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Supply distances and territories in south-west France through the Middle and Upper Palaeolithic: a petro-techno-economic approach

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Résumé

Le passage du Paléolithique moyen au Paléolithique récent n'est désormais plus perçu comme une rupture franche mais comme la succession d'une mosaïque d'innovations (art, ornements, industries osseuses) apparues au cours du Paléolithique moyen. Il n'en demeure pas moins qu'une distinction forte demeure entre ces deux périodes : les groupes humains du Paléolithique moyen exploitent majoritairement les matériaux lithiques présents à courtes distances du gisement (moins de 50 km) tandis qu'au Paléolithique récent il est fréquent de trouver des évidences de circulations de géomatériaux sur plusieurs centaines de kilomètres. Nous présentons ici une étude comparative de deux gisements français : l'abri Pataud (Dordogne) pour le Paléolithique supérieur, et le gisement de Baume-Vallée (Haute-Loire) pour le Paléolithique moyen, basée sur une approche combinée de données pétrographique, technologique et économiques que nous nommons approche pétro-techno-économique (PTE). Cette approche intègre les démarches et avancées récentes des disciplines de la pétroarchéologie, et de la techno-typologie au service d'une problématique techno-économique (Geneste, 2010), et permet de mettre en évidence les comportements socio-économiques des populations passées. Nous proposons donc ici de discuter de la gestion des ressources lithiques au Paléolithique moyen en utilisant les mêmes termes, méthodes et questions que pour le Paléolithique récent.

Du point de vue méthodologique, l'étude des gisements de l'Abri Pataud et de Baume-Vallée s'est articulée autour d'une double approche. D'une part les déterminations pétroarchéologiques exhaustives à l'échelle macro-mésoscopique (loupe binoculaire à fort grossissement, x20 à x150, et microscope) selon des principes analytiques discutés et enrichis depuis les années 1980 (Masson, 1981 ; Séronie-Vivien *et al.*, 1987 ; Affolter *et al.*, 2008 ; Fernandes, 2012) et l'intégration des principes de chaîne évolutive (Fernandes et Raynal, 2006 ; Fernandes, 2012) permettant une meilleure compréhension et identification des géologies de collecte potentielles. D'autre part l'étude des comportements techno-économiques (Geneste, 2010) appliqués à chaque matériau suivant une analyse segmentée de la chaîne opératoire suivant quatre étapes principales (figure 4). Cette double approche permet la mise en évidence de groupes pétro-techno-économiques homogènes, utilisés pour discuter et comparer les comportements socio-économiques. Nous pouvons ainsi envisager les distances d'approvisionnement et les territoires des groupes humains, mais également identifier les variations de gestions sur certains itinéraires au sein de ces territoires, la planification des mobilités et les potentiels réseaux de transferts.

Les deux gisements étudiés montrent un espace d'approvisionnement en matière première lithique très large (figure 2 et 3) s'étendant sur plusieurs centaines de kilomètres autour du gisement. Si de tels résultats sont communs pour le Paléolithique récent, ils demeurent extrêmement rares pour le

Paléolithique moyen. Ils apparaissent notamment en contradiction avec la décroissance quantitative supposée des matériaux, et leur plus forte consommation économique, à mesure que la distance au gîte augmente.

Pour l'Abri Pataud, six groupes principaux de matières premières se répartissant en quatre groupes PTE de gestion ont été identifiés (tableau 1) : les silex sénoniens du Périgord (groupe PTE 1), les silex du Bergeracois et du Grain de Mil (groupe PTE 2), les silex du Turonien supérieur du Grand-Pressigny (groupe PTE 3) et les silex du Turonien d'Angoulême et du Crétacé de Chalosse (groupe PTE 4). Les interprétations divergent en fonction de l'importance accordée aux réseaux de transferts : si l'on favorise une acquisition directe des matériaux, les données pourraient illustrer un territoire organisé autour d'une mobilité saisonnière à longue distance entre le sud du Bassin parisien et le Périgord. Cette hypothèse peut être mise en relation avec les données issues des études archéozoologiques (Sekhr, 1998 ; Soulier, 2013) qui illustrent une chasse préférentielle au printemps et en été. La Charente constituerait alors un espace pivot, propice à la constitution de stock de matières premières avant un séjour en Périgord (Figure 5), quand les matériaux originaires de Chalosse marqueraient des transferts avec d'autres groupes situés vers les Pyrénées. Si l'on favorise l'hypothèse des acquisitions indirectes, les espaces charentais et périgordiens représenteraient les pôles terminaux d'un territoire social centré autour de la vallée de la Dordogne, et des espaces relais au sein d'un réseau de transfert intégrant des territoires voisins centrés sur le Sud du Bassin parisien et les Pyrénées. Ces hypothèses rejoignent celles déjà formulées antérieurement pour l'Aurignacien récent à burin busqué (Bordes *et al.*, 2005 ; Féblot-Augustins, 2008 et 2009 ; Caux, 2015 ; Caux et Bordes, 2016).

Pour Baume-Vallée, 37 groupes de matériaux issus de 15 géotopes principaux ont été identifiés (Vaissié *et al.*, 2017) et se répartissent en quatre groupes PTE de gestion (tableau 2) : silex oligocènes de la vallée de la Borne (groupe PTE 1) ; silex aaléniens du Velay, silcrète de Saint-Pierre-Eynac, silicifications du bassin de Naussac, silcrètes de la Paléo-Truyère et de Saint-Léger-du-Malzieu, silex du Turonien inférieur de la vallée du Cher et du Turonien supérieur du Grand-Pressigny (groupe PTE 2) ; silcrète de la vallée de la Laussone (La Collange), silex du Mazet-Saint-Voy, silcrète d'Aranc, silex barrémo-bédoulien de Rochemaure-Cruas, silex oligocènes du bassin des Limagnes et du bassin d'Aurillac (groupe PTE 3) ; silcrète pédogénétique de Madriat et silex sénoniens du Loiret (groupe PTE 4). Que ce soit par l'ampleur des circulations ou l'économie des matériaux représentés sur le site, les données pétro-techno-économiques livrent des résultats qui dénotent de la variabilité des comportements couramment observés au Paléolithique moyen. Loin d'exprimer les stratégies opportunistes couramment décrites, on observe une réelle planification et une anticipation des besoins en matière première, à la fois à une échelle régionale et extrarégionale (figure 6). Si l'hypothèse d'une acquisition directe semble pouvoir être privilégiée en majorité, la présence de matériaux faiblement représentés et dont l'acquisition implique le franchissement de contraintes naturelles majeures pourrait être un argument en faveur de la mise en évidence de réseaux de transferts. Dans ce cas, le territoire des groupes humains de Baume-Vallée s'organiserait suivant des cycles de nomadismes saisonniers à grande échelle entre le sud du Bassin parisien et l'espace vellave. Ce territoire pourrait s'articuler, via des réseaux sociaux structurés, avec d'autres territoires moustériens limitrophes : Bassin aquitain, Bassin parisien, Vallée du Rhône et potentiellement vallée de la Loire.

Abstract

It is now well-acknowledged that the passage from the Middle to the Upper Palaeolithic was not a clear break in Europe, but more closely resembled a mosaic of innovations (art, ornament and osseous industries) that first appeared during the Middle Palaeolithic. However, one strong position reveals a clear distinction between the Middle and Upper Palaeolithic: human groups from the Middle Palaeolithic mainly exploited lithic raw materials from a very limited area around campsites (less than 50 km), whereas during the Upper Palaeolithic it is common to find evidence of lithic raw material circulating within several hundred kilometres. Here, we present a comparative study of two French sites: Abri Pataud (Dordogne) from the Upper Palaeolithic and Baume-Vallée (Haute-Loire) from the Middle Palaeolithic, based on a combined analysis of petrographic, technological and economic data that we refer to as a petro-techno-economic (PTE) approach.

From a methodological point of view, studies of both Abri Pataud and Baume-Vallée show the importance of the PTE approach since it helps to trace not only supply distances or territories, but also the management routes within these territories. These sites reveal a huge supply area extending over several hundred kilometres around the main site. This is common for the Upper Palaeolithic but is exceptional for the Middle Palaeolithic. Our paper discusses Middle Palaeolithic raw material management using the same terms, models and questions as for the Upper Palaeolithic.

Key-words: supply territory; lithic raw material; petroarchaeology; technology; techno-economy; petro-techno-economy; group mobility; Middle Palaeolithic; Upper Palaeolithic; France.

Mots-clés : territoires d'approvisionnement ; matières premières lithiques ; pétroarchéologie ; technologie lithique ; techno-économie ; pétro-techno-économie ; mobilité ; Paléolithique moyen ; Paléolithique récent ; France

1. Introduction

Recent advances in Palaeolithic research have increasingly shown a reduction in long-standing perceived differences between the MP and the UP in Europe. Over the last two decades, the Upper Palaeolithic has been characterised by the systemisation and homogenisation of its art, ornaments, osseous industries and blade and bladelet lithic industries. However, a strong idea regarding a clear distinction between the Middle and Upper Palaeolithic (Féblot-Augustins, 1993, 1999; Vialou, 2005; Flas, 2007; Pettitt, 2007; Roebroeks, 2008; Slimak, 2017; Turq *et al.*, 2017) remains, namely, that human groups from the Middle Palaeolithic exploited lithic raw materials from a very limited area around their base camp (less than 50 km), while it is common to find evidence of lithic raw material circulating within several hundred kilometres for the Upper Palaeolithic period. In the last few years, evidence of long-term toolkit and *chaîne opératoire* management (Bourguignon *et al.*, 2004), symbolic behaviour (Zilhão *et al.*, 2010; Peresani *et al.*, 2013; Marquet *et al.*, 2014; Romandini *et al.*, 2014; Hoffmann *et al.*, 2018), use of colouring matter (Heyes *et al.*, 2016; Dayet *et al.*, 2019; Pitarch Martí *et al.*, 2019), investment in the subterranean environment (Jaubert *et al.*, 2016; Jaubert & Verheyden, 2017), movable or parietal art (García-Diez *et al.*, 2013; Rodríguez-Vidal J. *et al.*, 2014; Majkić *et al.*, 2017), and funeral behaviour (Peyrony, 1921; Maureille and Vandermeersch, 2007; Maureille, 2017) have been increasingly demonstrated for Neanderthal. At the same time, recent advances in technological and petrological studies (Fernandes & Raynal, 2006; Fernandes *et al.*, 2007, 2016; Fernandes, 2012; Tomasso, 2014; Caux, 2015; Caux & Bordes, 2016; Delvigne, 2016; Delvigne *et al.*, 2018a) allow us to address a wide range of issues with new data. Is this perceived difference in the raw material economy due to a true shift in modes of nomadism, an increase in long-distance transfers between groups, or a lack of data or investigation? Moreover, our comparisons still only involve supply distances and fail to consider the global lithic systems, in other words, the balance between technical traditions and the raw materials available in specific areas. How was each raw material managed at an archaeological site? What were the circulation routes for human groups within their territory? Were modes of nomadism really so different between the Middle and Upper Palaeolithic?

To address these issues, we present here a comparative study of two French sites: the Upper Palaeolithic site of Abri Pataud (Dordogne) and the Middle Palaeolithic site of Baume-Vallée (Haute-Loire). Beyond the issues relating to supply distances and territories, the aim of the study was to examine the entire lithic system to explore modes of nomadism and routes across the two periods. To this end, we present a petro-techno-economical approach (PTE) that crosses the main results of petroarchaeology and techno-economy based on the analysis of every piece of the archaeological series.

2. The petro-techno-economical approach: why this term?

From the earliest research on lithic industries, prehistorians have noted the importance of identifying the diversity of raw materials used in archaeological assemblages (Lartet & Christy, 1864; Damour, 1865; Vinay, 1867, among others). For several decades now, this issue has witnessed the development of research aimed at determining the origin of each material and understanding the supply territory, highlighting the economic and social behaviour of prehistoric human groups. This knowledge has logically been associated with lithic technology, constituting a revival for the latter after being

approached for many years in terms of typology. However, we feel it is appropriate here to underscore the distinction between “technology”, “techno-economy” and “petroarchaeology”.

The meaning given to the techno-economic approach varies considerably depending on the authors and the period. While, today, it is generally used with regard to the territories of human groups (Bracco, 2005; Moncel *et al.*, 2007; Djindjian *et al.*, 2009; Goval, 2012; S. Caux, 2015; Turq *et al.*, 2017; Tomasso, 2018), as practised until recently (Eid, 2017), the approach gave a preponderant position to the identification of global technological strategies, which made it possible to:

- recognise the type of lithic industry by the different *chaîne opératoire*, distinguishing between methods and techniques, as well as the variety of classes of manufactured tools;
- assess the segmentation of the technological process in time and space by recognising the presence/absence of steps in the different *chaînes opératoires*, leading to a consideration of the role and place of the site in the territorial occupation and exploitation strategies adopted;
- highlight the influence of materials in the determinism and technical choices implemented as part of the technological treatment.

This last point was discussed specifically by M. L. Inizan (1976, 1980), then developed by C. Perlès (1991), with a distinction made between “economy of *débitage*” (differences in production methods) and “economy of raw materials” (differential technological treatment of raw materials). In this case, however, raw materials are considered in terms of parameters (quality, morphology, volume and accessibility) when discussing the choices and determinisms underlying the technical actions carried out by the group (e.g., Boëda *et al.*, 1990; Morala & Turq, 1991; Perlès, 1991; Geneste, 2010; Brenet, 2011). This use of the notion of “economy” is similar to that used in the field of economic anthropology (Godelier, 1965, 1974, 2000; Bourdieu, 2017). We can summarise it as follows: economic technology (techno-economy) describes the structure of technical (lithics) production systems and their evolution to explain their logic, itself inherited from all the social relations of a group or a society. This definition is partly in line with the notion of technology as used by certain scholars in the Anglo-Saxon world (Torrence, 1983, 1989; Bamforth, 1986, 1990; Shott, 1986; Bettinger, 1987; Chatters, 1987; Shott *et al.*, 1989; Simek, 1994; Sutton, 2000), where the technological composition is directly analysed in terms of economics and mobility schemes (Shott, 1986; Eid, 2017).

At the same time, petroarchaeology developed as a disciplinary field at the crossroads of geology and prehistory. Petroarchaeologists developed other determination methods based on different scales of analyses (Štelcl & Malina, 1970; Masson, 1981; Séronie-Vivien & Séronie-Vivien, 1987a; Bressy, 1998; Grégoire, 2001; Fernandes & Raynal, 2006; Fernandes *et al.*, 2007; Affolter *et al.*, 2009; Fernandes, 2012; Caux & Bordes, 2016): analysis of the sedimentological and micropalaeontological content (mostly at the mesoscopic scale), analysis of the mineralogical composition (molecular scale), and analysis of the geochemical composition (elementary scale). However, the increasing degree of specialisation of the analyses provided by these long and invasive methods hampers their application in the context of a systematic determination of every artefact in archaeological collection. Moreover, the development of petroarchaeology as an independent discipline has led to specialised training in this field (Fernandes, 2012; Delvigne, 2016), resulting in the introduction of distinct issues from those of the techno-economic fields, such as fundamental research on the mechanisms of rock silicification or processes in the evolutionary chains of materials (Fernandes, *op. cit.*).

Other authors have used the techno-economy concept to discuss the analysis of the segmentation of the *chaîne opératoire* for each raw material to examine its management by human groups (e.g., Geneste, 1985; Pelegrin *et al.*, 1988; Desrosiers, 1991; Sellet, 1993) or to discuss the territories, circulation and mobility strategies of human groups (Féblot-Augustins, 1999, 2008, 2009). However, the last few years have led to a disciplinary split between actors of petroarchaeology and techno-typology. This dichotomy, which has been relatively marked since the establishment of the first petroarchaeologists, remains frequent between authors dealing above all with technology and the economics of *débitage* and raw materials, and those dealing with the origin of raw materials, circulation, mobility and territorial strategies of human groups. This dichotomy is beginning to be resolved (e.g., Porraz, 2005; Park, 2007; Slimak, 2008; Lebègue & Wengler, 2014; Tomasso, 2014, 2018; Caux, 2015; Vaissié *et al.*, 2017) thanks to the emergence of researchers trained in both methodologies and approaches of techno-typology and petroarchaeology. This is widely due to the current research dynamic in France, and specifically that of raw materials (PCR “Réseau de lithothèques” and GDR SILEX) aimed at harmonising practices and networking the various players in the field.

The term “petro-techno-economy” (Caux, 2015) is thus designed to underscore these new researcher profiles who master both the means and the tools of techno-typology and petroarchaeology. It also serves to emphasise the importance given to raw materials in this approach, not only in terms of pure technological treatment (economy of raw materials) or theoretical representations of the extension of supply territories, but the interest of integrated approaches and their potential for interpretations in terms of strategies and circulation routes. It allows us to partially map out a group’s itinerary (in space and time), visible from the documentation available on archaeological sites, and to highlight the socio-economic mechanisms underlying this organisation.

This proposition to use the term “petro-techno-economy” does not claim consensus within the community of prehistorians, but rather expresses our position as to the importance of distinguishing traditional “techno-economic” studies from those currently carried out under the impetus of the methodological renewal of the harmonisation of practices and the emergence of new researcher profiles.

3. Material

Abri Pataud is located at the bottom of a cliff (the Signal massif) on the left side of the Vézère (fig. 2). The material from Level 7 (Upper and Lower) of the excavations of H. Movius (Movius 1954, 1955, 1975, 1977) was attributed to the Classical Late Aurignacian with *busked burin* (Chiotti 1999; Michel 2010). Previous studies have based raw material determinations mainly on macroscopic criteria to propose a techno-economic analysis of each raw material. Our study first implemented, then revised, these determinations through a petroarchaeological study at a mesoscopic scale (*cf. infra*). We then considered all the 5,134 coordinated pieces from Level 7.

Located in the Velay Massif on the Devès plateau, Baume-Vallée is a basalt rock shelter (fig. 3). Excavated by A. Laborde (from 1966 to 1973), then by J.-P. Raynal (from 1974 to 1996), the deposits yielded a large stratigraphy with several archaeological levels from the Middle Palaeolithic (e.g., Daugas & Raynal, 1977; Raynal, 1983, 1992, 1997). Past studies (Decroix, 1984, 1985; Decroix-Bourhim

et al., 1990; Raynal & Decroix, 1986) led the whole archeostratigraphy being attributed to the Charentian Mousterian of the Ferrassie type. The first petroarchaeological study of this collection was conducted by one of the current authors during their Master's dissertation (Vaissié, 2016; Vaissié *et al.*, 2017). Herein, we present the findings based on a study of 2,984 artefacts from the upper units.

4. Method

4.1. Petroarchaeological determination and economic domains

The petroarchaeological determinations are based on multi-scalar observations at a macroscopic and a mesoscopic scale, following principles developed since the 1980s (Masson, 1979, 1981; Demars, 1980, 1982; Torti, 1980; Mauger, 1985; Séronie-Vivien and Séronie-Vivien, 1987; Séronie-Vivien and Lenoir [dir.], 1990, among others). We initially sorted them at a macroscopic scale, based on colour, texture and organisation of the siliceous phase (with respect to the sedimentary structures visible in flint). This first stage is particularly useful for material from the Aquitaine Basin which is very specific and well known. We present the main criteria for each of them in the results section, allowing us to distinguish between them. Every piece was then observed at a mesoscopic scale (with a binocular magnifier at x20 to x150 magnification) to check the correspondence of the sedimentary and micropalaeontological content with the initial attribution at a macroscopic scale. We based our mesoscopic analyses on a complementary approach inspired and simplified by previous methods, and considered several parameters such as the quantity of grains (estimated with graphic charts), type of grains (biotic, detrital, syn-sedimentary and diagenetic, and other minerals acquired from a secondary deposit) and the frequency of each type of grain (estimated with graphic charts) (Caux, 2015; Caux and Bordes, 2016). Furthermore, we included the raw materials in evolutionary chains (Fernandes and Raynal, 2006; Fernandes *et al.*, 2016) to get a better understanding of the different outcrops (primary or secondary deposits such as alteritic or alluvial deposits) collected by past groups. Generally, for well-known georesources, the mesoscopic observations confirmed the macroscopic determination, saving a considerable amount of time. Characterisation at a mesoscopic scale involving many different criteria is very useful to establish subtypes and specific outcrops on a small geographic scale with a large diversity of raw materials (Fernandes, 2012; Tomasso, 2014; Delvigne, 2016; Vaissié *et al.*, 2017). In this study, we aimed to address the economy of different raw materials on a macro-regional level. We focused on the presentation of large family raw material types to establish the frequentation and management of coherent geographical areas (referred to as geotopes).

The lack of a systematic association between petroarchaeology and techno-economic studies led to a segmentation of our perceptions of prehistoric territories at different scales (fig. 1). At a (macro-) regional scale, it is common to discuss the supply distances and the territory around an archaeological site. Within the supply territory, following a techno-economical study, a global management system of all the raw materials is then proposed. Without any systematic petroarchaeological study, there is an assumption that the representation of the *chaîne opératoire* is inversely related to the distance of the outcrops (Elston, 1992; Brantingham, 2003; Surovell, 2012), as the material from the furthest outcrops is only represented by the final stage in the *chaîne opératoire*. In this case, the distance between the site and the outcrops is measured in a direct line. The upshot of this division of space is that the boundaries set for the local, intermediate and distant areas can vary, sometimes significantly, depending on the techno-economic systems being studied. Thus, while there is consensus regarding the model proposed by Geneste (1985), using local (0 km to 5 km), extra-local (5 km to 30 km) and

distant (over 30 km) supply areas (Geneste, op. cit.; Féblot-Augustins, 1993; Delagnes and Rendu, 2011) for the Middle Palaeolithic, this is not the case for the Upper Palaeolithic. If we take the example of the local area, it varies with different authors: between 7 km and 20 km for F. Djindjian *et al.* (2000), 10 km for R. R. Larick (2011) and V. Delvigne (2016), 10 km to 15 km (Kelly, 2013) 20 km for J. Féblot Augustin (1999a) and F. Djindjian (2014), between 20 km and 30 km for A. Tarrino *et al.* (2015), and up to 40 km for R. A. Gould and S. Saggers (1985). While these models respond to real differences in terms of the techno-economic processing of materials, such variations do not follow the ethnographic guidelines proposed by Higgs and Vita-Finzi (1972) and L. R. Binford (Binford, 1982).¹ In addition, in view of such variability in the way the areas are defined, how can we discuss the real value of changes in mobility between different physical environments and chronological periods?

In the present paper, we decided to consider the raw materials as local if they came from within a radius of 5 km around the site. This limit corresponds to a distance that can reasonably be covered in a one-day round trip. From this perspective, and given the study context (i.e., steep-sided river valleys and mid-mountain terrain) and the role often granted to topography in fluctuating movements, it did not seem reasonable to consider longer distances. Materials outside this area can be discussed on a case-by-case basis and the minimum Euclidean distances to the heights are given for information only, since they do not represent the distances actually travelled, nor the real investment (whether the acquisition is direct or indirect) in time needed for their transfer.

4.2. The Petro-Techno-Economical (PTE) Management Group

For each collection, we determined the raw material for each piece, based on observations at a mesoscopic scale (*cf. supra*). We then studied the *chaîne opératoire* segmentation for each raw material. At Abri Pataud, we considered 4 main stages of the *chaîne opératoire* (fig. 4):

- a. acquisition and preparation of the blocks (blocks, tested blocks, numerous cortical flakes, etc.),
- b. blade production (core tablets, laminar flakes, cortical blades and cortical laminar flakes, numerous ordinary flakes, evidence of knapping accidents, etc.),
- c. bladelet production and use (bladelet cores, bladelet blanks, flakes and lamellar flakes for the maintenance of bladelet cores, etc.),
- d. laminar tools for retouching and use (laminar tools, retouching flakes, tool fragments, etc.).

At Baume-Vallée, we also considered 4 main stages of the *chaîne opératoire* (fig. 4):

- a. acquisition and preparation of the blocks (blocks, tested blocks, numerous cortical flakes, etc.),
- b. flake production, mostly Levallois (cores, management flakes for knapping and striking surfaces, *éclats débordants* and Levallois products, etc.),
- c. ramified production and use (cores on flakes, management flakes for knapping on flakes, isolated non-retouched predetermined products),
- d. retouching phase only (retouched products and/or retouching flakes).

¹ The local area is assumed to correspond to the foraging radius, i.e., the area covered during the daily pendular movement. While the distances suggested for this daily movement can vary according to context, it seems unlikely that points located more than 10 km away could be visited with a return to camp within a day (Binford, 1982).

For each collection, we then put all the raw materials that presented the same *chaîne opératoire* segmentation into a single PTE management group. The first group concerned the raw materials for which every stage in the *chaîne opératoire* was represented on-site. The second group concerned the raw materials that were represented by stages b to d, the third group by stages c and d, and the fourth group by stage d only. Finally, we analysed the geographical origin of each raw material within the supply territory in relation to its management group.

5. Results and interpretation

5.1. Abri Pataud

5.1.1. Raw material per PTE management group

We distinguished 6 main raw material families whose origin was already known, classified per management group (Table 1). The large group of senonian flint from the Périgord represents the only PTE management group 1, as all stages in the *chaîne opératoire* are represented in the collection. This group includes several geological types (mostly santonian and coniacian) and different colours (black, grey and blond) that could be collected very close to the site in the regolith, colluvium, and Dordogne alluvium (e.g., Demars 1980; Séronie-Vivien & Séronie-Vivien 1987; Turq 1992). These were usually small to middle-sized blocks (up to 20 cm on average), often with a knobbly, irregular surface, of mostly homogeneous quality flint.

Two raw materials represent PTE management group 2—Bergeracois flint and *Grain de Mil* flint—as we have evidence of blade and bladelet production and on-site use. Bergeracois flint is available near Bergerac on both sides of the Dordogne River, downstream of Abri Pataud (e.g., Demars 1980; Geneste 1985). This means it was imported to the site from at least 30 km to 50 km away (in a direct line). The main outcrops of *Grain de Mil* flint are located near Jonzac in the Charente-Maritime (Simonnet *et al.* 2007; Caux 2015; Caux & Bordes 2016), at least 130 km from Abri Pataud in a direct line. Both materials are available in the form of huge, regular blocks (up to 60–80 cm) of homogeneous material.

PTE management group 3 is represented by just one raw material, Grand-Pressigny flint, with 1 bladelet core and 4 retouched blades. This material is located to the north in the Parisian Basin (e.g., Primault 2003; Delvigne *et al.* 2018b). As with Bergeracois and *Grain de Mil* flint, Grand-Pressigny is frequently present as huge, regular blocks of homogeneous flint.

Finally, PTE management group 4 is represented by 2 raw materials: Turonian flint from Angoulême (2 blade tools) and Chalosse flint (1 blade tool). The first is located in the Charente (Séronie-Vivien & Séronie-Vivien 1987; Bordes 2002). It is present as large blocks of homogeneous flint. The second includes several types of Chalosse (e.g., Normand 1986; Bon *et al.* 1996; Séronie-Vivien *et al.* 2006) and is present as regular, medium-sized blocks.

5.1.2. From Supply Territory to Circulation Trajectories

The supply territory traced out for Abri Pataud is quite common for the Upper Palaeolithic in the Aquitaine Basin, extending more than 200 km in different directions around the site, specifically to the north and south, including material from the most “distant area” (over 150 km). However, on the map

(fig. 2) we can see that there is no clear correlation between the supply areas and the PTE management groups, since we have evidence that materials coming from more or less the same distance from the site (such as *Grain de Mil* and Turonian flint from Angouleme) belong to two very different management groups (Chiotti, 2003; Féblot-Augustins, 2008 and 2009; Caux, 2015).

We therefore need to consider two hypotheses regarding the possibility of direct or indirect acquisition. The first is that there were two exploitation modes, as some materials (e.g., Turonian flint from Angouleme) were knapped at the outcrop and only the blades were transported, while other materials (e.g. *Grain de Mil*) were knapped gradually, as and when needed, and the whole block or core would then be transported. However, in other techno-complexes such as the Early Aurignacian or Middle Magdalenian (Blades, 1999; Langlais, 2007; Langlais *et al.*, 2015; Secher & Caux, 2017), the management mode, involving knapping at outcrops and transporting blades only, usually concerned raw materials present in the form of huge blocks as they were difficult to transport but could provide long blades with a long lifetime (reduced by successive phases of retouching). In the Aquitaine Basin, this management mode mainly concerned Bergeracois flint and *Grain de Mil* flint (e.g., Demars 1980; Bon 2000; Caux 2015; Secher & Caux 2017). Here we have a different distribution as the Bergeracois and *Grain de Mil* flint present evidence of on-site knapping, whereas the Turonian flint from Angouleme and the flint from Chalosse are represented by a couple of retouched blades, but not mass importation of laminar blanks and tools. In this case, the quantitative and economic differences could be interpreted as resulting from seasonal long-distance mobility, hypothesis to be linked with archaeozoological data (Sekhr, 1998; Soulier, 2013) which underlined preferential spring or summer hunting. Groups moved along a north to south trajectory, between the south Parisian basin and the Pyrenean area. The low quantities of either end-product or end-products, plus small bladelet cores from Grand-Pressigny and Chalosse flint, could therefore be considered to represent residual personal gear (Kuhn, 1992) transported during long-planned seasonal moves, as proposed by Bordes *et al.* (2005) and Bon *et al.* (2005). The greater quantitative and economic representation of *Grain de Mil* and Bergeracois flint would thus be a part of a strategy of provisioning of places, and shows anticipated needs while moving to the Périgord area. Despite the relatively good quality of the local raw materials, this anticipation could be explained by the greater heterogeneity in the volume and quality of the local senonian flint (more rarely accessible in the form of large nodules than the *Grain de Mil* or the Bergeracois flint). This behaviour appears to be a response to a primary adaptive constraint, as witnessed in current or sub-actual nomadic populations (Binford, 1978; Torrence, 1983) regarding time-budgeting anticipation. The Charente would acts as a pivotal space, conducive to the constitution of suitable material reserves, before a time-stressed² stay in the Périgord. While this explanation could be applied to the northern supply area, the question of raw materials from the Chalosse area is more problematic. The absence of raw materials from the intermediate space between Périgord and the Pyrenees, coupled with a great circulation distance (200 km) and the economic representation of Chalosse flint, suggests a probable social separation. The few end-products in Chalosse flint may result from indirect procurement through social transfers with groups based in the south of the Aquitaine Basin. In this hypothesis, northern raw materials would constitute landmarks for part of the mobility

² Anticipating production is mainly linked to moving to an area that lacks good quality raw material (Féblot-Augustins, 2008 and 2009), or to counterbalance the constraints of subsistence activities (high mobility of prey or limited duration of the hunting season; Torrence, 1993). In the case of Pataud, it could be motivated by the need to have pre-formed raw material stocks capable of producing the full range of the group's technical objectives.

network of human groups in Pataud, while Chalosse raw materials would signal possible social links with southern groups.

The second hypothesis is that there was only one exploitation mode (the core was transported and knapped when needed), so representation of the *chaîne opératoire* is inversely related to the distance of the outcrops. However, in this case, it must be said that these distances are not at all congruent with previous estimations in a direct line. Moreover, raw materials are available within a specific geographical area, mainly marked by its topography and hydrography, but also by the influence of climate on the plant and animal biomass. Palaeolithic hunter-gatherers were nomadic groups moving within their territory in relation to all these parameters, so they were very unlikely to have moved to the sources in a straight line from the site. Some recent approaches based on “least-cost path analysis” (e.g., Adriaensen *et al.*, 2003; Barge *et al.*, 2004; Herzog, 2014; Vaissié, thesis in progress) with GIS have been conducted to try to model the preferential circulation axes mainly regarding topographic factors. In this case, alongside the petro-techno-economical approach, we have here a very efficient method for tracing the main circulation axes, marked by all the raw materials from PTE management groups 1 and 2, to compare the archaeological data with circulation predictions (Vaissié, thesis in progress).

We could thus suggest that human groups from the Late Aurignacian in the northern Aquitaine Basin mainly moved along an east-west axis marked by Bergeracois and *Grain de Mil* flint supplies. It is interesting to note that some other raw materials from the northern Aquitaine Basin (such as Fumelois, Gavaudun, Jasperoide or Calcedoine de Domme, which were well known by both prehistoric groups and prehistorians as they are very common in archaeological collections) are not present in Abri Pataud Level 7. While Calcedoine could have been neglected because of its medium-to-poor knapping qualities, this is not the case for the other materials. The same is true regarding the accessibility of these raw materials, all currently easy to find in primary and secondary outcrops and with suitable modules for long blade production. Their absence in the collection clearly shows that the eastern area of North Aquitaine was not part of the main circulation supply routes and areas, which could suggest its distance from the space socially invested by the group.

To the west, we can also note the main difference between *Grain de Mil* and Angouleme flint, as the first are located on the Seudre and Seugne hydrographic areas, whereas the outcrops of the second are located to the north along the Charente river basin. Differences in terms of representation could once again act as a territorial marker between the mobility networks of different groups. The same observation concerns the selection and transport of Grand-Pressigny flint (PTE management group 3), while there is no evidence of Vallée du Cher flint in the collection, although it is very good quality material and its outcrops are close to those of the Grand-Pressigny. Absence of the Vallée du Cher flint could also be a marker of greater social distance (Gallais, 1976, 1982; Gouletquer, 1990) reaching the south of the Paris Basin, suggesting indirect acquisitions via networks of transfers of only certain materials from this area (Turonian Flint of Grand Pressigny). Here again, it seems that it was more the circulation axes that influenced the collection of raw material rather than the search for raw material that influenced the circulation axes. For the raw materials coming from Chalosse, the interpretation remains (as in the first hypothesis) in favour of the weak integration of this area in the nomadic or social networks of Abri Pataud’s human groups in layer 7. Once again, this is based on the lack of intermediary raw materials and the lack of representation, both in economic terms and quantity.

Similar economic behaviour has also been documented for other late Aurignacian sites in the Périgord region, with busked burin such as Caminade D1-D2 (Michel, 2005; Caux, 2015), or Roc de Combe, layer 6 (Michel, 2010; Caux, 2015). In each case, the *Grain de Mil* flint comes in fourth position for the most frequently found raw material (mainly between thirty and fifty pieces), after the local senonian and tertiary flint, and the Bergeracois flint. It is represented by laminar and bladelet blanks (retouched or not), as well as cortical flakes and core maintenance products. The presence of more distant raw materials, such as those from Grand-Pressigny or Chalosse, is also noted but only in the form of a few end-products. These data can be added to those already published for this period in the south-west of France (Bordes *et al.*, 2005; Bon *et al.*, 2005; Féblot-Augustins, 2008 and 2009).

Following the idea that the distance of raw materials from the sites can be linked to the extension of the interaction network that is part of the group's social and life process (Féblot-Augustins, 2008), petro-techno-economical data suggest the presence of a tripartite space in the Aquitaine Basin (fig.5): i.e., the Charentian and Périgordian space, the area of Poitou and south of the Paris Basin, and the north Pyrenean space. The human group of Pataud (layer 7) mainly integrated the Charentian and Périgordian space in their nomadic network, with regular circulation between the valley of the Seugne and the Dordogne. The smaller amount of raw material arriving from the north and the south could have resulted in the greater social distance for these areas. Either they represent more dilated stages in time for the nomadism journey (raw material from Grand-Pressigny?) or they are only included in the transfer networks (raw material from Chalosse?). If we give a preponderant part of indirect acquisition, the Charentian and Périgordian centres could represent the terminals of a social territory marked by their status as a "relay space" with neighbouring territories. These interpretations extend those already formulated for the late Aurignacian with busked burin (Bordes *et al.*, 2005; Féblot-Augustins, 2008 and 2009; Caux, 2015; Caux & Bordes, 2016) and tend to mark Périgord as a pivotal space in the cultural territory of this technocomplex for the Atlantic facade. According to the modes of acquisition (embedded or transfer), the difference is down to the extent granted to the social territory of human groups.

5.2. Baume-Vallée

5.2.1. Raw material per management group

For the upper units of Baume-Vallée, we distinguished 37 different types of raw materials where the origin is already known. So as not to overload this presentation, we have grouped them into 15 main families of silicates (Table 2) (for a detailed list of raw materials, readers are referred to Vaissié *et al.*, 2017). We also added lithic objects in other raw materials (quartz, basalt and phonolite), which show the implementation of a knapping system substantially identical to that of flint (Vaissié *et al.*, 2017). The PTE Management group 1 is represented by all the different types of riparian silicification from the *Bassin du Puy* (plate 1, n° 1; Fernandes, 2012; Delvigne, 2016), imported from 15 km to 20 km to the north.³ All stages of the *chaîne opératoire* are represented in the collection and there is massive importation (Table 2) of rough or weak shaped blocks, with the presence of numerous cortical flakes and cores abandoned on the site.

³ The most proximal outcrops are located 12 km to the north but involve crossing a watercourse (the Dolaizon) and landforms making up the interfluvium with the Borne Valley. The most obvious path would follow the fluvial corridor of the Loire toward the Bassin du Puy, significantly lengthening the distances travelled (15 km to 20 km).

The PTE management group 2 is represented by 6 groups of raw materials: Aalenian flint present in the “*sables à chailles*” formation of the Velay, which is considered as the only local raw material (except for non silicites raw material) in this context (plate 1, n° 2 ; Fernandes, 2012), silcrete from Saint-Pierre-Eynac imported from over 20 km to the north-east (plate 1, n° 5; Fernandes, 2012; Delvigne, 2016; Wragg Sykes *et al.*, 2017), Bajocian and Tithonian flint from the Naussac Basin, imported from over 30 km to the south-west (plate 1, n° 8; Fernandes, 2012; Delvigne, 2016; Delvigne *et al.*, 2018a), silcrete from Saint-Léger-du-Malzieu and the Paleo-Truyère Valley, imported from 50 km to 60 km to the west (plate 1, n° 4; Fernandes, 2012; Delvigne, 2016), upper Turonian flint from Le Grand-Pressigny, imported from almost 300 km to the north-west (plate 2, n° 5; e.g., Primault, 2003), and lower Turonian flint from the Cher valley located 300 km to the north-west (plate 2, n° 6; Aubry, 1991; Primault, 2003). Other rocks (mainly quartz, but also basalt and phonolites) are used in significant quantities. Quartz is the most widely used local raw material (even more than Aalenian flint), with 259 artefacts for which most stages of the *chaîne opératoire* are represented. There is a deficit in cortical products, however (Vaissié *et al.*, 2017).

The PTE management group 3 is represented by 6 main groups of raw materials: close to the site, silcrete from La Collange, imported from over 10 km to the east (plate 1, n° 3 ; Fernandes, 2012), wetland silicifications from Mazet-Saint-Voy and the Lignon Valley, imported from over 40 km to the north-east (plate 1, n° 6), silcrete from Arlanc and the Dore Valley, located over 60 km to the north (plate 1, n° 7), barre-mo-aptian flint from Rochemaure in the Rhône valley, located 70 km to 80 km to the south-east (plate 2, n° 4; Delvigne *et al.*, 2018a), tertiary silicifications from the Limagne Basin, imported from 90 km to 100 km to the north-west (plate 2, n° 3), and Oligocene flint from the Aurillac Basin, imported from 100 km to 120 km to the west (plate 2, n° 2).

Finally, the PTE management group 4 is represented by 2 groups of raw materials: silcrete from Madriat (over 80 km to the north-west; plate 2, n° 1) and Senonian flint from the Loiret in the Paris Basin (over 300 km to the north; plate 2, n° 7 and 8).

5.2.2. From supply territory to circulation trajectories

These data provided two main findings:

- The supply territory, determined by the origins of the raw materials used in Baume-Vallée, is very unusual with respect to records for the Middle Palaeolithic. Local (under 5 km from the site) raw materials are surprisingly underrepresented in terms of both quantity (under 20% of the raw material; Vaissié, 2016; Vaissié *et al.*, 2017 ; Table 2) and representation in the *chaîne opératoire* (PTE management group 3). This kind of raw material is expected to be highly predominant in Mousterian sites (over 90% of the assemblages in most cases; e.g., Geneste, 1985) in terms of both number of pieces and use. The most frequently used raw materials were imported from primary or secondary outcrops, from 15 km to 50 km around the sites in different directions, but mainly from the north and the *Bassin du Puy* (Vaparian flint that represents over 50% of the lithic industry; Vaissié, 2016; Vaissié *et al.*, 2017), with a distance of at least 12 km from the site for the nearest Borne Valley outcrops, but also from the east (silcrete from Saint-Pierre-Eynac), the south (Jurassic flint from the secondary outcrops of Naussac Basin⁴) and the west (silcrete from Saint-Flour). Finally, the presence of distant

⁴ Jurassic flint from the Naussac Basin presents well-known characteristics in terms of neocortex and matricial evolution (Fernandes, 2012). Recognition of these criteria, associated with the presence of materials only known

(Aurillac Basin, Limagne Basin and Rhone valley silicifications) to very distant (Grand-Pressigny, Cher Valley and Loiret flint) resources is exceptional for the Middle Palaeolithic and shows the first evidence of transport from over 300 km away. In line with other authors (Porraz, 2005; Slimak, 2008a; Fernandes *et al.*, 2008; Lebègue, 2012) who showed evidence of long-distance circulation, these findings alter the generally accepted circulation models for Mousterian groups, inviting us to recognise (and accept) new evidence of long-distance circulation for the Middle Palaeolithic.

- Regarding the petro-techno-economic management of raw materials, Baume-Vallée is also quite unusual: running counter to the presumption of a relationship between distance and use (*cf. supra*), it appears that the petro-techno-economic management of raw materials does not correlate with a distance factor. Some nearby raw materials (Aalenian flint from the Velay and silcrete from La Collange) are rarely present or poorly represented, while other raw materials from greater distances are far more abundant. Issues underlying these observations can arise in terms of both variations in technical behaviour (and therefore requirements regarding raw materials quality) and in terms of mobility and transfer networks.

If we look at the possibility of a link between the quality and the representation of raw materials, the analogies do not appear evident. Local raw materials are poorly represented but do not show clear differences either in terms of suitability for knapping or availability of volumes with other raw materials. We refer especially to the vaparian flint from the *Bassin du Puy*, silcrete from Saint-Pierre Eynac and Jurassic flint from Naussac, but also to more distant resources such as silcretes from Saint-Flour (Saint-Léger-du-Malzieu) which are well represented. In addition, Aalenian flint and quartz are considered local by default, given that they are available in most of the Miocene alluvium in a large part of the Velay (within a radius of about thirty kilometres around the site; Fernandes, 2012). One could even argue that the relative lack of cortical products (Vaissié *et al.*, 2017) could foster acquisition from outside the strictly local domain. The technological treatment of these raw materials also shows little (quartz) or no (Aalenian flint) difference with that of all silcites. Production tends independently towards obtaining flakes with similar morpho-technical characteristics. Its low diversity is just one example of the technical variability and adaptability of Mousterian groups that had to manage with various raw materials. We could also add that in similar cultural contexts (with local raw materials of “poor quality”), the majority of examples in the Mousterian context show massive exploitation of local materials although the availability of other raw materials is at a distance equivalent to that observed at Baume-Vallée for the most common imports (*cf. riparian flint*). This is particularly true in the contexts of Quercy (Chalard *et al.*, 2007; Faivre, 2008; Faivre *et al.*, 2013). However, it applies not only to raw material from less than 50 km away, but also to more distant resources such as Turonian flint (upper from Grand-Pressigny and lower from the Cher Valley). These are not as well represented in terms of quantity in the lithic industry (respectively 29 and 52 artefacts), but the numbers are quite significant for the Middle Palaeolithic. Once again, and despite the quality that can be considered superior to the silcites from the regional space, the techno-economy of these materials does not differ fundamentally from materials sourced closer to home. We also have clear evidence of the on-site core exploitation and circulation of these long-distance resources.

in this outcrop, within the Baume-Vallée material, means we can exclude a collection of this type of Jurassic raw material within other secondary deposits accessible in the Velay area.

If we now turn to the supply strategy and its meaning in terms of settlement patterns and land use, the question of the acquisition modalities, both for regional and extra-regional areas, needs to be taken into consideration. For a regional area (under 50 km from the site), direct acquisition at the different outcrops is perfectly possible and most likely. The diversity of all raw materials within this area appears to indicate good knowledge of the landscape close to the site. The petro-techno-economic differences shown previously seem to be related to a differential space investment and to express recurrent moves between areas more or less strongly included in the subsistence territory during episodes of occupation (fig. 6). The most striking example is the frequentation of the area located in the heart of the *Bassin du Puy*, at the confluence of the Loire and the Borne. This vast depression is surrounded by the landforms of Devès (to the south and west), Meygal (to the east) and the threshold of Chaspinhac (to the north-east), presenting favourable geomorphological characteristics, specifically through the convergence of several rivers (the Loire, the Dolaizon, the Borne, the Gagne, the Sumène and the Chalon). This forms an area that probably conditioned the movement of animal populations, thereby creating attractive and strategic points for human groups within the context of subsistence activities. The same considerations apply to other materials in the PTE 2 group within the regional space, more specifically, the Naussac Basin (whose depression is now filled by an artificial lake) and the Saint-Flour Basin. These present geomorphological characteristics which seem marked by both the proximity of large watercourses (and a convergence area of minor watercourses) and a “basin” type shape surrounded by strong reliefs (which can serve as visual landmarks; Gallais, 1982; Bernus, 1995). If this observation should be qualified concerning the georesources of Saint-Pierre-Eynac, its peripheral position in the *Bassin du Puy* is certainly a factor that can explain its representation. The sector should be included with that of the Borne Valley and would signify a broad integration of the *Bassin du Puy* into the area frequently occupied by human groups. Combined with the PTE management groups of Baume-Vallée, this hypothesis is reinforced by the presence of many Mousterian occupations⁵ (in shelters or open-air sites) in the sector: Les Rivaux 1 and 2 (Daugas and Raynal, 1977; Raynal *et al.*, 2005), Sainte-Anne 1 (Raynal *et al.*, 2006; Santagata *et al.*, 2017), le Rond-du-Barry (Bayle des Hermens, 1970, 1987; Raynal, 1988), Rochelimaque (Quinqueton, 1991)... For materials from the Saint-Flour Basin and the Truyère Valley, the Euclidean distance to the outcrop (around sixty kilometres, the most proximal outcrops being around 45 km away) and the crossing of the landforms of Devès and the Margeride (as well as the deep valley of the Allier) leads to further discussion of the methods of circulation. Their relevant representation in the assemblage tends to point to a recurring frequentation of this area, which can be linked to a distinct mobility circuit, or one including the Naussac Basin. The link between the Truyère Valley and the Aquitaine Basin, and the resulting implications in terms of direct vs. indirect acquisition, should also be considered (see below).

The less represented geomaterials would, for their part, signal weaker links with their areas of origin, which could be related to satellite activity areas. As such, we note that the landforms of Meygal (east and south-east of the Puy Basin) appear little frequented or invested. Frequentation of the flint outcrops of Mazet-St-Voy (30 km in Euclidean distance) implies bypassing the north of Meygal. Despite the relative proximity of the outcrop, that of La Collange (7 km in Euclidean distance) involves crossing

⁵ Although the chronological framework of these sites cannot necessarily be linked to that of Baume-Vallée, the recurrence of occupations in the Borne Valley underscores its importance in the regional space.

the Loire and the Laussonne in a configuration of fairly steep topography, or bypassing the *Bassin du Puy*. The case of the *silcrète d'Arlanc* is more ambiguous: its techno-economic representation in the assembly could go beyond the framework of mobility within the area of occupation, implying its inclusion in planning strategies and a long-term economy of the tools (*cf. infra*).

Concerning the regional space, the petro-techno-economic data seem to point to a complex logistical mobility system (Binford, 1982; Kelly, 1983; Féblot-Augustins, 1999; Fougère, 2011). The position of the Baume-Vallée site appears to give it a central (or at least intermediate) position among the regional territory (i.e., base camp). Movements would be planned and made according to logistical expeditions of several days, linked to the exploitation of areas of high interest in terms of subsistence more than the frequentation of raw material outcrops. Mobility patterns incorporate geographic entities of the “basin” type in particular, which seem to operate as key activity areas embedded in subsistence strategies. The collection of raw materials probably occurred in parallel with subsistence activities, but does not necessarily represent personal gear at Baume-Vallée. PTE management, mainly for group 1 (riparian flint from the *Bassin du Puy*), but also group 2, seems to be related more to a “provisioning of places” (Kuhn, 1992) in the same way as the supply of food resources. At the same time, additional activity zones are also frequented. These lower frequentations are almost certainly related to less interest in the areas concerned (greater structural distance; Gallais, 1982) rather than to the effective distance separating them from the Baume-Vallée site. As such, comparison of the representations of georesources from the outcrops of La Collange and the Saint-Flour Basin are quite significant. Mobility and planning of supply strategies could be compared to the mobility systems of several nuclear families (Fougère, 2011) operating the supply areas either separately or collectively. The great diversity of the faunal spectrum (Raynal and Decroix, 1986) identified appears to confirm this hypothesis and evokes a certain proximity to the “restricted planned strategy” model proposed by F. Djindjian (2014). In this case, could the poor representation of local raw materials thus be linked to social distinctions between provider members and those remaining in the base camp?

Even if we only consider the regional scale, the mobility patterns and resource management strategies do not seem to fit in with widely accepted variability of behaviours during the Middle Palaeolithic (Tavoso, 1984; Geneste, 1985; Féblot-Augustins, 1999b; Porraz, 2005; Lebègue and Wengler, 2014). These data thus shed new light on the planning capacity of Mousterian groups, in line with certain other observations over the last twenty years (e.g., Bernard-Guelle, 2005; Bourguignon *et al.*, 2006; Park, 2007; Rendu, 2007; Delagnes and Rendu, 2011; Lebègue and Wengler, 2014).

For the extra-regional space and the more distant raw materials, it is harder to establish (Renfrew, 1975; Perlès, 1990; Féblot-Augustins and Perlès, 1992; Perlès, 2007), but we offer here some elements for discussion. The Allier corridor and the south of the Paris Basin form an entity that can be jointly considered, and its role as a corridor for long-distance north-south circulation has been highlighted many times for both middle and recent Palaeolithic (e.g., Masson, 1981; Bracco, 1991; Féblot-Augustins, 2008 and 2009; Fontana *et al.*, 2018; Delvigne *et al.*, 2019). The high proportion (for the Middle Palaeolithic) of Turonian georesources (lower and upper) from the south of the Paris Basin and the technological elements present in the collection argue in favour of the direct acquisition of these materials as part of a cycle of long-distance nomadism. The artefacts present on the site could thus be considered as elements of the hunter-gatherers’ personal gear, forming part of strong anticipated raw material needs during major seasonal trips. It should be noted, moreover, that while elements

indicating the redevelopment and on-site core-knapping have been found for these materials (Vaissié *et al.*, 2017), the cores are absent. These elements illustrate the passage of volumes, integrating a productive potential, through Baume-Vallée site, but which were probably exported. Transportation could have taken place within a new cycle of major travel itineraries or within the regional mobility pattern described above. This kind of behaviour is frequently observed, but rarely for such circulation distances in different contexts of the Middle Palaeolithic (Porraz, 2005; Slimak and Giraud, 2007; Slimak, 2008; Lebègue and Wengler, 2014). Another argument in favour of a seasonal mobility strategy is the presence of geomaterials from the intermediate area between the Velay and the south of the Paris Basin. The presence of resources from the Limagnes *s. l.*, in smaller proportions and following more fragmented stages of the *chaîne opératoire*, seem to point to acquisitions linked to the brief passage of human groups in this area. On the other hand, materials from areas on the fringes of the Allier corridor (Madriat and the Dore Valley) could mark variations in the nomadic circuit, with variations in seasonal routes or divergence depending on the families making up the human group. In the context of these long-distance movements, a valid question is whether groups penetrated into the Velay area. One of the routes envisaged is located between the landforms of Devès and Forez, joining the valley of La Borne. This seems to us of prime importance and could explain, on the one hand, the over-representation of materials from this area in the regional series, and, on the other hand, significant pointers to human settlement in this valley (see above).

The poor representation of raw materials from Yonne and Loiret raises the issue of their method of acquisition. If we consider direct acquisition, it could point to the development of a logistics mobility system in the south of the Paris Basin, as observed in the Vellave area (see above).

If, on the other hand, we prefer the hypothesis of indirect acquisition, it could suggest transfers with other Mousterian groups whose territory would extend to the north-east of this area. In this second hypothesis, the south of the Paris Basin would potentially act as a relay area between different Mousterian territories (see below). The absence of raw materials from the intermediate space between the south of the Paris Basin and the Limagne may seem problematic, but is not inconsistent with our knowledge in terms of diffusion. These outcrops mainly provide Cenozoic materials related to “workshop” type sites, but which are rarely exported outside their specific locality (Piboule *et al.*, 2018). At the same time, materials from the south of the Paris Basin and from the Limagnes have been recorded there, indicating circulation between these areas passing through the departments of Allier and Cher (Piboule *et al.*, *op. cit.*).

Regarding the two other distant materials, those from the Aurillac Basin and the Rhone Valley, the representation and the economy suggest little comparison with those from the south of the Paris Basin. They are present only by way of a very small number of artefacts and mainly in the form of retouched products or chips. While the minimum acquisition distances are lower (and by far) than those of the much more distant Turonian flint, we should nonetheless point out that journeys to these areas involve crossing significant physical barriers: contrasting topography (Devès, Margeride, Aubrac and Cantal for the Aurillac Basin; Monts d’Ardèche for the Rhone Valley) and major water courts (Allier and Truyère to the west specifically).

For the Aurillac Basin, the proximity of the more widely represented outcrops in the Saint-Flour Basin could lead to its inclusion in a parallel, long-term seasonal or logistical circulation network from the

activity area of the Truyère Valley. The three artefacts would thus be markers of expeditions linked to a short period of residence in the Aurillac Basin. However, we could also consider the hypothesis of an indirect acquisition from the Baume-Vallée site, one of the arguments being the very small quantity of artefacts and their very low diversity. We could also mention the position of the Aurillac Basin, traditionally included in the Aquitaine Basin area on the other side of landforms that can act as a natural border (Aubrac mountain ranges and the Cantal massif). Finally, regarding the dissemination of Oligocene materials from this area in the Mousterian archaeological series, on the one hand, they are frequently documented in sites in Aquitaine (Turq *et al.*, 2017), although generally in the form of blocks taken from the alluvium. The hypothesis of direct acquisition of these materials from their primary or sub-primary deposits is more rarely considered. On the other hand, they have rarely been mentioned for the Middle Palaeolithic in the Massif Central to date. These data encourage us to consider the possibility of a transfer of raw materials from the Aurillac Basin. The artefacts could have passed through the corridor of the Truyère Valley and the Saint-Flour Basin, which would then be considered as a relay space between the territory of the Aquitaine groups and that of Baume-Vallée. Concerning the Barremo-Bedoulian flint from the Rhone Valley, the absence of resources from the intermediary space that is the eastern flank of the Ardèche mountains raises questions. This is particularly true for Jurassic flint from Ardèche, Cretaceous flint from Lagorce and Rochecolombe, and riparian flint from the Barjac-Issirac Basin. All these materials are located in the Ardèche watershed, which does not seem to be included in the territory of the Baume-Vallée groups. If we envisage direct acquisition of Barrémo-Bedoulian flint from the Rhone Valley, one of the routes considered would follow the Eyrieux Valley and reach the Vellave plateaus near the Mazet-Saint-Voy outcrops. Given the poor representation of materials from Mazet and the Rhone Valley, we could possibly consider their acquisition during occasional circulation to the Rhone area.

Another hypothesis involves transfers between the Massif Central and the Rhone Valley via the corridor offered by the Gier furrow, between the Pilat and the Lyon mountains. We should note that this has already been suggested for another Mousterian context, the site of Champ-Grand (Slimak and Giraud, 2007; Slimak, 2008a, 2008b), where evidence of distant materials presents strong similarities with those of Baume-Vallée (specifically concerning the Cretaceous materials of the Paris Basin).

The data and hypotheses presented above demonstrate the exceptional character of the Baume-Vallée site. Whether by the extent of the circulation or the economy of the raw materials represented on the site, the petro-techno-economic data offer findings that reflect the variability of behaviours commonly observed in the Middle Palaeolithic. Far from expressing the opportunistic strategies commonly described, we can observe real planning and anticipation of raw material needs, both at regional and extra-regional level. If the hypothesis of direct acquisition appears to be most likely, the presence of materials which are poorly represented and whose acquisition implies crossing major natural hurdles could be an argument in favour of highlighting transfer networks. In this case, the Baume-Vallée human groups territory would be organised on a large scale according to cycles of seasonal nomadism between south of the Paris Basin and the Vellave area. This territory could be articulated via visible social networks through the transfer of raw materials with other neighbouring Mousterian territories: the Aquitaine Basin, Paris Basin, Rhone Valley and, potentially, the Loire Valley.

This diffusion, whether it results from direct acquisition or from transfer processes, in no way squares with the idea of opportunistic behaviour by Neanderthals. On the contrary, it suggests the inclusion of

planning strategies within more or less large cultural territories, and the existence of likely social networks structured between territories.

6. Discussion and Conclusion

In terms of supply distances and global raw material management strategies, both Abri Pataud and Baume-Vallée suggest a very large supply territory extending over several hundred kilometres around the site. This is common for the Upper Palaeolithic, but exceptional for the Middle Palaeolithic. On the contrary, most of the models proposed for this period, particularly in the Aquitaine Basin, describe high mobility, but within a small territory (less than 50 km around the main site; Geneste, 1988; Féblot-Augustins, 1999; Bernard-Guelle, 2005; Turq *et al.*, 2017). Here, we have evidence of long-distance raw material circulation similar to the Upper Palaeolithic. We should therefore discuss Middle Palaeolithic raw material management using the same terms, models and questions as for the Upper Palaeolithic: what do these long distances mean? The circulation of groups anticipating raw material needs and stock management, or the existence of broad transfer networks between different local groups? These questions have rarely been addressed for this period in western Europe since the notion of “anticipating needs” and “transfer networks” has always been reserved for the Upper Palaeolithic, with the assumption of a rupture between the two periods feeding the ‘opportunistic’ vision of Neanderthal’s lifeway (Djindjian, 2014). With Baume-Vallée (and to a lesser extent Champ-Grand, for example; Slimak, 2008a), this cleavage is called into question: the final evidence of a clear distinction between techno-economic strategies of the Middle and Upper Palaeolithic tends to fade.

It is clear that broad circulation networks existed before the Upper Palaeolithic, at least in the French Massif Central (Masson, 1981; Féblot-Augustins, 2008 and 2009). However, to date, there has been no similar evidence for the Aquitaine Basin (e.g., Turq, 2005; Chalard *et al.*, 2007; Turq *et al.*, 2017) or the Paris Basin (e.g., Féblot-Augustins, 1997; Lhomme *et al.*, 2004; Lamotte *et al.*, 2005; Koehler, 2016). However, ongoing studies tend to question this belief (Vaissié, thesis in progress). It could be due to a lack of research including systematic petroarchaeological determinations at a mesoscopic scale, but then how can we explain it when some distant key material types have nonetheless been recognised at a macroscopic scale by prehistorians in Upper Palaeolithic collections? This raises significant questions, especially as the broad networks highlighted at Baume-Vallée include neighbouring areas in which we still have no evidence of these networks, such as the Paris Basin. It is thus more likely that raw material selection and modes of transport were far more complex than previously thought, including high mobility in limited areas (foraging radius) and very broad circulation networks. It could also be due to the specific social or ecological status of the Massif Central (Féblot-Augustins, 2008 and 2009).

The supply routes traced out around Baume-Vallée in the French Massif Central are indeed quite similar to those observed in recent studies over the whole Upper Palaeolithic in the same area (Delvigne, 2016). However, the pre-existence of these broad networks at the end of the Middle Palaeolithic is very important here as they may have promoted the spread of new concepts (such as Protoaurignacian blade and bladelet knapping) during the Early Upper Palaeolithic. From a methodological viewpoint, the studies of both Abri Pataud and Baume-Vallée show the importance of a petro-techno-economical approach as we can now trace not only the supply distances and territories, but also the intensity of the frequentation of axes within these territories, potential planned activities and transfer networks. The techno-economic approach has always leaned towards this end. However, thanks to new improvements and adjustments in petroarchaeological determination methods, it is now possible at a mesoscopic scale.

This study also raises new questions regarding our understanding of supply strategies during the Palaeolithic. Since the origin of each raw material (and not only the most distant ones) is invaluable in tracing circulation routes, we must now work on the articulation between raw material outcrops and the environment. We illustrate this in our paper by comparing outcrop locations with hydrographic axes, but what about the influence of other factors such as topography, vegetation and snow cover. With a petro-techno-economical approach, the raw materials and their outcrops could serve as a pivot between the material culture (supply strategy) and the environment (location of the outcrops).

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Legend of figures

Figure 1: Theoretical schematization of techno-economical fractionation in archeological site.

Figure 2: Location of Abri Pataud and techno-economical representation of exploited raw materials in the site. Raw materials: 1. Senonian flints from Perigord; 2. Maastrichtian Bergeracois flint; 3. Upper Turonian flints from Angoulême; 4. Coniacian-Santonian Grain de mil flint; 5. Upper Turonian flint from Le Grand-Pressigny; 6. Maastrichtian Chalosse flint. Dotted lignes represent the -90 m costaline.

Figure 3: Location of Baume-Vallée and techno-economical representation of exploited raw materials in the site. Raw materials: 1. Jurassic flints of the “sables à chailles du Velay”; 2. Riparian silicifications from the Bassin du Puy; 3. Silcrete from La Collange; 4. Silcrete from Saint-Pierre-Eynac; 5. Wetland silicifications from Mazet-Saint-Voy and the Lignon valley; 6. Bajocian and Tithonian flints from the Naussac basin; 7. Silcrete from Saint-Léger-du-Malzieu and the paleo-Truyère valley; 8. Silcrete from Arlanc and the Dore Valley; 9. Barremo-aptian flint from Rochemaure in the Rhône valley; 10. Oligocene flints from the Aurillac basin; 11. silcrete from Madriat; 12. Tertiary silicifications from the Limagne Basin; 13. Senonian flints from the Loiret; 14. Lower Turonian flint from the Cher valley; 15. Upper Turonian flint from Le Grand-Pressigny.

Figure 4: Main stages of the chaîne opératoire considered in this study for Abri Pataud and Baume-Vallée.

Figure 5: map of the potential organization of the territory of the human groups of Abri Pataud.

Figure 6: map of the potential organization of the territory of the human groups of Baume-Vallée.

Plate 1: 1. Riparian silicifications from the Bassin du Puy; 2. Jurassic flints of the “sables à chailles du Velay”; 3. silcrete from La Collange; 4. silcrete from Saint-Léger-du-Malzieu and the paleo-Truyère valley; 5. silcrete from Saint-Pierre-Eynac; 6. wetland silicifications from Mazet-Saint-Voy and the Lignon valley; 7. silcrete from Arlanc and the Dore Valley; 8. Bajocian and Tithonian flints from the Naussac basin.

Plate 2: 1. silcrete from Madriat; 2. Oligocene flints from the Aurillac basin; 3. tertiary silicifications from the Limagne Basin; 4. barremo-aptian flint from Rochemaure in the Rhône valley; 5. upper Turonian flint from Le Grand-Pressigny; 6. lower Turonian flint from the Cher valley; 7 and 8. Senonian flints from the Loiret.

Tableau 1: Main raw materials and techno-economical treatment in Abri Pataud.

Tableau 2: Main raw materials, their representation (the % frequency are based on all the indentified raw materials) and techno-economical treatment in Baume-Vallée.

Légende des figures

Figure 1 : Schématisation théorique du fractionnement techno-économique dans un site archéologique.

Figure 2 : Position du site de l'Abri Pataud et représentation techno-économique des matériaux exploités dans le gisement. Matières premières : 1. silex Sénonien du Périgord ; 2. Silex Maastrichtien du Bergeracois ; 3. Silex du Turonien supérieur d'Angoulême ; 4. Silex Coniacien – Santonien de type Grain de Mil ; 5. Silex du Turonien supérieur du Grand-Pressigny ; 6. Silex Maastrichtien de Chalosse. Les lignes en pointillés représentent le trait de côte à -90 m.

Figure 3 : Position du site de Baume-Vallée et représentation techno-économique des matériaux exploités dans le gisement. Matières premières : 1. Silex jurassiques des “sables à chailles du Velay” ; 2. Silex oligocènes du Bassin du Puy ; 3. Silcrète de La Collange ; 4. Silcrète de Saint-Pierre-Eynac ; 5.

Silex du Mazet-Saint-Voy et de la vallée du Lignon ; 6. Silex bajociens et tithoniens du bassin de Naussac ; 7. Silcrète de Saint-Léger-du-Malzieu et de la paleo-Truyère ; 8. Silcrète d’Arlanc et de la vallée de la Dore ; 9. Silex barremo-aptien de Rochemaure et de la vallée du Rhône ; 10. Silex oligocène du bassin d’Aurillac ; 11. Silcrète de Madriat ; 12. Silicites tertiaires du bassin des Limagnes ; 13. Silex sénonien du Loiret ; 14. Silex du Turonien inférieur de la vallée du Cher ; 15. Silex du Turonien supérieur du Grand-Pressigny.

Figure 4: Principales étapes de la chaîne opératoire considérées dans cette étude pour Baume-Vallée et l’Abri Pataud.

Figure 5 : Représentation de l’organisation potentielle du territoire des groupes humains de l’Abri Pataud.

Figure 6 : Représentation de l’organisation potentielle du territoire des groupes humains de Baume-Vallée.

Planche 1 : 1. Silex oligocènes du Bassin du Puy ; 2. Silex jurassiques des “sables à chailles du Velay” ; 3. Silcrète de La Collange ; 4. Silcrète de Saint-Léger-du-Malzieu et de la paleo-Truyère ; 5. Silcrète de Saint-Pierre-Eynac ; 6. Silex du Mazet-Saint-Voy et de la vallée du Lignon ; 7. Silcrète d’Arlanc et de la vallée de la Dore ; 8. Silex bajociens et tithoniens du bassin de Naussac.

Planche 2 : 1. Silcrète de Madriat ; 2. Silex oligocène du bassin d’Aurillac ; 3. Silicites tertiaires du bassin des Limagnes ; 4. Silex barremo-aptien de Rochemaure et de la vallée du Rhône ; 5. Silex du Turonien supérieur du Grand-Pressigny ; 6. Silex du Turonien inférieur de la vallée du Cher ; 7 and 8. Silex sénonien du Loiret.

Tableau 1: Principales matières premières et traitement techno-économique à l’Abri Pataud.

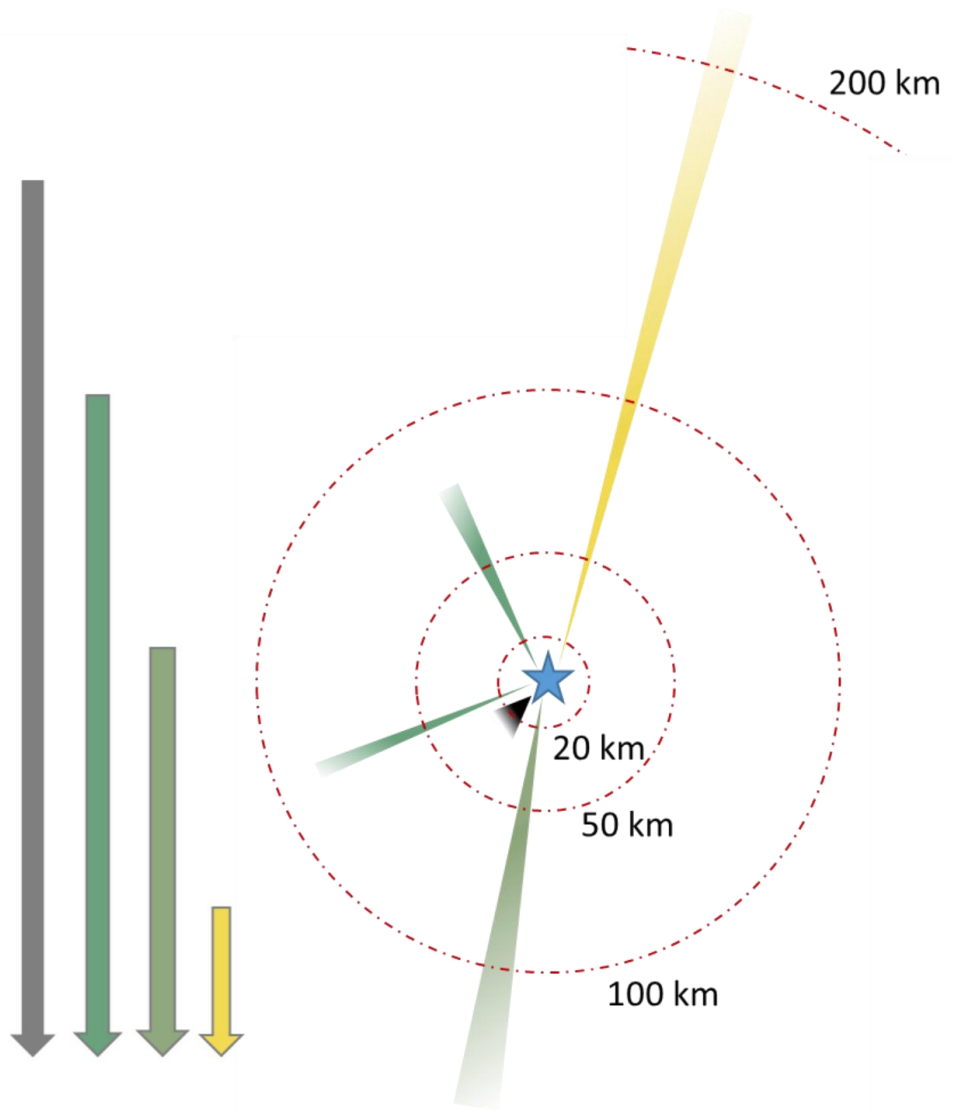
Tableau 2: Principales matières, leur représentation (la fréquence en % est basée sur la totalité des matériaux identifiés) et leur traitement techno-économique dans le site de Baume-Vallée.

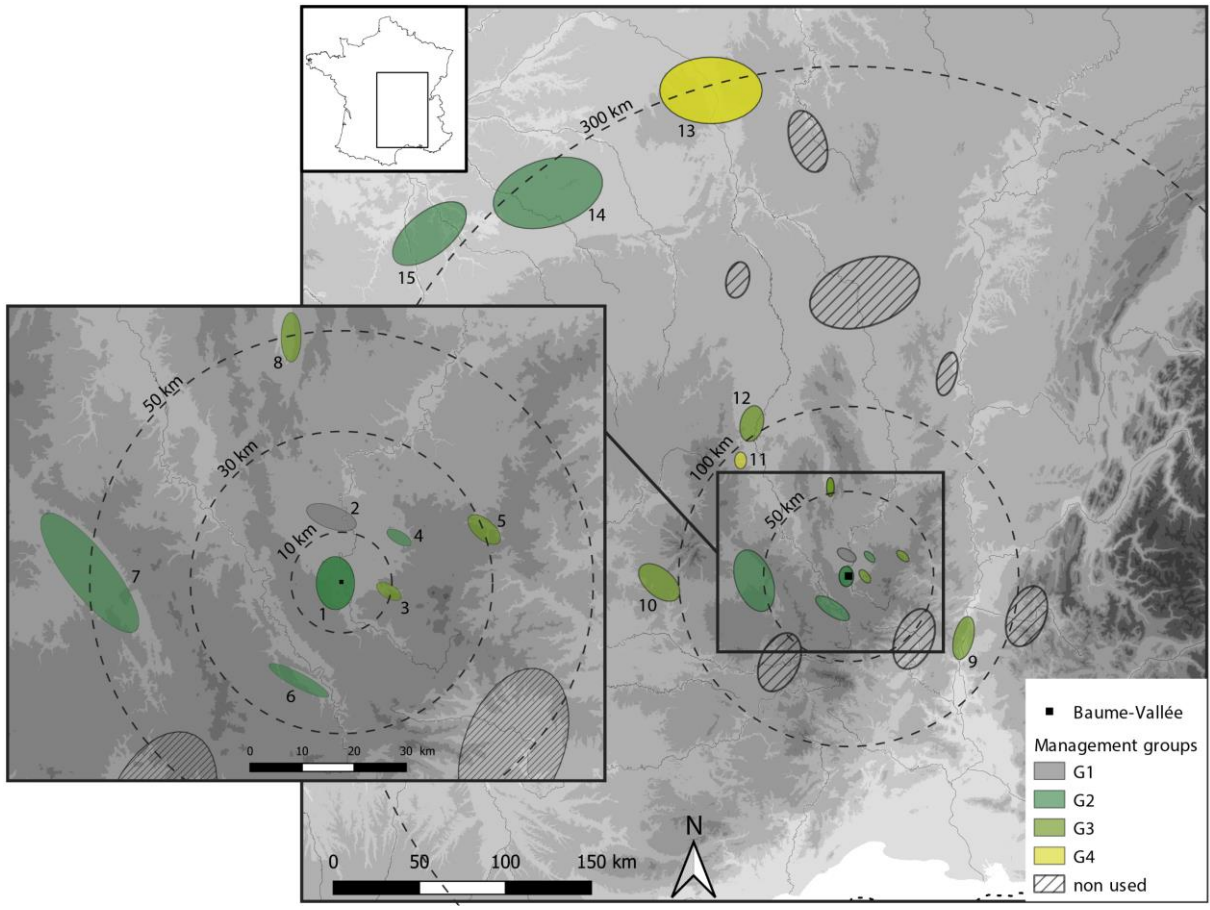
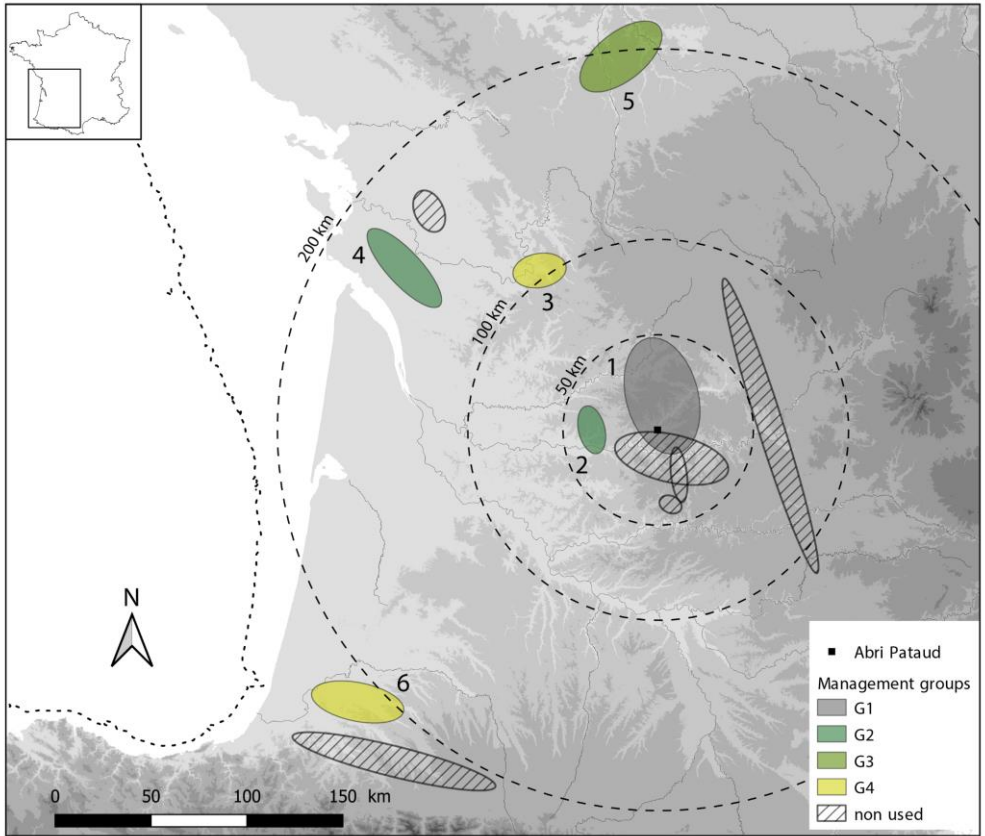
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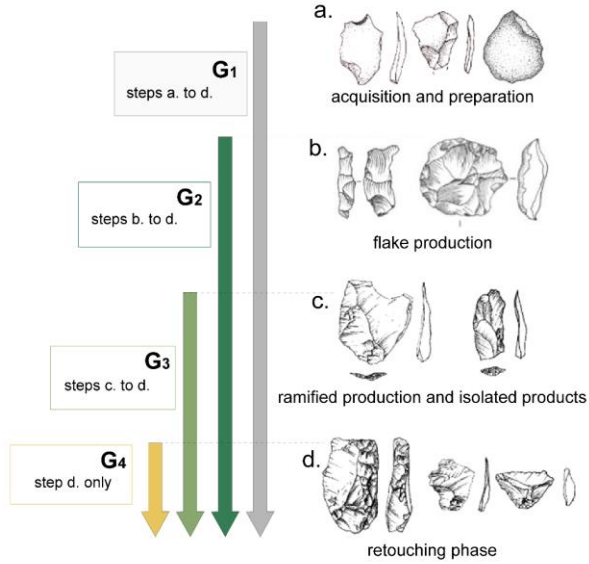
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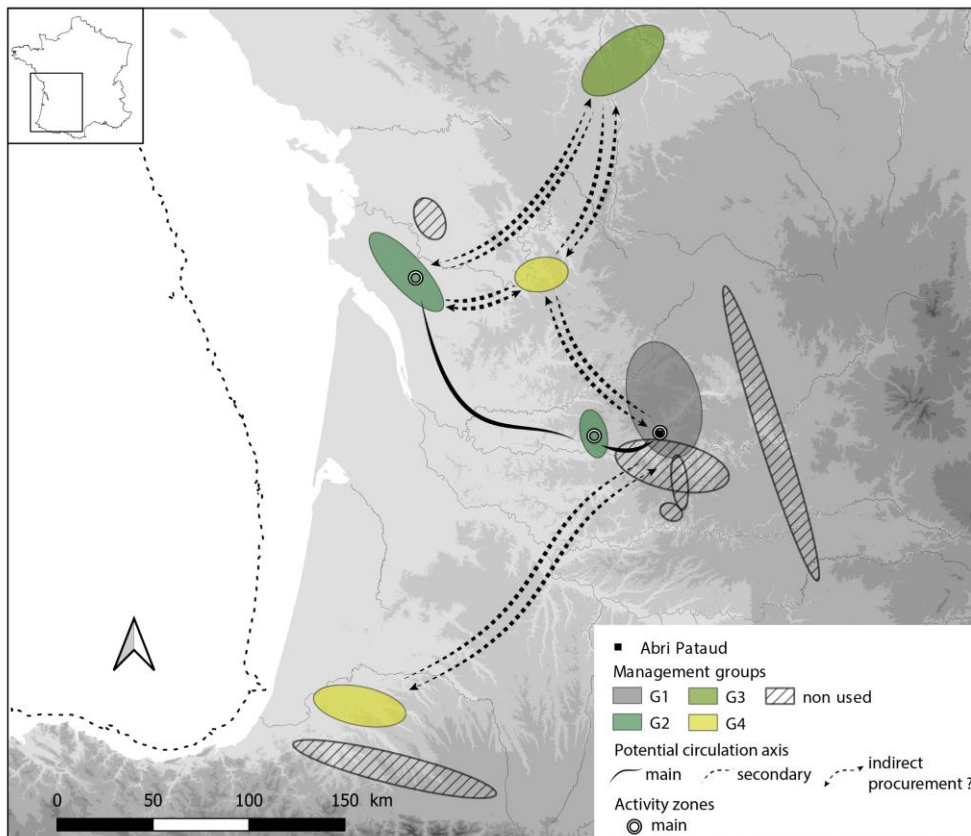
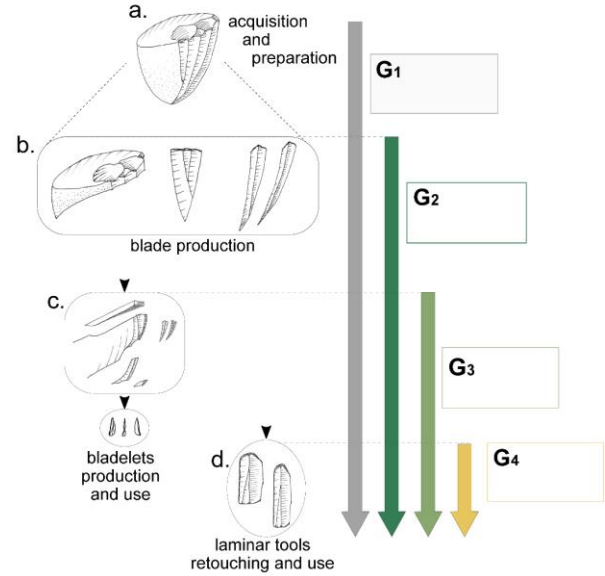


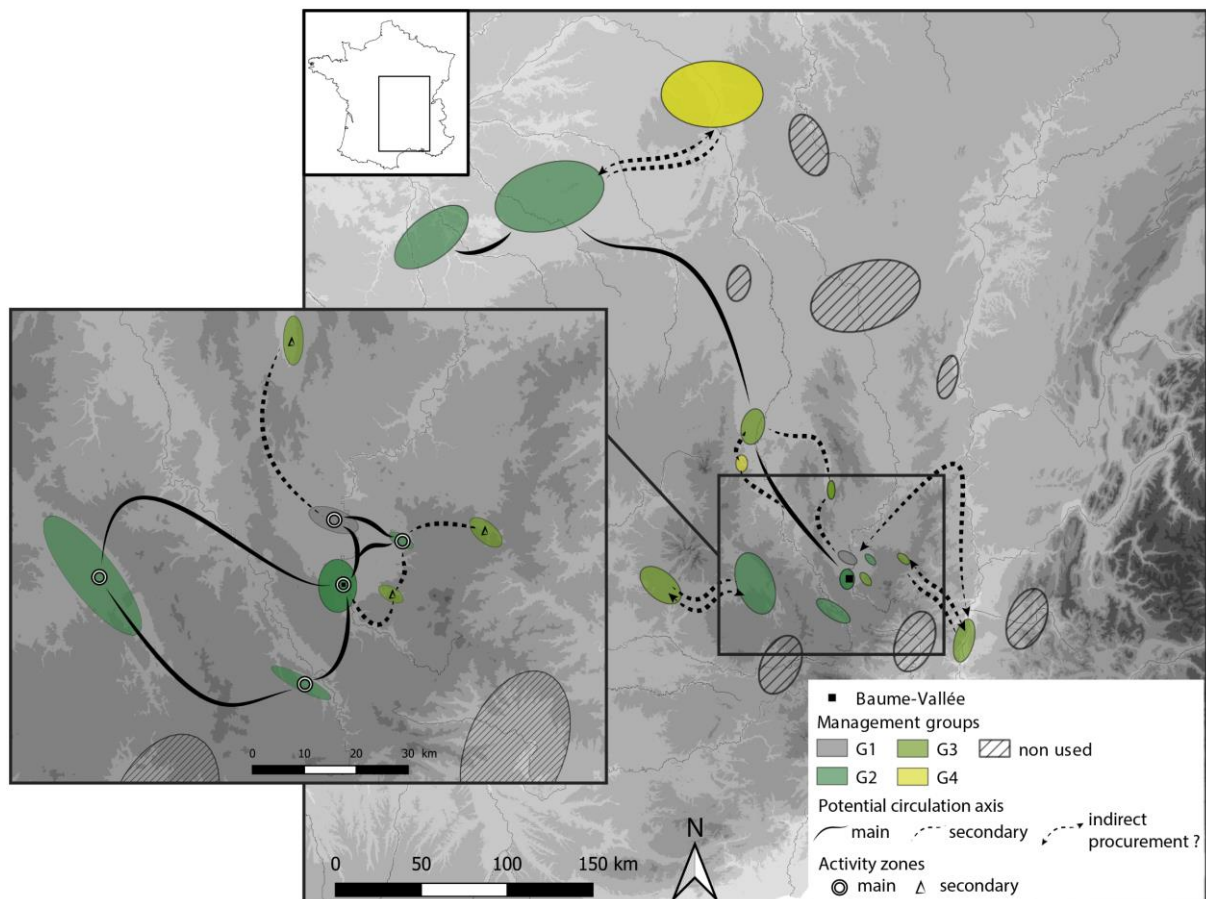


Baume-Vallée (Middle Paleolithic)
Chaîne opératoire



Abri Pataud (Late Aurignacian)
Chaîne opératoire





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