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Research Article

Elsa Defranould*, Sylvie Philibert, Thomas Perrin

Evolutionary Dynamics of Armatures in Southern France in the Late Mesolithic and Early Neolithic

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Abstract: The use of weapons, and therefore of arrowheads, contributed to structuring the technical, economic, social and cultural domains. In the technical sphere, emblematic projectile armatures are often considered to be loaded with cultural values and to embody the expression of human group identity. The study of their variability, in time and space, can shed light on mechanisms of mutation and innovation stemming from adaptive strategies and cultural choices. During the seventh and sixth millennia, the renewal of arrowheads corresponds to major changes in lithic equipment. Between the Late Mesolithic and the Early Neolithic, we observe a diversification of arrowhead shapes and the evolution of represented types. These observations enhance interpretative scenarios, especially questions concerning the transfer of know-how, techno-economic renewal and neolithisation. This article proposes to study these changes at the sequence of the Baume de Montclus site, a key site in Southern France. The selected sequence covers 1.5 millennia of occupation, roughly from 6500 to 5000 cal. BCE, with a corpus of geometric bitruncations of about 650 pieces. The combined study of microwear and technological and typological data leads to a comprehensive interpretation of manufacturing processes, hafting methods and function. These analyses provide valuable information on the diversity of arrowheads, the identification of specific technical traditions and the characterisation of techno-functional ruptures throughout this sequence. These results will subsequently be integrated into a wider, regional and extra-regional context, with a particular focus on the emergence of blade and trapeze complexes (BTC) and the neolithisation of the western Mediterranean basin.

Keyword: arrowheads, use-wear analyses, typo-technological study, technical traditions, neolithisation

1 Introduction

This article examines the place of weapons in prehistoric Mesolithic and Neolithic societies, by studying the variability of manufacturing processes and the use of projectile armatures, the most frequently preserved elements of prehistoric arrows. Historically, this topic has been widely discussed by archaeologists, as to a certain extent, it provides insights into the functioning of human groups, due to the fact that the manufacture and use of these objects respond to different technical, functional, social, cultural or symbolic

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constraints or traditions. For example, the search for lighter-weight implements of reduced size, combined with the optimisation of cutting and injuring capacities, has repercussions on the shape of arrowheads and the techniques used to make them (Léa, Gassin, & Linton, 2010). Hafting methods can also affect the morphology of these elements (Chesnaux, 2014; Philibert, 2016). Similarly, the function of arrows can be linked to specific hunting practices, to the species of hunted or possibly fished animals, to the distinction between hunting and war weapons and can explain the variability observed in armature types (Chesnaux, 2013; Lemonnier, 1987; Pétrequin & Pétrequin, 1990). Finally, cultural and/or social explanations can also be advanced to account for this diversity, when the manufacture or use of certain arrows becomes a marker of the status of individuals or groups (Pétrequin & Pétrequin, 1990). For these reasons, the study of the variability of these objects in time and space constitutes a good means of highlighting mutation mechanisms resulting from adaptive strategies and the technical, functional or cultural choices applied by the studied human groups.

The period spanning the seventh and sixth millennia BCE, i.e., the end of the Mesolithic and the neolithisation period in the north-western Mediterranean, is particularly propitious to the study of these technical-economic and functional changes. At that time, we observe the emergence and diffusion of the blade and trapeze complex (BTC) throughout Western Europe. This period corresponds to a renewal of knapped stone equipment (and therefore of part of the weapons), in terms of both function and production (e.g., Gassin, Marchand, Claud, Guéret, & Philibert, 2013; Gassin *et al.*, 2014; Marchand & Perrin, 2017; Perrin & Binder, 2014; Perrin *et al.*, 2009). About a millennium later, the advent of Neolithic lifestyles marks a second upheaval for societies and profoundly modifies human behaviour (Binder, 1987, 2013; Guilaine, 2000–2001; Perrin, 2013; Vigne, 2007). Indeed, agropastoral practices induce changes in the relationship of humans to their environment, to territories, to the role of hunting and therefore to the weapons used for this activity. This is also a period in which the question of potential contacts between the last indigenous hunter-gatherers and Neolithic arrivals arises. Technical innovations, transfers or, on the contrary, blockages in the transmission of technical know-how, perceptible in material productions, may result from these interactions. Thus, from the Late Mesolithic to the beginning of the Early Neolithic, we can develop interpretative scenarios by focusing on the diversification of arrowhead armatures, in particular with regard to the question of the transfer of know-how and techno-economic renewals in relation to processes of neolithisation. The aim of this article is to account for these changes, based on combined studies of technological, typological and microwear data from the armature corpus of a rich stratified site in the south of France: the Baume de Montclus.

2 La Baume de Montclus and the Assemblages of Studied Armatures

The Baume de Montclus is located at the northern end of the Gard, near the present-day Ardèche department. The shelter lies at the foot of a south-facing limestone wall and overlooks the left bank of the Cèze River, about 30 km from its confluence with the Rhône. The river floods regularly and transports a large part of the silty-sandy sediments making up a lot of the shelter's filling. The site was discovered in 1954 by M. Escalon de Fonton and then excavated for about 15 years between 1956 and 1971. It is an ideal setting for studying the technical and functional evolution of armatures. Indeed, the stratigraphy identified at the excavation extends over a thickness of 4 m, from the beginning of the Mesolithic to the Early Neolithic (e.g., Escalon de Fonton, 1966). Levels 16–4 are of particular interest to us here, corresponding to Late Mesolithic and Early Neolithic occupations, i.e., more than 1.5 millennia of occupations (Figure 1 and Table 1). Levels 16 and 15 correspond to a mixture of Early and Late Mesolithic occupations (Perrin & Defranould, 2016). These levels are dated by three measurements between 6690 and 6430 cal. BCE. However, given the mixed character of these occupations, it is not possible at present to ascertain whether these measurements relate to the Early or Late Mesolithic (Perrin & Defranould, 2016). Levels 14–9 are attributed to the Late Castelnovian Mesolithic, with successive dates without stratigraphic inversions or perceptible hiatuses ranging between 6350 and 5740 cal. BCE. Levels 8 and 7 were attributed by the excavator to a Final Castelnovian

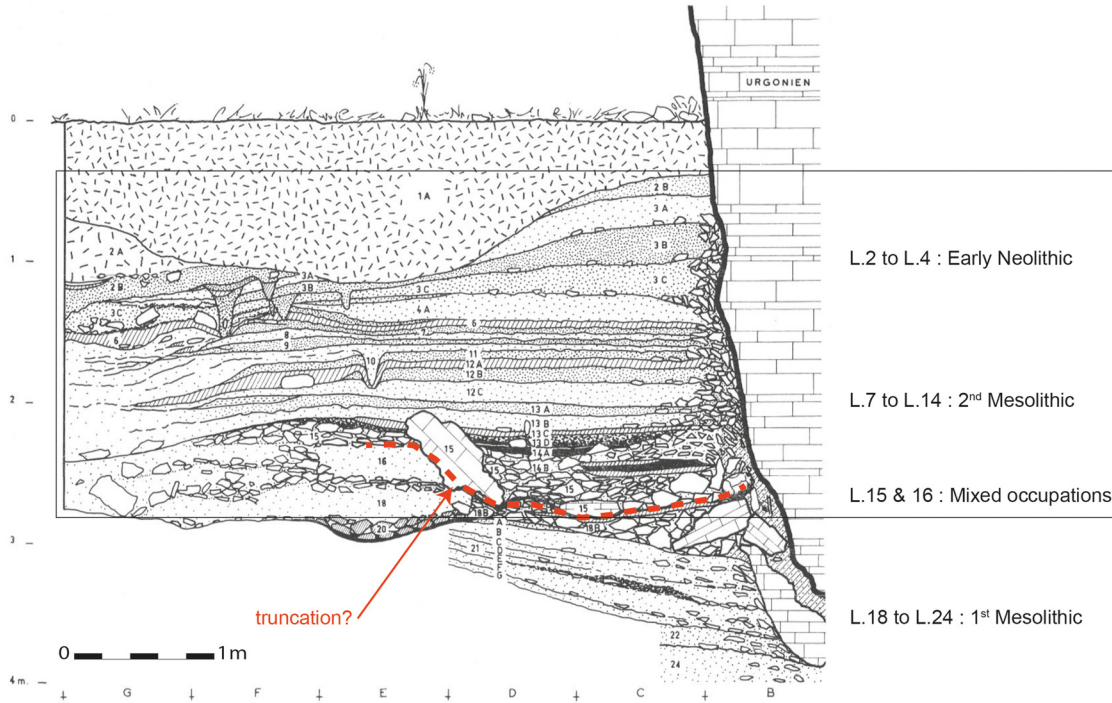


Figure 1: Main stratigraphy of Montclus, after Escalon de Fonton (1970, modified).

occupation, that is, to the end of the Late Mesolithic. A single radiocarbon measurement dates level 7 to between 5650 and 5480 cal. BCE. Finally, levels 5 and 4 correspond to Early Neolithic Cardial occupations and are dated between 5620 and 4850 cal. BCE.

All of these levels yielded 591 arrowheads, associated with 542 microburins (which correspond to the manufacturing waste of some of these armatures; Table 2). This is a substantial corpus, and data can be quantified by statistical processing. It is thus an ideal collection for studying techno-economic and functional variations, and therefore, the evolutionary mechanisms at work in this stratigraphic sequence.

3 Evolution of Arrowhead Manufacture

3.1 Raw Material Procurement Strategies

The geological environment of the Rhone corridor comprises abundant siliceous resources and three main families of flint were exploited by the Montclus chert knappers:

- A great variety of Local Tertiary cherts comprising diversified colours, shapes and suitability for knapping, with sources always located less than 10 km from the site (Boccaccio, 2005).
- Cenomanian cherts from the Uzès basin, about 20 km from the shelter (Boccaccio, 2005).
- Cretaceous blond fine-grained and very good-quality Bedoulian cherts, particularly well-suited to knapping. These cherts may come from primary deposits located on the banks of the Rhône, some 40 km to the east of the site for the closest sources, or from secondary deposits located in former alluvial terraces of the Rhône some 15 km from Montclus (e.g., Delvigne et al., 2019; Tomasso, Binder, Fernandes, Milot, & Léa, 2017).

The proportions of materials used to make arrowheads are relatively similar during the Late Mesolithic (layers 16–10), with a majority of local Tertiary flints, which represent between 55 and 80% of the

Table 1: Available radiocarbon dates for layers 16 to 4 of Montclus (all dates are calibrated with OxCal4.4 software and the IntCal20 curve)

Layer	Sample	Reference	Age (BP)	Two sigmas ranges (2σ)	Bibliography	Reliability
L.4A	Bone (petit ruminant)	Beta-460502	6090 ± 30	-5206/-4853	Unpublished (ANR Procome)	Good
L.4A	Bone (<i>Ovis/Capra</i>)	Beta-253458	6550 ± 40	-5617/-5390	Perrin <i>et al.</i> (2009)	Good
L.4C	Bone (small ruminant)	Beta-428105	6570 ± 30	-5612/-5477	Unpublished (ANR Procome)	Good
L.4C	Bone (small ruminant)	Beta-460503	6530 ± 30	-5608/-5386	Unpublished (ANR Procome)	Good
L.4	<i>Charcoal (indet.)</i>	<i>MC-694</i>	<i>6170 ± 200</i>	<i>-5523/-4616</i>	Delibrias, Évin, and Thommeret (1982)	<i>Doubtful</i>
L.4	<i>Os (indet.)</i>	<i>LY-304</i>	<i>6140 ± 140</i>	<i>-5372/-4726</i>	Evin, Longin, Marien, and Pachiaudi (1971)	<i>Doubtful</i>
L.4	<i>Charcoal (indet.)</i>	<i>LY-303</i>	<i>6300 ± 140</i>	<i>-5531/-4905</i>	Evin <i>et al.</i> (1971)	<i>Doubtful</i>
L.4	<i>Charcoal (indet.)</i>	<i>KN-181</i>	<i>6400 ± 160</i>	<i>-5638/-4991</i>	Escalon de Fonton (1970)	<i>Doubtful</i>
L.5	<i>Charcoal (indet.)</i>	<i>MC-695</i>	<i>6450 ± 100</i>	<i>-5616/-5216</i>	Delibrias <i>et al.</i> (1982)	<i>Doubtful</i>
L.5	Bone (indet.)	Beta-481086	6320 ± 30	-5363/-5216	Unpublished (ANR Procome)	Good
L.5	Bone (indet.)	Beta-481085	6480 ± 30	-5481/-5371	Unpublished (ANR Procome)	Good
L.5	Bone (indet.)	Beta-253159	6360 ± 40	-5471/-5218	Perrin <i>et al.</i> (2009)	Good
L.7	Bone (<i>Capreolus capreolus</i>)	Beta-253160	6660 ± 40	-5653/-5483	Perrin <i>et al.</i> (2009)	Good
L.7-8-9	<i>Charcoal (indet.)</i>	<i>MC-728</i>	<i>6880 ± 100</i>	<i>-5984/-5622</i>	Delibrias <i>et al.</i> (1982)	<i>Doubtful</i>
L.8	<i>Charcoal (indet.)</i>	<i>LY-494</i>	<i>6230 ± 150</i>	<i>-5478/-4803</i>	Evin, Marien, and Pachiaudi (1973)	<i>Doubtful</i>
L.9	Bone (<i>Cervus</i>)	Beta-428106	6960 ± 30	-5969/-5743	Unpublished (ANR Procome)	Good
L.10B	Bone (<i>Sus scrofa</i>)	Beta-253161	6990 ± 40	-5982/-5755	Perrin <i>et al.</i> (2009)	Good
L.12A	Bone (indet.)	Beta-253162	7170 ± 50	-6216/-5917	Perrin <i>et al.</i> (2009)	Good
L.13B	Bone (<i>Capreolus capreolus</i>)	Beta-253163	7190 ± 50	-6219/-5926	Perrin <i>et al.</i> (2009)	Good
L.13D	<i>Charcoal (indet.)</i>	<i>MC-729</i>	<i>7200 ± 100</i>	<i>-6339/-5844</i>	Delibrias <i>et al.</i> (1982)	<i>Doubtful</i>
L.14B	Bone (indet.)	Beta-253164	7320 ± 50	-6351/-6064	Perrin <i>et al.</i> (2009)	Good
L.14	<i>Carbonaceous soil</i>	<i>LY-495</i>	<i>6440 ± 230</i>	<i>-5794/-4845</i>	Evin <i>et al.</i> (1973)	<i>Doubtful</i>
L.14	<i>Carbonaceous soil</i>	<i>LY-496</i>	<i>7020 ± 140</i>	<i>-6216/-5639</i>	Evin <i>et al.</i> (1973)	<i>Doubtful</i>
L.15	Bone (<i>Cervus</i>)	Beta-255115	7770 ± 50	-6687/-6475	Perrin <i>et al.</i> (2009)	Good
L.16	<i>Bone (indet.)</i>	<i>LY-542</i>	<i>7540 ± 160</i>	<i>-6748/-6031</i>	Evin <i>et al.</i> (1971)	<i>Doubtful</i>
L.16	Bone (indet.)	Beta-253166	7670 ± 50	-6636/-6431	Perrin <i>et al.</i> (2009)	Good
L.16	Seed (<i>Vitis</i>)	Beta-432166	7760 ± 30	-6648/-6498	Unpublished (ANR Procome)	Good
L. 18B	Bone (indet.)	Beta-255116	7800 ± 50	-6771/-6571	Perrin <i>et al.</i> (2009)	Good
L.18	Bone (<i>Capreolus capreolus</i>)	Beta-428659	7830 ± 30	-6769/-6591	Unpublished (ANR Procome)	Good

Italics indicate possibly unreliable measurements, due to dispersed standard deviations or sample type.

Table 2: Counts of armatures and microburins per level, using typological classes defined by Perrin et al. (2017; BG1, BG2, BG3)

Layer	BG1	BG2	BG3	Total arrowhead	Use-wear analyses	Impacted	MB
L.4		8	50	58	55	15 (4?)	1
L.5	1	5	25	31			
L.7	6		7	13	13	2 (2?)	7
L.8	14	1	4	19	4	2	10
L.9	31			31			35
L.10	44			44	44	4 (6?)	38
L.11	80			80			65
L.12	53			53			57
L.13	156	1		157			186
L.14	62			62	62	19 (5?)	142
L.15		9		9			
L.16		34		34	34	5 (4?)	1
Total	447	58	86	591	212	62 (21?)	542

(x?): number of armatures with possible but uncertain impact marks. They have not been taken into account in this study. For layers 16 and 15 where Late Mesolithic occupations are mixed with Early Mesolithic occupations, the microliths of the 1st Mesolithic are excluded from these counts.

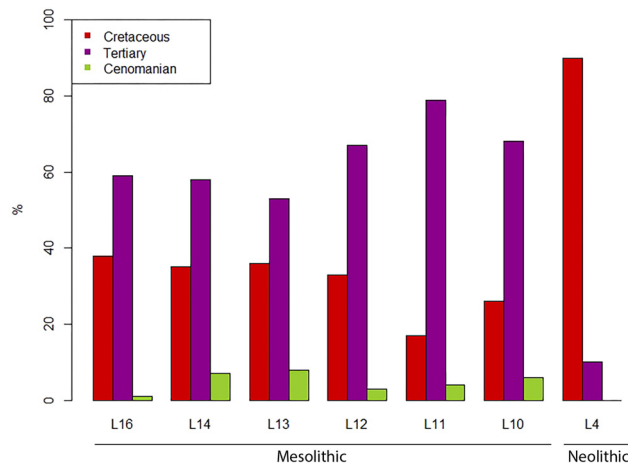


Figure 2: Proportion of different raw materials used for manufacturing armatures. Counts are insufficient for layers 15, 9, 8, 7 and 5. Total counts per layer for the determined raw materials: C16 = 29; C14 = 43; C13 = 92; C12 = 30; C11 = 47; C10 = 31; C4 = 30.

determinable raw materials (Figure 2). On the other hand, there is a clear rupture in acquisition strategies in layer 4, attributed to the Early Neolithic, where Cretaceous flint is almost exclusively used for the manufacture of arrowheads (90% of the assemblage).

3.2 Techno-Typological Point of View

In all levels, armatures were obtained by fracturing full-debitage blades, which were then retouched in various ways. During the Mesolithic and Neolithic periods, the blades selected for the production of geometrical shapes were always the most regular ones, with no cortex, with standardised dimensions, and therefore, correspond to optimal laminar production. Conversely, the common tools are less technically elaborate and are made on all types of blanks, cortical or not, and are less regular with less-standardised dimensions (Figure 3). Thus, the production of armatures is one of the main objectives of the laminar

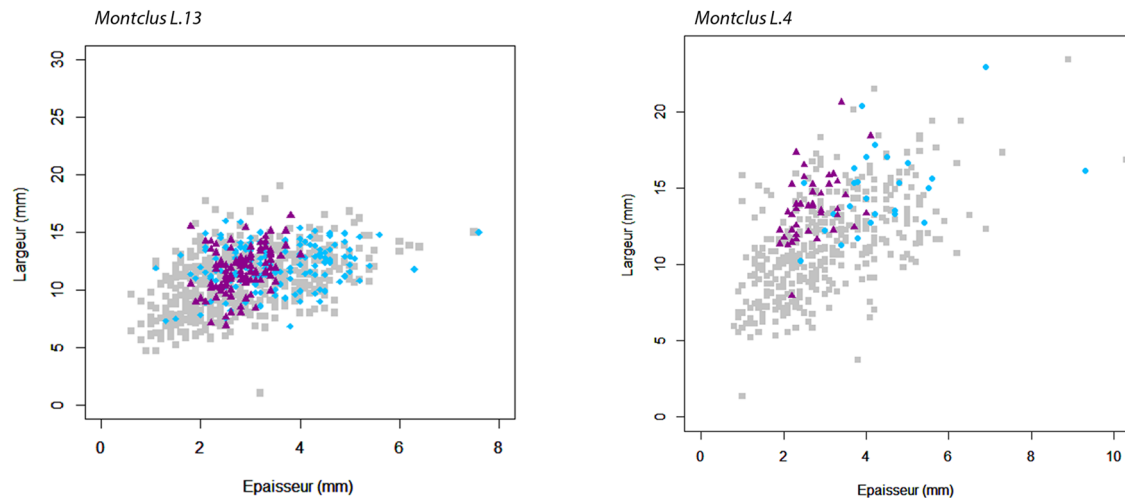


Figure 3: Example of width/thickness dispersion of unretouched blades (grey squares), common tools (blue diamonds) and arrowhead (magenta triangles) from layers 13 and 4 of Montclus.

“*chaîne opératoire*” and reflects increased technical effort by knappers. This validates the targeted analysis of these technical elements and their function.

In the course of the sequence, several technological ruptures are identified in armature production, indicating important changes in laminar “*chaîne opératoire*.” The first consists of a change in blade removal techniques, with an undifferentiated use of pressure and indirect percussion for Mesolithic layers 16–7, whereas indirect percussion becomes the only blade knapping technique in the Early Neolithic in layers 5 and 4. The distinction between indirect percussion and pressure is often delicate, as the stigmata can overlap, so the recognition of one or other of the knapping techniques cannot be based solely on an isolated piece, but rather on the recurrence of certain observations. We considered that the conjunction of multiple criteria on several pieces, blanks and *nuclei*, could be symptomatic of the use of pressure technic (faceted butts, prominent, sensitive and high sitting bulb, bulb scars, *angle de chasse* greater than 90° and high straightness of the blanks: e.g., Binder, 1984; Briois, Ferrari, Fontana, & Perrin, 2017; Collina, 2015; Pellegrin, 2012; Tixier, 1984).

The second technological rupture concerns blade fracturing methods for the production of bitruncations. At the beginning of the sequence, in layers 16 and 15, microburins are almost totally absent from the assemblages, probably indicating blade fracturing by bending for the production of geometrical shapes. Then, in layers 14–7, microburin waste is frequent, attesting to the use of this fracturing technique to make bitruncations. Finally, for the Early Cardial Neolithic, no microburins are found in layer 5, and only one out of 58 armatures in layer 4, which suggests that this object is intrusive in the assemblage and that this fracturing technique was abandoned from that time onwards (Table 2).

The typological approach used here combines technical and morphological components. It takes into account the type of blank, the location, type and angle of retouch. This approach (Perrin, Angelin, & Defranould, 2017) is adapted from that of Binder (1987). It was defined on the basis of Late Mesolithic and Neolithic productions in Southern France and is therefore perfectly adapted to the armatures considered in this study. If we focus on the different typological classes of armatures, new discontinuities in the sequence emerge (Figure 4):

- At the beginning of the Late Mesolithic, in layers 16 and 15, the assemblage is composed exclusively of class BG2 symmetrical trapezes with direct truncations.
- In layers 14–9, class BG1 geometric bitruncations appear generally asymmetrical, and with oblique truncation. This class of arrowhead covers various morphologies, with trapezoidal or triangular shapes, even if, in cases where the small base is very reduced, the distinction between triangles and trapezoids may be questionable. Except in layer 10, which stands out from the others, trapezoidal shapes remain in

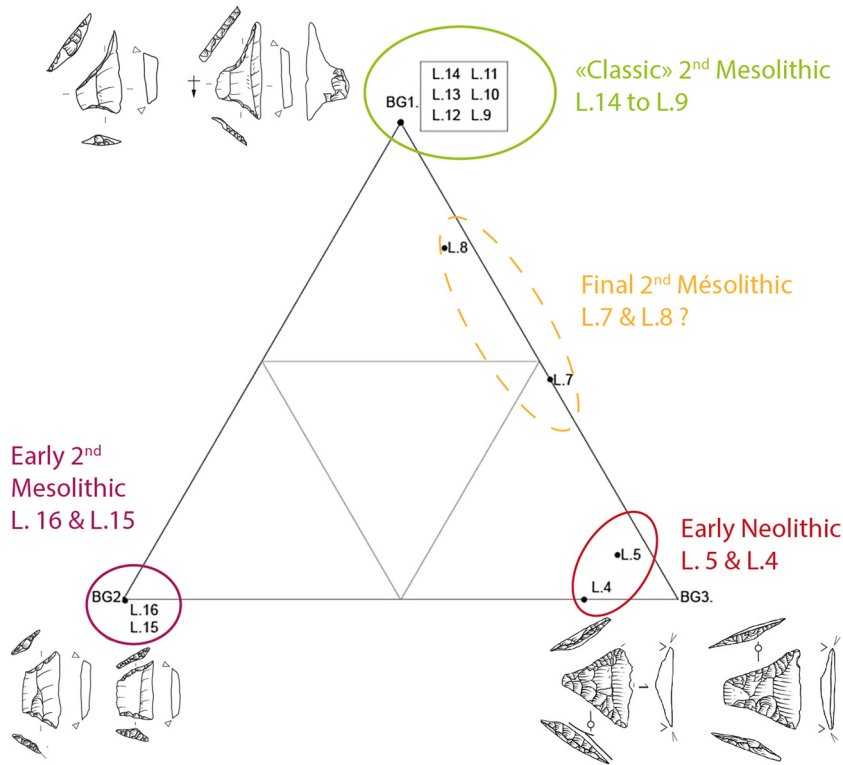


Figure 4: Ternary diagram of classes of armatures in each layer.

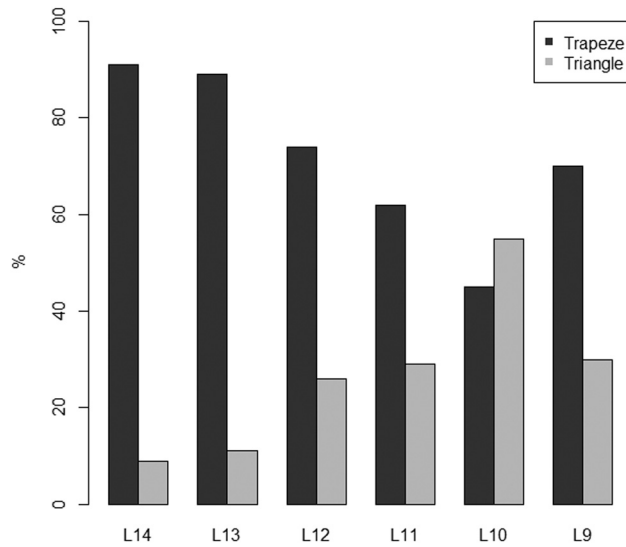


Figure 5: Proportion of trapezoidal and triangular arrowhead between layers 14 to 9 (counts: L14 = 58, L13 = 144, L12 = 42, L11 = 77, L10 = 38, L9 = 30).

the majority but decrease over time, from 90% trapezoids in layer 14 to 62% in layer 11 or 70% in layer 9 (Figure 5). Finally, these elements sometimes bear flat retouch on the small truncation, extending at times over the upper or lower face of the armature. Within this corpus, we note a minor variation over time. Indeed, among class BG1, we observe an increase in flat retouch on the upper or lower face from layer 11 onwards. Thus, the proportion of armatures with flat retouches increases from 18 to 21% for

layers 14–12 to 38 to 43% for layers 11–9. In conjunction with the increase in flat retouch, in some cases, the appearance of very small retouches with minimal effect on the morphology on the large base of the arrowhead can be noticed. We do not currently have a functional interpretation of this arrangement, but it would be interesting to track it down in future research.

- Levels 8 and 7 yielded approximately 50% of BG1, which is classic for the Late Mesolithic, and 50% of BG3, which is more frequently attributed to the Early Neolithic (Perrin, Marchand, Valdeyron, & Sam, 2019). The interpretation of these mixed assemblages (resulting from one occupation or a mixing of several occupations?) will be discussed in detail below.
- In levels 5 and 4, attributed to the Early Neolithic, the armature corpus consists for the most part of geometric bitruncations, with inverse truncations, sometimes with flat retouch on the upper surface, which correspond to class BG3. In addition to these types of armatures, we observe occasional type BG2 geometrical bitruncations with direct truncations.

3.3 Functional Variability

Do the variations observed in armature types also correspond to functional variations? In order to address this question, use-wear analysis was carried out on the trapezes corpus from layers 16, 14, 10, 7 and 4, while more specific observations were made on BG3 type bitruncations of layer 8 (Table 2). From a methodological point of view, the characterisation of projectile use is based, in this article, on the DIF (diagnostic impact fracture) approach while bearing in mind interpretative biases such as the multi-causal origin of some damage (e.g., Chesnaux, 2014; Coppe & Rots, 2017; Rots & Plisson, 2014; Taipale, Chiotti, & Rots, 2022). Experimental databases generally agree on most a set of diagnostic criteria even if they are not strictly transposable from one type of arrowhead to another (Albarello, 1988; Chesnaux, 2014; Coppe & Rots, 2017; Domingo Martinez, 2003; Fisher, Vemming Hensen, & Rasmussen, 1984; Gassin, 1991; Odell & Cowan, 1986; Philibert, 2002; Yaroshevich, Kaufman, Nuzhnyj, Bar-Yosef, & Weinstein-Evron, 2010). These data have been complemented by our own experimental programme aimed at testing the damage model and various ways of hafting of geometric bitruncations from the Second Mesolithic (Castelnovian) and Early Neolithic (Impressa/Cardial) periods, whose results are currently being processed and published (Philibert, Chesnaux, Costamagno, in progress).

For this first step of the research on evolutionary dynamics of arrowheads, we considered mainly the macroscopic impact features, break and scars, bending initiated with step, hinge or feather termination, burin-like fractures and secondary removals (spin-off). The high magnification analysis to identify microscopic linear impact traces (MLITs) was implemented for level 16 only. The macroscopic and microscopic observations were made using a Nikon Z800 stereomicroscope (6×–50×) and a Nikon Eclipse LV150 metallographic microscope with reflected light (50×–200×). The photographs were taken using a Nikon DS-Fi2 camera and NIS software.

In layer 16, bitruncations are narrow, trapezoidal and symmetrical. Nine of the 34 trapezes show fractures but in four cases, the damage – very tiny bending breaks or scars, striation – was not considered diagnostic of projectile use, although possible. There are doubts about their origin because of their tenuous and isolated nature. Unequivocal impact fractures were identified in five trapezes. Invasive removals affect large bases (in one case also the small base), in particular complex bending fractures with step and hinge (overshot) termination and scarring. The various macro-traces can be bifacial ($n = 3$) and frequently combined with each other, which is one of the diagnostic validation criteria. On a trapeze, both ends of the large base are impacted. For the five trapezes, the fractures are initiated from the large base of the microliths and are perpendicular to it. On two of these armatures, MLITs, with a very slightly oblique orientation, are associated with the large base damages from which they arise (Figure 6). The combination of the different marks, their location and recurring orientation might suggest that symmetrical bitruncations from layer 16 were used as transverse projectile tips.

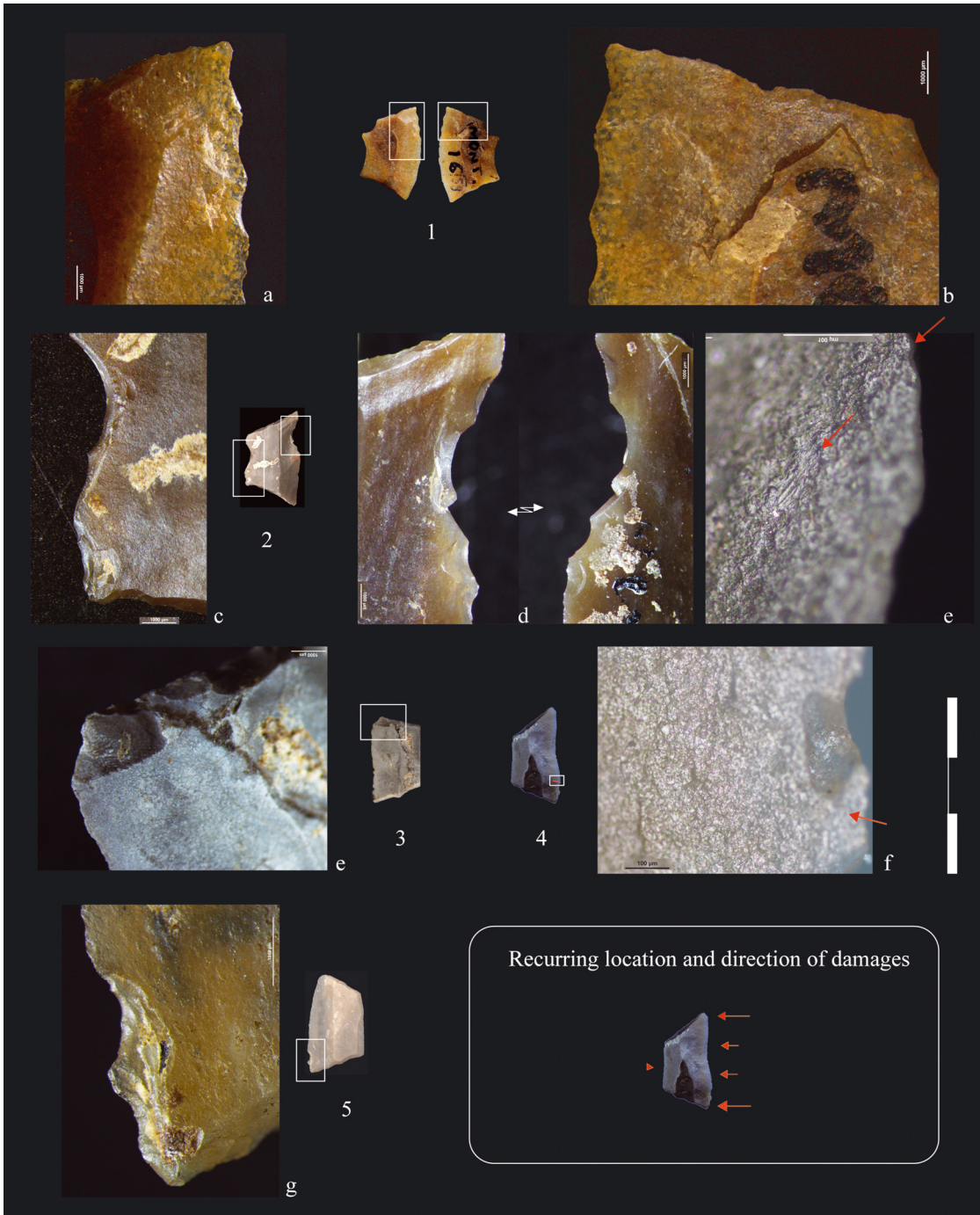


Figure 6: Montclus layer 16, diagnostic impact fractures on Geometric Bitruncations (BG2). (1) Bifacial bending fracture initiated from the large base, deep scars with step and hinge termination (a) and elongated scar with fissured overshoot termination (b). (2) Bifacial removal with step termination (d) associated on the dorsal face with an MLIT. (e) Small base break and spin off (c). (3) Hinge-terminated break along the truncation of the trapeze. (4) MLIT from scars, slightly oblique (f). (5) Step and hinge termination of deep overlapping scars (g).

From layer 14 onwards, the appearance of asymmetrical arrowhead reflects major functional changes. For layer 14, characteristic projectile impact marks were identified on 19 trapezes out of 62 bitruncations (30%). Fractures are preferably located at the main point of the trapezes (13/19), where the most common are complex bending breaks with stepped and hinged terminations (9/13), often bifacial. Then, there are

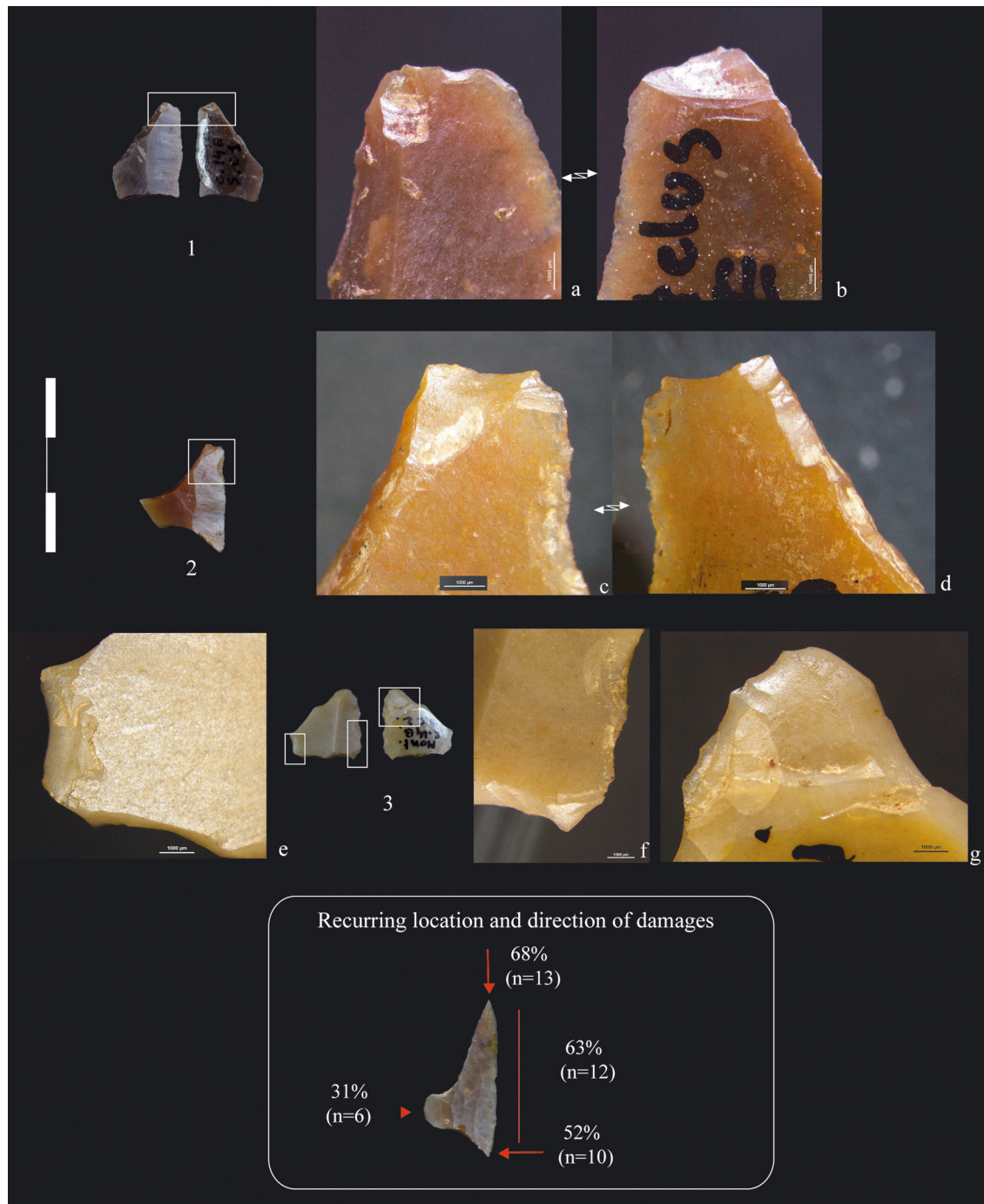


Figure 7: Montclus layer 14, diagnostic impact marks on Geometric Bitruncations (BG1). (1) Complex fracture localised at the main point of the trapeze, elongated scar with step termination on the dorsal face (a), break with secondary removal (spin off) on the ventral face (b). (2) Complex break (c and d) with, on the ventral face, a burin-like fracture developed along the truncation (d). (3) Trapeze with several impacted zones, a complex fracture with step and hinge termination at the main tip (g), bifacial large scars on the long base and fracture at the small point (f) and bending step fracture at the small base (e).

burin-like fractures (4/13) and secondary scars (spin-off; Figure 7). All these fractures develop in the similar orientation, slightly oblique with respect to the debitage axis of the trapeze (parallel to the bisector of the angle of the main point). The majority of the arrowheads show a combination of fractures (14/19), with up to four impacted zones. Associated with main point damages, we observe slightly obliquely oriented scarring

on the large base, often continuous and bifacial, with step termination (8/13) and/or small point fracture (8/13). The overall characteristics of diagnostic impact fractures argue that asymmetrical trapezes, as a whole, have been hafted as piercing arrowheads.

In addition to typology, the consideration of shaping intentions is likely to provide information on the diversity of hafting modes and positions of the trapeze on the shaft: for example, the presence or absence of a small point, made by inflection, and varying degrees of concavity of the small truncation. The study of the distribution of impacted zones on each type of asymmetrical trapezes seems to indicate slight variations; a majority of breaks and scars affect the main tip and on the apical half of the large base of the trapezes with straight small truncation whereas the active zone appears to extend to the entire length of the large base and to the small point on armatures where this has been well cleared by the concavity of the small truncation (Figure 8). These variations could reflect the diversity of piercing arrowheads that can be axial or axiolateral points. Trapezes with an offset small base are more frequently damaged at the large base than at the main point which could be the result of a different hafting, perhaps a lateral insertion. These correlations between design and functioning are, at this stage of the study, only hypotheses. The data are insufficient for the moment and need to be validated by more observations, extended to the whole corpus of the different levels and will also have to integrate high magnification analysis to identify MLITs, which has not been done for this layer.

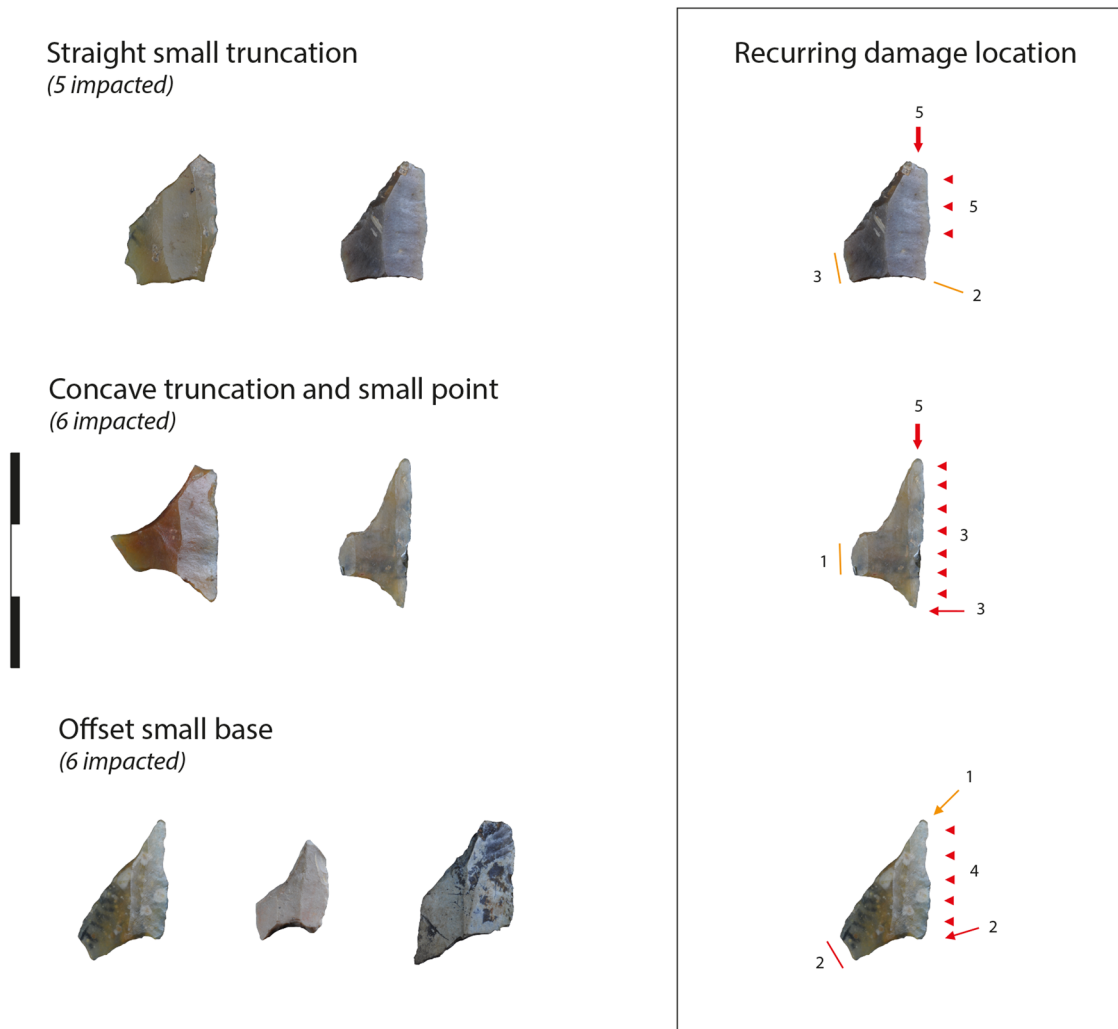


Figure 8: Montclus layer 14, recurring damage location on Geometric Bitruncations according to their morphology. Expressed as the number of trapezes with damage in the area indicated by the arrows (breaks) or triangles (lateral scarring).

For layers 14–10, we investigated whether the flat retouch on some trapezes (type BG13) could be related to a specific function. In one impacted BG13 from layer 14, flat inverse retouch is associated with crushing fractures of the small base that could result from counter-pressure within the shaft upon impact. This seems to confirm that such retouch is related to the part of the arrowhead lodged inside the hafting arrangement. It is therefore possible that this retouch served to adjust the thickness of the trapeze to facilitate hafting, or else served to make surface irregularities to reinforce adhesion between the glue and the arrowhead. Still on the subject of hafting, we observed the presence of reddish residues on the small bases and truncations of three trapezes in layer 10, two trapezes without traces and one impacted trapeze with flat retouch. These mineral residues are distributed over the supposedly hafted part and could therefore illustrate the use of additives to the glue to improve adhesion and resistance properties (Allain & Rigaud, 1986; Gibson, Wadley, & Williamson, 2004; Lombard, 2006, 2007; Salomon, 2009; Wadley, 2005). Such ochre-coloured residues have also been identified at other Castelnovian sites, in particular at Mourre de Sève and Font-des-Pigeons Rockshelter in Southern France (De Stefanis, 2018) and at Gaban Rockshelter in northern Italy where the residues would, according to the author, come from the ochre-treated leather bindings used to fix the trapezes (Cristiani, Pedrotti, & Gialanella, 2009). Beyond this technical role, this red dye could have a sign, aesthetic, identity or symbolic function that escapes us.

Finally, layer 4, attributed to the Early Neolithic, yielded 15 armatures with diagnostic impact fractures out of a total corpus of 55 pieces. Whatever the types of armatures, BG22, BG31, BG32 or BG34, impact fractures initiated from the large base of the trapezes and are systematically perpendicularly oriented to it. These are essentially burin-type breaks propagating along the truncations (Figure 9). All these elements suggest that the arrowheads were used as transverse cutting arrowheads. Again, reddish residues were observed on one piece, which can again be interpreted as the addition of additives to the glue. However, differences in the fracturing model are observable compared to the bitroncatures of layer 16. The increase in impact rate and damage intensity, with more burin-like fractures and elongated removals with step and hinge termination sometimes fissured, probably indicates changes in the hunting sub-system, maybe in the hafting arrangement, in the power of the bows or in the nature of the target.

3.4 Focus on Layers 7 and 8: Coexistence of Two Types of Armatures and the Question of the Transition Between the Mesolithic and Neolithic

Let us now focus on layers 8 and 7, considered by M. Escalon de Fonton as “Epi-Castelnovian,” a now-obsolete notion supposed to mark the transition between the Mesolithic and Neolithic (Escalon de Fonton, 1971). As we have seen, a new type of arrowhead appeared in these two levels, bitroncations with inverse truncations and flat retouch (BG3), also called “Montclus arrows.” These armatures are very frequently found in Early Neolithic contexts in Southern France (Perrin *et al.*, 2019). They coexist here with BG1, more typical of the Late Mesolithic. Thus, these armatures in levels attributed to the Late Castelnovian contribute to the debate on their hypothetical Mesolithic origin (Perrin *et al.*, 2019). Here, the question is whether this combination of two types of armatures reflects an archaeological reality with the appearance of a new type of arrowhead in Mesolithic levels, or whether we are faced with a taphonomic bias stemming from the mixing of lithics from distinct occupations.

To attempt to answer this question, it is fitting to ask whether the BG32 of levels 8 and 7 show variations with respect to their counterparts in unquestionably Neolithic levels, which would indicate an invention in Mesolithic contexts on the basis of techno-functional arguments. The raw materials used for each type of armature diverge slightly, but the number of armatures for which raw materials have been determined is so low that no definitive conclusion can be reached. We can only note that the BG3 in layers 8 and 7 are more made of Bedoulian chert than Tertiary chert (4/7 of the armatures are in Bedoulian chert and 3/7 in Tertiary chert), whereas BG1 are mostly made of Tertiary chert (6/10 of the armatures are in Tertiary chert and 4/10 in Bedoulian chert). Thus, the BG3 from these intermediate levels seem more like the armatures of the Early

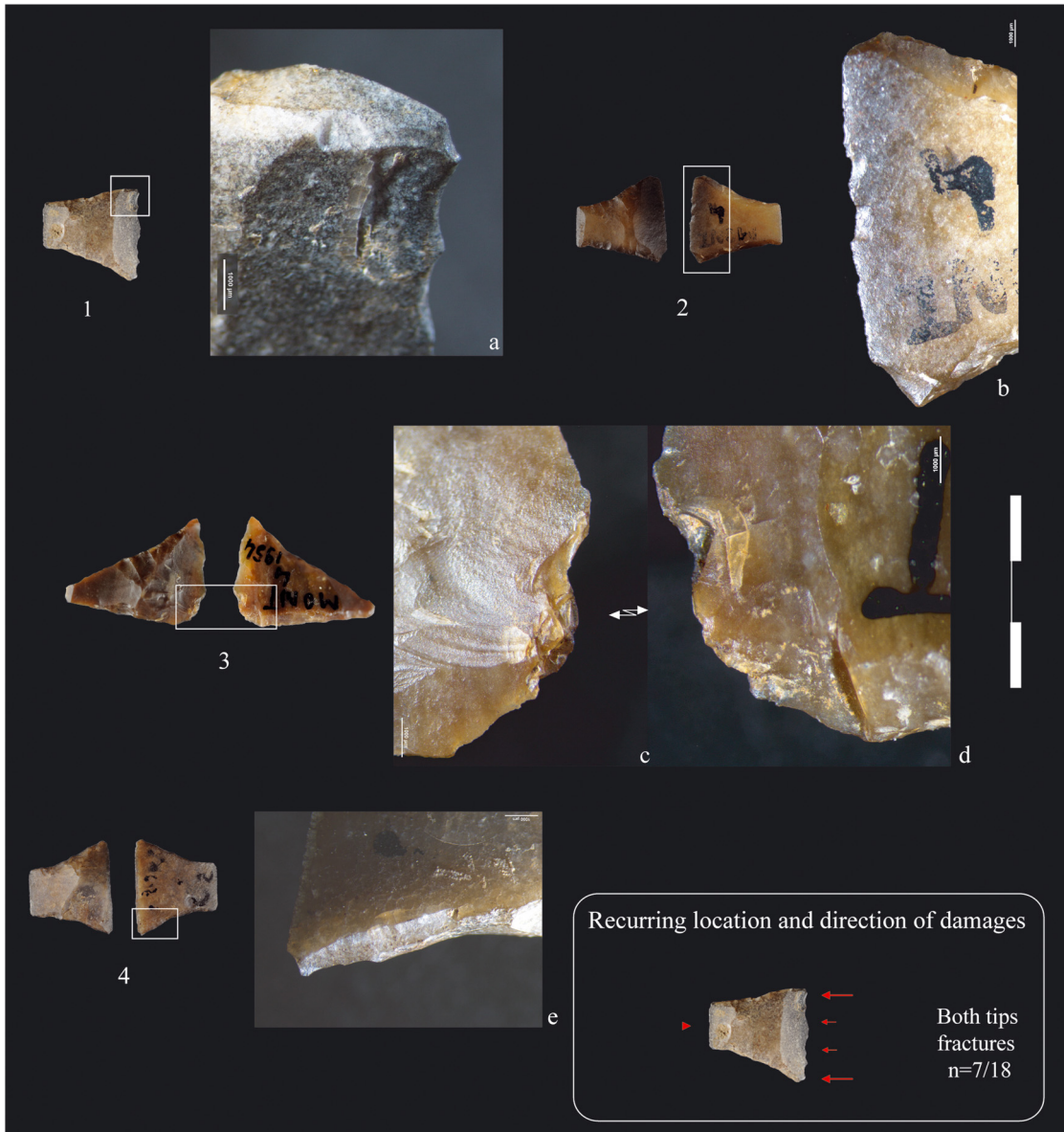


Figure 9: Montclus layer 4, diagnostic impact marks on Geometric Bitruncations (BG3). Impact damages initiated from the large base of trapezes, oriented perpendicularly to it. (1) Bending step fracture and burin-like spin off along the truncation (a). (2) Impact damages at the both points of the trapeze, burination break and bending step fracture (b). (3) Bifacial break with complex termination combining step and hinge and fissured zone (c and d). (4) *Montclus arrowhead* with burin-like break propagated on the ventral face, along the truncation (e), as is the case for 7 trapezes out of 15.

Neolithic upper levels, with a prevalent use of Bedoulian chert, whereas the BG1 are more like those from the underlying levels, with a predominance of Tertiary chert.

Moreover, no technical relationship can be noted between BG1 and BG3. For example, no remnants of “*piquant trièdre*” were identified on the BG3. This suggests that the microburin technique was not used for fracturing those blades, as is also the case for the BG3 from the upper levels, attributed to the Early Neolithic. Similarly, the invasive direct retouch on BG3 seems to mark an important change in arrowhead shaping techniques. Thus, techno-economic data on armature shaping indicate a significant break between BG1 and BG3, but also proximity between the BG3 from levels 8 and 7 with those from Early Neolithic levels 5 and 4.

Microwear data also pinpoint a functional break between the two types of armatures, as they are hafted differently. Indeed, out of the 11 BG3 from layers 8 and 7, 4 arrowheads show impact fractures that clearly correspond to a hafting as transverse cutting arrowheads.

In addition to economic and techno-functional considerations, the substantial corpus of BG3 is noteworthy (20% of the armature corpus for layer 8 and half of the corpus for layer 7; Table 2). Given the considerable number of armatures, the intermittent intrusion of material from the upper levels seems unlikely. Moreover, the spatial distribution of both types of armatures and microburins seems random and does not show any spatial exclusion of one type or the other (Figure 10). As it stands, spatial analysis does not point to intrusions of remains from the upper Neolithic levels, for example, from a pit that was not identified during the excavation. Other field data concerning these levels are ambiguous. On the one hand, the excavator mentioned the possibility of erosive processes affecting the hearths of layer 7, linked to the flooding of the Cèze and runoff from the wall (Escalon de Fonton, 1967, p. 178). On the other hand, the existence of a sterile level between layers 7 and 5 minimises the possibility of elements infiltrating down from the upper Neolithic levels. Similarly, the absence of pottery in layers 8 and 7 further undermines the hypothesis of the intrusion of Neolithic material into the Late Mesolithic assemblages.

In summary, techno-economic and functional data point to a break in the manufacture and use modes of the two types of armatures in these levels, while ambiguity still pervades spatial and field data. As it stands, it is therefore difficult to definitively conclude that assemblage mixing occurred or that these different armature types were genuinely associated with each other. If we consider the as-of-yet tenuous hypothesis of an intact assemblage, we can plausibly accept the idea of the introduction of a new type of armature, the BG3 alias Montclus arrow, in Mesolithic levels. In that case, Montclus would be an addition to the sparse corpus of sites with such armatures in Late Mesolithic contexts, notably Essart in the Vienne and Cuzoul de Gramat in the Lot (Marchand, 2009; Perrin *et al.*, 2019; Valdeyron, Manen, & Bosc-Zanardo, 2013). However, the hypothesis of the combined use of both types of armatures also entails its share of problems, since there seems to be a very clear break in how the two different types of armatures were made and used. If this joint manufacture and use of two different arrowheads is proven, it could be indicative of complex hunting systems, or even of social and cultural practices, and would still require further explanations (Figure 10).

4 Synthesis

In conclusion, the evolutionary sequence of production and use of armatures from the Late Mesolithic and Early Neolithic of Montclus can be divided into several stages (Figure 11).

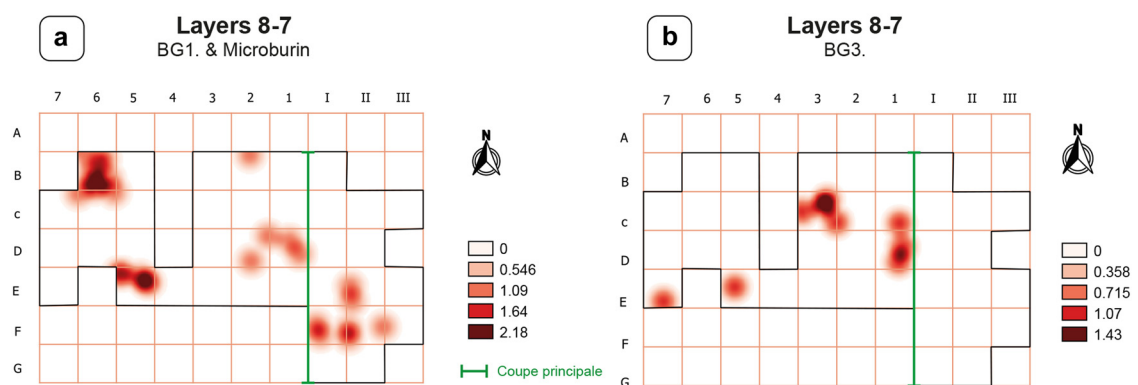


Figure 10: Spatial distribution of armatures and microburins from layers 7 and 8. (a) Spatial distribution of BG1 and microburins, (b) Spatial distribution of BG3.

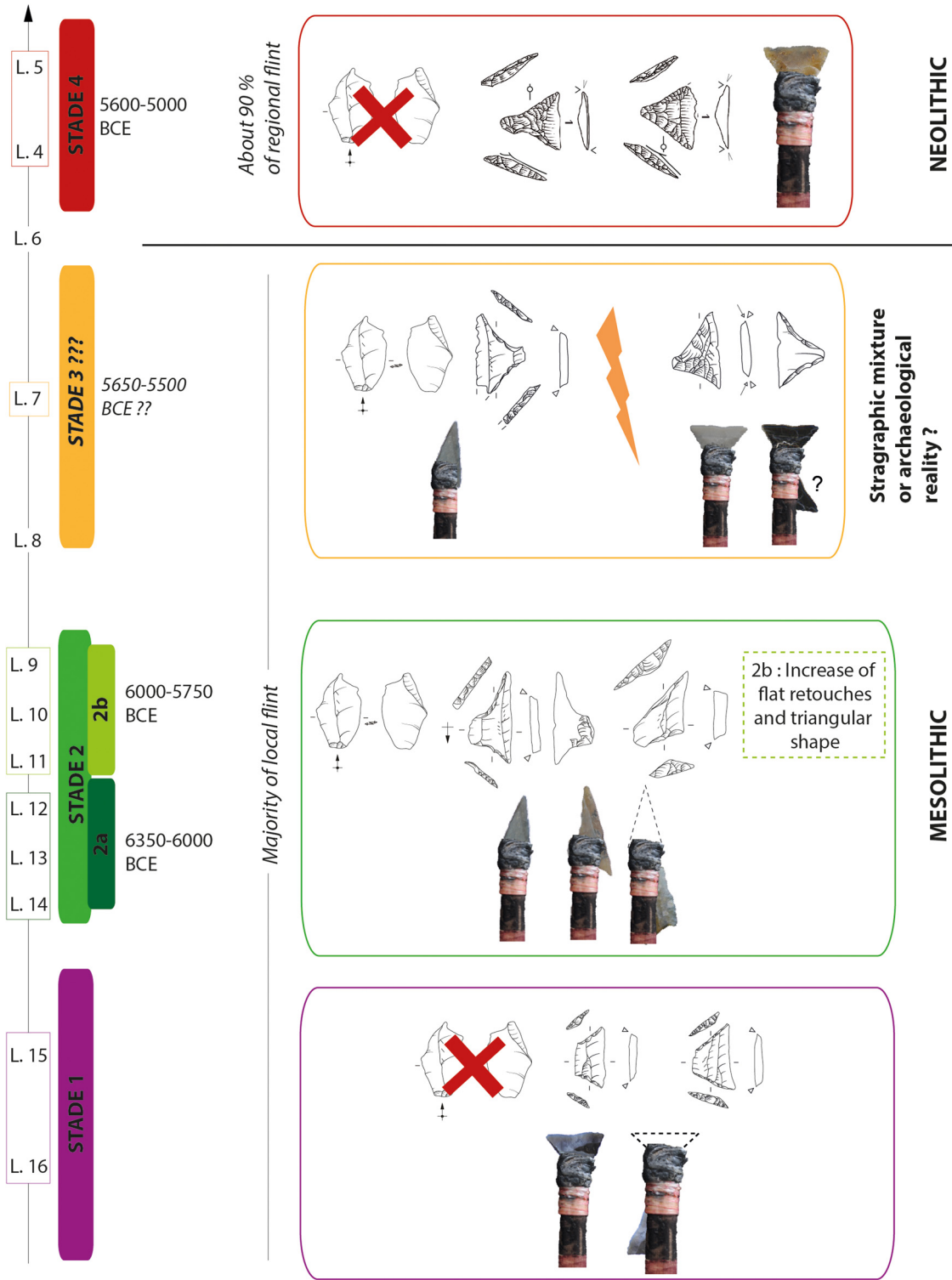


Figure 11: Evolutionary synopsis of production and use of arrowhead armatures from layers 16 to 4 of la Baume de Montclus. Drawings: C. Fat-Cheung & E. Defranould, scale 2/3.

At the beginning of the sequence, layers 16 and 15, are marked by a mixture of different Early and Late Mesolithic occupations (Perrin & Defranould, 2016). Leaving aside the Sauveterrian component, layers 16 and 15 appear to mark a first Late Mesolithic evolutionary stage. However, it is difficult to date this probable

stage due to the stratigraphic mixing observed in these layers. We now have three dates, between 6690 and 6430 cal. BCE, which are chronologically very similar to those of Early Mesolithic occupations from underlying layer 18. These measurements must therefore date from Early Mesolithic occupations, although the exact age of this first stage of our sequence is hard to define. In any case, this possible initial phase would be marked by the production and use of symmetrical trapezes hafted transversely to the shaft and used as cutting arrowheads. This represents a major break with the earlier Sauveterrian period. The use of innovative pressure flaking and indirect percussion techniques for the production of regular and standardised supports and the manufacture of trapezoidal armatures are the most obvious manifestations of this. The new way of assembling (cutting) arrows is again a complete break with the Early Mesolithic, both in terms of technical design and the ballistic properties of arrows (e.g., Chesnaux, 2014; Philibert, 2002; Visentin, 2017). These productions are well characterised at Montclus, but our understanding of how this first stage fits in with the diffusion of blade and trapeze industries on the scale of the western Mediterranean (Perrin *et al.*, 2009) is still incomplete. Apart from Montclus, several other sites are key markers for this transitional stage: Grande Rivoire in the Northern Alps (Angelin, 2017); Latronico in Basilicata (Collina, Gassin, & Gueret, 2019; Dini, Grifoni Cremonesi, Kozłowski, Molara, & Tozzi, 2008); and Abrigo de Los Baños (Utrilla, Montes, Mazzo, Martínez Bea, & Domingo, 2009; Utrilla & Rodanés, 2004), Forcas (Utrilla & Mazzo, 2014) and Falguera phase VIII (García Puchol, 2006) in Spain. However, more detailed comparisons are required to clarify associations.

The second stage is again marked by major changes in the design and use of armatures, with the appearance of bitruncations shaped by the microburin technique and used as piercing arrowheads. The ballistic properties of composite Sauveterrian arrows are combined here in a single element, with perforating, dilacerating and retaining functions. The armatures are morphologically variable (trapezes, triangles, trapezes with offset bases), which could be correlated with different functions and mounting methods. These differences could thus indicate functional adaptations, or possibly other social or symbolic marker functions. In any case, this stage is characteristic of the Castelnovian techno-complex, as it has been described elsewhere in Southern France, for example, at Font-des-Pigeons (Binder, 1987). This phase can be split into two, on the basis of minor variations in manufacture modes, namely a gradual increase in triangular shape and an increase in the number of armatures with flat retouch from layer 11 onwards. The increase in this retouch technique may possibly be linked to the diversification of hafting methods and new know-how in glue manufacture. Dates for this stage 2 are consistent, without stratigraphic inversions or perceptible gaps. Stage 2a can thus be dated between 6350 and 6000 cal. BCE, while stage 2b is positioned between 6000 and 5750 cal. BCE.

After a gap of slightly less than a century, a hypothetical stage 3 can be dated by a measurement between 5650 and 5510 cal. There is a slight time difference between this date and those from Early Neolithic layer 4 but also a significant overlap. Thus, we cannot use chronometric data to decide in favour of the hypothesis of stratigraphic mixing of several occupations or the existence of a genuine evolutionary stage at the end of the Late Mesolithic, associating two types of clearly different arrowheads, from a technical and functional point of view. These levels thus pose more problems than they solve. It is now fitting to look for points of comparison for this hypothetical phase, which appears rather isolated both in terms of lithics and dates. Indeed, the latter place it right in the hiatus between Castelnovian and Cardial (Perrin, 2013; Binder, Battentier, Delhon, & Sénépart, 2017).

Finally, the last stage of our sequence is marked by the almost exclusive presence of BG3, exclusively used as transverse cutting arrowheads, and corresponds to Early Neolithic Cardial occupations. These occupations can be dated between 5620 and 4850 cal. BCE, i.e., at the height of Cardial expansion, or even at the beginning of the establishment of this chrono-cultural entity in southern France (Manen *et al.*, 2019). Depending on whether or not we accept the hypothesis of an actual stage 3, the techno-functional break between this stage and the previous ones is marked to varying degrees. In any case, raw material procurement strategies differ markedly Late Mesolithic strategies, with a marked recourse to Barremo-Bedoulian blond chert to the detriment of local resources. Blades are exclusively knapped by indirect percussion and then fractured by bending to produce BG3, otherwise known as Montclus arrows, which are widely found throughout the Cardial sphere of Southern France. With the development of agro-pastoral

practices, it is logical to assume that the status of these objects underwent some changes in Neolithic societies. Nevertheless, we note that these elements were still used as projectile points, with impact fracture rates close to those observed in the Mesolithic (27% in layer 4, 30% in layer 14 and 15% in layer 16), suggesting a degree of continuity in the use of these objects for hunting or possibly human conflicts.

5 Conclusion

The evolutionary dynamics of the armatures at the Baume de Montclus highlight a consistent projectile function but also diversified technical and functional choices over time. These choices are apparent at all levels of the production chain and in the use of armatures: raw material acquisition strategies, techniques for knapping laminar blanks, arrowhead shaping techniques, the composition of glues and even the ways in which armatures were inserted and assembled on shafts. At Montclus, through this comprehensive approach to microliths, we can gain insights into how certain technical traditions reflect the economic, cultural or functional choices made by prehistoric societies. Several major techno-functional discontinuities can be observed in this sequence, in particular between the Sauveterrian and the Castelnovian; between the Castelnovian and the Early Cardial Neolithic but also between the first expressions of the Castelnovian and its “classical” phase. It seems legitimate to construe these major breaks in the sequence as markers of economic or socio-cultural mutations.

The cutting arrow model, which had already discreetly appeared in Late Laborian contexts in Western France (Jacquier, Langlais, & Naudinot, 2020), reappears here in the equipment of the very early Late Mesolithic, disappears in the middle of the Late Mesolithic sequence and resurfaces again in the Early Neolithic. The intermittent and apparently disconnected resurgence of this innovation is puzzling, especially since this is only applicable to the cutting arrow and not to the rest of the armature production system, which is specific to each techno-complex. For the time being, the reasons underlying these significant changes in hunting equipment still largely escape us. In Late Glacial contexts, the renewal of armatures between the Classical Laborian and the Late Laborian does not seem to be related to hunted game species, as the latter are similar in each of these contexts. For the time being, no explanation can be put forward (Jacquier, Langlais, & Naudinot, 2020; Langlais et al., 2020) and we wonder exactly what this question means for the beginning of the Late Mesolithic as well as the beginning of the Early Neolithic. Can we imagine that these different arrows reflect different hunting, fishing or even inter-human conflict practices?

In any case, we now need to contextualise and correlate the technical choices highlighted here with other environmental and economic data. The aim is ultimately to enhance our understanding of the origin, diffusion mechanisms and functioning of Late Mesolithic societies and the emergence of Neolithic lifestyles.

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