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Several Lower Palaeolithic Sites along the Rhine Rift Valley, Dated from 1.3 to 0.6 Million Years

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Abstract: The important discoveries of Lower Palaeolithic artefacts in stratigraphical context within Lower and early Middle Pleistocene deposits in the western continental part of Europe along the rift systeme of the Rhine Valley are pointing at the possible continuous presence of hominins since the Lower Pleistocene. This paper reports on lithic industry from its early appearance at around 1.3 million years (Ma) at the site of Münster-Sarmsheim to the latest pre-Elsterian period at around 0.6 Ma at Mauer, Mosbach, and Miesenheim.

Keywords: Lower Pleistocene Palaeolithic; fluvial terrace sediments; Homo erectus heidelbergensis

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1. Introduction

An increasing dataset and a plethora of new questions have arisen from discoveries in the last two decades concerning the early expansion of late Pliocene and early Pleistocene hominins within the Old World (Rodríguez et al. 2011, 2013). Different explanations have been established to explain the spread of early man beyond the African continent (i.e., Out of Africa I-hypothesis) (Turner 1992, 1999; Rolland 1998; Arribas and Palmqvist 1999; Bar-Yosef and Belfer-Cohen 2001; Van der Made 2001, 2011; Carbonell et al. 2010; de Lumley 2012; Van der Made and Mateos 2010). The point in time when hominins (*Homo erectus* s.l.) were able to settle for the first time in northern latitudes is one of the most debated issues and is associated with the development of new skills and the adoption of a high level of social cohesion in order to withstand new requirements and constraints of new climate zones and environments (Binford 2007; Tappen 2009; Rolland 2010; Cohen et al. 2012; Fiedler 2013).

The Caucasian site of Dmanisi (Georgia) bears witness to the earliest known wide-ranging spreading of early man on the Eurasian continent dated to 1.8 myr (Gabunia and Vekua 1993; Gabunia et al. 2000; Lordkipanidze et al. 2007; Ferring et al. 2011). At approximately the same time, hominins were already present at the northwestern edge of Africa, which is evidenced at the sites of Ain Hanech, El Kherba, and Ain Boucherit in Algeria (Sahnouni and de Heinzelin 1998, 2002, 2013, 2018) and Souk-el-Arba-du-Gharb in Morocco (Fiedler 1993b), their spread into both western and eastern parts of Asia having been proven at ca. 1.7 myr BP at the latest (Rendell and Dennell 1985; Dennell et al. 1988; Swisher et al. 1994; Zhu et al. 2001, 2004; Dennell 2004; Pappu et al. 2011; Ao et al. 2013; Liu et al. 2014; Malassé et al. 2016).

The first arrival of hominins on the southwestern margins of the European subcontinent has up to now been documented at around 1.4 myr (Figure 1; Oms et al. 2000, 2011; Agustí and Madurell 2003; Toro-Moyano et al. 2011, 2013; Arzarello et al. 2009, 2012; Crochet et al. 2009; Bourguignon et al. 2016). Although paleoanthropological data point to the first peopling of Europe coming from the East (Carbonell et al. 2008; de Castro and Martinón-Torres 2013), migration into the European continent is considered to have taken place on two major geographical routes: either along the northern shores of the

Black Sea across the Anatolian plateau using the Bosporus land bridge (Peri-Pontic, Trans-Marmaran, and coastal/Trans-Aegean pathways), or by crossing the Strait of Gibraltar (Straus 2001; Sahnouni et al. 2002, 2010; Derricourt 2005; Kuhn 2010; Gibert et al. 2016; Spassov 2016; Strait et al. 2016). It is also still a matter of debate as to whether the first occupants of southern Europe were long-term residents or more occasional visitors disappearing in Europe during cooler climate periods by dying out or migration into refuges in southwest Asia (Agustí et al. 2009; Blain et al. 2009; Dennell 2003; Dennell et al. 2010; de Castro and Martinón-Torres 2013; MacDonald et al. 2012; Garcia et al. 2014).

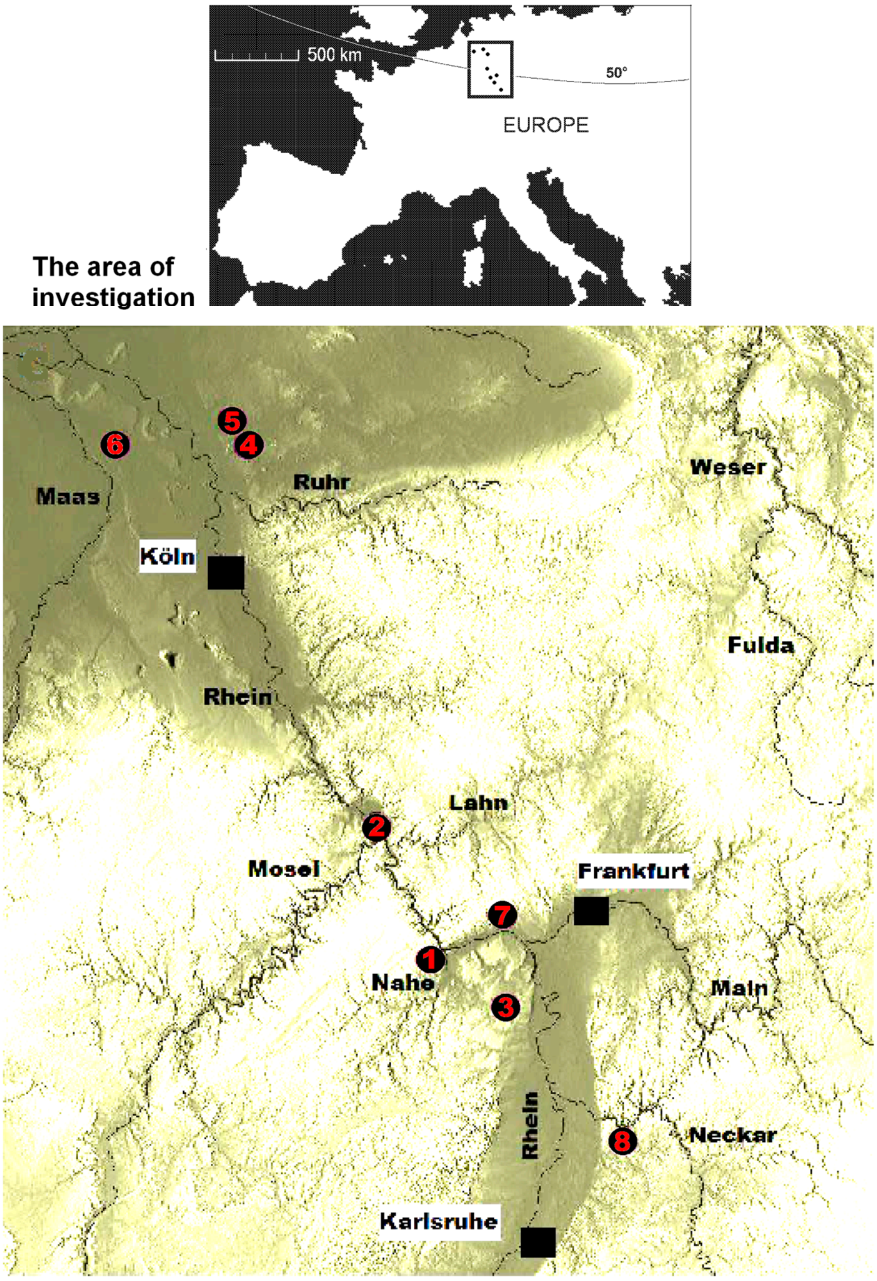


Figure 1. The geoposition of the northwestern European archaeological and/or paleontological sites dated in the Lower and Middle Pleistocene. 1. Münster-Sarmsheim, 2. Koblenz-Bisholder, Kärlich, Miesenheim, 3. Dorn-Dürkheim, 4. Kirchhellen, 5. Schermbeck, 6. Weeze, 7. Wiesbaden-Mosbach, 8. Mauer. (Graphics: G. Landeck)

Northern Europe was held by most researchers not to be occupied before 500–600 kyr until the late 1990s on the basis of archaeological and/or paleoanthropological evidence at Mauer, Kärlich G and H, and Miesenheim 1 in Germany and Boxgrove in England (Roberts et al. 1986; Bosinski 1995; Roebroeks and van Kolfschoten 1995; Roberts and Parfitt 1999; Dennell 2003), a view still maintained by others (Haidle and Pawlik 2010; Hertler et al. 2013). Two new discoveries of archaeological sites in East Anglia (Pakefield and Happisburgh 3) in the first decade of the new millennium bear witness to an earlier settlement of European mid-latitudes, going back to the time of the Matuyama–Brunhes polarity change and early Middle Pleistocene (Parfitt et al. 2005, 2010; but see Westaway 2009a, 2009b, 2011). An even earlier peopling of the interior of Europe was already considered 30 years ago by the finds of three choppers in a low energy deposit at the Kärlich clay pit in Germany (Layer A), and, not to forget, the polyhedron from Červený kopec and other early finds in the Czech Republic (Valoch 1977). The lithics from Kärlich were associated with remains of *Hippopotamus* sp. and magnetostratigraphically dated to the Jaramillo Subchron at ca. 1.0 myr (Würges 1986; Bosinski 1986, 1995).

Further evidence of a late Lower Pleistocene presence of hominins comes from the nearby site of Dorn-Dürkheim 3, where lithic tools were found in spatial association with faunal remains in lake shore sediments showing reverse polarization (Franzen 1999; Fiedler and Franzen 2002). The lithic materials of the Dorn-Dürkheim and the Kärlich site have been discussed controversially with regard to their intentional origin (Roebroeks and van Kolfschoten 1995; Vollbrecht 1997; Bosinski 2008; Haidle and Pawlik 2010).

2. Materials and Methods

We report on archaeological materials of several German localities in western Central Europe (Figure 1) recovered from late Lower Pleistocene and early Middle Pleistocene deposits in order to confirm the hypothesis of early dispersals of hominins to the western European mid-latitudes from ca. 1.3 myr onwards. Two sites represent new archaeological discoveries: Münster-Sarmsheim and Mosbach. New lithic artefacts and/or butchery marks on bone specimens of associated fauna were also introduced from Mauer. We integrated materials from the recently published sites of Dorn-Dürkheim 3 and important find localities of the Lower Rhine Embayment: Weeze, Dorsten-Schermbeck, and Kirchhellen by new photo documentation (Figures 23–26). Two well-published early Middle Pleistocene archaeological occurrences of Kärlich and Miesenheim 1 are discussed in this context. We have analyzed technical features and core reduction methods of lithic artefacts in order to make inferences on technological traditions or modes and on their possible variation over time. At three sites, lithic artefacts are spatially associated with faunal remains: Dorn-Dürkheim 3, Mosbach, and Mauer. Hitherto, investigations of anthropogenic bone modifications of faunal remains were undertaken at Mauer (N = 362). A comparison of butchering practices is represented by preliminary results in this article. Bone surface analyses of remains from the Mosbach site (Wiesbaden-Biebrich, Hessia) have been carried out on isolated specimens ('Hauptfauna') only. Stone tool cut marks on bones are direct evidence of animal butchery by hominins (e.g., skinning, evisceration, meat removal, and disarticulation). For the identification of cut marks, we have applied diagnostic criteria established following the descriptions by Bunn (1981), Potts and Shipman (1981), and Yravedra et al. (2010).

3. Archaeological/Paleoanthropological Sites

3.1. Münster-Sarmsheim (Rhineland-Palatinate, Germany)

Lower Palaeolithic surface finds including archaic handaxes on high terraces of the Nahe River near its confluence with the Rhine River have been known since their discovery by H. Bell in the late 1940s and were later also recovered from fluvial deposits of denuded high terraces in the Middle Rhine area (Fiedler 1975/1977, 1990; Prado-Nóvoa et al. 2017). Unfortunately, most archaeologists did not take notice of these finds or rejected their identification as intentional artefacts (Baales et al. 2000). Indeed, unambiguous evidence of their contemporaneity with the terrace development did not exist due to the lack of larger exposures of deposits. The situation has changed in recent years, though, after systematical archaeological research (by S. and M. Stoll) has been conducted in a new large gravel pit extracting gravel from a 'Main Terrace' at Münster-Sarmsheim in the Lower Nahe Valley (tributary of the Rhine River; Figure 1). There, the gravel extraction in the Kesslers-Berg pit uncovers deposits of the ancient Nahe River (tNa 5.1-2; 200 m above sea level = a.s.l.) near its confluence with the Rhine River (Upper Middle Rhine Valley). The profile of the terrace is composed of the Main Terrace and a wide crossing diagonal gully in it, both of the same geological age. Lithic artefacts were not solely found in sieved gravels, but also recovered in situ from terrace deposits.

Based on geomorphological investigations conducted in the second half of the 20th century, the development of this terrace was traditionally attributed to the 'Jüngere Hauptterrasse' (Younger Main Terrace) according to its position in the sequence of Rhine terraces. This model contains 12 Quaternary terrace levels correlating the development of the Younger Main Terrace with the very early Middle Pleistocene at ca. 700 kyr (Bibus and SeMMel 1977; Bibus 1983). Its age has recently been challenged (Preuss et al. 2015) by re-mapping the terraces of the Upper Terrace Group in the Upper Middle Rhine Valley with the help of 728 borehole drillings, using high precision contour level maps derived from a LIDAR terrain model (Figure 2). The results show that, in this valley section, 28 different terrace levels can be distinguished. Based on the findings of Zagwijn (1998), Preuss et al. (2015) were able to correlate them with the Marine Isotope Stages of Cohen and Gibbard (2011) andwith the 31 terraces of the Belgian Maas River (Van den Berg 1996). According to this model, the finds of Münster-Sarmsheim are attributable to the newly classified tRh 5.1/tNa 5.1-2-terrace (200 m a.s.l.) and, thus, must be dated to 1.33 myr into the Cobb Mountain Event (Preuss et al. 2015; Figure 2).

Taking these results into account, the paleomagnetic reversal (from negative to positive polarization) identified in a higher terrace ('Ältere Hauptterrasse') near Werlau (Upper Middle Rhine Valley, tRh 4.1, 212 m a.s.l., ca. 25 km downstream), which has previously been referred to the Matuyama–Brunhes boundary (Fromm 1978), following Preuss et al. (2015) would correspond to the Gilsa-Event (MIS 56, ca. 1.68 myr.

The following lithic artefacts were recovered in situ from the fossil terrace deposits at Münster-Sarmsheim (Figure 3):

(a) a bilaterally retouched scraper made out of dark moss agate. It is characterized by a smooth (lissé) striking platform and dorsal negatives with distal remains of the side seeming to overlap with negatives originating less probably from core reduction and, most probable from thinning detachment (Figure 4–upper Figure);
(b) a marginally retouched Kombewa flake made of quartzite (Figure 5);
(c) an unretouched quartzite flake with a natural striking platform bearing on its dorsal side one bigger flake removal with proximal overlapping of some smaller negatives caused by preparing the core to detach flakes. The specimen shows minor abrasion and only moderate patina, indicating rapid burial (Figure 6, photo). Devonian quartzite cobbles serving as raw material occur very frequently in the gravels of the Nahe River;
(d) a larger moderately retouched flake from a quartzite cobble (Figure 4, lower part; Figure 4–lower image, Figure 7) with dorsal negatives showing features of its origin from an 'Acheulian core' (Bordes [1961] 1967) with opposite striking platforms (Figures 7 and 8);
(e) a small reddish translucent agate flake (maximum length 25 mm) with a smooth (lissé) striking platform and dorsal flake removals resulting from the reduction of a multidirectional core. Distal denticulated retouches may, at least partially, be caused by sediment compaction. The agate raw material appears frequently in the Hunsrück region and its nodules show very infrequent occurrences in Nahe River deposits (note that agate does not tend to patinate);
(f) an elongated fragment of a bipolar struck jasper flake with a borer-like tip shaped by retouches, and
(g) a retouched quartzite flake characterized by dorsal evidence of flake removals from different directions originating from a discoidal core (Figure 9a). The retouch typical for Lower Palaeolithc

flake tools resembles that on flake tools from Mauer, Dorn-Dürkheim, Mosbach, and Schermbeck (Figure 12, Figure 17, and Figure 20a).

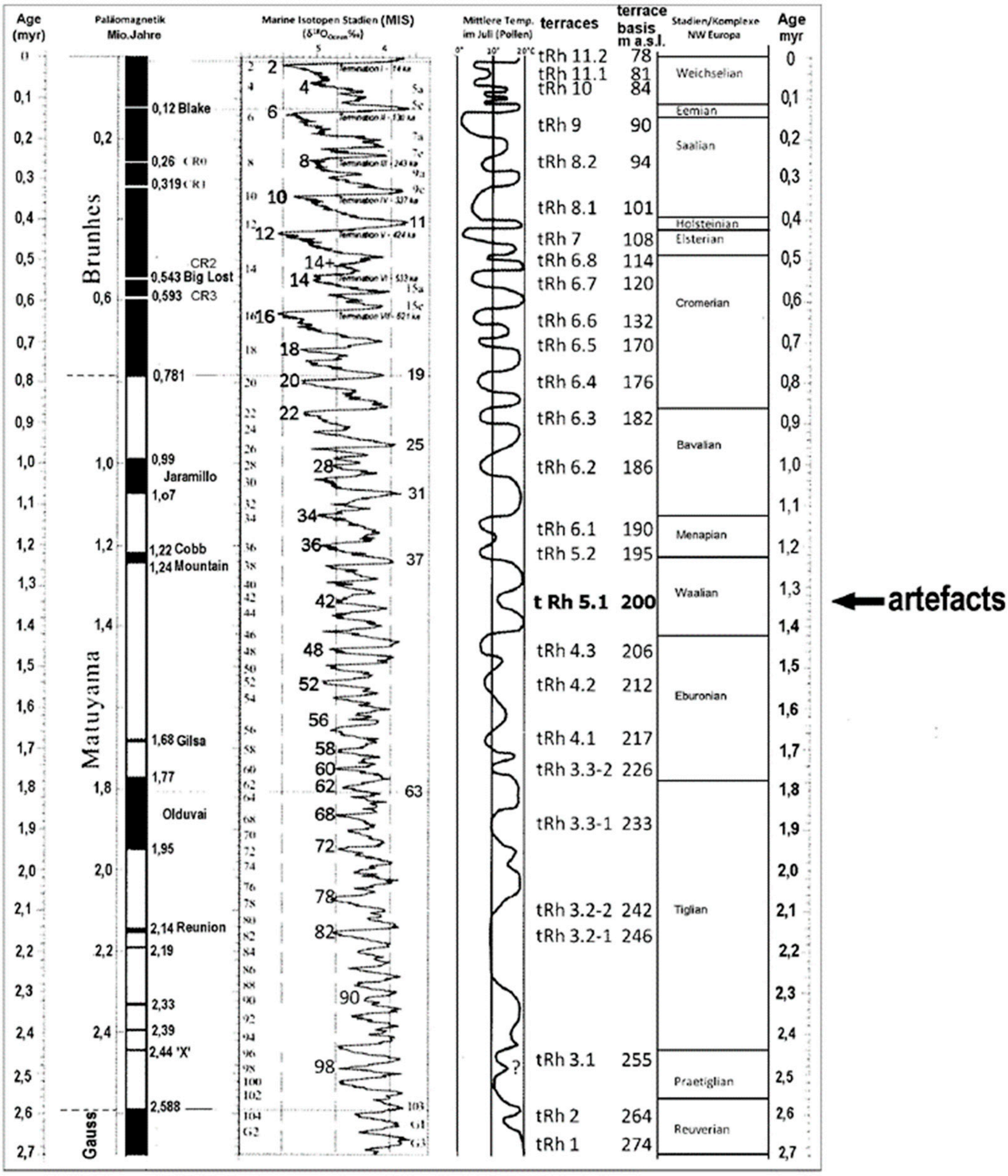
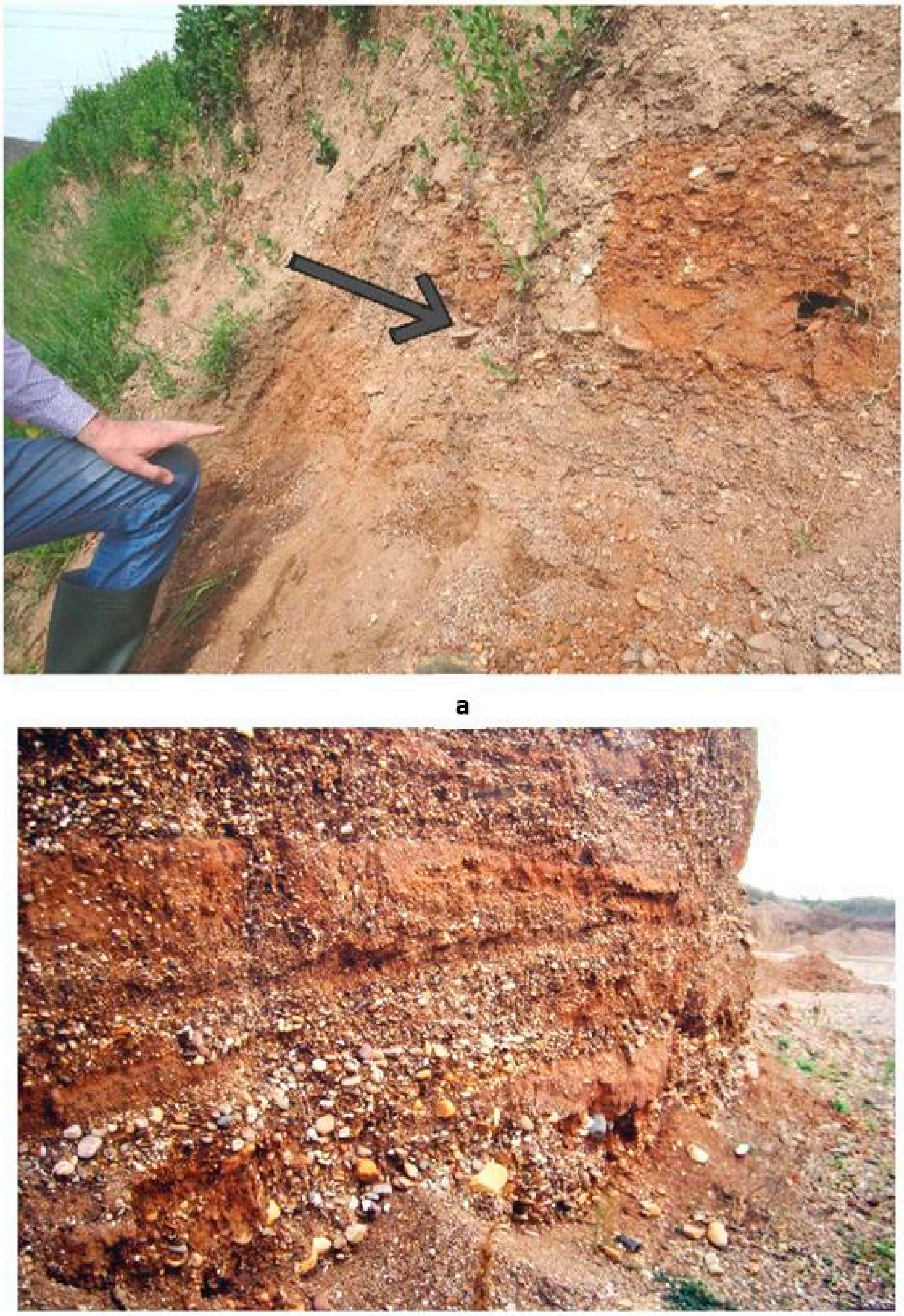


Figure 2. The terraces of the upper Middle Rhine and Lower Nahe. Black letters: tRh/Na 5.1 (After Preuss et al. 2015, modified). This table applies only to this region, because its terrace sequence is the result of the special geological uplift of the Hunsrück Massive during the Pleistocene.



a

b

Figure 3. Münster-Sarmsheim. (**a**) Upper part of the terrace, Kombewa flake in situ; (**b**) the gravel pit at the Kesslers-Berg, about 125 m above the recent river level. The not exploited coarse gravel on the ground is bedded on sandstone bedrock. (Photos: 1.M. Stoll, 2. S. Stoll.).

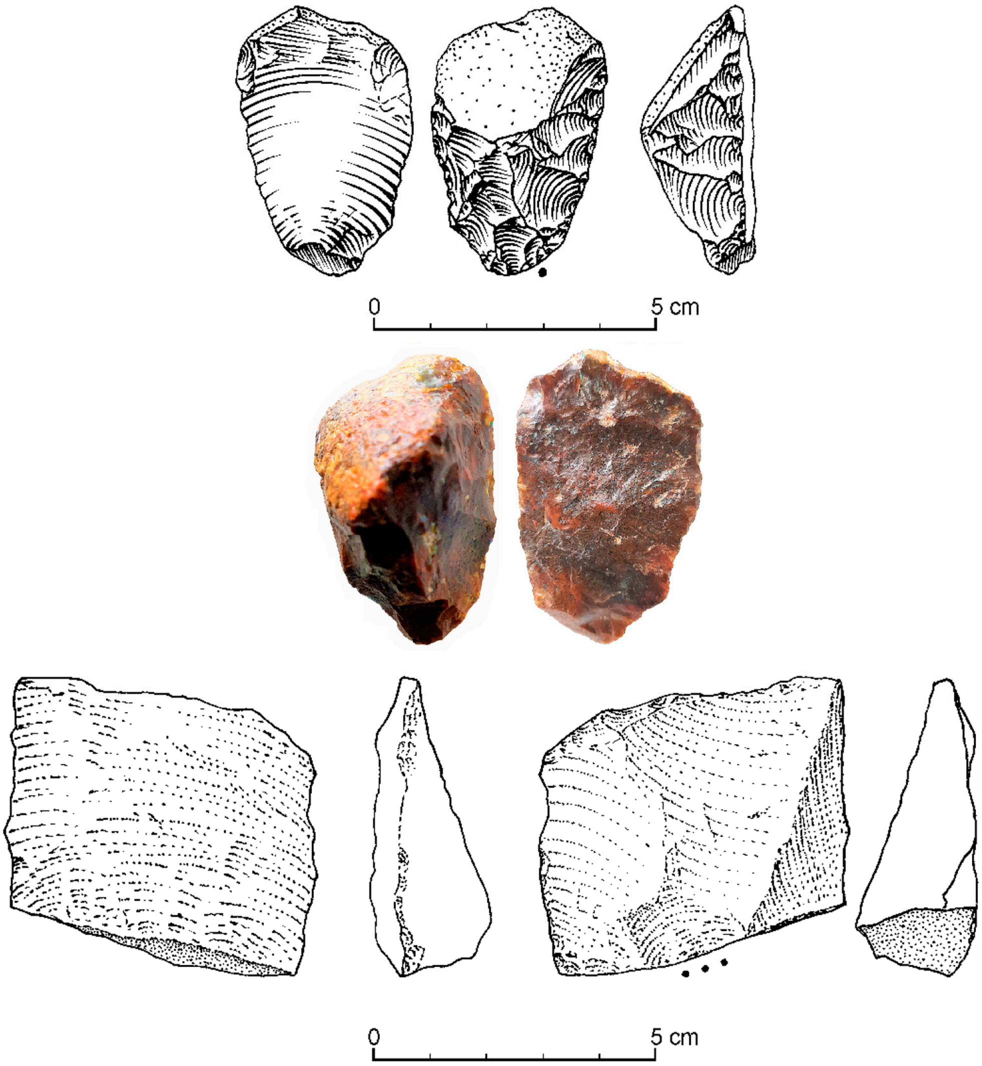


Figure 4. Münster-Sarmsheim. In situ finds from the 200 m tNa 5.1-2 terrace: double-side scrapper (agate) and a quartzite flake from a core with opposite striking platforms. The three dots symbolize three identifiable impact points. (Photo: S. Stoll, drawing: L. Fiedler).

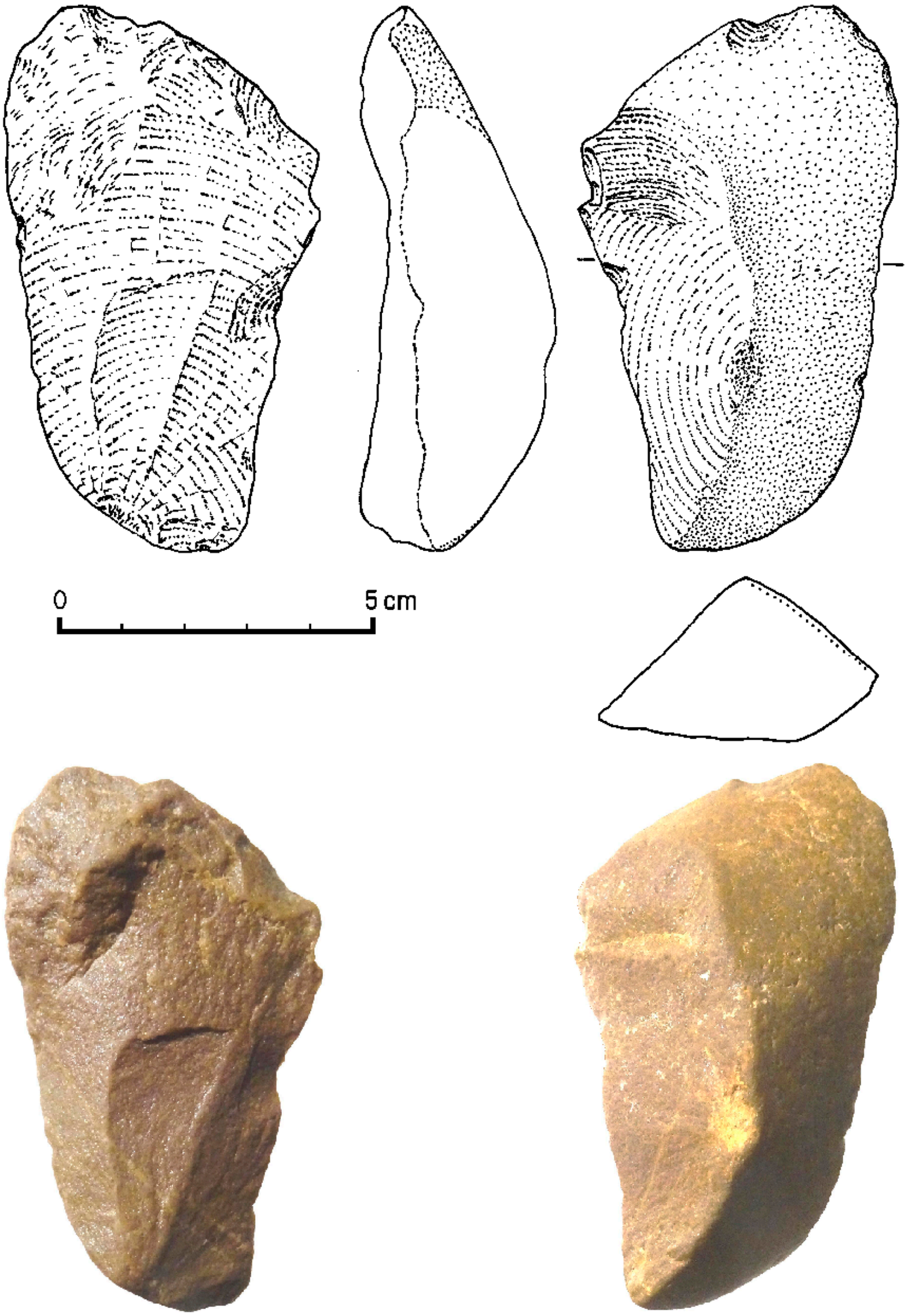


Figure 5. Münster-Sarmsheim. Kombewa flake (quartzite) in situ out of the 200 m tNa 5.1 terrace. (Photo: C. Humburg, drawing: L. Fiedler).

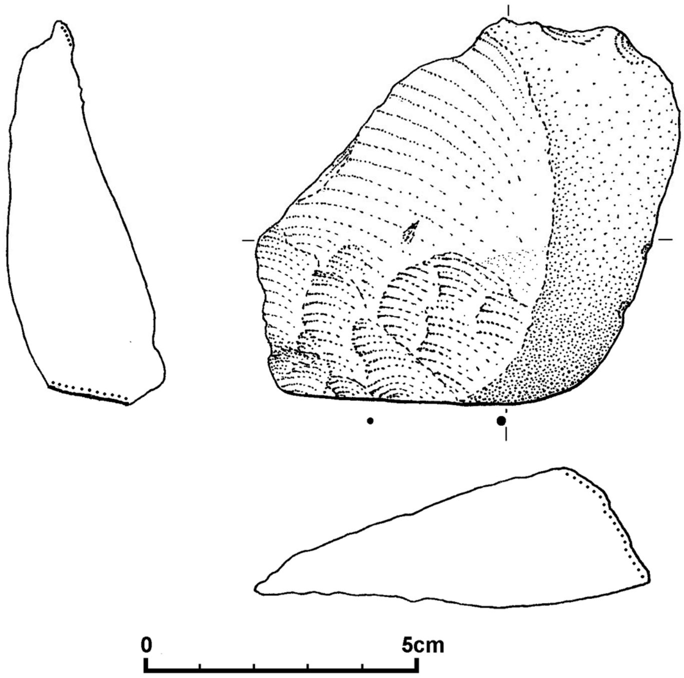


Figure 6. Münster-Sarmsheim. Quartzite flake in situ out of the 200 m tNa 5.1 terrace on the Kesslers-Berg gravel pit. (Photo: S. Stoll, drawing: L. Fiedler.).

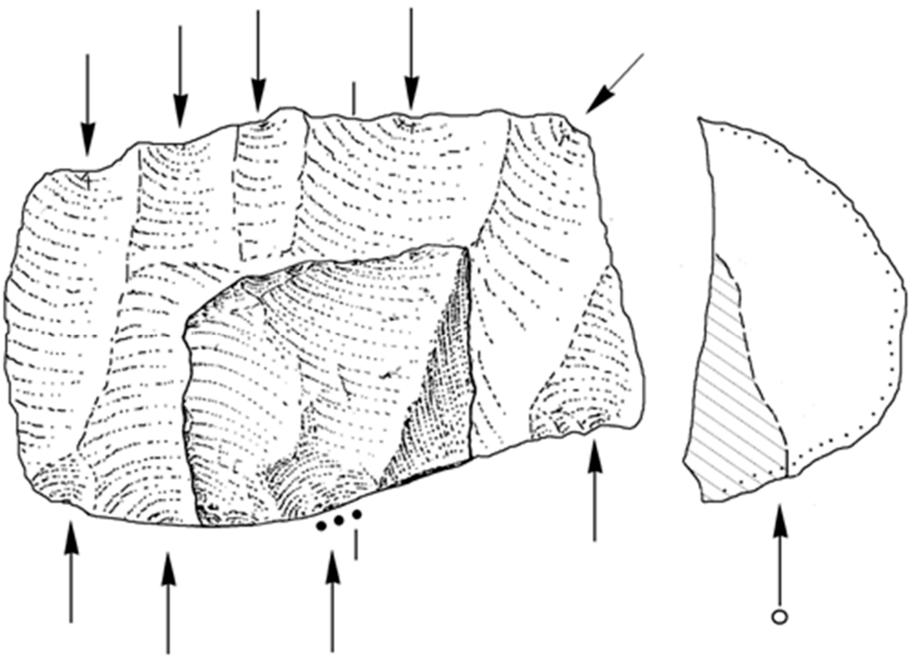


Figure 7. The flake from Figure 4 fitted on a virtual bidirectional core (typical for the Acheulian). (Drawing: L. Fiedler).

Figure 8. Münster-Sarmsheim. Typical Acheulian core, found on the outcropping terrace nearby the gravel pit. (After Fiedler and Hochgesand 1980).

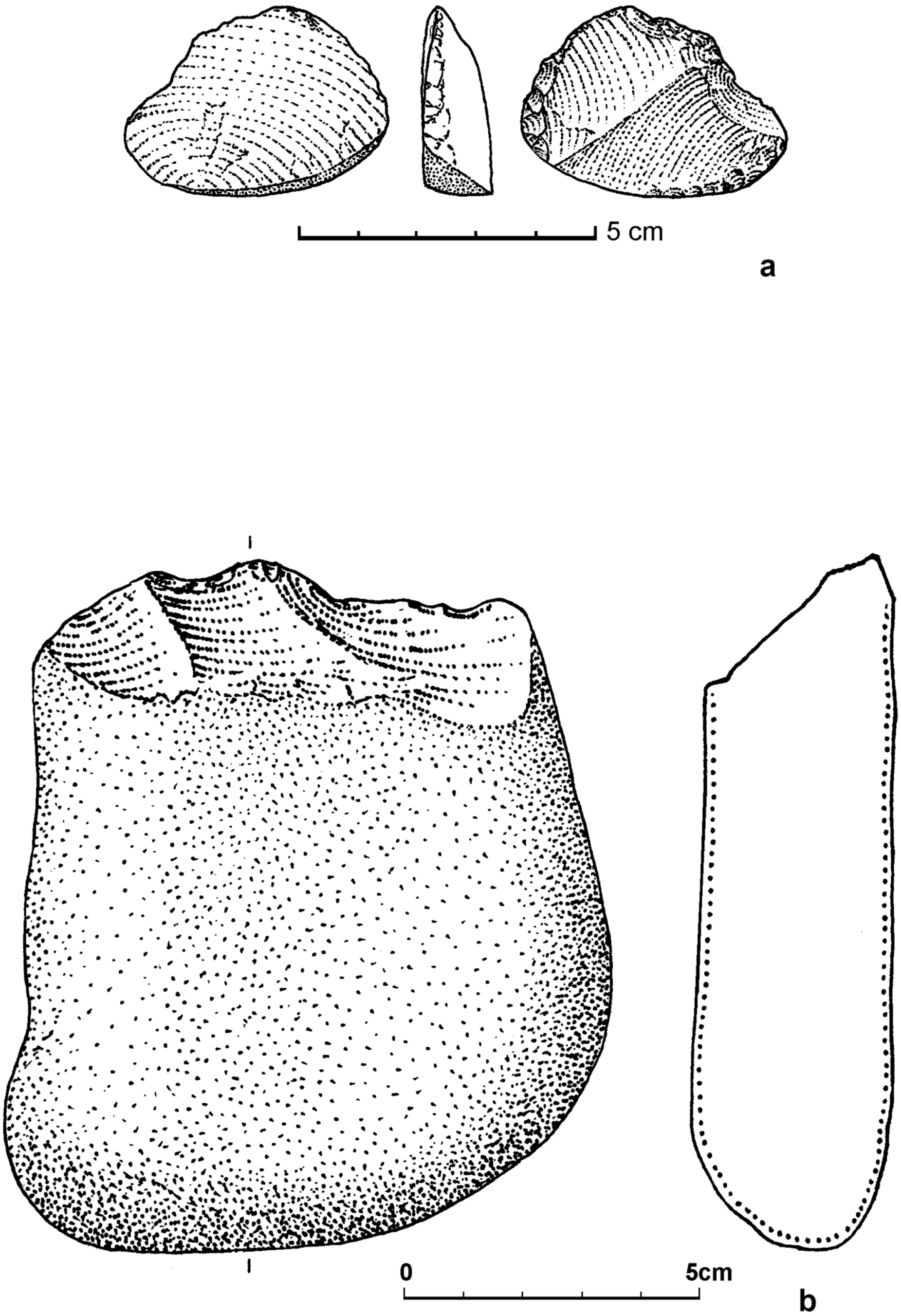


Figure 9. Münster-Sarmsheim. (**a**) Retouched quartzite flake ('scrapper') in situ out of the terrace; (**b**) Chopper—fallen down from a sandy layer within the terrace. (Drawings: L. Fiedler.).

Lithic artefacts a)–c) were recovered from thin, but very wide sand lenses (several metres long) within the terrace gravels, which excludes a younger age caused by intrusion of younger lithic material by the development of ice wedges occurring occasionally. Lithics d)–g) were recovered from the infill (small-to-medium grained gravel) of a broad overlapping channel/gully. The slightly different preservation status of in situ artefacts indicates varying transport distances during their deposition. It is important to note that the gravels of the tNa 5.1-2 terrace are characterized in general by pronounced edge abrasion, which is not seen in the artefacts. Specimens with sharp edges are, without exception, flakes. Alterations of cobbles by repeated natural impacts or battering during terrace formation are not in evidence. Similar observations have been made regarding further artefacts from the terrace gravel, containing one bifacially worked large cutting tool (Bridgeland and White 2015; Figure 10c), some choppers (Figure 9b; Figure 10b) and several large flakes including one end-struck scraper (Figure 11a).

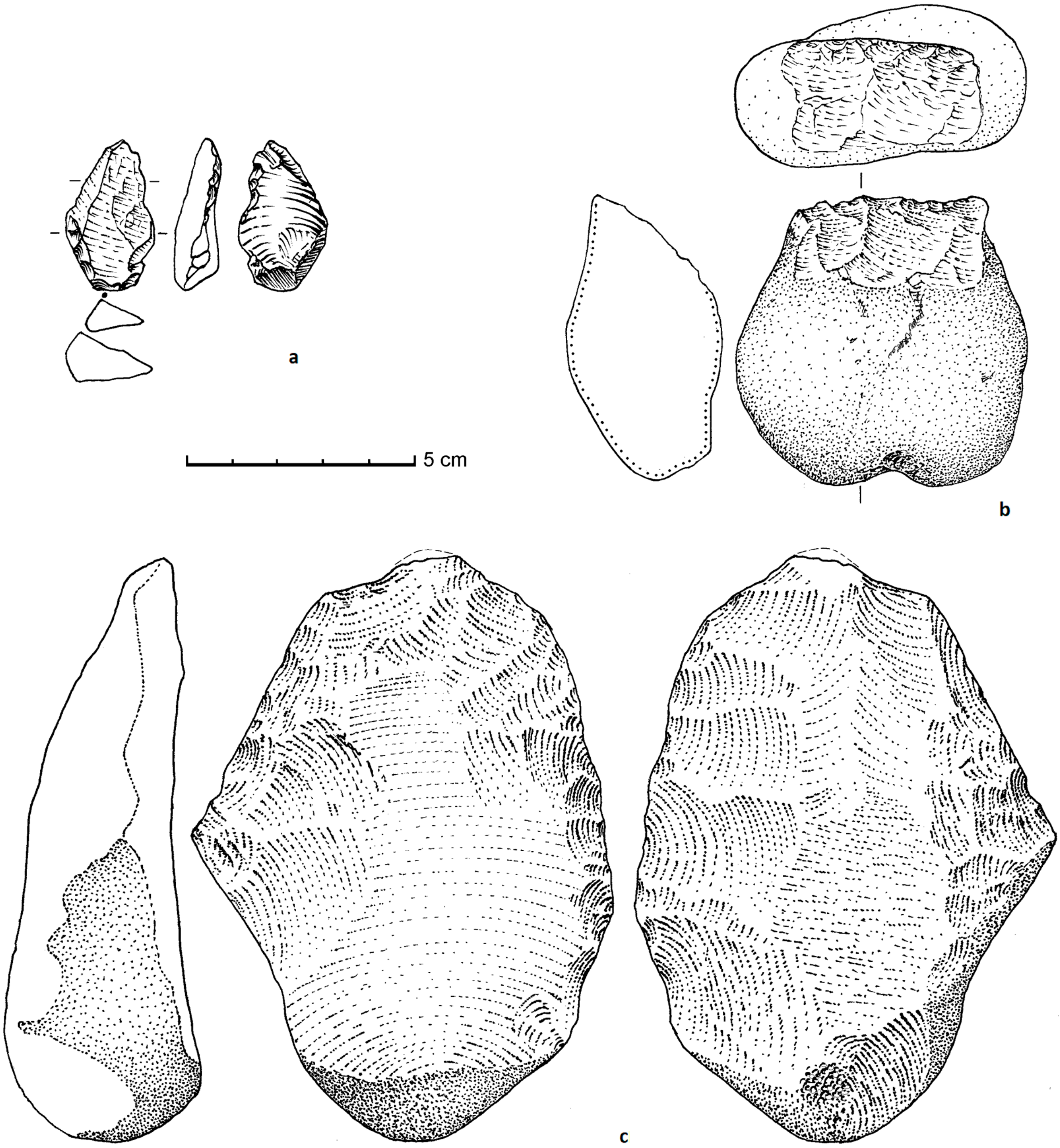
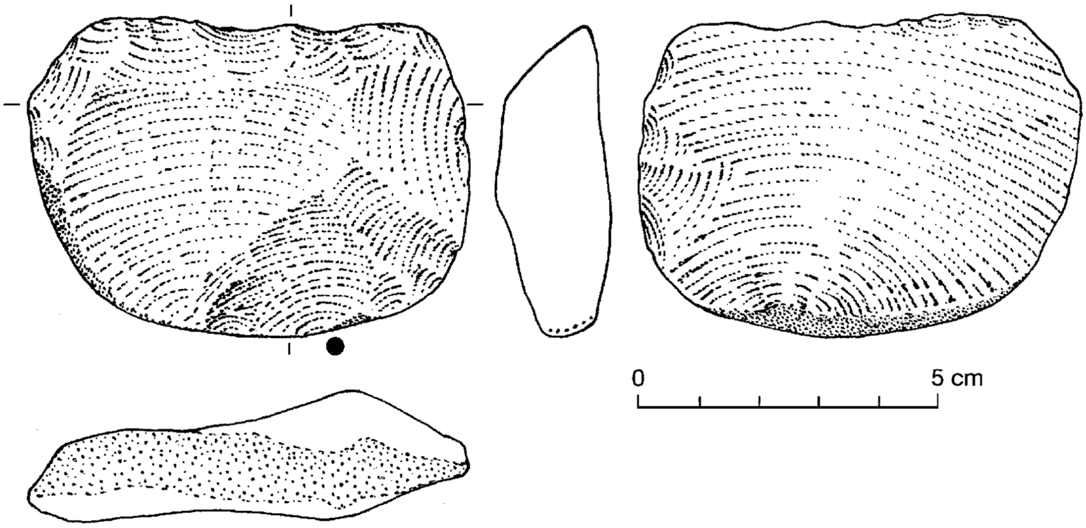


Figure 10. Münster-Sarmsheim. Some of the artefacts originating out of the terrace gravel at the Kesslers-Berg quarry. (**a**) agate flake; (**b**) chopper (vein quartz); (**c**) ovate bifacially worked large cutting tool on a quartzite flake. (Drawings: L. Fiedler.).



a

b

Figure 11. Münster-Sarmsheim. (**a**) End struck quartzite flake (sraper); (**b**) silified sandstone with a typical cupule and use wear impacts. (Photo: C. Humburg, drawing: L. Fiedler.).

One of the remarkable in situ artefacts is a pitted siliceous sandstone slab (Figure 11b). Such kind of cupuls appear since Bed 1 in all other levels of the Olduvai Gorge and everywhere in the African Acheulian (Jones 1994), but seem to be rare in the European Palaeolithic (Humburg 2018).

3.2. Dorn-Dürkheim 3 (Rhineland-Palatinate, Germany)

The elimination of cover sediments during ongoing excavations at the Upper Miocene faunal site of Dorn-Dürkheim (Figure 1, N° 3) in 1989 directed by J.L. Franzen (Senckenberg Research Institute at Frankfurt) unexpectedly led to the discovery of a late Lower Pleistocene faunal concentration with well-preserved large and small mammal remains. This layer is stratigraphically superimposed by a fresh water marl deposit of 0.8 m thickness characterized by reverse geomagnetic polarization. Thus, on biostratigraphically grounds, the faunal remains (teeth of small rodents) are assigned to the late Matuyama Chron (MIS 21–19) corresponding to an age of ca. 0.82–0.78 myr. (Figure 12a); Franzen 1999; Franzen et al. 2000; Fiedler and Franzen 2002).

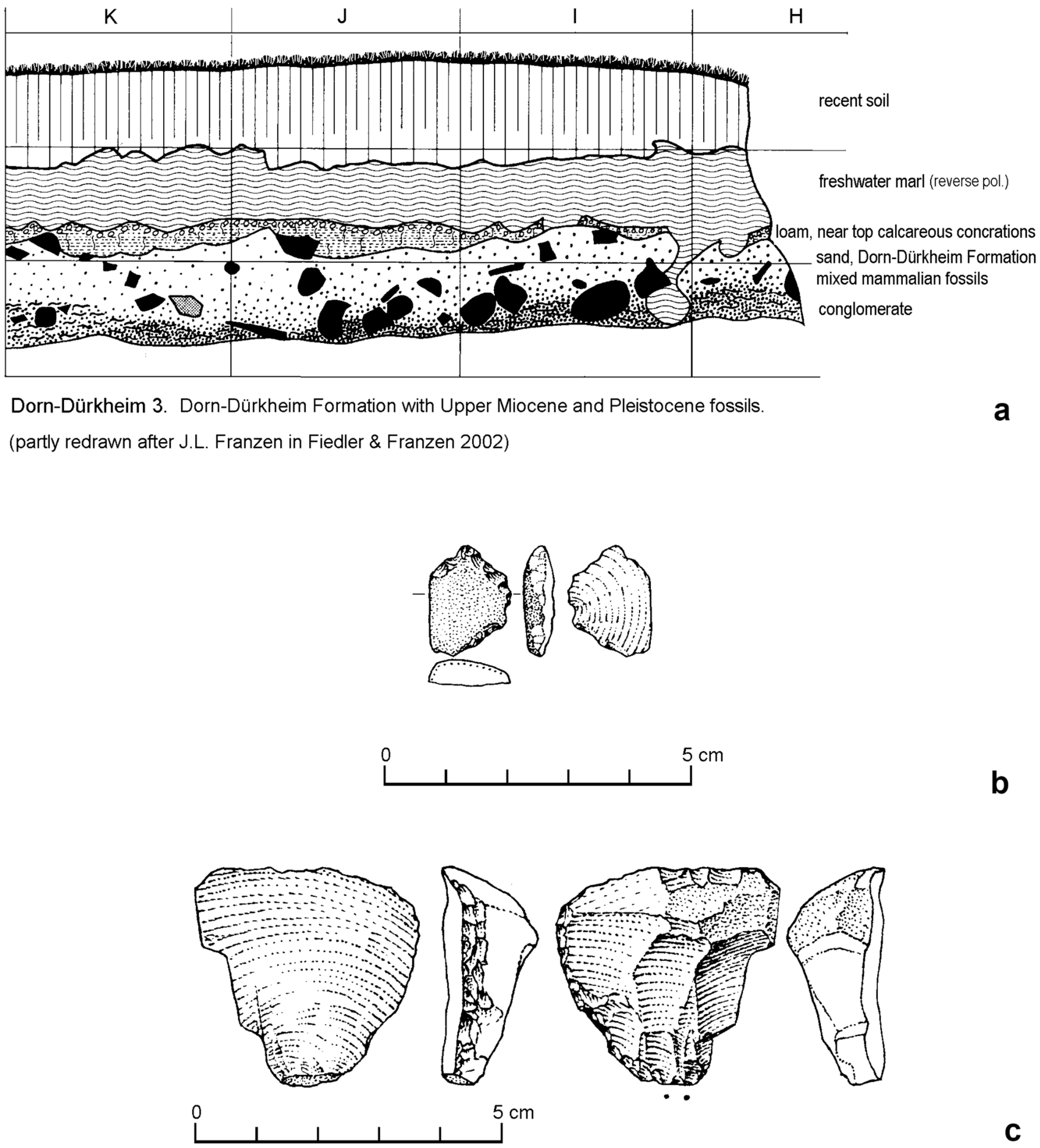


Figure 12. Dorn-Dürkheim 3. (**a**) The stratigraphy; (**b**) drill out of a quartz flake; (**c**) scraper out of quartzite. (Partly redrawn after Fiedler and Franzen 2002).

The excavation of the fossiliferous layer also uncovered an area of 60 m^2 with a conspicuous ovate/circular distribution of almost 100 molars of *Mammuthus trogontherii* (Figure 13). This suggested an anthropogenic origin and directed attention to the occurrence of possible stone tools, which were identified shortly after (Fiedler and Franzen 2002).

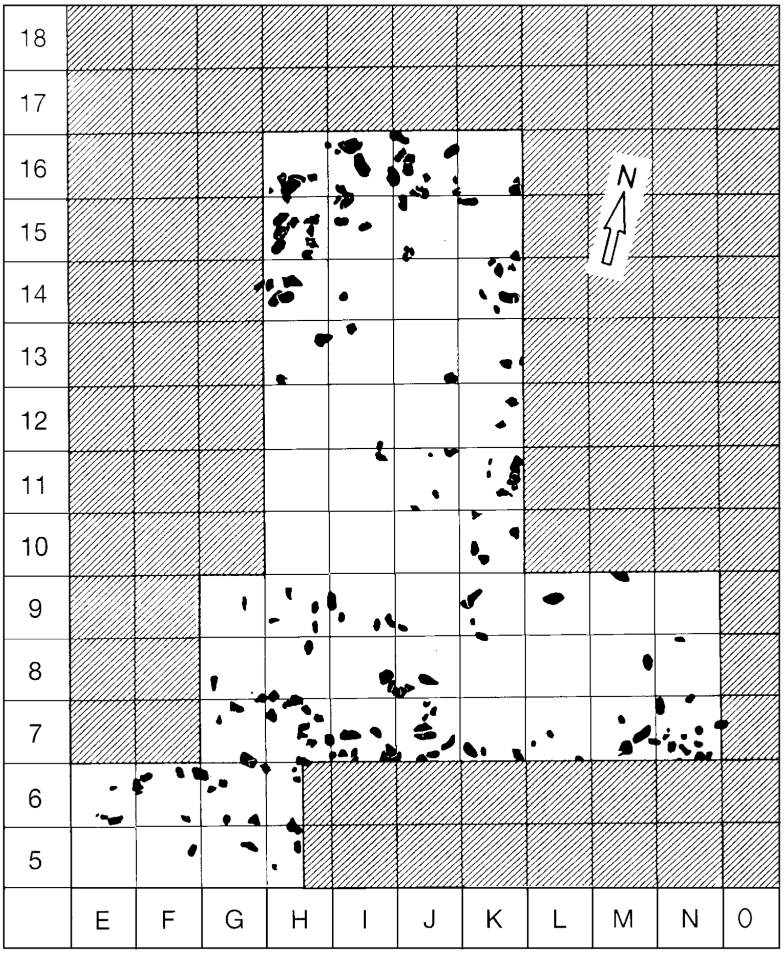


Figure 13. Dorn-Dürkheim 3. Distribution of molares from *Mammuthus trogontherii*. (After J.L. Franzen in Fiedler and Franzen 2002).

The small assemblage (N = 10) contains:

(a) a polyhedron made out of a cobble of Devonian quartzite in good preservation, of 62 mm maximum diameter. The tool bears at least 25 flake removals inflicted by hard hammer percussion (Figure 14a). The larger removals were used as striking platforms in the ongoing reduction process. The cortex is preserved in less than half of the whole artefact surface and the specimen exhibits good preservation, with some superficial concretions of carbonate and iron/manganese oxide, which have been partly removed for technological analysis. The sequence of flaking can be reconstructed by the identification of removals and lithotechnological features (Figure 14b). Only larger detached flakes can serve as tools, which is evidenced by some large flake removals. Thus, the numerous smaller ones may argue against its utilization as a core to obtain flakes. The possible usage for percussion does not explain its extensive shaping because unworked cobbles would be functionally sufficient. The only deducible benefit of the polyhedron may have been its utilization as a throwing projectile, its angular shape making it more effective as a weapon (Fiedler and Cubuk 1988; Fiedler 1993a, 1993b, 2003, 2007, 2012a, 2012b, 2012c, 2012d; Fiedler and Franzen 2002; Kaiser et al. 2005; Fiedler et al. 2011;)

(b) a scraper out of Devonian quartzite (Figure 12c) made from a flake with a cortical striking platform and dorsal flake removals. Dorsal thinning is caused by light chipping, most probably after detachment of the blank (Figure 15b). On its left margin, the flake exhibits a stepped retouch and, distal, a short retouch caused by use. Its technological design is comparable to the scraper from Münster-Sarmsheim (Figure 9a);

(c) a quartz flake shaped to a drill-like tool by retouching. Its dorsal side is covered by the cortex of the pebble blank (Figure 12b);

(d) a small retouched rhyolite flake;

(e) a rhyolite core reduced by bipolar-on-anvil technique; and

(f) some detached pieces, one of them with bifacial flaking (Figure 15a).

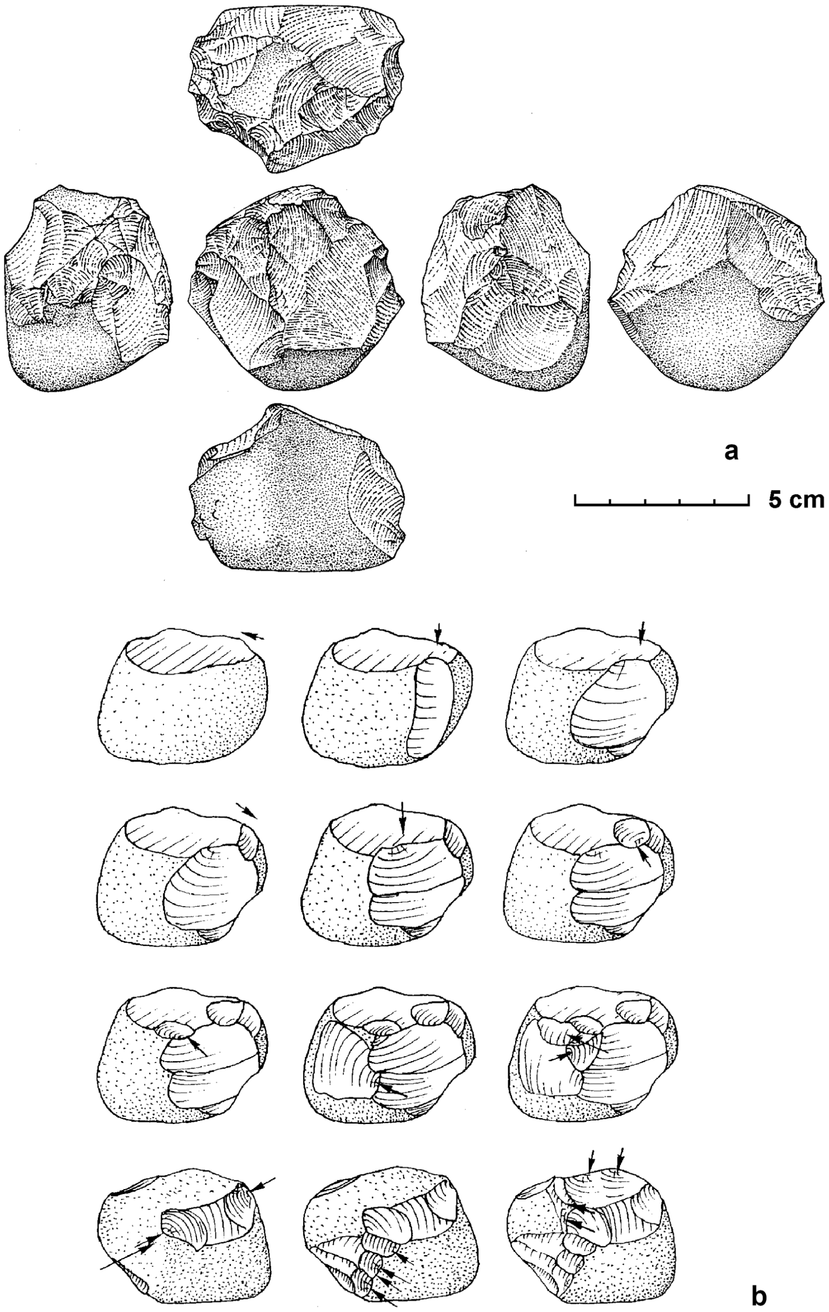


Figure 14. Dorn-Dürkheim 3. (**a**) Polyhedron (quartzite); (**b**) stages of its manufacturing. (Redrawn after Fiedler and Franzen 2002).

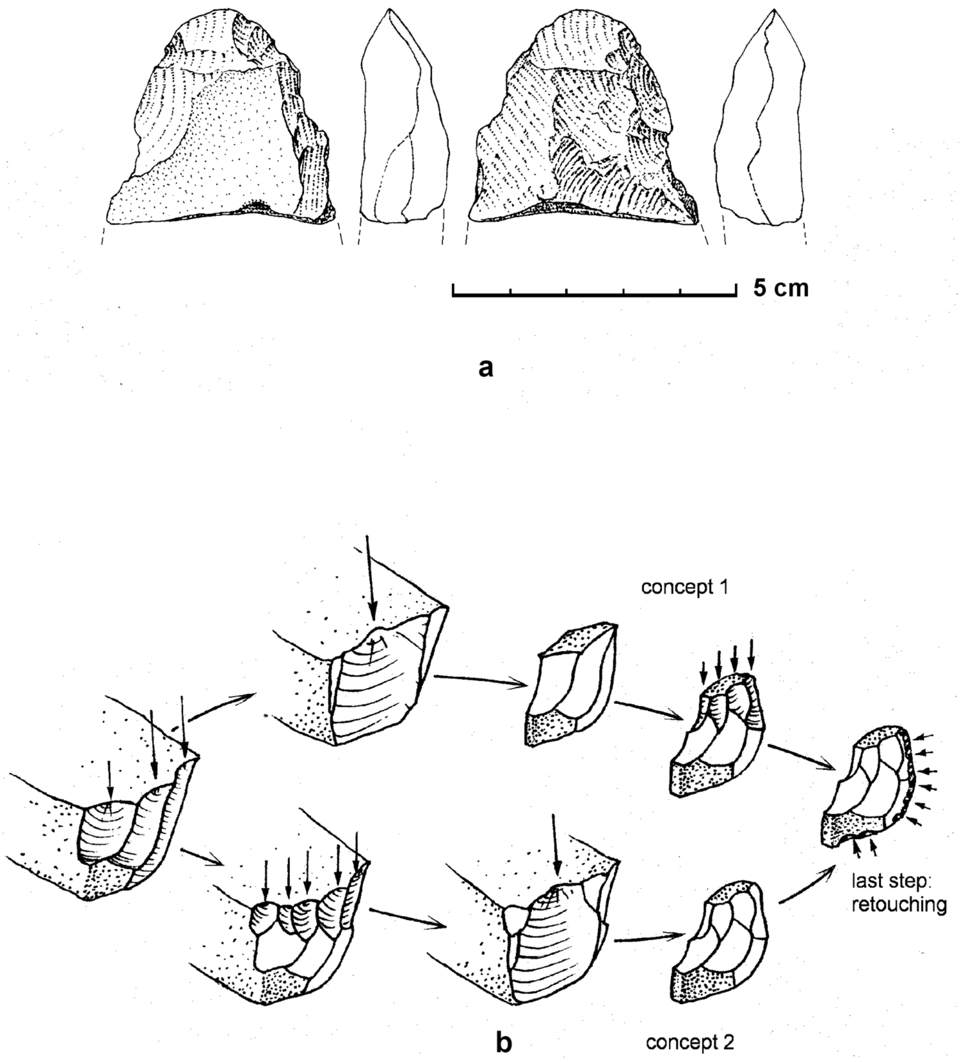


Figure 15. Dorn-Dürkheim 3. (**a**) A bifacially worked artefact made out of 'basalt'; (**b**) two different ways of working out the scraper (with dorsal reduction on the core or later reduction on the flake). (After Fiedler and Franzen 2002).

The site is interpreted to represent a lake-shore environment of the large 'Rhinehessen Lake' evidenced by freshwater marls and limnic ostracods and mollusk shells. Modifications of the bones by water transport (abrasion) are absent. The taxonomic composition of the large mammal fauna is dominated by grassland inhabitants (three-quarters of all individuals are from large mammals); semiaquatic mammals are most notably lacking. Direct evidence of animal butchery (cut marks on bones) has not been identified, which may be due to the severe weathering of the bone surfaces (Franzen 1999). Nonetheless, the involvement of hominins in the bone accumulation may be indicated by:

(a) the herbivore fauna, which contains animal species often considered to have been the prey of early hominins;
(b) anatomic selection of skeletal elements (under representation of cranial bones and antlers);
(c) the conspicuous accumulation of ca. 250 elephant molars on the spot (Figure 13) without presence of elephant crania and low abundances of tusk-fragments;
(d) the nearly complete lack of complete limb bones; and
(e) presence of stone tools in horizon bearing mammalian remains (Franzen 1999; Franzen et al. 2000; Fiedler and Franzen 2002).

3.3. Mauer (Baden-Württemberg, Germany)

The famous mandible of *Homo heidelbergensis* was recovered from the gravelly 'Lower Mauer Sands' (fluvial deposits of the River Neckar) exposed in the sand pit Grafenrain at Mauer, a village southeast of Heidelberg (Figure 1, N° 8) in 1907 and was later on defined as the type-specimen of the taxon *H. heidelbergensis* (Schoetensack 1908). The sand pit was well known as a find site of numerous animal fossils since the 19th century. Geomorphologic, magnetostratigraphic, and biostratigraphic data (large and small mammals, especially *Arvicola cantiana*) indicate a late pre-Elsterian age of the deposition of the 'fossil bearing' sands during one of the younger interglacials of the 'Cromerian Complex' according to the northwestern European Pleistocene subdivision, and recent radiometric dates (609+/−40 kyr) favour attribution to MIS 15 (Von Koenigswald 1992, 1997; Wagner et al. 1997, 2010, 2011; Cohen and Gibbard 2011).

In 1924, the archaeologist Karl Friedrich Hormuth was the first to retrieve small chert artefacts in situ from the stratigraphical layer of the hominin mandible ('Lower Mauer Sands', below the important stratigraphical horizon of the 'Lettenbank'; Figure 16). These lithics and many of his numerous other finds retrieved from the surface of the quarry ground directly at the base of the profile (a total of 220 chert specimens, Figure 17) were stored at the Museum Zeughaus and later at the Reiss-Engelhorn Museum Mannheim. One of these artefacts, published by its finder Hormuth, has been attributed to the Mousterian technological tradition by Hauser (1927). Thus, the site was considered to be solely paleontological and paleoanthropological, as it was characterized by older fauna until the second half of the 20th century. Stone tools recovered and published by Rust (1956), which appear to be problematic quartzitic sandstone artefacts, were widely rejected by German archaeologists, although the occurrence of 'heavy duty tools' is known from many Lower Palaeolithic assemblages.

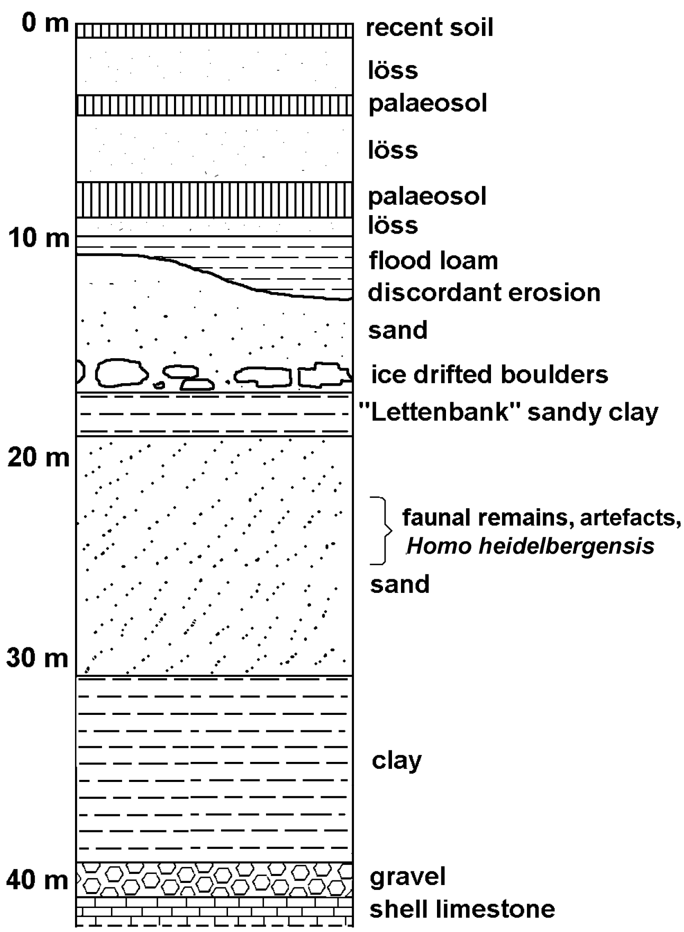


Figure 16. Mauer, "Grafenrain" pit. (Redrawn after Zöller et al. 1997 in Wagner et al. 1997).

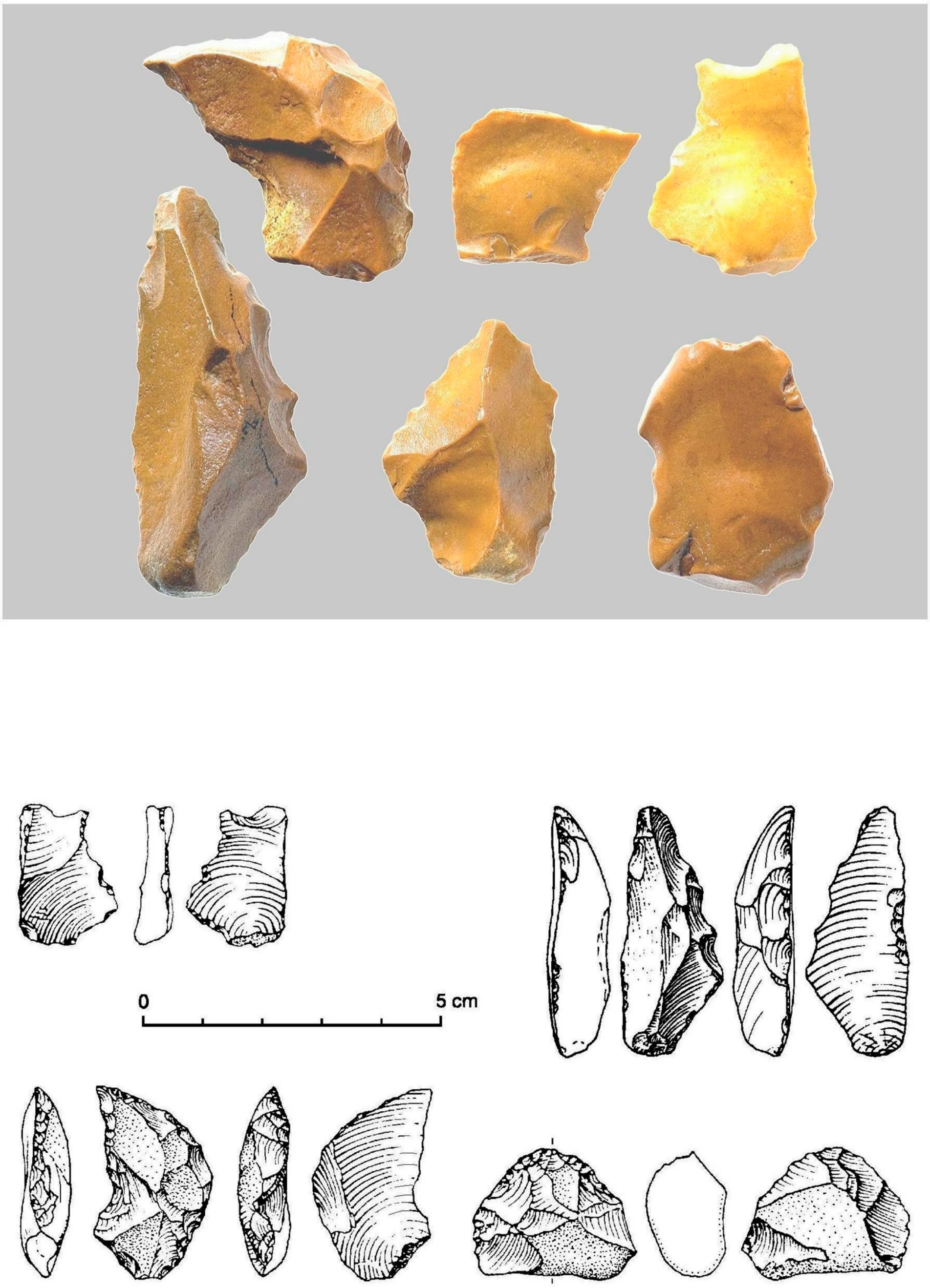


Figure 17. Mauer. Some of the chert artefacts found in situ and/or collected by Hormuth in the first half of the 20th century in the sand pit "Grafenrain" at Mauer. (Drawings: B. Kaletsch, photo: Reiss-Engelhorn-Museum Mannheim.).

In the course of a later rearrangement of the Mauer finds stored in the repositories of the Reiss-Engelhorn Museum, Karl W. Beinhauer recognized the significance of the stone artefacts recovered by Hormuth and started fresh analyses (Beinhauer et al. 1992; Fiedler 1992, 1993a, 1995a, 1996, 1997b). All the lithic artefacts from Mauer are made of chert nodules, not larger than 5 cm and obtained from the fluvial gravels near the river banks of the ancient Neckar. For the production of larger tools, only angular cobbles of sandstone would have been available, but, due to the manifold natural damages of items, no clear identification of anthropogenically modified specimens is possible (Fiedler 1991). Thirty-two chert specimens showing unambiguous traces of intentional knapping have been identified in the Hormuth's find assemblage. All of them are characterized by a glossy surface caused by abrasion and are therefore suggested to have undergone short fluvial transport and/or to have experienced little in situ abrasion on the banks of the ancient Neckar loop. Figure 17 shows two artefacts which were both recovered in situ from the Lower Mauer Sands, and examples of artefacts found on the ground at the base of the profile with identical preservation status. Besides clearly anthropogenically modified knapping waste, the assemblage yields 4 cores, 1 mini-biface, 1 micro chopping tool, 8 flakes lacking intentional modifications, 1 bifacially shaped scraper and 6 tools made out of flakes with significant retouches. The latter group contains at least 4 specimens with intentionally shaped borer-like points knapped from the dorsal side (Fiedler 1996).

The Mauer artefacts are assigned to Mode 1 technology (Clarke 1969). They are comparable to the artefacts of Tautavel and Soleihac (France), Bilzingsleben, Kärlich-Seeufer, and Cannstatt (Germany), Monte Poggiolo and Isernia (Italy), and Vertesszöllös (Hungary). Their similarities do not arise from a technocultural and age-related system, but rather from the local availability of the small-sized raw materials, which accounts for the small dimensions of tools and the archaic appearance of applied technology and shaping. It should be noted that the classification of a lithic assemblage as belonging to a Mode 1 technology does not in every case match its cultural context and may, in this case, represent a local variation and an integral part of the Acheulian, which is evidenced by handaxes made of greywacke and limestone at the Tautavel site (France) (Fiedler 1995b, 1997a, 1997b, 1998a, 1998b). Suitable raw materials for knapping handaxes were not available to *H. erectus heidelbergensis* in his habitat in the Neckar Valley.

The Mauer site has yielded more than 4500 finds of macro- and microvertebrates from different layers, which are, to date, mainly stored at the State Museum of Natural History, Karlsruhe. The museum magazines contain skeletal remains from the Upper Mauer Sands, the 'Lettenbank' (LB), and the Lower Mauer Sands. Bone surface analysis of stratified fossil animal remains recovered from a stratigraphical level of 4.1–5.1 m below the Lettenbank (Number of identified specimens, NISP = 133) in the unit of the Lower Mauer Sands, which includes the stratigraphical level of the position of the Mauer mandible and also overlaps with the layer of in situ artefact finds, has been undertaken by Günter Landeck. Preliminary results show that 5.3% (7/133) of the analyzed specimes exhibit cut marks (de Juana et al. 2010). More than two-thirds of these specimens are bones from *Bison schoetensacki* (5/7). The fact that 20.3% (27/133) of the analyzed bones are remains of this taxon may indicate that this species was the dominant prey of *Homo heidelbergensis*. Figure 18 shows two examples of cut-marked bison bones (humerus and lumbar vertebra; in situ finds 4 m below LB). The anatomical position of incisions on both skeletal elements indicates the removal of meat which usually would have been removed in advance by carnivores if hominins scavenged from their prey (Domínguez-Rodrigo et al. 2009, 2010). Carnivore tooth marks on the humerus are not detectable. Cut marks on the proximal spinous process of the vertebra are truncated by a gnawed-off distal portion (Figure 18a,b), probably caused by durophaguous carnivores. Both examples suggest early hominin access to prey.

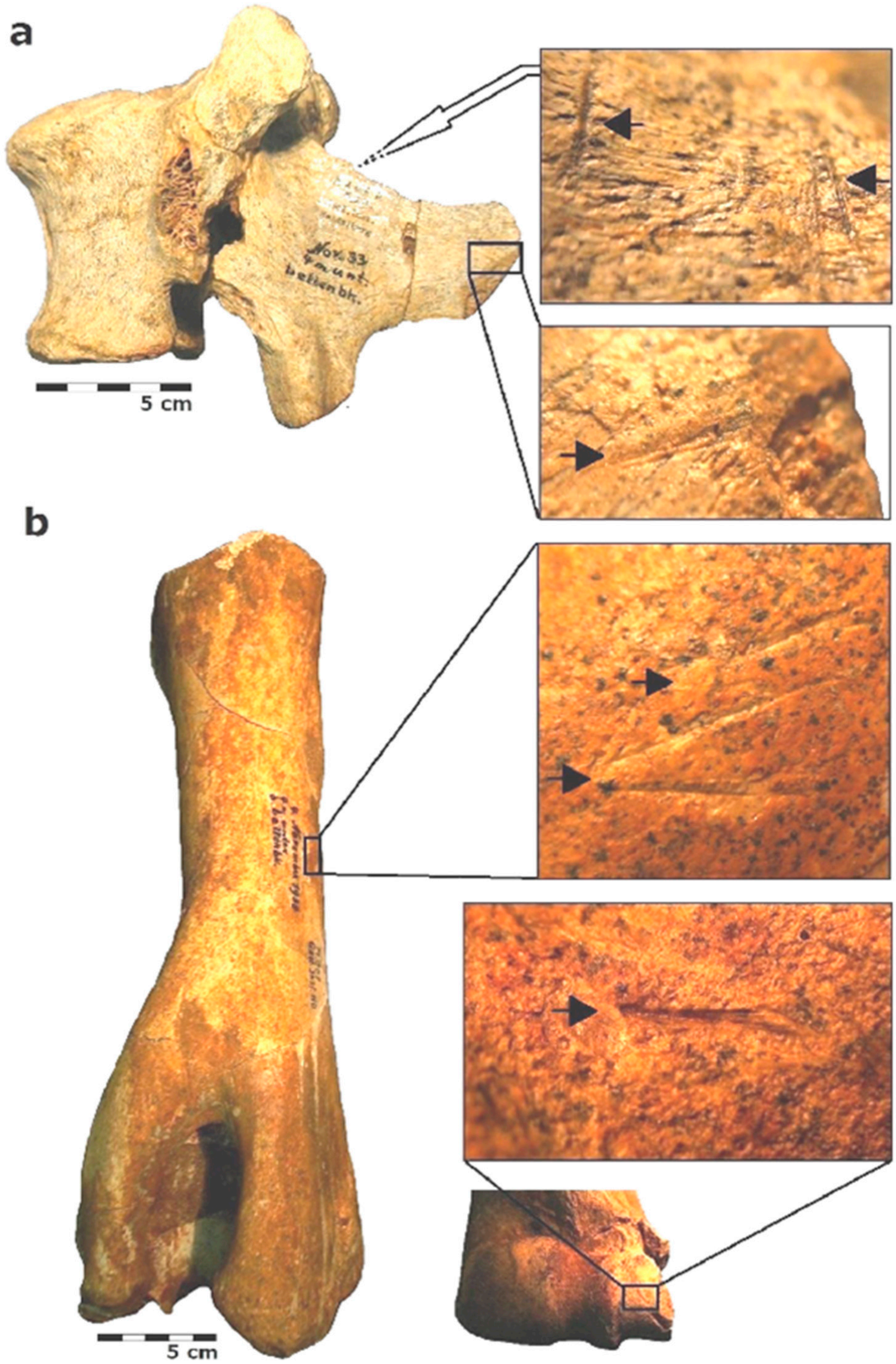


Figure 18. Mauer. (**a**,**b**) Cutmarks on bones. (Photo and analysis by G. Landeck.).

3.4. Mosbach (Wiesbaden-Biebrich, Hessia)

In the vicinity of the city of Wiesbaden (Figure 1 N° 7), a sequence of Lower-to-Upper Pleistocene sediments deposited on Miocene limestones and marls have been preserved (Figures 19c and 20a,b). The locality is a long-standing, well-known paleontological site since the 18th century where a huge amount of fossil faunal remains has come to light from the so-called Mosbach Sands and Gravels situated in the ancient confluence of the large rivers Rhine and Main, ca. 35–60 m above the current riverbeds. The lowermost Pleistocene sediments called 'Coarse Mosbach', showing reversed magnetic polarization, contain the Mosbach 1 fauna with remains of *Mammuthus meridionalis* and *Stephanorhinus etruscus* and belong to the Pre-Jaramillo time period (Koči et al. 1973; Boenigk 1978).

The Mosbach 2 fauna ('Hauptfauna') originating from sands and gravels of 10–15 m thickness ('Grey Mosbach' characterized by fine-to-medium grained grey/green coloured sands, interstratified by thin gravel layers, Figure 20a,b) is positioned higher in the stratigraphical sequence and contains Middle Pleistocene faunal elements like *Mammuthus trogontherii*, *Stephanorhinus etruscus/hundsheimensis*, *S. kirchbergensis*, as well as one of the oldest populations of the vole genus *Arvicola* (Von Koenigswald and Tobien 1987; Von Koenigswald and Heinrich 1999; Maul et al. 2000; Keller 2004, Table 2). Within this section, Keller (2004) recognizes three sediment sequences which represent changing river morphology and which contain different taphocoenoses of a mixture of "warmer" and "cooler" mammalian species. Both faunal units were separated by a layer of high-flood loam, 4–5 m thick. Boenigk (1978) reports that the high flood loam and the Mosbach 2 faunal level exhibit normal magnetizations. On the basis of paleomagnetic finds and the composition of the large mammalian taxa, a late stage of the Cromerian is indicated, especially by the diversity of small mammalian remains and the evolutionary stage of *Arvicola* (Maul et al. 2000; Von Koenigswald et al. 2007; Maul et al. 2017).

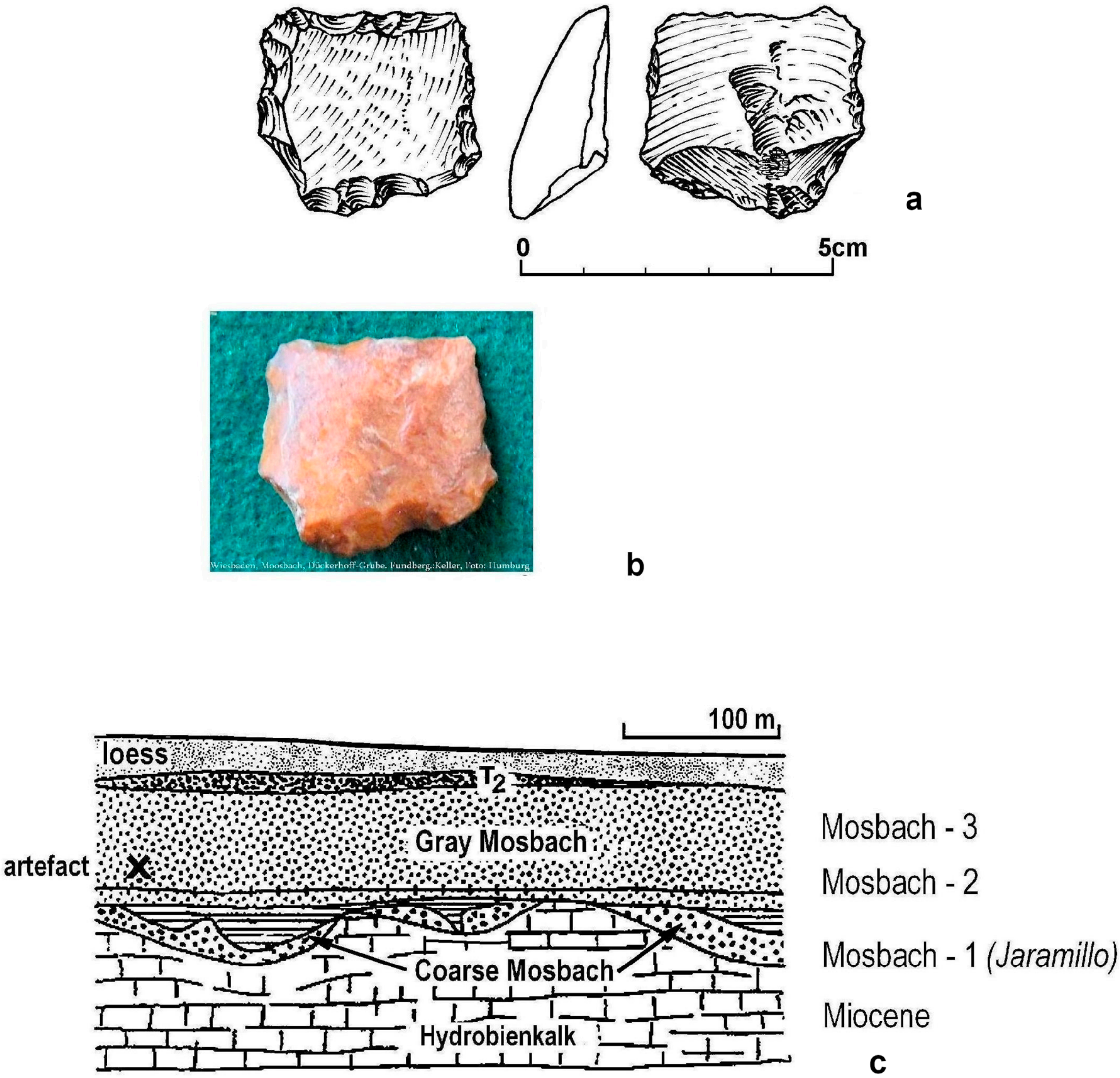


Figure 19. Mosbach (Wiesbaden). (**a**,**b**) Scraper (chert)—in situ out of the Middle Pleistocene level. (**c**) stratigraphy of the Mosbach Sands and the faunal stages. Mosbach 2 and 3 belong to the Brunhes period, while Mosbach 1 is clearly Matuyama/Jaramillo. (Drawing: L. Fiedler, N° 3 modified after Boenigk 1978, photo: C. Humburg.).

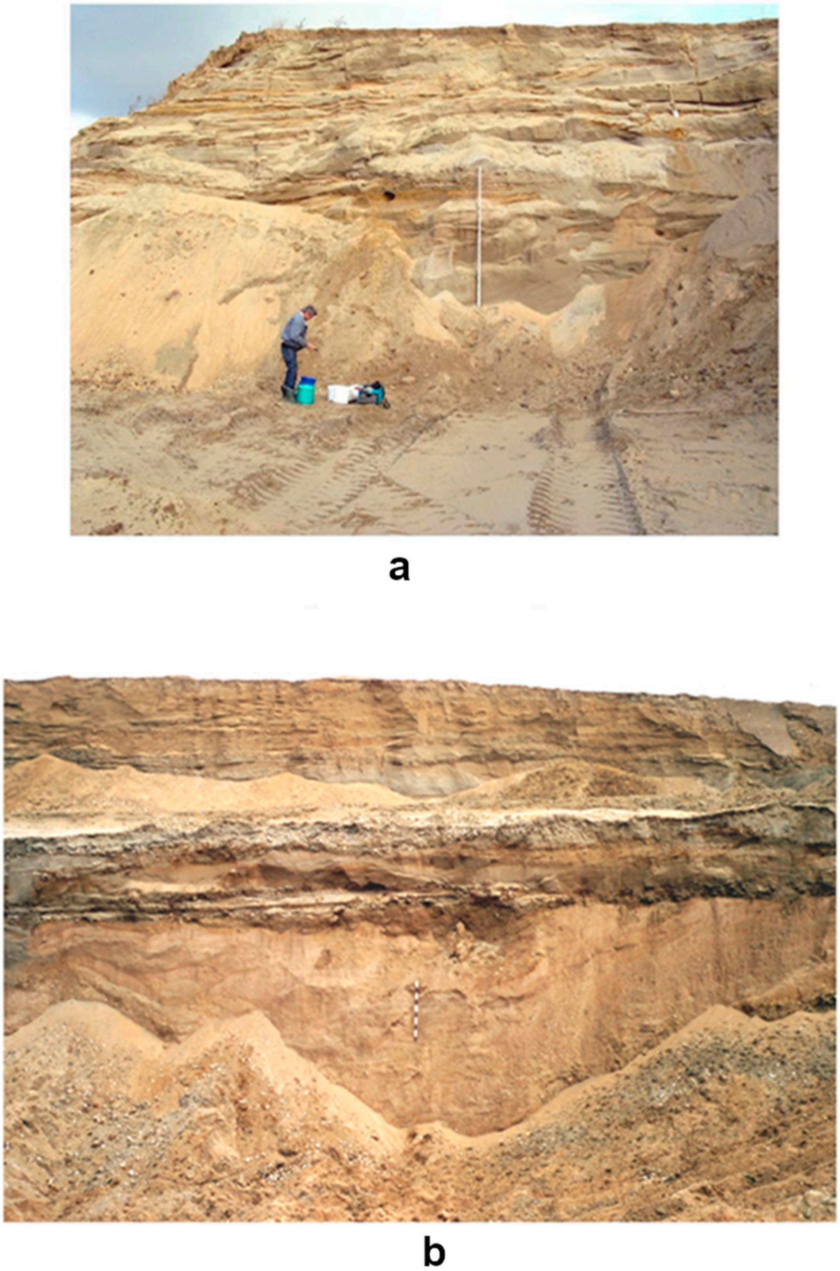


Figure 20. The Mosbach Sands (Wiesbaden). (**a**) The upper part, Middle Pleistocene; (**b**) the lower part, Lower Pleistocene. (Photos: LfD Hessen, T. Keller.).

In search of traces of human activity linked with the emergence of animal fossils in the Mosbach Sands, lithic artefacts were collected from the quarries in and around Wiesbaden by Schmidtgen as early as 100 years ago (Schmidtgen 1929, 1931), but without stratigraphic documentation. Fresh investigations started in recent times, exclusively including specimens recovered with controlled documentation, have identified several stratified chert specimens (N = 16) from the Mosbach III unit (Mosbach 2 fauna, 'Hauptfauna', 'Graues Mosbach'). All these finds exhibit brown patination and polish by abrasion. Only one item of this collection is an undoubted retouched scraper (Figure 19a,b). Marginal anthropogenetic interaction with fauna is indicated by a cut-marked petrified metatarsal of horse (cf. Equus mosbachensis), suggesting disarticulation of limb segments and/or skinning (Figure 21) (Binford 1981; Nilssen 2000, Potts and Shipman 1981).

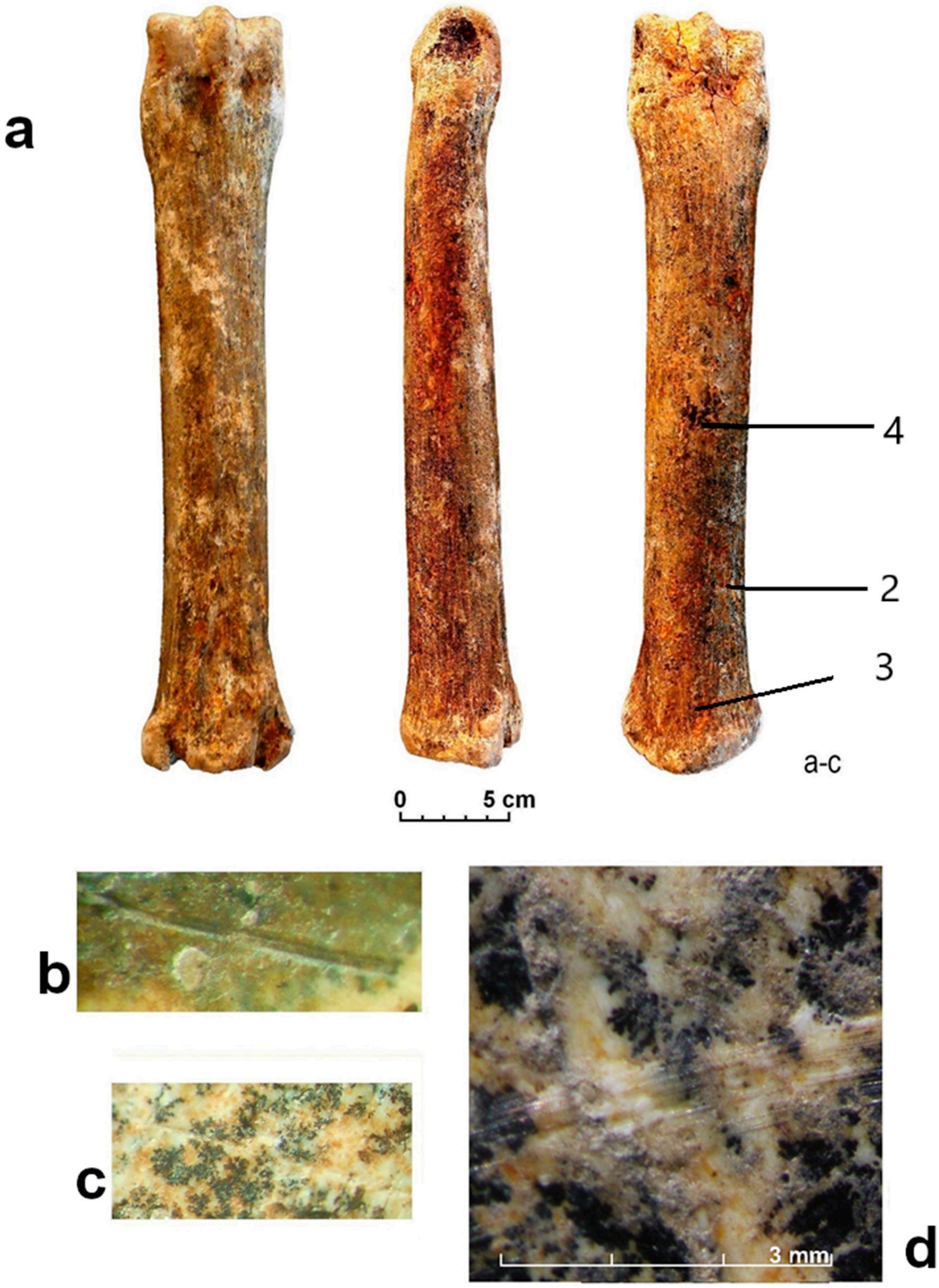


Figure 21. Mosbach. (**a**) Silicified metatarsus from a horse with cut marks (**b**–**d**). (Photos: C. Humburg.).

3.5. Lower Middle Rhine and Moselle (Rhineland-Palatinate)

Besides many Lower Palaeolithic artefact finds (including handaxes) on the surfaces of the terrace gravel bodies of the Younger Main Terrace ('Jüngere Hauptterrasse', ca. 200 m a.s.l.) in the confluence area of the rivers Rhine and Moselle and in the Lower Moselle Valley (Figure 1 N° 2) (Fiedler 1975/1977; Von Berg and Fiedler 1983, 1987), only a few unequivocal lithic artefacts have been recovered in situ from the terrace gravels. Between Koblenz-Metternich and Winningen three artefacts (choppers and a core) were retrieved directly from the terrace gravel layers, exposed in two gravel pits (Von Berg and Fiedler 1987; Von Berg 1997). A crude handaxe (*biface partiel*) manufactured of Devonian quartzite has been found on the surface of outcropping gravels close by one of the gravel pits (Von Berg and Fiedler 1987; Bosinski 2008).

The terrace formation (tM5; Bibus 1983) has been, hitherto, dated to the beginning of the Middle Pleistocene (ca. 0.7 myr) by parallelization with the tR 5-terrace of the Middle Rhine Valley (ca. 200 m a.s.l.). New results on the number and sequence of terraces in the Upper Middle Rhine Valley by Preuss et al. (2015) also hypothesize an older age of the higher terrace formation in the river section of the Lower Middle Rhine Valley and at least the confluence areas of large tributaries like the Moselle River. According to the new terrace system, and in accordance with the site of Münster-Sarmsheim, the in situ artefacts recovered from the 200 m-terrace of Koblenz-Bisholder could at least be dated to ca. 1.3 myr. A magnetic reversal detected in the higher tM4-terrace of the Lower Moselle Valley near Dreckenach (225 m a.s.l.) and the positive magnetization of the lower tM6-terrace in the Lower Moselle Valley at Koblenz-Metternich (180 m a.s.l., orientated towards the Koblenz basin) detected by Fromm (1978) could be interpreted to represent the Gilsa-Event and the earliest part of the Brunhes Chron (Figure 2). L. Fiedler found a heavy but doubtless core in situ in a gravel quarry dug into this Metternich terrace 35 years ago (unpublished).

A few kilometres downstream of the Mosel-Rhine-confluence, Lower Palaeolithic finds were made in the Kärlich clay pit NW of Koblenz where High Terrace gravels were deposited by Rhine and Moselle on Tertiary clay (Figure 1). Grey Rhine facies gravels are separated from the overlying red-coloured Moselle gravels by a sand layer (developed from eluviations), exhibiting reverse magnetization as against normal magnetization in the Moselle layers, perhaps recording the Matuyama/Brunhes boundary at ca. 0.78 myr (OIS 19). Three lithic artefacts associated with remains from *Hippopotamus* sp. (Brunnacker et al. 1980) were recovered from tilted deposits (gravels, sands, and loess; Kärlich A) preserved only locally below the High Terrace sequence. This stratigraphical unit yielded three different directions of magnetic fields, interpreted as a magnetic reversal from normal to reverse polarity in its lower part and a magnetic change of reverse-to-normal polarity in its upper parts (Koči et al. 1973; Boenigk et al. 1974; Fromm 1978). Thus, the upper part of the unit was assigned to the Jaramillo Subchron by these authors. This interpretation was later challenged by Boenigk and Frechen (1998), arguing that the positive magnetic field, directions in the coarsely clastic lower parts and stronger pedogenically affected upper parts of the unit may possibly represent secondary effects, which would mean that the whole unit can also represent a warm stage in the late Matuyama Chron, possibly referring it to the Bavel or Leerdam interglacial. One lithic artefact (trachytic tuff core) was discovered at the base of the Rhine gravel sequence (Kärlich Ba) and must be chronologically placed in a late phase of the Lower Pleistocene. Eight lithic artefacts (two cores, four flakes, one chopper, and a pick-like tool) were recovered from the surface of the Moselle gravel facies (Kärlich Bb) and must be dated to the initial phase of the Middle Pleistocene, shortly after the Matuyama/Brunhes boundary, probably being coeval with faunal remains (*Cervus* sp., *Bos/Bison*) found in a comparable stratigraphical position. Fourteen lithic artefacts made of quartz and quartzite cobbles (three cores, five flakes, one cleaver-like tool, and two borer-like tools) and numerous large and small mammal bones recovered from the Kärlich G layer, attributable to the beginning of the *Arvicola terrestris cantianus* stage, which belong to a later period of the early Middle Pleistocene (OIS 14, 13) (Würges 1986; Vollbrecht 1992; Turner 1990, 1991; Bosinski 1992, 1995, 2006; Brunnacker et al. 1980).

Another Lower Palaeolithic occurrence (known since 1982) from the first half of the Middle Pleistocene in the Lower Middle Rhine region is the Miesenheim 1 site located on the eastern bank of the Nette stream, not far from the present-day confluence with the river Rhine near the town of Andernach (Rhineland-Palatinate; Figure 1). The site has yielded lithic artefacts in spatial association with fauna indicating warm climatic conditions (layers G and F). A pumice layer stratified above the archaeological horizon, identical with pumice KAE-DT 1 at Kärlich, has yielded a maximum age of 618 +/− 13 kyr (Van den Bogaard et al. 1989; Van den Bogaard and Schmincke 1990). The local pumice deposited within a layer of fossil Parabraunerde at the Miesenheim 1 locality was later dated to 464 +/− 4 kyr using the same 40 Ar/ 39 Ar single-grain laser method, thus probably representing MIS 13. Due to deposits interstratified between the archaeological horizon and the layer of Parabraunerde (which both represent a single cold cycle), the correlation of the archaeological horizon with the pre-Elsterian interglacial period of MIS 15 (Cromerian IV; roughly 600 kyr) is suggested (Turner 2000). The archaeological finds are associated with a late Cromerian fauna characterized by the occurrence of *Arvicola terrestris cantianus* (Van Kolfschoten and Turner 1996). The lithic assemblage containing 108 lithic artefacts with some conjoinable pieces (no handaxes) recovered from the archaeological horizons are made of quartz cobbles (93% of total number). Butchering of fauna (total NISP=1148; the larger vertebrate fauna dominated by roe deer, red deer, and horse, 18.4% of individuals carnivores) is only evidenced by a few hammerstone-related fractures on some long bone shafts, suggesting marrow exploitation, whereas cut-marked bones were not identified. Due to the lack of axial elements, the dominance of adult animals, low density of artefacts, and the location of the site in the backwaters of a floodplain Miesenheim I is interpreted as a place to which hominins occasionally came to hunt (Turner 2000).

3.6. Lower Rhine Embayment (North Rhine Westphalia)

Several sources of Lower Palaeolithic stone artefacts which were recovered in situ from late Lower Pleistocene and early Middle Pleistocene river terrace sediments of the Rhine River throughout its course further northwest to the North Sea were reported by Schmude (1992, 1996, 1997) and Klingelhöfer (1997) (Figure 1 N° 4–6). In contrast to the Middle Rhine section (Rhenish Slate Hills) where plateau uplift has formed distinguishable terrace steps ('terrace staircase') and deposition of fluvial sediments, especially in Lower and Middle Pleistocene times, concurrent subsidence in the adjacent part of the Lower Rhine area resulted in large-scale buried, stacked sequences with formation of terrace steps at the eastern margin of the tectonic depression area only (Boenigk and Frechen 2006).

Here we report on three fluvial sites where lithic assemblages contain artefact types of Mode 2 technology which have been recovered from the Upper Terrace 3 (UT3, 'Jüngere Hauptterrasse 3') of the Lower Rhine (Figure 22). This type of terrace formation is frequently preserved in western and assigned the Upper Terrace (UT3) to the early part of the "Cromerian" (Boenigk 1978; Boenigk and Frechen 2006; Jansen and Schollmayer 2014; but see Kemna 2008). Paleomagnetic analyses of enclosed silts ('Schluffe') and clays in the vicinity of Weeze and Wemb (near Kleve) have shown reverse magnetization of the fluviatile deposits but normal magnetization of sediments of paleosoils at the top of exposures (Schnütgen et al. 1975). On the basis of heavy-mineral analyses, has correlated the UT 3 deposits with Glacial B of the Dutch classification of Pleistocene subdivisions. Considering that the gravels at Weeze are reversely magnetized and Glacial B is positioned in the Brunhes Chron (normal magnetic polarization), Klostermann (1992), correlates the deposits with Glacial A (MIS 20).

This is supported by the earliest appearance of ice-wedge formations in UT 3 gravels (Kowalczyk 1969; Klostermann 1992), which is also identified at Weeze, and the heavy-mineral spectrum which is not in disagreement with Glacial A deposits (Zagwijn et al. 1971). Recent investigations have shown that the Matuyama/Brunhes boundary most probably coincides with the warm climate phase postdating Glacial A (Tauxe et al. 1996; Zhou and Shackleton 1999; Nawrocki et al. 2002; Hyodo and Kitaba 2015), therefore, a MIS 20 age would be more plausible. In the late 1980s and 1990s, Schmude (1992, 1997) identified lithic artefacts made of quartzite cobbles incorporated in the UT 3 terrace gravels exposed by mining activities in the Welbers quarry near Weeze (Figure 23). The assemblage contains 89 specimens which frequently are an integral part of a core-chopper or Mode 1 industry (choppers, pics, Figure 23) unifacial unipolar cores, a few bipolar cores, and some retouched flakes (Figure 24) and others without shaping), and also yielded some specimens ascribed to Lower Acheulian tradition or Mode 2 industries (picks, crude bifaces).

Another assemblage recovered partly (2 specimens) in situ from UT 3 deposits at the Spickermann quarry of Kirchhellen (Bottrop) comprises, in total, 81 specimens containing finds of several flakes, cores and some abraded crude bifaces (including a trihedral pick). Ice wedges and cryoturbations are likewise evidenced in the terrace deposits, which show normal magnetization of interposed clayish sediments (Wrede 2000).

Further important finds of Lower Palaeolithic artefacts from the UT 3 terrace in the Lower Rhine area were made in a quarry complex (Boer quarries) between Dorsten (Recklinghausen) and Schermbeck (Wesel). The assemblage yielded 89 artefacts (8 specimens recovered in situ, 82 artefacts from the quarry floor or sieving activities) containing mainly unmodified flakes with some occurrences of shaped flakes (e.g., scrapers, notched specimens), a preponderance of unifacial cores, and only rare centripetal cores comparable with the Kirchhellen site are two heavily abraded handaxe-like specimens found on the surface beneath the terrace profile (Figures 25b and 26) (Klingelhöfer 1997). Analyses of magnetic polarization of terrace sediments at the Boer sand-pit (Schermbeck, Figure 22) have shown positive magnetization and indications of cold climate conditions during their formation. The formation of the UT 3 deposits under cold climatic conditions is indicated by ice wedges and cryoturbations at all of these locations, which do not occur in older terrace deposits (Kowalczyk 1969; Klostermann 1992; Wrede 2000). Faunal remains have not been preserved at these locations.

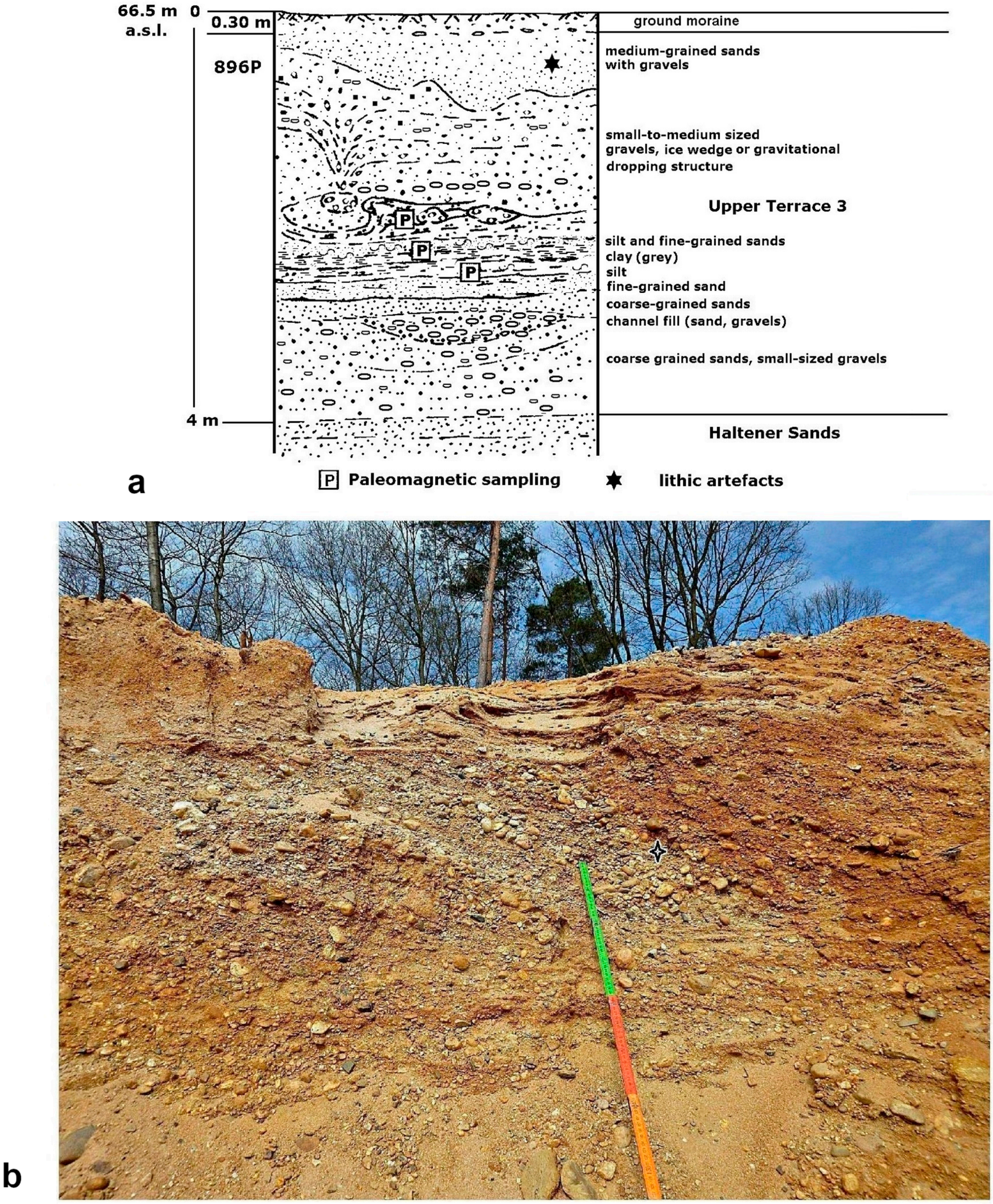


Figure 22. Dorsten-Schermbeck. (**a**) Terrace profile (outlined by G. Landeck); (**b**) the upper part of the terrace (Photo: H. Klingelhöfer.).

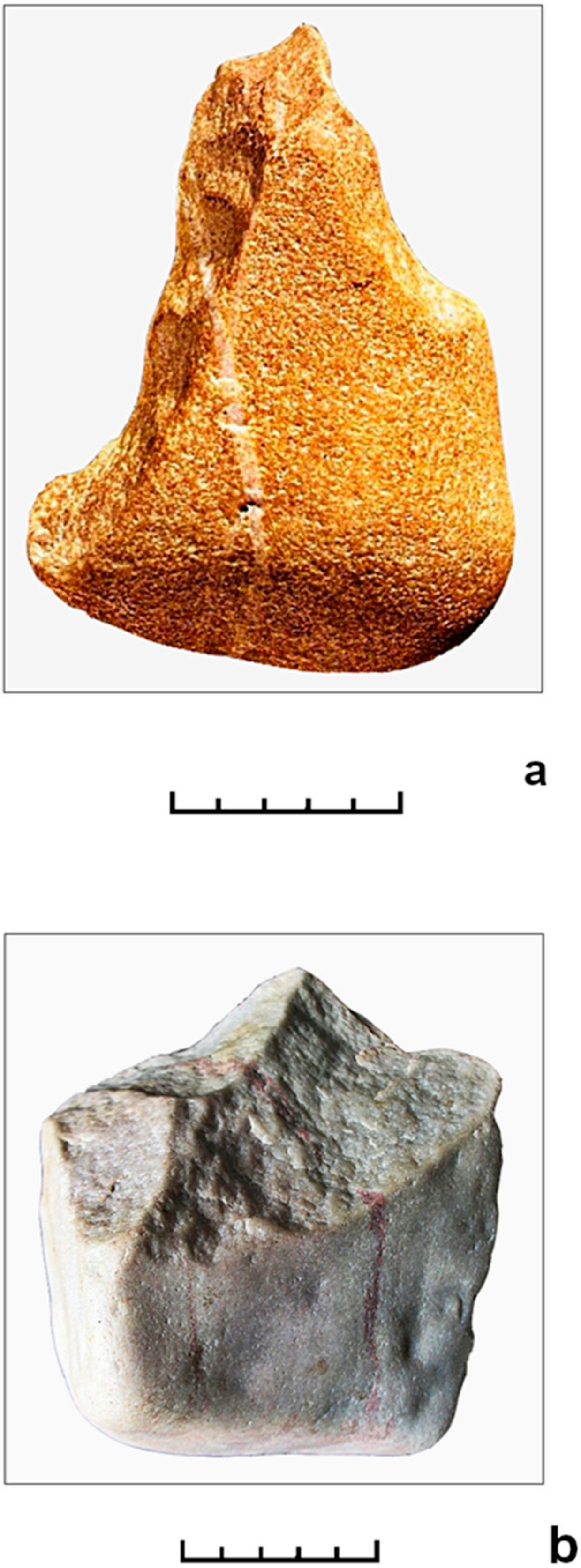


Figure 23. Weeze. (**a**) Pic of the Terra Amata type; (**b**) crude core or pointed chopper; both tools are made out of quartzite. (Photo: H. Klingelhöfer.).

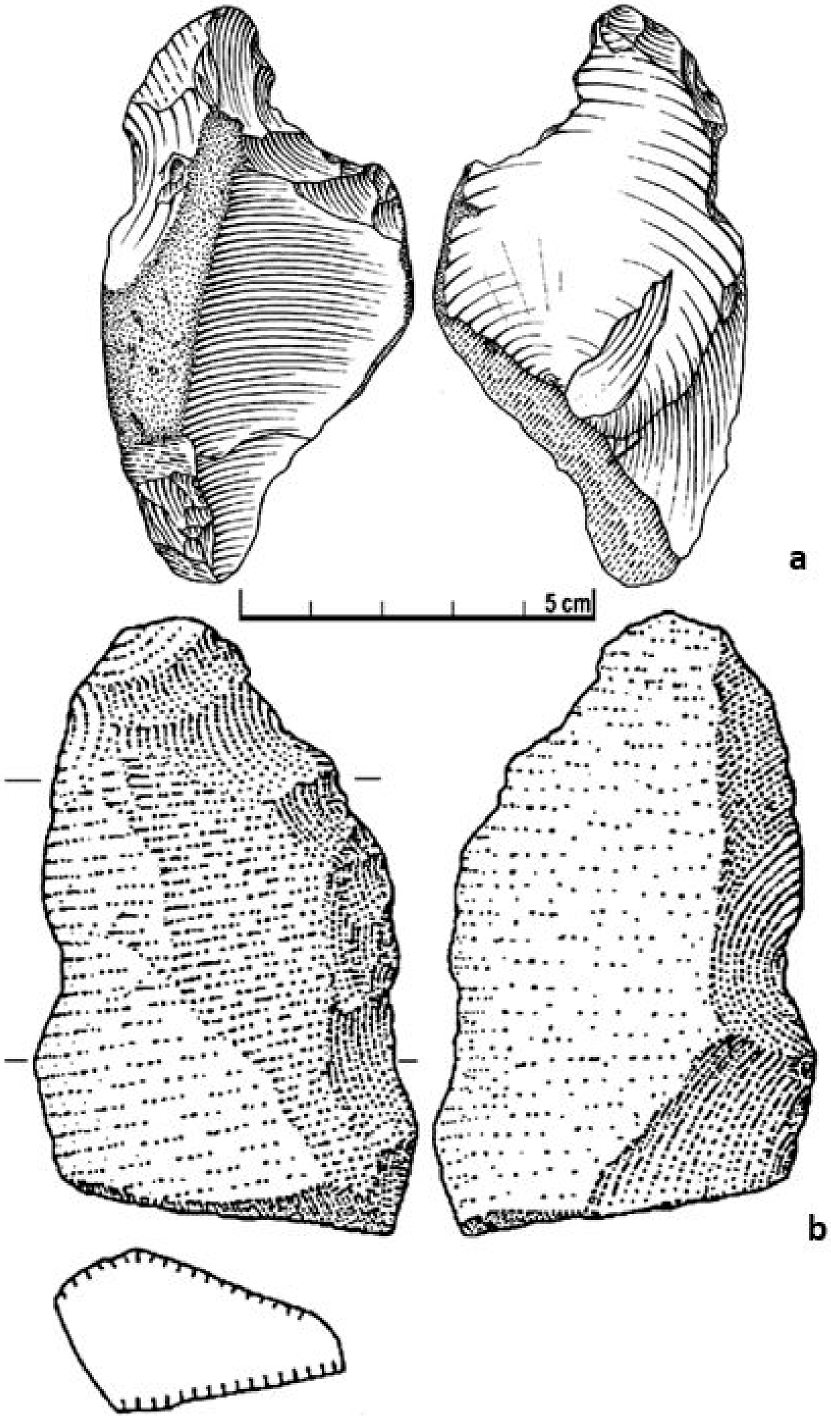


Figure 24. Dorsten-Schermbeck, in situ finds. (**a**) Clacton flake with distal notches (flint); (**b**) side scraper out of a shattered quartzite. (Drawing: B. Kaletsch.).

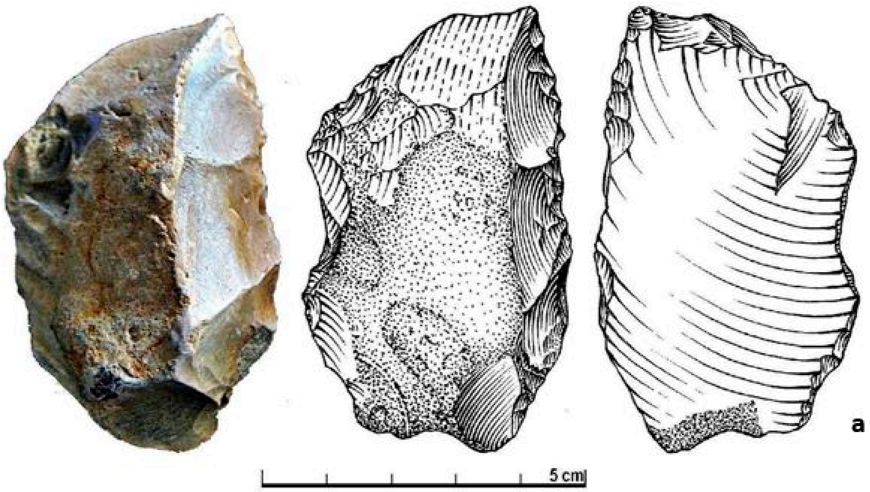


Figure 25. Dorsten-Schermbeck. (**a**) Denticulated knife (flint), in situ find; (**b**) side-struck flake with a pic-like tip, rolled, from the floor of the pit. (Drawing: B. Kaletsch, photo: H. Klingelhöfer.).

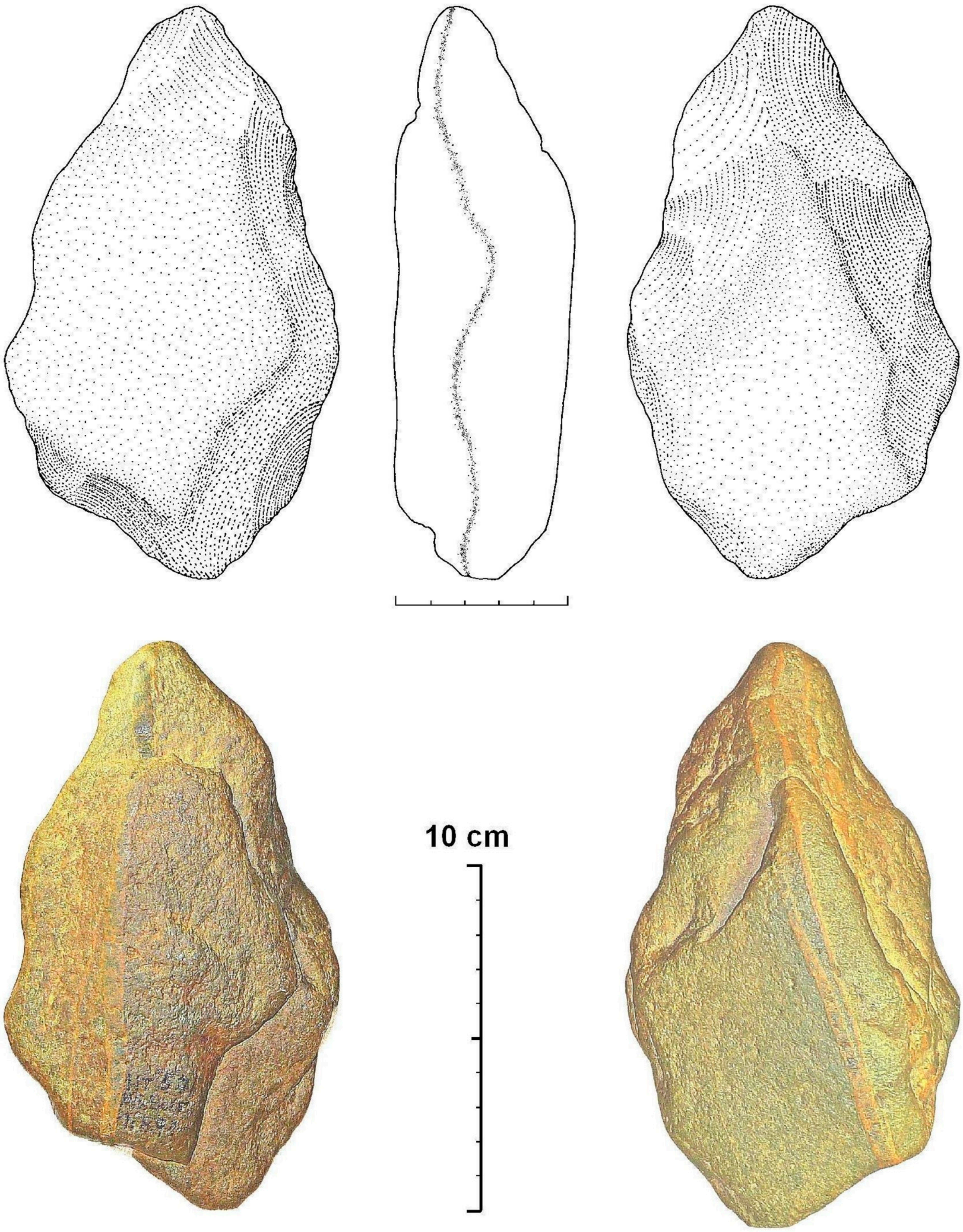


Figure 26. Dorsten-Schermbeck. Heavily rolled handaxe (quartzite) and its graphic interpretation by Beate Kaletsch. (Photo: H. Klingelhöfer.).

In this context, the reverse magnetization of the terrace deposits at Weeze seems to be contradictory to the magnetic polarization of UT 3 in Kirchhellen and Schermbeck, placing the latter sites into the early Brunhes Chron. Schnütgen et al. (1975) have reported a paleomagnetic reversal in the lower part of UT3 with positive magnetization throughout the upper part of the terrace body. If secondary magnetization can be ruled out, this could mean that the terrace body has probably developed over an extended time period, including the M/B boundary. Unfortunately, faunal remains have not been preserved at any of these locations.

4. Conclusions

We are reporting on new data which is of great importance for the assessment of time and mode regarding early occupation of Europe, especially the northwestern part of continental Europe.

Following the new chronological classification of Middle Rhine terraces on the basis of 723 borehole drillings and the remapping of 28 terrace levels established by using precise contour level maps (LIDAR terrain model) reported by Preuss et al. (2015) and its correlation to the Marine Isotope Stages (Cohen and Gibbard 2011), the lithic artefacts of the Münster-Sarmsheim site must be dated to around 1.3 Ma (Figure 2).

The discovery of several archaeological sites in the Middle and Lower Rhine Valley and new dating of terraces and deposits of this river section confirm, in addition to the already known site of Dorn-Dürkheim 3, that the presence of humans has to be seen much earlier than presumed before.

The in situ situation of artefacts at Münster-Sarmsheim (1.3 Ma), Kirchhellen and Schermbeck (near to 0.8 Ma), Dorn-Dürkheim (more than 0.75 Ma), Mauer (about 0.6 Ma), Mosbach and Kärlich (lower Middle Pleistocene) supports a theory of a continuous settlement along the Rhine Valley by *Homo erectus s.l.* at least since the late Lower Pleistocene.

Author Contributions: Conceptuation: L.F.; methology: C.H. and L.F.; software: paint (microsoft, windows), investigation: L.F., C.H., H.K., M.S., S.S.; site survey: L.F., C.H., H.K., M.S., S.S.; formal analyses: L.F., C.H., H.K., M.S., S.S.; resources: L.F., C.H., H.K., M.S., S.S.; data curation: C.H.; writing: L.F., C.H., H.K., M.S., S.S.; Writing—review and edition: C.H. and L.F.; supervision: L.F.; founding: only by the authors. Authorship mainly by L.F., C.H., H.K. and S.S.—same former preparations by Günter Landeck in parts of the intuduction as well as in chapter N° 3.3 and in the discussion. G.L. left the team of the authors before we started the final project.

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