International Journal of Osteoarchaeology
Int. J. Osteoarchaeol. **14**: 225–243 (2004)
DOI: 10.1002/oa.758

Change and Continuity in Subsistence during the Middle and Upper Palaeolithic in the Ach Valley of Swabia (South-west Germany)

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ABSTRACT This paper examines the faunal assemblages from Middle Palaeolithic cave sites in the Ach Valley and views them in a broader chronological context along with the Upper Palaeolithic assemblages of the region. We present data from the key Middle Palaeolithic sites of Geißenklösterle, Sirgenstein, Große Grotte and Kogelstein. Except Kogelstein, which is a hyena den, the other three sites served as cave bear hibernation dens, where cave bear is the most abundant species. The most frequent game species during the Upper Palaeolithic are horse, mammoth and reindeer. But these animals are mainly represented by specific skeletal elements, which were important as raw material for the production of organic tools. The large variety of organic tools made from bone, antler, and ivory, and the refuse resulting from their production in Upper Palaeolithic layers stands in contrast to the extreme rarity of organic tools and production debris in Middle Palaeolithic layers. The faunal assemblages in the Ach Valley document continuity in the seasonal use of the landscape and the preferred game, but reflect changes in the use of sites and organic technology between the Middle and the Upper Palaeolithic.

Based on the faunal and lithic assemblages from the caves of the Ach Valley, most of the sites were used more intensively in the Upper Palaeolithic than in the Middle Palaeolithic. If these assemblages provide representative samples, the available data suggest lower population densities and greater mobility of Neanderthals during the Middle Palaeolithic than of modern humans during the Upper Palaeolithic.

Key words: Neanderthals; fauna; human impact on bones; seasonality; Ach Valley; Swabian Jura; SW Germany

History of research

The most important sites in the Ach Valley are Geißenklösterle, Hohle Fels, Brillenhöhle, Große Grotte, Sirgenstein and Kogelstein (Figure 1). Palaeolithic 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the 'Königliche Naturalienkabinett in Stuttgart' and Theodor Hartmann excavated the Hohle Fels (Fraas, 1872; C. Saier, unpublished MA dissertation, 1994). At that time Fraas wanted to demonstrate 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

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Received 1 April 2003
Revised 29 May 2003
Accepted 25 November 2003

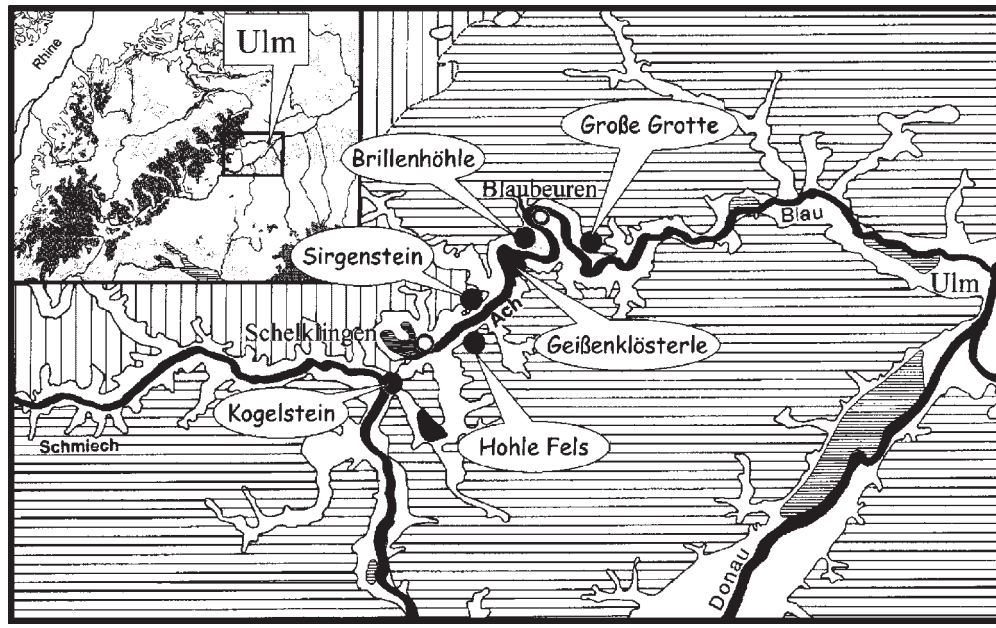

Figure 1. Palaeolithic sites in the Ach and Blau Valleys.

system (Schmidt, 1910, 1912). Several decades later in the 1950s and 1960s archaeological work was continued by Gustav Riek in Brillenhöhle (Riek, 1973) and Große Grotte (Wagner, 1983).

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, this multidisciplinary research was continued under the direction of Nicholas Conard (Conard & Malina, 2003 Conard *et al.*, 2003).

The chronological framework of the Ach Valley sites comprises a Late Magdalenian dating to ca. 13,000 BP (Table 6), then a probable hiatus either in sedimentation or in human occupation of at least 10,000 years caused by the Last Glacial Maximum, then an early Gravettian dating between 27–30,000–BP. The upper Aurignacian dates to between ca. 30–35,000, a lower Aurignacian between ca. 35–40,000 BP. Finally there are several Middle Palaeolithic layers, dating to ca. 43,000 and older in Geißenklösterle (Richter *et al.*, 2000; Conard & Bolus, 2003), as well as Middle Palaeolithic layers in Sirgenstein, Große Grotte, Kogelstein and Hohle Fels (Conard *et al.*, 2003). Here it is important to note that current research has documented major fluctuations in global atmospheric radiocarbon concentrations between 30,000 and 50,000 years (Conard & Bolus, 2003). Thus radiocarbon ages need, whenever possible, to be confirmed by other techniques.

Geißenklösterle

Geißenklösterle cave is part of a limestone massif, a rock formation which rises 60 m above the valley bottom. Excavations at Geißenklösterle began in 1973 when Eberhard Wagner of the Landesdenkmalamt opened up a test-trench (Hahn, 1988). Joachim Hahn (1988) of the University of Tübingen continued the excavation from 1974 until 1991. Since 2000 the current team has continued work at the site and has focused on the Aurignacian and the Middle Palaeolithic layers (Conard & Malina, 2003).

The site has provided a stratigraphic sequence from 10,000 BP up to at least 43,000 BP (Richter *et al.*, 2000; Conard & Bolus, 2003). A small fireplace and a small number of artefacts (^{14}C-AMS date ca. 13,000 BP) are the only evidence of a Magdalenian occupation of the cave. The underlying horizon contains Gravettian artefacts (AH I)

and several archaeological features dating mainly between 27–29,000 BP.

The upper Aurignacian layer (AH II), with split based points, which follows next, has been dated by ^{14}C-AMS to ca. 33,000 BP and with TL to ca. 37,000 BP (Richter *et al.*, 2000). AH II has produced four carved ivory figurines depicting a human, a mammoth, a bear and a bison. A limestone pebble painted with three colours, 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). Below level AH II is a lower Aurignacian layer (AH III) dated to 33–40,000 BP using ^{14}C-AMS dating, and ca. 40,000 BP using thermoluminescence (Richter *et al.* 2000). This archaeological horizon yielded a fireplace and an ivory workshop (Christensen, 1999; Liolios, unpublished doctoral dissertation, 1999). Horizon III also produced a rich lithic assemblage and numerous organic artefacts and ornaments (Hahn, 1988; Conard & Bolus, 2003). An almost sterile layer of 30 cm separates the Aurignacian from the uppermost Middle Palaeolithic layer. The deepest layers exposed in the 2002 excavation contain additional finds from the Middle Palaeolithic (AH IV–VIII). In some square metres bedrock was reached, but no occupation features, such as fireplaces, have been recognized. The Middle Palaeolithic deposits are characterized by limestone rubble in a silty matrix with low densities of artefacts.

Faunal evidence

The large mammal species in Geißenklösterle represent a diverse faunal spectrum (Table 1) and are indicative of the 'mammoth steppe environment' (Guthrie, 1990), with characteristic species such as mammoth, woolly rhino, wild horse and reindeer. Alongside cave bear, which is the best represented species in nearly all the caves in the Swabian Alb, several other carnivores, including lion and hyena, are present. The Middle Palaeolithic layers yielded four different cervids: giant deer, red deer, reindeer and roe deer, with very different ecological needs. Roe deer appears first in the lower Aurignacian, and points to a climatic amelioration that might be correlated with the Hengelo interstadial.

The quantitative analysis was conducted using bone weight (Uerpmann, 1973) as an approximation of the biomass that was brought to—or left in—the cave (Figure 2). In Geißenklösterle cave bear is the best represented species in all archaeological layers, despite the fact that the cave today is more a rock shelter than a typical cave bear cave. The most frequent game animals in the Upper Palaeolithic are mammoth, horse and reindeer.

The faunal spectrum changes from the Middle to the Upper Palaeolithic. The percentage of cave bear decreases, while mammoth increases dramatically from just a few molars and pieces of ivory in the Middle Palaeolithic, to hundreds of specimens, including numerous worked pieces of ivory, in the Aurignacian. Cervids,[1] small ruminants, as well as medium- to large-sized carnivores such as wolf, lynx, lion and hyena, are better represented in layers IV–VIII than in the Upper Palaeolithic layers. The same tendency is recognizable in the bone fragments identified to body-size classes (Figure 3). The number of bone fragments of horse- to bear-size decrease from the Middle to the Upper Palaeolithic, while those in the mammoth- to rhino-size increase.

Taphonomic considerations and human activities

The preservation of the fauna in the Middle Palaeolithic layers is not very good. 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 (Figure 4). Many of the stone artefacts have also been damaged by cryoturbation or other geological processes. In the Middle Palaeolithic layers sediment modifications are present on 56% of the bones number of individual specimens (NISP),

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

Table 1. Geißenklösterle: NISP and bone weight (g) of large mammal species

Industry	Magdalenian		Gravettian		Upper Aurignacian		Lower Aurignacian		Sterile		Middle Palaeolithic	
Archaeological layers	AH Io		AH I		AH II		AH III		GH 17		AH IV–VIII	
Radiocarbon years (BP)	13,000		ca. 27–30,000		ca. 30–35,000		ca. 30–38,000				ca. < 32–34,000	
TL- and ESR-Age (BP)					TL ca. 37.000		TL ca. 40.000				ESR ca. ≤ 43,000	
Species	NISP	Weight	NISP	Weight	NISP	Weight	NISP	Weight	NISP	Weight	NISP	Weight
Brown/Arctic hare (*Lepus* sp.)	13	11.1	240	238.9	182	210.1	27	12.0	1	3.0	8	8.8
Marmot (*Marmota marmota*)	—	—	—	—	—	—	—	—	—	—	1	0.1
Wolf (*Canis lupus*)	—	—	14	41.1	56	282.6	35	134.8	5	17.2	19	103.6
Red fox (*Vulpes vulpes*)	3	11.2	5	15.0	8	8.5	4	5.5	—	—	1	2.6
Arctic fox (*Alopex lagopus*)	—	—	5	7.3	2	1.9	3	2.5	—	—	—	—
Red/Arctic fox (*Vulpes* or *Alopex*)	25	10.6	99	64.9	63	32.9	79	67.6	13	15.0	25	31.9
Cave bear (*Ursus spelaeus*)	26	15.6	1418	4441.0	1656	7905.6	1316	4781.2	386	2270.4	586	2945.4
Brown bear (*Ursus arctos*)	2	63.8	1	2.2	—	—	—	—	—	—	—	—
Cave lion (*Panthera leo spelaea*)	—	—	1	1.0	—	—	1	4.1	—	—	4	28.4
Lynx (*Felis lynx*)	1	1.5	—	—	1	1.2	1	0.5	—	—	1	1.0
Wild/Domestic cat (*Felis* sp.)	23	45.7	—	—	—	—	—	—	—	—	—	—
Polecat (*Mustela putorius*)	1	0.2	—	—	1	0.2	—	—	—	—	—	—
Stoat/ Weasel (*Mustela erminea/nivalis*)	—	—	1	0.2	—	—	1	0.2	—	—	—	—
indet. marten (*Martes* sp.)	—	—	—	—	1	0.2	1	0.5	—	—	1	0.2
Wolverine (*Gulo gulo*)	—	—	1	0.2	—	—	—	—	—	—	—	—
Otter (*Lutra lutra*)	1	0.2	—	—	—	—	—	—	—	—	—	—
Hyena (*Crocuta spelaea*)	—	—	2	1.9	5	7.5	8	14.3	9	70.0	7	13.5
indet. small carnivores	2	0.4	4	0.8	6	1.4	7	7.1	3	1.4	—	—
indet. large carnivores	—	—	7	4.6	8	14.0	28	23.5	9	5.2	7	14.9
Mammoth (*Mammuthus primigenius*)	—	—	204	1725.4	1883	4697.3	3178	2941.5	8	19.2	20	25.2
Wild horse (*Equus ferus*)	3	23.8	116	1125.8	381	5091.8	102	1359.7	24	572.7	21	316.6
Woolly rhino (*Coelodonta antiquitatis*)	—	—	4	20.5	19	119.6	43	749.2	4	348.4	8	129.2
indet. large ungulates	—	—	3	1.4	3	1.2	5	1.6	—	—	—	—
Giant deer (*Megaloceros giganteus*)	—	—	—	—	1	51.8	—	—	1	17.0	7	68.9
Red deer (*Cervus elaphus*)	—	—	3	196.9	5	63.1	5	80.2	3	38.5	2	250.1
Roe deer (*Capreolus capreolus*)	5	17.5	—	—	—	—	4	20.9	—	—	2	5.9
Reindeer (*Rangifer tarandus*)	11	43.2	183	1198.9	263	1728.3	230	1189.4	14	49.3	53	1106.8
large bovid (*Bos* or *Bison*)	1	1.0	—	—	—	—	1	12.5	1	6.9	—	—
Ibex (*Capra ibex*)	1	1.0	43	245.3	51	250.3	53	274.0	11	82.7	20	268.1
Chamois (*Rupicapra rupicapra*)	—	—	7	43.0	17	62.0	18	53.8	5	22.0	5	30.5
indet. small ruminants	20	28.9	105	205.2	95	190.3	151	330.8	19	30.8	64	231.0
indet. large ruminants	1	1.0	4	0.6	2	24.2	2	1.3	2	1.2	—	—
indet., no size class	23	5.7	1396	416.8	4407	847.7	1129	386.4	109	31.7	118	74.5
indet., smaller than hare- to fox-size	35	3.3	8	0.0	—	—	—	—	—	—	—	—
indet., hare- to fox-size	5	2.1	113	38.9	37	16.8	38	16.7	2	1.3	5	3.0
indet., middle-sized carn. to small rumin.	—	—	45	44.2	22	35.0	34	41.2	1	0.5	14	23.8
indet., ibex-, reindeer- & red deer size	23	20.6	153	195.0	135	200.8	323	451.5	18	33.8	80	186.5
indet., bear- to horse-size	4	15.5	388	1045.7	757	2248.8	664	1724.7	114	293.2	220	790.6
indet., mammoth- to rhino-size	—	—	110	1034.4	147	2051.3	42	510.6	2	17.4	9	58.1
Total	229	323.9	4683	12357.1	10214	26146.4	7533	15199.8	764	3948.8	1308	6719.3

TL; Thermoluminescence, ESR; Electron Spin Resonance.

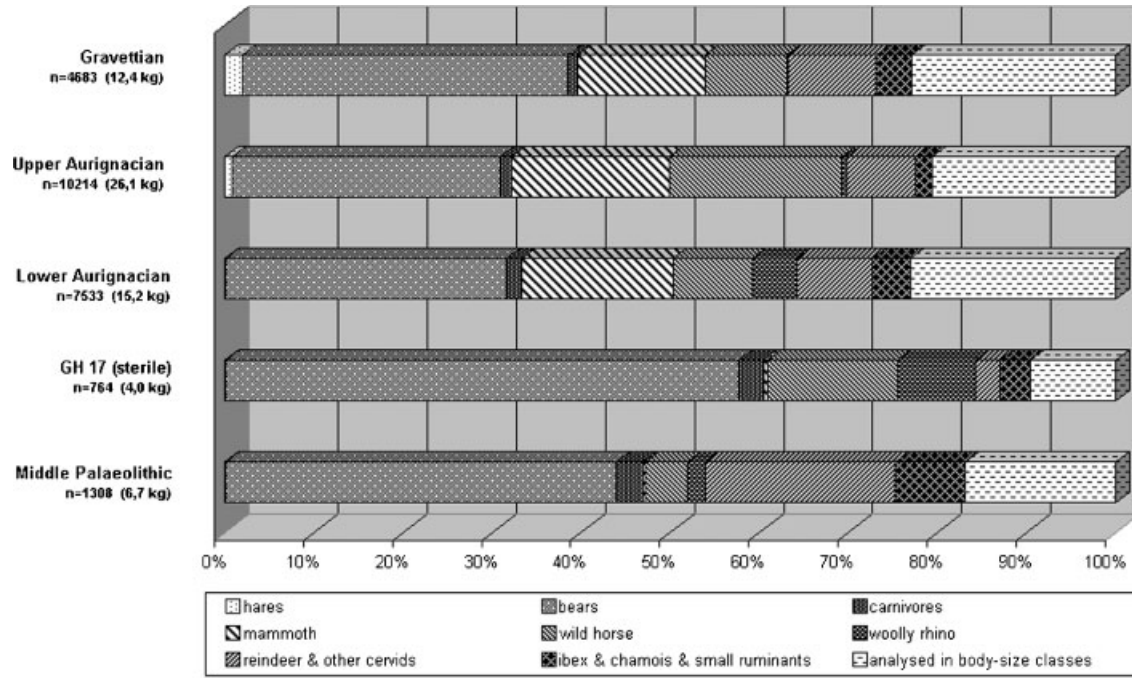

Figure 2. Geißenklösterle—bone weight of large mammal species.

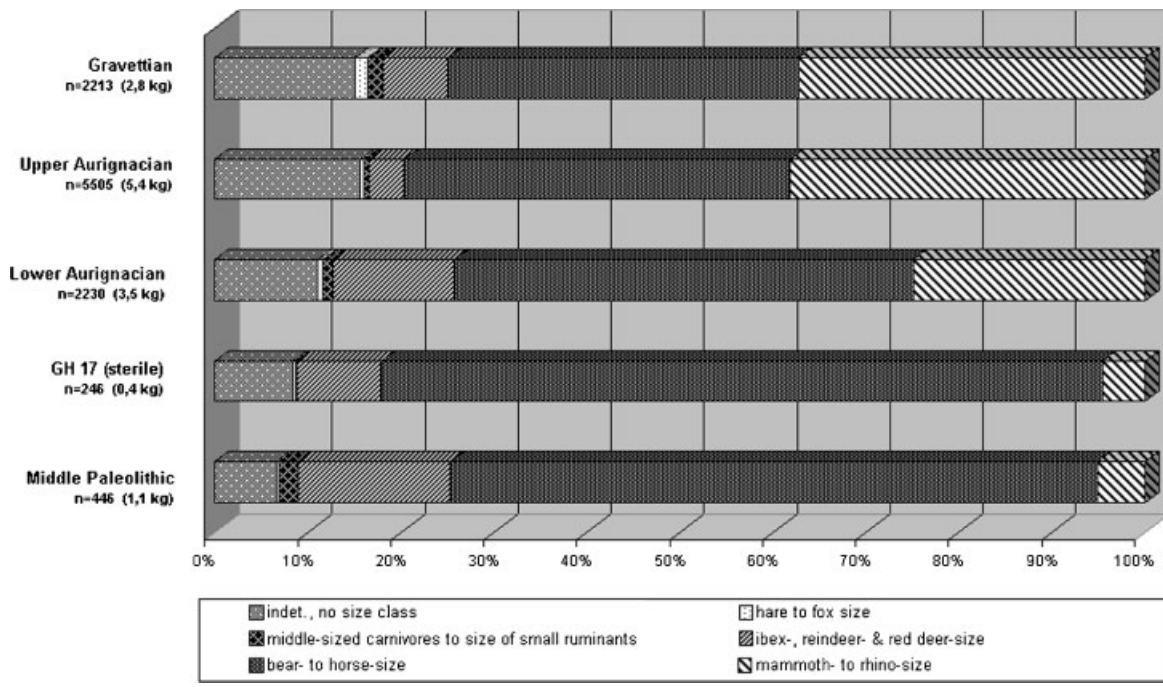

Figure 3. Geißenklösterle—bone weight of unidentified bone fragments in size classes.

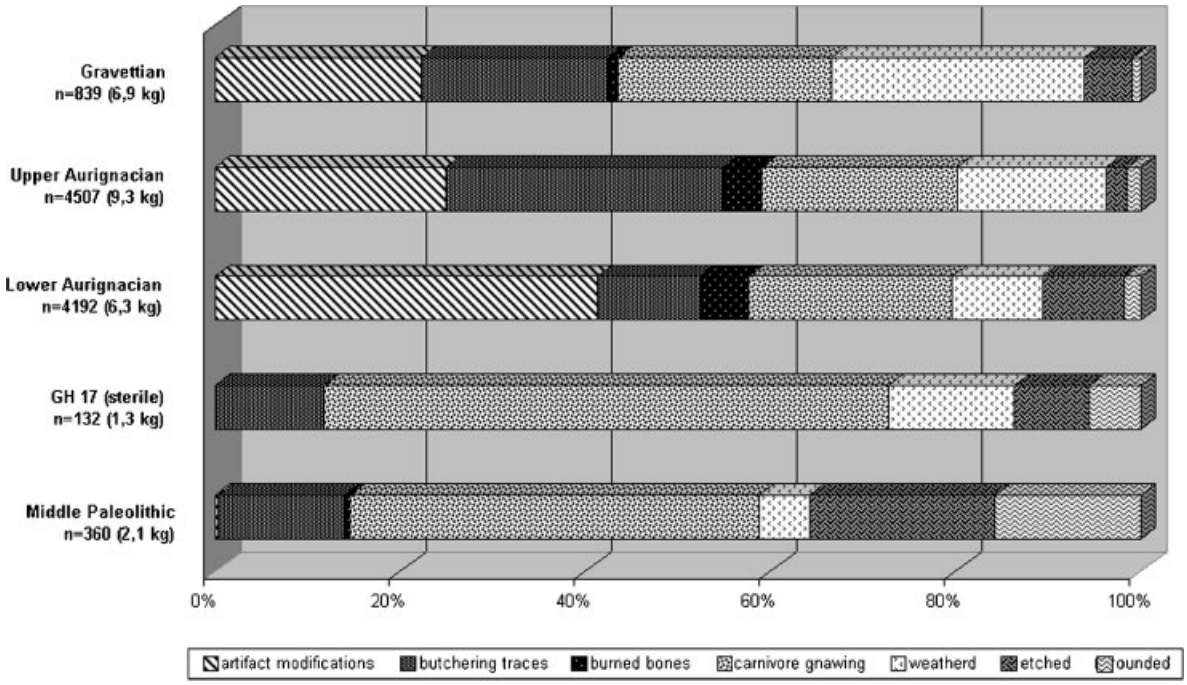

Figure 4. Geißenklösterle—modifications on bones and their proportion in bone weight.

and carnivores damaged the surfaces of over 27% of the bones (NISP). 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 an ibex bone and there are impact marks on chamois and roe deer remains. Still, there is a striking difference between the abundant human modifications in the Upper Palaeolithic and the scarcity of anthropogenic modifications in the Middle Palaeolithic layers.

Table 2. Geißenklösterle: NISP and bone weight (g) of three-dimensionally recorded burned bone pieces*

Archaeological layers	NISP	NISP (%)	weight (g)	weight (%)
Gravettian (2 fire places)	54	1.9	65.1	8.0
Upper Aurignacian (large ash lense)	2310	79.8	395.4	48.8
Lower Aurignacian (1 fire place)	518	17.9	335.0	41.3
GH 17 (sterile)	4	0.1	1.2	0.1
Middle Palaeolithic	10	0.3	13.7	1.7
Total	2896	100.0	810.4	100.0

*The data for the large quantities of burned bones from the screened samples are not yet available.

Another remarkable difference concerns the proportion of burned bones (Table 2).

Sirgenstein

Sirgenstein cave stands 35 m above the valley bottom. R.R. Schmidt excavated at Sirgenstein in the summer and autumn of 1906 (Schmidt, 1910, 1912). He distinguished eight archaeological layers and correlated them with the French chronological system: one Magdalenian, one 'Solutreen' (Gravettian), four Aurignacian and two Middle Palaeolithic layers (type 'La Quina' and 'Primitiv-Mousterien'). The lithic material from the Middle Palaeolithic was reanalysed by Çep (1996).

Between the Middle Palaeolithic layers VIII/VII and the Upper Palaeolithic layer VI, Schmidt mentioned a thin sterile layer with a concentration of small rodents (*untere Nagerschicht*). He suggested a possible hiatus in human occupation between the Middle and the Upper Palaeolithic, but argued that the typology of the stone tools shows a continuity.

Table 3. Middle Palaeolithic fauna of Sirgenstein VIII and VII

Analysis by Koken (see Schmidt, 1912)		Reanalysed by Münzel (2002)				
Species list	Quantitative remarks in the text of Koken	Species list	NISP		Bone weight (g)	
			n	n%	g	g%
Lepus variabilis		Brown/Arctic hare (*Lepus* sp.)	1	2.9	1.4	0.2
Canis lagopus		Arctic fox (*Alopex lagopus*) (*missing*)	—	—	—	—
Canis lupus		Wolf (*Canis lupus*) (*missing*)	—	—	—	—
Canis sp. (?)		(*Missing*)	—	—	—	—
Ursus spelaeus	Most common 90%	Cave bear (*Ursus spelaeus*)	17	48.6	220.5	26.8
Felis lynx (?)		Lynx (*Felis lynx*) (*missing*)	—	—	—	—
Elephas primigenius		Mammoth (*Mammuthus primigenius*)	2	5.7	4.4	0.5
Equus caballus	Second common	Wild horse (*Equus* sp.)	7	20.0	449.4	54.6
Rhinoceros tichorhinus	(Mentioned in the text)	Woolly rhino (*Coelodonta antiq.*) (*missing*)	—	—	—	—
Megaloceros giganteus (missing)		Giant deer (*Megaloceros giganteus*) (see 2 retouchers)	2	5.7	117.6	14.3
Rangifer tarandus	Common	Reindeer (*Rangifer tarandus*)	2	5.8	10.7	1.3
Bison priscus		Bison (*Bos* or *Bison*) (*missing*)	—	—	—	—
Ibex sp.		Ibex (*Capra ibex*)	1	2.9	11.8	1.4
		Hare to fox size	1	2.9	0.9	0.1
		Small deer size	1	2.9	0.9	0.1
		Bear to horse size	1	2.9	5.9	0.7
		Total	35	100.0	823.5	100.0

Faunal evidence

The faunal analysis was conducted by Koken, a palaeontologist at the University of Tübingen (Koken in Schmidt, 1912) (Table 3). Koken produced a species list, but no quantitative results, except remarks like 'common' or 'very common'. Schmidt mentioned 90% cave bear in the Middle Palaeolithic layers, but so far very few of these specimens have been found in the collections of the University of Tübingen. Horse is the second most important species, followed by reindeer and giant deer; the latter is represented by two bone retouchers (Figure 7). Mammoth is represented only by an unworked piece of tusk from a juvenile animal.

Schmidt argued that all the fauna was hunted by man, including the cave bears. Many of the large bones, including those of cave bear, he wrote, showed traces of impact fractures, and only a few gnawing marks from hyena were observed.

Trying to reanalyse and quantify the fauna for the Middle Palaeolithic layers at Sirgenstein, we recognized that despite the careful excavation, many of the faunal remains are missing (Table 3). For example, cave bear should have been 'very common' in all layers, but the available faunal inventory is very small, considering the size of the cave and assuming that cave bear hibernated in Sirgenstein. Thus the quantitative results for layers VII and VIII are not conclusive.

Human activities

The profile below the entrance shows a vertical sequence of ash lenses or hearths dating from the Middle Palaeolithic to the Middle Ages (Schmidt, 1912). During the whole sequence the entrance was the preferred place of occupation. Each of the two Middle Palaeolithic layers contained a hearth, with that of layer VIII being the larger. The stratigraphic position of the hearths indicates at least two different periods of Neanderthal occupation. Neanderthal activities, however, are not just reflected by stone tools and fireplaces, but also in the bones. Despite the small quantity of faunal remains, there are some clear cutmarks on horse bones including a first phalanx (Figure 5) and a proximal metacarpal (Figure 6). These two levels also yielded several retouchers or 'compresseurs' from long bone shafts of giant deer (Figure 7) and horse (Figure 8), as well as a retouched bone that resembles a side scraper. The use of shaft

Figure 5. Cut mark (arrow) on a horse phalange from Sirgenstein VII.

fragments as retouchers is well documented in both the Middle and Upper Palaeolithic of Swabia (Taute, 1965).

Seasonal evidence

In several layers (AH III, VI, VII) of Sirgenstein foetal horse bones were found, but they are not mentioned by either Schmidt or Koken. Middle Palaeolithic layer VII revealed one right femur, one right radius and two left humeri (Figure 9). All of the foetal horse remains reflect six to seven months of gestation (Prummel, 1987). Since wild horses mate in early summer (May/June) and the gestation period is 11 months (MacFadden, 1992), the foetal horse remains point to the use of the cave in the winter (December/January). Unfortunately this is the only evidence of seasonality for the Middle Palaeolithic sites, but foetal horse bones are consistently present during younger periods in the Ach Valley (Table 6).

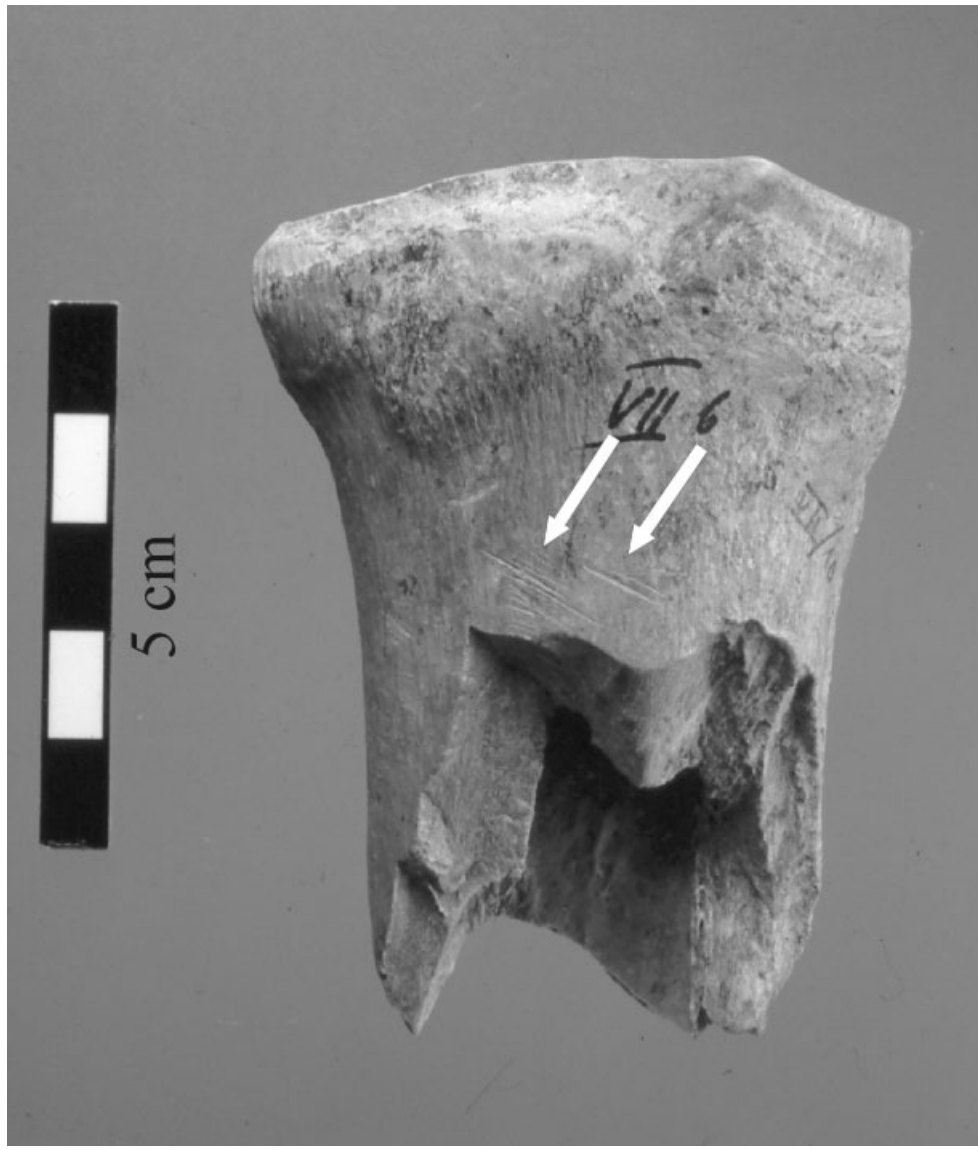

Figure 6. Cut marks (arrows) on horse metacarpal from Sirgenstein VII.

Große Grotte

Große Grotte lies 76 m above the valley floor. Excavations at Große Grotte were carried out by Gustav Riek in the 1960s, who distinguished 12 Middle Palaeolithic layers (II–XIII). The artefacts and fauna were published in a monograph by Eberhard Wagner (1983), but during an inventory in the Natural History Museum in Stuttgart new faunal material was found and all faunal remains were reanalysed by Jaco Weinstock (1999). Layer II, the richest in faunal and lithic materials, belongs to a late Mousterian with bifacial points. In this paper we concentrate on layer II, since the faunal assemblages of the other layers are too small.

Faunal evidence

Weinstock described the fauna of Große Grotte as a cave bear hibernation den with no evidence of

Figure 7. Retoucher on a giant deer tibia from Sirgenstein VII.

human modifications of the bones except a few impact fractures. Cave bear dominates in all layers of Große Grotte, while more typical prey animals are rare. As at Geißenklösterle and Sirgenstein, mammoth is represented by only one or two pieces, in this case a molar of a juvenile animal.

Compared with Geißenklösterle, the quantitative dominance of cave bear in Große Grotte is striking (Figure 10) and the percentage of potential human prey animals is small. Ibex is the most common species after cave bear, and together with the reindeer shows the highest percentage of carnivore gnawing marks (ca. 30%). Weinstock (1999) has argued that bones of ibex accumulated due to natural causes rather than as a result of human hunting. Considering the size of the cave, it appears that the faunal remains that were kept during the excavation were highly selected, and therefore we probably lack much information.

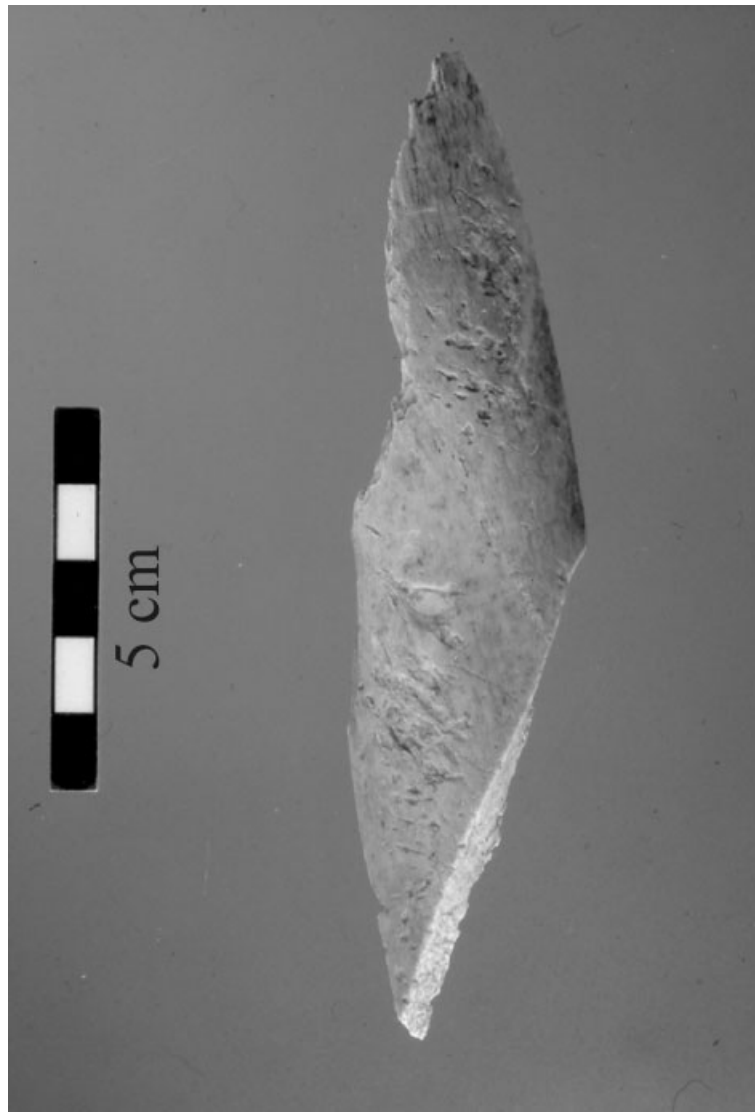

Figure 8. Retoucher on a horse humerus from Sirgenstein VII.

Human activities

Although Neanderthal activities are not reflected in obvious butchering marks, the late Mousterian layer II revealed a carefully worked antler point (Figure 11) from either reindeer or red deer antler. The point shows splintering at the tip, indicating that it was used. Furthermore Riek recovered a so-called 'hide smoother' or 'burnisher' manufactured from a mammoth rib (Wagner, 1983; Weinstock, 1999: 26). Other human activity is documented by burned bones from several layers (II, III, V, VII and VIII) (Weinstock, 1999), and in five of 16 excavation profiles ash lenses are recognizable (Wagner, 1983). In profile 11 three ash lenses, one on top of the other, indicate that layer II can be subdivided into at least three occupation phases.

Kogelstein

Kogelstein is a limestone outcrop near Schmiechen and stands on the valley bottom at the intersection of the Ach and Schmiech valleys

Figure 9. Foetal horse bones from Sirgenstein VII (from left to right: femur, radius and 2 × humerus).

(Figure 1). In former times it must have been a small cave, probably in the westernmost part of a small rock massive called 'Schelklinger Berg'. At the beginning of the 20th century large parts of the rock formation were blasted during road and railway building (Böttcher *et al.*, 2000). Some stone artefacts and faunal remains were collected during this time.

In 1987 and 1996 an area of 18 m^2 was excavated southwest of the Kogelstein by Joachim Kind of the Landesdenkmalamt to see if there were any intact archaeological layers preserved (Kind in Böttcher *et al.*, 2000).

Faunal evidence

Reinhard Ziegler (2000) of the Natural History Museum in Stuttgart analysed the fauna. Hyena remains form the main bulk of the fauna. The age composition is characterized by a high proportion of cubs, therefore Ziegler concluded that the site served as a hyena den. Many of the bones show heavy gnawing typical of hyena dens (Zapfe, 1942; Sutcliffe, 1970). The faunal composition in a hyena den differs significantly from a cave bear hibernation site. Figure 12 compares Kogelstein with Geißenklösterle and Große

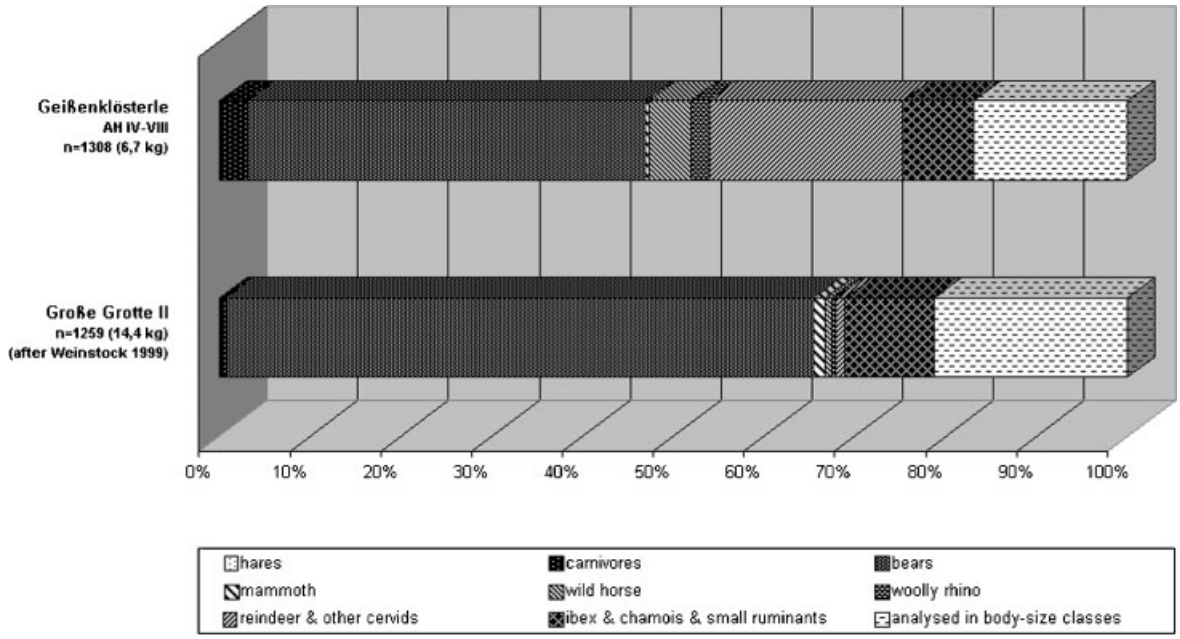

Figure 10. Bone weight of large mammal species in Geißenklösterle and Große Grotte.

Grotte by NISP, because bone weight is not available for Kogelstein. In comparison to the other cave sites in the Ach Valley cave, bear is rare at Kogelstein, but other carnivores including foxes are well represented along with large ungulates, like horse, cervids and bovids, and interestingly, marmot. The faunal composition shows more diversity than the composition in cave bear hibernation dens like Große Grotte or Geißenklösterle. Stiner (1994:212) showed that the diets of humans and hyenas are very much alike, while wolves leave a somewhat different prey composition. So the question is not whether humans or hyenas occupied the Kogelstein—they probably both did.

Human activities

Bones of several species show cut marks and document exploitation by Neanderthals. Cut marks are present on a calcaneus of red fox, plus carnivore bite marks; on a humerus shaft of horse, and on a femur of marmot (new excavation: Ziegler, 2000). Cut and impact marks, as well as striations are present along the tibia shaft of giant deer (old collection: Steppan in Böttcher *et al.*, 2000). Cut marks are also visible on a reindeer metacarpal at the edge of the distal articulation, and finally, cut marks are preserved on the shaft of a complete radius of cave bear.[2] Interestingly none of the many hyena bones show cut marks, but one of the very few bear bones preserves cut marks. For three of the major species, fox, horse and marmot (Figure 12), exploitation by human hunters can be demonstrated. The evidence shows that, in addition to hyenas, humans were partly responsible for the faunal input of these species. Neither a fireplace nor ash lenses were found during the recent excavation at Kogelstein, but burned bone indicated that a fire existed somewhere within the former cave.

Conclusions

Obviously, it is very difficult to track the activities of Neanderthals in the Ach Valley based on faunal remains. They left almost no bone artefacts, so it seems likely most weapons and other

[2]The old collection was restudied by S. Münzel in the Stadtmuseum Ehingen, August 2002.

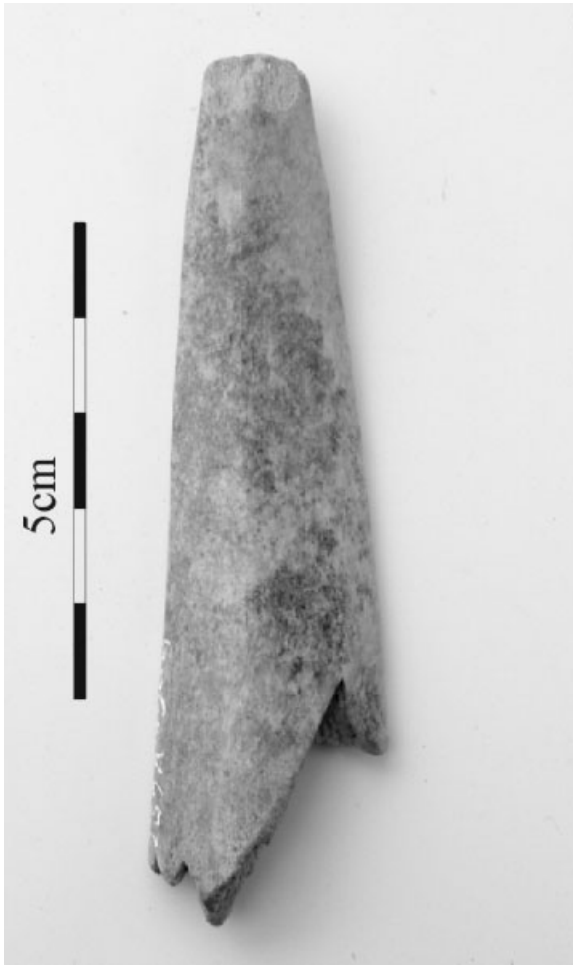

Figure 11. Antler point (anterior view) from Große Grotte II.

tools were made from wood or other perishable material. Some bone points have been recognized in the Middle Palaeolithic, as documented from the Ach Valley by the antler point from Große Grotte (Wagner, 1983), and in the Lone Valley by a bone point and a large pointed rib from the Vogelherd cave layer VI (Riek, 1934). Having almost no bone industry, Neanderthals produced little refuse from the manufacture of bone artefacts. This pattern stands in contrast to Upper Palaeolithic sites of the region.

The faunal analysis of the Upper Palaeolithic layers in the Geißenklösterle has shown that certain skeletal elements of the main prey species are abundant at the site because they were needed as raw material for tool production. For example, mammoth is one of the dominant species from which primarily ribs and ivory were brought onto 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 manufacturing of bone points was accompanied by a great amount of refuse (Münzel, 2001). There is also evidence for the presence of mammoth in the form tusks and ivory fragments during the Middle Palaeolithic in the Ach Valley, but they were not used as raw material. Since elements used as raw material are missing in Neanderthal assemblages, the faunal composition is more dominated by cave bear and less specialized in respect to raw material selection for bone tools, ornaments, or artwork.

The elements chosen for raw material in the Upper Palaeolithic probably needed careful cleaning before they could be used to manufacture tools. Therefore, butchering closer to the bone resulted in more cut marks, and cleaning of the bone produced striations. In conclusion, some differences in butchering techniques between Neanderthals and modern *Homo sapiens* probably existed as a result of the latter group's heavy use of organic technology based on bone, ivory and antler working. This may be one of the reasons why fewer cut marks are present in on faunal assemblages of Neanderthals. The number of cut marks cannot answer the question of whether Neanderthals hunted or scavenged. Butchering is possible without leaving any cut marks, and if Neanderthals scavenged, they certainly used knives to disarticulate animals and to cut off the meat. To view the relation of carnivore versus human activities, it is instructive to examine the quantitative and qualitative parameters of the faunal and lithic assemblages from the caves, as proposed by Villa & Soressi (2000). But the relationship between gnawing and cut marks or stone artefacts to bones is significantly dependent on excavation techniques and other parameters, so they are not ideal for quantifying the activities of Neanderthals in these cases. Table 4 shows the strong dependence of quantitative results on excavation conditions in the Ach Valley.

The discovery of throwing spears in Schöningen in association with 20 horses demonstrates that Lower Palaeolithic hominids were already competent hunters (Thieme, 1997). Studies by

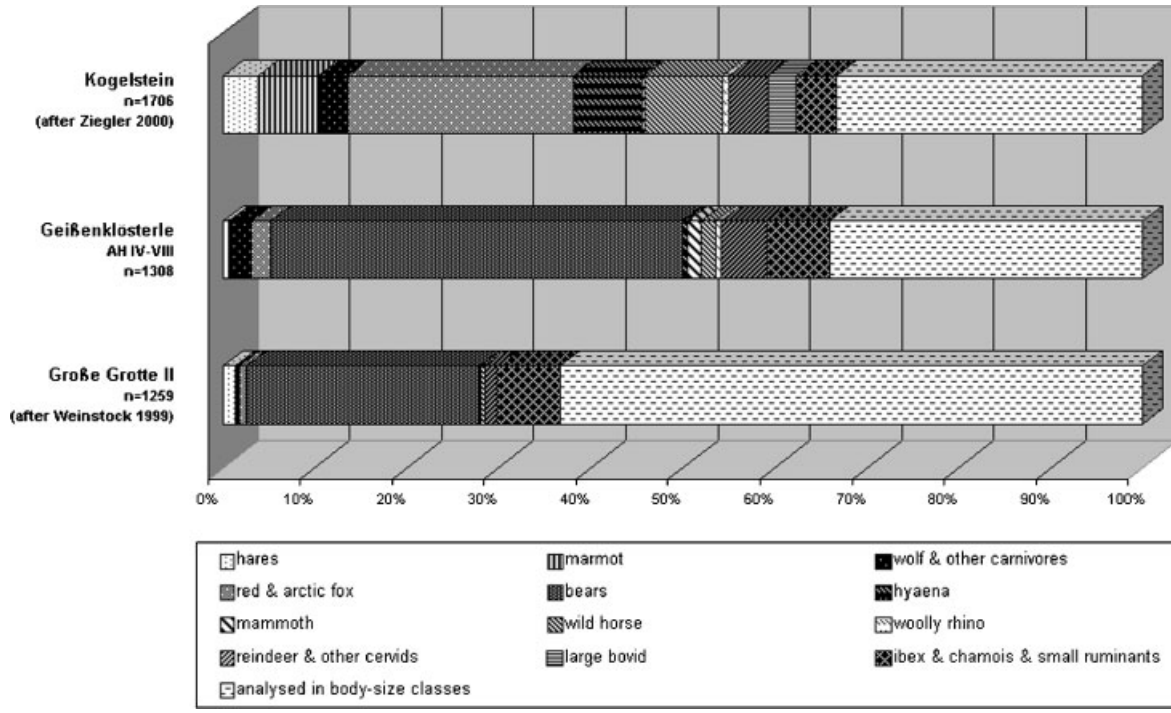

Figure 12. NISP of large mammal species in Kogelstein, Geißenklösterle and Große Grotte.

Conard (1992), Conard & Prindiville (2000), Gaudzinski (1995, 1996). Jöris (2001) and Gaudzinski & Roebrooks (2003) have provided good evidence for hunting during the Middle Palaeolithic in Germany. Neanderthals probably did not hunt less, but they brought less material to the caves of the Ach Valley than modern humans.

Another striking point is the high percentage of cave bear and small ruminants in Middle Palaeolithic assemblages. This is in part a taphonomic effect—if there is less human influence on the faunal input, then the percentages of bear and ibex increase; both were inhabitants of the karstic, mountainous environment. The abundance of cave bear is reduced in the Upper Palaeolithic levels because *H. sapiens* left more cultural refuse. Still the occupation density in most Middle Palaeolithic strata is lower than in many Upper Palaeolithic horizons. This suggests a somewhat lower occupation intensity and perhaps a lower population density. Here we must be cautious, because we have little data from open-air sites in the region (Çep & Waiblinger, 2001).

In the Ach Valley there is evidence for both change and continuity between Neanderthal and *H. sapiens* societies. There is continuity in one category of bone tool between the Middle and Upper Palaeolithic: large mammal long bones used as retouchers. Taute (1965) postulated a typological continuity between Mousterian and Aurignacian retouchers, but a typological break with the Gravettian retouchers. On the other hand, in another tool category, the points, there is a drastic change in technology, perhaps in connection with a shift from wooden to bone points.

Faunal data from the four Middle Palaeolithic cave sites in the Ach Valley are highly variable. While there is evidence for the exploitation of nine different species (Table 5), it is difficult to recognize a subsistence pattern for Neanderthals in this region. However, if we view these data in a larger context and compare them with data from the Upper Palaeolithic in the area, we recognize continuity. For example, it appears that the hunters visited the Ach Valley during winter. There are very few seasonal indicators during the Middle Palaeolithic in the Ach Valley, but those that exist are consistent with the Upper Palaeolithic pattern of winter occupation. Table 6 summarizes the seasonal indicators, including

Table 4. Quantitative parameters of the Middle Palaeolithic cave sites

	Sirgenstein VIII and VII	Große Grotte II	Kogelstein	Geißenklösterle IV-VIII
Year of excavation	R.R. Schmidt 1906	G. Riek 1960–64	J. Kind 1987, 1996	J. Hahn, N. Conard 1973–2002
Faunal analyst	Koken (1912)	Weinstock (1999)	Ziegler (2000)	Münzel (2003)
Size of excavated area	141 m^2	At least 80 m^2	8 m^2	14 m^2
Stone artefacts	n = 1980	n = 482	n = 449	n = 329*
Fauna, ident. to species	n = 32	n = 499	n = 1.114	n = 694
Fauna, ident. to size categories	n = 3	n = 760	n = 22.311 (incl. sieved materials)	n = 365
Carnivore gnawing	n = 2	n = 77	n = 38	n = 90
'Etched or digested' bones	None	(Gnawed and digested)	n = 24	n = 82
Bone tools	4 retouchers 1 'side scraper'	1 antler point 1 burnisher	None	None
Butchering	Cut and impact	None	Cut and impacts	Cut and impact
Fire	Large hearth	Large hearths, 3 layer	Burned bone pieces	Burned bone pieces

* Not including ca. 540 sample units from wet screening.

foetal horse bones, burnt bone ash lenses, and the remains of mammoth infants. The data show a seasonal pattern of winter and spring occupation during the Upper Palaeolithic. Often, layers with foetal horse bones also contain thick burnt bone ash lenses, which are consistent with winter occupations when the use of fire would be essential for heating and cooking. The foetal horse bones in layer VII of Sirgenstein suggest continuity in the exploitation of horses in winter.

During both the Middle and Upper Palaeolithic bone served as a fuel (Théry-Parisot, 2002; Schiegl *et al.*, 2003) in glacial environments lacking abundant supplies of wood. In both the Middle and Upper Palaeolithic, the caves of the Ach Valley contain burned bone ash lenses and

Table 5. Species list of Middle Palaeolithic cave sites in the Ach Valley

Cave site Archeological layers	Sirgenstein VIII and VII	Große Grotte II	Kogelstein 0, Io, Iu, II	Geißenklösterle AH IV–VIII
Brown/Arctic hare (*Lepus* sp.)	•	Arctic hare and *L.* sp.	Brown hare and *L.* sp.	•
Marmot (*Marmota marmota*)			••X	•
Wolf (*Canis lupus*)	•?	•	•	•X
Red/Arctic fox (*Vulpes* vel *Alopex*)	•?	Arctic and red fox	Arctic and red fox X	•
Cave bear (*Ursus spelaeus*)	••••	••••	•X	••••X
Lion (*Panthera leo spelaea*)		•		•
Wild cat (*Felis silvestris*)		•		
Lynx (*Felis lynx*)	•?			•
Indet. marten (*Martes* sp.)				•
Stoat (*Mustela erminea*)			•	
Weasel (*Mustela nivalis*)			•	
Badger (*Meles meles*)			•	
Hyena (*Crocuta spelaea*)			•••	•
Mammoth (*Mammuthus primigenius*)	•	•	•	•
Wild horse (*Equus* sp.)	••X	•	•••X	•X
Woolly rhino (*Coelodonta antiquitatis*)	•?	•	•	•
Giant deer (*Megaloceros giganteus*)	•X		•X	•
Red deer (*Cervus elaphus*)		•	•	•
Roe deer (*Capreolus capreolus*)				•X
Reindeer (*Rangifer tarandus*)	••	•	•X	•
Bovid (*Bos* vel *Bison*)	•		•	
Ibex (*Capra ibex*)	•	••	•	•X
Chamois (*Rupicapra rupicapra*)		•	•	•X

X = species with human modifications.

Table 6. Chronology in the Ach Valley and season of occupation

Techno-complex	C-14[a]	Chrono-stratigraphy	Cave sites	Layer	Winter	Burnt bone ash lenses	Man/bear interaction	Spring/early summer
Magdalénian	13,000	Dryas I	Geißenklösterle	Io				
			Hohle Fels	Ia-c	Foetal horse			
			Brillenhöhle	IV	Foetal horse	Small hearth		
	14,000		Sirgenstein	I		Large hearth		
			Hohle Fels	II a?				
Hiatus	Glacial Maximum							
Gravettian	27–29,000		Hohle Fels	II b			Cut marks	
			Brillenhöhle	V	Foetal horse	Small hearths		
			Brillenhöhle	VI	Foetal horse	Small hearths		
	>25 and >29,000		Brillenhöhle	VII	Foetal horse	Large hearth	Cut marks	Juvenile mammoth
	27–30,000		Geißenklösterle	I			Cut marks	Mammoth infants
	27,000	Denekamp	Sirgenstein	II				
	29,000		Hohle Fels	II c	Tooth eruption and oxygen isotops	Large hearth	Cut marks and projectile	Mammoth infants
Aurignacian	30,000		Sirgenstein	III	Foetal horse			
	28,000		Sirgenstein	IV				
	27,000		Sirgenstein	V				
			Brillenhöhle	XIV				
	30,000		Sirgenstein	VI	Foetal horse	Large hearth		
	31,000		Hohle Fels	III-V				
	33,000		Hohle Fels	IV				
	ca. 33–36,000		Geißenklösterle	II	Foetal horse and foal	Large hearth		Mammoth infants
			Brillenhöhle	XIV				
	ca. 35–40,000	Hengelo	Geißenklösterle	III		Small hearth	Cut marks	Mammoth infants
			Geißenklösterle	GH 17			Cut marks	
Middle Palaeolithic	43,000 (ESR)		Geißenklösterle	IV–VIII			Cut marks	Juvenile mammoth
	>45,000		Kogelstein				Cut mark	
			Sirgenstein	VIII/VII	Foetal horse	Large hearth		Juvenile mammoth
			Große Grotte	II		3 layers of charred bone		Juvenile mammoth

[a] For more details see Richter *et al.* (2000); Conard & Bolus (2003); for Kogelstein see Kind in Böttcher *et al.* (2000 : 49 f); for Brillenhöhle see Riek (1973).

were likely used most intensively during winter and spring. These cold season 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.

During both the Upper and Middle Palaeolithic the caves of the Ach Valley were repeatedly used by both bears and humans. A consistent pattern of a small percentage of human modified cave bear bones suggests that people had the upper hand when these species met. In Hohle Fels, another cave site in the Ach Valley, a flint projectile in a thoracic vertebra of a cave bear, dating to 28,000 BP, provides proof of cave bear hunting in the Gravettian during hibernation (Münzel *et al.*, 2001; 2002). Thus, the cut marks observed on cave bear bones from Kogelstein and from Middle Palaeolithic levels in Geißenklösterle fit into a general pattern of cave bear exploitation. In conclusion, there is continuity in the seasonal occupation of exploitation of the Ach Valley, but a break in the pattern of exploitation of raw materials between Neanderthals and modern *H. sapiens*.

References

Böttcher R, Çep B, Kind CJ, Mörike D, Pawlik A, Rähle W, Steppan K, Torke W, Ziegler R. 2000. Kogelstein—eine mittelpaläolithische Fundstelle bei Schelklingen-Schmiechen. *Fundberichte aus Baden-Württemberg* **24**: 7–176.

Çep B. 1996. Die Steinartefakte der Schichten VIII/VII und VI des Sirgensteins bei Weiler. In *Spuren der Jagd—die Jagd nach Spuren*, Campen I, Hahn J, Uerpmann M (eds). Tübinger Monographien zur Urgeschichte **11**: 207–216.

Çep B, Waiblinger J. 2001. The use of cave and open-air sites in southern Germany. In *Settlement Dynamics of the Middle Palaeolithic and Middle Stone Age*, Conard NJ (ed.). Kerns Verlag: Tübingen; 251–263.

Christensen M. 1999. Technologie de l'ivoire au Paléolithique supérieur. Caractérisation physiochimique du matériau et analyse fonctionelle des outils de transformation. *BAR International Series* 751: 1–201.

Conard NJ. 1992. Tönchesberg and its position in the prehistory of Northern Europe. *Monographien Römisch-Germanisches Zentralmuseum* **20**: Bonn.

Conard NJ, Bolus M. 2003. Dating the appearance of modern humans and timing of cultural innovations in europe: new results and challenges. *Journal of Human Evolution* **44**: 333–373.

Conard NJ, Malina M. 2003. Abschließende Ausgrabungen im Geißenklösterle bei Blaubeuren. *Archäologische Ausgrabungen in Baden-Württemberg* 2002, Theiss Verlag: Stuttgart; 17–21.

Conard NJ, Langguth K, Uerpmann HP. 2003. Einmalige Funde aus dem Aurignacien und erste Belege für ein Mittelpaläolithikum im Hohle Fels, Schelklingen, Alb-Donau-Kreis. *Archäologische Ausgrabungen in Baden-Württemberg* 2002, Theiss Verlag: Stuttgart; 21–27.

Conard NJ, Prindiville TJ. 2000. Middle Palaeolithic Hunting Economies in the Rhineland. *International Journal of Osteoarchaeology* **10**: 286–309.

Fraas O. 1872. Resultate der Ausgrabungen im Hohlefels bei Schelklingen. *Jahreshefte des Vereins für Vaterländische Naturkunde in Württemberg* **28**: 21–36.

Gaudzinski S. 1995. Wisentjäger in Wallertheim. Zur Taphonomie einer mittelpaläolithischen Freilandfundstelle in Rheinhessen. *Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz* **39**/1992: 245–423.

Gaudzinski S. 1996. On Bovid Assemblages and their consequences for the knowledge of subsistence patterns in the middle palaeolithic. *Proceedings of the Prehistoric Society* **62**: 19–39.

Gaudzinski S, Roebroeks W. 2003. Profile analysis at Salzgitter-Lebenstedt. A reply to Munson & Marean. *Journal of Human Evolution* **44**: 275–281.

Guthrie D. 1990. *Frozen Fauna of the Mammoth Steppe. The Story of Blue Babe.* University of Chicago Press: London & Chicago.

Hahn J. 1977. Nachgrabungen im Hohlen Felsen bei Schelklingen, Alb-Donau-Kreis. *Archäologisches Korrespondenzblatt* **7**: 241–248.

Hahn J. 1988. Die Geißenklösterle-Höhle im Achtal Bei Blaubeuren I. *Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg* 26. Landesdenkmalamt Baden-Württemberg. Theiss Verlag: Stuttgart.

Hahn J, Münzel SC. 1995. Knochenflöten des Aurignacien im Geißenklösterle. *Fundberichte aus Baden-Württemberg* **20**: 1–12.

Hahn J, Waiblinger J. 1997. Ein Gravettien-Fundhorizont im Hohle Fels bei Schelklingen, Alb-Donau-Kreis. *Archaologische Ausgrabungen in Baden-Württemberg* 1996: 27–29.

Jöris O. 2001. Der spätmittelpaläolithische Fundplatz Buhlen (Grabungen 1966–69). Stratigraphie Steinartefakte und Fauna des Oberen Fundplatzes.

Universitätsforschungen zur Prähistorischen Archäologie **73**: Habelt Verlag: Bonn.

MacFadden B. 1992. *Fossil Horses: Systematics, Paleobiology, and Evolution of the Family Equidae*. Cambridge University Press: Cambridge.

Münzel SC. 2001. The production of upper palaeolithic mammoth bone artefacts from Southwestern Germany. In *The World of Elephants. Proc. of the 1st International Congress*, Cavarretta G, Gioia P, Mussi M, Palombo MR (eds). Consiglio Nazionale delle Richerche: Rome; 448–454.

Münzel SC. 2002. Cave bear hunting on the Swabian Alb (Germany), 30.000 years ago. In *Cave-Bear-Researches, Höhlen-Bären-Forschungen*, Rosendahl W, Morgan M, López Correa M (eds). *Abhandlungen zur Karst- und Höhlenkunde* **34**: 36–39.

Münzel SC, Langguth K, Conard NJ, Uerpmann HP. 2001. Höhlenbärenjagd auf der schwäbischen alb vor 30.000 jahren. *Archäologisches Korrespondenzblatt* **31**/3: 317–328.

Münzel SC, Seeberger F, Hein W. 2002. The Geissenklösterle-Flute—Discovery, Experiments, Reconstruction. Hickmann E, Kilmer AD, Eichmann R (eds). Studien zur Musikarchäologie III; Archäologie früher Klangerzeugung und Tonordnung; Musikarchäologie in der Ägäis und Anatolien. *Orient-Archäologie* Bd. 10. Verlag Marie Leidorf GmbH: Rahden/Westfalen; 107–118.

Prummel W. 1987. Atlas for identification of foetal skeletal elements of Cattle, Horse, Sheep and Pig. Part 2. *ArchaeoZoologica* **I/2**: 11–41.

Richter D, Waiblinger J, Rink WJ, Wagner GA. 2000. Thermoluminescence, electron spin resonance and ^{14}C-dating of the Late Middle and Early Upper Palaeolithic Site Geißenklösterle Cave in Southern Germany. *Journal of Archaeological Science* **27**: 71–89.

Riek G. 1934. *Die Eiszeitjägerstation am Vogelherd*. Akademische Verlagsbuchhandlung Fanz F. Heine, Tübingen.

Riek G. 1973. Das Paläolithikum der Brillenhöhle bei Blaubeuren (Schwäbische Alb). *Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg* **4/I**: Theiss Verlag: Tübingen.

Schiegl S, Goldberg P, Pfretzschner HU, Conard NJ. 2003. Palaeolithic Burnt Bone Horizons from the Swabian Jura: Distinguishing between *In Situ* Fireplaces and Dumping Areas. *Geoarchaeology* **18**: 541–565.

Schmidt RR. 1910. *Der Sirgenstein und die Diluvialen Kulturstätten Württembergs*. Schweizerbart'sche Verlagsbuchhandlung: Stuttgart.

Schmidt RR. 1912. *Die diluviale Vorzeit Deutschlands*. Schweizerbart'sche Verlagsbuchhandlung: Stuttgart.

Stiner M. 1994. *Honor Among Thieves: A Zooarchaeological Study of Neanderthal Ecology*. University Press: Princeton, NJ.

Sutcliffe A. 1970. Spotted hyena: crusher, gnawer, digester and collector of bones. *Nature* **227**(5263): 1110–1113.

Taute W. 1965. Retouscheure aus Knochen, Zahnbein und Stein vom Mittelpaläolithikum bis zum Neolithikum. *Fundberichte aus Schwaben* N.F. **17**: 76–102.

Théry-Parisot I. 2002. Fuel Management (Bone and Wood) During the Lower Aurignacian in the Pataud Rock Shelter (Lower Palaeolithic, Les Eyzies de Tayac, Dordogne, France). Contribution of Experimentation. *Journal of Archaeological Science* **29**: 1415–1421.

Thieme H. 1997. Lower palaeolithic hunting spears from Germany. *Nature* **385**: 807–810.

Uerpmann HP. 1973. Ein beitrag zur methodik der wirtschaftshistorischen Auswertung von Tierfunden aus Siedlungen. In *Domestikationsforschung und Geschichte der Haustiere*. Matolcsi J (ed.). Akademiai Kiado: Budapest; 391–395.

Villa P, Soressi M. 2000. Stone tools in carnivore sites: the case of Bois Roche. *Journal of Anthropological Research* **56**: 187–215.

Wagner E. 1983. Das Mittelpaläolithikum der Großen Grotte bei Blaubeuren (Alb-Donau Kreis). *Forschungen und Berichte zur Vor- und Frühgeschichte Baden-Württembergs* **16**: Theiss Verlag: Stuttgart.

Weinstock J. 1999. The Upper Pleisticene mammalian fauna from the Große Grotte near Blaubeuren (southwestern Germany). *Stuttgarter Beiträge zur Naturkunde* Serie B, Nr. **277**: 1–49.

Zapfe H. 1942. Lebensspuren der eiszeitlichen Höhlenhyäne: Die Urgeschichtliche Bedeutung der Lebensspuren kochenfressender Raubtiere. *Palaeobiologica* **7**: 111–146.

Ziegler R. 2000. Die Großsäugerfauna. In Böttcher R, Çep B, Kind CJ, Mörike D, Pawlik A, Rähle W, Steppan K, Torke W, Ziegler R. Kogelstein—eine mittelpaläolithische Fundstelle bei Schelklingen-Schmiechen. *Fundberichte aus Baden-Württemberg* **24**: 64–75.

