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Late Middle Palaeolithic lithic technocomplexes (MIS 5-3) in the northeastern Aquitaine Basin: Advances and challenges

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a b s t r a c t

Establishing and interpreting patterns of lithic assemblage variability is of great interest to archaeologists as they shed light on cultural adaptations in the deep past. Nowhere has this topic provoked more interest and debate than in the Middle Palaeolithic of southwestern France. The region's rich archaeological record has produced numerous sites, many of which have been recently excavated and thus provide a reliable dataset for better structuring Mousterian lithic variability. Researchers working with these types of datasets frequently employ the *chaîne opératoire* concept to approach lithic assemblage variability; however, the validity of such analyses has recently been questioned. Here we present results of a combined quantitative and qualitative technological analysis of a large sample of assemblages from numerous well-contextualised sites in the northeastern Aquitaine Basin. We selected clearly identifiable diagnostic elements typical of different flake production systems that can be quantified by different analysts in a replicable fashion. Our results show strong differences in assemblage composition in terms of dominant production systems as well as a smaller number of mixed assemblages that combine two or more flake production methods. When considered together, these results provide not only a means for defining lithic technocomplexes and subsequently comparing assemblages but also for investigating elements of Neanderthal material culture variability.

1. Introduction

The last decade has seen renewed and intense interest in Palaeolithic industrial variability, the definition of its constituent elements as well as their interpretation. While commonly associated with the Western European record, similar questions and problems are confronted by researchers around the world, resulting in varying approaches, each with a specific research history. Moreover, varying aspects of lithic assemblages are privileged, such as type fossils (e.g. Châtelperronian or Gravettian points), distinct technological (e.g. pressure flaking or the Levallois method) or quantitative features (e.g. numbers and sizes of tools) by different researchers for comparing assemblages. Underlying the selection of the most relevant comparative or interpretative elements lie clear

conceptual differences that are at times difficult to articulate together. Even a cursory survey of recent literature concerning lithic analysis reveals what can best be described as ‘different schools of thought’ built from divergent research trajectories.

This heuristic divide is nowhere more evident than in the interpretation of Middle Palaeolithic assemblage variability, the choice of a proper analytical approach for comparing assemblages from this period, and the relative influence of climatic, environmental, biological, cultural, and demographic factors. These types of questions are of equal importance regardless of the study region, as similar discussions concern, for example, the Middle Stone Age record of North and South Africa, the Mousterian of the Near East and southwestern France, and, for more recent periods, the ethnographic record of Australia (Holdaway and Douglass, 2011). Southwestern France has played a fundamental role in the development of Palaeolithic systematics both in terms of typological aspects, for example, the so-called Bordesian method, as well as defining

technological features of lithic assemblages. Its rich archaeological record has been the testing ground for numerous interpretive interpretations beginning with F. Bordes culture-historic ‘five tribes’ model (Bordes, 1953), which was almost immediately countered by chronological (Mellars, 1965, 1970, 1996) and functional models (Binford and Binford, 1966), followed by processual approaches that incorporated aspects of tool reduction (Dibble, 1987, 1995) and the influence of occupation intensity and changing climatic conditions (Rolland and Dibble, 1990; Dibble and Rolland, 1992). The relationship between climatic data and the economy of lithic raw material also focused attention on the interrelation between lithic assemblages and group mobility patterns. This situation led to inferences of differential mobility for certain raw materials and tool types or technologies (Geneste, 1985, 1988, 1991; Turq, 1989, 1990, 1992; Delagnes and Rendu, 2011). These models, while having clearly enriched our understanding of the possible factors underlying patterns observed in Middle Palaeolithic assemblages, have also led to conflicting interpretations, with each practitioner defending their position or, in extreme instances, highlighting the ‘inutility’ of certain methodological criteria for studying lithic assemblages (i.e. Monnier and Missal, 2014).

Important aspects concerning Palaeolithic systematics continue to be problematic, including confusion surrounding the emergent designation of archaeological assemblages as lithic techno-complexes (e.g. Delagnes et al., 2007; Jaubert et al., 2011; Jaubert et al., 2011) and the possible risk of plunging us into ‘another Mousterian debate’ (Monnier and Missal, 2014: our emphasis). While the actors have changed, disagreements concerning the degree to which climate, culture, form and function underlie the character of lithic assemblages remain effectively the same as in other words, the curtain never really closed on the original Mousterian debate of Bordes and Binford. From the mid 1980s onwards, the culture-historicism underlying Bordes’ ‘facies’ with its emphasis on retouched tool frequencies came to be replaced by a more holistic approach to lithic assemblage composition embodied in the *chaîne opératoire* concept (hereafter CO) and associated technological approaches (Tixier, 1978; Tixier et al., 1980; Cahen et al., 1980; Geneste, 1985, 1991; Boëda, 1986; Inizan et al., 1999). The CO approach moved attention away from retouched tools, focusing instead on the totality of a lithic assemblage. In doing so, assemblages were viewed from the perspective of the organisation of the different technical processes and actions responsible for the ultimate form of an artefact, its place within the reduction sequence, as well as the segmentation of actions in time and space (see Bleed, 2001; Bar-Yosef and Van Peer, 2009; Soressi and Geneste, 2011 for syntheses).

In parallel, the last decade has seen the development of alternative methods of lithic analysis based on the statistical treatment of quantitative and categorical attributes (e.g. Brantingham and Kuhn, 2001; Tostevin, 2003, 2012; Dibble and Rezek, 2009; Lycett and Eren, 2013; Scerri et al., 2015). Lithic analysts working within these alternative analytical paradigms have contested the ability of technological studies, more specifically, the validity of the CO approach, for investigating and interpreting lithic assemblage variability. Certain researchers have gone so far as describing the identification of particular end-products, the attribution of elements to a specific reduction phase, or the ability of such approaches to track cultural trends as a ‘fallacy’ based on ‘intuition’ (Monnier and Missal, 2014:61). Thus, the core issue at hand for palaeoanthropology appears to be the choice of the most appropriate methodology for both analysing and best comparing lithic assemblages.

The opinion that technological analyses boil down to ‘intuition’ neglects the fact that, as with other methods, the CO approach can infuse interpretations with quantitative data acquired in a reproducible fashion. The CO approach frequently uses refitting and experimentation data to characterise assemblages and facilitate their comparison. In order to move the debate forward and answer to critics, we 1) selected common diagnostic technological elements that can be securely identified by different analysts and 2) tested if statistical analysis of the proportions of these elements in a selected region, the north-eastern Aquitaine Basin of southwestern France, over a given period (MIS 5-3), highlights differences between assemblages that are coherent with previous research performed within a CO framework. The selected study region has produced amongst the highest densities of recently excavated Middle Palaeolithic enclosed and open-air sites anywhere in the world. Nearly four decades of technological analyses, experimentation, and refitting combined with comprehensive raw material surveys create an ideal testing ground for exploring the structure of Mousterian lithic assemblage variability. Finally, we conclude by reflecting on the present and future role of lithic technology in material culture studies.

2. Material and methods

The northeastern Aquitaine Basin is limited by the Garonne Valley to the south, the Dronne Valley to the north and the Massif Central in the northeast. This region includes a varied topography and numerous hydrological networks centered around four main rivers, the Isle, Dordogne, Lot and Garonne and their tributaries (Fig. 1). The sample includes 41 assemblages from 24 Middle Palaeolithic sites, including caves and rock-shelters as well as open-air occupations, which were either recently excavated or revised and for which the artificial mixing of material from different layers can be ruled out. Table 1 presents the dominant group of retouched tools for each assemblage alongside associated flake production system described by previous CO analyses as either exclusive or mixed. We focused our analysis on a sub-sample of 24 assemblages for which detailed technological counts are available (Table 2). The dataset was explored using correspondence analysis performed with the PAST software package on artefact numbers for 7 specifically chosen technological artefact types that are best suited for inter-assemblage comparisons (see below).

In addition to assemblage size and proportion of retouched tools for each context studied, we quantified products belonging to seven specific, consistently identifiable technological categories typical of well-documented Middle Palaeolithic flake production methods. The first and second categories comprise Levallois flakes and cores (Fig. 2). The Levallois method produces predetermined removals according to specific recurrent modalities (unipolar, bipolar, centripetal, convergent; e.g. Boëda, 1986, 1994; Geneste, 1988; Boëda et al., 1990; Delagnes, 1992; Van Peer, 1992; articles in Dibble and Bar Yosef, 1995; Lycett and Eren, 2013) or a single flake for preferential or lineal modalities (Boëda, 1986). The Levallois products identified in the studied assemblages therefore correspond to a wide range of sizes and shapes (e.g. elongated, triangular, quadrangular) that clearly result from Levallois flaking methods as evidenced by associated cores.

The third and fourth category includes pieces with a thick ‘back’ that corresponds to a removed portion of the lateral edge of the core. This ‘back’ may retain a combination of contrabulbs, flake negatives or cortical portions (Locht and Swinnen, 1994; Mourre and Jaubert, 1996; Pasty, 2000; Peresani, 2003).

Table 1
Technological and typological data for the overall Middle Palaeolithic assemblage sample.

Site	Layer ^a	Previous technological attribution ^b	Evidence for bifacial shaping	Dominant retouched tool type ^c	Included in statistical analyses	References
Cantalouette IV	2	Lev	Yes	S	X	Blaser et al., 2012
Moustier G1/G2	G1/G2	Lev	Yes	S	X	Gravina and Discamps, 2015; Gravina, in press
Corbiac	M1–M2–M3	Lev	Yes	S		This study
Toutifaut	—	Lev	Yes	S		This study
La Plane	—	Lev	Yes	S		Turq, 2000
La Ferrassie	4	Lev	No	S		This study
Chemin d'Herbe	—	Lev	Yes	S	X	Brenet, 2012
Caminade Est	M1/M2	Lev	No	S		Perinotto, 2015
Roc de Marsal	XI	Quina	Yes	S	X	Turq, 1992
Roc de Marsal	X	Quina	Yes	S	X	Turq, 1992
Roc de Marsal	IX	Quina	Yes	S	X	Turq, 1992
Combe-Grenal	17	Quina	No	S	X	Faivre, 2011
Combe-Grenal	20	Quina	No	N&D	X	Faivre, 2008
Caminade Est	M3	Quina	No	S		Perinotto, 2015
Combe-Capelle bas	I–1b–c	Quina	No	N&D		Dibble and Lenoir, 1995
Moulin du Milieu	—	Quina	No	S		Turq, 2000
Moustier	H2–H9	Crđ Disc	Yes	N&D	X	Gravina and Discamps, 2015
Champs de Bossuet	—	Crđ Disc	No	N&D	X	Bourguignon and Turq, 2003
Combe Grenal	14	Crđ Disc	No	N&D	X	Bourguignon and Turq, 2003
Les Fieux	G7	Crđ Disc + Ctp Disc	No	N&D		Faivre, 2004
Les Fieux	I–J (S)	Crđ Disc	No	N&D	X	Faivre, 2011
Roc de Combe	Zone 2 (S)	Crđ Disc	No	N&D	X	Lorenzo Martinez et al., 2014
Roc de Combe	Zone 2 (Q)	Crđ Disc	No	N&D	X	Lorenzo Martinez et al., 2014
Regourdou	4	Crđ Disc	No	N&D	X	This study
Bouffia 118	—	Crđ Disc	No	N&D		Rendu et al., 2014; this study
Les Fieux	K (S)	Crđ Disc	No	N&D	X	Thiébaud et al., 2009
Les Fieux	Ks (Q)	Ctp Disc	No	S		Faivre, 2003, 2006
Cantalouette IV	1	Lev + n-L lam	Yes	S	X	Blaser et al., 2012
Abri du Musée	—	Lev + n-L lam	Yes	S	X	Bourguignon and Morala, in press; Detrain et al., 1991
Combe Brune 1	1	Lev + n-L lam	Yes	S	X	Bourguignon et al., 2011a,b
Combe-Grenal	29/30	Lev + n-L lam + Crđ Disc	No	S	X	Faivre, 2011, 2012
Vieux Coutet	3	Lev + Crđ Disc	Yes	S	X	Bourguignon et al., 2004a,b
Combe-Grenal	27	Lev + Crđ Disc + n-L lam	No	S	X	Faivre, 2008
Combe-Grenal	12	Crđ Disc + Lev + n-L lam	No	N&D	X	Faivre, 2008
Pech de l'Azé IV	3a–3b	Crđ Disc + Lev	Yes	N&D		McPherron and Dibble, 1999; Turq et al., 2009
Combemenuue	–(S)	Lev	No	S		Brenet, 2012
Combemenuue	–(Q)	Ctp Disc	No	S		Brenet, 2012
Les Fieux	K (Q)	Ctp Disc + bipanv	Yes	N&D	X	Thiébaud et al., 2009
Les Fieux	Ks (S)	Lev	Yes	S		Faivre, 2006
Pech de l'Azé 1	4	EUF + Lev	Yes	S		Soressi, 2002; Faivre, 2003
Cantalouette 2	—	UF + Lev	Yes	S		Bourguignon et al., 2008

^a (S): flint artefacts; (Q): quartz artefacts.

^b Lev: Levallois; n-L lam: non-Levallois laminar; Crđ Disc: Cordal Discoid; Ctp Disc: Centripetal Discoid; bipanv: bipolar on anvil; Shap: bifacial shaping; UF: unipolar flaking; EUF: elongated unipolar flaking method.

^c S: scraper; N&D: notches and denticulates.

As originally defined by Boëda (1993), these products are detached along a *chordal* orientation meaning that their flaking or technological axis is oblique to the axis of the piece. We distinguish two types of chordal flakes. The first (Fig. 2, n° 8–14) have a distal point created by the intersection of two either unilineal or crossed removals opposite the 'back', referred to as a "pseudo-Levallois point" by Bordes (1961), while the second type (Fig. 2, n° 15–18), termed *éclat débordant*, has a lateral back oriented along the technological axis of the flake that is opposite one or two edges. Although both the Levallois and Discoid methods produce pseudo-Levallois points and *éclats débordants*, they are significantly more abundant and thicker in Discoid assemblages (see below).

The fifth category corresponds to cores fulfilling the technological features of the Discoid method (e.g. Boëda, 1993; Peresani, 2003). These cores have a single (unifacial) surface (Fig. 3, n° 1) or at least two (bifacial or multidirectional) opposed surfaces (Fig. 3, n° 3) formed by a series of secant, primarily obliquely oriented removals that are both predetermined and predetermining and simultaneously maintain the necessary surface convexities.

Certain raw materials, particularly metaquartzites, are more often associated with the unifacial modality or bipolar percussion (Fig. 3, n° 4–6).

The sixth category corresponds to large asymmetrical flakes (in section or profile) with thick, large cortical or flat platforms typical of the Quina flaking method (Turq, 1989; Bourguignon, 1996, 1997; Faivre, 2008; Hiscock et al., 2009; Fig. 4, n° 1–7). Despite their asymmetry, these flakes clearly differ morphologically from the chordal flakes described above (Turq, 1989; Bourguignon, 1996, 1997, Fig. 4, n° 1–7). The substantial volume of these pieces potentially permits both long tool reduction sequences (i.e. sharpening, resharpening, Fig. 4, n° 8–10) and act as a raw material reserve for producing additional flakes (Fig. 4, n° 11).

Table 2

Assemblage sizes, retouched tool proportions and counts of different technological groups of the analysed assemblages included in the correspondence analysis.

Code	Sites	Layer	% RT ¹	AS ²	Nb Lev f ³	Nb Lev c ⁴	Nb p-Lp ⁵	Nb ED ⁶	Nb Disc c ⁷	Nb Q-t f ⁸	Nb n-L lam ⁹	References
AdM	Abri du Musée	—	9.2%	4122	562	103	0	785	0	0	6	Bourguignon and Morala, in press; Detrain et al., 1991
CantIV-1	Cantalouette IV	1	6%	364	36	14	2	15	0	0	100	Blaser et al., 2012
CantIV-2	Cantalouette IV	2	2%	182	11	2	0	15	0	0	0	Blaser et al., 2012
ChB	Champs de Bossuet	0	2.9%	10,692	0	0	926	1661	820	0	0	Bourguignon and Turq, 2003
ChH	Chemin d'Herbe	—	7.4%	335	43	8	7	5	0	0	0	Brenet, 2012
CB1	Combe Brune 1	1	12.2%	524	77	18	4	111	0	1	11	Bourguignon et al., 2011a,b
CG-12	Combe Grenal	12	6%	1671	17	3	148	158	24	0	26	Faivre, 2008
CG-14	Combe Grenal	14	1.9	2885	0	0	174	543	386	0	0	Bourguignon and Turq, 2003
CG-17	Combe Grenal	17	13.5%	3060	0	0	8	163	0	323	0	Faivre, 2011
CG-20	Combe Grenal	20	12%	1578	0	0	9	28	0	448	0	Faivre, 2008
CG-27	Combe Grenal	27	24%	2220	400	26	86	42	11	0	19	Faivre, 2008
CG-29/30	Combe Grenal	29/30	12%	4138	515	54	136	59	3	0	295	Faivre, 2011
F-I/J(S)	Les Fieux	I/J (S)	3%	1000	0	0	256	112	19	0	0	Faivre, 2011
F-K(S)	Les Fieux	K (S)	6.4%	288	0	0	22	40	12	0	0	Thiébaud et al., 2009
F-K(Q)	Les Fieux	K (Q)	2%	277	0	0	17	—	15	0	0	Thiébaud et al., 2009
Mo-G1-2	Moustier	G1-G2	1.7%	2787	94	8	25	127	1	0	0	Gravina and Discamps, 2015; Gravina, in press
Mo-H2-9	Moustier	H2-H9	2.2%	4722	1	0	235	264	28	0	0	Gravina and Discamps, 2015
REG	Regourdou	4	2.5%	68	0	0	10	10	6	0	0	This study
RdC(S)	Roc de Combe	Z2 (S)	8.2%	4910	0	0	254	376	225	0	0	Lorenzo Martinez et al., 2014
RdC(Q)	Roc de Combe	Z2 (Q)	2.9%	456	0	0	14	17	33	0	0	Lorenzo Martinez et al., 2014
RdM-XI	Roc de Marsal	XI	63.5%	524	7	0	2	9	0	205	2	Turq, 1992
RdM-X	Roc de Marsal	X	52.4%	521	4	0	—	10	0	188	0	Turq, 1992
RdM-IX	Roc de Marsal	IX	43.8%	641	7	0	2	11	0	181	0	Turq, 1992
VC	Vieux Coutet	3	18.4%	804	155	17	26	126	6	0	2	Bourguignon et al., 2004a,b

Nb: number; ¹ retouched tools; ² assemblage size; ³ Levallois flake; ⁴ Levallois core; ⁵ pseudo-Levallois point; ⁶ éclat débordant; ⁷ Discoidal core; ⁸ Quina-type flake; ⁹ non-Levallois laminar production (including blades, blade cores and by-products).

The seventh category comprises products associated with non-Levallois blade production systems (Fig. 5). Mousterian blade technologies are now well recognized and widely documented in Europe, especially northern France and Belgium (e.g. Boëda, 1988; Conard, 1992; Otte, 1994; Revillion, 1995; Delagnes, 2000; Kuhn and Bietti, 2000; Kozlovsky, 2001; Depaepe, 2002), where these assemblages are particularly well represented in MIS 5. These types of flaking systems, while considerably less frequent in south-western France, have nevertheless been documented from contexts spanning MIS 5b to 3 (Soressi, 2002; Blaser et al., 2012; Faivre, 2012; Ortega et al., 2013). Our sample includes prismatic or semi-prismatic cores as well as laminar removals clearly distinct from Levallois products given their elongation, robustness and trapezoidal or triangular cross-sections. Elements related to the maintenance of the debitage surface and volume (e.g. neo-crests, cortically-backed blades) were also counted.

All of these categories correspond to products of particular, well-documented flaking methods. We have, however, intentionally excluded bifacial tools and evidence for their production in the analysis for several reasons. First, bifacial shaping is seldom exclusively represented in any assemblages and, those that do have a heavy bifacial component (bifaces and/or evidence for their manufacture) come from old excavations (e.g. La Ferrassie, Pech de L'Aze I, Le Moustier, Abri Peyrony) suffering clear collector bias and lacking systematic sieving. Second, site function issues, the high spatio-temporal fragmentation of bifacial shaping (Geneste, 1985; Turq, 2000; Soressi, 2002; Turq et al., 2013; Brenet et al., 2016; Deschamps, in press) in combination with the high potential of reshaping of bifacial tools (Boëda et al., 1990, 1991; Bourguignon, 2001) as well as the elevated mobility of bifaces presently makes discerning the importance of bifacial shaping in any given assemblage difficult. For example, while no bifaces and a handful of bifacial thinning flakes were recovered from layer K of Les Fieux (Faivre, 2006) the opposite is true for La Plane (Turq, 2000).

Finally, our database of recently excavated and critically reassessed assemblages shows nearly half (n 19) to be associated with one or several of the dominant flake production systems (Table 1). Before bifacial shaping can be integrated in any discussion of the structure of Mousterian variability considerable work needs to be done, including new modern excavations, which fortunately is the case for several of the sites mentioned above, alongside a systematic revision of small finds from recent field projects in order to identify typical by-products associated with biface manufacture and maintenance (e.g. Gravina, in press).

3. Results

Table 2 presents raw counts of technologically diagnostic elements for each assemblage. Correspondence analysis demonstrates three factors to explain 91.4% of the variability in our dataset (Fig. 6). Factor 1 distinguishes assemblages principally according to the abundance of Quina-type flakes. Factor 2 separates assemblages richer in pseudo-Levallois points, éclats débordants and Discoid cores (these 3 variables being highly correlated) from assemblages with a heavy Levallois (flakes and cores) and non-Levallois blade component. Factor 3 individualises assemblages with more evidence of non-Levallois blade production.

Plotting the assemblages along these 3 factors (Fig. 6) reveals a strong clustering of assemblages in at least 3 distinct groups. These three groups gather assemblages that were previously described as being dominated by Quina, Discoid or Levallois CO. In no case does an assemblage previously identified with one dominant CO appear in a cluster correlated with any of the other two. The first group is the most distinctive in that it contains assemblages where the Quina CO is exclusive. In the second group, assemblages exclusively associated with the chordal Discoid CO are highly clustered together and separated from other assemblages; while the more “mixed” assemblages of Combe-Grenal level 12 (chordal Discoid Levallois laminar) and the quartz component from Les Fieux level K (Centripetal Discoid bipolar anvil) are closer to the other groups.

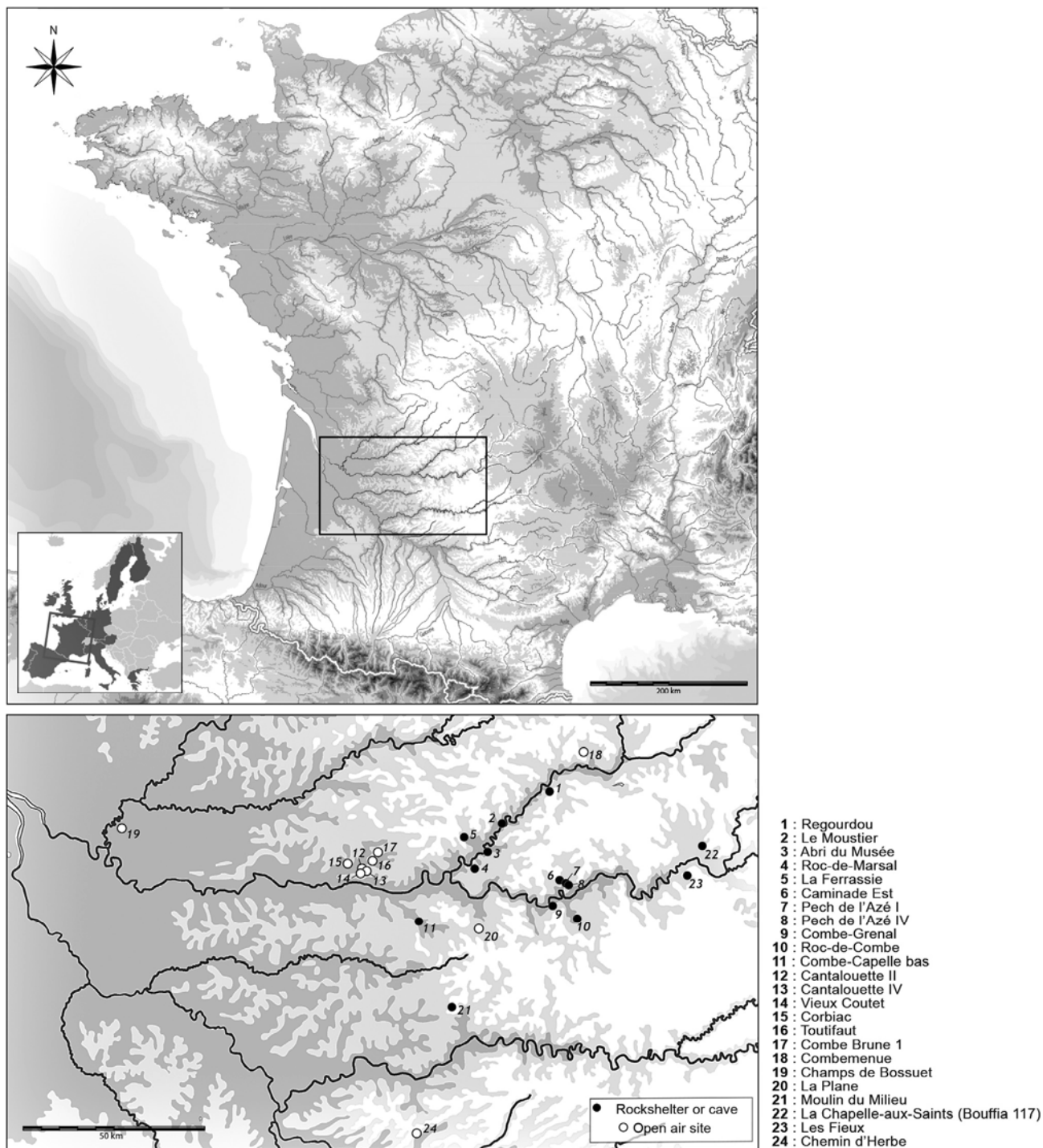


Fig. 1. Study area and Middle Palaeolithic sites included in the analysis.

Assemblages from the third group, dominated by Levallois CO (green and blue circles (in the web version) on Fig. 6), can be partially separated from each other on the third axis, with two assemblages (Cantalouette 1 and Combe-Grenal level 29-30) richer in non-Levallois blade products. The comparison of retouched tools proportions with flake production systems, as well as their exclusive or coexisting character, highlights several notable differences (Fig. 7). The Quina assemblages from Roc-de-Marsal are distinguished by a higher percentage of retouched tools than in all the other assemblages.

As noted elsewhere (Faivre et al., 2013; Gravina and Discamps, 2015), assemblages in which the chordal Discoid method is exclusive or dominant contain less than 10% retouched tools. The same is true for Les Fieux (level K), where the use of metaquartzites likely conditioned flaking choices (bipolar on anvil and centripetal Discoid), the low rate of retouched tools (in most cases less than 5% of the entire series) being closely correlated to chordal Discoid flaking method. Assemblages dominated by Levallois CO have more variable percentages of retouched tools, but remain low when the Levallois method is exclusive.

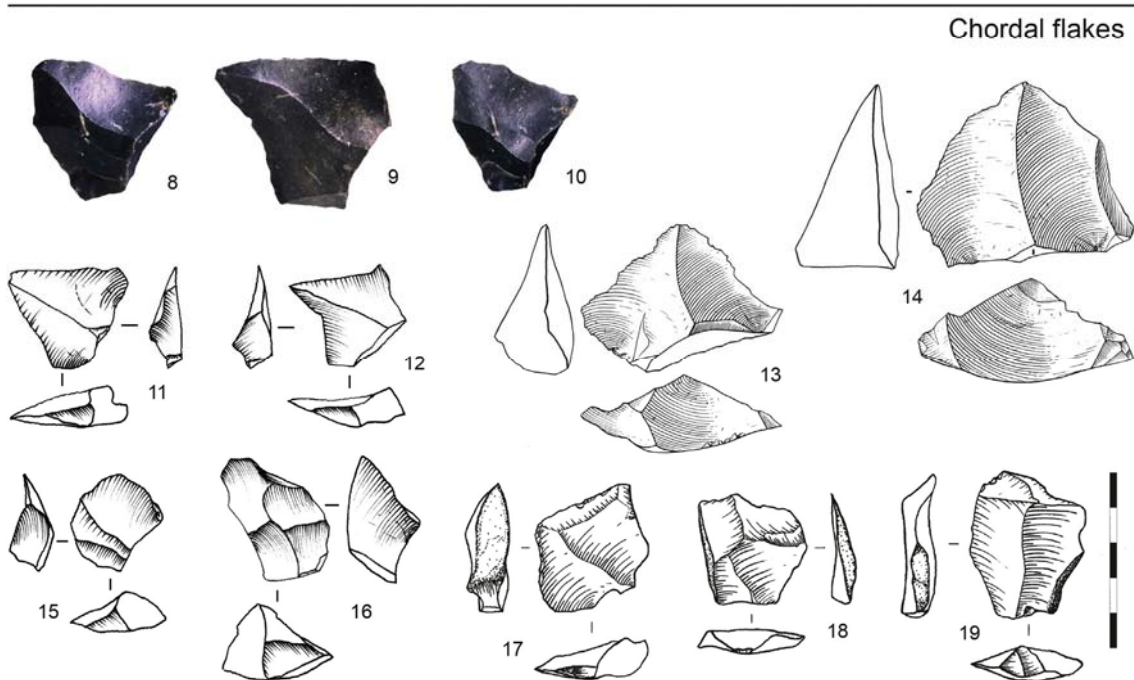
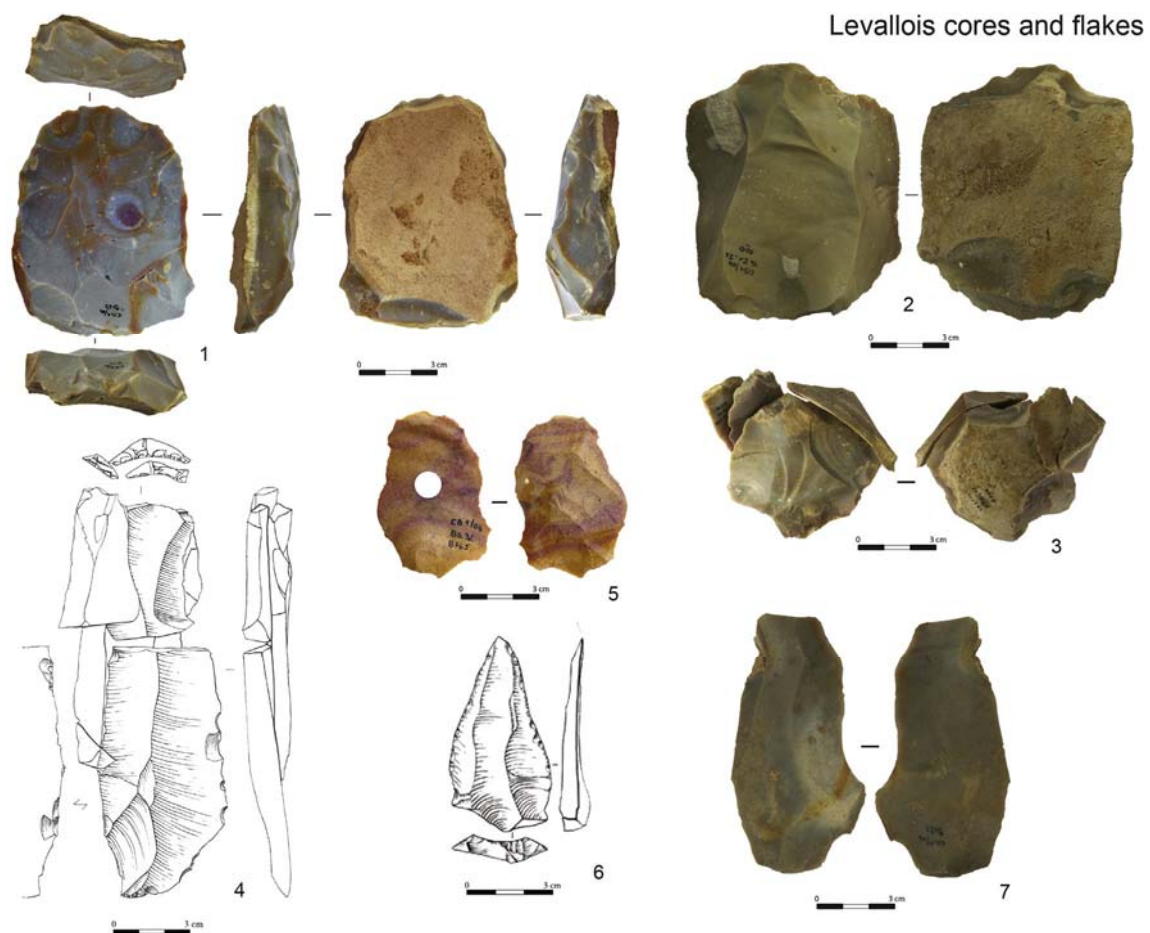


Fig. 2. Levallois cores (n° 1e3) and products (n° 4e7). Pseudo-Levallois points (n° 8e14) and *éclats débordants* (n° 15e19). Illustrations n° 13 and 14 (Le Moustier) by G. Devilder.

Discoid cores and bipolar on anvil cores

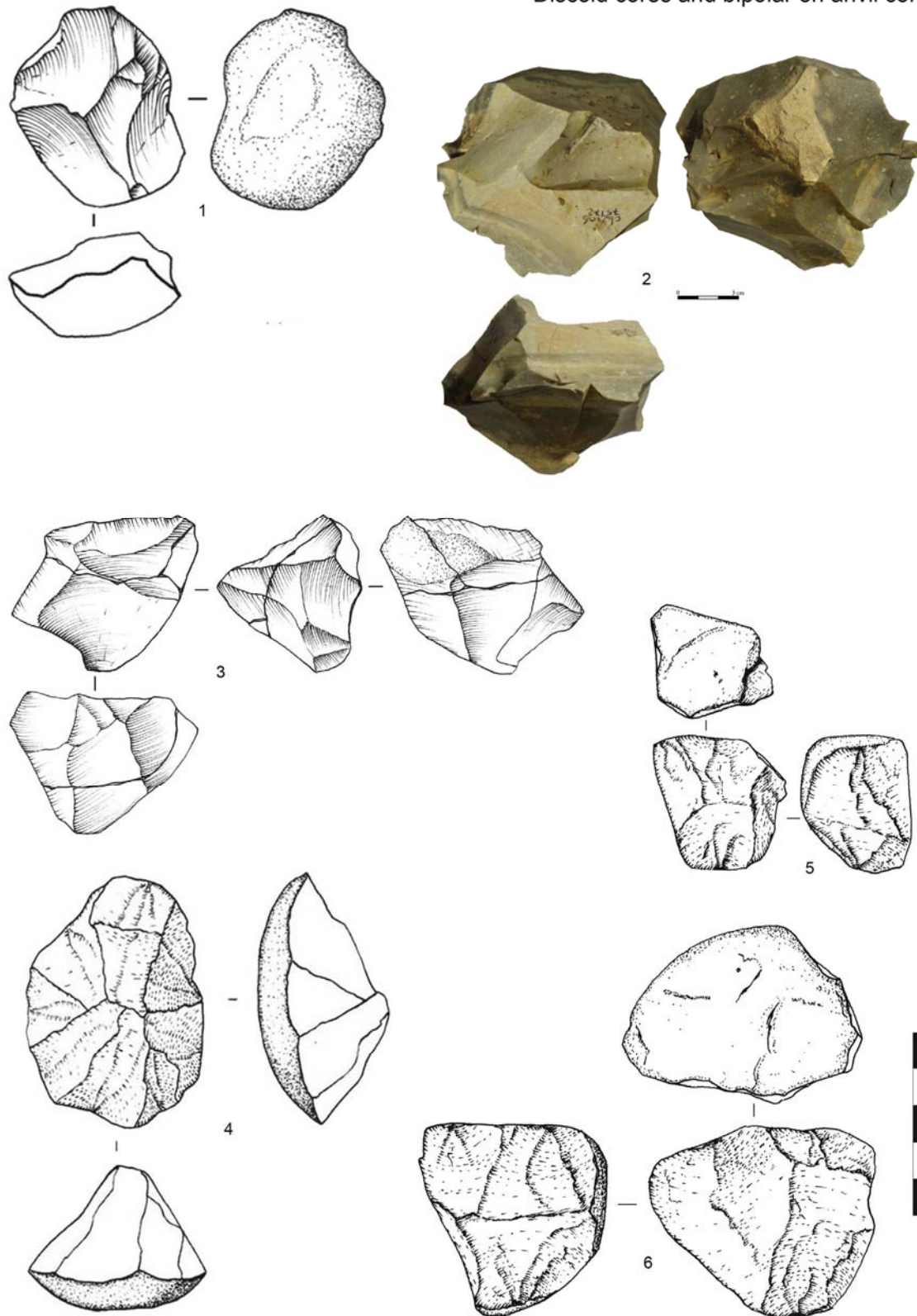


Fig. 3. Discoid cores. Unifacial e flint (n° 1), unifacial e metaquartzite (n° 4), bifacial e flint (n° 2, 3). Bipolar debitage on metaquartzite (n° 5, 6).

4. Discussion

The nature of any lithic assemblage is, by necessity, structured by different elements, including natural processes such as

sedimentation rates. Cultural factors (choices) determine artefact use and discard as well as the form in which artefacts are ultimately incorporated into the archaeological record, each resulting from a specific phase in the reduction of a volume of raw material.

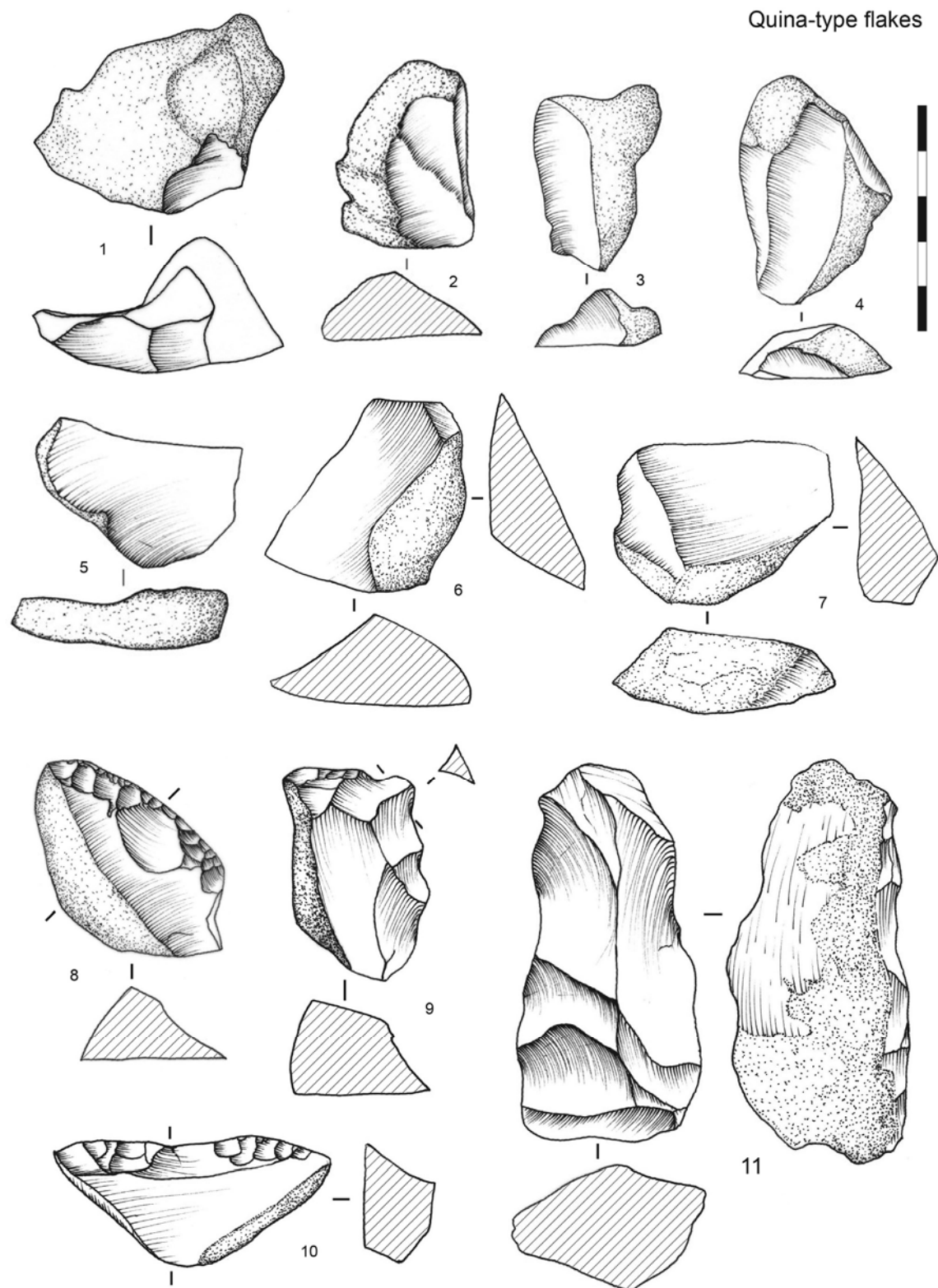


Fig. 4. Quina-type flakes.

Experimental data collected over the last 20 years and commonly employed in CO analysis permits many but certainly not *all* diagnostic objects to be reliably placed in a specific stage of the reduction sequence (e.g. Geneste, 1988; Turq, 1990; Brenet et al., 2009, 2011, 2013; Roussel et al., 2009; Bourguignon et al., 2011a, 2013; Ortega et al., 2013).

Moreover, progress in raw material sourcing and the tracing of their post-genetic alteration (Fernandes, 2012) allow aspects of artefact mobility and the segmentation of the CO to be better understood (Turq et al., 2013). What emerged from these works was not, as misunderstood by

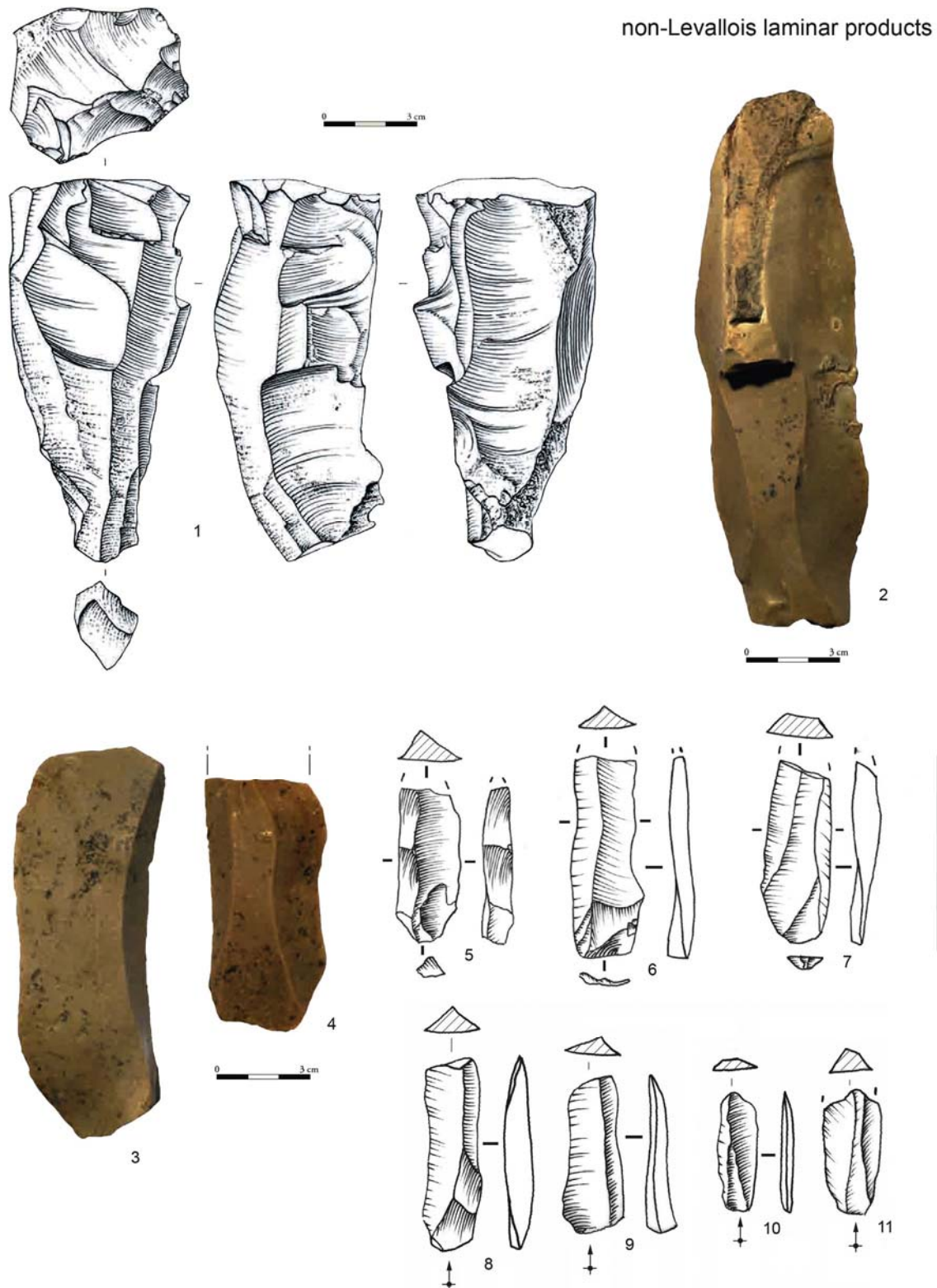


Fig. 5. Non-levallois blade cores and products.

Monnier and Missal (2014:61), a “severe blow to the notion that the CO approach enables us to reconstruct the intentions of prehistoric knappers”, but simply that other artefact forms (e.g. large cortical and non-cortical flakes, cores, etc.) in addition to identifiable end-products are also moved around the landscape (see also Turq et al., in press), reflecting more

complex economic choices than previously thought.

The identification of any specific reduction sequence, for example Levallois or Discoid, should never be determined solely on the presence of a single object.

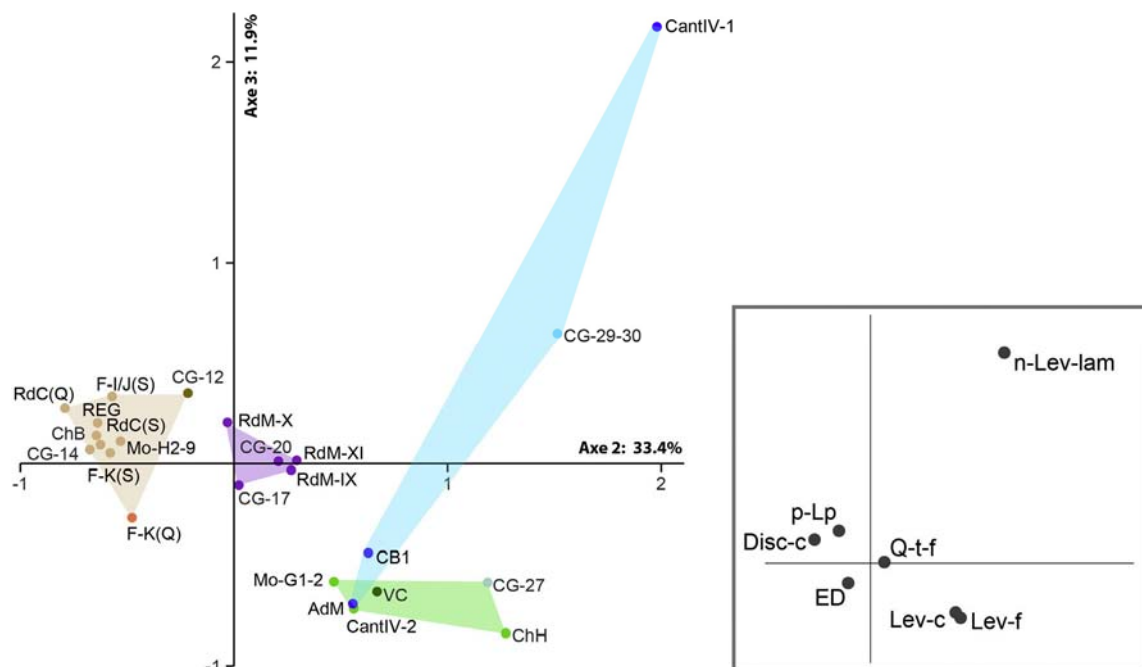
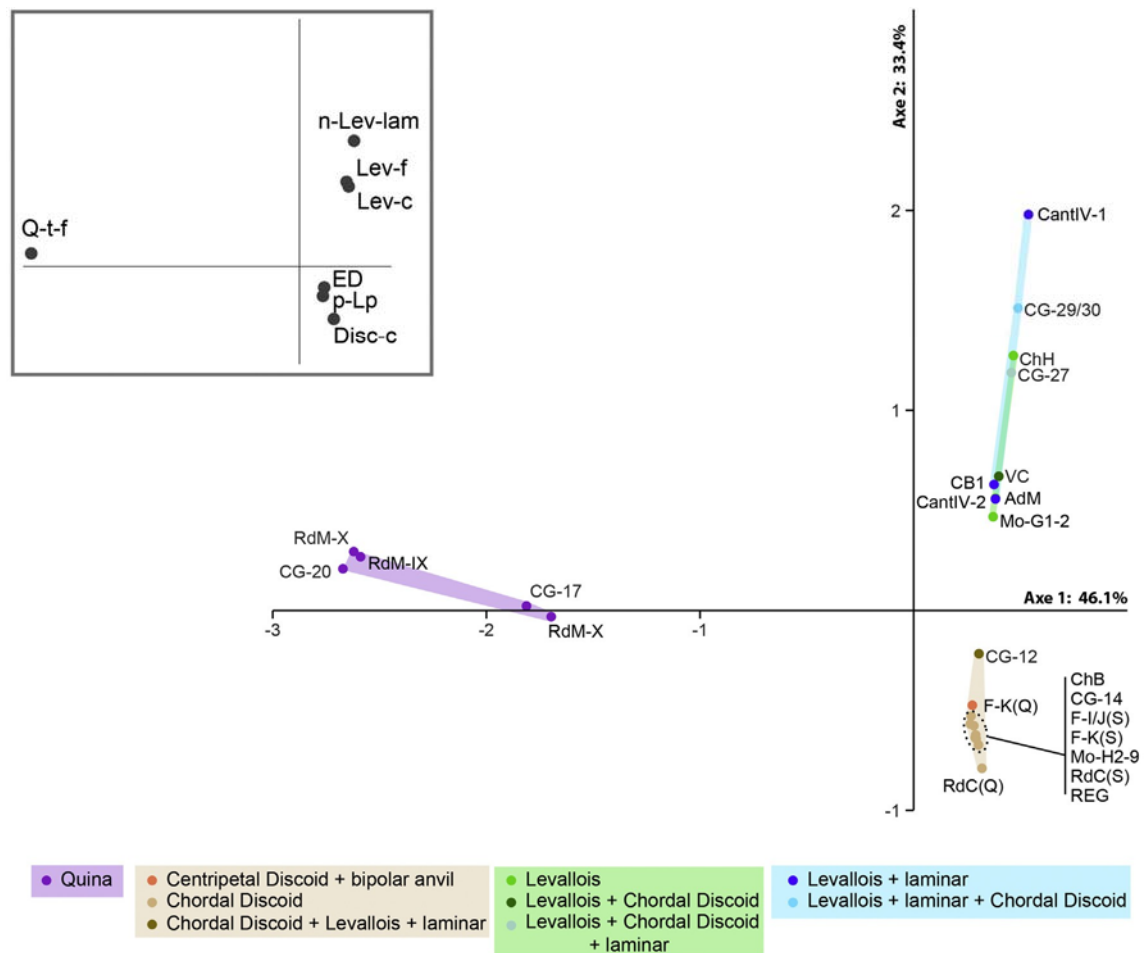


Fig. 6. Correspondence analysis. For site codes see Table 2.

The presence of *éclats débordants* is not necessarily synonymous with Levallois or Discoid debitage, it is, rather, the conjunction of typical products and by-products with specific technical criteria determined by experimentation and refitting that allows the production methods underlying the formation of an assemblage to be determined.

In the same sense, assemblage type should never be determined solely with recourse to core type or form.

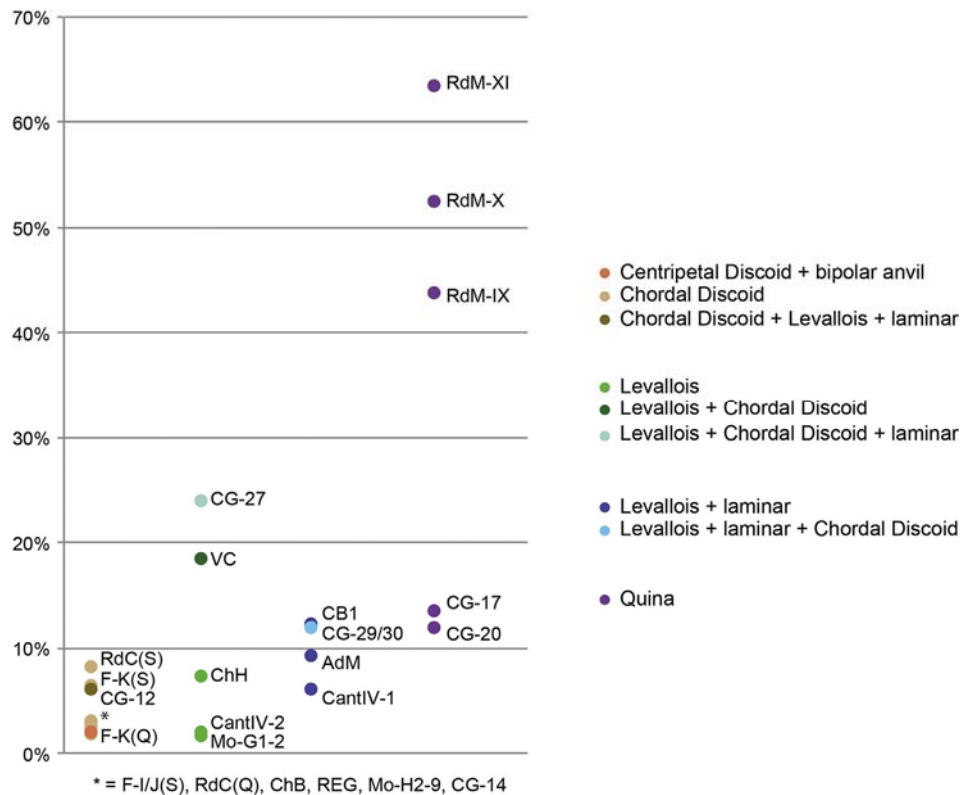


Fig. 7. Proportion of retouched tools by assemblage. For site codes see Table 2.

For example, while 30 years ago the problems originally noted by Lenoir and Turq (1995) and repeated by Monnier and Missal (2014) did exist in terms of distinguishing Discoid from Levallois debitage, they have, in no small part, been resolved by refitting studies, numerous technological analyses and experimentation (e.g. articles in Peresani, 2003).

5. On the identification and definition of technocomplexes

Correspondence analysis confirms that a quantitative technological approach is possible, and that the commonly employed groups (Quina, Discoid, Levallois) pertain to genuine differences in the relative representation of technologically diagnostic elements in lithic assemblages. Moreover, the artifact counts treated in the correspondence analysis were produced by different analysts (Table 2), reinforcing the reproducibility of a technological approach to Middle Palaeolithic lithic assemblages.

The proportions of these diagnostic technological elements can serve as the structural framework for better defining lithic technocomplexes (LTC). Middle Palaeolithic LTC were initially defined as the material expression of the practical know-how evident in lithic reduction sequences (or *chaîne opératoire*), which is shared across a range of human groups (Delagnes et al., 2007). Defined as such, this concept was subsequently used to restructure Mousterian variability and revisit the archeo-sequences from southwestern France (Jaubert et al., 2011; Jaubert, 2012). This revision, while not completely departing from certain of Bordes' facies, provided a new vision of the chronological patterning of Mousterian assemblage types in the region. Monnier and Missal (2014:63) took exception to this new synthesis, while at the same time clearly recognizing the fact that Jaubert had underlined the preliminary nature of the synthesized Middle Palaeolithic archaeo-sequence for south-western France.

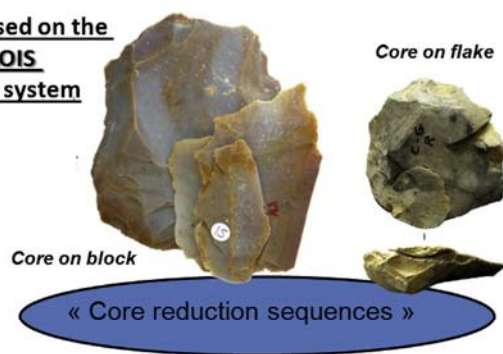
They note that (1) no data is presented to support the technocomplexes, (2) it is unlikely that different researchers would attribute the same assemblage to the same LTC, and (3) that these LTC are not explicitly defined. We have already addressed the first two criticisms above.

Investigating industrial variability via coarse-grained patterns in median Levallois or biface indices, relative proportions of Levallois versus non-Levallois assemblages, retouched tool frequencies with the basic chronological unit being Marine Isotope Stage, as Monnier and Missal have done (Monnier, 2006; Monnier and Missal, 2014) appears inadequate, particularly given both the increasing recognition of rapid technological change within MIS 3 alone and the current resolution of absolute dating methods for the periods in question (e.g. Discamps et al., 2011; Jaubert et al., 2011; Faivre et al., 2014; Gravina and Discamps, 2015). The key element for both defining LTC and addressing aspects of Neanderthal techno-economic behavior should remain lithic production systems, which can be exclusive or coexist within assemblages. Several decades of research, experimentation and refitting, within a CO framework or otherwise, have resulted in a series of clearly identifiable and quantifiable elements (i.e. the technological groups used in the correspondence analysis, see above) that distinguish each system. Based on the above, at least three main techno-complexes can be identified in our study region.

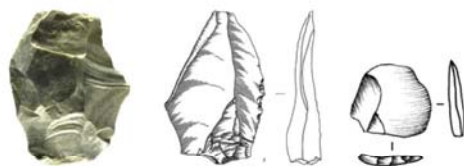
5.1 Levallois system LTC

In the LTC based on the Levallois system (Boëda, 1986, 1994, 2013; Geneste, 1988; Boëda et al., 1990), the organisation of core reduction sequence plays a central role (Fig. 8). The Levallois system (Boëda, 1986, 1994; Geneste, 1988; Boëda et al., 1990) produces standardized blanks with a high degree of predetermination (Lycett and Eren, 2013). The productivity of the method can vary, ranging from a single preferential flake to multiple production episodes

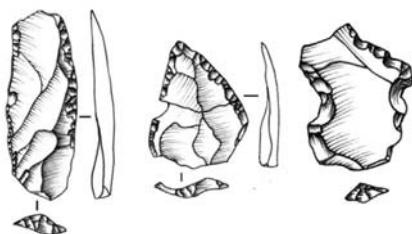
TCL based on the LEVALLOIS flaking system



End-products with a wide range of determined functional characters

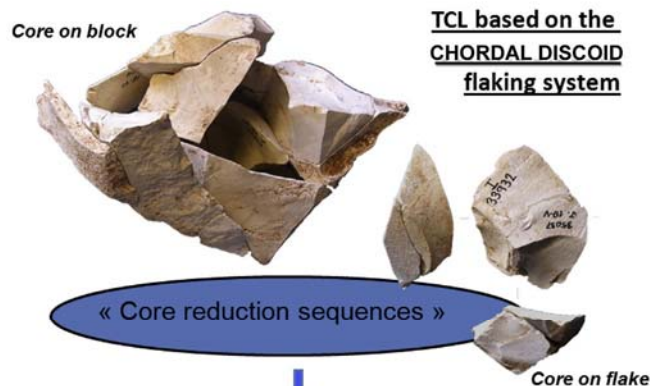


A wide range of retouched tools

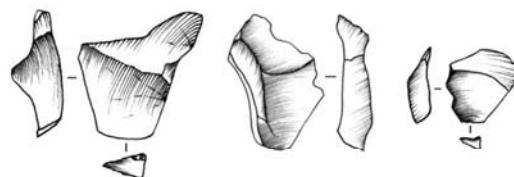


Core on block

TCL based on the CHORDAL DISCOID flaking system



End-products with the same determined functional aspects



Few and poorly diversified retouched tools

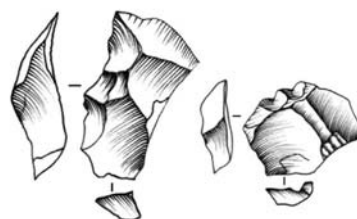


Fig. 8. Organisation of Levallois and Discoid LTC.

(Bourguignon et al., 2006), following the reinstallation of the core volume and the removal of specific convexity management flakes (Boëda's 2013, Type E). Levallois products present a wide range of functional features, either when unmodified or following resharpening or reduction trajectories of different intensities resulting in various scraper and denticulate tool forms (Dibble, 1984, 1987, 1995). This large variety of tool types, the foundation of Bordes' facies, is a component of the Levallois techno-complex not a defining feature. The fact that unmodified Levallois products are readily functional likely explains the low number of retouched tools in several assemblages (Fig. 7). Moreover, the exportation of both large Levallois and other types of flakes from certain sites, as demonstrated by a technological analysis and refitting of the open-air assemblage from Cantalouette 2 (Bourguignon et al., 2008), probably also influences the proportion of retouched Levallois products.

5.2 Discoid system LTC

The LTC based around the Discoid system (Boëda, 1993; Mourre and Jaubert, 1993; Peresani, 2003) are marked by flaking modalities (one, two or several flaking surfaces) whose particular configuration produces a series of predetermining and predetermined flakes (Fig. 8). However, the initial configuration stage is less complex (Bourguignon et al., 2006); flaking surfaces are unprepared and require no specific maintenance flakes (Type D volume; Boëda, 2013). Removals are essentially oriented around the continual maintenance of suitable flaking angles between

flaking surfaces and striking platforms, with the creation of ridges (guides) as the main predetermining criteria. In the study region, the chordal Discoid method (see above) is geared around the recurrent production of flakes with the same morpho-technical features along the same technological axis (oblique) of the core (Boëda, 1993). This highly productive flaking system is primarily connected to the production of "pseudo-Levallois points" and *éclats débordants*. The identification of a ramified Discoid reduction sequence involving flakes, often thick cortical elements, used as cores introduces variability in the sizes of these two main production objectives (Turq and Bourguignon, 2003; Bourguignon et al., 2004; Faivre, 2008; Gravina and Discamps, 2015).

This system appears organised around the production of identical or highly similar removals, and finds some similarities with Levallois systems. Both are flake production methods, varying in complexity depending on the operational stage, whose objective is the production of standardized flakes in terms of form. The functionally predetermined nature of Levallois products is equally evident in those produced by the Discoid flaking system, as can be seen in the low retouch frequencies for most Discoid assemblages in the northeastern Aquitaine Basin. Typical Discoid products (i.e. pseudo-Levallois points and *éclats débordants*), with their predetermined functional properties, an active edge opposite a "back", were probably used unretouched, as supported by several use-wear analyses (Bourguignon et al., 2000; Lemorini et al., 2003; Rios-Garaizar, 2007). These types of assemblages have also been associated

with specific site types geared around butchery activities (Brugal, 1999; Loch, 2003; Martinez et al., 2003; Coumont, 2005; Brugal et al., 2013).

If the chordal modality is best represented in the studied assemblages, the centripetal Discoid modality appears uniquely in association with the use of metaquartzites, which are the main raw materials available in certain geographical areas (e.g. Quercy region). Several technological studies have shown that this modality, often associated with bipolar flaking on anvil, could be a response to raw material constraints, with the natural convex surface of quartz pebble serving as effective striking platforms (Jaubert and Mourre, 1996; Thiébaud et al., 2008; Faivre et al., 2013). These modalities produce secant centripetal flakes with wide, thick cortical platforms opposite two convergent edges. Whatever the flaking modality (chordal on flint or centripetal on quartz), end-products seem to share the same morpho-technical features (Faivre, 2004).

5.3 Quina system LTC

The Quina system (Turq, 1989; Bourguignon, 1996, 1997; Faivre, 2008, 2011) is structured around a combination of operational stages that are no less complex than either the Levallois or Discoid systems. Central to the Quina flaking methods is the production of a wide range of predetermining and predetermined flakes which are integrated into various functional and production objectives (Fig. 9). Importantly, the Quina system is not limited to strictly functional objectives represented by a specific tool group - side-scrapers with Quina or demi-Quina retouch. Quina debitage is organised around the production of asymmetrical flakes

(in section or profile) with at least one elongated edge opposite a thick face (lateral back or platform) (Turq, 1989; Bourguignon, 1996, 1997; Faivre, 2008, 2011). These products, although varying in size over the course of the reduction sequence, nevertheless remain essentially identical and afford *diverse* and *complementary* morpho-functional possibilities (Bourguignon et al., 2006). Moreover, the volumetric potential of Quina-type flakes, particularly in terms of their thickness, allows different core-on-flake/tool (the *éclat matrice* in French; Bourguignon et al., 2004; Faivre, 2011) reduction sequences. This represents an important departure from the standardised products typical of the Levallois and Discoid systems to the extent that technical investment is not primarily focused on the 'core'.

5.4 Mixed system LTC

A number of assemblages (n=11, Table 2) provide evidence for the combination of two or more systems described above. It is important to note that in all of these mixed LTC, one system is clearly dominant (the first listed in Table 2). It is interesting to note that the Quina is the only system never found in association with another one. Levallois and non-Levallois blade systems are found together in 3 instances, 5 cases combine the chordal Discoid and Levallois systems with evidence for non-Levallois blade production, with the final 3 described as a mix of Levallois with the production of unipolar elongated flakes (see below). In some cases, these mixed assemblages may be interpreted as local adaptations to raw material constraints, where imported elements (non-local raw materials) of one system are found alongside those of another produced on-site in, what are often, poor quality raw materials (Chalard et al., 2007; Faivre et al., 2013).

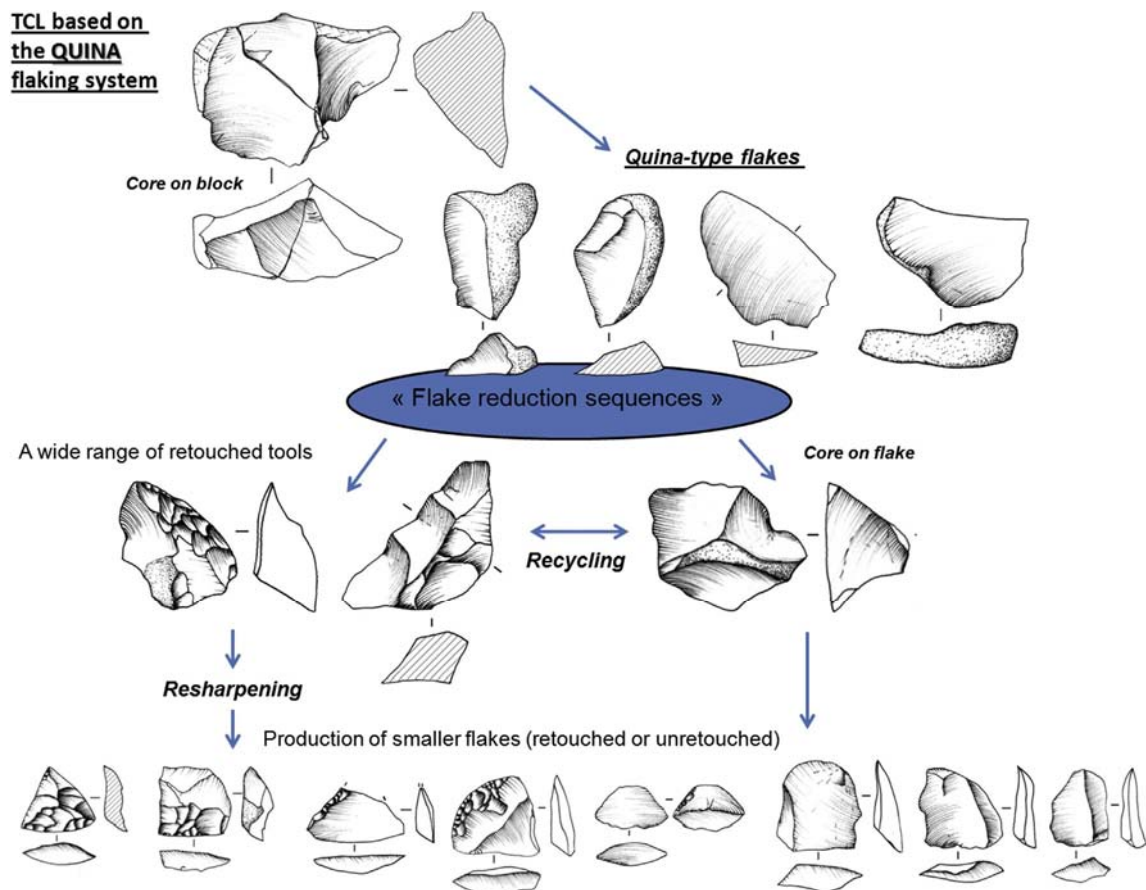


Fig. 9. Organisation of the Quina LTC.

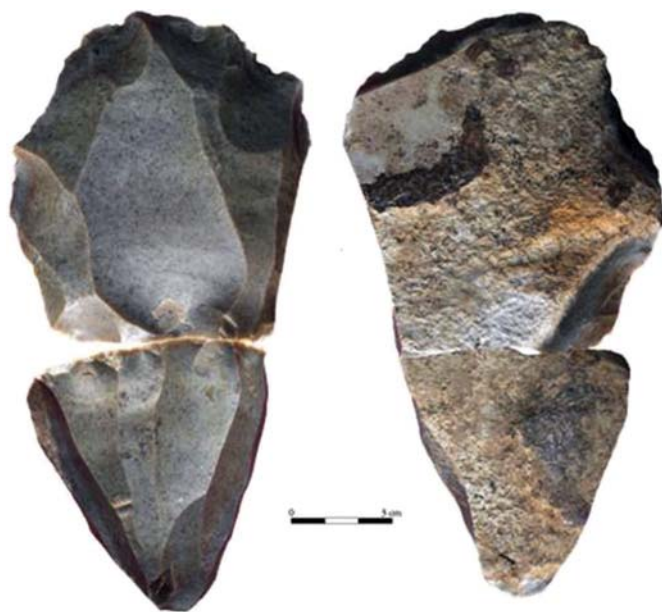


Fig. 10. Refit between a Levallois core and a non-Levallois blade core from Cantalouette IV (Blaser et al., 2012).

More often than not, mixed assemblages concern the same local raw material, rendering it difficult, if not impossible, to distinguish imported elements. Here, the combination of different systems could be interpreted as reflecting disturbances between different non-synchronous assemblages, especially in cave or rock shelter sequences. However, spatial data and refits at open-air sites succinctly demonstrate the coexistence of Levallois and non-Levallois blade production within the same occupation, as at Cantalouette IV (Blaser et al., 2012; Fig. 10). Additionally, several open-air assemblages show the combination of Levallois and chordal Discoid systems in the same knapping areas or, as revealed by refits, between adjacent areas (Brenet, 2012).

6. Conclusion

Lithic technology, like any other research field, is based on concepts and terminology shared by an international community of researchers who worked and are still working on the contexts discussed in this paper. Here we have shown that, based on well-defined technological criteria (i.e. an *explicit* typology), the *chaîne opératoire* approach can rely on quantitative data. Statistical analysis of this quantitative technological data supports previous qualitative CO descriptions. The identification of a specific CO in a given lithic assemblage is thus neither ad hoc nor intuitive, but rather a reliable methodological tool supportable by quantitative data. Certain LTC can be defined both qualitatively and quantitatively and serve as the most secure basis for advancing our understanding of Mousterian techno-economic variability. Similar approaches combining quantitative data and *chaîne opératoire* derived observations have also been successively employed to either identify reduction stages (Scerri et al., 2015) or incorporate technological analysis with raw material economy (Will et al., 2014). Despite the fact that the combination of different analytical approaches is more often than not beneficial, the advantages of including technological data in lithic studies are, in our opinion, evident. The *chaîne opératoire* approach elaborated here not only succeeded in identifying clear patterns of shared technological behaviour but also infuses models of Neandertal techno-

economy, mobility patterns, and landscape exploitation with a dynamism that strictly quantitative approaches are, in our opinion, likely to fail to detect.

The LTC identified here group distinct assemblages that share a common, recurrent and, more often than not, exclusive flake production system. The technological definition of LTC succinctly moves us beyond both the dependence on retouched tool types and the dichotomy of Levallois and non-Levallois assemblages, leading to the ultimate abandonment of the culturally charged 'facies' concept of Bordes. The preliminary adoption of the more neutral term 'techno-complex' embodies shared technological behaviours that structure Mousterian industrial variability. Currently, the search for their 'meaning', however, appears pre-mature, confounded by the lack of faunal data, raw material exploitation patterns, and comparable chronological information for many of the assemblages considered here.

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