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Excavations at Schöningen and paradigm shifts in human evolution

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ABSTRACT

The exceptional preservation at Schöningen together with a mixture of perseverance, hard work, and sheer luck led to the recovery of unique finds in an exceptional context. The 1995 discovery of numerous wooden artifacts, most notably at least 10 carefully made spears together with the skeletons of at least 20 to 25 butchered horses, brought the debate about hunting versus scavenging among late archaic hominins and analogous arguments about the purportedly primitive behavior of *Homo heidelbergensis* and Neanderthals to an end. Work under H. Thieme's lead from 1992 to 2008 and results from the current team since 2008 demonstrate that late *H. heidelbergensis* or early Neanderthals used sophisticated artifacts made from floral and faunal materials, in addition to lithic artifacts more typically recovered at Lower Paleolithic sites. The finds from the famous Horse Butchery Site and two dozen other archaeological horizons from the edges of the open-cast mine at Schöningen provide many new insights into the technology and behavioral patterns of hominins about 300 ka BP during MIS 9 on the Northern European Plain. An analysis of the finds from Schöningen and their contexts shows that the inhabitants of the site were skilled hunters at the top of the food chain and exhibited a high level of planning depth. These hominins had command of effective means of communication about the here and now, and the past and the future, that allowed them to repeatedly execute well-coordinated and successful group activities that likely culminated in a division of labor and social and economic patterns radically different from those of all non-human primates. The unique preservation and high quality excavations have led to a major paradigm shift or "Schöningen Effect" that changed our views of human evolution during the late Lower Paleolithic. In this respect, we can view the behaviors documented at Schöningen as a plausible baseline for the behavioral sophistication of archaic hominins of the late Middle Pleistocene and subsequent periods.

1. Introduction

In general one should avoid superlatives in science, but in the case of the excavations and remarkable discoveries at Schöningen, a degree of effervescence seems justified. Few, if any, Paleolithic sites in Eurasia have so radically changed our views of the past. For instance, Sima de los Huesos (Spain) certainly produced vastly more hominin remains (Arsuaga et al., 2014), and for that matter more handaxes. Boxgrove (UK) contributed greatly to our understanding of Acheulean technology and to the debate on the early settlement of Europe (Roberts and Parfitt, 1999). One could also mention a few other sites that for various reasons have a place in the Paleolithic pantheon, but few colleagues would question that the discoveries in Schöningen caused a radical shift in our views of Middle Pleistocene hominins. This special volume of JHE presents many results from the quarter century of excavations at Schöningen and reviews the state of knowledge about the site. In the process, it both corrects a number of scientific myths about Schöningen and

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underlines the importance of the locality with its many and varied find horizons. At a minimum, this volume with its 20 papers on diverse topics makes reliable and up-to-date information on the locality available for the first time to a wide international audience. The volume answers many questions and raises numerous new issues for future research. The papers underline some archaeological knowledge that has long been available in German in a more preliminary form. But, more importantly, the contributions present a vast array of new results from the ongoing excavations, as well as new studies of classes of material that have considerable bearing on the interpretation of the locality and the famous Horse Butchery Site, also known as the Spear Horizon.

The scientific community is indebted to Hartmut Thieme for his long-term study of the archaeology of Schöningen. After finishing his Ph.D. on the Middle Paleolithic locality of Rheindahlen and conducting innovative research in the Rheinland, he took a post in the heritage office of Lower Saxony (*Niedersächsische Landesamt für Denkmalpflege* or NLD) where he was responsible for Stone Age archaeology in the second largest state in Germany. In 1982, Thieme began work at Schöningen and founded the Project *»Archäologische Schwerpunktuntersuchungen im Helmstedter Braunkohlerevier« (ASHB)* of the NLD in Hannover to rescue the sites threatened by large-scale, open-cast lignite mining (Figs. 1 and 2). Initially, this work focused on the excavations of Holocene sites. In March 1992, Thieme discovered the first Paleolithic artifacts in association with large mammal bones and in the same year established a research team including Dietrich Mania (Geology, Malacology), Brigitte Urban (Botany), and Thijs van Kolfschoten (Zoology).

Thieme's team began to recover important, and at times unusual, materials from the Middle Pleistocene deposits at Schöningen. The first wooden artifacts that the team identified in 1992 were so-called *Klämmschäfte,* or handles. In 1994 the crew excavated the now famous *Wurfholz* or "throwing stick" (Fig. 3). These and other important finds were published in a number of articles and in a small, but well-known book entitled *Archäologische Ausgrabungen im Braunkohletagebau in Schöningen, Landkreis Helmstedt* (Thieme and Maier, 1995).

Thieme's work in these Pleistocene deposits received little attention from archaeologists at first, but excursions to the site in connection with meetings of several societies and in particular of the XIV International Union of Quaternary Research (INQUA) in August 1995 brought many colleagues to the Schöningen exposures, primarily to study the outstanding geological profiles. As is often the case with unexpected finds, the research community needed a little time to understand the uniqueness and the unusual potential of the locality. Small salvage excavations on the edge of the mine recovered well-preserved faunal material and occasional lithic artifacts of Middle Pleistocene age.

The fundamental beauty of the Pleistocene archaeology of Schöningen is that it combined the brilliant preservation of a waterlogged site with the excavation convenience of open-air localities. By lowering the water table in the entire area of the mine, new opportunities emerged. Due to the great speed of the mining operations, Thieme and his crew needed to work fast under difficult conditions to save areas from destruction. Fortunately, the mining company agreed to leave a block of sediments that included promising horizons for study. This area of 3900 m^2, known as the *Sockel,* became the central focus of excavation in 1994 and 1995. The crew worked fast on a tight budget, but the results spoke for themselves and Thieme's experience as a field archaeologist paid high dividends.

This led to a remarkable situation in the fall of 1995. Thieme called numerous colleagues in late October and invited them to visit the site on Friday November 1 to review, discuss, and confirm the existence of a series of unique and wholly unexpected finds.

Speaking from the point of view of the first author and for the coauthors and Thieme's long-term collaborating colleagues Urban and van Kolfschoten, who also visited Schöningen on November 1, 1995, Thieme's claims to have discovered dozens of butchered large

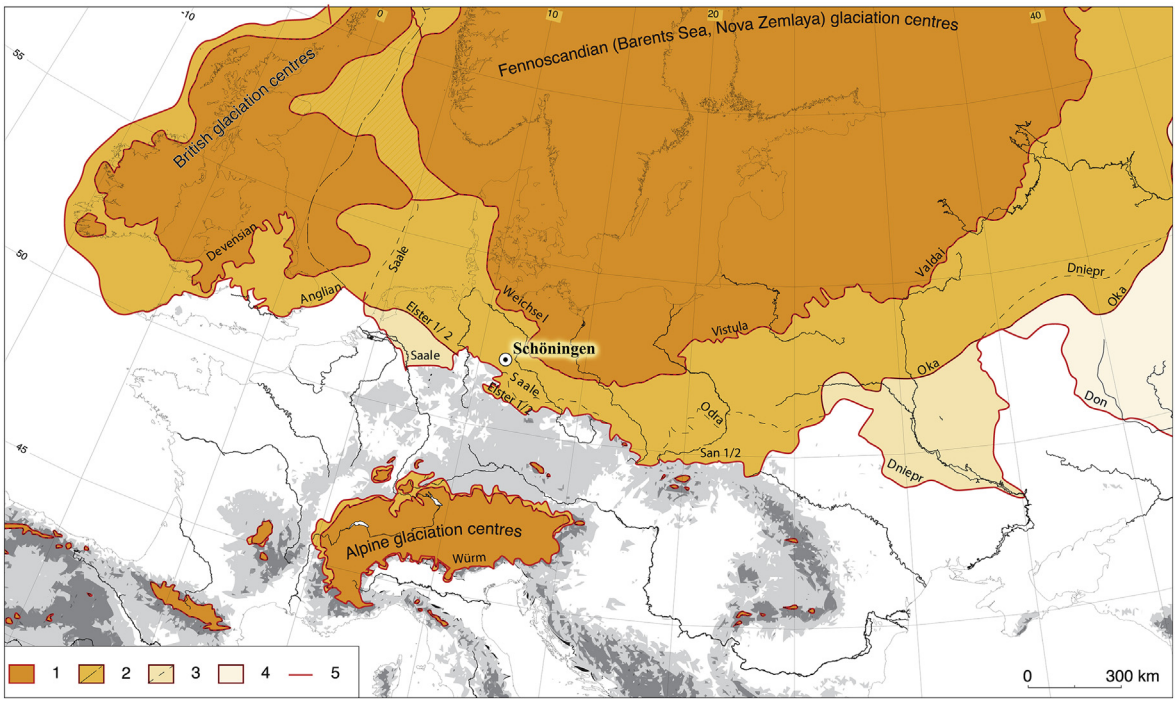

Figure 1. Schöningen. Position of the locality between the maximum southern expansion of the Elsterian and the Saalian and Weichselian continental glaciers. Image: Modified from van Gijssel (2006).

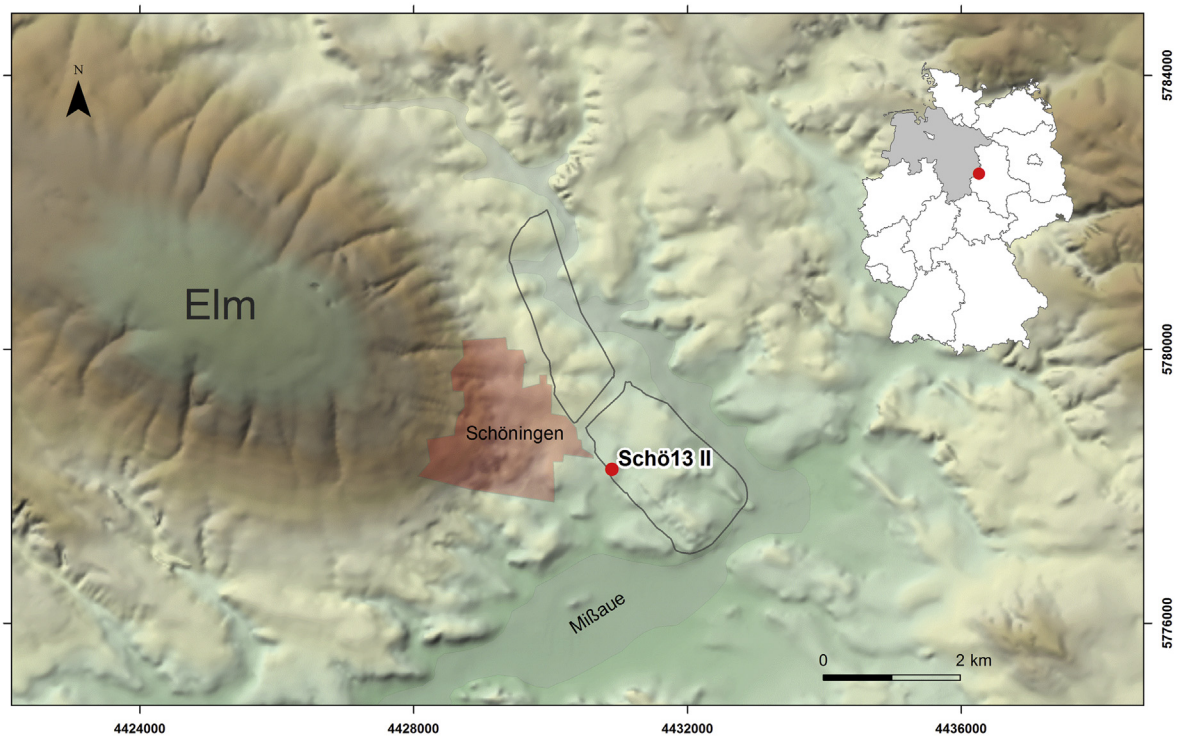

Figure 2. Schöningen. Topography around the town of Schöningen (red area). To the west lies the ridge of the Elm Forest, to the east lies the open-cast mine and the archaeological sites. The northern and southern mining pits are separated by the so called "Damm,"which was excavated in 2008 and 2009 by the Tübingen team. Schö13 II and red dot indicate the position of the Horse Butchery Site. Image: U. Böhner and D. Fabian.

Figure 3. Schöningen 13 II-4. Hartmut Thieme excavating the "throwing stick" in the autumn of 1994. This discovery was the first indication that Schöningen was to become a truly exceptional locality. Photo: Niedersächsisches Landesamt für Denkmalpflege (Thieme, 2007a:16, Figure 1).

Mosbach horses, several perfectly preserved wooden spears, multiple fireplaces, and numerous lithic artifacts in close archaeological association surpassed what any sane archaeologist could reasonably consider to be possible. Before Thieme's work at Schöningen, the corpus of well-documented wooden artifacts from the Lower and Middle Paleolithic was limited to the fragmentary spear tip carved from yew wood from the Middle Pleistocene site of Clacton-on-Sea (Oakley et al., 1977) and the complete spear carved from

yew wood from the Eemian Interglacial site of Lehringen (Adam, 1951; Thieme and Veil, 1985). On November 1, the lead author made the long train trip from Tübingen to Schöningen, without ever considering that Thieme's claims could possibly be true. Not knowing what to expect, everyone headed to Schöningen.

The group of about 25 people, including the excavation team and locals, assembled in Schöningen in the early afternoon of this gray and slightly foggy day. Hartmut Thieme led the group to the excavation of the now famous Horse Butchery Site, Schöningen 13 II-4, and proceeded to show us the spears, horse bones, fireplaces, and lithic artifacts. Everything was still lying in situ at the interface between the gray calcareous silt and the overlying peat layer of the fourth transgressional sequence of the second sedimentary depression exposed on the *Sockel*. The mood on this day can only be describe as euphoric, as all present quickly realized that they were witnessing a discovery unrivaled in the annals of archaeology. The photos in Figures 3–6 give an impression of the context of the finds, and Figure 7 presents the distribution of artifacts and faunal remains in the area of the richest concentration of finds. In addition to the excavation team, the lead author noted the presence of colleagues including, L. Fiedler, D. Mania, R. Maier, T. Weber, and O. Jöris, among the group of scholars assembled.

The shockwaves from discoveries at Schöningen traveled around the world in the following days and weeks. Thieme published preliminary reports in German (Thieme, 1996), and later with support from colleagues in Leiden prepared a paper published in Nature (Thieme, 1997).

With the publication of the spears from Schöningen, the great debate about the purported hunting capabilities of late archaic hominins came to an abrupt end. The debate had begun in the 1980s and early 1990s when Lewis Binford (1981, 1987, 1989) and others developed models arguing that Neandertals and other late archaic hominins subsisted primarily on the basis of systematic scavenging of carcasses of medium size and large mammals. These studies represented a break with a long tradition of zooarchaeological studies going back at least to Henri Martin's (1910) systematic research at La Quina, where he demonstrated the use of bone tools by Middle Paleolithic Neanderthals and argued that they regularly hunted large ungulates. In the views of Binford and likeminded colleagues, only modern humans were granted the capabilities to hunt medium and large game. This position is found, for example, in Clive Gamble's (1987) enigmatic paper "Man the Shoveler," in which Gamble argued that the spears from Clacton-on-Sea and Lehringen represented snow probes for finding frozen elephant carcasses in the deep snow of the Middle and Late Pleistocene. The fact that both of these spears were made of yew wood, a species associated with full interglacial conditions, and, in the case of Lehringen, the spear was found with a straight-tusked interglacial elephant (*Palaeoloxodon antiquus*) contradicted Gamble's model. This paper suggests how influential the scavenging paradigm had become.

During this time, however, some archaeologists remained skeptical of the scavenging hypothesis based on a range of zooarchaeological data (Jaubert et al., 1990; Conard, 1992; Farizy et al., 1994; Gaudzinski, 1995), and Stiner (1990, 1994) put forth a version of the model in which she credited Neanderthals with the ability to hunt or scavenge, depending on the circumstances. The discoveries from 1995 in Schöningen effectively brought the hunting vs. scavenging debate to an end for late *Homo heidelbergensis* and for Neanderthals in Europe. This debate is still being played out today, most notably in the scientific arena of the East African Earlier Stone Age (Bunn and Kroll, 1986; Blumenschine, 1988, 1995; Dominguez-Rodrigo and Pickering, 2003; Bunn, 2007; Domınguez-Rodrigo et al., 2007). The increased awareness that scavenging is practiced widely among contemporary hunters and gatherers has also brought more clarity into the debate on past patterns of subsistence (O'Connell et al., 1988).

Over the subsequent years, Schöningen, despite the scant number of publications in English, has often been viewed as proof that well-quipped, late archaic hominins occupied the top of the

Figure 4. Schöningen 13 II-4. "Throwing stick" carved from spruce wood at the time of discovery in the autumn of 1994; length 78 cm. The artifact lay at the interface of the calcareous marl and the peat-like organic horizon. Photo: Niedersächsisches Landesamt für Denkmalpflege (Thieme, 2007a).

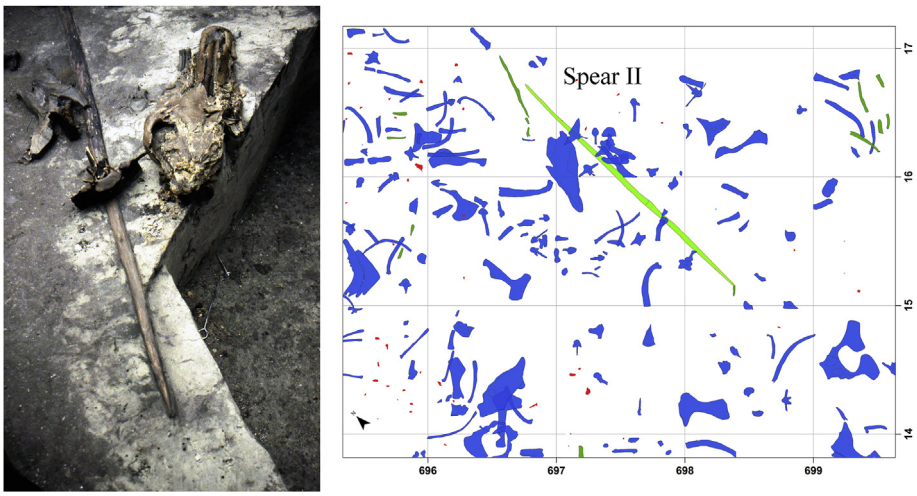

Figure 5. Schöningen 13 II-4. Spear II and horse bones at the interface of the calcareous marl and the peat-like organic horizon. The photo was taken when the new finds were presented on November 1, 1995. Photo: N. J. Conard. Plan: U. Böhner.

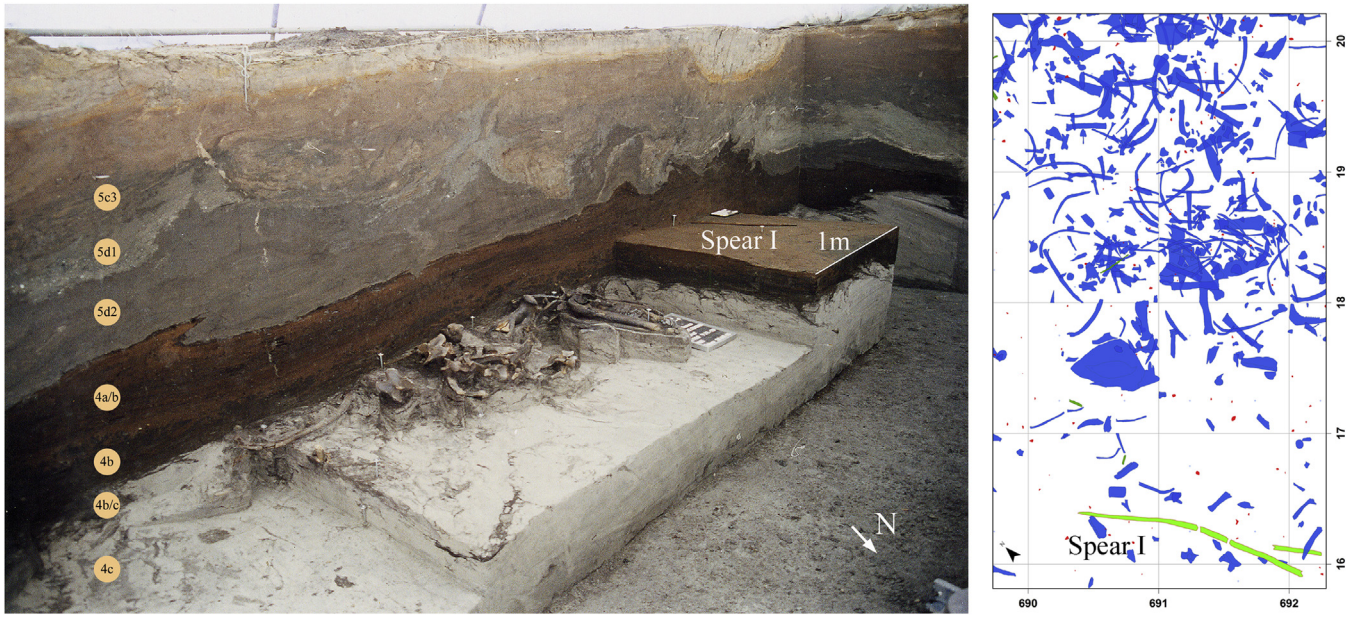

Figure 6. Schöningen 13 II-4. View of the stratigraphic position of faunal remains and Spear I, autumn 1995. Photo: Niedersächsisches Landesamt für Denkmalpflege, Plan: U. Böhner.

food chain and were the most effective predator on the Eurasian landscape of the Middle and Late Pleistocene. Schöningen, however, represents a landmark locality for numerous other debates in Paleolithic archaeology and paleoanthropology. As we will see below, cooperative hunting using diverse, high-tech tool kits points to sophisticated planning and communication, necessitating the exchange of information about the past and future, as well as the here and now. The sheer number of butchered horses and the implication of access to such rich resources has been used by Thieme (2007a) and others as a starting point for developing models for complex social and economic behavior in the late Lower Paleolithic. The finds from Schöningen have important ramifications for our understanding of the evolution of organic and lithic technology (Conard, 2015 and references therein). Additionally, the purported hearths from Schöningen have often been viewed as a kind of gold standard for evidence of the early controlled use of fire (Roebroeks and Villa, 2011; Thieme, 2007a). For all of these reasons, among others, the archaeological record of Schöningen warrants detailed, critical examination.

At a more specific level, the discoveries at Schöningen led Thieme to develop his interpretation of the Horse Butchery Site. The key elements of his interpretation can be summarized as follows (Thieme, 2007a). On an autumn day after a period of relatively dry conditions, a group of late *H. heidelbergensis* executed a major hunt of horses on the muddy shores of a lake. These hominins killed several dozen horses using many carefully engineered throwing spears and butchered them near the shoreline. The vast supply of meat and animal resources provided an opportunity for a major aggregation of hominins who processed the meat, marrow, and hides of the horses, and perhaps dried or smoked meat to facilitate storage for future needs. Members of the group built fires near the kill site, and these fireplaces were

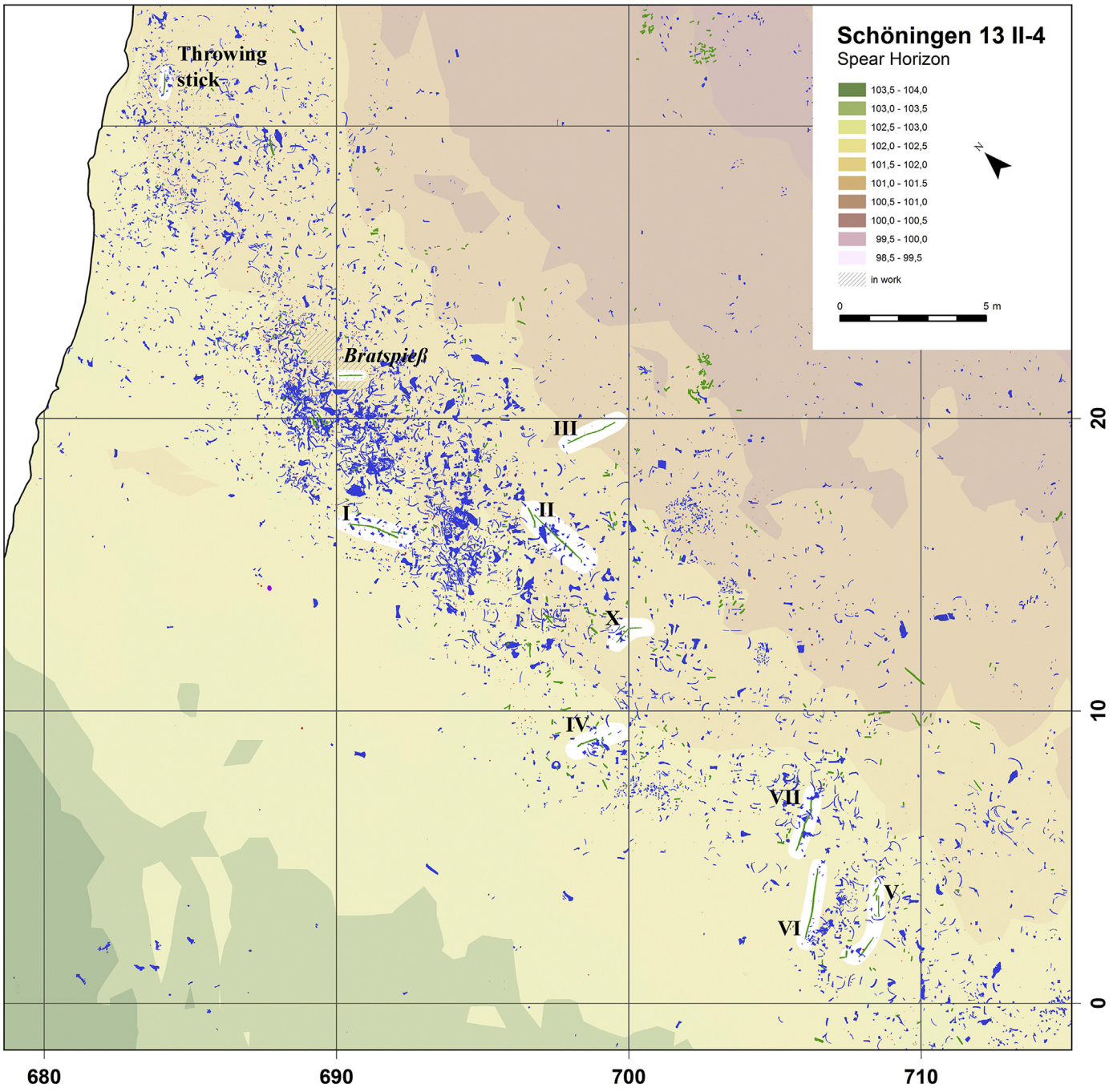

Figure 7. Schöningen 13 II-4. Central distribution of finds with the deeper and wetter part of the find horizon to the east, and higher and drier part of the find horizon to the west. The "throwing stick" from 1994, the *Bratspieß*, which is purported to be a burnt artifact, and spears I, II, III, IV, V, VI, VII, and X are indicated in the distribution. Each square depicted is 10 × 10 m. Plan: U. Böhner.

used for cooking and social interaction including discussions of the success of this great hunt. The spears, although some of them were undamaged, were left at the site as an offering for natural forces that had helped the hunters and had guided the horses. This seasonal kill and aggregation site demonstrated the importance of high-tech adaptations for the social and economic lives of the Middle Pleistocene hunters and gatherers of the Northern European Plain. After this single event, rain and runoff led to a rise in the lake levels that covered the site and preserved the finds much like Vesuvius covered Pompeii for future archaeologists. Thieme's model and the hypotheses it is based upon have never been systematically tested. With this volume, we examine the data from Schöningen to test which elements of this explanation are refutable and which elements are plausible. At the same time, the current team is working to formulate and test multiple hypotheses that may lead to a better understanding of how the Horse Butchery Site formed. Additionally, since the Horse Butchery Site is only one of two dozen sites from the Reinsdorf Interglacial sequence (Urban, 1995, 1999, 2006; Urban et al., 2011; Serangeli et al., 2015a), our team is working to model the settlement dynamics and social and economic systems documented by landscape archaeology in Schöningen.

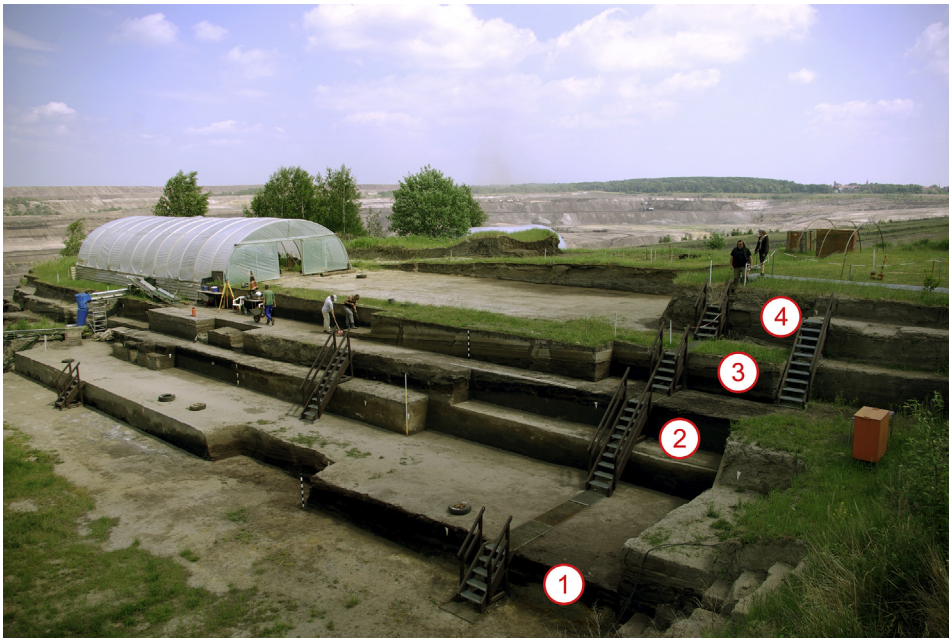

Figure 8. Schöningen 13 II. View of the ongoing excavations in 2014 showing the position of the four preserved sedimentary cycles from the paleolake at Schöningen. Sedimentary cycle 5 was truncated by mining and is not visible in the picture. Photo: J. Serangeli.

Finally, a few words are needed to explain the structure and goals of the current excavation team (Fig. 8). In 2007, the Ministry of Science of Lower Saxony established an interdisciplinary commission to determine the course of work at Schöningen. The Ministry of Science in close cooperation with the Schöningen Commission and the Heritage Office of Lower Saxony (NLD) then initiated a major research project that aimed at revitalizing research at Schöningen, while at the same time working to establish a museum for Paleolithic archaeology in Schöningen. In this context, the first author was asked to direct long-term excavations at Schöningen. Thieme was asked to support the work in the planned museum and to prepare publications on the results of his excavations that went beyond the important catalog from the large state exhibit on Schöningen from 2007 (Thieme, 2007a). In 2008, J. Serangeli was hired to lead the excavations that run 10 months each year from March to December.

To assure a good transition between the earlier and current phases of the project, the excavation technicians and professional excavators, some of whom have been with the project for decades, formed the majority of the excavation team, along with students from Tübingen and other universities. No radical changes were undertaken in the field methods employed, but in contrast to periods of rescue excavation under Thieme's and the new team's lead, the current excavation proceeds with great caution and a higher portion of the excavated deposits are waterscreened to recover small artifacts and all classes of small finds. The sediments at Schöningen are soft and fine-grained and easy to dig carefully with spades and trowels. In keeping with Thieme's work and the German tradition of Paleolithic research, all finds are piece-plotted and photographed in situ. In addition, collaboration with international partners from various disciplines has been pursued and intensified. This is particularly the case in the cooperation with B. Urban (University of Lüneburg and University of Tübingen), who was the first researcher to join Thieme's team in 1982 for environmental studies of the Holocene and Pleistocene sequences, and T. van Kolfschoten (University of Leiden), who has led the paleontological and zooarchaeological work in Schöningen since the discovery of Paleolithic finds in 1992. In 2008 and 2009, we began collaboration with geologist J. Winsemann (University of Hannover) and many of the colleagues who have contributed to this volume joined the research project. This volume represents the culmination of a special session on Schöningen that was presented at the Society of American Archaeology meeting in April 2012 in Memphis (Balter, 2014). In 2012, S. Gaudzinski-Windheuser (University of Mainz and *Römisch-Germanisches Zentralmuseum*) secured funding and assembled a team to analyze several aspects of the faunal remains from the Horse Butchery Site, while in 2013, T. Terberger joined the NLD to help coordinate the Schöningen project and other topics of Paleolithic heritage in Lower Saxony.

In the first two years of work, the current team focused on a large-scale rescue excavation in a 10 hectare area that separated the northern and southern pits of the lignite mine. This part of Schöningen goes by the name *Damm* or the *DB-Pfeiler*, the latter term referring to the train tracks that separated the northern and southern part of the mine at this spot. Starting in 2010, with additional support from the *Deutsche Forschungsgemeinschaft* (DFG), the current crew continued the excavation of the *Sockel* on the western edge of the mine where the Horse Butchery Site had been discovered (Serangeli et al., 2015a). This excavation continues without interruption today and is planned to continue for several decades with support from the Ministry of Science and other funding agencies and institutes (Fig. 8). In the spring of 2013, the "paläon" opened and serves as both a major museum for Paleolithic archaeology, as well as a research center for Schöningen and related topics in early prehistory and Quaternary ecology. Building on the seminal work by Thieme, this volume summarizes the research conducted so far at Schöningen by the current team, and points to new directions for the future.

2. Setting, chronology, and site formation processes

Schöningen is situated north of the Harz Mountains at the southern edge of the flat expanse of the northern German plain within the state of Lower Saxony (Figs. 1 and 2). Mining operations at an open-cast lignite mine uncovered a 45 m thick sequence of Pleistocene and Holocene deposits that span three major glacial

cycles (Elsterian, Saalian, and Weichselian) and corresponding interglacials (Holstein, Reinsdorf, and Schöningen; Urban et al., 2011; Urban and Bigga, 2015). Sandwiched between the Elsterian and Saalian glaciogenic sediments, the deposits corresponding to the Reinsdorf Interglacial consist of calcareous marls, organic-rich silts, and peats in which the archaeological materials are embedded. The origin of these lacustrine deposits has been controversial. Elsner (1987) initially proposed that the deposits formed within a kettle-lake as dead-ice buried within the Elsterian till melted. Mania (1998), on the other hand, argued that the deposits represent at least three major phases of fluvial channel incision and infilling, influenced by dissolution of subsurface salt (Mania, 1995). Recently, in a detailed study combining data from outcrops, boreholes, and geophysical prospection, Lang et al. (2012, 2015) argued that the deposits accumulated within a tunnel-valley that formed subglacially during the Elsterian. Following deglaciation, the underfilled tunnel-valley became a lake that, based on subsurface 3D modeling, was up to 2.5 km long, 300–400 m wide, and 6–7.5 m deep (Lang et al., 2012). During the interglacial, the lake filled with prograding shallow-water deltaic sediments and corresponding marls, organic silts, and peats.

The interglacial lacustrine deposits show evidence for cyclical fluctuations in the lake level, likely related to climatic changes (Fig. 8). At Schöningen 13 II, it was possible to identify five cycles of lake level shallowing (*Verlandungen*), indicated by layers of calcareous marl that grade upwards into organic silts and peats (Thieme, 2007; Urban, 2007; Lang et al., 2012; Urban and Bigga, 2015). Archaeological materials have been found in all of the shallowing cycles; however, excavators uncovered the densest concentration of archaeological materials, including the famous spears, in the fourth shallowing cycle (Schöningen 13 II-4).

Thieme (1997) initially suggested that the remains from Schöningen 13 II-4 dated to around 400 ka BP. However, since then, new uranium series dates (Sierralta et al., 2012) and luminescence ages (Richter and Krbetschek, 2015) confirm litho- and biostratigraphic evidence suggesting that the archaeological deposits correspond with MIS 9, about 300 ka BP (van Kolfschoten et al., 2012; Urban and Sierralta, 2012; van Kolfschoten, 2014). While the original date of 400 ka BP fit well with the assumption that *Homo heidelbergensis* was responsible for the archaeological finds at Schöningen, the new dates leave open the possibility that the site was used by early Neanderthals. Since late *H. heidelbergensis* and early Neanderthals represent chronospecies, distinguishing between the two taxa will likely remain a matter of conjecture and debate for some time to come.

Although there has been much discussion in the German literature about the potential correlation of the find horizons of Schöningen with the Holstein Interglacial (Behre, 2012), we prefer to use the local observations to place the key find horizons within the sedimentary cycles of the Reinsdorf Interglacial, which appears to postdate the Holstein Interglacial. Urban's (1995, 1999, 2006; Urban and Bigga, 2015) detailed study of the locality's botanical record demonstrates that the Horse Butchery Site, which formed during the fourth sedimentary cycle, correlates with the end of the Reinsdorf Interglacial. The climatic optimum of the Reinsdorf Interglacial corresponds to the first sedimentary cycle of Schöningen 13 II. The paleobotanical results are consistent with an array of biostratigraphic results from van Kolfschoten's (2014) analyses of the micro- and macrofauna.

The taphonomic history of the Schöningen faunal assemblages is rather complex and is difficult to tease out into single events or snapshots. Animals are often attracted to water when they are sick or dying, so lakeshore deposits naturally contain some amount of background fauna. At several Schöningen sites, there are no traces of hominin modifications on bones, so we conclude that animals in these areas died naturally (van Kolfschoten, 2014). This likely occurred in find horizons that also preserve signatures of hominin activities. At Schöningen 12 B, Schöningen 12 II-4, and Schöningen 13 II-4, there is ample evidence of hominin modifications in the form of cut marks and the use of bones for tools (Voormolen, 2008; van Kolfschoten et al., 2012, 2015a, b; van Kolfschoten, 2014; Julien et al., 2015a; Starkovich and Conard, 2015). Mortality data reflect a catastrophic age profile with large numbers of prime-aged adult animals, as well as young animals that must have been part of family herds (Voormolen, 2008). Analysts link similar profiles at other archaeological sites to hunting by hominins (Klein, 1981, 1982; Stiner, 1990; Kahlke and Gaudzinski, 2005; Saladié et al., 2011). Based on these mortality profiles, extensive butchery evidence, and the wooden spears, we agree with previous analysts (e.g., Thieme, 2000, 2005, 2007; Musil, 2007; Voormolen, 2008; van Kolfschoten et al., 2012; van Kolfschoten, 2014; Starkovich and Conard, 2015) that the faunal assemblages from Schöningen are largely the result of hominin hunting, as opposed to scavenging from natural deaths or carnivore kills. Nonetheless, each find horizon reflects specific conditions that require contextualized taphonomic studies to disentangle the agents that contributed to the accumulations.

A more contested issue is whether the horses from 13 II-4 died at once, or in multiple events. Thieme (2000, 2005, 2007) initially hypothesized that the animals were part of a single mass kill. Upon further analysis of the materials, Voormolen (2008) and Musil (2007) contend that the fauna are the result of multiple smaller hunting episodes. van Kolfschoten (2014) left the scenario deliberately open and underlines, in addition to hominin activities, the importance of natural processes resulting in the accumulation of a background fauna. Evidence from isotope studies (Julien et al., 2015b) and horse tooth meso- and micro-wear studies (Rivals et al., 2015) supports the hypothesis of multiple hunts, as the individuals in their studies were from different populations that died at different times of year. Taken together, we conclude that the Horse Butchery Site represents multiple kill events that could range from one to many animals, along with the natural accumulation of at least a few skeletons. Furthermore, based on the low degree of weathering of the faunal remains (Voormolen, 2008; van Kolfschoten, 2014; Van Kolfschoten et al., 2015a; Starkovich and Conard, 2015), burial was fairly rapid. We can imagine the accumulation of the archaeological materials represents a palimpsest that formed on the relatively short scale of years, decades, or centuries but probably not many millennia.

Geoarchaeological analyses of the depositional environment at Schöningen 13 II-4 (Stahlschmidt et al., 2015a) and a spatial analysis of finds (Böhner et al., 2015) support the faunal evidence for a complex accumulation of archaeological materials at the site. Stratigraphically, most of the materials are dispersed throughout several tens of centimeters near the contact between a gray calcareous marl and an overlying organic-rich silt (layers 4c, 4b/c and 4b; Figs. 3–6). Although the faunal remains, wooden artifacts, and lithic artifacts are often concentrated near the interface of these stratigraphic units, our geological observations do not permit precise claims about the period over which these rich deposits accumulated. Interestingly, individual wooden spears and bones are often embedded in both of these deposits, indicating a degree of plasticity of these sediments. This situation is consistent with the idea that the sediments were soft and saturated by water. It is only in these very wet lakeside sediments that archaeologists have recovered abundant archaeological material. Conditions of preservation farther from the lake on perennially dry ground are less favorable.

Böhner et al. (2015) and others (Thieme, 2007a) note that the bones, wooden implements, and lithics form a roughly linear concentration trending from the north to south, with diffuse materials occurring to the east and still less material found to the west of this line. They also convincingly argue that this concentration likely corresponds with the shoreline of the ancient lake. Micromorphological and organic petrographic studies of the sediments associated with the main concentration of artifacts showed no clear evidence for an exposed surface, subaerial weathering, or terrestrial sedimentation (Stahlschmidt et al., 2015a). Rather, the deposits appear to have accumulated in more or less continuously standing water. Stahlschmidt et al. (2015a) argue that the lake margin was not a linear shoreline but was likely a dynamic, marshy, mosaic environment that was largely submerged or water saturated, explaining the excellent organic preservation at the site.

The results from the spatial, faunal, and geoarchaeological analyses are difficult to meld with a "Pompeii-like" formation history for the site. It seems more likely that the assemblage at Schöningen 13 II-4 represents repeated episodes of hunting and butchery of horses and occasionally other species including cervids and large bovids along the margins of a lake in an area with scattered remains of animals that died naturally.

The exceptional preservation at Schöningen is limited to these water saturated settings. Despite the wealth of finds from this context, we postulate that places on the landscape that were attractive for more long-term occupations would have been on dry land further from the lake. In this sense, we regard the Horse Butchery Site as a palimpsest of kill and butchery events, alongside the scattered remains of animals that died naturally, rather than a place that served as an aggregation site for more long-term occupation. The recent excavations on the southern extension of the Horse Butchery Site in the area of the Upper Berm (Serangeli et al., 2015a; Starkovich and Conard, 2015) demonstrate that large areas of the lakeside served as productive locations for hunting, and the entire shoreline that has been studied so far over a length of at least 130 m is rich in butchered remains of horses and other larger mammals. The sites from the other sedimentary cycles provide similar but far less spectacular variations on this pattern of landuse.

While the excellent preservation of the finds from the wet lake sediments provides unique conditions for rapid burial and preservation, we must look elsewhere for the residential sites of the Schöningen hominins. This view is consistent with the lack of evidence for fire, as discussed below and with the lack of evidence for features, architecture, and provisioning of place (Kuhn, 1995).

3. Lithic technology

The lithic assemblage at Schöningen has yet to be published in detail, and any assessment of the lithic artifacts from the locality will remain incomplete until the finds from Thieme's excavation are fully published. Since lithic artifacts provide the primary means of distinguishing between Lower and Middle Paleolithic assemblages, this class of material is important from a taxonomic perspective, as well as from technological and economic perspectives. With an age of ca. 300 ka BP and a paleoenvironmental correlation with MIS 9, the sites at Schöningen fall near the cusp between the Lower and Middle Paleolithic. Since the assemblages from Schöningen contain many carefully modified scrapers and completely lack handaxes, some colleagues (Jöris and Baales, 2013) have suggested that the site should be classified as belonging to the early Middle Paleolithic. Although this is a purely semantic issue, we favor classifying the sites at Schöningen as belonging to the late Lower Paleolithic due to the relatively non-standardized short reduction sequences, the thick and broad flakes, the opportunistic modification of natural spalls, and the absence of Levallois technology, the hallmark for the start of the Middle Paleolithic in Northern Europe and many other places.

The lithic assemblages recovered by the current team at Schöningen are consistent with the published materials from Thieme's excavations (Serangeli and Conard, 2015). Given that the locality of Schöningen includes about two dozen sites with broadly similar assemblages where lithic artifacts have been recovered, it seems that the lithic artifacts used during the Reinsdorf Interglacial reflect a robust and stable technological adaptation.

Local Senonian flint of excellent quality dominates the lithic assemblages. This material is readily available in the Elsterian gravels that underlie the Reinsdorf Interglacial sequence and there is no reason to think that hominins active near the paleolake at Schöningen would have trouble finding high quality lithic raw materials. Nonetheless, the finds studied so far provide no evidence of the existence of long reduction sequences. Instead, the artifacts mainly reflect isolated flakes, retouched scrapers, and small and micro debitage. This signature is consistent with distal portions of reduction including making tools, resharpening artifacts with soft hammers, use, and discard. With the possible exception of parts of the Horse Butchery Site, find densities are below one artifact per square meter, and seemingly document the repeated ephemeral use of the landscape by mobile hunters and gatherers.

The blanks used for making tools are usually thick and are the product of what appears to be non-systematic reduction methods. Sometimes frost spalls are used as blanks, and at times, used edges are subsequently damaged by frost fractures as microwear studies demonstrate (Rots et al., 2015). This strong influence of thermal damage to the assemblage accentuates the informal appearance of the lithic technology. The absence of handaxes and Levallois technology and the consistent nature of the lithic artifacts and their techno-economic signature suggest that we are not looking at a chance accumulation of informal tools and sporadic debitage, but rather at the archaeological record of a well-adapted and highly effective technological system. The results of usewear and residue analyses indicate that the tools and flakes from Schöningen served many purposes including butchery, woodworking and processing of plant fibers (Rots et al., 2015). The extremely large number of cut marks on the faunal assemblage from the Horse Butchery Site, as well as occasional cut marks from other find horizons demonstrate the effectiveness of the lithic assemblage for butchering large mammals (Voormolen, 2008; Van Kolfschoten et al., 2015a, b; Starkovich and Conard, 2015). The absence of long reduction sequences refutes the hypothesis that primary knapping frequently occurred at Schöningen. Instead, the assemblages seem to reflect something closer to the personal gear brought to the site with the specific intent of using the artifacts for butchering and related purposes. The lack of longer reduction sequences does not clearly support or refute Thieme's hypothesis that the Horse Butchery Site served as a major aggregation site for relatively long-term occupation. The scarcity of primary lithic production, however, is more consistent with mobile hominins repeatedly engaging in hunting and butchery along the lakeshores at Schöningen.

4. Organic technology

Perhaps the most remarkable aspect of the sites at Schöningen is the outstanding organic preservation that results from the constant anaerobic conditions of the waterlogged deposits. While Schöningen is synonymous with wooden artifacts, the locality has also produced a wide range of faunal tools that are the subject of two papers in the current volume (Julien et al., 2015a; Van Kolfschoten et al., 2015b), as well as the earlier doctoral

dissertation by Boudewijn Voormolen (2008). With over a dozen published examples of wooden artifacts and over one hundred published faunal tools, Schöningen provides by far the best example of organic technology ever recovered from a Lower or Middle Paleolithic site. The observations from these assemblages provide a glimpse of what is so often lacking in our studies of early Paleolithic lifeways and suggest how much is routinely missing as a result of destruction due to less favorable conditions for preservation. This is a key contribution of the research at Schöningen, and the so called "Schöningen Effect" refers to the systematic underestimation of the technological diversity and general underestimation of the material culture of the past due to poor organic preservation.

Prior to the discoveries at Schöningen, the complete yew spear from Lehringen and the tip of a spear from Clacton-on-Sea demonstrated that wooden weapons existed during the Lower and Middle Paleolithic. Due to the unlikelihood of making such discoveries researchers could reasonably assume that these finds represent only a small portion of the botanical tool kit of archaic European hominins. The Lehringen find with its length of 2.4 m and considerable weight, has long been viewed as a thrusting spear for close-quartered killing, as likely reflected by the skeletal remains *of Palaeoloxodon antiquus* at Lehringen. In contrast, the much more complete record from Schöningen documents the presence of a multiple weapons system including the double pointed "throwing stick" made from spruce wood found in 1994 (Thieme, 1997), and various sizes of javelin-like throwing spears made from hard, slow growing spruce wood. The four complete or nearly-complete throwing spears vary in length from 1.84 to 2.29 m and include specimens with maximum thicknesses of ca. 4.7 cm (Schoch et al., 2015), although it must be said that the wooden artifacts were deformed partly by postdepositional processes. Contrary to frequent claims in the literature (Rice, 2007; Berna and Goldberg, 2008; Coolidge and Wynn, 2009; Alperson-Afil and Goren-Inbar, 2010; Weiner, 2010), there is no evidence that the tips of these spears were fire hardened. Finally, a 2.53 m long lance of spruce (Spear VI; Schoch et al., 2015) with an irregular diameter and form likely served as a thrusting spear, and could also have been used to keep injured prey or dangerous carnivores at bay.

In addition to the pointed wooden tools that likely served as hunting weapons (Milks and Pope, 2014; Schoch et al., 2015), Schöningen 12 II has yielded several objects that have been described as handles (*Klemmschäfte*; Thieme and Maier, 1995; Thieme 2007a; Schoch et al., 2015). Although Bigga et al. (2015) have shown that several of the purported handles with forked ends are natural objects, others seem to have been used to haft stone tools or other artifacts. Nearly all of the wooden tools from Schöningen 13 II-4 (the Horse Butchery Site) were carved from spruce wood (*Picea* sp.; Table 1 in Schoch et al., 2015). The one exception is the incomplete spear IV, which was carved from pine (*Pinus sylvestris*). The extremely precise craftsmanship reflected in the choice of raw materials and the carving of wooden artifacts points to a well-established tradition of high quality woodworking during the Reinsdorf Interglacial. Furthermore, although we cannot be sure why the wooden artifacts were left at Schöningen, their presence in high numbers strongly suggests that they were in common use at this time. Some of the wooden tools, such as Spears I, II, and III, seem to have been unbroken at the time of discard, while others such as Spear V are found in broken pieces in neighboring but not directly adjacent articulated contexts. Had hominins found wooden artifacts to be particularly valuable, we might expect fewer specimens to be present at the Horse Butchery Site. We, however, are skeptical of the symbolic interpretation favored by Thieme (2007a) that the spears were left at the site as offerings to the animals killed or the spirits that helped to make the hunts successful.

Almost as impressive as the many wooden artifacts from Schöningen is the exceptional evidence for faunal artifacts. Voormolen (2008) identified 7 examples of horse metapodials and one of a bovid metatarsal with percussion damage that he interpreted as knapping tools. Subsequent work by van Kolfschoten and colleagues (2015b) demonstrate that retouchers and metapodials used as hammers for flintknapping are common at Schöningen. In the Horse Butchery Site alone, we have recovered more than 80 retouchers, several of them with pieces of flint embedded in them and at least 15 bone hammers.

In addition to the roughly 90 bone tools from the Horse Butchery Site, Julien et al. (2015a) have identified a range of different faunal tools including a large and elongate heavily polished ivory wedge of unknown function and several pounding tools made from bone. These finds originate from the rescue excavation of Schöningen 12 II and other low-density find horizons and appear to document a wide range of functions that require further study. The presence of a low-density distribution of faunal tools discarded in isolation suggests that the hominins of the late Middle Pleistocene used faunal artifacts more often and in more settings than has been suspected before now. This observation represents another paradigm shift brought on by the research at Schöningen. Until fairly recently, many colleagues assumed that organic artifacts including faunal tools were generally absent in the tool kits of archaic hominins and only came into frequent use among late Neanderthals in MIS 3 (d'Errico et al., 2003). Bone tools, for example, from Middle Paleolithic sites in northern and southern Germany (Riek, 1934; Wagner, 1983; Gaudzinski, 1999) and the identification of bone handaxes (Tromnau, 1983; Segre and Ascenzi, 1984; Walker, 1999) raised questions about this view. M. Soressi et al. (2013) have also argued, based on faunal tools from the French Middle Paleolithic, that the use of bone tools by Neanderthals predates the arrival of modern humans in Europe lending more credibility to the hypothesis that faunal tools were relatively common in Europe prior to the Upper Paleolithic. Now, with Schöningen, we can show that bone tools were not only present during the late Lower Paleolithic, but that bone tools represent a major part of the technological repertoire of late Middle Pleistocene hominins (Julien et al., 2015a; Van Kolfschoten et al., 2015b).

5. Fire

The mastery of fire was one of the most significant technological achievements in human evolution. Fire provides warmth, light, and protection, it can be used to cook and modify raw materials, and it can serve as a central place in an occupation, thereby promoting social interaction and cohesion (Oakley, 1955; Clark and Harris, 1985; Bellomo, 1994; Gilligan, 2010). Because of the adaptive advantages provided by the control of fire, many researchers view fire as a prerequisite for the settlement of colder, northern latitudes (Oakley, 1955; Brace et al., 1987; Straus, 1989; Gowlett, 2006; Preece et al., 2006). In recent years, as a more critical approach based on analytical data has rejected many claims for the early use of fire. The Horse Butchery Site at Schöningen, due to its context and high degree of preservation, was often viewed as a particularly strong case for the controlled use of fire in the late Middle Pleistocene (Roebroeks and Villa, 2011).

Thieme (2007a) and Schiegl (Schiegl and Thieme, 2007) reported several lines of evidence for hominin use of fire at Schöningen, including the remains of four hearths, burnt wood, burnt wooden artifacts (e.g., a *Bratspieß* = roasting stick), and heated pieces of flint. Following a major, multiproxy assessment of these purportedly burnt materials, Stahlschmidt et al. (2015b)

conclude that there is no convincing evidence for hominin use of fire at Schöningen. Through the application of micromorphology, mineral magnetic measurements, thermoluminescence, and organic petrology, they show that there is no anthropogenic ash or charcoal associated with the hearths, and the reddened patches likely formed recently as a result of water-table lowering during mining activities. Thermoluminescence measurements confirm the presence of heated flints at Schöningen; however, Richter (2007) notes that none of the heated and dated flints from Schöningen 13 I show evidence of hominin modification, making it difficult to determine any anthropogenic source for their heating (Roebroeks and Villa, 2011). In addition, Stahlschmidt et al. (2015b) also used organic petrology to show that a supposedly burnt artifact (the so-called *Fackelkopf* or torch) was not burnt, but acquired a dark color as a result of humification. The study of the *Fackelkopf* calls into question the identification of other potentially burnt, wooden artifacts from Schöningen, such as the so-called *Bratspieß*, until researchers can conduct further analyses.

Furthermore, the generally water-saturated sediments of the Horse Butchery Site, while providing ideal conditions for the preservation of botanical and faunal finds, represent an unlikely context for the use of fire. If indeed the Schöningen hominins used fire, we would expect to see evidence for it not at the swampy lakeside but on dry land further away, where we postulate the presence of occupations in more upland settings.

The lack of evidence for the hominin use of fire at Schöningen does not prove that hominins did not have the ability to use or control fire at the end of the Lower Paleolithic in Northern Europe. It is difficult for us to imagine that the highly advanced hominins who made the spears and successfully hunted and butchered large game did not have some knowledge of fire. The results from Schöningen, however, fit with the arguments of Roebroeks and Villa (2011) and others (James et al., 1989; Sandgathe et al., 2011) that there is scanty evidence for hominin use of fire in the Lower Paleolithic of northern Europe. The study by Stahlschmidt and colleagues shows that many discussions and hypotheses about the emergence of fire-related behaviors in human evolution rely on evidence for fire that has not been critically studied or assessed. Advances in geoarchaeological methods and concepts over the past several decades have allowed archaeologists to confirm or reject claims of early use of fire at a number of important Lower Paleolithic sites including Qesem, Zhoukoudien, and Wonderwerk (Weiner et al., 1998; Karkanas et al., 2007; Berna et al., 2012). Studies similar to those conducted at these sites and at Schöningen are needed before we can test hypotheses about the emergence of pyrotechnology.

6. Subsistence

At this stage of research, despite the locality's remarkable preservation, there is no direct and unambiguous evidence for the use of plants in the diet of the Schöningen hominins. The environment of the locality, however, contained a large number of plants potentially useful for hominins, including a range of sedges and vitamin-C-rich pine and birch bark, bearberries, elder, raspberry, and *Ranunculus* or *Chenopodium* leaves (Bigga et al., 2015). Indeed, many plants found at Schöningen are commonly used by modern foraging groups (Densmore, 1974; Usher, 1974; Turner and Szczawinski, 1979). A particularly good source of carbohydrates that would have been amply available in a lakeshore environment are underground storage organs (Jones, 2009), which are also eaten by our closest primate relatives such as chimpanzees (Hernandez-Aguilar et al., 2007). Unfortunately, despite their utility and our speculation that the Schöningen hominins were skilled gatherers as well as skilled hunters, remains of these kinds of plants rarely preserve archaeologically and are absent from the site.

Hominins at Schöningen would also have had access to medicinal plants with mild antiseptic effects, and those that soothed injured skin or upset stomachs, such as alder bark, bearberries, and various parts of birch trees (Bigga et al., 2015). Yet, however likely the use of such plants may have been, claims for the use of medicinal plants, while plausible, remain speculative.

In contrast to the ambiguous evidence for the use of plants, the faunal evidence from Schöningen provides clear arguments that late Lower Paleolithic hominins at the site were successful hunters of large ungulate prey. This is based on the accumulation of dozens of extensively butchered large-bodied equids, mainly prime-aged adult and juvenile animals, found alongside the wooden hunting implements (Thieme, 2000, 2005, 2007a, b; Voormolen, 2008; Van Kolfschoten et al., 2012; van Kolfschoten, 2014; Julien et al., 2015a; Starkovich and Conard, 2015). This is particularly the case at Schöningen 13 II-4, 12 II-4, and 12 B. It is clear that the Schöningen hominins were able to anticipate the behavior of prey to the extent that they knew that equids and other ungulate taxa would be repeatedly drawn to this spot on the landscape for its reliable supply of water. The diverse hunting equipment recovered from the localities at Schöningen, most notably the Horse Butchery Site, was clearly produced well in advance of its use and represents curated personal gear rather than expedient technology produced spontaneously immediately prior to executing a hunt.

Abundant evidence shows that hominins shared their hunting niche with two or more large-bodied carnivores: wolves and saber-toothed cats (Voormolen, 2008; van Kolfschoten, 2014; Serangeli et al., 2015b; Starkovich and Conard, 2015). These animals were part of the ecosystem of this lakeside locality that attracted prey animals and hominin hunters, as demonstrated by the skeletal remains of the animals themselves (van Kolfschoten, 2014; Serangeli et al., 2015a, b), and a large number of bones gnawed by carnivores (Voormolen, 2008; Van Kolfschoten et al., 2015a, b; Starkovich and Conard, 2015). Nearly all of the evidence for prey selection and butchery indicates that hominins had primary access to the carcasses while the carnivores had secondary access. There are a few specimens that display both carnivore bites and butchery marks on a single bone (Voormolen, 2008; Starkovich and Conard, 2015). In most of these instances, carnivore bites overlie cut marks, supporting the hominins-first scenario. Only a few bones show a reversal of this trend (Van Kolfschoten et al., 2015a, b). Though we do not know the exact nature or frequency of interactions between top predators in the late Lower Paleolithic, hominins were certainly aware of their presence, which would have influenced decisions they made about selecting locations for base camps and butchering animal carcasses. Given the hunting technologies they possessed, in addition to occasionally taking advantage of scavenging opportunities, as do modern hunters (O'Connell et al., 1988; Bunn, 2001), the Schöningen hominins may have also practiced “power scavenging” of fresh carcasses (e.g., Bunn, 2001). Therefore, there are at least two avenues by which cut marks could come to overly bite marks. Nonetheless, prudent hominins would have avoided dangerous situations, and we view violent conflicts with dangerous carnivores as more the exception than the rule.

After hominins hunted or scavenged ungulates at Schöningen, they went to work processing the animals. A lack of caudal (tail) vertebra provides evidence for skinning, and extensive cut marks and impact fractures indicate that hominins removed meat, disarticulated the carcasses, and extracted nutrient-rich marrow from long bones (Voormolen, 2008; van Kolfschoten, 2014; van Kolfschoten et al., 2015a, b). Patterns of cut marks suggest that Schöningen hominins were skilled butchers with an intimate knowledge of the anatomy of their prey. Based on a small amount of

comparative data on the distribution and orientation of cut marks, their butchery strategies differed somewhat from later Neanderthal and modern human groups (Starkovich and Conard, 2015). This could reflect different social roles within the group, or the practicalities of mobilizing multiple hominins to butcher prey at a kill site. Another feature of the faunal assemblage is that, with the exception of the missing caudal vertebra and an underrepresentation of some foot elements, the horse carcasses are fairly complete (Voormolen, 2008; Starkovich and Conard, 2015). This leads us to conclude that there was not extensive transport of the remains by either hominins or carnivores. Overall, the data from Schöningen indicates that, at least in this location, the Middle Pleistocene hominins had entered the Eurasian predator guild as successful social hunters, capable of procuring and processing large-bodied prey, and most likely supplementing their diet with seasonally available plant foods. Both zooarchaeological data and isotopic studies of horse dentitions point to multiple seasons during which hominids used the locality (Thieme, 2003; Julien et al., 2015b; Van Kolfschoten et al., 2015a; Rivals et al., 2015).

7. Settlement dynamics and landuse

While the Horse Butchery Site is justifiably the best know site at Schöningen, the locality contains 24 excavated areas that contain artifacts. These sites vary greatly in their area and in the size and nature of the assemblages they produced. At one end of the spectrum the Horse Butchery Site contains ca. 15,000 mammalian specimens, not counting microfauna, and about 1,500 lithic artifacts, including small and micro-flakes. The same horizon contains about a dozen wooden tools (Schoch et al., 2015) and at least 100 faunal tools (Kolfschoten et al., 2015). At the other end of the spectrum, some excavations yielded extremely few finds, and in many cases the distinction between archaeological sites, background accumulations of artifacts, and paleontological sites blur. At sites including Schöningen 12 B and 12 II-4 (Voormolen, 2008; Julien et al., 2015a, b), lithic artifacts represent single isolated finds that seem to be the signature of either isolated tools that were used in the area of their recovery, or objects lost or left behind as hominins passed through the landscape. Considering only the lithic artifacts, all of these sites, including the Horse Butchery Site, would be classified as low or very low density sites, by most standards, and the isolated finds could be viewed as traces of off-site archaeology (Isaac, 1981; Conard, 1998; De Loecker and Roebroeks, 1998).

Most of the sites at Schöningen shows a similar lithic signature, rather than documenting diverse activities and find densities. Knapping concentrations and workshops are completely absent. Refitting and technological analyses have yet to document long sequences of reduction and use beyond the occasional resharpening of tools (Serangeli et al., 2015b). Oddly, the great number of bone retouchers and hammers could lead one to expect a great wealth of lithic debitage (Voormolen, 2008; Van Kolfschoten et al., 2015a, b). Instead, the lithic assemblages include tools, small and micro-debitage characteristic of distal parts of reduction sequences, but more detailed conclusions must wait for the publication of the lithic assemblages from Thieme's excavation.

Beyond the palimpsest of the Horse Butchery Site, other areas such as Schöningen 12 II-4 and 12 B also preserve anthropogenically modified bones and lithic artifacts. In these cases, however, the bones only show sparse signs of hominin intervention. In these settings, we have difficulty distinguishing the role of anthropogenic and natural agents of accumulation. Although all archaeology can be considered landscape archaeology, the ultra-low density sites at Schöningen do look like the traces of hominins moving along the lakesides of Schöningen and interacting here and there with the landscape and the resources it provided. As in other settings at Schöningen, these sites are best preserved in the saturated sediments of the lake margins. These sites, as has been demonstrated in much later times (e.g., Clark, 1954; Street, 1989), are in part a reflection of find distributions that extend into the water-saturated lakeside, while on truly dry land organic preservation is poor. Any base camps or areas of longer occupation must have been located on dry ground in nearby but slightly upland settings that, if preserved at all, have yet to be excavated at Schöningen. Extrapolating from the well-documented kill and butchering events focusing on horses, but occasionally involving bovids, cervids, and a possible bear (Voormolen, 2008), we can safely assume that groups of hominins, not just individuals, were moving across the landscape. We view the many killed animals and butchered carcasses as proof of coordinated, planned group activities and almost certainly of food sharing.

Without data from sites resulting from more long-term use, our null-hypothesis is that these hominins of the Reinsdorf Interglacial were highly mobile but well-equipped and technologically savvy. We also hypothesize that future research areas further from the lakeside will produce evidence for more long-term occupations with a more diverse archaeological signature. Unfortunately, the study of these sites, if they can be found, will not profit from the excellent preservation that characterizes the anaerobic sites from water-saturated sediments. We further hypothesize that successful hunts could only occur through well-coordinated activities and that successful kills of single large prey or multiple animals in one event would provide the subsistence base for social aggregation and high levels of social engagement and communication. Food storage, although not demonstrated, would be a valuable adaptation under such conditions of surplus following kills.

The wealth of botanical materials and diverse remains of small animals indicate the range of potential resources available in the environment, including seeds, fruits, tubers, insects, eggs, and perhaps small mammals, birds, fish, amphibians, and lizards; however, there is currently no evidence for their use. Bigga (2014) argues that the Schöningen locality would have produced abundant botanical food resources that almost certainly contributed to the diet and also drew hominins to the lake. Gathering plants and other resources, however, left few if any archaeologically visible traces. While difficult to prove, these hypothesized activities fit well with our arguments for high mobility in a resource rich environment. The specific nature of sites at which hominins spent more time will remain a matter of speculation until such sites are excavated and empirical data can be found to reconstruct this aspect of the lifeways of the late Middle Pleistocene. The discovery of hominin fossil remains could also open new lines of inquiry into the diet, mobility and social behavior of the Schöningen hominins.

8. Language and social behavior among Middle Pleistocene hominins

The excavations at Schöningen have important implications for debates that continue today about cognitive evolution, cooperative behavior, resource sharing, planning depth, and the evolution of language. The data from Schöningen allow a range of key inferences to be made that have bearing on these questions.

Although many non-hominin species hunt and at times hunt in groups, such as is the case with wolves and hyenas, this behavior is often viewed as mutually beneficial behavior rather than cooperation leading to food sharing (Gittleman, 1989). After a successful hunt, wolves and hyenas typically feed following relations of rank with dominant animals controlling access to the prey. In the case of large prey, animals engage in feeding in parallel in a manner tolerated by the dominant animals.

Systematic studies of non-human primates in the wild and under reproducible experimental conditions also show marked and systematic differences in how human and non-human primates interact. Chimps, for example, in contrast to young children, only engage in joint activities for individual gain and they ignore the needs of other chimps. Tomasello, Warneken, and colleagues (Warneken and Tomasello, 2006; Tomasello et al., 2012; Warneken, 2013; Tomasello, 2014) have repeatedly shown that even young human children have a strong and experimentally reproducible disposition toward true cooperative behavior that is not dictated only by self-interest. Thus, these authors view the rise of shared intentionality and interdependency as key developments toward the evolution of modern humans. These robust patterns raise the question of what evolutionary selective pressures led to the strongly developed predisposition toward cooperative behavior, helpfulness, and sharing. Extrapolating from these observations, we would expect to be able to document the evolution of cooperative behavior in hominins in the archaeological record.

To address these and related questions we can turn to Schöningen. The finds from Schöningen clearly demonstrate a high degree of planning depth in combination with the use of deadly weaponry. The throwing and thrusting spears, as well as the purported throwing stick from the Horse Butchery Site, must have been made well in advance of the execution of the hunts that led to their deposition in the lakeshore environments. The preferred raw material for spears was slow-growing spruce that grew under dry or otherwise unfavorable conditions. The trunk and main stem of these small trees constituted ideal material for making hard and strong spears. The point of the spears was placed off center so the tip would be carved from hard wood with very close growth rings, rather than from the soft center of the tree. Schoch and colleagues (2015) describe the spears in detail and repeatedly point to the fact that they were carefully made. The complexity of the manufacture of the spears has been further documented by Haidle (2006, 2009, 2010) using a cognigram based on her problem-distance solution analysis. We argue that the characteristics of the spears were the result of experimentation, optimization, and the exchange of information within and between generations. More specifically, it is inconceivable that the spears were made in an expedient manner after a group of hominins decided to hunt. The spears almost certainly reflect curated gear, as one would expect for sophisticated and valuable hunting gear. Both the time needed to make a spear, which has been estimated to be a several hours and the fact that small, slow growing spruce trees would not be expected in the near lakeshore environment constitute arguments against claims that the wooden hunting tools reflect expedient gear made on the spot as a result of an immediate need. Were this the case, the target prey would not be available to hunt by the time the hominins made their equipment and geared up.

The far more likely scenario is that these hominins made their equipment well in advance of using it, and curated the hunting weapons beyond the impetus to make them. The manufacture, transport, use, repair, and ultimate discard of these wooden artifacts demonstrates a high degree of planning depth. Gärdenfors and Osvath (2010) have used similar reasoning based on lithic artifacts to argue for a high degree of planning depth during the Early Stone Age. These types of observations suggest that the Schöningen hominins were able to communicate about contexts beyond the here and now and in this regard their technology can be viewed as evidence of linguistic displacement.

Examining the plausible modes of executing hunts of large, fast, and dangerous mammals underlines the high probability that the Schöningen hominins practiced linguistic displacement as well as sophisticated forms of communication. There is as of yet no consensus on the number of horses killed at one time at Schöningen, with some colleagues arguing for perhaps a dozen or more animals (Thieme, 2005, 2007), while others emphasizing the importance of multiple events in the formation of the Horse Butchery Site (Voormolen, 2008; Julien et al., 2015b, Starkovich and Conard, 2015). Nonetheless, we can return to Voormolen's insightful monograph to envision the events that occurred on the shore of the paleolake at Schöningen. Voormolen stresses the difficulty and danger of hunting horses on foot with hand propelled weapons. We agree with Voormolen that a horse cannot be killed easily by spears thrown and thrusted and that wounded horses would be mobile and dangerous until blood loss weakened and eventually killed them. Thus, returning to a spot repeatedly and killing dozens of horses over a relatively short period of time would require highly coordinated groups and highly effective cooperation. This is the kind of cooperative behavior that Tomasello and colleagues (2012; Tomasello, 2014) have suggested is lacking in non-human primates but is well developed in humans—even those of only a few years of age.

Voormolen describes the scene on the lakeshore of the Horse Butchery Site as follows:

> *If surprised and rapidly closed in by a group of hominids equipped with spears, it should be possible to drive the animals into the wet soft lakeshore zone to minimize their mobility. This would have enabled the killing of the horses with the use of multiple spears by throwing and stabbing at close distance, minimizing the risk for the hominid hunters of horse defence attacks. Ambushing a whole horse group at once could explain the presence of multiple horse individuals and the presence of foals which are normally only to be found within horse family groups. It is likely however that multiple horse kill/butchery events are represented in the Schöningen 13 II-4 horse assemblage* (2008:128).

Tomesello (2008, 2014; Tomasello et al., 2012) argues that much can be communicated via gestures and non-verbal signals and that *H. heidelbergensis* lacked spoken syntactical language, including temporal displacement. We hypothesize that the Schöningen hominins likely had still more sophisticated language skills, likely including vocal communication with the ability to convey information about the past, present, and future, as well as spatial relationships beyond those of their immediate surroundings.

We have demonstrated that the Schöningen hominins were on the top of the food chain. Additionally, we argue that they deliberately made effective tools and multiple, well-engineered weapons in advance of their use. The Schöningen hominins carefully planned cooperative hunts in a manner that allowed them to communicate in a dynamic realm of time and space. While much of the communication would have been concrete and would not have necessitated complex syntax, concepts related to the past and future and distant places would be facilitated by spoken language and vocal and verbal formulations reflecting an array of nouns, verbs, prepositions, and descriptive terms. This is not to say that Schöningen hominins had their Shakespeares and Kants, or that their linguistic repertoire fit within the range of modern humans. On the contrary, we first see what we consider as unambiguous evidence for fully modern language with the evolution of modern humans and well-documented assemblages of symbolic artifacts in the Late Pleistocene (Conard et al., 2006; Conard, 2008, 2015). This appearance of fully developed symbolic and syntactical communication helps to explain the spread of modern humans across the globe around 50,000 years ago, while prior to that time multiple hominin taxa competed on a broadly even behavioral and linguistic playing field.

The findings from Schöningen further erode the concept that human use of language with its recursive capabilities is an all or nothing proposition (Hauser, 1996; Hauser et al., 2002). We follow Bickerton (1981, 1990), Gärdenfors (2004, 2013), and others who argue that syntactical communication and language as is known among all living human communities must have developed gradually over the course of human evolution. This being said, there is no reason to assume that this evolution was uniformly gradual, and we speculate that a mosaic pattern of cultural change occurred. Much as has been argued in the context of the debate on the evolution of what has been referred to as "cultural modernity" (Conard, 2008, 2015), language likely did not evolve from a single point source.

When considering the data from the Middle Pleistocene, we view the finds from Schöningen as a particularly strong example for the evolution of effective systems of communication among archaic hominins. The arguments presented above about the evolution of language represent another aspect of the paradigm shifts derived from observations made at Schöningen. From our point of view, archaeological data from the past and the inferences they allow about how hominins lived are particularly important for documenting the cadence and tempo of the evolution of language. Experimental studies today are invaluable for generating data and ideas that can provide insight into the past, but only archaeology and paleoanthropology provide direct observations from the past and are thus uniquely valuable for reconstructing the evolution of language.

As Gärdenfors (2013) points out, the appearance of cooperation and a division of labor in the archaeological record represents a key feature for establishing the rise of syntactic language. He emphasizes the importance of cooperation and indirect reciprocity as valuable indicators for the evolution of language. Moving beyond the skillfully executed cooperative hunts documented at Schöningen, these behaviors have important ramifications for our reconstructions of hominin behavior during the Middle Pleistocene. After the animals or groups of animals were dispatched on the lakeside of Schöningen, hominins systematically butchered the horses, as well as bovids and cervids. Although some details varied, Voormolen has documented similarities and differences in how the hominins processed the carcasses of each of these taxa. Voormolen's (2008) and our work underline the many similarities in the patterns of horse butchering documented by modern humans of the European Upper Paleolithic and in Schöningen.

Sticking to the case of the equids, where the most data and the clearest signal is available, we argue that the kills provide unambiguous evidence for cooperative group activities and coordinated actions of hominins acting rationally to carefully plan and execute their hunts. The successful hunts were not windfalls, but the result of their planning and coordinated action. Given that the success of the hunt proves that these groups of hominins worked together toward shared goals, a pattern of behavior standing in contrast to virtually all non-human primates; the treatment of the carcasses may also follow the same logic of respecting the interests of both the group and the individual. Since the amount of food and other resources provided by even a single adult *Equus mosbachensis* weighing as much as 550 kg would far exceed the needs of an individual hominin, we view these kills and the intense phases of butchery as proof of regular food sharing.

Since it is unlikely that old and young and females and males shared identically in the activities of the hunt or in labor related to working hides and making and using lithic and organic tools, the behavioral signatures documented at Schöningen can also be seen as evidence for a division of labor among the Schöningen hominins. The carefully made wooden artifacts themselves suggest that hominins who were skilled and experienced in this area carved the spears. This craftsmanship also excludes the possibility that they were expediently made by just any hominin. Using ethnographic data as a starting point, O'Connell, Hawkes, and colleagues (O'Connell et al., 1999; Blurton Jones et al., 2000; Hawkes, 2003; Marlowe, 2003) have developed similar arguments in the case of *Homo erectus* and argue that hominin biology and the ethnographic record would argue against the old and slow, the young and vulnerable, and pregnant woman or breastfeeding mothers participating in the most dangerous aspects of hunting large game (but see Kuhn and Stiner, 2006). In the case of Schöningen, multiple members of the group likely profited from the successful hunts via the sharing of meat, marrow, hides, and other valuable resources. Such food sharing constitutes a pattern of behavior radically different than the mutually beneficial tolerated feeding among carnivores who engage in group hunting and competitive feeding following the kill. As with the evolution of language, we hypothesize that evolution of a division of labor and its ramifications (Durkheim, 1997 (1893)) did not reflect an all or nothing proposition, but rather a mosaic pattern of vectored change over hundreds of thousands, if not millions of years. By the time of the Schöningen hominins, this process was well on its way toward that of modern hunters and gatherers (Kelly, 2013).

9. Conclusions

Sometimes theoretical developments and the dynamics of academic discourse drive our views of human evolution. Other times discoveries and new empirical observations in the field or laboratory lead to shifts in our understanding of the past. The work at Schöningen represents a case of the second phenomenon. The finds from the Horse Butchery Site brought the debate about hunting versus scavenging among late archaic hominins and analogous arguments about the purportedly primitive behavior of *H. heidelbergensis* and Neanderthals to an abrupt end. Work under H. Thieme's lead and the ongoing research of the current team demonstrate that the Schöningen hominins used sophisticated artifacts made from botanical and faunal materials in addition to lithic artifacts more typically recovered at Lower Paleolithic sites. The finds from the famous Horse Butchery Site at Schöningen and two dozen other archaeological horizons provide many new insights into the technology and behavioral patterns of hominins on the Northern European Plain about 300 ka BP. An analysis of the finds from Schöningen and their contexts shows that the inhabitants of the site were highly successful hunters at the top of the food chain and exhibited a high level of planning depth and cooperative behavior. These hominins had command of effective language skills about the here and now, the past and the future, and about distant spatial relationships that allowed them repeatedly to execute well-coordinated and successful group activities that likely culminated in a division of labor and social and economic patterns radically different from those of all non-hominins and well on the way to behavior similar to that of living people today. The unique conditions of preservation and high quality excavation has led to a major paradigm shift, or "Schöningen Effect," that changed our views of human evolution during the late Lower Paleolithic. All else being equal, we can view the behaviors documented at Schöningen as a plausible baseline for the behavioral sophistication of late *H. heidelbergensis* and subsequent archaic hominins.

Ongoing excavations at Schöningen and continuing laboratory work will serve to test these arguments and will provide a more refined view of this key phase of hominin evolution prior to the rise of modern humans. We hope with this special issue of JHE dedicated to the research at Schöningen to have made a broad range of

information on this uniquely important locality available to a wide audience. We hope this work will stimulate debate and critical assessment of models for human evolution.

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