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Building models of Neanderthal territories from raw material transports in the Aquitaine Basin (southwestern France)

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a b s t r a c t

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The Middle Palaeolithic of southwestern France has long been a testing ground for models of Neanderthal lithic assemblage variability and mobility strategies. Advances in our understanding of the lithological structure of the northern Aquitaine Basin combined with numerous raw material studies allows connections between different areas of the region to be revealed based on the movement of particular ‘tracer’ materials. By comparing technological data with raw material transport patterns elements of Late Neanderthal techno-economic behaviour emerge. Raw materials were transferred over longer distances in both the Levallois and Quina techno-complexes compared to the Discoid techno-complexes, where evidence for similar movements are almost entirely absent. Comparing these patterns of raw material provisioning and transfer against the distribution of key Middle Palaeolithic sites forms the basis of a new model for the territorial organisation of Late Neanderthal groups in the Aquitaine Basin to be built.

1. Introduction

The northeast of the Aquitaine Basin has produced numerous Middle Palaeolithic sites and presents considerable diversity in terms of ecosystems and varieties of lithic raw materials. Several recent studies focusing on the relationship between raw materials and stone tool technology have shed new light on the territorial organisation of Neanderthal groups (e.g. Turq et al., 2013a,b). Additionally, the last thirty years have seen the growth of a naturalist approach to the geological and geographical characterisation of raw materials from across southwestern France (Demars, 1980; Morala, 1980, 1983; Rigaud, 1982; Geneste, 1985) with the aim of better understanding the organisation of Palaeolithic hunter-gatherer groups within the territories they exploited. This data moves interpretations of Neanderthal mobility patterns beyond traditional definitions of subsistence territories connected to particular occupation types, allowing both relationships within and between territories to be explored. This type of analysis requires defining specific lithological zones (hereafter LZ) whose geological formations contain specific raw materials. Any given territory includes one or several LZ that contain evidence for the movement of raw

materials in all stages of the *chaîne opératoire*, including blank production, bifacial shaping as well as tool manufacture and use.

This techno-economic approach is based not only on the continued revision of Mousterian lithic techno-complexes (e.g. Delagnes et al., 2007; Turq et al., 2011; Jaubert, 2011; Faivre, 2011, 2014, in press; Gravina and Discmaps, 2015) but also traditional models of hunter-gatherer mobility systems (e.g. Binford and Binford, 1969; Binford, 1979; Kuhn, 1992, 1995; Andrefsky, 2009). Raw material analysis combined with a consideration of techno-economic patterns builds upon and refines previous models of Neanderthal mobility strategies based on blank production systems and bifacial shaping (e.g. Delagnes, 2010; Delagnes and Rendu, 2011). The development of rescue archaeology over the last two decades has produced an important number of open-air sites, which, when coupled with the revision of key sequences from both rock shelter and cave sites and methodological advances in absolute dating techniques (Guibert et al., 2008; Vieilleuvre et al., 2008), provide important contextual data for reconstructing patterns of Neanderthal land-use and raw material transport patterns.

Fig. 1. Different lithological zones (LZ).

2. Material and methods

2.1. Study area and definition of lithological zones (LZ)

Here we focus on the Middle Palaeolithic occupation of the northern Aquitaine Basin from the Garonne Valley in the south to the limits of Poitou in the north (Fig. 1). The region's concentric geological structure creates a mosaic of different ecosystems containing diverse lithological zones cut by the drainage basins of the

Garonne (right bank), Lot, Dordogne, Isle and Charente Rivers. We applied well-established lithological methods (Demars, 1980; Morala, 1980, 1983; Séronie-Vivien, 1987; Turq, 1992a,b) to define raw materials characteristic of each LZ, including the morphology of the blocks (e.g. irregular nodules, lenses, small slabs), macro- (e.g. texture, cortex, couleur, granulometry) and microscopic observations (e.g. microfossils). The depositional context and post-genetic patterns of alteration (Fernandes, 2012) were equally taken into account for these 'tracer' materials.

Fig. 2. Connections between different lithological zones. The red lines indicate an intermediary region where raw material from the south and north has been recovered. This region separates the Charentes from the study area to the south, where connections between different lithological zone are numerous. (For interpretation of the references to colour in this figure, the reader is referred to the web version of this article.)

Fig. 3. Discard state of flint from two neighbouring lithological zones: Senonian flint from open-air sites in the Périgord (left), Bergeracois flint from enclosed sites in the Périgord (right). Large flake (A), scraper retouch flakes (B), scraper on a bifacial-thinning flake (C), functional tool capable of producing flakes. Photos © Philippe Jugie, Musée national de la Préhistoire.

22. Lithological zones (LZ)

Based on these criteria it is possible to discern 11 LZ within the northern Aquitaine Basin (See Table 1 and Fig. 1 for their principle characteristics and geographic extension, respectively). The Infraliassic LZ appears as sporadic sources along the northern limits, with the Jurassic and Cenozoic Massif Central LZ to the east. The most extensive Senonian LZ comprises the Charentes and over-lapping ‘grain de mil’ LZ to the north of the more central Périgord Senonian, Isle, and Bergeracois LZ. Finally, the Haut Agenais LZ, formed by the Fumelois and Gavaudan flints, and the Tertiary LZ lie to the south. The geography of these lithological ‘tracers’ and the organisation of the hydrographical network make it impossible to document the west-east movement of raw materials to the east of Bergerac. Additionally, tracing the circulation of raw materials in the west is complicated by the fact that eastern materials can be collected downstream in alluvial deposits across the Aquitaine Basin. Therefore, only pieces with non-alluvial cortex were considered, meaning that jaspers, Cenozoic flint from the Massif Central and Jurassic flints are absent or underrepresented. On-going work concerning the post-genetic alteration of these raw materials (Fernandes, 2012) will hopefully provide more reliable information in terms of their acquisition and transport.

3. Material and methods

The analysed collections primarily come from recently excavated sites, including rescue excavations (see Table 2). In order to include the maximum amount of relevant data for establishing connections between the different LZ, we integrated data from the archaeological mapping project of the French Ministry of Culture (*Reseau nationale des lithothèques*) as well as lithological data compiled from surface collections and isolated pieces in public and private collections. Although these latter pieces lack reliable contextual information, their degree of patination compared to examples from secure MIS 6 contexts and their conforming to the techno-typological characteristics of the so-called “MTA” bifaces (Boëda et al., 1990, 2005, 2013; Soressi, 2002) nevertheless strongly suggest their dating to MIS 5e3.

Our techno-economic approach takes into account the most recent advances in both technological and lithological analysis, including integrating genetic and post-genetic phenomenon (Turq, 2004; Fernandes, 2012) that go beyond simply determining flint type. In certain cases not only can the type of source be identified (e.g. primary, secondary, alluvial) but also the minimum number of exploited blocks (Turq et al., 2013a,b). Finally, bearing in mind the ramified nature of certain reduction systems (Bourguignon et al., 2004) as well as the identifiable waste products from the manufacture and maintenance of certain tools (Bourguignon, 1992, 1997, 2001; Bourguignon et al., 2013), we also examined the small fraction from more recent excavations. These elements are rarely if ever included in most lithic analyses.

4. Results

Unlike the situation further north, the rarity of archaeological sites towards the northern limits of the Aquitaine Basin (see above) likely reflect unfavourable ecological conditions of the Massif Central, including the expansion of the Cantal ice sheet during cold periods. Similarly, the mollasic formations of the Dropt and Lot valleys in the southern area likely explains the low density of sites in this area (Le Tensorer, 1979; Le Brun Ricalens, 1988), while substantial aeolian deposits in the Garonne Valley probably led human groups to desert the area (Bruxelles and Jarry, 2011; Bertran et al., 2013; Sitzia, 2014). Finally, the Atlantic Coast, whose position varied according to fluctuating sea levels, represents the western limit of the basin (Fig. 2).

In order to avoid using arbitrary geographic limits, discontinuities in connections between lithological zones (LZ) provide a more reliable indicator of different territories (Table 2). Objects from southern LZ are never found in the Charentes and become increasingly rare north of Périgueux, whereas Charentian materials do not move beyond the Dronne Valley. Transfers from the south and north go no further than the area around Bourdeilles or

Table 1 - Comparison of the origin of raw materials and archaeological data. Colors correspond to the broad lithological zones, apart from the brown for the Charentes. Infralias (violet), Jurassic (blue), Cretaceous (green), Cenozoic (yellow), Metaquartzites (white). D indicates the dominant raw material, X securely identified materials, x probable raw materials as their acquisition from alluvial deposits cannot be ruled out. In addition to the list of studied assemblages can be found a synthesis of 6000 bifaces held in different private and public collections; Musée national de Préhistoire des Eyzies, Musée des Antiquités Nationale de Saint-Germain-en-Laye, Musée d'Aquitaine in Bordeaux, Musée du Périgord in Périgueux, musée Labenche in Brive, Musée A. Lemozi in Cabrerets et the museums of Agen, Montauban, Cahors, Agen and Sainte Bazeille (Bernard-Guelle et al., 2014, Bordes, 2002, Bruxelles et al., 2010, Cassedoubat and Platel, 1976, Caux, 2015, Cavaillé 1978, Chadelle, 1983, Chalard, 1996, Chalard, 1999, Charly, 1993, Combaz, 1966, Sonnevile-Bordes, 1953, Turq, 1977, Turq, 1988, Turq, 1990b, Vergne, 1929, Weyns, 1972, Dawson et al., 2012, Féblot-Augustins et al., 2005, Féblot-Augustins and Park, 2009, Fernandes et al., 2012, Fouéré 1994, Landesque, 1887, Larick, 1983, Lorblanchet, 1969, Monméjean et al., 1964, Muratet, 1983, Park, 2007, Pasty et al., 1999, Rey-Solé et al., 2014, Roussel, 1972, Simon-Coinçon, 1989; Coulonges and Sonnevile-Bordes, 1953; Cubaynes et al, 1989).

DESIGNATION	TYPE	GEOLOGICAL FORMATION	CHARACTERISTICS	REFERENCES
Massif Central	Flint	Lacustrine Tertiary (Oligocene)	Texture : mudstone to wackestone Colour : grey-beige with blue and pink green tones, Paleonto. : fresh water flora and fauna (Gastropodes, Characeae)	Muratet 1983; Simon-Coinçon 1989; Turq 1992; Charly 1993; Pasty et al 1999; Turq and Morala 2013
Aquitaine Basin	Chalcedonous flint Chalcedony Gritstone	Lacustrine Tertiary	Texture : mudstone Colour : beige Paleonto. : when present Characeae, Gastropodes	Demars 1980; Morala 1980. ; Chadelle J.-P. 1983, Larick 1983 ; Geneste 1985 ; Lebrun-Ricalens 1988 ; Turq 1992 ; Turq and Morala 2013.
Bergeracois	Flint	Maestrichtian (Campanian 4-5 Paleogene epigenesis)	Texture : mudstone to wackestone Colour : initially brown, beige or grey, uniform or with red, orange or blueish zonation Paleonto. : <i>Orbitoides media</i> ,...	Landesque 1887; Combaz 1966 ; Demars 1980 ; Morala 1980 ; Larick 1983 ; Geneste 1985 ; Turq 1992 ; Turq and Morala 2013
Charentian Cretaceous	Flint	Senonian and Turonian	Texture : mudstone to wackestone or packstone Colour : black or grey Paleonto. : <i>incertae sedis</i> , Bryozoa,	Seronie-Vivien 1987, Fouéré 1994, Bordes 2002, Féblot-Augustin et al. 2005, 2009, Park 2007,
&Grain de mil"	Flint	Senonian (Santonian)	Texture : wackestone or packstone Colour : blond to grey or black Paleonto. : bioclastes, Bryozoa	Fernandez 2012, Dawson et al. 2012, Bernard Guelle et al. 2014, Rey Sola et al. 2014, Caux 2015
Grey and black Périgord Senonian	Flint	Senonian (Coniacian, Santonian and Campanian)	Texture : mudstone to wackestone, or packstone Colour : grey or black Paleonto. : Bryozoa, Foraminifera (<i>Nummofallotia</i>),...	Roussel 1972, Demars 1980, Morala 1980, Rigaud 1982, Larick 1983, Geneste 1985
Blond and brown Périgord Senonian	Flint	Senonian (Coniacian, Santonian and Campanian)	Texture : mudstone to wackestone or packstone Colour : light to dark brown Paleonto. : Bryozoa, Foraminifera (<i>Nummofallotia</i>)	
Pseudo-Gavaudun or Truffel	Flint	Upper Santonian to Lower Campanian (Paleogene epigenesis)	Texture : mudstone to wackestone Colour : beige, brun-beige, Paleonto. : Bryozoa, Foraminifera (<i>Nummofallotia</i>), miliolidae	
Belves	Flint	Lower Campanian	Texture : mudstone Colour : grey to dark grey and black Paleonto. : Foraminifera (<i>Subalvéolina dordonica major</i> , <i>Orbitoides tissoti</i>)	
Gavaudun	Flint	Lower Coniacian	Texture : mudstone Colour : light beige Paleonto. : Bryozoa	Vergnes 1929 ; Monméjean <i>et al.</i> 1964 ; Bordes 1964 ; Le Tensorer 1979 ; Morala 1980, 1982 ; Séronie-Vivien 1987 ; Turq 1992 ; Turq and Morala 2013
Fumélois	Flint	Lower Turonian	Texture : mudstone Colour : dark blue, uniform or zoned; honey brown or black Paleonto. : Bryozoa, Annelida	Sonneville-Bordes 1953; Coulonges and Sonnevile-Bordes 1953 ; Monméjean et al. 1964; Weyns 1972; Turq 1977a; Le Tensorer 1979; Morala 1980; Rigaud 1982; Chadelle 1983; Larick 1983; Morala 1983 and 1990; Cassoudebat-Platel 1976; Geneste 1985 ; Séronie-Vivien 1987; Turq 1992; Turq and Morala 2013
Missère	Flint	Tithonian (Purbeckian)	Texture : mudstone, vertical tubes Colour : beige, brown, greenish,... Paleonto. : (not specified)	Lorblanchet 1969, Cavaillé 1978, Demars, 1980, Séronie-Vivien 1987, Cubaynes and al. 1989, Turq 1990, 1992, Chalard 1996, 1999, Bruxelles and al. 2010, Turq and Morala 2013
Dogger	Flint	Aalenian, Bajocian and Bathonian	Texture : mudstone, packstone or grainstone (oolithic) Colour : grey or beige with yellow-orange zonation and red filaments Paleonto. : marine (Foraminifera) and lacustrine (Characeae) to Bathonian,	
Lias Moyen	Flint	Carixian, Domerian (Pleinsbachian)	Texture : mudstone, wackestone, Colour : beige, brown, grey, more rarely greyish black Paleonto. : large canicular spicules	
Infralias	Jasper	Hettangian and Sinemurian (epigenesis)	Texture : mudstone, wackestone, packstone (oolithic) Colour : mustard yellow, greenish, brown, manganese spots or dendrites (brown-black) Paleonto. : shell fragments	Demars 1980, Bordes 2002, Geneste 1985; Turq 1992; Turq and Morala 2013

Table 2

Comparison of lithic techno-complexes with the origins of raw material as well as the archaeological data. The legend is the same as Table 1.

Lithological Zones (LZ)	Studied sites	N° fig.6	type	hettangien jasper	Bathonian flint	Bajocian flint	titonian flint	Charentes flint	Grain de mil Flint	Perigord senonian flint	Isle valley flint	Fumelois flint	Gavaudun flint	Bergeracois flint	tertiary lacustrine flint	Aurillac type flint	Métaquartzite
Bergeracois	Combe Brune 1	1	O			X				X	X			D	X		
	Toutifaut	2	O							X				D	X		
	Corbiac	3	O							X				D	X		
	Vieux cloutet	4	O							X				D	X		
	Bois des vergnes	5	O							X				D	X		
	BIFACES									X				D	X		
Haut Agenais	Sous les Vignes	6	O							D		X	X		X	x	X
	Las Pelenos	7	E							D		X	X		X	x	X
	Moulin du Milieu	8	E							X		X	D			x	
	Las Planes	9	O							X					X		D
	La Pronquière	10	E							X							D
	Cassegros	11	E							X							D
	Les Ardailloux	12	O							D							
	BIFACES									D				X	X		
Périgord sud	La Plane	13	O	X		X	X			D		X		X	X		X
	Combe capelle	14	E							D		X	X				
	Combe Capelle bas	15	O							D		X	X				
	BIFACES									D				X			
Périgord central ou Périgord noir	Roc de Marsal	16	E	X						D		X		X	X		X
	Pech de l'azé 1	17	E	X						D				X	X		X
	Pech de l'azé IV	18	E	X						D				X	X		X
	Grotte XVI	19	E							D				X	X		X
	Combe grenal	20	E	X			X			D		X		X	X	x	X
	Roc de Combe	21	E							D					X		X
	Le Moustier	22	E							D				X	X		X
	La Rochette	23	E							D				X	X		X
	La Gane	24	E	X						D		X		X	X		X
	Pech de Bourre	25	E	X		X				D		X		X	X		X
	La Ferrassie petit abri	26	E							D				X			X
	Vaufrey	27	E							D				X			X
	La Ferrassie grand abri	28	E	X						D				X			X
	BIFACES									D	X			X			X
Périgord nord	Les Festons		E							D							
	Tabaterie		E							D			X				
	Fonseigner		E	X						D				X	X		X
	Le Roc		O	X						D					X		
Formation molassique	Chemin d'herbes	29	O							X					D		X
	Estelet bulit	30	O							X				X	D		X
	Chinchon	31	O							X				x	D		
	Soumensac	32	O							X				X	D		X
	BIFACES									X				X	D		
Quercy	Mas Viel	33	E		X	X				X				X	X		D
	Les Fieux	34	E		X	X				X					X		D
	Pradayrol	35	E		X	X				X					X		D
	Le Pech	36	O			D				X					X	x	
	BIFACES									D							X
Charentes	La Quina		E					D									
	Les Pradelles		E			D		X		X							
	Artenac		E					D									
	Montmorillon		O					D									
	Dirac		O					D									
	bourgeois delaunay		E					D									X
	Abri Suard		E					D									X
Bassin de Brive	Bouffia bonneval		E			X				X					X	x	D
	Bouffia 118		E			X				X					X		D
	Chez Pourré-Chez Comte		E			X				X					X	X	D
	Combe brune		O							X					X		D
	BIFACES									D							X

Table 3

Comparison of lithic techno-complexes (LTC) with raw material provenances as well as the sites and levels studied. See Table 1 for the colour legend.

SITE		Hettangien jasper	Bathonian flint	Bajocian flint	Tithonian flint	Perigord Senonian flint	Isle valley flint	Fumélois flint	Gavaudun flint	Bergeracois flint	Tertiary lacustrine flint	Aurillac-type flint	Métaquartzite
LEVALLOIS	Combe-Grenal c.38									X	X		
	Combe-Grenal c.36									X	X		
	Combe-Grenal c.35 *	X	X							X	X		X
	RdM c.I									X			
	RdM c.II									X			
	RdM c.IV									X			
	RdM c.V									X			
	RdM c.VI									X			
	RdM c.VII									X			
	Le Moustier c.G1/G2 (1)*												
	La Ferrassie c.4 (1)									X			
	Pech de l'Azé IV c.8												
	Pech de l'Azé IV c.7												
	Pech de l'Azé IV c.6												
	Pech de l'Azé IV c.5												
	La Plane (1)*	X		X	X			X		X	X		
	Toutifaut*					X							
	Corbiac M1*					X							
	Corbiac M2*					X							
	Corbiac M3*					X							
	Chemin d'Herbe												X
	Pech de l'Azé II c.3*												
	Caminade c. M1*												
	Caminade c. M2*												
QUINA	Caminade c.M3 (1)*									X			
	Roc-de-Marsal c.XII*									X			
	Roc-de-Marsal c.XI*	X						X		X	X		
	Roc-de-Marsal c. X*							X		X	X		
	Roc-de-Marsal c.IX*							X		X			
	Roc-de-Marsal c.VIII*									X			
	Combe-Grenal c.17 *	X	X							X	X		X
	Combe-Grenal c.18 *	X								X			
	Combe-Grenal c.19*	X	X								X		X
	Combe-Grenal c.20*	X									X		X
	Combe-Grenal c.21 *	X								X	X		X
	Combe-Grenal c.22*	X	X					X		X	X		X
	Combe-Grenal c.23 *	X	X					X		X	X		X
	Combe-Grenal c.24*	X	X					X		X	X		X
	Combe-Grenal c.25*	X								X	X		X
	Combe-Grenal c.26*	X	X							X	X		X
	Combe-Capelle bas							X	X				
	Moulin du Milieu*							X				X	

[illegible]

Table 4
Distribution of bifaces in Bergeracois and Perigodian Senonian flint according to the different LZ.

Brantôme, where Mousterian sites are numerous but more often than not excavated early on and under-studied in terms of technology and raw materials. Given the fact that the majority of material from this region derives from old and heavily biased collections, we have excluded sites from this area, retaining the Isle Valley as the northern limit of the study area.

Research over the last 20 years has produced evidence of raw material transfers that, at least regionally, appear as general behavioural patterns (Turq, 2000, 2003). Raw materials were almost exclusively (95-100%) procured from local sources independent of their available in the vicinity of the site. Groups adapted their technologies to the immediately available raw materials

regardless their quality or abundance. This is the case, for example, at Corbiac and virtually all the other Mousterian sites in the Bergerac region in close proximity to high-quality flint, as well as Moulin du Milieu in the Haut Agenais, where Gavaudun flint was almost exclusively used. In the Périgord, the same pattern is evident at Roc de Marsal in the use of average-quality, medium-sized alteritic flint and flint from the alluvia of the Vézère River. In both the Quercy (Les Fieux, Mas Viel, Pradayrol) and at La Chapelle-aux-Saints in the Corrèze, locally available metaquartzites are best represented followed by much smaller quantities of jaspers at the latter. The preferential use of local metaquartzites is equally observable despite flint sources being immediately available less than 5 km from the site, as at Las Planes and La Pronquière in the Lot Valley.

Discoid exclusive one. Moreover, these assemblages share more similarities between them than they do with layers from neighbouring sites (e.g. Combe Grenal, Turq, 1992a,b; Vaufray, Geneste, 1985, 1988a,b). This preference for local resources is evident for all the northern Aquitaine LZ, a pattern that becomes less strict with the emergence of the Upper Palaeolithic (Jaubert and Barbaza, 2005).

In all the studied sites, raw material transfers do not exceed 80–100 km as the bird flies (e.g. Combe Brune 1, Bourguignon et al., 2006a,b, 2011a,b; Turq et al., 2014; Pailhs, Jaubert et al., 2001; Mas-Viel, Turq, 1992a,b; Le Moustier, Geneste, 1985), with certain types of objects (Levallois flakes, retouched tools, bifaces) appearing more mobile (Geneste, 1985). More recent studies have nuanced this overall pattern, demonstrating that cores in different stages of reduction and cortical flakes were equally transported (Turq, 1992a,b; Bourguignon et al., 2006a,b, 2011a,b; Delagnes et al., 2006).

4.2. Lithological zones and lithic techno-complexes (LTC)

We revised 69 assemblages from 23 sites distributed across the different lithological zones in order to trace artefact movements away from their source zone(s) (Table 2 and see also Faivre et al., in press). Overall, the sample includes 58 assemblages assigned to lithic techno-complexes characterised by an exclusive flake production system (24 Levallois, 18 Quina, and 16 Discoid) and 19 to mixed techno-complexes. Of these 69 assemblages, 28 also contain evidence for bifacial shaping (10 for the Levallois, 17 for the Quina, and 1 for the Discoid).

4.2.1. Techno-complexes with strictly local raw materials

Certain LTC are characterised by raw materials procured less than 5 km from the site, the majority being cordal Discoid assemblages. Like the other LTC and despite the small territory exploited, a comparison of archaeological with experimental data shows all categories of artefact types typical of the cordal Discoid system to have been both imported (e.g. unretouched or decorticated blocks, still reducible cores and pseudo-Levallois points at Les Fieux (Faivre, 2011)) and exported (e.g. pseudo-Levallois points and cores at Regourdou (this study)).

4.2.2. Techno-complexes with both local and distant raw materials

Levallois techno-complexes are all found in caves and rock shelters (Combe Grenal and Roc de Marsal, 9 assemblages) and most contain evidence for non-local raw materials to have been transported over approximately 50 km, essentially from the Bergerac region or, in the case of Combe Grenal (layer 35), both this region and the Fumel area. Non-local raw materials were introduced in various forms (unmodified flakes, retouched tools, cores, etc.) and, in certain cases, from sources no more than 15 km from the site. Patterns of raw material transport for the Quina LTC appear very similar to LTC associated with only immediately available sources (>5 km) for fourteen assemblages from four different sites. Bergeracois and Fumelois flint can be found in assemblages from the same site, while distant raw materials are absent from others (e.g. layer 20 of Combe Grenal).

4.2.3. Mixed lithic-technocomplexes

The mixed LTC evince longer transport distances, particularly for western sites (La Chapelle-aux-saints, Mas-Viel and Pailhs), where the introduction of Bergeracois flint from sources nearly 100 km to the east is frequent. However, the homogeneity of these assemblages is still debated. Artefacts most commonly transported over distances of 90–100 km are connected to bifacial shaping, although retouched flake tools (e.g. a double scraper in Puy d'Issolud-type Bajocian flint at Combe Brune 1) can also be transported over similar distances. In these mixed LTC, non-Levallois blades and unipolar elongated flakes are primarily made on locally available raw materials, apart from a single example of a non-Levallois blade core from Cantalouette IV, Blaser et al., 2012). In the case of mixed TCL with a discoidal element, non-local raw materials may, in fact, be connected to associated assemblage components, Levallois or otherwise.

5. Discussion

In the study area, only the cordal Discoid LTC, stands out given the recurrent use of immediately available raw materials (<5 km). When this LTC is accompanied by evidence for bifacial shaping, it frequently involves pieces introduced from more distant sources. The Quina and Levallois LTC portray identical transport patterns in terms of quantity, diversity, and distances. It is equally interesting to note that the Quina and Levallois LTC lacking a non-local raw material component are commonly associated with temperate fauna, as in layers 1 to 4 of Roc de Marsal dominated by red deer (Gurin et al., 2012). On the other hand, for these same LTC, as transport distances increase and become more diversified they are more often associated with predominantly cold fauna (e.g. Combe Grenal layers 22 and 23; Turq, 1990a).

5.1. Anticipation of needs

Data from recent rescue excavations of open-air sites shed important light on the anticipation of needs. The exposure of large surfaces likely representing the entire occupation area has allowed for the systematic testing of refits. Unlike cave and rock shelter sites where the entire occupation is rarely excavated and often suffers post-depositional disturbances at its outer edges, assemblages from open-air contexts are more readily interpretable, as in most cases all of the material associated with an occupation is recovered. Refit analyses, as at Cantalouette II (Bourguignon et al., 2008a,b), have demonstrated the limited number of exported elements to also be highly variable (e.g. cortical flakes, end-products). Similar analyses at Combe Brune 1 (Bourguignon et al., 2006a,b, 2007) and Abri du Muse (Bourguignon et al., 2006a,b) went beyond the simple attribution of material to geological formation. By incorporating the post-genetic evolution of flint (Fernandes, 2012), it was possible to identify the specific type of outcrop (Turq, 2000) and thus certain individual blocks (Bourguignon et al., 2006a,b, 2007).

5.1.1. Reduction and curation

Patterns of tool reduction and curation are only observable when objects are transported outside their zone of origin. Identifying different curation strategies for transported materials requires petrographic analysis that includes the small fraction (<25 mm). This type of approach applied to Bergeracois flint and raw materials from the Prigord region is particularly instructive. In the Bergerac LZ, several previously excavated sites (Tautou, Barbas, and Corbiac), as well as all six Mousterian sites excavated in rescue contexts by the INRAP, revealed the same behaviour. The same raw materials (grey and black Senonian flint) and artefact types, namely unretouched flakes, tools and intentionally broken flakes were transported over long distances. When considered against the absence of evidence for resharpening and the fact that tools are seldom transformed into cores, this pattern reflects the limited 'curation' of artefacts that were replaced (personal gear) and/or complemented by objects in Bergeracois flint.

Fig. 4. Périgord Senonian flint artefacts found in the Quercy: 1, tool fragments reused as cores; 2, core on flake; 3, Levallois flake; 4 scraper retouch flakes. Photos © Philippe Jugie, Musée national de la Préhistoire.

In the caves and rock shelters of the Périgord, which are often interpreted as habitation sites (Roc de Marsal, Combe-Grenal, Pech de l'Azé I & IV), imported artefact types also appear relatively similar (unretouched flakes, particularly Levallois products, retouched or bifacial tools), particularly by-products from the resharpener of bifaces or scrapers that were recycled as retouched tools and the occasional intentionally fractured and reused artefact (Fig. 3).

The considerable reduction of tools and the retouching of waste suggest considerable curation. For example, at Mas Viel in the southeastern Jurassic LZ, more than one hundred pieces of Senonian flint and a handful in Bergeracois flint are represented by unmodified flakes, heavily reduced pieces, cores on flake, resharpener by-products and highly fragmented tools often transformed into cores. This pattern reflects a heavily reduced assemblage where pieces are pushed to exhaustion (Fig. 4).

5.2 A lithological approach to Middle Palaeolithic bifaces

Certain raw material were seldom used for the production of bifaces, and only in their lithological zone (e.g. Fumelois or Bajocian flint), while other bifacial tools were transported into nearby lithological zones, as can be seen with jasper, Gauvaudun flint and flint from the Isle Valley. Other materials often considered difficult to knap, such as metaquartzites, although rare, are present in all lithological zones apart from the Bergerac region. In terms of raw material transfers, only two raw materials are present in all lithological zones - Bergeracois flint and Senonian flint from the Périgord.

This pattern once again confirms the particular status of the biface in Neandertal mobility strategies and demonstrates three different lithological zones to have seen a particular influx of bifaces: the Dropt Valley, which stands out compared to other Cenozoic lacustrine areas, the Brive Basin, and the Quercy. While more detailed faunal and environmental data is still lacking for better contextualising these patterns, we can nevertheless note the concentration of bifaces around Brive above the confluence of the Vézère and Corrèze and in the area of Eymet in Dropt Valley at the confluence of several waterways. In the Quercy region, areas rich in biface find-spots have been noted around streamsinks, interpreted as favourable contexts for hunting large herbivores (Champagne and Faivre, 1999) Maynard et al., 2005.

5.3 Territorial organisation

The fact that the greatest density of sites with long stratigraphic sequences, as well as those having produced sub-complete Neandertal skeletons, are all found on Cretaceous formations, suggests the Périgord region to have been a preferential zone of residence (Fig. 5) connected most frequently with the Bergerac region and the Haut-Agenais. Available seasonality data from all large sites in the northeast Aquitaine Basin equally indicates these sites to have been occupied during different seasons (Rendu et al., 2010). Hunter-gatherers exert a daily pressure on their immediate and surrounding environments to such an extent that diminished resource availability may require frequent displacements. In a zone where water, raw materials, and natural shelters are abundant, residential movements are easier. Moreover, the attractiveness of natural shelters varies seasonally as a function of changing wind directions altering ambient temperature and degree of protection.

Relationships between the different lithological zones evince “centrifugal” movements of raw materials away from their place of origin and “centripetal” movement of non-local material towards particular regions. Centrifugal movements concern raw materials introduced to peripheral territories and occasionally beyond, as can be seen with Bergeracois flint and Senonian flints from the Périgord. On the other hand, materials move only between two neighbouring zones, such as Cenozoic lacustrine or Jurassic flints.

Finally, two centrifugal transport patterns, Fumelois and Haut-Agenais flint to the north and Isle Valley flint to the south-east beyond of the Dordogne River valley, crisscross a large portion of the Senonian lithological zone.

Fig. 5. Distribution of sites with long stratigraphies or sub-complete Neanderthal skeletons (black squares) and numerous Neanderthal remains (red squares), preferential zone of residence (dotted line). 1 La Ferrassie, 2 Roc-de-Marsal, 3 et 4 Abri Chadourne et Abri Audi, 5 Laussel, 6 le Moustier, abri supérieur et inférieur, 7 La Rochette, 8 Le Regourdou, 9 Chez-Pourré-Chez-Comte, 10 La Chapelle-aux-saints, 11 Pech-de-Bourre, 12 Caminade, 13 les Pech-de-l'Azé, 14 La Gane, 15 Combe-Grenal, 16 Vaufray et Grotte XVI, 17 Moulin-du-Milieu, 18 Monsempron. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Centripetal movements are more substantial and concern the Bergeracois and Senonian lithological zones that receive raw materials from neighbouring territories as well as further afield. These two zones appear to play a more important role in the organisation of Neanderthal territories, as the others are associated only with materials from peripheral zones. This is the case with the Haut-Agenais where only Bergerac and Senonian flint varieties are found. These observations equally concern elements of

different production systems (i.e. Quina, Discoid, Levallois) as well the more frequently transported bifaces (Fig. 6).

Raw materials transported over long distances are also those that derive from the largest outcrops, for example Senonian and Bergeracois flint is available over 4600 and 220 km², respectively. Connections between different lithological zones correspond either to unidirectional (Cenozoic zones), the Quercy and the Brive Basin or bidirectional movements (Bergerac region, Périgord and Haut

Fig. 6. General relationships between different lithological zones and Neanderthal territorial organisation.

Fig. 7. a, Techno-economic model of lithic production systems (modified after Delagnes and Rendu, 2011); b, comparison of the techno-economic model with raw material transport patterns.

Agenais), with consistent relationships between the Bergerac region, the Haut Agenais and the Périgord. Moreover, this latter region appears to be a central hub for the movement of Neanderthal groups in the region.

5.4. Mobility patterns

Evincing relationships between different lithological zones is currently the most secure manner for deducing raw material provisioning zones. However, such relationships reflect the movement of materials and not necessarily the movement of the entire group. In a recent model, Delagnes and Rendu (2010) proposed specific types of mobility patterns associated with different technological systems (i.e. Discoid, Quina, Levallois, MTA) distinguished by their degree of technical investment and standardisation evident in the products. The Discoid and Quina systems are interpreted as reflecting comparable mobility patterns (more logistic) and subsistence strategies based around the high-versatility of both systems combined with extended use-lives and reduced technical investment in the latter. On the other hand, the reduced versatility and resharpening potential of Levallois or blade systems would represent more residential (sensu Binford, 1979) mobility strategies. The curation potential of the bifacial system would occupy an intermediate position between the two mobility patterns. Models of group mobility patterns are currently difficult to test in the Aquitaine Basin due to both the lack of faunal data from many cave and rock shelter sites and the fact that numerous lithic assemblages still require systematic revision. While some of our results may appear to contradict certain aspects of their model, notably the high mobility of Levallois products considered by Delagnes and Rendu as representing a "more residential" system (Fig. 7), they are better seen as complementary. Their model is based on "types" of mobility, while we focus on the transport distances of particular artefacts in the landscape, which help define the actual territories we attempt to model.

6. Conclusion

Here we have shown that the provisioning of lithic raw material during the Middle Palaeolithic of the northern Aquitaine Basin essentially involved immediately available raw materials, independent of their distribution in the landscape, and the absence of dedicated forays for their acquisition. Similarly, apart from a few rare contexts associated with the production of bifaces, very few sites correspond to what are broadly termed 'workshops' characterised by a high proportion of artefact export. Raw materials move no more than 40-100 km and were likely acquired primarily during

subsistence rounds, with exchanges between groups or individuals impossible to rule out. The most frequently transported raw materials derive from the largest outcrops, while 'tracer' materials from smaller sources, such as the Fumelois, Gavaudun and Isle Valley flints, are rarely represented except at Moulin du Milieu in the Gavaudun region.

Our most important result is the demonstration of different lithological zones resulting in a preliminary model for the territorial organisation of Neanderthal groups in the northern Aquitaine Basin during MIS 5-3. The middle valleys of the Dordogne, where outcrops of Senonian flints and natural shelters are abundant and water available, functioned as a preferential zone of residence surrounded by an eastern zone around Bergerac with evidence for numerous Middle Palaeolithic sites and the frequent movement of raw materials to and from the region. To the south, the Haut Agenais was only occasionally visited, playing a similar role to the eastern zone in terms of occupation.

The three remaining lithological zones, the Cenozoic lacustrine regions, the Quercy, and the borders of the Massif Central (Limargue and the Brive Basin), are organised around this central hub. Although visited, locally available raw materials were infrequently used and or transported, suggesting areas dedicated to seasonal subsistence activities. These provisioning and transport patterns reveal a sophisticated knowledge of raw material sources and the constant anticipation of future needs. Individuals or mobile groups transported personal gear that both allowed them to meet needs encountered during forays and could be replaced or complemented when the opportunity presented itself. Progressively, as displacements went beyond 40-50 km, raw materials available in neighbouring lithological zones were preferentially exploited (Porraz, 2005). This anticipation of future needs does not necessarily translate as a higher degree of artefact standardisation or the transport of the same artefact types. While it is difficult to determine any fixed rule underlying the choice to transport certain objects, they many appear to share a high degree of curation potential and or reduction.

A fuller understanding of the territorial organisation of hunter-gatherer groups requires the integration of complementary data sets, including paleoenvironmental, subsistence practices and use-wear analysis, as well as new field work and the development of more sophisticated petro-archaeological analyses. Unfortunately, faunal data is only exploitable from a limited number of cave and rock shelter sites, including recent excavations integrating the systematic recovery of the fine fraction (lithics and fauna). More-over, incorporating use-wear analyses and focusing attention on estimating the degree of reduction or curation of both lithic assemblages and particular artefact classes requires integrating experimental work.

Similarly, advances in understanding the post-genetic alteration of lithic raw materials should begin to help identify the origin of non-cortical pieces, adding more detail and nuance to raw material provisioning strategies. Finally, despite the region's long research history, certain areas, such as the Dronne Valley, have either been ignored or rarely consider and older collections still require revision. The re-excavation of known sites and the discovery of new ones will undoubtedly provide valuable new information for the interpretation of Neanderthal raw material provisioning strategies and territorial organisation. As a final point of reflection, the observations presented here reflect the choices of human groups at a particular moment in time, in a given region and, while certainly providing an interesting case study, they may not be readily exportable to study behaviour in another region with different lithological and ecological conditions.

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