al., 2018; Krahn et al., 2021; Urban et al., 2023a, 2023b), plant remains (pollen, wood, leaves, and seeds; Urban and Bigga, 2015), and aquatic microfossils (Krahn et al., 2021) from the shores of the paleolake of Schöningen provide a very clear overview of the mosaic landscape in the region and its changes over the centuries and millennia. In the lower and warmer part of the sequence, in the interglacial optimum (Schöningen 13 II-1a-13 II-2c5), the landscape appears to be more forested. Later, towards the top end of this sequence, towards the beginning of glacial conditions, the landscape opened up and the paleolake dried out (Urban et al., 2023 a,b).

The excavations of the Middle Pleistocene site complex of Schöningen have yielded over 20,000 skeletal remains (e.g. Voormolen, 2008; van Kolfschoten, 2014; van Kolfschoten et al., 2015a; Starkovich and Conard, 2015; Turner et al., 2017; Serangeli et al., 2018; Hutson et al., 2018, 2021). Large mammals are (to a limited extent) indicative of the regional environment. For example, the presence of water buffalo (*Bubalus* cf. *murrensis*) at the site Schöningen 12 II-1 indicates warm conditions without any excessive cold winter temperatures during the interglacial optimum. The large herbivore fauna from Schöningen includes two other species of bovids (*Bison priscus* and *Bos primigenius*), two species of horses (*Equus mosbachensis* and *Equus hydruntinus*), two species of rhinoceros (*Stephanorhinus kirchbergensis* and *Stephanorhinus hemitoechus*), wild boar (*Sus scrofa*), three species of deer (*Cervus elaphus*, *Megaloceros giganteus* and *Capreolus capreolus*), the straight-tusked

Fig. 8 - Tusk fragment of a straight-tusked elephant with flat removals and smoothed tip from Schöningen 12 II-4c, Plateau 5 (ID 17530). Photos: Volker Minkus.

elephant (*Palaeoloxodon antiquus*), and two species of beaver (*Castor fiber* and *Trogontherium cuvieri*). The large carnivore fauna from Schöningen includes two large felids (*Panthera leo* ssp. and *Homotherium latidens*), the wolf (*Canis lupus*), the fox (*Vulpes vulpes*), two species of bears (*Ursus* ex gr. *deningeri/spelaeus* and *Ursus thibetanus*) as well as the Eurasian badger (*Meles meles*).

It is important to underline the absence of faunal species indicating glacial conditions within an extensive cold steppe landscape within the Reinsdorf sequence (van Kolfschoten, 2014).

3. THE ELEPHANTS OF SCHÖNINGEN

In the last 30 years, teeth, tusks, and large bones of several elephants (*Palaeoloxodon antiquus* and probably also *Mammuthus primigenius*) have been recovered in the context of mining activities. Unfortunately, most of the remains were collected during mining operations and do not have any specific information on their stratigraphic position. Some ended up in private collections, others in the collection of the mining company or in the collections of the local museums.

Completely different is the case of the remains of at least ten straight-tusked elephants (*Palaeoloxodon antiquus*) that have been recovered by the archaeologists while investigating the deposits from MIS 9 (Thieme, 2007). Although these are mostly isolated finds, which were often saved from the bucket-wheel excavator (Fig. 3) during rescue excavations under time pressure, the stratigraphy and position have been well-documented.

The presence of elephants was also confirmed by the footprints documented in the campaigns of 1994, 2011, and 2018 (Altamura et al., 2023; Altamura and Serangeli, 2023, this volume).

In the summer of 2015, a rib with numerous scratch marks and a 1.6 m long tusk of a straight-tusked elephant was discovered at the Schöningen 13 II-2 site (Fig. 9).

While the scratch marks first appeared to be possibly anthropogenic (Serangeli, 2016; Lehmann and Serangeli, 2017), they turned out to be caused by natural abrasion in the sediment (Tucci et al., 2021). However, the presence of hominins in this layer is indicated by a bone tool and some stone artifacts (Tucci et al., 2021).

The fact that rib and tusk are isolated, the high proportion of sand in the sediment, as well as the clear turbulences in the sediment are indicative of a deposition during a strong water flow. Therefore, it is probable that the water has dispersed the findings.

The excavation of these layers is still ongoing; therefore, it is possible that more remains of this individual will be recovered.

From September 2017 until 2020, an almost complete skeleton of a straight-tusked elephant was excavated within an area of about 64 m². It was found about 1.5 m higher up in the sequence compared to the 2015 tusk and rib, at the transition between Schöningen 13 II-2 and Schöningen 13 II-3 (Fig. 2). In order to distinguish it from the other single individuals, of which only a few remains exist, this animal was given the name of Nelly, after the member of excavation-team who first discovered it, Neil Haycock.

Nelly died on what was then the western lakeshore. The depositional environment of the elephant skeleton (13 II-2 / II-3) is characterized by decreasing lake level at the transition from the first dry, cool post-interglacial steppe phase into the first post-interglacial woodland phase (Urban et al., 2023a). The skeleton is oriented more or less parallel to the lakeshore with the head in a northerly direction and the rump in a southerly direction (Fig. 10). The mandible, tusks, vertebral column, and one leg were largely in an anatomically correct arrangement. The left front leg is still missing along with the scapula, almost all the foot bones of two other legs, parts of the pelvis, and several caudal vertebrae. Some fragments of the pelvic bone were discovered about 10 m away, higher up on the lakeshore. Hominins or carnivores could be responsible for the displacement of some of the bones, but other elephants could also have moved some of the bones, as modern-day elephants show the behavior of repeatedly visiting their deceased conspecifics and moving bones or even carrying them over a certain distance (Haynes 2012).

Most of the bones and the tusks are in very good condition (Fig. 11), showing only minor weathering damage. On the other hand, the less stable skull, interspersed with cavities and over 1 m tall, was exposed to a greater extent, which caused its severe weathering and fragmentation into thousands of small pieces. Slight wave action on the lakeshore in conjunction with seasonal lake level fluctuations may have subsequently displaced the fragments along with eroded sediments a few meters towards the deeper lake basin, fanning out in several strata of sediment in an easterly direction.

Carnivore bite marks are found on the vertebral processes, on several ribs, on a scapula, and on a single foot bone. For the most part, however, the bones show no bite marks. These observations and the bones embedded in organic mud layers indicate that the animal was in

Fig. 9 - Elephant tusk (in the middle) and rib (at the bottom right) from the layer Schöningen 13 II–2c3 in-situ. Photo: Wolfgang Mertens.

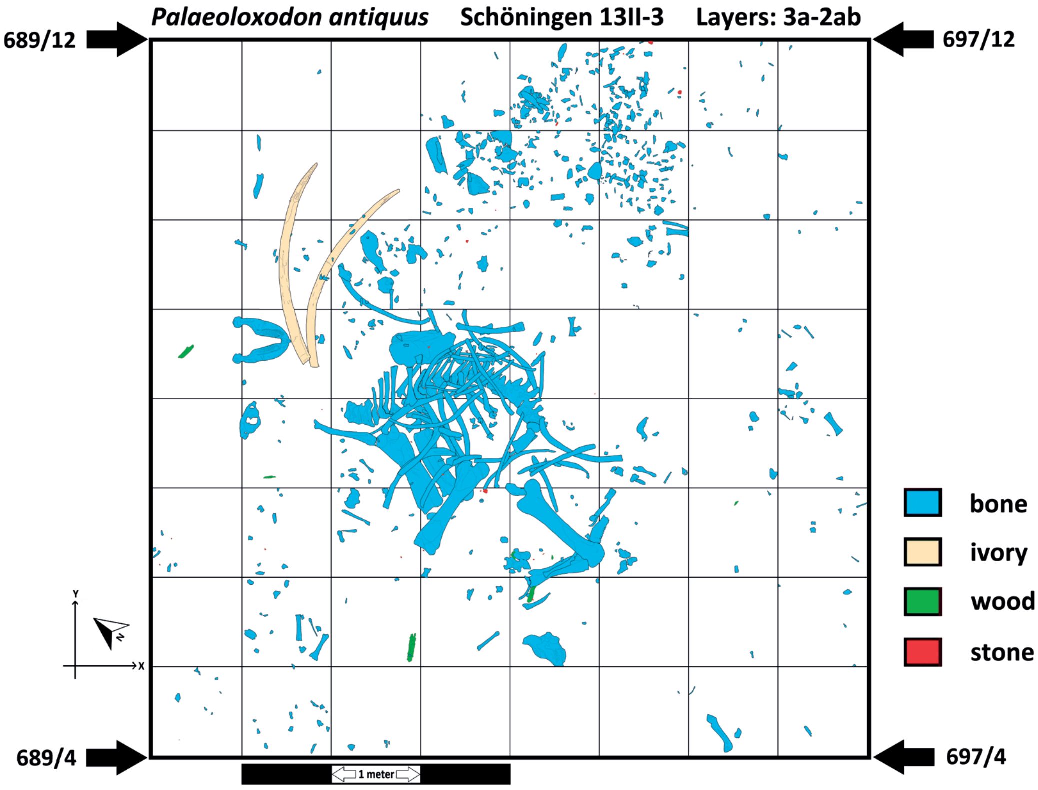

Fig. 10 - GIS-map of the area with the skeleton of the straight-tusked elephant. Image: Dennis Mennella.

Fig. 11 - The front part of the straight-tusked elephant embedded in the lakeshore. Photo: Jens Lehmann.

the water and freely accessible to predators and humans above the water level for a certain period of time. It is still unclear which large predator could have caused the bite marks. In Schöningen, remains of bears, lions, and the saber-toothed cat were found, and in the find layer itself, only a few meters next to the elephant skeleton, remains of a wolf.

After the first analysis, the skeleton belonged to an adult female individual with an approximate age of 50 years, indicated by tooth wear of the last lower molars and the 2.3 m long tusks. This animal had a shoulder height of about 3.2 m and weighed about 6.8 t.

Human activity is also indicated at the elephant carcass by small flint flakes, mostly between 5 and 15 mm, found during excavation. All the sediments in which the elephant bones were embedded (layers 2b to 3bc) were washed with a sieve of 2 mm mesh size. In total, about 57 small flint chips or microflakes were recovered from an area of 64 m^2 around the elephant, which were created by humans during tool work and the resharpening processes of stone implements. The refitting of two small flakes (Fig. 12) confirms that flint knapping for resharpening took place at the same spot where the elephant skeleton was found (Venditti et al., 2022).

In addition to the stone artifacts, three bone tools were also identified. A complete left metatarsal of a red deer, almost 30 cm in length, has four flat areas with typical retouching marks. It was discovered on the southwest side of the elephant. The second bone tool is a long bone fragment of about 12.5 cm in length. A third bone

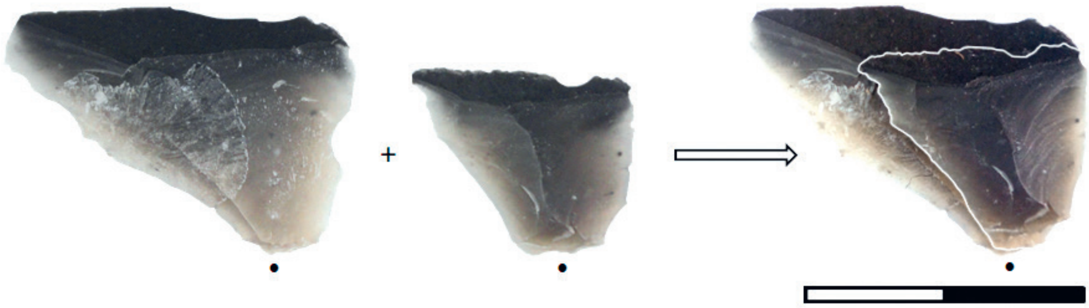

Fig. 12 - Two refitting small flakes (ID 29716 and ID 29817) originating from resharpening a flint tool in the area around the elephant carcass. The scale is 2 cm. Photo: Bárbara Rodríguez-Álvarez.

tool is 17.9 cm long. The second and third bone tools lack morphological characteristics to identify them to species. Both show flat surfaces with impact marks from retouching, in which under a microscope embedded flint splinters are visible.

The elephant bones do not show any cut marks or traces of human impact so far. However, this observation does not argue against the presence of humans, considering that an adult elephant consists of several tons of meat. Therefore, there was no need for humans to cut or scrape the last remnants of flesh from the bones leaving cut marks on the skeleton.

4. ELEPHANT HUNTING VERSUS SCAVENGING

Several films and publications show the elephant hunting group of the Bayaka, Mbuti, Baka, Efe, and Aka in the Congo Basin (Central African Republic, Republic of the Congo and Cameroon) during the traditional hunting of elephants (e.g. Lewis, 2015, 2021; Ichikawa 2021; Yasuoka, 2021). Martin Porr (2004) pointed out that these films date from the colonial period or are even younger. These hunts should rather be understood as a consequence of the great demand for ivory in Europe and can thus not be used uncritically as an ethnographic parallel to elephant hunting in the Paleolithic. Moreover, Porr (2004) questioned an elephant hunt among the Pygmies before their contact with the Europeans.

Findings from famous archeological sites such as Gesher Benot Ya'aqov (Israel), Áridos 1 and 2 (Spain), Notarchirico (Italy), Ebbsfleet (England), Bilzingsleben (Thuringia, Germany), Gröbern (Saxony-Anhalt, Germany), and Lehringen (Lower Saxony, Germany), where the remains of a single or a few elephants surrounded by stone artifacts were discovered, seem to confirm that regular elephant hunting took place in the Middle Pleistocene, although many questions are left unanswered (for an overview of the discussion about the interaction between hominins and proboscideans and single-carcass butchering sites during the Pleistocene: e.g. Isaac and Crader, 1981; Cavarretta et al., 2001; Meller, 2010; Agam and Barkai, 2018; Gioia, 2020; Konidaris et al., 2021; Gaudzinski-Windheuser et al., 2023). But are stone artifacts in the vicinity of elephant bones sufficient to prove elephant hunting in general? In the case of the Lehringen site, an approximately 2.5 m long and 3 cm thick thrusting lance made of yew wood was discovered, supposedly lying between two elephant ribs. Unfortunately, the documentation for this find from 1948 is lacking: neither a photograph was taken nor a drawing was made (Thieme and Veil, 1985). Therefore, this finding unfortunately does not serve as a clear argument for an early elephant hunt and must be viewed critically. In the Eemian site of Neumark-Nord 1, the age at the time of death and the predominance of males of at least 57 elephant individuals argues for a systematic and repeated hunt for these pachyderms during the Middle Paleolithic (Gaudzinski-Windheuser et al., 2023).

Thorsten Uthmeier argues from a different angle. He concludes that, given the assumed size of the clans of that time of five to ten people and a shelf life of 30 days for meat, only animals weighing up to one ton could be considered common hunting game for the people of that time: i.e., large bovids, deer, horses, or young rhinos. Since elephants provide up to ten times more meat than the group could consume during this period, he believes that regular elephant hunting in the Lower and Middle Paleolithic is not likely (Uthmeier, 2006).

Regardless of whether one is inclined to consider elephant hunting a typical Lower Paleolithic activity or not, elephants certainly played an important role at several European sites from the Lower Paleolithic. An elephant carcass was interesting for the Stone Age hunters due to different resources: meat, tendons, fat, marrow, and bones. However, although some bones show clear-cut marks, it cannot be concluded whether these animals were hunted or whether dead animals were butchered (Baales, 2006).

5. PRELIMINARY INTERPRETATION OF THE CONTEXT OF THE ELEPHANT CARCASS FROM SCHÖNINGEN

Although archeological investigations in the immediate vicinity of the elephant site and the study of the skeleton are still ongoing, we can already give a preliminary interpretation of the context. It is not unusual for a 50-year-old elephant to die of a natural cause. Elephants living today show a habit of staying near calm waters when they are ill and in old age. Modern elephants need 70 to 150 liters of drinking water a day, and in water, their heavy bodies benefit from a noticeable alleviation. Therefore, due to their natural behavior, elephants often die on the shores of the lake (Haynes, 2012). So far, there is no indication of the cause of the animal's death in the material found at the site. However, the presence of humans can be concluded from the artifacts found close to the carcass. The many small microflakes, and the three bone tools indicate that a sharp-edged implement, probably a scraper, was resharpened several times on-site (Venditti et al., 2022). Given the excellent surface preservation of most of the bones, the process between the time of death of the straight-tusked elephant, the complete decomposition, and embedding in the sediment cannot have lasted very long. This is because many of the bones are still in an almost correct anatomical arrangement, while others are dispersed over the surrounding area. Except for the skull and pelvis, they are all in a very good state of preservation. In conclusion, hunters living at the lakeshore of Schöningen about 300,000 years ago were equipped with different weapons such as throwing spears, thrusting lances, and throwing sticks. But they also had digging equipment with them and depending on the season they probably used different food resources such as roots, seeds, berries, fruits, nuts, fish, eggs, etc., which ensured a varied diet for the small groups of people (e.g., Bigga, 2018). Based on the current data from Schöningen about the natural resources and the technical capabilities of the hominins, we can therefore rather assume that for this late *Homo heidelbergensis*, it was not necessary to put themselves in danger to hunt adult elephants.

The artist's impression by Benoît Clarys (Fig. 13) of a scene with hominins shortly after the death of a straight-tusked elephant (*Palaeoloxodon antiquus*) shows what the situation could have looked like in Schöningen. From the picture, it is unclear whether the animal died naturally or if it was killed by hominins. The elephant is reconstructed with a coat, based on the fact that it was able to survive this far north at the end of an interglacial period.

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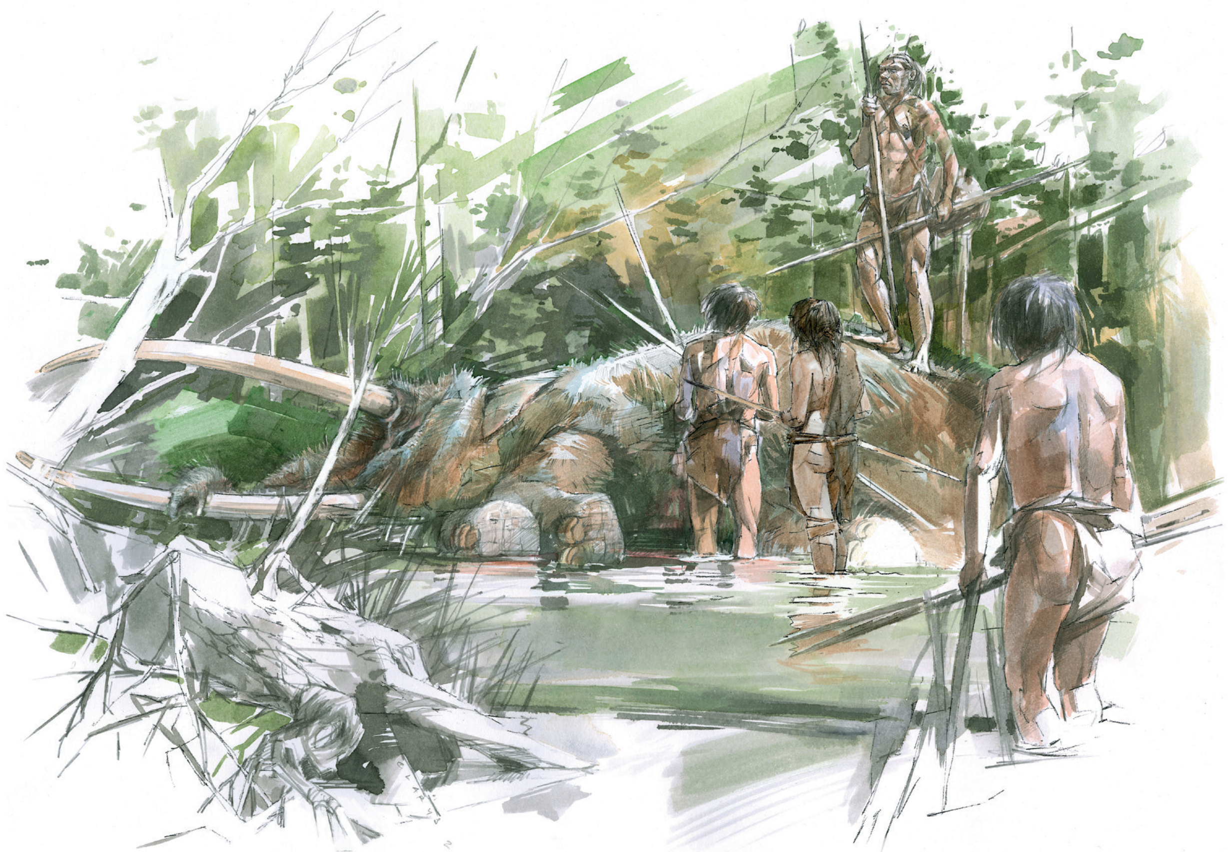

Fig. 13 - This is how it might have looked when hominins discovered the dying old elephant or already the elephant's carcass. Drawing: Benoît Clarys.

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