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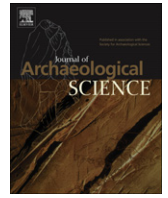
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# The recognition of a new type of bone tools in Early Aurignacian assemblages: implications for understanding the appearance of osseous technology in Europe

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## ABSTRACT

Despite being at the heart of the question of the emergence of the European Upper Palaeolithic, the Aurignacian osseous industry is essentially known by the production of split-based points, ornaments and portable art whereas bone tools, usually dedicated to domestic tasks and with variable technical complexity, have been largely ignored. However, when the high number of unworked tools is included – i.e. bone fragments recovered from food processing and used directly as tools with no previous shaping phase – bone tools represent a significant proportion of the Early Aurignacian industry. Among these unworked tools, is a newly-discovered type: “unworked intermediate tools.” This article presents a detailed description based on taphonomic, typological and technological characters. It shows that these tools are diaphyseal fragments which are used directly as a wedge, very likely for woodworking and perhaps for antler processing. The processes behind the appearance of osseous technology at the beginning of the Upper Palaeolithic in Europe are then discussed in light of this discovery and, more generally, the revised composition of the Early Aurignacian toolkit. The high proportion of unworked bone tools, a type more commonly associated with the Middle Palaeolithic, suggests a more gradual technological shift between Middle and Upper Palaeolithic than has previously been considered. As part of this hypothesis, the emergence of working osseous material could be due to a gradual transfer of techniques previously applied to wood, as others have proposed.

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## 1. Introduction

In Europe, the passage from the Middle to the Upper Palaeolithic (~45,000–30,000 BP) is marked by profound changes. This shift includes both *biological* components with the arrival of Anatomically Modern Humans and the disappearance of Neanderthals, and *cultural* components with the replacement of Mousterian techno-complexes with those of the Upper Palaeolithic, the Aurignacian in particular. Although working of osseous materials has been sporadically identified in transitional assemblages (such as the Châtelperronian: Baffier and Julien, 1990; Granger and Lévêque, 1997; D'Errico et al., 1998, 2003; and the Uluzzian: Gioia, 1990; Palma di Cesnola, 1993; Gambassini, 1997), the systematization of osseous industry production (antler, bone, ivory) is one of the major innovations associated with the Aurignacian. The presence of ornaments and mobile art along with a rich antler and bone industry made up of weapons (points) and tools (smoothers, awls, pierced batons) contrasts with the rarity of

osseous tools in the Middle Paleolithic, generally limited to opportunistic use of bone by-products of food processing (Vincent, 1993; Leroy-Prost, 1975; Tartar, 2004). Consequently, the dramatic shift in the utilization of osseous materials has been a strong argument of migration-based theories (Mellars, 1989; Demars and Hublin, 1989; Kozłowski, 1993; Davies, 2001; Harrold and Otte, 2001) as it marks a clear technological and conceptual break with the Mousterian techno-complexes. Additionally, the rapid diffusion of osseous industry across Europe, evidenced by the wide distribution of split-based points, has been seen as a testament to the unity and distant origin of the Aurignacian.

However, interest remains mainly focused on the osseous products considered most innovative (*i.e.* split-based points, ornaments and portable art, *e.g.* Hahn, 1986; Conard, 2009; Knecht, 1991, 1997; Liolios, 1999, 2006; White, 1993, 1995) while bone tools, usually dedicated to domestic tasks and with variable technical complexity, are poorly known. Yet, bone tools represent a significant proportion, often a majority, of the osseous material from Early Aurignacian levels (Tartar, 2009). Their comprehensive study questions the idea that Aurignacian osseous technology is completely innovative and casts doubt on the existence of a true technological breakthrough in this technology across the Middle to

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Upper Paleolithic transition. In fact, unworked tools or tools made from unshaped bone fragments, like those commonly found in the Middle Paleolithic, represent a significant part of the Early Aurignacian osseous industry. Among these, is a previously unknown type of tool here defined as “unworked intermediate tools” (“*Outils intermédiaires bruts*” Tartar, 2009). Found within the faunal remains of several Early Aurignacian assemblages, these tools are simple by-products of long bones fractured for marrow extraction and then used as a wedge.

This article reviews the circumstances leading to the discovery of this tool type. It then presents a detailed description based on a thorough analysis of taphonomic, typological and technological characters. In the light of their discovery context, several points are addressed: the origin and specificity of these tools, their chrono-cultural distribution and their function. This is concluded with a discussion of the implications of this discovery for our understanding of Aurignacian society and the mechanisms underlying the development of bone tools in the Early Upper Paleolithic of Europe.

## 2. Archaeological setting

This study concerns the Early Aurignacian levels of three sites in southwestern France: Abri Castanet, the Grotte des Hyènes, and Gatzarria (Fig. 1).

Abri Castanet is a collapsed rockshelter in the valley of Castel-Merle in the Commune of Sergeac in Dordogne. In terms of archaeological material it is one of the richest Aurignacian sites, and has been subject to two major excavations. At the beginning of the 20th century (in 1911–1912 and again in 1924–1925), D. Peyrony excavated the north part of the site and distinguished two layers: one of which he attributed to the Early Aurignacian (layer A) and the other to the Middle Aurignacian (layer C, Peyrony, 1935). After an exploratory operation in the northern sector in 1994, J. Pelegrin and R. White undertook excavations in the south part of the site

from 1995 to 1998 (note 1), continued by R. White alone between 2005 and 2010 (Mensan et al., in press; White et al., in press). They encountered the continuation of D. Peyrony's layer A, which they divided into about ten sedimentary units. The osseous material discussed in this article comes from the Early Aurignacian deposits in the shelter's north (layer A) and south sector (US 131 and underlying levels), with  $^{14}\text{C}$  dates on fifteen bone samples averaging to 32,400 non cal. BP (Mensan et al., in press).

The Grotte des Hyènes is one of the four caves of Brassempouy in the south of the Department of the Landes in Chalosse. Excavated in part as early as the 19th century, H. Delporte conducted the first methodical excavations in 1981, continued by D. Buisson and then D. Henry-Gambier and F. Bon until 2002. *Ensemble 2* represents most of the fill and comprises about ten stratigraphic units, all assigned to the Early Aurignacian (Bon, 2002; Henry-Gambier et al., 2004; note 2) and  $^{14}\text{C}$  dated to between 33,000 and 31,500 non cal. BP (Fontugne, in press). The unworked intermediate tools come from these levels.

Gatzarria is a cave in the massif of the Arbailles at Suhare in the Pays Basque. G. Laplace conducted excavations there from 1961 to 1976. The cave contains an important stratigraphic sequence including the Middle Palaeolithic and the beginnings of the Upper Palaeolithic (Laplace, 1966). The material studied comes from the layer *cbci-cbf*, attributed to the Early Aurignacian.

## 3. Presentation of the unworked intermediate tools

### 3.1. Identification of the tools

The first specimens of unworked intermediate tools (Tartar, 2003, in press) were identified by studying the osseous productions of the Early Aurignacian levels of the Grotte des Hyènes (ensemble 2). A piece isolated by C. Letourneux, in charge of the zooarchaeological study (Letourneux, 2003, 2005), was the first noted (Fig. 2a). The piece is a 115 mm long diaphyseal fragment

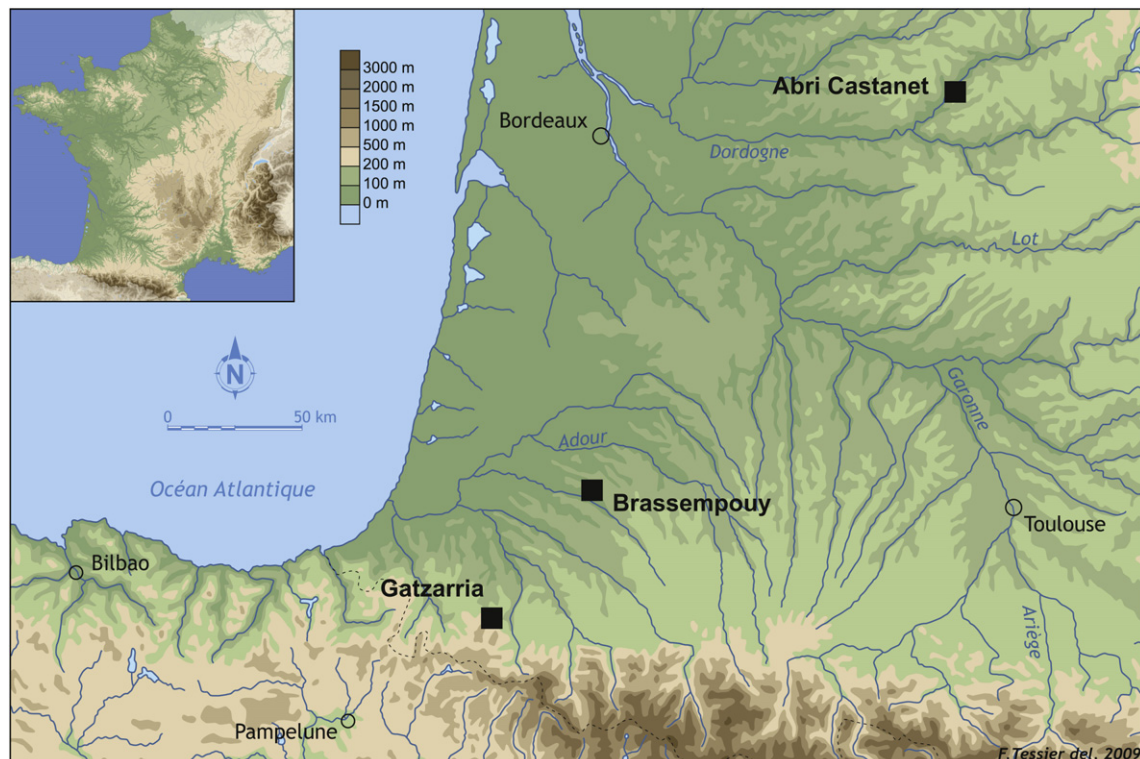


Fig. 1. Location of the sites.

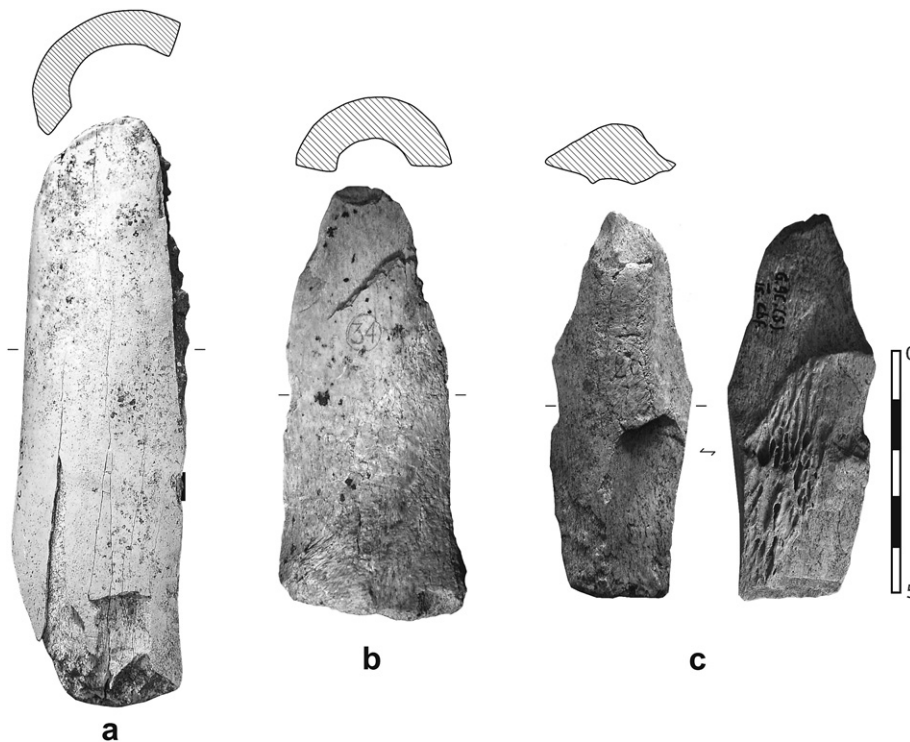


Fig. 2. Examples of unworked intermediate bone tools from Early Aurignacian assemblages: a. Grotte des Hyènes, BE4-1307, unit 2C, b. Gatzarria, 6E [5] 9, c. Gatzarria, 9C [5] 15, layer cbci-cbf.

from the femur of a large ungulate. It shows traces of use as an intermediate piece in indirect percussion. Particularly, the distal end is compressed and the proximal end shows battering and some removal scars on the upper surface. Other pieces with similar stigmata have been subsequently isolated. We have named them “unworked intermediate tools” (*outils intermédiaires bruts*) because they are simple splinters of long bones obtained by fracturing diaphyses (via direct percussion). These tools are not formally worked and are only recognizable by the percussion marks at their ends (Fig. 2).

With the small number of identified pieces, the initial thought was that these bone fragments had only been sporadically used and to a limited extent. However, they were subsequently identified in other Early Aurignacian bone assemblages: most saliently at Gatzarria (layer cbci-cbf) but also at Abri Castanet (north sector: layer A, and south sector: in and under US 131). At Gatzarria, A. Saenz de Buruaga previously reported the existence of a particular type of bone fragments. In his study, he attempted to classify these tools (“chipped pieces”, “chisels”, “scrapers”, etc.) using the analytical typology developed by G. Laplace (Saenz de Buruaga, 1987, 1988, 1991). He also identified them in a comparative sample from the site of Les Abeilles (Saenz de Buruaga, 2006). However, these studies were essentially based on morphological criteria and did not include taphonomic analysis or descriptions of the stigmata on the pieces (anthropic or otherwise). On one occasion an intermediate tool use was presented for some “chipped pieces” (*“Ecaillés tranchants”*, Saenz de Buruaga, 2006, p. 128) but the pieces’ functional purposes was not the subject of the study.

Meticulous study of the faunal remains enabled these pieces to be identified, as they had not been recognized during excavation. Taphonomic analysis of their context reduces the risk of confusion with pseudo-tools produced by non-anthropogenic agents. In particular, carnivores are known to produce pseudo-retouch on bone fragments (Binford, 1981; Villa and Bartram, 1996) but these modifications can be found anywhere on the bone surface. On the

contrary, the removal flake scars present on intermediate tools are only found on their ends and are systematically associated with crushing from use in indirect percussion. Moreover, none of the pieces selected shows marks from teeth, claws, or any chemical alterations like those caused by gastric juices (Binford, 1981; Shipman, 1981; D’Errico and Villa, 1997).

Here, a total of **102** pieces classified as unworked intermediate tools are presented (Fig. 3). This includes **15** from Castanet North, **7**

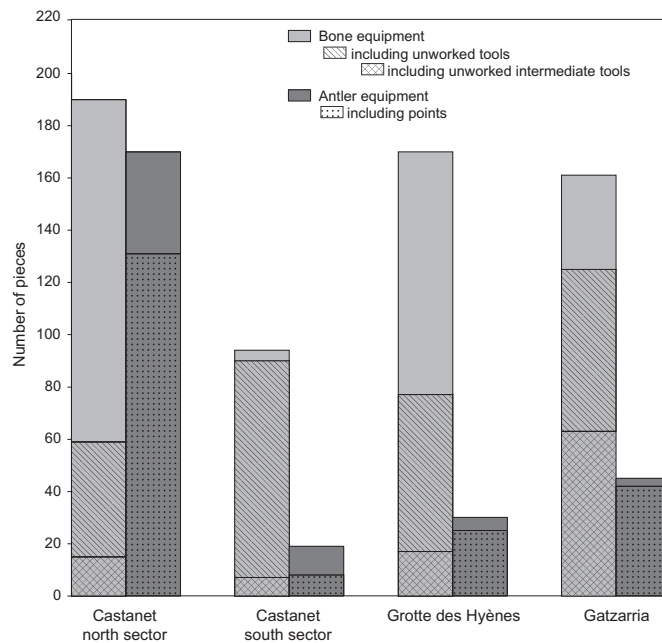


Fig. 3. Comparison of the frequency of different types of osseous tools from Abri Castanet north (layer A) and south sector (US 131 and below), Grotte des Hyènes (ensemble 2) and Gatzarria (layer cbci-cbf).



from Castanet South, **17** for the Grotte des Hyènes and **63** for Gatzarria. These numbers are a minimum (Tartar, 2009): most of the animal remains collected during D. Peyrony's excavations at Abri Castanet (north sector) are today lost. Additionally, a large proportion were also abandoned on site. Although sieving a part of the Peyrony's backdirt has recovered abundant material (note 3), the unworked tools are still clearly under-represented. The same applies at Gatzarria where the quantity of unwashed faunal remains was great enough that we have only analyzed 7 m<sup>2</sup> of excavation (out of about 30 m<sup>2</sup> total).

The percentage of unworked intermediate tools in the assemblages is variable: ranging from 7% of the identified osseous tools from Abri Castanet south sector ( $n = 7$ ) to nearly 40% at Gatzarria ( $n = 63$ ). These unworked intermediate tools can be added to the sample of other unworked bone tools, which tend to be well represented at these sites by large numbers of retouchers (*retouchoirs*, Tartar, 2012). In Abri Castanet north sector, the unworked bone tools make up 31% of the total bone industry ( $n = 59$ ). Although high, this percentage is certainly an underestimation, given the drastic selection the artifacts underwent during the Peyrony excavations (Tartar, 2009). They comprise 44% of the Grotte des Hyènes bone tools ( $n = 75$ ) and 77% of those from Gatzarria ( $n = 125$ ). At Abri Castanet south sector, the unworked tools account for 96% ( $n = 90$ ) of the total number of bone tools, but the small extent of the excavations show that sampling bias may have affected this percentage. It is interesting to note that at all sites (except at Castanet North sector, where collection bias is apparent), the number of bone tools greatly exceeds that of worked antler implements.

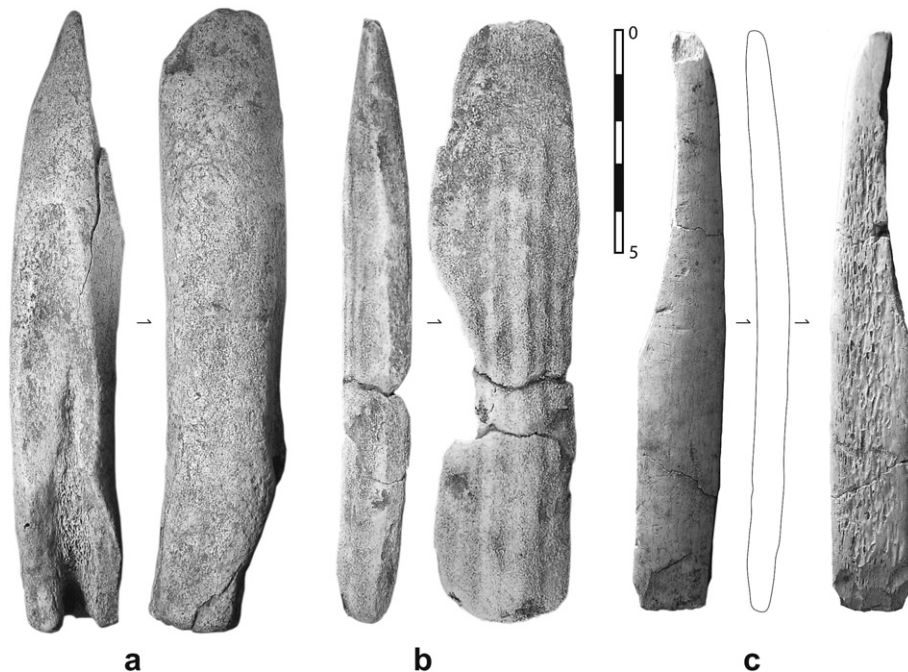
### 3.2. A new category of Aurignacian intermediate tools

The unworked tools presented here widen the range of osseous intermediate tools known for the Upper Palaeolithic (Camps-Fabrer et al., 1998). Previously, formal intermediate tools, which were identified early in the history of archaeology owing to their resemblance to traditional or modern tools (Lartet and Christy,

1865–1875; Chauvet, 1910), were frequently found within Upper Palaeolithic assemblages. Unlike the unworked intermediate tools, these pieces were shaped at least on their distal part and given a unifacial or bifacial bevel form (Deffarges et al., 1974; Provenzano, 1998; note 4). Mainly made in antler, they are known from the Early Aurignacian onwards (Provenzano, 1998) and are found among the tools at Castanet, the Grotte des Hyènes, and Gatzarria (Fig. 4). The Upper Palaeolithic bone assemblages also yield worked specimens made from fragments of long bones, but they are much rarer – due, no doubt, to the lower resistance of bone to longitudinal compression (note 5) (Albrecht, 1977; Currey, 1979; MacGregor and Currey, 1983). The existence in the Early Aurignacian of intermediate tools made from half-ribs (produced by splitting the rib lengthwise) should also be noted. These pieces – recognized in Castanet (north sector), Grotte des Hyènes, and Gatzarria assemblages – are quite particular and original (Fig. 4c; Tartar, 2009). In a few cases, they are fragments of roughly shaped half-ribs used with no further working. Most often however, these pieces were recycled smoothing tools (*lissoirs*) indicating that they were used for a secondary purpose. They differ from the previously mentioned pieces in so far as they have no beveling but rather a rounded profile at the distal end.

### 3.3. Typically Aurignacian tools?

An important question lies in whether these unworked intermediate tools are only found in the Early Aurignacian. Their recognition within the assemblages of this period is insufficient proof for a strict chrono-cultural identity. Previous publications show a few pieces that more or less resemble this new tool type. In addition to A. Saenz de Buruaga's research, J. Mujika indicates some ten pieces coming from Protoaurignacian and Early Aurignacian levels at Labeko Koba (Mujika, 2000). N. Goutas also describes a piece coming from Isturitz layer C4d1 ascribed to the Protoaurignacian (Goutas, 2002). Furthermore, current research by the author on the osseous industry of Gatzarria from the levels over- and underlying the Early Aurignacian (a sequence from the



**Fig. 4.** Examples of other types of osseous intermediate tools from the Early Aurignacian. (a) on a section of antler beam (Gatzarria, 10C [1] 13, layer cbci-cbf), (b) on elongated antler beam flake (Castanet, north sector, layer A), (c) on half rib (Castanet, north sector, layer A).

Mousterian to the Gravettian) has yielded a few specimens in the Protoaurignacian (Cjn1 and Cjn2) and the evolved Aurignacian (Cb, Laplace, 1966). Unworked intermediate tools thus seem to be present in the various phases of the Aurignacian. But specimens have also been recognized within earlier assemblages. Notably, there are some among the animal remains from the Mousterian levels of Gatzarria (Cj, Cjr, and Cr). Additionally, A. Burke and F. D'Errico (2008) report the discovery of a specimen from the Mousterian level III at the site of Karabi Tamchin (Crimea, Ukraine). It is an equid diaphyseal tibia fragment of which the distal end appears to have been retouched (Burke and d'Errico, 2008, p. 848).

#### 4. Choice of the blanks and technological description of the tools

##### 4.1. Selection from food remains

The unworked intermediate tools are diaphyseal fragments, probably recovered from food processing. In each assemblage examined, the long bones that yielded the tools were systematically fractured for marrow extraction (Castanet: Castel, in press; grotte des Hyènes: Letourneux, 2003, 2005; Gatzarria: personal observation). Many unused bone fragments similar to the ones used as tools can be found among the faunal remains. So the hypothesis that the intermediate tools were intentionally produced as such seems unsupported. However, the flakes used were carefully selected among the available bone fragments. Blanks with a rectilinear profile were favored through the preferential selection of tibia, radius and metapodial fragments as these are the long bones with the most regular diaphyses (note 6). This choice was certainly related to how the tools were used. For intermediate tools, a rectilinear profile works to disperse the force of blows and resist transverse fractures. Moreover, the bone fragments selected mostly come from large size classes (large ungulates: bovids, equids) guaranteeing long, broad and solid tools. This selection has been demonstrated for each of the assemblages, even where the large size classes constitute a minority of the animal remains, as is the case at the Grotte des Hyènes and Castanet (Fig. 5). At Gatzarria, large bovids and horse make up most of the remains but reindeer are well represented at the Grotte des Hyènes (depending on the

stratigraphic units, from 25% to 72% of the determined remains, Letourneux, 2003, 2005) and constitutes most of the Castanet fauna (more than 90% of the determined remains, Castel, in press).

##### 4.2. Morphometry

Being unworked and probably a by-product of breaking long bones for marrow extraction, the bone fragments used vary in their morphology. They underwent considerable fracturing during their use and it is sometimes difficult to determine their original morphology, especially that of the distal portion which is decisive for evaluating tool function. It can be difficult to distinguish between breakage planes due to marrow extraction, which forms the original shape of the piece, and breakage planes produced during use. It is thus important to precisely study the morphology of these planes as well as their location on the piece, and their position in relation to use-wear traces.

In most cases, it seems the used pieces have a distal end with a broadly convex shape and a naturally beveled profile (note 7). This profile, formed by the intersection of the bone's outer surface with the fracture planes of the edges, is common on splinters resulting from green bone fracturing (Villa and Mahieu, 1991). It produces an angle that can range from 15° to 40° but is mainly between 20° and 35° (Fig. 6c). The distal end can be a solid square in section and made of compact bone, but most often has a convex-concave section with the marrow canal forming the concave side. When well preserved the tool's proximal end is generally flat perpendicular to the longitudinal axis of the pieces. The hammer's repeated blows having progressively compressed and flattened the bone fibers.

Given the pieces' substantial fracturation, the comparison of the dimensions depends on a small sample of complete pieces. Nonetheless, the tools' dimensions appear to be quite variable (Fig. 6a, b). Lengths range between 64 and 144 mm (with an average of 100 mm). The distribution of width and thickness is equally varied (widths from 18 to 50 mm, average – 35 mm; thicknesses from 7 to 37 mm, average – 16 mm). These data imply that the dimensional requirements for choosing a piece of bone are not very strict. However, the tools' changing morphology during stages of use can partly explain the variations in dimensions.

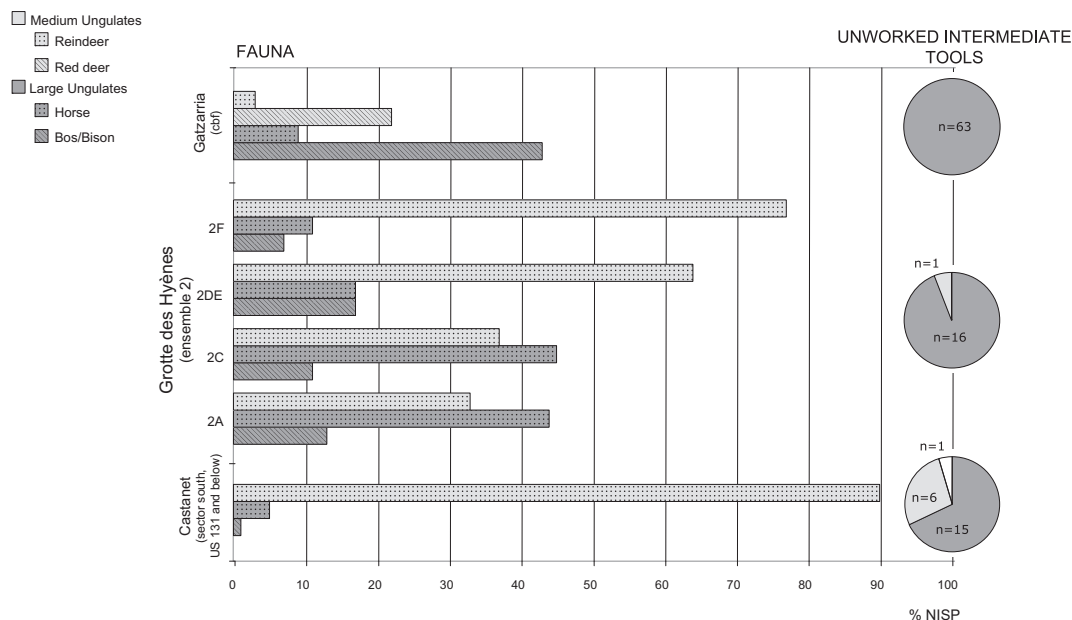
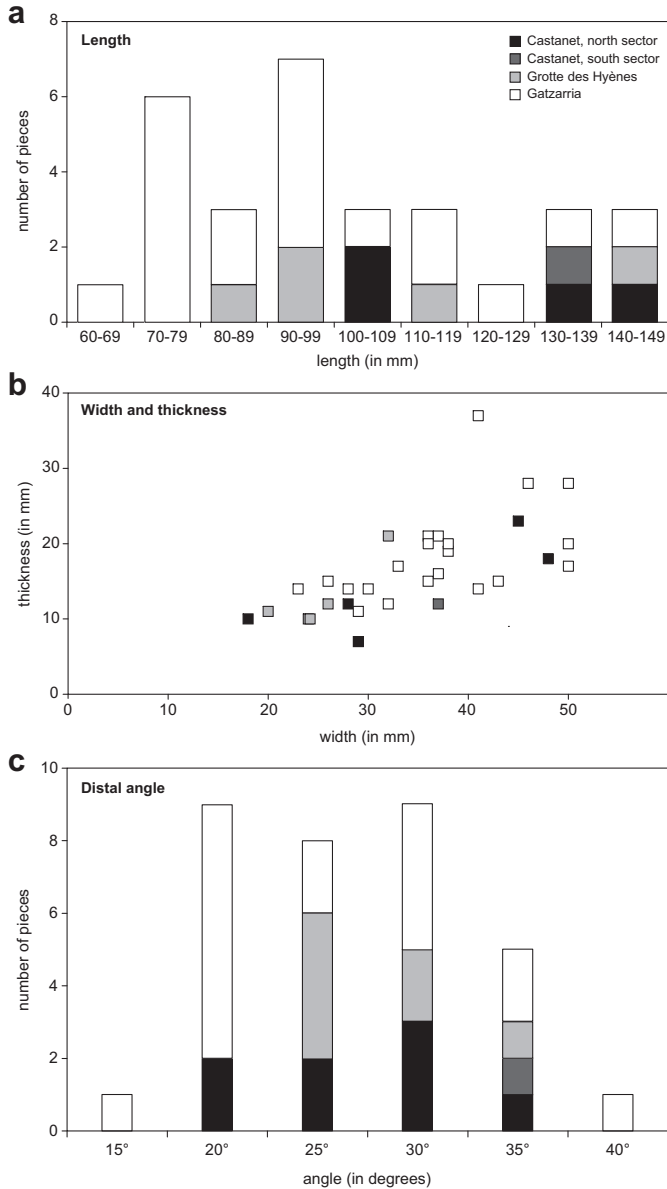


Fig. 5. Comparison of the taxonomic origins of unworked intermediate tools among sites.

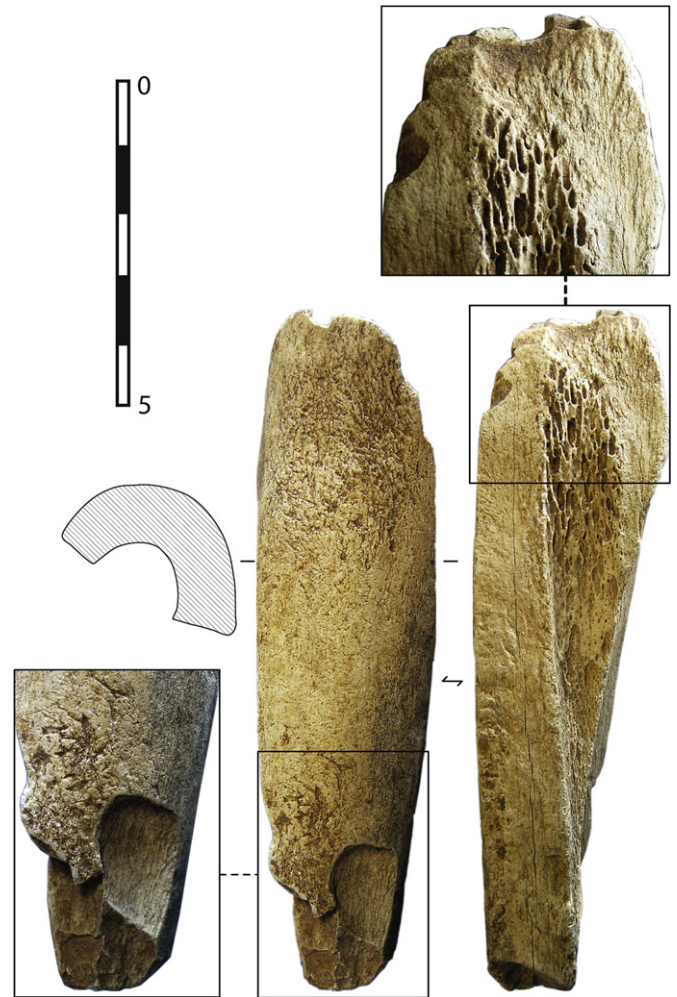


**Fig. 6.** Dimensions and distal angle of unworked intermediate tools from Abri Castanet north (layer A) and south sector (US 131 and below), Grotte des Hyènes (ensemble 2) and Gatzarria (layer cbci-cbf).

**4.3. Use marks**

The observation of these tools with a binocular microscope ( $\times 10$  or  $\times 15$  magnification) has enabled three main types of use marks to be identified on the ends: blunting, crushing, and removal scars (Provenzano, 1998; Fig. 7; Table 1: for the sake of clarity, all pieces from the various assemblages are considered together).

Blunting is a distal scar that corresponds to a deformation in the bone’s surface caused by the wear of the tool in contact with the material it is used on. It is present on the edge and extends over both faces. It is not, however, always identifiable. It depends on the condition of the tool’s surface and can be eclipsed by later removal scars. It is generally discontinuous and not particularly pronounced. It is found on both faces, but is more marked on the lower. The ridges formed between the marrow canal and the fracture planes as well as the asperities of the fracture planes themselves record the blunting better than the smooth surface of the upper face. It is not



**Fig. 7.** Use-wear marks on unworked intermediate tools (Castanet, north sector, layer A). On the distal end, the artifact shows use-wear polish and crushing; on the proximal end, several flake removal scars. The artifact has also been used as a retoucher.

always easy to estimate its extent precisely but typically affects a zone between 14 and 53 mm from the extremity.

Crushing can be found at both ends. It is the consequence of the compression of the bone fibers caused by the hammer’s repeated blows at the proximal end and at the distal end through contact with the worked material. It can take the form of faceting of the surface but repeated or more violent use separates the bone fibers and makes them fold back upon themselves. It is very pronounced in the proximal part and often accompanied by this folding of the bone fibers. On the distal end it is typically less marked and limited to compacting.

Removal scars on both ends can result from conchoidal fracturing following a violent shock with the hammer or the worked material. However, they tend to be more numerous and larger in the proximal part.

To these traces must be added the numerous breakage patterns resulting from use.

Longitudinal fracture planes, the most frequent, result from fractures starting at one extremity and following the bone’s fibers along a sagittal (perpendicular to the bone surface), frontal (parallel to the bone surface) or intermediate axis. In certain cases the fracture progresses as far as the opposite end. Most often, the fracture follows a curved or angular trajectory towards an edge or face (Fig. 8). Longitudinal fracturing is typical of use by indirect

**Table 1**  
Use marks identified on distal and proximal ends of unworked intermediate tools (samples considered represent only complete and well preserved ends).

	Distal ends	Proximal ends
Blunting	43	–
Crushing	46	57
faceting	45	16
folding of fibers	–	27
both	1	14
Removal scars	30	41
small	6	3
large	11	14
both	13	24
Total	46	57

percussion. It is the consequence of the hammer's blows on the proximal end or of their counterblows at the distal end in contact with the worked material. It is frequent on bone intermediate tools owing to this material's low resistance to longitudinal compression (*cf.* note 5). The damage this type of fracture causes can be important. If it only removes a small portion of the distal or proximal end, the tool can still be used but loss of a larger portion can unbalance the tool and make it unusable.

The transversal – or slightly oblique – fracture planes are less frequent and generally terminate in a tongue or saw-tooth fracture. They are the consequence of a rupture from bending the bone fibers. This type of fracture did not necessarily end the life of the tool, depending on the area affected. A transversal fracture in the distal part for example removes the tool's active part making it unusable. In case of transversal fracture in the mesial part on the other hand, the tool's mesio-distal portion can be reused if the fracture planes is then used as the new percussion surface.

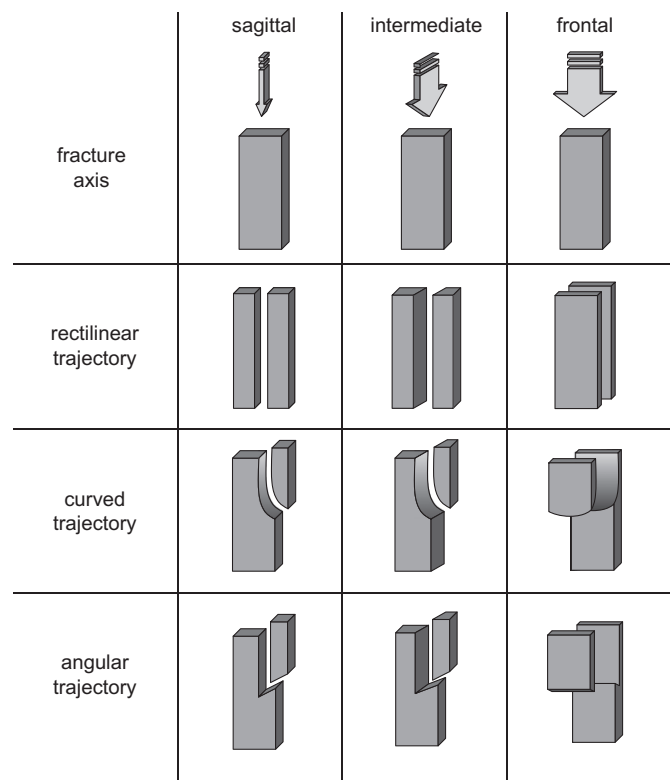
The tools were used intensively and specimens retaining their initial morphology are rare. Studying the distribution of wear traces and breakage patterns shows use produced a succession of

fractures that progressively modified the tools' dimensions and morphology. They show no evidence of maintenance and were probably used exhaustively until a major alteration left them unusable.

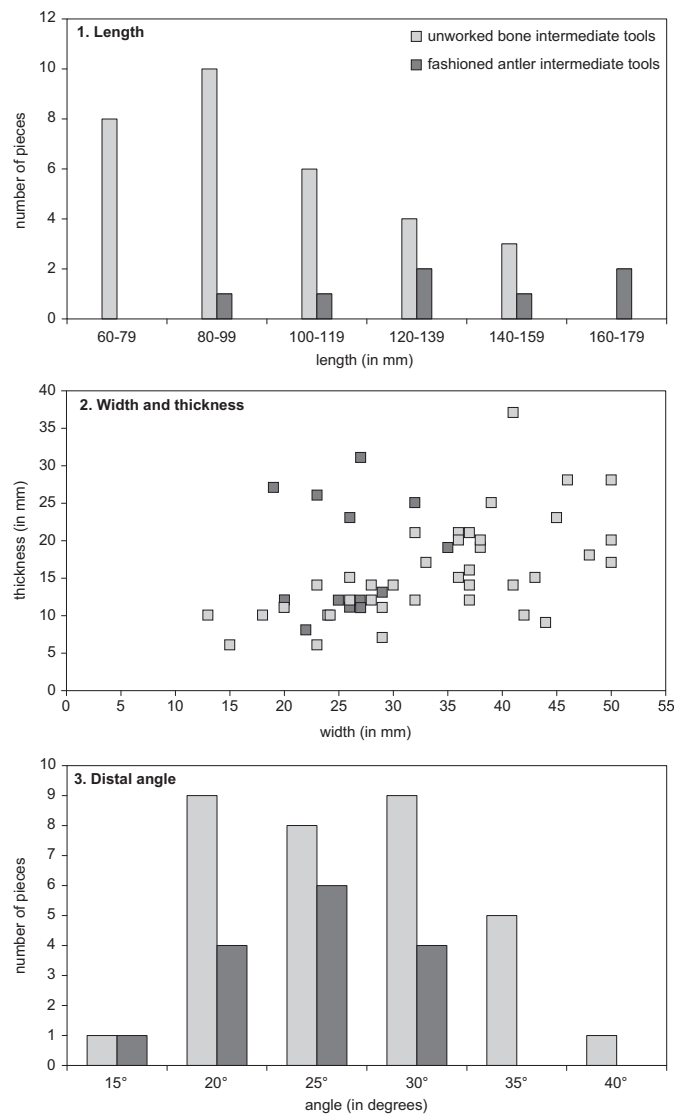
**5. An expedient equipment**

A striking point to emerge from studying unworked bone intermediate tools is the morpho-functional convergence between these tools and formal tools made from antler. Although absent from the Abri Castanet south sector, 23 antler pieces have been found in the site's north sector, four come from in the Grotte des Hyènes and one from Gatzarria. They were usually made from sections of the beam of reindeer antler, more rarely from *baguette*-flakes taken from the antler beam and in a few exceptional cases from the tines (Fig. 4a, b).

Both the formal and unworked intermediate tools have similar dimensions. Graphs of these data show that their dimensions overlap (Fig. 9: for the sake of clarity and owing to the small number of complete worked tools, the pieces in the various



**Fig. 8.** Longitudinal fracture typology of intermediate tools.



**Fig. 9.** Comparison of dimensions and distal angle between unworked bone and worked antler intermediate tools. Specimens from Abri Castanet north (layer A) and south sector (US 131 and below), Grotte des Hyènes (ensemble 2) and Gatzarria (layer cbc1-cbf) are considered together.



assemblages are considered together). The unworked tools are generally somewhat shorter and wider than the worked tools. But the most notable as well as the most determinative functional similarity concerns the angle subtended by the distal part. Except for one specimen, the worked tools have a bevel of between 20° and 30° while 80% of the sample of unworked intermediate tools considered here have an angle in this same range (Fig. 9c). In addition, the wear traces observed on the ends are very similar between the formal and unworked tools.

This finding allows a common working mode for both categories of tools to be posited. However, antler's higher resistance to longitudinal compression implies a longer use life. In addition, they show markedly less wear than the unworked bone tools. Thus, it seems that the Aurignacians have adopted two different technical solutions for the same functional purpose: the use of durable shaped antler intermediate tools and the use of unworked bone specimens. These latter tools, which are more likely to break during use but easier to make, can be classified as "expedient".

## 6. Function of Early Aurignacian unworked and formal intermediate tools

Previous anthropological and archaeological work highlights three main functions for intermediate tools made from osseous materials (e.g. Stewart, 1984; Miles, 1963; Rigaud, 1984; Ettos, 1991; Provenzano, 1998; Legrand, 2000; Maignot, 2003). These include use 1). as a wedge for splitting hard fibrous materials (e.g. wood, antler, ivory and bone), 2). as a chisel to chop these same materials, and 3). as a punch for use in flintknapping. In this sample, the extent of the crushing and removal scars as well as the use fractures on the unworked and formal intermediate tools is indicative of violent use. When combined with the bifacial distal blunting, this suggests forcible penetration of the target material worked. These factors exclude the punch hypothesis as the active part of a punch is strictly limited to the distal end (Ettos, 1991). Additionally, Aurignacian flintknapping has been described by many scholars as including direct percussion by hard hammer (for flakes) and soft hammer (for blades and bladelets) whereas indirect percussion has never been attested (Kuhn and Stiner, 1998; Bon, 2002; Bordes, 2006; Teyssandier, 2007). On the other hand, use as a wedge or chisel on hard fibrous materials is compatible with the traces seen on the archaeological pieces. So this implies splitting and chopping wood and osseous materials like antler, bone, ivory. However, of these activities only antler splitting has been conclusively shown in Early Aurignacian.

### 6.1. Tools for antler splitting? ...

Processing antler by fracturing plays a major economic role in the Early Aurignacian. It is the only known operation by which the *baguettes*, or more exactly the elongated flakes (note 8), used in making split-based points could be obtained (Liolios, 1999). In this respect, the Castanet and Grotte des Hyènes assemblages have yielded evidence (waste, elongated flakes at various shaping stages) indicating the operational stages for producing points took place on site (Liolios, 1999; Pétilion, in press). According to D. Liolios, in the Aurignacian the elongated antler flakes were obtained by splitting (Liolios, 1999 but see also Tejero et al., 2012, Fig. 10a). This process consists of chopping sections of antler beam and then using a wedge inserted at one end of the section to longitudinally split the piece along the grain. In this process, the splitting tool used had to have a beveled end for it to cut while separating the material (Liolios, 1999). The unworked and worked intermediate tools thus seem suitable for this task.

However, splitting was certainly not the only process used for working antler. In fact this process produces blanks that preserve

traces at the ends of the chopping that made the sections (Tejero et al., 2012). These traces are fairly rare on unworked elongated antler flakes from the Aurignacian assemblages studied. Moreover, notches corresponding to a percussion impact point have been found on the edges of a few blanks from the Grotte des Hyènes (Pétilion, in press) and Castanet (personal observations). This evidence suggests direct percussion fracturing such as was practiced on long bones in marrow extraction (Fig. 10b). While the use of an intermediate tool cannot be ruled out – especially for separating the fissures made by the direct percussion and removing the flakes – the archaeological assemblages studied have yielded two other categories of intermediate tools that could have been used for this purpose: flint splintered pieces (*pièces esquillées*, Allain et al., 1974; Rigaud, 2004) and intermediate tools made from half-ribs (note 9) (Fig. 4c).

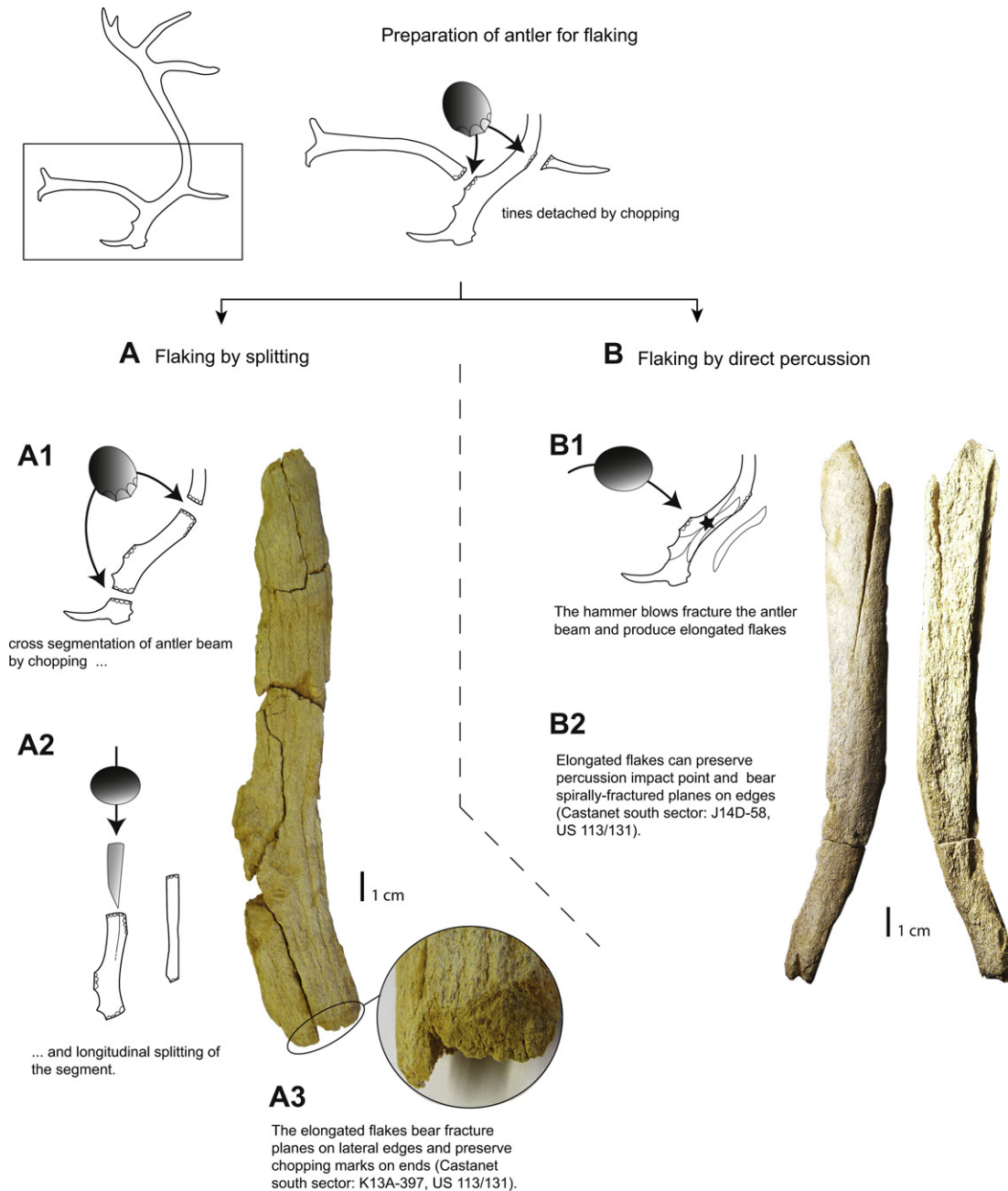
So, the question of the use of unworked and worked intermediate tools to split antler needs to be reexamined with the aid of experimental reconstruction. Regardless, the data collected at Gatzarria suggest the intermediate tools from this site were meant for another activity, probably linked to wood working.

### 6.2. ... or wood working?

The Early Aurignacian layers (cbci-cbf) of Gatzarria have yielded some sixty antler pieces (Tartar, 2009). Two thirds of these are finished objects ( $n = 45$ ) and a third are manufacturing products and waste ( $n = 19$ ). The finished objects consist mainly of split-based points, which are the only objects to have been made from elongated flakes and thus to have involved longitudinal fracturing of the antler. The points for which taxonomic origin can be determined are all made of reindeer antler, with the exception of two specimens made from red deer antler. The same also applies for the few unfinished points, tongued pieces and partially shaped elongated flakes that accompany them. Only a few pieces of red deer antler waste have been observed: one base, two beam portions, and three tines showing chopping marks. This suggests that red deer antler was exploited occasionally but that the processing of reindeer antler, the main material used, did not take place on site. Everything tends to show it was brought onto the site in the form of blanks (which may explain the presence of unfinished points) and/or directly as finished objects. Under these conditions, it is hardly probable that the use of unworked ( $n = 63$ ) and worked ( $n = 1$ ) intermediate tools had something to do with the exploitation of antler. But this finding seems to apply to all osseous materials: it is unlikely these tools were used for processing ivory given the very small numbers of items made of this material, mainly raw or unfinished blanks (Saenz de Buruaga, 1989 and R. White, *pers. com.*). The same applies to processing bone. At Gatzarria, only ribs were split to make smoothing tools (*lissoirs*) but the caliber of the unworked and worked intermediate tools compared with that of the ribs makes their effectiveness seem doubtful (Tartar, 2009). For the time being therefore, the transformation of wood is the activity best able to explain the presence of these tools within the Early Aurignacian layer at Gatzarria.

As Palaeolithic sites only exceptionally conserve plant items, there is insufficient data to fully test this hypothesis. The best documented type of exploitation is as fuel. This is a very old practice (Texier et al., 2005; Théry-Parisot and Meignen, 2000; Weiner et al., 2000) and is well attested in the Early Aurignacian by the presence of charcoal at several sites (Théry-Parisot, 1998; Marquer, 2010; Marquer et al., 2010; Goldberg, 2010).

Furthermore, the study of wood charcoal (anthracology) at Abri Castanet has demonstrated the exploitation of several tree species including *Rhamnus alpina*, *Salix*, *Pinus cf. sylvestris*, *Juniperus* (Théry-



**Fig. 10.** Schematic of antler processing by percussion flaking.

Parisot, 1998). Evidence of wooden tools is rare, but several exceptional finds, such as javelins and spears in the Lower and Middle Paleolithic, attest to an ancient tradition of woodworking (Oakley et al., 1977; Thieme and Veil, 1985; Carbonell and Castro-Curel, 1992; Thieme, 1997). To this must be added the indirect testimony supplied by microwear and traces left on stone tools (e.g. edge-wear and hafting traces) suggesting that the wood has long been a material frequently used (Keeley, 1980; Anderson, 1980; Beyries, 1987; Marquez et al., 2001). The systematic absence of certain components of the Aurignacian spears is another indication of the place held by the wood in material culture. This is particularly the case of shafts on which the split-based points were hafted. It is also probable that points were used with flint bladelets mounted laterally. Indeed, this use of bladelets is currently the most commonly accepted functional hypothesis (Bon, 2002; O'Farrell,

2005; Pelegrin and O'Farrell, 2005). However, the elliptical cross section and the lack of constructed groove on the split-based points precludes the association of bladelets with these points. Given the absence of other point-types in the osseous industry of the western Europe Early Aurignacian, hafting these bladelets into wooden points seems more likely.

To conclude, although evidence for working wood is still rare, the data collected support the belief that this material played a strong economic role during the Palaeolithic and still more in the Early Aurignacian. From this point of view, one can approach the variability in the wood species present within the Aurignacian hearth identified at Abri Castanet (e.g. *Salix*, *P. cf. sylvestris* and *Juniperus*). While these species are of course useful for fire, they also have properties making them very suitable for use in a wood industry.

## 7. Discussion

Previous research into the Aurignacian osseous industry has focused on antler (Hahn, 1974; Otte, 1977; Knecht, 1991, 1997; Liolios, 1999, 2004) and ivory (Hahn, 1972; White, 1993, 1995; Conard, 2003, 2009). In actuality, the abundance of informal bone tools has been dramatically underestimated (Tartar, 2009, 2012). When the high number of these informal tools are included, many assemblages are, in fact, dominated by bone tools. This reassessment of the composition of the Aurignacian osseous industry calls for several comments.

First, the large quantity of bone tools necessitates a widening of the field of research. In fact, osseous material exploitation in the Early Aurignacian is characterized by functional divisions among materials. On the whole, antler appears to be mainly used for hunting, ivory reserved for personal ornamentation and *objets d'art*, and bone used for domestic activities (Liolios, 1999, 2004; Tartar et al., 2006). Previously, most research has been devoted to the hunting and symbolic spheres – with their high social value and degree of technical expertise. Bone tools also merit attention. Although less technically remarkable, their use for domestic purposes makes them essential for reconstructing the socio-economic structure of Aurignacian groups. The extent of Early Aurignacian bone tools is generally thought to amount to no more than a few smoothing tools and awls for hideworking. The record of domestic equipment however is much more extensive and holds evidence for a broader range of activities. In fact, the study of unworked bone intermediate tools in the light of their discovery context corroborates their use for working wood and possibly antler. Retouchers (*retouchoirs*) are another type of informal bone tools that are very well represented in Aurignacian assemblages and should also be mentioned. These tools played a very important role in retouching lithic tools and possibly also in bladelet production (Schwab, 2009; Tartar, 2012). Thus, progression in our knowledge of the earliest Upper Palaeolithic cultures requires considering and studying all the items they produced no matter how simple their form (Astruc et al., 2006).

Second, this reassessment of the Early Aurignacian's composition and the importance of informal bone tools implies that the technological changes that mark the transition from the Middle to the Upper Palaeolithic are not as abrupt as they may have previously appeared. Owing to their meager antecedents in Europe, the attention given to Aurignacian hunting equipment and personal ornamentation has long fostered the idea of a clear break between the Middle and Upper Palaeolithic. Recent data suggest this passage was, on the contrary, part of a more gradual technological and conceptual shift (Teyssandier, 2008; Teyssandier et al., 2010). In the field of lithics, bladelet systematization is one of the Aurignacian's most noticeable innovations, but it was only one technical solution among a wide range of options selected from the end of the Middle Palaeolithic for producing light lithic blanks for armatures (Pelegriin, 1995; Bar-Yosef, 2000; Skrdla, 2003; Tsanova, 2006; Flas, 2008). It should also be remembered that while bladelet production was systematized in the Protoaurignacian, it was in the Early Aurignacian that this production technique became autonomous by separating from the manufacture of tools made for domestic tasks (Kuhn and Stiner, 1998; Bon et al., 2006; Bordes, 2006; Teyssandier, 2007).

This progressive technological evolution can also be seen in the osseous materials. The exploitation of ivory did not really develop until the Early Aurignacian when it was mainly used for producing personal ornaments (White, 1995; Vanhaeren, 2002). In the Protoaurignacian it was still rare, limited to making few points and rods (Julien et al., 2002; Szmjdt et al., 2010) at a time when personal ornamentation still primarily consisted of shells (Bartolomei et al.,

1994; Kuhn and Stiner, 1998; Vanhaeren and D'Errico, 2006). As far as the ivory figurines from the Swabian Jura are concerned, they seem to have emerged later when graphic representation was in full development in the late phases of the Aurignacian (Conard and Bolus, 2003; Zihlão and D'Errico, 1999; Zihlão, 2007). As for the tools, the exploitation of antler and the production of projectile points in particular were turning-points and very characteristic of the Aurignacian and the European Upper Palaeolithic in general, but such evidence is still rare in the Protoaurignacian (Julien et al., 2002; Teyssandier and Liolios, 2008). Moreover, except for a few exceptionally rich sites in the Southwest of France (e.g. Castanet, Isturitz), the exploitation of antler is less developed compared to that of bone in the Early Aurignacian. Indeed, there is a much more extensive industry of unworked bone than was previously thought, with many components already present in the Middle Paleolithic. This is the case for retouchers, who's presence in Mousterian contexts has long been known (Chase, 1990; Vincent, 1993; Armand and Delagnes, 1998; Karavanic and Sokec, 2003). But, this is also the case for the unworked intermediate tools. Several specimens have been identified in the Middle Palaeolithic and the Protoaurignacian, particularly at Gatzarria cave (*cf.* 3.3.). At this stage, one cannot say for certain that these Mousterian pieces are linked to working wood. Likewise, owing to the lack of research on unworked tools, it cannot be said 1) if these pieces are present in other Middle Palaeolithic assemblages as well as in transitional techno-complexes such as Châtelperronian and Ulluzzian and 2) whether they were part, just like the retouchers, of the range of tools used on a daily basis. If indeed this was the case, these informal intermediate tools would be tangible proof that wood was commonly exploited in the Middle Palaeolithic and that this practice continued into the Upper Palaeolithic.

Here we touch on a crucial point in the debate about the mechanisms for the emergence of working osseous materials in Europe. It is probable that early working of osseous materials used techniques transferred from previous woodworking. This hypothesis, put forward by D. Liolios (1999, 2003), is based on the fact the techniques used in the Early Aurignacian to transform osseous materials (i.e. splitting, chopping, sawing, and scraping) and in particular the new materials of antler and ivory were identical to those long used on wood (Oakley et al., 1977; Thieme and Veil, 1985; Carbonell and Castro-Curel, 1992; Thieme, 1997). Moreover, the author points out that in spite of a very wide geographic distribution, the split-based points are really abundant only in the Franco-Cantabrian region and in a few sites in central Europe (Geißenklösterle, Vogelherd, Istallöske) where they rarely exceed a density of 20 specimens per level. Outside these regions they are rare and frequently represented by only one or two specimens. Since it is unlikely that these small assemblages represent initial production, the author suggests they were augmented with points made from wood. The potential use of these points on a wooden shaft with laterally mounted flint bladelets (*cf.* 6.2.) here makes a lot of sense. In other words, the application of techniques first used exclusively for wood would explain the emergence of the formal osseous industry at the beginning of the Upper Palaeolithic in Europe. The manufacture of reindeer antler points, of tools made from bone (like smoothing tools and awls) and of personal ornaments seem to have developed progressively, in parallel with the already longstanding exploitation of wood and unworked bone.

## 8. Conclusion

Despite being at the heart of the question of the emergence of the European Upper Palaeolithic, the Aurignacian osseous industry is essentially known by the production of its most emblematic tools: split-based points, ornaments and portable art. This paper,



however, has shown that bone tools represent an important component of the Early Aurignacian osseous industry given the large proportion of informal tools, such as retouchers, but also the previously ignored unworked intermediate tools. The high frequency of this tool type, generally attributed to the Middle Paleolithic, indicates that Aurignacian osseous technology is not innovative in every way, but also reflects the endurance of an older technological process involving direct use of bone fragments. These new elements run contrary to the idea of a true technological breakthrough in osseous tools between the Middle and Upper Paleolithic and instead suggest a more gradual technological shift. As part of this hypothesis, the emergence of working osseous material could belong to a gradual transfer of techniques previously applied to wood, as proposed by D. Liolios (1999, 2003).

As a long-established skill, working osseous materials does not seem to have been the result of new skills or even of technical innovation properly speaking. Without doubt, its emergence would rather be due to a shift in the social representations of the animal world (Otte, 1990, 2001, Liolios, 1999, 2003). A change in symbolic relations with species of animals (particularly the reindeer and mammoth) may in fact explain the full integration of osseous materials into the range of raw materials exploited in the Upper Palaeolithic. In this way, the development of work on osseous materials should not be interpreted as owing strictly to a biological determinism associated with the cognitive capacities of anatomically modern humans so much as to a process of cultural evolution.

#### Notes:

- (1) Publication in preparation: PELEGRIN J. (Ed.), *L'abri Castanet, Sergeac, Dordogne. Fouilles du nouveau secteur (1994–1998)*, special issue of *Paleo*.
- (2) Publication in preparation: Henry-Gambier, D., Bon, F. (Eds.), *L'Aurignacien de la grotte des Hyènes (Brasempouy, Landes)*.
- (3) Operation carried out in 1994, during the resumption of the excavations by J. Pelegrin and R. White.
- (4) Not all the beveled pieces are intermediate tools (e.g.: stripper, hide scraper “defleshing tool”, etc.). Those interesting us here are classified as intermediate tools because they show percussion marks on both ends.
- (5) The breaking point of bone is at 2075 kg/cm<sup>3</sup>, 2250 kg/cm<sup>3</sup> for antler and 2400 kg/cm<sup>3</sup> for ivory (Albrecht, 1977).
- (6) Unlike the humerus and femur which exhibit more twisted diaphyses.
- (7) It cannot be excluded that certain intermediate tools have a distal end with a different morphology, a pointed morphology in particular.
- (8) The term “*baguette*” tends to be reserved for blanks from extraction by a double longitudinal groove (Averbouh, 2000), the term “*elongated flake*” is more appropriate for the antler blanks obtained by percussion fracturing (direct percussion or splitting).
- (9) For example, the number of flint splintered pieces (*pièces esquillées*) for ensemble 2 of the Grotte des Hyènes amounts to 162 (Bon, 2002) and 85 for the layer cbci-cbf of Gatzarria (Laplace, 1966). As for the half-rib intermediate tools, we have identified 23 from the north sector of Abri Castanet (layer A), 4 at the Grotte des Hyènes (ensemble 2) and one at Gatzarria (layer cbci-cbf, Tartar, 2009).

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