D. Vialou, J. Renault-Miskovsky, M. Patou-Mathis (dir.), *Comportements des hommes du Paléolithique moyen et supérieur en Europe: territoires et milieux*. Actes du Colloque du G.D.R. 1945 du CNRS, Paris, 8-10 janvier 2003.
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MAMMOTH REMAINS IN THE UPPER AND MIDDLE PALEOLITHIC LAYERS OF GEIßENKLÖSTERLE CAVE (ACH VALLEY, SWABIAN JURA, SOUTHWESTERN GERMANY)

Hunting season, acquisition of raw material and tool production at Geißenklösterle Cave

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Abstract. This paper compares the faunal evidence of Upper and Middle Paleolithic layers in Geißenklösterle. The most frequent game animals found are mammoth, horse and reindeer. They are mainly represented by certain skeletal elements, which were preferably used as raw material for the production of organic tools. This analysis will focus on mammoth remains. Elements like mammoth ribs and ivory are predominant in the Upper Paleolithic layers, because the great length of mammoth ribs and tusks was an important advantage for the production of projectile points. From the Aurignacian to the Gravettian layers the raw material for points shifts from ivory to mammoth ribs. The large variety of organic tools from bone, antler and ivory and refuse of their production in the Upper Paleolithic stands in contrast to the almost non existing organic tool industry in the Middle Paleolithic layers. A taphonomic explanation of this imbalance in tracking *Homo sapiens* and Neandertal activities on bone, with special respect on mammoth bones, will be attempted.

Résumé. Restes de Mammouths dans les couches du Paléolithique moyen et supérieur de la grotte de Geißenklösterle (Vallée de l'Ach, Jura Souabe, Sud-Ouest de l'Allemagne). Saison de chasse, acquisition de matière première et production d'outils dans la grotte de Geißenklösterle. Cette communication compare les données fauniques dans les couches du Paléolithique supérieur et moyen de Geißenklösterle. Les animaux les plus fréquents sont les chevaux, les mammouths et les rennes. Ils sont représentés pour la plupart par des éléments du squelette utilisés de préférence comme matière première pour la production d'outils. L'analyse se concentrera sur les restes de mammouths. Des éléments tels que les côtes de mammouths et l'ivoire prédominent dans les couches du Paléolithique supérieur en raison de la taille importante des côtes de mammouths et des défenses car elles représentent un grand avantage pour la production de pointes de projectiles. Des couches de l'Aurignacien à celles du Gravettien, on passe de l'ivoire comme matière première aux côtes de mammouths. La grande variété d'outils faits à partir d'os, de bois de cervidés et d'ivoire renvoie à leur production au Paléolithique supérieur alors que l'industrie d'outils en matières organiques est pratiquement inexistante dans les couches du Paléolithique moyen. A travers une étude taphonomique de ce déséquilibre, on s'efforcera de suivre les activités sur os de l'*Homo sapiens* et du Neandertal. Les fouilles de Geissenklösterle débutèrent en 1973 lorsque E. Wagner du Landesdenkmalamt y fit un sondage. Elles furent poursuivies de 1974 jusqu'en 1991 par J. Hahn, de 2000 à 2002 par N. Conard. Le site présente une séquence stratigraphique qui s'étend de 50.000 à 10.000 BP. La couche la plus profonde mise au jour contient des restes du Paléolithique moyen (AH°V-VIII); la couche suivante quant à elle provient de l'Aurignacien inférieur (AH°III, daté à environ 38.400 BP par 14C-AMS et 40.200 BP par TL) et est suivie d'une couche de l'Aurignacien supérieur (AH°II, pointes à base fendue) datée par 14C-AMS à environ 33.500 BP et par TL à 37.000 BP. Cette dernière couche a révélé 4 figurines taillées en ivoire, des pierres de calcaire peintes de trois couleurs ainsi que des fragments de deux flûtes faites à partir d'os d'oiseaux. La couche suivante renvoie à une occupation gravettienne (AH°I) avec plusieurs zones d'activités (datée à environ 27-29.000 BP par 14C AMS). Après le Gravettien, il semble qu'il y ait eu un hiatus dans l'occupation du Sud-Ouest de l'Allemagne, probablement dû au dernier maximum glaciaire. Un foyer de petite taille (daté à environ 13.000 BP par 14C-AMS) est l'unique preuve d'une occupation de la grotte pendant le Magdalénien.

History of research

Paleolithic research in the valley of the Ach River, a tributary of the Danube, started in 1870, when Oscar Fraas, the head of the "Königliche Naturalienkabinett in Stuttgart" and Theodor Hartmann excavated the Hohle Fels (Fraas 1872; Saier 1994). At that time Fraas wanted to prove the coexistence of Pleistocene animals and humans. Most of their finds, mainly cave bear remains, were lost in World War II. Following Fraas' work a long history of research conducted by the Institute of Pre- and Protohistory and Archaeology of the Middle Ages at the University of Tübingen began. In 1906 R.R. Schmidt, the founder of the Tübingen Institute, started excavating at Sirgenstein. In a careful excavation, digging in thin layers and dry-sieving the sediments, he distinguished eight archaeological layers and correlated them to the French chronological system (Schmidt 1910, 1912; fauna: Koken in Schmidt 1912). Several decades later in the 1950s and 1960s archaeological work was continued by Gustav Riek in Brillenhöhle (Riek 1973; faunal analysis: Boessneck & von den Driesch 1973) and Große Grotte (Wagner 1983; faunal reanalysis: Weinstock 1999).

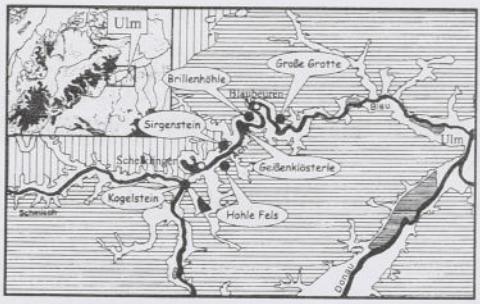

Figure 1. Paleolithic cave sites of Ach Valley.

Excavations at Geißenklösterle were started in 1973 when Eberhard Wagner (Landesdenkmalamt) opened up a test-ditch. In the 1970s Joachim Hahn started his research in the Ach Valley with excavations in Geißenklösterle (Hahn 1988) and Hohle Fels (Hahn 1977; Hahn & Waiblinger 1997), introducing modern excavation techniques. After Hahn's death in 1997, his multidisciplinary research was continued under the direction of Nicholas Conard. While the excavations in Geißenklösterle were closed in 2002 (Conard & Malina 2002, 2003; faunal analysis: Münzel in prep.) the excavations in Hohle Fels continue (Conard *et al.* 2003, preliminary faunal analysis in: Münzel *et al.* 2001; Münzel 2002).

This contribution focuses on Geißenklösterle since the faunal analysis was recently completed (Münzel in prep.) and it offers the opportunity to compare the faunal composition of Upper and Middle Paleolithic assemblages. The results will be compared in a larger context with the other cave sites in the Ach Valley (fig. 1), such as Brillenhöhle, Hohle Fels, Sirgenstein, Große Grotte and Kogelstein, another Middle Paleolithic site (Böttcher *et al.* 2000).

Geißenklösterle cave is part of a limestone rock formation, which rises 60 m above the bottom of the Ach Valley. Geißenklösterle has provided a stratigraphic sequence from 10,000 BP to at least 50,000 BP, thus far it is the most complete stratigraphic sequence in this area (table 1) (Richter *et al.* 2000; Conard & Bolus 2003). Table 1 shows the stratigraphic sequence of Geißenklösterle within the chronological context of the other caves in the Ach Valley.

A small fireplace and a small number of artifacts (14C-AMS date ca. 13,000 BP) are the only evidence of a Magdalenian occupation of the cave. A hiatus follows in either sedimentation or human occupation of at least 10,000 years between the Magdalenian and the underlying Gravettian layers, probably caused by the Last Glacial Maximum. The underlying horizon contains Gravettian artifacts (AH I) and several archaeological features dating to 27-29,000 BP.

The following upper Aurignacian layer (AH II), with split based points, has been dated by 14C-AMS to ca. 33,500 BP

Techno-complex	C-14	Chrono-stratigraphy	Cave sites	Layer	% of Bears	Winter	Burnt Bone Ash Lenses	Man/Bear Interaction	Spring/Early Summer
Magdalenian	12-13.000	Dryas I	Geißenklösterle	Io	4%				
			Hohle Fels	Ia-c		Fetal Horse			
			Brillenhöhle	IV	3%	Fetal Horse	Small Hearth		
	14 000		Sirgenstein	I			Large Hearth		
			Hohle Fels	II a					
Hiatus	Glacial Maximum								
Gravettian			Hohle Fels	II b			Large Hearth	Cut marks	
			Brillenhöhle	V	30%	Fetal Horse	Small Hearths		
			Brillenhöhle	VI	42%	Fetal Horse	Small Hearths		
	>25 & >29.000		Brillenhöhle	VII	32%	Fetal Horse	Large Hearth	Cut marks*	„Juvenile" Mammoth
	27-29.000		Geißenklösterle	I	38%			Cut marks	Mammoth Infants
	27 000	Denekamp	Sirgenstein	II					
	29 000		Hohle Fels	II c		Tooth Eruption, Oxygen Isotops	Large Hearth	Cut marks & Projectile	Mammoth Infants
Aurignacian	30 000		Sirgenstein	III		Fetal Horse			
	28 000		Sirgenstein	IV-V					
	30 000		Sirgenstein	VI		Fetal Horse	Large Hearth		
	29-35.000		Hohle Fels	III-V					
	33-36.000		Geißenklösterle	II	30%	Fetal Horse & Foal	Large Hearth		Mammoth Infants
	38-40.000	Hengelo	Geißenklösterle	III	33%		Small Hearth	Cut marks	Mammoth Infants
			Geißenklösterle	GH17	65%			Cut marks	
Middle Palaeolithic	43.000 (ESR)		Geißenklösterle	IV-VIII	58%			Cut marks	Mammoth Infant
	>45.000		Kogelstein					Cut mark	
			Sirgenstein	VIII/VII		Fetal Horse	Large Hearth		
			Große Grotte	II	80%		3 layers of burnt bone		Juvenile Mammoth

* Cut mark on a penis bone (Riek 1973)

Table 1. Chronology in the Ach Valley and season of occupation.

and with TL to ca. 37,000 BP (Richter *et al.* 2000). AH II has produced four carved ivory figurines depicting a human (the so-called 'adorant', mammoth, bear and bison. A limestone pebble painted with three colors, as well as ivory beads, perforated and dyed fish vertebrae and ornamental objects of antler and ivory were also found (Hahn 1988). During faunal analysis, fragments of two flutes made from the bones of birds were recovered in wet-sieved samples and could be reconstructed. The more intact flute was manufactured from the radius of a swan, probably a whooper swan (*Cygnus cygnus*) (Hahn & Münzel 1995; Münzel *et al.* 2002). Stratified below this is a lower Aurignacian layer (AH III), dated to 33-40,000 BP 14C-AMS and ca. 40,000 BP with thermoluminescence (Richter *et al.* 2000). This archaeological horizon provided a fireplace and an ivory workshop (Christensen 1999; Liolios 1999). Horizon III also produced a rich lithic assemblage and numerous organic artifacts and ornaments (Hahn 1988).

An almost sterile layer of 30 cm separates the Aurignacian from the uppermost Middle Paleolithic layer. The deepest layers exposed in the 2002 excavation contain additional finds from the Middle Paleolithic (AH IV-VIII). In some square meters the bedrock was reached, but no occupation features, such as fireplaces, have been recognized. The Middle Paleolithic deposits are characterized by limestone rubble in a silty matrix with low density of artifacts.

Faunal Record in the Geißenklösterle

The large mammal species in the Geißenklösterle represent a diverse faunal spectrum (table 2) and are indicative of the "Mammoth steppe environment" (Guthrie 1990), with characteristic species such as mammoth (*Mammuthus primigenius*), woolly rhinoceros (*Coelodonta antiquitatis*), wild horse (*Equus* sp.) and reindeer (*Rangifer tarandus*). Alongside cave bear (*Ursus spelaeus*), which is the best represented species in nearly all the caves in the Swabian Alb, several other carnivores, including lion (*Panthera leo spelaea*) and hyena (*Crocuta crocuta*) are present.

The Middle Paleolithic layers yielded four different cervids: giant deer (*Megaloceros giganteus*), red deer (*Cervus elaphus*), reindeer (*Rangifer tarandus*) and roe deer (*Capreolus capreolus*), with very different ecological needs. Roe deer, which appears first in the lower Aurignacian, points to a climatic amelioration that might be correlated with the Hengelo interstadial.

The quantitative analysis of the fauna in Geißenklösterle was conducted using bone weight (Uerpmann 1973). Uerpmann showed that the bone weight of a species correlates with its body weight, thus the bone weight is an approximation of the biomass that was brought to -or- left in the cave. In Geißenklösterle cave bear is the best represented species in all

Industry	Magdalenian	Gravettian	upper Aurignacian	lower Aurignacian	(steril)	Middle Paleolithic
Archeological layers	AH Io	AH I	AH II	AH III	GH 17	AH IV-VIII
Dating (BP)	13.000	27-29.000	34-36.000	38-40.000		43.000
Brown/Arctic Hare (*Lepus* sp.)	•	•	•	•	•	•
Marmot (*Marmota marmota*)						•
Wolf (*Canis lupus*)		•	•	•	•	•
Red/Arctic Foc (*Vulpes* or *Alopex*)	V+A	A+V	V+A	V+A	V	A
Cave Bear (*Ursus spelaeus*)	•	•	•	•	•	•
Brown Bear (*Ursus arctos*)	•	•?				
Lion (*Panthera leo spelaea*)		•		•		•
Cat (*Felis* sp.)	•					
Lynx (*Felis lynx*)		•	•			•
Polecat (*Mustela putorius*)	•		•			
indet. Marten (*Martes* sp.)			•	•		•
Stoat/ Weasel		•		•		
Wolverine (*Gulo gulo*)		•				
Otter (*Lutra lutra*)	•					
Hyaena (*Crocuta spelaea*)		•	•	•	•	•
Mammoth (*Mammuthus primigenius*)		•	•	•	•	•
Wild Horse (*Equus* sp.)	•	•	•	•	•	•
Woolly Rhino (*Coelodonta antiquitatis*)		•	•	•	•	•
Giant Deer (*Megaloceros giganteus*)			•		•	•
Red Deer (*Cervus elaphus*)		•	•	•	•	•
Roe Deer (*Capreolus capreolus*)	•			•		•
Reindeer (*Rangifer tarandus*)	•	•	•	•	•	•
Large Bovid (*Bos* or *Bison*)	•			•	•	
Ibex (*Capra ibex*)	•	•	•	•	•	•
Chamois (*Rupicapra rupicapra*)		•	•	•	•	•

Table 2. Large mammal species list from Geißenklösterle.

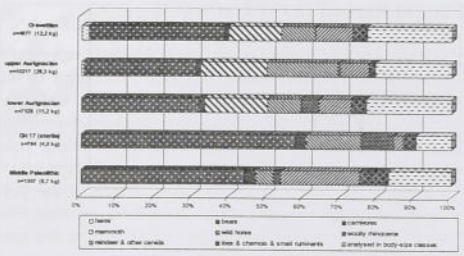

Figure 2. Geißenklösterle. Bone weight of large mammal species.

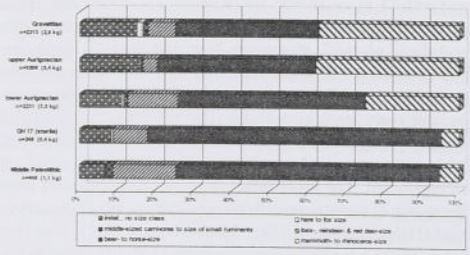

Figure 3. Geißenklösterle. Bone weight of unidentified bone fragments in body-size classes.

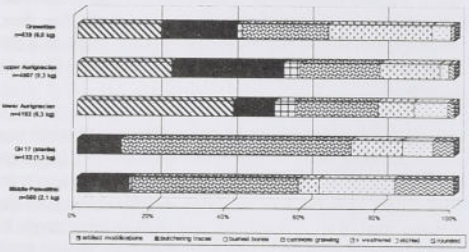

Figure 4. Geißenklösterle. Modifications on bones and their proportion in bone weight.

archaeological layers, while the most frequent game animals in the Upper Paleolithic are mammoth, horse and reindeer (fig. 2); reindeer is included in the 'cervids'. However it is difficult to get a realistic picture of which species were exploited by Neandertals, since the preservation of the fauna in the Middle Paleolithic layers is poor. There are a few fresh looking bones, but the majority of the fragments are etched, rounded and surface weathered, or show signs of carnivore activity (fig. 4).

Despite this poor preservation there are still some butchering marks preserved. Cut and impact marks are preserved on remains of wolf, cave bear, and horse; a cut mark is preserved on a first phalange of an ibex and impact marks on chamois and roe deer remains.

The quantitative composition of the fauna changes from the Upper to the Middle Paleolithic layers (fig. 2). The percentage of cave bear increases, while the abundance of mammoth decreases dramatically from hundreds of specimens including numerous worked pieces of ivory in the Aurignacian to just a few molar and ivory pieces in the Middle Paleolithic. But cervids [1] and small ruminants, as well as middle-sized to large carnivores, such as wolf (*Canis lupus*), lynx (*Felis lynx*), lion (*Panthera leo spelaea*) and hyena (*Crocuta crocuta*), increase in the Middle Paleolithic layers IV-VIII.

The same tendency is recognizable in the bone fragments identified to body-size classes (fig. 3): the bone fragments of horse- to bear-size increase from the Upper to the Middle Paleolithic, while those in the mammoth- to rhino-size decrease.

Acquisition of mammoth

The role of mammoth is often underestimated at central European sites, simply because its remains are less abundant here than at Upper Paleolithic sites in eastern Europe and Russia. The only exception in Southern Germany is the Vogelherd in the neighboring Lone Valley, which revealed a large amount of mammoth bones and teeth (Niven 2001, Diss. in prep.).

In contrast to Vogelherd no large long bones or jaws with molars were transported into Geißenklösterle, instead only selected material was brought in. But we have to consider that Geißenklösterle lies 60 m above the valley bottom. However the importance of mammoth in Geißenklösterle is evident by looking at weapons, tools and jewelry manufactured from mammoth remains.

Therefore this contribution would like to emphasize the importance of including organic tools and the remains of their production into archaeozoological analyses, as opposed to examine them simply as artifacts.

Often one reason for the underestimation of mammoth remains is their fragmentary condition and the difficulty in identifying these bone fragments. Another reason is the use of inadequate quantitative methods. The use of minimum number of individuals (MNI) is very common in quantitative analyses, but is not an appropriate method for highly processed faunal remains at sites with dense occupation "floors" such as Geißenklösterle and Hohle Fels. MNI and other quantitative methods based on articular ends, but also on diagnostic bone parts, mainly reflect the taphonomic survival of certain elements or bone parts (Münzel 1988) and not their value or importance for the Paleolithic hunter.

[1] The high percentage of cervids in the Middle Paleolithic is partly caused by a heavy cast red deer antler base.

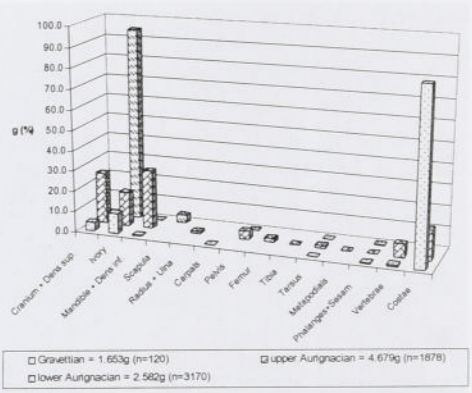

Figure 5. Geißenklösterle. Bone weight for mammoth elements.

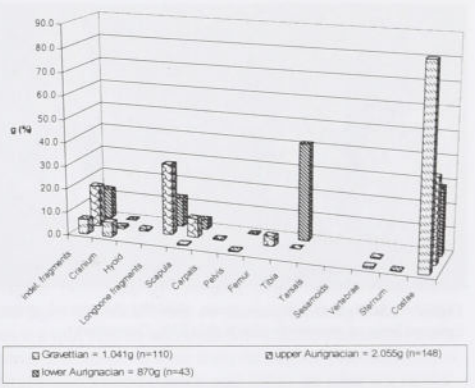

Figure 6. Geißenklösterle. Bone weight of mammoth- to rhinoceros-sized bone fragments.

Therefore, this analysis uses bone weight to compare the mass of different species brought into the site, a method introduced by Uerpmann in 1973. This method is a useful quantitative tool not only for species representation, but also for skeletal element representation. For the skeletal element analysis, bone weight highlights under- and over-represented elements respectively in comparison to a standard individual (Münzel 1988).

The bone weight analysis of the mammoth remains (fig. 5) shows that the element representation is highly biased. Instead of limb bones, which are the heaviest parts in a mammoth skeleton, ribs and ivory are the predominant elements of mammoth at Geißenklösterle. Mammoth ribs and ribs of rhinoceros-mammoth size (fig. 6) predominate in the Gravettian (AH I). In the Aurignacian layer (AH II), remains of several very young mammoths were found, including skull fragments, milk tusks, foot bones and finger bones. These remains are from at least three infants. In addition, ivory and ribs of older individuals are present. In the lower Aurignacian layer (AH III) mammoth is represented almost exclusively by ivory, but also by ribs of mammoth- to rhinoceros-size, while in the Middle Paleolithic layer just a few ivory pieces were found and a molar of a juvenile mammoth [2].

The same situation was recorded at Sirgenstein (AH VII-VIII, Late Mousterian) and Große Grotte (AH II, Mousterian with leaflet points), where only a few ivory pieces and molar fragments, but no bone fragments of mammoth, were recovered from the Middle Paleolithic layers.

To conclude, ribs and ivory are the predominant elements of mammoth in all the Upper Paleolithic layers discussed here. In terms of identification these elements are easy to recognize. On the other hand, it is obvious that ivory and ribs were the preferred raw material for the manufacture of tools and this coincidence of specific elements and their use for tools implies a selection of these elements by the Paleolithic hunter and gatherer.

The other prey animals, such as horse and reindeer, show similar patterns in that elements important as raw material dominate. Other bone remains were either not brought to the site or used as fuel in the fire places (Schiegl *et al.* 2003).

Tool production

During the Gravettian, mammoth ribs were preferred for the production of bone points, and this is a characteristic feature in the Gravettian layers of Geißenklösterle, Hohle Fels and Brillenhöhle (Münzel 2001b). According to Knecht (1991) the distribution of these "mammoth rib points" is temporally and regionally limited to Gravettian sites in South Germany. All of the thick bone points show on one side the cancellous bone (spongiosa) as well as a spongy compact bone typical of mammoth ribs (fig. 7). The ribs were processed in a standardized fashion. First they were notched along the edges on both sides to facilitate splitting afterwards (fig. 8). After splitting, the ribs were either used as a skin smoother or manufactured into points. To thin the split rib halves, they were planed along the edges and smoothed on both dorsal and ventral sides until they developed a typical circular or oval cross-section. At the Geißenklösterle all stages of this "*chaîne opératoire*" were found: the ribs with notches, split rib pieces, partly finished products, rejected base parts and even the bone spalls produced when planing and smoothing the points (fig. 9) (Martina Barth, Diss. in prep.). The length of the mammoth ribs and their straightness is an important prerequisite for production of points and lances.

[2] The sample sizes in the Middle Paleolithic layers were to small to include them in figures 5 and 6.

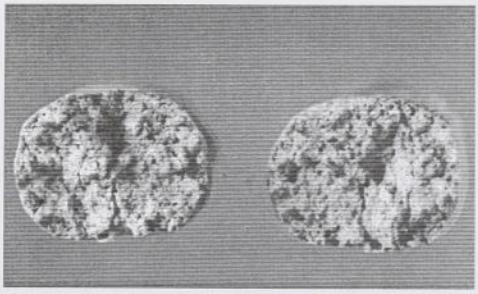

Figure 7. Section of a broken point, showing the typical spongy compact bone of mammoth ribs, Hohle Fels, Gravettian.

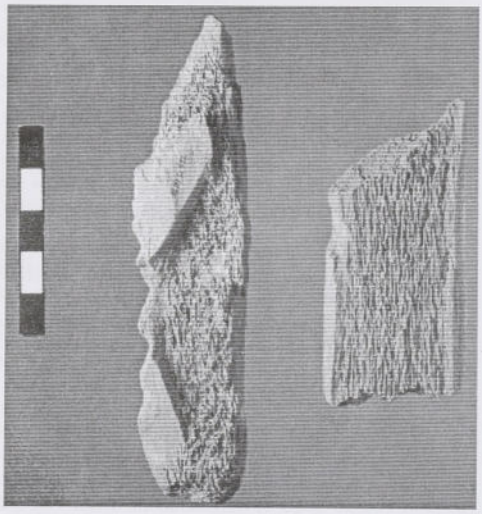

Figure 8. Two rib fragments in mammoth- to rhinoceros-size notched along the etches and split, Geißenklösterle AH I, Gravettian.

In the upper Aurignacian layer at Geißenklösterle the typical points with split bases (the so-called "Leitfossils") were made from reindeer antler, but the long projectile points were fashioned from ivory (fig. 10) (Hahn 1988). Obviously mammoth ribs were not favored for these purposes in the Aurignacian, even if the splitting of ribs is a much easier task than the technically more complicated sectioning of tusks into segments and baguettes and the shaping of ivory points. The technology of producing these long ivory points and lances is still not quite unders'ood (Christensen 1996; Liolios 1999; Hiller 2002). Hahn (1986) suggested that the grooving technique used to produce long spalls has still not been proven for the Aurignacian.

Why did this change in the use of the raw material for long projectile points occur? Is it a change in weapon technology or was it simply due to a shortage of ivory in the Gravettian?

Figure 9. Two finished mammoth rib points, a rejected base part, two bone spalls (from left to right), Geißenklösterle AH I, Gravettian.

In all three main occupation layers at Geißenklösterle (AH I, II and III), remains of very young mammoths were recovered, animals that must have been hunted together with their mothers in spring/early summer. Even in the Middle Paleolithic horizons one milk tusk of an infant mammoth was found, but mammoth remains are generally very scarce in all the Ach Valley caves during the Middle Paleolithic.

Although the raw material situation was probably the same in all the cultural horizons, different skeletal elements were selectively brought to the site for the manufacture of the long projectile points or lances. So I think the change in raw material for the long projectiles from Aurignacian to Gravettian must have been instead a change in weapon technology than a shortage in either ivory or ribs.

The faunal record of the Geißenklösterle and the other caves also shows that mammoth was present in that area from at least 50,000 years ago until 24,000 BP [3]. But the

[3] Its presence after the Last Glacial Maximum is questionable in the Ach Valley. The 14C-dated mammoth remains from Sirgenstein layer I (Magdalenian) turned out to be much older (Anthony Stuart, Oxford; pers. com. and the mammoth radius from the Magdalenian layer IV in Brillenhöhle needs to be dated.

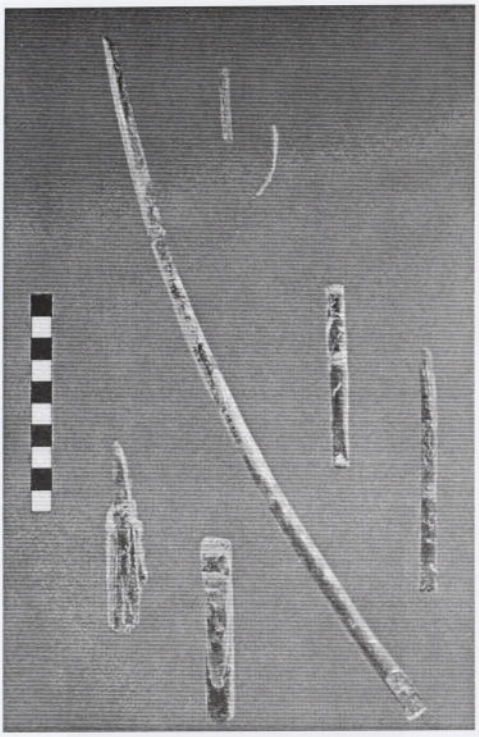

Figure 10. Long ivory point, rejected base part, three smaller ivory points and two ivory spalls.

quantitative presence of mammoth remains in archaeological deposits of Geißenklösterle depends very much on its use as raw material for the tool production. Neandertals probably hunted mammoth, but brought less material to the cave, because they did not use it as raw material. Since Neandertals left almost no bone industry, it seems likely most weapons and other organic tools were made from wood.

However very few bone points have been recognized in the Middle Paleolithic, as documented from the Ach Valley by the antler point from Große Grotte layer II (fig. 11) a layer belonging to the late Middle Paleolithic "Blattspitzen"-complex (Wagner 1983), and by two bone points from the Vogelherd cave layer VI (Riek 1934) in the neighbouring Lone Valley. One is a split pointed mammoth rib, which is comparable to the pointed mammoth rib tools from the Middle Paleolithic site of Salzgitter-Lebenstedt (Gaudzinski 1998), the other is a carefully worked small point probably made from a rib (fig. 12).

Hunting Season for Mammoth and Season of Occupation

Until now, there was a general consensus that the valleys of the Swabian Jura were only visited during the warm seasons of the year by the Paleolithic hunter and gatherer (Sturdy 1975; Weniger 1982, 1987; Hahn 1983; Eriksen 1991). The new archaeozoological results from Geißenklösterle and Hohle Fels show that the Ach Valley was repeatedly occupied during winter and spring and data from the other caves fit this same seasonal pattern. Table 1 summarizes all available data for season of occupation in the Ach Valley.

In several layers of different caves fetal horse bones from the 6th to 7th month (Prummel 1987) of (the eleven month

Figure 11. Antler point from Große Grotte II (l: 91,5 mm, b: 25 mm).

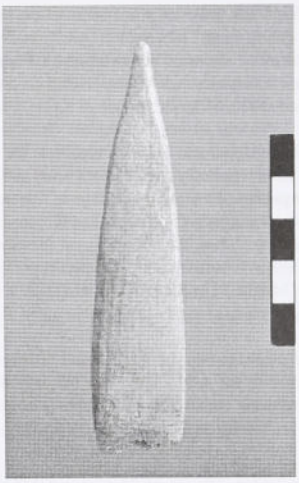

Figure 12. Bone point from Vogelherd.

lasting) gestation were found. Since the birth of wild horses is confined to late spring/early summer (MacFadden 1992), the age at death of the fetal horse bones point to winter. Additionally, remains of a six to ten-month old foal (proximal humerus and an articular end of scapula with cut marks, belonging to the same individual) were found in the upper Aurignacian layer of Geißenklösterle and confirm a winter hunting season for horse (Münzel 1997).

Seasonal indicators are limited for the Middle Paleolithic in the Ach Valley, but they are consistent with the Upper Paleolithic pattern of winter and spring occupation. In this respect the fetal horse bones in the Middle Paleolithic layer VII of Sirgenstein (Münzel & Conard in press) suggest continuity in the exploitation of horse in winter (fig. 13).

A characteristic feature in the caves of the Ach Valley are thick ash lenses of burnt bone (Schiegl *et al.* 2003). During both the Middle and Upper Paleolithic bone served as a fuel (Théry-Parisot 2002) in glacial environments lacking abundant supplies of wood. During all periods the caves of the Ach Valley contain burned bone ash lenses and have been used most intensively during winter and spring. These cold period camps certainly do not reflect the entire settlement system, and future research should be directed towards finding open-air sites that would probably help to document occupations during the warmer seasons of the year.

Cave bear hunting also took place during late winter and spring. Several skull fragments of cave bear cubs show cut marks (Münzel 1997). One canine of a young cave bear from Hohle Fels shows heavy cut marks (fig. 14), this specimen deriving from a cave bear in its second winter (respectively its first hibernation winter) and gives direct evidence of human-bear interaction during winter. A recent find from the Hohle Fels, a flint projectile embedded in a thoracic vertebra of a cave bear dating to 28,000 BP, provides proof of cave bear hunting in the Gravettian during bears' hibernation. Additionally, cut marks on several skeletal elements demonstrate all steps of the butchering process similar to what is conducted on ordinary game (Münzel *et al.* 2001; Münzel 2002).

During both the Upper and Middle Paleolithic the caves of the Ach Valley were repeatedly used by both bears and humans and a consistent pattern of a small percentage of humanly modified cave bear bones suggests that people had the upper hand when these species met. Thus, the cut marks on the cave bear bone from the Middle Paleolithic site Kogelstein [4] (table 1) and those of the Middle Paleolithic in Geißenklösterle fit the general pattern of cave bear exploitation.

Remains of infant mammoths were found in several layers of different caves in the Ach Valley. The majority of the young mammoth remains comes from the upper Aurignacian layer,

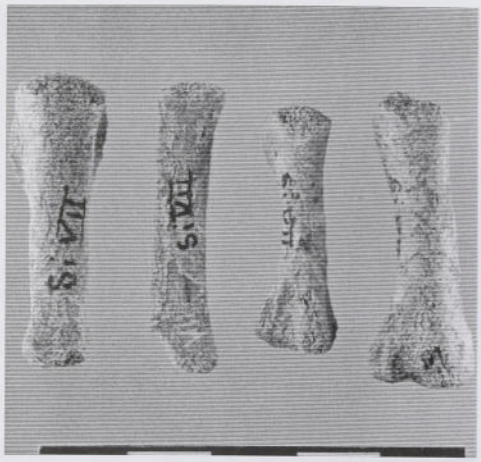

Figure 13. Fetal horse bones from Sirgenstein layer.

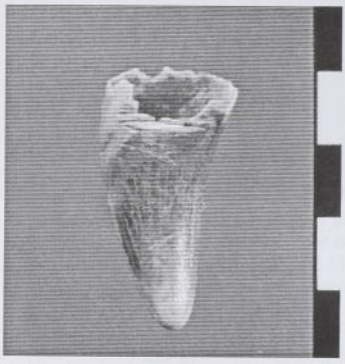

Figure 14. Cave bear canine with cut marks from Hohle Fels, Gravettian.

but infant mammoth remains are present in all layers of Geißenklösterle (Münzel 2001a), even in the Middle Paleolithic a milk tusk and a molar of an infant mammoth was found. Other infant mammoth remains were found in the Gravettian layers of Hohle Fels. Several of these bones bear cut marks, thus the anthropogenic exploitation of these animals is proven. Recently Kuzmina (1999) and Maschenko (2002) published the ages of several infant mammoths from Siberia and southern Russia. The description of the teeth development of a two-four week-old mammoth from Sevsk and of a four week-old from Yamal best fits tooth eruption stages of three upper jaws from Geißenklösterle (fig. 15). Most of the numerous skull fragments, tarsal and carpal bones of infant mammoth belong to the same body-size, thus the majority of the infant mammoth remains from Geißenklösterle and Hohle Fels

[4] The faunal material of the old collection was restudied by the author in the Stadtmuseum of Ehingen.

Figure 15. Maxillae of infant mammoths, Geißenklösterle AH, upper Aurignacian.

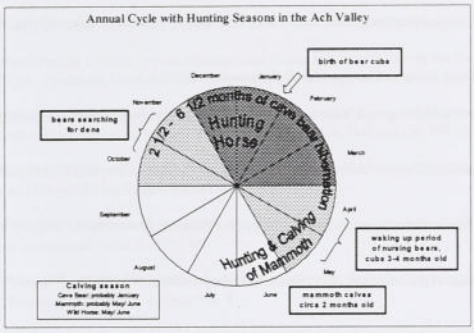

Figure 16. Annual cycle with hunting seasons in the Ach Valley.

probably came from individuals circa one month old at death. Mammoth calves must have been born synchronously in the early spring to maximize their growth during the first summer and survive the following winter (Guthrie 1990).

Some slightly younger, as well as older calves are also represented in the teeth material as well as in the post-cranial elements, suggesting that the hunting season varied. Thus the variation in size of the infant mammoth remains is due to a prolonged hunting season not to different calving seasons. In summary, the exploitation of mammoth and the acquisition of mammoth bone and ivory raw material took place in spring and early summer at these sites.

In summary, the Ach Valley shows a consistent pattern of winter and spring occupation, which lasted for several thousand years and shows an environmental adaptation that survived the transition from Neandertal to modern *Homo sapiens*. Figure 16 shows a summary of the seasonal pattern in the Ach Valley.

Conclusions

The faunal analysis of the Upper Paleolithic layers in the Geißenklösterle has shown that certain skeletal elements of the main prey species are abundant at the site based on their value as raw material for tool production. Mammoth is one of the dominant species of which primarily ribs and ivory were brought to the site. Mammoth ribs were important for the manufacture of bone points in the Gravettian and ivory for the manufacture of projectile points in the Aurignacian. The manufacture of points produced a great amount of refuse. There is also evidence for the presence of mammoth in the form of tusk and ivory fragments during the Middle Paleolithic in the Ach Valley, but these elements were not used as source of raw material for the tool production. Since these elements for raw material are missing in the Geißenklösterle as well as in other Neandertal assemblages, such as Sirgenstein and Große Grotte, the faunal composition is more dominated by cave bear and less specialized in respect to raw material selection for bone tools, ornaments, or artwork.

In addition, this study has demonstrated that there is continuity in the seasonal occupation and exploitation of the Ach Valley, but a break in the exploitation of raw materials between Neandertals and modern *Homo sapiens*.

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