

Site formation and faunal remains of the Middle Pleistocene site Bilzingsleben

Fundplatzgenese und Faunarestes der mittelpleistozänen Fundstelle Bilzingsleben

Werner MÜLLER^{1*} & Clemens PASDA^{2*}

¹ Laboratoire d'archéozoologie, Université de Neuchâtel, Avenue de Bellevaux 51, CP 158, CH – 2009 Neuchâtel

² Bereich für Ur- und Frühgeschichte, Universität Jena, Löbdergraben 24a, D – 07740 Jena

ABSTRACT - Bilzingsleben is internationally known as a palaeontological, palaeoanthropological and archaeological reference site of a Middle Pleistocene Interglacial (Holstein). From 1969 until 2003 Dietrich Mania excavated almost 1800 m² and retrieved several tons of faunal material which he interpreted as remains of human hunting. In order to confirm this interpretation, three areas were excavated between 2004 and 2007. The aim of the present study is to add to an understanding of the site formation processes by an analysis of the stratigraphy and taphonomy of the faunal remains of these recent excavations. In addition, the already published results of the faunal investigations of the former excavations were assembled and are presented.

The stratigraphic relationships of the former excavation were confirmed. In addition, the relative abundance of the different species is very similar for the former and recent excavations, with the predominance of rhinoceros and red deer, followed by beaver and bear with significantly fewer remains, while bovid, horse and elephant remains are very rare. Also very rare are bird and fish remains, while mid-sized mammals are absent. The frequencies of the skeletal elements demonstrate, at least for the two dominant species, that all elements were present and became incorporated into the find-bearing layer. Traces on the surfaces of the bones that, according to their morphology and position on the bones, must be identified as human-made cut-marks, are very rare. Taken together this indicates that the faunal remains have to be considered as natural components of the Interglacial palaeo-landscape. However, incorporated in the find-bearing layer are also local stones including flint, as well as pre-Pleistocene ostracods and fish remains. This means that parts of still older sediments were also reworked. The non-selective recovery and three-dimensional recording of all faunal remains during the recent excavations revealed a vertical distribution of over 1 m in depth, independent of animal species and size. Furthermore, in areas where the find-bearing layer is inclined the obliquely embedded elements show a preferred orientation towards the slope of the layer. This all points towards an embedding of the faunal remains under the influence of fluvial, terrestrial and limnic processes.

ZUSAMMENFASSUNG - Die Steinrinne bei Bilzingsleben ist eine international anerkannte Referenzfundstelle für die Paläontologie, Paläoanthropologie und Archäologie eines mittelpleistozänen Interglazials (Holstein). Von 1969 bis 2003 grub Dietrich Mania fast 1800 m² der Fundstelle aus und barg dabei mehrere Tonnen Tierknochen, die er als Reste menschlicher Jagd interpretierte. Um diese Interpretation zu überprüfen wurden von 2004 bis 2007 an drei Stellen der Steinrinne Ausgrabungen durchgeführt. Ziel der hier vorgelegten Arbeit ist es, einen Beitrag zum Verständnis der Fundplatzgenese zu leisten, und zwar sowohl anhand der stratigraphischen als auch taphonomischen Verhältnisse der geborgenen Faunarestes der neueren Grabungen. Darüber hinaus werden die bereits publizierten Ergebnisse der Faunauntersuchungen der älteren Grabung zusammenfassend dargestellt.

Die stratigraphischen Verhältnisse der älteren Grabung ließen sich bestätigen. Ebenso entsprechen die Häufigkeiten der Tierarten der neueren Grabungen denjenigen der Grabung von 1969-2003. Es dominieren Nashorn und Rothirsch, gefolgt von Biber und Bär mit geringeren Anzahlen, während Rind, Pferd und Elefant selten auftreten. Mittelgroße Tierarten fehlen, Vogel- und Fischreste sind sehr selten. Die Häufigkeiten der Skelettelemente belegen, zumindest für die dominierenden Tierarten, Nashorn und Hirsch, Vorhandensein und Einbettung aller Körperbereiche in die Fundschicht. Oberflächenveränderungen, die aufgrund ihrer Form und Lage als Schnittspuren zu interpretieren sind, sind sehr selten. Dies alles spricht dafür, die Faunarestes vor allem als natürliche Bestandteile der interglazialen Landoberfläche anzusehen. Im Fundhorizont sind mit den Tierknochen zahlreiche lokale Steine und Feuersteine sowie prä-pleistozäne Ostrakoden und Fischknochen vergesellschaftet. Das heißt, auch Bestandteile aus zum Teil älteren Sedimenten der Paläolandschaft kamen hier zur Ablagerung. Die nicht-selektive Bergung und dreidimensionale Einmessung aller Tierknochen der neuen Grabung belegen eine vertikal bis 1 m hoch streuende Verteilung von Knochen unabhängig von Größe und Tierart. Zugleich sind die Knochen in schräg gestellten Fundhorizonten deutlich eingeregelt. Dies spricht für eine Einbettung der Faunenreste im Fundhorizont durch unterschiedliche fluviale, terrestrische und limnische Prozesse.

KEYWORDS - Middle Pleistocene, Interglacial, site formation, taphonomy, *Homo erectus* Mittelpleistozän, Interglazial, Fundplatzgenese, Taphonomie, *Homo erectus*

*corresponding authors:

werner.mueller@unine.ch; clemens.pasda@uni-jena.de

Introduction

The site of Bilzingsleben has gained international renown due to its interpretation as a Lower Palaeolithic base camp on the shore of a travertine forming lake with huts inhabited over several years with hearths and an artificial pavement, more than 100 000 flint artefacts including small tools and pebble tools, modified bones and bone tools, and evidence of large mammal hunting and the ritual use of human skulls (e.g. Mania & Mania 2005). This interpretation has been challenged since the early 1990s (e.g. Becker 2003: 84; Davidson 1990; Gamble 1999: 159, 161; Gaudzinski 1998: 199; Kolen 1999: 144-145; Orschiedt 1999: 60; Steguweit 2003; Stopp 1997: 41-43, 46; Vollbrecht 2000; White & Plunkett 2004: 155). Alternative interpretations, however, have been hampered by a lack of data necessary to understand site formation processes and site integrity. It became evident that only new excavations would yield the required information. Following a reassignment of the scientific direction of the site to the chair of prehistory of the University of Jena, new fieldwork started in 2003, with excavations carried out in 2004, 2005 and 2007.

The present publication has several aims. First, to present the results of the archaeozoological and taphonomic analysis of the faunal remains of the new excavations; secondly, to assemble the results of archaeozoological and palaeontological studies of the faunal material of the older excavations that have been already published in several articles and monographs and are sometimes not easily accessible, and, thirdly, to incorporate these results into an analysis of site formation processes and to compare them with the results from other disciplines.

The site *Steinrinne* at Bilzingsleben

The *Steinrinne* is a Quaternary travertine deposit 1 km south of the village of Bilzingsleben (district of Sömmerda, federal state of Thuringia, Germany; Fig. 1). The name *Steinrinne*, which may be translated as "gully in a rock", possibly derives from an artificial, path-like channel present until the mid-19th century. The research history of the *Steinrinne* has already been published in detail by Toepfer (1980) and is closely linked to the exploitation of the hard travertine rock that was quarried at least since high medieval times. Because of the presence of animal bones and plant remains, the *Steinrinne* became a well-known geological research area in the late 19th and early 20th century. With the end of World War II, travertine quarrying ceased and the area became heavily overgrown by vegetation. In the late 1960s, Dietrich Mania studied Pleistocene stratigraphy and ecology by investigating several Quaternary deposits between the rivers Elbe and Saale (Gramsch 2003). While doing fieldwork he came to the *Steinrinne* in August 1969 and recognized its potential for more extensive

investigation. He started excavations officially in 1971 as part of the scientific research of the State Museum of Prehistory at Halle/Saale (Grünberg 2002). With the discovery of the first specimen of the oldest human fossil in Central Germany, the *Steinrinne* became a well-known "Lower Palaeolithic travertine site" (Mania 1974: 157), where research was headed by Dietrich Mania for more than three decades (Gramsch 2003). The results of research by Dietrich Mania and his colleagues on palaeontology, palaeobotany, anthropology and archaeology were published in several monographs and numerous articles (references in Mania & Mania 2001), producing "one of the most detailed accounts we have of a Holsteinian Interglacial locale" (Gamble 1999: 155).

Chronological setting

Palaeontological evidence, e.g. rodents (Heinrich 2000), large mammals (e.g. van der Made 2000), molluscs and flora (Mania & Mai 2001) indicate that the Bilzingsleben sediments were deposited during a Middle Pleistocene Interglacial. According to biostratigraphy (Heinrich 1998, 2000, 2004a, 2004b; Maul & Heinrich 2007; but see Escudé et al. 2008), Bilzingsleben is younger than the Cromerian and Elsterian complexes but older than the Saalian complex. Absolute age estimates vary between 420-350 ka (Mania & Mai 2001: 80) and 250-200 ka (Eissmann 1997: fig. 30). The correlation with global environmental records ranges from older than OIS 11 (Mallick 2001) to OIS 11 (Bridgland et al. 2004; Jöris & Baales 2003: Anm. 3; Steguweit 2003: 29), to OIS 11/9 (Gamble



Fig. 1. Location of middle Pleistocene site Bilzingsleben.

Abb. 1. Lage der mittelpleistozänen Fundstelle Bilzingsleben.

1999: Tab. 4.3) and to OIS 9/7 (Eissmann 1994: 85). According to recent ostracod analysis (Daniel & Frenzel 2010), mean temperatures during this mid-Pleistocene Interglacial were slightly above those of today: in July between +16 and +20 °C (mean: +18 °C), in January between -7 and +4 °C (mean: +0.5 °C). During that time, the area was situated near the (now completely eroded) slope of the former valley of the river *Wipper*.

The recent excavations (2004 - 2007)

Figure 2 depicts the different excavation areas, with the approximately 1800 m² excavated during the years 1969 through 2003 by Dietrich Mania at the centre. The blue region is the part of the supposed pavement that has been conserved and is now protected by an exhibition hall. For the recent excavations, carried out in 2004, 2005 and 2007, three areas were chosen: area A is situated at the supposed living-floor at the lake shore, area B in the supposed fluvial fan deposits, and area C near the supposed travertine spring. Field methods were those proposed by Joachim Hahn (1989), where the excavation follows the curvature of geological horizons with three-dimensional recording of each find. Dry sieving was performed for units of ¼ m² of approximately 3 cm depth.

Geological features

Research on the geological texture and genesis of the find horizon is not yet completed but some results can already be presented here (Beck et al. 2007; Daniel & Frenzel; Vökler 2009): in all three areas, the find horizon extends over a depth of 80-100 cm and is situated on top of a silty layer and below coarse (areas A and C) or fine travertine clasts (area B). These layers had been covered by several meters of travertine rock, which was removed during the century long quarrying activities. The higher the excavation area is situated, the more pronounced is the inclination of the geological layers as well as the orientation and the dip of the finds (Fig. 3). In all three areas the find horizon is characterized by a huge amount of rock clasts generally of 3-4 cm length. Single rocks of up to 50 cm diameter as well as bones and wood fragments of more than 40 cm length occur as well. The amount of travertine increases towards the former mid-Pleistocene valley floor (area A). The proportion of Muschelkalk increases towards the former valley slope (area C). The numbers of flint, quartz and other rocks, which stem from local fluvial and glacial sediments, are highest at the centre of the excavated area (area B).

Area A

At area A, the find horizon (see Fig. 8: GH 12 and 13) is comprised of fine sand with lenses of pure carbonatic sands. Ostracod analysis does not reveal any internal stratification but a mix of species indicates both fresh-water sources in the lowermost part and dominant lake-like environments above. Furthermore, mixing

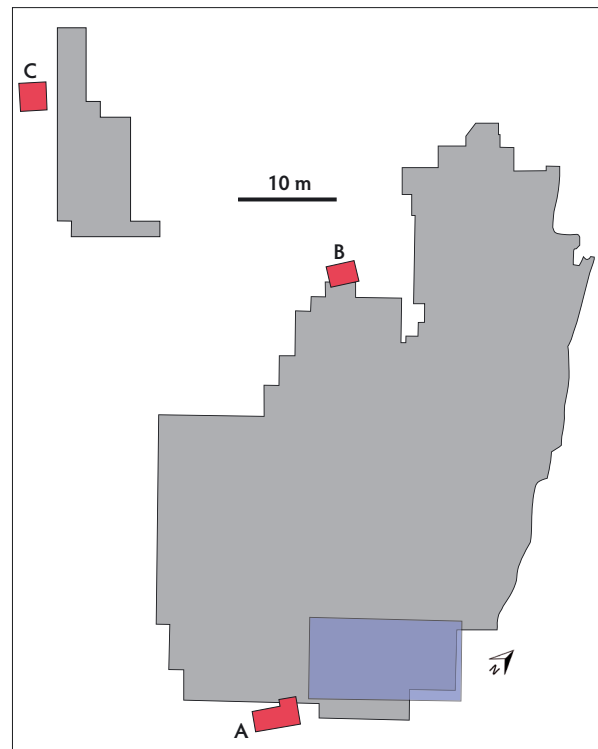


Fig. 2. Excavation areas. grey: areas excavated from 1969-2003; red: areas A, B & C excavated from 2004-2007; blue: part of the supposed pavement that has been conserved and is now protected by an exhibition hall.

Abb. 2. Grabungsflächen. Grau: Flächen ausgegraben von 1969-2003; Rot: Flächen A, B & C, ausgegraben von 2004-2007; Blau: Teil der vermeintlichen Pflasterung, welcher heute von einer Ausstellungshalle überdacht ist.

with older layers is possible as single Mesozoic species were found and single ostracod valves occur in lenses of pure carbonatic sands. Concerning the mollusc fauna, area A is distinct from the other areas: fragmentation is much lower (47%), species representation much higher (n=34), presence of terrestrial species very high (n=20) and the presence of water-loving species elevated (n=14). In general, the number of individuals is high, in particular in the

	area A	area B	area C
surface area	10 m ²	6 m ²	9 m ²
height above sealevel	165.25 m	165.50 m	167.50 m
vertical find distribution	80-100 cm	80-100 cm	80-100 cm
inclination of geological horizons	none	present	strong
orientation of finds	none	present	strong
number of rocks per m ²	~3080	~3020	~1930
amount of travertines	96%	40%	12%
amount of Muschelkalk	<1%	13%	68%
amount of flint	4%	38%	15%
amount of quartz	<1%	6%	4%
amount of other rocks	<1%	3%	1%
presence of wood	rare	none	none

Fig. 3. Characteristics of the find horizon at Bilzingsleben.

Abb. 3. Merkmale des Fundhorizonts von Bilzingsleben.

upper part of the find horizon. Mollusc species indicate a predominant sedimentation from fresh-water sources but there are also species present with a preference for forested as well as open, steppe-like environments. In the lowermost part of the find horizon of area A, only fragmented mollusc shells are found. Therefore, sedimentation in this part must have been more turbulent, indicating that no living-floor was present on top of the silt. The presence of wooden fragments, compacted to ~1 mm thickness, may be an indication of pool conditions with supply of running water.

Area B

At area B, the find horizon can be divided into a lower (see Fig. 13: GH 3) and an upper part (Fig. 13: GH 2). The lower part consists of poorly sorted sands with a high amount of quartz and other minerals. This lower part is further characterized by equal amounts of mollusc species from fresh-water source, open and forested habitats. Ostracod species indicate its accumulation by fluvial processes. In contrast, the upper part of the find horizon consists of fine sand. Various ostracod species indicate its accumulation in a lake-like environment with salty water which may derive from outwash of local Triassic sediments. With the exception of the uppermost part, Mesozoic ostracods and foraminifera are present in the whole find horizon which indicates the incorporation of older, pre-Pleistocene sediments.

Area C

At area C, the basal part of the find horizon (see Fig. 18: GH 5) is characterized by many large Muschelkalk slabs, in contrast to the upper part of the find horizon where sand dominates (Fig. 18: GH 4). From the ostracod analysis, area C is similar to area B. Molluscs are rare in the find horizon, but fresh-water loving molluscs are the most obvious just above the find horizon. In contrast to area A, molluscs remains are much more fragmented in areas B and C (80-85%), species representation is much lower there (16 and 21 species), presence of terrestrial species is very low (5 and 9 species) and presence of water-loving species is lower (11 and 12 species) as compared to area A.

It is too early for a concluding interpretation of these data since micromorphological analysis of sediments is still ongoing. However, as the general stratigraphy of areas A-C does not differ from the area excavated in 1969-2003 (Mania & Altermann 2004), the preliminary interpretation presented here may be representative for the whole *Steinrinne*: the characteristics, i.e. the vertical chaotic mixing of large and small clasts (rock, bone, wood) of local origin as well as of pre-Pleistocene deposits, with significant orientation and dip in areas B and C, point to a natural accumulation of former parts of older sediments and of palaeo-land surfaces.

Faunal remains from the recent excavation

Introduction to the zooarchaeological data

The aim of the present archaeozoological study is to contribute to an understanding of the site formation processes. As a consequence, emphasis was put on certain aspects of archaeozoological analysis while others were of minor interest. Approximately 2 600 bone fragments with a total weight of 63 kg were collected from areas A, B and C (Fig. 4). All bones have been treated with Mowilith (Kremer Pigmente GmbH, D-88317 Aichstetten) and have absorbed different amounts of this consolidating liquid. However, the weight of this product after drying in relation to the weight of the bone or tooth itself is estimated to be less than 5%. Since the analysis is not to be based on the weight of the material for most aspects, this effect should be negligible. The numbers given in the following chapters represent the number of fragment units as assigned during the excavation (Hahn 1989: 151). Some of these units may comprise up to 100 small fragments (e.g. collected finds from dry-sieving per quarter square metre of 3 cm depth) while others may represent one large single bone or tooth. In case that different skeletal elements or different species were identified in these fragment units, sub-numbers were attributed and the sub-units were treated separately. The greatest length and width of the remains have been recorded and the elongation index (length/width=LB-Q) calculated. For the obliquely oriented remains, the lower end has been taken as the "tip" of the object. The orientation has been checked for the different elongation indices, assuming that the more elongated objects would yield more significant results. However, due mostly to the small numbers, this was not apparent, for which reason in the present elaboration, all objects with an index larger than 1.5 are portrayed together.

When taking into account that during the 1969-2003 excavations several tons of faunal material (Mania 1990a: 180) were collect from 1 770 m² (Mania & Altermann 2004: 151) it becomes understandable that the 63 kg of bones from 26 m² of the recent excavations are not likely to yield "new" information in terms of represented species, their systematic affiliation and evolution, their morphology, size, or other

	area A	area B	area C	total
m ²	12	6	8	26
number (n)	480	1880	204	2564
weight (g)	12425	39856	10416	62697
g/n	26	21	51	24
n/m ²	40	313	26	99
g/m ²	1035	6643	1302	2411

Fig. 4. Faunal remains of the different excavation areas.

Abb. 4. Faunamaterial der verschiedenen Grabungsflächen.

palaeontological questions. Some of these aspects have been treated for various species by several authors (Böhme 1998, 2001, 2004, 2009; Fischer 1991a, 1991b, 2004, 2009; Fischer & Heinrich 1991; Guenther 1991; Hebig 2003; Heinrich 1991, 1998, 2000, 2004a, 2004b; Mania 1986a, 1986b, 1991, 1997; Musil 1991a, 2000, 2002; Toepfer 1983; Turner 2004; van der Made 1998, 2000; Vlček 2003; Vollbrecht 2000). Also for the reason of sample size it was expected that species represented by only a few fragments in the 1969-2003 excavations were unlikely to be found in the recent excavation.

The texture of the bone fragments, which might be to some extent indicative of preservation conditions, is very similar for the three areas. The bones are of a light grey colour with the surface in many cases perfectly intact, in other cases with various degrees of corrosion. However, there is no correlation of corrosion to any particular area. Also, the degree of fragmentation appears to be quite similar for area A and B, with 26 g average weight for area A, and 21 g for area B, but almost double of that for area C with an average weight of 51 g (Fig. 4). However, this higher value is likely due to a few large fragments from the elephant among a relatively small number of fragments over all (see Fig. 11), which is demonstrated by a very high standard deviation. These observations make it likely that preservation conditions do not vary significantly between the different areas. However, the three excavation areas showed different find densities (Fig. 4): Area B, with more than 300 fragments and approximately 7 kg per square metre is the richest area. In contrast, areas A and C yielded only 40 fragments with 1.0 kg, and 26 fragments with 1.3 kg per square metre, respectively. Since the preservation conditions appear to be comparable for the three areas, this difference indicates that the amount of bones at the time of the embedding had been different for the three areas.

Presentation of faunal data per area

In the following description, the three areas are depicted separately by the number of identified specimens and weight of the different faunal categories. The fragments were assigned to the different categories according to the following procedure: fragments were assigned to a particular species only if the fragments could be exactly positioned at the respective skeletal element. Otherwise they were assigned to the different size classes, i.e. "elephant-rhino"=m1 (=Mammal1), "horse-bovid"=m2 (=Mammal2), "elephant-rhino-horse-bovid"=m1+2, "small ungulate"=m3 (=Mammal3), and "Mammalia indet."=m4 (=Mammal4) in order to give a more complete picture of the amounts of remains (Brain 1974, 1981). Bone fragments attributed only to size classes were not determined to bone type, e.g. long bone, flat bone, etc., although this information could be useful to characterize MNE profiles (Marean et al. 2004: 70). However, due to the low number of

fragments of the assemblage, this analysis would not yield significant results. For the purpose of the present investigation the numbers of identified specimens of species will be sufficient to characterize the *Steinrinne* fauna. Although some clear impact marks have been recorded, no exhaustive attempt was made to differentiate intentional versus natural fracture (Villa & Mahieu 1991). Furthermore, each bone was examined under the stereomicroscope for possible cut marks and other traces on their surface (see below).

In the enormous material of the earlier excavations, the presence of the two rhinoceros species *Stephanorhinus hemitoechus* and *S. aff. kirchbergensis* had been demonstrated by van der Made (2000). An unequivocal determination is possible on some of the teeth present in the material of the new excavation: of the four specimens of P₂, one can be attributed to *S. hemitoechus* and three to *S. aff. kirchbergensis*. However, for the sake of brevity, both species are treated together in the present study. The same applies for the two species of beaver, *Castor fiber* and *Trogotherium cuvieri*, which are present at different frequencies among the remains from the older excavations (Fischer 1991a; Heinrich 1991, 2004a, 2004b), and which will be treated here together.

Area A

At area A two thirds of all bones are represented by fragments which are too small to be determined (Fig. 5). 13% of the bones were only determined to size categories. These mostly larger fragments represent animals of elephant, rhinoceros, horse or bovid size. Looking at the species spectrum (Fig. 6) it may be argued that most of the 2.7 kg of remains of the category m1 should be attributed to the rhinoceros as well, and likewise for the 1.1 kg of the category m1+2. The rhinoceros *Stephanorhinus kirchbergensis/hemitoechus* dominates both in numbers and weight. As argued above, interpretation of size classes may reinforce the dominance of the remains of the rhinoceros for this area. Only red deer with 23

	NISP	%	weight (g)	%
rhinoceros	42	8.7	2621.1	21
red deer	23	4.8	1365.3	11
beaver	21	4.4	55.1	0.4
bear	6	1.3	110.9	0.9
elephant	1	0.2	5.1	0.04
determined by species (total)	93	19.4	4157.7	33.5
size class m1 (elephant-rhino)	11	2.3	2703.0	21.7
size class m1+2 (ele-rhi-bovid-horse)	56	11.7	1147.0	9.3
determined by size (total)	67	13	3850.0	31
indet. (total)	320	66.6	4417.3	35.5
total	480	100	12425.0	100

Fig. 5. Area A: Relative abundance of species and size classes.

Abb. 5. Fläche A: Relative Häufigkeiten der verschiedenen Tierarten und Größenklassen.

	rhinoceros		red deer		beaver		bear		elephant	
	NISP	weight (g)	NISP	weight (g)	NISP	weight (g)	NISP	weight (g)	NISP	weight (g)
Os cornu			13	1197						
Cranium							2	100		
Dentes max.	2	211	1	2	6	8	1	3		
Mandibula	1	120			1	5				
Dentes mand.	4	219	1	0	1	5				
Dentes indet.	25	71	2	1	9	7	1	2	1	5
Costae	1	11								
Scapula	2	1280								
Humerus			1	70						
Radius			1	64						
Ulna			1	10						
Os coxae	4	1829			1	3				
Femur					2	20				
Tibia	1	100								
Calcaneus	1	26			1	8				
Metatarsalia princip.			1	15						
Metapodium princip.			1	5						
Phalanx prox.							1	2		
Phalanx media	1	35					1	5		
Sesamoideum			1	2						
Total	42	3901	23	1365	21	55	6	111	1	5

Fig. 6. Area A: NISP and weight per skeletal elements and species.
 Abb. 6. Fläche A: Anzahl und Gewicht der Skelettelemente pro Tierart.

fragments and beaver with 21 fragments are represented by considerable numbers. Just one more species is present with a few bones, namely bear with six fragments. The elephant is represented by just one tooth fragment.

Regarding the numbers and weight of the different skeletal elements (Fig. 6) several features become apparent: for the rhinoceros, teeth are largely over-

represented, with 32 pieces out of a total of 42. However, only two upper and four lower teeth were complete enough to be determined, beside 25 fragment units (made up of 73 individual fragments). The remaining postcranial fragments come from axial as well as upper and lower limb portions, but clearly the numbers are too small to be interpreted. For the red deer, 13 pieces of antler make up more than 80 %

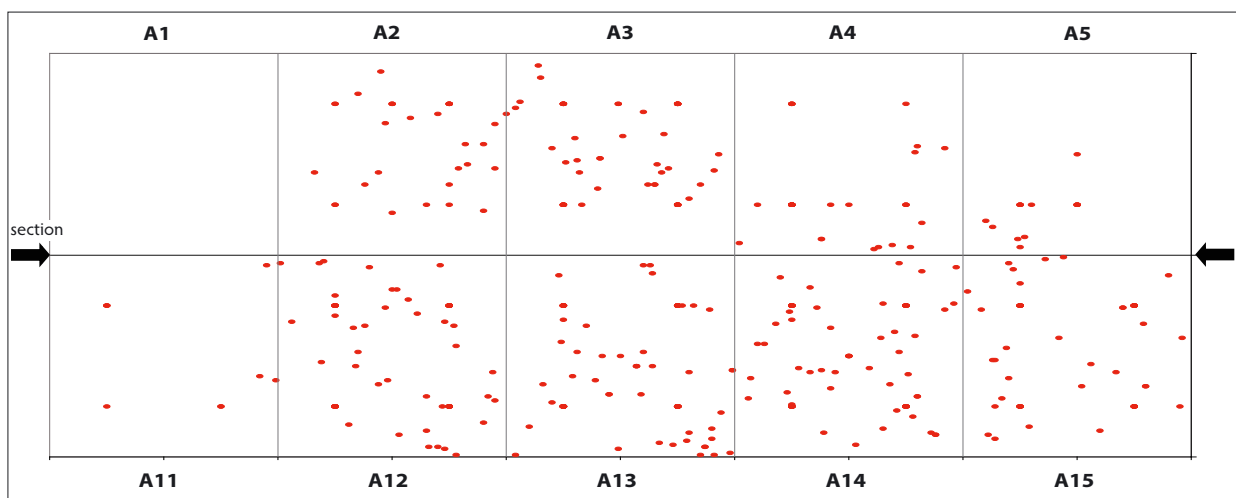


Fig. 7. Area A: Horizontal distribution of faunal remains.
 Abb. 7. Fläche A: Horizontale Verteilung der Faunareste.

of the weight of all deer remains. Of these, one piece is a fragment of a shed antler that alone accounts for 900 g. The postcranial elements of the red deer represent portions from upper and lower limbs, but again, the numbers are too small to be further interpreted. For the beaver, teeth remains represent the largest portion of the entire NISP as well (17 of 21), and, as already stated above, elephant is represented by one (small) tooth fragment only. The overrepresentation of teeth remains represents a so-called head dominated or Type II assemblage (Marean et al. 2004). This pattern is commonly a result of "(1) a combination of taphonomic factors that selectively destroy bone portions based on relative density and (2) analytical procedures that subsequently selectively bias against those same bone portions" (Marean et al. 2004: 69).

This is certainly also the case for the present assemblage, with 320 bone fragments (Fig. 5) being too small to be determined to species and the well-known ease of identification of even small fragments of teeth to species as well as their good preservation (Lyman 1994: 80).

Spatial distribution of the faunal remains

The horizontal distribution of the faunal remains does not show any particular concentrations (Fig. 7). In the square metres A1, A11 and to some extent A5, the number of finds diminishes greatly due to the disappearing find-bearing layer (see Fig. 8). The vertical distribution of the faunal remains has been projected onto the profile of square meters A1/A11 through A5/A15 (Fig. 8a & b). Their distribution within

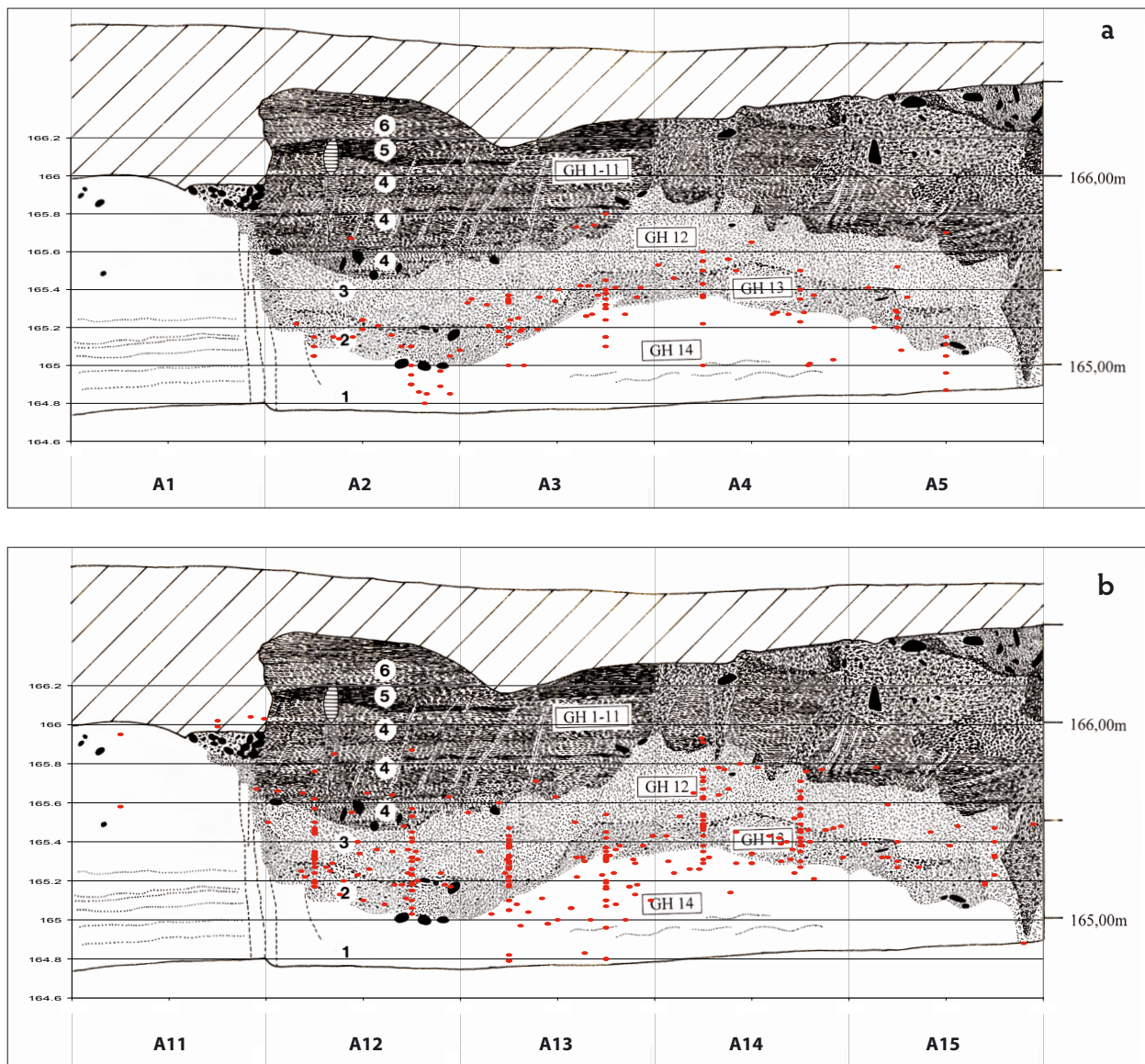


Fig. 8. Area A: Vertical distribution of faunal remains of square metres a) A1-A5, and b) A11-A15, projected onto the stratigraphy section (see Fig. 7).

Abb. 8. Fläche A: Vertikale Verteilung der Faunarestes der Quadratmeter a) A1-A5, und b) A11-A15, projiziert auf das Profil (siehe Abb. 7).

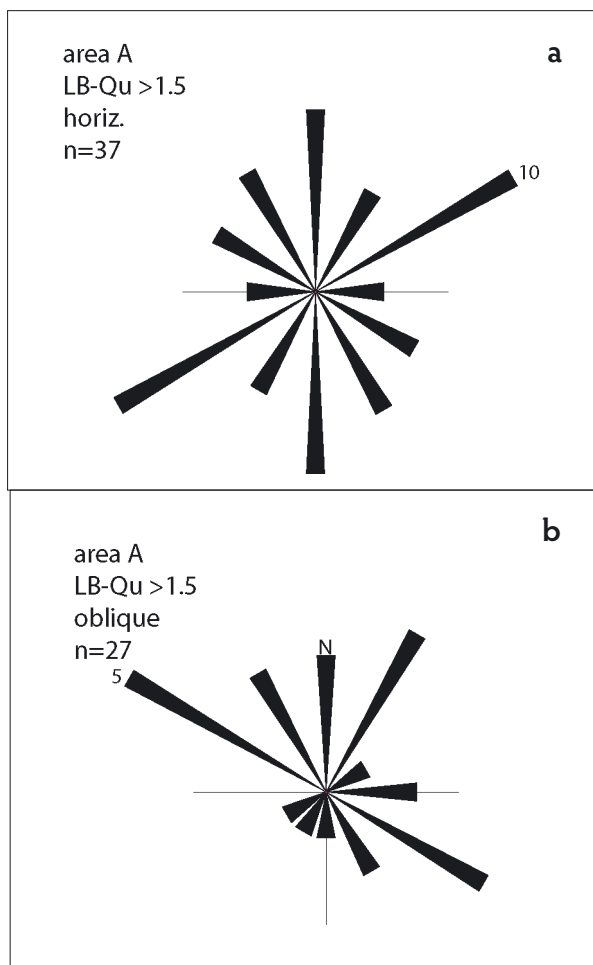


Fig. 9. Area A: Orientation of a) horizontally and b) obliquely embedded faunal remains. Note that for the horizontally embedded bones, one half of the diagram is mirror imaged.

Abb. 9. Fläche A: Orientierung der a) waagrecht und b) schräg eingeregelteten Faunaresten. Bei den waagrechteten Knochen ist eine Hälfte des Diagramms gespiegelt.

a relatively large band of sediment of up to 1 m in depth becomes evident. This is in agreement with the vertical distribution of the other find categories (Beck et al. 2007: figs. 4 & 5). The vertical distribution of the faunal remains has been checked also for each species and size class separately, but without any apparent differences. The view of a living floor of an occupation event of several years seems difficult to reconcile with this find distribution.

The analysis of the orientation of the objects shows that the remains lying horizontally clearly do not show a preferred direction (Fig. 9a), which was to be expected. Even though the obliquely embedded ones (Fig. 9b) do not show a significant orientation it is nevertheless apparent that south-western directions are underrepresented. Yet, it has to be kept in mind that the number of fragments (27 in the case of the obliquely embedded ones) is very low.

Area B

Area B has yielded the richest assemblage with 1 880 fragment units weighing almost 40 kg (Fig. 10).

As in area A, bones of red deer and rhinoceros dominate and bear, beaver and elephant are present. There are some differences to area A; i) small undeterminable bone fragments are less frequent, ii) some (small) bone fragments of horse are present, iii) some (heavy) bone fragments of a bovid are present, and iv) two teeth from a fish, the tench (*Tinca tinca*), and one phalanx from a bird, probably a large raptor (Accipitridae) are present as well. A large part of the 8.4 kg of the size-category m1 may also be attributed to the rhinoceros. Most part of the 4.8 kg of the category m1+2 ought to be attributable to the rhinoceros and the bovid.

For most species, the teeth form the largest part in terms of numbers of remains (Fig. 11), which is similar to area A. Accordingly, area B also has to be considered a "Type II assemblage". In terms of weight, however, teeth are not overrepresented: teeth of elephant (18%), rhinoceros (20%), beaver (25%) and bear (36%) are represented by low weight percentages. Only the very small numbers of horse remains show equality between teeth and postcranial bones both in numbers and weight. By contrast, red deer is dominated by postcranial bones (50% of all remains, representing 33% by weight) and antler (30% of all bones, representing 64 % by weight). No teeth, but cranial parts and postcranial bones of bovid were found. Nonetheless, it can be repeated what was already apparent for the area A: bones of all body regions are present, and for species with numerous fragments, like the red deer, even most of the skeletal elements (cranial parts, vertebrae, upper and lower limb bones) are represented.

Spatial distribution of the faunal remains

The horizontal distribution of the faunal remains displays a rather homogenous scattering of the finds (Fig. 12). The vertical distribution is spread again over

	NISP	%	weight (g)	%
red deer	196	10.4	5368	13.5
rhinoceros	177	9.5	5585	14
bear	55	2.9	711.4	1.8
beaver	46	2.4	145.3	0.4
elephant	24	1.3	406.6	1
bovid	12	0.6	2512.7	6.3
horse	9	0.5	291.5	0.7
Fish	2	0.1	0.2	-
Bird	1	0.1	0.5	-
determined by species (total)	522	27.8	15021.2	37.7
size class m1 (elephant-rhino)	427	22.7	8423	21.1
size class m1+2 (ele-rhi-bovid-horse)	73	3.9	4895	12.3
determined by size (total)	500	26.6	13318	33.4
indet. (total)	858	45.6	11516.8	28.9
total	1880	100	39856	100

Fig. 10. Area B: Relative abundance of species and size classes.

Abb. 10. Fläche B: Relative Häufigkeiten der verschiedenen Tierarten und Größenklassen.

	red deer		rhino		bear		beaver		elephant		bovid		horse	
	NISP	weight (g)	NISP	weight (g)	NISP	weight (g)	NISP	weight (g)	NISP	weight (g)	NISP	weight (g)	NISP	weight (g)
Os cornu	58	3453.5												
Cranium	4	141	3	179	4	147					2	58.7		
Dentes max.	9	30.5	5	380	8	78	10	17.6	2	16.2			2	48
Mandibula			7	1305	1	15.7								
Dentes mand.	18	59.3	3	78	4	81.7	7	10.2	1	6.9			2	94
Dentes indet.	12	15	134	627.5	12	95.8	13	8.3	20	48.5			1	0.5
Alv. (mand./max.)			2	35.5										
Vert. cervicales	1	6			1	20							1	17
Vert. thoracicae	2	37.5									1	208		
Vert. lumbales	1	1					1	5			1	44		
Vert. sacrales	1	37.6												
Vert. caudales							1	4.5						
Vert. indet.			2	67										
Costae	1	1.7					1	0.5			1	41		
Os penis					1	6.5								
Scapula	1	33.4	1	50										
Humerus	3	206			1	45	2	3.5	1	335				
Radius	5	136											1	38
Radius-ulna	1	5												
Ulna	3	59	1	102	1	34					1	177		
Carpalia	4	78	2	86	1	2.7					1	61	1	21
Metacarp. princip.	9	92			2	24.8								
Os coxae	6	185.9	1	555			1	13			1	847		
Femur	2	63.7	2	1332	1	36.5	3	65.6			1	245	1	73
Tibia	6	173.8	1	316			2	11.7			1	625		
Talus	2	77.8												
Calcaneus	2	46.7			2	99.7								
Tarsalia	1	4.4			1	1.8	1	0.2			1	166		
Metatars. princip.	30	330.7	1	285			2	3						
Metapod. princip.	6	56.4	2	70	1	1	1	1.7						
Phalanx prox.	3	12.2			4	21.2					1	40		
Phalanx media			3	174.5										
Phalanx distalis	3	21.4	4	74.5			1	0.5						
Phalanx indet.			1	11										
Sesamoideum	2	2.5	3	42										
Total	196	5368	178	5770	45	711.4	46	145.3	24	406.6	12	2512.7	9	291.5

Fig. 11. Area B: NISP and weight per skeletal elements of species (without fish and bird).

Abb. 11. Fläche B: Anzahl und Gewicht der Skelettelemente pro Tierart.

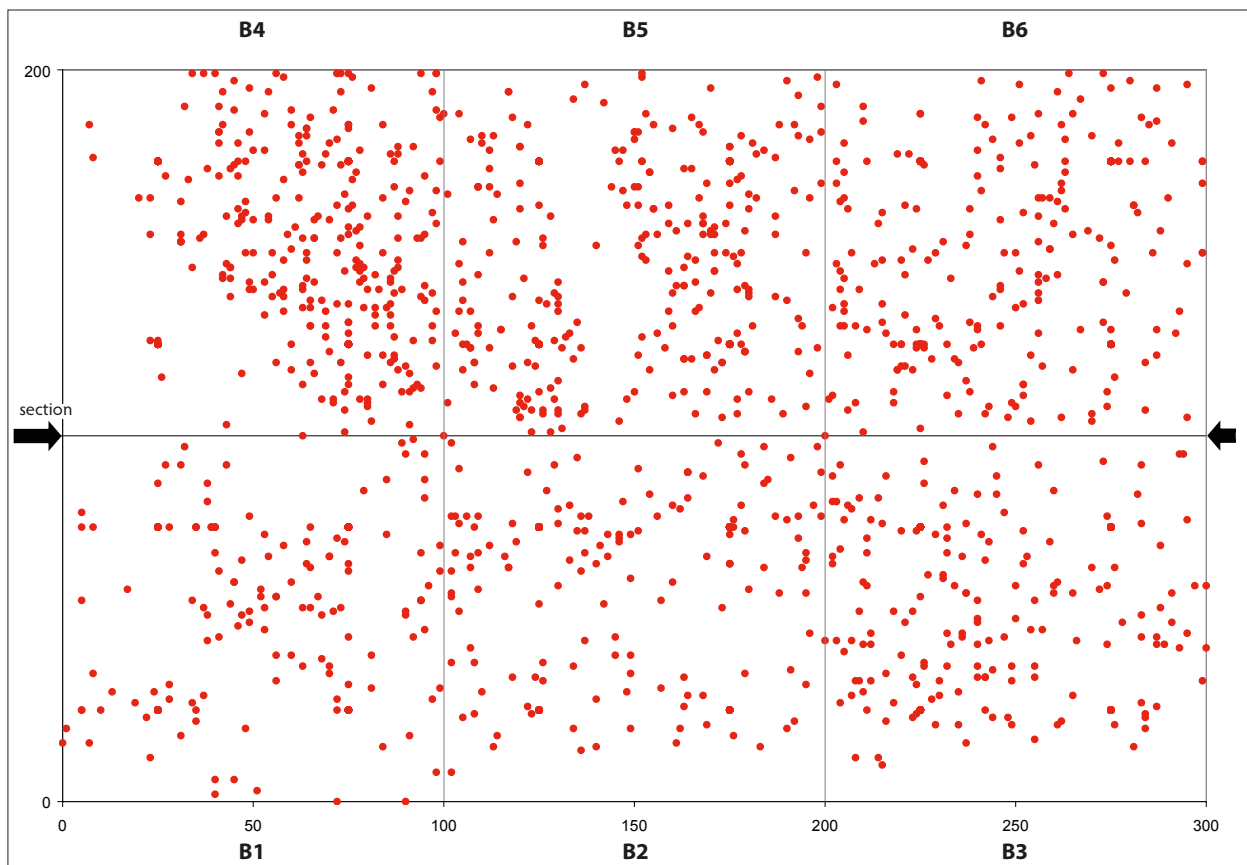


Fig. 12. Area B: Horizontal distribution of the faunal remains.

Abb. 12. Fläche B: Horizontale Verteilung der Faunarestes.

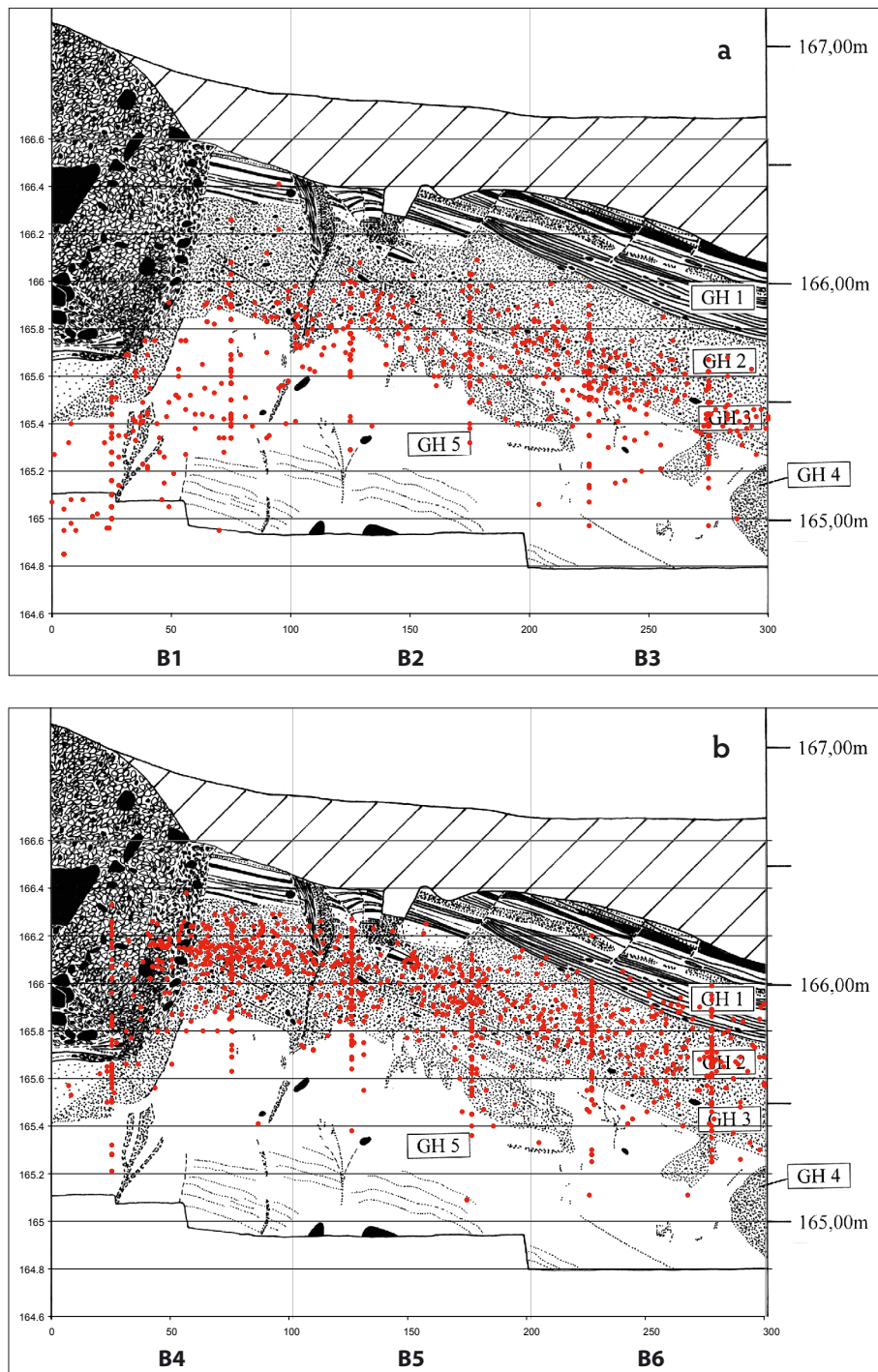


Fig. 13. Area B: Vertical distribution of faunal remains of square metres a) B1-B3, and b) B4-B6, projected onto the stratigraphy section (see Fig. 12.).

Abb. 13. Fläche B: Vertikale Verteilung der Faunareste der Quadratmeter a) B1-B3, und b) B4-B6, projiziert auf das Profil (siehe Abb. 12).

a band of about 1 meter in depth (Fig. 13a & b), as was already found for the rocks and stones (Beck et al. 2007: figs. 7-9). The vertical distribution was also compared between the species with considerable numbers of remains, but no differences in terms of size of the animals or weight of their bones or the like could be discerned.

The find-bearing layer of area B has a pronounced inclination (Fig. 13). In the diagram of the orientation of the bones the difference to area A becomes evident. The horizontally embedded fragments (Fig. 14a) do not show a preferred orientation but the obliquely embedded ones are clearly inclined towards the slope of the find-bearing layer (Fig. 14b).

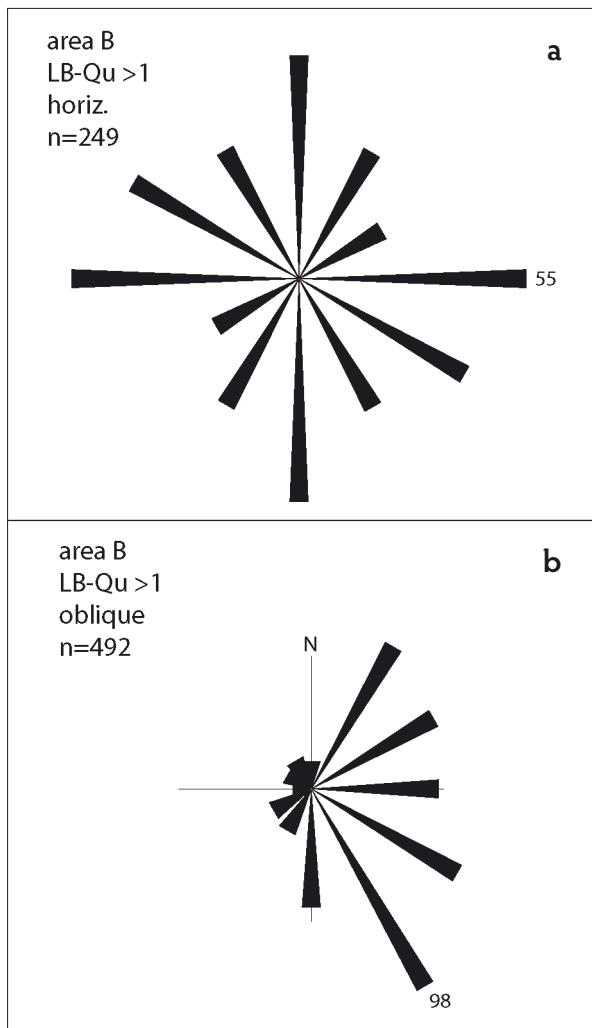


Fig. 14. Area B: Orientation of a) horizontally and b) obliquely embedded faunal remains. Note that for the horizontally embedded remains, one half of the diagram is mirror imaged.

Abb. 14. Fläche B: Orientation der a) waagrecht und b) schräg eingeregeltten Faunareste. Bei den waagrechten Resten ist eine Hälfte des Diagramms gespiegelt.

	NISP	%	weight (g)	%
red deer	10	4.9	315.5	3
rhinoceros	7	3.5	368	3.5
beaver	6	2.9	8.5	0.1
elephant	2	1	5570	53.5
fish	1	0.5	0.1	0
bird	1	0.5	0.2	0
determined by species (total)	27	13.3	6262.3	60.1
size class m1 (elephant-rhino)	7	3.4	2917	28
size class m1+2 (ele-rhi-bovid-horse)	11	5.4	560.7	5.4
determined by size (total)	18	8.8	3477.7	33.4
indet. (total)	159	77.9	676	6.5
total	204	100	10416	100

Fig. 15. Area C: Relative abundance of species and size classes.

Abb. 15. Fläche C: Relative Häufigkeiten der verschiedenen Tierarten und Grössenklassen.

Area C

Area C has yielded the smallest number of faunal remains (Fig. 15), with only 204 fragments in total. With nearly 80% the number of small undeterminable bone fragments is much higher than in area A (67%) and area B (46%). As the undetermined fragments of area C represent only 6.5% in term of weight it becomes obvious that they are of small size. This becomes even more evident when taking into account the elephant remains: only two elephant elements, i.e. a 4.0 kg fragment of a tusk and a nearly 1.6 kg heavy dorsal spine of a vertebra (Fig. 16), account for more than half of the weight of all the fragments in area C. Red deer, rhinoceros, beaver and elephant are present, as well as another tooth of tench (*Tinca tinca*) and a fragment of a coracoid of a bird. If and how much of the weight of the size categories m1 and m1+2 should also be attributed to the elephant and how much to the rhinoceros is hard to judge. Overall the assemblage has to be considered intensely fragmented with very few appreciably larger bones.

Again, the teeth dominate among deer and rhinoceros remains (Fig. 16). Although the small number of fragments forbids any far-reaching interpretations, it seems permissible to state that the overall abundance of skeletal elements does reflect roughly the conditions in the excavation areas A and B.

	red deer		rhinoceros		beaver		elephant	
	NISP	weight (g)	NISP	weight (g)	NISP	weight (g)	NISP	weight (g)
Os cornu	1	260						
Dentes max.							1	4000
Mandibula	1	6						
Dentes mand.	4	11.7			1	2		
Dentes indet.	2	1.5	5	11.2				
Vert. cervicales			1	300				
Vert. thoracicae							1	1570
Costae			1	56.8				
Radius	1	35			3	5.5		
Ulna					1	0.5		
Metatarsalia princip.	1	1.3						
Phalanx distalis					1	0.5		
Total	10	315.5	7	368	6	8.5	2	5570

Fig. 16. Area C: NISP and weight per skeletal elements of species (without fish and bird).

Abb. 16. Fläche C: Anzahl und Gewicht der Skelettelemente pro Tierart (ohne Fische und Vögel).

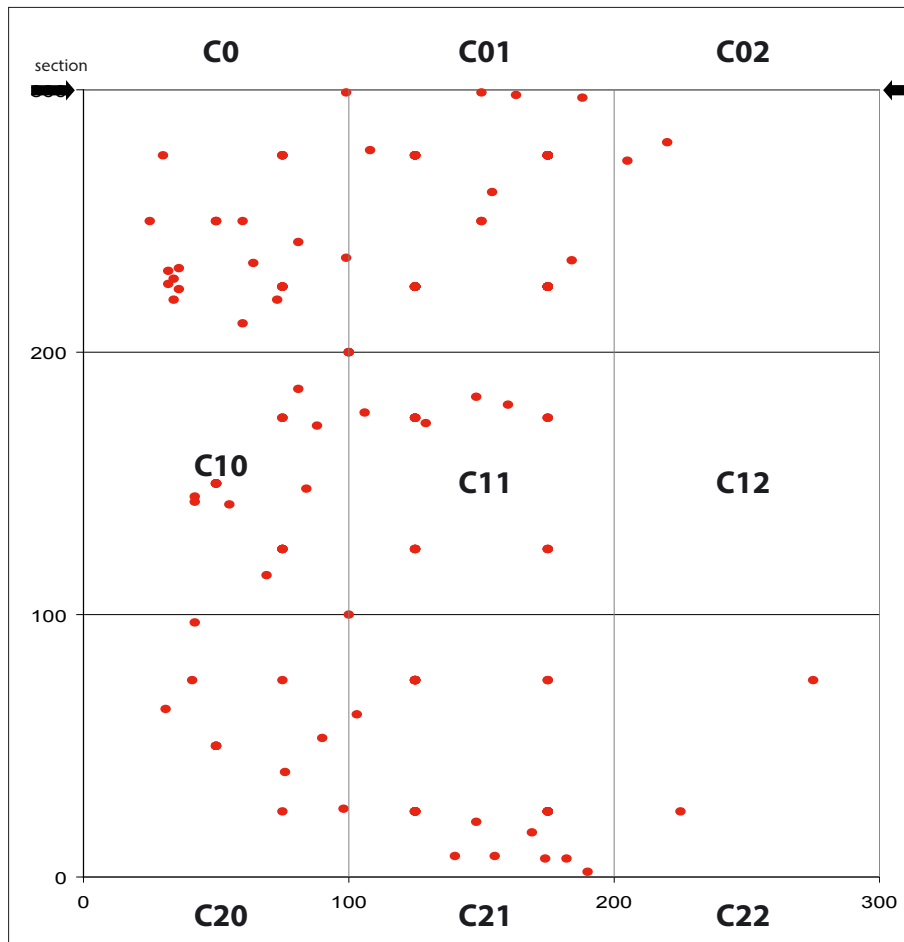


Fig. 17. Area C: Horizontal distribution of faunal remains.
 Abb. 7. Fläche C: Horizontale Verteilung der Faunareste.

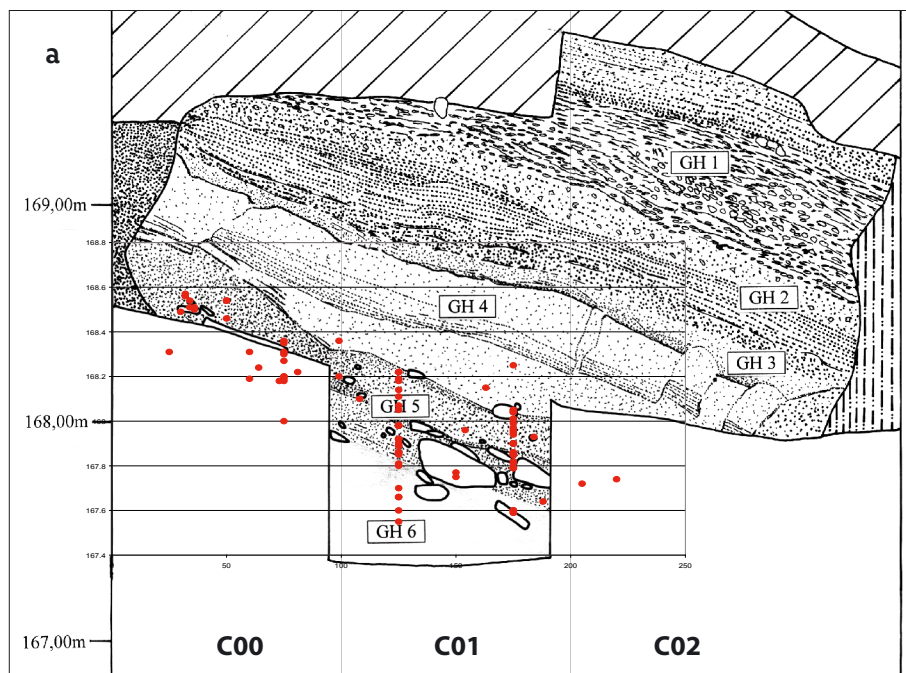


Fig. 18. legend see next page.
 Abb. 18. Legende siehe nächste Seite.

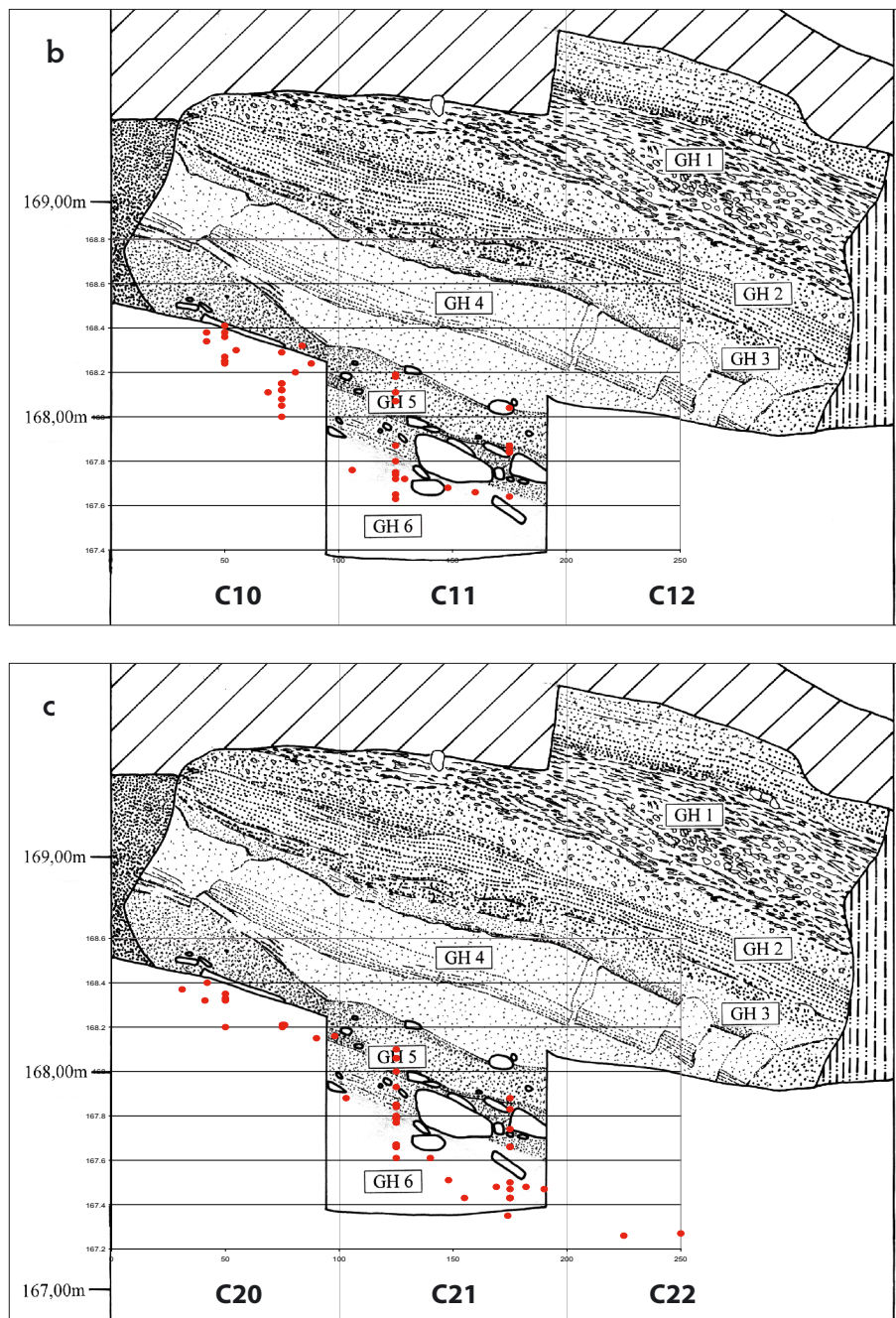


Fig. 18. Area C: Vertical distribution of faunal remains of square metres a) C00-C02, b) C10-C12, and c) C20-C22, projected onto the section (see Fig. 17).

Abb. 18. Fläche C: Vertikale Verteilung der Faunareste der Quadratmeter a) C00-C02, b) C10-C12, und c) C20-C22, projiziert auf das Profil (siehe Abb. 17).

The horizontal distribution of the faunal remains is rather homogenous (Fig. 17), similar to the two other areas. In the vertical distribution diagram (Fig. 18a, b & c) it becomes again evident that the find-bearing layer extends over about 1 meter in height, as was already shown for the two areas, A and B.

The find-bearing layer displays a strong inclination (Fig. 18). Horizontally embedded bones do not show a preferential direction (Fig. 19a), whereas the obliquely embedded ones show an orientation towards the slope of the find-bearing layer (Fig. 19b) which seems

to be more pronounced than in area B (see Fig. 14b). However, due to the small number of fragments, especially for the horizontally embedded ones, the significance of these statements is rather limited.

Traces on the surface of the faunal material

Heat-altered bones were not discovered among the faunal material from areas A, B and C. However, three bones show traces that, regarding their morphology and anatomical position, should be considered as being made with lithic tools by humans (e.g. Bello et al.

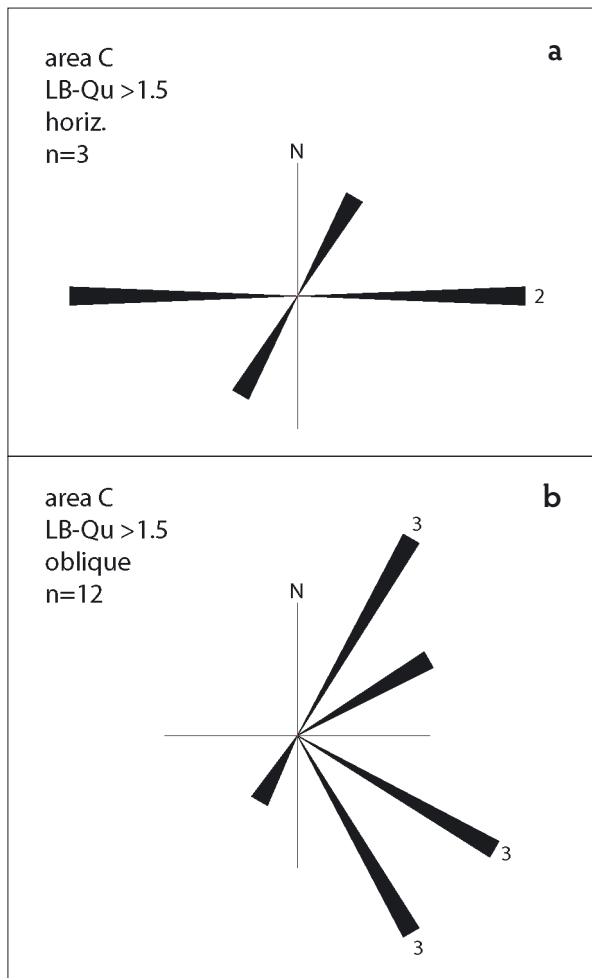


Fig. 19. Area C: Orientation of a) horizontally and b) obliquely embedded faunal remains. Note that for the horizontally embedded remains, one half of the diagram is mirror imaged.

Abb. 19. Fläche C: Orientation der a) waagrecht und b) schräg eingeregeltten Faunareste. Bei den waagrechten Resten ist eine Hälfte des Diagramms gespiegelt.

2009; de Juana et al. 2010; Domínguez-Rodrigo & Barba 2005). A tarsal bone (*Os centroquartale*) of a large bovid is depicted in Figure 20. The micro-morphology of the cut marks as well as their location leaves no doubt that these were anthropogenic cut marks. These kinds of traces are produced by separating the metatarsus from the tarsal bones (Binford 1981: 119). Cut marks at this location are rather frequent in Palaeolithic contexts (e.g. Morel & Müller 1997; Turner 2002; etc.). A mid-Pleistocene example of this is the site of Schöningen (Lower Saxony), where one fourth of the horse tarsal bones show cut marks (Voormolen 2008). The two other bones with cut marks are a radius of a horse and a femur of a bear. However, these three bones are at one end of a grey area including traces that are difficult or impossible to unambiguously attribute to human origin: for all three areas, this grey area is represented by 174 remains that carry traces which warrant further analysis to differentiate between

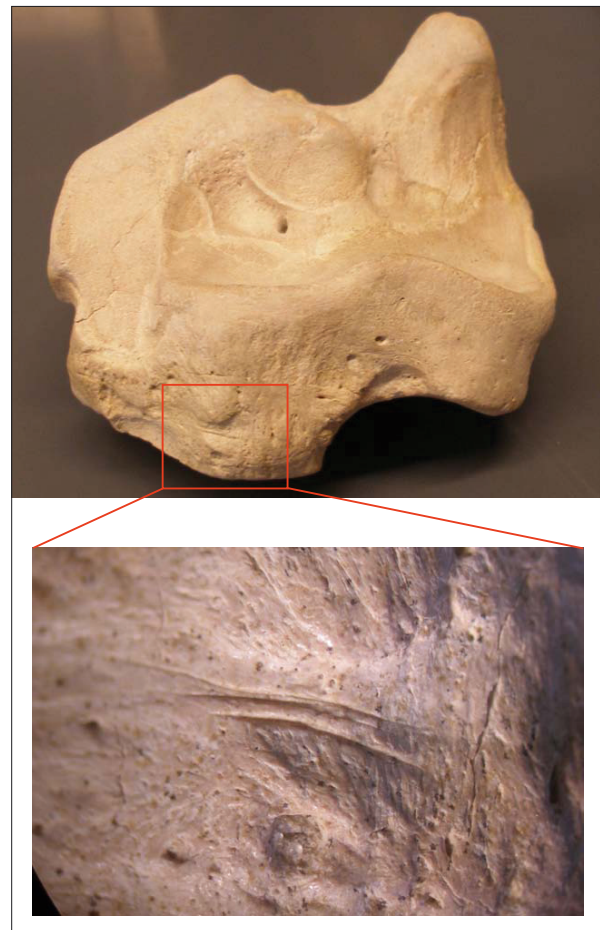


Fig. 20. Tarsal bone (*Os centroquartale*) of a large bovid with cut marks.

Abb. 20. Fusswurzelknochen (*Os centroquartale*) eines grossen Rindes mit Schnittspuren.

abiotic and biotic processes, such as sediment abrasion, rolling, trampling, gnawing and digesting, which can result in traces on bone surfaces that mimic human action (e.g. Andrews & Cook 1985; Behrensmeyer et al. 1986, 1989; Binford 1981; Blumenshine 1995; Blumenshine & Marean 1993; Boschian & Saccà 2010: 7; Fisher 1995; Fiorillo 1989; Haynes 1980; Lyman 1994: 204-205, 210-211; Oliver 1989; Potts & Shipman 1981; Shipman 1981, 1983; Shipman & Rose 1983).

Short summary on the faunal remains of the recent excavations

At areas A, B and C, the find-bearing layer of the *Steinrinne* is characterized by many small, undeterminable bone fragments. In all areas animal bones, ranging from fish-size to elephant-size, fragmented or not, are scattered vertically over approximately 1 m of depth. Obliquely embedded bones show a distinct orientation parallel to the inclination of the geological horizon. The area of the highest elevation (area C) is characterized by the lowest amount of bones overall and the highest number of bone splinters. Area B in the centre of the excavation is characterized by the

	area A		area B		area C		total			
	n	weight (g)	n	weight (g)	n	weight (g)	n	%	weight (g)	%
rhinoceros	42	2621	177	5585	7	368	226	35.2	8574	33.7
red deer	23	1365	196	5368	10	316	229	35.7	7059	27.8
beaver	21	55	46	145	6	8	73	11.4	208	0.8
bear	6	111	55	711	-	-	61	9.5	822	3.2
elephant	1	5	24	407	2	5570	27	4.2	5982	23.5
bovid	-	-	12	2513	-	-	12	1.8	2513	9.9
horse	-	-	9	292	-	-	9	1.4	292	1.1
fish	-	-	2	-	1	-	3	0.5	-	-
bird	-	-	1	-	1	-	2	0.3	-	-
total	93	4157	522	15021	27	6262	642	100	25440	100

Fig. 21. Overview of NISP and weight of different species in areas A-C.

Abb. 21. Übersicht von Anzahl und Gewicht der verschiedenen Tierarten in den Flächen A-C.

highest amount of bones overall and, consequently, the highest amount of determinable specimens. Area A, being situated somewhat lower, takes an intermediate position. In area B the highest find density was found (>300 bones/m²). Here, the most species are present (n=9) and undetermined bones are less frequent (46%). In terms of weight postcranial bones predominate. In areas A and C the density of finds is much lower (26-40 bones/m²), species representation is lower (5-6 species), undetermined small bone fragments are much better represented (67-78%) and teeth as well as antler outnumber postcranial bones. However, among the dominant small fragments single very large bones occur, e.g. at area C. Even with low numbers of determinable bones in areas A, B and C all body regions are present, and for species with numerous fragments most of the skeletal elements are represented. No milk teeth and no bones of young animals were found. Approximately 10-25% of all bones can be determined by size, representing very large mammals only, ranging from elephant/rhinoceros to horse/bovid size. No bones of size class m3 ("small ungulate") are present in areas A-C, this being also characteristic for the *Steinrinne* fauna of the earlier excavations, as reported below, where small-sized species are present by few or single bones only. About 10-30% of all bones can be determined to species level. Among them rhinoceros (*Stephanorhinus* aff. *kirchbergensis/hemitoechus*) and red deer (*Cervus elaphus*) are the most numerous ones (Fig. 21). All other species occur in much lower numbers, among which beaver (*Castor fiber/Trogotherium cuvieri*) and bear (*Ursus* sp.) are the most numerous. Elephant (*Palaeoloxodon antiquus*) and bovid (*Bos/Bison*) are present by rare but heavy fragments. Horse (*Equus* sp.) bones are also present. Three teeth of tench (*Tinca tinca*) and two bird bones show that the representation of small species is very low.

With the data obtained through the new excavations, the site formation processes responsible for the presence of animal remains at areas A, B and C become apparent, although not yet in every detail. The unordered vertical distribution of small and large bones with a distinct orientation in a sandy matrix and their co-occurrence together with numerous small

and large rocks of local origin indicate that natural processes were responsible for the formation of the find horizon: different processes may have been at work, e.g. flood plain and channel dynamics, (sub)aquatic reworking, mixing under low-energy conditions in oxbow lakes, travertine pools or beaver ponds as well as transport and accumulation by debris or mass flows with high-energy reworking, e.g. by block fall or clast avalanches from nearby cascades, walls or slopes.

Review of the animal remains of the 1969-2003 excavations

As in areas A-C, the bones excavated in 1969-2003 were situated in a sandy layer above the silt (Mania & Altermann 2004: 151-152, 164). Regrettably, the vertical distribution of animal bones and the other remains is either not published or not available for the 1969-2003 assemblage so that a comparison with the remains of the new excavations is restrained to species presence and abundance. However, the number of identified specimen (NISP) for the most abundant species is not or not precisely known. Since the data of the different faunal analyses were published spread over an extended period of time in different journals, monographs and reports which are sometimes difficult to access, an attempt is made here to gather the existent information and to present them in a comprehensive format. From an overview of the data given in two tables (Figs. 22 & 23) it becomes already obvious that the depth and methodology of the different analyses vary considerably. The applied method for estimating or calculating the minimum number of individuals (MNI) is in general not mentioned so that caution should be exercised when comparing these data and taking them at face value.

According to Mania (1997) of all bones from larger animals roughly 50% are attributed to the two species of rhinoceros (the smaller *Stephanorhinus hemitoechus* and the larger *S.* aff. *kirchbergensis*) and 35 % to the elephant (*Palaeoloxodon antiquus*). Not much information is published on the rhinoceros bones, except that an MNI of 270 is present (oral

species		% of all larger bones	NISP	MNI	entire collection analysed?
rhinoceros	<i>Stephanorhinus</i> aff. <i>kirchbergensis</i> <i>Stephanorhinus hemitoechus</i>	50%	?	270	?
elephant	<i>Palaeoloxodon antiquus</i>	35%	~2200	60-70	yes?
red deer	<i>Cervus elaphus</i>	~2%	>160 postcran. bones ~1850 antlers	12 (on bones) 150 (on antlers)	no
roe deer	<i>Capreolus</i> aff. <i>suessenbornensis</i>		„very small number“	2	no
fallow deer	<i>Dama dama clactonia</i>		~20	?	no
giant elk	<i>Megaloceros giganteus</i>		„occurs“	?	no
beaver	<i>Castor fiber</i> <i>Trogotherium cuvieri</i>		~510	17 (on Castor bones) 82 (on Castor teeth) 12 (on Trogonth. teeth)	yes
large bovid	<i>Bison priscus/Bos</i> sp.	~5%	~380	17 (on teeth)	yes
horse	<i>Equus mosbachensis</i>	~2%	~110	?	no
bear	<i>Ursus</i> cf. <i>deningeri</i>	~3%	~600	>90	no?
wild boar	<i>Sus scrofa</i>		54	4	yes
lion	<i>Panthera leo spelaea</i>		21	2?	yes
wolf	<i>Canis lupus</i>		9		yes
marten	<i>Martes</i> sp.		4		yes
red fox	<i>Vulpes vulpes</i>		1		yes
badger	<i>Meles meles</i>		3		yes
wild cat	<i>Felis sylvestris</i>		2		yes
otter	<i>Lutra lutra</i>		6		yes
hyena	<i>Crocuta crocuta spelaea</i>		„some“		yes
macaque	<i>Macaca florentina</i>		2		yes
Hominide	<i>Homo erectus bilzingslebenensis</i>		40	2	yes

Fig. 22. Overview of mammal remains from the 1969-2003 excavations, assembled from the available literature.

Abb. 22. Übersicht der Säugetierreste der Ausgrabungen von 1969-2003, zusammengestellt aus den publizierten Quellen.

species		NISP
birds		
mallard or goldeneye	<i>Anas platyrhynchos</i> or <i>Bucephala clangula</i>	13
mute swan	<i>Cygnus olor</i>	4
white-tailed eagle	<i>Haliaeetus albicilla</i>	4
tawny owl	<i>Strix aluco</i>	1
thrush	<i>Turdus</i> sp.	1
game bird	Galliformes	3
scaled reptiles		
water snake	<i>Natrix</i> sp.	23
slow-worm	<i>Anguis fragilis</i>	17
lizard	<i>Lacerta</i> sp.	2
amphibians		
common toad	<i>Bufo bufo</i>	>19
frog/common frog	<i>Rana</i> sp./cf. <i>temporaria</i>	15
newt/smooth newt	<i>Triturus</i> sp./cf. <i>vulgaris</i>	4
spadefoot toad	<i>Pelobates</i> sp.	3
fishes		
tench	<i>Tinca tinca</i>	~130
common minnow	<i>Phoxinus phoxinus</i>	4
wels catfish	<i>Silurus glanis</i>	5
european bullhead	<i>Cottus gobio</i>	4
cyprinid	Cyprinidae	8
northern pike	<i>Esox lucius</i>	2
common rud	<i>Scardinius erythrophthalmus</i>	1

Fig. 23. Overview of non-mammal remains from the 1969-2003 excavations, assembled from available literature.

Abb. 23. Übersicht der Nicht-Säugetierreste der Ausgrabungen von 1969-2003, zusammengestellt aus den publizierten Quellen.

comm. D. Mania in: Steguweit 2003: 49). An exception is the contribution by van der Made (2000) that half of both rhinoceros species are represented by calves and young animals (see also: Mania 1991: 21; 1997: 66-67). As mortality of rhinoceros may be linked to sociality (Mihlbachler 2003) only a detailed analysis of all rhinoceros bones from the 1969-2003 excavation will show by which process these became part of the find horizon. However, in the excavations of 2004-2007 rhinoceros is represented also by high numbers of teeth, cranial fragments, vertebrae and upper as well as by lower limb bones. Therefore not only "high survival elements" (Marean & Cleghorn 2003; Cleghorn & Marean 2004) but also less dense, grease-laden axial elements and small compact bones of rhinoceros were incorporated into the find-bearing layer. This may be an indication that fluvial transport of bones (Behrensmeier 1975; Pante & Blumenschine 2010) was not the main taphonomic factor responsible for the accumulation of the rhinoceros remains.

For the elephant, 128 molars and 20 tusks, excavated in 1969-87, led Guenther (1991, 150) to estimate the MNI at 60-70 individuals, among which young individuals (<5 yr) predominate with a dominance of very young (<1 yr) animals. In contrast, among the postcranial elements, bones of adult individuals dominate (Mania 1991: 21). Guenther (1991: 169) draws attention to the high amount of molars with signs of malnutrition. Mania (1991) published

all elephant bones found in 1969-84, emphasizing that only these bones were used by hominids for the manufacture of tools, among them are 252 bone flakes and 119 bone tools. Not all of these items are accepted as artefacts (Becker 2003: 84), e.g. single published specimens are interpreted as being modified by hyenas (Gaudzinski 1998: 199). Also, the intense fragmentation of bones (Gamble 1999: 161) with the preponderance of old-bone fractures "suggests considerable disturbance to this deposit unrelated to human or carnivore activity" (Stopp 1997: 42). The latter interpretation is supported by microscopic research at Bilzingsleben which showed that bone surfaces are often damaged due to turbulent reburial within sediment (Steguweit 2003). In former times, these traces have been interpreted as evidence of early art (Behm-Blancke 1986, 1990), of abstract and symbolic thinking, calendrical observation and existence of language (Mania 1990a: 267, 1990b: 49; Mania & Mania 2005: 113). Unfortunately, the criteria by which these objects have been selected out of tons of animal remains have not been published. However, at least individual bones of the material excavated in 1969-2003 exhibit cutmark-like traces (Steguweit 2003) which are interpreted as being made during domestic activities (Becker 2003: 84; Yravedra et al. 2010). This holds true as well for the material of the assemblage excavated in 2004-2007 (see above).

The presence of rhinoceros and elephant makes two remarks on site formation processes necessary: Modern large mammals and smaller herbivores influence the morphology of slopes and lake shores by removing vegetation, soil and sediments (Boelhouwers & Scheepers 2004; Haynes 2006). As an elephant destroys a mean of four trees a day in recent African savannahs (Walter 1984: 107) the presence of wooden fragments is no surprise in fluvial sediments. Therefore, processes which took place in former times but which are not well-known in recent mid-latitude forest environments are rarely taken into consideration in discussion of site formation processes.

In the 1969-2003 assemblage, only 2% of all bones from larger mammals represent different species of cervids (Mania 1997: 66), among these, the dominant species is *Cervus elaphus*. Mania (1986a: 58) reported the presence of all skeletal elements and counted a MNI of 12 on the material excavated until the early 1980s (van der Made 1998: figs. 1 & 2). The antlers found between 1969 and 1982 were investigated by Mania (1986b): 1 846 pieces interpreted as artefacts are documented. 55% are shed antlers contrasted with 45% unshed. With the exception of a single unshed antler all antlers are fragmented. Among the antler fragments, broken tines are the most common (>40%), complete tines (~20%) and undetermined fragments (~14%) predominate crowns (<10%) and shaft fragments (<5%). A larger sample of antlers was investigated by Vollbrecht (2000) who counted an MNI of about 150. Tines dominate. Refitting of

fragments was possible over distances of up to approximately 30 m but breakage patterns of antlers with attached head bones indicate natural fragmentation along skull sutures. This may indicate that antlers became fragmented while being accumulated in sandy sediment. As 47 antlers exhibit traces of gnawing by deer (Vollbrecht 2000) before being fossilized, the antlers may have been scattered over the mid-Pleistocene landscape. At areas A, B and C, it is obvious that antlers are not more numerous than the other red deer skeletal elements but that antler fragments are larger and heavier (Fig. 24). However, as for other sites (Bratlund 1999; Boschian & Saccà 2010: 8-9; Conard 1992: 97-105; Street 2002: 69), it is difficult to judge who was responsible for the accumulation. As red deer is characterized by the best representation of all skeletal elements of all animal species, maybe whole deer carcasses were present on the *Steinrinne* palaeo-landsurface. This is in contrast to other species (with the exception of rhinoceros) which were represented by single bones or carcass parts only. Of course, processing of deer by mid-Pleistocene humans cannot be ruled out (Rabinovich et al. 2008). A remark may be necessary here on presence of deer antlers in natural environments: antlers concentrations are found in Pleistocene sediment traps like volcanoes (Conard 1992; Street 2002), in fluvial, lacustrine or fan deposits (Boschian & Saccà 2010; Villa et al. 2005) or at animal scavenger sites (Attard & Reumer 2009; Mangano et al. 2005; Palmqvist & Arribas 2001). However, in more recent landscapes, concentrations of shed antlers are not reported. Whether this is due to natural processes not yet fully understood or to intensive human collection of this resource in historic times (Becker 2003: 111; Erath 1996: 40-41; MacGregor 1991: 355-356) remains to be investigated.

In general, Pleistocene beaver bones are more frequent in fine clastic deposits of silting-up river arms or lakes, which represent protracted sedimentation processes (Kahlke 2006: 79). Therefore it is no surprise that beaver remains are a common element of the Bilzingsleben fauna. Approximately 110 postcranial bones of *Castor fiber* are present in the 1969-2003 assemblage (Fischer 2009: 39), of which about 50% are rather fragmented parts of the long bones. Some *Castor* teeth exhibit old fractures (Heinrich 1991: 41). For the 1969-2003 assemblage, MNI counts of *Castor fiber* are published as 49 (Heinrich 1991: 49) and

	area A		area B		area C		total	
	n	weight (g)	n	weight (g)	n	weight (g)	n	weight (g)
antler	13	1197	58	3454	1	260	72	4911
other bones	10	168	138	1914	9	56	157	2138
total	23	1365	196	5368	10	316	229	7049

Fig. 24. Comparison of number and weight of antler and bone remains of red deer.

Abb. 24. Vergleich von Anzahl und Gewicht der Geweih- und Knochenreste vom Rothirsch.

subsequently 82 (Heinrich 2004a) based on teeth, and a MNI of 17 is given based on the left femur (Fischer 1991a: 63). According to Fischer (1991a: 63) among *Castor fiber* bones femora dominate over tibia, humerus, talus, calcaneus, ulna and os coxae. Other skeletal elements are rare with only single tail vertebrae and some lower extremities from the foot being present. Among the bones excavated in 1969-2003, postcranial bones of the larger beaver species *Trogontherium cuvieri* are rare (Fischer 1991a; Heinrich 2004b), for example Fischer (2009: 40-42) mentioned six bones of which only one can be attributed to this beaver species with certainty. It is represented by a MNI of 12 based on teeth (Heinrich 2004b). Based on tooth morphology and wear, age determinations for *Trogontherium* show the same classes recognized in *Trogontherium* accumulations without human impact, e.g. Mosbach or Tegelen (Heinrich 2004b). This may indicate the natural accumulation of remains of this particular species at the *Steinrinne*. In addition, at Bilzingsleben age classes of *Trogontherium* are comparable to those of *Castor fiber* (Heinrich 2004a & b) established on the condition of the femoral epiphysis. Fischer (1991a: 65, 2009: 40) showed a dominance of young (<2.5 yr) with rare senile (>12 yr) *Castor fiber* individuals. This result is supported by age determination of teeth (Heinrich 1991: 49-50; 2004a: Abb. 2) demonstrating that 80% represent juveniles/young adults (<4.5 years). Beaver remains from Thuringian travertine localities where lithic artefacts were also found, such as Taubach (OIS 5e) and Weimar-Ehringsdorf (OIS 7?) display the same mortality profiles (Heinrich 1991: 50). However, no clear evidence of cultural agency responsible for the presence of beaver bones is present in the entire area excavated from 1969-2003. Although teeth of *Castor fiber* were found across the entire excavation area, they were concentrated at its centre (Heinrich 2004a) where the amount of flint, quartz and rocks from fluvial deposits is the highest (see chapter 1, area B).

Again a remark may be necessary on general site formation processes since beaver heavily influence water flow, valley floor morphology and vegetation, and are often responsible for accumulation of silty alluvial sediments (Morgan 1868: 194-209). Therefore landscape evolution on a local scale may have been driven more by this species than by climate-triggered factors (Holtmeier 2002: 198-212; Rosell et al. 2005). Of course, wood should be a normal component of river valleys (Montgomery & Piégay 2003) but due to the presence of beaver, even more wooden fragments can be expected in the mid-Pleistocene *Steinrinne* inventory (Rybczynski 2008).

Bear, bovid and horse remains are present in low percentages in the 2004-2007 assemblage as well as in the material excavated before 2003. According to Mania (1997: 66-67) 5% of all bones from larger animals excavated until the mid 1990s represent *Bison/Bos*. Fischer (1991b, 2009: 50) determined

about 380 bovid bones, among them both *Bison priscus* and *Bos* sp., the later identified by four *os cornu* (Fischer 2009: 50; Mania 1990a: 187), and counted a MNI of 17 by the presence of the lower third molar.

Horse remains account for 2% of all bones from larger animals excavated till the mid 1990s (Mania 1997: 66). The horse bones were analyzed by Musil (1991b, 2000, 2002) reporting approximately 90 single teeth and 21 postcranial bones of *Equus mosbachensis*. Only single teeth and one distal radius represent young horses.

In the assemblage excavated until the mid 1990s, only 3% of all bones from larger animals represent bear (Mania 1997: 66). Their metrical variability does not allow determination to species level (Musil 2000), which may be a result of a chronological variant of a single species (Turner 2004: 190). Bear bones excavated from 1969-86 were analyzed by Musil (1991a) who counted a MNI of about 90. However, the MNI is expected to be much higher (Turner 2004: 191), as "since 1986 many more ursid remains have been recovered, but they have not, as yet, been sorted from the extremely large sample of mammalian bones" (Turner 2004: 189). According to Turner (2004: 190) 75% of the material represents dental and cranial elements, while 22% represents foot and hand bones and only 4% other postcranial bones. Bear tooth size is difficult to interpret but both male and female bears are present (Turner 2004: 191). According to the supposed behaviour of mid-Pleistocene bears, the MNI of more than 90 "must represent several years of accumulation" (Turner 2004: 191). Analyzing 430 teeth, Turner (2004: 190-191) counted 35% adults and 1% neonates, concluding that the domination of juveniles (64%) "suggests that the juveniles were not dying [...] during winter dormancy [...] but [...] at some time during [...] their first and [...] second summer" (Turner 2004: 191). The dominance of yearlings and individuals in their second year is not an indication of selective human hunting as hunting them is possible only "in perhaps one of the most dangerous circumstances, since the mothers guard the cubs jealously" (Turner 2004: 191). In sum, the results of his investigation "warn us that the bear sample at least is not a pristine accumulation that can be interpreted at face value, and the same may very well be true for other components of the assemblage at the site" (Turner 2004: 192).

Species that are present in the assemblage of the 1969-2003 excavation but not in the one of the recent excavation are usually represented by only a few fragments. These are eight carnivore species, three cervid species, wild boar as well as primates: *Panthera leo spelaea* is represented by twelve bones (Fischer 2009: 44-45) among them at least one left maxilla fragment (Toepfer 1983) representing two individuals that died in early adulthood (Turner 2004). Three additional incisor fragments (Mania 1986a: 58) as well as "several incisors of juveniles" (Mania 1991: 22) are

published. Turner (2004: 189) analyzed a proximal left femur and a distal right tibia, proposing the presence of one adult lion individual of moderate stature but, according to Fischer (2009: 44), three postcranial bones are from juvenile individuals. *Canis lupus* is represented by six teeth and three postcranial bones from juvenile as well as adult individuals (Fischer 2004). Three teeth and a femur fragment represent *Martes* sp., a single tooth is identified as *Vulpes vulpes* (Fischer 2009: 46) and *Meles meles* is represented by two mandible fragments and one postcranial bone (Fischer 2009: 46). One mandible and one distal femur are determined as *Felis sylvestrus* (Fischer 2004). *Lutra lutra* is represented by six canini (Fischer 2009: 47). Recently, Fischer (2009: 44) mentioned "some" postcranial bones of hyena (*Crocuta crocuta spelaea*). While the amount of carnivore bones in recent hyena dens varies between species, ranging from 15-70% for brown hyena, to less than 15% for striped hyena under 10% for spotted hyena (Lacruz & Maude 2005), the small number of carnivore remains in the *Steinrinne* seems to indicate that the hyenas were not the major agent for their accumulation. Of course, human hunting/scavenging/processing of large felids can also never be ruled out (Blasco et al. 2010).

Small-sized ungulate species are present only in very low numbers in the 1969-2003 assemblage: *Capreolus* aff. *suessenbornensis* is represented by a "very small number of bones and teeth" (van der Made 1998: 109) on which Mania (1986a: 57) counted a MNI of 2. *Dama dama clactoniana* is represented by a few antlers, eight teeth and six astragali (van der Made 1998: 110, figs. 1 & 2). Mania (1997: 67) mentioned in addition the occurrence of *Megaloceros*. 54 teeth and bones of *Sus scrofa* have been identified so far (Fischer 2009: 48). According to the lower molars, wild boar is represented by a MNI of 4, other teeth represent "robust individuals" and "strong males" (Fischer & Heinrich 1991). As wild boar is also a scavenger (Selva 2004a; Selva et al. 2003; Wilcox & van Vuren 2009) tooth marks left by pigs might be expected on the bone remains. A mid-Pleistocene macaque, *Macaca florentina* (COCCHI, 1872), is represented by one upper and one lower molar (Vlček 2003). Last but not least, fossil human remains of at least two individuals have also been found at the *Steinrinne*, comprising about 30 skull fragments, nine single teeth and a part of a mandible (Vlček 1999; Vlček et al. 2002). This skeletal part representation can be seen as a typical bias resulting from natural disarticulation and selective transport in fluvial environments (Haglund & Sorg 1997).

Fish and bird bones occur rarely in the 2004-2007 assemblage (Fig. 21). The same observation was made for the material excavated in 1969-2003 (Fig. 23): in contrast to the enormous amount of mammal bones, the "extraordinary low" (Böhme 2009: 32) number of small animal remains, even after sieving 95 samples of roughly 600 excavated quadrants (Böhme 2009: 25)

was emphasized. The fish remains from the area excavated in 1969-2003 were analyzed by Böhme (1998, 2009, Hebig 2003). With about 130 teeth, the tench (*Tinca tinca*) is the most common fish species, showing that in the mid-Pleistocene Interglacial small and large tench lived in the setting of the later excavation area. Common minnow (*Phoxinus phoxinus*) is represented by four dental bones, wels catfish (*Silurus glanis*) by four vertebrae and one cranial bone, European bullhead (*Cottus* cf. *gobio*) by some otoliths and one preoperculum, carp (Cyprinidae indet.) by eight otoliths, northern pike (*Esox lucius*) by two bones and common rudd (*Scardinius erythrophthalmus*) by one bone. For the pike, one individual was identified as measuring more than 1 m in length. Both *Phoxinus* and *Cottus* live in oxygen-rich, cold and fast running water and are typical elements of Middle and early Upper Pleistocene travertine deposits in Central Germany, indicating them as "part of a natural thanatocenosis" (Böhme 1998: 104). In contrast, *Tinca*, *Silurus*, *Esox* and *Scardinius* live in mild, slow running but deep waters or lakes with swampy bottom and vegetation-rich shores. Therefore these fish species are supposed not to favour travertine environments as their habitat (Böhme 1998). However, *Tinca* is represented only by its button-like teeth which with their "better rolling ability facilitated transport through running water" (Böhme 2009: 33-34). In general, fish bones are fragmented, not in anatomical connection and often show rounded surfaces (Böhme 1998: 102). Moreover, redistributed teeth from Mesozoic fishes are present "in samples from several excavated areas" (Böhme 1998: 100). These observations make it unlikely that human cultural site formation processes were responsible for the presence of fish bones. Additionally, five otoliths and three cranial parts of a freshwater species of the cod family, the burbot (*Lota lota*), as well as two otoliths from a cyprinid (Cyprinidae indet.) were determined out of samples from the fluvial gravels below the silty layer (Böhme 1998: 97, 2009: 26; Hebig 2003: 90), showing that the older mid-Pleistocene layer also contained fish bones.

The same mixing of animal species that prefer contrasting habitats is made evident by amphibian and reptile bones from the 1969-2003 assemblage that display the same state of preservation as the fish bones (Böhme 1998, 2004, 2009). With two cranial parts, 17 ilium fragments as well as "several fragments of extremities" (Böhme 2009: 31) the common toad (*Bufo bufo*) is the most common amphibian, representing a MNI of 5 - 9. A frog (*Rana* sp./*Rana temporaria*) is represented by 15 bones, a newt (*Triturus* sp./cf. *vulgaris*) by four bones, and a spadefoot toad (*Pelobates* sp.) by one cranial part and two postcranial bones. With 23 bones a water snake (*Natrix* sp.) is the most common reptile, followed by 17 fragments from slow-worm (*Anguis fragilis*) and two bones from a lizard (*Lacerta* sp.). In contrast to slow-worm and

lizard, water is a prerequisite for the habitat of frogs, toads, the newt and the snake (Böhme 1998).

As in areas A-C, bird remains are rare in the assemblage excavated from 1969 to 2003: here, only some few bones of six species/genera are present (Fischer 2004, 2009): mallard (*Anas platyrhynchos*) or common goldeneye (*Bucephala clangula*), mute swan (*Cygnus olor*), white-tailed eagle (*Haliaeetus albicilla*), tawny owl (*Strix aluco*) and a thrush (*Turdus* sp.). Recently, Fischer (2009: 39) added three fragments of gamefowl (Galliformes). Among the remains of duck and eagle occur bones of juvenile animals (Fischer 2004: 183-184).

The underrepresentation of small-sized animal species is a characteristic of both the earlier and the recent excavation at the *Steinrinne* with its excellent conditions of preservation. As the underrepresentation of bones from small-sized species is a typical pattern in modern African and Canadian grasslands, the presence of these species at Bilzingsleben may also have been influenced by carnivore mastication, trampling and weathering on animals and bones which were part of the mid-Pleistocene landscape (Behrensmeyer et al. 1979, 2003; Haynes 1988: 230).

Conclusion

The site formation processes responsible for the 1 metre thick find horizon at areas A, B and C of Bilzingsleben have been reconstructed with sufficient certainty, albeit not in every detail. As a general conclusion it can be said that these were characterized by a combination of different natural processes. These included geological or animal induced flood plain and channel dynamics with aquatic reworking, mixing under low-energy conditions in oxbow lakes, travertine pools or beaver ponds as well as transport and accumulation by debris or mass flows with high-energy reworking, e.g. by block fall or clast avalanches from nearby cascades, walls or slopes. It is through these processes that rocks such as flint and erratics, animal and human remains, snails, but also single flint artefacts and cut-marked bones were reworked from the mid-Pleistocene land surface of which they were part and became embedded in a sandy matrix. Further to this, objects from older sediments, e.g. Mesozoic ostracods and fish bones, also became incorporated. All objects in the find horizon, whether they are related to humans or not, are in a secondary position. Because of the similarities between areas A, B, C and the area of the excavations from 1969-2003, the conclusions drawn from the former should hold true for that area as well.

The ensuing question of how archaeological and animal remains became part of the mid-Pleistocene landscape is difficult to answer with certainty. Currently, the interpretation of the British Lower Palaeolithic record denies the existence of camp-sites but rather emphasizes the formation of an archaeo-

logical landscape by movements of humans exploiting mobile and static resources. This then leads to a distribution pattern of anthropogenic remains where single artefacts are widely dispersed, with dense lithic concentrations in between (Ashton 1992, 2004; Ashton et al. 2006; Hallos 2004, 2005; Pope 2004; Pope & Roberts 2005; Wenban-Smith et al. 2000; Wenban-Smith 2004). Therefore, the presence of single man-made flakes in the material excavated in 2004-2007 is explicable but remains difficult to quantify against the grey area of natural flints and eoliths (Beck et al. 2007).

On the other hand, animal remains, from carcasses to single bones, were probably a typical component of the Interglacial landscape as may be inferred by recent conditions in near-natural temperate forests in Europe (Cortés-Avizanda et al. 2009; Elgmork 1982; Elgmork & Tjørve 1995; Fosse et al. 2004; Krofel et al. 2007; Laudet & Selva 2005; Rösner et al. 2005; Selva 2004a, 2004b; Selva & Fortuna 2007; Selva et al. 2003, 2005). Some examples from Africa and the Americas can be mentioned as well (Egeland 2008; Faith & Behrensmeyer 2006; Haynes 2006; Lansing et al. 2009; Pokines & Kerbis Peterhans 2007). Additionally, just like recent waterholes and river valleys, the *Steinrinne* may have acted as a magnet, regularly attracting different animals, among them nutritionally stressed individuals or potential prey for carnivores (Lyman 1994: 192; Selvaggio 1998). Consequently, these localities are then also frequently visited by the human hunters/scavengers (O'Connell et al. 2002: 849-851) responsible for the presence of the few cut-marked bones. When the *Steinrinne* area was an attractive area for mid-Pleistocene wildlife, rhinoceros and red deer carcasses and bones in particular perhaps accumulated here due to natural deaths and carnivore kills. Bear bones were already explicitly interpreted by Turner (2004) in this way. Rareness of small-sized animals, like birds, and deer gnawing-marks on antlers may show that some faunal remains were not buried immediately after death. Additionally, the *Steinrinne* may have been a typical zone of fluvial accumulation (Zepp 2004: 123, 146-147). All the material collected and transported by the *Wipper* river and/or its tributaries ultimately accumulated downstream close to, beside or in the *Steinrinne* area. Such situations are "the most likely places for final burial of fluvially transported bones" (Behrensmeyer 1975: 499); for example when migrating animals cross large rivers, the carcasses of drowned individuals float downstream producing concentrated, dense accumulation of faunal remains (Lyman 1994: 174). The beaver bones and fish remains of the *Steinrinne* may be explained in this way. However, not only flash floods but also sediment-loaded mass-flows are responsible for naturally derived animal bone accumulations (for pre-Pleistocene and Lower Pleistocene localities see i.a. Bandyopadhyay et al. 2002; Fiorillo et al. 2000; Khajuria & Prasad 1998; Křísek et al. 1992; Price & Webb 2006; Ryan et al.

2001; Sachse 2005; Turnbull & Martill 1988; Valli 2005). The early Pleistocene site Untermassfeld (Kahlke & Gaudzinski 2005; Kahlke 2006) provides an example from Thuringia. Only rarely have these sites been compared with supposed Lower Palaeolithic habitation sites (e.g. Villa & Lenoir 2009: 64-67). In the case of the *Steinrinne* these site formation processes are corroborated by the presence of old bone-fractures and breakage, traces of sediment-crushing on large mammal bones, the lack of anatomical connection and the diffuse vertical distribution of material with distinct orientation patterns.

In summary, the statement of Stopp (1997: 41-46) regarding the animal bones of the *Steinrinne* can only be reiterated, namely that "their deposition at this location is the result of a combination of the local catchment system and natural deaths, rather than the activity of (...) hunters" (Stopp 1997: 42). The common occurrence of faunal remains together with artefacts in a find horizon therefore does not necessarily indicate a causal association.

Taphonomic research on bones must be seen as a major tool of Lower Palaeolithic scientific research (e.g. Pickering et al. 2007). Recent archaeozoological studies have changed former interpretations of a dominant human influence for the occurrence of faunal remains at sites like Ambrona (Villa et al. 2005), Isernia (Villa & Lenoir 2009), Zhoukoudian (Boaz et al. 2000) or Olduvai Bed I (Domínguez-Rodrigo et al. 2007). However, these sites also represent good examples that this kind of research can provoke polemic discussions (Dalton 2007). We therefore want to emphasize that even though the irreversible modification of our understanding of human prehistory is a result of archaeological activity shaped by linearity in the development of this field, "there is no evidence that archaeologists at any one period are less influenced by subjective beliefs and social circumstances than they are at any other" (Trigger 1996: 39).

ACKNOWLEDGEMENTS: We gratefully acknowledge financial support by the Deutsche Forschungsgemeinschaft (Pa 527/5-1). The comments of two anonymous reviewers were much appreciated.

Literature cited

- Andrews, P. & Cook, J. (1985). Natural modifications to bones in a temperate setting. *Man* 22: 675-691.
- Ashton, N. (1992). The spatial distribution of the flint artefacts and human behaviour. In: N. Ashton, J. Cook, S. G. Lewis & J. Rose (Eds.) *High Lodge: excavations by G. de G. Sieveking 1962-68 and J. Cook 1988*. British Museum Press, London, 251-258.
- Ashton, N. (2004). The role of refitting in the British Lower Palaeolithic: a time for reflection. In: E. A. Walker, F. Wenban-Smith & F. Healy (Eds.) *Lithics in action*. Oxbow Books, Oxford, 57-64.
- Ashton, N., Lewis, S. G., Parfitt, S. & White, M. (2006). Riparian landscapes and human preferences during the Hoxnian (MIS 11) Interglacial. *Journal of Quaternary Science* 21: 497-505.

- Attard, I. R. & Reumer, J. W. F. (2009). Taphonomic re-interpretation of a bone sample of endemic Pleistocene deer from Crete (Greece): osteoporosis versus regurgitation. *Palaeodiversity* 2: 379-385.
- Bandyopadhyay, S., Roychowdhury, T. K., & Sengupta, D. P. (2002). Taphonomy of some Gondwana assemblages of India. *Sedimentary Geology* 147: 219-245.
- Beck, M., Gaupp, R., Kamradt, I., Liebermann, C. & Pasda, C. (2007). Bilzingsleben site formation processes. Geoarchaeological investigations of a Middle Pleistocene deposit: preliminary results of the 2003-2005 excavations. *Archäologisches Korrespondenzblatt* 37: 1-18.
- Becker, C. (2003). Bone artefacts and man – an attempt at a cultural system. In: G. Grupe & J. Peters (Eds.) *Decyphering ancient bones*. Documenta Archaeobiologiae 1, Verlag Marie Leidorf, Rahden/Westfalen, 83-124.
- Behm-Blancke, G. (1986). Zur geistigen Welt des *Homo erectus* von Bilzingsleben. *Jahresschrift für mitteldeutsche Vorgeschichte* 70: 41-82.
- Behm-Blancke, G. (1990). Zur Vorstellungswelt des *Homo erectus* von Bilzingsleben. In: J. Herrmann & H. Ullrich (Eds.) *Menschwerdung - biotischer und gesellschaftlicher Entwicklungsprozeß*. Schriften zur Ur- und Frühgeschichte 41. Akademie-Verlag, Berlin, 287-291.
- Behrensmeyer, A. K. (1975). The taphonomy and paleoecology of Plio-Pleistocene vertebrate assemblages east of Lake Rudolf, Kenya. *Bulletin of the Museum of Comparative Zoology* 146: 473-578.
- Behrensmeyer, A. K., Western, D. & Dechant Boaz, D. E. (1979). New perspectives in vertebrate paleoecology from a recent bone assemblage. *Paleobiology* 5: 12-21.
- Behrensmeyer, A. K., Gordon, K. D. & Yanagi, G. T. (1986). Trampling as a cause of bone surface damage and pseudotrampling marks. *Nature* 319: 768-771.
- Behrensmeyer, A. K., Gordon, K. D. & Yanagi, G. T. (1989). Non-human bone modification in Miocene fossils from Pakistan. In: R. Bonnichsen & M. H. Sorg (Eds.) *Bone modification*. Peopling of the Americas Publications, Orono, Maine, 99-120.
- Behrensmeyer, A. K., Strayton, C. T. & Chapman, R. E. (2003). Taphonomy and ecology of modern avifaunal remains from Amboseli Park. *Paleobiology* 29: 52-70.
- Bello, S. M., Parfitt, S. A. & Stringer, C. (2009). Quantitative micromorphological analyses of cut marks produced by ancient and modern handaxes. *Journal of Archaeological Science* 36: 1869-1880.
- Binford, L. R. (1981). *Bones: ancient man and modern myths*. Academic Press, New York.
- Blasco, R., Rosell, J., Arsuaga, J. L., Bermúdez de Castro, J. M. & Carbonell, E. (2010). The hunted hunter: the capture of a lion (*Panthera leo fossilis*) at the Gran Dolina site, Sierra de Atapuerca, Spain. *Journal of Archaeological Science* 37: 2051-2060.
- Blumenshine, R. J. (1995). Percussion marks, tooth marks, and experimental determinations of the timing of hominid access to long bones at FLK Zinjanthropus, Olduvai Gorge, Tanzania. *Journal of Human Evolution* 29: 21-51.
- Blumenshine, R. J. & Marean, C. W. (1993). A carnivore's view of archaeological bone assemblages. In: J. Hudson (Ed.) *From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Zooarchaeological Remains*. Center for Archaeological Investigations, University of Southern Illinois, Carbondale, 273-300.
- Boaz, N. T., Ciochon, R. L., Qinqi, X. & Jinyi, L. (2000). Large mammalian carnivores as a taphonomic factor in the bone accumulation at Zhoukoudian. *Acta Anthropologica Sinica* 19: 224-234.
- Boelhouwers, J. & Scheepers, T. (2004). The role of antelope trampling on scarp erosion in a hyper-arid

- environment, Skeleton Coast, Namibia. *Journal of Arid Environments* 58: 545-557.
- Böhme, G. (1998).** Neue Funde von Fischen, Amphibien und Reptilien aus dem Mittelpleistozän von Bilzingsleben. *Praehistoria Thuringica* 2: 96-107.
- Böhme, G. (2001).** Eigelege der Sumpfschildkröte, *Emys orbicularis* Linnaeus, 1758, aus dem mittelpleistozänen Travertin von Bilzingsleben. *Praehistoria Thuringica* 6/7: 39-45.
- Böhme, G. (2004).** Reste von Amphibien und Reptilien aus der Fundstelle Bilzingsleben und die quartären fossilen Herpetofaunen Thüringens. In: D. Mania (Ed.) *Bilzingsleben V. Beiträge zur Ur- und Frühgeschichte Mitteleuropas* 4. Beier & Beran, Langenweissbach, 113-120.
- Böhme, G. (2009).** Reste von Fischen, Amphibien und Reptilien aus dem Mittelpleistozän von Bilzingsleben /Thüringen. *Praehistoria Thuringica* 12: 24-36.
- Boschian, G. & Saccà, D. (2010).** Ambiguities in human and elephant interactions? Stories of bones, sand and water from Castel di Guido (Italy). *Quaternary International* 214: 3-16.
- Brain, C. K. (1974).** Some suggested procedures in the analysis of bone accumulations from southern African quaternary sites. *Annals of the Transvaal Museum* 29: 1-8.
- Brain, C. K. (1981).** *The hunters or the hunted? An introduction to African cave taphonomy*. University of Chicago Press, Chicago.
- Bratlund, B. (1999).** Taubach revisited. *Jahrbuch des Römisch-Germanischen Zentralmuseums* 46: 61-174.
- Bridgland, D. R., Schreve, D. C., Keen, D. H., Meyrick, R. & Westaway, R. (2004).** Biostratigraphical correlation between the late Quaternary sequences of the Thames and key locations in central Germany. *Proceedings of the Geologists Association* 115: 125-140.
- Cleghorn, N. & Marean, C. W. (2004).** Distinguishing selective transport and in situ attrition: a critical review of analytical approaches. *Journal of Taphonomy* 2: 43-67.
- Conard, N. J. (1992).** Tönchesberg and its position in the Paleolithic prehistory of Northern Europe. *Monographie des Römisch-Germanischen Zentralmuseums* 20. Habelt, Bonn.
- Cortés-Avizanda, A., Selva, N., Carrete, M. & Donazar, J. A. (2009).** Effects of carrion resources on herbivore spatial distribution are mediated by facultative scavengers. *Basic and Applied Ecology* 10: 265-272.
- Dalton, R. (2007).** War of words erupts over fossil dig. *Nature* 448: 12.
- Daniel, T. & Frenzel, P. (2010).** Ostrakoden aus der mittelpleistozänen Hominiden-Fundstelle Bilzingsleben. *Tagungsheft der 52. Jahrestagung der Hugo Obermaier-Gesellschaft, Leipzig, 6.-10.4.2010*: 73-78.
- Davidson, I. (1990).** Bilzingsleben and early marking. *Rock Art Research* 7: 52-56.
- de Juana, S., Galán, A. B. & Domínguez-Rodrigo, M. (2010).** Taphonomic identification of cut marks made with lithic handaxes: an experimental study. *Journal of Archaeological Science* 37: 1841-1850.
- Domínguez-Rodrigo, M. & Barba, R. (2005).** A study of cut marks on small-sized carcasses and its application to the study of cut-marked bones from small mammals at the FLK Zinj site. *Journal of Taphonomy* 3: 121-134.
- Domínguez-Rodrigo, M., Barba, R. & Egeland, C. P. (Eds.) (2007).** *Deconstructing Olduvai I: taphonomic study of the Bed I sites*. Springer, Dordrecht.
- Egeland, C. P. (2008).** The taphonomy of bone-crunching carnivores. *Journal of Taphonomy* 6: 250-428
- Eissmann, L. (1994).** Grundzüge der Quartärgeologie Mitteldeutschlands (Sachsen, Sachsen-Anhalt, Südbrandenburg, Thüringen). In: L. Eissmann & T. Litt (Eds.) *Das Quartär Mitteldeutschlands*. Altenburger Naturwissenschaftliche Forschungen 7: 55-135.
- Eissmann, L. (1997).** Das quartäre Eiszeitalter in Sachsen und Nordostthüringen. *Altenburger Naturwissenschaftliche Forschungen* 8. Altenburg.
- Elgmork, K. (1982).** Caching behavior of brown bear (*Ursus arctos*). *Journal of Mammalogy* 63: 607-612.
- Elgmork, K. & Tjørve, E. (1995).** Brown bear *Ursus arctos* scavenging patterns. *Wildlife Biology* 1: 239-242.
- Erath, M. (1996).** *Studien zum mittelalterlichen Knochenschnitzhandwerk. Die Entwicklung eines spezialisierten Handwerks in Konstanz*. PhD dissertation, University of Freiburg/Breisgau.
- Escudé, E., Montuire, S., Desclaux, E., Quéré, J.-P., Renvoise, E. & Jeannet, M. (2008).** Reappraisal of 'chronospecies' and the use of *Arvicola* (Rodentia, Mammalia) for biochronology. *Journal of Archaeological Science* 35: 1867-1879.
- Faith, J. T. & Behrensmeier, A. K. (2006).** Changing patterns of carnivore modification in a landscape bone assemblage, Amboseli Park, Kenya. *Journal of Archaeological Science* 33: 1718-1733.
- Fiorillo, A. R. (1989).** An experimental study of trampling: implications for the fossil record. In: R. Bonnichsen & M. H. Sorg (Eds.) *Bone modification*. Peopling of the Americas Publications, Orono, Maine, 61-71.
- Fiorillo, A. R., Padian, K. & Musikasinthorn, C. (2000).** Taphonomy and depositional setting of the *Placerias* Quarry (Chinle Formation: late Triassic, Arizona). *Palaios* 15: 383-386.
- Fischer, K. (1991a).** Postkraniale Skelettreste von Bibern (*Castor* L., *Trogontherium* Fischer, Castoridae, Rodentia, Mamm.) aus dem Mittelpleistozän von Bilzingsleben. In: K. Fischer, E.W. Guenther, W.-D. Heinrich, D. Mania, R. Musil & T. Nötzold (Eds.) *Bilzingsleben IV. Veröffentlichungen des Landesmuseums für Vorgeschichte in Halle/Saale* 44. Berlin, 63-70.
- Fischer, K. (1991b).** Wildrinderreste (Bovidae, Artiodactyla, Mammalia) aus dem mittelpleistozänen Holstein-Komplex von Bilzingsleben. In: K. Fischer, E.W. Guenther, W.-D. Heinrich, D. Mania, R. Musil, & T. Nötzold (Eds.) *Bilzingsleben IV. Veröffentlichungen des Landesmuseums für Vorgeschichte in Halle/Saale* 44. Berlin, 139-147.
- Fischer, K. (2004).** Vögel (Aves) und mittelgroße bis kleine Carnivoren (Mammalia) aus dem Holstein-Komplex von Bilzingsleben (Thüringen). In: D. Mania (Ed.) *Bilzingsleben V. Beiträge zur Ur- und Frühgeschichte Mitteleuropas* 4. Beier & Beran, Langenweissbach, 183-188.
- Fischer, K. (2009).** Weitere Fossilfunde von Vögeln und ausgewählten Säugetieren aus dem mittelpleistozänen Travertin von Bilzingsleben. *Praehistoria Thuringica* 12: 37-52.
- Fischer, K. & Heinrich, W.-D. (1991).** *Sus scrofa* L. (Mammalia: Artiodactyla, Suidae) aus der altpaläolithischen Fundstelle Bilzingsleben in Thüringen. In: K. Fischer, E.W. Guenther, W.-D. Heinrich, D. Mania, R. Musil, & T. Nötzold (Eds.) *Bilzingsleben IV. Veröffentlichungen des Landesmuseums für Vorgeschichte in Halle/Saale* 44. Berlin, 131-138.
- Fisher, J. W. (1995).** Bone surface modifications in zooarchaeology. *Journal of Archaeological Method and Theory* 2: 7-68.
- Fosse, P., Laudet, F. Selva N. & Wajrak A. (2004).** Premières observations néotaphonomiques sur des assemblages osseux de Bialowicza (N.-E. Pologne): intérêts pour les gisements pléistocènes d'Europe. *Paléo* 16: 91-116.
- Gamble, C. (1999).** *Palaeolithic societies of Europe*. Cambridge University Press, Cambridge.
- Gaudzinski, S. (1998).** Knochen und Knochengeräte der mittelpaläolithischen Fundstelle Salzgitter-Lebenstedt (Deutschland). *Jahrbuch des Römisch-Germanischen Zentralmuseums* 45: 163-220.
- Gramsch, B. (2003).** Zum Geleit – Dietrich Mania anlässlich seines 65. Geburtstages. In: J. M. Burdukiewicz, L. Fiedler, W.-D. Heinrich, A. Justus & E. Brühl (Eds.) *Erkenntnisjäger – Kultur und Umwelt des frühen Menschen (Festschrift für Dietrich Mania)*. Veröffentlichungen des Landesamt für Archäologie Sachsen-Anhalt 57, Halle/Saale, 13-18.

- Grünberg, J. M. (2002). Die paläolithische und mesolithische Sammlung des Landesamtes für Archäologie Sachsen-Anhalt. *Jahresschrift für mitteldeutsche Vorgeschichte* 85: 11-61.
- Guenther, E. W. (1991). Die Gebisse der Waldelefanten von Bilzingsleben. In: K. Fischer, E. W. Guenther, W.-D. Heinrich, D. Mania, R. Musil & T. Nötzold (Eds.) *Bilzingsleben IV*. Veröffentlichungen des Landesmuseums für Vorgeschichte in Halle/Saale 44. Berlin, 149-174.
- Haglund, W. D. & Sorg, M. H. (Eds.) (1997). *Forensic taphonomy. The postmortem fate of human remains*. CRC Press, Boca Raton.
- Hahn, J. (1989). Zur Methodik von Höhlengrabungen. In: E. Gersbach (Ed.) *Ausgrabung heute*. Wissenschaftliche Buchgesellschaft, Darmstadt, 131-160.
- Hallos, J. (2004). Artefact dynamics in the Middle Pleistocene: implications for human behaviour. In: E. A. Walker, F. Wenban-Smith & F. Healy (Eds.) *Lithics in action*. Oxbow Books, Oxford, 26-37.
- Hallos, J. (2005). "15 minutes of fame": exploring the temporal dimensions of Middle Pleistocene lithic technology. *Journal of Human Evolution* 49: 155-179.
- Haynes, G. (1980). Evidence of carnivore gnawing on Pleistocene and recent mammalian bones. *Paleobiology* 6: 341-351.
- Haynes, G. (1988). Mass deaths and serial predation: comparative taphonomic studies of modern large mammal death sites. *Journal of Archaeological Science* 15: 219-235.
- Haynes, G. (2006). Mammoth landscapes: good country for hunter-gatherers. *Quaternary International* 142-143: 20-29.
- Hebig, W. (2003). Die Fische von Bilzingsleben. *Præhistoria Thuringica* 9: 89-96.
- Heinrich, W.-D. (1991). Biometrische Untersuchungen an Fossilresten des Bibers (*Castor fiber* L.) aus der Fundstätte Bilzingsleben. In: K. Fischer, E.W. Guenther, W.-D. Heinrich, D. Mania, R. Musil & T. Nötzold (Eds.) *Bilzingsleben IV*. Veröffentlichungen des Landesmuseums für Vorgeschichte in Halle/Saale 44. Berlin, 35-62.
- Heinrich, W.-D. (1998). Weitere Funde von Kleinsäugetieren aus dem Travertinkomplex Bilzingsleben II in Thüringen. *Præhistoria Thuringica* 2: 89-95.
- Heinrich, W.-D. (2000). Rodentier-Biostratigraphie und Altersstellung der mittelpleistozänen *Homo erectus*-Schichten der Travertinfundstelle Bilzingsleben II in Thüringen, Mitteldeutschland. *Præhistoria Thuringica* 4: 28-40.
- Heinrich, W.-D. (2004a). Zur Taphonomie, Paläoökologie und Biostratigraphie fossiler Kleinsäugetierfaunen aus dem mittelpleistozänen Travertinkomplex Bilzingsleben II in Thüringen. In: D. Mania (Ed.) *Bilzingsleben V*. Beiträge zur Ur- und Frühgeschichte Mitteleuropas 4. Beier & Beran, Langenweissbach. 121-134.
- Heinrich, W.-D. (2004b). Über *Trogontherium cuvieri* (Mammalia, Rodentia: Castoridae) aus dem mittelpleistozänen Travertinkomplex Bilzingsleben II in Thüringen. In: D. Mania (Ed.) *Bilzingsleben V*. Beiträge zur Ur- und Frühgeschichte Mitteleuropas 4. Beier & Beran, Langenweissbach, 135-182.
- Holtmeier, F.-K. (2002). *Tiere in der Landschaft. Einfluss und ökologische Bedeutung*. Ulmer UTB, Stuttgart.
- Jöris, O. & Baales, M. (2003). Zur Altersstellung der Schöninger Speere. In: J. M. Burdukiewicz, L. Fiedler, W.-D. Heinrich, A. Justus & E. Brühl (Eds.) *Erkenntnisjäger. Kultur und Umwelt des frühen Menschen (Festschrift für Dietrich Mania)*. Veröffentlichungen des Landesamtes für Archäologie Sachsen-Anhalt 57. Halle/Saale, 281-288.
- Kahlke, R.-D. (2006). *Untermassfeld – A late Early Pleistocene (Epivillafranchian) fossil site near Meiningen (Thuringia, Germany) and its position in the development of the European mammal fauna*. BAR International Series 1578, Archaeopress, Oxford.
- Kahlke, R.-D. & Gaudzinski, S. (2005). The blessing of a great flood: differentiation of mortality patterns in the large mammal record of the Lower Pleistocene fluvial site of Untermassfeld (Germany) and its relevance for the interpretation of faunal assemblages from archaeological sites. *Journal of Archaeological Science* 32: 1202-1222.
- Khajuria, C. K. & Prasad, G. V. R. (1998). Taphonomy of a late Cretaceous mammal-bearing microvertebrate assemblage from the Deccan inter-trappean beds of Naskal, peninsular India. *Palaeogeography, Palaeoclimatology, Palaeoecology* 137: 153-172.
- Kolen, J. (1999). Hominids without homes: on the nature of Middle Palaeolithic settlement in Europe. In: W. Roebroeks & C. Gamble (Eds.) *The middle Palaeolithic occupation of Europe*. University of Leiden, Leiden, 139-176.
- Krissek, L. A., Horner, T. C., Elliot, D. H. & Collinson, J. W. (1992). Stratigraphy and sedimentology of vertebrate bone-bearing beds in the Triassic (and Jurassic?) Fremouw and Falla formations, Beardmore Glacier region, Antarctica. In: Y. Yoshida, K. Kaminuma & K. Shiraishi (Eds.) *Recent progress in Antarctic Earth Science*. Terra Scientific Publishing Company, Tokyo, 249-256.
- Krofel, M., Potočnik, M. & Kos, I. (2007). Topographical and vegetational characteristics of lynx kill sites in Slovenian Dinaric Mountains. *Natura Sloveniae: revija za terensko biologijo* 9: 25-36.
- Lacruz, R. & Maude, G. (2005). Bone accumulations at brown hyena (*Parahyaena brunnea*) den sites in the Makgadikgadi Pans, northern Botswana: taphonomic, behavioural, and palaeoecological implications. *Journal of Taphonomy* 3: 43-53.
- Lansing, S. W., Cooper, S. M., Boydston, E. E. & Holekamp, K. E. (2009). Taphonomic and zooarchaeological implications of spotted hyena (*Crocuta crocuta*) bone accumulations in Kenya: a modern behavioural ecological approach. *Paleobiology* 35: 289-309.
- Laudet, F. & Selva, N. (2005). Ravens as small mammal bone accumulators: first taphonomic study on mammal remains in raven pellets. *Palaeogeography, Palaeoclimatology, Palaeoecology* 226: 272-286.
- Lyman, R. L. (1994). *Vertebrate taphonomy*. Cambridge University Press, Cambridge.
- MacGregor, A. (1991). Antler, bone and horn. In: J. Blair & N. Ramsey (Eds.) *English medieval industries. Craftsmen, techniques, products*. Hambledon Press, London, 355-378.
- Mallick, R. (2001). Präzise Th/U-Datierung archäologisch relevanter Travertinvorkommen Thüringens. In: G. Wagner & D. Mania (Eds.) *Frühe Menschen in Mitteleuropa. Chronologie, Umwelt, Kultur*. Aachen, 77-89.
- Mangano, G., Bonfiglio, L. & Petruso, D. (2005). Excavations of 2003 at the S. Teodoro cave (North-Eastern Sicily, Italy): preliminary faunistic and stratigraphic data. *Geo. Alp* 2: 71-76.
- Mania, D. (1974). Bilzingsleben, Kr. Artern: Eine altpaläolithische Travertinfundstelle im nördlichen Mitteleuropa (Vorbericht). *Zeitschrift für Archäologie* 8: 157-173.
- Mania, D. (1986a). Die Siedlungsspuren des *Homo erectus* von Bilzingsleben. In: D. Mania & T. Weber (Eds.) *Bilzingsleben III*. Veröffentlichungen des Landesmuseums für Vorgeschichte in Halle/Saale 39. Berlin, 9-64.
- Mania, D. (1986b). Die Geweihartefakte des *Homo erectus* von Bilzingsleben. In: D. Mania & T. Weber (Eds.) *Bilzingsleben III*. Veröffentlichungen des Landesmuseums für Vorgeschichte in Halle/Saale 39. Berlin, 233-256.
- Mania, D. (1990a). *Auf den Spuren des Urmenschen. Die Funde auf der Steinrinne bei Bilzingsleben*. Deutscher Verlag der Wissenschaften, Berlin.
- Mania, D. (1990b) *Der Mensch vor 350000 Jahren. Ein Bericht aus unserer Vergangenheit*. Landratsamt, Artern.
- Mania, D. (1991). Zur Paläontologie der mittelpleistozänen Travertine von Bilzingsleben. – In: K. Fischer, E.W. Guenther, W.-D. Heinrich, D. Mania, R. Musil & T. Nötzold (Eds.) *Bilzingsleben IV*. Veröffentlichungen des Landesmuseums für Vorgeschichte in Halle/Saale 44. Berlin, 9-28.

- Mania, D. (1997).** Bilzingsleben – Ein kulturgeschichtliches Denkmal der Stammesgeschichte des Menschen. *Præhistoria Thuringica* 1: 30-80.
- Mania, D. & Altermann, M. (2004).** Zur Geologie des altpaläolithischen Fundhorizontes von Bilzingsleben (Thüringen) unter Berücksichtigung des geologischen Wirkfaktors „Mensch“. *Hercynia N.F.* 37: 143-184.
- Mania, D. & Mai, H.-D. (2001).** Molluskenfaunen und Floren im Elbe-Saalegebiet während des mittleren Eiszeitalters. *Præhistoria Thuringica* 6/7: 46-91.
- Mania, D. & Mania, U. (2001).** 30 Jahre Bilzingsleben-Forschung. *Præhistoria Thuringica* 6/7: 3-25.
- Mania, D. & Mania, U. (2005).** The natural and socio-cultural environment of *Homo erectus* at Bilzingsleben, Germany. In: C. Gamble & M. Porr (Eds.) *The hominid individual in context. Archaeological Investigations of Lower and Middle Palaeolithic landscapes, locales and artefacts*. Oxon, New York, 98-114.
- Marean, C. W. & Cleghorn, N. (2003).** Large mammal skeletal transport: applying foraging theory in a complex taphonomic system. *Journal of Taphonomy* 1: 15-42.
- Marean, C. W., Domínguez-Castro, M. & Pickering, T. R. (2004).** Skeletal element equifinality in zooarchaeology begins with method: the evolution and status of the "shaft critique". *Journal of Taphonomy* 2: 69-98.
- Maul, L. C. & Heinrich, W.-D. (2007).** Neue Daten zur Kleinsäugerstratigraphie und Altersabfolge deutscher Quartärfundstellen. In: Archäologische Gesellschaft in Thüringen e.V. (Ed.) *Terra Præhistorica. Festschrift für Klaus-Dieter Jäger zum 70. Geburtstag*. Beiträge zur Ur- und Frühgeschichte Mitteleuropas 48. Beier & Beran, Langenweißbach, 96-110.
- MacGregor, A. G. & Currey, J. D. (1983).** Mechanical properties as conditioning factors in the bone and antler industry of the 3rd to 13th century AD. *Journal of Archaeological Science* 10: 71-77.
- Mihlbachler, M. C. (2003).** Demography of late Miocene rhinoceroses (*Teleoceras proterum* and *Aphelops malacorhinus*) from Florida: linking mortality and sociality in fossil assemblages. *Paleobiology* 29: 412-428.
- Montgomery, D. R. & Piégay, H. (2003).** Wood in rivers: interactions with channel morphology and progress. *Geomorphology* 51: 1-5.
- Morel, P. & Müller, W. (1997)** *Hauterive-Champréveyres, 11. Un campement magdalénien au bord du lac de Neuchâtel. Étude archéozoologique*. Archéologie neuchâteloise, 23, Musée cantonal d'Archéologie, Neuchâtel.
- Morgan, L. H. (1868).** *The American beaver and his works*. Lippincott, Philadelphia.
- Musil, R. (1991a).** Die Bären von Bilzingsleben. In: K. Fischer, E.W. Guenther, W.-D. Heinrich, D. Mania, R. Musil & T. Nötzold (Eds.) *Bilzingsleben IV. Veröffentlichungen des Landesmuseums für Vorgeschichte in Halle/Saale* 44. Berlin, 81-102.
- Musil, R. (1991b).** Die Pferde aus Bilzingsleben. In: K. Fischer, E.W. Guenther, W.-D. Heinrich, D. Mania, R. Musil & T. Nötzold (Eds.) *Bilzingsleben IV. Veröffentlichungen des Landesmuseums für Vorgeschichte in Halle/Saale* 44. Berlin, 103-130.
- Musil, R. (2000).** Bilzingsleben – die Funde von Pferden und Bären. *Præhistoria Thuringica* 4: 65-66.
- Musil, R. (2002).** Morphologische und metrische Differenzen der Pferde von Bilzingsleben und Schöningen. *Præhistoria Thuringica* 8: 143-148.
- O'Connell, J. F., Hawkes, K., Lupo, K. D. & Blurton Jones, N. G. (2002).** Male strategies and Plio-Pleistocene archaeology. *Journal of Human Evolution* 43: 831-872.
- Oliver, J. S. (1989).** Analogues and site context: bone damage from Shield Trap Cave (24CB91). In: R. Bonnicksen & M. H. Sorg (Eds.) *Bone modification*. Peopling of the Americas Publications, Orono, Maine, 73-98.
- Orschiedt, J. (1999).** *Manipulationen an menschlichen Skelettresten: taphonomische Prozesse, Sekundärbestattungen oder Kannibalismus?* Urgeschichtliche Materialhefte 13. Mo Vince, Tübingen.
- Palmqvist, P. & Arribas, A. (2001).** Taphonomic decoding of the paleobiological information locked in a lower Pleistocene assemblage of large mammals. *Paleobiology* 27: 512-530.
- Pante, M. C. & Blumenschine, R. J. (2010).** Fluvial transport of bovid long bones fragmented by the feeding activities of hominins and carnivores. *Journal of Archaeological Science* 37: 846-854.
- Pickering, T. R., Schick, K. D. & Toth, N. (Eds.) (2007).** *Breathing life into fossils: taphonomic studies in honor of C. K. (Bob) Brain*. Stone Age Institute Press, Gosport.
- Pokines, J. T. & Kerbis Peterhans, J. C. (2007).** Spotted hyena (*Crocuta crocuta*) den use and taphonomy in the Masai Mara National Reserve, Kenya. *Journal of Archaeological Science* 34: 1914-1931.
- Pope, M. (2004).** Behavioural implications of biface discard: assemblage variability and landuse at the Middle Pleistocene site of Boxgrove. In: E. A. Walker, F. Wenban-Smith & F. Healy (Eds.) *Lithics in action*. Oxbow Books, Oxford, 38-47.
- Pope, M. & Roberts, M. (2005).** Observations on the relationship between Palaeolithic individuals and artefact scatters at the Middle Pleistocene site of Boxgrove, UK. In: C. Gamble & M. Porr (Eds.) *The hominid individual in context. Archaeological Investigations of Lower and Middle Palaeolithic landscapes, locales and artefacts*. Oxon, New York, 81-97.
- Potts, R. & Shipman, P. (1981).** Cutmarks made by stone tools on bones from Olduvai Gorge, Tanzania. *Nature* 291: 577-580.
- Price, G. J. & Webb, G. E. (2006).** Late Pleistocene sedimentology, taphonomy and megafauna extinction on the Darling Downs, southeastern Queensland. *Australian Journal Earth Sciences* 53: 947-970.
- Rabinovich, R., Gaudzinski-Windheuser, S. & Goren-Inbar, N. (2008).** Systematic butchering of fallow deer (*Dama*) at the early middle Pleistocene Acheulian site of Gesher Benot Ya'aqov (Israel). *Journal of Human Evolution* 54: 134-149.
- Rosell, F., Bozsér, O., Collen, P. & Parker, H. (2005).** Ecological impact of beavers *Castor fiber* and *Castor canadensis* and their ability to modify ecosystems. *Mammal Reviews* 35: 248-276.
- Rösner, S., Selva, N., Müller, T., Pugaciewicz, E. & Laudet, F. (2005).** Raven *Corvus corax* ecology in a primeval temperate forest. In: L. Jerzak, B. P. Kavanagh & P. Tryjanowski (Red.) *Ptaki krukowate Polski*. Nauk, Poznan, 385-405.
- Ryan, M. J., Russell, A. P., Eberth, D. A. & Currie, P. J. (2001).** The taphonomy of *Centrosaurus* (*Ornithischia: Certopsidae*) bone bed from the dinosaur park formation (Upper Campanian, Alberta, Canada, with comments on cranial ontogeny. *Palaio* 16: 482-506.
- Rybczynski, N. (2008).** Woodcutting behaviour in beavers (*Castoridae*, Rodentia): estimating ecological performance in a modern and a fossil taxon. *Paleobiology* 34: 389-402.
- Sachse, M (2005).** A remarkable fossiliferous mass flow deposit in the Eocene Eckfeld Maar (Germany) - Sedimentological, taphonomical, and palaeontological considerations. *Facies* 51: 173-184.
- Selva, N. (2004a).** *The role of scavenging in a predator community of Białowieża primeval forest*. Ph.D. dissertation, Universidad de Sevilla.
- Selva, N. (2004b).** Life after death – Scavenging on ungulates. In: B. Jędrzejewska & J. M. Wójcik (Eds.) *Essays on mammals of Białowieża forest*. Mammal Research Institute, Polish Academy of Sciences, Białowieża, 59-68.
- Selva, N. & Fortuna, M. A. (2007).** The nested structure of a scavenger community. *Proceedings of the Royal Society*, B 274: 1101-1108.
- Selva, N., Jędrzejewska, B. & Jędrzejewski, W. (2003).** Scavenging on European bison carcasses in Białowieża primeval forest (eastern Poland). *Ecoscience* 10: 303-311.

- Selva, N., Jędrzejewska, B., Jędrzejewski, W. & Wajrak, A. (2005). Factors effecting carcass use by a guild of scavengers in European temperate woodland. *Canadian Journal of Zoology* 83: 1590-1601.
- Selvaggio, M. M. (1998). The archaeological implications of water-cached hyena kills. *Current Anthropology* 39: 380-383.
- Shipman, P. (1981). *Life history of a fossil*. Harvard University Press, Cambridge, MA.
- Shipman, P. (1983). Early hominid lifestyle: hunting and gathering or foraging and scavenging? In: J. Clutton-Brock & C. Grigson (Eds.) *Animals and archaeology. Hunters and their Prey Vol. 1*. BAR International Series 163, Archaeopress, Oxford, 31-49.
- Shipman, P. & Rose, J. (1983). Early hominid hunting, butchering, and carcass-processing behaviors: approaches to the fossil record. *Journal of Anthropological Archaeology* 2: 57-98.
- Steguweit, L. (2003). *Gebrauchsspuren an Artefakten der Hominidenfundstelle Bilzingsleben (Thüringen)*. Tübinger Arbeiten zur Urgeschichte 2. Verlag Marie Leidorf, Rahden/Westfalen.
- Stopp, M. P. (1997). Modelling mythologies of early human adaptation in the northern hemisphere. In: I. J. Jackson & P. T. Thacker (Eds.) *Caribou and reindeer hunters of the northern hemisphere*. Avebury, Aldershot, 32-51.
- Street, M. (2002). Plaidter Hummerich – An early Weichselian Middle Palaeolithic site in the central Rhineland, Germany. *Monographien des Römisch-Germanischen Zentralmuseums* 45. Habelt, Mainz.
- Toepfer, V. (1980). Die geologisch-paläontologische und archäologische Erforschung des Travertinkomplexes von Bilzingsleben 1710-1970. In: D. Mania, V. Toepfer & E. Vlček (Eds.) *Bilzingsleben I*. Veröffentlichungen des Landesmuseums für Vorgeschichte in Halle/Saale 32. VEB Deutscher Verlag der Wissenschaften, Berlin, 11-41.
- Toepfer, V. (1983). Ein Oberkieferfragment des Löwen aus dem Travertinkomplex von Bilzingsleben, Kr. Artern, und die Fundstellen pleistozäner Löwen im Gebiet der DDR. In: D. H. Mai, D. Mania, T. Nötzold, V. Toepfer, E. Vlček & W.-D. Heinrich (Eds.) *Bilzingsleben II*. Veröffentlichungen des Landesmuseums für Vorgeschichte in Halle/Saale 36. VEB Deutscher Verlag der Wissenschaften, Berlin, 163-173.
- Trigger, B. G. (1996). *A history of archaeological thought*. Cambridge University Press, Cambridge, reprint 2007, 2nd edition.
- Turnbull, W. D. & Martill, D. M. (1988). Taphonomy and preservation of a monospecific titanotheres assemblage from the Washakie Formation (late Eocene), southern Wyoming. An ecological accident in the fossil record. *Palaeogeography, Palaeoclimatology, Palaeoecology* 63: 91-108.
- Turner, A. (2004). Bears and lions of Bilzingsleben: palaeo-ecological implications. In: D. Mania (Ed.) *Bilzingsleben V*. Beiträge zur Ur- und Frühgeschichte Mitteleuropas 4. Beier & Beran, Langenweissbach, 189-195.
- Turner, E. (2002). Solutré. An archaeozoological analysis of the Magdalenian horizon. Monographie des Römisch-Germanischen Zentralmuseums 46, Habelt, Bonn.
- Valli, A. M. F. (2005). Taphonomy of the late Miocene mammal locality of Akkaşdağı, Turkey. In: S. Sen (Ed.) *Geology, mammals and environments at Akkaşdağı, late Miocene of Central Anatolia*. Geodiversitas 27: 793-808.
- van der Made, J. (1998). A preliminary note on the cervids from Bilzingsleben. *Præhistoria Thuringica* 2: 108-122.
- van der Made, J. (2000). A preliminary note on the rhinos from Bilzingsleben. *Præhistoria Thuringica* 4: 41-64.
- Villa, P. & Lenoir, M. (2009). Hunting and hunting weapons of the Lower and Middle Paleolithic of Europe. In: J. J. Hublin & M. P. Richards (Eds.) *The evolution of hominin diets: integrating approaches to the study of Palaeolithic subsistence*. Springer, Berlin, 59-85.
- Villa, P. & Mahieu, E. (1991). Breakage patterns of human long bones. *Journal of Human Evolution* 21: 27-48.
- Villa, P., Soto, E., Santonja, M., Pérez-González, A., Mora, R., Parcerisas, J. & Sesé, C. (2005). New data from Ambrona: closing the hunting versus scavenging debate. *Quaternary International* 126-128: 223-250.
- Vlček, E. (1999). Der fossile Mensch von Bilzingsleben: Die Rekonstruktion der Schädel, zu ihrer Morphologie und taxonomisch-phylogenetischen Stellung. *Præhistoria Thuringica* 3: 11-26.
- Vlček, E. (2003). *Macaca florentina* von Bilzingsleben im Vergleich mit mittelepleistozänen Funden Europas. In: J. M. Burdukiewicz, L. Fiedler, W.-D. Heinrich, A. Justus & E. Brühl (Eds.) *Erkenntnisjäger. Kultur und Umwelt des frühen Menschen (Festschrift für Dietrich Mania)*. Veröffentlichungen des Landesamtes für Archäologie Sachsen-Anhalt 57, Halle/Saale, 623-645.
- Vlček, E., Mania D. & Mania U. (2002) *Der fossile Mensch von Bilzingsleben*. Bilzingsleben V. Beiträge zur Ur- und Frühgeschichte 35. Beier & Beran, Langenweißbach.
- Vökler, D. (2009). *Untersuchungen zur Genese eines Fundplatzes früher Hominiden (Bilzingsleben) auf der Grundlage ökologischer Indikatoren (Mollusken)*. Master thesis, University of Jena, 123 p.
- Vollbrecht, J. (2000). Die Geweihfunde aus Bilzingsleben, Ausgrabungen 1969-1983. *Internet Archaeology* 8, (http://intarch.ac.uk/journal/issue8/vollde_doc.html).
- Voormolen B. (2008). *Ancient hunters, modern butchers. Schöningen 13II-4, a kill-butcher site dating from the northwest European Lower Palaeolithic*. PhD thesis, Universiteit Leiden, private publication.
- Walter, H. (1984). *Vegetation und Klimazonen*. Universitäts-taschenbücher 14. Stuttgart.
- Wenban-Smith, W. (2004). Bringing behaviour into focus: archaic landscapes and lithic technology. In: E. A. Walker, F. Wenban-Smith & F. Healy (Eds.) *Lithics in action*. Oxbow Books, Oxford, 48-56.
- Wenban-Smith, F., Gamble, C. & Apsimon, A. (2000). The Lower Palaeolithic site at Red Burns, Portchester, Hampshire: bifacial technology, raw material quality, and the organization of archaic behaviour. *Proceedings of the Prehistoric Society* 66: 209-255.
- White, M. & Plunkett, S. (2004). *Miss Layard excavates: a Palaeolithic site at Foxhall Road, Ipswich, 1903-1905*. Western Academic & Specialist Press, Liverpool.
- Wilcox, J. T. & van Vuren, D. H. (2009). Wild pigs as predators in oak woodlands of California. *Journal of Mammalogy* 90: 114-118.
- Yravedra, J., Domínguez-Rodrigo, M., Santonja, M., Pérez-González, A., Panera, J., Rubio-Jara, S. & Baquedano, E. (2010). Cut marks on the Middle Pleistocene elephant carcass of Áridos 2 (Madrid, Spain). *Journal of Archaeological Science* 37: 2469-2476.
- Zepp, H. (2004). *Geomorphologie. Eine Einführung*. 3. Aufl., Schöningh, Paderborn.

Quartär

Internationales Jahrbuch zur Eiszeitalter- und Steinzeitforschung

International Yearbook for Ice Age and Stone Age Research

Band – Volume
58

Edited by

Werner MÜLLER, Berit Valentin ERIKSEN,
Martin STREET, Gerd-Christian WENIGER



Verlag Marie Leidorf GmbH · Rahden/Westf.
2011

220 Seiten mit 193 Abbildungen

Manuskript-Richtlinien und weitere Informationen unter <http://www.quartaer.eu>
Instructions for authors and supplementary information at <http://www.quartaer.eu>

Bibliographische Information der Deutschen Nationalbibliothek

Müller, Werner / Eriksen, Berit Valentin / Street, Martin / Weniger, Gerd-Christian (Eds.):

Quartär: Internationales Jahrbuch zur Eiszeitalter- und Steinzeitforschung; Band 58

International Yearbook for Ice Age and Stone Age Research; Volume 58

Rahden/Westf.: Leidorf, 2011

ISBN: 978-3-86757-924-7

Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliographie.
Detaillierte bibliographische Daten sind im Internet über <http://dnb.ddb.de> abrufbar.

Gedruckt auf alterungsbeständigem Papier

Alle Rechte vorbehalten

© 2011



Verlag Marie Leidorf GmbH

Geschäftsführer: Dr. Bert Wiegel

Stellerloh 65 - D-32369 Rahden/Westf.

Tel: +49/(0)5771/ 9510-74

Fax: +49/(0)5771/ 9510-75

E-Mail: info@vml.de

Internet: <http://www.vml.de>

ISBN : 978-3-86757-924-7

ISSN 0375-7471

Kein Teil des Buches darf in irgendeiner Form (Druck, Fotokopie, CD-ROM, DVD, Internet oder einem anderen Verfahren) ohne schriftliche Genehmigung des Verlages Marie Leidorf GmbH reproduziert werden oder unter Verwendung elektronischer Systeme verarbeitet, vervielfältigt oder verbreitet werden.

Umschlagentwurf: Werner Müller, CH-Neuchâtel, unter Mitwirkung der Herausgeber

Redaktion: Werner Müller, CH-Neuchâtel, Berit Valentin Eriksen, D-Schleswig,

Martin Street, D-Neuwied und Gerd-Christian Weniger, D-Mettmann

Satz, Layout und Bildnachbearbeitung: Werner Müller, CH-Neuchâtel,

unter Mitwirkung von Anne Dombrowsky, D-Greifswald

Druck und Produktion: druckhaus köthen GmbH, Köthen

Inhalt - Contents

Fisch-, Amphibien- und Reptilienreste aus der Höhlenruine Hunas bei Hartmannshof (Mittelfranken) <i>Lower vertebrate remains (fish, amphibians, reptiles) from the cave deposits of Hunas near Hartmannshof (Middle Frankonia, Bavaria, Germany)</i>	
Gottfried BÖHME.....	7-23
Site formation and faunal remains of the Middle Pleistocene site Bilzingsleben <i>Fundplatzgenese und Faunarestes der mittelpleistozänen Fundstelle Bilzingsleben</i>	
Werner MÜLLER & Clemens PASDA.....	25-49
Repolust Cave (Austria) revisited: Provenance studies of the chert finds <i>Fundrevision der Repolusthöhle (Österreich): Herkunftsbestimmungen der Hornsteinfunde</i>	
Michael BRANDL, Christoph HAUZENBERGER, Walter POSTL, Daniel MODL, Christoph KURTA & Gerhard TRNKA.....	51-65
A new site of the Mousterian of Acheulian Tradition in the northern Netherlands <i>Ein neuer Fundplatz des Moustérien in Acheuléen-Tradition in den nördlichen Niederlanden</i>	
Marcel J. L. T. NIEKUS, Dick STAPERT, Jaap R. BEUKER & Lykke JOHANSEN.....	67-92
Gruta Nova da Columbeira (Bombarral, Portugal): Site stratigraphy, age of the Mousterian sequence, and implications for the timing of Neanderthal extinction in Iberia <i>Gruta Nova da Columbeira (Bombarral, Portugal): Fundplatz-Stratigraphie, Alter der Moustérien-Schichtenfolge, und Schlussfolgerungen für die Chronologie des Aussterbens der Neanderthaler auf der Iberischen Halbinsel</i>	
João ZILHÃO, João Luís CARDOSO, Alistair W. G. PIKE & Bernhard WENINGER.....	93-112
New perspectives on recycling of lithic resources using refitting and spatial data <i>Neue Nachweismöglichkeiten der Wiederverwendung von lithischem Rohmaterial mittels Zusammensetzungen und räumlicher Verteilung</i>	
Manuel VAQUERO.....	113-130
Fire-places, frequentations and the environmental setting of the final Mousterian at Grotta di Fumane: a report from the 2006-2008 research. <i>Feuerstellen, Wiederbegehungen und Umweltverhältnisse des späten Moustérien der Grotta di Fumane: Zwischenbericht der Forschungen von 2006 bis 2008.</i>	
Marco PERESANI, Julia CHRAVZEZ, Alice DANTI, Martina DE MARCH, Rossella DUCHES, Fabio GURIOLI, Simona MURATORI, Matteo ROMANDINI, Luca TROMBINO & Antonio TAGLIACOZZO.....	131-151

Revisiting the Middle Palaeolithic site Volkringhauser Höhle (North Rhine-Westphalia, Germany)

Eine Neubetrachtung des mittelpaläolithischen Fundplatzes Volkringhauser Höhle (Nordrhein-Westfalen, Deutschland)

Yvonne TAFELMAIER.....153-182

First evidence of eastern Preboreal pioneers in arctic Finland and Norway

Erste Beweise für östliche präboreale Pioniere in den arktischen Gebieten von Finnland und Norwegen

Tuija RANKAMA & Jarmo KANKAANPÄÄ.....183-209

Book reviews

Buchbesprechungen.....211-220