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Design Strategies of Early Upper Paleolithic Bone and Antler Projectile Technologies

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1. Introduction

Results of a study of around 700 Early Upper Paleolithic bone and antler projectile points from sites in France, Belgium and Germany indicate that Early Upper Paleolithic (EUP) projectile technologies differ over time in technique of manufacture, morphology, hafting and performance. The design of all EUP bone and antler projectile points was, of course, concerned with the efficient performance of these objects as the armatures of projectile weapons. However, there is a great deal of variation among the solution chosen in the design of different types of bone and antler projectile points.

From the outset, with the selection of the raw material of manufacture, the prehistoric artisan opted for a particular design strategy as the solution to the problem of the production of an efficient hunting weapon. Contemporary design standards dictated the final morphology of the projectile point. The hafting mechanism used was determined by the prevailing approach to tool design, manufacture and use. While different strategies of design, manufacture and performance were emphasized throughout the EUP, an efficient hunting weapon was always produced. The changes evident in the design of projectile points over time represent different technological approaches to the production and use of the weapons.

2. Methods

2.1. Technique of manufacture

Raw material selected for production, manufacture waste, pieces at various stages of completion, and micro- and macroscopic manufacturing stigmata on completed projectile points provided clues to the sequence of production. The hypothesized manufacturing strategies were tested through experimental replication of the projectile points.

2.2. Morphology

Variations and discontinuities in the morphology of the bone and antler projectile points were explored through analysis of nominal and ratio scale variables. Patterning was elicited through basic statistical manipulations of both metric dimensions and geometric forms.

2.3. Hafting

The hypothesized systems of hafting the different projectile points were primarily suggested by (1) the morphology of the proximal ends of the projectile points; (2) additional technological elements associated with the projectile points in archaeological assemblages; and (3) ethnographic and modern hafting technologies.

2.4. Performance

The discussion of the use and performance of Early Upper Paleolithic bone and antler projectiles is based upon the results of a series of preliminary experiments conducted during May, 1990, in conjunction with the program of *Technologie fonctionelle des pointes de projectiles préhistoriques* (TFPPP). Bone and antler projectile points, identical in size and form to particular Paleolithic specimens, were attached to wood handles. These spears were launched with a calibrated crossbow into goat cadavers suspended in anatomical position. Velocity of the projectile, location of contact, depth of penetration, and any damage to the projectile were noted.

3. Split based points

On the basis of their abundance in level F of La Ferrassie, Peyrony (1934) designated split based points as the index fossil of his Aurignacian I. More recent research indicates that split based points do seem to be limited to the earlier portions of the Aurignacian

(Albrecht, Hahn & Torke, 1972; Hahn, 1988b; Leroy-Prost, 1975; 1979).

3.1. Technique of manufacture

Contrary to their designation as split based bone points in much of the archaeological literature, split based points were virtually always manufactured of antler (table 1). Peyrony (1928) reconstructed the process of manufacture of split bases as involving the removal of a tongued piece from between the two "wings" of the split (fig. 1). However, observation of Aurignacian split based points and experimental production of split bases demonstrate that the split was manufactured by simple cleavage of the antler (Knecht, 1991).

Antler	372
Antler (?)	2
Antler/Bone	7
Bone	1

Table 1 — Raw material of split based points.

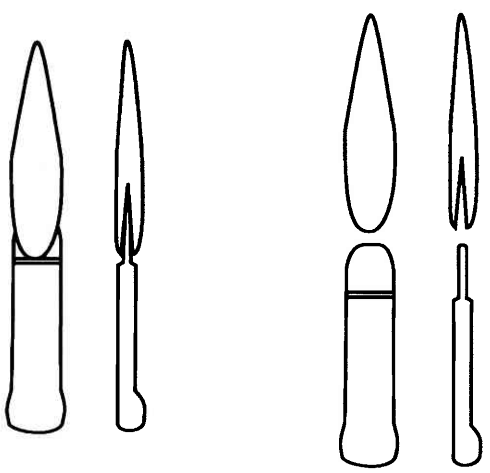

Fig. 1 — Split based point manufacture according to Peyrony (1928).

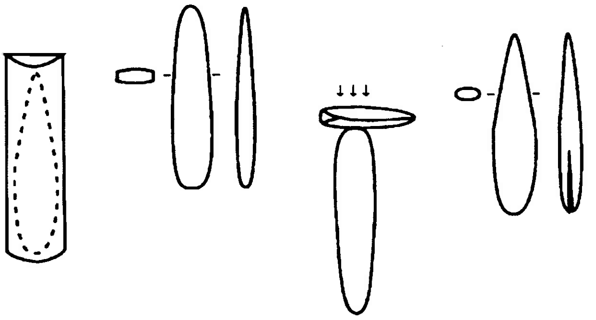

Fig. 2 — Manufacture of split based point.

Split based points were manufactured from semi-cylindrical segments of antler (fig. 2). The projectile point blank was shaped primarily by removal of material from the lateral edges and the inferior surface. Observation of unfinished split based points indicates the split was produced after only preliminary shaping of the piece. Once a successful split was obtained, the final shaping of the piece, including shaping of the distal point, was achieved by additional removal of material from the surfaces and lateral edges.

3.2. Morphology

There is a high degree of patterning in split based point size. All dimensions have normal distributions. The lengths of the 114 whole split based points studied range from 29 to 178 mm (fig. 3). The maximum widths of the split based points (n = 252) range from 6 to 43 mm (fig. 4).

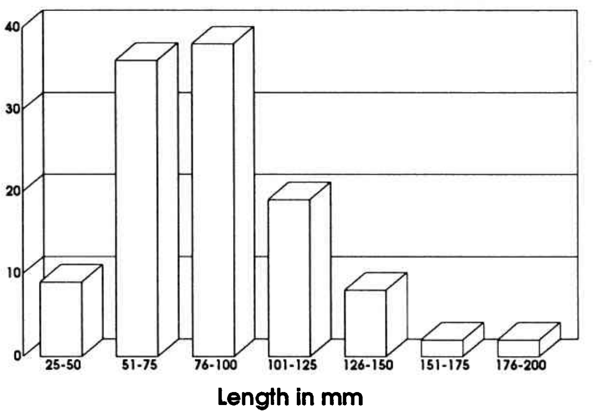

Fig. 3 — Split based point lengths.

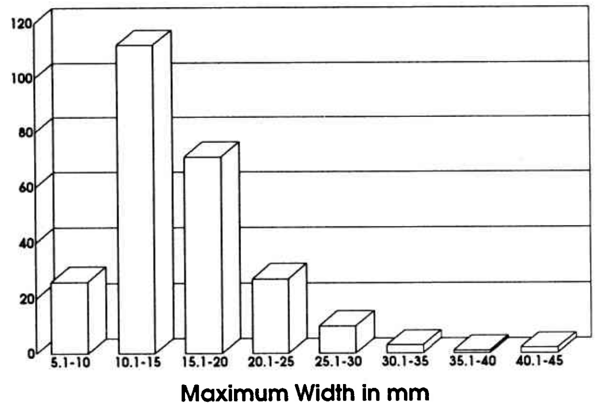

Fig. 4 — Maximum widths of split based points.

3.3. Hafting

An association between tongued pieces (*pièces à languette*) and split based points has long been recognized. Since Peyrony's (1928) suggestion that tongued pieces are by-products generated during the fabrication of split based points, this explanation of their association has been accepted (see fig. 1).

While studying the split based points and tongued pieces from Abri Castanet in the collections of the *Musée National de la Préhistoire* at Les Eyzies, 27 pieces which appeared to be negative removals from tongued pieces were found. Observations of these small rectangular pieces and numerous tongued pieces from sites throughout France has allowed for the delineation of the sequence of manufacture of tongued pieces. Examples of each stage of this sequence of production have been observed among archaeological assemblages (fig. 5).

1. A parallel-sided blank was shaped from a semi-cylindrical segment of antler. The proximal end was left unworked.
2. Perpendicular incisions were made across both the inferior and superior faces of the blank.
3. Flat rectangular pieces were removed from the distal end of the blank by splitting or cleavage.

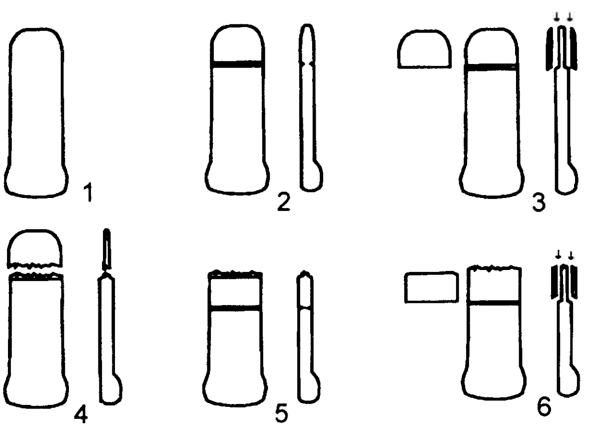

Fig. 5 — Manufacture of tongued piece and wedges.

Two small wedges and one tongued piece resulted from this procedure. The tongued piece was then used as the source of additional wedges:

4. First, the tongue was snapped off of the tongued piece.
5. Then perpendicular incisions were again made across both faces of the tongued piece.
6. Two small wedges were once again split off producing a new tongue.

The entire process could be repeated until all that remained of the tongued piece was the unworked proximal portion and a small remnant of the worked blank.

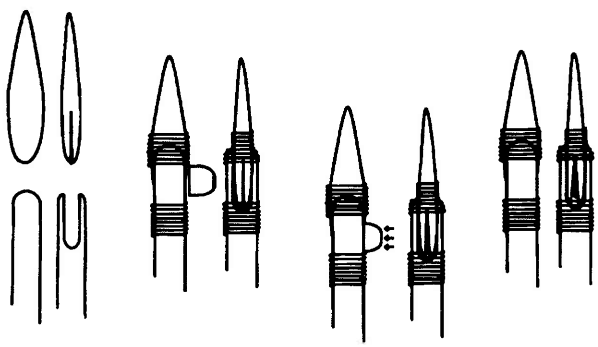

Fig. 6 — Hafting a split based point.

Experimentation supports the probability that these small wedges were used in hafting split based points (fig. 6). It is likely that split based points were attached to shafts by use of a wedging mechanism. When antler is split by cleavage, the split remains closed. For the experimental reconstructions, the distal end of a wood spear shaft was whittled out to form a U-shaped housing for the proximal end of the split based point. The split base point was inserted into the handle and held in place by a ligature. When the ligature was wrapped around the point, an opening was left so that the split was accessible. Once the point was bound to the shaft, a small wedge like those removed from tongued pieces was inserted into the split by gentle tapping. The wedge forced open the split until the wings of the base pressed firmly against the inside of the housing in the wood shaft.

3.4. Performance

During experimentation, spears armed with split based points penetrated the hide and soft tissue of the animal with no damage to the point or the haft regardless of the size or form of the point. When a point was projected into bone, its penetration was halted, but the point and haft usually remained intact.

4. Aurignacian points with simple bases

Subsequent to the Early Aurignacian, projectile points with simple bases (Hahn, 1988a) appear in the archaeological record. Peyrony (1934) divided Aurignacian points with simple bases into three morphological categories, *pointes losangiques, pointes à section ovale* and *pointes biconiques*, which he viewed as chronological indicators of his Aurignacian phases. While overlap in the sequence of appearance of the "types" defined by Peyrony at La Ferrassie has been demonstrated (Leroy-Prost, 1979), from a technological point of view, losange-shaped and spindle-shaped projectile points are clearly distinguishable. Because a new technology is designed and even implemented does not necessarily dictate that the existent technology, will be immediately replaced (Schiffer & Skibo, 1987).

Losange-shaped points (*sagaies losangiques*) narrow both proximally and distally from a maximum width that is situated at or around the midpoint of the piece. Their width is considerably greater than their thickness; i.e., they are flatter than they are wide. Like losange-shaped points, spindle-shaped points (*sagaies fusiformes*) have their maximum width situated near the midpoint of the length of the piece. However, their thickness is nearly equal to their width i.e., they are subcircular or even circular in cross-section.

4.1. Technique of manufacture

Both losange-shaped and spindle-shaped points were usually manufactured of antler (table 2). There does not seem to be any inherent mechanical explanation for the selection of antler over bone for the raw material of production of points with simple bases. It is likely that if size were an important characteristic, compact bone with the desired thickness along sufficient lengths may not have been available. Even though large mammals, such as horse, reindeer and red deer were hunted, Delpech and Rigaud (1974) have demonstrated the extreme fragmentation of long bones resulting from food preparation processes.

Losange-shaped points were manufactured from semi-cylindrical segments of antler (fig. 7), i.e., a fragment of antler cut in half along its length. The antler semi-cylinder was reduced to its final form by whittling, shaving and scraping. The curvature of the diameter of the antler to some degree dictated the form of the cross-section of the point; some portion of the exterior surface of the antler is still visible on extensive portions of the surface of most losange-shaped points.

	Losange	Spindle
Antler	103	31
Antler (?)	2	0
Antler/Bone	1	2
Ivory	1	1

Table 2 — Raw material of points with simple bases.

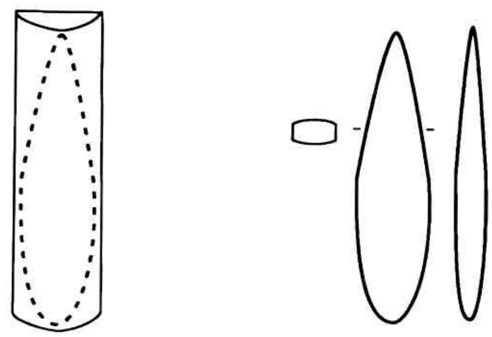

Fig. 7 — Manufacture of losange-shaped point.

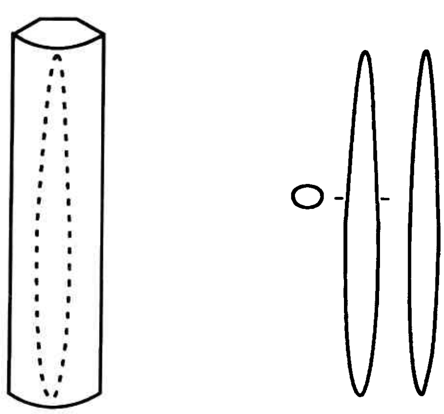

Fig. 8 — Manufacture of spindle-shaped point.

Spindle-shaped points were manufactured from a segment of antler sectioned along its length (fig. 8). The cross-section of the antler blank was probably dependent upon the diameter and cross-section of the antler and the relative proportion of compact to cancellous material. Analysis of manufacturing stigmata indicates the blank was shaped by longitudinal scraping. Unlike losange-shaped points, material was removed from all surfaces. It seems that spindle-shaped points were manufactured "in-the-round"; the flat lateral edges so clearly visible on many losange-shaped points are never seen on spindle-shaped points.

4.2. Morphology

The dimensions of both losange- and spindle-shaped points are normally distributed. However, spindle-shaped projectile points are, on average, shorter and narrower than losange-shaped points. The lengths of most of the whole spindle-shaped points (n = 14) in the study sample tightly cluster between 76 mm and 125 mm, while the lengths of most of the whole losange-shaped points (n = 19) are between 126 and 150 mm (fig. 9).

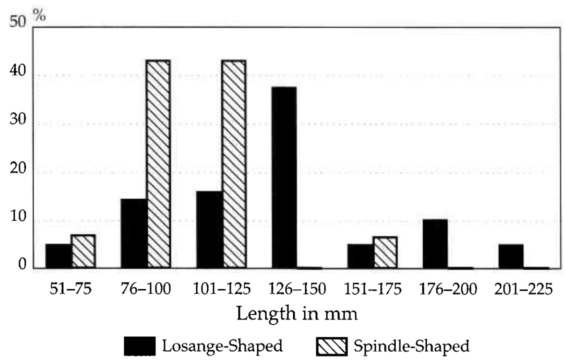

Fig. 9 — Losange- and spindle-shaped point lengths.

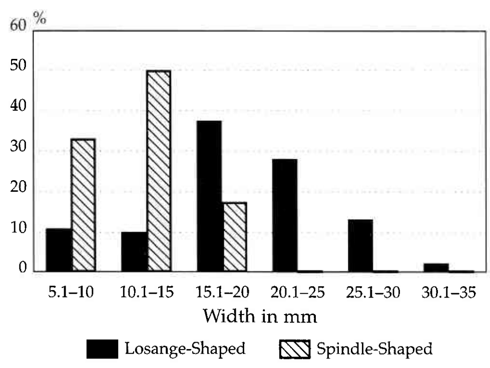

Fig. 10 — Maximum widths of losange- and spindle-shaped points.

The maximum widths of the spindle-shaped points (n = 30) are normally distributed between 7 mm and 19 mm, while the distribution of the maximum widths of the losange-shaped points (n = 101) peaks between 15 and 20 mm, but extends to as high as 33 mm (fig. 10). The differences in size between losange- and spindle-shaped points may be related to differences along the production trajectory as well as to differential selection for particular features affecting hafting and / or performance.

4.3. Hafting

The basal thinning of Aurignacian points with simple bases clearly allows for their insertion into a shaft. Experimentation has demonstrated at least two possible hafting strategies:

a. (fig. 11) The points may have been set into a U-shaped housing whittled out of the distal end of a wood shaft. During experimentation, the attachment was further stabilized by insertion of the nubby proximal end of the point into a socket at the bottom of the housing. Application of resin strengthened the attachment. Experimentation has shown that resin alone is insufficient for maintenance of the attachment upon impact with a hunted animal; it is necessary to fasten the point to the shaft with some form of ligature.

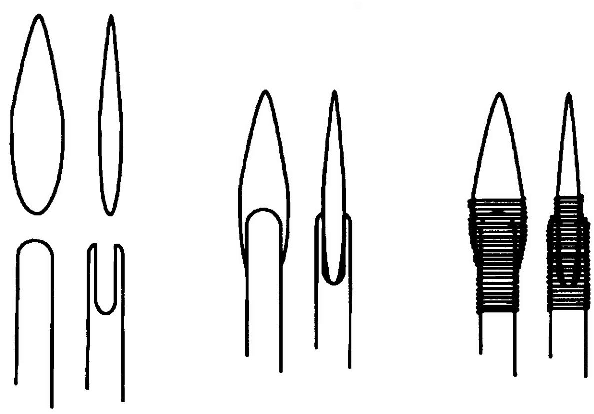

Fig. 11 — Hafting a losange-shaped point.

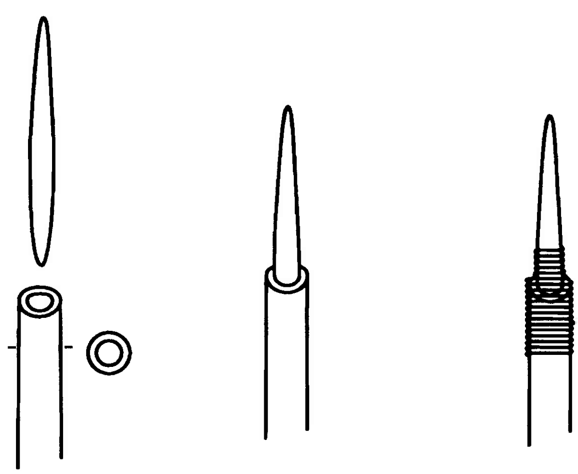

Fig. 12 — Hafting a spindle-shaped point.

b. (fig. 12). It is possible that the nearly round spindle-shaped points were inserted into a socket in the distal end of a spear shaft. Experimentation has demonstrated that when inserted into a handle to just short of the maximum width, the spindle-shaped point could not move back-and-forth or side-to-side. Fixation with resin strengthened the attachment. Binding with a ligature stabilized the attachment if and when the spear or point were twisted.

4.4. Performance

During experimentation, when points with simple bases were inserted in handles and affixed with both a ligature and resin, the attachment was strong enough to withstand impact with either soft or hard animal tissue or with the ground.

5. Gravettian projectile points

While Gravettian bone and antler industries are usually described as less abundant than those of the Aurignacian (Hahn, 1977; Leroy-Prost, 1975, 1979; Otte, 1981). There is still good evidence of Gravettian (including Perigordian) bone and antler projectile technology (Bricker & David, 1984; David, 1985; Otte, 1979; Passemard, 1944; de Saint-Périer & de Saint-Périer, 1952). In western Europe, Perigordian non-lithic projectile points are characterized by single-beveled bases and by flattened zones on otherwise rounded surfaces. The Gravettian of southwest Germany has yielded numerous tapered projectile points manufactured of mammoth ribs (Munzell, *n.d.*).

6. Points with single-beveled bases

6.1. Technique of manufacture

Even though antler was still available from both red deer and reindeer during the Gravettian (Cordy, 1984; Delpech, 1983; Otte, 1981), most single-beveled projectile points were manufactured of bone (table 3). The bone was broken apart into large splinters (fig. 13). The blank was then worked to a gentle taper by removal of material along the longitudinal axis of the splinter. The bevel was manufactured by whittling or scraping down the cancellous surface at the proximal end of the point.

Bone	61
Bone (?)	4
Bone/Antler	2
Antler	3

Table 3 — Raw material of single-beveled points.

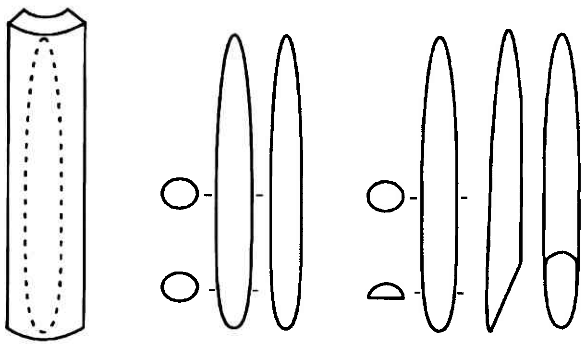

Fig. 13 — Manufacture of point with single-beveled base.

The thickness of the projectile points was dictated by the thickness of the cortical bone. The thickest part of points with single-beveled bases, i.e., the area just distal to the bevel, often displays some cancellous bone. Cancellous material also often remains on the beveled bases of these points. On Perigordian single-beveled points of which the bevel was manufactured on smooth compact bone, the surface of the bevel was often scored with oblique incisions or textured with irregular grooves.

6.2. Morphology

All except 13 of the 95 points with single-beveled bases studied were broken. Therefore, it is difficult to make any comparative statement about their lengths, especially since many of the broken fragments are longer than the whole specimens. There seems to be considerable variation in the widths and thicknesses of the shafts of the pieces. Thickness was most likely determined by the thickness of the cortical bone from which the points were manufactured. However, there is a linear relationship between the proportion of width to thickness of points with single-beveled bases (fig. 14).

6.3. Hafting

Experimental manufacture and use of bone projectile points with single-beveled bases has demonstrated the efficacy of the hafting mechanism proposed by Peyrony (1938) for these points. The distal end of the wood shaft was whittled

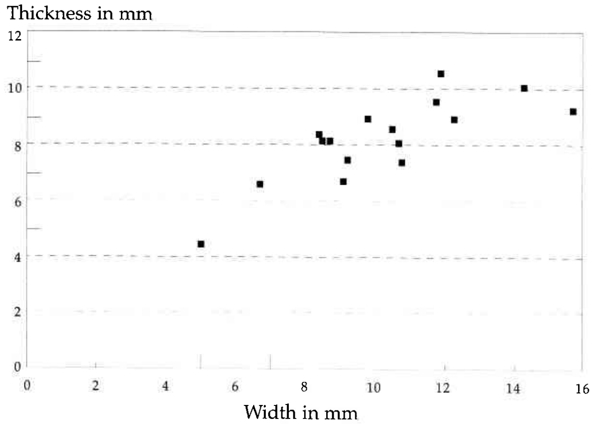

Fig. 14 — Points with single-beveled bases: width × thickness.

down to form a bevel at an angle which matched that of the beveled base of the points (fig. 15). During experimentation, a step-like structure was left at the end of the bevel on the handle to impede the dislocation of the point upon impact. Also, resin was applied to the beveled surfaces to increase adhesion. The irregular surface of the bevel created by the natural openings of the cancellous bone increased the tenacity between the base and the end of the handle; smooth surfaces would have allowed for slippage. The shafts of Gravettian projectile points with single-beveled bases were sometimes scored with incisions

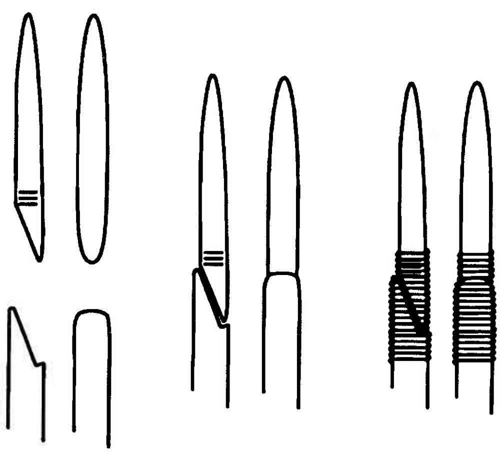

Fig. 15 — Hafting a point with single-beveled base.

perpendicular to the axis at the distal end of the bevel. It is likely that these incisions reduced slippage of the ligature with which the point was bound to the shaft.

6.4. Performance

Armed with these weapons, Paleolithic hunters would have been capable of maiming or killing both large and small animals. During experimentation, the spears were found to easily enter and even pass through the animal.

7. Mammoth-rib points

Projectile points manufactured from mammoth ribs are known from several Gravettian sites in Germany. Pieces representative of each stage of the manufacturing process of mammoth rib points were studied. The mammoth rib was first divided into flat segments. The segment was next sectioned longitudinally. The fragment was then reduced by longitudinal scraping to form a gently tapering point that was oval or circular in section. During shaping, the compact bone was completely removed from the piece. The resultant point was formed entirely of cancellous bone.

Many of the mammoth rib points are scored with fine incisions which run both perpendicular and oblique to the longitudinal axis of the piece. Some of the mammoth rib points have flattened portions along their otherwise rounded shafts. Several features of mammoth rib points are analogous to attributes of Perigordian single-beveled points: the use of cancellous bone; scoring or incising along lateral edges; and flattened surfaces. The system for hafting mammoth rib points remains to be explored.

8. Conclusion: Early Upper Paleolithic projectile technologies

There are distinct differences among the various Early Upper Paleolithic bone and antler projectile technologies. These technologies are distinguishable from the outset of the manufacturing process on the basis of the selection of bone or antler as the raw material for production. Given the selected raw material, techniques suitable for working of that material were used to produce different types of projectile points. Particular attention was given to the manufacture of various forms of hafting mechanisms. Attached to shafts, the different types of projectile points would have allowed for the construction of several different but equally effective hunting weapons.

Both the manufacture and hafting of Early Aurignacian split based points were based on the principles of splitting and wedging. Given the mechanism used for attachment of the point to the spear shaft, it would not have been necessary to use resins to hold the point in place.

This Early Aurignacian approach to systems of attachment is inherently different than that of subsequent Aurignacian hafting technologies.

The manufacture of both losange- and spindle-shaped points involved the reduction of longitudinal segments of antler. The artisan was concerned with working down the antler blank by removal of the cancellous material. The ultimate form of a particular losange-shaped point was determined, to a large extent, by the contours of the antler from which it was manufactured. The final form of spindle-shaped points which were worked "in-the-round" was controlled by the artisan to a greater degree. The mechanics of hafting points with simple bases required the use of both resin and ligature to maintain the attachment upon impact and to create a spear whose morphology would not impede the trajectory of the projectile.

It is with the Gravettian that bone, instead of antler, began to be used for the production of projectile points. While several kinds of points were in use during the Gravettian, a few characteristics pervade all Gravettian bone and antler projectile technology: (1) textured surfaces formed either by the natural crevices of cancellous bone or by intentionally made striae; (2) notched or incised lateral edges; and (3) flattened portions of otherwise rounded surfaces. These features are most likely associated with the manner in which objects were fastened together—either the attachment of a point to a shaft or the splicing of components of a composite tool technology.

In sum, while Early Upper Paleolithic bone and antler projectile technologies are highly differentiated over time, there is a considerable element of similarity among contemporaneous systems. A single set of technological principles oriented the strategy of design, manufacture and use of each system of EUP projectile technology.

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