Ahead of the times: blade and bladelet production associated with neandertal remains at the Bau de l'Aubesier (Mediterranean France) between MIS 7 and MIS 5d

Carmignani, L.; Soressi, M.A.

Ahead of the Times: Blade and Bladelet Production Associated with Neandertal Remains at the Bau de l'Aubesier (Mediterranean France) Between MIS 7 and MIS 5d

LEONARDO CARMIGNANI*
Faculty of Archaeology, Leiden University, Einsteinweg 2, 2333 CC Leiden, THE NETHERLANDS; l.carmignani@arch.leidenuniv.nl

MARIE SORESSI
Faculty of Archaeology, Leiden University, Einsteinweg 2, 2333 CC Leiden, THE NETHERLANDS; m.a.soressi@arch.leidenuniv.nl

*corresponding author: Leonardo Carmignani: *l.carmignani@arch.leidenuniv.nl*

submitted: 15 July 2022; revised: 10 October 2022; accepted: 14 October 2022

Handling Editor-in-Chief: Karen Ruebens

ABSTRACT

Middle Paleolithic blade production is documented in north-western Europe as early as 250 ka between the Seine and the Rhine valleys. If Middle Paleolithic blade production is now a well-established fact, it is still unclear whether bladelets – or microlithic blade production – were intentionally produced during the Middle Paleolithic. Evidence suggesting Middle Paleolithic bladelet production is sparse, often debatable, perhaps unrecognized in the old collections and usually dated to MIS 3 and, less frequently, to MIS 4. Here, a detailed *chaîne opératoire* analysis is applied to more than 100,000 lithic artifacts (including the microlithic elements collected through sieving) excavated in fourteen different layers at the Bau de l'Aubesier rock shelter in south-eastern France. The Bau de l'Aubesier contained several Neandertal and (pre) Neandertal remains, and Electron Spin Resonance (ESR), Uranium-Thorium (U-Th), Thermoluminescence (TL), and biostratigraphy indicate that the oldest layers are at least 200,000 years old, while the top of the sequence is ~110,000 years old. We found blade production in several layers, constituting direct evidence for laminar reduction strategies in the south of Europe from MIS 7 to MIS 5d and as early as 200 ka. Blades show distinct morpho-technical features that result from using both volumetric and non-volumetric reduction strategies. We also document the earliest independent bladelet production to date in a sedimentary context (level 4) radiometrically dated to MIS 5d and containing six Neandertal teeth. Bladelet cores on flakes and maintenance bladelets are found in the MIS 5d level only, and only rare irregular bladelets are found in levels older than MIS 5d—suggesting that recurrent bladelet production was not used at the Bau de l'Aubesier before MIS 5d. Our results support the idea that detailed and exhaustive technological analyses of the entirety of lithic assemblages are required to identify Middle Paleolithic bladelet production, which would otherwise go unnoticed. We suggest that Middle Paleolithic bladelet productions still remain to be discovered, especially in the old collections, and that a better understanding of their variability through time and space is a prerequisite to reconstructing the significance of these technologies some 50 to 200 ka and before the proliferation of Upper Paleolithic blade and bladelet technologies.

INTRODUCTION

The earliest evidence of laminar technology is documented in Africa, the Levant, and north-western Europe in the second half of the Middle Pleistocene (Supplementary Information [hereafter, SI] Figure S1). In north-western Europe, Middle Pleistocene blade production is known in contexts attributed to the end of MIS 8, MIS 7, and MIS 6 (Heinzelin and Haesaerts, 1983; Révillion, 1995; Delagnes and Ropars, 1996; Koehler, 2008; Hérisson et al., 2016a, 2016b). Cave dall'Olio in Italy is the only European site that may be older than MIS 5 and that is not located in north-western Europe (Figure 1A). It is tentatively attributed to MIS 9 (Fontana et al., 2009, 2010, 2013) based on paleosol correlations and no radiometric dating is presently available.

In Europe, assemblages with laminar technologies seem to become more frequent during MIS 5 (Figure 1B)—with most of the known assemblages still located in north-western Europe (Cliquet and Revillon, 1990; Conard, 1990; Otte et al., 1990; Cliquet, 1992; Ameloot-Van der Heijden,

 https://doi.org/10.48738/2023.iss1.127 ISSN 1545-0031

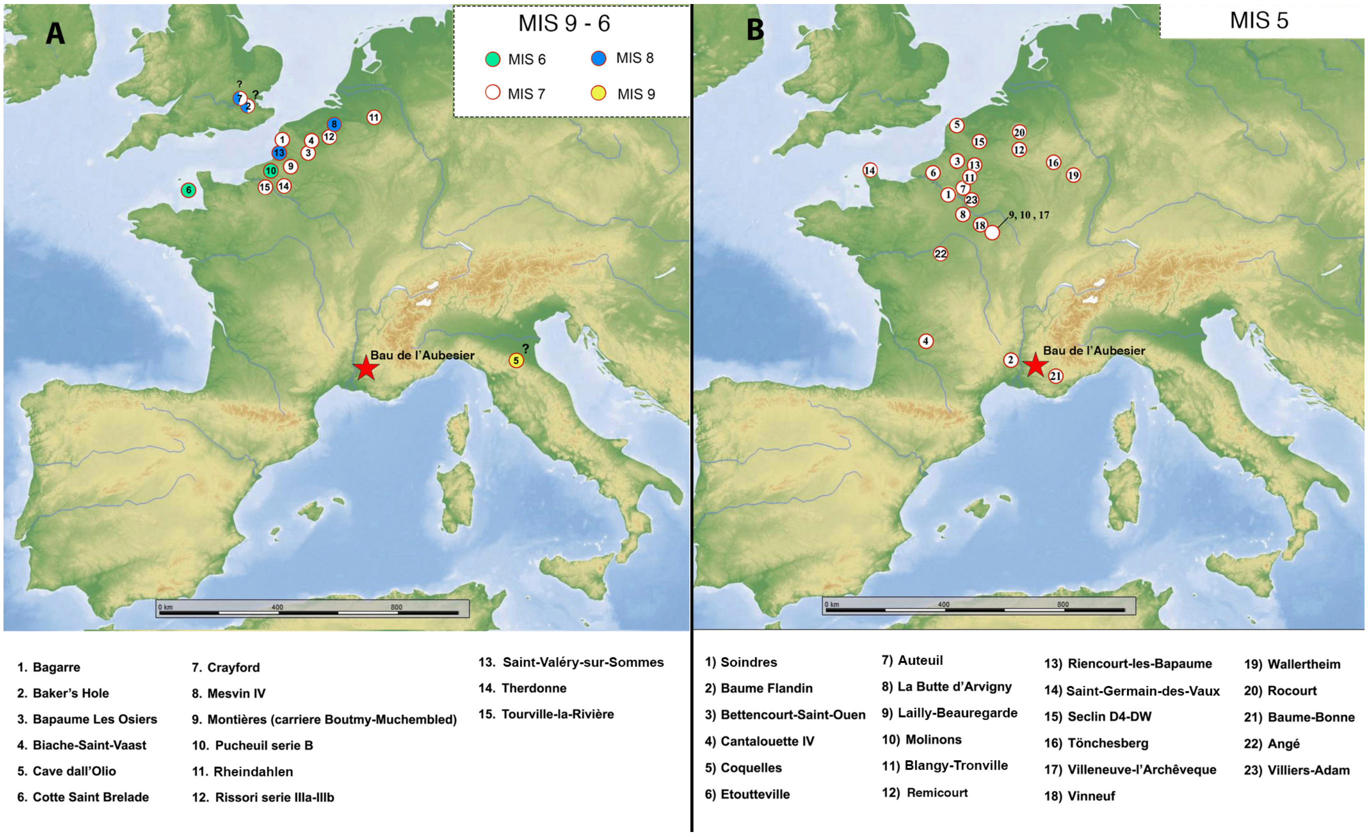


Figure 1. Location of the Bau de l'Aubesier and other Middle Paleolithic sites with blade production chronologically attributed to MIS 9, 8, 7, or 6 (map A), and chronologically attributed to MIS 5 (map B).

1993; Otte, 1994; Révillion, 1994; Révillion and Tuffreau, 1994; Conard and Adler, 1997; Depaepe et al., 1999; Locht, 2002; Vande Walle, 2003; Goval and Hérisson, 2006; Haesaerts et al., 2011; Locht and Chaussé, 2021) and some in central and south France (Gouédo, 1994; Gagnepain et al., 2004; Gagnepain and Gaillard, 2005; Blaser et al., 2012; Koehler et al., 2014; Locht et al., 2015).

Starting from MIS 4 and more significantly with MIS 3, blade technologies in Mousterian contexts seem to become more widespread across Europe (Chabaï and Sitlivy, 1994; Nehoroshev and Vishnyatsky, 2000; Chabaï, 2001; Patou-Mathis and Chabaï, 2003; Arzarello and Peretto, 2004, 2005; Arzarello et al., 2004; Chabaï et al., 2004; Nehoroshev, 2004; Chabaï et al., 2006; Sitlivy and Zieba, 2006; Carmignani, 2010; Peresani, 2012; Peresani and Centi Di Taranto, 2013; Marciani et al., 2016; Carmignani, 2017; Carmignani and Sarti, 2018; Carmignani et al., 2020; Peretto et al., 2020). Despite its large geographical distribution, blade production in European Middle Paleolithic contexts during MIS 4 and 3 seems not to be a ubiquitous phenomenon as most of the Iberian peninsula as well as Greece and the Balkans (Monteagudo et al., 2007; Quirós and Maíllo-Fernández, 2009; Baena et al., 2012; Dogandzic, 2021) do not show clear and well-dated evidence of blade production before the onset of the Upper Paleolithic.

If Middle Paleolithic blade production is now a well-established fact, it is still unclear if bladelet production existed in Europe at sites older than the final Mousterian. Intentional bladelet production—or microlithic blade production—in Mousterian contexts seems difficult to identify because: 1) a small number of bladelets can be accidentally produced during almost any debitage process; 2) Mousterian bladelet cores often exhibit a small number of removals indicative of a relatively short production sequence (Faivre, 2012; Carmignani and Sarti, 2018; Marciani et al., 2018); and, 3) blade cores can be reduced until they produce small blades similar in size to bladelets (Koehler et al., 2014). These factors have cast doubt on the intentionality of bladelet production in Europe before the onset of the Upper Paleolithic. Overall, the number of European sites preserving Middle Paleolithic bladelet technology is small—likely less than a dozen, almost all attributed to MIS 3 and a few to MIS 4 (Slimak, 1999, 2006; Maíllo Fernández, 2001; Maíllo Fernández et al., 2004; Maíllo-Fernández, 2004; Slimak and Lucas, 2005; Carmignani, 2010; Pastoors and Tafelmaier, 2010; Tafelmaier, 2011; Peresani, 2012; Faivre, 2012; Peresani and Centi Di Taranto, 2013; Marciani et al., 2016; Peresani et al., 2016; Carmignani and Sarti, 2018; Marciani, 2018; Carmignani et al., 2020; Peretto et al., 2020). At each of these sites, the blade/bladelet production is a minor component of the lithic assemblage.

Here, we conduct a detailed and exhaustive *chaîne opératoire analysis* of 14 lithic assemblages (including materials from sieving) excavated at the Bau de l'Aubesier in southeast France. The Bau de l'Aubesier rock-shelter preserves a 13-meter thick sequence radiometrically dated from >200 ka at the bottom to <110 ka at the top. Through a detailed study of such a long sequence, we investigate when blade and bladelet production appears in the sequence, what type of flake production is associated with blade and bladelet production, and how blade and bladelet production changed through time. The apparent lack of blade production in southern France earlier than MIS 5 is mitigated by our results. Furthermore, the unexpected evidence of an independent bladelet production found at the Bau de l'Aubesier, securely dated to MIS 5d and associated with Neandertal remains, shows that intentional bladelet production can be expected in Europe within deposits at least 30,000 years older than previously thought.

MATERIAL AND METHODS

BACKGROUND INFORMATION: THE BAU DE L'AUBESIER

The Bau de l'Aubesier is a large rock shelter located in the gorge of the Nesque river in the Vaucluse, south-eastern France. The site contains an approximately 13m deep archaeological sequence. The site has been known since the beginning of the 20th century (Moulin, 1904) and was excavated from 1987 to 2000 by Serge Lebel and his team (Lebel, 2000; Wilson, 2021). The excavations were conducted on three distinct but contiguous areas named the Moulin Trench (covering 20–25m²), the Lower Slope (63m²) and Trench L (50m²) (Wilson, 2021). Fourteen archaeological levels were defined (Figure 2). More than 100,000 lithic artifacts and a rich corpus of faunal remains were excavated. A fragmentary human mandible was discovered in level I and nine human teeth were discovered in levels 2, 4, I and K (see Figure 2). All the human remains were attributed to Neandertal and pre-Neandertal specimens (Trinkaus et al., 2000a, 2000b; Lebel and Trinkaus, 2001, 2002; Lebel et al., 2001).

ESR measurements on two mammal teeth excavated in level J4 place the bottom of the sequence between 190 and 220 ka (Blackwell et al., 2000, 2001). TL, ESR, and U/Th measurements for level H yielded a minimum age of 169±17 ka and a maximum age of 191±15 ka placing level H between MIS 7a and MIS 6 (Blackwell et al., 2000, 2001). At the top of the sequence, level 4 sits on top of a thick speleothem dated by U/Th to 141.85±5.3 ka (Ghaleb, 2006). ESR and U/Th dates for level 4 indicate an age around 110 ka (Blackwell et al., 2001). The composition of the faunal assemblages supports the chronology deduced from radiometric dating (Fernandez, 2001, 2006; Fernandez and Legendre, 2003; Crégut-Bonnoure et al., 2010). Layers 3 and 2 were not radiometrically dated but sedimentological observations indicate that level 3 can be attributed to the end of MIS 5 and level 2 can be attributed to a colder time period, likely MIS 4 (Wilson, 2021).

The lithic assemblages are composed of good quality Cretaceous and Oligocene nodular flint available in both primary (outcrop) and secondary (alluvial or colluvial) localities. Numerous sources of flint are known in the region, and most of the lithics came from raw material sources located within about 20km of the site, although a few came from more distant sources (Wilson, 2007a,b,c, 2011; Browne and Wilson, 2011, 2013; Wilson and Browne, 2014; Pop et al., 2022).

CATEGORIZATION OF THE LITHIC ASSEMBLAGE

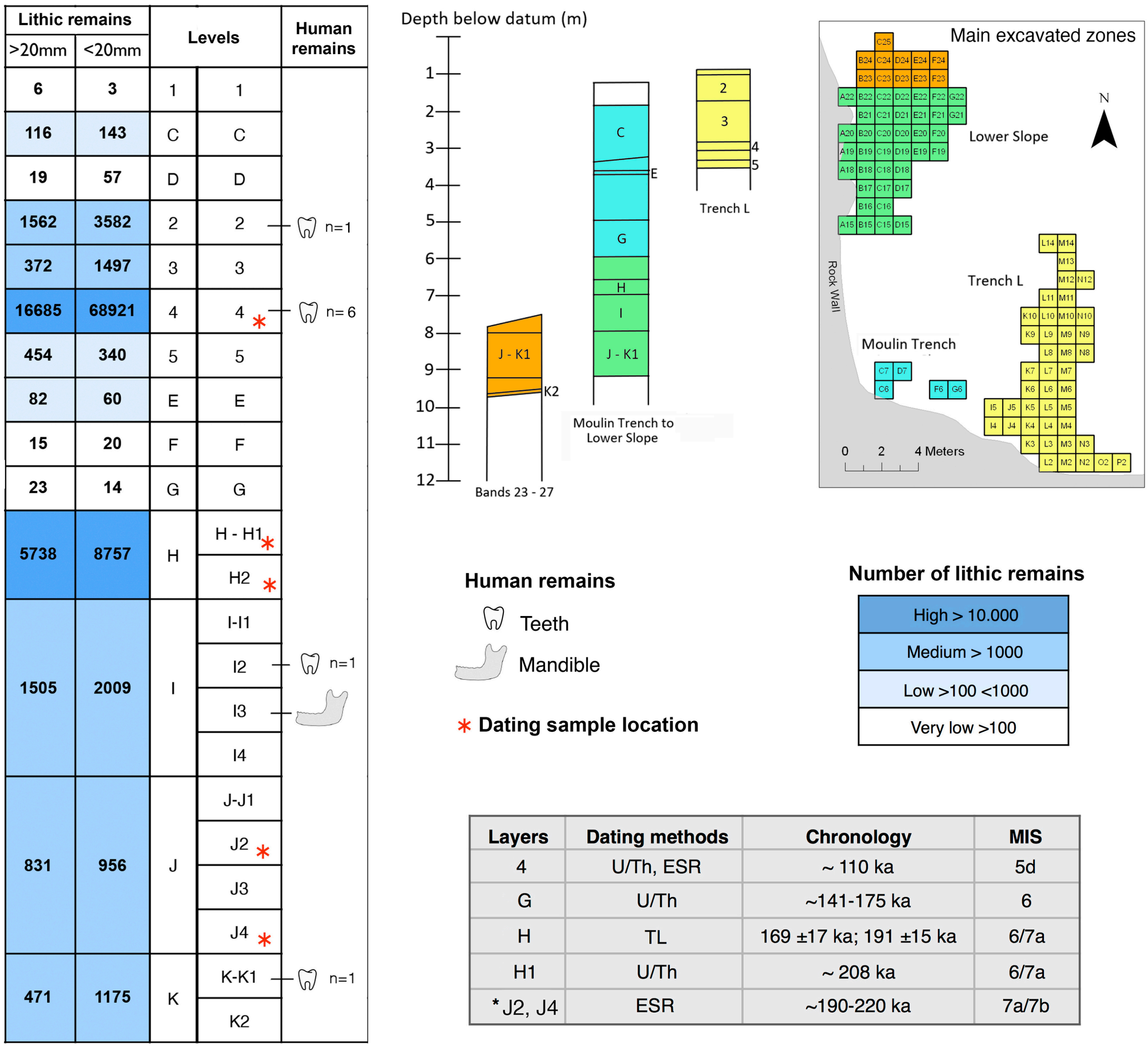
The entire lithic collection from the new excavations was studied. Lithic material originally excavated by Franky Moulin (Moulin, 1904) and recovered in the Moulin Trench area (levels C, D, E, F, and G) was only partially available because it had been dispersed prior to our study among several museums and collectors (see Wilson, 2021).

A total of 115,413 lithic artifacts, regardless of size, were counted. We performed a chaîne opératoire analysis and, considering the substantial quantity of artifacts, we grounded our analysis on: 1) techno-typological categorization of all available lithics; and, 2) detailed analysis and measurement of the most informative pieces (Pelegrin et al., 1988; Boëda et al., 1990; Soressi and Geneste, 2011). With this, we provide a first global overview of the lithic industries from the Bau de l'Aubesier and pave the path for more detailed analyses in the future.

A preliminary sorting procedure was adopted dividing the lithic collection into two categories—'undetermined' and 'determined' items. Deeply patinated pieces or pieces with disorganized scars that do not allow us to attribute them to a specific reduction strategy, method, techno-typological category, or core management procedure were classified as 'undetermined' pieces. 'Determined' items consist of pieces (complete or fragmented) that can be linked to specific reduction strategies (e.g., Levallois, Discoid), methods (e.g., unidirectional, centripetal), or core management procedures (e.g., striking platform flake, crested blade). All pieces were counted but only 'Determined' pieces were studied in detail.

Diacritic analyses (Dauvois, 1976) were performed to reconstruct the direction and chronology of the removals. The diacritic schemes were used to reconstruct the stages of production, the core configurations, and the volumetric concepts used in each assemblage. The number, direction and the organization of the scars on the flaking surface of cores and dorsal surface of blanks defined the methods used. The definition of volumetric concept and distinction between methods of initialization and methods of production are based on Boëda (2013). The term "reduction strategy" in the manuscript refers to both the concepts and the methods used. The definition and characterization of blade cores was guided by four technical parameters: 1) the volumetric concept, 2) the type of core configuration, 3) the direction, and 4) the organization of the removals (Figure 3).

We intentionally avoid using the concepts of 'Levallois' and 'Non-Levallois' for blade production. This choice is motivated by the fact that attribution of a blade production to the Levallois concept has been proven to be problematic (Svoboda and Škrdla, 1995; Tuffreau, 1995; Boëda et al., 2013). Levallois-based blade technology has been used as a proxy to trace a technological filiation or rupture



Lithic remains >20mm	Lithic remains <20mm	Levels		Human remains
6	3	1	1	
116	143	C	C	
19	57	D	D	
1562	3582	2	2	Teeth n=1
372	1497	3	3	
16685	68921	4	4 *	Teeth n= 6
454	340	5	5	
82	60	E	E	
15	20	F	F	
23	14	G	G	
5738	8757	H	H - H1 *	
			H2 *	
1505	2009	I	I-I1	
			I2	Teeth n=1
			I3	Mandible
			I4	
831	956	J	J-J1	
			J2 *	
			J3	
			J4 *	
471	1175	K	K-K1	Teeth n=1
			K2	

Layers	Dating methods	Chronology	MIS
4	U/Th, ESR	~ 110 ka	5d
G	U/Th	~141-175 ka	6
H	TL	169 ±17 ka; 191 ±15 ka	6/7a
H1	U/Th	~ 208 ka	6/7a
* J2, J4	ESR	~190-220 ka	7a/7b

*Figure 2. Bau de l'Aubesier stratigraphy indicating the number of lithic artifacts studied for this paper and hominin remains recovered in each level as well radiometric ages obtained for each level (map of the excavated area and section sketch after Wilson 2021). *Part of the lithics excavated in layers C, D and E, F, G was partially dispersed among several museums and collectors and was not possible to include in this study.*

with the local substratum in between the final Mousterian and the first Upper Paleolithic in eastern Europe (Usik and Demidenko, 1993; Chabaï, 2001; Richter et al., 2008). Nonetheless, the difficulties in confidently assigning blades and blade cores to either Levallois or non-Levallois blade production concepts are evidenced through the persistent use in the literature of equivocal terms such as "blade Levallois-like" (Richter et al., 2008) or "Levallois-leptolithic" (Svoboda, 2003). For these reasons we ground our reconstruction with no reference to the Levallois concept sensu stricto, and instead distinguish between surface and volumetric exploitation as originally proposed by E. Boëda (1990).

The correct identification of a volumetric or a surface exploitation is particularly important because the use of one or the other system has a direct consequence on the morphology of the blanks (Ortega et al., 2013; Hoggard, 2017a,b). For the diagnosis of blades coming from a volumetric or from a surface exploitation, we use features identified on experimentally produced assemblages (Ortega et al., 2013; C. Hoggard, 2017a,b) and archaeological assemblages (Meignen and Bar-Yosef, 2020). Following these authors, blades produced with direct/internal percussion through volumetric exploitation are characterized by a thick cross-section and more obtuse cutting edge, while blades from surface exploitation are characterized by a thin cross-section and a more acute cutting-edge (Figure 4).

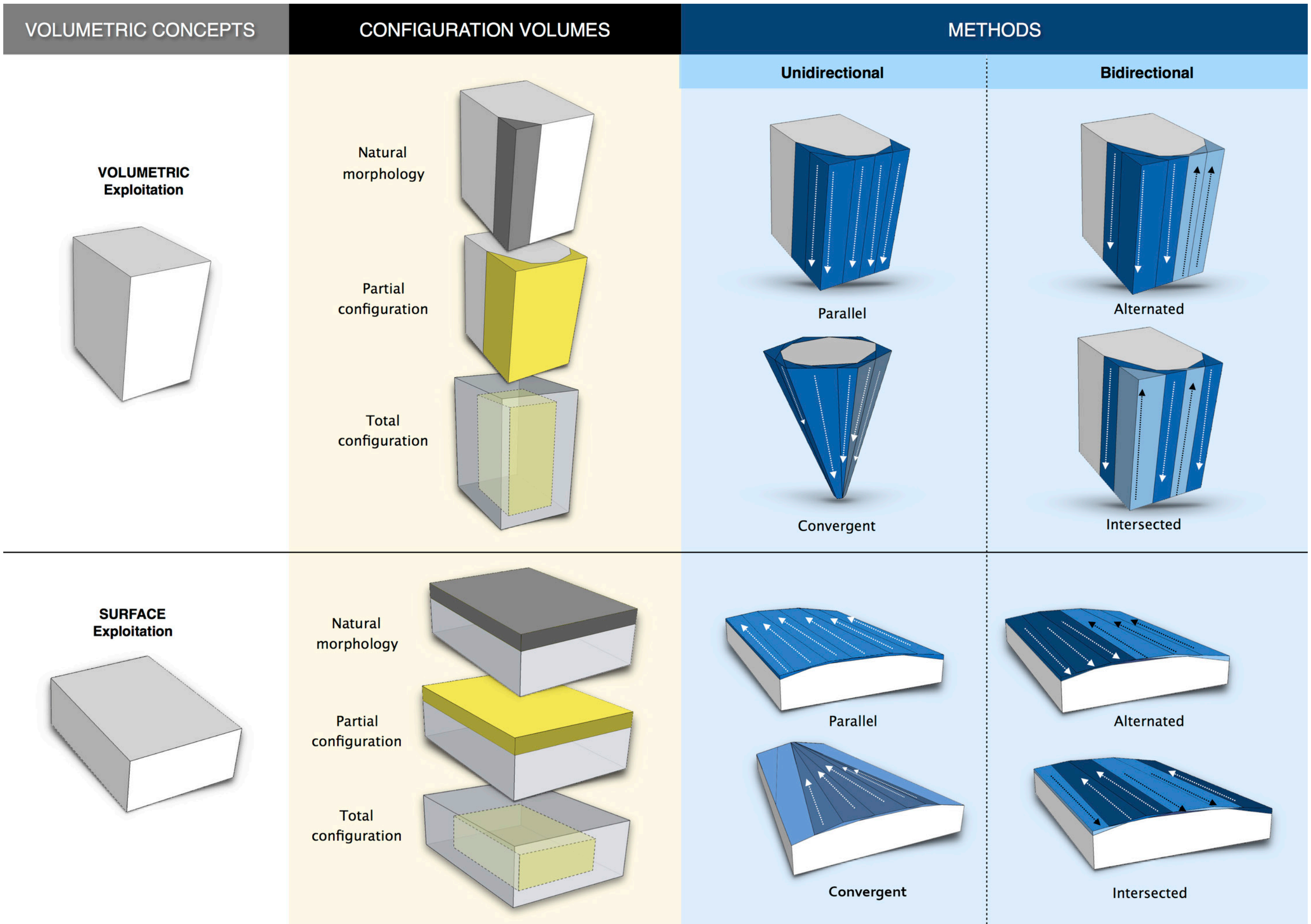


Figure 3. Terminology and categorization used to describe blade reduction strategies.

In addition, the type of platform preparation, the blank profile, and the orientation and position of the removals, were used to attribute each blank to a specific techno-type belonging to either volumetric or surface exploitation. Each blade was assigned to one of eight distinct techno-types based on the direction, the chronology of the removals on the dorsal face, and the morphology of the blade (SI Figure S2).

Percussion techniques for blades and bladelets were determined using the criteria and terminology derived from experimental studies by Pelegrin (1991, 2000, 2005) and Soriano et al. (2007). The maximum dimensions (length, width, thickness) of complete blades and bladelets were measured using digital calipers. The length of complete artifacts was measured according to the direction of the blow (i.e., technological axis). Elongation was defined as the ratio of length to width. Blades here are at least twice as long as they are wide and were grouped into eleven elongation classes based on their length and width (Figure S3 in Suppl.).

To distinguish blades from bladelets we used the standard width cut-off (12mm). However, attribution of a blank to a specific category (flake, blade, bladelet) was, first of all, grounded on the identification of its technological attributes and its position inside the chaîne opératoire. For instance, elongated thick flakes wider than 12mm with bladelets scars on their dorsal surfaces were attributed to a bladelet reduction strategy and classified as rejuvenation bladelets.

When describing flake production, we use the term Levallois-type flake (instead of Levallois flake). Reduction systems other than Levallois can indeed produce flakes that are similar to flakes produced by a Levallois concept (White and Ashton, 2004; Soriano and Villa, 2017).

RESULTS

The lithic assemblages are characterized by a combination of flake and blade reduction strategies. This dichotomy is true for all the archaeological levels. However, flake production is always the dominant mode of production, complemented by a numerically smaller component of blade or bladelet production systems. The proportion of complete blades ranges from 21% in level K (the bottom level) to 3% in level 3 (one of the top levels) (Table 1). Blade cores range from 18% at the bottom of the sequence to 3% in level 4 (Table 2).

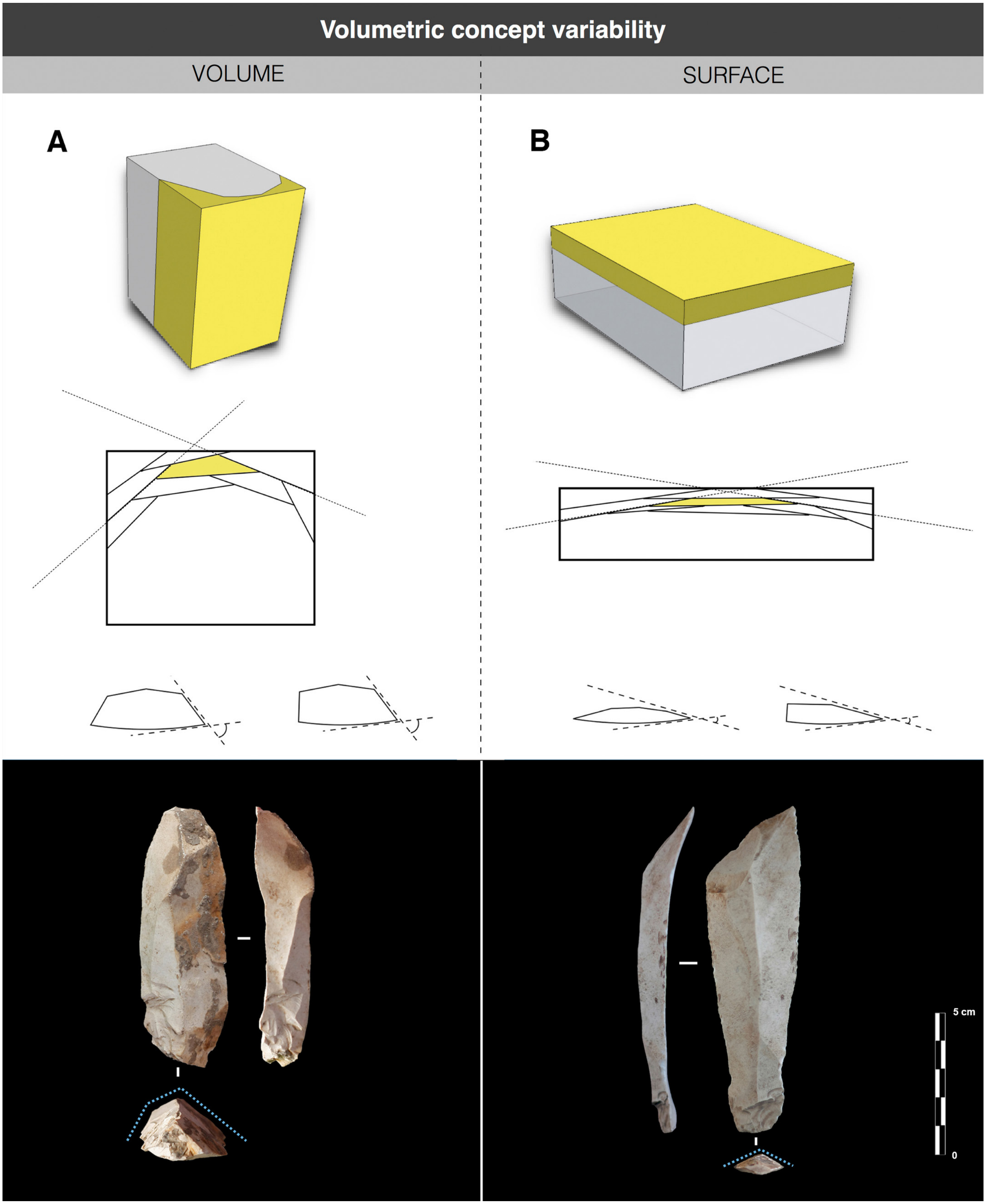


Figure 4. Schematic representation of volumetric (A) and surface exploitation (B) of blade cores (after the definition by Boëda 1990), with photographs of blades from the Bau de l'Aubesier level 4.

TABLE 1. COMPLETE BLANKS, EXCLUDING WASTE, CHUNKS, AND FRAGMENTS.

Levels	K		J		I		H		5		4		3		2	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Flakes	150	*78.5*	273	*89.2*	786	*95.3*	1960	*94.9*	190	*96.9*	4535	*90.8*	100	*92.6*	430	*90.5*
Blades	40	*20.9*	33	*10.8*	39	*4.7*	90	*4.4*	6	*3.1*	399	*8*	3	*2.8*	32	*6.7*
Bladelets	1	*0.5*	-	-	-	-	16	*0.8*	-	-	62	*1.2*	5	*4.6*	13	*2.7*
Total	191	*100*	306	*100*	825	*100*	2066	*100*	196	*100*	4996	*100*	108	*100*	475	*100*

TABLE 2. CORES.

Levels	K		J		I		H		5		4		3		2	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Flake cores	12	*70.6*	34	*68*	34	*89.5*	187	*76.6*	13	*61.9*	312	*73.1*	8	*72.7*	28	*70*
Blade cores	3	*17.6*	4	*8*	4	*10.5*	11	*4.5*	2	*9.5*	14	*3.3*	-	-	-	-
Bladelet cores	-	-	-	-	-	-	-	-	1	*4,8*	33	*7.7*	-	-	2	*5*
Tested blocks	-	-	-	-	-	-	6	*2.5*	-	-	2	*0.5*	1	*9.1*	1	*2.5*
Core fragments	2	*11.8*	12	*24*	-	-	40	*16.4*	5	*23.8*	66	*15.5*	2	*18.2*	9	*22.5*
Total	17	*100*	50	*100*	38	*100*	244	*100*	21	*100*	427	*100*	11	*100*	40	*100*

TABLE 3. BLADE CORE VARIABILITY.

Blade cores variability: Concept of débitage / methods		**LEVELS from bottom (left) to top (right)**															
		K		**J**		**I**		**H**		**5**		**4**		**3**		**2**	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
SURFACE	Unidirectional	-	-	-	-	1	*25*	5	*27.8*	-	-	8	*34.8*	-	-	2	*66.7*
	Bidirectional	-	-	-	-	-	-	2	*11.1*	-	-	1	*4.3*	-	-	1	*33.3*
	Convergent	-	-	-	-	-	-	-	-	-	-	4	*17.4*	-	-	-	-
VOLUME	Unidirectional semi-rotating	1	*33.3*	5	*100*	2	*50*	8	*44.4*	2	*100*	7	*30.4*	-	-	-	-
	Unidirectional rotating	-	-	-	-	-	-	2	*11.1*	-	-	-	-	-	-	-	-
	Sub convergent semi-rotating	-	-	-	-	1	*25*	1	*5.6*	-	-	3	*13*	-	-	-	-
	Convergent (half-pyramidal)	2	*66.7*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	3	*100*	5	*100*	4	*100*	18	*100*	2	*100*	23	*100*	-	-	3	*100*

Bladelets are found in the upper part of the sequence (levels 4, 3 and 2) and in level H, in the lower slope part of the sequence. Yet, as will be explained in detail, bladelets found in level H exhibit different morpho-technical features than the bladelets found in the upper part of the sequence.

An overview of the composition of the assemblages is provided in Table S1 (SI). Micro-fragments and small flakes (<20mm) are abundant throughout the sequence, attesting to intense flaking activity in or close to the excavated area. Undetermined micro fragments (<20mm) range from 46% in level J to 74.7% in level IV (see SI Table S1). Numerous cortical flakes suggest the introduction of flint nodules to the site in the first phases of exploitation. The proportion of cortical flakes is similar in all the levels except for level K, which shows a lower proportion. The proportion of fully cortical flakes ranges from 3% in level K to 13% for level H and the proportion of semi-cortical flakes varies from 13% in level K to 19% for level H (SI Table S2).

BLADE PRODUCTION

Both volumetric and surface exploitation systems were used. These two *débitage* concepts either coexist or are exclusive depending on the level (Table 3).

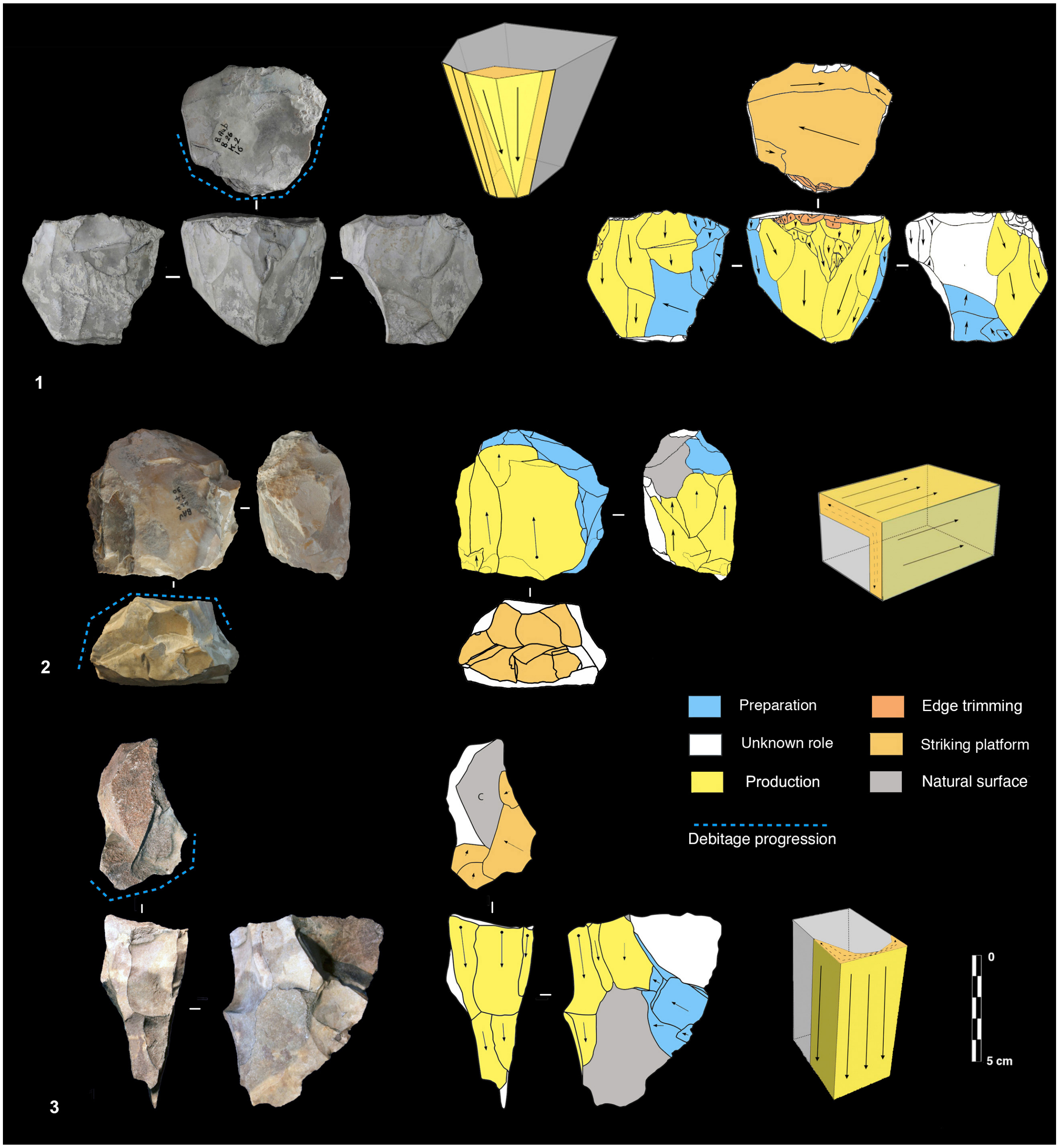


Figure 5. Bau de l'Aubesier. Volumetric blade cores: 1) half-pyramidal core from level K; 2) unidirectional semi-rotating core from level J; 3) volumetric core from level 4.

Volumetric Blade Cores

Volumetric cores display unidirectional semi-rotating reduction strategies (see Table 3; Figure 5: 2, 3). Only two cores with rotating exploitation were identified—both recovered from level H. The management of lateral convexities is performed by *debordant* removals. Flaking surfaces are frequently restored with short removals struck from an opposing striking platform or by rear lateral removals. The lack of a standardized core configuration militates frequent adjustments of the flaking surface to remove hinge terminations and imperfections. As a result, sometimes cores, at the end of the exploitation, have an irregular morphology (SI Figure S4).

The maintenance of the flaking surface was done through the extraction of *debordant* and plunging blades (Figure 6: 1, 3, 4, 6). The core initialization by crested blades is rare: only three frontal crested blades were found in level 4 and four in level H (Figure 6: 2, 5). Products related to the renewal of striking platforms or "core tablets" are absent.

Two cores found in level K show a different reduction system (see Table 3). On these cores the exploitation is carried out through convergent removals from a single strik-

Figure 6. Bau de l'Aubesier. Volumetric maintenance blades. From level 4: 1) plunging blade; 2) crested blade; 3) debordant blade. From level H: 4) plunging blade; 5) crested blade; 6) debordant blade.

ing platform giving the cores a half-pyramidal morphology (Figure 5: 1). Core maintenance was guaranteed by the *débitage progression* as the blade removals automatically maintained the convexities throughout the core reduction process.

Surface Blade Cores

A group of cores displays the management of the volume based on surface exploitation (Figure 7). These cores are found in levels 2, 4, H, and I and are absent in the bottom levels J and K (see Table 3). Removals are unidirectional, bidirectional, and convergent. Surface exploitation cores with convergent removals were found exclusively in level 4 (see Figure 7: 4). These cores follow a unifacial exploitation (see Figure 7: 2–4). Only one core found in level I is exploited on opposing surfaces by means of unidirectional removals (see Figure 7: 1). Removals are struck from a single or two opposite striking platforms which have been carefully prepared. Lateral convexities are maintained by *debordant* blades. A second opposite striking platform is sometimes used to correct the distal convexity by means of short subsecant removals (see Figure 7: 4). *Debordant* removals in surface exploitation, in contrast to volumetric exploitation, do not invade the lateral edge of the cores; they maintain the flat morphology of the flaking surface permitting a second series of parallel plan removals (see Figure 4).

Blade End-Products

The diversity of production systems evidenced by the cores is consistent with the related end-products. We recorded

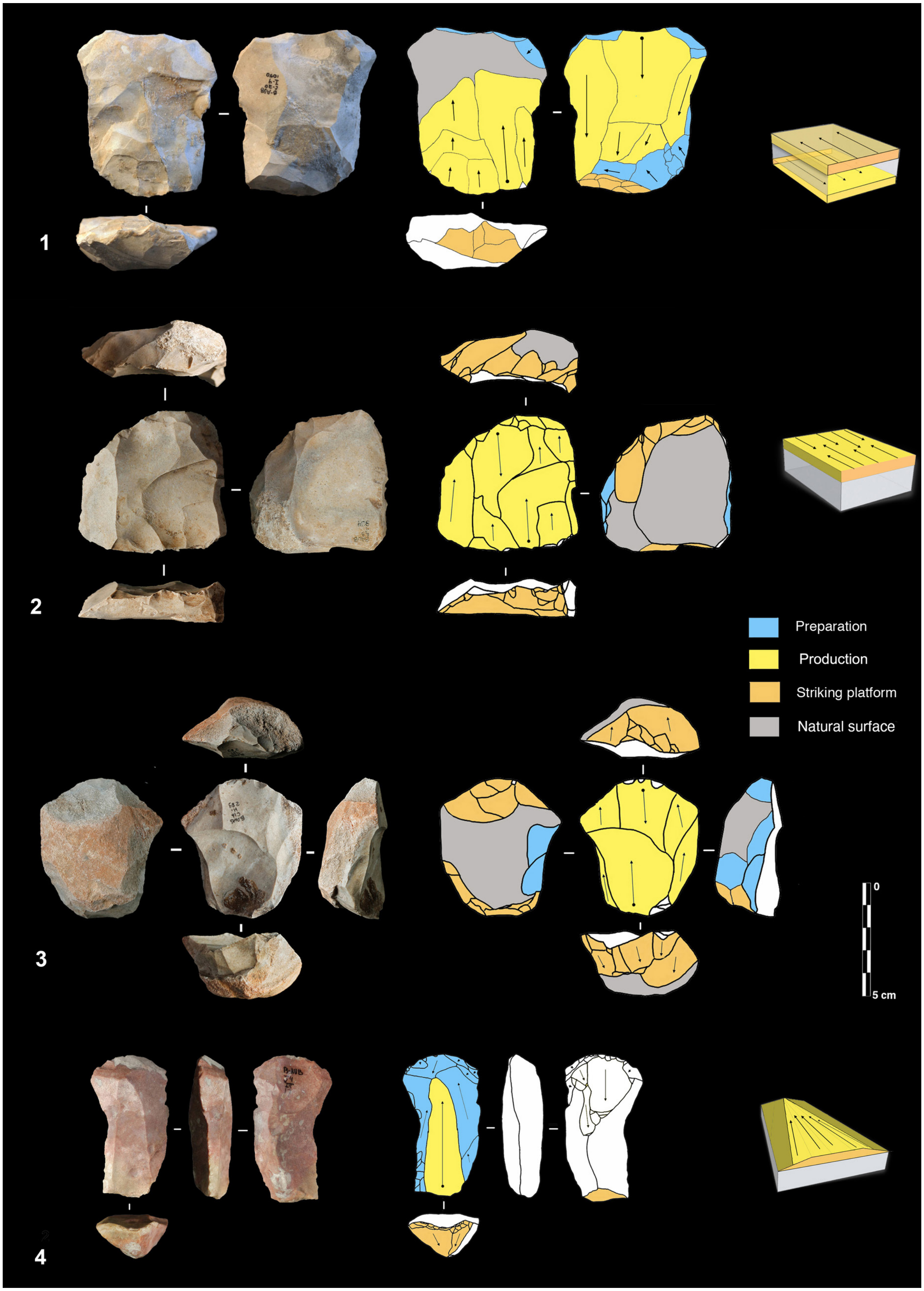


Figure 7. Bau de l'Aubesier. Surface blade cores: 1) unidirectional bifacial core from level I; 2) bidirectional intersected core from level 4; 3) bidirectional sub-convergent core from level H; 4) unidirectional convergent core from level 4.

TABLE 4. VOLUMETRIC AND SURFACE EXPLOITATION BLADE QUANTITIES.

Levels	K		J		I		H		5		4		3		2	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Blades from volume	17	*42.5*	13	*39.4*	8	*20.5*	28	*31.1*	3	*50*	116	*29.1*	-	-	5	*15.6*
Blades from surface	3	*7.5*	6	*18.2*	11	*28.2*	27	*30*	2	*33.3*	137	*34.3*	-	-	15	*46.9*
Undetermined (mixed features)	20	*50*	14	*42.4*	20	*51.3*	35	*38.9*	1	*16.7*	146	*36.6*	3	*100*	12	*37.5*
Total	40	*100*	33	*100*	39	*100*	90	*100*	6	*100*	399	*100*	3	*100*	32	*100*

642 entire blades and 455 fragmented blades (SI Table S3). The highest percentage of complete blades is found in levels K (87%) and H (77%). Fragmented blades are constituted mainly by proximal and distal fragments (see SI Table S3).

Blades from both surface and volumetric concepts are present in the sequence in different proportions depending on the level. In levels K and J, blades from volumetric reduction are dominant, while in levels I, H, and 4, blades from surface and volumetric reduction are equally represented (Table 4).

Volumetric blades tend to be thicker than blades from surface reduction, while the length-width ratio is similar (SI Figure S5). The platforms of blades from surface reduction are frequently faceted or partially faceted, showing a more curated preparation of the striking platform. The platforms of blades from volumetric exploitation are generally plain (SI Table S4). This difference, seen on the end-products, is in line with those observed on the striking platform preparation visible on the cores themselves.

Non-convergent blades (S0, S1, S2, S3 types: see SI Figure S2) are the most frequent across the entire sequence and are clearly dominant in the middle of the sequence (levels I and H) (SI Table S5).

Convergent blades (P1 and P2 type: see SI Figure S2) are present throughout the sequence in different proportions, and they are more frequent in levels K, 4, and 2. Convergent blades in the lower levels (K, J) show features typical of a volumetric exploitation and were likely extracted from cores of sub-pyramidal type as found in level K (Figure 8: 7–10). Convergent blades found in level 4 show morphological features typical of a surface exploitation—finely prepared striking platform, thin cross-section, and a more acute cutting-edge (Figure 8: 1–6). It is important to point out that this specific type of convergent blades, as well the surface core with convergent method, were only found in level 4—reinforcing the idea of a technological correlation between these cores and their likely related end-products (see Table 2; SI Table S6).

Non-convergent blades from surface exploitation are present across the entire sequence but in different proportions depending on the level (Figure 9). The major concentration is in level H (see SI Table S6). As is the case with convergent blades from surface exploitation, these blades often show a carefully prepared striking platform (see Figure 9: 3–7). The dorsal surface of these blades often bears short sub-secant negatives located on the distal and lateral edges indicating a curated management of the flaking surface before their extraction (see Figure 9: 4, 5). The presence of a rounded cortex on the distal part of some blades suggests that the initialization of the core was occasionally done by taking advantage of the natural shape of the nodule (see Figure 9: 1–3).

Unlike the blades from surface reduction, non-convergent blades from volumetric reduction are present throughout the sequence in similar proportions (see SI Table S6). The dorsal surfaces of these blades have two, or more rarely three, unidirectional scars. Striking platforms are predominantly plain, and the blades have robust cutting-edge angles and a thick cross-section (see Figure 9: 8–12). These blades can be easily correlated with the volumetric cores (unidirectional and bidirectional scar pattern) found in the same levels across the sequence.

In level H, 85% of the blades from surface reduction have a peripheral cutting edge (Type S0) and *debordant* blades are rare (see SI Table S6). This is consistent with what is observed from the analysis of the cores. In the surface exploitation, *debordant* blades (i.e., with no peripheral edge) do not occur frequently because they are only used to re-establish the lateral convexities of the flaking surface between two series of removals. Conversely, in volumetric exploitation *debordant* blades are systematically used to exploit the cores around their periphery in a seamless recurrent *débitage*.

BLADELET PRODUCTION

Bladelets are found in the upper part of the sequence (levels 4, 3, and 2) and in level H, in the lower slope part of the sequence. Almost all bladelet cores were found in level 4 (n=33 in level 4) (see Table 2). Flakes, but also small chunks, were used to produce bladelets (SI Table S7). Bladelet cores are exploited most frequently by parallel unidirectional removals (SI Table S8). Nonetheless, bladelets were removed in a convergent pattern on eight cores (Figure 10: 1, 2, 4). Striking platforms are mainly prepared by one or two removals creating a plain platform (e.g.; Figure 10: 1, 3; Figure 11: 1, 3). Five cores have a faceted platform showing a more curated preparation (Figure 11: 2, 4). The initial stage of production entails a first removal that follows one of the natural edges adjacent to the striking platform. In the case of the cores on flakes, bladelets are usually removed from only one edge of the flake, except for the core illustrated in Figure 11:1. Crested bladelets are only occasionally set.

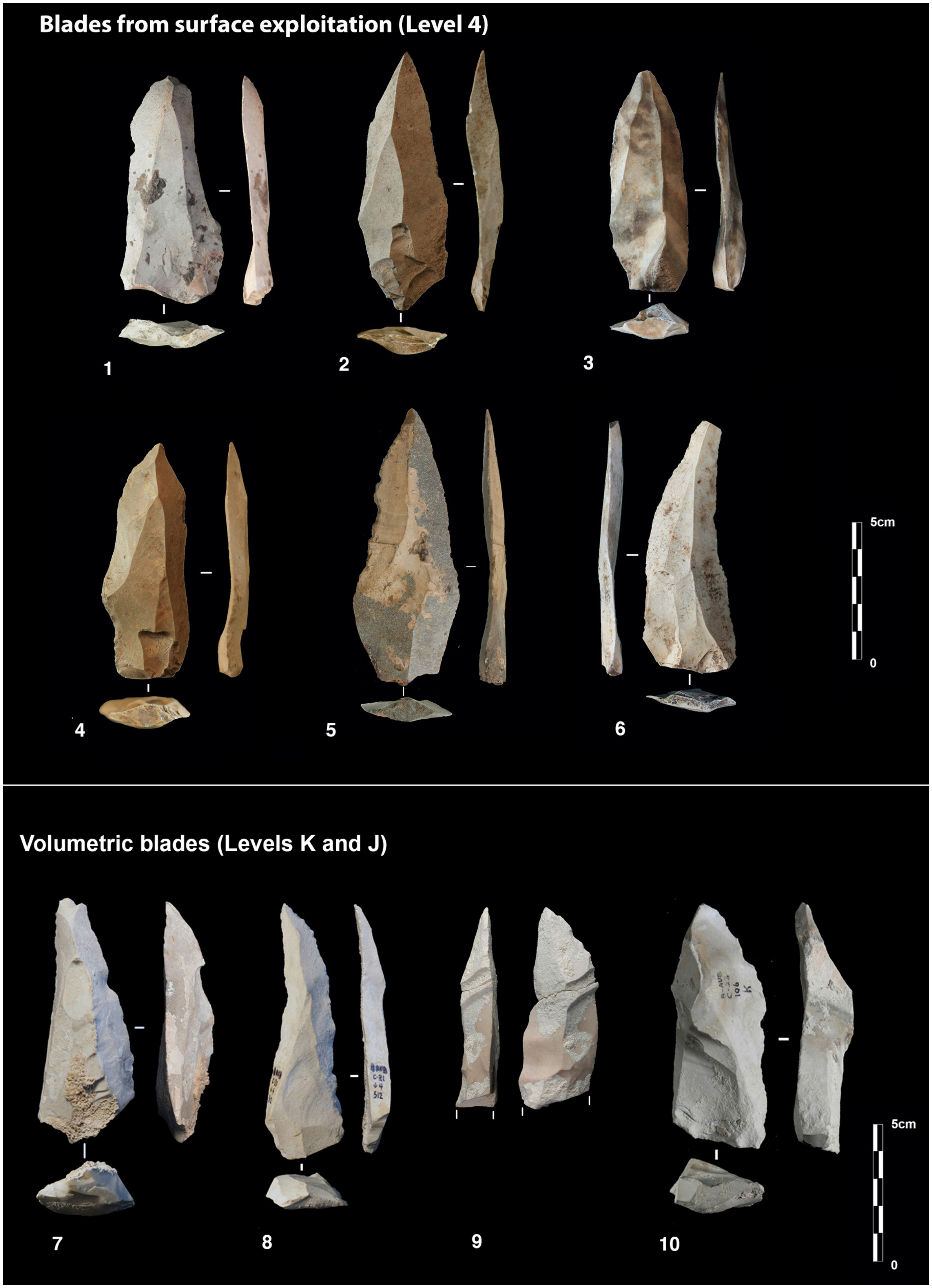


Figure 8. Bau de l'Aubesier. Convergent blades: 1–6) convergent blades from unidirectional surface exploitation from level 4; 7–10) convergent blades from volumetric sub-pyramidal exploitation from levels K and J.

Figure 9. Bau de l'Aubesier. Non-convergent blades: 1–3) blades with cortical distal edge from level 4; 4–7) blades from surface exploitation from level 4; 8, 9) volumetric blades from level 4; 10) volumetric debordant blades from level 4; 11, 12) volumetric blades from level H and level K, respectively.

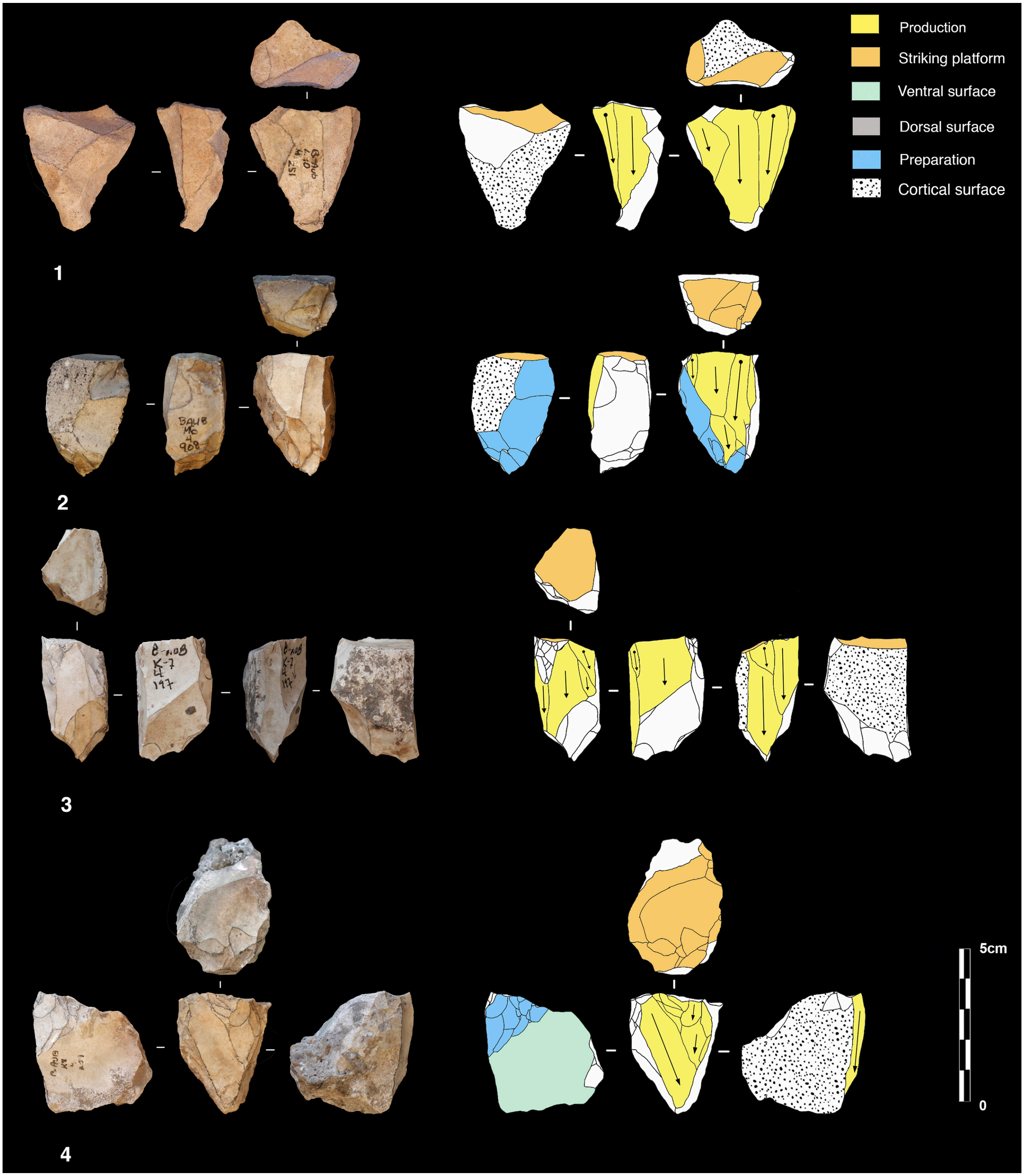


Figure 10. Bau de l'Aubesier. Bladelet cores from level 4: 1, 2) cores on chunks with convergent removals; 3) core on chunk with parallel removals; 4) core on flake with convergent removals.

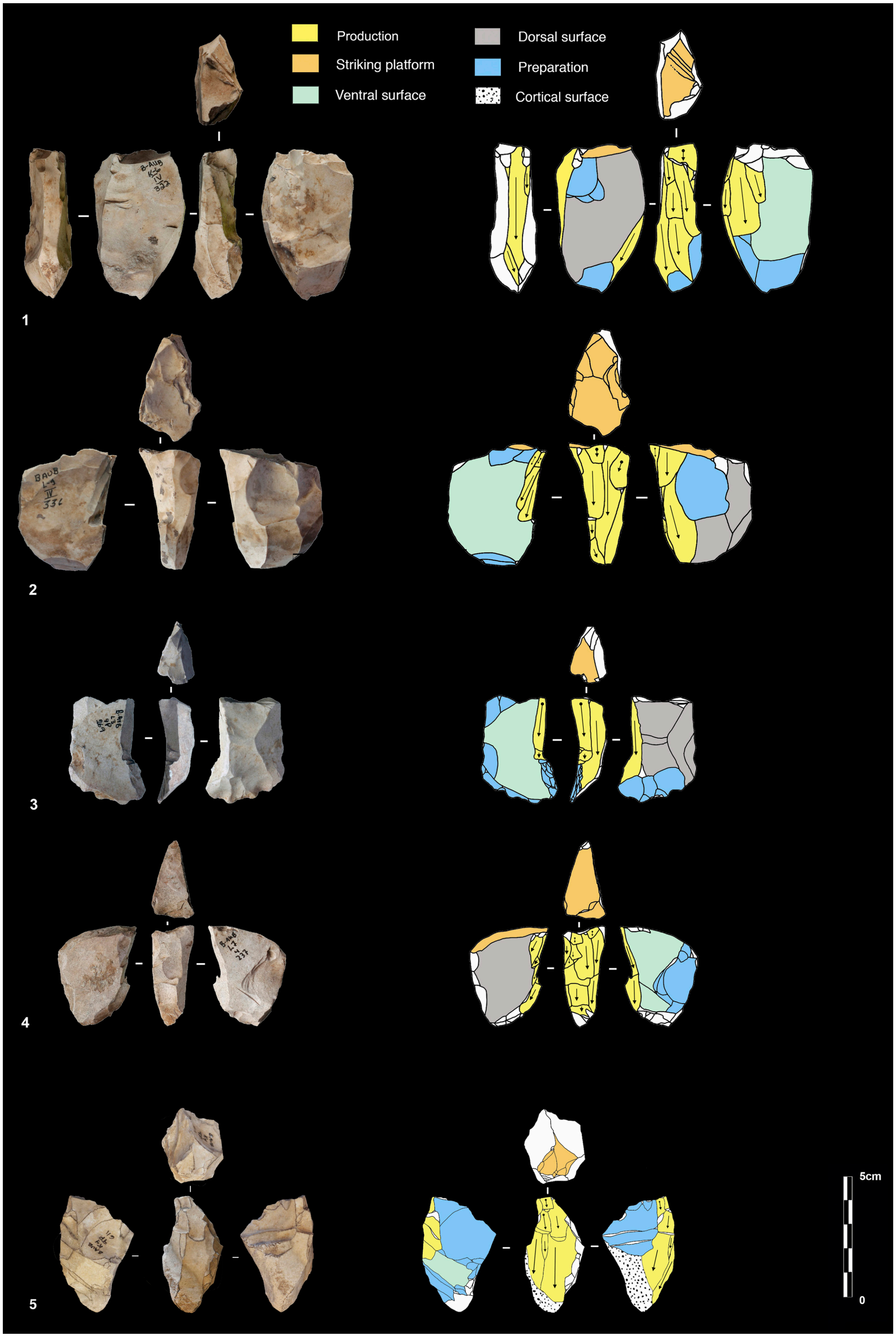


Figure 11. Bau de l'Aubesier. Bladelet cores on flakes with unidirectional parallel removals from level 4.

Figure 12. Bau de l'Aubesier. Technical bladelets from level 4: 1–3) rejuvenation bladelets; 4–6) crested bladelets.

Only six crested bladelets were found (Figure 12: 4–6).

The lack of a fully controlled and predetermined configuration is the cause of frequent hinged fractures and the subsequent abandonment of the core (Figure 11: 2–5). Hinged fractures are resolved in some cases by the extraction of a rejuvenation bladelet creating a new exploitable flaking surface (Figure 12: 1–3). However, there is no indication of a systematic maintenance of the cores. As observed also for blade production, products related to the renewal of striking platforms (i.e., core tablets) are absent and only two neo-crested bladelets, related to the reconfiguration of the flaking surface, were found in or close to the excavated area (SI Figure S11). The analysis of the number of negatives on the flaking surfaces indicates short series of removals. On 22 of 36 cores, the number of negatives on the flaking surface is less than five, and only 11 cores show more than five negatives (SI Table S9). The absence of a systematic reconfiguration of the cores and the lack of a long exploitation suggests that the core's volume was designed to produce a single short series of removals before being discarded.

The dimensions of the last complete and successful elongated scars on bladelet cores indicate that the minimal length of desired products ranges from 17mm to 20mm (SI Figure S6)

Bladelet end-products were found in the upper part of the sequence (levels 4, 3, 2). As with the bladelet cores, the highest number of bladelets, 62 entire pieces and 102 fragments, was recorded in level 4 dated to MIS 5d (SI Table S10). Bladelets were also found in level H, dated to the MIS 6 (see SI Table S10), but in smaller proportions. Bladelets found in level H differ from bladelets found in the upper levels. They have an irregular shape (Figure 13), suggesting that their morphology was less controlled than those found

Figure 13. Bau de l'Aubesier. Irregular, elongated "bladelet-like" pieces from level H.

in the upper layers. Also, bladelet cores and maintenance items (i.e., rejuvenation bladelets, bladelet core tablets, crested bladelets) are absent in level H. The bladelets from level H could be by-products of non-bladelet production, which were occasionally produced during blade or flake production. In contrast, the 62 complete bladelets found in level 4 display a symmetrical morphology and regular cutting edges (Figure 14).

The majority of bladelets have a plain striking platform. Punctiform, linear, and facetted platforms are also present but in smaller proportions (SI Table S11). The percussion point is located 2–3mm behind the platform edge. The longitudinal profile of the bladelets is usually straight or slightly curved (SI Table S12). Trimming or abrasion of the platform edge is uncommon. The vast majority of platform edges, more than 80%, are left unmodified (SI Table S13). The combination of these features likely indicates the use of an internal percussion technique.

A large proportion of bladelets show rectilinear edges (Type S0, S1, S2, S3), but convergent bladelets (P1 and P2) are also present (SI Table 14).

The elongation of both blades and bladelets increases throughout the sequence, from the bottom levels to the upper levels. Elongated blades occur only in levels 4 and H. Narrow blades and very elongated blades were found only in level 4 (Figure 15; SI Table S15). At the same time, we do observe that elongated products smaller than 30mm in length are well represented in level 4, while they are not found in the rest of the sequence (see Figure 15). A few elements under 30mm are also present in level H but, as mentioned above, these pieces are likely by-products of other lithic reduction activities rather than the products of discrete bladelet production. This tendency towards the microlithization of the elongated products in the upper levels, and especially in level 4, also emerges when plotting the length and width values for the entire sample of blades and bladelets (Figure 16).

FLAKE-BASED REDUCTION STRATEGIES

In the lower part of the sequence (levels K, J, and I) a few Levallois cores were found—one in level J (SI Figure S7) and three in level I (SI Table S16). In contrast, flakes are mainly produced following a parallel plan exploitation with either no or minimal preparation of the flaking surface and the striking platform (see SI Table S16). The methods used are centripetal, orthogonal, unidirectional, bidirectional, or convergent (SI Figure S8). Secant partial exploitation cores are present in levels K, J, and I, and progressively decrease from level K (18%) to level I (4%). Discoid cores are also found in levels K (n=3) and I (n= 5) (SI Table S16 and Figure S8). In level I, a few Kombewa-type cores (n=3) were also found. In the upper part of the sequence (levels H to 2), non-Levallois exploitation by parallel plans continues to be present but in smaller percentages compared to the lower levels (K, J, and I) (see SI Table S16). Starting from level H, the Levallois concept, which is sporadically present in the lower levels, becomes the main reduction system used to produce flakes (Figure 17: 2–5).

The proportion of complete Levallois cores in the middle and upper levels ranges from 35.6% in level H to 9% in level 2 (see SI Table S16). The large majority of Levallois cores are recurrent centripetal, and in level 4, some show convergent exploitation (n=7) (Figure 18: 1). Cores on flakes (Kombewa-type cores) are only sporadically present in level I and become more frequent in the upper levels and especially in level 4 (see SI Table S16; Figure 18: 4, 5). Abundant use of the Levallois (and Kombewa-type) reduction systems characterizes the middle and the upper part of the sequence (levels H to 2), and represents one of the major elements of rupture with the lower part of the sequence (levels K to I)—especially with level K where Levallois production is absent. Discoid reduction is used throughout the sequence except in level J and constitutes a common background technology across all assemblages (see SI Table S16).

The morpho-technical features of flake end-products are consistent with the cores found in the same levels. Levallois-type flakes are present throughout the entire sequence (see SI Table S2). However, Levallois-type flakes found in the middle and upper levels (from H to 2) show different characteristics compared to those in the lower levels (K, J, and I). Levallois-type flakes in the upper levels have a more curated preparation of the striking platform and a more symmetrical silhouette (Figure 19: 1–8). Furthermore, the short negatives related to the preparation of the distal and lateral convexities are often visible on the dorsal surface of Levallois-type flakes from the upper levels. The association of these features is rare on the Levallois-type flakes found in the lower levels (K, J, and I) and is more consistent with a non-Levallois parallel plan core exploitation—consistent with the cores found in the same levels, as discussed above (Figure 19: 9–16).

Secant centripetal flakes and unidirectional flakes constitute an important component of the (non-Levallois) end-products (see SI Table S2). Secant centripetal flakes progressively increase from the lower levels (from 3 % in level J and 10% in level I) to the upper levels (from 13% in level 5 and 20% in level 3). These flakes are short and thick with a robust cutting edge. They have an inclined platform and the dorsal surface is characterized by secant centripetal scars (Figure 20: 1–3). These features can be linked to the discoid reduction system or more generally to a peripheral secant plan exploitation observed on the cores. Unidirectional and bidirectional quadrangular flakes are common throughout the sequence (see SI Table S2; Figure 20: 4–6) and can be associated with simple unidirectional and multidirectional cores that are also present throughout the sequence (see SI Table S2).

The presence of Kombewa-flakes confirms the use of the Kombewa-type reduction system. As for the cores, Kombewa-flakes are more common in the upper part of the sequence (see SI Table S2 and Figure S9).

FORMAL TOOLS

More than a thousand retouched tools (n=1017) were identified throughout the sequence (Table 5). Blades are more

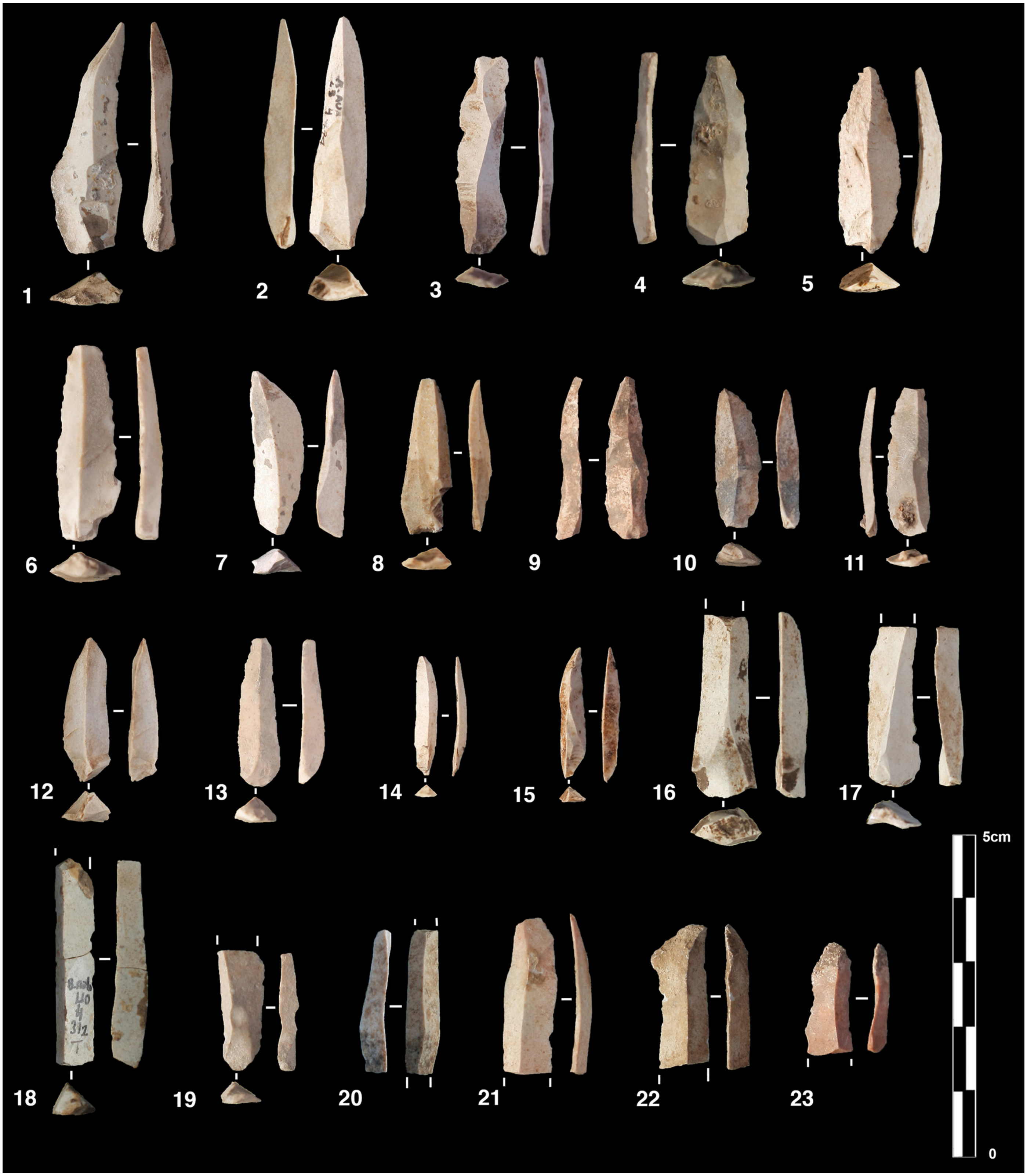


Figure 14. Bau de l'Aubesier. Bladelets from level 4: 1–15) complete bladelets; 16–23) fragmented bladelets.

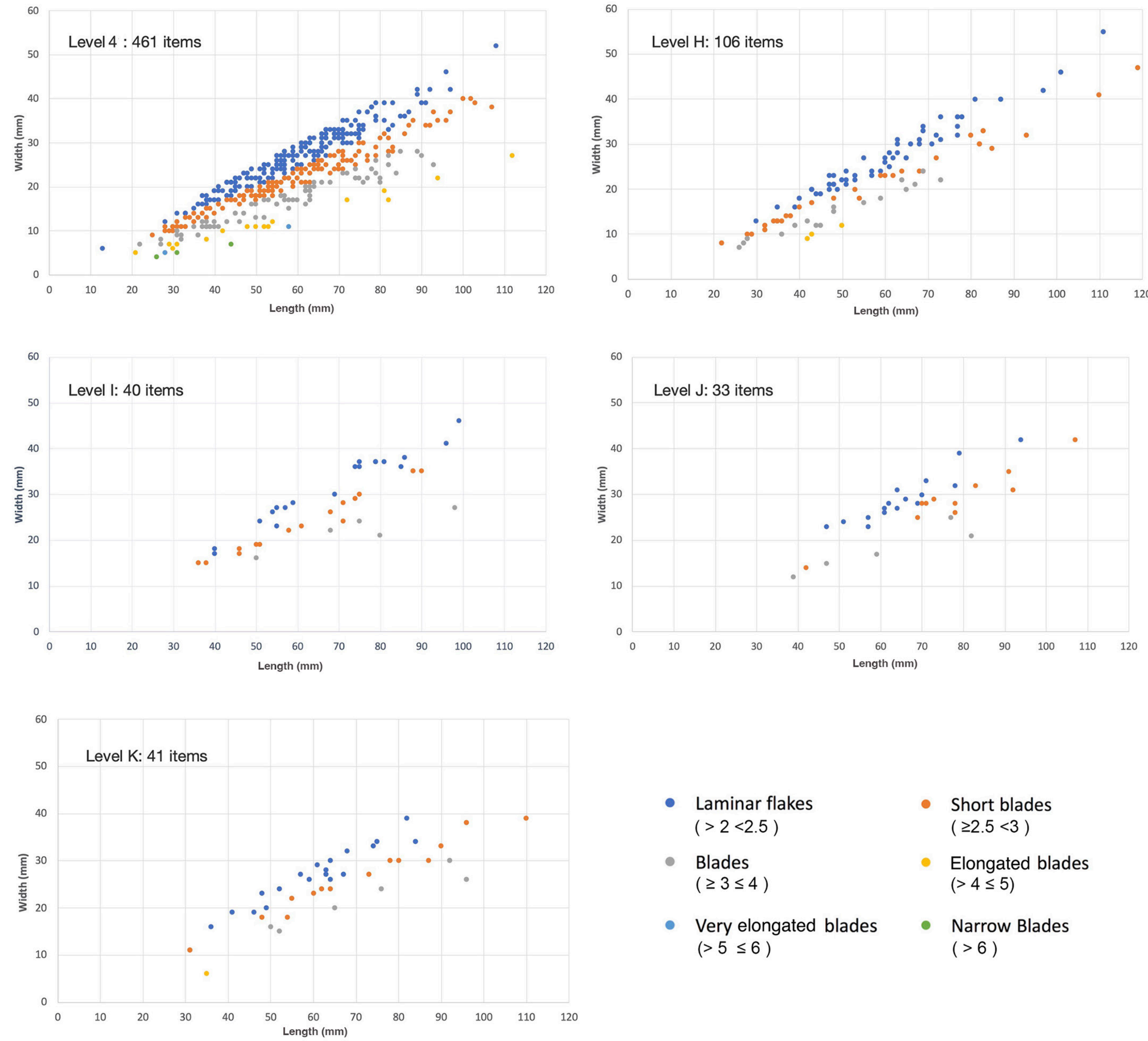


Figure 15. Bau de l'Aubesier. Length-width ratio and elongation of blade and bladelet classes throughout the sequence.

frequently retouched (from 28% in level I to 12 % in level 2) than flakes, except in the level K assemblage (see Table 5). All bladelets were left unretouched.

Retouch rarely modifies the shape of the blank and usually only regularizes the cutting edge without changing the original morphology. For that reason and also because almost all the retouched artifacts would fall into the scraper category, we have not used a typological classification. However, some retouched tools differ from this pattern. Fifteen pieces (12 from level K and 3 from J) are partially shaped into a rostrum (or carenoid) shape (Figure 21). A few of these pieces look morphologically similar to what are described as carinated cores for bladelet production. However, the first series of removals creates a plan-convex or plan-rectilinear cutting edge that shapes the morphology of these pieces. Small flakes (and not real bladelets) shape the rostrums. A second series of removals regularizes the last 2–3mm of the distal cutting edge overlapping the first series of removals. As a consequence, we think these objects are retouched tools, and not bladelet cores.

Forty-four pieces found in level 4 display bifacial thinning on one or two sides of the flake. One or more series of small flakes were removed from the ventral and dorsal surfaces. The thinning is placed directly opposing a point or close to a straight edge (Figure 22: 1–4). Six pieces were thinned on two sides (Figure 22: 5).

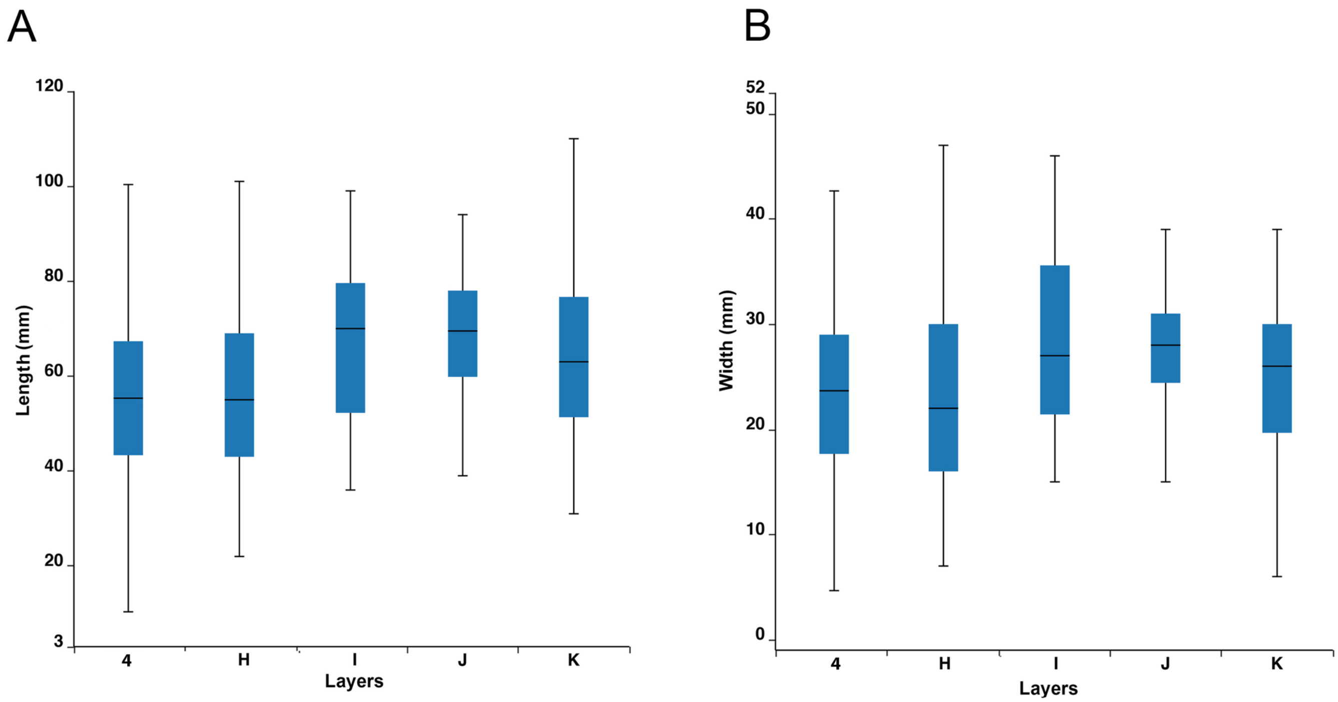


Figure 16. Box plot of length (A) and width (B) values for the entire sample of blade and bladelets from the Bau de l'Aubesier.

SUMMARY

Flake and blades co-exist at the Bau de l'Aubesier for over 100,000 years. Direct internal percussion is the only technique used to produce flakes, blades, and bladelets. However, beyond this stable macro-technological structure, there is variability at various levels: concepts of *débitage*, core configuration, methods, and end-products. Figure 23 summarizes the changes in the blade and bladelet production and for the main flake reduction strategies.

Sub-pyramidal volumetric blade production is only visible in level K at the bottom of the sequence and is dated to the end of MIS 7. In levels J and I, blades are produced on the large surface of the cores with minimal configuration of the flaking surfaces. From level J to level 4, there is an increase in the number of surface configurations used for the production of blades, as well as for the production of flakes.

A major technological discontinuity is seen with the upper levels (4, 3, and 2) and most specifically with level 4. In this level, we identified bladelet production—as well as a specific production of convergent blades. Convergent blades are produced using a surface exploitation close to the Levallois concept (whereas in level K convergent blades were produced using a volumetric reduction strategy). Volumetric blade and bladelet production show a similar configuration of the cores based on a minimal preparation and maintenance of their volume.

Discontinuities are also visible through time in the flaking technology. Level K is characterized by non-Levallois reduction systems and in levels J and I Levallois cores are rare. Starting with level H, flake production is instead dominated by the centripetal Levallois reduction system. Flake production in level 4 repeats to a large extent the variability observed in level H with some minor differences—the Levallois convergent method increases and the Kombewa-type exploitation, already present in level H, here includes the use of convergent sequences producing small pointed flakes.

DISCUSSION

With the blade production found in the lower levels (K, J) at the Bau de l'Aubesier, it is now clear that blade production was used outside of the cluster of sites dated to MIS 7 and located between the Seine and the Rhine valleys. Blade production in the south of France is 100,000 years older than previously thought. Bladelet production in Level 4 is clearly associated with Neandertal remains and is radiometrically dated to MIS 5d. This discovery shed new light on the technological variability of the Neanderthal groups but also invites us to be more cautious in searching for a strict correlation between particular types of artifacts and a specific human species.

THE VARIABILITY OF BLADE PRODUCTION DURING MIS 7

The reasons for the use of blade production in the south of France as early as MIS 7 are unknown. One hypothesis could be a derivation from the north with a possible local readaptation, but an independent origin with local reinvention cannot be excluded. There are similarities in the way blades were produced during MIS 7 at the Bau de l'Aubesier and in the area between the Seine and Rhine valleys—the unidirectional and bidirectional volumetric blade productions used at the Bau de l'Aubesier are well documented in

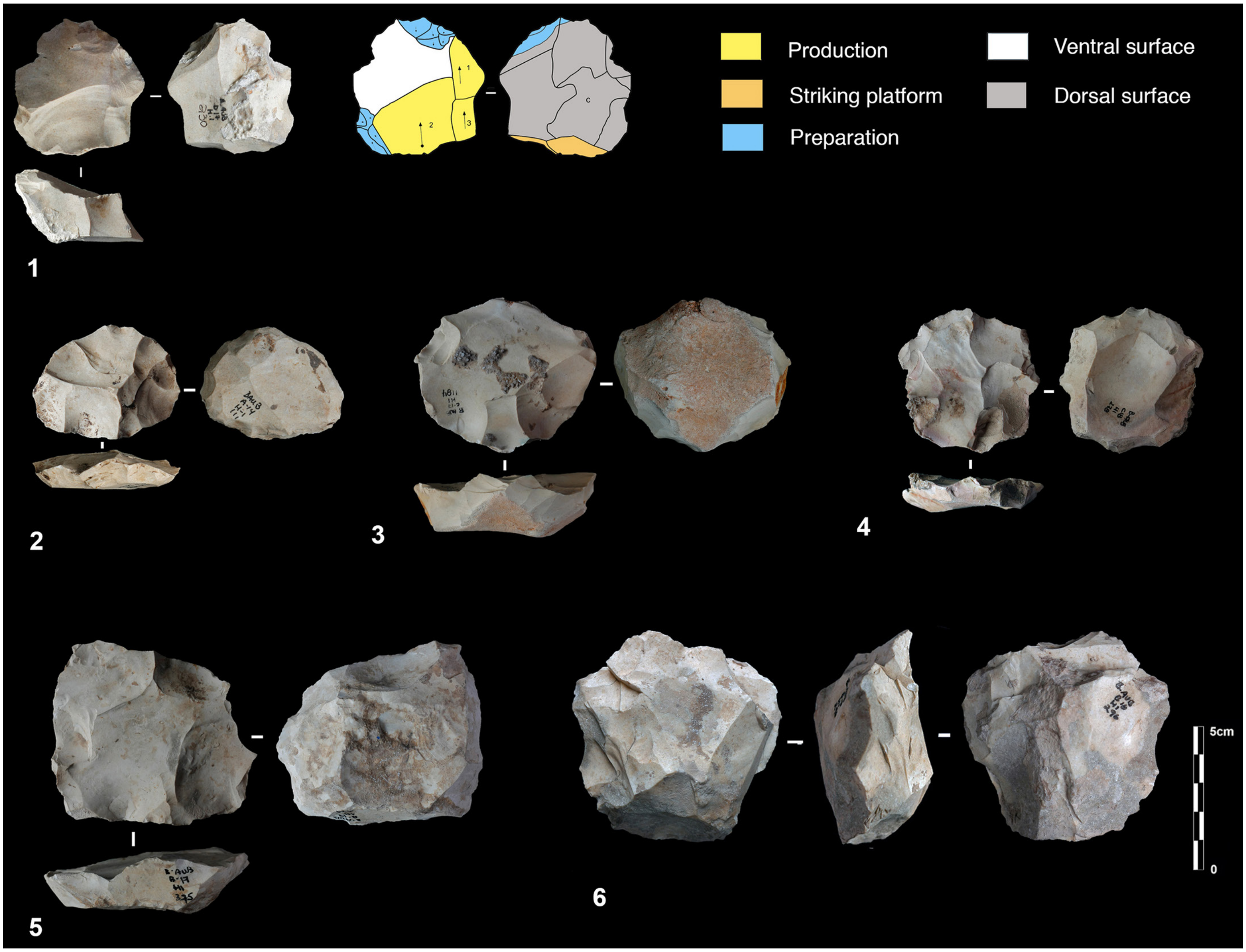


Figure 17. Bau de l'Aubesier. Cores from Level H: 1) Kombewa type core; 2–5) Levallois centripetal cores; 6) discoid core.

the cluster in the north of France/Belgium (e.g., Heinzelin and Haesaerts, 1983; Koehler, 2008; Locht et al., 2010). In contrast, the convergent sub-pyramidal systems found at the bottom of the sequence in the Bau de l'Aubesier level K and dated to the end of MIS 7 do not find any analogue within sub-contemporary blade reduction strategies, and appear to be unique for the time period. The site of Cave Dall'Olio, tentatively attributed to the MIS 9 based on paleosol correlations (Fontana et al., 2009, 2010, 2013), and located at the northern borders of the Italian peninsula, also shows a sub-pyramidal blade production similar to the one studied here. Radiometric dating would be needed at Cave Dall'Olio before the relationships between these two sites can be discussed further. For now, the small number of studied sites and their spread over long periods of time and large geographic areas mean we can only speculate when attempting to discuss the reasons for the development of blade production systems in these different regions.

More generally, the mechanisms behind the appearance of laminar assemblages remain poorly understood. The long-term duration and the large diffusion of the laminar phenomenon do not show any strict correlation of this technology with a specific hominin species (see SI Figure S1). From a macroscopic point of view, blade technology can be defined as a reduction process that led to obtaining, in a more systematic way, longer cutting edges than on flakes. About the question of why producing blades instead of flakes, it is difficult for the moment to give a satisfactory answer. Response to raw material constraints, technological expediency to optimize the production, different function, and/or hafting are possible explanations (e.g., Bar-Yosef and Kuhn 1999; Eren et al. 2008; Kuhn 2020). It is more than reasonable to think that the choice to produce elongated items can find its origin in multiple factors that are difficult to reduce into a single explanation.

DIFFERENT BLADES FOR DIFFERENT TOOLS?

The use of both surface and volumetric blade production, as seen at the Bau de l'Aubesier in MIS 7, 6, and 5d, is also known at other Middle Paleolithic sites. For instance, both strategies are documented in the same level at Etouteville (Delagnes, 1996) and at Etricourt-Manacourt (Hérisson,

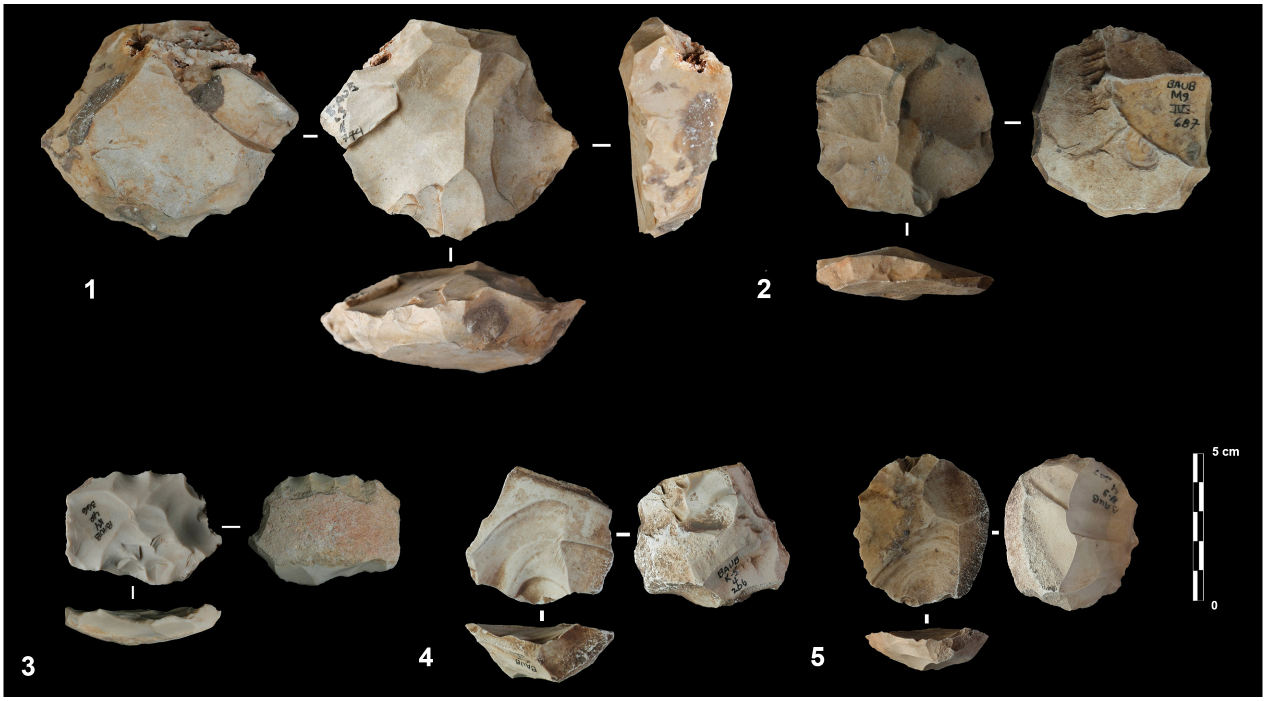


Figure 18. Bau de l'Aubesier. Cores from Level 4: 1) Levallois convergent core; 2, 3) Levallois centripetal core; 4, 5) Kombewa type cores.

2015). The total replacement of Levallois blade production, and to a lesser extent of surface blade production, by volumetric systems only takes place in Europe with the emergence of Upper Paleolithic industries.

Why were these two types of production kept in use for a such a long time? One may wonder how the raw material shape or availability triggers the use of one or the other production system, especially in areas where the raw material is rare or difficult to access. At the Bau de l'Aubesier, flint sources are abundant and easily accessible. Over 350 possible sources have been identified in the region (Wilson, 2007b; Browne and Wilson, 2011; Wilson and Browne, 2014). The raw material is composed of good quality flint that is available in nodule form in both primary and secondary positions (Wilson, 2007a,b,c; Browne and Wilson, 2011). In our view, it is unlikely that raw material was a constraint.

The volumetric and surface reduction strategies used at the Bau de l'Aubesier produce a panoply of blades with different characteristics. As illustrated above, the use of one or the other *débitage* concept has consequences for thickness-width ratio and the cutting-edge angle of the blades. These two different procedures may have been chosen by the past knappers to obtain more robust blades in one case and a sharper cutting edge in the other, albeit this needs to be confirmed with further experiments.

Also, the use of unidirectional or convergent production has an effect on the distal termination of the blades (i.e., convergent or non-convergent morphology). It is noticeable that these blades are only slightly retouched, suggesting that there was little need to adjust the shape of the blades after their production because this was predetermined in the *débitage* methods. Considering that the shape of the blades is constrained and controlled by the production system used, and that the hominins persisted in using two different production strategies providing quite different blade morphologies, we can speculate that the different type of blades had different roles in the tool-kit and different functions. Functional analysis of these different blade shapes, produced using different production systems, would likely shed light on the significance of the persistence of these distinctive reduction strategies and resulting blade morphologies.

THE RECOGNITION OF BLADELET PRODUCTION IN MOUSTERIAN ASSEMBLAGES OLDER THAN MIS 4

A clear and intentional bladelet production from bladelet cores (mostly being cores on flakes) and their associated maintenance bladelets was found at the Bau de l'Aubesier in level 4. Level 4 is radiometrically dated to MIS 5d and contains six Neandertal teeth. The entire bladelet *chaîne opératoire* is present. The study of the cores, products and by-products indicates an independent reduction strategy producing bladelets.

Two bladelet cores dating back to the end of MIS 8 have recently been highlighted at the site of Payre by one of us and colleagues (Carmignani et al., 2017). Nevertheless, despite the presence of these two cores, the total absence of products and by-products of bladelet production make it difficult to interpret the significance of these bladelet cores in a MIS 8 context. At Bapaume les Osiers, dated to the end of MIS 7 and the beginning of MIS 6, one bladelet core and four bladelets were reported but classified as "cores

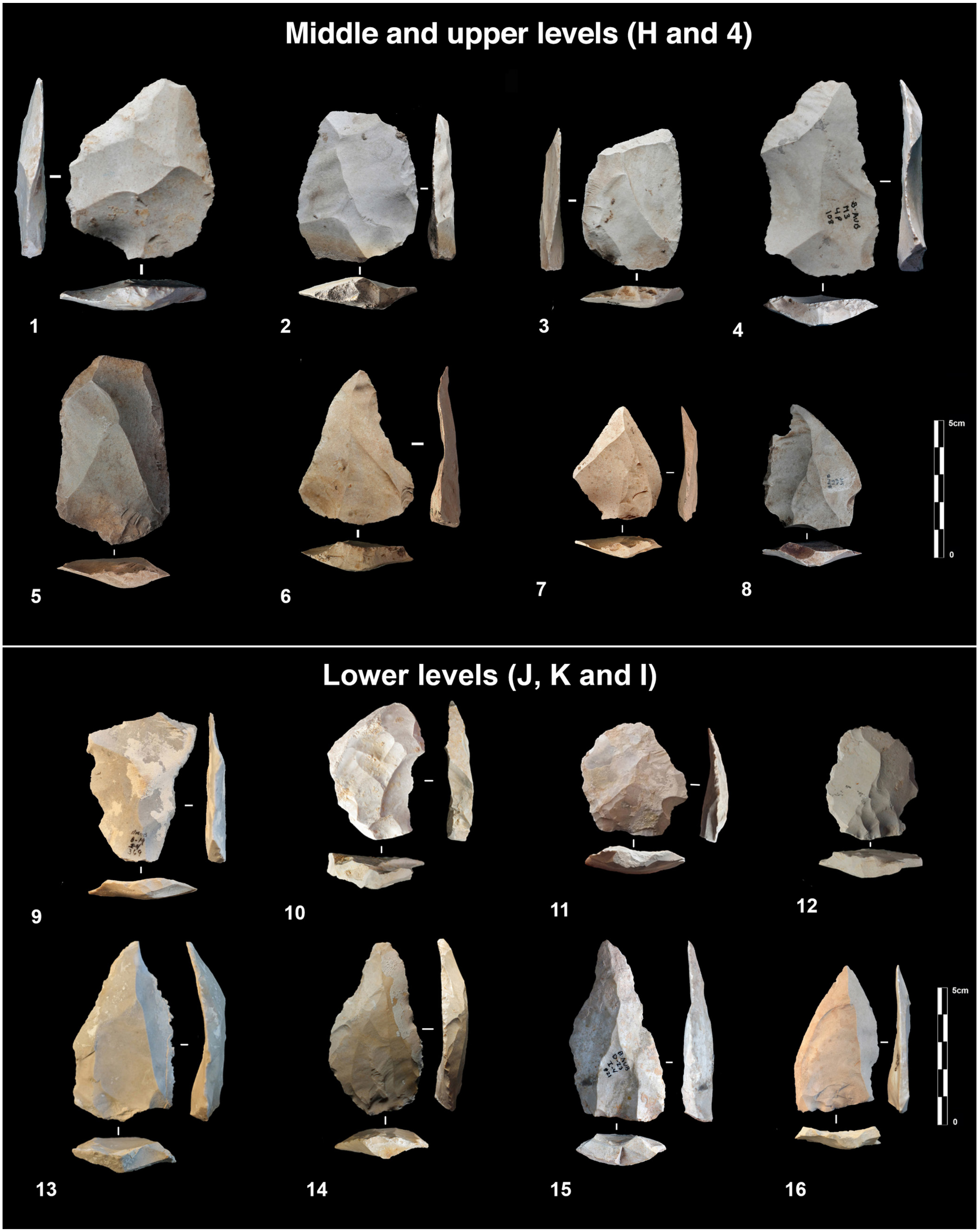


Figure 19. Bau de l'Aubesier. Levallois type flakes: 1–3) Levallois centripetal flakes from level H; 4) Levallois centripetal flake from level 4; 5, 6, 8) Levallois convergent flakes from level 4; 7) Levallois convergent flake from level H; 9) Levallois-type centripetal flake from level I; 10–12) Levallois-type centripetal flakes from levels K and J); 13, 14) convergent flakes from level I; 15, 16) convergent flakes from levels J and K.

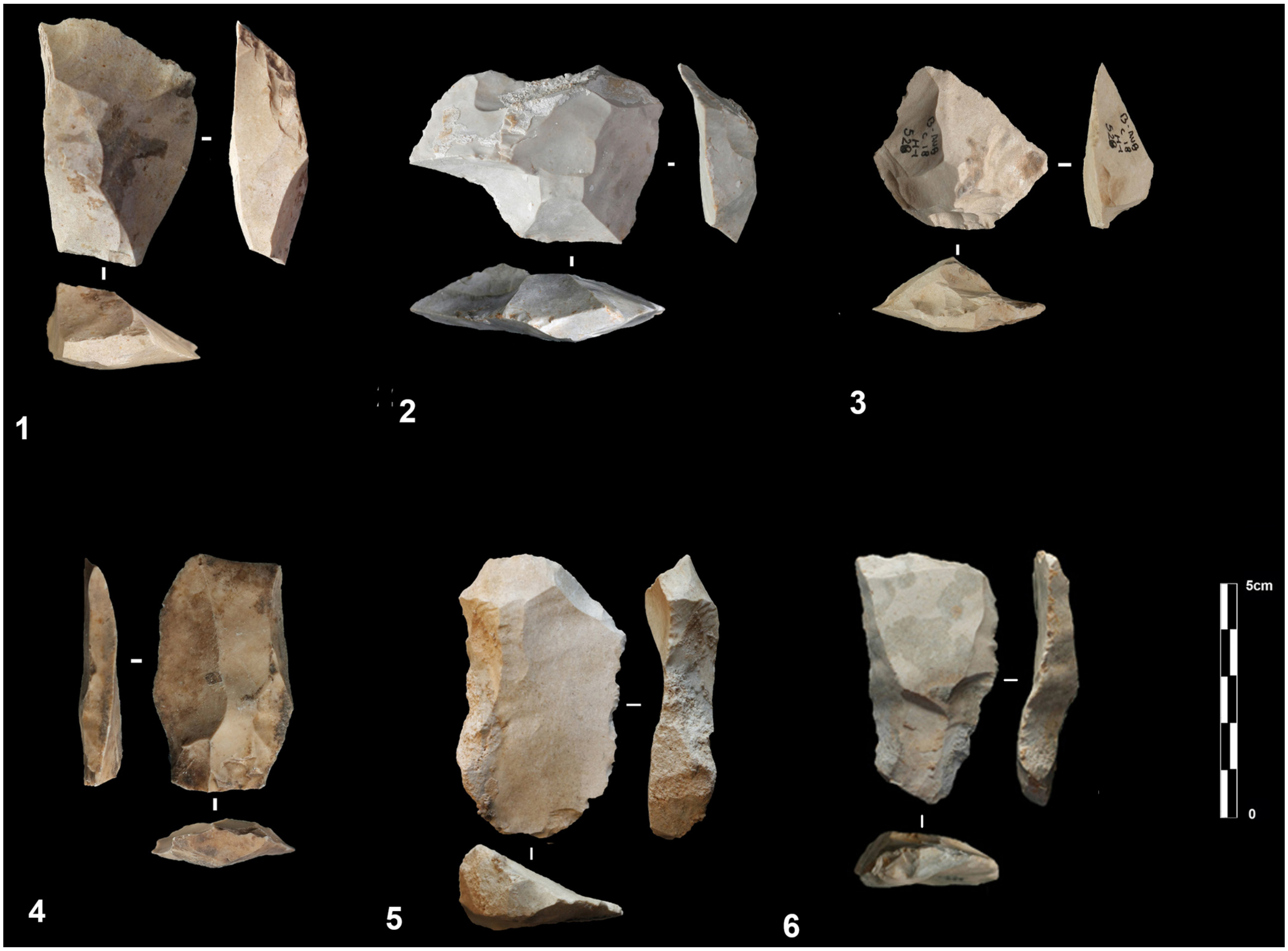


Figure 20. Bau de l'Aubesier. Non-Levallois flake end-products: 1–3) secant centripetal flakes from level H; 4) bidirectional flake from level 4; 5) unidirectional debordant flake from level H; 6) unidirectional flake from level J.

TABLE 5. PROPORTION OF ENTIRE RETOUCHED BLADES, FLAKES, AND BLADELETS RELATIVE TO THE TOTAL NUMBER OF BLADES, FLAKES, AND BLADELETS IN THE ASSEMBLAGES.

Levels	Blades			Flakes			Bladelets		
	Total	Ret. N	*Ret %*	Total	Ret. N	*Ret %*	Total	Ret. N	*Ret %*
2	32	4	*12.5*	430	48	*11.1*	13	-	-
3	3	-	-	105	9	*8.5*	5	-	-
4	399	95	*23.8*	4535	496	*10.9*	61	-	-
5	6	-	-	192	29	*15.1*	-	-	-
H	90	23	*25.5*	1960	143	*7.2*	16	-	-
I	40	11	*27.5*	785	72	*9.1*	-	-	-
J	33	6	*18.1*	273	33	*12.1*	-	-	-
K	39	7	*17.9*	150	40	*26.6*	1	-	-

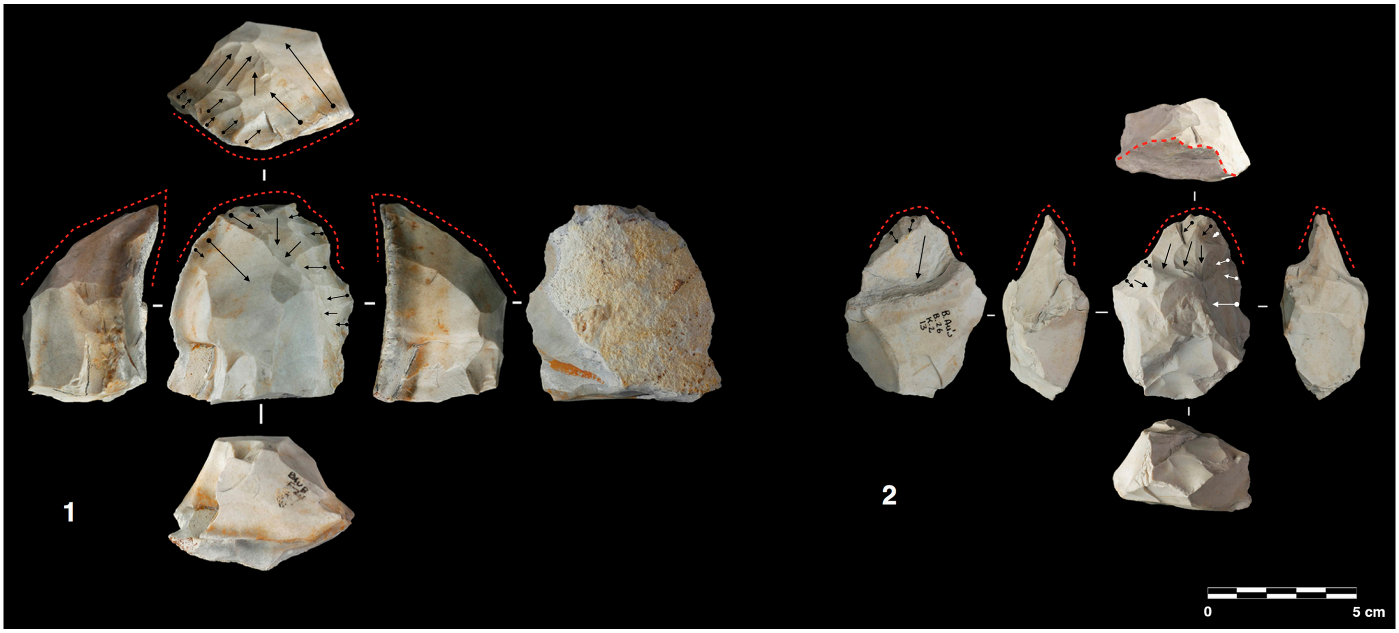


Figure 21. Bau de l'Aubesier. Partially shaped pieces from level K.

for small blades" (Koehler, 2008). Currently, the bladelet production found in Bau de l'Aubesier level 4 is for the moment the earliest clear bladelet production described in Europe, and it precedes by 30,000 years the bladelet production previously described at Combe-Grenal and attributed to MIS 4 based on biostratigraphy and geochronological data (Guadelli and Laville, 1988; Faivre, 2012). It is also the first bladelet production found in direct association with Neandertal remains.

SIEVING FOR BLADELETS AND STUDYING LARGE ASSEMBLAGES

With this said, we wonder if the small number of Middle Paleolithic assemblages with bladelet production, especially Middle Paleolithic assemblages older than MIS 3, could be due to the history of research and the theoretical framework used to study lithic assemblages. One of the first challenges to overcome in recognizing bladelet production is to systematically retrieve them during the excavation. At the Bau de l'Aubesier, sieving was done with a 2mm mesh (Wilson, 2021). However, in France, it is commonplace to wet-sieve Mousterian sediment with a mesh of 5mm. Meanwhile a mesh of 2mm is often used to sieve Upper Paleolithic assemblages. Studies have shown that a 2mm mesh is indeed required to collect Early Upper Paleolithic bladelets that would otherwise be lost (Soressi and Tavormina, 2011).

Another factor that may influence bladelet recovery is the size of the studied assemblage, and the level of detail with which the study is conducted. Here, the total number of lithics studied in level 4 is large. The careful study by one of us of the almost 17,000 lithics larger than 2cm, as well as almost 70,000 lithics smaller than 2cm, enabled the discovery of 33 bladelet cores, 61 complete bladelets, and 200 fragmented bladelets (see Figures 11, 12, and 15). The percentage of bladelets in level IV is 1.4% of the complete blanks (see Table 1). It is possible that Middle Paleolithic bladelets only become "visible" in large assemblages.

BLADELETS INSTEAD OF "SMALL BLADES" OR "SMALL ELONGATED" PRODUCTION

Another challenge is likely imposed by the classification system currently in use. For the Middle Paleolithic, the existence of a true bladelet production seems to be validated only through the presence of independent reduction strategies clearly separated from blade production.

At Angé, an open-air site located in the center of France and attributed to MIS 5a (Koehler et al., 2014), small blades—of the size and shape of bladelets—were produced in continuity with the blade production and no independent reduction strategy for bladelets was identified. For these reasons, the authors use the term "small blades" instead of bladelets. Similarly, the drawings published for level SW of Seclin dated to MIS 5 (Révillion, 1994, 1995; Révillion and Tuffreau, 1994) indicate that some of the volumetric "small blade" cores measure from 3cm to 5cm in their maximum dimension and the products coming from these cores are named "small blade." At Saint-Germain-de-Vaux sector 1, some "blade cores" measure from 4cm to 5cm and "blades" 3cm to 4cm long are illustrated but, once again, these pieces are reported as small blades and small blade cores (Cliquet and Revillon, 1990).

Prior to the 2000s, it was inconceivable to talk about bladelet production in Mousterian assemblages. The first researcher using the word bladelet in a Mousterian context is Slimak in 1999 (Slimak, 1999). The publication of one of us (albeit on more recent Mousterian assemblages) clearly testifies to the production of volumetric bladelet cores that are not named as such (Soressi, 2002; Soressi et al., 2008). However, the "small blades" coming from the "small volu-

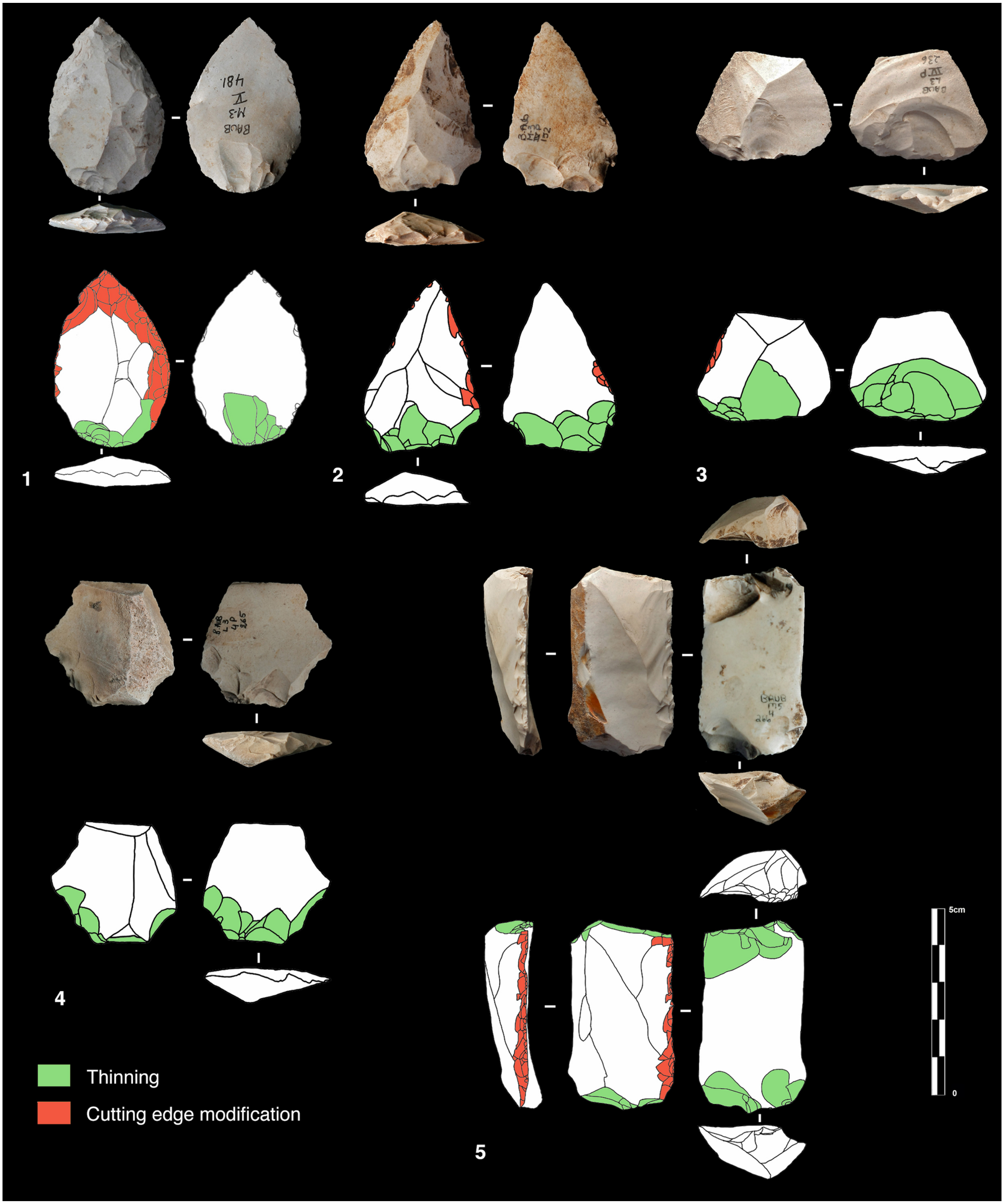


Figure 22. Bau de l'Aubesier. Thinned pieces from level 4.

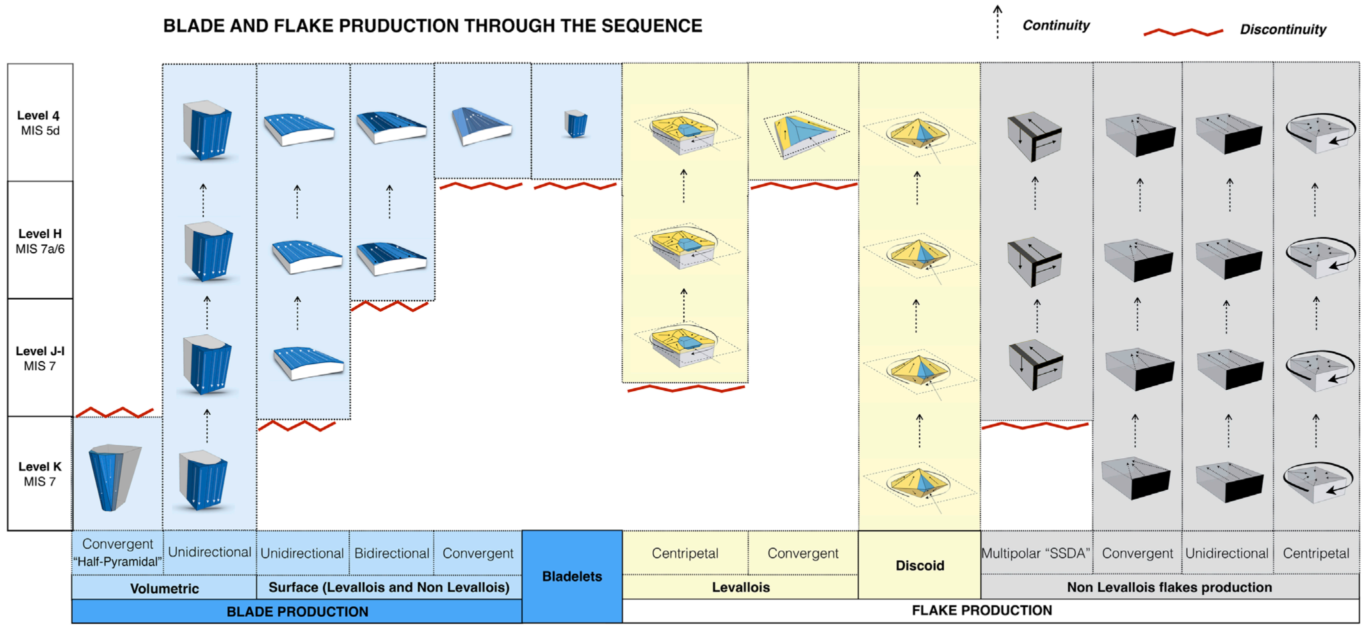


Figure 23. Bau de l'Aubesier. Blade, flake and bladelet production systems at the Bau de l'Aubesier.

metric blade cores" are, morphologically speaking, likely not different from the bladelets produced in level 4 at the Bau de l'Aubesier. It is therefore now questionable if there is any reason to maintain the use of this arbitrary distinction (small blade *versus* bladelet) for products that have identical morpho-technical features and that are proven to be intentionally produced.

It is also important to highlight that, curiously, bladelet production in continuity with the blade core reduction process has also been recognized in Protoaurignacian industries (Bon, 2002). However, in this latter case we do not speak about production of small blades but rightly of bladelet production.

Another proxy commonly used to certify the presence of "real" bladelets is the retouch and/or the presence of use-wear traces confirming their use as a tool. But here again we notice that in Aurignacian and Proto-Aurignacian assemblages, the function of bladelets can be diverse and is not strictly linked to a specific usage (e.g., Normand et al., 2006; Bataille and Conard, 2018; Dinnis et al., 2019; Chu et al., 2022). Differences in size between blades and bladelets in Middle Paleolithic indicate a difference in terms of production objectives and likely a different function. Unfortunately, there are no data yet available to prove that these bladelets and small blades found in the Middle Paleolithic had different functions and future research should definitely focus on studying those products under the lens of use wear and residue analysis. However, the lack of functional analysis on bladelets is a gap that does not touch only the specific case of Bau de l'Aubesier, and more in general the Middle Paleolithic, but also the Initial Upper Paleolithic assemblages, the transitional industries and to a lesser extend also the Early Upper Paleolithic. In many cases, identification of bladelets are exclusively made, like we did here, only through the reconstitution of the reduction systems and production targets (e.g., Roussel et al., 2016; Demidenko et al., 2020; Zwyns, 2020).

Despite the small quantity of recognized bladelets and their sporadic presence at the Bau de l'Aubesier, our study confirms that bladelets were part of the Mousterian technological repertoire and their production was performed by Neandertals at least from MIS 5 onward.

Several questions remain to be solved. For instance, why is bladelet production in Middle Paleolithic contexts extremely rare and found only in very small quantities? Can this anecdotal presence be related to specific functions or activities that occur much less frequently than others—thus it is archeologically near-invisible? Or, could it be related to some of the research biases mentioned earlier?

CONCLUSION

The documentation of blade and bladelet production at the Bau de l'Aubésier enriches our understanding of the complexity of Neandertal technology. Blade production was used in the south of Europe during MIS 7 and was not circumscribed to a specific area of north-western-Europe between the Seine and the Rhine valleys. Blades were produced at the Bau de l'Aubesier from MIS 7 to MIS 5d and as early as 200 ka; and blade production in MIS 7 levels is associated with Neandertal and Pre-Neandertal remains including one mandible. The design of the blades was diversified and blades show distinct morpho-technical features that are the consequence of the use of different reduction strategies, i.e., volumetric and non-volumetric. Middle Paleolithic blade production occupied a technological niche and was always a small component compared to flakes. However, the presence of blade production at the Bau de l'Aubesier in several levels dated across 100,000 years suggests that the usage of blades may represent a long-term trend at specific sites during the Mousterian and across several large climatic variations (i.e., from MIS 7 to MIS 5d).

Independent bladelet production is documented at the Bau de l'Aubesier in a sedimentary context containing six Neandertal teeth, radiometrically dated by U/Th, ESR, and biostratigraphy to MIS 5d and overlain by three other Mousterian levels and a roof-fall closing the sequence. Bladelets were produced at the Bau de l'Aubesier 30,000 years earlier than previously thought and at least 50,000 years before the advent of the Upper Paleolithic in Europe. Current knowledge does not help us to clarify the existence, or lack thereof, of bladelet production during and prior to MIS 5 at other sites in Europe. Our research suggests the need to study, in detail, whole assemblages that have been recovered with sieving that yields the fine lithic fraction. Our study also highlights the need to standardize the terminology used to describe Mousterian bladelet production.

The reasons for the emergence and the persistence of blade and/or bladelet technologies remain enigmatic. We can speculate that their production and use may be linked to the emergence of new needs and especially new activities. The persistence of these productions through time suggests the existence of a shared knowledge transmitted through generations and constrained by social behaviors.

Our analysis of the Bau de l'Aubesier lithics demonstrates that the trajectory of technological changes in stone-tool production (and products) is far from being homogeneous in time and space. The debate about the meaning of the diversity within and between Middle Paleolithic assemblages is far from over.

ACKNOWLEDGEMENTS

Access to the collection was granted to L. Carmignani and scientifically supported by Mr. Xavier Delestre, Conservator in Chief of the Service régional de l'Archéologie, Ministry of Culture, conservateur général du Patrimoine, and by Mr Pierre-Jean Texier. We are grateful to Igor Djakovic and Lucy Wilson who polished the English of the manuscript and offered comments on its content. We also thank M. Roussel and the Human Origins research unit in Leiden for stimulating us with interesting questions during the writing of this article. We are indebted to Valentina Cozzolino, Jacopo Gennai, Chiara Zen, and Anna Bendini Mainardi, who helped L. Carmignani to do the initial sorting of the more than 100,000 lithic artifacts from the Bau de l'Aubesier.

The data for the lithic assemblages of the Bau de l'Aubesier was collected by L. Carmignani during his Ph.D. studies and was supported by the IDQP (International Doctorate in Quaternary and Prehistory). A special thanks goes to Marie-Hélène Moncel for her support and the stimulating discussions with L. Carmignani during his Ph.D. L. Carmignani and M. Soressi were supported during the writing of this paper by a VICI grant awarded to M. Soressi by the NWO (Dutch Research council, VI.C.191.070).

DATA STATEMENT

All the data are contained within this article and supplements.

REFERENCES

Ameloot-Van der Heijden, N., 1993. L'industrie laminaire du niveau CA du gisement paléolithique moyen de Riencourt-lès-Bapaume (Pas-de-Calais). Bull. Soc. Préhist. française 90, 324–327.

Arzarello, M., Peretto, C., 2004. L'industrie lithique moustérienne (Tagli 40-42) du Riparo Tagliente (Verone, Italie). In: Le Secrétariat du Congrès (Ed.), Le Paléolithique Moyen/The Middle Palaeolithic General Sessions and Posters. BAR International Series 1239. Oxford, Archeopress, pp. 169–175.

Arzarello, M., Peretto, C., 2005. Nouvelles données sur les caractéristiques et l'evolution techno-économique de l'industrie moustérienne de Riparo Tagliente (Verona, Italie). In: Molines, N., Moncel, M., Monnier, J. (Eds.), Les Premières Peuplements En Europe. Colloque International (Rennes, 22-25 Septembre 2003). BAR International Series 1364. Rennes, pp. 281–289.

Arzarello, M., Berardinelli, L., Minelli, A., Pavia, M., Rufo, E., Sala, B., Thun Hohenstein, U., Peretto, C., 2004. Il sito paleolitico medio di Grotta Reali (Rocchetta al Volturno, molise, Italia). Riv. Sci. Preist. LIV, 249–269.

Baena, J., Carrión, E., Cuartero, F., Fluck, H., 2012. A chronicle of crisis: the Late Mousterian in north Iberia (Cueva del Esquilleu, Cantabria, Spain). Quatern. Int. 247, 199–211.

Bar-Yosef, O., Kuhn, S.L., 1999. The big deal about blades: laminar technologies and human evolution. Am. Anthropol. 101(2), 322–338.

Bataille, G., Conard, N.J. 2018. Blade and bladelet production at Hohle Fels Cave, AH IV in the Swabian Jura and its importance for characterizing the technological variability of the Aurignacian in Central Europe. PLoS One 13(4), e0194097.

Blackwell, B.A., Leung, H.Y., Skinner, A.R., Schwarcz, H.P., Lebel, S., Valladas, H., Blickstein, J.I.B., Divjak, M.N., 2000. External dose rate determinations for ESR dating at Bau de l'Aubesier, Provence, France. Quatern. Int. 68, 345–361.

Blackwell, B.A.B., Skinner, A.R., Blickstein, J.I.B., Lebel, S., Leung, H.Y.M., 2001. ESR Isochron dating analyses at Bau de l'Aubesier, Provence, France: clues to U uptake in fossil teeth. Geoarchaeol. 16, 719–761.

Blaser, F., Bourguignon, L., Sellami, F., Rios, J., Vieillevigne, E., Guibert, P., 2012. Un site à composante laminaire dans le Paléolithique Moyen du sud-ouest de la France: le site de Cantalouette 4 (Creysse, France). Bull. Soc. Préhist. française 109, 5–33.

Boëda, E., 1990. De la surface au volume: analyse des conceptions des débitages Levallois et laminaire. In: Farizy, C., Combier, J. (Eds.), Paléolithique Moyen Récent et Paléolithique Supérieur Ancien En Europe, Actes Du Colloques International de Nemours 1988. Mémoire du Musée de Préhistoire d'Ile de France, Nemours, pp.

63–68.

Boëda, E., 2013. Techno-Logique & Technologie: Une Paléo-Histoire des Objets Lithiques Tranchants. @rchéo-éditions, Paris.

Boëda, E., Geneste, J.-M., Meignen, L., 1990. Identification de chaînes opératoires lithiques du Paléolithique ancien et moyen. Paléo 2, 43–80.

Boëda, E., Hou, Y.M., Forestier, H., Sarel, J., Wang, H.M., 2013. Levallois and non-Levallois blade production at Shuidonggou in Ningxia, North China. Quatern. Int. 295, 191–203.

Bon, F., 2002. L'Aurignacien entre mer et océan: réflexion sur l'unité des phases anciennes de l'Aurignacien dans le Sud de la France. Société préhistorique française, Joué-Les-Tours. Mémoire XXIX de la Société Préhistorique Française, Paris

Browne, C.L., Wilson, L., 2011. Resource selection of lithic raw materials in the Middle Palaeolithic in southern France. J. Hum. Evol. 61, 597–608.

Browne, C.L., Wilson, L., 2013. Evaluating inputs to models of hominin raw material selection: map resolution and path choices. J. Archaeol. Sci. 40, 3955–3962.

Carmignani, L., 2010. L'industria litica del livello FIIIe di Grotta del Cavallo (Nardò, Lecce) : osservazioni su una produzione lamino-lamellare in un contesto del Musteriano finale. Origini 32, 7–26.

Carmignani, L., 2017. Between the flake and the blade: associated systems of production at Riparo Tagliente (Veneto, northern Italy). J. Lithic Studies 4, 1–37.

Carmignani, L., Martini, F., Sarti, L., 2020. Le produzioni litiche dello strato F. In: Sarti, L., Martini, F. (Eds.), Il Musteriano Di Grotta Del Cavallo Nel Salento (Scavi 1986-2005). Culture e Ambienti. MILLENNI, Firenze, pp. 155–246.

Carmignani, L., Moncel, M.H.E., Fernandes, P., Wilson, L., 2017. Technological variability during the Early Middle Palaeolithic in Western Europe. Reduction systems and predetermined products at the Bau de l'Aubesier and Payre (South-East France). PLoS One 12, e0178550.

Carmignani, L., Sarti, L., 2018. Blade and bladelet reduction systems in the Italian Middle Paleolithic. The case of Grotta del Cavallo,(Nardò–Lecce). In: Borgia, V., Cristiani, E. (Eds.), Palaeolithic Italy: Advanced Studies on Early Human Adaptations in the Apennine Peninsula. Sidestone Press, Leiden, pp. 37–58.

Chabaï, V., Sitlivy, V., 1994. The blade component in the Middle Palaeolithic of Ukraine : origin and evolution. In: Révillion, S., Tuffreau, A. (Eds.), Actes de La Table Ronde "Les Industries Laminaires Au Paléolithique Moyen." Dossier de Documentation Archéologique n. 18. CNRS edition, Paris, pp. 161–167.

Chabaï, V., 2001. The Late Middle and Early Upper Paleolithic in Crimea (Ukraine). In: Zilhão, J., Aubry, T., (Eds.), Les Premiers Hommes Modernes de La Péninsule Ibérique: Actes Du Colloque de La Commission VIII de l'UISPP: Vila Nova de Foz Côa, 22-24 Octobre 1998, Trabalhos de Arqueologia 17. Instituto Portugues de Arcqueologia, Lisboa, pp. 25–36.

Chabaï, V., Marks, A.E., Monigal, K., 2004. Crimea in the context of the Eastern European Middle Paleolithic and Early Upper Paleolithic. In: Chabay, V., Monigal, Katherine, Marks, A.E. (Eds.), The Paleolithic of Crimea, III. The Middle Paleolithic and Early Upper Paleolithic of Eastern Crimea. Etudes et Recherches Archéologiques de l'Universté de Liège, Liège, pp. 419–460.

Chabaï, V., Richter, J., Uthmeier, T. (Eds.), 2006. Palaeolithic Sites of Crimea Vol 2: KABAZI II: The 70.000 Years Since The Last Interglacial, Palaeolithic Sites of Crimea. University of Cologne, Cologne.

Chu, W., McLin, S., Wöstehoff, L., Ciornei, A., Gennai, J., Marreiros, J., Doboș, A., 2022. Aurignacian dynamics in Southeastern Europe based on spatial analysis, sediment geochemistry, raw materials, lithic analysis, and use-wear from Românești-Dumbrăvița. Sci. Rep. 12(1), 1–16.

Cliquet, D., 1992. Le gisement paléolithique moyen de Saint-Germain-des-Vaux/Port-Racine (Manche) dans son cadre régional: essai palethnographique. University of Paris 1, Paris.

Cliquet, D., Revillon, S., 1990. L'industrie lithique du secteur 1 du gisement paléolithique moyen de L'Erguillière-Port-Racine à Saint-Germain-des-Vaux (Manche). Bull. Soc. Préhist. française 87, 333–340.

Conard, N.J., 1990. Lithic assemblages from the Last Interglacial Complex in Northwestern Europe. J. Anthropol. Res. 46, 243–262.

Conard, N.J., Adler, D.S., 1997. Lithic reduction and hominid behavior in the Middle Paleolithic of the Rhineland. J. Anthropol. Res. 53, 147–175.

Crégut-Bonnoure, E., Boulbes, N., Daujeard, C., Fernandez, P., Valensi, P., 2010. Nouvelles données sur la grande faune de l'Éemien dans le Sud-Est de la France. Quaternaire 23, 227–248.

Dauvois, M., 1976. Précis de dessin dynamique et structural des industries lithiques préhistoriques. Pierre Fanlac, Périgueux.

Delagnes, A., 1996. Le site d'Etoutteville (Seine-Maritime): l'organisation technique et spatiale de la production laminaire à Etoutteville. In: Delagnes, A., Ropars, A. (Eds.), Paléolithique moyen en Pays de Caux : Le Pucheuil, Etoutteville, Deux Gisements de Plein-Air En Milieu Loessique, Documents Archéologiques Français (D.A.F. 56). Maison des Sciences de l'Homme, Paris, pp. 164–228.

Delagnes, A., Ropars, A. (Eds.), 1996. Paléolithique moyen en Pays de Caux : Le Pucheuil, Étoutteville, deux gisements de plein air en milieu lœssique, Documents d'Archéologie Française, Documents. ed. Maison des Sciences de l'Homme, Paris.

Demidenko, Y. E., Škrdla, P., Rychtaříková, T., 2020. Initial Upper Paleolithic bladelet production: bladelets in Moravian Bohunician. Prehled Vyzkumu, 61(1), 21–29.

Depaepe, P., Guerlin, O., Swinnen, C., Antoine, P., 1999. Occupations du Paléolithique moyen à Blangy-Tronville (Somme). Rev. Archéol. de Picardie 3, 3–21.

Dinnis, R., Bessudnov, A., Chiotti, L., Flas, D., Michel, A.,

2019. Thoughts on the structure of the European Aurignacian, with particular focus on Hohle Fels IV. Proc. Prehist. Soc. 85, 29–60.

Dogandzic, T., 2021. Techno-typological variability of the late Middle Paleolithic in the southern Balkans. Ph.D. thesis, Leiden University.

Faivre, J.-P., 2012. A material anecdote but technical reality. Bladelet and small blade production during the recent Middle Paleolithic Combe-Grenal rock shelter. Lithic Technol. 37, 5–24.

Fernandez, P., 2001. Étude paléontologique et archéozoologique des niveaux d'occupations moustériens au Bau de l'Aubesier (Monieux, Vaucluse): implications biochronologiques et palethnologiques. Université Claude-Bernard, Lyon I, Lyon.

Fernandez, P., 2006. Etude paléontologique des ongulés du gisement moustérien du Bau de l'Aubesier (Vaucluse, France) : morphométrie et contexte biochronologique. Documents des Laboratoires de Géologie Lyon 161, Lyon.

Fernandez, P., Legendre, S., 2003. Mortality curves for horses from the Middle Palaeolithic site of Bau de l'Aubesier (Vaucluse, France): Methodological, palaeo-ethnological, and palaeo-ecological approaches. J. Archaeol. Sci. 30, 1577–1598.

Fontana, F., Moncel, M.H., Nenzioni, G., Onorevoli, G., Peretto, C., Combier, J., 2013. Widespread diffusion of technical innovations around 300,000 years ago in Europe as a reflection of anthropological and social transformations? New comparative data from the western Mediterranean sites of Orgnac (France) and Cave dall'Olio (Italy). J. Anthropol. Archaeol. 32, 478–498.

Fontana, F., Nenzioni, G., Peretto, C., 2010. The southern Po plain area (Italy) in the mid-late Pleistocene: human occupation and technical behaviours. Quatern. Int. 223–224, 465–471.

Fontana, F., Peretto, C., Nenzioni, G., 2009. First recognition of predetermined core reduction sequences in the Southern Po Plain area before MIS 8 at the site of Cave dall'Olio (Bologna, Italy): an "ancient series" revisited. Hum. Evol. 24, 43–56.

Gagnepain, J., Gaillard, C., 2005. La grotte de la Baume Bonne (Quinson, Alpes de Haute-Provence): synthèse chronostratigraphique et séquence culturelle d'après les fouilles récentes (1988-1997). In: Molines, N., Moncel, M.-H., Monnier, J. (Eds.), Les Premiers Peuplements En Europe, Données Récentes Sur Les Modalités de Peuplement et Sur Le Cadre Chronostratigraphique, Géologique et Paléogéographique Des Industries Du Paléolithique Ancien et Moyen En Europe (Rennes, 22–25 Septembre 2003). BAR International Series Vol. 1364. Archeopress, Oxford, pp. 73–86.

Gagnepain, J., Gaillard, C., Notter, O., 2004. La composante laminaire dans les industries lithiques du Paléolithique moyen du Verdon (Sud-est de la France). In: Van Peer, P. (Ed.), Section 5 : Le Paléolithique Moyen : Sessions Générales et Posters. Actes Du XIVème Congrès UISPP (Liège, Belgique, 2–8 Septembre 2001). Archeopress, Oxford, pp. 57–65.

Ghaleb, B., 2006. Datation U/Th. In: Lebel, S. (Ed.), Le Bau de l'Aubesier, Abri Sous Roche Moustérien des Gorges de la Nesque: Rapport de Mission 2006. Report Presented to the Ministére de la Culture et de la Communication de France, DRAC-PACA, Aix-en-Provence, Section 11-B.

Gouédo, J.-M., n.d. Remontage d'un nucleus à lames du gisement micoquien de Vinneuf (Yonne). In: Tuffreau, A., Revillon, S. (Eds.), Les Industries Laminaires Au Paléolithique Moyen. CNRS edition, Paris, pp. 77–102.

Goval, E., Hérisson, D., 2006. Coexistence des chaînes opératoires Levallois et laminaires au sein des assemblages C12 et C de Riencourt-lès-Bapaume (Pas-de-Calais, France). Notae Praehist. 26, 25–39.

Guadelli, J.-L., Laville, H., 1988. L'environnement climatique de la fin du Moustérien à Combe-Grenal et à Camiac. In: Farizy, C., Combier, J. (Eds.), Paléolithique Moyen Récent et Paléolithique Supérieur Ancien En Europe. Ruptures et Transitions: Examen Critique Des Documents Archéologiques. Mémoires du Musée de Préhistoire d'Ile-de-France. APRAIF éd., Nemours, pp. 43–48.

Haesaerts, P., Di Modica, K., Pirson, S., 2011. Le gisement paléolithique de la Sablière Gritten à Rocourt (province de Liège). Le Paléolithique moyen en Belgique. Mélanges Marguerite Ulrix-Closset. Bull. Soc. royale belge d'études géolog. archéolog. «Les Chercheurs de la Wallonie» (hors-série n. 4) et Etudes et Recherches archéologiques de l'Université de Liège, Liège, vol. 4, 359–374.

Heinzelin, J., Haesaerts, P., 1983. Un cas de débitage laminaire au Paléolithique ancien: Croix l'Abbé à Saint Valéry sur Somme. Gallia-Préhist. 26, 189–201.

Hérisson, D., 2015. Les occupations du Paléolithique inférieur et du Paléolithique moyen d'Etricourt-Manancourt. INRAP, coordination Canal Seine-Nord Europe, Service Régional de l'Archéologie de Picardie. Technical report, Amiens.

Hérisson, D., Brenet, M., Cliquet, D., Moncel, M.H., Richter, J., Scott, B., Van Baelen, A., Di Modica, K., De Loecker, D., Ashton, N., Bourguignon, L., Delagnes, A., Faivre, J.P., Folgado-Lopez, M., Locht, J.L., Pope, M., Raynal, J.P., Roebroeks, W., Santagata, C., Turq, A., Van Peer, P., 2016a. The emergence of the Middle Palaeolithic in north-western Europe and its southern fringes. Quatern. Int. 411, 233–283.

Hérisson, D., Coutard, S., Goval, E., Locht, J.L., Antoine, P., Chantreau, Y., Debenham, N., 2016b. A new key-site for the end of Lower Palaeolithic and the onset of Middle Palaeolithic at Etricourt-Manancourt (Somme, France). Quatern. Int. 409, 73–91.

Hoggard, C., 2017a. Assessing the role of artefact design within the Middle Palaeolithic repertoire: determining the behavioural potential of blade production strategies. Ph.D. thesis, University of Southampton.

Hoggard, C.S., 2017b. Considering the function of Middle Palaeolithic blade technologies through an examination of experimental blade edge angles. J. Archaeol. Sci.: Rep. 16, 233–239.

Koehler, H., 2008. L'apport du gisement des Osiers à Bapaume (Pas-de-Calais) au débat sur l'émergence du Paléolithique moyen dans le nord de la France. Bull. Soc. préhist. française 105, 709–735.

Koehler, H., Drwila, G., Duplessis, M., Locht, J.-L., 2014. Représentativité et mobilité du débitage laminaire au Weichsélien ancien dans le Bassin parisien. Bull. Soc. préhistor. française 111, 5–17.

Kuhn, S.L., 2020. The Evolution of Paleolithic Technologies. Routledge Studies in Archaeology. Routledge, New York.

Lebel, S., 2000. Le Bau de l'Aubesier, Monieux, Vaucluse: fouilles 1998-1999-2000. Report presented to the Ministére de la Culture et de la Communication de France. Aix-en-Provence.

Lebel, S., Trinkaus, E., 2001. New discoveries of Middle Paleolithic human remains from the 'Bau de l'Aubésier (Vaucluse, France). Bull. Mém. Soc. Anthropol. Paris 13, 15–21.

Lebel, S., Trinkaus, E., 2002. Middle Pleistocene human remains from the Bau de l'Aubesier. J. Hum. Evol. 43, 659–685.

Lebel, S., Trinkaus, E., Faure, M., Fernandez, P., Guérin, C., Richter, D., Mercier, N., Valladas, H., Wagner, G. A, 2001. Comparative morphology and paleobiology of Middle Pleistocene human remains from the Bau de l'Aubesier, Vaucluse, France. Proc. Nat. Acad. Sci. USA 98, 11097–11102.

Locht, J.-L. (Ed.), 2002. Bettencourt-Saint-Ouen (Somme): Cinq occupations paléolithiques au début de la dernière glaciation. Éditions de la Maison des sciences de l'homme, Paris. doi:10.4000/books.editionsmsh.20993

Locht, J.-L., Antoine, P., Hérisson, D., Gadebois, G., Debenham, N., 2010. Une occupation de la phase ancienne du Paléolithique moyen à Therdonne (Oise). Chronostratigraphie, production de pointes Levallois et réduction des nucléus. Gallia préhist. 52, 1–32.

Locht, J.-L., Chaussé, C., 2021. Cinq occupations du Paléolithique moyen du Début Glaciaire weichselien : le gisement de Soindres (Yvelines). Stratigraphie et industries lithiques. Gallia Préhist. 61, pp. 5–54.

Locht, J.-L., Coutard, S., Soressi, M., Kiefer, D., Koehler, H., Debenham, N., 2015. Angé (Loir-et-Cher) : un site moustérien à influences multiples. Les plaines du Nord-Ouest : carrefour de l'Europe au Paléolithique moyen ? : Actes de la table ronde d'Amiens, 28-29 mars 2008. Mémoire de la Société Préhistorique Française 59, 101–125.

Maíllo Fernández, J.M., 2001. Aproximación al fenómeno laminar en el Paleolítico medio: el ejemplo de Cueva Morín (Villanueva de Villaescusa, Cantabria). Espacio, Tiempo y Forma, Serie I. Prehist. Arqueol. 14, 79–105.

Maíllo-Fernández, J.M., 2004. Esquemas operativos lıticos del Musteriense Final de Cueva Morın (Villanueva de Villaescusa, Cantabria). In: Montes, R., Lasheras, J.A. (Eds)., Neandertales Cantabricos: Estado de La Cuestion. Museo de Altamira, Santander, pp. 301–313.

Maíllo Fernández, J.M., Cabrera-Valdés, V., Bernaldo de Quirós, F., 2004. Le débitage lamellaire dans le Moustérien final de Cantabrie (Espagne) : le cas de El Castillo et Cueva Morin. Anthropol. 108, 367–393.

Marciani, G., 2018. Continuities and discontinuities during the late Middle Palaeolithic at the Oscurusciuto rock shelter (southern Italy). An integrated study of lithic manufacture in the strata SU 15, SU 14, SU 13 and SU 11. Ph.D. thesis, Universitat Rovira i Virgili.

Marciani, G., Arrighi, S., Aureli, D., Spagnolo, V., Boscato, P., Ronchitelli, A., 2018. Middle Palaeolithic lithic tools: techno-functional and use-wear analysis of target objects from SU 13 at the Oscurusciuto rock shelter, Southern Italy. J. Lithic Studies 5(2), https://doi.org/10.2218/jls.2745

Marciani, G., Spagnolo, V., Aureli, D., Ranaldo, F., Boscato, P., Ronchitelli, A., 2016. Middle Palaeolithic technical behaviour: material import-export and Levallois production at the SU 13 of Oscurusciuto rock shelter, Southern Italy. J. Lithic Studies 3, 497–520.

Meignen, L., Bar-Yosef, O., 2020. Acheulo-Yabrudian and Early Middle Paleolithic at Hayonim Cave (Western Galilee, Israel): continuity or break? J. Hum. Evol. 139, 1–19.

Monteagudo, F.C., Martín-Puig, D., Preysler, J.B., 2007. Propuesta experimental para el análisys tecnoecoónomico de conjuntos líticos: el caso de la industria laminar del nivel XVII de la Cueva de el Esquilleu (Castrocillorico, Cantabria). In: Sainz, M.L.R., UrquijoJ.E.G., Preysler, J.B. (Eds.), Arqueología Experimental En La Península Ibérica: Investigación, Didáctica y Patrimonio. Asociación Española de Arqueología Experimental, Santander, pp. 113–120.

Moulin, M.F., 1904. L'abri moustérien du Bau de l'Aubesier (Vaucluse). Bull. Soc. préhist. de France 1, 14–20.

Nehoroshev, P.E., 2004. Technology of primary flaking at the site of Shlyakh, Layer 8 (The Middle Don, Russia). In: Le Secrétariat du Congrès (Ed.), Acts of the XIVth UISPP Congress, University of Liège, Belgium, 2-8 September 2001. Section 5, The Middle Palaeolithic, General Sessions and Posters. BAR International Series 1239, Liège, pp. 117–126.

Nehoroshev, P.E., Vishnyatsky, L.B., 2000. Shlyakh – a new Late Middle Paleolithic site in the South Russian Plain. In: Orschiedt, J., Weniger, G.. (Eds.), Neanderthals and Modern Humans – Discussing the Transition: Central and Eastern Europe from 50.000 – 30.000 B. P. Neanderthal Museum, Mettmann, pp. 256–266.

Normand, C., O'Farrell, M., Garaizar, J. R., 2006. The function (s) of Archaic Aurignacian bladelets: data and thoughts based on examples from Isturitz Cave (Pyrénées-Atlantiques, France). In: Pétillon, J.-M., Dias-Meirinho, M.-H., Cattelain, P., Honegger, M., Normand, C., Valdeyron, N. (Eds.), Projectile Weapon Elements from the Upper Palaeolithic to the Neolithic (Proceedings of Session C83, XVth World Congress UISPP, Lisbon, September 4–9, 2006. Palethnology 1, 6–44..

Ortega, I., Locht, J.L., Rios-Garaizar, J., Bourguignon, L., Blaser, F., Goval, É., Grigoletto, F., Sellier-Segard, N., 2013. La producción laminar en el Paleolítico Medio en el Norte y el Sur-Oeste de Francia: el aporte de la experimentación. In: Palomo, A., Pique, R., Terradas, X. (Eds.), Experimentación En Arqueología. Estudio y Difusión Del Pasado, Sèrie Monogràfica. MAC-Girona, Girona, pp. 219–228.

Otte, M., 1994. Rocourt (Liège, Belgique): industrie laminaire ancienne. In: Revillon, S., Tuffreau, A. (Eds.), Les Industries Laminaires Au Paléolithique Moyen. Dossier de Documentation Archéologique 18. CNRS, Paris, pp. 180–186.

Otte, M., Boëda, E., Haesaerts, P., 1990. Rocourt: industrie laminaire archaïque. Helinium 30, 3–13.

Pastoors, A., Tafelmaier, Y., 2010. Bladelet production, core reduction strategies, and efficiency of core configuration at the Middle Palaeolithic site Balver Höhle (North Rhine Westphalia, Germany). Quartär 57, 25–41.

Patou-Mathis, M., Chabaï, V., 2003. Kabazi II (Crimée, Ukraine): un site d'abattage et de boucherie du Paléolithique moyen. Anthropol. 107, 223–253.

Pelegrin, J., 1991. Sur une recherche technique expérimentale des techniques de débitage laminaire. In: Barbier, M., Vincent, A. (Eds.), Archéologie Expérimentale. Tome 2-La Terre: L'os et La Pierre. La Maison et Les Champs, Paris, pp. 118–128.

Pelegrin, J., 2000. Les techniques de débitage laminaire au Tardiglaciaire: critères de diagnose et quelques réflexions. In: Valentin, B., Bodu, P., Christensen, M. (Eds.), L'Europe Centrale et Septentrionale Au Tardiglaciaire. Confrontation Des Modèles Régionaux. Mémoires du Musée de Préhistoire d'Île-de-France, Nemours, pp. 73–86.

Pelegrin, J., 2005. Remarks about archaeological techniques and methods of knapping: elements of a cognitive approach to stone knapping. In: Roux, V., Bril, B. (Eds.), Stone Knapping the Necessary Conditions for a Uniquely Hominin Behaviour. MacDonald Institute monograph series, Cambridge, pp. 23–34.

Pelegrin, J., Karlin, C., Bodu, P., 1988. Chaînes opératoires: un outil pour le préhistorien. Technol. préhistor. 25, 55–62.

Peresani, M., 2012. Fifty thousand years of flint knapping and tool shaping across the Mousterian and Uluzzian sequence of Fumane cave. Quatern. Int. 247, 125–150.

Peresani, M., Centi Di Taranto, L.E., 2013. Blades, bladelets and flakes: a case of variability in tool design at the dawn of the Middle-Upper Palaeolithic transition in Italy. C. R. Palevol 12, 211–221.

Peresani, M., Cristiani, E., Romandini, M., 2016. The Uluzzian technology of Grotta di Fumane and its implication for reconstructing cultural dynamics in the Middle-Upper Palaeolithic transition of Western Eurasia. J. Hum. Evol. 91, 36–56.

Peretto, C., Arzarello, M., Coltorti, M., Bertolini, M., Cui, Q.-Y., De Curtis, O., Lebreton, V., Lembo, G., Marquer, L., Pieruccini, P., Ravani, S., Rufo, E., Sala, B., Talamo, S., Thun Hohenstein, U., 2020. Grotta Reali, the first multilayered Mousterian evidences in the Upper Volturno Basin (Rocchetta a Volturno, Molise, Italy). Archaeol. Anthropol. Sci. 12, 1–30.

Pop, C.M., Wilson, L., Browne, C.L., 2022. Evaluating landscape knowledge and lithic resource selection at the French Middle Paleolithic site of the Bau de l'Aubesier. J. Hum. Evol. 166, 103152.

Quirós, de F.B., Maíllo-Fernández, J.M., 2009. The transitional Aurignacian and the Middle-Upper Palaeolithic transition model in Cantabrian Iberia. In: Camps, M., Chauhan, P.R. (Eds.), Sourcebook of Paleolithic Transitions. Methods, Theories, and Interpretations. Springer, New York, pp. 341–359.

Révillion, S., 1994. Question typologique à propos des industries laminaires du Paléolithique moyen de Seclin (Nord) et de Saint-Germain-Des-Vaux / Port-Racine (Manche) : lames levallois ou lames non levallois ? Bull. Soc. préhist. française 90, 269–273.

Révillion, S., 1995. Technologie du débitage laminaire au Paléolithique moyen en Europe septentrionale: état de la question. Bull. Soc. préhist. française 92, 425–442.

Révillion, S., Tuffreau, A., 1994. Valeur et signification du débitage laminaire du gisement paléolithique moyen de Seclin (Nord). In: Révillion, S.,Tuffreau, A., (Eds.), Les Industries Laminaires au Paléolithique Moyen. Dossier de documentation archéologique n°18. CNRS éd., Paris, pp. 19–43.

Richter, D., Tostevin, G., Škrdla, P., 2008. Bohunician technology and thermoluminescence dating of the type locality of Brno-Bohunice (Czech Republic). J. Hum. Evol. 55, 871–885.

Roussel, M., Soressi, M., Hublin, J. J., 2016. The Châtelperronian conundrum: blade and bladelet lithic technologies from Quinçay, France. J. Hum. Evol. 95, 13–32.

Sitlivy, V., Zieba, A., 2006. Eastern and Central Europe before 30 kyr BP: Mousterian, Levallois and blade industries. In: Chabai, V. , Richter, J., Uthmeier, T. (Eds.), Kabazi II: The 70 000 Years since the Last Interglacial. Palaeolithic Sites of Crimea, Vol. 2. Simferopol, Cologne, pp. 361–418.

Slimak, L., 1999. Mise en évidence d'une composante laminaire et lamellaire dans un complexe moustérien du Sud de la France/Evidence of blade and bladelet debitage in a Mousterian complex from Southern France. Paléo: Rev.Archéol. Préhistor. 11, 89–109.

Slimak, L., 2006. Les dernières expressions du Moustérien entre Loire et Rhône. Bulletin de la Société préhistorique française, 103(3), 614-617.

Slimak, L., Lucas, G., 2005. Le débitage lamellaire, une invention aurignacienne? In: Le Brun-Ricalens, F., Bordes, J.-G., Bon, F., (Eds.), Productions lamellaires attribuées à l'Aurignacien: Chaînes opératoires et perspectives technoculturelles. XIVe congrès de l'UISPP, Liège 2-8 Septembre 2001. Musée de Préhistore de Luxembourg, Luxembourg, pp. 75–100.

Soressi, M., 2002. Le Moustérien de tradition acheuléenne du sud-ouest de la France. Discussion sur la signification du faciès à partir de l'étude comparée de quatre sites: Pech-de-l'Azé I, Le Moustier, La Rochette et la Grotte XVI. Ph.D. thesis, Université de Bordeaux I.

Soressi, M., Geneste, J.-M., 2011. The history and efficacy of the chaîne opératoire approach to lithic analysis: studying techniques to reveal past societies in an evolutionary perspective. PaleoAnthropol. 2011, 334–350.

Soressi, M., Rendu, W., Texier, P.-J., Claud, É., D'Errico, F., Laroulandie, V., Maureille, B., Niclot, M., Schwortz, S., Tillier, A.-M., 2008. Pech-de-l'Azé I (Dordogne, France): nouveau regard sur un gisement moustérien de tradition acheuléenne connu depuis le XIXe siècle. In: Jaubert, J., Bordes, J.G., Ortega, M.I. (Eds.), Les Sociétés Paléolithiques d'un Grand Sud-Ouest : Nouveaux Gisements, Nouvelles Méthodes, Nouveaux Résultats. - Actes Des Journées Décentralisées de La SPF. Mémoire XLVII de La Société Préhistorique Française. Société Préhistorique française, Paris, pp. 95–132.

Soressi, M., Tavormina, C., 2011. L'intérêt du tri du refus de tamis de maille 5 mm et 2 mm dans l'analyse d'assemblages lithiques du Protoaurignacien et de l'Aurignacien ancien. Bull. liaison inform.-Assoc. Archéol. de Poitou-Charentes 40, 9–16.

Soriano, S., Villa, P., 2017. Early Levallois and the beginning of the Middle Paleolithic in central Italy. PLoS One 12, e0186082.

Soriano, S., Villa, P., Wadley, L., 2007. Blade technology and tool forms in the Middle Stone Age of South Africa: the Howiesons Poort and post-Howiesons Poort at Rose Cottage Cave. J. Archaeol. Sci. 34, 681–703.

Svoboda, J., 2003. The Bohunician and the Aurignacian. In: Zilhão, J., D'Errico, F. (Eds.), The Chronology of the Aurignacian and of the Transitional Technocomplexes: Dating, Stratigraphies, Cultural Implications. Proceedings of the Symposium. Instituto Português de Arqueologia, Lisboa, pp. 123–131.

Svoboda, J., Škrdla, P., 1995. The Bohunician technology. In: Bar-Yosef, O., Dibble, H.L. (Eds.), The Definition and Interpretation of Levallois Technology. Prehistory Press, Madison, pp. 429–438.

Tafelmaier, Y., 2011. Revisiting the Middle Palaeolithic site Volkringhauser Höhle (North Rhine- Westphalia, Germany). Quartar 58, 153–182.

Trinkaus, E., Lebel, S., Bailey, S.E., 2000a. Middle Palaeolithic and recent human dental remains from the Bau de l'Aubesier, Monieux (Vaucluse). Bull. Mém. Soc.Anthropol. Paris 12(3-4), 207–226.

Trinkaus, E., Smith, R.J., Lebel, S., 2000b. Dental caries in the Aubesier 5 Neandertal primary molar. J. Archaeol. Sci. 27, 1017–1021.

Tuffreau, A., 1995. The variability of Levallois technology in northern France and neighbouring areas. In: Dibble, H.L., Bar-Yosef, O. (Eds.), The Definition and Interpretation of Levallois Technology. Prehistory Press, Madison, pp. 413–427.

Usik, V.I., Demidenko, Y.E., 1993. The problem of changes in Levallois technique during the technological transition from the Middle to Upper Palaeolithic. Paléorient 19, 5–15.

Vande Walle, H., 2003. La production des outils au Paléolithique moyen : comparaison diachronique des occupations de Riencourt-lès-Bapaume (Pas-de-Calais, France). Paléo 15, 169–194.

White, M.J., Ashton, N., 2004. Lower Palaeolithic core technology and the origins of the Levallois method in North-Western Europe. Curr. Anthropol. 44, 598–609.

Wilson, L., 2007a. Terrain difficulty as a factor in raw material procurement in the Middle Palaeolithic of France. J. Field Archaeol. 32, 315–324.

Wilson, L., 2007b. Understanding prehistoric lithic raw material selection: application of a gravity model. J. Archaeol. Method Theory 14, 388–411.

Wilson, L., 2007c. The Vaucluse raw material project: artifact provenance and landscape context in the Middle Palaeolithic of southern France. In: Wilson, L., Dickinson, P., Jeandron, J. (Eds.) Reconstructing Human-Landscape Interactions: Papers of the Developing International Geoarchaeology 2005 Conference. Cambridge Scholars Pub, Cambridge, pp. 234–251.

Wilson, L., 2011. Raw material economics in their environmental context: an example from the Middle Palaeolithic of southern France. In: Wilson, L. (Ed.) Human Interactions with the Geosphere: The Geoarchaeological Perspective. Geological Society Special Publications 352, London, pp. 163–180.

Wilson, L., 2021. Sounds of Laughter, Shades of Life: Pleistocene to Modern Hominin Occupations of the Bau de l'Aubesier Rock Shelter, Vaucluse, France. BAR International Series 3035. BAR Publishing, Oxford.

Wilson, L., Browne, C.L., 2014. Change in raw material selection and subsistence behaviour through time at a Middle Palaeolithic site in southern France. J. Hum. Evol. 75, 28–39.

Zwyns, N.,2021. The Initial Upper Paleolithic in Central and East Asia: blade technology, cultural transmission, and implications for human dispersals. J. Paleo. Archaeol. 4(3), 1–39.

Supplement 1: Ahead of the Times: Blade and Bladelet Production Associated with Neandertal Remains at the Bau de l'Aubesier (Mediterranean France) Between MIS 7 and MIS 5d

LEONARDO CARMIGNANI
Faculty of Archaeology, Leiden University, Einsteinweg 2, 2333 CC Leiden, THE NETHERLANDS; l.carmignani@arch.leidenuniv.nl

MARIE SORESSI
Faculty of Archaeology, Leiden University, Einsteinweg 2, 2333 CC Leiden, THE NETHERLANDS; m.a.soressi@arch.leidenuniv.nl

SUPPLEMENT 1
This file includes: Text and Figures from S1 to S10 and Tables from S1 to S20.

GENERAL OVERVIEW OF BLADE PRODUCTION DURING THE MIDDLE PLEISTOCENE

Laminar production is uncommon overall during the Middle Pleistocene (Figure S1). Ancient laminar technologies are known in central Africa (McBrearty et al., 1996; Johnson and McBrearty, 2010), in south Africa (Wilkins and Chazan, 2012; Wilkins, 2013), the Near-East (Barkai et al., 2003, 2005, 2009; Mercier and Valladas, 2003; Hauck et al., 2010; Hauck, 2011; Richter et al., 2011; Wojtczak, 2014, 2015; Wojtczak et al., 2014) and in north-western Europe (Heinzelin and Haesaerts, 1983; Révillion, 1995; Locht et al., 2010; Hérisson et al., 2016). To date there is no robust evidence for blade production in Asia during the Middle Pleistocene (Boëda et al., 2013; Li and Bodin, 2013; Peng et al., 2014). The easternmost Middle Pleistocene assemblages containing blade technologies have been documented at Djruchula in the Georgian Republic dated between 260 ka and 140 ka (Meignen and Tushabramishvili, 2006, 2010; Mercier et al. 2010) and further at east at Khonako in Tadjikistan—dated to around 170 ka (Schäfer and Ranov, 1998; Schäfer et al., 1998).

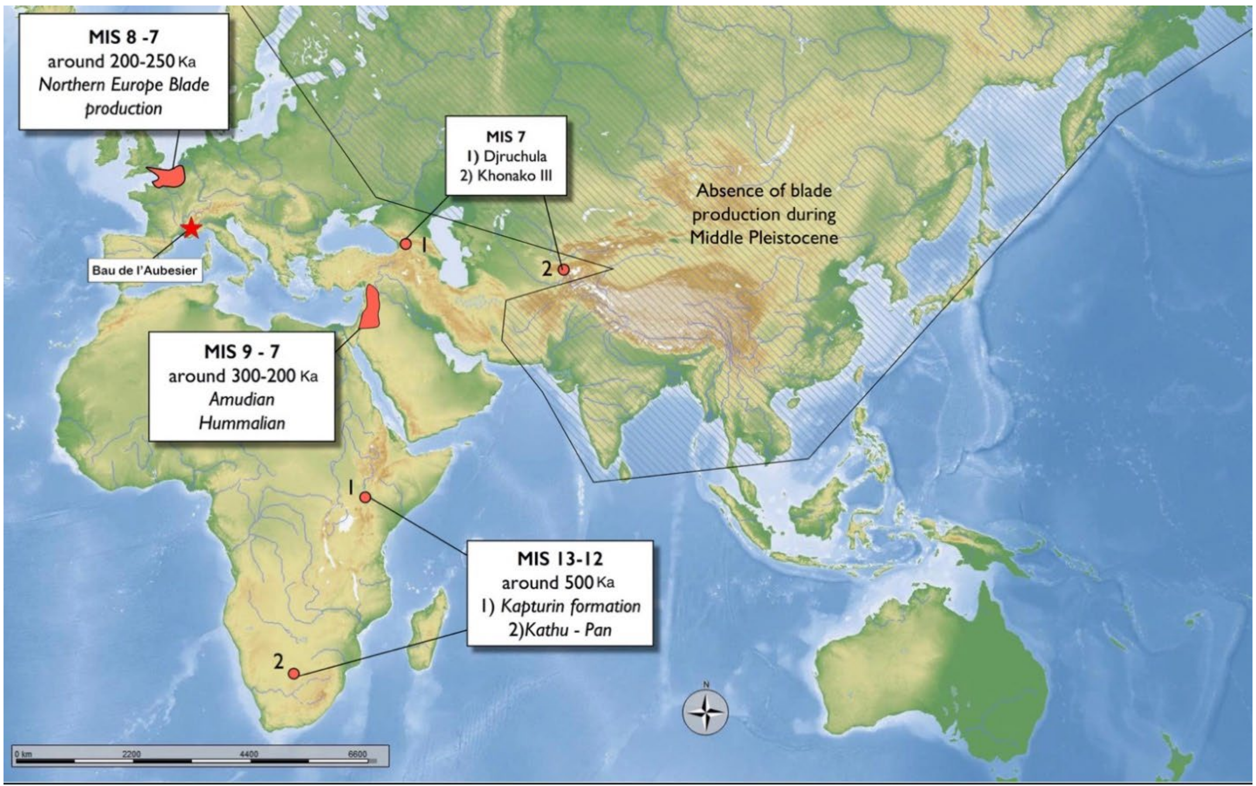


Figure S1. Synthetic representation of Middle Pleistocene blades production and location of the Bau de l'Aubesier.

REFERENCES

Barkai, R., Gopher, A., Lauritzen, S.E., Frumkin, A., 2003. Uranium series dates from Qesem Cave, Israel, and the end of the Lower Palaeolithic. Nature 423, 977–979.

Barkai, R., Gopher, A., Shimelmitz, R., 2005. Middle Pleistocene blade production in the Levant: an Amudian assemblage from Qesem Cave, Israel. Eurasian Prehist. 3, 39–74.

Barkai, R., Lemorini, C., Shimelmitz, R., Lev, Z., Stiner, M.C., Gopher, A., 2009. A blade for all seasons? Making and using Amudian blades at Qesem Cave, Israel. Hum. Evol. 24, 57–75.

Boëda, E., Hou, Y.M., Forestier, H., Sarel, J., Wang, H.M., 2013. Levallois and non-Levallois blade production at Shuidonggou in Ningxia, North China. Quatern. Int. 295, 191–203.

Hauck, T., Wojtczak, D., Wegmüller, F., Le Tensorer, J.-M., 2010. Variation in Lower and Middle Paleolithic land use strategies in the Syrian Desert steppe: the example of Hummal (El Kowm area). In: Conard, N.J., Delagnes, A. (Eds.), Settlement Dynamics of the Middle Paleolithic and

Middle Stone Age, Vol. III. Kerns Verlag (Tübingen publications in prehistory), Tübingen, pp. 145–162.

Hauck, T.C., 2011. Mousterian technology and settlement dynamics in the site of Hummal (Syria). J. Hum. Evol. 61, 519–537.

Heinzelin, J., Haesaerts, P., 1983. Un cas de débitage laminaire au Paléolithique ancien: Croix l'Abbé à Saint Valéry sur Somme. Gallia Préhist. 26, 189–201.

Hérisson, D., Brenet, M., Cliquet, D., Moncel, M.H., Richter, J., Scott, B., Van Baelen, A., Di Modica, K., De Loecker, D., Ashton, N., Bourguignon, L., Delagnes, A., Faivre, J.P., Folgado-Lopez, M., Locht, J.L., Pope, M., Raynal, J.P., Roebroeks, W., Santagata, C., Turq, A., Van Peer, P., 2016. The emergence of the Middle Palaeolithic in north-western Europe and its southern fringes. Quatern. Int. 411, 233–283.

Johnson, C.R., McBrearty, S., 2010. 500,000 year old blades from the Kapthurin Formation, Kenya. J. Hum. Evol. 58, 193–200.

Li, Y., Bodin, É., 2013. Variabilité et homogénéité des modes de débitage en Chine entre 300 000 et 50 000ans. L'Anthropol. 117, 459–493.

Locht, J.-L., Antoine, P., Hérisson, D., Gadebois, G., Debenham, N., 2010. Une occupation de la phase ancienne du Paléolithique moyen à Therdonne (Oise). Chronostratigraphie, production de pointes Levallois et réduction des nucléus. Gallia Préhist. 52, 1–32.

McBrearty, S., Bishop, L., Kingston, J., 1996. Variability in traces of Middle Pleistocene hominid behavior in the Kapthurin Formation, Baringo, Kenya. J. Hum. Evol. 30, 563–580.

Meignen, L., Tushabramishvili, N. 2006. Paléolithique moyen Laminaire sur les flancs sud du Caucase : productions lithiques et fonctionnement du site de Djruchula (Géorgie). Paléorient 32(2), 81–104.

Meignen, L., Tushabramishvili, N., מיינן, ל., טושאבראמישווילי, נ., 2010. הקווקז הרי של הדרומיים במורדות רוקולה׳ג מערת הגדולים: שלוחה צפונית של תופעת הלהבים מהתקופה הפליאוליתית התיכונה במזרח התיכון / Djruchula Cave, on the southern slopes of the Great Caucasus: an extension of the Near Eastern Middle Paleolithic blady phenomenon to the north. Mitekufat Haeven: J. Israel Prehist. Soc. 40, 35–61, מתקופת האבן .מ.

Mercier, N., Valladas, H., 2003. Reassessment of TL age estimates of burnt flints from the Paleolithic site of Tabun Cave, Israel. J. Hum. Evol. 45, 401–409.

Mercier, N., Valladas, H., Meignen, L., Joron, J.-L., Tushabramishvili, N., Adler, D.S., Bar-Yosef, O., 2010. Dating the Early Middle Palaeolithic Laminar Industry from Djruchula Cave, Republic of Georgia. Paléorient 36, 163–173.

Peng, F., Wang, H., Gao, X., 2014. Blade production of Shuidonggou Locality1 (Northwest China): a technological perspective. Quatern. Int. 347, 12–20.

Révillion, S., 1995. Technologie du débitage laminaire au Paléolithique moyen en Europe septentrionale : état de la question. Bull. Soc. Préhist. française 92, 425–442.

Richter, D., Hauck, T.C., Wojtczak, D., Le Tensorer, Jean-Marie, Muhesen, S., Otte, M., 2011. Chronometric age estimates for the site of Hummal (El Kowm, Syria). In: Le Tensorer, J.-M, Jagher, R., Otte, M. (Eds.), The Lower and Middle Palaeolithic in the Middle East and Neighbouring Regions. ERAUL, Liege, pp. 249–261.

Schäfer, J., Ranov, V., 1998. Middle Palaeolithic blade industries and the upper Palaeolithic of Central Asia. In: Otte, M. (Ed.), Préhistoire d'Anatolie, Genèse de Deux Mondes. ERAUL, Liège, pp. 785–814.

Schäfer, J., Ranov, V., Sosin, P., 1998. The 'Cultural Evolution' of man and the chronostratigraphical background of changing environments in the loess palaeosoil sequences of Obi-Mazar and Khonako (Tadjikistan). Anthropol. 36, 121–135.

Tushabramishvili Meignen, L., N., Tushabramishvili Meignen, L., N., 2006. Paléolithique moyen laminaire sur les flancs sud du Caucase : productions lithiques et fonctionnement du site de Djruchula (Géorgie). Paléorient 32, 81–104.

Wilkins, J., 2013. Technological Change in the Early Middle Pleistocene: The Onset of the Middle Stone Age at Kathu Pan 1, Northern Cape, South Africa. Department of Anthropology, University of Toronto.
Wilkins, J., Chazan, M., 2012. Blade production ~500 thousand years ago at Kathu Pan 1, South Africa: support for a multiple origins hypothesis for early Middle Pleistocene blade technologies. J. Archaeol. Sci. 39, 1883–1900.
Wojtczak, D., 2014. The early Middle Palaeolithic blade industry from Hummal, Central Syria. University of Basel.
Wojtczak, D., 2015. Cores on flakes and bladelet production, a question of recycling? The perspective from the Hummalian industry of Hummal, Central Syria. Quatern. Int. 361, 155–177.
Wojtczak, D., Le Tensorer, J.M., Demidenko, Y.E., 2014. Hummalian industry (El Kowm, Central Syria): core reduction variability in the Levantine Early Middle Palaeolithic. Quartar 61, 23–48.

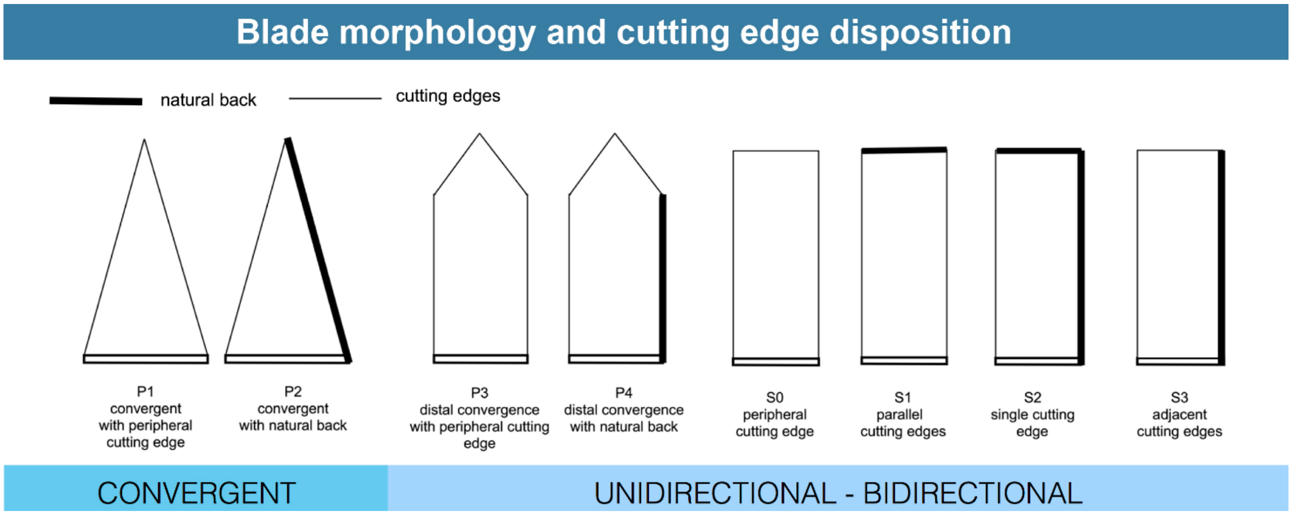


Figure S2. Schematization of blade variability in relation to the method used and the disposition of the removals on the flaking surface. Types P1, P3 and SO are extracted at the center of the flaking surface and preserve a peripheral cutting edge. Types P2, P4, S2 and S3 are extracted on the edges of the core's flaking surface and are characterized by a back opposite to a cutting edge.

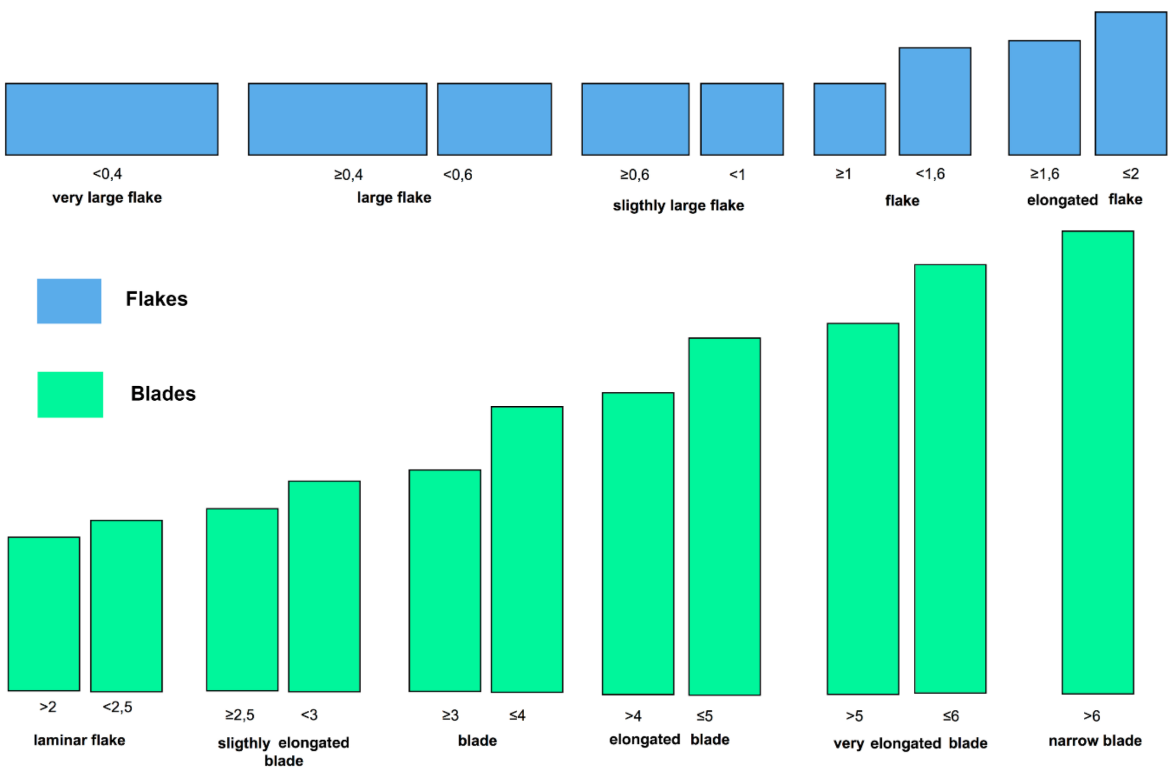


Figure S3. Elongation classes of blades and flakes used in this study based on length/width ratio.

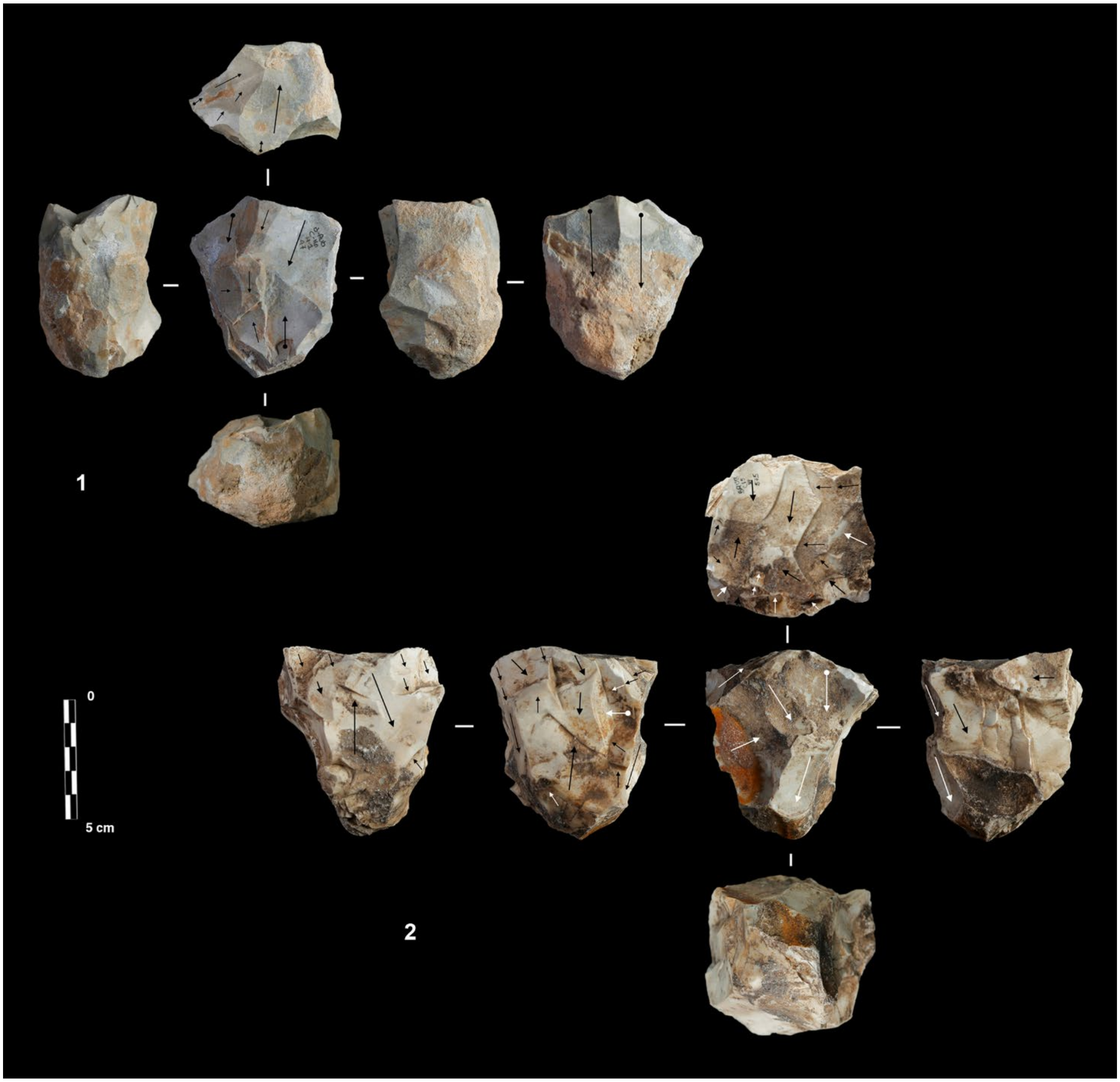
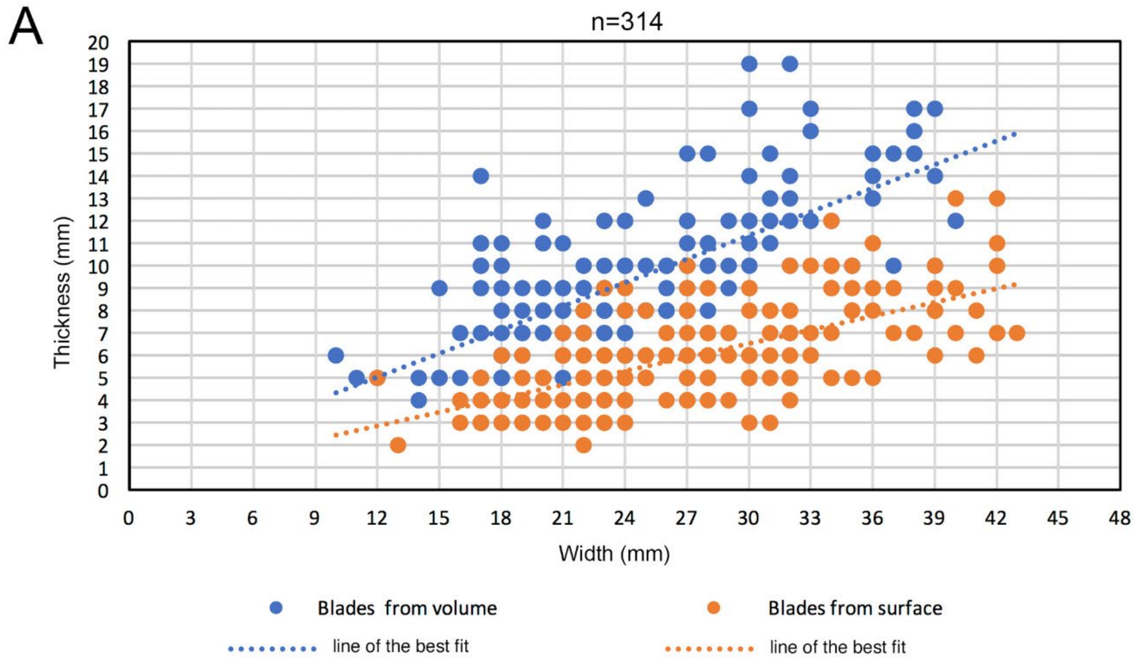


Figure S4. Bau de l'Aubesier. Exhausted volumetric blade cores from level H with multiple attempts at reconfiguration of the volume.



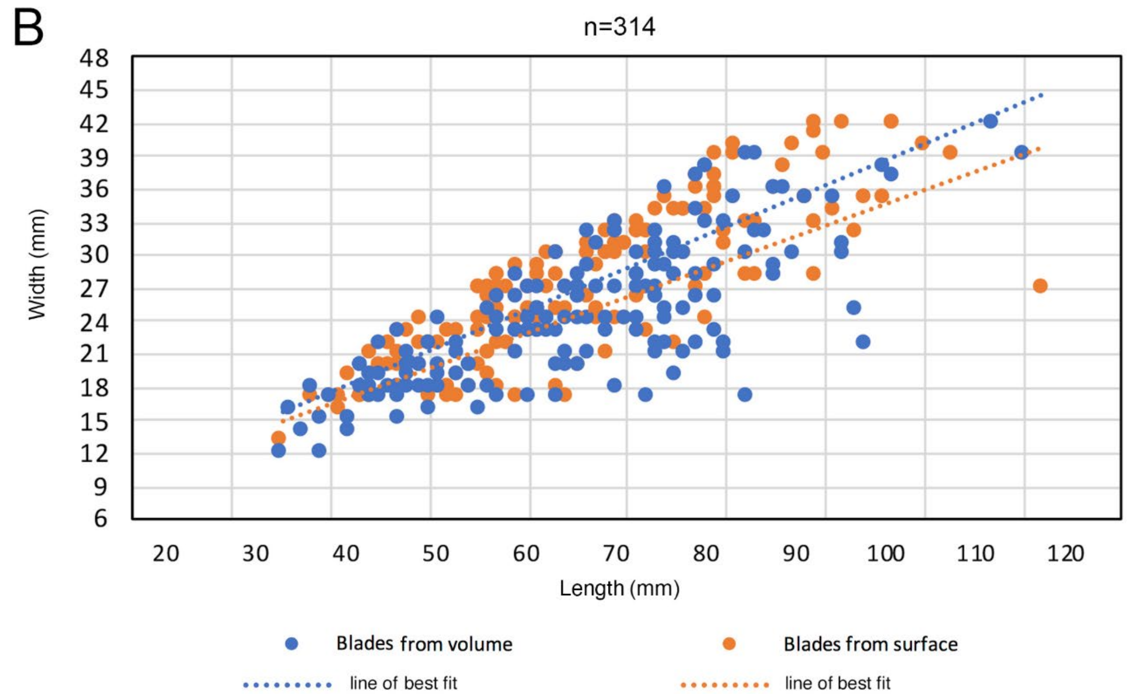


Figure S5. Bau de l'Aubesier : A) dimensions of volumetric blades and surface blades: B) thickness/width ratio, length/width ratio.

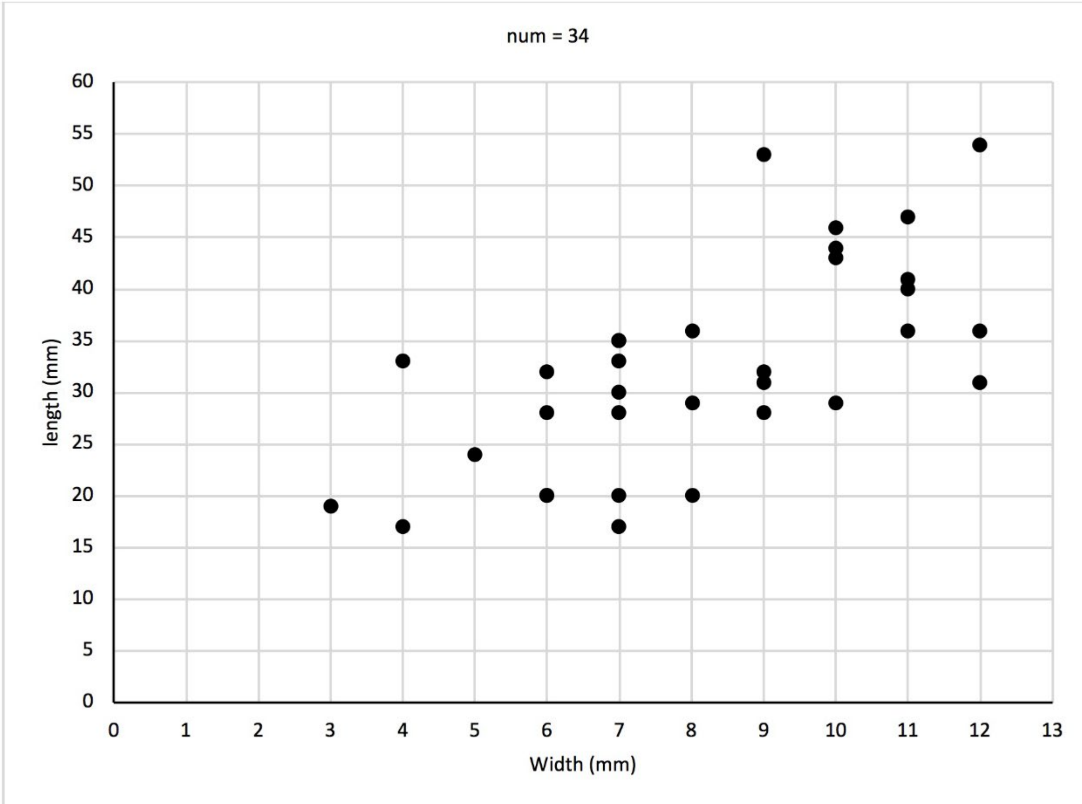


Figure S6. Bau de l'Aubesier. Length-width ratio of the last complete and successful elongated scar on bladelet cores.

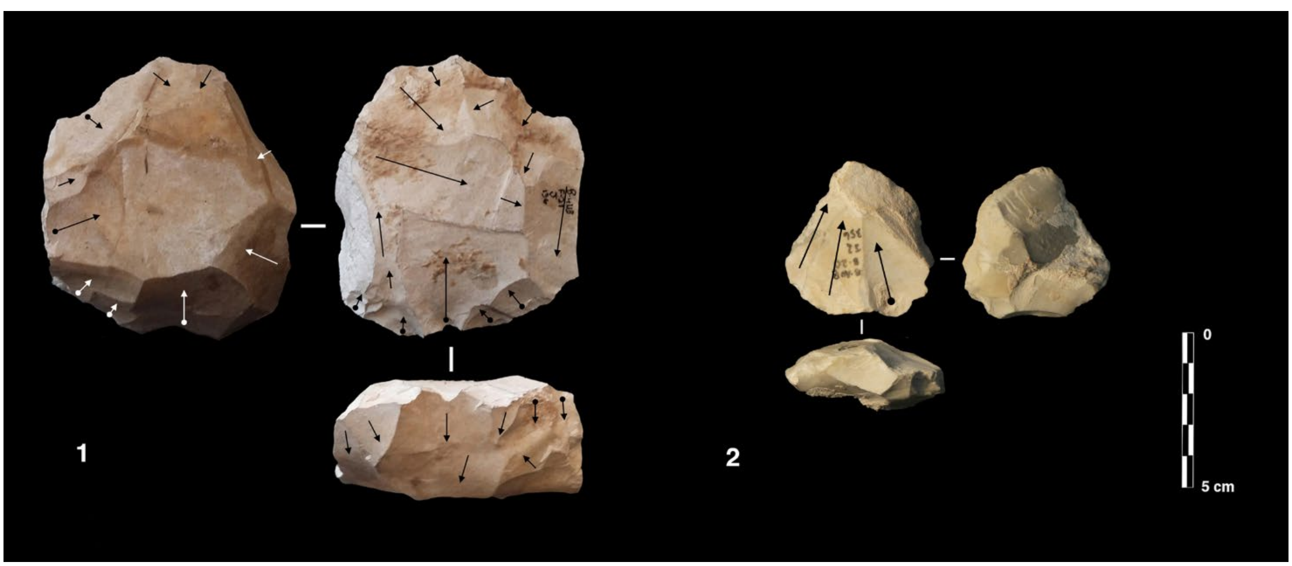


Figure S7. Bau de l'Aubesier. Cores from Level J: 1) Levallois centripetal core; 2) convergent exploitation.

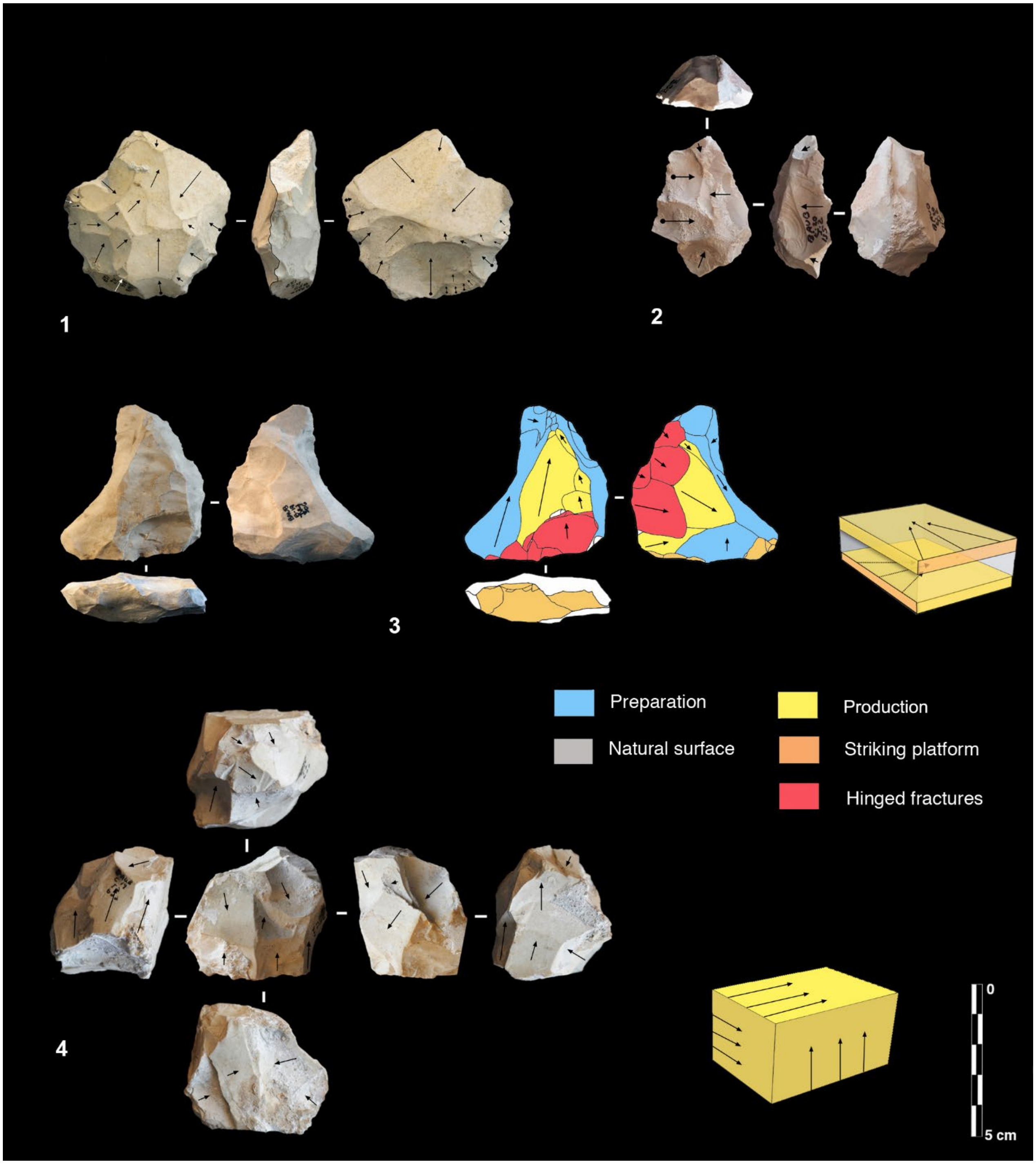


Figure S8. Bau de l'Aubesier. Cores from lower levels (K, J, I): 1) discoid core from level K; 2) centripetal exploitation from level J; 3) convergent exploitation from level I; 4) multidirectional exploitation from level I.

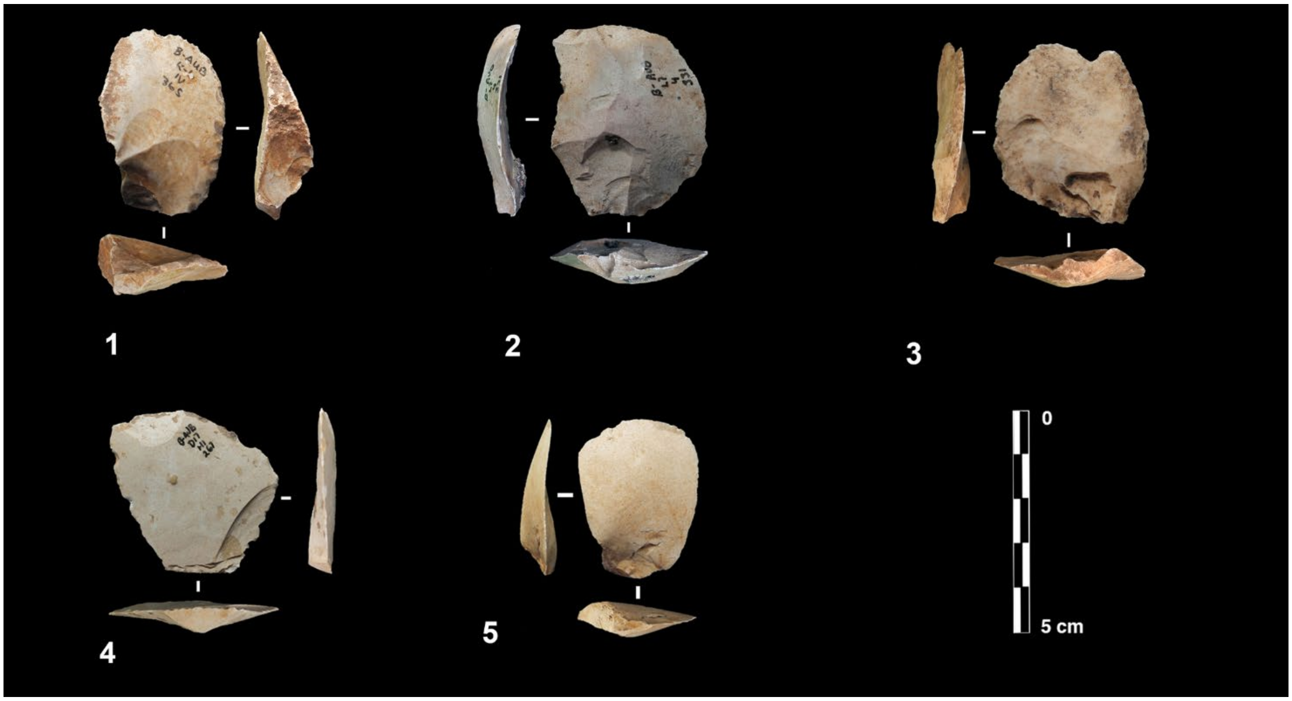


Figure S9. Bau de l'Aubesier. Kombewa flakes from levels H and 4: 1-3) Kombewa flakes from level 4; 4, 5) Kombewa flakes from level H.

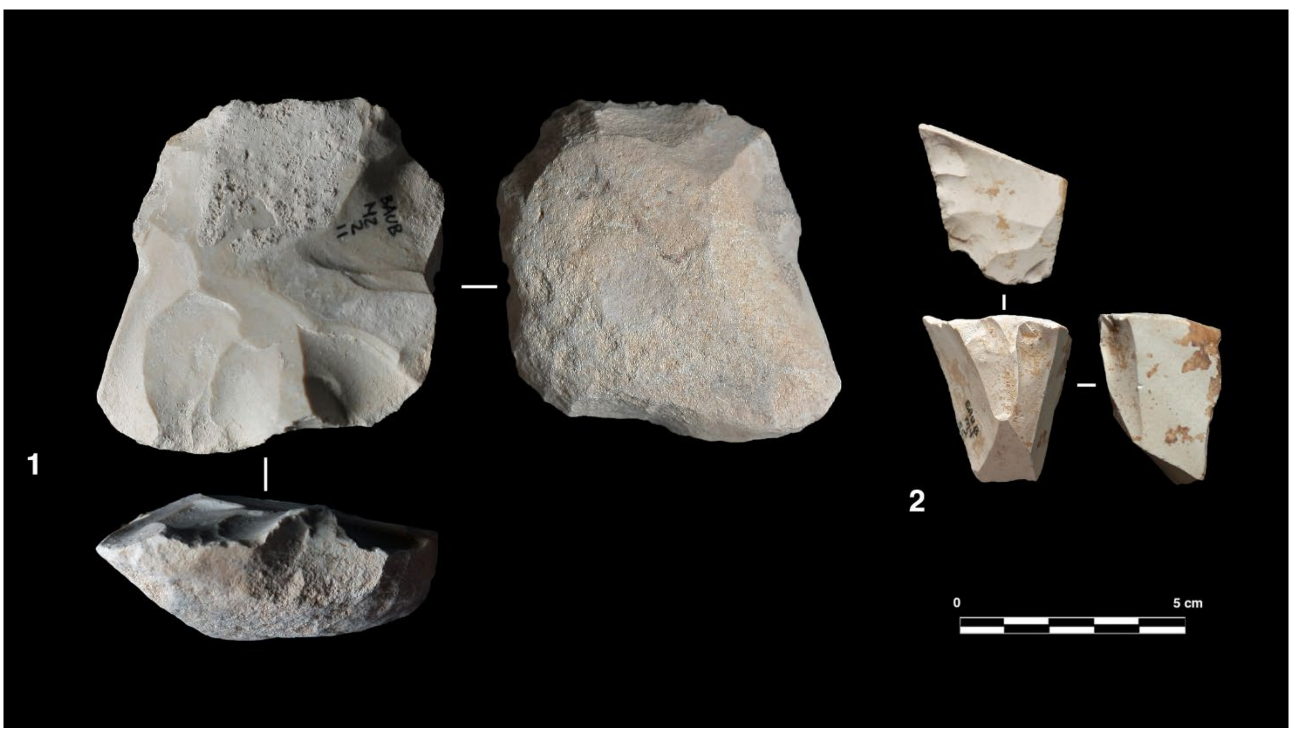


Figure S10. Bau de l'Aubesier. Cores from level 2: 1) Levallois centripetal core; 2) bladelet core.

Figure S11. Bau de l'Aubesier. Bladelets from level IV: 1, 6) rejuvenation bladelet; 2) cortical bladelet; 3-4) neo-crested bladelets; 5) crested bladelet.

TABLES (S1 to S20)

Table S1. Bau de l'Aubesier. Overall composition of the lithic assemblages.

Levels	K		J		I		H		G		F		E		5		4		D		C		3		2		1	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Undetermined fragments <20mm	953	57.9	834	46.7	1742	49.6	7606	52.5	8	21.6	16	45.7	49	34.5	256	32.2	63963	74.7	46	60.5	131	50.6	1188	63.6	2856	55.5	2	22.2
Undetermined fragments >20mm	137	8.3	275	15.4	227	6.5	1595	11	3	8.1	3	8.6	11	7.7	86	10.8	5945	6.9	5	6.6	34	13.1	110	5.9	440	8.6	-	
Undeterminable blanks <20mm	222	13.5	122	6.8	267	7.6	1151	7.9	6	16.2	4	11.4	14	9.9	84	10.6	4958	5.8	11	14.5	12	4.6	309	16.5	726	14.1	-	-
Undeterminable blanks >20mm	65	3.9	70	3.9	157	4.5	1164	8	3	8.1	2	5.7	8	5.6	52	6.5	3303	3.9	5	6.6	26	10	101	5.4	271	5.3	1	11.1
Determinable blanks	191	11.6	306	17.1	825	23.5	2066	14.3	11	29.7	7	20	38	26.8	198	24.9	4996	5.8	9	11.8	37	14.3	108	5.8	475	9.2	3	33.3
Determinable fragments	61	3.7	141	7.9	246	7	669	4.6	4	10.8	2	5.7	18	12.7	97	12.2	2014	2.4	-	-	11	4.2	42	2.2	336	6.5	3	33.3
Cores	17	1	39	2.2	50	1.4	244	1.7	2	5.4	1	2.9	4	2.8	21	2.6	427	0.5	-	-	8	3.1	11	0.6	40	0.8	-	-
Total	1646	100	1787	100	3514	100	14495	100	37	100	35	100	142	100	794	100	85606	100	76	100	259	100	1869	100	5144	100	9	100

Table S2. Bau de l'Aubesier. Overall composition of flake, blade and bladelet techno-types across the sequence.

Levels	K		J		I		H		5		4		3		2		1	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Flakes (Cortex >50%)	6	3.1	27	8.8	77	9.3	264	12.8	13	6.6	429	8.6	10	9.3	25	5.3	1	33.3
Flakes (Cortex<50%)	15	7.9	51	16.7	127	15.4	389	18.8	32	16.2	771	15.4	14	13	83	17.5	-	-
Levallois type centripetal	10	5.2	27	8.8	95	11.5	270	13.1	30	15.2	389	7.8	6	5.6	17	3.6	-	-
Levallois type unidirectional	3	1.6	15	4.9	28	3.4	34	1.6	8	4	232	4.6	1	0.9	11	2.3	-	-
Levallois type bidirectional	-	-	-	-	7	0.8	7	0.3	4	2	8	0.2	-	-	1	0.2	-	-
Levallois type orthogonal	1	0.5	4	1.3	1	0.1	2	0.1	-	-	1	-	-	-	1	0.2	-	-
Levallois type convergent	2	1	5	1.6	7	0.8	13	0.6	10	5.1	54	1.1	-	-	1	0.2	-	-
Debordant Levallois type flakes	6	3.1	8	2.6	24	2.9	42	2	7	3.5	58	1.2	1	0.9	3	0.6	-	-
Blades	40	20.9	33	10.8	40	4.8	90	4.4	6	3	399	8	3	2.8	32	6.7	-	-
Bladelets	1	0.5	-	-	-	-	16	0.8	-	-	62	1.2	5	4.6	13	2.7	-	-
Pseudo-levallois	-	-	-	-	6	0.7	21	1	-	-	29	0.6	-	-	5	1.1	-	-
Secant centripetal flakes	13	6.8	9	2.9	88	10.7	362	17.5	26	13.1	733	14.7	22	20.4	58	12.2	1	33.3
Kombewa	3	1.6	1	0.3	9	1.1	22	1.1	7	3.5	101	2.2	5	4.6	10	2.1	-	-
Unidirectional flakes	32	16.8	51	16.7	180	21.8	196	9.5	16	8.1	553	11.1	10	9.3	72	15.2	1	33.3
Bidirectional flakes	10	5.2	2	0.7	4	0.5	22	1.1	2	1	38	0.8	1	0.9	3	0.6	-	-
Orthogonal flakes	-	-	1	0.3	7	0.8	3	0.1	2	1	48	1	2	1.9	20	4.2	-	-
Convergent flakes	9	4.7	31	10.1	33	4	83	4	11	5.6	484	9.7	7	6.5	37	7.8	-	-
Debordant flakes	13	6.8	17	5.6	45	5.5	116	5.6	9	4.5	241	4.8	11	10.2	32	6.7	-	-
Macro-tools	12	6.3	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Striking platform flakes	8	4.2	7	2.3	8	1	16	0.8	5	2.5	163	3.3	3	2.8	21	4.4	-	-
Shaping/retouching flakes	1	0.5	3	1	17	2.1	39	1.9	5	2.5	99	2	2	1.9	14	2.9	-	-
Rejuvenation flakes	2	1	2	0.7	10	1.2	18	0.9	2	1	44	0.9	2	1.9	5	1.1	-	-
Crested flakes	-	-	-	-	3	0.4	14	0.7	2	1	21	0.4	3	2.8	5	1.1	-	-
Siret accident	4	2.1	9	2.9	9	1.1	27	1.3	1	0.5	39	0.8	-	-	6	1.3	-	-
Total	191	100	306	100	825	100	2066	100	198	100	4996	100	108	100	475	100	3	100

Table S3. Bau de l'Aubesier. Blade fragmentation.

Levels	K		J		I		H		5		4		3		2	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Complete blades	40	87	33	61.1	39	44.8	90	76.9	6	37.5	399	57.1	3	37.5	32	45.7
Distal fragments	2	4.3	10	18.5	23	26.4	17	14.5	4	25	112	16	-	-	15	21.4
Mesial fragments	2	4.3	3	5.6	6	6.9	3	2.6	4	25	64	9.2	4	50	4	5.7
Proximal fragments	2	4.3	8	14.8	19	21.8	7	6	2	12.5	124	17.7	1	12.5	19	27.1
Total	46	100	54	100	87	100	117	100	16	100	699	100	8	100	70	100

Table S4. Bau de l'Aubesier. Platform type of blades from volume and blades from surface exploitation.

Levels	**K**		**J**		**I**		**H**		**5**		**4**		**3**		**2**	
Blades from volume	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Completely Faceted	-	-	1	7.7	-	-	1	3.6	-	-	7	6	-	-	-	-
Partially Faceted	2	11.8	2	15.4	2	25	4	14.3	1	33.3	19	16.4	-	-	1	20
Dihedral	2	11.8	2	15.4	-	-	-	-	-	-	8	6.9	-	-	-	-
Unprepared (Plain)	7	41.2	5	38.5	4	50	19	67.9	2	66.7	61	52.6	-	-	3	60
Unprepared (Cortical)	1	5.9	1	7.7	-	-	2	7.1	-	-	2	1.7	-	-	-	-
Punctiform	2	11.8	-	-	-	-	1	3.6	-	-	5	4.3	-	-	1	20
Linear	-	-	1	7.7	-	-	-	-	-	-	6	5.2	-	-	-	-
Absent (fracture)	1	5.9	1	7.7	2	25	1	3.6	-	-	3	2.6	-	-	-	-
Absent (removed by retouch)	2	11.8	-	-	-	-	-	-	-	-	5	4.3	-	-	-	-
Total	17	100	13	100	8	100	28	100	3	100	116	100	-	-	5	100
Blades from surface																
Completely Faceted	2	66.7	3	50	7	63.6	9	33.3	1	50	23	16.8	-	-	6	40
Partially Faceted	-	-	-	-	3	27.3	7	25.9	-	-	31	22.6	-	-	3	20
Dihedral	-	-	-	-	-	-	3	11.1	-	-	8	5.8	-	-	-	-
Unprepared (Plain)	1	33.3	1	16.7	1	9.1	4	14.8	1	50	47	34.3	-	-	4	26.7
Unprepared (Cortical)	-	-	-	-	-	-	-	-	-	-	2	1.5	-	-	-	-
Punctiform	-	-	2	33.3	-	-	-	-	-	-	8	5.8	-	-	-	-
Linear	-	-	-	-	-	-	3	11.1	-	-	5	3.6	-	-	-	-
Absent (fracture)	-	-	-	-	-	-	1	3.7	-	-	10	7.3		-	2	13.3
Absent (removed by retouch)	-	-	-	-	-	-	-	-	-	-	3	2.2	-	-	-	-
Total	3	100	6	100	11	100	27	100	2	100	137	100	-	-	15	100
Blades with volume/surface mixed features																
Completely Faceted	1	5	1	7.1	5	23.8	3	8.6	-	-	6	4.1	-	-	-	-
Partially Faceted	2	10	3	21.4	1	4.8	2	5.7	1	100	27	18.5	-	-	3	25
Dihedral	2	10	-	-	1	4.8	2	5.7	-	-	4	2.7	-	-	-	-
Unprepared (Plain)	8	40	6	42.9	8	38.1	10	28.6	-	-	75	51.4	3	100	7	58.3
Unprepared (Cortical)	-	-	-	-	-	-	2	5.7	-	-	2	1.4	-	-	-	-
Punctiform	3	15	-	-	1	4.8	4	11.4	-	-	9	6.2	-	-	1	8.3
Linear	-	-	1	7.1	1	4.8	11	31.4	-	-	11	7.5	-	-	1	8.3
Absent (fracture)	2	10	3	21.4	3	14.3	1	2.9	-	-	10	6.8	-	-	-	-
Absent (removed by retouch)	2	10	-	-	1	4.8	-	-	-	-	2	1.4	-	-	-	-
Total	20	100	14	100	21	100	35	100	1	100	146	100	3	100	12	100

Table S5. Bau de l'Aubesier. Morpho-types of blades throughout the sequence.
See Figure S2, for explanations of categories.

Levels	**K**		**J**		**I**		**H**		**5**		**4**		**3**		**2**	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
P1 convergent	6	*15*	4	*12.1*	4	*10.3*	1	*1.1*	-	-	69	*17.3*	-	-	8	*26.7*
P2 convergent with natural back	1	*2.5*	-	-	-	-	3	*3.3*	-	-	4	*1*	-	-	1	*3.3*
P3 distal convergent	3	*7.5*	5	*15.2*	5	*12.8*	9	*10*	-	-	31	*7.8*	-	-	3	*10*
P4 distal convergent with natural back	2	*5*	-	-	1	*2.6*	2	*2.2*	-	-	2	*0.5*	-	-	1	*3.3*
S0 peripheral cutting edges	13	*32.5*	9	*27.3*	16	*41*	52	*57.8*	2	*33.3*	139	*34.8*	1	*33.3*	12	*40*
S1 parallels cutting edges	10	*25*	6	*18.2*	7	*17.9*	12	*13.3*	1	*16.7*	71	*17.8*	1	*33.3*	-	*0*
S2 single cutting edge (natural back)	2	*5*	7	*21.2*	4	*10.3*	7	*7.8*	3	*50*	53	*13.3*	1	*33.3*	3	*10*
S3 adjacent cutting edge (natural back)	3	*7.5*	2	*6.1*	2	*5.1*	4	*4.4*	-	-	30	*7.5*	-	-	2	*6.7*
Total	40	*100*	33	*100*	39	*100*	90	*100*	6	*100*	399	*100*	3	*100*	30	*100*

Table S6. Bau de l'Aubesier. Comparisons between blade morphology and concept of production.

Levels	K		J		I		H		5		4		3		2	
Blades from volume	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
P1 convergent	3	*17.6*	4	*30.8*	2	*25*	-	-	-	-	20	*17.2*	-	-	1	*20*
P2 convergent with natural back	1	*5.9*	-	-	-	-	3	*10.7*	-	-	1	*0.9*	-	-	-	-
P3 distal convergent	1	*5.9*	3	*23.1*	3	*37.5*	2	*7.1*	-	-	15	*12.9*	-	-	-	-
P4 distal convergent with natural back	2	*11.8*	-	-	-	-	2	*7.1*	-	-	1	*0.9*	-	-	1	*20*
S0 peripheral cutting edges	5	*29.4*	2	*15.4*	2	*25*	6	*21.4*	-	-	28	*24.1*	-	-	2	*40*
S1 parallel cutting edges	-	-	2	*15.4*	-	-	8	*28.6*	1	*33.3*	25	*21.6*	-	-	-	-
S2 single cutting edge	2	*11.8*	1	*7.7*	1	*12.5*	5	*17.9*	2	*66.7*	14	*12.1*	-	-	1	*20*
S3 adjacent cutting edge	3	*17.6*	1	*7.7*	-	-	2	*7.1*	-	-	12	*10.3*	-	-	-	-
Total	17	*100*	13	*100*	8	*100*	28	*100*	3	*100*	116	*100*	-	-	5	*100*
Blades from surface																
P1 convergent	-	-	-	-	-	-	-	-	-	-	24	*17.5*	-	-	2	*13.3*
P2 convergent with natural back	-	-	-	-	-	-	-	-	-	-	1	*0.7*	-	-	1	*6.7*
P3 distal convergent	1	*33.3*	1	*16.7*	2	*18.2*	3	*11.1*	-	-	11	*8.0*	-	-	3	*20*
P4 distal convergent with natural back	-	-	-	-	1	*9.1*	-	-	-	-	-	-	-	-	-	-
S0 peripheral cutting edges	2	*66.7*	4	*66.7*	5	*45.5*	23	*85.2*	2	*100*	71	*51.8*	-	-	6	*40*
S1 parallel cutting edges	-	-	1	*16.7*	2	*18.2*	-	-	-	-	21	*15.3*	-	-	-	*0*
S2 single cutting edge	-	-	-	-	-	-	-	-	-	-	3	*2.2*	-	-	1	*6.7*
S3 adjacent cutting edge	-	-	-	-	1	*9.1*	1	*3.7*	-	-	6	*4.4*	-	-	2	*13.3*
Total	3	*100*	6	*100*	11	*100*	27	*100*	2	*100*	137	*100*	-	-	15	*100*
Blades with volume/surface mixed features																
P1 convergent	3	*15*	-	-	2	*9.5*	1	*2.9*	-	-	25	*17.1*	-	-	5	*41.7*
P2 convergent with natural back	-	-	-	-	-	-	-	-	-	-	2	*1.4*	-	-	-	-
P3 distal convergent	1	*5*	1	*7.1*	-	-	4	*11.4*	-	-	5	*3.4*	-	-	-	-
P4 distal convergent with natural back	-	-	-	-	-	-	-	-	-	-	1	*0.7*	-	-	-	-
S0 peripheral cutting edges	6	*30*	3	*21.4*	10	*47.6*	23	*65.7*	-	-	40	*27.4*	1	*33.3*	6	*50*
S1 parallel cutting edges	10	*50*	3	*21.4*	5	*23.8*	4	*11.4*	-	-	25	*17.1*	1	*33.3*	-	-
S2 single cutting edge	-	-	6	*42.9*	3	*14.3*	2	*5.7*	1	*100*	36	*24.7*	1	*33.3*	1	*8.3*
S3 adjacent cutting edge	-	-	1	*7.1*	1	*4.8*	1	*2.9*	-	-	12	*8.2*	-	-	-	-
Total	20	*100*	14	*100*	21	*100*	35	*100*	1	*100*	146	*100*	3	*100*	12	*100*

Table S7. Bau de l'Aubesier. Types of blanks used to produce bladelets.

Levels	**5**	**4**	**2**
Flakes	1	18	1
Chunks	-	11	1
Cortical flakes	-	2	-
Recycled tools	-	2	-
Total	1	33	2

Table S8. Bau de l'Aubesier. Direction of the removals on bladelet cores.

Levels	**5**	**4**	**2**
Convergent	-	7	1
Sub-convergent	-	5	1
Parallel unidirectional	1	21	-
Total	1	33	2

Table S9. Bau de l'Aubesier. Numbers of scars on bladelet cores.

Numbers of scars	**Layer 5 (n=1)**	**Layer 4 (n=33)**	**Layer 2 (n=2)**
2	1	4	-
3	-	5	1
4	-	10	1
5	-	3	-
>5	-	11	-

Table S10. Bau de l'Aubesier. Bladelet fragmentation.

Levels	**K**		**J**		**I**		**H**		**5**		**4**		**3**		**2**	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Complete bladelets	1	*100*	-	-	-	-	16	*64*	-	-	62	*32*	5	*45.5*	13	*32.5*
Bladelets distal	-	-	-	-	-	-	7	*28*	-	-	50	*25.8*	3	*27.3*	9	*22.5*
Bladelets mesial	-	-	-	-	-	-	-	-	-	-	35	*18*	1	*9.1*	8	*20*
Bladelets proximal	-	-	-	-	-	-	2	*8*	1	*100*	47	*24.2*	2	*18.2*	10	*25*
Total	1	*100*	-	-	-	-	25	*100*	1	*100*	194	*100*	11	*100*	40	*100*

Table S11. Bau de l'Aubesier. Bladelet platforms.

Levels	K		H		4		3		2	
	N	%	N	%	N	%	N	%	N	%
Completely Faceted	-	-	-	-	5	*8.1*	-	-	1	*7.7*
Partially Faceted	-	-	-	-	3	*4.8*	-	-	-	-
Dihedral	-	-	-	-	3	*4.8*	-	-	-	-
Plain	1	*100*	9	*56.3*	24	*38.7*	4	*80*	7	*53.8*
Cortical	-	-	1	*6.3*	2	*3.2*	-	-	-	-
Punctiform	-	-	1	*6.3*	12	*19.4*	1	*20*	4	*30.8*
Linear	-	-	5	*31.3*	10	*16.1*	-	-	-	-
Absent (fracture)	-	-	-	-	3	*4.8*	-	-	1	*7.7*
Total	1	*100*	16	*100*	62	*100*	5	*100*	13	*100*

Table S12. Bau de l'Aubesier. Bladelet longitudinal profiles.

Levels	K		H		4		3		2	
	N	%	N	%	N	%	N	%	N	%
Straight	1	100	9	56.3	37	59.7	4	*75*	10	*76.9*
Slightly curved	-	-	4	25	10	16.1	-	-	2	*15.4*
Curved	-	-	3	18.8	4	6.5	-	-	-	-
Irregular	-	-	-	-	3	4.8	1	*25*	1	*7.7*
Twisted	-	-	-	-	8	12.9	-	-	-	-
Total	1	100	16	100	62	100	5	*100*	13	*100*

Table S13. Bau de l'Aubesier. Modifications of the striking platform edges of bladelet cores.

Levels	K		H		4		3		2	
	N	%	N	%	N	%	N	%	N	%
Edge trimming	-	-	1	*6.3*	5	*8.1*	-	-	1	*7.7*
Edge abrasion	-	-	3	*18.7*	6	*9.7*	-	-	1	*7.7*
Unmodified	1	*100*	12	*75*	51	*82.3*	4	*80*	11	*84.6*
Undetermined (partially fractured)	-	-	-	-	-	-	1	*20*	-	-
Total	1	*100*	16	*100*	62	*100*	5	*100*	13	*100*

Table S14. Bau de l'Aubesier. Bladelet techno-types.

Levels	**K**		**H**		**4**		**3**		**2**	
	N	%	N	%	N	%	N	%	N	%
P1 convergent	-	-	-	-	12	19.4	1	20	4	30.8
P2 convergent with natural back	-	-	-	-	2	3.2	-	-	2	15.4
P3 distal convergent	-	-	1	6.2	5	8.1	1	20	-	-
P4 distal convergent with natural back	-	-	-	-	1	1.6	-	-	-	-
S0 peripheral cutting edges	1	100	12	75	18	29	3	60	5	38.5
S1 parallels cutting edges (plunging bladelet)	-	-	-	-	17	27.4	-	-	-	-
S2 single cutting edge (natural back)	-	-	1	6.2	5	8,1	-	-	1	7.7
S3 adjacent cutting edge (natural back)	-	-	2	12.5	2	3.2	-	-	1	7.7
Total	1	100	16	100	62	100	5	100	13	100

Table S15. Bau de l'Aubesier. Blade and bladelet elongation classes.

Levels	**K**		**J**		**I**		**H**		**5**		**4**		**3**		**2**	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
laminar flake (> 2 <2.5)	19	*46.3*	17	*51.5*	19	*47.5*	54	*50.9*	4	*66.7*	212	*46*	2	*28.6*	22	*48.9*
short blade (≥2.5 <3)	15	*36.6*	11	*33.3*	16	*40*	32	*30.2*	2	*33.3*	153	*33.2*	1	*14.3*	15	*33.3*
blade (≥ 3 ≤ 4)	6	*14.6*	5	*15.2*	5	*12.5*	17	*16*	-	-	75	*16.3*	1	*14.3*	4	*8.9*
elongated blade (> 4 ≤ 5)	-	-	-	-	-	-	3	*2.8*	-	-	16	*3.5*	3	*42.9*	2	*4.4*
very elongated blade (> 5 ≤ 6)	1	*2.4*	-	-	-	-	-	-	-	-	2	*0.4*	-	-	1	*2.2*
narrow blade (> 6)	-	-	-	-	-	-	-	-	-	-	3	*0.7*	-	-	1	*2.2*
Total	41	*100*	33	*100*	40	*100*	106	*100*	6	*100*	461	*100*	7	*100*	45	*100*

Table S16. Bau de l'Aubesier. Flake and blade core techno-types across the sequence.

Levels	**K**		**J**		**I**		**H**		**5**		**4**		**3**		**2**	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Levallois centripetal	-	-	1	*2.6*	2	*4*	78	*32*	5	*23.8*	51	*11.9*	1	*9.1*	4	*10*
Levallois unidirectional	-	-	-	-	-	-	5	*2*	-	-	8	*1.9*	-	-	2	*5*
Levallois bidirectional	-	-	-	-	-	-	2	*0.8*	-	-	1	*0.2*	-	-	1	*2.5*
Levallois convergent	-	-	-	-	-	-	-	-	-	-	7	*1.6*	-	-	-	-
Levallois lineal	-	-	-	-	1	*2*	2	*0.8*	-	-	3	*0.7*	-	-	-	-
Levallois cores fragmented	-	-	-	-	-	-	13	*5.3*	1	*4.8*	5	*1.2*	-	-	-	-
Centripetal	-	*5.9*	9	*23.1*	10	*20*	1	*0.4*	1	*4.8*	20	*4.7*	1	*9.1*	3	*7.5*
Unidirectional	-	-	4	*10.3*	1	*2*	7	*2.9*	2	*9.5*	21	*4.9*	2	*18.2*	1	*2.5*
Bidirectional	3	*17.6*	1	*2.6*	1	*2*	2	*0.8*	-	-	9	*2.1*	-	-	-	-
Orthogonal	1	*5.9*	1	*2.6*	-	-	2	*0.8*	-	-	-	-	-	-	-	-
Convergent	1	*5.9*	8	*20.5*	1	*2*	1	*0.4*	-	-	24	*5.6*	-	-	1	*2.5*
Multidirectional	-	-	6	*15.4*	8	*16*	28	*11.5*	-	-	47	*11*	-	-	-	-
Linear / Non Levallois	-	-	-	-	-	-	-	-	-	-	10	*2.3*	-	-	-	-
Kombewa	-	-	-	-	3	*6*	16	*6.6*	3	*14.3*	51	*11.9*	-	-	5	*12.5*
Kostienky	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	*22.5*
Discoid	3	*17.6*	-	-	5	*10*	24	*9.8*	1	*4.8*	46	*10.8*	1	*9.1*	2	*5*
Secant partial exploitation	3	*17.6*	4	*10.3*	2	*4*	1	*0.4*	-	-	9	*2.1*	3	*27.3*	-	-
Trifacial core	-	-	-	-	-	-	5	*2*	-	-	-	-	-	-	-	-
Convergent on surface	-	-	-	-	-	-	-	-	-	-	4	*0.9*	-	-	-	-
Unidirectional semi-rotating	1	*5.9*	5	*12.8*	3	*6*	8	*3.3*	2	*9.5*	7	*1.6*	-	-	-	-
Unidirectional rotating	-	-	-	-	-	-	2	*0.8*	-	-	-	-	-	-	-	-
Sub convergent semi-rotating	-	-	-	-	1	*2*	1	*0.4*	-	-	3	*0.7*	-	-	-	-
Half pyramidal cores	2	*11.8*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bladelet cores	-	-	-	-	-	-	-	-	1	*4.8*	33	*7.7*	-	-	2	*5*
Tested block	-	-	-	-	-	-	6	*2.5*	-	-	2	*0.5*	1	*9.1*	1	*2.5*
Core fragments	2	*11.8*	-	-	12	*24*	40	*16.4*	5	*23.8*	66	*15.5*	2	*18.2*	9	*22.5*
Total	17	*100*	39	*100*	50	*100*	244	*100*	21	*100*	427	*100*	11	*100*	40	*100*

Table S17. Bau de l'Aubesier. Count of all determined removals from the Moulin Trench Area (layers F to C) and the top of the slope area (layer G).

Levels	**G**		**F**		**E**		**D**		**C**	
	N	%	N	%	N	%	N	%	N	%
Flakes (Cortex >50%)	-	-	-	-	-	-	-	-	-	-
Flakes (Cortex<50%)	-	-	1	*14.3*	1	*2.6*	3	*33.3*	4	*10.8*
Levallois type centripetal	-	-	3	*42.9*	7	*18.4*	1	*11.1*	5	*13.5*
Levallois type unidirectional	-	-	-	-	-	-	-	-	-	-
Levallois type bidirectional	-	-	-	-	-	-	-	-	-	-
Levallois type orthogonal	-	-	-	-	-	-	-	-	-	-
Levallois type convergent	-	-	-	-	-	-	-	-	-	-
Debordant Levallois type flakes	-	-	-	-	-	-	-	-	-	-
Blades	1	*9.1*	-	-	2	*5.3*	1	*11.1*	1	*2.7*
Bladelets	-	-	-	-	1	*2.6*	-	-	1	*2.7*
Pseudo-Levallois	-	-	-	-	1	*2.6*	-	-	1	*2.7*
Centripetal flakes	4	*36.4*	1	*14.3*	7	*18.4*	-	-	6	*16.2*
Kombewa	-	-	-	-	3	*7.9*	-	-	3	*8.1*
Unidirectional flakes	3	*27.3*	2	*28.6*	6	*15.8*	1	*11.1*	6	*16.2*
Bidirectional flakes	1	*9.1*	-	-	-	-	1	*11.1*	2	*5.4*
Orthogonal flakes	-	-	-	-	4	*10.5*	-	-	2	*5.4*
Convergent flakes	-	-	-	-	3	*7.9*	1	*11.1*	1	*2.7*
Debordant flakes	1	*9.1*	-	-	1	*2.6*	1	*11.1*	3	*8.1*
Macro-tools	-	-	-	-	-	-	-	-	-	-
Striking platform flakes	-	-	-	-	-	-	-	-	-	-
Shaping/retouching flakes	-	-	-	-	-	-	-	-	1	*2.7*
Rejuvenation flakes	-	-	-	-	1	*2.6*	-	-	-	-
Crested flakes	-	-	-	-	1	*2.6*	-	-	-	-
Siret accident	1	*9.1*	-	-	-	-	-	-	1	*2.7*
Total	11	*100*	7	*100*	38	*100*	9	*100*	37	*100*

Table S18. Bau de l'Aubesier. Count of determined and fragmented pieces across the sequence.

Levels	**K**		**J**		**I**		**H**		**G-F-E-D-C**		**5**		**4**		**3**		**2**		**1**	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Cortex >50 % dist	-	-	-	-	1	*0.4*	7	*1*	-	-	1	*1*	11	*0.5*	-	-	3	*0.9*	-	-
Cortex >50 % mes	-	-	-	-	-	-	1	*0.1*	-	-	-	-	1	-	-	-	-	-	-	-
Cortex >50 % prox	-	-	-	-	-	-	4	*0.6*	-	-	-	-	4	*0.2*	-	-	1	*0.3*	-	-
Cortex <50% dist	1	*1.6*	-	-	3	*1.2*	26	*3.9*	3	*8.6*	-	-	18	*0.9*	-	-	4	*1.2*	-	-
Cortex <50% mes	1	*1.6*	-	-	1	*0.4*	6	*0.9*	1	*2.9*	-	-	4	*0.2*	-	-	-	-	-	-
Cortex <50% prox	2	*3.3*	-	-	-	-	51	*7.6*	-	-	2	*2.1*	17	*0.8*	1	*2.4*	4	*1.2*	-	-
Levallois flakes dist	2	*3.3*	5	*3.5*	12	*4.9*	17	*2.5*	-	-	3	*3.1*	33	*1.6*	-	-	5	*1.5*	-	-
Levallois flakes mes	-	-	3	*2.1*	1	*0.4*	1	*0.1*	-	-	-	-	4	*0.2*	1	*2.4*	1	*0.3*	-	-
Levallois flakes prox	1	*1.6*	8	*5.7*	36	*14.6*	46	*6.9*	1	*2.9*	7	*7.2*	166	*8.2*	1	*2.4*	20	*6*	-	-
Blades dist	2	*3.3*	10	*7.1*	23	*9.3*	17	*2.5*	1	*2.9*	4	*4.1*	112	*5.6*	-	-	15	*4.5*	-	-
Blades mes	2	*3.3*	3	*2.1*	6	*2.4*	3	*0.4*	4	*11.4*	4	*4.1*	64	*3.2*	4	*9.5*	4	*1.2*	-	-
Blades prox	2	*3.3*	8	*5.7*	19	*7.7*	7	*1*	3	*8.6*	2	*2.1*	124	*6.2*	1	*2.4*	19	*5.7*	-	-
Bladelets dist	-	-	-	-	-	-	7	*1*	-	-	-	-	50	*2.5*	3	*7.1*	9	*2.7*	-	-
Bladelets mes	-	-	-	-	-	-	-	-	-	-	-	-	35	*1.7*	1	*2.4*	8	*2.4*	-	-
Bladelets prox	-	-	-	-	-	-	2	*0.3*	1	*2.9*	1	*1*	47	*2.3*	2	*4.8*	10	*3*	-	-
Debordant flakes dist	-	-	-	-	2	*0.8*	2	*0.3*	-	-	-	-	1	-	3	*7.1*	2	*0.6*	-	-
Debordant flakes mes	-	-	-	-	-	-	-	-	-	-	1	*1*	4	*0.2*	-	-	1	*0.3*	-	-
Debordant flakes prox	3	*4.9*	-	-	4	*1.6*	1	*0.1*	-	-	2	*2.1*	17	*0.8*	-	-	8	*2.4*	-	-
Centripetal flakes dist	-	-	2	*1.4*	6	*2.4*	9	*1.3*	1	*2.9*	1	*1*	19	*0.9*	1	*2.4*	6	*1.8*	-	-
Centripetal flakes mes	-	-	-	-	4	*1.6*	2	*0.3*	-	-	-	-	2	*0.1*	-	-	-	-	-	-
Centripetal flakes prox	-	-	-	-	4	*1.6*	9	*1.3*	-	-	-	-	25	*1.2*	1	*2.4*	5	*1.5*	-	-
Unidirectional flakes dist	5	*8.2*	8	*5.7*	11	*4.5*	27	*4*	4	*11.4*	7	*7.2*	145	*7.2*	4	*9.5*	20	*6*	-	-
Unidirectional flakes mes	14	*23*	20	*14.2*	17	*6.9*	26	*3.9*	1	*2.9*	4	*4.1*	50	*2.5*	1	*2.4*	18	*5.4*	-	
Unidirectional flakes prox	20	*32.8*	41	*29.1*	26	*10.6*	78	*11.7*	6	*17.1*	11	*11.3*	199	*9.9*	7	*16.7*	42	*12.5*	-	-
Bidirectional flakes dist	-	-	1	*0.7*	-	-	1	*0.1*	-	-	-	-	2	*0.1*	-	-	1	*0.3*	-	-
Bidirectional flakes mes	-	-	-	-	-	-	2	*0.3*	-	-	-	-	1	-	-	-	-	-	-	-
Bidirectional flakes prox	-	-	-	-	-	-	3	*0.4*	-	-	-	-	3	*0.1*	-	-	1	*0.3*	-	-
Convergent flakes dist	6	*9.8*	11	*7.8*	11	*4.5*	12	*1.8*	4	*11.4*	3	*3.1*	88	*4.4*	3	*7.1*	16	*4.8*	-	-
Convergent flakes mes	-	-	2	*1.4*	1	*0.4*	-	-	-	-	-	-	2	*0.1*	-	-	1	*0.3*	-	-
Convergent flakes prox	-	-	-	-	1	*0.4*	-	-	-	-	1	*1*	7	*0.3*	-	-	2	*0.6*	-	-
Undetermined flakes dist	-	-	3	*2.1*	15	*6.1*	86	*12.9*	-	-	7	*7.2*	196	*9.7*	-	-	18	*5.4*	-	-
Undetermined flakes mes	-	-	2	*1.4*	12	*4.9*	38	*5.7*	1	*2.9*	7	*7.2*	107	*5.3*	-	-	17	*5.1*	-	-
Undetermined flakes prox	-	-	14	*9.9*	30	*12.2*	178	*26.6*	4	*11.4*	29	*29.9*	456	*22.6*	8	*19*	75	*22.3*	3	*100*
Total	61	*100*	141	*100*	246	*100*	669	*100*	35	*100*	97	*100*	2014	*100*	42	*100*	336	*100*	3	*100*

Table S19. Bau de l'Aubesier. Cores from from the Moulin Trench Area (layers F to C) and the top of the slope area (layer G).

	Levels	G	F	E	D	C
Flake cores	Levallois centripetal	1	-	-	-	2
	Unidirectional	-	-	1	-	2
	Bidirectional	-	-	-	-	1
	Multidirectional	-	-	1	-	-
	Kombewa	-	-	-	-	1
	Kostienky	-	1	-	-	-
	Discoid unifacial	-	-	1	-	-
Blade cores	Unidirectional semi-rotating	-	-	-	-	1
	Convergent semi-rotating	-	-	-	-	1
	Half pyramidal cores	-	-	-	-	-
	Core fragments	1	-	1	-	-
	Total	2	1	4	-	8

Table S20. Bau de l'Aubesier. Dimensions (maximum length) of Levallois flakes.

Levels	H		5		4		3		2	
	num	%	num	%	Num	%	Num	%	Num	%
>10mm <20mm	11	*3.4*	2	*3.7*	44	*6.4*	-	-	1	*3.4*
>20mm <30mm	65	*19.9*	8	*14.8*	188	*27.5*	1	*25*	2	*6.9*
>30mm <40mm	108	*33.1*	16	*29.6*	200	*29.2*	2	*50*	7	*24.1*
>40mm <50mm	87	*26.7*	14	*25.9*	126	*18.4*	-	-	11	*37.9*
>50mm <60mm	32	*9.8*	8	*14.8*	77	*11.3*	1	*25*	7	*24.1*
>60mm <70mm	11	*3.4*	3	*5.6*	46	*6.7*	-	-	1	*3.4*
>70mm <80mm	2	*0.6*	1	*1.9*	3	*0.4*	-	-	-	-
>80mm <90mm	8	*2.5*	2	*3.7*	-	-	-	-	-	-
>90mm	2	*0.6*	-	-	-	-	-	-	-	-
Total	326	*100*	54	*100*	684	*100*	4	*100*	29	*100*