Taphonomic methods and a database to establish the origin of sedimentary silicified rocks from the Middle-recent Gravettian open-air site of La Picardie (Indre-et-Loire, France)

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Abstract:

For several years, multidisciplinary archaeological operations organized by the Ministry of Culture and named 'Collective Research Projects' (PCR) have enabled the design and use of a descriptive database for a part of southern and central France. This data base describes and stores the main geological aspects of sedimentary silicified rocks of chemical, biochemical or diagenetic origin (abbreviated SSR in the rest of the text) and their primary and secondary outcrops. Data were collected through a survey form describing the flint formations and using different observation grids which make up complete identity cards for each type of flint. Using their spatial attributes, these different data are linked to a shape file for flint formations, themselves digitized with *ArcGIS* and *QGis* on the basis of harmonized protocols with several layers of the WebMapService (WMS) *Infoterre* of the *BRGM*. Today, data sharing is made possible through the use of the *ArcGisOnLine* platform (AGOL) meeting the needs of the various users.

Applied to an archaeological series, the database considers the concept of an *evolutionary chain of SSR* and extends an enquiry into the prehistoric relationship between SSR and their environments. According to the same criteria as those defined for the characterization of geological samples (petrology and alterology forms), it allows one to reconstruct the route traveled by any flint before its collection by prehistoric humans and then, by the use of a taphonomic form, decrypts the post-depositional SSR evolution in order to decipher the intensity and chronology of the mechanisms likely to have taken part in the sedimento-genesis of the archaeological site.

In terms of understanding paleogeography, the ultimate aim of this approach, the accuracy of petro-archaeological studies is firmly established rather than being anecdotal. By demonstrating that only quantity, genetic and gitological diversity and the way in which materials from coherent geological spaces (i.e. geotopes) are introduced into the archaeological sites, allows one to discuss the method of acquisition of the materials concerned and thus to approach an understanding of the organization of prehistoric societies through their management of landscape and their relationship to territoriality. After the application of this method using the database the results are presented for particular materials coming from the Middle Gravettian series of la Picardie (Preuilly-sur-Claise, Indre-et-Loire, France).

Keywords: Petroarchaeology, Methodology, Evolutionary chain, Middle Gravettian, France.

1. Introduction

Studies of the origin and characterization of raw materials used in prehistory, and more specifically on sedimentary silicified rocks of chemical, biochemical or diagenetic origin (abbreviated SSR in the rest of the text) of various types including flint, chert, silcrete and jasperoid (a precise definition of these terms is given in the supplementary information), became common in western Europe at the down 19th century following closely the advent of the discipline of prehistory (e.g. Meillet 1866; Boule 1887; Hue 1910; Hewitt 1915; Curwen 1940; Méroc 1943; Bordes et Sonneville-Bordes 1954; Valensi 1955; Hurst and Kelly 1961; Aspinall et al. 1975; Demars 198; Torti 1980; Masson 1981; Simonnet 1982; Morala 1984, 2018; Geneste 1985; Mauger 1985; Aubry 1991; Chalard 1992; Binder et Courtin 1994;

Grünwald and Affolter 1995; Séronie-Vivien 1995; Bon et al. 1996; Riche 1998; Feblot-Augustin 199;, Surmely et Pasty 2003; Floss 2000; Grégoire 2000; Turq 2000; Affolter 2002; Bazile 2002; Bressy 2002; Bordes 2002; Primault 2003; Néraudeau 2004; Allard et al. 2005; Djindjan 2005; Foucher et al. 2005; Fernandes 2006, 2012; Marchand 2010; Tomasso 2014; Bostyn et Geligny, 2014; Foucher 2015; Sanchez de la Torre 2015; Caux 2015; Delvigne 2016; Vaissié et al. 2017). While this research has long been carried out by isolated individuals, for about fifty years geologists, crystallographers, mineralogists, micro-paleontologists, geo-archaeologists, use wear analyst, archaeometrists, geochemists and physicists have tried to collaborate. Their attempts are exemplified by the several "flint symposiums", which in various forms, have taken place since 1969 (e.g. Kraayenhagen et al. 1975; Clark and Voigt 1979; Sieveking and Hart, 1986; Lenoir et Séronie-Vivien 1990; Yamada and Ono 2014). Note, that it was during this same period, that Stecl and Malina (1970) laid the foundations of the discipline now called petroarchaeology.

Various authors trace the history of "flint" petroarchaeology and some talk about its renewal (Masson 1981; Fernandes 2012; Delvigne 2016; Delvigne et al. 2019a), but the classical method, founded on the techniques of sedimentary geology, was well exposed by Marie-Roger and Micheline Séronie-Vivien (1987). The method requires the determination of the paleoenvironment and age of the sedimentary formations which are silicified, by analyzing the allochems whose bioclasts are contained in the SSR. In this paper we use 'SSR' to refer to all silicified rocks whose chemical, biochemical or diagenetic origin, with the exception of sandstones and particularly quarzitic sandstone, are siliceous. This allows us to avoid the term "flint" which has multiple meanings in varied contexts and is anyway somewhat controversial. We use the term "flint" only for rocks with a siliceous epigenesis and that carry a cortex. The classical petroarchaeological method allows one to define the genetic type of SSR. However, the petroarchaeological approach is not confined to discovering the stratigraphic origin of a SSR, but rather aims to characterize the formations from which it was collected by prehistoric humans, noting that these formations are sometimes located far from the primary SSR-bearing deposit. Furthermore, we note that classical diagnoses do not allow precise description of all lithic objects because of confusion at different scales of observation and that the vocabulary developed in archaeology is not always the same as that in geology, leading to misunderstandings. Moreover, the analytical tools - especially regarding geochemistry - are not always applicable to SSR (Fernandes 2012; Delvigne et al. 2017; Fernandes et al. 2020). Finally and most importantly, SSR evolution characteristics are insufficiently recorded.

However, analysis of the data 'memorized' in a SSR is not new, having been exploited by many researchers, especially regarding patina and gloss, (Hewit 1915; Hue 1929; Curwen 1940; Hurst and Kelly 1961; Rottländer 1975; Stapert 1976; Masson 1981 ; Levi-Sala 1986; Howard 2002; Glauberman et Thorson 2012; Thiry et al. 2014) but also regarding changes related to displacement, and exposure to temperature variation (Journaux et Coutard 1974; Donahue 1994; Burroni et al. 2002; Caspar et al. 2003; Fernandes et al. 2007; Coutard et Ouzouf 2008; Hardaker 2012) and mineralogical transformation (Cayeux 1930; Besançon 1982; Vilas Boas 1975; Aubry 1975; Thiry 1981; Fernandes 2012; Glauberman et Thorson 2012; Graetsch et Grünberg 2012). Research into these characteristics was the foundation on which the concept of an evolutionary chain for SSR was developed (Fernandes and Raynal 2006). This concept describes and records the various alteration processes undergone by the rocks before and after their collection by prehistoric humans. Our goal is to identify accurately the origin of the raw materials represented by lithic artefacts found in archaeological units and to establish which transformative mechanisms contributed to the sedimentary-genesis of the particular archaeological units.

Beside questions of methodology and protocol, our practical aim in this paper is to use this method to discuss the case of the purported allochthonous SSR of the Middle Gravettian site of La Picardie.

2. Method and theoretical background

2.1. Theoretical background

The evolutionary chain concept is based on an assertion that the mineral structure of SSR undergoes changes during each physico-chemical modification of the environment in which they are metastable. This evolution, dependent upon mineralogical changes induced by a search for a state of equilibrium represented by quartz (Fernandes et al. 2007, 2020; Fernandes 2012; Thiry et al, 2014), not only affects the envelope of the rock, but its whole volume and can be expressed at different scales:

macroscopic, mesoscopic, microscopic and ultramicroscopic. These mineralogical changes induce a secondary epigenesis within the siliceous matrix that transforms the microfacies in certain ways: diminution of the amount of figurative elements because of their recrystallization, color changes due to the incorporation of new chemical elements (especially iron), variation of the mineralogical composition etc. During petrographic analysis, it is necessary to quantify the degree of evolution of the figurative elements (allochems) and the inside components, the microcrystalline binding materials of matrix or cement (orthochems) (Folk and Weaver 1952 ; Folk 1959) in every zone in order to place the archaeological objects within their respective evolutionary chains. Clearly, the various evolutionary chains of different geological SSR must be deciphered previous to petrographic analysis because each SSR type has its own evolutionary path.

SSR sources can be divided into several categories (Fernandes and Raynal 2006; Fernandes 2012; Delvigne et al. 2019b):
1) primary sources in which the whole volume of the SSR is still present in its host rock;
2) residual formations with flints (or "alterites") resulting from the *in situ* dissolution of the protolith, the SSR being trapped in the residual sediments (e.g. clay containing flint);
3) colluvial secondary deposits (e.g. screes, solifluction flows, etc.) which are slope deposits close to the formations from which they derive. They are formed gravitationally following freeze/thaw cycles, runoff etc. and define the various types of colluvial deposits;
4) alluvial secondary deposits integrating all the SSR located in the bed of active watercourses;
5) secondary deposits of ancient alluviums (or terraces) corresponding to the geological formations found in fossil riverbeds; they are subdivided into "low terraces", "medium terraces" and "high terraces";
6) secondary deposits on beaches; coastal formations subject to wave action and located in the intertidal zone (between the high and low tide limits);
7) secondary deposits on fossil shorelines which correspond to fossilized beach formations;
8) moraine secondary deposits, in which the stones occur within disorganized deposits (diamicton) on the flanks and in the heart of glacial valleys.
These eight basic categories can be modulated and combined into as many categories as necessary (e.g. colluviums from clay with flint).

When reading the chronology of the stigmata carried by the natural surface - (neo)cortex and lithoclase - of the SSR and deciphering the degree of evolution of the orthochem and allochems, it becomes possible to allocate with precision the SSR to specific collection places and to define its gitological type. Among the characteristics noted are the presence of (neo)cortex and its defining criteria (thickness, wear, cementing and roughness gradient, intensity and type of shock, as well as intensity and type of dissolution) and these provide powerful tools to retrieve the gitological origin of archaeological pieces (Fernandes et al. 2007). For example, figure 1 presents the different degrees of alteration of the (neo)cortex for the *Yonne* Valley Upper Turonian flint. We have observed that on the most recent terraces the shocks carried by the (neo)cortex are few or not altered; the evidence for the shocks begins to disappear and corrosion gulfs develop on the surface of the siliceous matrix in the middle terraces, while in the upper terraces cementation is total. The anterior shocks are almost invisible and following pedogenesis, a true neocortex develops in the hollows (Figure 1). Such elements identify several gitological types derived from one genetic type (Fernandes and Raynal 2006). For example, Upper Turonian from the Yonne Valley (genetic type D0066.1)

- in primary position (gitological type D0066.1g1),
- in the slope deposits close to the primary position (gitological type D0066.1g2),
- in the clay with flint (gitological type D0066.1g3),
- in the bed of the Yonne River (gitological type D0066.1g4),
- in the low terraces (gitologic type D0066.1g5),
- in the middle terraces (gitologic type D0066.1g6),
- in the high terraces (gitologic type D0066.1g7) and so on.

This approach is obviously crucial to the reconstruction of prehistoric economies as usually, humans used secondary sources as their main resources (Turq 2005; Fernandes and Raynal 2007; Delvigne et al. 2014).

2.2. Analytical tables

Our observations are recorded on an analytical form contained in a database developed under Microsoft Access©, Filemaker© and adapted for Microsoft Excel©. Each item is described in three stages that document a particular aspect of the SSR's life:

- Grid 1 "Petrography" contains information on its genesis;
- Grid 2 "Gitology" describes the processes related to the pre-depositional phase; the observed surfaces corresponding to the cortical zones associated with the pre-depositional lithoclase;
- Grid 3 "Taphonomy" recording the processes linked to post-depositional phases; the observed elements related exclusively to the surface transformation by knapping processes.

The three tables are not always used together, depending on whether the sample is archaeological or geological. In the case of a geological sample, grid n° 3 is useless since it corresponds to the anthropic and post-anthropic life of the sample which does not exist for a geological SSR. The different fields of the database are not enumerated in this paper, whose purpose is simply to illustrate one example of archaeological results using this method.

Grid 1 contains 82 fields that describe the microfacies in order to determine the main definition criteria, the formation environment, the age of the SSR and thus the genetic type. Its principal focus is the allochems in terms of repartition, abundance, sorting, smoothing, sphericity, size and nature for every allochem type. We use the abacuses and grids utilized by sedimentologists (e.g. Krumbein and Sloss 1963; Bullock et al. 1985). Moreover, if we consider the biogenic fraction of the allochems as important, we should not forget that the detrital fraction may prove invaluable in distinguishing variations in genetic types (e.g. Fernandes 2012; Delvigne 2016; Tomasso et al. 2019). The latter is defined through binocular analysis, Raman spectroscopy and, when thin sections are available, optical microscopy.

Grid 2 aims to identify the gitological facies of the genetic type defined in grid 1. In it, 44 descriptive fields are synthesized into seven points of paramount importance:

- inherited color / acquired color ratio of the matrix;
- inherited color / acquired color ratio of the allochems;
- type of neocortex and / or natural surface;
- type of porosity and poro-necrosis;
- mineralogic composition of the orthochem;
- description of the sub-cortical zone;
- color and the intensity of the pre-depositional patina and gloss.

At this stage of the analysis and for every surface type, we decipher the types of physical actions (such as cracking or fragmentation), as well as chemical processes whose kinetics are slower (such as alterations or diffusion of oxides in the matrix). These phenomena, controlled among other factors by the positioning of the surfaces, i.e. the gitological polarity, overlap each other forming a sequence that provides the key to understanding the succession of prepositional transformations. Thus, in the same way as for the *chaîne opératoire* in lithic technology, it is a matter of deciphering the order of the natural processes affecting the SSR; the stigmata associations being characteristic of residential formation types.

Finally, Grid 3 - the taphonomy grid - is composed of 38 fields that describe the type and intensity of post-depositional patina, the intensity of shocks and alterations borne by the edges, ridges and surfaces discerned from the microtopography; the type and intensity of surface gloss and the intensity of thermal shocks. Whereas for grids 1 and 2 we examine the natural surfaces which give information about the collection place, for grid 3 only the knapped surfaces are studied. They indicate the edaphic processes that followed the abandonment of the object. Consequently, the third grid gives an indication of the integrity of archaeological levels and guides further discussion on site taphonomy.

The final goal of this approach is to gather and collate data imported from different disciplines involved in the study of SSR into a unique dynamic tool in order to identify the most discriminating indicators, type of material by type of material, evolutionary stage by evolutionary stage.

2.3. Digital tools for an inventory and spatial analysis of flints

This integrated approach, from collection to the final analysis, is backed by the formation's GIS for flint that we are developing online in the ArcGis server (Tuffery et al. 2018, 2019; Delvigne et al. 2019b) and is the result of collaboratively developed methods, tools and vocabulary for western Europe. As shown by comparative analyses performed by different users, the database for the french collective research project *PCR Réseau de lithothèques* and research group *GDR Silex* is a tool well suited to examine SSR origins and gives meaningful answers for archaeological problems.

In practice, the data produced and/or analyzed for these studies are linked by their spatial distribution (geometry, georeference coordinates) and their physical attributes. A new integrated protocol, using the WebMapService (WMS) Infoterre, with scanned geological maps at 1/50 000 of the French National Geological Survey *(BRGM)* in the background, was designed for digitizing flint formations as shape files, so that it could be used with a variety of GIS tools (QGis, ArcGIS, etc.) (Figure 2).

Fieldwork data were produced using different analog and digital forms. These data were put into a common geospatial database on the ArcGisOnLine cartographic platform which allowed the development of a web mapping application using ArcGisOnLine WebApp Builder (Figure 3).

This platform uses various standards such as WMS, WFS as well as ISO 19115 geographic information metadata, which allows access to data and metadata that can be downloaded by researchers, according to FAIR principles (Figure 4)

2.4. Implications for geochemical analysis

To source the SSR precisely, the results must be subjected to statistical analysis during geochemical analyses. As the results of such analyses may vary widely, the analytical model must be chosen accurately (Ferguson 1975; Luedtke 1979; Shackley 1998; Andrefsky 2009). Moreover, the extent and diversity of the geological data used in the model is key to securing the determination: “There are millions of chert sources on earth, and unless you control every one of them there is always the possibility that the artifact in question is actually made from a material outside your sampling universe.” (Luedtke 1992: 117). Three main errors are inherent in such an approach (Luetdke 1979):
1) an SSR of type “A” is placed in group type “B”; this could be the case for SSRs close to one another in space and time (Sieveking et al. 1970; Ferguson 1975; Luedtke 1978, 1979, 1992; Bressy et al. 2002; Bressy 2002; Evans et al. 2007);
2) an SSR remains an “unknown source” even if it derives from a well-known source; generally this is the case when the source characterization is incomplete, when the variability of the source is not covered totally by sampling or when post-depositional processes have affected the composition of the SSR;
3) an SSR is related to a known source but does not belong to any recognized type. This is a typical error induced by uniquities in the geochemical facies (Blet et al. 2000).

Preliminary steps leading to accurate sourcing are:
1) well-considered geological sampling and
2) incorporation of the largest amount of data possible in models.
For Luedtke (1978, 1992), as well as Bressy et al. (2002), a minimum of 10 measurements is necessary on a single sample to access the geochemical variability of an artefact or a source, but 30 would be more significant. It should be the same for secondary sources, namely active and fossil alluviums, which have been often ignored in previous geochemical studies (Bressy et al. 2005) but which formed a significant source of raw materials for prehistoric peoples (Turq et al. 1999; Turq 2005; Shackley 1998).

Basically, the identification of an SSR relies on the amount and the quality of its geological data. Consideration of samples out of their geological contexts leads to inconclusive results (Stockmans et al. 1981). For example, Speer (2014) who studied raw materials from the Edwards Plateau (Texas, USA) using LA-ICPMS, concluded a macro-regional identification at 100% but could not be more than 70% certain about a precise source. This is close to an observation result made by the naked eye. In our opinion, the characterization of SSR types of raw materials is an interdisciplinary process in which the geochemical analyses play only a complementary role to the investigation of very peculiar elements (e.g. Masson 1981; Kinnunen et al. 1985; Bush et Sieveking 1986 ; Turq et al. 1999 ; Blet et al. 2000 ; Gregoire 2001 ; Bazile 2002 ; Bressy 2002, 2007 ; Bressy et al. 2002 ; Delage 2003 ; Fernandes 2006, 2012 ; Fernandes et Raynal 2006 ; Fernandes et al. 2007, sous presse ; Tarrino et al. 2014 ; Delvigne 2016 ; Sanchez de la Torre et al. 2017; Brandl et al. 2018 ; Collin 2019).

For a better understanding of the element transfers during the 'life' of an SSR, it is necessary to study in detail its evolutive chain (which includes all the materials from its various secondary sources) through a strict non-destructive and statistically controlled protocol using an MEB coupled with a EDS microprobe and by LA-ICPMS. Some sources remain difficult to identify under binocular magnification only; in these cases, it can be useful to undertake limited geochemical 'mapping' based on decrypting the elementary transformations and an in-depth naturalistic observation. In order to better address "the SSR question" we currently test the validity of different analytical tools (DRX, LA-ICP-MS, MEB-EDS, RMN, RPE, Raman spectrometry, XRF) and try to determine the geochemical profiles of a single SSR type e.g. the Upper Turonian flint from "Grand-Pressigny" Type D0018.1 (Delvigne et al. 2017) in its different primary, sub-primary (alteritic) and secondary sources (recent alluviums of the Claise River and ancient terraces of the Creuse River).

3. Results: case study of the Middle Gravettian lithic assemblage from La Picardie

3.1. Archaeological context

Located in *Preuilly-sur-Claise (Indre-et-Loire*, France), about ten kilometers south of *Le Grand-Pressigny*, the site of *La Picardie* is situated on the edge of an Oligocene clayey plateau (Rasplus et al. 1978) framed by two left-bank tributaries of river *Claise*. The site, interpreted as a base camp (Klaric et al. 2011, 2018), rises to almost 135 meters ASL and dominates the valley. Discovered during the 80's by B. Walter, and surveyed with T. Aubry in 1999 and 2001, over 84 m^2 of it was excavated between 1998 and 2008 by one us (LK). The site provided a rich lithic industry attributed to the Rayssian phase belonging to the second half of the Middle Gravettian (Klaric 2003, 2007; Klaric et al. 2011, 2018). The technological study of the lithic industry permitted to identify a new type of projectile - the *lamelle de La Picardie* – considered along with the *Burin du Raysse* as a *fossile directeur* or marker of this period (Klaric et al. 2002; Klaric 2017). The excavation of the western sector alone, covering 40 m^2 provided 13,126 artifacts as well as several thousand chips less than 2 cm in maximum dimension, collected in each quarter m^2 but not recorded individually. The collection includes a total of 405 blade, flake and bladelet cores, 738 domestic tools and at least 218 retouched bladelets. Level 2b, approximatively 20 cm thick which contains the majority of the lithic industry, suffered deformations related to freezing and thawing, but resisted displacement or truncation by solifluction flows (Bertran et al. 2010; Klaric et al. 2011, 2018).

Most of the SSR supply resulted from the exploitation of adjacent Upper Turonian flint deposits of the *Claise* valley (Masson 1986; Giot et al. 1986; Aubry 1991; Primault 2003 Delvigne et al. 2017), with these flints making up nearly 99% of the total. However, some lithic objects had other origins. Preliminary sorting and examination by the naked eye and low magnification observations by J. Féblot-Augustin and T. Aubry (in Klaric et al. 2011) led to the recognition of 19 genetic types whose origins evoked relationships with the northeast towards *Cher* and *Loir-et-Cher*, and also southwards with the *Charente*. The aim of this review is to not only test the validity of these previously defined groups, but also to determine and describe the genetic, gitological and taphonomic variability of this supposedly exogenous lithic sample.

On a larger scale, documenting the origin of objects found on archaeological sites elucidates the structure and extent of networks that circulate materials – and thus ideas – which are themselves foundations of Palaeolithic cultures and may suggest their likely dissemination. As such, the Rayssian is an ideal case study having less than thirty identified sites (n = 28) in a large portion of southwest France (Klaric 2003, 2007, 2008, 2017); sites which are themselves grouped into three large regions: The *Périgord* - *Bassin de Brive* – *Quercy* complex; The *Touraine* – *Poitou* complex and the *Yonne* Valley. Other sites indicate the use of areas outside these regions: *Plasenn'al Lo*mm in Brittany; *La Martinière* in *Anjou*; *Les Battuts* rockshelter in *Tarn* (Figure 5). It is therefore necessary to question the relationships between all these sites to understand the hierarchy of exploited spaces and therefore the paleogeography at the end of the Middle Gravettian. For example, some observations at la *Grotte du Renne* in Burgundy also point to *Le Grand-Pressigny* area as a central location, as some of the flint originating from Upper Turonian sources has been identified in this Rayssian site (Primault, 2003). We have also identified many *Raysse* burins knapped in flint originating from the south of the Paris Basin (Upper Turonian of the *Bossay-sur-Claise* region and Lower Turonian of the *Cher* Valley, respectively D0018.4 and F0038.1 in Delvigne et al. 2018) in the Rayssian industries of the *Bassin de Brive*: *Bouyssonie* cave and *Les Morts* rockshelter (Delvigne and de Parthenay, unpublished). This last observation illustrates the importance of relationships between *Aquitaine*, which contains most of the

Rayssian sites, and the south of the *Paris* Basin. Similarly, there are questions to ask about the status of the apparently empty spaces: the *Charente*, middle *Loire* valley and central *Paris* Basin. As presented here, the precise petrographic description of the different types of SSR is therefore intended to document the diversity of materials present in the site and thus to make a first step in the study of "networks of places" (Debarbieux 2009; Delvigne, 2016) used in the Middle-recent Gravettian.

3.2 Petrological diagnosis

The series considered in this analysis concerns only the SSR deemed to be exogeneous (n = 148, 36 of which produced 15 refitted objects). They come from excavations that took place between 1999 and 2008 (1999, n = 1 ; 2001, n = 12 ; 2003 n = 19 ; 2004 n = 18 ; 2005 n = 51 ; 2006 n = 19 ; 2007 n = 6 ; 2008 n= 22) and came from 28 different squares (E1, F1, D98, D99, D100, E100, E96, E97, E98, E99, F96, F97, F98, F99, F100, G96, G97, G98, G99, G100, H98, H99, I96, I97, I98, I99, J98, K98). Each piece has been described using the 164 fields of the three database forms described above and which define the genetic, the gitological and taphonomic variability of this part of the total lithic assemblage.

Eighty-three of the total of 148 pieces have no patina. For the remainder, the main post-depositional alteration is the formation of a white patina. Thus, besides one piece with a strong red patina, 69 pieces have developed a white patina, 34 of which are of low intensity, 23 of medium intensity and 12 of strong intensity. Of the 69 pieces, 21 show a patination polarity (that is to say that the patina affects only a part of the piece), while 48 are completely patinated. Three pieces show a double patina attesting to (re)knapping following an initial period of alteration, either for *débitage* operations (n = 2) or for a retouching operation. Regarding the attrition of the pieces, 76 have slight shocks on their edges and 20 of these also have shocks on the ridges and three on other surfaces (streaks and shocks). No evidence of any thermal alteration was observed (mostly freezing or rarely heating), although in the rest of the series many pieces were broken by freezing (Klaric et al. 2011). Most post-depositional gloss is of medium intensity (n = 133) and only three pieces have a high luster.

This analysis shows that the degree of integrity of the levels, particularly level 2, is reasonable despite the geoarchaeological studies and field observations that revealed the remobilizing processes, particularly cryoturbation that affected the deposit (Bertran et al. 2010; Klaric et al. 2011). Disparity between our conclusion of rather weak remobilization and the geoarchaeological evidence probably results from sampling, remembering that the vast majority of the 13,126 pieces were not studied, because our analysis was focused on the presumed allochthonous material and not on the Upper Turonian flint that outcropping near the site.

On this site, the patina formation process related to very local specific taphonomic conditions seems very complex (Caux, pers. com.). As was noticed, artefacts recovered from under large limestone blocks were fresh looking and unpatinated while those coming from exposed locations were considerably patinated. Some refitted objects illustrate this phenomenon well as some unpatinated blades fit on patinated cores excavated from different excavation squares (Klaric et al. 2018). However, the existence of a few double-patinated artefacts (n = 3) in allochthonous SSR (group 01, 04 and 07), cannot be explained satisfactorily at present:

- 1) the objects were knapped and abandoned prior to their introduction into the site, then knapped a second time (or retouched) before or upon their arrival at *La Picardie*. This hypothesis suggests a spatial separation between the several steps of the *chaîne opératoire*;
- 2) the objects were knapped and abandoned in the site. After a time, humans returning to the site have recovered the previously knapped elements in order to re-use them. This hypothesis suggests a diachronous occupation of the site.

In order to better understand this patination phenomenon, a first step would consist of identifying double patination in the non-examined part of the lithic assemblage, if any.

We identified 12 different genetic types of SSR (as opposed to the 19 identified in the previous studies based on 140 objects, see Table 1), divided into different source types (Table 2). Six pieces remain indeterminable because of excessive degrees of post-depositional alteration. The recognition criteria for each group are summarized in Table 3. Details of the different genetic groups identified by indicating as far as possible their gitological diversity, the previous group in which they were placed and our hypotheses in terms of origin is described in the supplementary information provided and each is illustrated in plates SI-1 and SI-2.

3.3 Example of the gitological approach

As we have seen above (section 2.1), evolutionary processes not only affect the outer envelope of a rock but its whole volume and their intensity depends largely on the rock's degree of porosity (Thiry et al. 2014). In this respect, it is possible to recognize the gitological origin of a sample, even one lacking a cortical zone, but only if the geological references (rock libraries) are complete, well described and integrated with the concept of an evolutionary chain. Taking as an example the Upper Turonian from the *Claise* Valley, whose different sources are now well identified thanks to the work of the *PCR Réseau de lithothèques en Centre-Val-de-Loire* we begin to see the usefulness of our methodology.
We illustrate this assertion in Figure 6. We observe at top left a geological sample from the middle terrace of the *Creuse* Valley collected in the vicinity of *Yzeure-sur-Creuse*. All the micro-faciological criteria indicate that this flint comes from the Upper Turonian formation like those outcropping nowadays eastward in the *Claise* Valley, between *Preuilly-sur-Claise* and *Le Grand-Pressigny* (type D0018.1 see Delvigne et al. 2017, 2018). It bears a neocortex typical of an ancient alluvium exposed to wind activity (Figure 6a) marked by smoothed shock marks (of crescent and V forms), a black patina, an intense recrystallisation process that formed a true neocortex and a shiny polish. Its endocortical zone is marked by depigmentation due to an increase of neo-porosity induced by the dissolution of the siliceous matrix and the over-oxidation of the allochems (Figure 6b). This is a classical phenomenon for this flint zone, which is the most porous and therefore most hydraulically active (Fernandes et al. under press). In the inner body (Figure 6c), matrix evolution is less pronounced and comparable to that observed in samples coming from "clay with flints" (Figure 6e) but because of secondary siliceous epigenesis, the allochems have begun to disappear.
Such microfacies, with a highly evolved endocortical zone and a less evolved inner zone but marked by a disappearance of allochems is observed on archaeological pieces (respectively Figures 6d and 6e). Despite their distinct macroscopic appearance, these two objects are made of *Claise* Valley Upper Turonian flint as proven by their microfacies and particularly their micropaleontological contents: same size, type and abundance of detrital quartz grains and pelloïdes, same family and size of benthic foraminifera (miliolids; cf. *Quinqueloculina*), scarcity of monaxone spicules of Demosponges, absence of cheilostome bryozoans and glauconite and so on. The macroscopic variability of these two objects is a direct consequence of 1) the journey taken by the rocks between the primary deposit and the old alluviums of the *Claise* River formations and 2) the zone of the block from which they were knapped (inner zone vs. endocortical zone).

This example illustrates the necessity for creating rock reference libraries that take into account the different types of deposits (alterites, colluviums, alluviums of different ages...), but also that archaeological objects need studying with a perspective that incorporates the concept of an evolutionary chain. Such allows not only better categorization of the types of raw materials by grouping objects that with the naked eye have different characteristics, but places them in their geographical context, and documenting complex human behaviors in respect to the mineral environment.

4. Discussion

In addition to the critical review of the groups and origins of lithics previously identified at *La Picardie*, the aim of this work was to establish the petrographic profile of each object in order to enrich the knowledge about the petrographic variability of the rocks exploited by prehistoric humans (see supplementary information). Indeed, if it is necessary to establish rock libraries with data as precise as possible (see the *GDR Silex* project that started in 2019 in France), it is also essential to properly document and illustrate the SSR types present in the archaeological sites. This work is all the more important now that we are increasingly recognizing the circulation of lithic raw materials that took place over long distances in western Europe, and this not only for different periods of the Upper Palaeolithic (e.g. Masson, 1981; Bordes et al. 2005; Primault 2003; Foucher 2015; Delvigne et al. 2017, 2019a; Sécher et Caux 2017; Tomasso 2018), but also for the late Middle Paleolithic (Raynal et al. 2007; Fernandes 2012; Vaissié et al. 2017; Vaissié PhD in progress). The results presented are based on the approach we develop since several years in the *Centre-Val de Loire* region of France. In this respect, the description in several papers of the autochthonous types - notably of the Lower Turonian and Upper South of the *Paris* Basin (Delvigne 2016 ; Delvigne et al. 2017, 2018) makes it possible to establish with precision the origin of these materials and to identify their variability (see chapter 3); but the study we undertook at *La Picardie* goes far beyond since we identified extra-regional materials or rarely exploited regional materials (Middle Turonian flints, Eo-Oligocene silcretes) which nevertheless circulated over great distances as seen in the recent Gravettian series of *Le Blot* (Delvigne 2016) or in the middle Magdalenian of *Bouyssonie* cave (Langlais et al., in press).

Coupled with the design of rock libraries incorporating the concept of an evolutionary chain of SSR, the method set up and developed in the form of a database documenting the different stages in the life of archaeological artefacts provides results, not only in terms of genetic diversity (identification of geotopes), but also in terms of geological variability (diversity within various geotopes). The case of the three non-cortical blades known to be allochthonous (former groups 10, 15 and 18), but in fact corresponding to a post-genetic evolution of the local upper Turonian flints in the terraces of the *Claise* river (group 3), is a good example (see 3.3., and Figure 6). Thus, even for objects bearing no cortical surface, we have been able to determine their genetic and gitological origins. Beyond the identification of the geotope exploited, the contribution of finished products - here blades - in evolved Upper Turonian flint, on a site where the production and the manufacture of blades in Upper Turonian flint from residual formations is ultra-dominant, reflects a particular economic behaviour of the Middle Gravettian humans who moved within the entire valley of the Claise.The idea of *La Picardie* being a base camp (Klaric et al. 2011, 2018) as already suggested by the activities carried out there, is reinforced by a behaviour towards raw material supply and landscape relationships favouring local geotope resources : Middle Turonian flint collected near the primary deposit (group 09, c. 8.5 km northwest) and probably in ancient alluvium (group 10 and 12) of the Claise Valley, or from the neighbouring watershed (group 11, Upper Turonian from the Brignon Valley, c. 15 km west).

In addition to these local flints, we confirmed the existence of the two main source areas suspected during previous studies: the *Charente*, and more particularly the *Angoulême* region with groups 01 and 08, respectively from Coniacian and Turonian terrains (c. 150 km southwest) - and the lower and middle part of the *Cher* Valley (Figure 7). About *Charente*, it appears that most of the flint was acquired near the primary deposits in the residual formations containing flint or in the slope deposits. On the other hand, flint from the *Cher* valley shows a different deposit source: clay with flints for group 04 (c. 50 km northeast) and low terraces of the *Cher* near *Saint-Aignan* for group 07 (c. 60 km northeast). If they also indicate an eastern geotope, the two silcrete elements of group 02 were collected near deposits located about 120 km to the east, in the middle *Cher* valley. Finally, in addition to five elements of indeterminate origin (too strongly weathered), two artefacts of unknown origin remain. They correspond to pedogenetic silcretes which probably come from the Eo-Oligocene terrains of the north-western margin of the Massif Central. But to confirm this point we need to extend the survey into this area and expand the existant rock libraries. The size of this litho-space (*sensu* Delvigne 2016) thus makes it possible to widen the distribution range of the Middle-recent Gravettian to areas previously devoid of sites from this cultural period.

In a techno-economic approach to analysing lithic industries, it is essential to identify the genetic and gitological diversity of the materials (*supra*), but it is also necessary to coordinate these data with those of the lithic technology (Table 4). To count the number of artefacts in such an approach we have to consider the number of refitted pieces (e.g. if three bladelet fragments in the general count fit together they count as 1 bladelet), this explains the difference in total numbers between tables 2 and 4. Having taken this coordinating step we can now make assumptions about how landscapes were used since their value in paleo-ethnographic terms is different if a zone is defined using a single raw material or by several raw materials treated in a particular way. However, techno-economic reconstructions are eminently dependent upon sampling, insofar as we consider it *a priori* as the reflection of an archaeological reality valid at any given time. In our case, we assume that the sampling of allochthonous materials is technologically consistent with respect to the excavated area (c. 40 m^2), (assuming that our interpretations are valid at this scale for the site), and to petro-archaeological sorting between autochthonous and allochthonous materials. Indeed, we think that during the first sorting made with the naked eye, the part of allochthonous materials has been over emphasised, as shown by our reallocation of five of the twelve groups back to the local environment. It is therefore a question of structuring the litho-space of *La Picardie* in terms of quantity, gitological diversity and type of introduction for each raw material (Figure 7).

Local flint types (03, 09, 10, 11, 12) were brought in as knapped products (blades and flakes), either unmodified or transformed (e.g. as burins). A hypothesis for on-site knapping of burin spalls and their subsequent export from the site (or from the excavated area of the site) remains for types 03 (Upper Turonian from the *Claise* valley), 11 (Upper Turonian from the *Claise* valley) and 12 (undifferentiated Turonian from *Touraine*).

Concerning the flints from *Charente* (types 01 - Figure 8.1 to 8.5 - and 08 - Figure 8.10, 8.11, 8.13 to 8.15), we determined that they were brought as raw and retouched blanks (including blades) and, perhaps for type 01 (Coniacian from *Angoulême* region), as a prepared blade core. Indeed, some rare knapping maintenance flakes of type 01 were identified, testifying to knapping activities occurring at the site. The blades of type 01 and 08, which were probably transformed into burin were used on the site, as well as autochthonous Upper Turonian flints (Klaric et al. 2011, 2018). In the same way, comparison between the number of burins and bladelet-like blanks (especially burin spalls) group of material by group of material (table 4) suggests:
1) the export of some burins or bladelet-cores from the excavated area,
2) the introduction into the site of previously knapped bladelet-like blanks or,
3) a mix of these two hypotheses.
All the more that during the initial sorting of the raw material with the naked eye, it is possible that some bladelet-like material, because of patination could be still present in sieve residues.
This economic behaviour is all the more surprising for type 01 that it occurs farthest from the site (c. 150 km).
The flint of the low and middle valley of the *Cher*, that of groups 04 and 07, arrived in the form of knapped products transformed into domestic tools (retouched elements, scrapers, etc) (Figure 8.6 to 8.9 and 8.12) or hunting weapons (retouched bladelets) (Figure 8.X). Similar introductions occurred for silcretes of groups 02 (Eo-Oligocene from the middle part of the *Cher* valley), 05 and 06 (both Eo-Oligocene from the northern margin of the Massif Central), (Figure 8.16 and 8.17), brought to the site as bladelet-like products - retouched or unmodified - which suggests *in situ* repair of hunting weapons.
It should be noted that the *lamelles de la Picardie* are made of *Angoulême* Coniacian and Turonian flint (types 01 and 08) (n = 10 and n = 1), from the Lower Turonian of the *Cher* valley (type 04) and in Eo-Oligocene silcrete from the north of the Massif Central (type 06) (n = 1). The heavy presence of group 01 flint is probably due to the dominance of this type (50%) within the allochthonous assemblage, but we have not found any *burin du Raysse,* or cores for *lamelles de la Picardie,* in groups 01, 08 or 06; the only *burin du Raysse* made in allochthonous raw material being of type 04 (n = 1). Therefore, a question arises: where are the hunting implements associated with type 04 and cores of types 01, 06 and 08? Were these elements carried away when humans left the site? Are they located in an unexcavated zone suggesting a spatial organisation for site activities? Or were *lamelles de la Picardie* of types 01, 08 and 06 brought into the site already attached to a weapon possibly damaged?

It seems that the local landscape (c. 20 km around the site), and especially the *Claise* watershed, was widely traveled, possibly during the course of other activities. For the *Charente*, the lithological diversity is very low with just two genetic types, probably coming from the same type of deposits, and the flint being brought into the site as already knapped products and perhaps as already prepared cores. This behavior evokes a scene in which one or a few individuals arrive carrying ready prepared materials which are maintained and flaked on the site when undertaking daily activities. There are few and consequently rare Rayssian clues for this region mainly from the site of *Les Vachons* in *Voulgézac* (*Charente*). Between *La Picardie* and this site, only three Rayssian sites have been identified (Figure 5) and in all of them *Raysse* burins are very scarce according to what has been published (*Les Roches* rockshelter at *Pouligny-Saint-Pierre (Indre), Laraux* rockshelter at *Lussac-les-Châteaux (Vienne)* and *Le Taillis des Côteaux* at *Antigny (Vienne)*. For the low and middle valley of the *Cher*, it appears that most of the objects were brought to the site in the form of a domestic tool-kit that also contained armatures, suggesting the group participated in other activities prior to their arrival at the site or, less probably given the distance and the low diversity of gitological types, of logistic mobility strategies involving *La Picardie* site. The status of the *Cher* valley is thus different, but here again we do not know any Rayssian site. However, these regions are poorly studied and the works undertaken this past three years by different research teams in the framework of preventive and programmed French archaeology will certainly bring new insights.

5. Conclusion

The use of a database containing all the genetic, gitological and taphonomic information for the study of the lithic raw materials made it possible to group in a different manner the objects previously sorted with the naked eye using the criteria of color and roughness (Table 1). This result points out the difficulty in identifying precise groups of material and their sources with the naked eye alone (e.g. Mauger 1985, Valensi 1955; Masson 1981; Fernandes 2006, 2012; Delvigne 2016; Delvigne et al. 2019a). In thi; respect, the use of the database we propose makes it possible to define the different types of materials with a set of standardized variables. Indeed, only the combination of the different detrital, chemical, biogenic and structural characteristics makes it possible to define the genetic types which can then themselves be subdivided into as many gitological groups as necessary according to the criteria of alteration like inherited color, whitening of the allochems, degree of secondary epigenesis, natural use-wear, pre-depositional patina and gloss, type of porosity and poro-necrosis etc. Above all, it is the accuracy of the attributes in the database with its 164 descriptive fields, that allows these groupings to be determined. Even when a large family of material can be discerned using the naked eye, there generally remains a group of objects that do not fit the pre-established categories or which have a confused identity. But it is these latter elements which are interesting as they may indicate long-distance contacts between groups or perhaps locally exploited formations that demonstrate human great familiarity with a geotope. We conclude that it is only by knowing the diversity, quantity and mode of introduction into a site of the different types derived from discrete areas that one can postulate the type of acquisition into a site, either direct or indirect. Our assertion thus indicates a crucial need to properly decipher the genetic and gitological variability of the lithic industries.

Identifying the collection locations requires:
1) the integration of an evolutionary chain concept at the very beginning of the survey work;
2) a rather exhaustive inventory of sources;
3) a database of discriminating characteristics according to the different types of superficial formations.
Such inventories exist, especially those developed in the different *PCR Réseaux de lithothèques* and the *GDR Silex* operating in France. The ultimate objective of these projects is to build a community around common projects, bringing participants together regularly in order to share knowledge and know-how that goes beyond the individual initiatives and quests. This paper is offered from this perspective, since it is a question of presenting for a given site the different identified siliceous facies, along with their origin. It thus creates the beginning of an archaeological reference with broad access because petroarchaeology usually suffers cruelly from a lack of searchable and usable published references. Therefore, even if the origin of certain materials remains unknown (cf. groups 04 and 05), it seems essential to describe them as fully as possible so that others may take up the problem and possibly achieve their identification; hence the importance of differentiating between unknown, indeterminate, and indeterminable origins.

Thanks to the different rock libraries recently established, and by considering the concept of an evolutionary chain of SSR, we were able to identify (or at least present assumptions about) the origin of the groups of materials defined at *La Picardie*. This allowed the confirmation of geotopes where late-middle Gravettian Rayssian period sites are rare or even absent, like in the *Charente* or the *Cher* valley. Note that some older or younger sites are known in this region - few *burins du Raysse* and recent Gravettian at *les Vachons* (Bouyssonie, 1948) and early-middle Gravettian (Noaillian) at *André Ragout* rockshelter in *Vilhonneur* (Tixier, 1958) for the *Charente*, as Noaillian and recent Gravettian at *La Croix de Bagneux* (Kildéa and Lang 2011) an open air-site at *Mareuil-sur-Cher* for the *Cher* valley, suggesting the sustained use of a this geographical spaces during the second half of the Gravettian culture. It is thus a matter of questioning the structure of the relationships between spaces with indices of sites and without indices of sites. In this, the Rayssian period is a useful case study because of the small number of sites and their location in very discrete spaces. We deem it necessary to develop this approach for other sites, as undertaken in the *Bassin de Brive*. It will also be very interesting to set up similar approaches for sites located outside the "classical" areas of the Middle-recent Gravettian: Brittany including *Plasenn-al-Lomm* open air site (Monnier 1982; Le Mignot 2000), the Lower *Loire* valley with *La Martinière* open air site (Allard, 1986) and *Yonne* valley with the sites of *Grotte du Trilobite* and *Grotte du Renne* at *Arcy-sur-Cure* (Leroi-Gourhan et Leroi-Gourhan 1964; Schmider et Leroi-Ghouran 2002; Klaric 2008; Goutas 2013) and thus better understand the dynamics of lithic diffusion and landscape structures of this prehistoric culture.

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Bibliography

Affolter, J. (2002) – Provenance des silex préhistoriques du Jura et des régions limitrophes. Neuchâtel : Service et musée cantonal d'archéologie (Ed.), 2 tomes, 341 p. (Archéologie neuchâteloise 28).

Allard, M. (1986) - Le gisement préhistorique de La Martinière à La Pommeraye (M.-et-L.). Bulletin de la Société préhistorique française, 83(3), 78-82.

Allard, Pierre, Françoise Bostyn, and Jacques Fabre (2002) - Origine et circulation du silex durant le Néolithique en Picardie. Des premières approches ponctuelles à une systématique régionale. Revue archéologique de Picardie, 22, 49-74.

Andrefsky, W.J. (2009) – The analysis of stone tool procurement, production, and maintenance. Journal of Archaeological Reasearch, 17(1), 65-103.

Aspinall, A., Feather, S.W., Phillips, P. (1975) – Preliminary analyses of southern franch flint samples. In : F.G.H. Engelen (Dir.), Proceedings of the second international Symposium on flint (Maastricht, 8-11 Mei 1975). Maastricht : Nederlandse Geologische Vereniging (Ed.), pp. 42-46 (Staringia 3).

Aubry, M.P. (1975) – Recherches sur la nanopétrographie des roches siliceuses. Bulletin Trimestriel de la Société Géologique de Normandie, 62 (2), p. 7-34.

Aubry, T. (1991) – L'exploitation des ressources en matières premières lithiques dans les gisements solutréens et badegouliens du bassin versant de la Creuse (France). Thèse de doctorat, Université de Bordeaux-1, 327 p.

Bazile, F. (2002) – Matières premières minérales et Paléolithique supérieur en Languedoc oriental : une entreprise délicate. In : J.-C. Miskovsky et J. Lorenz (Dir.), Pierre et Archéologie, Actes du colloque (Tautavel, 14-16 mai 1998). Perpignan : Presses universitaires (Ed), pp. 151-176.

Bertran, P., Klaric, L., Lenoble, A., Masson, B., Vallin, L., (2010) - The impact of periglacial processes on Palaeolithic sites: The case of sorted patterned grounds. Quaternary International, 214 (1-2), 17-29.

Besançon J. (1982) - Les figures d'altération des silex du Liban et leurs implications, Archéologie au Levant, Recueil à la mémoire de R. Saidah, CMO 12, Arch. 9, Lyon: Maison de l'Orient et de la Méditerranée Jean Pouilloux (Ed.), pp. 21–32

Binder, D., Courtin, J. (1994)- Un point sur la circulation de l'obsidienne dans le domaine provençal. Gallia préhistoire, 36(1), 310-322.

Blet M., Binder, D., Gratuze, B. (2000) – Essai de caractérisation de silex provençaux par analyse chimique élémentaire. Revue d'Archéométrie, 24, 149-167.

Bon, F., Chauvaud, D., Dartiguepeyrou, S., Gardere, P., Mensan, R. (1996) - La caractérisation du silex de Chalosse. Antiquités nationales, (28), 33-38.

Bordes, F., Sonneville-Bordes, D. (1954) - Présence probable de jaspe de Fontmaure dans l'Aurignacien V de Laugerie-haute. Bulletin de la Société Préhistorique Française, 51 (1), 67-68.

Bordes, J.-G. (2002) - Les interstratifications châtelperronien / Aurignacien du Roc de Combe et du Piage (Lot, France). Analyse taphonomique des industries lithiques. Implications archéologiques. Thèse de doctorat, Université Bordeaux 1, 365 p.

Bordes, J.-G., Bon, F., Le Brun-Ricalens, F. (2005) - Le transport des matières premières lithiques à l'Aurignacien entre le nord et le sud de l'Aquitaine : faits attendus, faits nouveaux. In : J. Jaubert et M. Barbaza (Dir.), Territoires, déplacements, mobilités, échanges durant la Préhistoire. Terres et Hommes du Sud, Actes des 126ème congrès nationaux des sociétés historiques et scientifiques (Toulouse, 2001). Paris: CTHS (Ed.), pp.185-198.

Bostyn, F., Giligny, F. (dir.) (2014) - Lithic Raw Material Ressources and Procurement in Pre- and Protohistoric Times, Proceedings of the 5 th International Conference of the UISPP Commission on Flint Mining in Pre- and protohistoric Times (Paris, 10-11 September 2012), BAR IS, 2656, 130 pages.

Boule, M. (1887) – Alluvions anciennes à silex taillés de Malzieu (Lozère). In : Association Française pour l'Avancement des Sciences, Compte rendus de la 16ème session (Toulouse 1887), pp. 294-295.

Bouyssonie, J. (1948) - Un gisement aurignacien et périgordien, les Vachons (Charente), L'Anthropologie, 52, 1-42.

Brandl, M., Martinez, M. M., Hauzenberger, C., Filzmoser, P., Nymoen, P., Mehler, N. (2018) - A multi-technique analytical approach to sourcing Scandinavian flint: Provenance of ballast flint from the shipwreck "Leirvigen 1", Norway. PloS one, 13(8), e0200647.

Bressy, C. (2002) – Caractérisation et gestion du silex des sites mésolithiques et néolithiques du Nord-Ouest de l'arc alpin. Une approche pétrographique et géochimique. Thèse de doctorat, Université Aix-Marseille I, 677 p.

Bressy, C. (2007) – Caractérisation géochimique des silex tertiaires : contribution à l'identification des matières premières diffusées au Néolithique final. In : J. Vaquer et F. Briois (Dir.), La fin de l'âge de pierre en Europe du sud : matériaux et productions lithiques taillées remarquables dans le Néolithique et le Chalcolithique du sud de l'Europe. Toulouse: Archives d'Ecologie préhistorique (Ed.), pp. 221-231.

Bressy, C., Poupeau, G., Bintz, P. (2002) – Caractérisation géochimique et provenance des silex. In : J.-C. Miskovsky (Ed.), Géologie de la Préhistoire. Paris: Géopré (Ed.), pp. 943-950.

Bressy, C., Poupeau, G., Bintz, P. (2005) – Geochemical characterisation in flint sourcing. Application to the Chartreuse and Vercors massifs (Western Alps, France). Anschnitt, 19, 9-17.

Bullock, P., Fedoroff, N., Jongerius, A., Stoops, G., & Tursina, T. (1985) - Handbook for soil thin section description. Wolverhampton: Waine Research (Ed.), 152 p..

Burroni, D., Randolph, E., Donahue, R., Pollard, A.M. (2002) – The surface features of flint artefacts as a record of environmentals processes. Journal of Archaeological Science, 29, 1277-1287.

Bush, P.R. et Sieveking, G. de G. (1986) – Geochemistry and the provenance of flint axes. In : G. de G. Sieveking et M.B. Hart (Dir.), The scientific study of flint and chert, Proceedings of the fourth international flint symposium (Brighton, 10-15 avril 1983). Cambridge: Cambridge University Press (Ed.), pp. 133-140.

Caux S. (2015) - Du territoire d'approvisionnement au territoire culturel. Pétroarchéologie et techno-économie du silex Grain de mil durant l'Aurignacien dans le Sud-ouest de la France. Université de Bordeaux I, 2015, 247 p.

Caspar, J.-P., Masson, B., Vallin, L. (2003) – Poli de bois ou poli de glace au Paléolithique inferieur et moyen ? Problèmes de convergence taphonomique et fonctionnelle. Bulletin de la Société préhistorique française, 100 (3), 453-462.

Cayeux, L., (1930) - Patine des silex de la craie, In : Cinquantenaire de la Société française de minéralogie : livre jubilaire, Paris : Masson (Ed.), pp. 60-73.

Chalard P. (1992) - Essai d'interprétation de l'industrie lithique, technologique et économie du débitage et analyse de la répartition des silex, d'un habitat de Magdalénien moyen (couche 3) du gisement des Peyrugues à Orniac (lot). Toulouse : Mémoire de l'École des hautes Études en sciences sociales, 234 p.

Clark, G., Voigt, E. (dir.) (1979) - Proceedings of the third international Symposium on flint (Maastricht, 24-27 Mai 1979). Maastricht: Nederlandse Geologische Vereniging (Ed.), 146 p. (Staringia 6).

Collin, J.-P. (2019) - De la mine à l'habitat : Economie des productions minières du Bassin de Mons au Néolithique. De la fin du 5e millénaire à la fin du 3e millénaire. Thèse de doctorat, Universités de Paris-Panthéon-Sorbonne et de Namur.

Coutard, S., Ozouf, J. C. (2008) - Nouvelle approche de l'altération des galets de silex dans les dépôts marins Pléistocènes. Contribution à l'étude des plates-formes marines du Val de Saire (Normandie, France). Quaternaire, Revue de l'Association française pour l'étude du Quaternaire, 19(4), 335-344.

Curwen, E.C. (1940) – The white patination of black flint. Antiquity, 14, 435-437.

Debarbieux, B. (2009) – Territoire-Territorialité-Territorialisation : aujourd'hui encore, et bien moins que demain ... In : Vanier M. (Dir.), Territoires, territorialité, territorialisation. Controverses et perspectives. Actes des entretiens de la cité des Territoires (Grenoble, 7 et 8 juin 2007). Rennes : Presses universitaires de Rennes (Ed.), pp. 19-30.

Delage, C. (2003) – Siliceous rocks and prehistory. Bibliography on geo-archaeological approaches to chert sourcing and prehistoric exploitation. Oxford: Archaeopress (Ed.), 216 p. (BAR international S1168).

Delvigne, V. (2016) - Géoressources et expressions techno-culturelles dans le sud du Massif central au Paléolithique supérieur : des déterminismes et des choix. Université de Bordeaux, 1297 p.

Delvigne, V. (2019) - Materials, spaces and territories of men : an approach of networks of places of the western Europe during the ancient Gravettian. Annales de la Fondation Fyssen, 119-141

Delvigne, V., Fernandes, P., Piboule, M., Lafarge, A., Geneste, J.-M., Moncel, M.-H., Raynal, J.-P. (2014) - Ressources en silex au Paléolithique supérieur dans le Massif central : réseaux locaux et approvisionnement lointains revisités. In : Otte, M., Le Brun-Ricalens, F. (Dir.), Modes de contacts et de déplacements au Paléolithique eurasiatique. Actes du colloque international de la commission 8 de l'UISPP (Liège, 28–31 mai 2012). Liège, ERAUL et Luxembourg, ArchéoLogiques, pp. 403–435.

Delvigne, V., Fernandes, P., Piboule, M., Lafarge, A., Raynal, J.-P. (2017) - Circulation de géomatières sur de longues distances au Paléolithique supérieur : le cas des silex du Turonien du sud du Bassin parisien. Comptes rendus Palevol, 16 (1), 82-102.

Delvigne, V., Piboule, M., Fernandes, P., Lafarge, A., Primault, J., Aubry, T., Mangado, X . Raynal, J.-P. (2018) - Principales matières premières lithiques disponibles au Paléolithique entre le Bassin parisien et l'Auvergne : partie 2 - Loir-et-Cher, Indre-et-Loire. Le cas du Turonien inférieur et supérieur. In : Troubat, O. (Ed.), Préhistoire de la France centrale. Actualité de la recherche, actes du colloque interrégional de Montluçon (Montluçon, 19 Novembre 2016). Cercle d'Archéologie de Montluçon et de la région, Montluçon, pp. 28-49.

Delvigne, V., Fernandes, P., Piboule, M., Bindon, P., Chomette, D., Defive, E., Lafarge, A., Liabeuf, R., Moncel, M.-H., Vaissié, E., Wragg Sykes, R., Raynal, J.-P. (2019a) - Barremian–Bedoulian flint humanly transported from the west bank of the Rhône to the Massif-Central Highlands–A diachronic perspective. Comptes rendus Palevol, 18 (1), 90-112, https://doi.org/10.1016/j.crpv.2018.06.005

Delvigne, V., Fernandes, P., Tuffery, C., Angevin, R., Lethrosne, H., Aubry, T., Creusillet, M.- F., Depont, J., Le Bourdonnec, F.X., Lafarge, A., Liabeuf, R., Mangado-Llach, X., Moncel, M.- H., Philippe, M., Piboule, M., Primault, J., Raynal, J.-P., Recq, C., Sanchez de la Torre, M., Teurquety, G., Verjux, C. (2019b) - Grand-Pressigny was not alone: acquiring and sharing data about raw materials in the collective research project “Réseau de lithothèques en region Centre-Val de Loire” (France). Journal of lithic studies, 5 (2), https://doi.org/10.2218/jls.2798

Demars, P.-Y. (1980) – Les matières premières siliceuses utilisées au Paléolithique supérieur dans la bassin de Brive. Thèse de 3ème Cycle, Université de Bordeaux-1, 173 p.

Djindjian, F. (2005) – Approvisionnement en matières premières dans le Paléolithique supérieur d’Europe occidentale : Méthodes et résultats. Archeometriai Muhely, 4, 1-16.

Donahue, R. E. (1994) - The current state of lithic microwear research. In : Aschton, N. and David, A. (dir.), Stories in stone. London: lithic Studies Society (Ed.), pp. 156-168.

Evans, A.A., Wolframm, Y.B., Donahue, R.E., Lovis, W.A. (2007) – A pilot study of ‘‘black chert’’ sourcing and implications for assessing hunter-gatherer mobility strategies in Northern England. Journal of Archaeological Science, 34, 2161-2169.

Féblot-Augustin, J. (1997) – La circulation des matières premières au Paléolithique. Liège : Eraul (Ed.), 2 volumes, 275 p. et 247 p.

Fergusson, J. (1975) – Statistical analysis of flint trace element data. In : F.G.H. Engelen (Dir.), Proceedings of the second international Symposium on flint (Maastricht, 8-11 Mei 1975). Maastricht : Nederlandse Geologische Vereniging (Ed.), pp. 46-48 (Staringia 3).

Fernandes, P. (2006) – Pétroarchéologie des matériaux siliceux utilisés au paléolithique moyen dans le sud du Massif central : méthodologie et résultats préliminaires. Mémoire de diplôme de l’Écoles des hautes études en sciences sociales, Écoles des hautes études en sciences sociales de Toulouse.

Fernandes, P. (2012) – Itinéraires et transformations du silex : une pétroarchéologie refondée, application au Paléolithique moyen. Thèse de doctorat, Université de Bordeaux 1, 2 volumes, 623 p.

Fernandes, P. et Raynal, J.-P. (2006) – Pétroarchéologie du silex : un retour aux sources. Comptes rendus Palevol, 5, 829-837.

Fernandes, P. et Raynal, J.-P. (2007) – Les matières premières siliceuse (hors roche tenace) du niveau J1 de la grotte Sainte Anne 1 (Polignac, Haute-Loire). In : Raynal, J.-P. (Dir.), La grotte de Sainte Anne I. Le paléolithique moyen de l’unité J1. Laussonne : Archéo-Logis (Ed.), pp. 59-98 (Dossier de l’Archéo-logis n°3).

Fernandes, P., Le Bourdonnec, F.X., Raynal, J.-P., Poupeau, G., Piboule, M., Moncel, M.-H. (2007) – Origins of prehistoric flints: The neocortex memory revealed by scanning electron microscopy. Comptes rendus Palevol, 6, 557-568.

Fernandes, P., Delvigne, V., Dubernet, S., Le Bourdonnex, F.- X., Morala, A., Moreau, L., Piboule, M., Turq, A., Raynal, J.-P. (2020). Flint studies revisited: the “chaîne évolutive” concept. In: H. Collet, A. Hauzeur et F. Bostyn (Dir.) Reports of the 7th international conference of the UISPP Commission on Flint Minning in Pre- and Protohistoric times. Mons and Spienne (Belgique), september 2016. Bruxelles : bulletin de la Société royale belge d'anthropologie (Ed.), pp. 263-269 (Anthropologica et præhistorica, 128).

Floss, H. (2000) – La fin du Paléolithique en Rhénanie (Magdalénien, groupe à Federmesser, Ahransbourgien). L’évolution du choix des matières premières lithiques, reflet d’un profond changement du climat, et du comportement humain. In : B. Valentin, P. Bodu et Christensen M. (Dir.), L’Europe centrale et septentrionale au Tardiglaciaire: confrontation des modèles régionaux de peuplement, Actes de la Table ronde de Nemours, (Nemours, 13 au 16 mai 1997). Nemours : APRAIF (Ed.), pp. 87–96 (Mémoires du musée de Préhistoire d’Ile de France 7).

Folk, R.L. (1959). Practical classification of limestone. American Association of Petroleum Geologists Bulletin, 43, 1-38.

Folk, R.L., Weaver, C.E. (1952). A study of the texture and composition of chert. American Journal of Science, 250, 498-510.

Foucher, P., San Juan, C., Chambord, E. (2005). La circulation des matières siliceuses dans le Gravettien pyrénéen. In : J. Jaubert et M. Barbaza (Dir.), Territoires, déplacements, mobilités, échanges durant la Préhistoire. Terres et Hommes du Sud, Actes des 126ème congrès nationaux des sociétés historiques et scientifiques (Toulouse, 2001). Paris : CTHS (Ed.), pp. 199-216.

Foucher, P. (2015). Flint economy in the Pyrenees: A general view of siliceous raw material sources and their use in the Pyrenean Gravettian. Journal of lithic studies, 2(1), 111-129.

Geneste, J.-M. (1985) – Analyse lithique d'industries moustériennes du Perigord : une approche technologique du comportement des groupes humains au Paléolithique moyen. Thèse de 3ème Cycle, Université de Bordeaux-1, 567 p.

Giot D., Mallet, N., Millet, D. (1986) – Les silex de la région du Grand-Pressigny. Recherche géologique et analyse pétrographique. Revue archéologique du Centre de la France, 25 (1), 21-36.

Glauberman, P.J., Thorson, R.M. (2012) – Flint Patina as an Aspect of "Flaked Stone Taphonomy": A Case Study from the Loess Terrain of the Netherlands and Belgium. Journal of taphonomy, 10 (1), 21-43.

Goutas, N. (2013) - Nouvelles données sur l'industrie osseuse du Gravettien des grottes d'Arcy-sur-Cure (Yonne, France): Vers l'identification de nouveaux marqueurs techniques et culturels du Gravettien moyen à burins du Raysse In : P. Bodu, L. Chehmana, L. Klaric, L. Mevel, S. Soriano et N. Teyssandier (Dir.), Le Paléolithique supérieur ancien de l'Europe du Nord-Ouest. Réflexions et synthèses à partir d'un projet collectif de recherche sur le centre et le sud du Bassin parisien. Actes du colloque de Sens (Sens, 15-18 avril 2009), Paris : Société préhistorique française (Ed.), pp. 89-115 (Mémoire 56).

Graetsch, H.A., Grünberg, J.M. (2012) - Microstructure of flint and other chert raw materials. Archaeometry, 54(1), 18-36.

Gregoire, S. (2000) – Origine des matières premières des industries lithiques du Paléolithique pyrénéen et méditerranéen : contribution à la connaissance des aires de circulations humaines .Thèse de doctorat, Université de Perpignan, 246 p.

Grégoire, S. (2001) – Apports et limites des nouvelles techniques de pétroarchéologie préhistorique. Comptes rendus de l'Académie des Sciences, 332 D, 479-482.

Grünwald, C., Affolter, J. (1995) - Les ressources en matière première siliceuse dans le Vercors, Ve congrès international UISPP, XIIe commission « Épipaléolithique et Mésolithique en Europe », livret-guide de l'excursion Préhistoire et Quaternaire en Vercors, pp. 41-43.

Hardaker, T. (2012) - The artefacts from the present land surface at the Palaeolithic site of Warren Hill, Suffolk, England. Proceedings of the Geologists' Association, 123 (5), 692-713.

Hewitt, H.D. (1915) – Some experiments on patination. Proceedings of the Prehistoric Society of East Anglia, 45-51.

Howard, C.D. (2002) – The Gloss Patination of Flint Artifacts. Plains anthropologist, 47, 283-287.

Hue, E. (1910) – Distribution géographique de l'industrie en silex du Grand-Pressigny. In : XIème session du Congrès préhistorique de France, Comptes rendus (Tours, 1910). Paris : Société préhistorique française (Ed.), pp. 390-436.

Hue, E. (1929) – Recherches sur la patine des silex. Bulletin de la Société préhistorique française, 26 (9), 461-468.

Hurst, V.J. et Kelly, A.R. (1961) – Patination of cultural flints. Science, 134, 251-256.

Journaux, A., Coutard, J.P. (1974) - Expérience de thermoclastie sur des roches siliceuses, Bulletin centre de Géomorphologie de Caen, 18, 7-20.

Kildéa, F., LANG, L. (2011) – le Gravettien de la vallée du Cher : le site de la Croix-de-Bagneux à Mareuil-sur-Cher (Loir-et-Cher, France). In : N. Goutas, L. Klaric, D. Pesesse et P. Guillermin (Dir.), À la recherche des identités gravettiennes. Comptes rendus de la table ronde sur le Gravettien en France et dans les pays limitrophes (Aix-en-Provence, 6-8 octobre 2008), Paris : Société préhistorique française (Ed.), pp. 273-290 (Mémoire 52).

Kinnunen, K., Tinny, R., Hokkanen, K., Taavitainen, J.-P. (1985) – flint raw material of prehistoric Finland: rock types, surface textures and microfossils. Geological survey of Finland, 334, 5-59.

Klaric, L. (2003) – L'unité technique des industries à burins du Raysse dans leur contexte diachronique, réfléxions sur la diversité culturelle au Gravettien à partir des données de la Picardie, D'Arcy-sur-cure, de Brassempouy et du Cirque de la Patrie. Thèse de doctorat, Université Paris 1 Panthéon – Sorbonne, 427 p.

Klaric, L., 2007. Regional groups in the European Middle Gravettian. A reconsideration of the Rayssian technology. Antiquity, 81, 176-190.

Klaric L. 2008. Anciennes et nouvelles interprétations culturelles des assemblages du Gravettien moyen en France : La question de la place des industries à burins du Raysse au sein de la mosaïque gravettienne. In: Rigaud, J.-Ph. (Dir.), Actes de la table ronde des Eyzies-de-Tayac. Le Gravettien: entités régionales d'une paléoculture européenne. Les Eyzies-de-Tayac : Musée National de Préhistoire (Ed.) pp. 257-276 (Paléo 20)

Klaric, L., 2017. La réussite d'une production dépend de l'attention prêtée aux détails : l'exemple des débitages lamellaires par méthode du Raysse. Journal of Lithic Studies, 4 (2), https://doi.org/https://doi.org/10.2218/jls.v4i2.2547

Klaric L., Aubry, T., Walter, B. (2002) – Un nouveau type d'armature en contexte gravettien et son mode de production sur les burins du Raysse (La Picardie, commune de Preuilly-sur-Claise, Indre-et-Loire). Bulletin de la Société préhistorique française, 99 (4), 751-764.

Klaric, L., Liard, M., Bertran, P., Dumarçay, G., de Araujo Igreja, M., Aubry, T., Walter, B. (2011) - La Picardie : 9 ans de fouilles sur un gisement Rayssien finalement pas si mal conservé ! In : N. Goutas, L. Klaric, D. Pesesse et P. Guillermin (Dir.), À la recherche des identités gravettiennes. Comptes rendus de la table ronde sur le Gravettien en France et dans les pays limitrophes (Aix-en-Provence, 6-8 octobre 2008), Paris : Société préhistorique française (Ed.), pp. 291-310 (Mémoire 52).

Klaric, L., Bertran, P., Dumarçay, Gaë., Liard, M., (2018) - A long and winding road: Towards a palethnograpic interpretation of the middle-Gravettian site of la Picardie (Indre-et-Loire, France), Quaternary International, doi: https://doi.org/10.1016/j.quaint.2018.09.035.

Kraayenhagen, F.C., Nillesen, J.H.M., Engelen, F.G.H. (1975) - Proceedings of the second international Symposium on flint (Maastricht, 8-11 Mei 1975). Maastricht : Nederlandse Geologische Vereniging (Ed.), 99 p. (Staringia 3).

Krumbein, W.C., Sloss, L.L. (1963) – Stratigraphy and Sedimentation. Second edition. San Fransisco : Gilluly, J. & Woodford, A.O. (Ed.), 660p.

Langlais, M., Delvigne, V., Jacquier, J., Lenoble, A., Beauval, C., Bismuth, T., Chrzavzez, J., Lesvignes, E., Peschaux, C., Rodriguez Fernandez, A.M., Pesesse, D. (in press). Une nouvelle archéo-séquence pour le Magdalénien en Corrèze. Premières données sur le Magdalénien moyen ancien de la grotte Bouyssonie (Brive-La-Gaillarde, Corrèze). Paléo.

Le Mignot, Y. (2000). La question de la production d'armatures sur le site gravettien de Plasenn-al-Lomm (Ile de Bréhat, Côtes d'Armor). Revue archéologique de l'Ouest, 17(1), 7-24.

Lenoir, M., Séronie-Vivien, M.R. (1990) – le silex de sa genèse à l'outil, Actes du 5ème flint Symposium (Talence, 17 septembre-2 octobre 1987). Paris : CNRS (Ed.), 2 volumes, 645 p. (Cahier du Quaternaire 17).

Leroi-Gourhan, A., Leroi-Gourhan, A. (1964) - Chronologie des grottes d'Arcy-sur-Cure (Yonne). Gallia préhistoire, 7(1), 1-64.

Levi Sala, I. (1986) – Use Wear and Post-Depositional Surface Modification : A word of caution. Journal of Archaeological Science, 13, 229-244.

Luetdke, B.E. (1978) – Chert sources and trace-element analysis. American Antiquity, 43(3), 413-423.

Luetdke, B.E. (1979) – The identification of sources of chert artefacts. American Antiquity, 44, 744-756.

Luetdke, B.E. (1992) – An Archaeologist's Guide to Chert and Flint. Los Angeles: Institute of Archaeology, University of California (Ed.), 172 p.

Marchand, G. - 2010 - Des groupes mobiles de chasseurs au centre de la Bretagne, In : Menez Y., Hinguant S. (dir.), Fouilles et découvertes en Bretagne, 28.

Masson, A. (1981) – Pétroarchéologie des roches siliceuses, intérêt en Préhistoire. Thèse de doctorat, Université de Lyon, 101 p.

Masson, A. (1986) – Nouvelles contributions aux études pressigniennes. Revue archéologique de l'Ouest, Supplément 1, 11-120.

Mauger, M. (1985) – Les matériaux siliceux utilisés au paleolithique superieur en Île-de-France. Thèse de doctorat, Université Paris 1 Panthéon – La Sorbonne, 406 p.

Meillet, A. (1866) – Recherches chimiques sur la patine des silex taillés. Montauban : V. Bertuot (Ed.), 15 p.

Meroc, L. (1943) – Le silex dans le bassin sous-pyrénéen de la Garonne et son emploi par l'homme préhistorique. Bulletin de la Société archéologique du Midi, 5, 234-254.

Monnier, J. L. (1982). Le gisement paléolithique supérieur de Plasenn-al-Lomm (Ile de Bréhat, Côtes-du-Nord). Gallia Préhistoire, 25(1), 131-165.

Morala, A. (1984) – Périgordien et Aurignacien en Haut-Agenais. Étude d'ensembles lithiques. Toulouse: École des hautes études en sciences sociales (Ed.), 140 p. (Archives d'écologie préhistorique 7).

Morala, A. (2018) - Les silicifications des bassins versants de la Dordogne et de la Vézère : évaluation des ressources lithiques et implications préhistoriques. Les Eyzies-de-Tayac : MNP (Ed.), 110 p. (Paléo, numéro special)

Néraudeau, D. (2004) - Les silex fossilifères du nord du littoral charentais et leur utilisation au Paléolithique. Bulletin de l'Association Manche Atlantique pour la Recherche Archeologique dans les Iles, 17, 5-16.

Primault, J. (2003) – Exploitation et diffusion des silex de la région du Grand-Pressigny au Paléolithique. Thèse de doctorat, Université Paris X - Nanterre, 362 p.

Rasplus, L., Macaire, J.-J., Alcaydé, G. (1978) – Notice explicative, carte géologique de la France (1/50 000), Preuilly-sur-Claise (542). Orléans : BRGM (Ed.), 26 p.

Raynal, J.-P., Fernandes, P., Le Corre-Le Beux, M., Santagata, C. (2007) - Le Paléolithique moyen de Haute-Loire (France) : origines, diversité, affinités. In : R. Desbrosse et A. Thévenin (Dir.), Arts et cultures de la Préhistoire : hommages à Henri Delporte. Paris : CTHS (Ed.), pp.117-138.

Riche, C. (1998) – Les ateliers de silex de Vassieux. Exploitation des gîtes et diffusion des produits. Thèse de 3ème Cycle, Université Paris X - Nanterre, 476 p.

Rottlander R. (1975) – The formation of patina on flint. Archaeometry, 17 (1), 106-110.

Sanchez de la Torre, M.S. (2015) - Las sociedades cazadoras-recolectoras del Paleolítico superior final Pirenaico: Territorios económicos y sociales. Barcelona : SERP (Ed.), 314 p. (Monografía SERP 11)

de la Torre, M. S., Le Bourdonnec, F. X., Gratuze, B., Domingo, R., García-Simón, L. M., Montes, L., Mazo, C., Utrilla, P. (2017) - Applying ED-XRF and LA-ICP-MS to geochemically characterize chert. The case of the Central-Eastern Pre-Pyrenean lacustrine cherts and their presence in the Magdalenian of NE Iberia. Journal of Archaeological Science: Reports, 13, 88-98.

Schmider, B., Leroi-Gourhan, A. (2002). L'Aurignacien de la grotte du Renne: les fouilles d'André Leroi-Gourhan à Arcy-sur-Cure (Yonne). Paris : CNRS (ed.), 256 p.

Sécher, A., Caux, S. (2017) - Technologie lithique et circulation des matières premières au Magdalénien moyen ancien: l'exemple de Moulin-Neuf (Saint-Quentin-de-Baron, Gironde). Bulletin de la Société préhistorique française, 114 (2), 295-314.

Séronie-Vivien, M., Séronie-Vivien, M.R. (1987) – Les silex du Mesozoïque nord-aquitain. Approche géologique de l'étude des silex pour servir à la recherche préhistorique. Bordeaux : Société Linéenne de Bordeaux (Ed.), 136 p. (Supplement au tome 15 du Bulletin de la Société linéenne de Bordeaux).

Séronie-Vivien M.R. (1995) – La grotte de Pégourié, Caniac-du-Causse (Lot) : Périgordien, Badegoulien, Azilien, Age du Bronze. Cressensac : Préhistoire quernicoise (Ed.), 334 p. (Supplément 2).

Shackley, M.S. (1998) – Gamma Rays, X-Rays and Stone Tools: Some Recent Advances in Archaeological Geochemistry. Journal of Archaeological Science, 25, 259–270.

Sieveking, G.G., Hart, M.B. (Dir.) (1986) – The scientific study of flint and chert, Proceedings of the fourth international flint symposium (Brighton, 10-15 avril 1983). Cambridge : Cambridge University Press (Ed.), 263 p.

Sieveking, G. de G., Caddock, P.T., Hugues, M.T., Bush, P., Fergusson, J. (1970) – Caracterisation of prehistoric flint mine products. Nature, 228, 251-254.

Simonnet, R. (1982) – Carte des gîtes à silex des Prépyrénées. In : XXIème session Quercy du Congrès préhistorique de France, Comptes rendus (Montauban-Cahors-Figeac, 3-9 septembre 1979). Paris : Société préhistorique de France (Ed.), pp. 308-323.

Speer, C.A. (2014) – Experimental sourcing of Edwards Plateau chert using LA-ICP-MS. Quaternary international, 342, 1-15.

Stapert, D. (1976) – Some natural surface modifications on flint in the Nethe, Netherlands. Palaeohistoria, 18, 7-42.

Stecl, J., Malina, J. (1970) – Anwendung der Petrographie in der Archäologie. Folia facultatis scientiarum naturalium Universitatis Purkynianae Brunensis Geologia, 11(20), 5-111.

Stockmans, C., Bosmans, H., Vermeersch, P. (1981) – Trace element analysis of Belgium flint mine products. In: F.G.H. Engelen (Dir.), Proceedings of the third international Symposium on flint (Maastricht, 24-27 Mai 1979). Maastricht: Nederlandse Geologische Vereniging (Ed.), pp. 85-87 (Staringia 6).

Surmely, F., Pasty, J.-F. (2003) – L'importation de silex en Auvergne durant la Préhistoire. In : F. Surmely (Dir.), Les matières premières lithiques en Préhistoire, Actes de la table ronde internationale

(Aurillac, Juin 2002). Cressensac: Association de préhistoire du Sud-Ouest (Ed.), pp. 327-336 (Supplément au bulletin de Préhistoire du Sud-Ouest 5).

Tarrino, A., Elorrieta, I., García-Rojas, M. (2014) – Flint as raw material in prehistoric times: Cantabrian Mountain and Western Pyrenees data. Quaternary international, 364, 94-108.
Thiry, M. (1981) – Sédimentation continentale et altérations associées : Calcitisations, ferruginisations et silicifications. Les argiles plastiques du Sparnacien du Bassin de Paris. Thèse d'état, Université de Strasbourg, 173 p.

Thiry, M., Fernandes, P., Milnes, A., Raynal, J.-P. (2014) – Driving forces for the weathering and alteration of silica in the regolith: implications for studies of prehistoric flint tools. Earth Science Reviews, 136, 141-154.

Tixier, J. (1958) - Les burins de Noailles de l'Abri André Ragout: Bois-du-Roc, Vilhonneur (Charente). Bulletin de la Société préhistorique de France, 55 (10), 628-644.

Tomasso, A. (2014) – Territoire, système de mobilité et système de production. La fin du Paléolithique supérieur dans l'arc liguro-provençal. Thèse de doctorat, Université de Nice Sophia-Antipolis et Università di Pisa, 1069 p.

Tomasso, A. (2018) - Territoire de mobilité et territoire social: structuration du territoire d'approvisionnement en matières premières lithiques dans l'Épigravettien récent au nord-ouest de l'Italie. Bulletin de la Société préhistorique française, 115(4), 677-700.

Tomasso, A., Binder, D., Fernandes, P., Milot, J., Léa, V. (2019) - The Urgonian chert from Provence (France): the intra-formation variability and its exploitation in petro-archeological investigations. Archaeological and Anthropological Sciences, 11(1), 253-269.

Torti, C. (1980) – Recherches sur l'implantation humaine en Limagne au Paléolithique moyen et supérieur. Thèse de 3ème Cycle, Université de Bordeaux-1, 270 p.

Tufféry, C., Fernandes, P., Delvigne, V., Morala, A. 2018. Combinaison d'un SMA et d'un SIG pour aider à la prospection pétroarchéologique. Exploration d'une approche multi-agents dans la modélisation des parcours naturels du silex. Archéologies numériques, 2 (1), DOI : 10.21494/ISTE.OP.2018.0276.

Tuffery, C., Fernandes, P., Delvigne, V., Bressy-Leandri, C., Renault, S. (2019) - Collecte, gestion et valorisation des données sur les formations et les gîtes à silex en France: pour des plateformes cartographiques et de publications partagées. Openscience.
URL : https://www.openscience.fr/IMG/pdf/iste_numear19v3n1_2.pdf

Turq, A. (2000) – Les ressources en matières premières lithiques. Paléo, 2 (1), 98-141.

Turq, A. (2005) – Réflexions méthodologiques sur les études de matières premières lithiques. Paléo, 17, 111-132.

Turq, A., Antignac, G., Roussel, P. (1999) – Les silicifications coniaciennes du Sarladais et du Gourdonnais: inventaire et implications archéologiques. Paléo, 11, 145-160.

Vaissié, E., Delvigne, V., Faivre, J. P., Fernandes, P., Turq, A., Raynal, J. P. (2017) - Techno-économie et signification culturelle de l'occupation moustérienne supérieure de Baume-Vallée (Haute-Loire). Comptes Rendus Palevol, 16(7), 804-819.

Valensi, L. (1955) – Étude micropaléontologique des silex du Magdalénien de St-Amand (Cher). Bulletin de la Société préhistorique française, 584-596.

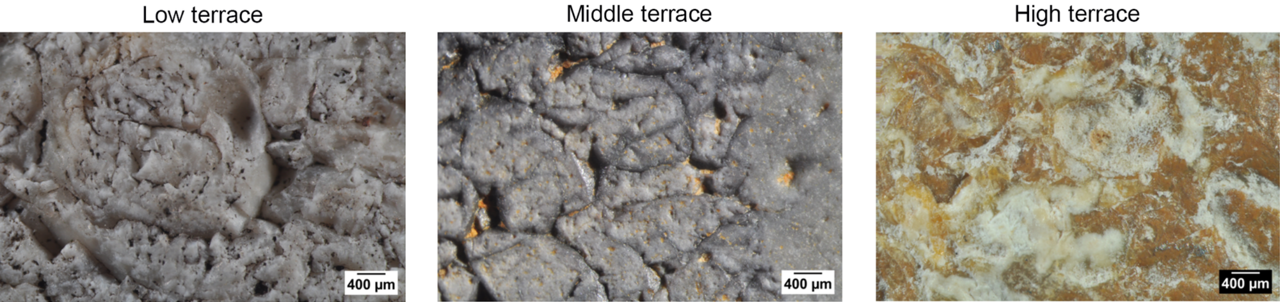
Vilas Boas, G. (1975) – L'altération des accidents siliceux, silex et chailles dans les formations paléogènes du Bassin de Paris. Thèse de 3ème Cycle, Université de Strasbourg, 110 p.

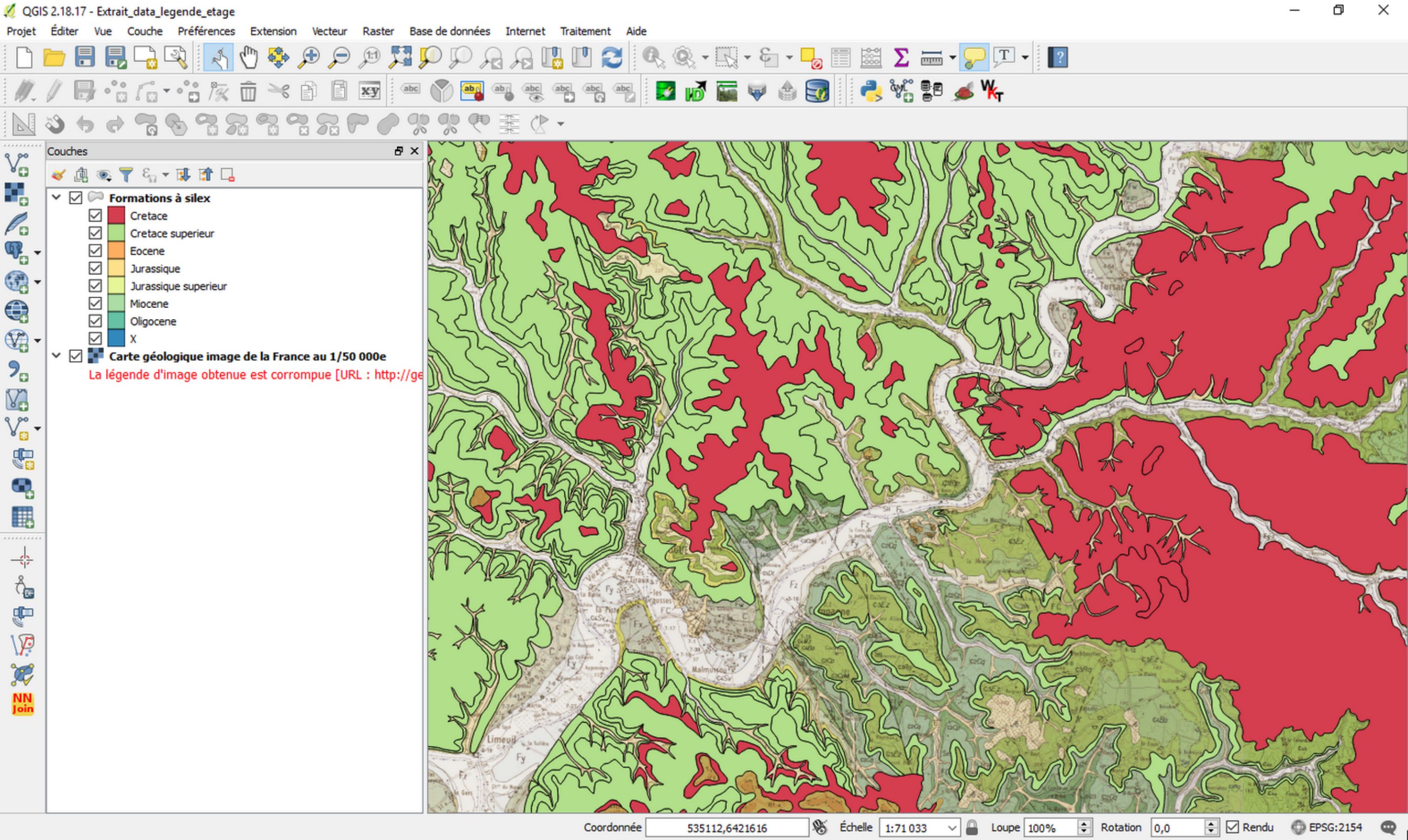
Yamada, M., Ono, A., (dir.) (2014) - Lithic Raw Material Exploitation and Circulation in Prehistory: A Comparative Perspective in Diverse Palaeoenvironments. Liège and Meiji: ERAUL (Ed.), 236 p.

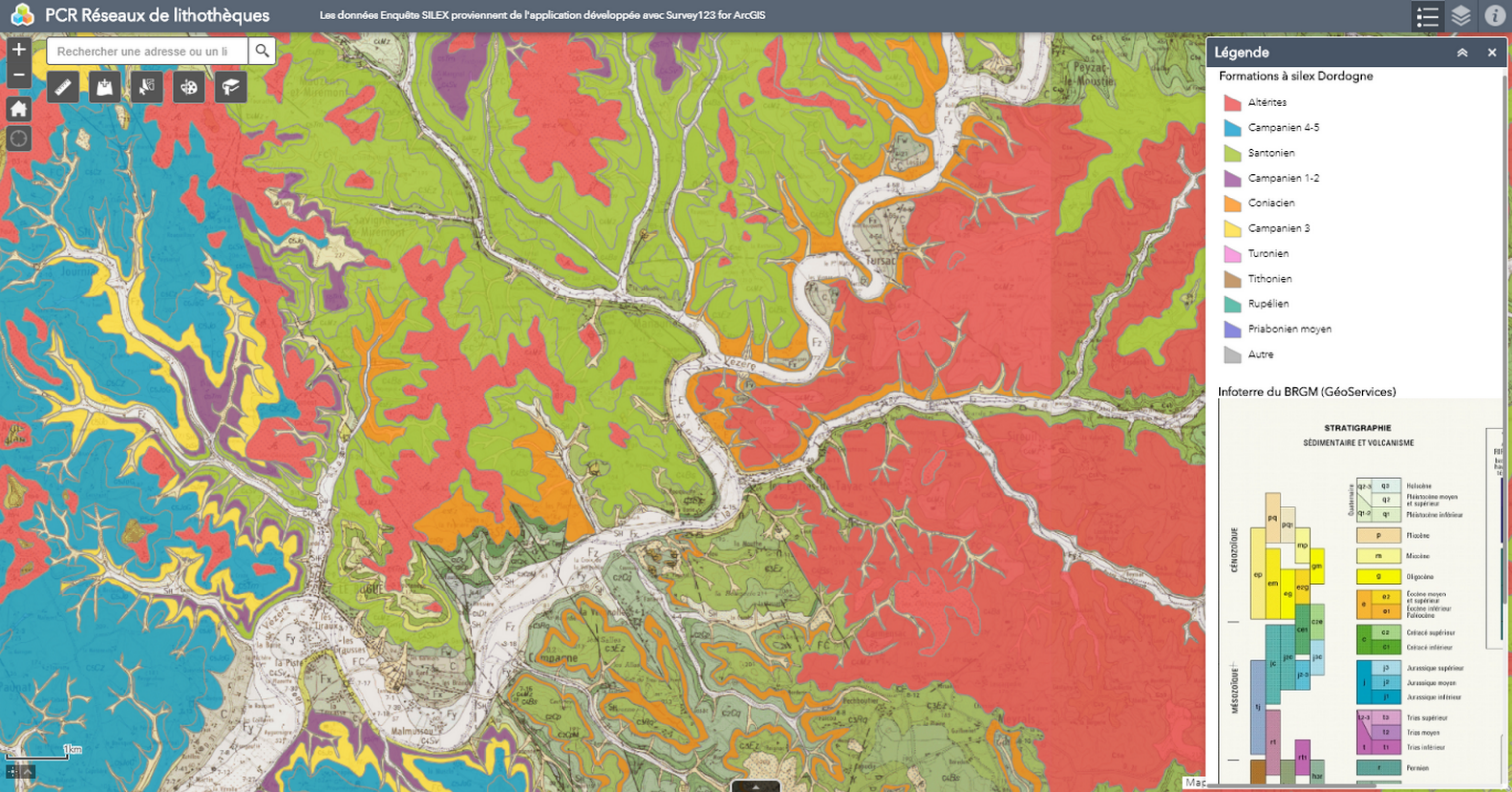
Figures captions

Figure 1: Examples of different degrees of transformation of (neo)cortex for the same genetic type flint (here the Turonian of the Yonne valley) collected in secondary position in the lower terraces (on the left), in the middle terraces (in the center) and in the high terraces (on the right).
Figure 2: Example of results of flint formations vector shapefiles digitized using the harmonized protocol, QGis software and scanned geological maps in the background.
Figure 3: ArcGisOnLine web mapping application showing scanned geological maps (background) used for digitizing flint formations (vector shapefile) according to the harmonized protocol.
Figure 4: Data description, metadata, webservices URL and downloading functionalities
Figure 5: Sites mentionned in the text. Black star: La Picardie ; White dots: other sites with Raysse burin-core; Grey dots: Gravettien sites with no Raysse burin-core. 1: Plasenn'al Lomm; 2: La Martinière; 3: La Croix de Bagneux; 4: Grotte du Renne and Grotte du Trilobite; 5: La Picardie; 6: Les Roches rocksheleter 7: Le Taillis des Côteaux; 8: Laraux; 9: Abri André Ragout and Vilhonneur; 10: Les Vachons ; 11: Grotte Bouyssonie and Les Morts; 12: Les Battuts. Little white dots correspond to site with Raysse burin-core not mentionned in the text.
Figure 6: An example of an evolutionary chain of SSR: the upper Turonian from the Claise Valley (Indre-et-Loire) with miliolid foraminifera (*Quinqueloculina sp.* marked Quin. on pictures). The microfacies of the two archaeological pieces (in the center; photos d and e) correspond to that of the geological sample collected in ancient alluviums deposits (top photos b and c). In addition, the differential alteration of the elements indicates that the G3_F98b_103 blade (bottom center) was made in the endocortical zone of a block, while the G3_I96_105 slide (lower right) was made in an inner zone of a block.
Figure 7: La Picardie - Litho-space. The solid lines are proven relations, the dotted lines correspond to hypothetic relations. The map background shows the formations with SSR (unpublished work of VD, PF and P. Tallet).
Figure 8: La Picardie – lithic artefacts.

Table 1: La Picardie - Correlation of groups of materials from the 140 objects studied previously. On line, this study; in column, previous sorting with the bare eye.
Table 2: La Picardie - Number, weight and gitology of the different groups of material. Prim = primary, Sup. = superficial formations (colluviums or alterites), All. = recent alluvial formations, Old All. = ancient alluvial formations (terraces), Ind. = Indeterminate.
Table 3: La Picardie - Synthetic table of SSR groups. (-) = rare; (o) = present; (+) = abundant; (+++) = very abundant.
Table 4: La Picardie - Mode of introduction into the site of the different groups of SSR. lp = *lamelle de la Picardie*, rb = retouched blade; rf = retouched flake, t = truncation; bb = backed bladelet; tb = truncated bladelet; rbl = retouched bladelet; s = scraper; b = *burin*.


Low terrace
Middle terrace
High terrace
400 µm
400 µm
400 µm


QGIS 2.18.17 - Extrait_data_legende_etage
Projet Éditer Vue Couche Préférences Extension Vecteur Raster Base de données Internet Traitement Aide
Couches
Formations à silex
Cretace
Cretace superieur
Eocene
Jurassique
Jurassique superieur
Miocene
Oligocene
X
Carte géologique image de la France au 1/50 000e
La légende d'image obtenue est corrompue [URL : http://ge
Coordonnée 535112,6421616
Échelle 1:71 033
Loupe 100%
Rotation 0,0
Rendu
EPSG:2154


PCR Réseaux de lithothèques
Les données Enquête SILEX proviennent de l'application développée avec Survey123 for ArcGIS
Rechercher une adresse ou un li
Légende
Formations à silex Dordogne
Altérites
Campanien 4-5
Santonien
Campanien 1-2
Coniacien
Campanien 3
Turonien
Tithonien
Rupélien
Priabonien moyen
Autre
Infoterre du BRGM (GéoServices)
STRATIGRAPHIE
SÉDIMENTAIRE ET VOLCANISME
Holocène
Pliocène
Miocène
Oligocène
Crétacé supérieur
Crétacé inférieur
Jurassique supérieur
Jurassique moyen
Jurassique inférieur
Trias supérieur
Trias moyen
Trias inférieur
Permien
CÉNOZOÏQUE
MÉSOZOÏQUE
Tursac
Vézère
1km

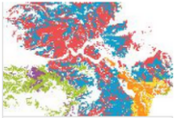
Accueil Bibliothèque Carte Scène Groupes Contenu Organisation

Inrap DST
INRAPESRI

Formations à silex Dordogne

Aperçu | Données | Visualisation | Utilisation | Paramètres

Modifier la miniature



Supprimer des favoris

Ajoutez un bref résumé de l'élément.

Modifier

Feature Layer (hébergé) par INRAPESRI

Création : 2 juin 2016 Mise à jour : 15 sept. 2017 Nombre de vues : 558

Ouvrir dans la visionneuse de carte

Ouvrir dans la visionneuse de scène

Ouvrir dans ArcGIS Desktop

Publier

Créer une couche de vue

Exporter des données

Mettre à jour les données

Partager

Métadonnées

Description

Modifier

Ajoutez une description détaillée de l'élément.

Couches

Formations_à_silex

Modifier

Ouvrir dans | Exporter vers | Paramètres de temps | Désactiver les pièces jointes | URL du service | Métadonnées

Conditions d'utilisation

Modifier

Ajoutez des restrictions spéciales, des clauses d'exclusion de responsabilité, des termes et conditions, ou des limitations quant à l'utilisation du contenu de l'élément.

Commentaires (0)

Laissez un commentaire.

Laissez un commentaire.

Informations sur l'élément

En savoir plus

Basse Elevée

Principale amélioration : Ajouter un résumé

Détails

Source : Feature Service

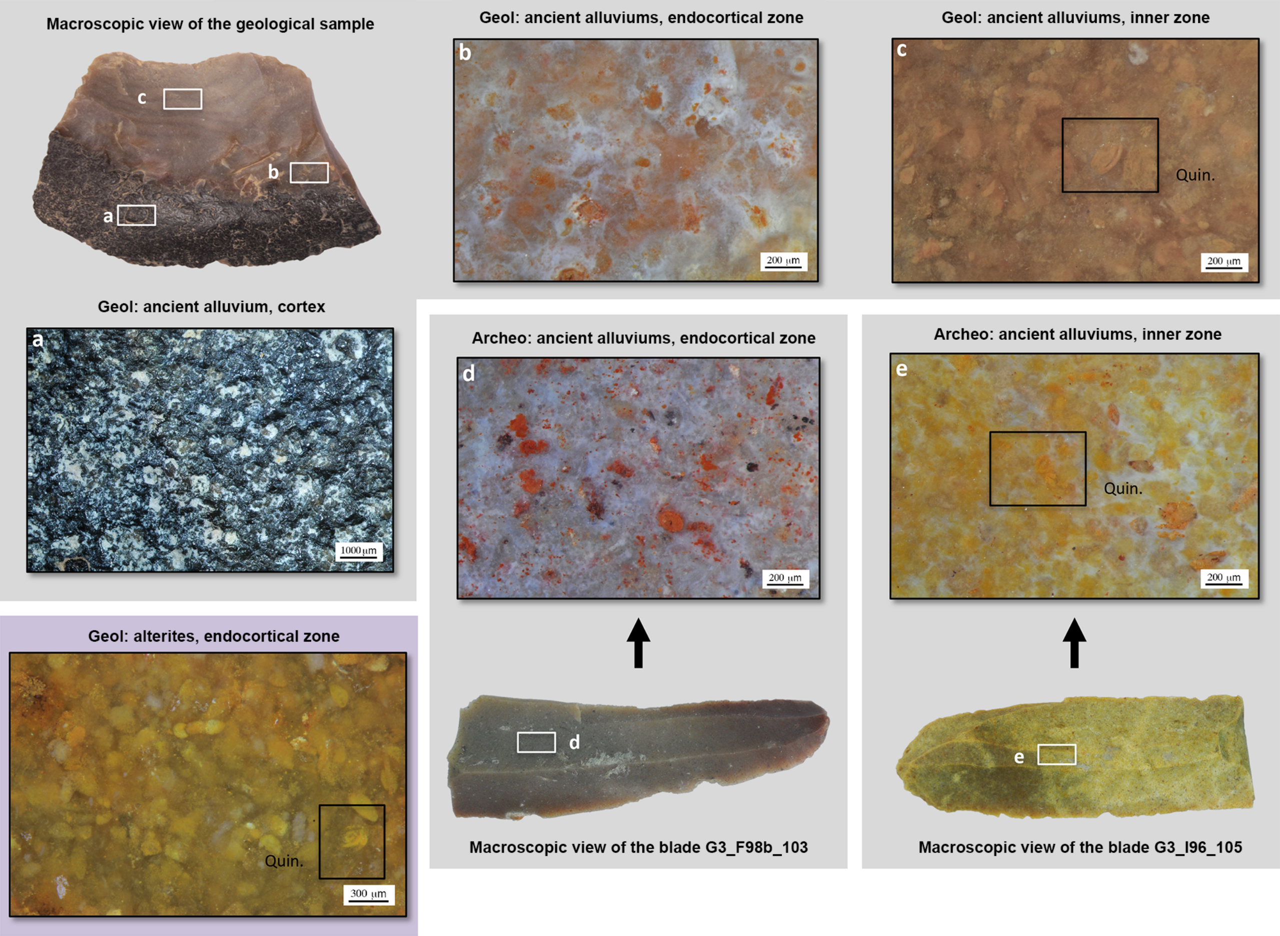
Créé à partir de : Formations à silex, Shapefile

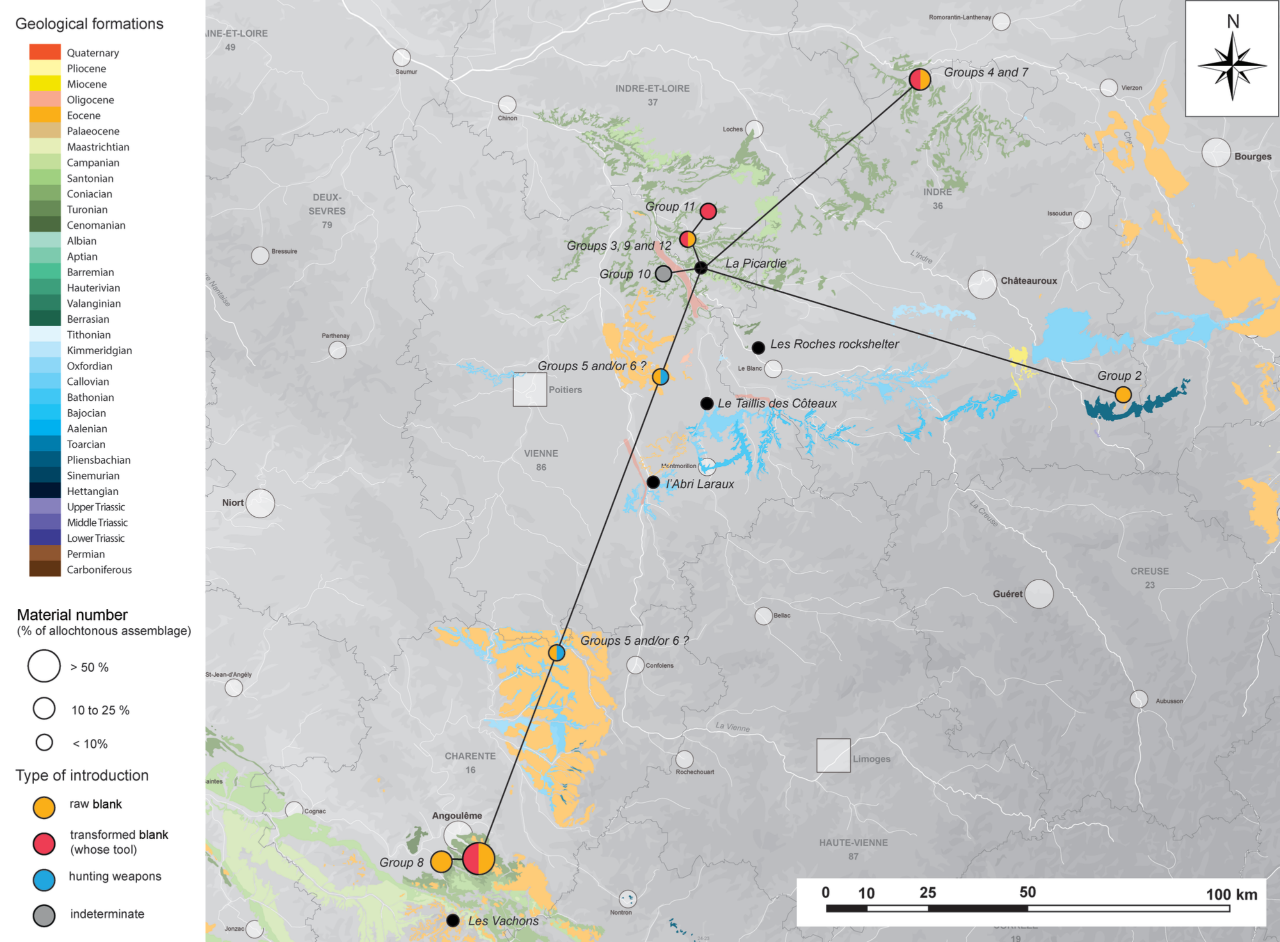
Dernière mise à jour des données : 15 sept. 2017 17:12:24

Taille : 11 MB

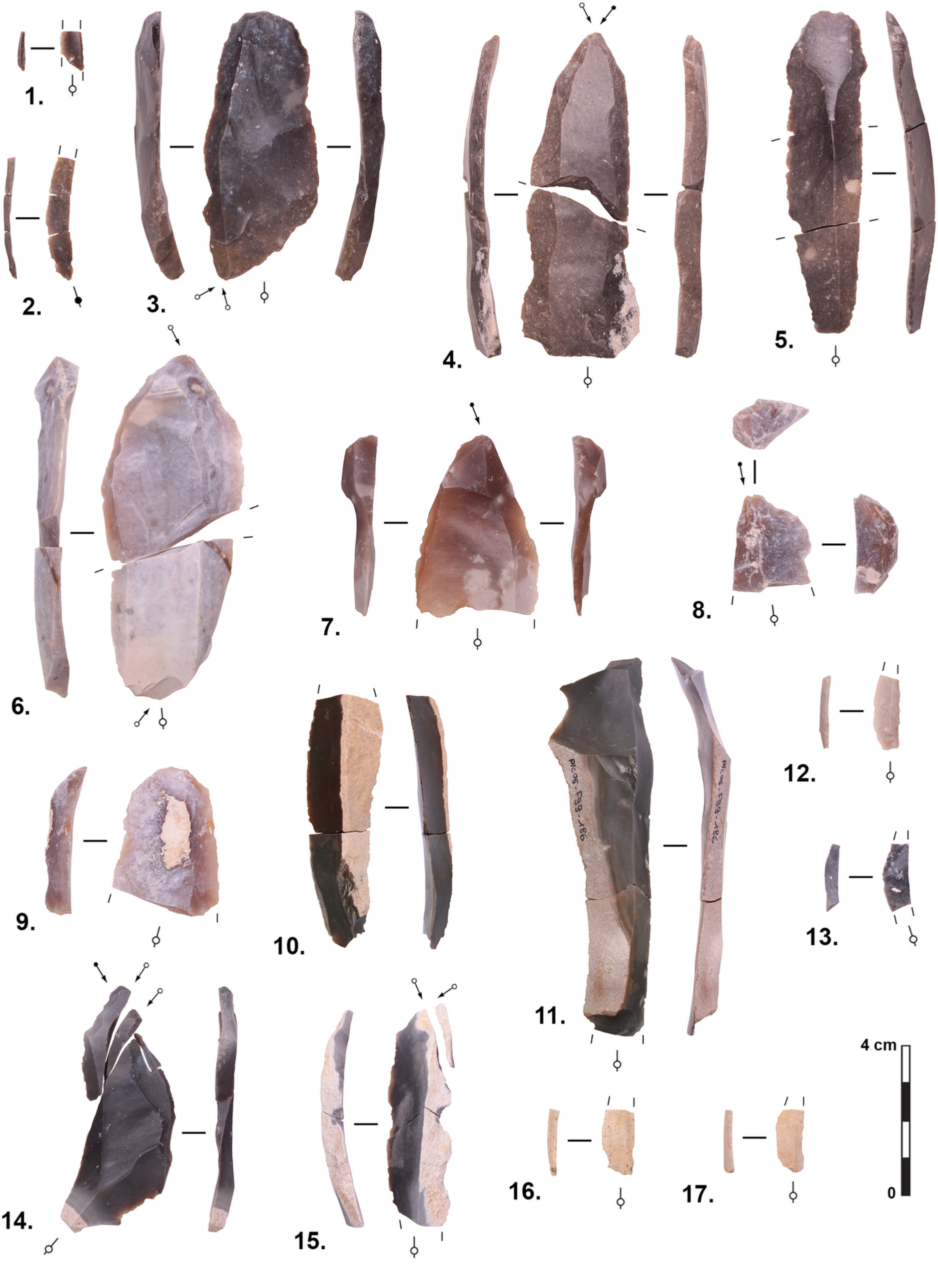
Partagé avec: TESTS_EXT, PCR

LA MANCHE
OCÉAN
ATLANTIQUE
MER MÉDITERRANÉE
MASSIF ARMORICAIN
BASSIN PARISIEN
ARDENNES
Plateau de Langres
MORVAN
VOSGES
JURA
ALPES
Plateau du Limousin
MASSIF CENTRAL
BASSIN AQUITAIN
PYRÉNÉES
Landes of Gascogne desert
1
2
3
4
5
6
7
8
9
10
11
12
0
100
200 km
IGN 2012 - Licence ouverte


Macroscopic view of the geological sample
c
b
a
Geol: ancient alluviums, endocortical zone
b
200 µm
Geol: ancient alluviums, inner zone
c
Quin.
200 µm
Geol: ancient alluvium, cortex
a
1000 µm
Archeo: ancient alluviums, endocortical zone
d
200 µm
Archeo: ancient alluviums, inner zone
e
Quin.
200 µm
Geol: alterites, endocortical zone
Quin.
300 µm
d
Macroscopic view of the blade G3_F98b_103
e
Macroscopic view of the blade G3_I96_105



Geological formations
Quaternary
Pliocene
Miocene
Oligocene
Eocene
Palaeocene
Maastrichtian
Campanian
Santonian
Coniacian
Turonian
Cenomanian
Albian
Aptian
Barremian
Hauterivian
Valanginian
Berrasian
Tithonian
Kimmeridgian
Oxfordian
Callovian
Bathonian
Bajocian
Aalenian
Toarcian
Pliensbachian
Sinemurian
Hettangian
Upper Triassic
Middle Triassic
Lower Triassic
Permian
Carboniferous
Material number
(% of allochtonous assemblage)
> 50 %
10 to 25 %
< 10%
Type of introduction
raw blank
transformed blank (whose tool)
hunting weapons
indeterminate
N
Groups 4 and 7
Group 11
Groups 3, 9 and 12
Group 10
La Picardie
Les Roches rockshelter
Groups 5 and/or 6 ?
Group 2
Le Taillis des Côteaux
l'Abri Laraux
Groups 5 and/or 6 ?
Group 8
Les Vachons
INDRE-ET-LOIRE
37
DEUX-
SEVRES
79
INDRE
36
VIENNE
86
CREUSE
23
CHARENTE
16
HAUTE-VIENNE
87
Saumur
Chinon
Loches
Romorantin-Lanthenay
Vierzon
Bourges
Issoudun
Châteauroux
Bressuire
Parthenay
Poitiers
Le Blanc
Montmorillon
Niort
Guéret
Bellac
Confolens
St-Jean-d'Angély
Aubusson
Limoges
Rochechouart
Cognac
Angoulême
Nontron
Jonzac
La Vienne
La Creuse
L'Indre
0 10 25 50 100 km


1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
4 cm
0

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	indet.
1						56	8	1											3	6
2															2					
3										1					1			3		
4	2															13				
5																				1
6													1							
7																5				
8		3		12	5						1									1
9			1														2			
11																		1	1	
12																		1		
indet.								1				1		1		2				

Type (Δ = 12)	Primary stratigraphic origin	Primary geographic origin	Primary geographic origin					Number	% Num.	Weight	% Wei.
			Prim.	Sup.	All.	Old All.	Ind.				
Group 01	Upper Cretaceous (Coniacian)	Angoulême region (Charente)		X				74	50.00	376.60	47.04
Group 02	Cenozoic (Eo-Oligocene)	Middle part of the Cher Valley (Cher)		X				3	2.03	15.10	1.89
Group 03	Upper Cretaceous (Upper Turonian)	Claise Valley (Indre-et-Loire)				X		4	2.70	58.60	7.32
Group 04	Upper Cretaceous (Lower Turonian)	Low part of the Cher Valley (Loir-et-Cher)		X				17	11.49	157.10	19.62
Group 05	Cenozoic (Eo-Oligocene)	northern margin of the French Massif Central					X	2	1.35	0.70	0.09
Group 06	Cenozoic (Eo-Oligocene)	northern margin of the French Massif Central					X	2	1.35	1.20	0.15
Group 07	Upper Cretaceous (Lower Turonian)	Low part of the Cher Valley (Loir-et-Cher)				X		8	5.41	27.00	3.37
Group 08	Upper Cretaceous (Turonian)	Angoulême region (Charente)		X				24	16.22	64.50	8.06
Group 09	Upper Cretaceous (Middle Turonian)	Claise Valley (Indre-et-Loire)		X				3	2.03	42.00	5.25
Group 10	Upper Cretaceous (Upper Turonian)	Claise Valley (Indre-et-Loire)				X		1	0.68	12.90	1.61
Group 11	Upper Cretaceous (Upper Turonian)	Brignon Valley (Indre-et-Loire)		X				2	1.35	22.30	2.79
Group 12	Upper Cretaceous (Turonian)	Claise Valley (Indre-et-Loire) ?				?		2	1.35	18.10	2.26
Indeterminate	undocumented	undocumented						6	4.05	4.50	0.56
Total								**148**	**100.00**	**800.60**	**100.00**

Geotope origin	Poitou		Cher Valley			Touraine					North-West Massif Central ?	
Type	**Group 08 - Angoulême region**	**Group 01 - Angoulême region**	**Group 04 - Cher Valley**	**Group 07 - Cher Valley**	**Group 02 - Cher Valley**	**Group 09 - Claise Valley**	**Group 03 - Claise Valley**	**Group 10 - Claise Valley**	**Group 11 - Brignon Valley**	**Group 12 - Claise Valley**	**Group 05 - North Massif Central**	**Group 06 - North Massif Central**
Primary stratigraphic origin	Upper Cretaceous (Turonian)	Upper Cretaceous (Coniacian)	Upper Cretaceous (Lower Turonian)	Upper Cretaceous (Lower Turonian)	Cenozoic (Eo-Oligocene)	Upper Cretaceous (Middle Turonian)	Upper Cretaceous (Upper Turonian)	Upper Cretaceous (Upper Turonian)	Upper Cretaceous (Upper Turonian)	Upper Cretaceous (Turonian)	Cenozoic (Eo-Oligocene)	Cenozoic (Eo-Oligocene)
Type of silicite	closed plateform marine flint near the barrier	inner (closed ?) plateform marine flint	external open plateform marine flint	external open plateform marine flint	pedogenetic silcrete	inner (open ?) plateform marine flint	inner closed plateform marine flint	inner closed plateform marine flint, near the shoreline	inner closed plateform marine flint	inner closed plateform marine flint	palustrial pedogenetic silcrete	palustrial pedogenetic silcrete
primary color(s)	grey to black	grey to black	grey	grey	grey	undeterminate and black	grey	green	grey to black	undeterminate	undeterminate	grey
acquired color(s)	brown	brown	blonde	blonde	blonde	orange to brown	brown	brown	brown	brown	undeterminate	blonde
Porogenesis	vuggy (-) and interparticle (o)	x	intraparticle (o)	x	intraparticle and channel	intraparticle	x	interparticle	interparticle and vuggy	x	x	channel
Poronecrosis	filled by amorphous or fibrous silica	x	filled by FeO oxides	x	linned by translucent silica	clogged by translucent silica	x	left empty	clogged with automorphic quartz	x	x	clogged with translucent silica
Structure	homogeneous to bioturbated	homogeneous to bioturbated	homogeneous	homogeneous to hetrogenous (even bioturbated)	homogeneous to bioturbated	homogeneous	homogeneous	homogeneous	homogeneous and zoned	homogeneous	bioturbated	bioturbated
Allochems (abundance) (%det ; %chi ; %bio)	50 % (75 to 50%, 10 %, 25 to 50 %)	≈ 30 % (75%, 10%, 15%)	< 10% (25%, 10%, 75 to 90%)	< 10% to 40% depending on the zone (10%, 0%, 90%)	< 20 % (80%, 20%, 0%)	≈ 50% (75%, 0%, 25%)	≈ 40% (10%, 60%, 30%)	30 to 40% (50%, 50%, 10%)	20 to 30% (40%, 20%, 40%)	< 10% (70%, 0%, 30%)	< 20% (100%, 0%, 0%)	< 20% (100%, 0%, 0%)
Sorting of clasts	well sorted	well sorted	undeterminable	undeterminable	very well sorted	well sorted	well sorted	very well sorted	well sorted	well sorted	well sorted	well sorted
Distribution of clasts	heterogenous	homogeneous	homogeneous	homogeneous	homogeneous	homogeneous	homogeneous	homogeneous	homogeneous	homogeneous	homogeneous	homogeneous
Type of allochems	multiple		biogenic	biogenic	detrital	multiple	multiple	detrital	multiple	multiple	detrital	detrital
authigenic minerals	< 50 microns (+++) ; pyrite (o)	50 to 200 microns (+++)	x	x	x	50 to 200 microns (+++)	x	x	x	< 50 microns (++)	x	x
Detrital component	quartz grains (o), glauconite (-), black volcanic minerals (o)	quartz grains (+) ; black volcanic minerals (o)	quartz grains (-), white and black exoclasts (-)	quartz grains (---), white exoclasts (---)	quartz grains (++)	quartz grains (+) ; glauconite (o)	quartz grains (o), clay exoclasts (-)	quartz grains (+++), glauconite (+++), initially carbonate clasts (-)	quartz grains (o), glauconite (o), initially micritic clasts (o)	quartz grains (o)	quartz grains (o) ; white undeterminate clasts (o)	black volcanic clasts (o)
Shape of detrital clasts	sp. 0,7-0,9 ; arr. 0,7-0,9	sph. 0,5-0,7 ; arr. 0,7-0,9	sph. 0,7-0,9 ; arr. 0,9	sph. 0,7 ; arr. 0,9	sph. 0,7-0,9 ; arr. 0,9	sph. 0,5-0,7 ; arr. 0,9	sph. 0,7-0,9 ; arr. 0,5-0,7	sph. 0,5-0,9 ; arr. 0,7-0,9	sph. 0,7-0,9 ; arr. 0,5-0,7	sph. 0,7, arr. 0,5-0,7	sph. 0,5 ; arr. 0,5	sph. 0,7-0,9 ; arr. 0,9
Average size of detrital clasts	100 to 200 microns	50 to 100 microns	< 100 microns	< 100 microns	50 to 100 microns	< 100 microns	100 microns	150 microns	100 microns	100 microns	50 to 200 microns	50 to 200 microns
Chemical component	pelloids (200 microns) (-)	pelloids (200 microns) (---)	pelloids 200 microns (---)	x	vadoids (> 500 microns) (-)	x	pelloids (150 to 200 microns) (+++)	pelloids (150 to 200 microns) (+++)	pelloids (150 to 200 microns) (+)	x	x	x
Algae	dasycladaceae (o)	lithopyllum (o)	x	x	x	dasycladaceae (-)	dasycladaceae (-)	x	x	dasycladaceae (-)	x	x
Echinoids	plates and spikes (o > +++)	plates and spikes (o)	plates and spikes (+)	spikes (---)	x	plates and spikes (-)	x	x	x	x	x	x
Bivalves	fragments of shell (+)	fragments of shell (-)	fragments of shell (o)	fragments of shell (-)	x	fragments of shell (-)	fragments of shell (o)	fragments of shell (-)	x	x	x	x
Gastropods	x	x	x	x	x	x	x	x	x	x	x	x
Sponges	Hexactinnellids: monaxones (o) ; triaxones (-)	Hexactinnellids: monaxones (o) ; triaxones (-)	Hexactinnellids: monaxones (o) ; triaxones (o) or fused (o)	Hexactinnellids: monaxones (+) ; triaxones (+) or fused (+)	x	Demosponges : monaxones (o)	Demosponges : monaxones (o)	Demosponges : triaxones (-)	Demosponges : monaxones (o)	Demosponges : monaxones (-)	x	x
Bryozoans	cheilostomes (---)	x	cheilostomes (o)	x	x	x	cheilostomes (-)	x	cheilostomes (o)	cheilostomes (-)	x	x
Benthic foraminifera	Textularideae (o) ; Rotalideae (o) ; Miliolideae (---)	Textularideae (-) ; Rotalideae (o) => juvenile forms	Rotalideae (o)	x	x	x	Textularideae (o) ; Miliolideae (++)	x	Textularideae (o)	Textularideae (o) ; Miliolideae (o)	x	x
Planktonic foraminifera	x	x	Globorotalideae (o)	Heterohelicideae (o), Globorotalideae (o), Hedbergellideae (o)	x	x	x	x	x	x	x	x
Ostracoda	x	x	x	x	x	x	x	x	x	x	x	x
Organic material	x	x	x	x	x	x	x	x	x	x	x	x
Other(s)	isolated worms tubs (-) ; *Incertae sedis* (o)	Incertae sedis (+ > +++)	fish vertebra (o) ; colonial worms tubs (o)	fish vertebra (-) ; colonial worms tubs (-)	tubular roots (o)	x	x	x	Incertae sedis (o)	x	worm-shaped forms (o)	roots (o)

	Type of blank							Generic category of tools			Mode of introduction on the site					Anomaly inferred from the previous data
Type	Core	Flake	Blade	Bladelets	Burin spall	Debris	Retouch flakes	Retouched products	Hunting point	Domestic tool	unshaped block	already shaped cores	blank	finished product	indet.	missing products
Groupe 01	-	**7**	**17**	**15 (10lp)**	**21**	**2**	**5**	**5rb+1rf**	**1bb**	**1s+6b**	-	**(for blades ?)**	**Blades**	**Retouched pieces**	-	**Bladelets cores + Burin du Raysse**
Groupe 02	-	**1**	0	**1**	-	-	-	-	**1tb**	**1b**	-	-	-	**tool + hunting point**	-	-
Groupe 03	-	-	**4**	-	**1**	-	-	-	-	**1b**	-	-	**Blades**	-	-	**Burin spall ?**
Groupe 04	-	**1**	**8**	**2**	-	**1**	-	**1t+1rb**	**2rbl**	**3b + 2s**	-	-	**(Blades ?)**	**Retouched pieces**	-	-
Groupe 05	-	-	-	**1**	-	-	-	-	**1rbl**	-	-	-	-	**Retouched bladelet**	-	-
Groupe 06	-	-	-	**1 (1lp)**	-	-	-	-	-	-	-	-	**Bladelet**	-	-	-
Groupe 07	-	-	-	**1**	**1**	-	**2**	-	**1rbl**	**1b**	-	-	**Blade**	-	-	-
Groupe 08	-	-	**7**	**1**	**9**	**2**	**1**	-	-	**2b**	-	-	**Blades**	-	-	**Burin ?**
Groupe 09	-	**1**	**2**	-	-	-	-	**1t**	-	-	-	-	**Blades**	-	**?**	-
Groupe 10	-	-	-	-	-	**1**	-	-	-	-	-	-	-	-	**?**	-
Groupe 11	-	**1**	**1**	-	-	**1**	-	-	-	**1b**	-	-	-	**Burin + flake**	-	**Burin spall ?**
Groupe 12	-	-	**1**	-	-	-	-	-	-	**1b**	-	-	-	**Burin**	-	**Burin spall ?**