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**Lithic territories during the Late Middle Palaeolithic in the central and western Pyrenees:
New data from the Noisetier (Hautes-Pyrénées, France), Gatzarria (Pyrénées-Atlantiques,
France) and Abauntz (Navarre, Spain) Caves.**

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Abstract

Over the past few years, research on the Late Middle Palaeolithic in the Pyrenees has been
30 reinvigorated by excavations carried out at the Noisetier Cave (Fréchet-Aure, Hautes-Pyrénées,
France). Lithic assemblages produced using local raw materials were documented at this site, with
some extra-local imported flints completing the picture. Samples gathered from various alluvial
formations on the mountainside were compared with archaeological materials, allowing us to
conclude that toolmakers were highly selective in their choice of local raw materials, ultimately
35 reflecting their intimate knowledge of locally available resources. Petrographic analysis of flints

allowed us to determine that these Middle Palaeolithic populations were familiar with and/or frequented a large territory. Further west in the Pyrenean mountain range, studies are currently underway at Gatzarria Cave (Ossas-Suhare, Pyrénées-Atlantiques, France), which allow us to envisage novel trans-Pyrenean travel routes, while research on the surroundings of Abautz Cave (Arraitz-Orkin, Navarre, Spain) has contributed to our knowledge of the exploitable flint sources in the northern Iberian Peninsula.

Introduction

It has often been assumed that the resource areas exploited by Neanderthal groups were relatively small and less extensive compared to the raw material procurement strategies developed by Upper Palaeolithic societies (Geneste, 1985; Féblot-Augustins, 1997), the implication being that Neanderthals mainly relied upon local mineral environments (e.g. Turq, 1992) with rare objects and small supplies of objects from extra-local contexts (Kuhn, 2013). Although the economic networks of Middle Palaeolithic groups appear to have been less structured and systematized in this respect than those of the Upper Palaeolithic (Anderson et al., 2015), several studies have nonetheless shown that materials were sometimes imported into Middle Palaeolithic occupations from great distances (over 80 km, Geneste, 1988). The importation of these extra-local materials has often been considered as an anecdotal and occasional supplement to local materials, rarely exceeding a radius of 100 km from sites (Geneste, 1988; Féblot-Augustins, 1999), yet some instances exceeding this radius have nevertheless been documented (e.g. Porraz 2005; Slimak and Giraud, 2007; Thiébaud et al., 2012).

In addition, Middle Palaeolithic operational schemas (*schémas opératoires*) have often been presented as being operationally flexible in order to facilitate contextual adaptations to variable environments. The Discoid concept, which can be easily adapted to a wide range of raw materials, is a particularly pertinent example of such flexibility (Delagnes and Rendu 2011; Turq et al., 2017; Delpiano et al. 2018). In contrast, Levallois concept seems to have required higher quality raw materials, a dichotomy has sometimes been emphasized as a distinguishing characteristic between Levallois and Discoid systems (e.g. Jaubert and Mourre, 1996; Mourre et al., 2007; Thiébaud et al., 2009). However, recent work has called into question this proposition as Levallois production using quartzite has been documented at several Middle Palaeolithic sites in the Pyrenees and Iberian Peninsula (e.g. Rios, 2012; Eixea et al., 2016; Deschamps, 2019). In any case, Neanderthal groups seem to have been highly adaptable and able to explore various environments, even those deemed inhospitable or difficult to access (e.g. Domingo et al., 2017).

70 Travelling through an environment known to be difficult would have required groups to carry out a minimum of preparation. Thus, by exploring the relationships between environmental resources, supply strategies, and mobility systems, we should be able to estimate the degree to which groups planned, and therefore adapted, to a given environment (Binford, 1979; Roebroeks et al., 1988; Geneste, 1991; Féblot-Augustins, 1999; Porraz, 2009; Turq et al., 2017).

75 Non-local materials could have been imported into sites in different ways and for different purposes. The techno-economic study of lithic materials allows us to determine the ways in which they were introduced into the site, and therefore evaluate the underlying provisioning strategy, that of places or that of individuals (Kuhn, 1995). Middle Palaeolithic hunter-gatherers lived nomadic lifestyles based on the cyclical use of habitat sites involving varying degrees of permanence.

80 Transporting a small amount of essential equipment from one site to the next allowed the groups to anticipate future needs. This notion of curated “personal gear” (Binford, 1979) or “mobile toolkits” (Kuhn, 1994) can explain why tools made from extra-local or extra-regional raw materials are sometimes found abandoned at different sites. Studying the remains that result from retouching, resharpening, and recycling activities, by analyzing lithic materials smaller than 2 cm, is also of
85 great importance, as this permits us to identify the passage of tools "through" a site (Porraz, 2005), described elsewhere as “phantom tools” (Cahen and Keeley, 1980). The degree to which tools are maintained or abandoned, in relation to the object's raw material origin, can also be interpreted using Binford's (1979) dichotomy between expedient and curated tools.

Mountainous landscapes are particularly interesting to investigate through this strategic lens, as
90 Neanderthal groups wishing to traverse such spaces would have had to carefully plan their journey and select different stopping points within a rigorous environment (Meignen et al., 2001; Bernard-Guelle, 2002; Porraz, 2005; Arrizabalaga et al., 2013; Biagi et al., 2017; Deschamps, 2017; Delpiano et al., 2018).

The characterization of raw materials and circulation networks in the western Pyrenees is a subject
95 that has already been addressed by previous research (Tarrío, 2006; Tarrío et al., 2015; Rios and García Moreno, 2015). However, we propose to reinvestigate this question using sites that are located further within the Pyrenean mountain range. These sites are located outside flint-rich areas and therefore provide novel information in regards raw material circulation over medium and long distances, in addition to shedding light upon mobility strategies in foothill and mountainous
100 contexts.

Over the last few years, several new excavations and re-evaluations of old sequences have been conducted in the southern Aquitaine Basin and in the northern flanks of the Pyrenees (Mourre et al., 2008, 2009; Thiébaud et al., 2012; Rendu et al., 2012; Deschamps, 2014, 2017; Bernard-Guelle et al., 2014; Colonge et al., 2015; Deschamps et al., 2016; Deschamps, 2019; Deschamps and Flas,

105 2019), and these new projects can be linked pioneering work in the area conducted during the 1990s (Jaubert, 1993, 2005; Jaubert and Bismuth, 1996).

The above cited studies have offered a new understanding of the way in which raw materials circulated during the Late Middle Palaeolithic. Research on mineral resources provides a glimpse into interactions and decisions that underlie the techno-economic organization of Upper Pleistocene groups, allowing us to discuss lithic resources exploited and territories travelled. Additionally, mountainous environments provide an interesting context for the discussion of group mobility as these landscapes have generally quite patchy resource distributions whose access can be limited by significant natural barriers.

115 In many studies treating the Late Middle Palaeolithic in southwestern France, the Aquitaine Basin is often considered as a coherent entity (e.g. Soressi, 2002; Ruebens, 2013). More recently, however, several studies have suggested that Middle Palaeolithic industries in the south of the Aquitaine Basin (i.e. the Pyrenees, their foothills, and their associated river valleys) share more affinities with those of the Iberian peninsula rather than with their homologues in the north of the Aquitaine Basin (Deschamps, 2014; 2017). Geomorphological studies have also proposed that the alluvial plain of the Garonne River (Bruxelles and Jarry, 2011), along with the periglacial desert of the Landes de Gascogne (Bertran et al., 2013), comprised two adjacent landscapes that were particularly inhospitable during certain phases of the Palaeolithic, acting as a potential natural barrier to movement or exchange during different climatic phases and echoing models proposed concerning the Ebro river valley (Zilhão, 2000).

Several examples at different moments during the Upper Palaeolithic illustrate such a separation between the northern and southern Aquitaine Basin (Bertran et al., 2013). For older periods similar patterns can be envisaged at different moments within the chronology and, furthermore, there is a higher frequency of archaeological sites dated to the Lower Palaeolithic than to the Middle Palaeolithic in the Garonne Basin (Bruxelles and Jarry, 2011).

- In this study we sought to test the natural barrier hypothesis for the Landes desert and Garonne river valley during the Late Middle Palaeolithic using information on lithic resources and exploited territories.
- 135 - We also wanted to investigate the permeability of the western Pyrenees where altitudes are much less accentuated than in other parts of the mountain range. Could travel routes privileging paths through the mountains, rather than by way of the coast, have existed, notably in order to access the interior Basque Country? In other words, do the Pyrenees in

140 this area divide, or articulate and connect, distinct Middle Palaeolithic raw material territories?

- Finally, we wished to question the strategic choices made by groups in regards to territory from a diachronic perspective by studying variation in raw material provisioning throughout successive archaeological levels within the same sequence.

145 By asking these various questions, this study advances our comprehension of raw material territories in the central and western Pyrenees, ultimately allowing for a deeper reflection concerning human geography in southern France and northern Spain during the Late Middle Palaeolithic.

150 **1. General presentation**

1.1. Environmental context

The Pyrenees can be divided into several distinct geological entities (Canérot, 2008; fig. 1). From north to south, there is the Aquitaine Foreland Basin, the Sub- and North Pyrenean Zones, the High Primary Range, the South-Pyrenean Zone and finally the Ebro Basin. To the west, the coastal area of the Gulf of Gasconne and the sand deposits of the Landes de Gasconne merit a particular mention. These entities have distinct geomorphological characteristics, are impacted by marked seasonal changes, and show distinct shifts in floral and faunal populations during the Quaternary. This particular configuration results in a compartmentalized environment with significantly contrasting adjacent biomes.

160 The general asymmetry of the Pyrenean mountain range along its north-south axis is also an important geomorphological feature. Due to tectonic compression, the northern flanks of the Pyrenees are much steeper than the southern flanks. As a result, northern valley bottoms are more incised, entailing greater altitudinal variations. In this topographically variable environment, the hydrographic system is essential as it offers invaluable and traversable paths into the heart of the mountain range, therefore facilitating movement between piedmont and mountainous environments *stricto sensu*. In the Western Pyrenees, the main basins of the Nive, Gaves and Adour rivers are oriented southeast/northwest and represent potential travel routes between the Atlantic coast and the interior mountain region.

170 The distribution of the lithic raw materials and their accessibility vary in each geographical sector. Flint sources have been identified in the Sub- and North Pyrenean Zones (fig. 1), near the coast and its adjacent basins, while the interior mountain regions are relatively flint-poor. Mountain regions, however, do offer a great diversity of rocks suitable for knapping, most often found in the alluvial

deposits of the various valleys. On the northern slope, a classification for different types of quartzite
175 has been proposed in order to distinguish between geomorphological domains within the Aquitaine
Basin and the northern Pyrenees (Colonge and Mourre, 2009; Colonge et al., 2012).
[fig. 1 Here]

Various works have highlighted multiple flint sources, and such studies became increasingly
180 systematic within the region as of the 1980s (Simonnet, 1981, 1999; Normand, 1986, 2002;
Lacombe, 1998; Barragué et al., 2001; Bon et al., 2002; Tarrío, 2006, 2007; Séronie-Vivien et al.,
2006, 2012; Chalard et al., 2010; Colonge et al., 2011; Minet, 2013; Fernandes et al., 2013;
Foucher, 2015; Tarrío et al., 2015; Sánchez de la Torre and Mangado, 2016). The primary deposits
185 exploited during the Pleistocene are Upper Cretaceous flysch successions, particularly those found
within the Bidache limestone (*Calcaires de Bidache*) formation. Flint sources also attributable to
the Upper Cretaceous are found in outcrops adjacent to the Tercis, Salies-de-Béarn, and Chalosse
diapirs. Towards the east the Cretaceous Hibarette/Montgaillard flints can also be found, as well as
other Cretaceous and Paleocene flints characteristic of the Central Pyrenean foothills (*Les Petites*
Pyrénées) and their adjacent anticlines. These sources in the northern Pyrenees and associated river
190 valleys were exploited by hunter-gatherers during multiple periods while further south, in the
Basco-Cantabrian Basin, the major flint sources are the Paleocene deposits from the Urbasa Range
(*Sierra de Urbasa*) and the Miocene deposits from the Treviño syncline.

This geographic disparity in raw material sources begs the question as to how groups exploited the
Pyrenees and adjacent regions, including Neanderthals and their relationship with mountainous and
195 adjacent foreland basin environments. Recent research conducted at three cave sites (Noisetier,
Gatzarria, and Abauntz) has been oriented towards the investigation of such questions in a Middle
Palaeolithic context, as all three caves share a common denominator: they are situated well within
the Pyrenean mountain range, far away from exploitable flint sources.

200 **1.2. Noisetier Cave (Fréchet-Aure, Hautes-Pyrénées, France)**

Noisetier Cave sits at an altitude of 825 m a.s.l. (fig. 2.1a, b), and is perched 145 m above the
current floor of the Neste Valley, with access being particularly difficult due to the particularly
steep terrain. It is the highest Late Middle Palaeolithic site known on the northern side of the
205 Pyrenees (Jaubert, 2005). After a first series of excavations that took place between 1987 and 1993
(M. Allard dir.), the site was initially interpreted as a hunting camp focusing on different species of
mountain ungulates. The scarcity of Middle Palaeolithic sites within the centre of the Pyrenean
range was therefore explained; Neanderthals conducted only brief and punctual incursions into the

heart of the mountains. This hypothesis concerning the site's function has recently been
210 reconsidered after a second series of excavations carried out from 2004 to 2014 (V. Mourre dir., see
Costamagno et al., 2008; Bachellerie et al., 2011; Mallye et al., 2012).

These excavations have highlighted a stratigraphic sequence subjected to various and sometimes
considerable post-depositional processes. Despite this complexity, several individualized
archaeological levels were identified, some of them showing high degrees of preservation (e.g. *in*
215 *situ* combustion structures). These levels have yielded human teeth from young Neanderthals, in
addition to bone retouchers and indicators of the repeated consumption of generalist species, such
as deer.

The faunal assemblages (mammals and micromammals) from the various levels show that the site
was occupied on several different occasions during MIS 3. The only absolute dates currently
220 available for the sequence used the radiocarbon method, and suggest an occupation range between
47 to 42 ka BP in conventional measures (see Mourre et al., 2008). In the present study, we focused
only on the principal assemblages recognized within the sequence, namely Layers 1, gb, and 2/33
(fig. 2.1d). These three assemblages belong to directly superposed levels which overlay each other
in the central part of the cave, which happens to show the highest degrees of preservation.
225 Distinctions between these levels are both sedimentary and industrial in nature, meaning they
correspond to distinct geological and archaeological stratigraphic units.

Globally, the lithic industry is characterized by the exploitation of local raw materials; 90% of all
finds are fabricated in local materials (Mourre et Thiébaud, 2009; Thiébaud et al., 2012). These are
mostly quartzites, some schists, and, more rarely, lydites and cinerites (fig. 2.1c). Small proportions
230 of flint were also imported throughout the entire sequence.

Various modes of exploitation have been documented for the different raw materials, and seem to
vary as a function of level. The industry from layer 1 contains markers of the Vasconian
technocomplex (Deschamps, 2014, 2017), which is characterized by the presence of cleavers (a
macro-tool that is more emblematic of the older Acheulean) in an MIS 3, and therefore relatively
235 recent, chronoclimatic context. These are generally accompanied by bifaces and a predominantly
Discoid with pseudo-Levallois points blank production system (Discoid *stricto sensu*, Mourre,
2003). In layer 1 quartzites and schists are mainly used for these purposes (fig. 2.1c, fig. 3) and they
are also accompanied by small amounts of Levallois and Kombewa debitage. The small proportion
of flint within the assemblage takes the form of already produced blanks and retouched tools.
240 Furthermore, flint artefacts only rarely show cortical surfaces, which may indicate that imported
blanks were from the later/final stages of core exploitation. Two other observations support such an
idea. Firstly, a significant proportion (78%) of the flint artefacts are flakes and fragments smaller

than 2 cm in size, and secondly, many of these elements appear to be retouched or rejuvenation flakes.

245 Level gb presents a different industry, yet it should be noted that water runoff has likely truncated this level and therefore partly biased the assemblage within. Analyses of the Noisetier's stratigraphy are still ongoing, making it difficult to be precise regarding the degrees of preservation at this time. In contrast with Layer 1, the industry in this level is dominated by Levallois production, in addition to small proportions of Kombewa and Discoid flake production (Thomas, 2016). Flint flakes show
250 few cortical surfaces and no flint cores have been identified. Retouched tools represent 9% of flint remains, and retouching and rejuvenation flakes are more common than in Layer 1.

The quantity of remains in Layer 2/33 is less than in the other levels, which is largely related to the fact that it has been excavated over a smaller surface area. In this assemblage, flints are rare while quartzites are more abundant. The production system involves secant centripetal removals similar to
255 a Discoid *lato sensu* system. Striking platforms are left neocortical and short removals have been made with wide or even pervasive butts. A Discoid *stricto sensu* production system is also present in a secondary form. The rare flint in this level appears to have been introduced on site as finished products and tools, which were subsequently resharpened *in situ*, a fact demonstrated by the identification of retouch flakes. Such a pattern, however, does not exclude the possibility that flint
260 blanks were produced on site using cores which were already quite reduced when introduced, though at the moment this is non-demonstrable.

[fig. 2 Here]

1.3. Gatzarria Cave (Ossas-Suhare, Pyrénées-Atlantiques, France)

265 Gatzarria Cave is located in the western Pyrenees and opens towards the northeast. Located at an altitude of 270 m a.s.l. in the Arbailles massif, it sits within a typical middle mountain region, with altitudes raging from 800 to over 1200 m. Traces of Middle Palaeolithic exploitation have recently been documented at the summit of the local mountain range immediately to the south of Gatzarria
270 and in the Mendive Valley, which sits on the southern side of the range (Marticorena et al., 2017).

The archaeological potential of the site was discovered by P. Boucher in 1950, and the first excavations were conducted by G. Laplace between 1951 and 1976, revealing an important stratigraphic sequence containing a succession of Middle and Upper Palaeolithic levels. As of 2017 the sequence at Gatzarria is being re-excavated and reanalyzed, under the direction of M.
275 Deschamps, D. Flas, and L. Anderson. Various post-depositional disturbances have been identified, thus calling into question the homogeneity of some layers as they were initially defined by Laplace (Deschamps and Flas, 2019; Deschamps, 2019). Initially, three levels were attributed to the Middle

Palaeolithic, namely Layers Cj, Cjr and Cr (Laplace and Saenz de Buruaga, 2002-2003), though recent work has underlined the presence of two distinct layers within the Cjr unit itself: Cjgr and the underlying Cjr-base (Deschamps, 2019; fig. 2.2a, b). Materials studied for the purposes of this article are from both Laplace's excavations and the more recently defined level Cjgr, the latter of which happens to be the richest level in the Middle Palaeolithic of Gatzarria's archaeological sequence. Our recent work in the cave has allowed us to identify the nature of the Cjgr sedimentary unit, which consists of brown-green silty clays with rolled fragments of ferrous hardpan. These features are indicative of a reworked deposit resulting from the alteration of the Urgonian limestone, while the coloration of the deposits betray their pseudo-gley nature, highlighting that the profile was, at one or multiple points, saturated with water (Deschamps and Anderson dir., 2020). Nevertheless, a coherent chronostratigraphic sequence in regards to the succession of the different industries seems to have been retained, with the exception of contact areas between archaeological levels (for more details, see Deschamps, 2019).

The latest dates conducted on materials for the overlaying unit, the Mousterian Cj level, produced an age range spanning from 47 to 44 ka BP (Ready and Morin, 2013), while dates obtained from cut marked deer bone from Cjgr yielded minimum ages of > 47,4 and > 50,3 ka BP (Barshay-Szmidt et al., 2012). New sampling is currently in progress and should allow us to further refine this chronology (Deschamps and Anderson, dir.).

The lithic industry contained within Cjgr can be attributed to the Vasconian technocomplex (Deschamps, 2014). Production predominantly follows the Discoid method using quartzites from local alluvial deposits, while some bipolar production using an anvil, though rare, has also been documented. The retouched toolkit consists mainly of side scrapers, followed numerically by denticulates. Flake cleavers, a necessary element of the Vasconian technocomplex, are also present in this layer (Deschamps, 2017), though no bifaces have been identified. The flint objects present within the assemblage are mostly blanks and retouched or resharpened tools (fig. 2.2c, d), as well as a few exhausted cores. These exhausted cores present significant accidents, which render an identification of the specific concepts applied for their reduction rather arduous. Flint flakes, which are generally small in size and often fragmented, are relatively ubiquitous, and flint is commonly used among the flake tools (Deschamps, 2019).

[fig. 3 Here]

1.4. Abautz Cave (Arraitz-Orkin, Navarre, Spain)

310

Abautz Cave sits at 620 m a.s.l. along a gorge of the Zaldazain, an affluent of the Ultzama River in the Ebro Basin (fig. 2.3b, c). The cave entrance is found near the main European watershed. Its archaeological potential was discovered in 1932 by T. de Aranzadi and J. M. de Barandiarán.

The first generation of excavations took place between 1976 and 1979 (P. Utrilla dir.), while a second was conducted between 1988 and 1996, though the latter were rescue excavations (P. Utrilla and C. Mazo dir.). The stratigraphic sequence is complex and presents a succession of levels attributed to the Middle Palaeolithic, the Upper Palaeolithic, the Neolithic, the Chalcolithic, and late Antiquity (fig. 2.3.a; Mazo et al., 2011-2012). The level attributed to the Middle Palaeolithic is Layer h. The AMS dates produced a result of > 45 ka BP, whilst amino acid racemization methods gave a date of 47 ± 7 ka BP (Utrilla et al., 2015). Level h is variable in thickness, reaching up to 50 cm in places, and is easily distinguishable from the other silty levels that sit above and below (Mazo et al., 2011-2012). Its silty sediment is dark in colour, and angular limestone blocks, sometimes of important size, are equally incorporated within the sedimentary matrix. These blocks are more numerous in the upper portions of the level, while some areas in the lower parts of the level incorporate pockets of gravel, indicating localized hydric flows (Mazo and Utrilla, 1996). Deer bones bearing anthropic cut marks have also been identified in this level, as well as burned bones, but the large majority of faunal remains found within the cavity are related to its intensive occupation by carnivores (primarily cave bears, see Utrilla, 2000). It is therefore more than likely that level h has been, at least partly, reworked by ursine occupations. However, sterile levels sit above and below level h and, furthermore, the upper portion of the level appears to be sealed by roof collapse events, both protection the level from significant mixing.

The lithic sample collected is very small in comparison to the other sites, comprising a dozen flake cleavers and a few bifaces (fig. 2.3d, e; fig. 3). The raw materials used are igneous, metamorphic, and sedimentary rocks, whose outcrops are located near the cave or are readily available in local alluvial deposits. The flints introduced into the site take the form of blanks, retouched tools, two cores, and one biface. The number of flakes is small, and most lack characteristic features that would allow us to determine the dominant production method employed, though several Levallois flakes have been identified. There are no signs of silicified deposits within the local limestones, despite such a potential having been identified for formations found further west (Tarrío et al., 2015). A non-local origin for the flint found in this cave was therefore suspected very early on (Utrilla, 1982), but petrographic characterization remained lacking until recently.

2. Methods

2.1. Analysis of Pyrenean rocks

345

Pyrenean rocks can be easily found within the region's alluvial systems (fig. 4.1; Colonge and Mourre, 2009; Colonge et al., 2012), and are therefore generally considered as readily accessible (strictly local environment; Jaubert, 1993). Recent work has proposed an in-depth characterization of the quartzites in the Cantabrian region (Prieto, 2018; Prieto et al., 2019, 2020), using a reference
350 set of thin sections and non-destructive observation methods conducted at several scales of analysis. This work has highlighted a greater diversity of quartzites than previously known and therefore provides novel data for investigating the raw material management, mobility, and strategies employed by Middle Palaeolithic groups. For the time being our application of the above methods has only concerned Noisetier cave, and investigations remain preliminary and based only on
355 macroscopic characterization. This approach will, however, be further applied to the different sites studied, which will allow us to deepen our comprehension of the origins of the quartzites found within.

Other preliminary works comparing alluvial deposits to archaeological assemblages have underlined a highly selective process for raw material acquisition, showing that these do not
360 necessarily come from the immediate surroundings of sites (Deschamps et al., 2010, 2011; Bruxelles et al., 2012; Roy Sunyer et al., 2015). These observations ultimately reject the hypothesis proposing that rocks other than flint were used on a purely opportunistic basis when the former was unavailable.

In order to establish when quartzites appeared in alluvial deposits, river terraces must be sampled. A
365 series of systematic sample collections were conducted on alluvial deposits along the Neste River and its affluents, up and down river from the site (fig. 4.2). The objective of this survey was to identify the appearance and disappearance of rock types in the drainage basin in order to discern potential supply zones and identify the degree of selection of raw materials within the environment. This in turn allowed us to evaluate how well Neanderthals knew of the mountainous landscapes
370 they traversed.

Six samples were taken in various alluvial zones along the main waterway of the Neste d'Aure (fig. 4.3). An additional sample was taken from the Neste du Louron (zone 3). The remains of some old terraces are present close to the site, but these are usually covered over by superficial deposits, rendering them inaccessible. Only one of these ancient river terraces could be sampled in the area
375 (zone 8). Field investigations were therefore mostly concerned with recent alluvial deposits, and the successive changes to the hydrographic network constitute a limit to our interpretation of the deposits that were or were not available during the Pleistocene.

In each zone, cobbles with a diameter equal or superior to 10 cm were collected or identified, as these dimensions were equally observed among cobbles documented in the archaeological
380 assemblages. The sampling zone had a radius of 1 m and each collection involved 100 samples. The

alluvial deposits tested were systematically surveyed in order to complete the quantitative sample with qualitative observations, and also in order to look for rarer materials (e.g. lydites and cinerites). It was necessary to group some rocks according to generic types, particularly for those that were absent from the cave, as a high diversity of rocks was encountered in the sampled deposits.

385 Granitoids were eliminated from the collections because they dominated all the samples and would have therefore masked pertinent data from other rocks found in smaller proportions. Samples were observed with the naked eye and using low magnification (x20) and were evaluated in collaboration with a petrography specialist (C. Servelle). Volcanic and metamorphic rocks whose mechanical properties simply did not align with the conchoidal fracture mechanics necessary for a stone to be

390 knapped were grouped into large categories, again, because of the high diversity encountered within the samples. This allowed us to focus on rock types whose structure allows for conchoidal fracture. Quartzites were also differentiated according to the size of the quartz grains found within their compositional matrices. Three granulometric categories were established through observations with the naked eye and using low magnification (fine, medium, and coarse-grained quartzites, fig. 5.2).

395 Rocks from the archaeological datasets were studied following the same protocol, and the quantification of the distinct categories allowed us to determine percentage composition profiles for natural and archaeological samples. While this study should be completed by a detailed geoarchaeological approach in the future, our preliminary results already show quite significant differences between the composition of natural and archaeological samples.

400 [fig. 4 Here]

2.2. Characterizing the origin of flints

The so-called microfacies method (Brown, 1943; Cuvillier, 1951; Séronie-Vivien, 2003) was used

405 to study flints from the three sites. This was complemented by an analysis of surface features following the evolutionary chain method (Fernandes and Raynal, 2006; Fernandes, 2012) and by the study of samples available in the TRACES laboratory lithic reference library (Briand, 2010) or those obtained through survey (e.g. Minet, 2015). Our descriptive approach was based on the model for carbonate rocks, and took into account the behaviour of silica in natural systems (Thiry et al.,

410 2014). All the petrographic characteristics (structural, mineralogical, sedimentological and paleontological) of the rocks from the three sites were analyzed using a stereomicroscope with magnification of up to x160 (PARALUX stereomicroscope model XTB ZOOM). These observations collected permitted us to situate samples within original palaeoenvironmental contexts. In other words, flints and silicified formations were compared and weathering and alteration

415 processes were taken into account in order to propose hypotheses in regards to the exact origins of

the raw materials collected, within their natural distribution network (primary sources, altered deposits, alluvial sources, etc., see Fernandes et al., 2007; Fernandes, 2012). These comparisons were based both on the bibliographic data as well as on the systematic collection of geological control samples for each type presented here (Table 1).

420 [Table 1 Here]

2.3. Calculation of "palaeo-itineraries" (routes)

The western Pyrenees have often been described as the "Basque crossroads" (e.g. Arrizabalaga et al., 2013), highlighting the fact that this geographic region is an important travel route that circumvents higher altitude areas in the mountain chain; a feature that particularly apparent during the Upper Palaeolithic. The Basque corridor, following the coastline, has also been proposed as a possible travel route during the Middle Palaeolithic (Arrizabalaga and Rios, 2012).

Given that the sites studied here are found further inland, well within the Pyrenean mountain range, we felt it pertinent to explore the possibility of travel routes that cross the middle altitude mountain ranges of the Basque Country, rather than assuming that circumvention was the only way to move around this rugged landscape. This sector presents significant topographic variability, and therefore we used tools borrowed from the information technology domain in order to calculate optimal routes, as has been done by several scholars before us in the Iberian Peninsula (López Romero, 2005; Llobera, et al., 2011), in addition to recent work conducted regionally on the Upper Palaeolithic (Sánchez et al., 2016; Prieto et al., 2016).

The route calculations were conducted using the GRASS module integrated into QGIS (Quantum GIS) software package. GRASS (Geographic Resources Analysis Support System) is a raster focused GIS (Geographic Information System) software that is now integrated with and can be used within QGIS.

Route calculation implies the use of digital elevation models (DEM), which are raster files whose pixels contain altimetry values for the area under study. For the present study this concerns nearly 20 000 km², all within the coordinate system produced by the Shuttle Radar Topography Mission (SRTM). This DEM allowed us to create a new slope raster where each cell contains a value (in degrees) that corresponds to the gradient of the raster surface. Using GRASS we then calculated a cumulative cost raster. From a given coordinate point parameter a cost was attributed to reach each pixel. This cumulative cost raster made it possible to propose least-cost paths between different points, i.e. the routes that were the least energetically demanding and therefore had the lowest slope gradients. This calculation method in turn allowed us to propose routes between different sites. The calculation of such "palaeo-itineraries" is obviously plagued by several potential biases, the first

being the impact of recent modern human occupation on the landscape. While current infrastructures (cities, bridges, roads) are not present within the DEMs used for our calculations, it is nevertheless difficult to evaluate the amplitude of anthropic transformation over the areas considered in the present study. Our DEMs use current elevation data, and slope calculations are
455 dependent on the pixel resolution of the DEMs themselves (approximately 30 m in this example).

The second source of bias concerns the actual environment. Besides sea-level differences, climatic transformations had an impact on the placement or movement of waterways as well as on vegetation and soil characteristics and composition. In the regrettable absence of sufficiently precise palaeoenvironmental data for the targeted study area, our analyses here use only slopes in cost
460 calculations.

Finally, the calculation of itineraries in proximity to mountainous areas necessarily forces us to ask questions regarding the capacities and effort levels required of the individuals traversing these landscapes, and the nature of the strategies adopted: is it more "complex" to adopt a strategy that necessitates a sustained low-level effort over a long period, or can such a higher "complexity" be
465 rather assigned to high intensity effort over a short period? The different routes proposed here consider mostly the latter, i.e. routes to cross the Pyrenean chain directly, rather than to circumvent it.

3. Results

470

The relative distances between mountain sites and foreland basin flint deposits did not, it would seem, constitute a barrier to human presence in the western Pyrenees. Various types of rocks from the High Primary Range were exploited (quartzites, schists, lydites, cinerites, and quartz), and several Pyrenean raw materials have reasonable knapping potential and offer cutting edges that are
475 more resistant than those of flint.

3.1. Selection of local Pyrenean raw materials at Noisetier Cave

In the three levels studied, assemblages are dominated (roughly 90%) by rocks other than flint
480 (fig. 5.1). In the context of the Pyrenees, these sedimentary, metamorphic, and volcanic rocks exploited cover a wide variety of materials, including quartzites, schists, quartzes, ophites, sandstones, lydites, cinerites, and granites. These rocks are generally considered to have been collected locally as they are generally accessible in the alluvial deposits and ancient terraces of the different watercourses. At the Noisetier Cave, all artefacts made on local Pyrenean rocks present
485 alluvial neocortical surfaces.

When the natural and archaeological samples are compared, the latter include quartzites and schists in proportions similar to those identified in the alluvial deposits, except for in Layer 2/33 where quartzites are much more common (fig. 5.2). Furthermore, the alluvial schists often present very marked cleavage patterns, making them unsuitable for knapping. Among these only spotted schists were introduced on site.

Another important difference between the natural and archaeological samples concerns lydites and cinerites. Lydite is a siliceous sedimentary rock with dark chalcedonic cement. It is common in carboniferous deposits and is often found with limestones and schists (Foucault and Raoult, 2005). Lydite often has numerous joints and breaks following an echelon fracture pattern. Cinerite is a pyroclastic rock created by ash fall deposits. It forms in well stratified levels in marine and lake environments and can alternate with tuff or sedimentary layers.

Lydites represent between 7 and 15% of the knapped materials in the archaeological assemblages and the cinerites between 2 and 4%. In alluvial deposits, however, these rocks are rare and were mostly found in zones 3 and 4, in the Neste du Louron and upriver of its confluence with the Neste d'Aure. Moreover, the natural samples' characteristics do not correspond to those of the archaeological materials: they are smaller in size and present more numerous natural fractures, making them much less suitable for knapping. The exact context for the acquisition of lydites and cinerites therefore remains to be determined. Primary deposits of these rocks are said to exist upriver in the Aure and Louron valleys within formations rich in phosphate nodules attributable to the Carboniferous (fig. 4.3). They are therefore potentially present in ancient alluvial deposits, but rarely contribute to the background "noise" in currently active waterways. As a rule, lydites and cinerites present themselves as linear outcrops, oriented east-west, and are systematically cross-cut by south-north running waterways. Cinerite outcrops, however, are present in relatively small quantities compared to other geological formations. In periglacial and glacial contexts, their fracturing mode favours their movement on mountainsides where they can be altered, discoloured, or disaggregated. All these factors can explain their absence within the various samples.

The granulometry of quartz grains in the cement of quartzites also points towards specific and intentional selection practices for these raw materials. Fine-grained quartzites systematically dominate the archaeological assemblages, while this is never the case for natural alluvial samples, which implies that a form of qualitative selection of these rocks was being conducted by groups as they scoured the concerned alluvial deposits.

These comparisons, using modern reference and sample collections, demonstrate how difficult it can be to identify specific raw material acquisition areas in the Pyrenees and, furthermore, underline the necessity for new fieldwork in order to propose valid territorial reconstructions. Similar investigations are being conducted at Gatzarria Cave, where the composition of alluvial deposits

from the Saison River and its principal affluents will be compared with the various raw materials identified in the cave's Late Middle Palaeolithic levels.

[fig. 5 Here]

525 **3.2. Flint procurement at Noisetier, Gatzarria, and Abauntz**

Access to flint resources, as well as the quality of the materials themselves, are highly dependent on structural and climatic factors in the Pyrenees. These constraints contribute to very specific palaeogeographic route choices associated with these raw materials. The classification system
530 adopted here refers to the original palaeoenvironmental contexts of the silicified deposits (Tarrío *et al.*, 2015). In order to homogenize results, all distances presented in the following section are estimations “as the crow flies”, despite the obvious topographical distortions that such estimations entail. Only the closest sources have been considered (fig. 6; fig. 7).

[fig. 6 Here]

535 [fig. 7 Here]

3.2.1. Flysch silicifications

Most of the flint artefacts are attributable to the various flysch formations found in the Pyrenees and
540 associated with the Upper Cretaceous and Palaeogene sequences. They present microfacies that are quite typical of turbiditic deposits. They often present sponge spicules (fig. 8.1), metal oxides, and detrital quartzes. Their structure generally appears porous, often in relation to euhedral rhombs derived from the dissolution of the initial carbonates. They can also present laminations, be bioturbated, and have some carbonate phases. Some specimens contain veins of secondary silica or
545 present a dendritic surface (fig. 8.2, 3).

The majority of artefacts from the Noisetier Cave (64%), and a few elements from Gatzarria ($n = 5$; see fig. 8.5), are similar to the Hibarette/Montgaillard (HIB) type of flysch (Barragué *et al.*, 2001). Their microfacies are usually oxidized and they have relatively unstructured peloids (*ibid.*, Lacombe, 1998; Foucher *et al.*, 2016; Sánchez de la Torre *et al.*, 2017). The preserved natural
550 surfaces correspond to secondary deposits. Post-depositional processes can cause surfaces to take on a white patina, though a brown-orange crystalline background is still visible (fig. 8.4). This characteristic has also been observed on several types of flysch flint (FLY) from the western Pyrenees (Tarrío *et al.*, 2015). Some of the elements from Noisetier cave are attributable to these formations (FLY) from the western Pyrenees (14% of remains). These FLY flints differ from the
555 HIB type in their darker facies, which are grey to black (fig. 8.6, 7) and are not oxidized. Some

contain more bioclasts (spicules and small fragments of foraminifera) and possible amorphous organic matter. The preserved natural surfaces also suggest primary or sub-primary deposits. FLY deposits are located between the “Bande d'Asson” (south of Pau, Sub-Pyrenean Zone, see Lacombe, 1998, fig. 1) and the Oloron region, further west. Our preliminary surveys have revealed the presence of similar flints in the municipality of Rébénacq, east of Oloron (Pyrénées-Atlantiques).

Numerous elements from Gatzarria Cave (33%) correspond to the Iholdy (IHO) flint type (Normand, 2002), which is characterized by generally coarser grained and darker silicifications, similar to those documented in the Mauléon Basin. The natural surfaces observed suggest a collection of IHO flint in primary or sub-primary deposits, and the sources are most likely situated roughly 10 km downstream, to the northwest of the site.

The other FLY flints from Gatzarria are primarily of the Bidache type (41%, see Normand, 2002). These are more heterogeneous in appearance and come from finer silicifications than those attributable to the IHO type. They are grey and/or blue but can be white and opaque when altered. Outcrops of this type have been documented downstream of the Saison, about 30 km from the site, and this flint is often collected in the form of slabs or nodules.

Even if the formation processes are similar across several turbiditic sequences within the Pyrenees, additional types can be distinguished from the generic FLY type as they present some distinct characteristics. In Level Cjgr of Gatzarria Cave, a variety of the Gaintxurizketa (GAIN) flint type was identified. It is characterized by its dark surface, its numerous rhombs of authigenic carbonates, and indications of bioturbation. This element is similar to resources found in megaturbidic formations in the Deba-Irun corridor located near the coastline (Tarrío, 2006).

The majority of remains from Abauntz Cave (75%) are attributable to the Olabe (OL) flint type. Resources from this area were long suspected since the discovery of distinct archaeological flint samples on the Ultzama terraces (Beguiristain Gúrpide, 2000). These formations were located through surveys conducted in 2018. Several silicification contexts were documented on Monte Aliseto, though these were independent from any known archaeological deposits (fig. 9.1-1a). These survey observations were supported by the discovery of *in situ* flint in an old quarry (fig. 9.1-1b), therefore confirming the existence of primary or sub-primary deposits near Olabe. The local formations correspond to the Eocene Hecho Group of turbidites and to the carbonate megabreccias interbedded within them (Paricio and Pérez dir., 1994-1995; Payros et al., 1999). The flint samples contain various bioclasts also found in the microfacies present in the Abauntz assemblage (fig. 9.2a, b). These include foraminifera of the *Nummulitidae* group, associated with echinoids and sponge spicules. The natural surfaces of the artefacts in Abauntz indicate collection from primary or sub-primary deposits. These materials therefore seem to come from downstream areas, about 15 km

590 south of the site. Two other flints from Abauntz Cave correspond to the Perdón (PER) flint type
(Beguiristain Gúrpide, *op. cit.*). They present oxidized microfacies with peloids, sponge spicules,
and traces of glaucony (fig. 9.2c). One of these conserves a natural surface typical of an ancient
secondary deposit, while the other has been affected by general surface bleaching. These flints are
poorly documented, but are available in great quantities in the Sierra del Perdón conglomerates
595 (ibid.; Paricio et al. dir., 1993). Once again, geological surveys have allowed us to find samples
similar to those described for the archaeological assemblage, 30 km south of Abauntz.

[fig. 8 Here]

[fig. 9 Here]

600 **3.2.2. Pelagic silicifications**

Two remains from Layer gb and one element from 2/33 at Noisetier Cave appear to be attributable
to the Salies-de-Béarn type (Normand, 2002, 2003). These flints (SDB) are typical of a pelagic
sedimentation and contain abundant microspheres (*Pithonella, incertae sedis*, see Odin, 2008, 2010;
605 fig. 10.1, 2). They have a greyish tint, and their structures include many bioturbated and carbonate
zones. The geological formation that yields these types of flint is Campanian-Maastrichtian in age
(Henry et al., 1974). One element from Layer gb has a natural surface indicating a secondary
deposit. These flints were therefore obtained 100 km to the west of Noisetier cave, with directions
of transport being similar to the aforementioned FLY type flints (Thiébaud et al., 2012). Several
610 artefacts from Level Cjgr of Gatzarria (14%) show similar microfacies, though their natural surfaces
are indicative of collection from primary or sub-primary deposits, which are found 30 km to the
north of the site.

Nine other elements grouped among the pelagic flints from Gatzarria Cave present a darker
microfacies that is grey to blue-black in colour and translucent. Sponge spicules are frequent,
615 especially triaxones (fig. 10.3) as well as numerous diffuse bodies, including *Echinoid* fragments.
These characteristics allow us to attribute these flints to the Aturian facies of the Campanian-
Maastrichtian platform to basin transition of the Aquitaine. The closest sources for this flint are
found in deposits surrounding the Tercis anticline (TER), roughly 5 km to the southwest of the city
of Dax. The natural surfaces found on the materials in the archaeological sample correspond to both
620 primary to secondary deposits, meaning that the route used to obtain these flints may have followed
the Adour River to the Tercis region, about 60 km north of the site.

[fig. 10 Here]

3.2.3. Carbonate platforms silicifications

Layer 2/33 of Noisetier Cave contains two artefacts attributable to raw material sources encountered in the North Pyrenean foreland basin, where one can find flint in Campanian-Maastrichtian platform limestone formations. The first element contains characteristic fossils, notably the *Lepidorbitoides* (LEP) and *Siderolites* genera (fig. 11.1, 2). The structural properties of this element (translucent), its microfacies (low proportion of grains), and its bioclastic contents (absence of *Orbitoides media*) confirms that this material is not attributable to one of the Maastrichtian flint sources known in the Central Pyrenean foothills (*Les Petites Pyrénées*, see Séronie-Vivien et al., 2006; Foucher, 2015). The closest outcrops of flint with the same markers are found in the Chalosse region (Landes, see Bon et al., 2002), though deposits with comparable raw material have been located further upstream in the Adour Basin (Gers, e.g. Colonge et al., 2011; Séronie-Vivien et al., 2012; Minet, 2015) in the municipality of Labarthète, over 85 km to the northwest of the Noisetier. There are no observable natural surfaces on this element but its oxidized facies is compatible with a collection from ancient secondary deposits. The second element presents a microfacies with numerous small foraminifera, notably of the *Rotaliida* order (cf. *Nonionella*; fig. 11.3, 4). The nature of the various elements present within the flint, their shape and their organization, all point to flint types from the Montsaunès/Ausseing sector (MON), 50 km away from the site (Simonnet, 1999) in the Central Pyrenean foothills (*Les Petites Pyrénées*), attributable to Maastrichtian formations.

Some flints from Gatzarria (5%) are also attributable to silicifications found in carbonate platform environments. Five of these artefacts correspond to the LEP type (fig. 11.5), and the only observable natural surfaces underline collection from sub-primary deposits. The nearest formations susceptible of yielding such flints are in the Chalosse region, around 60 km to the north of the site.

Among the other platform flints found in the collections of Gatzarria, an Urbasa (URB) flint type was also identified (Tarrío et al., 2007). Its bioclastic microfacies, lightened by alteration, includes a species of the genus *Discocyclina* (fig. 11.6). The presence of these large foraminifera allows us establish a connection with Thanetian raw materials documented on the Urbasa plateau, found roughly 100 km away in the Ebro Basin. One of the flints from Level h at Abauntz is also attributable to the URB type. Its microfacies contains *Nummulitidae* and species of the genus *Discocyclina* (fig. 9.2d). There is no observable natural surface on this artefact, making it difficult to determine the context of raw material collection, but the Urbasa plateau is around 40 km to the southwest of Abauntz.

[fig. 11 Here]

3.2.4. Continental silicifications

660 One element from Layer gb and four from Layer 2/33 at Noisetier Cave are attributable to flint types found in Cenozoic outcrops throughout the Sub-Pyrenean Zone and Southern Aquitaine Basin. These are silicifications from continental environments, or at least marginal marine evaporitic contexts. The microfacies analyzed are azoic, translucent, and can sometimes contain manganese oxide concentrations (fig. 10.4, 5). They are attributable to raw materials found in the
665 Central Pyrenean foothills (*Les Petites Pyrénées*) within Danian (DAN) aged formations (Simonnet, 2002). Here, we cannot exclude the possibility that they came from the adjacent anticlines of this area, about 40 km to the northeast of the site (Rouquerol, 2000). The natural surfaces visible on two elements from Layer 2/33 underline primary or sub-primary collection contexts.

Six elements from Level Cjgr at Gatzarria also correspond to silicifications from continental, riparian, or lacustrine environments. The documented microfacies are varied, are more or less brecciated, matte, and are sometimes bioclastic. Gastropod and ostracod fragments have been found
670 in one of these elements (fig. 10.6). The natural surfaces observed on two elements indicate, in one case, a sub-primary deposit, and in the other case, a secondary deposit. These flints can be attributed to the Treviño (TREV) flint varieties, accessible in Miocene outcrops (Tarrío, 2006) found roughly
675 150 km from Gatzarria, towards the high Ebro basin.

4. Multi-scale interpretations of techno-economic organization

4.1. Diachrony at the intra-site level

680 Studying the origins of the available raw materials in the archaeological levels of the Noisetier has allowed us to identify diachronic differences in supply territories. Technological variations as a function of different raw materials and their distance from the site can also be perceived, underlining distinct economic strategies. The different raw materials identified in this cave have also allowed us to explore the relationship between this site and the Pyrenean piedmont (fig. 6).

685 Within Layer 2/33, the main raw materials are HIB type flint, available at a distance of about 30 km from the site, followed by FLY and SDB type flints whose main outcrops are found roughly 100 km to the west, and finally LEP type flint from further north (85 km, fig. 6.1, 2). While a central tendency is observed where materials come from the west, a secondary axis or circulation to the east is observable through the presence of DAN and MON type flints.

690 Among the FLY and HIB type flints, flakes with no cortical surfaces are the most numerous, while flake fragments, retouched tools, and retouch/rejuvenation flakes are also relatively widespread. Both the DAN and LEP type flints were introduced in the form of retouched tools. A single retouch flake, in addition to other fragments related to tool maintenance, are also present. The only MON

695 type element identified is a partially cortical flake, while the two tools produced in DAN type flint also use cortical flakes as blanks.

Raw materials were therefore introduced into the Layer 2/33 assemblage primarily from the west in the form of cores that had already been shaped and partly exploited, and their exploitation continued on site. Only a single core of SDB type flint remains on site, and this example is particularly exhausted. A smaller quantity of elements are introduced from the east, yet these seem to represent 700 abandoned personal gear (Binford, 1979), rather than a real management of material in order to supply needs specifically related to the site.

In Layer gb, which superposes layer 2/33 stratigraphically and therefore chronologically, the connection with raw material sources to the east disappears, while the exploitation of HIB type flint deposits, which are closer to the site, intensifies (fig. 6.3, 4). This material seems to have been 705 partially knapped on site. FLY type flint is less common but also seems to have been occasionally knapped on site, while SDB type flint was introduced exclusively in the form of cortical flakes already shaped into side scrapers. Some of the side scrapers in the assemblage present scalar retouch that can be likened to Quina type retouch. As the area around the site is bereft of high quality raw materials this scalar retouch could be interpreted as a higher degree of tool 710 conservation, i.e. a higher degree of tool curation (Binford, 1979). In such a context the scalar retouch, a morphology of retouch that results from the successive and intensive rejuvenation of tool edges, underlines a particular intensive single-use event, or, more likely in this instance, a desire to lengthen the tool's use life. The likening to Quina retouch is therefore the result of morphological, and to a degree economical, convergence, rather than a demonstration of actual Quina scraper edge 715 shaping.

Finally, the area of raw material exploitation observed for layer 1 is further reduced, with only small proportion of HIB and FLY type flints represented (fig. 6.5, 6). The absence of tools in FLY type flint, combined with the presence of retouch and rejuvenation flakes in the same material, suggests that the tools were used and maintained on site but were judged as still useful upon the breaking of 720 camp and were therefore exported as part of the curated tool kit (Cahen and Keeley referred to such transitive objects as "phantom" or "ghost" tools, see Cahen and Keeley, 1980).

Whatever the cause, variations in the raw material provisioning across the levels of Noisetier cave were observed. These changes are likely related to variations in group mobility strategies and/or site function. For example, a residential site occupied for longer periods could have favoured the more 725 varied exploitation of the local and regional mineral environment identified in Layer 2/33 (increased dependence on long-distance logistical mobility). The absence of raw materials from the east, coupled with a dependence on exotic materials from the west, as observed in Layer 1 and Layer gb, could indicate that during these periods of occupation Noisetier cave was situated on the

730 oriental periphery of seasonal/annual mobility circuits. At any rate, it would appear that the lithological territories on either side of the cave were treated as separate territorial and economic entities.

4.2. Regional overview

735 The chrono-stratigraphic data, discussed above, permits us to situate Layer 1 of Noisetier cave, Level Cjgr of Gatzarria cave, and Level h of Abauntz cave all within MIS 3. In addition, both Layer 1 from the Noisetier and Level Cjgr from Gatzarria present technological characteristics that are coherent with an attribution to the Vasconian technocomplex (Deschamps and Mourre, 2013; Deschamps, 2014, 2017). Level h at Abauntz should be treated with more caution given the small
740 sample size, yet both cleavers and bifaces are present, and dates appear coherent with those of the other two sites, making a Vasconian and MIS 3 connection quite possible as well.

At any rate, the origins of raw materials from Level Cjgr of Gatzarria demonstrate high regional diversity. The flints collected originate from deposits that stretch over roughly 30 km, mostly situated downstream in the Saison Valley. While outcrops of IHO type flint are situated in close
745 proximity to the site, it is not the most represented flint variant at Gatzarria. It would appear that occupants favoured higher quality materials found further north, notably the FLY and SDB flint types, despite the close proximity of IHO type deposits.

The retouched elements that compose the industry of Gatzarria's level Cjgr are more commonly in IHO flint rather than in the FLY and SDB types, yet the latter two types are significantly over-
750 represented by retouch/rejuvenation, demonstrating a wide gap in terms of tool maintenance across different materials (Deschamps, 2014). When the ratio of retouch/rejuvenation flakes to tools are considered by raw material type, a clear pattern can be seen: sub-local raw materials (quartzites and IHO flint) have low maintenance to tool count ratios, while non-local materials demonstrate higher ratios. This pattern fits well with the dichotomy between expedient and curated tools as initially
755 defined by Binford (1979); "expedient tools" are produced, used, and abandoned on site using, in this instance, sub-local materials, while higher quality non-local materials circulate more widely and demonstrate a higher degree of maintenance, allowing us to place them within the "curated tool" category.

TER and LEP type flints from further north show occasional use, and rejuvenation activities seem
760 to have been particularly important in the case of LEP type flint. Here again, the coupled concepts of a curated tool kit (Binford, 1979) and transitory "phantom tools" (Cahen and Keeley, 1980) are powerful explicative models. A highly exhausted core fragment in LEP was also identified.

The presence of GAIN and HIB type flints demonstrate rarer alternate modes of circulation along the East-West axis of the Pyrenees. The rare HIB type flints are particularly interesting in that they
765 represent an overlap between the lithic exploitation territories of Noisetier and Gatzarria caves, and therefore an indirect link between the two sites (fig. 7).

URB and TREV type flints, while present and identified, are relatively rare. URB type flint is present in the form of an isolated tool, while TREV type flint is more common and present in the form of both tools and flakes. It is also interesting to note that TREV flint is present in quantities
770 similar to those of TER and LEP type flints to the north, yet it the latter sources are much closer to Gatzarria, less than half as far away as TREV flint sources.

In the case of Layer 1 at Noisetier, as at Gatzarria, the scarcity of flint cores compared to flakes from these materials suggests the importation of unretouched or retouched blanks onto the sites, rather than cores “in transit” (Porraz, 2005); the rare cores identified are all fragmented or have
775 been very extensively used. Cortical products are also found in small numbers at Noisetier, although they are more common at Gatzarria, and frequently transformed into tools. This type of flake, which is generally relatively thick, is an ideal blank for tools with long use lives as it permits successive phases of tool maintenance. At Gatzarria, we can consider that the quartzite, FLY and IHO sources were introduced as unworked matrices because there is production on site showing every step of the
780 operational sequences and tools made from these raw materials are very common even if the FLY artefacts show a higher rate of retouch/rejuvenation flakes. This underlines the possibility of strategies approaching Kuhn's (1994) notion of provisioned places. On the other hand, materials from more distant sources, such as SDB, TER, LEP, HIB and TREV flints are more likely to have involved elements of personal gear used, then abandoned on site.

785 Finally, Layers Cjgr of Gatzarria and 1 of Noisetier share the use of connected supply territories in terms of mineral resources and this feeds the idea previously mentioned of a relationship between them.

4.3. Trans-Pyrenean contacts and long-distance travel

790 As already mentioned above, small quantities of TREV and URB type flints were identified at Gatzarria. These elements reveal connections that span more than 150 km as the crow flies, and moreover, represent the oldest direct evidence for circulation across the northern and southern flanks of the Pyrenees.

795 It is possible that travel routes existed through the Basque mountains, which offer mountain passes that are significantly lower than those of the High Primary Range in the Central Pyrenees. We have attempted to reconstruct alternative routes between the south and the north sides of the mountains

range (fig. 12) using the computational methods described earlier. The calculation of these least-cost paths should be understood as propositions for travel routes that cost the lowest amount of energy per unit of distance travelled (see section 2.3).

Two routes were calculated in order trace a path between Gatzarria, Abauntz, and the Urbasa and Treviño outcrops. The first route (fig. 12.1, 3) proposes a path that firstly descends well into the Aquitaine Basin before roughly following the Atlantic coast. The distance travelled is long, but altitudinal variations are small (Gatzarria-Treviño = 283 km/ Δ alt 8,5 km). The second route favoured shorter distances rather than limiting altitudinal, and therefore slope, variations. This second route passes directly through the Basque mountains in order to reach Abauntz, followed by Urbasa and Treviño, and is ultimately quite a bit shorter (Gatzarria-Treviño = 211 km/ Δ alt 11 km). The most direct passage through the Basque mountains is near the town of Saint-Étienne-de-Baïgorry, where travellers would then have to brave the Ispéguy Pass (altitude = 672 m), before descending into the southern foothills via one of the tributary river valleys of the Bidassoa.

While reconstructing prehistoric travel routes with exact certainty is a fool's errand, the correlation between the location of the four entities and the path proposed crossing the Ispéguy Pass (fig. 12.2, 4) suggests these mountains were perhaps not impermeable barriers. Some natural routes into and across the Pyrenean mountain range may have facilitated circulation and communication across the north and south flanks of the Pyrenees during the Middle Palaeolithic.

[fig. 12 Here]

5. Discussion

At a broader scale, these results allow use to propose several hypotheses in regards to the mobility strategies and circulation networks of Late Middle Palaeolithic groups in the Pyrenees.

First of all, the presence of flint from the Ebro Basin on the northern side of the Pyrenees implies, for the very first time in the regional Middle Paleolithic, direct evidence of connections with the Iberian Peninsula. The existence of common technical traditions between the southern portion of the Aquitaine Basin and the northern Iberian Peninsula, using analyses of the lithic industries in the sectors (Deschamps, 2017), has previously been proposed, and this tradition appears to be distinct relative to sub-contemporary industries documented in the northern Garonne Basin.

When the results obtained here are compared with patterns observed in the northern Aquitaine Basin (Turq et al., 2017), it would appear that circulation networks concern greater distances in the south (fig. 13). While this is easily explained by the less regular and more clustered geographical distribution of raw material sources in the study area relative to the northern Aquitaine Basin, such an explanation cannot be applied to the various flysch deposits that contain flint, which are more

regularly distributed. Be that as it may, it would appear that the particular geographical configuration of quality flint sources in the south may have favoured acquisition strategies necessitating greater anticipation and planning, or at least rendered such strategies more easily identifiable by analysts. Regardless of how one interprets such patterns, raw material distributions in the northern Aquitaine Basin are inherently more conducive to less anticipatory and more *ad hoc* collection strategies, as quality materials are abundant and readily available in both primary/sub-primary and, especially, secondary alluvial contexts, which are often easily accessible.

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840 Furthermore, the existence of areas completely devoid of flint does not seem to have prevented human occupation on the northern side of the Pyrenees, where other local non-flint raw materials were often used. These Pyrenean rocks, mainly composed of quartzites and schists, were nevertheless subjected to an active selection by occupants, given the significant differences observed between natural and archaeological samples from the Noisetier. An expedient toolkit using local non-flint materials was, however, continuously supplemented by the introduction of small quantities of non-local flints which evokes the repeated introduction personal gear by individuals frequenting the site (Binford, 1980).

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At a regional level, we have demonstrated that the lithic exploitation territories of groups occupying both Gatzarria and Noisetier caves had strong similarities, even if proportions of primary raw materials imported vary as a function of each site's specific geographical location relative to the closest sources. It is particularly interesting to note that at the Noisetier, flints from the Central Pyrenean foothills (*Les Petites Pyrénées*) were not at all present in Layer 1 and Layer gb, whereas they are present in one of the deeper levels (2/33). From a technical point of view, Layer 1 at the Noisetier also represents the easternmost limit of the Vasconian technocomplex, meaning it could represent a limit between the eastern and western areas of the Pyrenees (Thiébaud et al., 2012). Furthermore, the Noisetier is located in the Neste Valley, a tributary to the west of the Garonne River which may have represented a natural barrier that influenced the territorial patterns of groups located on either the right or left banks.

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The circulation of flint over long distances seems to follow a west to east trajectory, though rare materials follow an east to west trajectory. While Gatzarria contains flint from the southern flanks of the Pyrenees, to date no Middle Palaeolithic sites located in the southern Basque Country contain flints from the north, with the exception of flints available inside the Deba-Irun corridor, as is the case at Amalda, Axlor, and Arlanpe (Rios, 2012; Rios et al., 2015). Our results reflect the existence of movement and/or contact along a main west/east direction from the north of the Iberian Peninsula to the south of the Aquitaine Basin.

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The hypothesis for trans-Pyrenean travel across the Ispéguy Pass, or other relatively low altitude paths through the western Pyrenees, does not call into question the validity or falsify the existence of travel routes favouring the coast, but rather suggests the existence of other secondary routes. It is even probable that the coast was a privileged travel corridor for Middle Palaeolithic nomads, 870 permitting groups to easily circulate between the southern Aquitaine Basin and the Basco-Cantabrian Basin (Arrizabalaga et al., 2013, 2014), and the presence of an artefact in GAIN type flint at Gatzarria is demonstrative of such connections between the northern Basque mountains and this coastal corridor. Nevertheless, according to our calculated itineraries, the distance travelled 875 between Gatzarria and Abauntz is twice as short if groups take the Ispéguy Pass rather than the coastal route, and the sum of altitudinal differences is only about 100 m more important if the mountain pass is favoured (fig. 12.4). Moreover, the least-cost path algorithm used to calculate travel itineraries between Gatzarria and Treviño proposed routes that cross both Abauntz and Urbasa. While these paths are probably not structuring corridors for Middle Palaeolithic 880 movements, the numerous valleys of the interior Basque Country do provide access between the north and south while cutting travel time considerably relative to the coastal route, even if the energy cost is higher yet certainly gradational.

The important quantity of sites along the Basque coastline illustrates the intensity of occupation in the area. However, cumulated factors, such as taphonomic biases and the fact that survey on 885 mountainous environments is difficult, have likely contributed to a reduced visibility of human occupation in the interior Basque Country. The discovery of both Lower and Middle Palaeolithic sites during surveys in the Mendive Valley, located in the interior Basque Country, further confirms such early occupation of the interior and further supports the notion of visibility biases (Marticorena et al., 2017).

890 On a broader chronological scale, several differences regarding circulation between the southern Aquitaine Basin and the Basco-Cantabrian Basin are notable when we compare the data obtained here concerning the Middle Palaeolithic and data that exists regarding the Upper Palaeolithic in the region (Arrizabalaga et al., 2013). During the Upper Palaeolithic, networks of raw material 895 circulation cover vast territories (Bordes et al., 2005). In Aurignacian assemblages south of the Garonne corridor, such as Brassempouy (Landes) and Isturitz (Pyrénées-Atlantiques), flint from the northern Aquitaine Basin (such as Bergeracois or Grain de mil type flints, see fig. 13) has been identified, while TREV type flints from the Ebro Basin are also present (Bon, 2002; Tarrío et Normand, 2002; Tarrío, 2006). At Gatzarria recent work has identified TREV type flints in the 900 Aurignacian and Gravettian assemblages; no flints from the northern Aquitaine Basin have yet been identified in Gatzarria's Upper Palaeolithic assemblages, but excavation and re-evaluation of

collections both remain in their early phases (Deschamps and Anderson, 2020). At a regional scale, connections between the southern and northern Aquitaine Basin are rarer during the Gravettian than during the Aurignacian, while flint resources along the Basque corridor and the upper Ebro valley
905 were more intensively exploited (Simonet, 2017; Calvo, 2019).

A significant break in the raw material circulation networks between the north and the south of the Aquitaine Basin has, however, been identified during the Middle Palaeolithic. To date there exists no evidence for the movement of raw materials between the right and left banks of the northern
910 Garonne River in the Middle Palaeolithic. This observation supports the hypotheses proposed respectively by Bruxelles and Jarry (2011) and by Bertran and colleagues (2013), that both the windy alluvial corridor of the Garonne and the periglacial desert of the Landes de Gascogne were particularly inhospitable areas during certain moments of the Pleistocene. These two adjacent geomorphological entities therefore formed a natural barrier whose relative permeability varied as
915 a function of climatic shifts and/or cultural adaptations. □

In the past, the Pyrenees have often been considered as both a natural and cultural barrier (Cazals et al., 2007). The results of the present study show, however, that this was not entirely the case during the Late Middle Palaeolithic and that paths crossing the lower mountains of the Basque Country
920 were possible, in addition to the well-established coastal routes. This implies that the inhospitable zone between the periglacial desert of the Landes de Gascogne and the Garonne corridor had more of an impact on the geographic distribution of Middle Palaeolithic technocomplexes during MIS 3 than did the western Pyrenees. However, the absence of preserved archaeological sites in the sector between the Gers department and the southern Garonne (Allard and Lassaube, 1987; Duclos, 1991;
925 Séronie-Vivien et al., 2012; Minet, 2013) constitutes a research vacuum that requires filling and whose study could eventually mitigate these results. Rare pieces of flint from the Bazas sector, located on the south bank of the Garonne, were introduced into Late Middle Palaeolithic open-air site of Latrote (Landes), on the right bank of the Adour, near Chalosse sources (1.4%; see Fernandes, 2012), which suggests that connections existed further north with the immediate
930 southern fringes of the Garonne.

[fig. 13 Here]

Conclusion

935 The investigation of raw materials at Noisetier, Gatzarria, and Abauntz has allowed us to shine the spotlight on a considerable circulation network during the Late Middle Palaeolithic in the Pyrenees.

The presence of Treviño and Urbasa flint types at Gatzarria implies movements of over 200 km. This indicates the existence of structured circulation networks and possibly specific mobility strategies, both necessitating the existence of an already quite robust demographic and socio-economic framework. Occupations in mountainous environments were therefore not the result of rare and isolated groups, but rather may have represented an attractive biome and seasonal complement to the subsistence economy of groups inhabiting the region more generally, as has been suggested elsewhere (e.g. Bernard-Guelle, 2002, 2005; Richter, 2006; Biagi et al., 2017). From a lithological point of view, the Pyrenees do not offer abundant flint resources and do not form an individualizable region, as it's the case for the Vercors plateau for example, where high quality raw materials easily explain the high density of open-air occupation and inversely low frequentation of the region's cavities (Bernard-Guelle, 2008). The significant diversity of the regional and even extra-regional resources in the three caves also implies links with the Piedmont areas. For each site, the introduced flints are the result of active selection strategies which leave recurrent material patterns: assemblages consist of a few exhausted cores, small flakes, and mostly retouched blanks with rejuvenation flakes. Such a pattern seems to be consistent with a strategy that focused on the provisioning of individuals (Kuhn, 1994) at all of the sites studies.

Finally, this study clearly demonstrates that the western Pyrenees did not seem to have represented a significant natural barrier to movement or occupation, and, inversely, that the periglacial desert of the Landes de Gascogne and the windy Garonne corridor was a barrier during some moments of the Late Pleistocene. Both of these observations had very important implications for the structuring of territories in the Late Middle Palaeolithic, implications that are clearly manifested by the raw material territory overlaps observed between the southern Aquitaine Basin and the northern Iberian Peninsula. Lithic exploitation territories also echo the technical similarities observed between the southern Aquitaine Basin and the northern Iberian Peninsula, which contrast significantly with the technical break observed at the same time when comparing the southern and northern Aquitaine Basin, divided between the left and right banks of the Garonne (Deschamps, 2014, 2017). The petroarchaeological investigations exposed in the present study serve to reinforce both the seeming unity of the southern Aquitaine Basin and the northern Iberian Peninsula, as well as the clear division between the northern and southern Aquitaine Basin during MIS 3.

Future research should allow us to refine our perception of Neanderthal occupation in the Pyrenees, all the while promoting new lines of inquiry in regards to past mobility strategies in mountain environments. Indeed, the unequal geographical distribution of mineral resources, the intense seasonal climatic variations and the steep topography of the Pyrenean isthmus leads us to envisage a strong planning of group organization and management of their territory.

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Figure captions

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fig. 1: Location of sites mentioned in the text. Geological layer after Canérot, 2008 (CAD: T. Minet)

1555 fig. 2: 1 Noisetier Cave (a); 3D view of the sites topographic context within the Neste Valley, after Mourre et al., 2004 (b); lithic industry and different raw materials (c); central stratigraphic profile after Mourre et al., 2012, and view from the cave after Sacchi and Vaquer, 1996 (d); 2 Gatzarria Cave, revised stratigraphy from Deschamps, 2019 (a/b); flint tools from Layer Cjgr (c); retouch and rejuvenation flakes in various flint types from Layer Cjgr (d); 3 Stratigraphic profile of Abauntz cave, after Mazo et al., 2011-2012 (a); views from/of the site (b/c); handaxe and flake cleaver, after 1560 Mazo et al., 2011-2012 (d); flint flakes and tools, after Mazo et al., 2011-2012 (e). (CAD: M. Deschamps and T. Minet)

fig. 3: Overview of the technological characteristics of each layer studied (CAD: M. Deschamps)

1565 fig. 4: Schematic distribution of raw materials in the southern Aquitaine Basin, after Colonge and Mourre, 2009 (1); view of the Neste Valley from the Noisetier site (2); IGN map with location of the sample zones (*plage*) and example of cinerite in primary position (3). (CAD: T. Minet and M. Deschamps)

1570 table 1: Main characteristics of flints treated in the present study known according to published works and personal observations (T. Minet)

fig. 5: Pyrenean rocks exploited at Noisetier cave(1), quartzite (1.1); spotted schist (1.2); lydite (1.3); cinerite (1.4); cumulated histograms of the various rock types in the alluvial deposits and in the archaeological layers of Noisetier Cave (2a); cumulated histograms of the different types of quartzite found in the alluvial areas and in the archaeological levels of Noisetier Cave (2b). (CAD: M. Deschamps)

fig. 6: Proportions of the main technological categories in relation to the different varieties of flint identified in the Noisetier sequence, according to the selected stratigraphic assemblages (1, 3, 5) (M. Deschamps); illustration of the main flint supply routes according to the stratigraphic assemblages selected (2, 4, 6). (CAD: T. Minet and M. Deschamps)

fig. 7: Proportions of the main technological categories according to the different varieties of flint identified in the selected layers of Gatzarria and Abauntz caves (1, 2) (M. Deschamps); illustration of the main flint sources according to the stratigraphic assemblages selected for the Gatzarria, Abauntz and Noisetier caves (3). (CAD: T. Minet and M. Deschamps)

fig. 8: Microfacies of a Hibarette/Montgaillard flint with bioclasts, including spicules, (1); microfacies of a Hibarette/Montgaillard flint with siliceous veins (2); oxidized microfacies of a Hibarette/Montgaillard flint with dentitric forms (3); altered microfacies of a Hibarette/Montgaillard flint with bleaching of a Hibarette/Montgaillard flint (4); oxidized microfacies of a Hibarette-Montgaillard flint with peloids (5); altered microfacies of a bioclastic flint with bleaching from a generic Flysch flint assemblage (6); altered microfacies of a dark flint with bleaching from a generic Flysch flint assemblage (7). (CAD: T. Minet)

fig. 9: Geological map of the Olabe sector (1); flint fragment collected in superficial deposits (1a); *in situ* flint fragment from an old quarry (1b); microfacies of the Abauntz flints (2); *Echinoid* fragments and spicules including triaxone from Olabe flint (2a); foraminifera of the *Nummulitidae* group of Olabe flint (2b); oxidized microfacies of Perdón flint with peloids and spicules (2c); bioclastic microfacies of Urbasa flint with *Discocyclus* sp. (2d). (CAD: T. Minet)

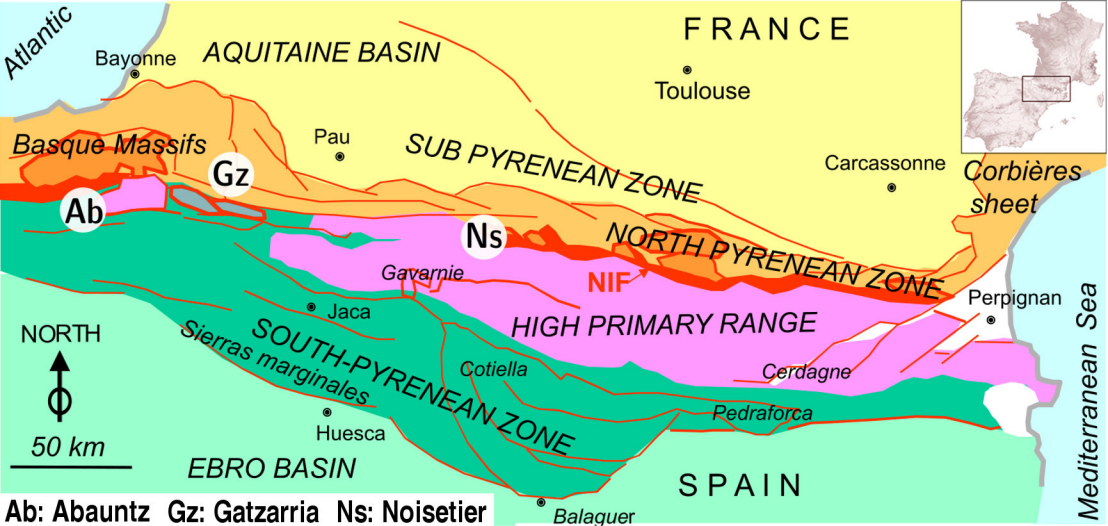
fig. 10: Microfacies of Salies-de-Béarn flint with bioclasts including microspheres (1); microfacies of Salies-de-Béarn flint with microspheres and impurities (2); bioclastic microfacies of Tercis flint with spicules including triaxone (3); translucent microfacies of Continental flint with manganese oxide concentration (4); translucent microfacies of Continental flint with manganese oxide

concentration (5); bioclastic microfacies of Treviño flint with gastropods and ostracods (6). (CAD: T. Minet)

1610 fig. 11: Microfacies of Platform flint with bioclasts including *Lepidorbitoides* sp. (1); microfacies of Platform flint with bioclasts including *Siderolites* sp. (2); microfacies of Montsaunès-Ausseing flint with numerous small bioclasts of the *Rotaliida* order (3); small foraminifera of Montsaunès-Ausseing flint of the *Rotaliida* order (4); bioclastic microfacies of Platform flint with *Lepidorbitoides* sp. (5); bioclastic microfacies of Urbasa flint with *Discocyclina* sp. (6, scale in
1615 millimetres). (CAD: T. Minet)

fig. 12: Possible routes from Gatzarria to Abauntz, and to the Urbasa and Treviño outcrops using QGIS software (CAD C. Mangier); the shore road circumventing the mountainous area (1) and the direct road crossing the Pyrenees via the Ispéguy pass (2). Tables showing distances in kms and the
1620 positive and negative elevation of the different routes (3-4). (CAD: C. Mangier and M. Deschamps)

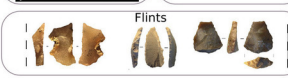
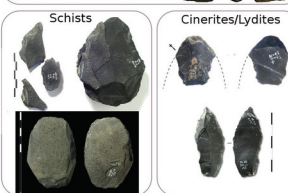
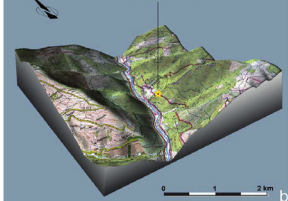
fig. 13: Map of southwestern France showing raw material circulation patterns and potential geomorphological barriers, from Bruxelles and Jarry, 2011 and Bertran et al., 2013. Raw material data in the northern Aquitaine after Turq et al., 2017. The raw material data in the southern
1625 Aquitaine is from this study, except for the Latrote site, which is cited from Fernandes, 2012. (CAD: M. Deschamps)



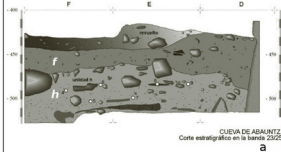
1 NOISETIER



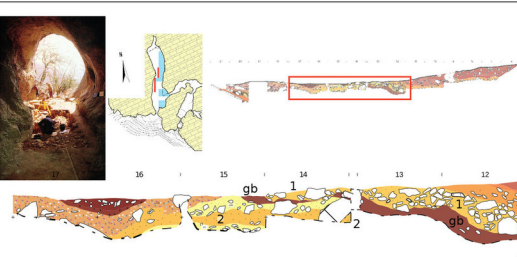
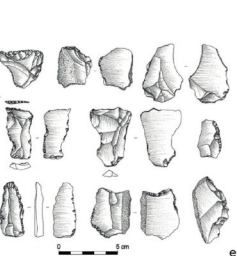
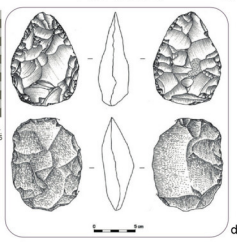
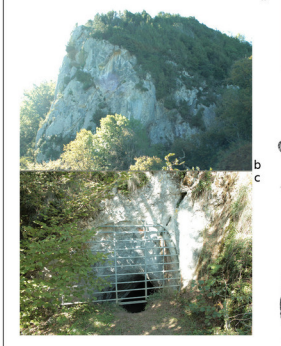
Noisetier cave



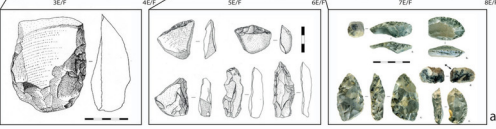
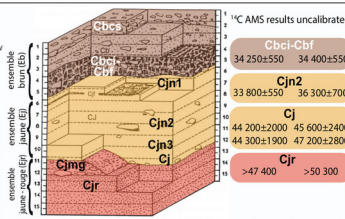
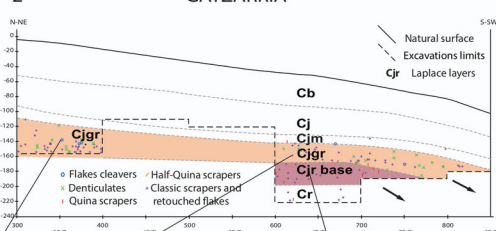
3 ABAUNTZ












CUEVA DE ABAUNTZ
Corte estratigráfico en la banda 2305



2 GATZARRIA



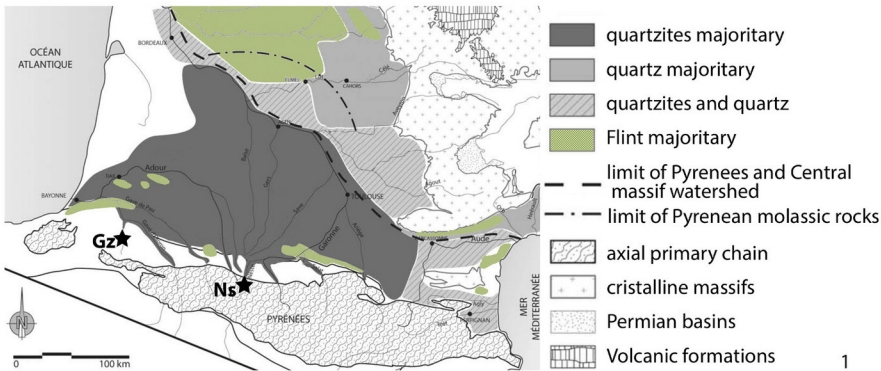
	Noisetier			Gatzarria	Abauntz
	c.1	c. gb	c. 2/33	Cjgr	h
Discoïde stricto sensu 			X		?
Discoïde lato sensu 	X				X
Levallois 					
Debitage on anvil 	X	X	X		X
Bifacial thinning flake 		X			
Biface 		X	X	X	
Fake cleaver 		X	X		
Tools on flake 	 	 	 		
Resharpener 					

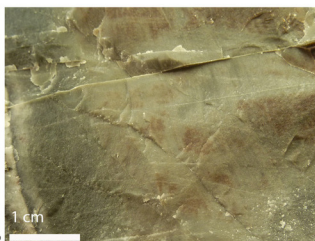
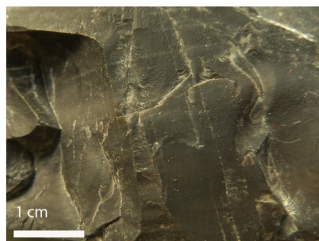
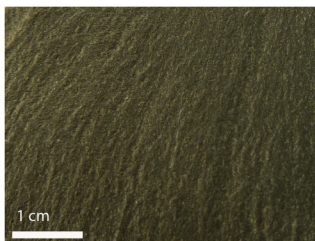
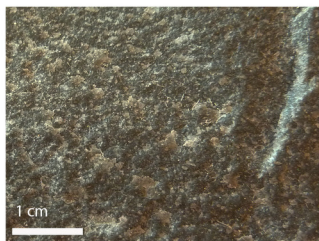


Dominant
Secondary



Allochthonous flint
Local pyrenean rocks





1

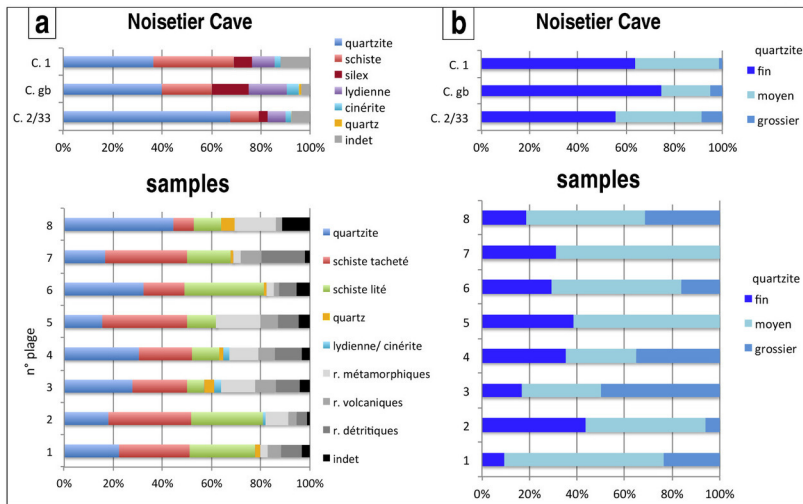
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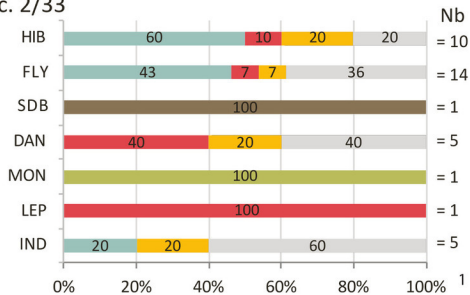
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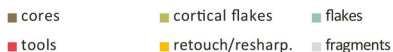
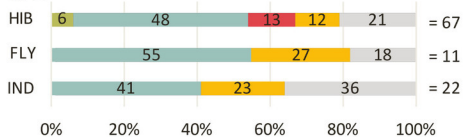
c. 2/33



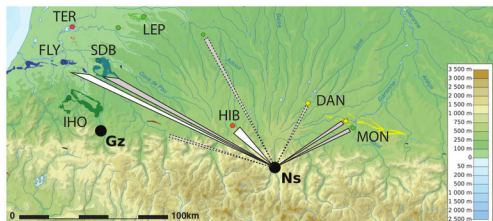
c. gb



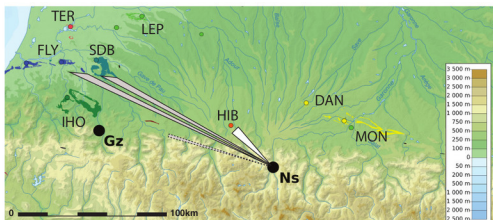
c. 1



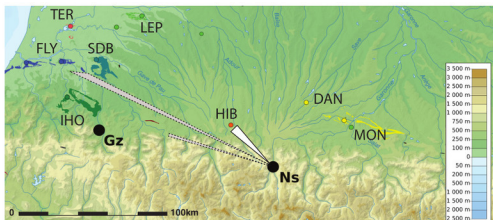
Main source Secondary sources Possible sources



2



4



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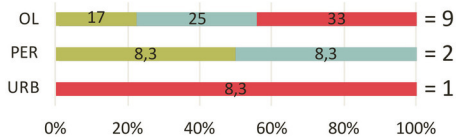
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Gatzarria - Cjgr

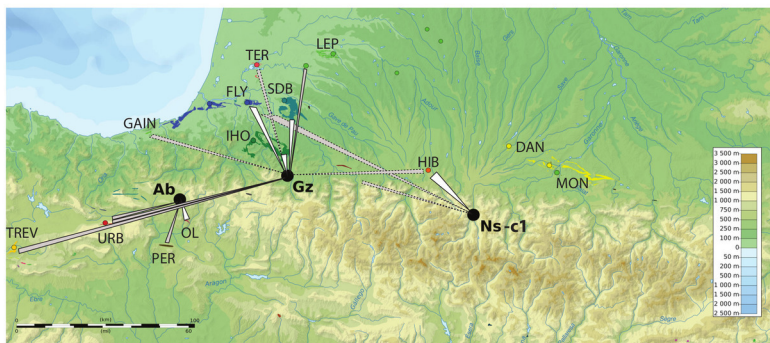


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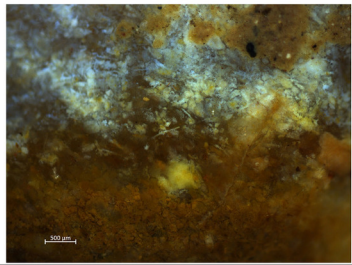
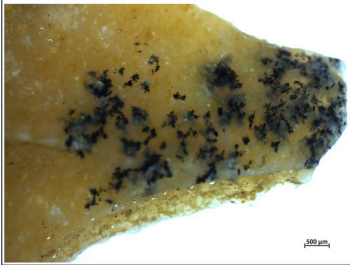
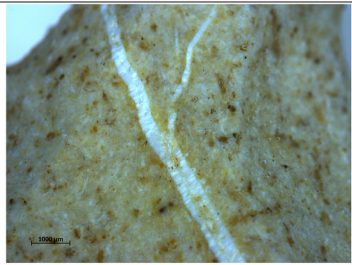
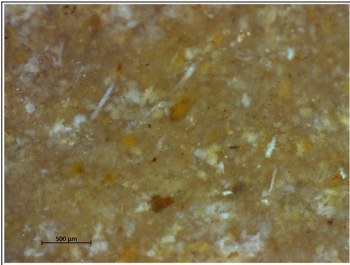
Abautz - H



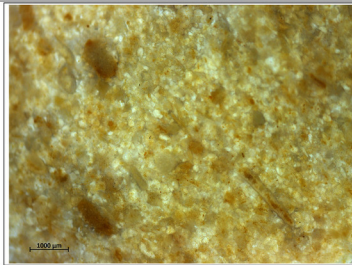
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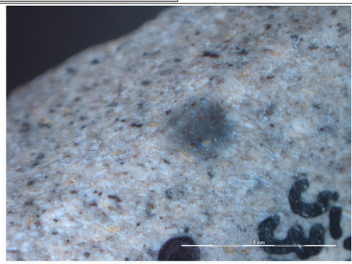
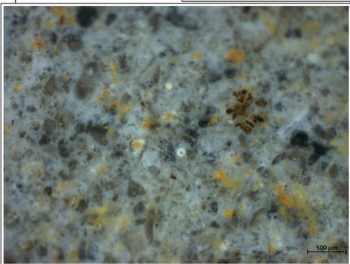
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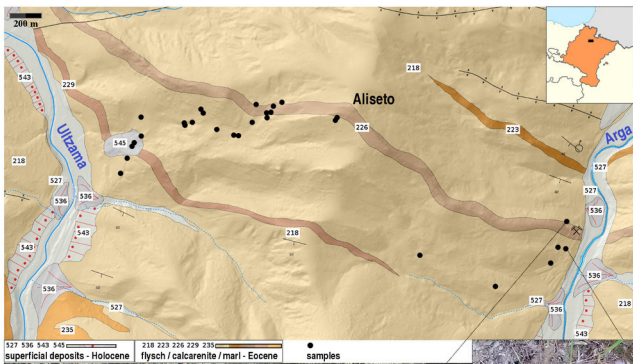


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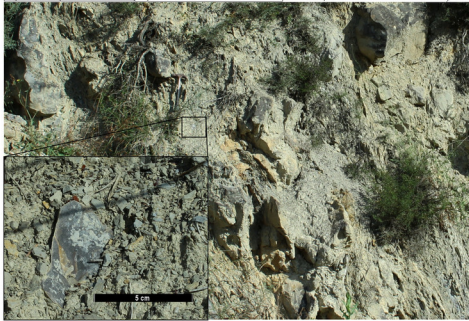


Gatzarria

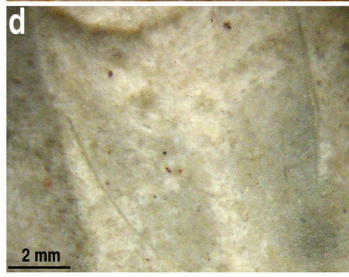
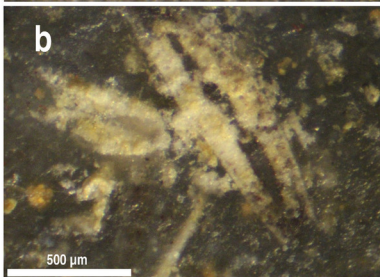
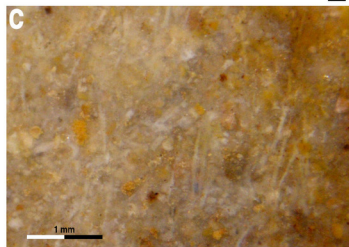
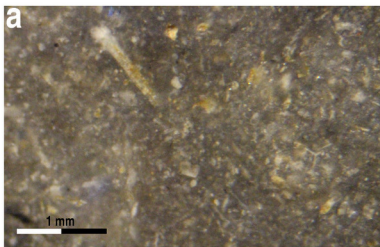


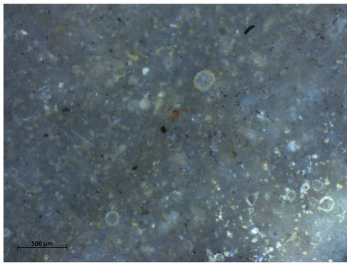


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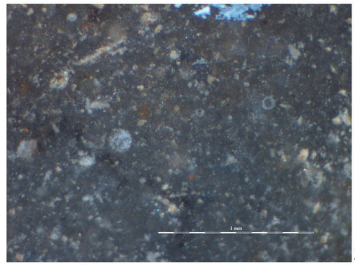


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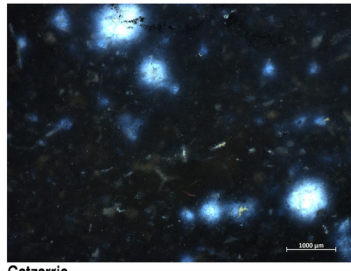


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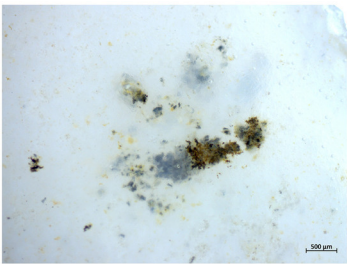
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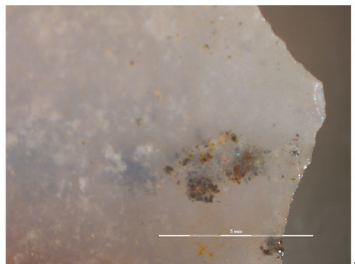


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Gatzarria

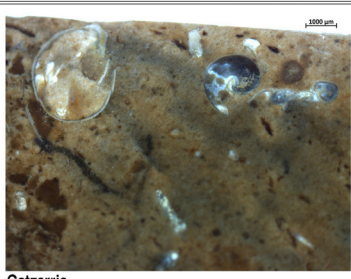


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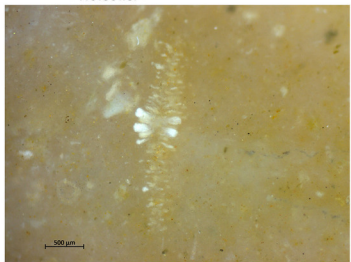
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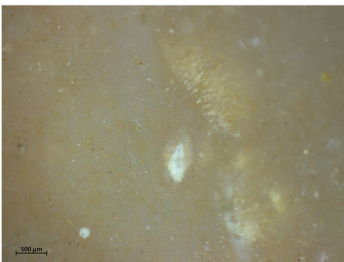
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Gatzarria

Noisetier



1



2

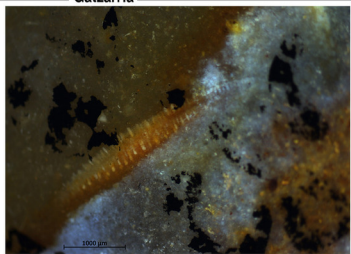


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Gatzarria

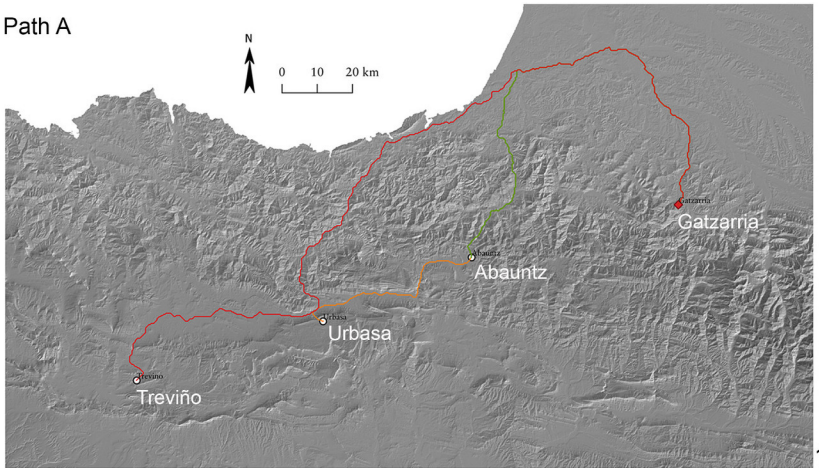


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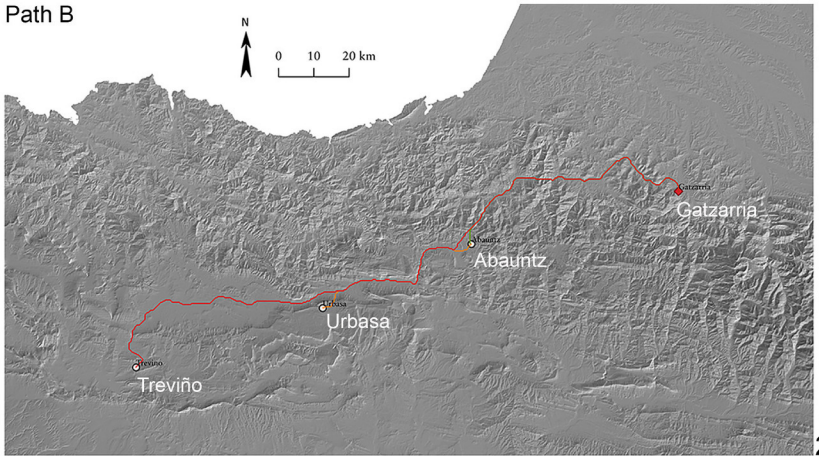
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Path A



1

Path B



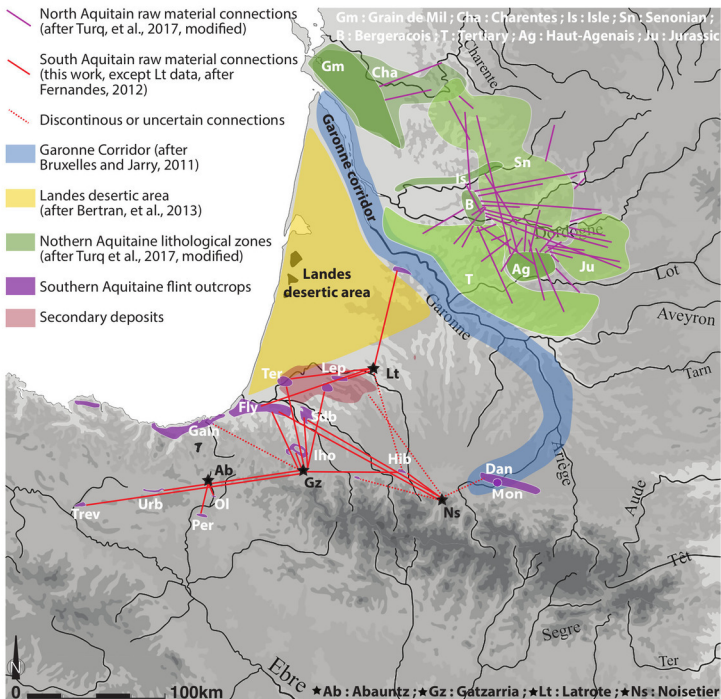
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Path A	Gatzarria	Abauntz	Urbasa	Treviño
Gatzarria	km	160,2	212,6	283,4
	↗	3382	3485	4136
	↘	-3692	-4071	-4319
Abauntz	km	160,2	62,4	141,2
	↗	3382	1293	2427
	↘	-3692	-1569	-2300
Urbasa	km	212,6	62,4	78,8
	↗	3485	1293	1134
	↘	-4071	-1569	-731
Treviño	km	283,4	141,2	78,8
	↗	4136	2427	1134
	↘	-4319	-2300	-731

3

Path B	Gatzarria	Abauntz	Urbasa	Treviño
Gatzarria	km	83,1	137,8	211,4
	↗	3445	4816	5396
	↘	-3755	-5402	-5579
Abauntz	km	83,1	57	133
	↗	3445	1349	2439
	↘	-3755	-1625	-2312
Urbasa	km	137,8	57	76
	↗	4816	1349	1090
	↘	-5402	-1625	-687
Treviño	km	211,4	133	76
	↗	5396	2439	1090
	↘	-5579	-2312	-687

4



Genetic group	Flysch Flint						Pelagic Flint		Marine Platform Flint			Continental Flint	
Code Flint type	FLY Bidache	HIB Hibarette/ Montgaillard	IHO Iholdy	GAIN Gaintzurizketa	OL Olabe	PER Perdón	SDB Salies-de-Béarn	TER Tercis	LEP Flint with <i>Lepidorbitoides</i>	MON Montsaunès/ Ausseing	URB Urbasa	DAN Danian varieties	TREV Treviño
Paleoenvironment (silicified deposits)	Deep basin (continental slope)	Deep basin (continental slope)	Deep basin (continental slope)	Deep basin (continental slope)	Deep basin (continental slope)	Deep basin (continental slope)	Deep basin (platform-slope transition)	Deep basin (platform-slope transition)	Marine carbonate platform	Marine carbonate platform	Marine carbonate platform	Marginal-marine to lacustrine- palustrine areas	Marginal-marine to lacustrine- palustrine areas
Chronostratigraphy (host rocks)	Upper Cretaceous	Turonian to Maastrichtian	Cenomanian	Campanian	Eocene	Eocene/ Miocene	Campanian	Campanian- Maastrichtian	Maastrichtian	Maastrichtian	Paleocene	Paleocene	Miocene
Sampled formation (stage/age)	Calcaires de Bidache (Cenomanian to Coniacian)	Poudingue de Palassou (Ypresian to Rupelian)	Formation du flysch à silex inférieur (Cenomanian)	Flysch gréseux du Culoir Deva- lirín (Campanian)	Hecho Group turbidites (Ypresian to Lutetian)	Conglomerados Superiores del Perdón (Aquitanian to Serravalian)	Formation du Flysch du Campanien (Campanian)	Série de faciès aérien (Campanian- Maastrichtian)	Calcaires de Dumes (Maastrichtian)	Calcaire nankin (Maastrichtian)	Calcarentas bioclásticas (Thanetian)	Calcaires sublithograhiques (Danian)	Margas blancas, calizas lacustres (Aquitanian to Tortonian)
Common habits	Slabs/nodules	Pebbles	Slabs/nodules	Blocks/ nodules	Nodules	Pebbles	Irregular nodules	Nodules	Nodules	Nodules	Nodules	Nodules	Nodules
Microfacies	Turbiditic deposits	Turbiditic deposits (oxidation)	Turbiditic deposits (dark)	Turbiditic deposits	Turbiditic deposits	Turbiditic deposits (oxidation)	Pelagic deposits	Pelagic deposits	Bioclastic	Bioclastic	Bioclastic	Azoic	Varied, Bioclastic/ more or less brecciated
Common bioclasts	Spicules	Spicules	Spicules	-	<i>Nummulitidae</i> , <i>Echinoids</i> , spicules	Spicules	Microspheres	Spicules (trioxones), <i>Echinoids</i>	<i>Lepidorbitoides</i> <i>Siderolites</i>	<i>Rotalia</i> (cf. <i>Nonionella</i>)	<i>Discocyclina</i> <i>Nummulitidae</i>	-	Gastropods, ostracodes
Main components	-	Peloids	-	-	-	Peloids Glaucony	-	-	-	-	-	-	-
Other components	Metal oxides Detrital quartz Euhedral rhombs	Metal oxides Detrital quartz Euhedral rhombs	Metal oxides Detrital quartz Euhedral rhombs	Numerous rhombs Detrital quartz Metal oxides	Metal oxides Detrital quartz Euhedral rhombs	Metal oxides Detrital quartz	Metal oxides	Metal oxides	Metal oxides	Metal oxides	Frequent metal oxides	Manganese oxide concentrations	Metal oxides
Structural features	Laminations Bioturbation/ Carbonate phases	Bioturbation/ Carbonate phases	Laminations Bioturbation/ Carbonate phases	Bioturbation/ Carbonate phases	Bioturbation/ Carbonate phases	-	Abundant bioturbations/ Carbonate phases	-	-	-	-	-	-
Other features	Veins	Veins Denticric zones	Coarse silicifications	Dark facies	Heterogeneous zones	-	Heterogeneous zones	Dark facies (translucent)	Translucent	Numerous grains	-	Translucent	Matte
Common alteration	Porosity Superficial whitening	Porosity Superficial whitening	Porosity	-	-	Porosity Superficial whitening	-	Superficial whitening	-	-	Superficial whitening	-	Superficial whitening
Main reference	Normand, 2002	Barragüé et <i>al.</i> , 2001	Normand, 2002	Tarriño, 2006	Beguirstain Gürpide, 2000	Beguirstain Gürpide, 2000	Normand, 2002	Normand, 2002	Bon <i>et al.</i> , 2002	Simonnet, 1999	Tarriño, 2006	Simonnet, 1999	Tarriño, 2006