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The contribution of lithic production systems to the interpretation of Mousterian industrial variability in south-western France: The example of Combe-Grenal (Dordogne, France)

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abstract

Disentangling the relative contribution of the various factors underlying Middle Palaeolithic industrial variability remains one of the foremost problems for researchers interested in Neandertal technological and behavioural adaptations. The site of Combe-Grenal (Dordogne) has figured prominently in these discussions given its long stratigraphic sequence and rich archaeological record that extends from MIS 6 to MIS 3 and contains all of F. Bordes' Mousterian facies. Departing from a strict typological approach, we provide a revised vision of the site's sequence focused on individualising lithic production systems. We investigate to what extent typologically different industries, beyond their separation imposed by the very idea of discrete Mousterian facies, nevertheless portray comparable production systems. By eschewing a chronology of the traditional Mousterian facies, our technological approach to the Combe-Grenal assemblages succeeded in identifying a clear stratigraphic succession where strictly typological approaches had previously failed. Moreover, comparison with other regional sequences shows the succession of Mousterian technological systems identified at Combe-Grenal not to be an exception in south-western France. We propose a revised chronology for the site's sequence based on a correlation of changes in the structure of regional faunal communities with independent palaeo-environmental data. Finally, comparing technological data with raw material provisioning strategies and elements of faunal exploitation, such as prey availability, provides insights concerning the interpretation of Mousterian variability and the investigation of changing patterns of Neandertal landscape use.

1. Introduction

Archaeological perspectives on Neandertal behavioural capacities remain a source of long-standing debate and have come to include a variety of interrelated and sometimes contradictory approaches integrating material, demographic, and social elements. These new research paradigms have also recently benefited from the development of regional environmental proxies and an expanded corpus of numerical dates providing important new contextual information (e.g. Guibert et al., 2008; Sánchez-Goni et al., 2008; Discamps et al., 2011; Guérin et al., 2012). Many of these competing ideas have, not surprisingly, taken the rich and varied Mousterian occupation of southwestern France as an ideal

testing ground. Over the last 60 years, our conception of this region's Middle Palaeolithic record has traversed several successive stages characterised by different theoretical perspectives and methodologies. From the development of François Bordes' typological approach during the course of the 1950s emerged the original definitions of the different Mousterian facies that are still in use today (Bordes and Bourgon, 1951; Bordes, 1953, Bordes, 1981). These industrial entities, characterised essentially by the relative frequencies of retouched tools, fixed the limits of what is now commonly referred to as "Mousterian variability". Once defined, these facies - "Typical", "Ferrassie", "Quina", "Mousterian of Acheulean Tradition" (MTA), and "Denticulate" - formed the basis for several interpretative models held to account for their variability. In order to avoid any terminological confusion, Bordes' typologically defined Mousterian facies are placed in quotations throughout this paper. For Bordes, who maintained that each of his

retouched tools types reflected a behavioural reality, which, when summed, represented normative stylistic traditions, defended the idea that behind his five Mousterian facies lay separate contemporaneous cultural phyla (Bordes and Bourgon, 1951; Bordes, 1961). With the emergence of the New Archaeology and its dissatisfaction with cultural-historical approaches came the cultural ecology influenced “functional model” of L. and S. Binford (Binford and Binford, 1966, 1969; Binford, 1973, 1977, 1989). Here, variations in tool frequencies were interpreted simply as different tool-kits geared around varying tasks, most notably butchery and woodworking.

Roughly contemporary with the so-called Bordes-Binford debate, Mellars (1965, 1969, 1970, 1988, 1989, 1996) introduced a chronological dimension to the debate based on his reading of the relative stratigraphic superimposition of Bordes' three major industrial variants (“Ferrassie”, “Quina”, “MTA”). While the general significance of the “Typical” and “Denticulate” variants remains a “largely open question” (Mellars, 1992:39), the explanation of a clear chronological separation of the more distinctive ones as being tied to unrelated technological traditions recalls certain aspects of Bordes' perception of the ‘cultural’ or ‘behavioural’ character of Middle Palaeolithic variability. Although Mellars' model loosely touches upon related issues of resource availability, site function, and environmental influences, the alternative tool reduction hypothesis of H. Dibble and N. Rolland (Dibble, 1984, 1987, 1995; Rolland, 1981, 1988; Dibble and Rolland, 1992; Rolland and Dibble, 1990) integrates them as principle causative factors. The central tenant of the reduction model is the typological plasticity of Bordes' variants whereby the progressive resharpener/reduction of blanks and retouched tools as a function of both occupation intensity and proximity to raw materials effectively controls the frequencies of retouched tools types in particular assemblages. In questioning the reality of Bordes' variants as discrete industrial entities, Dibble and Rolland emphasise the role of raw material contingencies and occupation intensity against their climatic backdrop, including biomass fluctuations, as the most parsimonious explanation of Middle Palaeolithic assemblage variability.

What is clear from the above is that, sixty years on, the significance of Mousterian variability in south-western France remains not only a topic of great interest but appears no closer to being satisfactorily resolved. A substantial obstacle inhibiting a clearer, more holistic understanding of this variability lies, in our opinion, with the multiplicity of analytical approaches privileging either typology or technology, or those that combine different elements of both (i.e., techno-typological approaches). Moreover, this relative wealth of approaches can easily confound the non-specialist: for example, the “Quina Mousterian”, as defined by the typological approach of Bordes (1961), differs considerably from that derived from a consideration of Quina reduction strategies as made evident in the technological analyses of Turq (1988, 1992) and Bourguignon (1997). This paradox is largely due to the persistence of blurred and ambiguous definitions of particular lithic techno-complexes (LTC) in recent techno-typological approaches, where the relative importance of typological elements, on the one hand, and technological arguments, on the other, are rarely made explicit.

One of the primary goals of this article is an attempt to untangle typology from technology such that current issues surrounding Late Mousterian assemblage variability in south-western France emerge clearer and framed more succinctly theoretically. Retouched tool types, historically considered typical of particular Mousterian facies, are influenced by the management of raw materials and concomitant technical demands of the production system, as well as being adaptable to specific contexts and differing economic decisions. Here we investigate to what extent typologically different industries, beyond their separation imposed by the very idea of discrete Mousterian facies, nevertheless portray identical production

systems. Finally, building on the chrono-cultural approach first developed by Mellars and eschewing the chronology of traditional typological variants as much as possible, we instead focus attention on the temporal succession of Mousterian production systems (Delagnes and Meignen, 2006; Faivre, 2011).

2. Material and Methods

2.1 The Combe-Grenal sequence

South-western France, and especially the Périgord region, is well known for its long tradition of archaeological research and rich Palaeolithic record. Amongst the region's numerous Middle Palaeolithic sites, including open-air localities, is the substantial archaeological sequence documented at Combe-Grenal (Dordogne, France; Fig. 1) by F. Bordes between 1953 and 1965. This 13-m thick deposit spread across three superimposed rocky terraces contains 55 Middle Palaeolithic layers. The final part of the sequence (layers 1-37; Fig. 2) on the uppermost terrace has produced an unequalled archaeological, climatic, and environmental record of the region's Mousterian occupation. Moreover, the diversity of the various industries documented at the site not only contributed to the original definition of Bordes' Mousterian variants but also the various interpretive models (see above) held to account for their variability both in south-western France and further afield. The study of material recovered from Combe Grenal has also allowed specific techno-economic aspects of particular reduction sequences (Geneste et al., 1997; Turq, 2000; Bourguignon and Turq, 2003; Bourguignon et al., 2004; Faivre, 2011) as well as patterns of scraper production and maintenance (Lenoir, 1986; Panabières, 1989), the reduction of notched tools (Hiscock and Clarkson, 2007), or the function of different tool-kits (Anderson-Gerfaud, 1981; Beyries and Walter, 1996) to be explored in greater detail.

Based on information gleaned essentially from Bordes' excavation notebooks, Dibble et al. (2009) have recently highlighted certain

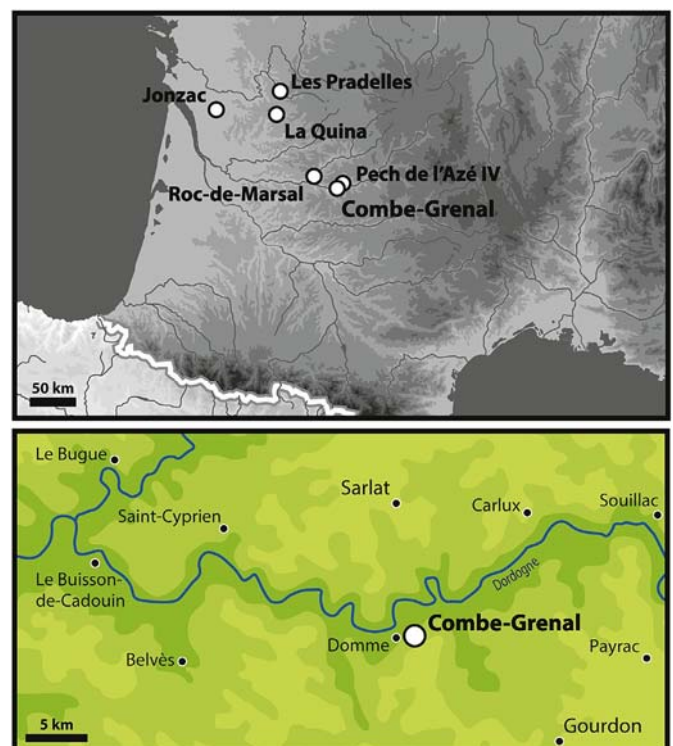


Fig. 1. Location of Combe-Grenal.

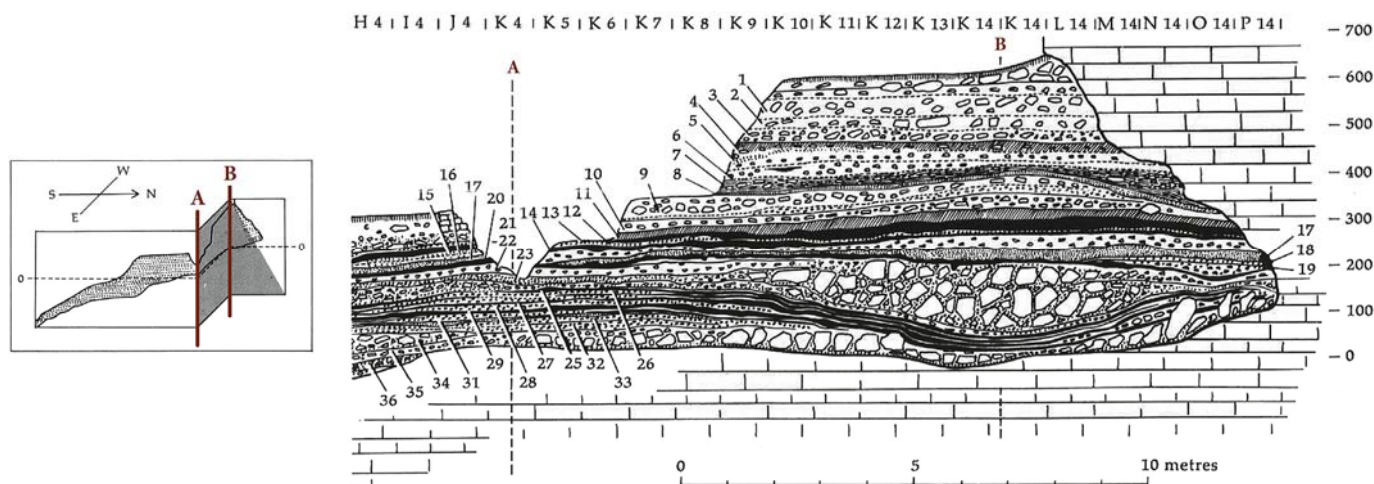


Fig. 2. Stratigraphy of the uppermost terrace at Combe-Grenal (after Bordes, 1972).

problems with the stratigraphic integrity of particular lithic assemblages from Combe-Grenal currently housed at the Musée national de Préhistoire (Les Eyzies de Tayac). These authors focus particular attention on problems evident in the existing documentation concerning these contexts (excavation notebooks and spatial data) as well as cumulative errors connected to the repeated manipulation of the material over numerous years. Despite the reality of these problems and their not unsubstantial implications for the study of this material, these biases are stratigraphically inconsistent and only differentially affect the Combe-Grenal assemblages. Moreover, in pointing out these issues, Dibble et al. do not question the chrono-cultural model whereby the “Quina Mousterian” succeeds the “Ferrassie Mousterian”. In our view, neither the feasibility of a technological analysis of the lithic material nor an investigation of associated raw material economies is in any great way compromised by these issues. This assertion is supported by recent studies (Faivre, 2011, 2012) demonstrating that these types of analyses, when applied to several successive layers, produce coherent results revealing broad techno-economic trends during the course of the last glaciation.

2.2 Methodology

Over the last few decades, research focused on Middle Palaeolithic industries has distinguished different lithic production systems characterised by a specific type of debitage. Currently, several such production systems have been identified according to the exclusive

sub-products (cortical or management flakes) that are then used as blanks (core-flakes) to produce a variety of secondary products with different morpho-technical and functional characteristics.

When this type of analysis is applied to the Combe-Grenal material, it becomes clear that each lithic production system functions according to its proper technical rules that themselves portray techno-economic concerns tied to different objectives, including, but by no means limited to, retouched tools. For instance, certain assemblages have a lower extremely limited retouched tool component leading to their being attributed to the “Typical” (e.g. layers 29–30) or “Denticulate Mousterian” (e.g. layer 38) by default. However, this limited proportion of retouched tools is often counterbalanced by an abundance of diverse, unmodified, and sought after end-products that are themselves the principle production objective.

While previous technological studies (Pelegriin, 1990; Delagnes, 1992; Turq, 2000; Bourguignon and Turq, 2003; Thiébaud, 2005; Faivre, 2011) of material from the upper layers of the Combe-Grenal sequence determined general trends in primary flaking strategies (Table 1), more recent work added further precision concerning techno-economic aspects. The revision of the Combe-Grenal sequence presented here is based on either detailed technological analyses or qualitative aspects of certain layers, complemented by already published information (see Table 1 for details).

Table 1
Combe-Grenal, upper terrace. Mousterian facies (after Bordes, 1972, 1981) and associated production systems.

Layer	Mousterian facies	Technological system	References
1–4	“Mousterian of Acheulean Tradition”	Discoid Bifacial shaping Non-Levallois laminar	Pelegriin 1990; this study
5–6	“Typical”	Discoid/Levallois	Faivre 2011, this study
7	“Typical”	Levallois	Faivre 2011, this study
10	“Typical”	Discoid/Levallois	This study
11–12	“Denticulate”	Discoid	Thiébaud 2005; Faivre 2008
13–15	“Denticulate”	Discoid	Bourguignon and Turq 2003
16	“Denticulate”	Levallois/Discoid Bladelet technology	Faivre 2011
17–19	“Evolved Quina”	Quina	Faivre 2011
20	“Denticulate”	Quina	Faivre 2009–2010
21–26	“Classic Quina”	Quina	Turq 2000
27	“Ferrassie”	Levallois	Faivre 2008
28–31	“Typical”	Levallois	Faivre 2011
32–35	“Ferrassie”	Levallois	Delagnes 1992, Faivre 2011
36–37	“Typical”	Levallois	Faivre 2011

use of a particular primary flaking strategy combined with a consideration of their variability: Levallois (Boëda and Pelegriin, 1983; Boëda et al. 1990; Van Peer, 1992; Boëda 1994; Dibble and Bar-Yosef, 1995; Scott, 2011), Discoid (Boëda, 1993; Jaubert, 1994; Locht and Swinnen, 1994; Jaubert and Mourre, 1996; Peresani, 1998; Bourguignon and Turq, 2003), Quina (Turq, 1989, 1992; Bourguignon, 1996; Hiscock et al., 2009), trifacial (Boëda, 1991; Chevrier, 2006), Clactonian (Ashton et al., 1992), a system of alternating debitage surfaces or SSDA (Forestier, 1993; Boëda 1997), bifacial shaping (Boëda, 1996; Soressi, 2002), or Mousterian blade production (Boëda, 1988; Otte et al. 1990; Meignen, 1995; Révillion, 1995).

Our technological approach is essentially based on the concept of the *chaîne opératoire ramifiée* or *ramified reduction sequence* (Geneste, 1991; Bourguignon et al., 2004; Faivre, 2011), also referred to as *dendritic reduction sequence* (Delagnes and Rendu, 2011), that aims to reconstruct economic considerations and behavioural choices underlying raw material use. Sub-divided into two interrelated operational stages, *ramified reduction sequences* initially involve block-cores supplying predetermined technical and functional products as well as

3. Results

3.1 Layers 35-27: the Levallois system and comparison between the "typical" and "Ferrassie" variants

Layers 31 through 28, as well as 37 and 36, are all assigned to the "Typical Mousterian" and found inter-stratified with "Ferrassie" assemblages (layers 35-32) in the heart of the Combe-Grenal sequence. Bordes' (1955) original publication qualified layers 28-30 as "attenuated Ferrassie Mousterian", which he subsequently reattributed to the "Typical Mousterian" nearly 20 years later in his synthesis of the Combe-Grenal sequence, "A Tale of Two Caves" (Bordes, 1972). This alteration was most likely motivated by the development of his analytical method and the relative importance of its different typological indexes.

However, while genuine differences certainly exist between these groups of assemblages, a closer examination of the original attributions of layers 28 through 30 is revealing. Focusing on the assemblages from layers 29-30 and 27, assigned, respectively, to the "Typical" and "Ferrassie Mousterian", it is possible to demonstrate that they all share common technological features (Fig. 3). Both share the same methods and conceptions of flake production, recurrent uni- and bipolar Levallois debitage, that, although subject to some insignificant quantitative variation, remain extremely homogeneous (e.g., differences in the proportions of Levallois cores are not statistically significant, $\chi^2 4.223$; $p > 0.05$; cf. Table 2). This consistency is reinforced by both the morphology and dimensions of similar sought-after Levallois products that could be used unmodified or transformed by retouch. In terms of this retouched tool component, both the variety and respective

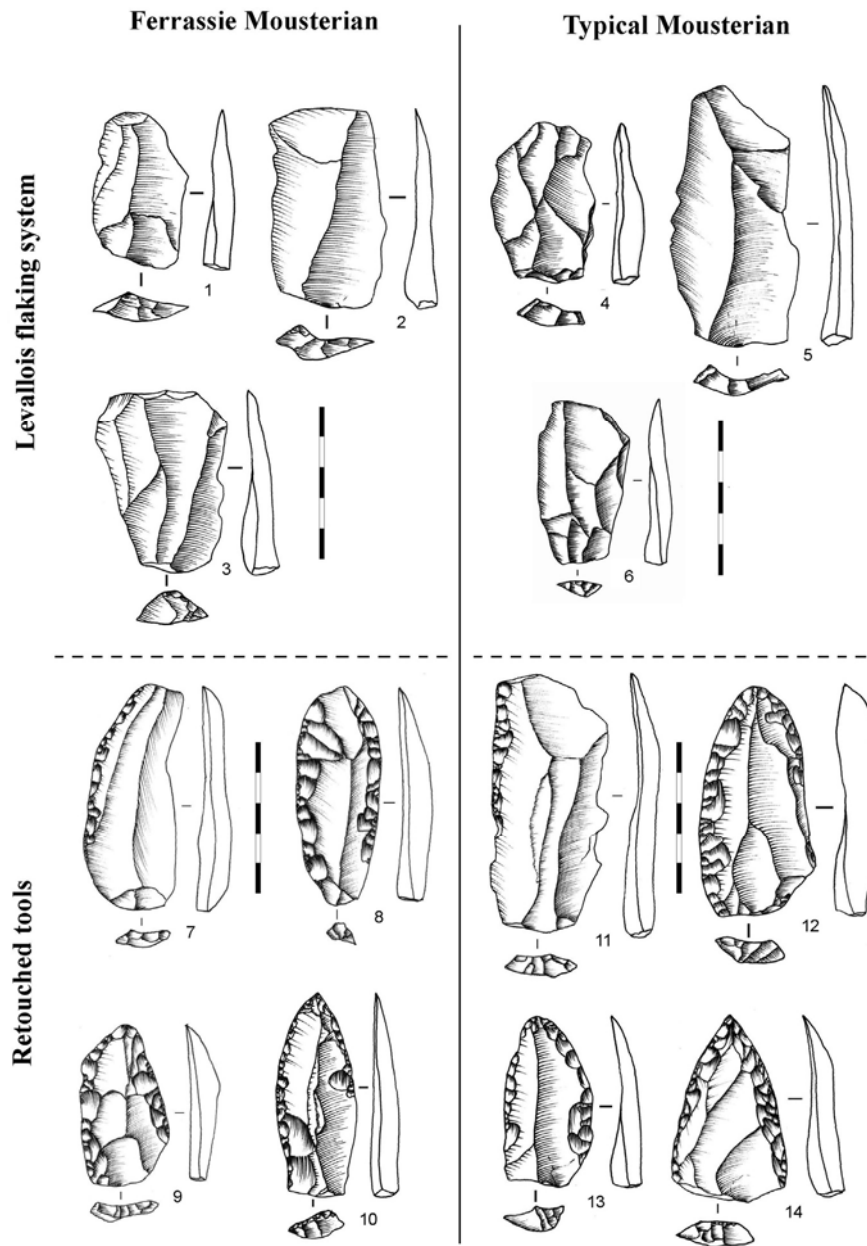


Fig. 3. Comparison of the Levallois production system in the "Ferrassie" (layer 27) and "Typical Mousterian" (layer 29 and 30) of Combe Grenal. 1-6: unretouched Levallois flakes; 7, 11: single side scrapers; 8-10 and 12-14: convergent scrapers and Mousterian points.

frequency of tool types are remarkably consistent (Table 3). Single or double scrapers (including convergent and Mousterian points) occur in high frequencies (differences between layers are not statistically significant, $\chi^2 = 0.036$; $p > 0.05$), while notches (Clactonian or retouched) and denticulates are less common and remain quantitatively consistent between the two industries (differences between layers are not statistically significant for notches, $\chi^2 = 1.242$; $p > 0.05$, but are, albeit not by much, statistically significant for denticulates $\chi^2 = 4.106$; $p < 0.05$). In terms of debitage economy, retouched tools are produced on two broad categories of blanks, Levallois products and partially cortical flakes. In addition to similarities in blank selection, coherent functional characteristics (retouch intensity, delineation of the retouched edges, working edge angles) reveal more or less identical processes of transforming the tool's active edges.

Table 2
Percentages of Levallois products (retouched or not) and cores for "Ferrassie Mousterian" (layer 27) and "Typical Mousterian" (layer 29-30).

	Ferrassie layer 27		Typical layers 29-30	
Unretouched Levallois product	196	50%	306	63%
Retouched Levallois product	198	50%	178	37%
Total	394	100	484	100
Levallois Cores	39	68%	48	77%

Table 3
Retouched tool counts for the "Ferrassie Mousterian" (layer 27) and "Typical Mousterian" (layers 29 and 30).

	Ferrassie layer 27		Typical layers 29-30	
	N	%	N	%
Single scrapers	127	39%	134	37%
Double scrapers	43	13%	48	13%
Convergent scrapers	25	8%	32	9%
Mousterian points	14	4%	16	4%
Déjeté scrapers	40	12%	17	5%
Transverse scrapers	12	4%	3	1%
End-scrapers (typical/atypical)	1	0.3%	3	1%
Truncations	1	0.3%	2	0.5%
Backed knives	1	0.2%	3	1%
Perçoirs	1	0.2%	2	0.5%
Clactonian notches	6	2%	15	4%
Retouched notches	13	4%	14	4%
Denticulates	23	7%	42	11%
Composite retouched tools	21	6%	34	9%
Total	328	100%	365	100%

The main difference between the assemblages ultimately resides in retouched tool frequencies, which are on average two times higher in the "Ferrassie" contexts (12% in layers 29-30, 24% in layer 27; differences are highly statistically significant, $\chi^2 = 171.508$; $p < 0.001$). Moreover, this higher frequency is accompanied by an elevated representation of resharpening flakes that translates as a clear marker of more intense tool reduction (5% in layers 29-30, 17% in layer 27; differences are highly statistically significant, $\chi^2 = 57.9$; $p < 0.001$). This character is also clearly apparent with double and convergent scrapers, some of which bear scaled and occasionally stepped retouch indicative of more prolonged reduction sequences, as anticipated in Dibble's reduction model (1987, 1995).

While the "Typical" and "Ferrassie" industries share the same method (Levallois) for producing blanks with predetermined morphologies, the frequency and intensity in which they are retouched and resharpened clearly differs. Although drawn from a common technological base, these differences may very well

represent varying functional and economic choices with a temporal significance. The variability of these assemblages effectively consists in the respective emphasis accorded to retouched tools and unmodified debitage products. This notion of economic and functional mechanisms or concerns underlying Levallois debitage is similarly echoed in the overlying Quina industries.

32 Layers 26 to 17: internal variability of the Quina production system. The example of layer 20

The Combe-Grenal sequence also contains evidence for the internal variability of the "Quina Mousterian", where the major element separating the 'classic' from 'evolved' forms is the increased importance of notched and denticulated tools in the latter (Le Tensorer, 1978; Turq, 1979). In this developmental model, traditionally considered as linear, a stark rupture is evident with layer 20 assigned to the "Denticulate Mousterian" by Bordes (1955, 1972). A recent re-analysis of this layer (Faivre, 2011) identified several elements that place it squarely within the diachronic variability of Quina reduction strategies at Combe-Grenal (layers 26-21 and 19-17). In both these groups of assemblages, as well as in layer 20, flake production is identical both in terms of debitage economy (the reduction of blocks/nodes and flakes) and production objectives (thick asymmetrical flakes, Fig. 4). The fact that two typologically different assemblages can nevertheless share the same technology has previously been identified by Dibble's (1995) comparison of layers 22 and 25 of Combe-Grenal with the material from Combe-Capelle Bas.

The second point of coherence specifically concerns functional options (i.e., transformation of Quina debitage products) responsible for the original attribution of layer 20 to the "Denticulate Mousterian". For instance, clear differences are perceptible in the transformation of flake blanks between layers 17 and 20, which are dominated, respectively, by scrapers or Clactonian notches and denticulates (layer 17, $n = 318$ tools, 52% scrapers, 32% notches/denticulates; layer 20, $n = 260$ tools, 13% scrapers, 78.5% notches/denticulates; differences are statistically highly significant $\chi^2 = 127.219$; $p < 0.001$). This variability is directly connected to the inherent flexibility of thick, asymmetric Quina-type flakes that are not only easily adapted to fulfil different functional requirements but also produced as part of an identical production system incorporating the same technical elements. These layers document equivalent technological behaviours geared around different functional objectives. By effectively effacing certain divisions between two industries, the identification of this technological coherence raises questions concerning the interpretation of differences between lithic techno-complexes or Bordes' Mousterian variants ("Quina" vs. "Denticulate").

33 A Complicated end for the Combe-Grenal sequence (layers 16-1): variable industries with somewhat unclear technological transitions?

While the succession of primary flaking strategies discussed above is fairly clear for layers 37 through 17, the situation in the final part of the sequence is more problematic. Despite the final four layers containing an extremely limited number of lithic artefacts ($n = 244$, 114, 144, and 99), the presence of several bifaces and associated waste products (Bordes, 1972; Pelegrin, 1990; Soressi, 2002; this study) have, not surprisingly, led to their being attributed to the "Mousterian of Acheulean Tradition". Artefact counts correspond to the number of pieces currently found in the boxes labelled levels 1-4 housed at the Musée national de préhistoire, Les-Eyzies-de-Tayac. Conversely, the absence of any clear typological or technological markers combined with the relatively small

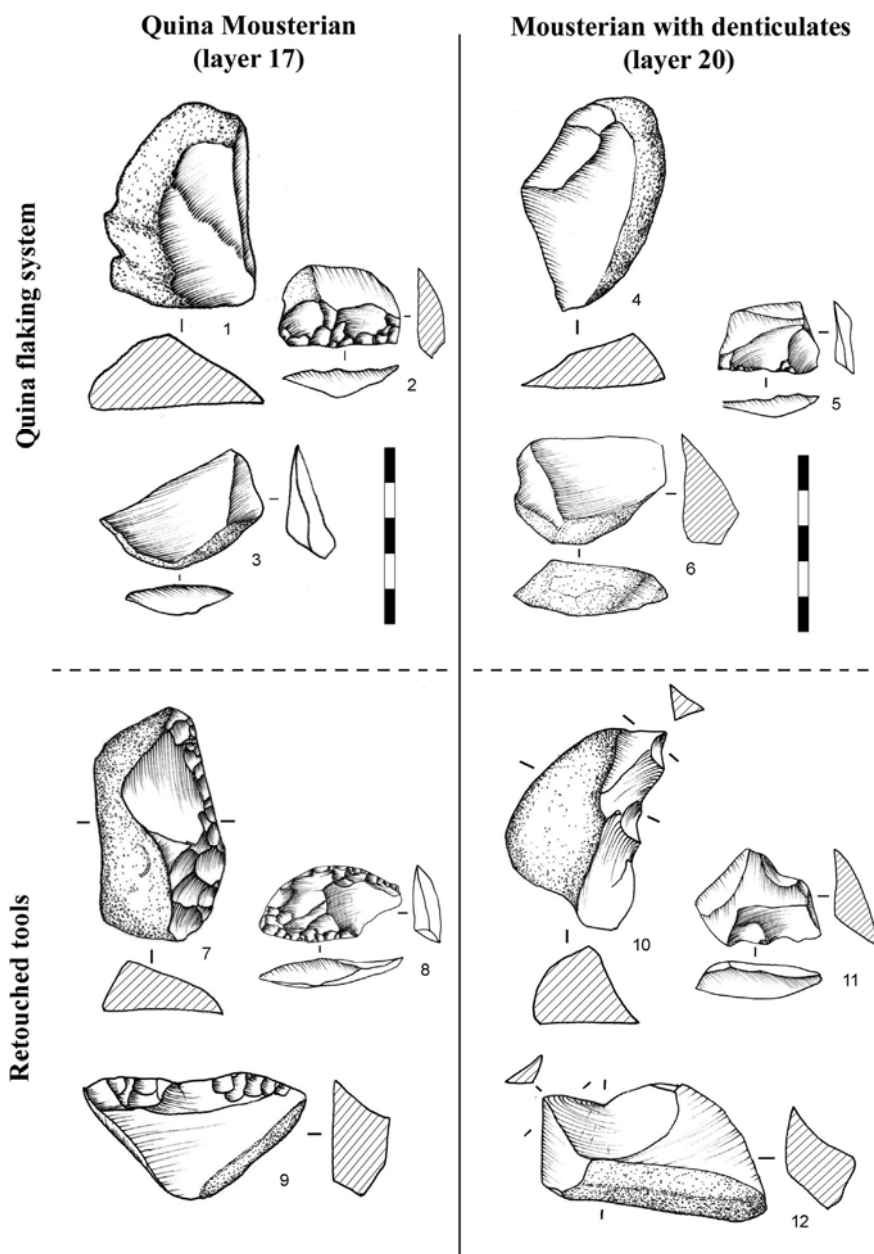


Fig. 4. Comparison of industries based on a Quina production system attributed to the “Quina Mousterian” (layer 17) and “Denticulate Mousterian” (layer 20). 1-6: asymmetrical flakes with cortical back or thick platforms; 7-9: scrapers made on asymmetrical flakes (as described in text); 10-12: Clactonian notches on asymmetrical flakes (as described in text).

size of the assemblages from layers 5 through 10 undoubtedly contributed to their attribution to the “Typical Mousterian”. Finally, the more consequential layers 11-16 were all characterised as “Denticulate Mousterian” by Bordes (1972). When viewed in terms of primary flaking strategies, by far the most important aspect of this portion of the sequence is the predominance of the Discoid method associated with notches and denticulates in layers 15 through 11 (Bourguignon and Turq, 2003; Thiébaud, 2005; Faivre, 2011, Fig. 5). Although Discoid and Levallois methods coexist in layers 16, 10-8, and 6-2, the small size of the assemblages precludes any certainty regarding the relative importance of either. Interestingly, the Levallois method is most prevalent in the scraper-rich layer 7.

In light of the questions raised by Dibble et al. (2009) concerning the stratigraphic integrity of some of the Combe-Grenal

layers, it is entirely possible that the elevated presence of Levallois products in layer 6 may be due in part to their introduction from the immediately underlying Levallois-rich layer 7 via either errors in the field, post-excavation mixing or re-attribution. For instance, Dibble et al. (2009) note that the three-dimensional plotting of nearly 15% of the objects assigned to layer 11 during excavations are incompatible with their assignment to this layer. Similarly, layer 16, which presents a stark technological departure from the underlying Quina layers given a mix of Discoid and Levallois elements and the anecdotal presence of blade/bladelet production (Faivre, 2012), may also have suffered some form of excavation bias. For instance, is the high proportion of denticulates in layer 16 a product of Bordes' excavation methodology (successive horizontal *décapages*), whereby objects were incorporated from the overlying denticulate-rich layer 15 assigned to the

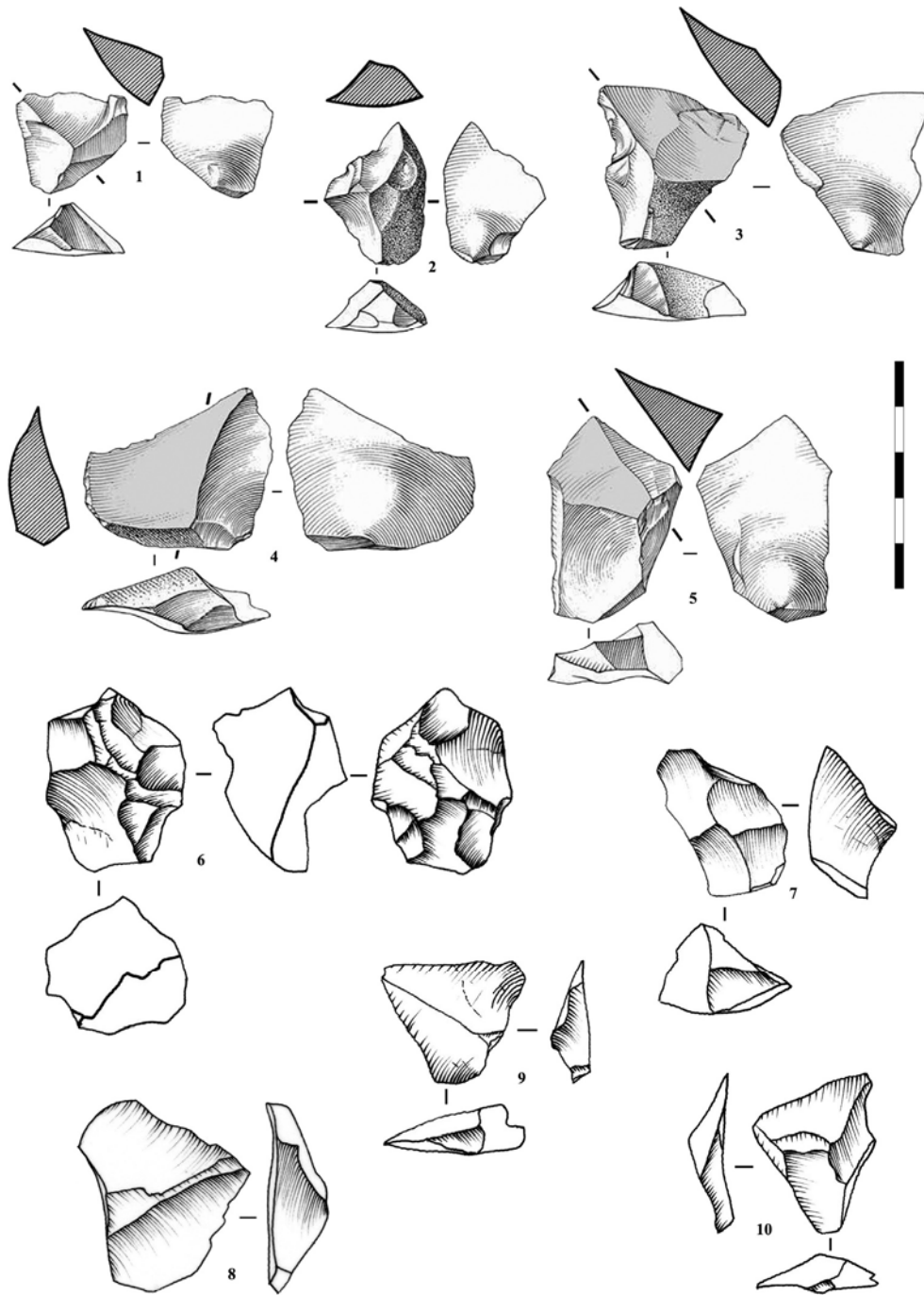


Fig. 5. Examples of Discoid products from layers 14 (1-5) and 12 (6-10): Kombewa-type pseudo-Levallois points (1-5) and pseudo-Levallois points (7-10), bifacial Discoid core (6) (after Bourguignon and Turq, 2003; Faivre, 2008).

“Denticulate Mousterian” (Bordes, 1972; Thiébaud, 2005) during fieldwork? The possible problems identified above combined with the likely event of some post-depositional mixing at the interface of each layer may go some way in explaining the variability of the thinner, less dense final layers and our inability to distinguish similarly clear patterning in primary flaking strategies. In comparison, the richer Quina and Levallois episodes (see above) were excavated over a larger area and portray substantial temporal stability in terms of technology.

In sum, while the final portion of the Combe-Grenal sequence presents what on the surface appears to be fairly straightforward

typological succession, the relatively small size of the assemblages leaves open some uncertainty. This is particularly the case with layers 1-4 assigned to the “MTA”, which, for the moment, is the one of the only known examples of this type of industry overlying the Discoid-Denticulate Mousterian in south-western France (Jaubert et al., 2011). The near exclusive presence of Discoid products (Table 4) in layer 1 does, however, question its attribution to the “MTA-B”. What is nevertheless clear is that from layer 16 onwards, the Discoid method appears with varying intensity, becoming the exclusive or dominant primary flaking strategy in layers 15 through 11 and in layer 1.

Table 4
Retouched tool and blank counts for the “MTA-B” (layer 1).

	Type	Nb
Core	Levallois	1
	Discoid	7
	multi-directional	1
	non-Levallois recurrent centripetal	1
	indeterminate	1
Flake	primary flake and cortical flake >50%	38
	cortical flake <50%	43
	Levallois	1
	typical pseudo-Levallois point	17
	atypical pseudo-Levallois point	26
	<i>eclat debordant s.l</i>	32
	non-Levallois centripetal flake	15
	elongated flake	1
	Kombewa-type	4
	sharpening/resharpening flake	11
	non-diagnostic flake	26
Waste		23
Biface		2
Retouched tool	single side scraper	1
	atypical back knife	7
	denticulate	3
	notch	4
Total		250

34 The chronological succession of primary flaking strategies at Combe-Grenal

Based on the above, the upper part of the Combe-Grenal sequence demonstrates an archaeo-stratigraphic organisation (Fig. 6), where a succession of Levallois, Quina, and ultimately Discoid debitage systems is readily apparent. Each can appear in equal measure (Levallois and Discoid) or come to be the dominant (Levallois or Discoid) or exclusive (Quina or Discoid) primary flaking system. Interestingly, our technological approach succeeded in identifying a clear stratigraphic succession where strictly typological approaches had previously failed (Fig. 6). While the “Quina Mousterian” from layers 17 through 26 at Combe-Grenal provides evidence for the emergence of an independent debitage system (Quina flaking system), assemblages attributed to the “Typical” (layers 28-31 and 36-37) and “Ferrassie Mousterian” (layers 27 and 32-25) both record the use of the Levallois system. Unlike the exclusive character of the Quina debitage system, the Levallois method, although always dominant, can coexist with other debitage systems (Discoid, laminar, “bladelet”; Faivre, 2011, 2012). Finally, the Levallois system in the lower layers is more important both in qualitative and quantitative compared to the post-Quina layers, where the Discoid system comes to dominate.

4. Discussion

4.1 Regional comparison: is the Combe-Grenal sequence an exception?

The Mousterian sequence recorded by F. Bordes at Combe-Grenal provides clear evidence for the temporal structure of the major Late Middle Palaeolithic production systems in south-western France (Delagnes and Meignen, 2006; Jaubert, 2008; Delagnes and Rendu, 2011; Discamps et al., 2011; Faivre, 2011). This stratigraphic distribution to some extent parallels Mellars' (1988, 1992, 1996) observations concerning technological change in the same region, notably the chrono-stratigraphic separation and superimposition of Bordes' “Ferrassie”, “Quina”, and “MTA” variants. Although accounting for the place of the “Typical” or “Denticulate Mousterian” in this linear conception of technological

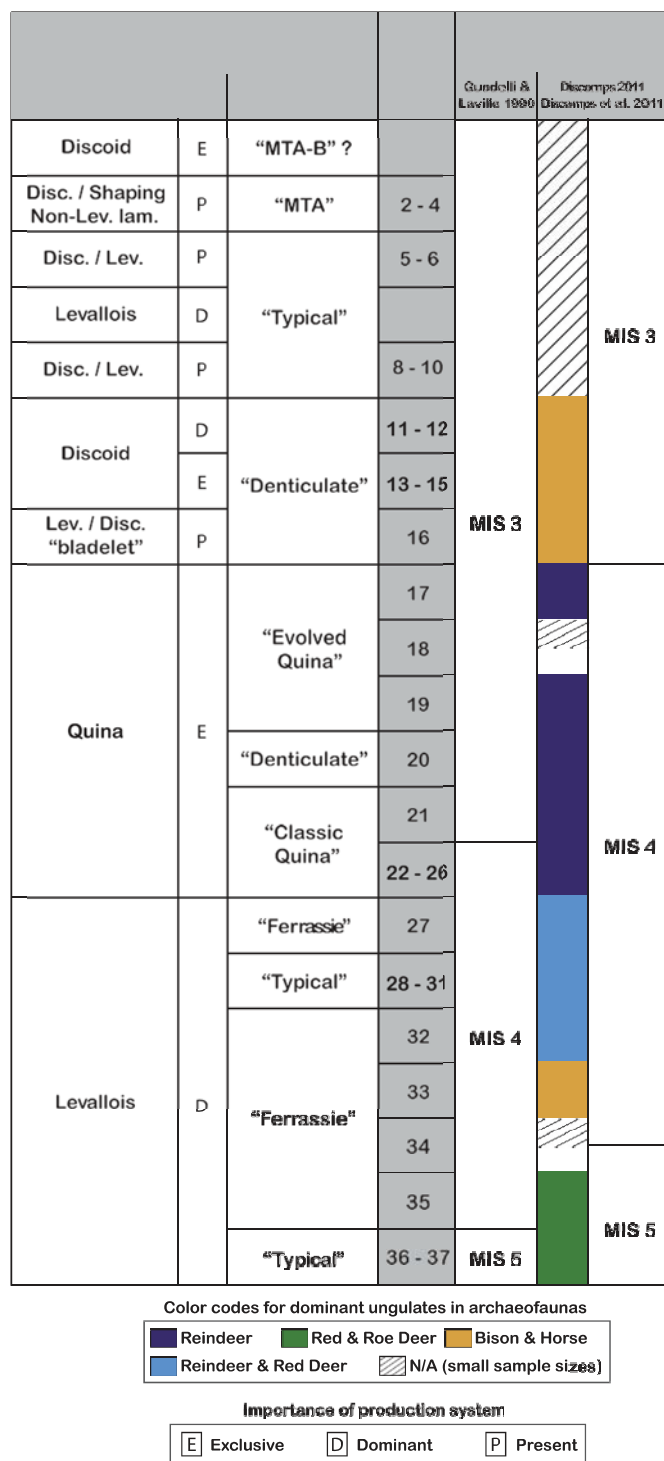


Fig. 6. Summary of the two chronological models proposed for the Combe-Grenal sequence based on faunal analyses. From left to right: 1) Technological system and its importance in each layer (e.g. exclusive), 2) Mousterian typological variants, 3) Combe-Grenal layers, 4) MIS attributions (after Guadelli and Laville, 1990), 5) Revised MIS attributions with the dominant fauna and code for the corresponding ungulate assemblage-zones (UAZ), as defined for south-western France (after Discamps, 2011, in press; Discamps et al., 2011).

evolution still remains its major stumbling block, to its credit Mellars' (1992, 1996) chronological model does mobilise technological characteristics deemed specific to the “Ferrassie”, “Quina”, and “MTA” facies (e.g. presence/absence of the Levallois method, bifacial shaping, Quina retouch, etc.).

In recent years, this regional model has been taken up anew and further elaborated using a techno-typological approach incorporating more precisely described lithic techno-complexes in comparison to Bordes' original industrial taxonomy (Jaubert, 2008, 2012, 2013; Discamps et al., 2011; Jaubert et al., 2011, Table 5). This revised archaeological succession incorporating new data from lithic technology undoubtedly represents an important step in our understanding of the Middle Palaeolithic of south-western France. With that said, the structure of this new model largely employs the same typological information and taxonomy inherited from Bordes, leaving the question of which forms of data should be given priority largely unanswered. For example, on what basis can a "Quina Mousterian" with denticulates be distinguished from a "Denticulate Mousterian" with a Quina flaking system (Faivre, 2009-10), or a scraper-rich "Typical Mousterian" with Levallois debitage from a "Ferrassie Mousterian"?

Table 5
Bordes' Mousterian facies compared with the diversity of regional lithic techno-complex (LTC) in south-western France identified by Jaubert (2012).

Mousterian facies (Bordes, 1953, 1981)	Lithic techno-complexes (Jaubert 2012)
MTA A	Recurrent Levallois, bifaces Successive crossed-unipolar Levallois/Discoid, bifaces Elongated flakes/Laminar/Discoid, bifaces
MTA B	Discoid with elongated flakes Discoid with elongated flakes and bifaces Discoid/Levallois with elongated flakes
Quina	Uni/bipolar & centripetal Levallois with backed knives Quina Quina with denticulates
Ferrassie	Levallois with large scrapers Centripetal Levallois Centripetal & unipolar Levallois Levallois/Discoid
Typical	Centripetal & Unipolar Levallois Levallois/Kombewa Levallois dominant/Discoid Levallois cf. Asinipodian
Denticulate	Discoid, denticulates Centripetal & Unipolar Levallois with denticulates Quina with denticulates Levallois dominant/Discoid with denticulates Discoid dominant/Levallois with denticulates

This conundrum effectively evokes the same issues highlighted above concerning the use of ill-defined and ambiguous industrial denominations in techno-typological approaches. The separation of Mousterian industries into discrete lithic techno-complexes still appears somewhat insufficiently substantiated in the sense that the criteria deemed apt for their definition or differentiation remain imprecise. Consequently, a reliance exclusively on quantitative data concerning retouched tool frequencies (typology), production methods (technology), raw material economy, or tool reduction models produce discordant and sometimes contradictory results. The amalgamation of these different processes and contingencies operating at different spatio-temporal scales probably goes some way in explaining differences between particular industries, and, in our opinion, the chronology of each of these doubtlessly interrelated aspects requires independent evaluation before any genuine temporal (or not) trends can be distinguished.

Although such an imposing project is still in its early stages, the results presented here do, however, allow the chronological dimension of lithic production systems to be addressed in more detail. Moreover, the succession of Mousterian technological

systems identified at Combe-Grenal is not an exception in south-western France. The same temporal organisation has been fully - or at least partially - documented in several other regional archaeological sequences (Delagnes and Meignen, 2006; Jaubert, 2008, 2013; Delagnes and Rendu, 2011): La Quina, Jonzac, and Hauteroche in the Charentes, Roc-de-Marsal, Pech de l'Azé IV, La Rochette, Abri Chadourne in the Dordogne, and La Rouquette in the Tarn.

4.2 The chronological position of the Combe-Grenal sequence

The numerical chronology of the Middle Palaeolithic in south-western France today benefits from a substantial corpus of radiometric dates (see Guibert et al., 2008 for a synthesis; Guérin et al., 2012; McPherron et al., 2012; Richter et al., 2013a, 2013b for the most recent dates). With that said, the reliability of the numerical dates produced by Bowman and Sieveking (1983) for Combe-Grenal have recently been severely questioned by Guibert et al. (2008) citing certain methodological shortcomings. Pending new numerical dates, correlating the Combe-Grenal sequence with other regional sequences and climatic events must rely on other arguments.

Based on bio-stratigraphic and geo-archaeological data available at the time, Guadelli and Laville (1990) proposed that the upper terrace layers extended from MIS 5 to 3, or between broadly 75 and 40 ka. More recently, faunal data from the Combe-Grenal sequence was integrated in a regional synthesis of Middle Palaeolithic archaeo-faunas (Discamps et al., 2011). Correlating changes in the structure of regional faunal communities with independent, high-resolution palaeo-environmental data (marine core MD04-2845 in the Gulf of Gascogne) was made possible by comparing all available stratigraphic and faunal data (from both anthropic and natural accumulations), as well as numerical dates, within the same analytical framework (Discamps, 2011; Discamps et al., 2011). This new regional archaeo-sequence allowed several Mousterian sequences to be placed within a numerical chronology, which was subsequently partly confirmed by a combination of faunal data and recently obtained radiometric dates (Guérin et al., 2012).

The revised chronology for the Combe-Grenal sequence (Discamps, 2011; Discamps et al., 2011) only differs slightly from that originally proposed by Guadelli and Laville (op. cit., cf. Fig. 6). In both models, Levallois dominated assemblages occupy the end of MIS 5 and beginning of MIS 4 (layers 37-27 of Combe-Grenal), a pattern reinforced by new radiometric dates obtained for Roc-de-Marsal (Guérin et al., 2012) and Pech de l'Azé IV (Richter et al., 2013). While Guadelli and Laville (1990) considered the 'classic' "Quina Mousterian" occupations to fall within MIS 4 and the 'evolved' variant in MIS 3, recent work tends to place the entirety of the Quina system in MIS 4 (Combe-Grenal layers 26-17). Unfortunately, numerical dates for Quina occurrences remain rare, a problem probably tied to the scarcity of burnt flint in these layers. However, recently obtained dates are nevertheless compatible with an MIS 4 age for the "Quina Mousterian", as at Jonzac (Richter et al., 2013b) and Les Pradelles (Vieilleigne and Guibert, 2007; Maureille, 2010). Both models place the uppermost part of the Combe-Grenal sequence (layers 16-1) in MIS 3.

4.3 The question of Mousterian variability

Centring analyses away from Bordes' typologically focused taxonomic system towards more holistic technological approaches clearly generates a new perception of Mousterian variability and the mechanisms underlying it. Moreover, research focused on

lithic production systems today allows for a better understanding of not only the succession and organisation of technical know-how, but patterns of techno-economic behaviour identified from the same context, which, in this case, spans a considerable period of time.

The question remains how to interpret the internal techno-economic variations of the different chronologically organised lithic production systems. This difficulty, in our opinion, harks back to questions concerning the impact of technology in models for the organisation of prehistoric groups and, more specifically, hunter-gatherer mobility strategies (e.g. Binford, 1979; Kelly, 1983, 1988; Bamforth, 1986; Kuhn, 1992, 1995; Andrefsky, 2009). In the context of south-western France, Neandertal mobility patterns have been approached by focusing on the inherent interrelation between lithic production and the dynamics of human movements taking into account, for instance, the transfer and spatio-temporal fragmentation of *chaînes opératoires* for certain raw materials or tools (Geneste, 1988, 1990, 1991; Turq, 2000; Turq et al., 2013) and the emergence of particular production systems in relation to group mobility patterns and different hunting strategies (Delagnes and Rendu, 2011).

In the case of Combe-Grenal, the comparison of technological data with information relative to raw material provisioning strategies and elements of subsistence strategies reveals interesting correspondences between lithic techno-complexes and patterns of landscape use. The Combe-Grenal sequences records substantial environmental changes during the period between MIS 5 and 3, changes readily perceptible in the faunal signal (Guadelli, 1987, 2011) and which very likely elicited significant fluctuations in available ungulate biomass (Discamps, 2011, in press). It would be expected that these environmental shifts had non-negligible effects on Neandertal behaviour and demography, including choices related to tool and or site function, subsistence strategies, and resource management. However, the Combe-Grenal sequence demonstrates that despite the amplitude and occasional rapidity of these environmental changes, they did not necessarily impact technology to any great extent. For instance, while reindeer dominate the Quina assemblages (layers 17-26), they also do in certain layers where the Levallois method prevails (layers 27-31). Interestingly, although in layer 20 reindeer gives way to horse, bovids, and deer, the lithic technology remains essentially unchanged - a techno-economic variant of the Quina production system.

Given the importance of the Combe-Grenal sequence for the Mousterian in south-western France, numerous researchers have attempted to mobilise the site's faunal assemblages to address questions related to, amongst others, subsistence strategies, symbolic manifestations, or organic tool industries (e.g. Chase, 1983, 1986, 2001; Vincent, 1993; Steele, 1999; Chase, 2001; Fernandez et al., 2006). Despite the important role of zooarchaeological data in reconstructing subsistence strategies or discussing site function, the Combe-Grenal faunal material should be interpreted with extreme caution (Guadelli, 1987, 2011). In addition to the probable curation problems highlighted by Dibble et al. (2009) concerning the lithic objects, F. Bordes himself considered that the recovery method used during his excavations certainly introduced major biases and inconsistencies in the representation of the skeletal material (Guadelli, 2011:202), a well-known problem for early excavations (e.g. Marean and Kim, 1998). Unfortunately, the zooarchaeological information currently available for the Combe-Grenal sequence is therefore extremely limited and of dubious analytical value. These biases are, however, of greater concern for zooarchaeological analyses (e.g., interpreting skeletal profiles) than for environmental inferences based on the abundance of macro-mammals (as in Fig. 6).

Raw material exploitation patterns also remain more or less the same between the Quina and Levallois production systems; both incorporate non-local sources (0-50 km; e.g. Bergeracois and Fumelois flint; Fig. 7) demonstrating an expansive provisioning territory. As already discussed above, internal variations evident with the Levallois system seem to result from a greater incidence of blank transformation for the "Ferrassie Mousterian" and a greater proportion of unmodified blanks for the "Typical Mousterian". These differences also seem to expose a contrast in tool use-lives: longer episodes for the "Ferrassie" (more heavily reduced retouched tools) and shorter for the "Typical". Recalling aspects of curated versus expedient tools (Binford, 1979), transport and reduction factors do not coincide with the long distance transfer of unmodified blanks or retouched pieces (e.g. 2.6% for the "Typical Mousterian" layers 20-30 versus 2.8% for the "Ferrassie Mousterian" in layer 27).

Departing from the pattern seen with the Levallois and Quina systems, the Discoid assemblages indicate a reduction in the raw material provisioning territory. This more local provisioning strategy, which becomes the trend throughout MIS 3 in the region Faivre et al. 2013, could reflect occupations oriented around the exploitation of resources directly available in the vicinity of the site. As seen with other well-documented Discoid contexts, these activities often take on a more specialised character connected to the specific function of typical Discoid products (e.g., butchery and carcass processing; Jaubert et al., 1990; Brugal, 1999; Coumont, 2005). These differences also undoubtedly portray a diversity of objectives tied in some way or another to site function. The influence of functional choices is also relevant for the assemblages from the end of the Combe-Grenal sequence (MIS 3), where the Discoid system is dominant. Notches and denticulates are either heavily represented ("Typical Mousterian") or nearly exclusive ("Denticulate Mousterian") in several other MIS 3 Discoid assemblages in south-western France (Jaubert et al., 1990; Faivre, 2004; Thiébaud, 2005). Unfortunately, the absence of robust zooarchaeological information for the entirety of the Combe-Grenal sequence precludes a more detailed discussion of the site's changing function.

5. Conclusion

Environmental fluctuations over the course of the last glaciation had a major and direct impact on the manner in which available resources were exploited by Neandertal groups and how they organised themselves techno-economically. Our technological analysis identified clear temporal trends in lithic production systems across the Combe-Grenal sequence, whose variability is an expression of differing functional and economic choices. While a clear succession of production systems (Levallois, Quina, and ultimately Discoid) is evident in the uppermost terrace, a more detailed taphonomic analysis of the archaeostratigraphy is necessary to investigate both the internal variations of each episode and whether shifts between production systems occur in a context of techno-economic continuity or rupture. Moreover, it is plainly clear from the foregoing that the heuristic potential of comparing faunal data and raw material provisioning strategies with temporal patterns in techno-economic behaviour undoubtedly warrants further attention and elaboration. Currently, this type of approach is extremely limited, due primarily to problems linked to the recovery and curation of the Combe-Grenal material. New multidisciplinary fieldwork incorporating a comprehensive numerical dating program is underway in order to not only address exactly these issues but gather new data from one of the most important Mousterian sequences in south-western France.

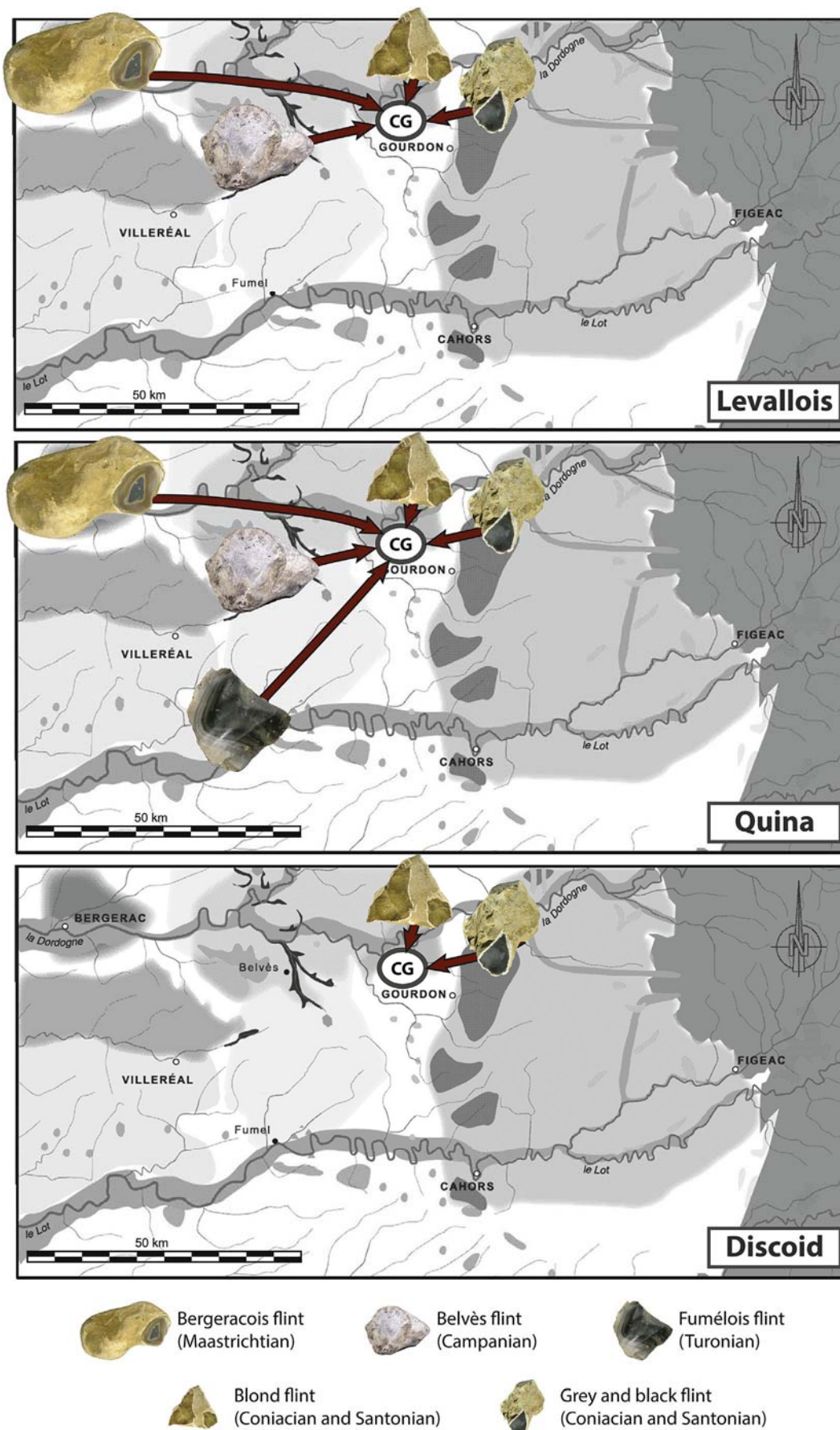


Fig. 7. Raw material provisioning territories for Combe-Grenal as a function of lithic production systems (layers 31-27 for the Levallois system, 26-17 for the Quina system, and 12-15 for the Discoid system).

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