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MIDDLE AND UPPER PALAEOLITHIC BONE RETOUCHERS FROM THE SWABIAN JURA: RAW MATERIALS, CURATION AND USE

Abstract

The present paper examines Middle and Upper Palaeolithic retouchers recovered from various sites of the Swabian Jura located in the Ach, Lone and Lauchert river valleys of southwestern Germany. We provide an updated account of the available evidence including some of the finds retrieved over the last 50 years. Our study builds on the work of Wolfgang Taute, who in the 1960s compiled an extensive review on the retouchers of Central Europe from the Middle Palaeolithic to the Neolithic. Bone retouchers are the only organic tool that "survived" the transition from Neanderthals to modern humans in a nearly unchanged form. No other organic tool has had such a long tradition. The analysis of bone retouchers from Hohle Fels, Geißenklösterle, Sirgenstein, Vogelherd, and Schafstall I enables us to shed new light on raw material choices and on tool use across the Middle and Upper Palaeolithic.

Keywords

Organic retouchers; Middle and Upper Palaeolithic; Swabian Jura

Introduction

The Swabian Jura of southwestern Germany has a long tradition of archaeological research that extends back to the second half of the 19th century (Fraas, 1862, 1886). Many of the caves and rock shelters in Jurassic limestone that form the karstic landscape of the Swabian Jura contain evidence for human occupation during the Middle and Upper Palaeolithic. Among these, several sites located in two tributary valleys of the Danube, the Ach and Lone, have been the subjects of systematic and continuous studies over the past century (e.g., Schmidt, 1912; Riek, 1934, 1973; Hahn et al., 1973; Hahn, 1988, Conard and Bolus, 2003, 2008; Conard et al., 2015). Additionally, a number of less intensively investigated sites exist in the neighbouring river valleys, including Lauchert Valley, where archaeological work was carried out at the beginning of the last century (Peters, 1936).

Years of research and investigation have produced an extensive literature on the lithic and organic technology represented at the Swabian cave sites, including remarkable examples of portable art and ornamentation ascribed to the Aurignacian (Riek, 1932, 1954; Conard, 2003, 2009; Conard et al.,

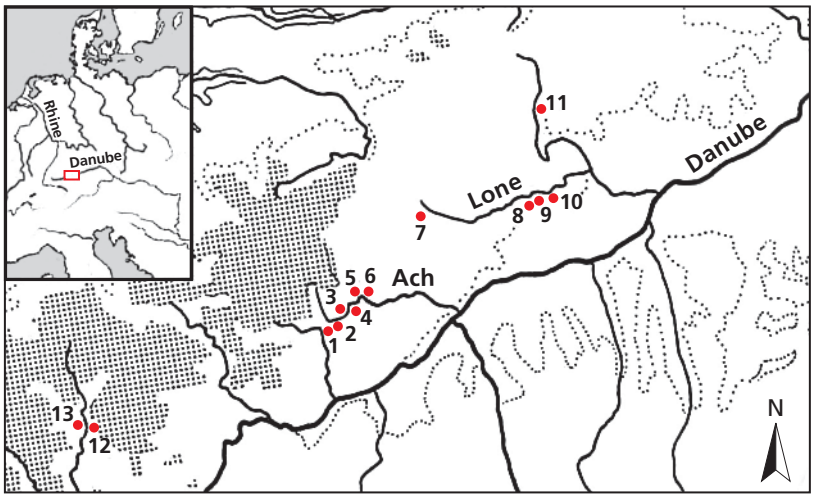

Figure 1 Map showing the main Middle and Upper Palaeolithic sites in the Swabian Jura. (1) Kogelstein, (2) Hohle Fels, (3) Sirgenstein, (4) Geißenklösterle, (5) Brillenhöhle, (6) Große Grotte, (7) Haldenstein, (8) Bockstein, (9) Hohlenstein, (10) Vogelherd, (11) Heidenschmiede, (12) Schafstall, (13) Göpfelsteinhöhle.

2004, 2009; Wolf, 2015). However, bone retouchers have often been dealt with only summarily. The first mention of retouchers in the archaeological record of the Swabian Jura was documented by Robert Rudolf Schmidt (1912), who referred to them as "compresseur". Later, Gustav Riek (1934) adopted the term "anvil" to describe three mammoth ivory fragments from Vogelherd that displayed a combination of percussion, hack and scratch marks. Around the same period, Eduard Peters (1936) published the discovery of various "auxiliary bone tools" from the Mousterian layers of Schafstall and Göpfelsteinhöhle. According to his interpretation, these tools were probably utilized for retouching stone artefacts. However, it was only with the work of Wolfgang Taute (1965) that the Swabian finds were grouped together into a specific tool class based on their functional use. In his study, Taute attempted to define a typological classification system for retouchers and summarized all the evidence available from European sites. Retouchers were subsequently recognized in a great number of assemblages, for example Vogelherd (Niven, 2006), Geißenklösterle (Hahn, 1988), Sirgenstein (Münzel and Conard, 2004) and Brillenhöhle (Riek, 1973; Barth, 2007); but, given their expedient nature, these tools were never studied in great detail. Hence, a growing need for a more comprehensive and exhaustive study has arisen. The present paper addresses this need through a detailed analysis of the retouchers recovered from the Swabian sites, with the objective of exploring inter- and intrasite variability, as well as diachronic shifts in technology.

Sites and archaeological context

The retouchers considered in this study come from five different sites distributed across several valleys: Hohle Fels, Geißenklösterle and Sirgenstein in the Ach Valley; Vogelherd in the Lone Valley; and Schafstall in the Lauchert Valley (**Figure 1**).

Sirgenstein was excavated in the early 20th century by Robert Rudolf Schmidt (1910, 1912), who uncovered a sequence of eight archeological layers ranging from the Mousterian to the Magdalenian. Four retouchers made of horse *(Equus* sp.*)* and giant deer *(Megaloceros giganteus)* bones (Münzel and Conard, 2004) were recovered from the bottom layer of the sequence (layer VII), which Schmidt assigned to the "Mousterian of La Quina type" or "Late Mousterian". Ernst Koken (1912) studied the faunal material from the lower layers. After re-examination by Münzel and Conard (2004), some of the species identified previously were not found; the updated faunal list now includes mammoth *(Mammuthus primigenius)*, horse *(Equus* sp.*)*, giant deer *(Megaloceros giganteus)*, reindeer *(Rangifer tarandus)*, aurochs or bison (*Bos* or *Bison)*, ibex *(Capra ibex)*, cave bear *(Ursus spelaeus)* and hare *(Lepus* sp.*)*. The cave

bear was described by Koken as representing the predominant species in the lower horizons, suggesting that the cave was alternately occupied by humans and cave bears throughout the Middle Palaeolithic, though only 17 specimens were collected during the excavation. Koken also observed that most of the remains displayed fracture marks related to human activities. The lithic assemblage associated with the retouchers consists mostly of Levallois artefacts in local Jurassic chert (Çep, 1996). Münzel and Conard (2004) also restudied the retouchers (**Table 1**).

The site of Hohle Fels has been under investigation since the end of the 19th century (Fraas, 1872), yielding one of the most complete archaeological sequences of the Swabian Jura. Excavations started by Joachim Hahn (1977) exposed a succession of nine archaeological horizons spanning the Middle to Upper Palaeolithic. The retouchers analysed in this study were unearthed during the more recent campaigns directed by Nicholas J. Conard between 2001 and 2009 (Conard et al., 2001; Conard and Malina, 2006a, 2008, 2009, 2010) and come from the basal layers of the Aurignacian (Archaeological Horizons III to V), which are separated from the Middle Palaeolithic deposits by a sterile layer. The lithic assemblage of these layers is characterized mostly by pointed blades and nosed and laterally retouched end scrapers on local Jurassic chert (Conard and Bolus, 2006).

Geißenklösterle, located east of Hohle Fels, is another site that yielded important evidence attributed to the Mousterian, Aurignacian, Gravettian and Magdalenian. After the initial excavation directed by Eberhard Wagner in 1973, further fieldwork was carried out by Hahn (1988) between 1974 and 1992 and by Conard in 2001 and 2002 (Conard and Malina, 2002, 2003). The majority of retouchers discovered at this site come from the Aurignacian layers (Hahn, 1988), where bone and antler retouchers were found together with split based antler points. In contrast, few retouchers were recovered from the Gravettian layers (Barth, 2007).

Vogelherd is one of the most important sites of the Lone Valley, with an incredibly high density of finds from the Aurignacian period and a smaller number of Middle Palaeolithic and Magdalenian finds. It was excavated in 1931 by Gustav Riek (1934) with techniques common for that time; thus, the sediments were excavated with shovels and not screened. The excavators did not collect all finds, systematically discarding bone fragments less than 3 cm in length. Between 2005 and 2012, the University of Tübingen, under the direction of Conard, excavated the old backdirt sediments, retrieving a large number of finds, including some zoomorphic ivory figurines (Conard and Malina 2006b; Conard et al., 2007, 2010). Ulf Boger carried out the faunal analysis of the remains from the recent excavation and also noted the presence of retouchers within the assemblage (Boger et al., 2014). These, however, are not taken into account in the present study due to the absence of a secure archaeological context. The faunal material from the old excavations, studied by Lehmann (1954) was re-analyzed by Laura Niven (2006), who recorded the presence of a great number of retouchers from the Aurignacian horizons, layers IV and V. Horse and reindeer are the most abundant species within these levels and seem to have been hunted intensively by the Aurignacian groups. Humans played a major role in the accumulation of the assemblage in contrast to carnivores, which appear to have had a limited impact on the assemblage (Niven, 2006).

The site of Schafstall in the Lauchert Valley was excavated by Eduard Peters (1936) during the first half of the 19th century. The area of the excavation corresponding to Schafstall I yielded several Mousterian artefacts as well as the retouchers presented in this study, and was attributed by Peters to the Middle Palaeolithic. Little information is available for these sites, as Peters was unable to fully publish his work before the outbreak of World War II, when most of the finds and documentation went missing.

In addition, a few other sites yielded lower numbers of retouchers and are worth mentioning (**Table 1**). Brillenhöhle, in the Ach Valley, yielded one bone retoucher assigned to the Gravettian (Barth, 2007), and small collections of Middle Palaeolithic retouchers were found at Hohlenstein-Stadel in the Lone Valley and at Heidenschmiede in the Brenz Valley. Hohlenstein-Stadel yielded three bone retouchers

Table 1 Summary of organic retouchers found at different sites of the Swabian Jura during current and previous analyses. n.s. = not studied.

Site	Current analysis	Previous analyses	Reference
Sirgenstein	4	4	Schmidt, 1912; Münzel and Conard, 2004
Hohle Fels	8	4	Conard and Malina, 2008, 2010, 2015; Münzel, 2013
Geißenklösterle	24	10	Hahn, 1988
Vogelherd	36	161	Riek, 1934; Taute, 1965; Conard and Malina, 2006b; Niven, 2006; Conard et al., 2015
Schafstall	12	19	Peters, 1936
Brillenhöhle	n.s.	1	Barth, 2007
Heidenschmiede	n.s.	7	Peters, 1931; Münzel and Çep, 2017
Hohlenstein-Stadel	n.s.	3	Wetzel, 1961, 1969; Kitagawa, 2014

Table 2 Number and percentage of retouchers from each site with several types of anthropogenic modifications. Percentages are expressed out of the total number of retouchers per site.

Site	Percussion		Cut marks		Retouched edges		Scraping	
Schafstall I	2	16.7%	0	0%	3	25.0%	4	33.3%
Geißenklösterle	5	20.8%	4	16.7%	1	4.2%	13	54.2%
Vogelherd	6	16.7%	4	11.1%	2	5.6%	5	13.9%
Hohle Fels	1	12.5%	1	12.5%	0	0%	3	37.5%
Sirgenstein	1	25.0%	1	25.0%	1	25.0%	2	50.0%

obtained on large-sized mammal limb fragments (Wetzel, 1961, 1969; Kitagawa, 2014). At Heidenschmiede, seven bone retouchers made on elements of reindeer, aurochs or bison, an unidentified large mammal and a small ruminant were recovered; two were published by Peters (1931) and five were recently identified during the current revision of the faunal remains (Münzel and Çep, 2017).

Materials and methods

We analyzed 84 retouchers for this study: four from Sirgenstein, eight from Hohle Fels, 12 from Schafstall I, 24 from Geißenklösterle and 36 from Vogelherd. Some of the retouchers found at Schafstall are probably missing, as Peters (1936) originally identified 19. Since the faunal material of this site is currently under study, it cannot be excluded that more retouchers will be identified in the future. The number of retouchers from Vogelherd presented here constitutes only a minimal part of the large amount recorded by Niven (2006), which contains a total of 161 retouchers. The decision to include a smaller sample was dictated by the fact that most of the retouchers were recorded as questionably belonging to the Aurignacian layers IV and V defined by Riek (1934).

In our analysis of the retouchers, length and breadth of the bones were recorded in millimetres using digital calipers. We then noted the number of use areas with concentrations of retouch marks. The orientation of the marks and their localization followed Mallye et al. (2012). The retouchers were oriented with respect to their longest axis and the orientation of the marks was determined accordingly.

We examined the retouch marks with the aid of a 12x magnifying lens and a 10-20x stereo microscope. The terminology used for their description

follows Mozota (2013, 2015, modified from Vincent, 1993): linear impressions, trihedral impressions and widespread chipping or scales. Linear impressions (*sensu* Mozota, 2013) are elongated and more or less straight marks, with V-shaped profiles, that are mostly found superimposed on one another. Impact marks in the form of pits were designated as trihedral impressions. Scales (*sensu* Mallye et al., 2012) are negative impressions left by the detachment of small plaques from the cortical surface of a bone fragment. We also paid attention to the orientation of marks, which could be transverse, parallel or oblique to the long axis of the bone. In the case of oblique marks, we made a distinction between diagonal marks inclined upwards to the right and upwards to the left, a feature which has also been observed in previous studies (Hahn, 1988; Malerba and Giacobini, 2002). The use areas were measured by taking the maximum length and breadth (in mm) only on retouchers that preserved a complete use area, that is, the use area was not broken or bisected.

Table 3 Number of bone retouchers and their respective taxon distributed by Archaeological Horizon (AH) for each site.

Site	MP	Aurig.	Grav.	Magd.
Geißenklösterle	AH IV-VIII	AH II-III	AH I	AH Io
Equus ferus		14	1	
Rangifer tarandus		3		
Capra ibex		1		
small ruminant		1		
Mammoth/*Coelodonta* size		3	1	
Hohle Fels	AH VI-IX	AH III-V	AH II b-e	AH I-II a
Ursus spelaeus		1		
Panthera leo spelaea		2		
Equus ferus		3		
Rangifer tarandus		1		
large carnivore		1		
Sirgenstein	AH VI-VII	AH III-V	AH II	AH I
Equus ferus	2			
Megaloceros giganteus	2			
Vogelherd	AH VI-VIII	AH IV-V		AH II-III
Ursus spelaeus		3		
Panthera leo spelaea		2		
Crocuta crocuta		1		
Mammuthus primigenius		3		
Equus ferus	2	11		
Rangifer tarandus		8		
Ibex/reindeer/red deer size		2		
Horse/bear size	2	2		
Schafstall I				
Bos/bison/giant deer size	10			
Horse/bear size	1			
unidentified	1			

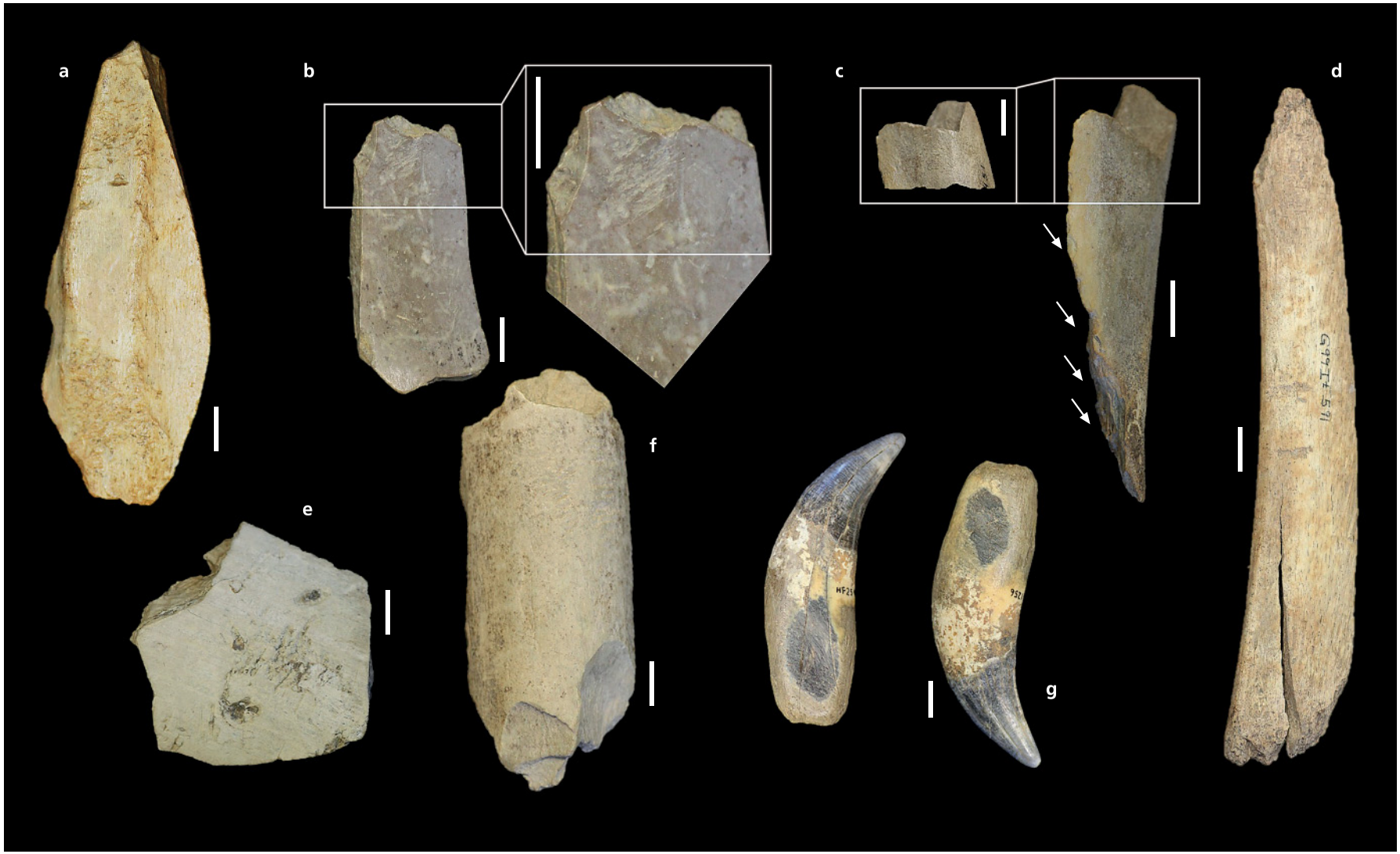

Figure 2 Organic retouchers from the Swabian Jura: a) giant deer tibia, Sirgenstein, Layer VII, Middle Palaeolithic; b) large ungulate long bone, Schafstall I, Middle Palaeolithic; c) horse tibia, Geißenklösterle, Layer IIb, Aurignacian; d) megaherbivore rib, Geißenklösterle, Layer It, Gravettian; e) mammoth ivory, Vogelherd, Layer V, Aurignacian; f) horse long bone, Layer VII, Vogelherd, Middle Palaeolithic; g) lion canine, Hohle Fels, Layer Vaa, Aurignacian. Scale = 1 cm.

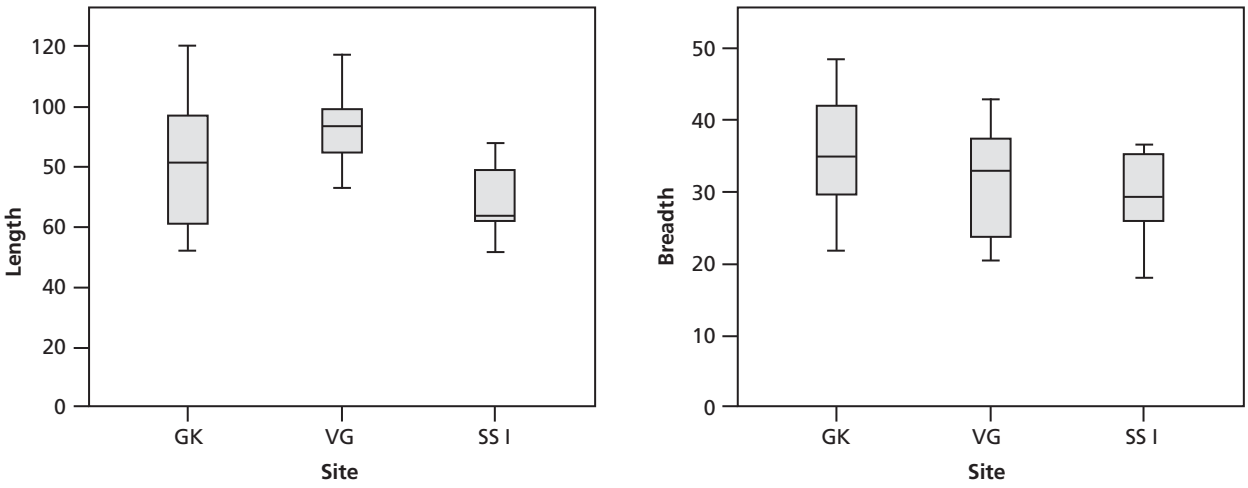

Figure 3 Length and breadth of retouchers made on long bone shafts. Samples from Hohle Fels and Sirgenstein are excluded from the count. Only elements with complete retouched areas are considered. Geißenklösterle = GK (n = 10), Schafstall I = SS I (n = 8) and Vogelherd = VG (n = 13). Measurements in mm.

Results

All the sites presented relatively good bone preservation, although some of the material from old excavations was affected by curation damage. Taphonomic observations on the retouchers show little evidence for bone weathering and no carnivore damage. The only modifications are related to anthropogenic activities. Cut and percussion marks (**Table 2**) typically associated with food consumption activities were distinguished from other types of marks, such as those produced by scraping, which are more likely linked to bone tool preparation.

Choice of raw material

Middle Palaeolithic bone retouchers are represented by a limited number of species. Horse and giant deer bone shafts were utilized at Sirgenstein. Four retouchers on horse/bear size long bones were found at Vogelherd, two of which have been identified as horse bone fragments (**Figure 2f**). At Schafstall I, almost all the retouchers on long bones belong either to a large bovid or to giant deer, even though horse bones dominate the faunal assemblage (**Table 3**; **Figure 2a, b**).

Aurignacian human groups appear to have utilized a broad array of animal resources and bone elements (see **Table 3**). Retouchers on horse long bones are dominant at Geißenklösterle, Hohle Fels and Vogelherd; furthermore, reindeer is the second most abundant species used for this purpose at Vogelherd. Mostly long bones, but also ribs, ivory, antler and carnivore teeth, were employed in knapping. At Geißenklösterle several bone remains of megafauna preserve retouch marks on their surfaces, while ivory retouchers are quite common at Vogelherd (**Figure 2e**). Though retouchers on carnivore remains are known from several Middle Palaeolithic (and earlier) localities across Europe (Auguste, 2002; Jéquier et al, 2012; Abrams et al., 2014; Serangeli et al. 2015), in the Swabian region they occur only in Aurignacian assemblages and are represented exclusively by canine teeth of cave bears, lions and spotted hyenas (**Figure 2g**). The Aurignacian retouchers are therefore characterized by a great variety of bone elements with preferential choice of long bone shafts.

As concerns retouchers on limb bone fragments, the length of the retouchers presents greater variation than the breadth (**Figure 3**). This is to be expected if there was no particular size preference, as complete limb bones are always significantly longer than they are wide. The retouchers of Geißenklösterle show the greatest spread of values in terms of length, while the long bone retouchers of Schafstall I are the shortest. Small and unequal sample sizes

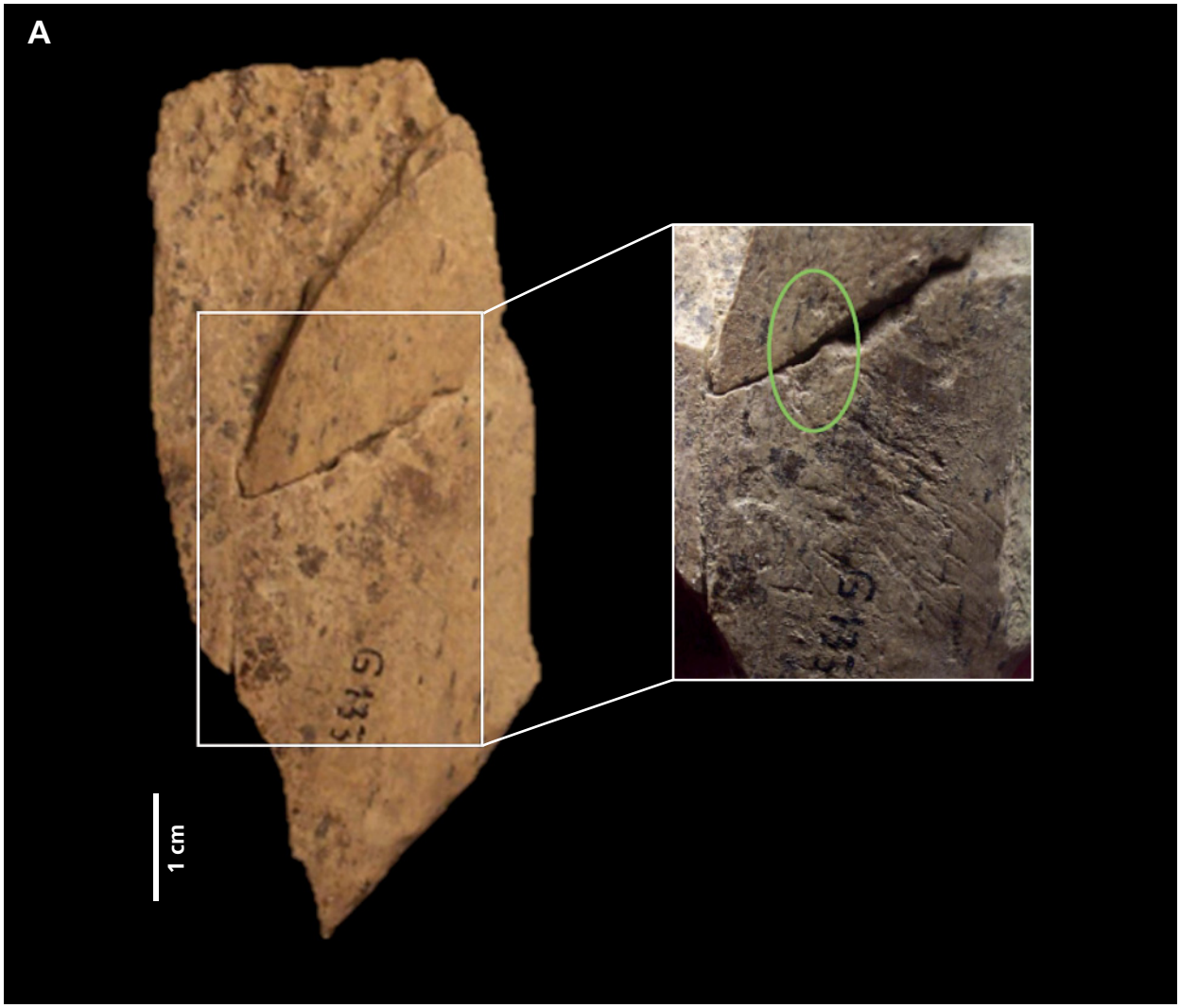

Figure 4 A) Geißenklösterle. Retoucher on a bone fragment that was subsequently splintered (Aurignacian); B) Vogelherd (next page). Retouch on worked antler base with perforation and mammoth relief (Aurignacian). Drawing by Achim Frey.

hindered statistical testing for size standardization across sites. Furthermore, it was not possible to compare retoucher size with general bone fragmentation for each site.

Especially concerning the Aurignacian retouchers, random selection of raw material seems to be supported by the variety of elements used, some of which are also expedient tools, such as bone blanks with splintered ends, similar to those described by Tartar (2012), and with retouched edges (**Figure 2c**). One specimen from Geißenklösterle with splintered ends bears retouch marks that were produced before the action that caused the splintering was performed (**Figure 4a**). These modifications were caused by two consecutive gestures that could have been part of the same *chaîne opératoire*. In this way, the bone blank was firstly used as a retoucher and secondly as a punch. Similar behaviour is also attested at Schafstall I, Sirgenstein and Vogelherd (**Figure 2f**) for the Middle Palaeolithic, where retouchers with modified edges, purportedly related to tool shaping or reduction of the bone blank, occur alongside unmodified bone fragments. Furthermore, in the Aurignacian assemblages, retouch marks also appear on very elaborate pieces. An extraordinary example (**Figure 4b**) is represented by a worked antler base from Vogelherd with the figure of a mammoth carved in half relief (Riek, 1934;

Hahn, 1986). This object also preserves a broken perforation, meaning that it served as a tool and was possibly worn as a pendant. Evidence like this suggests elaborate objects were used as retouchers in parallel with the exploitation of fragments discarded during food consumption.

Use areas and use marks

The number of areas affected by retouch marks varies from one to three (**Figure 5**). The majority of retouchers analyzed display only one use area. At Schafstall I this may be explained by the smaller size of the bone blanks, which corresponds to a smaller working area. Most of the retouchers from Hohle Fels and Sirgenstein exhibit two or three use areas. For Hohle Fels, this pattern can be partially explained by the small sample size and by the prevalence of carnivore canines exploited alternately on the buccal and lingual sides. At Vogelherd, the number of elements with one and two use areas does not differ much, and retouchers with three use areas are rare.

Retouch marks are very distinctive and could be recognized by the presence of linear and trihedral impressions, sometimes coupled with microstriations produced by the edge of the lithic tool impacting the bone surface. On a minority of specimens, these marks were less immediately observable and

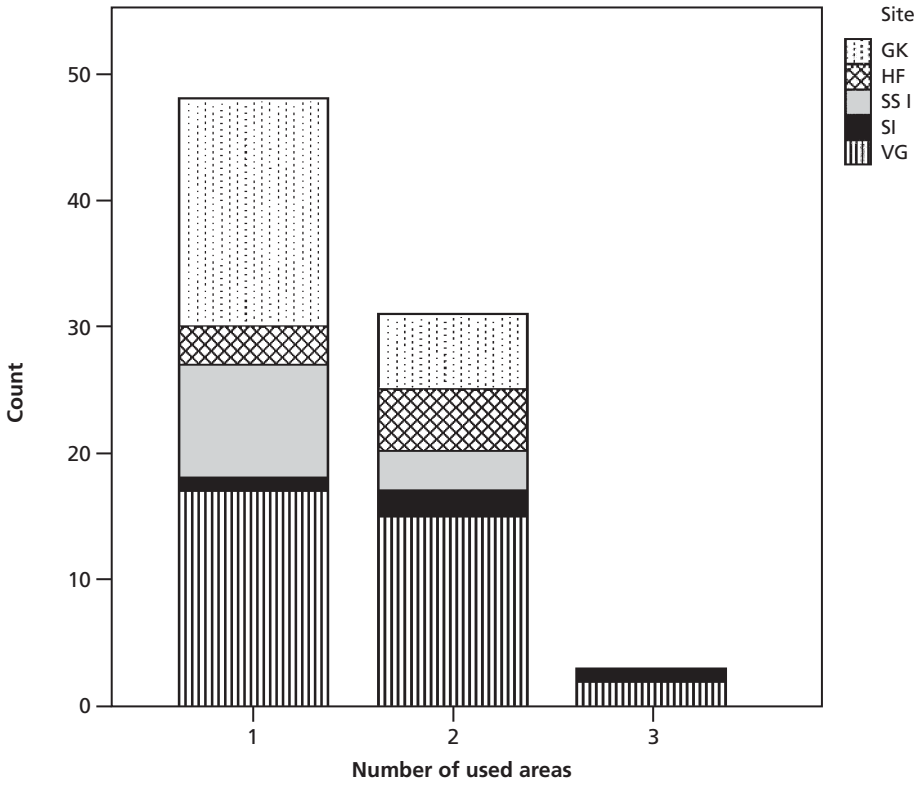

Figure 5 Number of use areas on each retoucher subdivided by site.

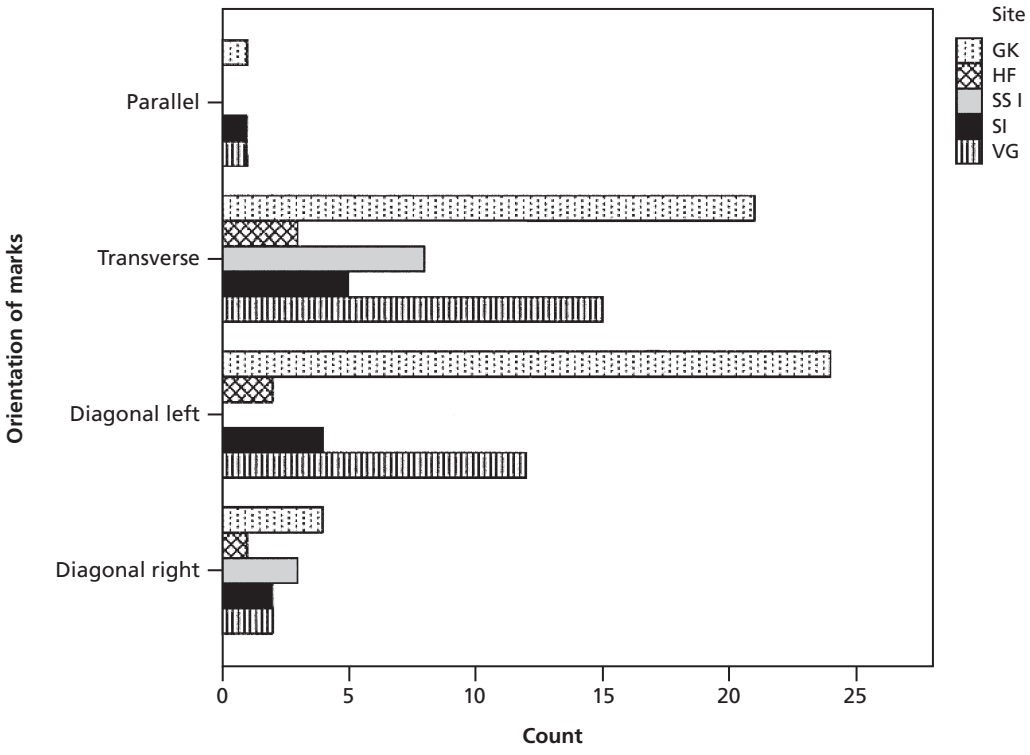

Figure 6 Frequency distribution of the orientation of retouch marks. All retouchers were considered.

were associated with scales. Experimental work carried out by Mallye et al. (2012) has shown that the occurrence of scaled areas while knapping is probably related to loss of bone freshness, thus indicating that bone elements were not always employed while fresh.

Scraping marks are often found underlying the retouched areas (see **Table 2**) and are easily identifiable, being generally long, parallel and extending beyond the use area. At Geißenklösterle, we recorded scraping marks on half of the sample. These appear more frequently on long bone retouchers and are likely related to the removal of the periosteum as a preparatory step of the working area in order to prevent the tool from slipping or rebounding (Vincent, 1993).

The orientation of the retouch marks in each assemblage is predominantly transverse and oblique, with marks inclined upwards to the left. This pattern is different at Schafstall I, where marks oriented obliquely are all inclined upwards to the right (**Figure 6**). More than one type of orientation often occurs in one use area. It has been suggested that the orientation of marks can be related to handedness (Hahn, 1988) rather than to the direction and method of use.

Comparison between samples of the length and breadth of the use areas shows that there is considerable overlap across the various assemblages, although the retouchers of Schafstall I stand out for having the smallest use areas (**Table 4**; **Figure 7**). This is likely related to the smaller size of the retouchers.

Table 4 Length and breadth of the use areas (= ua) for each site. Measurements in mm. Incomplete artefacts are excluded from the count. Number of retouchers with complete used areas per site: GK = 14 ; HF = 5; SI = 3, SS I = 8, VG = 23.

	Mean length	SD length	Mean breadth	SD breadth
GK	25.1	2.6	11.9	0.9
HF	35.4	6.9	20.8	3.0
SI	27.6	1.4	20.1	1.5
SS I	17.4	1.6	11.7	1.0
VG	29.4	2.6	16.3	1.4

Discussion

The scarcity of Middle Palaeolithic retouchers fits with the relatively low density of Mousterian finds from the Swabian sites. According to Conard et al. (2012), this reflects relatively low population densities and settlement intensity of Neanderthal groups in southwestern Germany. The beginning of the Upper Palaeolithic marks a change in this trend and is characterized by a higher find density. Indeed, the Aurignacian retouchers are the most numerous and include a broad range of species. Although the Gravettian and the Magdalenian are well represented at sites like Geißenklösterle, Hohle Fels and Brillenhöhle, only a limited number of organic retouchers were recovered from Gravettian contexts, while none were found in Magdalenian assemblages. The decline of organic retouchers may be related to an increased use of stone for retouching and sharpening the edges of lithic flakes, as Taute (1965) suggested. Moreover, Taute (1965) noted a significant decrease in organic retouchers accompanied by an increase in stone retouchers during the transition to the Mesolithic across the entire Western Palaeartic (**Figure 8**). This may reflect a shift in raw material choice that becomes apparent between the Aurignacian and the Gravettian with changes in weapon technology and ornamentation. Specifically, such changes are signaled by the disappearance of Aurignacian ivory points and their replacement with mammoth rib points during the Gravettian, and by the substitution of double perforated beads, a cultural indicator of the Aurignacian, with drop-shaped ivory beads and tooth pendants (see Barth et al., 2009; Wolf, 2015; Wolf et al., 2016; Münzel et al., 2017). In this respect, the abrupt decline of bone retouchers during the Gravettian could be interpreted as a behavioral change related to raw material choices and could have essentially represented a true cultural change. However, despite the scant evidence, organic percussors appear to have been still used during the Gravettian. In fact, as Moreau

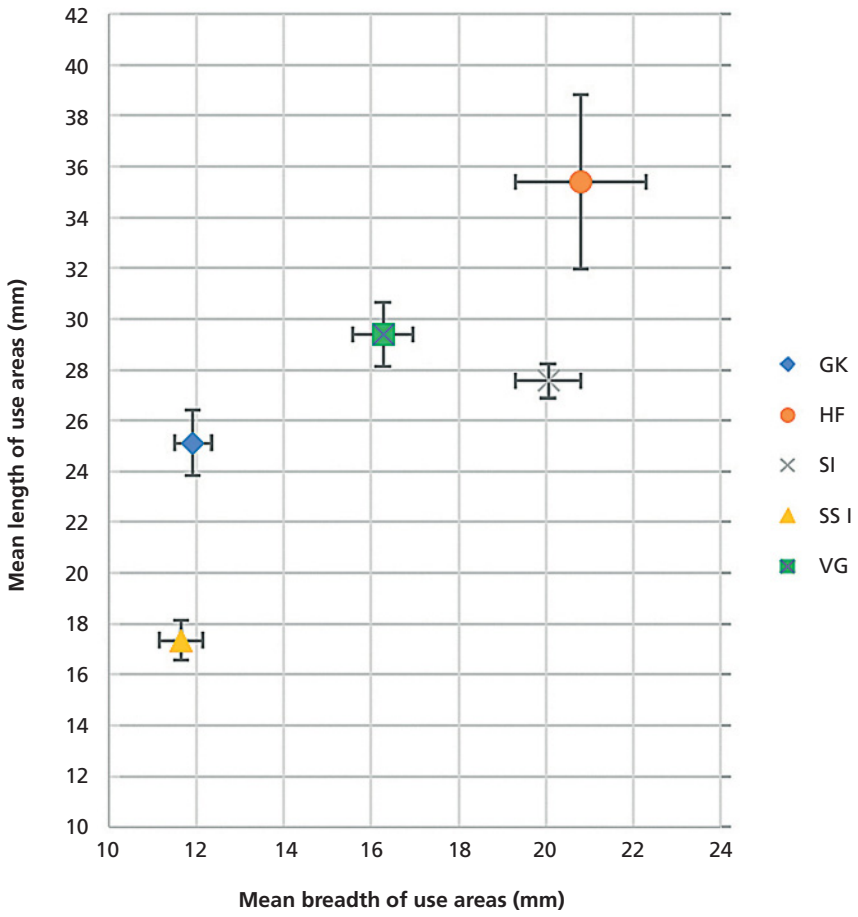

Figure 7 Mean length of use areas plotted against mean breadth of use areas. Number of complete undamaged use areas considered: GK = 18, HF = 8, SI = 7, SS I = 11, VG = 41. Error bars represent standard deviations given in Table 4.

(2009) suggested, there seems to be continuity in knapping techniques between the Aurignacian and the Gravettian. In his analysis of the Gravettian lithic industry of Geißenklösterle, Moreau (2009) was able to recognize, within one refitted nodule, the application of direct soft hammer percussion with organic and stone percussors. This led him to conclude that stone and organic hammers were both used and that only very fine lamellae were produced with stone percussors. There seems to be a discrepancy between the material evidence and the techniques applied; however, the markedly lower number of organic retouchers from Gravettian assemblages seems to fall in the same category of other important technological changes that could relate to a cultural shift in the choice of the raw material.

Consistent evidence for stone retouchers comes from the site of Brillenhöhle, where Riek (1973) reported the presence in the Gravettian and Magdalenian horizons of several retouchers, described as "Drücksteine" or "Retuscheure". With this term, Riek distinguished the small rounded pebbles used for pressure flaking from the much larger and elongated stone hammers used in percussion. This classification can be problematic, as the delineation between stone tools used by pressure or percussion is not always clear. Furthermore, some of the hammerstones described by Riek also exhibit retouch marks, meaning that they were used in different ways. The phallus-shaped siltstone retoucher from Hohle Fels is another example from the Gravettian, as it could have been used also as a hammerstone (Conard and Kieselbach, 2006).

As concerns the organic retouchers presented here, there seems to be no selection of raw material based on size, nor deliberate breakage aimed at retrieving elements of a predetermined size. However, it is reasonable to think that hominins would have preferred elements with morphological traits that facilitated handling. The Aurignacian retouchers, which constitute the bulk of the evidence, were not only made on discarded bone fragments, probably derived from food waste, but also on functional objects, such as decorated antler pendants and bone blanks that could have been used as punches and drills. Indeed, several bone retouchers display removal scars and splintered edges comparable to the type of marks found on worked and unworked osseous tools purportedly used as wedges and chisels, as described by Tartar (2012). Moreover, the occurrence of short, flat ivory fragments with retouch marks at Vogelherd and bone shafts with conspicuous grooves associated with retouch marks suggests that these tools also were used passively, possibly as anvils or chopping blocks. Experimental work conducted by Armand and Delagnes (1998) and Daujeard et al. (2014) has shown that violent percussion of lithic flakes against bone pieces used as anvils leaves marks comparable to those visible on the retouchers described above. It is therefore plausible that retouchers were used in various ways, although it remains difficult to differentiate percussion from pressure retouching and active from passive use. Generally speaking, the size of the use areas seems to depend on the dimensions and morphology of the bone fragment and on intensity of use; to some extent, intensity can be quantified by the number of use areas. This criterion does not account for intensively used retouchers with only one use area covering the whole or the majority of the bone surface (*sensu* Mallye et al., 2012). Retouchers with one use area covering the whole surface were recorded at Vogelherd, where about half of the analyzed sample presented two use areas, thus suggesting that at this site retouchers were exploited quite intensively. Though retouchers with two use areas are also frequent at Hohle Fels, such a pattern can be explained by the relatively high frequency of carnivore canines used on both sides and by the small sample size.

Researchers have occasionally regarded the orientation of retouch marks as an indicator of handedness (Semenov, 1964; Taute, 1965; Hahn, 1988; Uomini, 2011). Semenov's (1964) experimentation on pressure flaking with bone retouchers allowed him to establish the relation between lateralized

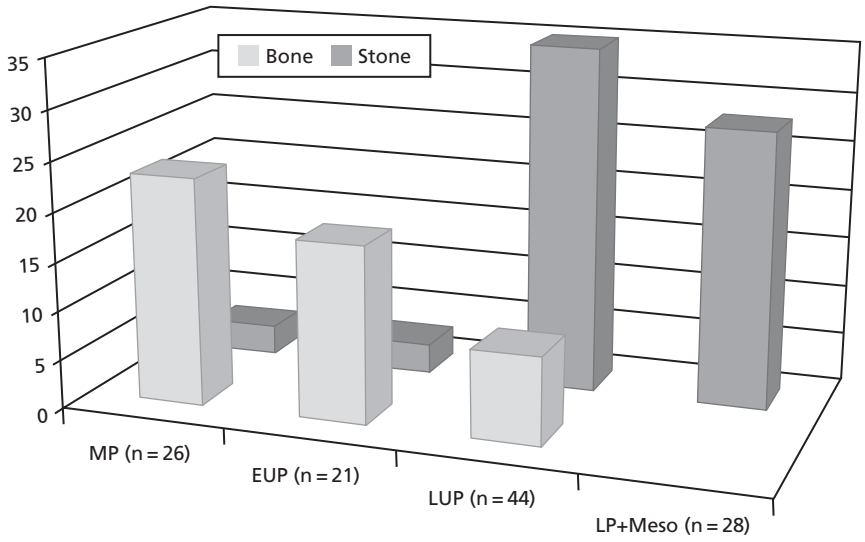

Figure 8 Comparison between bone and stone retoucher counts from Palaeolithic and Mesolithic sites in the Western Palaearctic listed by Taute (1965). MP = Middle Palaeolithic; EUP = Early Upper Palaeolithic; LUP = Late Upper Palaeolithic; LP+Meso = Late Palaeolithic and Mesolithic, as defined by Taute.

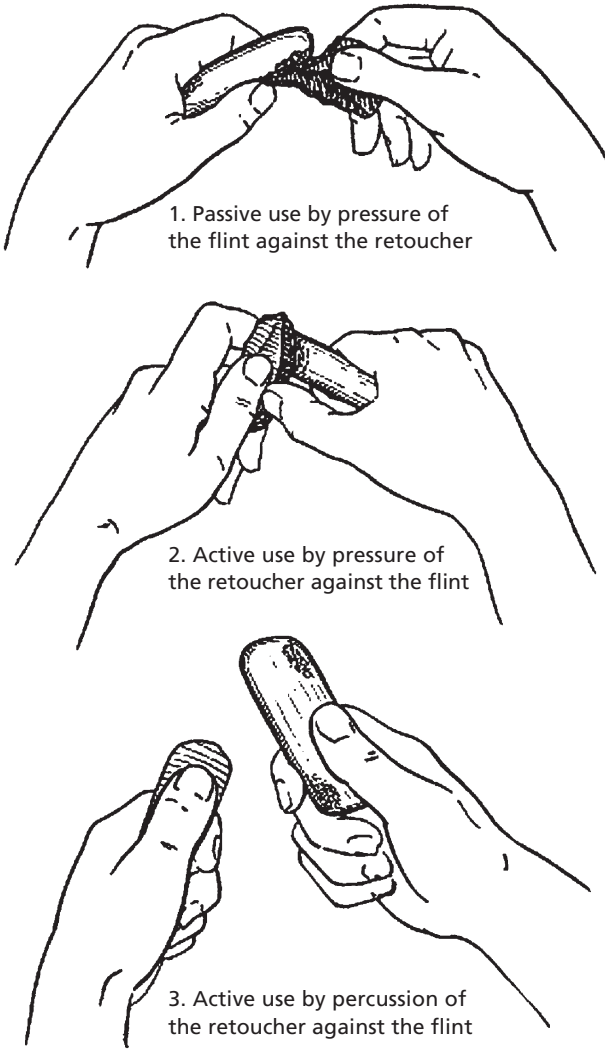

Figure 9 Passive and active uses of retouchers, modified from Taute (1965).

use wear and handedness. According to Semenov (1964), pressure flaking can be carried out by holding the bone retoucher and the flint at an angle of 75-85° and applying pressure on the bone against the flint. This configuration tends to produce a cluster of wear marks on the edge of the bone, which can then be re-used a second time by rotating it 180° around its long axis. If the bone retoucher is held in the right hand and the stone tool in the left, the marks will have an upper right to lower left orientation; held conversely, marks will be oriented in the opposite direction.

Most of the retouchers considered in this study exhibit transverse or diagonal marks with an upper left to lower right orientation; the Schafstall I retouchers have diagonal scars that are all oriented in the opposite direction. If only pressure flaking was used in retouching, then the majority of the retouchers would have been utilized by left-handed hominins. Based on these considerations, only at Schafstall I were the people (or person) exploiting such tools almost exclusively right-handed. This does not agree with other types of evidence indicating that Neanderthals and modern humans were primarily right-handed (Cornford, 1986; Bermúdez de Castro et al., 1988, Trinkhaus et al., 1994, Schmitt et al., 2003, Steele and Uomini, 2005; Uomini, 2011). It seems more likely that the orientation of use marks is also determined by the technique applied and by the active or passive use of the bone. An active use by percussion could perhaps produce marks that have an opposite orientation to those made by pressure flaking. In this respect, Taute (1965) distinguished four modalities: passive percussion and pressure of the stone tool against the bone retoucher, and active percussion and pressure of the bone retoucher against the stone tool (Figure 9). He suggested that the use of different retouching techniques influences the location of the retouch marks. Recent experimental work has explored this idea by looking at the relation between the location and types of marks and the different modalities of retouching with bone, also including retouch by counterblow (Karavanić and Šokec, 2003; Ahern et al., 2004; David and Pelegrin, 2009; Daujeard et al., 2014). The orientation of marks could perhaps be another interesting feature to take into account because it is intimately connected to the working angle, which depends not only on the shape of the stone tool being worked but also on the position of the retoucher with respect to the stone. These variables are ultimately associated with the technique applied.

Conclusions

Organic retouchers are a key component in the reconstruction of prehistoric technology. Their study goes hand in hand with that of lithic technology and contributes to our understanding of behaviour and

culture among hominins. Our study of organic retouchers provides insight into technological choices adopted by Neanderthals and modern humans in the Swabian Jura. Despite differences in sample sizes and taxonomic representation between the Middle Palaeolithic and Aurignacian, the main trend in the use of osseous retouchers is their decline and eventual replacement by pebble retouchers during the Gravettian. While Middle Palaeolithic retouchers are made exclusively on bone fragments, likely to have been primary food waste, Aurignacian people exploited a broader range of elements, including carnivore canines, elaborated objects, like worked antler bases, and unmodified objects that could have served multiple functions. The morphological variety and different orientation of retouch marks suggest that retouching was carried out with various techniques and that retouchers could have been used not only actively, but also passively as anvils or by pressure flaking.

In contrast, little evidence of bone retouchers is available from Gravettian and Magdalenian contexts. As previously pointed out by Taute (1965), during the Gravettian and Magdalenian, stone retouchers become more frequent and could have played a more prominent role in working lithic artefacts. Changes in raw material use from the Aurignacian to the Gravettian have also been observed for other types of organic artefacts in the Swabian Jura, such as points and personal ornaments (Wolf et al. 2016; Münzel et al. 2017). The decline of organic retouchers during the Gravettian and Magdalenian may fall within the same realm of behavior. Nevertheless, further studies that integrate stone retouchers and lithic technology will prove useful in assessing the validity of this model.

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