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Barremian–Bedoulian flint humanly transported from the west bank of the Rhône to the Massif-Central Highlands–A diachronic perspective

Le transport des silex du Barrémo-Bédoulien de la rive droite du Rhône jusqu'au cœur du Massif central français, approche diachronique

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ABSTRACT

Petro-archaeology is a powerful tool useful in understanding the origin and management of rocks discovered in prehistoric sites and the complexity of human territories. This research technique has been applied extensively to the Massif Central and its margins, allowing the revaluation of lithic imports from the Rhodanian corridor. Flint derived from Oligocene conglomerates at Rochemaure–Cruas (Ardèche) was a perennial and often preferred source for prehistoric groups inhabiting the Vivarais lowlands and was exported through the Monts d'Ardèche to the Velay highlands (Haute-Loire) during the upper Pleistocene and the Holocene. This modifies the previously drawn litho-spaces occupied by Neanderthals and Modern Humans and questions their land-use strategies in these contrasting natural landscapes.

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R É S U M É

La pétroarchéologie est un outil performant pour comprendre l'origine et l'utilisation des roches découvertes dans les sites préhistoriques et la complexité des territoires humains. Cette approche a été particulièrement développée dans le Massif central et ses marges, permettant la réévaluation des apports depuis le couloir rhodanien. Le silex des conglomérats oligocènes de Rochemaure–Cruas (Ardèche), ressource pérenne et souvent privilégiée par les groupes préhistoriques des basses terres du Vivarais, a été transporté par les monts d'Ardèche jusqu'aux hautes terres du Velay (Haute-Loire) au cours du Pléistocène supérieur et de l'Holocène. Les litho-espaces précédemment esquissés pour les occupations de Néandertal et de l'Homme moderne en Velay sont donc modifiés, et les stratégies de gestion de ces espaces naturels contrastés sont reconsidérées.

1. Introduction

Identifying land use patterns and regional mobility of prehistoric groups is a crucial study for modern archaeologists. Currently, characterizing the various lithic types, identifying their sources and the ways they were introduced into sites provide a dynamic view of occupations and how, over time, humans developed strategies adapted to various environments and climates. Working for more than two decades in the Massif Central and its margins, during which we developed a methodology for the precise identification of silicite[1] sources, we are now able to propose hypotheses on how humans occupied and at various times moved through this area in which several geographical barriers were formerly supposed to have constrained their mobility. The north-south drainage system of the Loire and Allier Rivers established by geological structures was once considered as a confining landform even though several low watersheds connected the southern mountainous Massif Central with its eastern Rhodanian margin.

Most studies of lithic raw material sources have an 'end-point' approach, but our work is devoted to the diffusion by humans of each flint type from its source-point through a regional space to an end-point. Although uncommon in Palaeolithic studies (e.g., Caux, 2015; Fernandes et al., 2012; Primault, 2003), this approach has already been applied to the Turonian lithics of the southern Paris Basin (Delvigne et al., 2017) and the silcrete of Saint-Pierre-Eynac (Wragg-Sykes et al., 2017). The present study, focusing on the South-East of the French Massif Central, provides an opportunity to examine a diachronic situation, describing Barremian-Aptian (Barremian–Bedoulian) flint from the right bank of the Rhône and its use in the Monts du Mézenc and Velay highlands. The results provide insights into the management of geo-resources by Palaeolithic and Mesolithic groups in the Vivarais and Velay provinces (equivalent to the modern departments of Haute-Loire, north-eastern Lozère and Ardèche) (Fig. 1). By applying our methodology to specific archaeological collections dated to the Middle and Upper Palaeolithic and the Mesolithic we were led to the identification of numerous locally sourced resources and thus were able to render more precise our vision of the mobility of Neanderthals and more modern Humans. Underlining the importance of understanding the economics of raw materials, our study revealed an unexpected polarity in the movement of one resource over a distance of one hundred kilometres and suggested the potential for exchanges to occur along the route.

The South of the Massif Central is often considered to lack siliceous raw materials suitable for use in Upper Palaeolithic blade technologies (Angevin, 2010; Bosselin, 1997; Bracco, 1992, 1994, 1995, 1996; Delporte, 1966; Franklin and Surmely, 2012; Surmely, 2000; Surmely and Pasty, 2003; Surmely et al., 1998, 2008; Virmont, 1981). It is nevertheless a propitious zone for petro-archaeological studies, as most of the outcrops of flakeable stone have now been identified and their characteristics described in many studies. While a significant presence of flint from "distant" sources (over 100 kilometres from the sites), along with a lesser amount of "local" flint, was observed in Auvergne at the Magdalenian site of Blanzat (Puy-de-Dôme) (Pomerol, 1888), this was only confirmed to be true for other sites in the region a century later (Masson, 1981). At the end of the last century, this observation was not immediately accepted, and it engendered much controversy (Aubry, 1991; Demars, 1985; Torti, 1980, 1983, 1985, among others). However, although flint originating from the South of the Paris Basin was identified within the Palaeolithic lithic series of the Velay and Auvergne regions (Masson, 1981) — an origin confirmed by recent studies (Delvigne, 2012, 2016; Delvigne et al., 2014a, 2014b; Surmely et al., 1998, 2008) — the contribution made to the overall lithic assemblages by local resources (particularly those from

[1] The term silicite was recently coined by Prichytal (2010) and refers to all rocks that have undergone silicification of chemical, biochemical or diagenetic origin. It allows the term flint to be avoided in some contexts, whose meaning is different when used by geologists, petrographers, sedimentologists or archaeologists. In this paper, we use 'silicite' for any siliceous sedimentary rock and 'flint' for a rock, which exhibits a cortex and has undergone an initial siliceous diagenesis followed by a siliceous epigenesis.

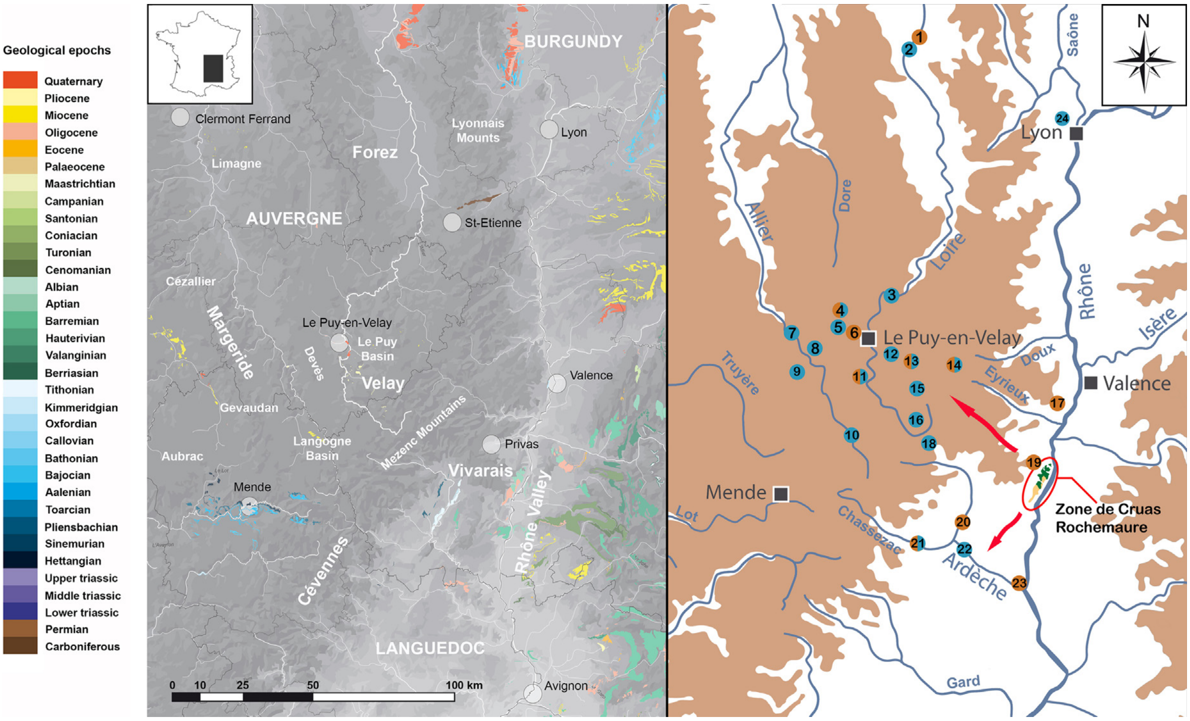


Fig. 1. Sites with Barremian–Bedoulian flints. Orange dots for Middle Palaeolithic (MP), blue dots for Upper Palaeolithic (UP) and Mesolithic. 1. Champ Grand (MP: Rhodanian Quina type; Saint-Jean-Saint-Maurice sur Loire, Loire); 2. La Vigne Brun (UP: Gravettian; Villerest, Loire); 3. Cottier (UP: Badegoulian; Retournac, Haute-Loire); 4. Le Rond-du-Barry (MP: Levallois techno-complex with scrapers, UP: Badegoulian and Magdalenian, Mésolithic; Polignac, Haute-Loire); 5. Sainte-Anne II (UP: Magdalenian; Polignac, Haute-Loire); 6. Sainte-Anne I (MP: Middle Palaeolithic with bifacial tools; Polignac, Haute-Loire); 7. Le Blot (UP: Gravettian, Badegoulian and Magdalenian; Cerzat, Haute-Loire); 8. Tatevin complex (UP: Gravettian and Magdalenian, Mesolithic; Chanteuges, Haute-Loire); 9. La Roche-à-Tavernat (UP: Badegoulian; Chanteuges, Haute-Loire); 10. Le Mas d'Armand (UP: Magdalenian; Naussac, Lozère); 11. Baume Vallée (MP: Levallois techno-complex with scrapers, UP: Magdalenian; Solignac-sur-Loire, Haute-Loire); 12. Abri Dufau (UP: Magdalenian; Blavozy, Haute-Loire); 13. Rapavi (MP: not specified, UP: not specified, Mesolithic; Saint-Pierre-Eynac, Haute-Loire); 14. Devesset (MP: isolated Mousterian point, Mesolithic; Devesset, Ardèche); 15. Longetraye (UP: Magdalenian, Mesolithic; Freycenet-la-Cuche, Haute-Loire); 16. Le col de Claron (Mesolithic; Cros-de-Géorand, Ardèche); 17. La Baume Moula Quercy (MP: Typical Late Mousterian; Soyons, Ardèche); 18. La Baumasse (Mesolithic; Montpezat-sous-Bauzon, Ardèche); 19. Payre (MP: Early Middle Palaeolithic; Rompon, Ardèche); 20. Les Barasses II (MP: Levallois techno-complex with scrapers,; Balazuc, Ardèche); 21. Abri des Pêcheurs (MP: Middle Paleolithic with Discoïd technology, UP: Aurignacian; Berrias-et-Casteljau, Ardèche); 22. Chauvet (UP:Aurignacian and Gravettian; Vallon-Pont-d'Arc, Ardèche); 23. Abri du Maras (MP: Levallois techno-complex with scrapers,; Saint-Martin-d'Ardèche, Ardèche); 24. Rue Claudy (Mesolithic; Lyon-Vaise, Rhône).

Fig. 1. Carte de situation des sites contenant des silex barrémo-bédouliens. Les points orange représentent les sites du Paléolithique moyen (PM), les points bleus, ceux du Paléolithique supérieur (PS) et du Mésolithique. 1. Champ Grand (PM : Quina rhodanien ; Saint-Jean-Saint-Maurice sur Loire, Loire) ; 2. La Vigne Brun (PS : Gravettien ; Villerest, Loire) ; 3. Cottier (PS : Badegoulien ; Retournac, Haute-Loire) ; 4. Le Rond-du-Barry (PM : Techno-complexe Levallois à racloirs, PS : Badegoulien et Magdalénien, Mésolithique ; Polignac, Haute-Loire) ; 5. Sainte-Anne II (PS : Magdalénien ; Polignac, Haute-Loire) ; 6. Sainte-Anne I (PM : Paléolithique moyen-ancien à bifaces ; Polignac, Haute-Loire) ; 7. Le Blot (PS : Gravettien, Badegoulien et Magdalénien ; Cerzat, Haute-Loire) ; 8. Complexe de Tatevin (PS : Gravettien et Magdalénien, Mésolithique ; Chanteuges, Haute-Loire) ; 9. La Roche-à-Tavernat (PS : Badegoulien ; Chanteuges, Haute-Loire) ; 10. Le Mas d'Armand (PS : Magdalénien ; Naussac, Lozère) ; 11. Baume Vallée (PM : Techno-complexe Levallois à racloirs, PS : Magdalénien ; Solignac-sur-Loire, Haute-Loire) ; 12. Abri Dufau (PS : Magdalénien ; Blavozy, Haute-Loire) ; 13. Rapavi (PM : non précisé ; PS: non précisé ; Mésolithique ; Saint-Pierre-Eynac, Haute-Loire) ; 14. Devesset (PM : pointe moustérienne isolée, Mésolithique ; Devesset, Ardèche) ; 15. Longetraye (PS : Magdalénien ; Mésolihtique ; Freycenet-la-Cuche, Haute-Loire) ; 16. Le col de Claron (Mésolihtique ; Cros-de-Géorand, Ardèche) ; 17. La Baume Moula Quercy (PM : Moustérien récent typique ; Soyons, Ardèche) ; 18. La Baumasse (Mésolithique ; Montpezat-sous-Bauzon, Ardèche) ; 19. Payre (PM : Paléolithique moyen-ancien ; Rompon, Ardèche) ; 20. Les Barasses II (PM : Techno-complexe Levallois à racloirs ; Balazuc, Ardèche) ; 21. Abri des Pêcheurs (PM : Paléolithique moyen à technologie Discoïde, PS : Aurignacien Berrias-et-Casteljau, Ardèche) ; 22. Chauvet (PS : Aurignacien et Gravettien ; Vallon-Pont-d'Arc, Ardèche) ; 23. Abri du Maras (PM : Techno-complexe Levallois à racloirs ; Saint-Martin-d'Ardèche, Ardèche) ; 24. Rue Claudy (Mésolihtique, Lyon-Vaise, Rhône).

secondary sources) or those from southern regions was totally underestimated, if not completely ignored.

Along with upper Pleistocene regional volcanism in Vivarais and in Limagne, three factors were once supposed to explain the Palaeolithic settlement of the Massif Central: climatic conditions; the topography and the availability of siliceous raw materials (Raynal and Daugas, 1992; Raynal et al., 1994). While it is likely that these environmental factors have influenced human behaviour, recent studies tend to temper their weight (Delvigne, 2016; Lafarge, 2014; Raynal et al., 2014; Surmely and Hays, 2011; Surmely et al., 2011), with the dynamics of inter-spatial relationships seemingly overcoming determinism by nature so that the links existing between Velay and Vivarais, can be seen to vary depending on the period in question.

2. Methodology

2.1. Epistemological, historical and geographical backgrounds

We do not aim to present an exhaustive review of the development of petro-archaeology, but it seems relevant to recall some epistemological precursors who established the foundations of our discipline. The origin and management of rocks in prehistoric sites has been a recurrent research topic in archaeology since the advent of the discipline as demonstrated by the works of Lartet and Christy (1864), Damour (1865), de Chasteigner (1868), Vinay (1867), Pomerol (1888) and Boule and Verniere (1899). Beginning in the 1930s, a methodology for lithic study was established in Germany and Poland (Eisenack, 1931; Kovalski and Kozlowski, 1959; Kozlowski and Kaczanowska, 1972; Krukowski, 1939; Wetzel, 1943, 1953). More recently the volume by Stelcl and Malina (1970) presented the first overview of the topic. In France, the discipline developed during the 1940s and 1950s, firstly by geologists from the centre and South of the Paris Basin (Deflandre, 1934, 1935, 1966; Foucher, 1971, 1974; Valensi, 1953, 1955a, 1955b, 1957, 1960), and later by archaeologists from the Aquitaine Basin led by those from the Quaternary Institute of Bordeaux, (Bordes and Sonnevilles-Bordes, 1954; Demars, 1980; Duchadeau-Kervazo, 1982; Geneste, 1985; Morala, 1979; Rigaud, 1982; Seronie-Vivien and Le Tensorer, 1979; Seronie-Vivien and Seronie-Vivien, 1987; Tavoso, 1984; Turq, 1977). During the 1980s, a high point of research in this field was marked by Masson in Auvergne (1981), Demars in the Brive Basin (1982), Mauger in the centre of the Paris Basin (1985) and T. Aubry in the South of the Paris Basin (1991). Masson (1981) detailed the history of petro-archaeology up to 1980 and one of us (Fernandes, 2012) presented an inventory of the studies conducted between 1980 and 2010.

Since 1970, boosted by the development of archaeometry and in parallel with a naturalistic approach (*supra*), several analytical methods were applied to the characterization of silicites. These methods aim to define the proportion of about twenty major and trace elements contained in silicites; (Al, As, Ba, Be, B, Cd, Ca, Cr, Co, Cu, Ge, Fe, Pb, Li, Mg, Mn, P, K, Ag, Na, Sr, Sn, Sb, Ti, V, Zn). The methods are either destructive, like optical emission spectroscopy (OES) and atomic absorption spectroscopy (ASA), (Sieveking et al., 1970, 1972) or conservative but lacking precision, such as neutron activation analysis (INAA), (Aspinall and Feather, 1972; Aspinall et al., 1975, 1981; Boulanger et al., 2015; Lyons et al., 2003). In the early 1990s, geologists, with the aim of characterizing diagenetic paleoenvironments, proposed the quantification of the rare earth elements (REEs) contained in silicites as a methodology, these elements being less subject to post-depositional alterations than major or trace elements (Kunimaru et al., 1998; Murray, 1994; Murray et al., 1991, 1992; Owen et al., 1999). This method of characterization, like most of those used in geochemistry, is destructive and cannot be used systematically on archaeological material. However, the paleoenvironment in which the diagenesis of a rock occurred is, in the great majority of cases, recognizable following examination with a binocular microscope. This technique has the merit of being fast, inexpensive and non-destructive. Since the development and availability of physicochemical instruments that will quantify the proportions of the various elements of which a substance is composed, analysis of this kind of lithic composition, often carried out without prior geological study, is also a recurrent and in our view somewhat pointless phenomenon in silicite archaeometry. This observation also applies to flint ΔO18 dosage studies (Dutta, 1998), that are based on the work of Knauth (1992) used to determine the diagenetic environment of silicites whether marine, continental of hydrothermal.

In parallel with the geochemical methods, physical characterization processes (also destructive and with irregular results) have been developed: cathodoluminescence (CL) (Akridge and Benoit, 2001; Dietrich and Grant, 1985; Marshall, 1988), best known as an application for dating; the characterization of detrital quartz by thermoluminescence (TL) (Prescott and Robertson, 1997; Roberts, 1997; Akridge and Benoit, 2001); proton activation analysis (PAA) (Blet et al., 2000) or X-ray diffraction in order to determine the proportion of the various different polymorphs of the quartz contained in the silicite matrix (Ciornei et al., 2014; Nash and Hopkinson, 2004; Navazo et al., 2008; Petrola, 2001). More recently, Fernandes et al. (2012), based on the work of P. Schmidt (2011), have characterized the degree of alteration of chalcedonite by infrared spectroscopy to distinguish the secondary sources from which Bergeracois flints were obtained (Dordogne, France). Finally, measuring ultraviolet fluorescence (Church, 1990; Elston, 1992; Hofman et al., 1991; Lyons et al., 2003), although non-destructive, is an imprecise technique currently used in America (Church, 1994).

Improvements to high-precision measuring instruments in the late 1990s and early 2000s made the development of new modes of characterization possible, such as where an SEM coupled with a dispersive energy spectroscopic (DHS) microprobe is used (Aubry and Mangado Llach, 2003; Bazile, 2002; Bustillo et al., 2009; Fernandes, 2006). This is a simple, inexpensive and non-destructive method. Another methodology uses Plasma Torch Spectrometers with Atomic Emission Spectroscopy, (ICP–AES: Bressy, 2002, 2007, 2003; Thompson et al., 1986; Volterra et al., 1998), or, more recently, the LA–ICP MS (Laser Ablation Inductively Coupled Plasma Mass Spectrometry), that destroys only a miniscule portion of the object, (e.g., Bressy, 1997, 2002, 2007; Dufresne, 1999; Blet et al., 2000; Grégoire, 2001; Bressy et al., 2002, 2005; Evans et al., 2007; Navazo et al., 2008; Surmely et al., 2008; Pettitt et al., 2012; Speer, 2014; Moreau et al., 2016; Sanchez de la Torre et al., 2017). Finally, strontium (Sr) dosage, considered by some authors to be invariant (Dufresne, 1999; Surmely et al., 2008), is a method under development, but the results are too uncertain to be considered *a priori* (Simonucci, 2000; Delvigne et al., 2017).

Despite the proliferation of analytical methods that have made many instruments available to the petro-archaeologist, the dynamics of elemental changes that produce physicochemical characteristics in open-system materials such as silicites remain poorly understood. This is mainly because of the varied and complex evolutionary processes to which they were subjected (Blet et al., 2000; Fernandes, 2012; Thiry et al., 2014; Trauth et al., 1987). For various epistemological, methodological, protective or economic reasons, petro-archaeology has developed multi-analytical approaches, based on clearly obvious naturalistic characterizations. Geochemical and/or physical analyses can no longer be used routinely, but may be applied in response to very specific problems such as the characterization of detrital phases by Raman spectrometry (Delvigne, 2016); infrared diffraction of quartz polymorphs for gitological characterization (Fernandes et al., 2012); quantification of current and sub-current edaphic pollution (e.g., Blet et al., 2000 and Fernandes et al., in press); drawing distinctions between materials that have remained or become ubiquitous at different scales of observation (Sanchez de la Torre et al., 2017) and the like. Far from being anecdotal or a matter only for specialists, the increase in accuracy of petrographic characterizations should become a useful tool relevant to all archaeologists since it has a significant impact in modelling past human behaviours. Indeed, the demonstration of the *schéma opératoire* according to raw material types makes it possible to better identify the processes and stages in the treatment of each lithic material type and to take to a further stage the interpretations of these resources in terms of local versus distant procurement alone, the heuristic scope of which, in anthropological terms, remains limited.

The Dordogne and southern Paris Basin, lying northwest of the Massif Central and Rhône Valley have long played a major part in the methodological construction of wider European petro-archaeology (e.g., Bracco, 1992, 1994; Delvigne, 2016; Delvigne et al., 2014a, 2014b; Fernandes, 2006, 2012; Fernandes and Raynal, 2006a, 2006b; Fernandes et al., 2006, 2007, 2008; Masson, 1979, 1981; Surmely et al., 1998, 2008; Torti, 1980, 1983, 1985). The Massif Central (Fig. 1) consists of middle-height volcanic mountains (300 and 1800 m. in altitude) overlooking the plains of the Paris Basin to the north, the Aquitaine basin to the west, Languedoc to the south and the Rhône corridor to the east. The relief is characterized by an extensive development of highlands (800 to 1200 m) interspersed with gorges and sedimentary basins representing Cainozoic collapsed structures of the Limagne. These basins form north-south corridors of low elevation that provided the valleys in which the two major regional rivers (the Loire and Allier) were accommodated. The basins provided the main axes of human penetration into the heart of the Massif Central from the north and the Bourbonnais but are more-or-less closed to the south by the highlands and mountains of Vivarais, Gevaudan and Aubrac (upper Allier and the mountainous South Margeride), which have significant topographic expression. To the south-east of the Puy basin, the high plateaus of the Velay-Vivarais (1000 m average altitude, Mount Mézenc the highest point at 1754 m) rise up between the Puy basin — and more broadly the heart of the Massif Central — and the Rhône Valley, whose significant slope (1500 m in 40 to 50 km) explains the intense dissection. To this major topographic feature is added the juxtaposition of different geological domains:

- volcanic highlands such as the upper Miocene volcanic events of the eastern Velay; Plio-Pleistocene volcanism of Devès; middle and upper Pleistocene volcanism of the Lower Vivarais;
- crystalline and crystallophyllian slopes of the Cévennes;
- low limestone plateaus of the Rhône foothills.

The result is a series of varied but complementary landscapes that favoured a series of sedimentary sequences constituting Europe-wide reference points that contribute to interpretations of Plio-Quaternary paleoclimatic and paleoenvironmental evolution. During all the Pleniglacial and the Old Dryas, these landscapes are testament to the development of very homogeneous environments marked by the expansion of heathlands and steppes with artemisia that developed on quasi-bare ground (e.g., Ablin, 1991; Andrieu and Reille, 1995; De Beaulieu and Reille, 1986; De Beaulieu et al., 1988, 1994, 2000a, 2000b; Reille and De Beaulieu, 1988; Reille et al., 1998, 2000; Roger et al., 1999; Thouveny et al., 1999).

2.2. Deciphering silicites

Over the last two decades, we have surveyed with some precision the flint resources of a large part of France developing and testing a method of silicite characterization based on the principle of a "silicite evolutionary chain" (Fig. 2). We have identified and described the transformations that take place from the genesis of the silicite until the time of its discovery in an archaeological site (Fernandes, 2006, 2012; Fernandes and Raynal, 2006a, 2007; Fernandes et al., 2007; Thiry et al., 2014). This process requires the identification of the source from which humans gathered the lithic raw materials (i.e. colluvial or alluvial), rather than just identifying the principal location where the lithic type occurs (i.e. the flint outcrop in its surrounding geological context). In the field of research focusing on lithic raw material sourcing, the limited notion of a primary deposit and its characteristic genetic type (Fernandes, 2012; Fröhlich, 1981, 2006), is only partly relevant; instead, a global vision of the flint evolutionary chain is crucial for a complete understanding of the actual collection points and intra-site taphonomic processes (Fernandes, 2012; Thiry et al., 2014). Such an approach was initially applied to Middle Palaeolithic assemblages (Fernandes and Raynal, 2006b; Fernandes et al., 2006, 2008) before being extended to the Upper Palaeolithic (Delvigne, 2012, 2016; Delvigne et al., 2014a, 2014b).

The diagnosis of silicite from a genetic (i.e. primary type definition) as well as depositional perspective when there are several types of deposits for the one genetic type and therefore many potential locations from where it could be gathered, requires the implementation of protocols based on a comparative analysis of mineralogical, petrographical and micromorphological variations and transformations (Ernst and Calvert, 1969; Fernandes, 2006,

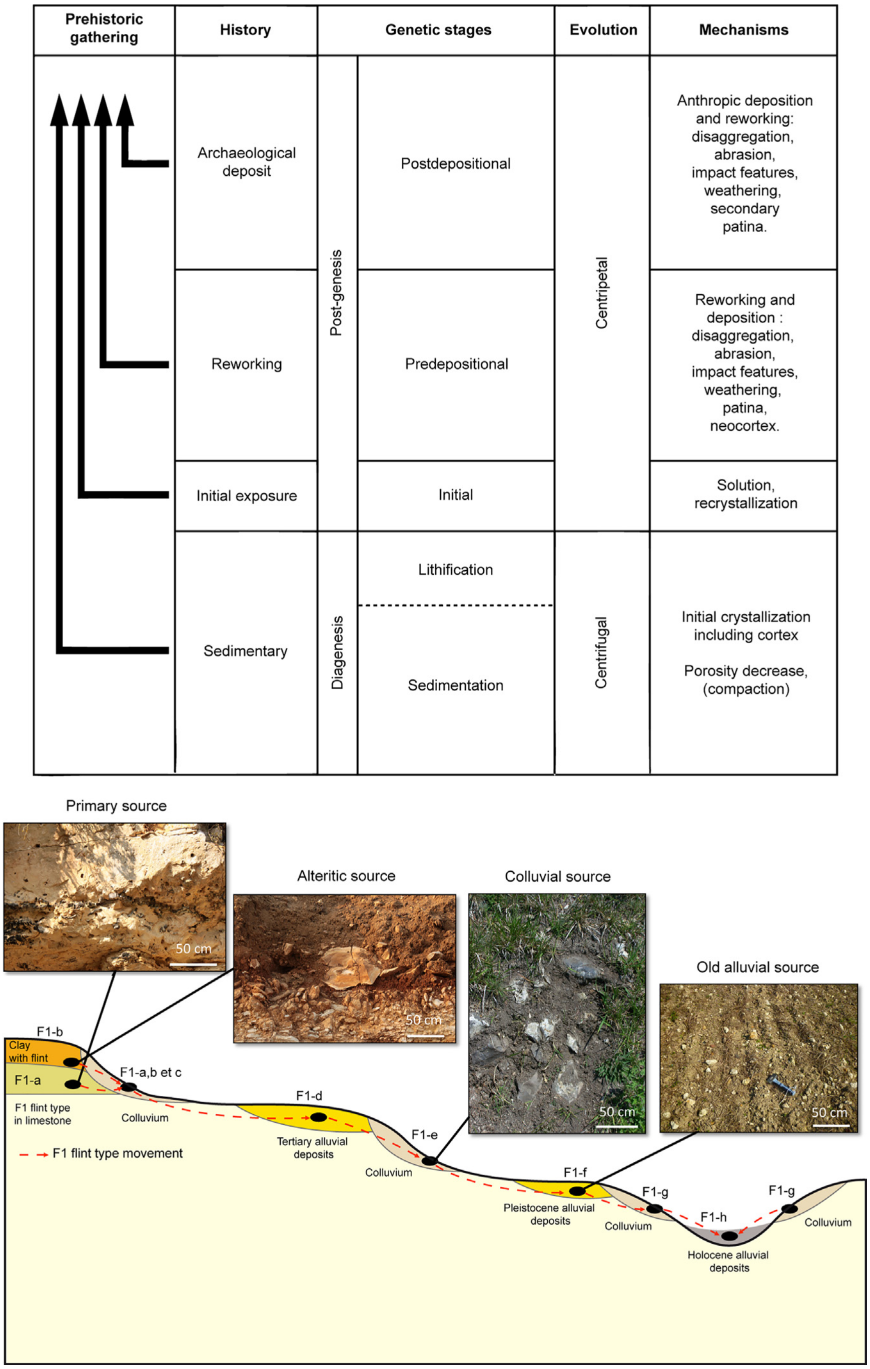


Fig. 2. At the top, the evolutionary chain of flints (Fernandes, 2006). At the bottom: a schematic itinerary of flint at its primary source and through its diverse secondary sources.

Fig. 2. En haut : le concept de chaîne évolutive des silex (Fernandes, 2006) ; en bas : parcours schématique des différents gîtes traversés par un silex.

2012; Fernandes and Raynal, 2006a, 2006b, 2007, 2010; Knauth, 1992; Siever, 1962; Thiry et al., 2014), as well as the use of the classic petrographic analysis technique which only prioritizes texture and clast associations (Affolter, 2002; Cuvillier, 1951; Delvigne, 2012, 2016; Fernandes, 2006, 2012; Fernandes and Raynal, 2006a, 2006b, 2007, 2010; Folk, 1962; Masson, 1979, 1981, 1986; Seronie-Vivien, 1995, 2003; Seronie-Vivien and Seronie-Vivien, 1987; Slimak and Giraud, 2007; Tomasso, 2014; Tomasso et al., 2017). The expanded diagnosis is complemented by a semi-quantitative dynamic approach incorporating various discriminatory criteria including biostratigraphy, petrography, morphometry, granulometry, mineralogy, micro-porosity measurements and surficial classifications.

The inclusion in this expanded approach of mineral and textural transformations and the associations between various surface features is inspired by the works of Le Ribault (1977) and adapted to the study of flint. In our methodology we also record a series of microscopic criteria on natural flint surfaces, enabling us to make associations between textural alterations or transformations and various superficial formations (Fernandes, 2012; Fernandes et al., 2007; Thiry et al., 2014).

Our field work has enabled us to establish a GIS for siliceous raw material resources for the South of France that includes more than 1200 sources (Fernandes et al., 2013). In the laboratory, our methodology is based on a multiscalar observation (macroscopic, mesoscopic, microscopic and ultramicroscopic) using the following tools: binocular polarizing microscope, SEM and confocal microscope. For the Barremian–Bedoulian flint from Ardèche, more than 500 geological samples have been described according to the concept of the evolutionary chain of silicites (*supra*). We carry out a complete examination of structures, petro-fabric, nature of clasts and the morphology of natural surfaces (lithoclase and cortex). Mineralogical characterization is deduced from polarizing microscope observations and comparisons between hundreds of petrographic thin sections.

2.3. Silicites and territories

Our identification and characterization of the mineral domains exploited by prehistoric groups allows us to define their litho-spaces[2]. If based solely on the ideas of Binford (1979), the litho-space could be confused with the annual exploitation of a geographical space by a group of hunter-gatherers. Like others (Aubry et al., 2012; Cattin, 2002; Grégoire, 2002; Newlander, 2018; Perlès, 1991, 2007, among others) we think that such confusion is based on the postulate of an exclusively direct and separate acquisition of each raw material being exploited. This remains to be demonstrated for the Palaeolithic and may be invalid given the importance of various social and economic exchanges[3] that take place in all current and sub-actual hunter-gatherer societies. The quantity, mode of introduction into sites and the diversity of lithic materials coming from coherent geotopes provide some elucidation of the occupation of any particular area or site by a human group and also provide information about the modes of acquisition of silicites and any possible or likely exchanges of them.

Moreover, our approach provides data relevant to an understanding of the prehistoric management of landscapes by groups and the likely constitution of their territories (*sensu* Bonnemaison, 1981; Bernus, 1985; Collignon, 1996; Debarbieux, 2004, 2009; Frérot, 1999, among others). Understanding the location and extent of Palaeolithic territories requires a knowledge of the network of different places frequented by the human groups, especially the silicite outcrops visited, using a choreographic approach, that is, by considering descriptions of the particular characteristics of places and their links with each other. Consequently, it is now necessary to consider the prehistoric geographical space in a reticular perspective (Delvigne, 2016), by restoring appropriate spatial values to the occupation sites and their silicite sources. To achieve these goals, categorizing each raw material introduced into an archaeological site and the way it was used are powerful tools to help in deciphering site function and consequently help to reveal that particular resource's role in the synchronic organization of the territory. In addition, a diachronic comparison of data related to the economy of a single geo-material found in several sites of different ages (and thus in different biotopes) opens windows on the respective weight of natural and cultural factors in the constitution of lithic assemblages used by human groups.

As an example, in this paper we document the links between certain archaeological sites and a particular source of raw material. We hope to show that this aspect of the prehistoric management of the mineral world contributes to the debate about the territoriality of human groups during the late Pleistocene and early Holocene.

3. The Barremian–Bedoulian flint from the right bank of the Rhône in the context of its mineral landscape

3.1. State of knowledge on silicites

In the middle part of the Rhône corridor, several archaeological and geological studies were carried out on the silicite from diverse Mesozoic and Cainozoic formations in the Ardèche, the Loire, the Drôme and neighbouring departments (Beeching et al., 1994; Binder, 1987; Combier, 1967; Slimak and Giraud, 2007). Beginning in 1997, studies were carried out on many sites in the Drôme as part of the CIRCALP program led by A. Beeching. The establishment of the PCR "Réseau de lithothèques en Rhône-Alpes" by C. Bressy-Léandri in 2006 continued that work (Fernandes and Raynal, 2006a). Other studies with a strictly geological and paleontological viewpoint focused on sedimentary formations with siliceous components (Busnardo et al., 1977; Cotillon et al., 1979; Delcey-Leduc, 1961; Fallot, 1885; Ferry, 1976; Giot and Elmi, 1987; Jacob, 1907; Moullade, 1966; Porthault, 1974; Renaud, 1978; Rio, 1982; Signolles, 1980; Sornay, 1939, 1943). The results of all these projects, confirmed by field examinations we made, now enable us to present an inventory of the variations in the different flint, silcrete and hydrothermal silica formations in

[2] Considering a given archaeological unit for which the geoarchaeological evolution of the deposit is well known, we call a 'litho-space', the geographical space defined by the maximum extent delineated by the origin of the raw materials

[3] We use the term "exchange" as synonymous with "transfers of materials" insofar as A. Testart (2007) demonstrated that gift (*sensu* Mauss, 1923) did not exist and that these transfers, if they do not result in acquisition are always included in a system of non-commercial exchanges (material against protection, power, knowledge...). Although these counterparts (material or not) remain inaccessible in prehistory, let us not forget that exchange — even if it aims to obtain materials not available in the living area of a group by trade, is above all a mean of establishing rules in a social system (Wiessner, 1982): status of the individual, communications, decreases in inter-group tensions, birth gift as symbol of kindship... Whatever the case, the materials exchanged are elements that physically symbolize the inter-group links that, in case of problems, remind one of past engagements (Earle, 1994).

the Ardèche department. A synopsis of the data acquired during these multiple works, is still in progress as part of the PCR project with an emphasis on producing dynamic resources maps (Fernandes et al., 2013, 2016). The preliminary results already describe a rich and varied siliceous regional landscape. Currently, more than 600 primary and secondary silicite sources have been recorded and documented.

Geologically, the Rhône Valley formations still accessible today include four silicite-rich zones (Fig. 3):

- Jurassic limestones;
- Cretaceous massifs including terrains with hemipelagic and Urgonian facies;
- Paleogene basins: Lutetian and Ludian;
- Superficial formations.

Mesozoic flints occurring on both banks of the Rhône are part of the Jurassic (from the Lias to the end of the Malm) and Lower and Upper Cretaceous formations. Around Aubenas, it is possible to collect flints from the micritic bioturbated Sinemurian limestones (Fig. 3, No. 3). Further south, flint bars occur in the Pliensbachian (Fig. 3, No. 4). Kimmeridgian flints containing *Aptychus* are present in the Païolive zone (Fig. 3, No. 6) and flints containing the extinct genus *Calpionella*, have been identified in the Tithonian limestones between the Ouvèze and Payre valleys (Fig. 3, No. 15). Most of the Barremian–Bedoulian spicular-rich flints are located along the right bank between Cruas and the Larnas-Bayne fault, and on the left bank, around the Marsanne forest (Fig. 3, No. 12). Other Barremian–Bedoulian flints, containing more foraminifera and less spicules, are found further south beyond l'Escoutay (Fig. 3, Nos. 2 and 11). This patterning indicates enrichment in spicules and depletion in benthic foraminifera proceeding from the south to the north, marking a progressive deepening of the pre-littoral domain (Contensuzas, 1980). To the north-west, below the Serre Palas, the flint forms are mainly cerebroid (Fig. 3, No. 10). Further north, flint disappears around the Serre de la Fourche (Fig. 3, No. 7).

Cainozoic flints found on the right bank of the Rhône belong to Lutetian and Ludian formations (Fig. 3, Nos. 17 and 18), whereas most flints on the left bank are in Stampian limestones. The group of elements characterizing the flints on the right bank were not found in the Crest Basin (Drôme).

> "Three fault troughs were filled with strong continental formations: the Rochemaure trough in the northeast, the Couijanet synclinal trough to the northeast of Saint-Alban and the Ellieux trough to the south of Bayne. The base of each of these continental formations is made up of conglomerate containing rounded blocks and large pebbles (up to 0.60 m dia.) of white Urgonian limestones and flint" (Elmi et al., 1996: 127).

This part of the Rhône region with its rich and varied mineral resources thus contains flints of marine, lacustrine and continental origin and there are specific petrographic characteristics for each major outcrop. Some of these flint types have special features that can be considered as "markers". This is particularly the case for the Barremian–Bedoulian flint at Rochemaure–Cruas that occurs in both primary and secondary position; the Turonian flints (mainly occurring on the left bank); two sources belonging to the Lutetian series from Laval-Saint-Roman and Ellieux; the Ludian flints with *Cyrenes*, *Characea* and *Striatella* from the Orgnac zone and lastly the Stampian flints from the left bank at Mélanies containing *Potamides*.

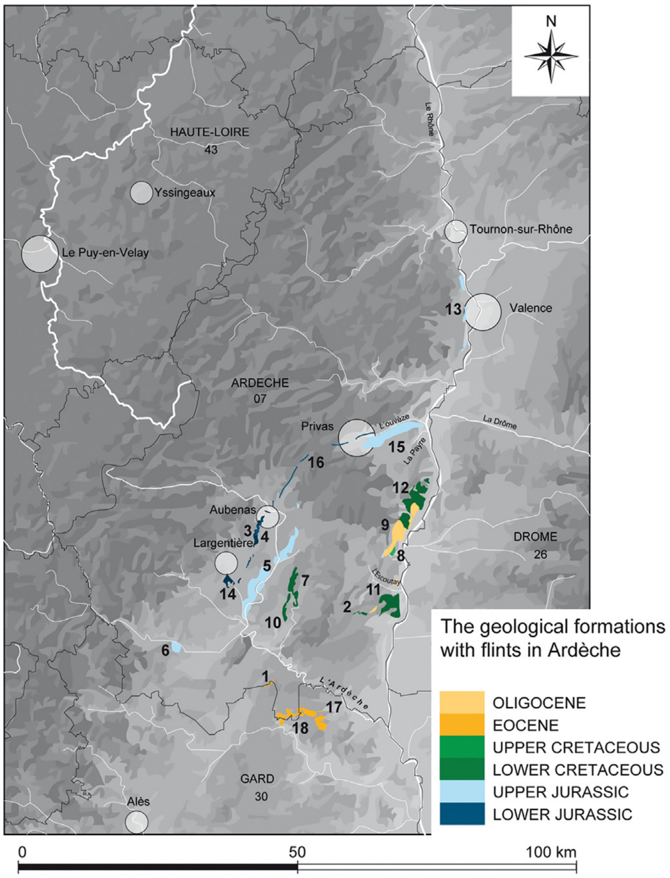
3.2. Barremian–Bedoulian flints

In the Upper Palaeolithic series of Velay, only one of the types described above was found, namely the Barremian–Bedoulian flint from the Oligocene conglomerates originating in the Rochemaure–Cruas area (Fig. 3, No. 9). We studied 500 geological samples from this formation. This flint outcrops as pluri-decimetric nodules, generally with a rather thick (centimetric) predominantly siliceous grainy cortex that is beige to yellow, with a slight porosity. Its contact with the silicified zone is clear and irregular, marked by frequent invaginations which take root in long monaxon spicules half way between the matrix and the cortex. The brown to red-coloured silicified zone is homogeneous, presenting an *allochem* to *orthochem* ratio of less than 20%. The matrix (*orthochems*) is mainly made up of cryptocrystalline to microcrystalline chalcedony. The well-sorted and evenly distributed elements (*allochems*), can be divided into three categories (Fig. 4):

- a detrital component represented by rare corroded quartz grains < 50 μ and small sub-rounded elements (sph. 0.7; arr. 0.7, after Krumbein and Sloss, 1963);
- a chemical component characterized by frequent small (70 to 110 μm) pelloids;
- a biological component made up of a variable frequency of small black elongated fragments thought to represent organic matter (stem fragments), by frequent monaxon relatively non-fragmented *Demosponge* spicules and by rare benthic foraminifera and urchin radioles.

In addition to these diagnostic elements, the Barremian–Bedoulian flints from the right bank of the Rhône are also characterized by abundant small, relatively non-altered dolomitic carbonate rhombohedra. In the most evolved facies, these mineral forms have been dissolved forming box-works subsequently infilled by Neogene silica (*infra*).

During previous petro-archaeological studies, the Barremian–Bedoulian flints in the Middle Palaeolithic series of the Velay tended to be confused with the evolved Bajocian flints from the Langogne Basin (Fernandes, 2012; Fernandes and Raynal, 2007; Raynal et al., 2007) or grouped with flints from the South of the Paris Basin (type 10 and certain type 23 flints after Masson, 1981) which are found in the Upper Palaeolithic series (Fig. 5). However, the micro-paleontological content of the Turonian flints from Berry or Touraine observed under the microscope at



Number	Age	Township
1	Priabonian	Vagnas, Labastide-de-Virac
2	Barremian-Bedoulian	Larnas
3	Sinemurian	Aubenas, Saint-Etienne de Fontbellon, Vinezac
4	Pliensbachien	Lachapelle-sous-Aubenas
5	Tithonian	Lussas, Lavilledieu, Saint-Germain, Vogüe, Lanas, Balazuc, Chauzon
6	Kimmeridgian	Bois de Païolive
7	Barremian-Bedoulian	Rochecolombe, Lagorce
8	Turonian	Le Teil
9	Oligocene s.l.	Messe, Rochemaure, Le Teil, Viviers
10	Barremian-Bedoulian	Lagorce
11	Barremian-Bedoulian	Viviers, Saint-Thomé-Bayne
12	Barremian-Bedoulian	Cruas, Messe, Rochemaure
13	Kimmeridgian	Châteaubourg, Cornas, Guilhérand
14	Sinemurian	Montréal, Laurac-en-Vivarais
15	Tithonian	Privas, Alissas, Chomérac, Saint-Symphorien-sous-Chomérac
16	Pliensbachian	Privas, Saint-Priest, Saint-Etienne-de-Boulogne, Vesseaux
17	Lutetian	Laval-Saint-Roman
18	Ludian	Barjac, Orgnac l'aven

Fig. 3. Map of flint bearing formations in the Ardèche.

Fig. 3. Carte des formations à silex d'Ardèche.

medium to strong magnification is very different from that observed in Barremian–Bedoulian flints (Delvigne et al., 2017), but remains difficult to differentiate from that of the evolved Bajocian flints. However, several key factors will, in most instances, separate the two types with the use of a stereomicroscope:

- Barremian–Bedoulian flints always contain more rhombohedra than the Bajocian flint, this mineral form being rare in the latter;
- no black fibrous fragments are found in Bajocian flints whereas this carbonaceous bioclast occurs frequently in Cruas flints;

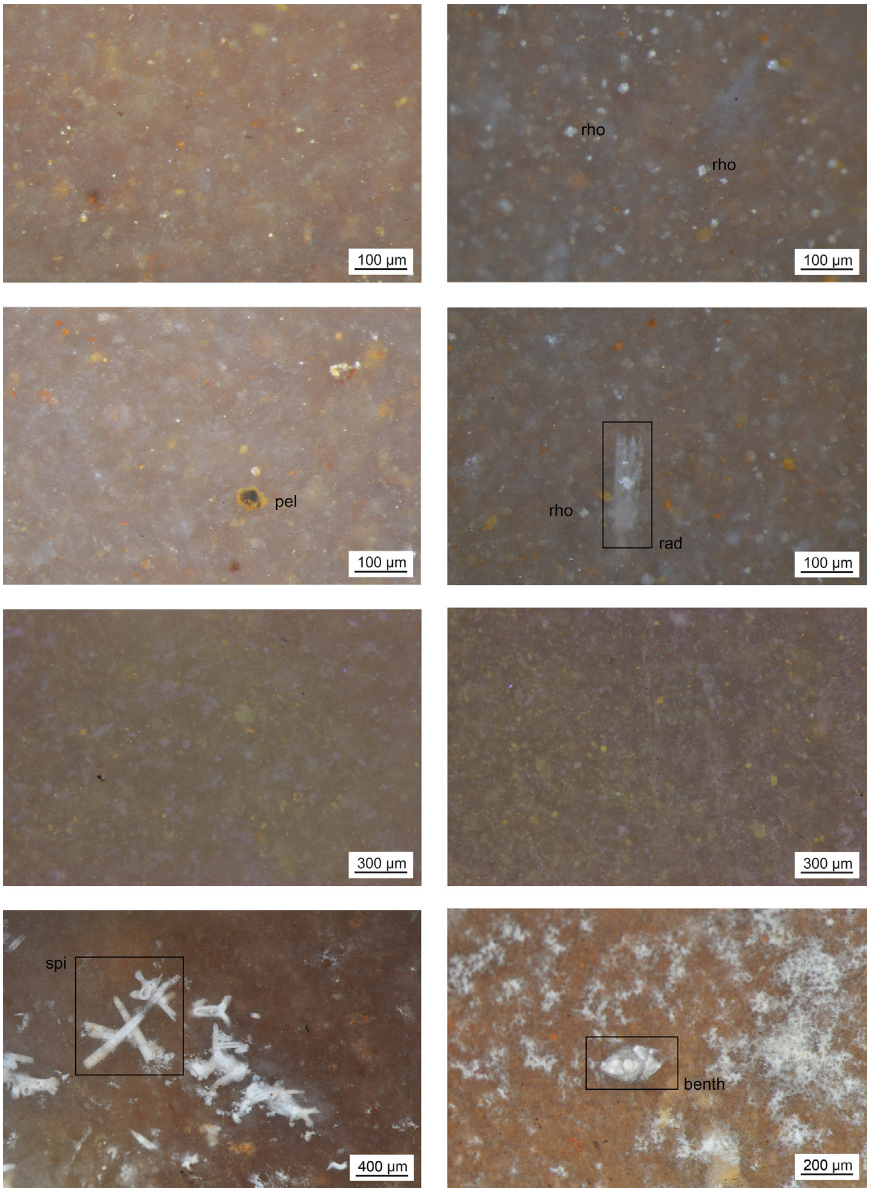


Fig. 4. Examples of siliceous microfacies from the Barremian–Bedoulian at Rochemaure–Cruas; rho: rhombohedron; pel: peloid; rad: radiole of echinoidea; spi: spicules of Demospongea; benth: benthic foraminifera.

Fig. 4. Exemples de microfaciès siliceux du Barrémo-Bédoulien de Rochemaure–Cruas ; rho : rhomboèdre ; pel : péloïde ; rad : radiole d'échinide ; spi : spicules de Démosponge ; benth : foraminifère benthique.

- floated muscovite-type detrital phases are frequent in Bajocian flints but are not found in Cretaceous flints;
- the allochem to orthochem ratio of type F0140.1 (Bajocian) flints is always over 50%, whereas the highest ratio found in the Barremian–Bedoulian flints is always less than 20%;
- unidentified elongated elements (stems?) occur in Barremian–Bedoulian flints but are totally absent in Bajocian flints;
- corroded detrital quartz fragments are more frequent in Bajocian flints than in Barremian–Bedoulian flints;
- *Dasycladaceae* fragments are common in Bajocian flints but are unknown in Barremian–Bedoulian flints.

Finally, we distinguished three main gitological groups for the Barremian–Bedoulian flints, essentially based on neocortical and matrix evolution:

- In primary and sub-primary positions, the cortex maintains the same beige colour as that of the host rock and bears no trace of wear or impact. Its appearance remains chalky despite the complete replacement of the carbonated micrite by silica. The matrix keeps its original petrofabric structure and colour;
- In colluviums, the neocortex adopts a white patina. Edges, arrises, and surfaces bear traces of impact and wear induced by the natural displacement of the blocks

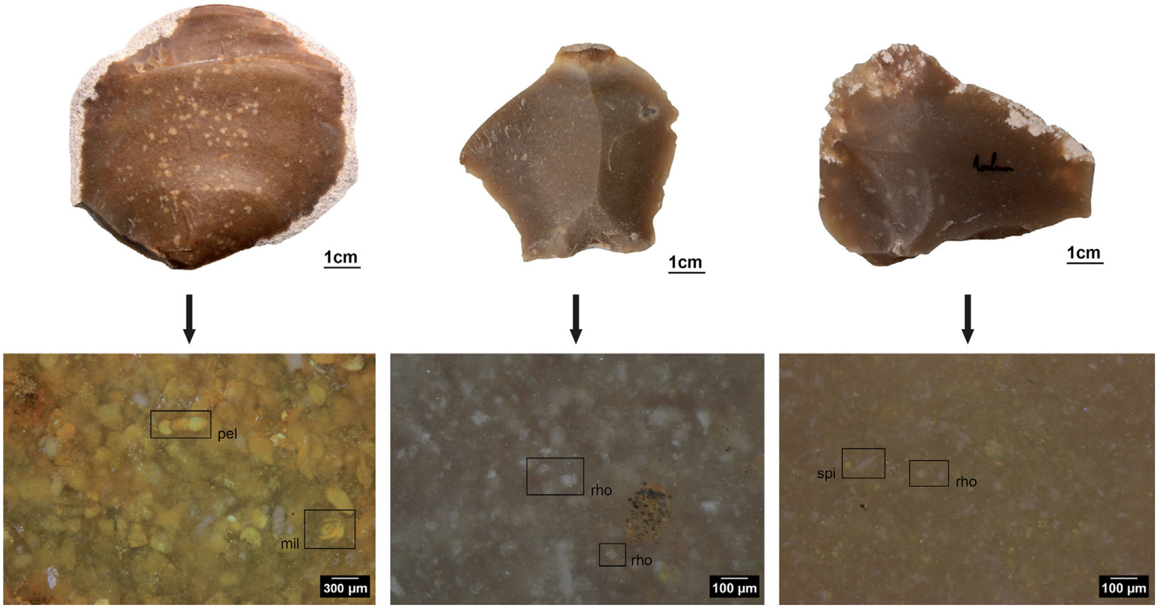


Fig. 5. Example of macroscopic convergence of facies. Left: Upper Turonian from Grand-Pressigny (Indre-et-Loire; Centre: Bajocian from Naussac (Lozère); Right: Bedoulian from Rochemaure (Ardèche); pel: peloid; mil: miliolidae; rho: rhombohedron; spi: spicules of Demospongea.
Fig. 5. Exemple de convergence macroscopique de faciès. À gauche : Turonien supérieur du Grand-Pressigny (Indre-et-Loire) ; au centre : Bajocien de Naussac (Lozère) ; à droite : Bédoulien de Rochemaure (Ardèche) ; pel : péloïde ; mil : miliolidé ; rho : rhomboèdre ; spi : spicule de Démosponge.

and some traces of dissolution/recrystallization processes. The petrofabric changes due to the disappearance of allochems or secondary silicification processes and the colour turns to varying degrees of brown because of irregular oxidation of the matrix and allochems, depending on the intensity of earlier mechanical processes;

- In the Oligocene conglomerates (e.g., at Rochemaure–Cruas) the cortex colour is affected by oxidation forming yellow to brown patinas. On their surfaces samples bear marked stigmata typical of transportation in alluvial environments as well as a thick neocortical film. The matrix becomes totally brown and the majority of the allochems have disappeared.

In summary, the natural transport of Barremian–Bedoulian flints induces cortex transformation, produces colours that evolve from grey to brown and the disappearance of biogenic and mineral allochems as a result of secondary silicification processes.

4. Archaeological implications — Middle Palaeolithic to the Mesolithic

Clearly, identification of the Barremian–Bedoulian flint under its different aspects has archaeological implications. It underlines the links between the Velay highlands of the southern Massif Central with the Vivarais lowlands in the Rhône corridor and questions the respective roles of these two areas in the patterns of prehistoric settlement and mobility in the south-eastern margins of the Massif Central during the Middle Palaeolithic and the Mesolithic.

4.1. *The Middle Palaeolithic*

During the last decade, fieldwork and collection revisions have provided an overview of Neanderthal occupations along the Rhône Valley and its tributaries, and so, in the southern Massif Central occupation sites can now be characterized according to their duration. Thus, we can now differentiate between bivouacs, short-term campsites and longer seasonal occupations with dates from MIS 7 to the beginning of MIS 3 (Daujeard and Moncel, 2010). In the lowlands, technological strategies are diverse and seem to correspond to various classical traditions, using Levallois, centripetal or laminar core technologies, and cover the whole technological gamut (Moncel and Daujeard, 2012). Flint is the main raw material used as expected in a region rich in flint outcrops. However, other local raw materials are used for the heavy-duty component and occur as debitage. Regarding the plateaus and the mountains to the west of the Rhône corridor, their technological behaviours and subsistence strategies still require clarification to determine the modes of occupation in geographical spaces poor in flint but rich in metamorphic and volcanic materials (Daujeard et al., 2012). Similar strategies are indicated for raw material collection by Neanderthals in Velay but were adapted to local conditions where raw materials other than flint dominate collections (e.g., at Rond de Saint-Arcons and Blassac shelters, Sainte-Anne I cave and the open-air site of Rochelimagne at Polignac). Technological strategies were governed primarily by the available raw materials but reduction sequences between flint and non-flint strategies are not completely dis-similar and are based on diverse recurrent modalities; mostly secant knapping on the non-flint raw materials and Levallois technique when that was possible (Raynal et al., 2007; Santagata et al., 2017). These data demonstrate the technical variability and adaptability of Mousterian groups and complicate to some extent the identification of relationships, which existed between areas that were either rich or poor in flint sources.

Along the Rhône corridor (Ardèche department), the movement of human groups gathering flint took place generally along a north-south axis bordering the Rhône Valley during MIS 7 (Payre unit Gb, Moncel, 2008; Abri du Maras, layer 4, Fernandes et al., 2008; Baume Moula-Guercy layers IV to VIII and XIV to XV, Defleur, 2015) or in northeast and southeast directions (Abri des Pêcheurs lower and middle units, Fernandes et al., 2008; Les Barasses II, Daujeard, in press), generally following the hydrographic network. The interfluves, rich in flint, were heavily exploited, whereas the Rhône Valley seems to have been considered more as a potential reserve. In contrast to observations made elsewhere such as in southwest France (e.g., Turq et al., 2017), the materials gathered from the outer edges of the lithospace are not used intensively, suggesting there may need to be a revision of previous interpretations of prehistoric land-use management, the status of mobile objects and the value of “rarity” to the Neanderthals.

The examples mentioned above suggest that lithic raw material procurement activities might be linked to a type of occupation where a seasonal presence, depending mainly on local provisioning, is opposed to an occasional presence that exploits local materials as well as a wide variety of imported previously knapped flints gathered from a wider geographical area (Fernandes et al., 2010).

At present it is difficult to unravel the relationship between the diversity of flint types and their exploitation zones, and the duration of site occupation. The age of the sites (ranging in time from MIS 7 to 3) and the environmental conditions (temperate for Payre, cold for Abri des Pêcheurs, Les Barasses II and Abri du Maras) cannot totally explain the differences in exploitation strategies, even though the steppe-like vegetation communities perhaps demanded different types of subsistence activity at various times and may possibly have led to greater mobility by human groups. For the present, it seems reasonable to surmise that two different occupation types (perhaps open air *vs.* cave sites) were the determining factors for two distinctly different procurement strategies (Bernard-Guelle et al., 2011; Daujeard et al., 2012; Daujeard and Moncel, 2010; Moncel et al., 2008).

Further to the northwest of the Rhône Valley centres, lithological conditions were very different for the mid-upland site of Sainte-Anne I (unit J1 dated to the end of MIS 6 and perhaps 5), at the heart of the Puy-en-Velay Basin. However, like at Payre, raw material provisioning here followed a similar pattern during seasonal occupations indicating an adaptation to a lithological environment that was governed by tool requirements and occupation type (Raynal, 2007). A similar situation existed for the Baume Vallée (Solignac-sur-Loire, Haute-Loire), where seasonal occupations dated to MIS 4 show occupation and spatial strategies like those of Payre, Sainte-Anne I and, to a lesser degree, Abri du Maras. As for the short duration occupation of layer H at the site of Le Rond-du-Barry (Polignac, Haute-Loire), dated to MIS 3 (Raynal et al., 2014), it appears similar to presumed ‘bivouacs’ and hunting stopovers located closer to the Rhône Valley (Abri des Pêcheurs, Barasses II), as shown by the preferential exploitation of local non-flint geo-materials (basalt, quartz and trachy-phonolites), and the wide variety of imported flint types that were brought to the site already knapped in the form of non-retouched blanks and tools (Fernandes et al., 2008; Moncel et al., 2006).

The curious similarity in occupation strategies and space management in the two areas on both sides of the northern Cévennes Mézenc Massif, is supported by the discovery of Barremian–Bedoulian flints from plateaus bordering the Rhône corridor (Rochemaure–Cruas formations) in several sites in the Velay highlands (Table 1): three pieces of flaking debris in Sainte-Anne I unit J1, several flakes and tools including a Levallois point in the upper units of Baume-Vallée (Vaissie et al., 2017; Fig. 6.2) and a side scraper in the assemblage from Rond-du-Barry layer H (Fig. 6.1). Moreover, the isolated Mousterian point from Devesset, a colluviated open-air site located in the upper reaches of the Doux River, a right bank tributary of the Rhône close to the Loire-Rhône divide, suggests movement across the Mézenc Massif; (identified more than 160 km north of the closest outcrops at the site of Champ Grand (Saint-Jean-Saint-Maurice-sur-Loire, Loire) dated to MIS 4 (Slimak and Giraud, 2007)).

Following several technological revisions of Middle Palaeolithic sites in south-eastern France (e.g., Bourguignon and Meignen, 2010; Daujeard and Moncel, 2010; Lebegue, 2012; Porraz, 2005, 2007) who have shown the great cultural homogeneity of the south-eastern part of France (Lebegue, 2012; Vaissie et al., 2017), the Barremian–Bedoulian flints from the right bank of the Rhône assist in circumscribing a large area enclosing hunting spaces and potential zones of movement. Such spaces were formerly named ‘territories’ (Feblot-Augustins, 1997; Geneste, 1985) but the small number of sites and their diachrony is no help in identifying different Neanderthal groups and their inter-relationships, effectively preventing the realistic application of such a concept (Daujeard et al., 2012; Raynal et al., 2012, 2013a, 2013b).

4.2. The Upper Palaeolithic

For the Upper Palaeolithic, the issues differ slightly from those of the Middle Palaeolithic. In order to identify the existence of links between the South-East of the Massif Central and the middle Rhône Valley, Upper Palaeolithic modalities need to be strictly defined. Indeed, and despite there being transportation of materials between these two geographical zones, we note that significantly different prehistoric cultures developed on either side of the Mézenc Mountains, especially during the LGM. In addition, the fact that during the entire Upper Palaeolithic, materials were transported over several hundred kilometres from the South of the Paris Basin to the eastern Massif Central (for a detailed review see Delvigne et al., 2018) shows that long-distance relationships and a network structure for the supply of materials (and of ideas) existed at this time.

A few Aurignacian assemblages exist in Ardèche at Abri des Pêcheurs (units F9 and F10) and Le Figuier (unit

Table 1
Synthetic table of Barremian–Bedoulian flint management in the Velay-Vivarais sites.
Tableau 1
Tableau synthétique du Barrémo-Bédoulien dans les sites du Velay-Vivarais.

Chrono-cultural attribution	Name	Nb BB	Nb total	% Nb BB	*Chaîne opératoire*	Bibliography
Middle Palaeolithic						
Middle Palaeolithic with bifacial tools	Sainte-Anne 1, unit J1	3	602	0.5	2	This work
Early Middle Palaeolithic	Payre, unit G b	245	578	42.3	1	This work
Middle Paleolithic with Discoid technology	Abri des Pêcheurs	51	181	28.1	3	This work
Levallois product (Middle Palaeolithic ?)	Sletter à Devesset	1	1	100.0	3	This work
Rhodanian Quina type	Champ Grand	(Biblio)**	No data	?	3	Slimak and Giraud, 2007
Levallois techno-complex with scrapers	Baume Vallée, upper units	9	2987	0.3	2	This work
Levallois techno-complex with scrapers	Baume Vallée, lower units	26	1996	1.3	2	This work
Levallois techno-complex with scrapers	Rond-du-Barry, unit H	1	100	1.0	3	This work
Levallois techno-complex with scrapers	Les Barasses II	82	167	49.1	2	This work
Levallois techno-complex with scrapers	Abri du Maras	245*	578*	42.4*	2	This work
Typical Late Mousterian	Baume Moula Quercy	(Biblio)**	2595	20.0 to 40.0	1	Defleur, 2015
Aurignacian or Gravettian	Chauvet-Pont-d'Arc cave	12*	18*	66.7*	Indet*	This work
Aurignacian and Gravettian	Abri des Pêcheurs	× (our obs.)	No data	?	Work in progress	This work
Old Gravettian	La Vigne Brun, OPIO	1	7722	> 0.1	Indet (1 core)	Pesesse, 2013
Badegoulian	Cottier cave	1	115	1.7	3	This work
Badegoulian	Rond-du-Barry, unit F2 (locus 1)	557	2682	20.8	2	This work
Badegoulian	Rond-du-Barry, unit F2 (locus 2)	74	885	8.4	2	This work
Badegoulian	Rond-du-Barry, unit F2 (locus 3)	100	445	22.5	2	This work
Badegoulian	Roche à Tavernat	1	657	0.2	3	This work
Middle Magdalenian	Abri Dufau	16	344	4.7	2	This work
Upper Magdalenian	Rond-du-Barry (new excavations)	84	1192	7.1	2	This work
Upper Magdalenian	Sainte-Anne II	143	6230	2.3	2	This work
Upper Magdalenian	Tatevin 2	2*	187*	1.1	3*	This work
Magdalenian sensu lato	Rond-du-Barry, unit E	× (our obs.)	20,510	?	Work in progress	This work
Final Magdalenian	Mas d'Armand	(Biblio)**	1493	?	Indet	Assénat et al., 2009
Final Magdalenian	Longetraye	(Biblio)**	?	?	Indet	Philibert, 1986
Azilian	Rue des tuilleries at Lyon-Vaise	7*	92*	7.6*	Indet*	Jallet and Bouvier, 2012
First Mesolithic	Longetraye	(Biblio)**	?	?	Indet	Philibert, 1986
First Mesolithic	La Baumasse	4265	9694	44.0	2	Leonce, 2010
(First ?) Mesolithic	Col de Claron	14	168	8.3	2	This work
(First ?) Mesolithic	Sletter à Devesset	36	114	31.5	1	This work
Mesolithic sensu lato	Cuze de Neussargue, C to E units	1	164	0.6	Indet	This work
Mesolithic sensu lato	Rue Claudy at Lyon-Vaise	3*	608*	0.5*	2	This work

The phases of the chaîne opératoire are focus on the Barremian–Bedoulian flint. 1: All phases of the chaîne opératoire; 2: Presence of debitage phase without initialisation products; 3: Presence of first intention products with or without retouching phase; 4: retouching phase only. Nb BB: number of Barremian–Bedoulian flint artefacts; Nb total: total number of the artefacts.
* Work in progress or sampling.
** Mentioned in literature with no supplementary information.

2) (Combier, 1967; Gely, 2005), the latter were recently re-allocated to Proto-Aurignacian (Woerz, 2009) a techno-culture also reported to be present at Chauvet–Pont-d'Arc Cave based on radiocarbon dates. Otherwise, Aurignacian is known in the North of the Massif Central in the Grotte des Fées at Châtelperron (Allier department) and by several isolated markers. The rare lithic source determinations made in the studied area are for the flint objects from Chauvet–Pont-d'Arc Cave, which are difficult to characterize from a cultural point of view (Aurignacian or Gravettian? Geneste, 2005). They indicate the use of the Barremian–Bedoulian flint deposits along the right bank

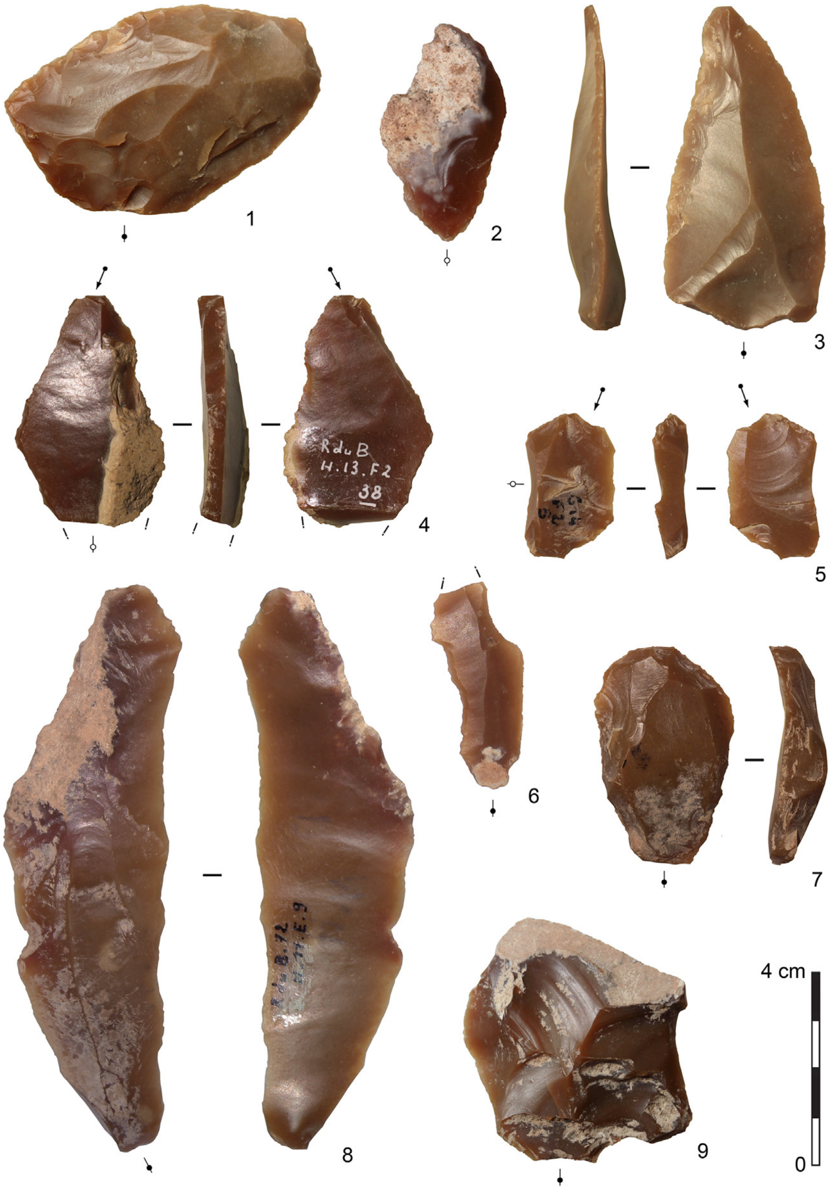


Fig. 6. Barremian–Bedoulian from Rochemaure–Cruas, type F0014–1, Rond-du-Barry, unit H, side-scraper; 2, Baume Vallée, unit 22 base, Mousterian point; 3, Devesset, Mousterian point; 4, Rond-du-Barry, unit F2, burin; 5, Rond-du-Barry, unit F2, burin; 6, Claron Path, Montbani bladelet; 7, Rond-du-Barry, unit F2, end-scraper; 8, Rond-du-Barry, unit E, blade; 9, Dufau Shelter, flake.

Fig. 6. Barrémo-Bédoulien de Rochemaure–Cruas, type F0014–1, Le Rond-du-Barry, couche H, racloir ; 2, Baume Vallée, base de la couche 22, pointe moustérienne ; 3, Devesset, pointe moustérienne ; 4, Le Rond-du-Barry, couche F2, burin ; 5, Rond-du-Barry, couche F2, burin ; 6, col de Claron, lamelle Montbani ; 7, Rond-du-Barry, couche F2, grattoir ; 8, Rond-du-Barry, couche E, lame ; 9, abri Dufau, éclat.

of the Rhône (Delvigne et al., 2014b; Geneste et al., in press). Due to the absence of petro-archaeological data for the more recent Gravettian, Badegoulian/Salpetrian and Magdalenian occupations in the Ardèche (Boccaccio, 2006; Joris, 2002), we focus here on the results obtained for the Upper Palaeolithic sites in the Velay highlands.

The Velay Upper Palaeolithic sequence begins with the Recent (layers 35 to 52) and Final (layers 22 to 34) Gravettian occupations of Le Blot rock shelter (Cerzat, Haute-Loire), in which all the silicites come from the Truyère Valley (Saint-Léger-du-Malzieu), the Limagne, the South of the Paris Basin (Berry and Touraine) and *pro parte* from the Aquitaine Basin (Périgord, Bergerac, Fumel). Analysis of the data provided by personal ornaments, raw materials, rhythm and temporal extent of the occupation, the faunal spectra and exploitation and the lithic *chaînes opératoires*, indicates a site specially adapted for meat acquisition, namely reindeer, located on the margins of an occupation zone, the focal point of which is situated about 200 km to the north in the southern part of the Paris Basin (Delvigne, 2016). No links with Ardèche, Provence or Languedoc emerge from an analysis of either the geo-materials or the technical processes. This is not surprising given that all the Gravettian occupations in Ardèche can be attributed to the Early and Middle Gravettian stages (Bazile, 2007). In the Early Gravettian of La Vigne Brun (Villerest, Loire), Barremian–Bedoulian flints are present. They were derived from the Oligocene conglomerates of Rochemaure–Cruas (Pesesse, 2013) but as a remarkable contrast, our observations reveal that the lithic material from the site of Le Sire (Mirefleurs, Puy-de-Dôme) also attributed to the Early Gravettian, contains no flints from the Middle Rhône Valley. This situation reinforces conclusions derived from other techno-economic data (Delvigne, 2016) suggesting that differences existed in the extent and management of territories prior to and after the Heinrich 3 event (25.47–27.39 ka BP Naughton et al., 2009, or 31.3–32.7 ka cal. BP, Sanchez Goñi and Harisson, 2010), which manifests as a reorganization of the exploited domains.

In Velay, there is an occupational lacuna of nearly two millennia between the last Gravettian units of Blot (21.3 ka BP or 26.0–25.2 ka cal. BP) and the first Badegoulian occupations of Rond-du-Barry (19.6 ka BP or 23.9–23.3 ka cal. BP) that corresponds to the Solutrean, a well-represented techno-culture in Ardèche and in the South of the Paris Basin. In all the studied Badegoulian sites of Velay, the presence of a combination of flint from Langogne Basin and the Middle Rhône Valley (Barremian–Bedoulian of Rochemaure, Bedoulian of Diois and/or Rocherenard, Viviers townland, collections from the Rhône terraces), either in large quantities (between 10 and 25% of the total flint at Rond-du-Barry at Polignac, Figs. 6.4, 6.5, 6.7; Table 1), or in trace amounts (La Roche-à-Tavernat at Chanteuges and Cottier at Retournac), appears to substantiate the existence of a preferred travel itinerary favouring the Rhône Valley by way of the high Allier Valley. This confirms Bazile's interpretation of the Naussac zone as a gateway to the Mediterranean world (Asséna t et al., 2009). We note that during the early phases of the Badegoulian (19.5 ka BP–18.0 ka BP), Languedocian (Salpêtrian) and Velay (Badegoulian) groups used the flint deposits of the Rochemaure–Cruas region despite not sharing the same technical complexities, whereas in more recent periods (18.0–17.0 ka BP), certain technical processes are congruent between the two groups (Lafarge, 2014) despite there being no overlap between their exploited litho-spaces.

The low diversity of flint types from the Middle Rhône Valley can be interpreted in two ways:

- a prehistoric reality, reflecting exchanges (in the Middle Rhône Valley or around Naussac) or logistic expeditions only seeking specific materials or;
- a prehistorian's reality, being a construct limited by our knowledge of the regional lithological diversity.

We are now capable of identifying the Mesozoic and Cainozoic flints of Ardèche or the Drôme, and it is possible that there are correspondences between some of the still to be defined lithic types and those flints from more southerly locations (the Tertiary basins of Salinelles or Collorgues, Costières in the Gard), for which field mapping and laboratory analyses remain to be done.

After the Badegoulian settlement, a new occupational lacuna in Auvergne corresponds with the Lower Magdalenian (*sensu* Langlais, 2007); this archaeological hiatus is confirmed by new site dates (Lafarge, 2014; Raynal et al., 2014). The subsequent Middle Magdalenian, which was long considered to be absent from the Auvergne region (Delporte, 1966, Raynal and Daugas, 1992), recently came to light in Limagne, (Thônes-le-Vieux at Grandeyrolles, Enval–unit in the Grange E4–and Chabasse SN 4 at Vic-le-Comte, Le Bay layer 2 at Martres-de-Veyre (Angevin and Surmely, 2013). It also occurs in Haute-Loire in Abri Dufau at Blavozy and in Le Rond-du-Barry complex E (layers E1, E2, E3) at Polignac. Petro-archaeological studies at these two latter sites have identified the Barremian–Bedoulian of Ardèche. A large flake from Abri Dufau, demonstrates exploitation of a secondary source in local colluviums near the primary deposit (Fig. 6.9) and at Le Rond-du-Barry various objects show that this flint type was brought to the site as preforms or pre-flaked blanks. Incidentally, the longest blades from the site are not made from Lower Turonian flint from Berry (Masson, 1981) but from Barremian–Bedoulian flint sourced from the right bank of the Rhône (Fig. 6.8). Detailed petrographic studies are lacking for the sites of Limagne, therefore we are unable to comment on the presence or absence of Ardèche flint in Limagne collections.

The Upper Magdalenian and the Upper-Final Magdalenian are well represented in the high valleys of the Loire and Allier (Daugas and Raynal, 1979, 2007). Here, typo-technological similarities between sites dating from the end of the Magdalenian in Velay and Ardèche (upper units of Oullins Cave, Baou-de-la-Selle, Ranc pointu, Ebbou and Figuier; Bauvais, 2017; Bazile and Monnet-Bazile, 2000; Combier, 1967; Joris, 2002) were thought to be present from very early on but were never able to be confirmed (Bayle des Hermens, 1970, 1972; Delporte, 1966; Virmont, 1981). The presence of Barremian–Bedoulian flint from the middle valley of the Rhône in the Magdalenian series of Velay (Rond-du-Barry layers E and D; Sainte-Anne II; Baume-Vallée; Tatevin II; Tatevin Banaud) now provides some confirmation of their correlation. As for the Badegoulian, the main routes for accessing the upper reaches of the Chassezac and the Ardèche seem to pass through the high valley of the Allier and the Langogne Basin. In addition to flints from the detrital Miocene deposits of Naussac found in the varied archaeological series in Velay, some Upper to Final Magdalenian or Epipaleolithic workshops were identified at Mas d'Armand (Asséna t et al., 2009) along the southeast bank of the present-day lake, where similar technical criteria to those of the Velay sites exist (debitage, continuum of small blades and bladelets, presence of small end scrapers on bladelets, relative abundance of backed bladelets). However, it is difficult to associate this complex definitively with that of the Auvergne Final Magdalenian due to the particular lithic facies from this workshop site in which non-local raw materials seem to come from the Velay and the Bedoulian *s.l.* The Magdalenian people from Velay and Ardèche exploited the Barremian–Bedoulian flint outcrops in the Rochemaure region, but the possibility of technical, artistic or symbolic connections between these two domains needs further examination.

4.3. The Epipaleolithic and the Mesolithic

The lithic industries attributed to the very end of the regional Magdalenian (Delporte, 1976) present a marked Epipaleolithic character, tending towards the Azilian. Furthermore, they are slightly more recent than expected, at around 12–11.5 ka BP, which is similar to those of the Upper Magdalenian occupation in the central Paris Basin (Debout et al., 2014). However, because of the poor conservation of faunal remains, these dates are considered to be somewhat unreliable. For this period, the questions relating to the origin of the silicites and the possible links between the Massif Central (Velay) and the Rhône Valley (Vivarais) are like those of the Middle Palaeolithic. We attempt an explanation of the mode of management of the middle montane sites in the South of the Massif Central rather than seeking the origin and cultural dynamics of all those who occupied the total area. Indeed, there are some clues, particularly in the lithic assemblages and for the Mesolithic, that bring the Velay into alignment with the South-East of France suggesting that at this time there may have been just one integrated single Velay-Vivarais territory.

Unit 4 of Longetraye at Freycenet-la-Cuche (Haute-Loire) gave a conventional age of 12,720 ± 680 BP (Ly 512) (Philibert, 1982), which seems slightly too old when compared to the dates obtained in Béraud Cave (Surmely et al., 2001) and Sainte-Anne II (Delvigne, 2016). The study carried out by A. Masson (1981) on a sample of 435 pieces brought to light the high proportion in the collection of remotely sourced flints type 10 (67%) and 23 (3%). Formerly these two types were considered to be sourced from the Paris Basin because the remainder of the series was made up of diverse local materials. In our opinion, flints of type 10 and 23 in other Velay lithic series can be identified as originating from the Rhône Valley (Barremian–Bedoulian) or from Naussac (Bajocian). In fact, although Masson (1981) and later Philibert (1982, 1986) included the lower layer (layer 4) of Longetraye in the Magdalenian circulation patterns of Auvergne linking Velay with the south of the Paris Basin, the assemblage is distinct from the sub-contemporaneous ones of the Allier Valley where there is a lower proportion of distantly sourced materials (Bracco, 1995). In our opinion, Masson's (1981) Longetraye results require revision, as the site is probably oriented more towards the Rhône Valley (and the Mediterranean world) than towards the Paris Basin. Importantly but intriguingly, Surmely et al. indicated that two pieces from Longetraye unit 4 analysed as part of their study, “do not correspond to the analysed geological sites, even though the trace element spectra are somewhat similar to those of group 117 (flint from the Southeast of France)” (2008: 129). A similar situation exists for another site from the region, namely Béraud Cave at Saint-Privat-d'Allier in Haute-Loire, for which petro-archaeological data are lacking. The polarity of flint/human movements across the relevant litho-spaces (Delvigne, 2016) can be questioned, as can the delineation of the litho-space borders in terms of cultural territories; the manner of exploitation of the mineral domain; and the technical solutions taken in response to changes in flora and fauna. In summary, questions remain about the modifications and adaptations to territorial management and occupation patterns that occurred during the Palaeolithic/Mesolithic transition.

After the Palaeolithic/Mesolithic transition, regional Epipaleolithic and Mesolithic groups settled at higher altitudes. In Velay, territories seem to contract and links with the Paris Basin weaken before disappearing completely. Exchanges with the southern zone, detected for earlier periods, become stronger as shown by an expansion in the number of small sites on the Mézenc Plateau (Devesset, le Cros-de-Géorand) and in the valleys (La Baumasse at Montpezat-sous-Bauzon, Chomette, 1991; le Rond-du-Barry unit C, Polignac). These contain materials from the Middle Rhône Valley (Table 1) and flints from the Puy Basin as well as silcretes from the Dore valley and from Rapavi at Saint-Pierre-Eynac (Fig. 6.6). In the Polignac site, this observation is confirmed by the presence of a small Mesolithic bladelet core in Sinemurian flint collected from a sub-primary source at Aubenas over 50 km south-west of the Mézenc Massif (Wragg-Sykes et al., 2017). Moreover, two flakes from the Mesolithic of Le Cuze de Neussargues (Sainte-Anastasie, Cantal), respectively in unit D1 (excavation J.-G. Rozoy) and in unit D (excavation A. Delpuech and P. Fernandes) are at present the furthest western occurrences of Barremian–Bedoulian flint derived from Rochemaure–Cruas conglomerates (Langlais et al., in press) while in the opposite direction, one core and two bladelets in Barremian–Bedoulian flint from Rochemaure were found in the Mesolithic industry of rue Claudy at Lyon-Vaise.

4.4. Mobility of Human groups over time between the southern Massif Central and the Rhône Valley

We postulate that the quantity, the form in which resources are introduced into the sites and the diversity of materials obtained from coherent geotopes, help to determine the methods by which the raw materials were acquired. While the majority of the geo-resources from the middle Rhône Valley are present in sites in the South of the Massif Central (Velay), some differences exist in their modes of introduction and in the amount introduced (Table 1). This may reflect journeys by different human groups and/or the diverse uses made of the sites and/or the frequented areas.

During the Middle Palaeolithic, the flint of Rochemaure–Cruas arrived in Velay in small quantities, mainly as finished products but some pieces show evidence of curation by knapping. It should be noted that in the Rhône Valley at the same time and for a comparable site type, namely a bivouac (e.g., l'Abri des Pêcheurs, Barasses II), the materials are treated indifferently, whether derived locally or more distantly. The diversity of silicite types relative to the number of lithic objects seems important and is possibly related to the site's function (Moncel et al., 2008). This situation departs from what has been identified in southwestern France (Turq et al., 2017). Recent studies in lithic technology tend to compare the technical traditions of the Middle Palaeolithic from the South and the East of the Massif Central with those of Languedoc (e.g., Vaissie et al., 2017). In addition to shared origins for the geo-resources, in the Middle Palaeolithic there seems to exist a similarity in the management mode of the mineral and biological landscapes (see Daujeard et al., 2012 for biology for example), between these two geographical areas; similarities that suggest that they may have been parts of one larger territory composed of complementary biotopes that were seasonally occupied by highly mobile human groups.

During the first half of the Upper Palaeolithic, the absence of sites and materials illustrating the occupational frequency of the two areas (the southern and eastern Massif Central and Languedoc) perhaps reflects a profound change in the material supply networks and exploited territories that existed between the Middle Palaeolithic and early Upper Palaeolithic. It is only since the Badegoulian, (that marks the return of humans to the upper Loire Valley), that we once more observe Barremian–Bedoulian flints in Velay. Note that during the old phase of this period (19.5–18.0 ka BP), the groups from Languedoc (Salpêtrian) and Velay (Badegoulian) both frequent at least one lithic source at Rochemaure but do not share common technical behaviours. Conversely, in more recent periods (18.0–17.0 ka BP), some lithic elements are comparable (modalities of blade-bladelet production, typological composition of tools, presence of scrapers *(raclettes)*, *etc*. see Lafarge, 2014), but the exploited litho-spaces do not seem to overlap. However, during the Middle Palaeolithic it seems that the southern part of the Massif Central and its south-eastern margin were united into one territory; apparently, during the LGM, the Mézenc Mountains may have constituted a cultural boundary. Connections existed, if not directly between groups that exchanged knowledge and techniques, then at least between geographical spaces they decided to exploit or not, as suggested by the paucity of Rhodanian geo-resources appearing in Velay sites throughout this period. The existence of such a boundary in the Mézenc seems less evident during the Magdalenian in the sites of Velay, since we find numerous Barremian–Bedoulian flints from that time, which do not present a specific technical treatment. Moreover, the technical know-how seems comparable on both sides of the Massif. Currently, in Vivarais, petro-archaeological and technological data remain poor for this period.

Finally, the links between the Massif Central (Velay) and the Rhône Valley (Vivarais) seem to become more closely forged during the Mesolithic. The circulation of materials gathered from remote locations (> 100 km) decreases but does not disappear, and silicites from the middle Rhône Valley seem to be treated similarly to those obtained more locally. Barremian–Bedoulian flints are no longer the only types to cross the Mézenc interfluve; now Oligocene and/or Sinemurian flints often accompany them. Similarly, the minimal proportion of silcretes from the Dore Valley or the Puy Basin seen in sites of the Mézenc mountains and the south-eastern slopes, seems to suggest the insularity of this geographical area at the beginning of the Holocene. Despite some trends beginning to appear, only complete revision with more petro-archaeological analyses of the lithic series, as well as an increase in interdisciplinary high-resolution studies, like those undertaken at l'Abri du Maras or Sainte Anne I for the Middle Palaeolithic and at the Rond-du-Barry cave for the Upper Palaeolithic, will better document the land-use and the territorial organization of prehistoric human groups in this part of France.

5. Conclusion

The accurate description of the petrographic characteristics of the Barremian–Bedoulian flints from the right bank of the Rhône, with an emphasis on their micropaleontological content, enabled us to define the various genetic sub-types of flint occurring along a north-south axis and also revealed the mineralogical transformations that gave rise to the different types of deposit. Consequently, macroscopic flint descriptions, based on (very subjective) colour and textural criteria alone, cannot be used for the study of a raw material provenance. The Barremian–Bedoulian flints from formations along the Rhône Valley provide an excellent example, because in the past, they were confused with Bajocian flints from Lozère occurring in secondary positions, or with the Turonian flints from the Southwest of the Paris Basin. However, using detailed and methodical micrographic examination, this erroneous conclusion can now be discarded.

An in-depth approach to descriptions of geological formations developed over the past ten years as part of the two collective research programs (PCR) "*Réseau de lithothèques Rhône-Alpes*" and "*Espaces et subsistance au Paléolithique moyen dans le sud du Massif central*", has enabled us to identify the Barremian–Bedoulian flints from the Oligocene conglomerates of the Rochemaure–Cruas region as an essential geo-resource for the Paleolithic of Ardèche. Moreover, these flints have been identified in significant amounts in almost all Velay sites, dating from the beginning of the Middle Paleolithic up to the Mesolithic, except for the Early Upper Paleolithic (Aurignacian, Gravettian, Solutrean), which is a relatively poorly represented period in the Auvergne region. One of the axes along which the flint travelled seems to pass through the massif crossing the high valley of the Allier and the Langogne basin, from where it is easy to access the high points of the Ardèche and the Chassezac, but the discovery of a Mousterian point from Devesset suggests that other routes may have existed, for example, through the valleys of the Doux or Eyrieux rivers.

Raw material sources confirm that the interfluves were crossed during the first Middle Paleolithic occupations and reveal, as we demonstrate above (part 4), that the Velay is at the intersection of multiple influences, giving it a place in extensive exchange and transmission networks. For the Middle Paleolithic, it is essential to continue the regional petro-archaeological characterization of the various lithic series, to continue fieldwork on the workshop deposits (e.g., Clos du Charnier at Lagorce, Ardèche) and to determine the characteristics of flint found in zones of high potential at places located between the Mediterranean and Atlantic worlds (e.g., Devesset). For the Upper Paleolithic and the Mesolithic, it is essential to increase the number of studies of sites so that indicators can be identified that will demonstrate the circulation of raw materials.

This is especially so for the Ardèche sites where petro-archaeological data is practically non-existent, and also for the Auvergne sites where the model established by Masson (1981) has clearly overshadowed the interpretation of the lithological characteristics of the toolkits. The presumption formed from insufficient data that results in the equation "marine flints from the south of the Paris Basin versus local flints", is an oversimplified and narrow vision of the petro-archaeological landscape; for example, the Upper Magdalenian site of Sainte-Anne II, yielded 101 different types of flint. The discovery of just one flint in an assemblage can cause major changes to previously constructed circulation models, and thus enhances our understanding of territorial economies, but to gain this understanding requires an exhaustive and fastidious study of a lithic series and avoidance of superficial examinations and random sampling.

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