Chapter 6
Projectile Weaponry from the Aurignacian to the Gravettian of the Swabian Jura (Southwest Germany): Raw Materials, Manufacturing and Typology

Sibylle Wolf, Susanne C. Münzel, Krista Dotzel, Martina M. Barth, and Nicholas J. Conard

Abstract Here we describe the variability of projectile points made from bone, antler, and ivory recovered from cave sites in the Ach and Lone Valleys (Swabian Jura), focusing on Aurignacian and Gravettian assemblages. Based on the faunal provenience of the points, we recognize a distinctive change in raw material use from the Aurignacian to the Gravettian: during the Aurignacian antler was used for the small split-base points, bone for highly variable points, and ivory for the comparatively large and unstandardized points. During the Gravettian hardly any antler points have been found and bone points were manufactured from mammoth ribs. The raw materials tend to be associated with a specific type of point and *chaîne opératoire*.

Keywords Projectile point • Raw material preference • Early Upper Paleolithic • Massive-base point • Split-base point

S. Wolf (✉) • N.J. Conard
Institute of Pre- & Protohistory and Medieval Archaeology, Early Prehistory and Quaternary Ecology, University of Tübingen, Schloss Hohentübingen, Burgsteige 11, 72070 Tübingen, Germany

Senckenberg Center for Human Evolution and Palaeoenvironment, Tübingen, Germany
e-mail: sibylle.wolf@ifu.uni-tuebingen.de; nicholas.conard@uni-tuebingen.de

S.C. Münzel
Institute for Archaeological Sciences, University of Tübingen, Archaeozoology, Rümelinstr. 23, 72070 Tübingen, Germany
e-mail: susanne.muenzel@uni-tuebingen.de

K. Dotzel
Institute of Pre- & Protohistory and Medieval Archaeology, Early Prehistory and Quaternary Ecology, University of Tübingen, Schloss Hohentübingen, Burgsteige 11, 72070 Tübingen, Germany
e-mail: krista.dotzel@uconn.edu

M.M. Barth
Kultusministerium des Landes Sachsen-Anhalt, Turmschanzenstr. 32, 39114 Magdeburg, Germany
e-mail: Martina.Barth@mk.sachen-anhalt.de

Introduction

The aim of this chapter is to give an overview of those points made from bone, antler, and ivory dating to the Aurignacian and Gravettian assemblages of the Swabian Jura. This area includes the sites of Hohle Fels, Geißenklösterle, Sirgenstein, and Brillenhöhle, which are located in the Ach Valley between the towns of Blaubeuren and Schelklingen. The other cluster of cave sites of interest is located in the Lone Valley and includes Vogelherd, Hohlenstein-Stadel, and the Bockstein-complex (Fig. 6.1). Both valleys are branches of the Danube River. There seems to be a clear preference in raw material for Aurignacian and Gravettian people; while antler and ivory were the preferred raw materials during the Aurignacian, Gravettian points seems to be exclusively made of ribs, preferably mammoth ribs. These different raw material preferences had implications for the shape as well as for the functional properties of the points.

Research History of the Swabian Jura

The Swabian Jura has been the site of many archaeological and paleontological excavations since the mid-nineteenth century, and excavations are still ongoing today. Most of the investigated Paleolithic sites contain either Aurignacian, Gravettian, or both, techno-complexes within their deposit. In order to better understand the osseous technology to be described below, we provide a brief excavation history of the key sites of the Swabian Jura.

The first excavations in the renown Hohle Fels Cave near Schelklingen were conducted in 1870/71, and the University of Tübingen has conducted yearly excavations at this site almost every year since 1977 (Hahn 1989; Blumentritt and Hahn 1991; Conard et al. 2000). At this site, the archaeological

Michelle C. Langley (ed.), *Osseous Projectile Weaponry*, Vertebrate Paleobiology and Paleoanthropology, DOI 10.1007/978-94-024-0899-7_6

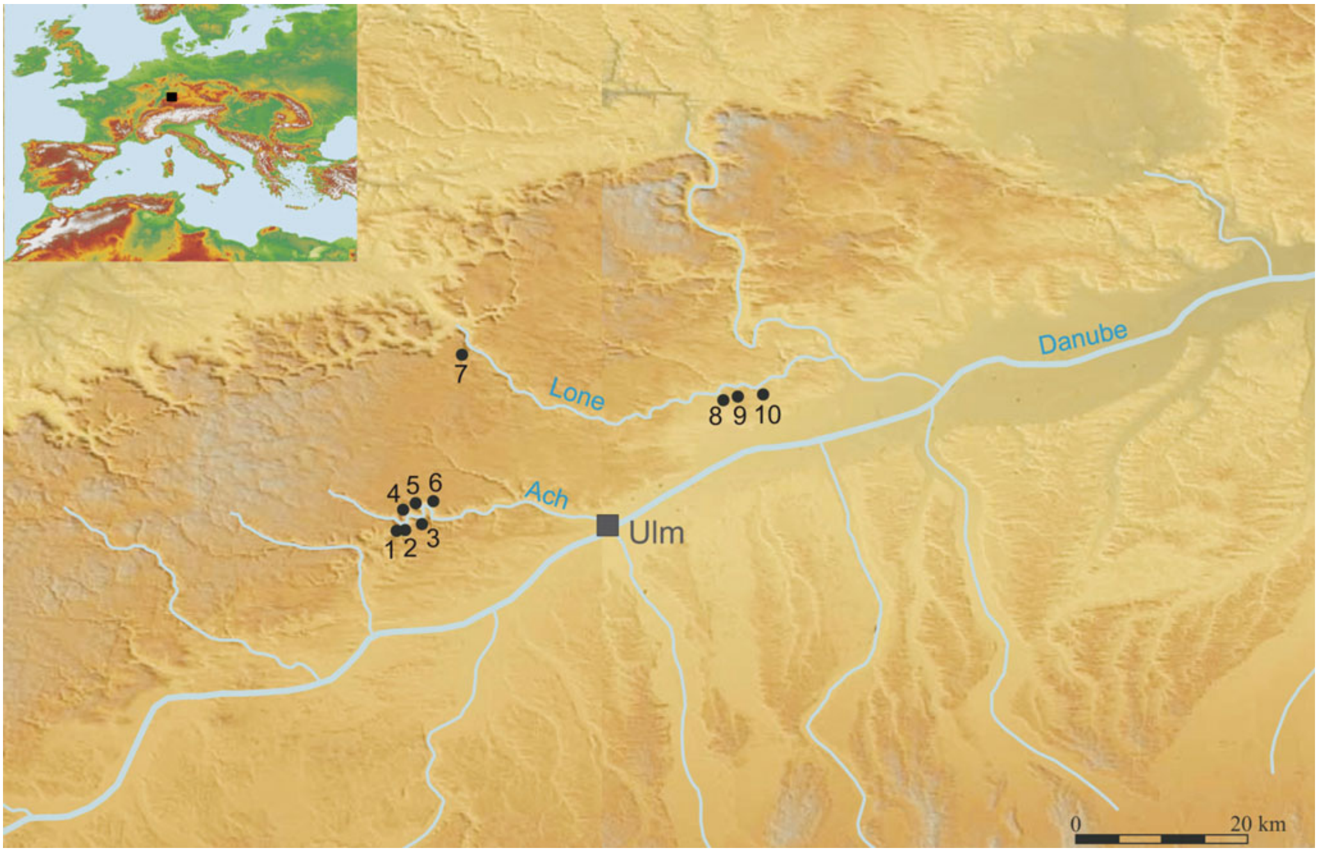

Fig. 6.1 Map of the caves of the eastern Swabian Jura: (1) Kogelstein; (2) Hohle Fels; (3) Geißenklösterle; (4) Sirgenstein; (5) Brillenhöhle; (6) Große Grotte; (7) Haldenstein Cave; (8) Bockstein; (9) Hohlenstein-Stadel; (10) Vogelherd. Map: University of Tübingen

horizons IIb to IIcf are Gravettian and date between 27,000 and 29,500 in uncalibrated calendar years. The Aurignacian layers, IId/e, III, IV, Va and Vb have provided dates between 29,500 and 35,700 years BP (Conard and Bolus 2003, 2006, 2008; Conard 2009).

Robert R. Schmidt excavated the Sirgenstein Cave, which lies in the valley between Hohle Fels Cave and Geißenklösterle Cave, in 1906 (Schmidt 1907, 1912). The Gravettian and Aurignacian layers here are designated II, III, IV and V and were occupied between 26,700 and 30,200 years BP (Conard and Bolus 2003, 2008). Joachim Hahn conducted excavations in the Geißenklösterle Cave between 1974 and 1991 (Hahn 1988). In 2001 and 2002 Nicholas J. Conard continued the work at this cave until he reached bedrock (Conard and Malina 2002, 2003). The Gravettian horizons Ip to Ic indicate an age between 24,400 and 32,900 years BP while the Aurignacian layers II and III date to between 29,300 and 39,000 years BP (Richter et al. 2000; Conard and Bolus 2003, 2008; Higham et al. 2012). Excavations at Brillenhöhle took place between 1955 and 1963 (Riek 1973). The Gravettian layers VII and VIII provide two old dates between 25,000 and 29,000 years BP (Riek 1973). The deeper layer, XIV, revealed only two Aurignacian points, which were directly dated to 30,400+240/-230 years BP and 32,470+270/-260 years BP respectively (Bolus and Conard 2006).

During his excavations in the Vogelherd Cave in 1931 Gustak Riek completely emptied the cave of sediments, dumping the backdirt onto the hill surrounding the cave (Riek 1934). The layers richest in finds were the Aurignacian layers IV and V, dating between 30,000 and 36,000 years BP. In contrast to these rich layers, Riek did not discover many Gravettian remains. Between 2005 and 2012 the Department of Prehistory and Quaternary Ecology of the University of Tübingen excavated the back dirt sediments of Riek's excavation. Because of the relatively rough excavation methods of the time of 1931, the new excavation was quite successful in finding an abundance of new artifacts, especially small finds (e.g., Conard et al. 2007, 2010). These artifacts, however, have no stratigraphic context and must be studied in tandem with finds from sites with well-documented stratigraphies.

Hohlenstein-Stadel, known for its famous lion-man (Schmid 1989; Kind et al. 2014), contains Aurignacian layers dated to between 31,500 and 35,000 years BP, but no significant Gravettian layers. The first significant archaeological investigations at Hohlenstein-Stadel took place between

1937 and 1939 by Robert Wetzel (1961). Between 2008 and 2013 Claus-Joachim Kind led excavations in front of and inside the cave (Kind and Beutelspacher 2010; Beutelspacher et al. 2011; Beutelspacher and Kind 2012; Kind et al. 2014).

Excavations at Bockstein Cave occurred on and off throughout the late nineteenth century through to the first half of the twentieth century (Schmidt 1912; Wetzel 1958; Wetzel and Bosinski 1969). The cave, as well as its entrance (Bockstein-Törle), has produced Aurignacian and Gravettian artifacts, however, the layers have proven difficult to distinguish from one another (Wetzel 1954; Krönneck 2012). The dates for the archaeological horizons IV to VI are between 20,400 (no AMS date) and 31,500 (AMS) years BP (Conard and Bolus 2003, 2008).

In 1972, Gerd Albrecht, Joachim Hahn, and Wolfgang Torke from the Institute of Prehistory and Quaternary Ecology of the University of Tübingen conducted the first and only systematic review and analysis of all organic projectile points from the Swabian Jura. They compared the Swabian points with other Aurignacian points from across Europe and conducted their analysis using innovative methods such as coding attributes and including statistical analysis (Albrecht et al. 1972). Since that time, however, many new projectile points have been excavated and no updated overview has been published. Here we update this work some 40 years later.

Materials and Methods

For the purposes of this chapter, we describe organic projectile points based on the criteria put forward by Albrecht et al. (1972; Fig. 6.2), and have thus measured the maximum length, width, and thickness of each point or point fragment. The main attribute of this artefact category is a pice from osseous material shaped into a pointed form. Projectile points are distinguishable from awls or other such pointed artifacts by their extensive shaping. They were whittled, scraped, or ground on all sides so that the artifact morphology is the result of carefully controlled manufacturing. In addition, these artifacts possess bases shaped in such a way to facilitate hafting.

During the Aurignacian and Gravettian different raw materials are documented for the production of projectile points. The people used bone, woolly mammoth ivory, and reindeer antler and each raw material possesses different properties that determine the manufacture and the function of the points (Albrecht 1977).

The identification of antler and ivory raw material is relatively simple, especially when compared to identifying the type and element of bone that was utilized as raw material for a point. Often only ribs can be identified, as these points exhibit a typical rib spongiosa (cancellous bone) on one side covered

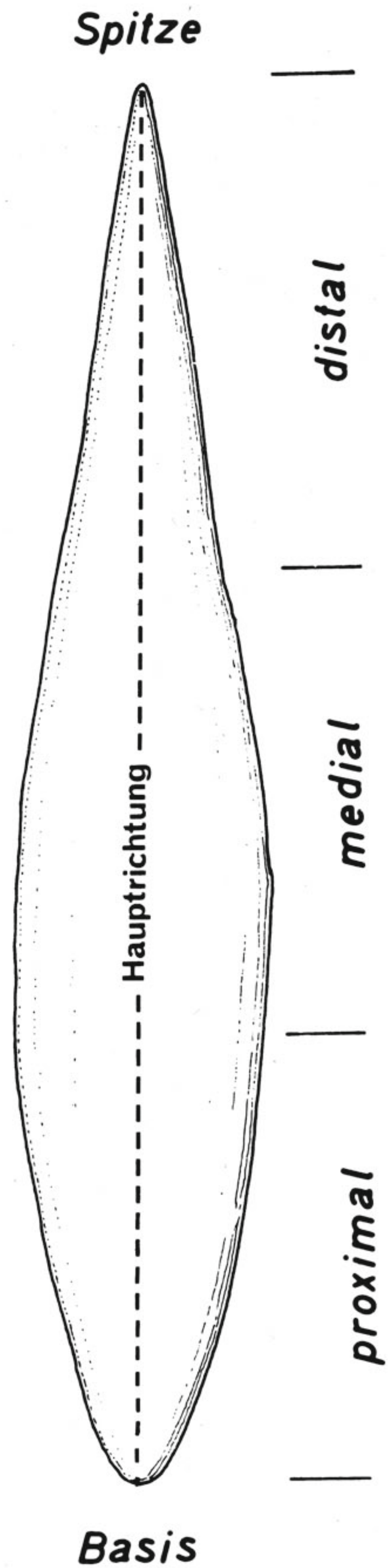

Fig. 6.2 Dimensions of a point. After Albrecht et al. (1972)

by a ‘spongy’ compacta (Münzel 2005). Another possibility is to use DNA to identify the animal and this method has been used to identify the raw material of the numerous Aurignacian bone points of Potočka zijalka, a high Alpine cave located in Slovenia. These latter points were probably made from cave bear long bones (Hofreiter and Pacher 2004).

Middle Paleolithic Points

Researchers have documented a handful of bone points ascribed to the Middle Paleolithic, though currently no ivory points have been identified for this period (Gaudzinski et al. 2005). In Germany, the first bone points appear during the Middle Paleolithic at the site of Salzgitter-Lebenstedt (Gaudzinski 1998). At this site, Neanderthals fashioned mammoth fibulae and ribs into pointed tools. At Vogelherd in the Swabian Jura, a similar tool, made of a split mammoth rib, has been documented from the late Middle Paleolithic layer VI. This tool is well preserved, with both the tip and the base whole. In addition, a massive-based bone point made from a horse-sized rib was excavated in 1931 (Bolus and Conard 2006; Fig. 6.4: 11). This point was recently directly dated to 31,310+240/-230 years BP, which, if correct, suggests it may instead originate from the Aurignacian. The Swabian site of ‘Große Grotte’, in the Ach valley, also produced a point from late Mousterian layers. This piece is a carefully worked antler point made from either reindeer or red deer (oral comm. Münzel 2013), and exhibits splintering at the tip, indicating it was well used (Wagner 1983).

Aurignacian Points

Aurignacian projectile points in the Swabian Jura all fit into one of two categories; massive-base points or split-base points.

Massive-Base Bone Points

These points take a variety of forms but generally have solid, rounded bases that were hafted by inserting them into a hollowed-out shaft. Most of the Aurignacian sites in the Swabian Jura have produced massive-base points, albeit not more than a few artifacts each. These points are highly variable in terms of shape and size. In particular, massive-base points are known from Sirgenstein, Hohle Fels, Geißenklösterle, Brillenhöhle, Bockstein-Törle, Hohlenstein-Stadel, and Vogelherd. These finds are described below.

In 1912, Robert R. Schmidt published a bone massive-base point recovered from Sirgenstein (Albrecht et al. 1972, Taf. 3, 24). Five fragments of antler points have been found at Hohle Fels, and one of these is likely a part of a split-base point (Fig. 6.4: 1). One bone massive-based point was also found here (Fig. 6.5: 4), and is a medial-proximal fragment made of mammoth/rhino rib. At Bockstein-Törle, excavations recovered two bone points with massive bases (Albrecht et al. 1972; Fig. 6.3: 1 and 3), while Hohlenstein-Stadel has revealed two bone massive-base points (Albrecht et al. 1972; Fig. 6.3: 2 and 4). Similarly, Brillenhöhle has produced two incomplete points from layer XIV (Riek 1973; Bolus and Conard 2006). One is probably a split-base point made of antler, while the other is a medial fragment of a bone massive-base point. Both have been recently dated revealed with the split-base point returning an age of 30,400+240/-230 years BP, and the massive-base point 32,470+270/-260 years BP (Bolus and Conard 2006).

Vogelherd has produced the greatest number of massive-base bone points from the Swabian Jura (n = 6). These points come from layers IV and V, as well as from the recent back dirt excavations. The points from Vogelherd are highly variable (Fig. 6.4: 6–8). Three of the points are oval in cross-section (except for the narrowing tip which is sub-circular in section) and resemble split-base points in both size and shape. Two of the points are lozenge-shaped and were probably quite similar in size when complete. The last point is substantially different to the others (number 33/73_127). While the others have thicker oval or rectangular cross-sections, this point is quite flat, with a length and width much longer than the others. These massive-base points are all made of antler.

Interestingly, Geißenklösterle Cave produced no bone massive-base points despite its rich variety of other osseous artifacts. The only known point varieties from this cave are antler split-base points and ivory points with massive or double beveled bases.

Split-Base Points

Split-base points are found at many Aurignacian sites throughout Western and Central Europe (Albrecht et al. 1972; Knecht 1990), and take their name from the characteristic slit up the middle of their base. Aside from the split-base, these points can take a variety of shapes and sizes. Almost all split-base points are made from antler rather than bone, which is most likely owing to the specific biomechanical properties that antler possesses as a raw material. Antler is not as brittle as bone, with several researchers who have experimented with antler reporting that it is more pliable and easier to work than bone, especially when wet (Newcomer 1977; Bonnichsen 1979; Guthrie 1983; Tartar and White 2013). Given that many other forms of organic projectile points are made from bone instead of antler, it may be the case that antler is especially good for creating the characteristic split-base morphology.

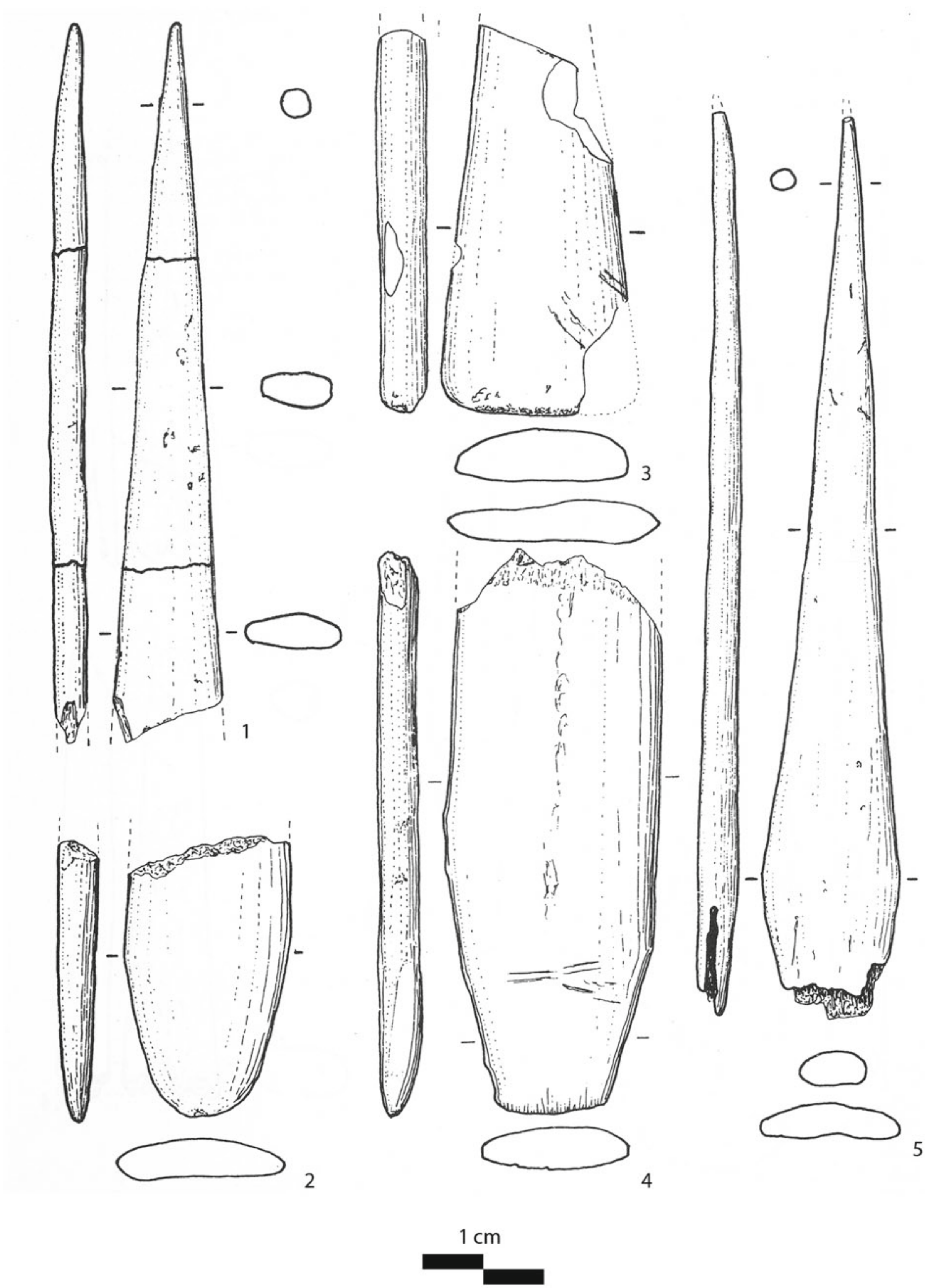

Fig. 6.3 Examples of Aurignacian points. Bockstein-Törle: (3) massive-base point, (1) point fragment; Hohlenstein-Stadel: (2, 4) massive-base points; Bockstein Cave: (5) split-base point. Drawings after Albrecht et al. (1972), Taf. 2

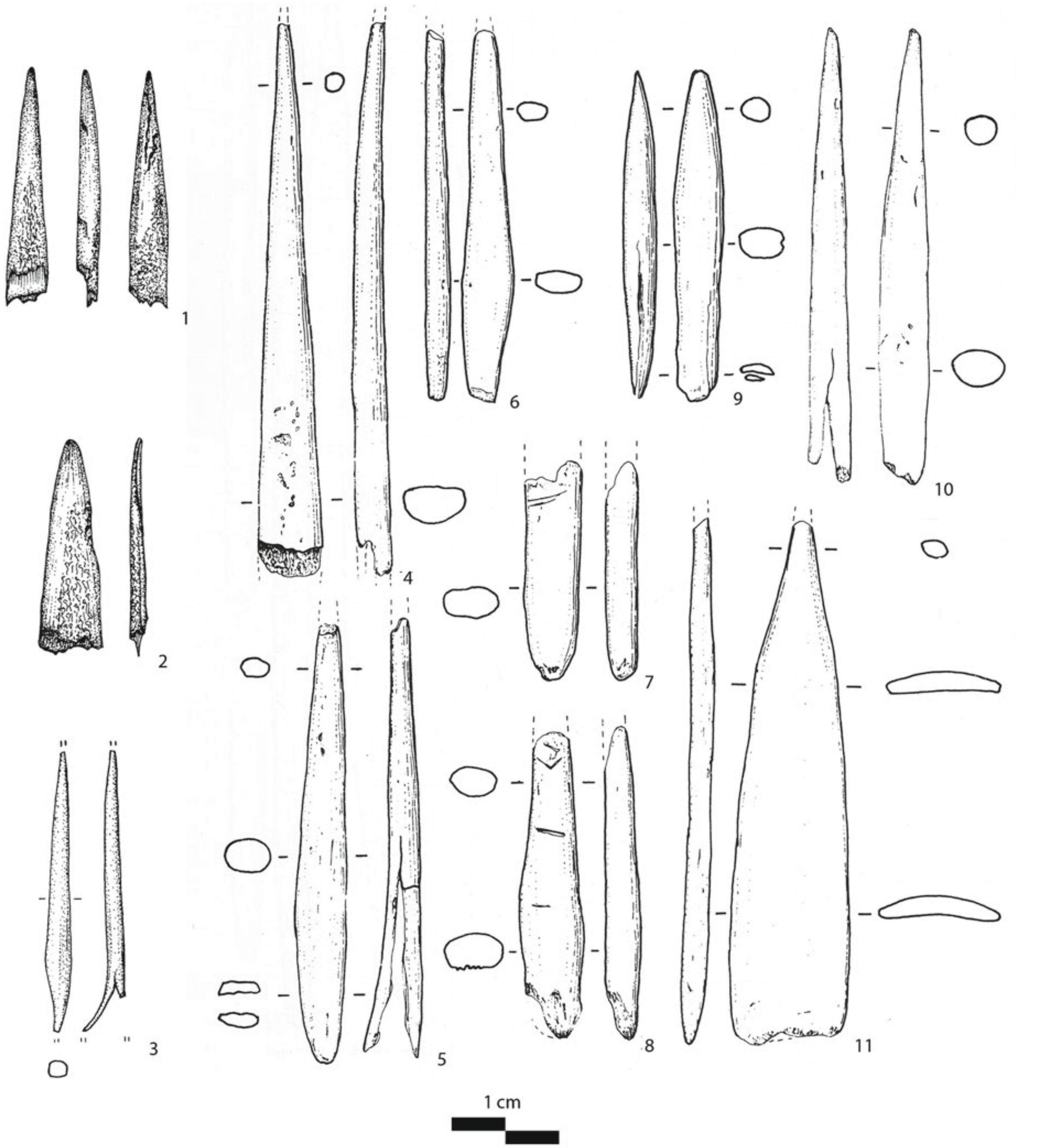

Fig. 6.4 Examples of Aurignacian points. Hohle Fels: (1–2) fragments from Hohle Fels IV, (3) split-base point from Hohle Fels Vb; Vogelherd VI: (11) massive-base point; Vogelherd V: (4, 5, 9, 10) split-base points, (6) massive-base point; Vogelherd IV: (7–8) massive-base points. Drawings 1, 2 after Conard et al. (2004), 3after Conard and Malina (2009), 4 – 11 after Albrecht et al. (1972), Taf. 4

The manner in which Aurignacian manufacturers created the split in their points has been somewhat of a contentious issue. Henri-Martin (1931) and later Knecht (1990) both argue that the split was created by simple cleavage to the basal end. Recent experimental work by Tartar and White (2013), however, found that splitting a point through simple cleavage was almost impossible. Instead they argue for a combination of Peyrony's (Peyrony 1935) and Henri-Martin/Knecht's method. They found that the most effective way to create the split was to cut transversal incisions onto the faces of a long blank where the desired base would be. They would then flex the blank on both sides until the force split the base (Peyrony 1935), which was then extended through cleavage. This created characteristic debitage in the form of a 'tongued piece'. This technique simultaneously created the 'tongued piece', the split, and removed material from inside of the wings of the

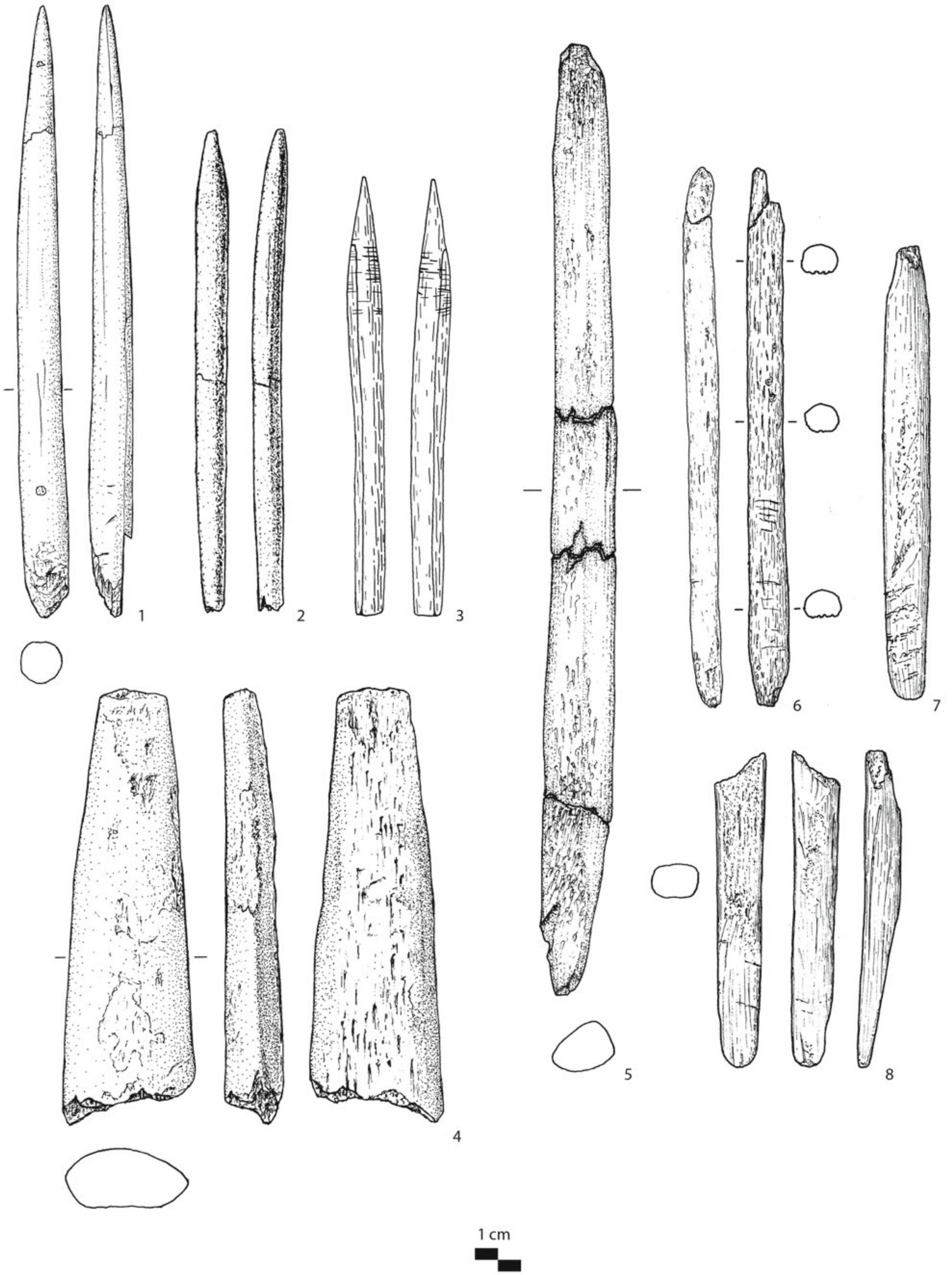

Fig. 6.5 Examples of Aurignacian points (1–4). Examples of Gravettian points (5–8). Hohle Fels AH IV (1, 2, 4), Hohle Fels AH Va (3), Hohle Fels AH IIb (5–6), Brillenhöhle AH VII (7–8). Ivory (1–3), mammoth/rhino rib (4–6), antler (7), unidentified bone (8). Massive-base points (5–6), double beveled base (7), single beveled base (8). Drawing 1 after Conard and Malina (2009), 2 after Conard and Malina (2006), 3 after Conard et al. (2003), 4 by R. Ehmann, 7 after Riek (1973), pl. 13, 10, 8 after Riek (1973), pl. 14, 7

point. While this argument is convincing, this construction method necessarily creates tongued pieces as debitage, which have not been observed in the Swabian Jura. Furthermore, Vogelherd has produced a handful of antler artifacts that appear to be point blanks roughly the size and shape of finished split-base points but which lack the split. If these artifacts are indeed split-base point blanks, this suggests that perhaps simple cleavage was, in fact, the preferred splitting method in the Swabian Jura. To construct a projectile point in the Swabian Jura then, it appears Aurignacian manufacturers' first extracted blanks from the compact part of the antler and shaped them into a roughly projectile point shape. Then the manufacturer would attempt to split the basal section of the blank through cleavage. If the split was successful, the final step would be to scrape the point blank into its final shape.

The split-base morphology almost certainly reflects a hafting mechanism. Based on her extensive experimental data, Knecht (1991) argues that a split-base allows hafting without the use of adhesive materials, if the distal end of a spear shaft was hollowed out into a U-shape to insert the base. To keep the points firmly fixed in the shafts, Aurignacian manufacturers would then insert a wedge inside the slit in order to splay the wings against the wood. Other researchers, such as Linda Owen (2005), however, suggest that split-base points were used as weaving or sewing tools rather than projectile points. Microscopic observations of split-base point tips, however, have shown impact fractures that are consistent with use as projectiles (Dotzel et al. in prep.; Tejero 2016).

Split-base points occur at several of the Aurignacian sites in the Swabian Jura, including Vogelherd, Geißenklösterle, Brillenhöhle, Hohle Fels, and Bockstein Cave. Vogelherd has produced by far the most split-base points out of the region with a total of 27 whole and fragmented points, followed by Geißenklösterle with 11 (Hahn 1988; Liolios 1999; Teyssandier and Liolios 2003; Dotzel 2011). The other three sites, however, have only produced one split-base point each.

The split-base points from Vogelherd and Geißenklösterle are a relatively homogenous group when compared with Aurignacian simple-based points. Unbroken points from these two sites range in length from 51 to 115 mm, with widths from 7 to 12 mm, and thicknesses from 4 to 7 mm. These points tend to be shorter and narrower than other varieties of organic projectiles, as well as split-base points from other regions (Albrecht et al. 1972). In terms of shape, the split-base points from these two sites also tend to be similar. Most of the points fall into one of two shape categories; 'curved' points and 'triangular' points. Triangular points are widest near their bases and feature straight lateral edges that taper evenly into a point with an overall shape that most closely resembles a triangle. Curved points, on the other hand, show lateral edges that are more rounded and gently slope toward the point. The maximum width of the latter type can occur anywhere along the shaft. Points from these sites also commonly feature cross-sections that resemble thick ovals or rectangles with rounded edges. While individual points from these sites vary in size and shape, makers usually adhered to a set range of patterns (Fig. 6.4: 4, 5, 9, 10).

The split-base points from Brillenhöhle, Hohle Fels, and Bockstein-Höhle, on the other hand, vary wildly both in form and size. The point from Hohle Fels is the smallest, nearly whole, split-base point in the Swabian Jura with a length of 51 mm, a width of 4 mm, and thickness of 3 mm. The piece derives from the deep layer Vb (Conard and Malina 2009; Fig. 6.4: 3), demonstrating that already in the very early Aurignacian this *fossile directeur* is present. The near complete split-base point from Bockstein-Höhle represents the other side of the spectrum with a length spanning 148 mm with a maximum basal width of 33 mm (Fig. 6.3: 5). In contrast to the Vogelherd, Geißenklösterle, and Hohle Fels split-base points, this artifact is quite flat, with a thickness of just 6 mm. Finally the split-base point from Brillenhöhle has a width of 23 mm and a thickness of 6 mm, making it a wide and flat basal fragment featuring straight, tapering, lateral edges. These three points show that split-base points were not standardized throughout the entire Swabian Aurignacian, even if the points from Vogelherd and Geißenklösterle were kept within a narrower range of morphologies and sizes.

Ivory Points

Ivory points were frequent throughout the Aurignacian times and were produced during all phases of the Swabian Aurignacian. The ivory of a mammoth tusk is composed of 60 % dentin, 30 % collagen and 10 % water (for detailed information see Locke 2008), making it an excellent raw material due to this unique composition which makes it extremely hard while also being elastic. Ivory appears to have been especially useful for constructing various tools and personal ornaments during this period (Wolf 2015). It was advantageous and attractive as a raw material because different forms in a variety of sizes could be carved from the massive dentine. The unique luster of ivory was also most likely a desirable trait (Conneller 2011), and in many cases the ivory points exhibit personalized characteristics, which demonstrate the expression of individuality.

To obtain ivory, people during the Aurignacian and Gravettian periods either hunted mammoths or collected tusks from the animals that perished in the landscape. So far, the evidence points more to systematic collection of tusks rather than hunting (Niven 2006; Wolf 2015). There are different methods for breaking down a tusk to create ivory projectile points. Manufacturers could: (1) etch a notch around the circumference of the tusk and then snap it; (2) split it length-wise into two halves; or (3) smash it using direct percussion (Khlopatchev and Girya 2010). These methods could also be used in combination. After the initial breaking down the ivory, manufacturers would use the groove and splinter technique to extract raw forms in the shape of long and slender rods. To obtain suitable blanks, Aurignacian and Gravettian people must have used the groove and splinter technique of blank extraction rather than try to flake the material as even a large flake is not regular enough to create a rod with the consistent thickness and length needed for a point longer than 200 mm. After the initial blank extraction, manufacturers would have chopped, scraped, ground, and smoothed the point until it reached its intended size and shape (Semenov 1957; Christensen 1999; Liolios 1999; Wolf 2015). Except for acquiring the ivory, all steps of the production sequence are documented in the collections of the Hohle Fels, Geißenklösterle and Vogelherd.

Ivory points were an important part of the Aurignacian toolkit. Altogether, 29 artifacts including five complete pieces are preserved in the archaeological record. These points show a great variety in size and shape but are all highly polished. In the Hohle Fels Cave, points (n = 11) have been excavated from all Aurignacian layers (Fig. 6.5: 1–3). These points show high variability in both form and size. Five pieces possess a massive base, one piece shows a double beveled base, and five points have bases which are indeterminate owing to preservation. The lengths of the completely preserved points vary between 93 and 238 mm. The widths vary between 6.5 and 40 mm, and the thickness between 6.2 and 14 mm. These points include a well-preserved 'Lautscher' or 'Mladeç' point (230 mm in length; Fig. 6.6), as well as a basal fragment of this same point type which would have been around the same size. The bases of these points bear an engraved cross-hatch pattern, likely to facilitate hafting. Two pencil-shaped pieces with a massive base and a round cross section have also been found. These pencil-shaped pieces have similar dimensions, except in length. One thick point even displays a curved groove on one side, which could be interpreted as a personal marking. The production sequence at Hohle Fels is well documented.

The excavations at Geißenklösterle produced points in the Aurignacian layers II and III (n = 5). Three pieces possess double beveled bases and two pieces have massive bases. They measure between 8 and 14 mm in width and between 6.5 and 11 mm in thickness (Hahn 1988).

At Vogelherd, three points came from layer V while the recent back dirt excavations produced an additional 13 items. At present about two thirds of the sediments from the excavations have been wet screened and sorted, so future work at Vogelherd may produce additional finds. So far, four pieces from Vogelherd have massive bases, four have double beveled bases, and the bases of five points remain undetermined. The length of the points with massive bases averages 4.6 mm and the width averages 0.9 mm. The artifacts from Vogelherd are generally consistent in size and shape and are relatively small. The manufacturers did carve points on site out of rods, though most of the ivory rods were used for the production of beads.

In summary, split-base points were made from antler and are quite numerous, while specimens made with a massive base are made either from bone or antler and are less numerous in comparison. Points made of ivory are again more frequent in their appearance in the Aurignacian record.

Gravettian Points

In the Swabian Jura, the Gravettian has been found only in the caves of the Ach Valley, including Hohle Fels, Geißenklösterle, Brillenhöhle and Sirgenstein. The Gravettian layers of all of these caves with the exception of Sirgenstein have produced a variety of tools and jewelry made of organic raw materials. The species that provided the majority of the raw material for organic tools were also the main game species and included mammoth, reindeer, and horse. More than 60 medial and 10 distal fragments derive from the Gravettian layers of these three cave sites. Raw material, similarities in shape, morphology, and cross-section as well as signs of impact-induced breakage suggest that these pieces, as well as some of the described basal fragments, should be interpreted as projectile points. The shape of the tips ranges from very pointed to rounded and blunted. Some of them show evidence of having reshaped tips through scraping (Barth 2007; Barth et al. 2009:14).

In contrast to the Aurignacian, Gravettian points were manufactured mainly from mammoth ribs and unidentified ribs of mammoth- to rhino-sized species (Münzel 2001, 2004, 2005), however, ribs of horses or of horse- to deer-sized animals and antler were also used. As very little on-site production of antler tools is recorded, we can assume that the few antler points found were brought as finished products into the caves of the Ach Valley (Barth 2007; Barth et al. 2009:16).

Production Sequence for Mammoth Ribs

Mammoth ribs used for projectile points were processed on-site in a standardized fashion. First they were notched along the edges on both sides to facilitate splitting (Münzel 2004:77, Figs. 5, 6). These split rib blanks could then be shaped into

Fig. 6.6 Lautscher/Mladeç point from Hohle Fels AH IV. Photos by H. Jensen. Drawings after Conard and Malina 2007

different tools with several possible functions. They could be used as chisel-/wedge-like tools, used as burnishers or smoothing tools, or manufactured into projectile points. To manufacture the points, the split rib halves were ground along the edges and smoothed on both sides until they developed a typically circular, oval, or rectangular cross-section. At Geißenklösterle and Hohle Fels, all stages of this production sequence are well documented on-site (Barth 2007). Bone points from Brillenhöhle show the same manufacturing pattern (Riek 1973; Barth 2007). The length of the mammoth ribs as well as their straightness may have been an important prerequisite for the production of projectile points.

Among the complete and near complete preserved mammoth rib points (n = 7), along with the clearly classifiable point fragments (n = 23), four different point types could be identified (Barth 2007). These include: points with massive base, those with a single beveled base, with a double beveled base, and points *à base machonée.*

Points with a Massive Base

Altogether four nearly complete points with round bases come from the Gravettian layers in Brillenhöhle (n = 2) and Hohle Fels Cave (n = 2). They are made of mammoth ribs, except for one specimen of non-identifiable bone from Brillenhöhle. One point from Hohle Fels (145 × 11 × 8 mm) is cylindrical in shape (Fig. 6.5: 6). The cross-section is partly oval, partly rectangular. The base and the lower medial part are incised with a few irregular, parallel, transversal lines. The tip is splintered at one side. The other point is larger (201 × 15 × 12 mm) and broke into four fragments after being deposited (Fig. 6.5: 5). The cross-section changes from rectangular to oval at the terminal end. The base is slightly splintered and the tip is a little weathered. Compared to the points from Hohle Fels, the two specimens from Brillenhöhle are short and stocky (97 × 14 × 8 mm; 113 × 12 × 9 mm). Their shapes are cylindrical and slightly converging with round and oval cross-sections.

There are 20 basal fragments from Hohle Fels (n = 3), Geißenklösterle (n = 8) and Brillenhöhle (n = 9). All bases from Geißenklösterle, eight from Brillenhöhle, and one from Hohle Fels are made of mammoth ribs. Reindeer antler served as raw material for one point only from Hohle Fels and another from Brillenhöhle. Most bases are slightly splintered, and two bases from Geißenklösterle and Brillenhöhle carry parallel, transversal incisions. One ivory basal point fragment was found in layer IIb in Hohle Fels (130 × 45 mm; Hiller 2003:18). This artifact has an irregular shape with the lower part of the base showing a scraped surface, while the pointed distal part is polished. In this case, the polish and further smoothing was likely carried out after the mounting or wrapping. So far, this artefact is the only ivory point known from the Gravettian of the Swabian Jura.

Points with a Single Beveled Base

Two points with single-beveled bases derive from layer VII of Brillenhöhle (Riek 1973: Fig. 13.9 & 14.7). One specimen is near complete. Its tip is tapered - suggesting that it was reworked after breaking—and broken. The other piece is a basal fragment with no further features (Fig. 6.5: 8). The bone used as raw material could not be further identified as the specimen was not available for reanalysis (Barth 2007:81).

Hohle Fels produced a basal fragment from layer IIc manufactured from mammoth rib. This piece is flat and slightly bent with a concave surface showing many parallel incisions, partly overlying each other. Unfortunately, it is too fragmented to clearly identify if it is, in fact, a point with a single beveled base.

Points with Double Beveled Base

Two examples of this point type were recovered from the caves of the Ach Valley. One near complete specimen from layer VII of Brillenhöhle is made of antler, probably reindeer (Fig. 6.5: 7). Its tip is broken and slightly drawn-in at one edge, perhaps indicating reworking of the tip. The double beveled base is roughened with chatter marks on the flat surfaces as well as on one edge.

The second double beveled base point is a basal fragment made from a mammoth rib recovered from layer IIcf at Hohle Fels Cave. Parallel and oblique incisions are present on both sides of the base.

Point à Base Machonée

In layer IIc of Hohle Fels Cave there is one small point (66 × 6 × 4 mm) produced from bone of an unidentified bear- to horse-sized animal. The tip is splintered and the base is tapered by *raclage en diabolo* (Barth 2007:43). At Gravettian sites in France, this technique was used as a technique of debitage, as well as a technique for repairing broken projectile points, so-called points *à base machonée* (Goutas 2004:146 & 573ff.). The specimen from the Hohle Fels is maybe an example of this type of manufacturing or maintenance activity (Table 6.1).

Discussion

Altogether 88 projectile points are known from the Aurignacian and 30 date to the Gravettian. These artifacts are common owing to the long research history in the Swabian Jura, and the detailed excavation methods utilized. While a gapless stratigraphic transition from the Aurignacian to the Gravettian is well documented in the caves of the Ach Valley (especially at Geißenklösterle and Hohle Fels), the Lone Valley produced scarcely any archaeological remains from the Gravettian (though rich in the Aurignacian).

The large mammal composition is broadly similar during the Aurignacian and Gravettian (Münzel and Conard 2004a, b). The caves of the Swabian Jura have revealed typical species of the Mammoth-steppe environment, such as mammoth, woolly rhinoceros, wild horse and reindeer. There is, however, a difference in the number of cervid species between the two time periods. During the Aurignacian four different cervids were present in the Ach Valley, namely giant deer, red deer, roe deer and reindeer. Each of these cervids requires different nutritional needs and represents

Table 6.1 Total number of points and fragments of points of the Swabian Aurignacian and Gravettian

		Ach Valley				Lone Valley				
	Point type/ Site	Hohle Fels	Geißen-klösterle	Sirgenstein	Brillenhöhle	Vogelherd	Hohlenstein	Bockstein Cave	Bockstein-Törle	Total
Aurignacian	Massive base (bone)	1		1	1		2		2	7
	Massive base (ivory)	11	5			13				29
	Massive base (antler)	5				6				11
	Split-based (antler)	1	11		1	27		1		41
	Total	18	16	1	2	46	2	1	2	88
Gravettian	Massive base (bone)	3	8		10					21
	Massive base (ivory)	1								1
	Massive base (antler)	1			1					2
	Single beveled	1 ?			2					3
	Double beveled	1			1					2
	à base machonée	1								1
	Total	8	8	–	14	–	–	–	–	30

different ecological niches. During the Gravettian period, however, only reindeer and red deer remained. This seems to indicate a climatic deterioration from the Aurignacian to the Gravettian in connection with the upcoming Last Glacial Maximum. This shift is also reflected in the avifauna from Geißenklösterle (Krönneck 2009). For carnivores such a shift is not visible, since their diet is based on the presence of game. Species such as cave and brown bear, hyena, lion, wolf, red and arctic fox are continuously present throughout both cultural periods.

Species which provided raw material for organic points, such as mammoth and reindeer, are present in both techno-complexes, but show a considerable bias towards specific elements. Concerning the sites in the Ach Valley, mammoth is mainly represented by ribs and ivory, with hardly any long bones, short bones or molars found. Similarly, reindeer is mainly represented by antler and metatarsi, which are elements important for tool making. Interestingly, a considerable change in the raw material preferences is seen from the Aurignacian to the Gravettian, even if there is no obvious shortage of one of the species (Münzel 2001, 2004). During the Aurignacian, reindeer antler and mammoth ivory were favored for point production. The manufacturers exclusively used antler to produce split-base points while ivory was used for a wide variety of point types.

Ivory points appear with the beginning of the Aurignacian and are present until the Gravettian. Except for the Lautscher point, which is characteristic for the Aurignacian, the ivory points of the Swabian Jura, in general, are not diagnostic for chronological purposes. This situation contrasts with the split-base point which appears from the very beginning of the Aurignacian and lasts until its end in the Swabian Jura (Bolus and Conard 2006). For the Swabian Aurignacian in general, the split-base point is used as a *fossil directeur*. Organic projectile points were abundant during the Swabian Aurignacian, and bone, antler, and ivory were used in ways well suited to the different qualities of each material. The Aurignacian people were intimately familiar with the properties and characteristics of the materials and knew how best to exploit them.

In comparison with the Aurignacian, almost all points from the Gravettian were manufactured from ribs. These ribs were from large mammals, such as mammoths, mammoth-to rhino-size animals, or horse-sized animals. These points made of mammoth ribs are a characteristic feature of the Gravettian layers at Geißenklösterle, Hohle Fels Cave, and Brillenhöhle (Barth 2007), and demonstrate a change from the utilization of antler and ivory to that of mammoth raw material within the Early Upper Paleolithic. According to Knecht (1991:235) the distribution of these "mammoth rib

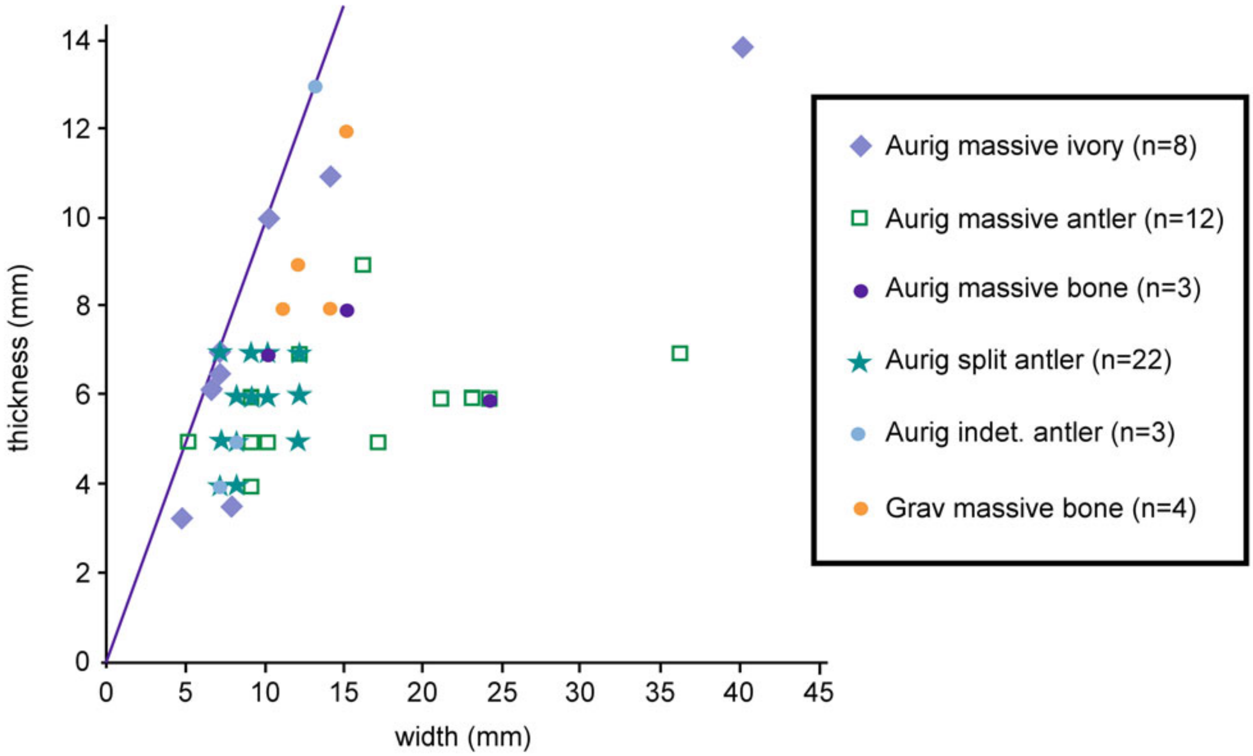

Fig. 6.7 Scatter plot of all complete or near complete point dimensions of the Swabian Aurignacian and Gravettian

points" is temporally and regionally limited to Gravettian sites in southern Germany. Mammoth ribs are of considerable size and the compact bone is thick enough to produce large projectile points. Shooting experiments demonstrate that bone points penetrate a carcass as deeply as do antler or ivory points (Knecht 1991:390), though their mechanical properties (hardness and brittleness) are less suitable for projectiles than antler and ivory.

Statistical analysis of the point dimensions found that split based points are best defined of all the Aurignacian and Gravettian osseous point types, owing to their tightly constrained dimensions (see Fig. 6.7 which only includes complete or almost complete specimens). This result, however, is not determined or dependent by the chosen raw material (antler), since thicker points were manufactured with massive bases from this same material in the Aurignacian. The ivory points from the Aurignacian have the largest dimensions (see the Lautscher point), especially in thickness, which is limited for antler but not for ivory. In the Gravettian there are not enough complete specimens to exactly define the group of "mammoth rib points" typical for southwest Germany (Knecht 1991). However, their width, thickness, and length are similar to those ivory points of the Aurignacian, and may replace them. The broader and flatter points with massive bases in the Aurignacian do not seem to have an analogous form in the Gravettian.

What happened during this transition from the Aurignacian to the Gravettian, and how do we explain this obvious change? Conard et al. (2004) postulated four different scenarios for the transition of the Aurignacian to the Gravettian in the Swabian Jura:

1. The local, gradual emergence of the new Gravettian material culture;
2. A fast development of the Gravettian *in situ*;
3. An extinction or migration of the Aurignacian people, followed by the arrival of the Gravettian people; or
4. A rapid adoption of the new artifact forms characteristic of the Gravettian from other regions with or without significant migration of people.

Based on the analysis of the lithic artifacts from Geißenklösterle and Brillenhöhle, Moreau argued for a regional development of the Gravettian out of the Aurignacian in the Swabian Jura (Conard and Moreau 2004; Moreau 2009, 2012). Bolus supports this hypothesis and states, based on the available lithic inventories, especially from

Geißenklösterle Cave, that the lithics indicate continuity or a slow transition of the Aurignacian forms to the forms of the Gravettian instead of a clear break between the two cultures (Moreau 2009; Bolus 2010; Moreau 2012).

Organic projectile points paint a different picture, however. We argue that, with respect to the organic artifacts, a clear break took place between the cultures. As mentioned above, there is no obvious lack of available animals during either time period. It is likely that a rapid cultural change took place around 30,000 uncalibrated radiocarbon years BP.

We cannot, however, totally exclude the possibility that limitations in raw material might have forced the Gravettian hunters to use mammoth ribs instead of antler or ivory for projectile points during that time (Barth et al. 2009). Rather than using ivory for projectiles, during the Gravettian it was used almost exclusively for personal ornaments during this period (Hiller 2003). Furthermore, the occurrence of mammoth in the Swabian Jura seems to diminish from the Aurignacian to the Gravettian and then again towards the Last Glacial Maximum (Barth et al. 2009), which may also help to explain this shift in raw materials. This is supported by Drucker's work with stable isotopes (^{13}C, ^{15}N). The typical ecological niche of mammoth with high $\delta^{15}N$ and low $\delta^{13}C$ values was gradually replaced during the Gravettian by horses in the Swabian Jura. This points to a deterioration of the living conditions for mammoth well before the Last Glacial Maximum (Drucker et al. 2015).

Furthermore, we know that at least two different systems of hunting weapons were present during both of these Upper Paleolithic periods: osseous points and lithic points. This is luckily reflected in a projectile point found embedded in the transversal process of a cave bear vertebra, recovered from the Gravettian layer IIc in Hohle Fels (Münzel et al. 2001; Münzel and Conard 2004b). This hunting lesion was caused by a triangular flint tip. With a length of 5 mm and a width and thickness of 2 mm, this would have been a remarkably small projectile with which to hunt a cave bear. The use of bow and arrow has not yet been documented in the Aurignacian or the Gravettian period. Because of this we assume that the weapon used in this case was a spear or a lance with a hafted flint tip, since osseous points with grooves or notches for inserting lithics are not known for this period. Furthermore, we know from experimental work with organic projectile points, that impacts of either lithic or osseous points are rarely distinguishable in bone (Letourneux and Pétillon 2008), and thus, leave little clearly identifiable damage on carcasses. This latter situation does not allow us to be able to clearly identify which prey was hunted with the osseous points.

To conclude, this chapter presented an overview of all osseous points from the Aurignacian and Gravettian of the Swabian Jura. It is obvious, especially at Hohle Fels, Geißenklösterle and Vogelherd, that these exceptionally rich sites allow a glimpse into the daily life of the first anatomically modern humans in Central Europe. The sites of the Ach Valley also provide a very good record of the transition from the Aurignacian to the Gravettian and the evolution of the Gravettian technology. Thus, even in this relatively small assemblage of projectile points from the Swabian Jura, a technological change in osseous weaponry technology and systems is well documented.

Acknowledgements We would like to thank Michelle Langley for inviting us to contribute to this volume, as well as two anonymous reviewers for their comments and suggestions on the draft of this manuscript.

References

Albrecht, G. (1977). Testing of materials as used for bone points of the Upper Palaeolithic. In H. Camps-Fabrer (Ed.), *Méthodologie appliquée à l'industrie de l'os préhistorique* (pp. 119–124). Paris: Colloques Internationaux du C.N.R.S. No. 568.

Albrecht, G., Hahn, J., & Torke, W. G. (1972). *Merkmalanalyse von Geschoßspitzen des mittleren Jungpleistozäns in Mittel- und Osteuropa*. Mainz, Germany: Verlag W. Kohlhammer GmbH.

Barth, M. (2007). *Familienbande? Die gravettienzeitlichen Knochen- und Geweihgeräte des Achtals (Schwäbische Alb)*. Rahden, Germany: Verlag Marie Leidorf GmbH.

Barth, M., Conard, N. J., & Münzel, S. (2009). Palaeolithic subsistence and organic technology in the Swabian Jura. In L. Fontana, F.-X. Chauvière, & A. Bridault (Eds.), *In search of total animal exploitation. Case studies from the Upper Palaeolithic and Mesolithic. Proceedings of the XVth UISPP Congress, Session C61, vol. 42, Lisbon, 4.-9- September 2006* (pp. 5–20). Oxford, England: BAR International Series.

Beutelspacher, T., Ebinger-Rist, N., & Kind, C. -J. (2011). Neue Funde aus der Stadelhöhle im Hohlenstein bei Asselfingen. In *Archäologische Ausgrabungen in Baden-Württemberg 2010* (pp. 65–70). Stuttgart, Germany: Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart.

Beutelspacher, T., & Kind, C.-J. (2012). Auf der Suche nach Fragmenten des Löwenmenschen in der Stadelhöhle im Hohlenstein bei Asselfingen. In *Archäologische Ausgrabungen in Baden-Württemberg 2011* (pp. 66–70). Stuttgart, Germany: Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart.

Blumentritt, R., & Hahn, J. (1991). Der Hohle Fels. In *Schelklinger Archäologischer Führer 1*. Schelklingen, Germany: Museumsgesellschaft Schelklingen, Heimatverein e.V.

Bolus, M. (2010). Continuity or Hiatus? The Swabian Aurignacian and the Transition to the Gravettian. In C. Neugebauer-Maresch & L.R. Owen (Eds.), *New aspects of the Central and Eastern European Upper Palaeolithic – Methods, chronology, technology and subsistence. Symposium by the Prehistoric Commission of the Austrian Academy of Sciences. Vienna, November 9–11, 2005* (pp. 139–150). Wien: Verlag der Österreichischen Akademie der Wissenschaften.

Bolus, M., & Conard, N. J. (2006). Zur Zeitstellung von Geschossspitzen aus organischen Materialien im späten Mittelpaläolithikum und Aurignacien. *Archäologisches Korrespondenzblatt, 36*, 1–15.

Bonnichsen, R. (1979). *Pleistocene bone technology in the Beringian refugium* (Mercury Series: Archaeology Survey of Canada Paper No. 89). Ottawa, ON, Canada: National Museum of Man.

Christensen, M. (1999). *Technologie de l´ivoire au Paléolithique supérieur* (BAR International Series 751). Oxford, England: Oxford University Press.

Conard, N. J. (2009). A female figurine from the basal Aurignacian of Hohle Fels Cave of southwestern Germany. *Nature, 459*, 248–252.

Conard, N. J., & Bolus, M. (2003). Radiocarbon dating the appearance of modern humans and timing of cultural innovations in Europe: New results and new challenges. *Journal of Human Evolution, 44*, 331–371.

Conard, N. J., & Bolus, M. (2006). The Swabian Aurignacian and its place in European prehistory. In O. Bar-Yosef & J. Zilhão (Eds.), *Towards a definition of the Aurignacian* (pp. 211–239). Trabalhos de Arqueologia 45. Lisbon, Portugal: Instituto Português de Arqueologia.

Conard, N. J., & Bolus, M. (2008). Radiocarbon dating the late Middle Palaeolithic and the Aurignacian of the Swabian Jura. *Journal of Human Evolution, 55*, 886–897.

Conard, N. J., Langguth, K., & Uerpmann, H. -P. (2000). Die Grabungen 1999 in den Gravettien-Schichten des "Hohle Fels" bei Schelklingen, Alb-Donau-Kreis. In *Archäologische Ausgrabungen in Baden-Württemberg 1999* (pp. 21–25). Stuttgart, Germany: Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart.

Conard, N. J., Langguth, K., & Uerpmann, H.-P. (2003). Einmalige Funde aus dem Aurignacien und erste Belege für ein Mittelpaläolithikum im Hohle Fels bei Schelklingen, Alb-Donau-Kreis. In *Archäologische Ausgrabungen in Baden-Württemberg 2002* (pp. 21–28). Stuttgart: Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart.

Conard, N. -J., Langguth, K., & Uerpmann, H. -P. (2004). Die Ausgrabungen 2003 in den Gravettien- und Aurignacien-Schichten des Hohle Fels bei Schelklingen, Alb-Donau-Kreis, und die kulturelle Entwicklung im frühen Jungpaläolithikum. In *Archäologische Ausgrabungen in Baden-Württemberg 2003* (pp. 17–22). Stuttgart, Germany: Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart.

Conard, N. J., Lingnau, M., & Malina, M. (2007). Einmalige Funde durch die Nachgrabung am Vogelherd bei Niederstotzingen-Stetten ob Lonetal, Kreis Heidenheim. In *Archäologische Ausgrabungen in Baden-Württemberg 2006* (pp. 20–24). Stuttgart, Germany: Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart.

Conard, N. J., & Malina, M. (2002). Neue Ausgrabungen in den untersten Schichten des Aurignacien und des Mittelpaläolithikums im Geißenklösterle bei Blaubeuren, Alb-Donau-Kreis. In *Archäologische Ausgrabungen in Baden-Württemberg 2001* (pp. 16–21). Stuttgart, Germany: Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart.

Conard, N. J., & Malina, M. (2003). Abschließende Ausgrabungen im Geißenklösterle bei Blaubeuren, Alb-Donau-Kreis. In *Archäologische Ausgrabungen in Baden-Württemberg 2002* (pp. 17–21). Stuttgart, Germany: Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart.

Conard, N. J. & Malina, M. (2006). Neue Ergebnisse zum Mittelpaläolithikum, zum Aurignacien und zu den letzten Neandertalern am Hohle Fels bei Schelklingen, Alb-Donau-Kreis. In *Archäologische Ausgrabungen in Baden-Württemberg 2005* (pp. 17–21). Stuttgart: Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart.

Conard, N. J. & Malina, M. (2007). Die Ausgrabungen am Hohle Fels bei Schelklingen, Alb-Donau-Kreis. In *Archäologische Ausgrabungen in Baden-Württemberg 2006* (pp. 17–20). Stuttgart: Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart.

Conard, N. J. & Malina, M. (2009). Spektakuläre Funde aus dem unteren Aurignacien vom Hohle Fels bei Schelklingen, Alb-Donau-Kreis. In *Archäologische Ausgrabungen in Baden-Württemberg 2008* (pp. 19–23). Stuttgart: Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart.

Conard, N. J., Malina, M., & Zeidi Kulehparcheh, M. (2010). Neue Kunst und erste Einblicke in ungestörte Schichten am Vogelherd. In *Archäologische Ausgrabungen in Baden-Württemberg 2009* (pp. 57–61). Stuttgart, Germany: Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart.

Conard, N. J., & Moreau, L. (2004). Current research of the Gravettian of the Swabian Jura. *Mitteilungen der Gesellschaft für Urgeschichte, 13*, 29–59.

Conneller, C. (2011). *An archaeology of materials. Substantial transformations in early prehistoric Europe*. New York: Routledge.

Dotzel, K. (2011). *Bone and antler technology at Vogelherd Cave: An investigation into aurignacian lives*. Master dissertation, Eberhard Karls Universität Tübingen.

Dotzel, K., Bolus, M., & Conard, N. J. (in prep.). Aurignacian Bone and Antler Projectiles from the Swabian Jura, Germany.

Drucker, D. G., Vercoutère, C., Chiotti, L., Nespoulet, R., Crépin, L., Conard, N. J., Münzel, S. C., Higham, T., van der Plicht, J., Lázničková-Galetová, M., Bocherens, H., Dobosi, V. T., Hannus, A., Johnson, E., Münzel, S. C., Scheer, A., & Villa, P. (2015). Tracking possible decline of woolly mammoth during the Gravettian in Dordogne (France) and the Ach Valley (Germany) using multi-isotope tracking (13C, 14C, 15N, 34S, 18O). *Quaternary International, 359–360*, 304–317.

Gaudzinski, S. (1998). Vorbericht über die taphonomischen Arbeiten zu Knochengeräten und zum faunistischen Material der mittelpaläolithischen Freilandfundstelle Salzgitter Lebenstedt. *Archäologisches Korrespondenzblatt, 28*, 323–337.

Gaudzinski, S., Turner, E., Anzidei, A. P., Àlverez-Fernández, E., Arroyo-Cabrales, J., Cinq-Mars, J., (2005). The use of Proboscidean remains in every-day Palaeolithic life. In G. Cavarretta, P. Gioia, M. Mussi, & M. R. Palombo (Eds.), *The world of elephants. Proceedings of the 1st International Congress, Consiglio Nazionale delle Ricerche, Rome 16–20 October* (pp. 179–194) Rom: CNR.

Goutas, N. (2004). *Caractérisation et évolution du Gravettien en France par l'approche techno-économique des industries en matièresdures animales (étude de six gisements du Sudouest).* Thèse du doctorat, Université de Paris I, Panthéon-Sorbonne.

Guthrie, R.D. (1983). Osseous projectile points: biological considerations affecting raw material selection and design among Paleolithic and Paleoindian peoples. In J. Clutton-Brock and C. Grigson (Eds.), *Animals and archaeology 1: Hunters and their prey. British Archaeological Reports International Series 163* (pp. 273–294). Oxford: Archaeopress.

Hahn, J. (1988). *Die Geißenklösterle-Höhle im Achtal bei Blaubeuren I. Fundhorizontbildung und Besiedlung im Mittelpaläolithikum und im Aurignacien*. Stuttgart, Germany: Konrad Theiss Verlag.

Hahn, J. (1989). Neue Grabungen im Hohlen Felsen bei Schelklingen, Alb-Donau-Kreis. In *Archäologische Ausgrabungen in Baden-Württemberg 1988* (pp. 20–22). Stuttgart, Germany: Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart.

Henri-Martin, L. (1931). *La station Aurignacienne de La Quina*. Angoulême, France: Impr. Ouvrière.

Higham, T., Basell, L., Jacobi, R., Wood, R., Bronk Ramsey, C., & Conard, N. J. (2012). Testing models for the beginnings of the Aurignacian and the advent of figurative art and music: The radiocarbon chronology of Geißenklösterle. *Journal of Human Evolution, 62*(6), 664–676.

Hiller, B. (2003). Die Nutzung von Elfenbein im Jungpaläolithikum des Hohle Fels bei Schelklingen. *Mitteilungen der Gesellschaft für Urgeschichte, 12*, 7–23.

Hofreiter, M., & Pacher, M. (2004). Using ancient DNA to elucidate raw material origin of bone points from Potočka zijalka (Slovenia): Preliminary results. In M. Pacher, V. Pohar & G. Rabeder (Eds.), *Potočka zijalka – Paleontologicla nad archaeological results of the campaigns 1997–2000* (pp. 201–210). Mitteilungen der Kommission für Quartärforschung der Österreichischen Akademie der Wissenschaften 13.

Khlopachev, G. A., & Girya, E. Y. (2010). *Secrets of ancient carvers of Eastern Europe and Siberia: Treatment techniques of ivory and reindeer antler in the Stone Age*. Naukaa, Russia: Sankt Petersburg.

Kind, C.-J., & Beutelspacher, T. (2010). Ausgrabungen 2009 im Stadel am Hohlenstein im Lonetal. In *Archäologische Ausgrabungen in Baden-Württemberg 2009* (pp. 62–69). Stuttgart, Germany: Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart.

Kind, C.-J., Ebinger-Rist, N., Wolf, S., Beutelspacher, T., & Wehrberger, K. (2014). The Smile of the Lion Man. Recent Excavations in Stadel Cave (Baden-Württemberg, Southwest Germany) and the Restoration of the Famous Upper Palaeolithic Figurine. *Quartär, 61*, 129–145.

Knecht, H. (1990). *Technological innovations and design during the early Upper Paleolithic. A study of organic projectile technologies*. Ph.D. thesis, New York University.

Knecht, H. (1991). Projectile points of bone, antler and stone. Experimental explorations of manufacture and use. In H. Knecht (Ed.), *Projectile technology* (pp. 191–212). New York: Plenum Press.

Krönneck, P. (2009). Vögel – Bonusmaterial in der Archäozoologie. In: R. de Beauclair, S. C. Münzel, & H. Napierala (Eds.), *Knochen Pflastern ihren Weg. Festschrift für Margarethe und Hans-Peter Uerpmann*. BioArchaeologica 5. Rahden, Germany: Marie Leidorf.

Krönneck, P. (2012). *Die pleistozäne Makrofauna des Bocksteins (Lonetal – Schwäbische Alb). Ein neuer Ansatz zur Rekonstruktion der Paläoumwelt*. Tübingen, Germany: Universitätsbibliothek: https://tue.ibsbw.de/aDISWeb/app?service=direct/0/Home/$DirectLink&sp=S127.0.0.1:23022&sp=SAKSWB-IdNr367463628

Letourneux, C., & Pétillon, J. M. (2008). Hunting lesions caused by osseous projectile points: Experimental results and implications for the Upper Palaeolithic. *Journal of Archaeological Science, 35*, 2849–2862.

Liolios, D. (1999). *Variabilite et Characteristiques du travail de matières osseuses au debut de l'Aurignacien: Approche technologique et economique*. Thèse de doctorat, Université de Paris X.

Locke, M. (2008). Structure of Ivory. *Journal of Morphology, 269*, 423–450.

Moreau, L. (2009). *Geißenklösterle. Das Gravettien der Schwäbischen Alb im europäischen Kontext*. Tübingen, Germany: Kerns Verlag.

Moreau, L. (2012). Le Gravettien ancien d'Europe central revisité: Mise au point et perspectives. *L'Anthropologie, 116*, 609–638.

Münzel, S. C. (2001). The production of Upper Palaeolithic mammoth bone artifacts from southwestern Germany. In G. Cavarretta, P. Gioia, M. Mussi, & M.R. Palombo (Eds.), *The world of elephants. Proceedings of the 1st International Congress, Consiglio Nazionale delle Ricerche, Rome 16–20 October* (pp. 448–454). Rom: CNR.

Münzel, S. C. (2004). Subsistence patterns in the Gravettian of the Ach valley, a former tributary of the Danube in the Swabian Jura. In J. A. Svoboda & L. Sedláčková (Eds.), *The Gravettian along the Danube. Proceedings of the Mikulov conference, 20.–21. November 2002, Institute of Archaeology, AS CR, Brno* (pp. 71–85). Dolni Vestonice Studies 11.

Münzel, S. C. (2005). 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. In D. Vialou, J. Renault-Miskovsky, & M. Patou-Mathis (Eds.), *Comportements des hommes du Paléolithique moyen et supérieur en Europe: Territoires et milieux* (pp. 39–49) Liège, Belgium: Eraul 111.

Münzel, S. C., & Conard, N. J. (2004a). Change and Continuity in Subsistence during the Middle and Upper Palaeolithic in the Ach Valley of Swabia (South-west Germany). *International Journal of Osteoarchaeology, 14*, 225–243.

Münzel, S. C., & Conard, N. J. (2004b). Cave Bear Hunting in the Hohle Fels, a Cave Site in the Ach Valley, Swabian Jura. *Revue de Paléobiologie, 23*(2), 877–885.

Münzel, S. C., Langguth, K., Conard, N. J., & Uerpmann, H. P. (2001). Höhlenbärenjagd auf der Schwäbischen Alb vor 30.000 Jahren. *Archäologisches Korrespondenzblatt, 31*(3), 317–328.

Newcomer, M. (1977). Experiments in Upper Palaeolithic Bone Work. In H. Camps-Fabrer (Ed.), *Methodologie appliqué et à l'industrie de l'os préhistorique* (pp. 293–302). Paris: CNRS.

Niven, L. (2006). *The Palaeolithic occupation of Vogelherd Cave. Implications for the subsistence behavior of late Neanderthals and early modern humans*. Tübingen, Germany: Kerns Verlag.

Owen, L. (2005). *Distorting the past. Gender and the division of labor in the European Upper Palaeolithic*. Tübingen, Germany: Kerns Verlag.

Peyrony, D. (1935). Le gisement de Castanet, vallon de Castelmerle, commune de Sergeac (Dordogne). *Bulletin de la Société Préhistorique Française, 32*, 418–443.

Richter, D., Waiblinger, J., Rink, W. K., & Wagner, G. A. (2000). Thermoluminescence, electron spin resonance and ^{14}C-dating of the late Middle and Early Upper Palaeolithic site of Geißenklösterle Cave in Southern Germany. *Journal of Archaeological Science, 27*, 71–89.

Riek, G. (1934). *Die Eiszeitjägerstation am Vogelherd im Lonetal*. Tübingen, Germany: Heine Verlag.

Riek, G. (1973). *Das Paläolithikum der Brillenhöhle bei Blaubeuren (Schwäbische Alb). Mit einem Beitrag von Wilhelm Gieseler and Alfred Czarnetzki. Teil 1*. Stuttgart, Germany: Verlag Müller & Gräff.

Schmid, E. (1989). Die altsteinzeitliche Elfenbeinstatuette aus der Höhle Stadel im Hohlenstein bei Asselfingen, Alb-Donau-Kreis. *Fundberichte aus Baden-Württemberg 14* (pp. 33–96). Stuttgart, Germany: Landesamt für Denkmalpflege im Regierungspräsidium.

Schmidt, R. R. (1907). Der Sirgenstein und die eiszeitlichen Kulturepochen Schwabens. *Fundberichte aus Schwaben, 15*, 2–7.

Schmidt, R. R. (1912). *Die diluviale Vorzeit Deutschlands. Mit Beiträgen von E. Koken und A. Schliz*. Stuttgart, Germany: E. Schweizerbartsche Verlagsbuchhandlung.

Semenov, S. A. (1957). *Prehistoric Technology. An experimental study of the oldest Tools and Artefacts from traces of Manufacture and Wear*. Russland 1957, 1964, 1. Englische Auflage, 1970, 2. Englische Auflage. Bath, England: Adams & Dart.

Tartar, E., & White, R. (2013). The manufacture of Aurignacian split-based points: An experimental challenge. *Journal of Archaeological Science, 40*(6), 2723–2745.

Tejero, J.-M. (2016). Spanish Aurignacian Projectile Points: An Example of the First European Palaeolithic Hunting Weapons in Osseous Materials. In M.C. Langley (Ed.), *Osseous projectile weaponry: Towards an understanding of Pleistocene cultural variability* (pp. 55–69). Dordrecht: Springer.

Teyssandier, N. & Liolios, D. (2003) Defining the earliest Aurignacian in the Swabian Alb: The relevance of the technological study of the Geissenklösterle (Baden-Württemberg, Germany) lithic and organcic production. In J. Zilhão & F. d'Errico (Eds.), *The chronology of the Aurignacian and the transitional technocomplexes. Dating, stratigraphies, cultural implications* (pp. 179–196). Lisbon, Portugal: Trabalhos de Arqueologia 33.

Wagner, E. (1983). *Das Mittelpaläolithikum der großen Grotte bei Blaubeuren (Alb-Donau-Kreis). Forschungen und berichte zur vor- und frühgeschichte Baden-Württembergs 16*. Stuttgart, Germany: Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart.

Wetzel, R. (1954). Das Törle an der alten Bocksteinschmiede. *Mitteilungen des Vereins für Naturwissenschaft und Mathematik in Ulm, Heft, 24*, 3–20.

Wetzel, R. (1958). *Die Bocksteinschmiede mit dem Bocksteinloch, der Brandplatte und dem Abhang sowie der Bocksteingrotte. Ein Beitrag zur europäischen Urgeschichte des Lonetals und zur geschichtlichen Morphologie des Menschen. Mit eigener Bearbeitung besonderer Sachgebiete durch P. Filzer, U. Lehmann, R. Mosebach and E. Schmid. Teil I*. Stuttgart, Germany: Kohlhammer.

Wetzel, R. (1961). Der Hohlestein im Lonetal. *Mitteilungen des Vereins für Naturwissenschaften und Mathematik in Ulm (Donau), 26*, 21–75.

Wetzel, R., & Bosinski, G. (1969). *Die Bocksteinschmiede im Lonetal (Markung Rammingen, Kreis Ulm)*. Veröffentlichungen des Staatlichen Amtes für Denkmalpflege Stuttgart, Reihe A, Heft 15.

Wolf, S. (2015). *Schmuckstücke – Die Elfenbeinbearbeitung im Schwäbischen Aurignacien*. Tübingen: Kerns Verlag, Germany.