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The Grain de mil flint, a key resource from south-western France during the Palaeolithic: Characterization and determination criteria in archeological contexts

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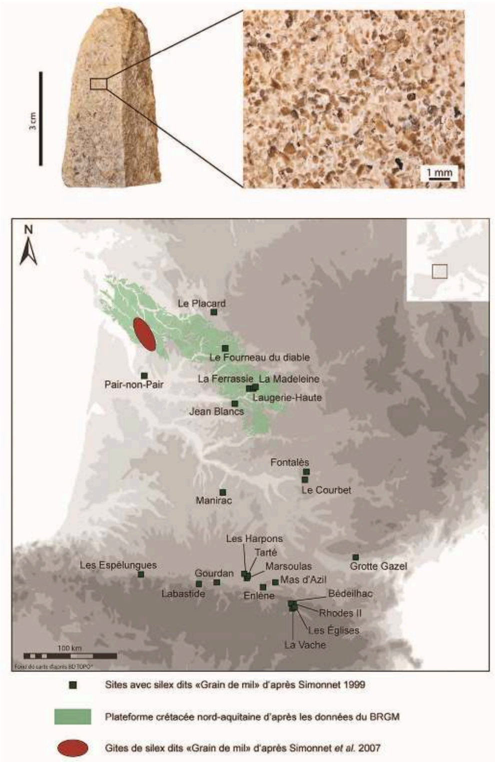
Introduction

1 A territory is defined as a geographic area where a society expresses its cultural identity through its relationship with the environment (Godelier 1984; Bourgeot 1991). The diversity of siliceous materials and their geological and geographic origin was considered at an early stage as an effective means of reconstructing the procurement territories of Palaeolithic groups (*e.g.* Lartet and Christy 1865-1875; Boule 1892; Vayson de Pradenne 1938; Bordes and Sonneville-Bordes 1954). Over the past decades, methodological advances in the study of siliceous rocks have led to the emergence of a new discipline: petroarchaeology (Stelcl and Malina 1970; Masson 1981). In association with typological, then technological analyses, the determination of the origin of lithic materials proposed, particularly in the southwest of France, the first territorial models for the Upper Palaeolithic, centred on the diffusion of local and regional flint in the north of Aquitaine, such as the Bergeracois flint (*e.g.* Guichard 1965; Guichard and Guichard 1966; Combaz 1966; Demars 1980, 1994). Broader knowledge of the resources

throughout the basin then led to a revision of these first models, and brought to light the diffusion of materials over greater distances, showing connections between the north and the south of this region, particularly during the early Aurignacian (*e.g.* Bordes, Bon, Le Brun-Ricalens 2005; Bon, Simonnet, Vézian 2005). However, in all these works, the list of objects of non-determined origin is still considerable. Among these, one type of material was identified in the 1980s but its outcrop area has never been documented: the so-called "Grain de mil" flint[1].

2 This material was mentioned for the first time by R. Simonnet to describe the raw material of one of the four blades found in the Magdalenian cache of Mas-d'Azil Cave in Ariège (Simonnet 1982). R. Simonnet described "the abundance of fossils discernible with the naked eye" which "have a millet grain aspect", leading to the name (fig. 1). Based on this macroscopic description, the so-called "Grain de mil" flint was subsequently identified in many sites throughout the Aquitaine basin (fig. 1), particularly during the Aurignacian and the Magdalenian (Simonnet 1982, 1999). The fact that it was diffused over a vast geographic area, and the quality and dimensions of the blocks estimated from the archaeological remains show that this was an exceptional resource, in the same way as the Bergeracois flint, in terms of its properties and its management (Simonnet 1999). Indeed, it was often used for making large blades or very retouched tools. In spite of this considerable technical and economic investment, the origin of this raw material has never been identified. When the raw material was identified, a first hypothesis was advanced: the Upper Cretaceous, or even the Danian of the west of the north Aquitaine carbonate platform (Peybernès cited in Simonnet 1985). The discovery of outcrops in the sector of Jonzac confirmed this hypothesis and resulted in the attribution of this material to the Coniacian or Santonian stages (Bordes 2002; Primault 2003; Airvaux, Berthet, Castel 2003; Simonnet *et al.* 2007). Nonetheless, it has also been suggested that other similar types of flint may exist in the sector of Saintes or in Dordogne (Morala, Lenoir, Turq 2005). The outcrop area of the so-called "Grain de mil" flint thus remains poorly identified. In addition, the determination criteria in an archaeological context have not yet been clearly defined and this flint is still mainly identified by its macroscopic aspect.

Figure 1 - Grain de mil.



a. Weathered Grain de mil: the numerous fossils suggestive of millet grain ("grain de mil"); b. Map of Grain de mil diffusion during the Upper Palaeolithic.

3 This history of research shows that three major questions need to be addressed through a petroarchaeological study of the "Grain de mil" flint:

1. What is the definition of the "Grain de mil" flint and how can it be recognized in an archaeological context as part of a techno-economic study: do the flints described up until now as "Grain de mil" flint always refer to the same material and the same sites?
2. Where was this material collected from during the Palaeolithic (outcrop area, type of deposits): does the Grain de mil flint only outcrop in Charente, or in other parts of north Aquitaine?
3. What properties of this flint (knapping quality, dimensions and shapes of the blocks) could have driven the selection and diffusion of this material?

4 In this article, we will first of all expound the methodological choices in relation to our aim: carrying out a petroarchaeological study of the Grain de mil flint, to be used as a basis for the techno-economic analysis, taking into account all the objects of an archaeological collection. We will then present the results and interpretations of our study in detail: geological origin, petrographic variability, variability of the blocks, outcrop area and contexts, determination criteria in archaeological contexts.

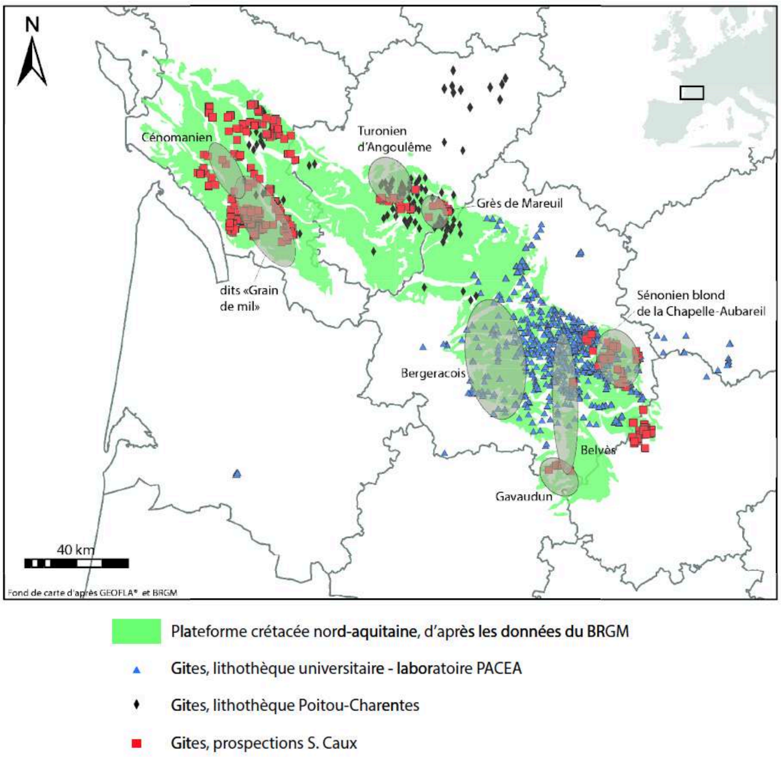
1 - Material and method

1.1 - Studied samples and prospection

5 First of all, we studied the "Grain de mil" flint from Charente-Maritime. As no petroarchaeological study of this material had been carried out up until now, the

existing lithothecas only contain rare samples (fig. 2), namely the Poitou-Charentes lithotheca (Delagnes *et al.* 2005) and the university lithotheca of the PACEA laboratory. These sparse samples are not sufficient for a study of the variability of this resource. In addition, in the absence of samples from primary outcrops, the geological origin is difficult to identify. Therefore, we conducted new prospections (Caux 2015), in primary and secondary alterite type outcrops, in order to specify the age and the context of the formation, as well as the petrographic (concerning the siliceous phase) and macroscopic variability (the shape and dimensions of the blocks) (fig. 2). The studied area includes previously known outcrops situated in the alterites of Coniacian and/or Santonian stages of the sector of Jonzac (Bordes 2002; Primault 2003; Airvaux, Berthet, Castel 2003; Simonnet *et al.* 2007), and extending until the sector of Saintes (Morala, Lenoir, Turq 2005).

Figure 2 - Origin of the studied samples.



6 In the second stage, in order to propose an effective identification key of the Grain de mil flint in archaeological contexts, the so-called "Grain de mil" flints from Charente-Maritime were compared to the other macroscopically similar flints from the north Aquitaine Cretaceous platform. There are lacunae in the Poitou-Charentes and PACEA lithothecas for some sectors for which the geological maps indicate similar limestones to the Grain de mil source rock. We thus based our comparative study not only on the samples from these lithothecas, but also on those from new prospections in order to identify all the similar types of flint to the Grain de mil flint (fig. 2).

7 During prospections, outcrop location was plotted using the topographic IGN map (Institut Géographique National) at 1/25000. The local geological context (type of outcrop and characterization of the surrounding limestones for primary outcrops) was noted in the field. The regional geological context was inferred from comparing field

observations with the BRGM (Bureau de la Recherche Géologique et Minière) geological maps at 1/50000. All of the data were processed with the ArcGis software (coordinate system: Lambert 93). All the collected samples were washed and marked (single outcrop number and sample number at the outcrop). All of the samples were deposited at the PACEA laboratory at the end of our research in order to complete the university lithotheca.

1.2 - Petrographic and petrological analysis of the samples

1.2.1 - Choice of a methodology and analysis tools adapted to our problem

8 Different methodological tools are used in petroarchaeology, each of which presents its own advantages and limits. They can be grouped into four categories: three of them are based on principles, methods and tools borrowed respectively from mineralogy, geochemistry and sedimentology, whereas the fourth is strictly empirical and involves macroscopic observation (*e.g.* Masson 1981; Séronie-Vivien and Séronie-Vivien 1987; Grégoire 2001; Bressy 2002; Fernandes 2012). The aim of our study is to propose an identification method for the Grain de mil flint allowing us to combine petroarchaeological and techno-economic data, i.e., a method applicable to the whole archaeological collection (Caux 2015). The different mineralogical and geochemical analyses cannot be systematically applied and are thus incompatible with the study of a whole collection: the measurements take too long, some of the analyses are destructive, the complex and expensive equipment is adapted to sporadic analyses but not to the study of an archaeological collection.

9 A sedimentological analysis based on the observation of samples at low and medium magnification thus seems to be the best adapted methodology to the petrological study of flint, as already proposed by M.-R. and M. Séronie-Vivien (1987), as part of the study of Mesozoic flint from primary outcrops. This method was elaborated for the petrological study of limestone; as flint is considered to be an epigenesis of these rocks (preserving the structures at a microscopic scale), the sedimentological analysis is still one of the most widely used methods by petroarchaeologists (*e.g.* Fernandes 2012; Tomasso 2014; Delvigne 2016). Nonetheless, before systematically applying this method to the study of flint, it is important to bear in mind four factors limiting its direct and integral transfer to the study of the siliceous raw materials used during the Palaeolithic.

10 First of all, the type of source rock differs because the sedimentological analysis was implemented for the study of limestone, which invalidates the use of certain classifications, such as, for example, that of Folk (1959). In fact, this classification is based on the type of matrix; a sedimentary rock is referred to as "micrite" for a limestone matrix and "sparite" for a recrystallized cement, for example siliceous. Following epigenesis, the matrix (or cement) and grains are generally replaced by silica, which makes Folk's classification unusable for flint.

11 Secondly, some of the analyses applied to limestone samples in sedimentary geology require sample destruction during preparation or observation phases, which is generally not possible in the scope of a petroarchaeological study. This is the case for example for the micropaleontological study based on the external or internal observation of fossils, particularly for foraminifera: the combination of all of the external (pores, protuberances, spines, etc.) and internal (layout of the cells, foramen

and partitions) characteristics allows for the determination of the species (*e.g.* Neumann 1967). For the observation of external criteria, geologists dissolve the limestone in order to study the residual microfossils. The internal criteria are observable on specific sections of fossils (longitudinal, axial, passing through the umbilicus, etc.); geologists thus multiply the number of thin sections for each sample in order to increase the probability of observing certain characteristics. Therefore, an archaeological sample, and *a fortiori* a lithic collection, cannot be studied as geological samples using these different analytic methods: the petroarchaeologist must make do with the fossil sections observed at random on the knapped surfaces, which determine the rate of precision of taxa determination.

12 Thirdly, the tools used for the study of limestones are petrological tools, that is, they allow for the interpretation of the genesis of limestone (age and facies) based on observation. Yet, the description of flint in petroarchaeology involves a dual objective: identifying the geological origin of the material (which is similar to the sedimentological analysis of the limestones) but also allowing for the determination of the material in an archaeological context. For this second objective, the global interpretation of the sedimentary facies is not sufficient: the most detailed petrographic description possible is required, allowing for the specific diagnostic criteria of the studied material, particularly in the case of convergent facies. The methodological tools used in sedimentology are thus not adapted. In this way, for example, the Dunham classification allows us to interpret the deposition energy of sediments based on the quantity of grains in four main categories: mudstone (less than 10 % of grains), wackestone (more than 10 % of non-joined grains), packstone (non-joined grains but presence of matrix), grainstone (joined grains with no matrix) (Dunham 1962). However, once they are epigenized, packstone and grainstone can be mixed up: in one case the matrix is epigenized, in the other a siliceous cement fills the inter-granular spaces. In addition, siliceous accidents in high energy environments are rare (grainstone and packstone limestone; Séronie-Vivien and Séronie-Vivien 1987) and by definition mudstone limestones only present very few grains and therefore few diagnostic criteria. We can thus conclude that almost all the flints for which the sedimentological analysis may be effective are in the "wackestone" category. The advantage of this classification in petroarchaeology is thus very limited.

13 Lastly, the transfer of the study methodology from limestones to flint is based on flint formation modes: after epigenesis, flint is a true image of the source rock. Yet this applies to the formation of flint (even in primary outcrops), and this image of the source rock may be modified after the evolution of flint in the different deposits (Fernandes and Raynal 2006; Fernandes 2012). Indeed, depending on the outcrop conditions, the mineralogical composition varies and tends to form increasingly voluminous crystals, which, in time, destroy the image of the grains and therefore of the source rock initially conserved during epigenesis (Folk 1959, 1965; Lasemi and Sandberg 1984; Munnecke 1997). For the most evolved flint samples (colluvium and alluvion contexts, in particular), the percentage of grains cannot thus be directly interpreted in terms of the deposition energy at the time of the formation of the surrounding limestone. Therefore, it is not appropriate to apply Dunham's classification to these elements. The percentage of grains, compared to Dunham's classification, thus only provides petrological information when the flint is not very evolved (primary deposits, even alterites). Nonetheless, the quantity of grains is still a descriptive characteristic, and can be used to identify a raw material: it is more fitting

to state it in percentage classes, and not following Dunham's classification. Another frequently used criterion in sedimentology is the shape of the grains. For bioclasts of more than 2 mm, blunting and rounding can be correlated to the transport and energy of the deposit along the platform (Pilkey *et al.* 1967). In the same way, different classifications allow us to interpret the shape of the quartz grains in the loose rocks in terms of deposit environments (Krumbein 1941; Powers 1953; Folk 1955; Krumbein and Sloss 1979). None of these classifications is adapted to the description of grains in flints which are only rarely silicified sands and in which there are very few bioclasts of more than 2 mm.

14 These four arguments highlight the need to adapt each methodological tool borrowed from sedimentology to the study of flint. This adaptation also involves the use of a rigorously chosen vocabulary. After that, geological and sedimentological terms are always preferentially used. When a term is not strictly adapted to the study of flint, another will be proposed and explained in order to avoid confusion.

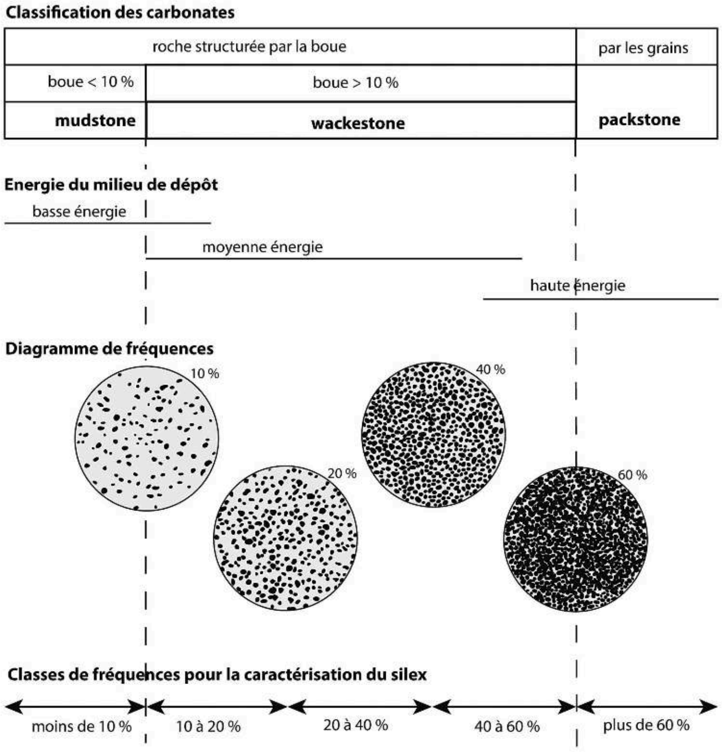
1.2.2 - Organization of the siliceous phase

15 The organisation of the siliceous phase refers to the term "structure" used during the study of limestone formations. The structure of a carbonated rock is characterized by different sedimentary figures observable with the naked eye (Demicco and Hardie 1994). Some of these large-scale figures (at the scale of an outcrop) are not visible at the centimetric scale of a block of flint. In addition, others are characteristic of the history of limestone during the late phase of diagenesis (*e.g.* compaction phenomena), whereas the epigenesis of limestone by silica occurs in the early phase of diagenesis (*e.g.* White and Corwin 1961; Baronnet 1988): thus these sedimentary figures do not exist in flint. The revision of the classification of the structures of carbonated rocks in view of the description of flints led us to reserve the term structure for its significance and current use; therefore the term "organization" seems to be preferable for the study of flint. Only the types of structures likely to have been conserved during epigenesis and visible at the scale of a centimetric sample have been retained: figures of stratification (stratified organization or with oriented grains) and deformation (volutes and mixing of phases). Homogeneous organization (absence of sedimentary figures) and heterogeneous organization were added to these types of organization (the siliceous phase is not identical in all aspects but does not present any directly interpretable sedimentary figures in terms of deposition conditions).

1.2.3 - Quantity of grains

16 In R. Dunham's classification, texture is the relationship between the quantity of grains and the quantity of liaison phase; this relationship is directly dependent on the energy in the limestone formation milieu (cf. *above*; Dunham 1962). The flint in the studied samples (primary deposits and alterites) is not very evolved, and the correlation between the percentage of grains observed and the energy of the deposition milieu is thus justified. However, the use of a graphic chart for frequency estimation (Baccelle and Bosellini 1965) is preferable to Dunham's classification, as it results in a more accurate description of the proportion of grains. There are more classes based on this graphic chart than in Dunham's classification, but they can be compared to the latter in order to infer the energy of the formation milieu of the flint (fig. 3).

Figure 3 - Graphic chart for the estimation of the proportion of grains in the flint, and correlation with Dunham's carbonate classification.

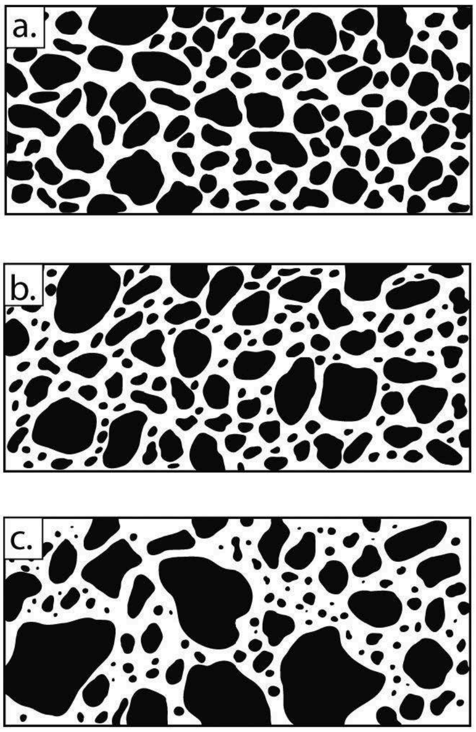


Modified after Dunham 1962 and Bacelle and Bosellini 1965.

1.2.4 - Sorting and transport mode of grains

17 The size of a grain contained in a carbonated rock depends on the transformations (fragmentation, blunting) resulting from transport and deposition conditions, which affect the grains differently depending on their type and initial size. The modes of transport are characteristic of the different sedimentary facies; the analysis of the size of the grains thus enables us to infer the formation zone along the platform. Many parameters are calculated and measured to describe the size of the grains in a limestone rock (*e.g.* Flügel 2004), and the most widespread of these, mode and sorting, were retained. The mode is the average diameter of the most frequent grain: it is estimated on the basis of about twenty measurements and the size classes are given according to the logarithmic scale of Wentworth (1922), where the following classes were considered for the study of flint: 125 – 250 µm; 250 – 500 µm; 500 µm – 1 mm; 1 – 2 mm; greater than 2 mm. The elements less than 125 µm were assimilated to the matrix as their internal structure is too modified by epigenesis and the recrystallisation of the flint during its evolution to be systematically characterized. Sorting refers to the distribution of the different sizes around the average (fig. 4); it is estimated using a graphic chart (Pettijohn, Potter, Siever 1973).

Figure 4 - Graphic chart for the estimation of grain sorting.



a. very good sorting; b. average sorting; c. poor sorting.
After Pettijohn *et al.* 1973.

1.2.5 - Type of grains

18 Generally, non-biotic grains comprise four main types with different natures and integration phases in the siliceous matrix (cf. Flügel 2004 and Fernandes 2012 for a summary):

- the carbonated grains form in carbonated mud depending on the sedimentation milieu conditions and their internal and external morphology point to a specific environment; for example, peloids, ooliths, etc.;
- the detrital elements indicate a terrigenous contribution and are present in carbonated mud; the most frequent is quartz although we can also find feldspars and micas;
- syn-sedimentary and diagenetic minerals form in carbonated mud when the latter is deposited or during diagenesis, such as iron oxides and glauconite;
- other minerals are integrated in flint during geochemical exchanges between the latter and its environment in different secondary outcrops; the most frequent of these are iron oxides.

19 Therefore, non-biotic grains do not all signify the same phenomena. Each of them can participate in the description of a sample. However, the formation of a flint facies is mainly characterized by carbonated and detrital grains.

20 Biotic grains are all the micropaleontological elements observable under the stereomicroscope, the optical microscope and the scanning electron microscope. This includes a wide range of very varied grains such as Foraminifera, Sponges, Bryozoans, Crinoids and Echinoderms (Bignot 2001; Horowitz et Potter 1971; Flügel 2004). Determinations were based on general morphological criteria, then described in detail

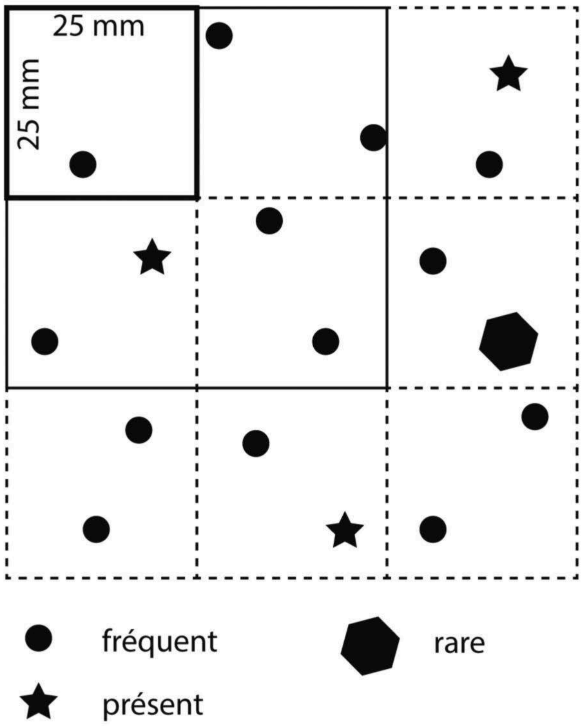
for the best represented groups such as, for the Grain de mil flint, Bryozoans (e.g. Stach 1936; Buge 1960; Moissette and Saint Martin 1995; Zagorsek and Kroh 2003; Smith, Key, Gordon 2006) and Foraminifera (Neumann 1967; Bilotte 1985; Loeblich and Tappan 1988; Bignot 2001). The characterization of Bryozoans was based on the classification of zoarial forms directly correlated with the growth environment of the colony (Stach 1936; Reguant et al. 1985), for which the criteria are observable in section, that is, in the siliceous phase of the knapped flints in an archaeological context. For foraminifera, we first of all characterized the fossils into broad, but ecologically significant groups. As well as giving an indication of the flint formation facies, this first description can be used as an identification key as it is based on general criteria that do not necessitate any particular fossil section. We then refined these determinations as much as possible in order to bring to light stratigraphic fossils providing information on the formation age of the flint. The classification used is that of the The World Foraminifera Database (Hayward et al. 2014) and the main characteristics were distinguished based on the descriptions of R. Loeblich and H. Tappan and G. Bignot (Loeblich and Tappan 1988; Bignot 2001).

1.2.6 - Frequency of each type of grain

21 The nature and relative importance of the different constituents of a carbonated rock characterize the associations of grains denoting environments with different deposits. It is difficult to count each type of grain as this depends on the total percentage of grains in the sample. Geologists quantify each type of grain either by a relative classification of abundance (rank 1 being the most represented grain type until rank 4, including all the other grains present), which requires large observation surfaces to estimate the frequency of each type of grain, or direct measurements with image-processing software (*e.g.* Flügel 2004). Therefore, neither of these methods is completely appropriate for the study of siliceous materials in archaeological contexts.

22 The study methodology for the Grain de mil flint has thus been adapted, including a semi-quantitative estimation of the frequency of each type of grain. The aim of this quantification is two-fold; on one hand, determining all the types of grains and quantifying them to characterize the sedimentary facies and the age of the formation; on the other hand, determining the types of grains that can be used for raw material identification in archaeological contexts. This second objective is restricted by the dimensions of the archaeological objects: at the moment, the objects are systematically recorded when they are over 2-3 cm on average, depending on the sites. A target with three meshes was thus implemented: “frequent”, “present”, “rare” (fig. 5). This target is independent of the overall proportion of grains, which limits estimation errors. A type is considered to be “frequent” if we can observe at least one grain in each 25 by 25 mm area, chosen randomly on the surface of the object. A type is “present” if we can observe at least one grain in each 50 by 50 mm area. A type is “rare” if we observe less than one grain per 50 by 50 mm area. There is no exact correspondence between the dimensions of the listed objects and the proposed target. In addition, the grains are not always distributed homogeneously in the siliceous phase, which modifies the evaluation of their frequency. Nonetheless, as the basic mesh corresponds to a 25 by 25 mm area, the “frequent” grains should in theory be observable on all the objects recorded at the excavation.

Figure 5 - Graphic chart for the estimation of grain frequency.



Frequent: observable once per 25x25 mm²; present: observable once per 50x50 mm²; rare: observable less than once per 50x50 mm².

1.2.7 - Analysis of the sedimentary facies

1.3 - Estimation of the Palaeolithic gathering area

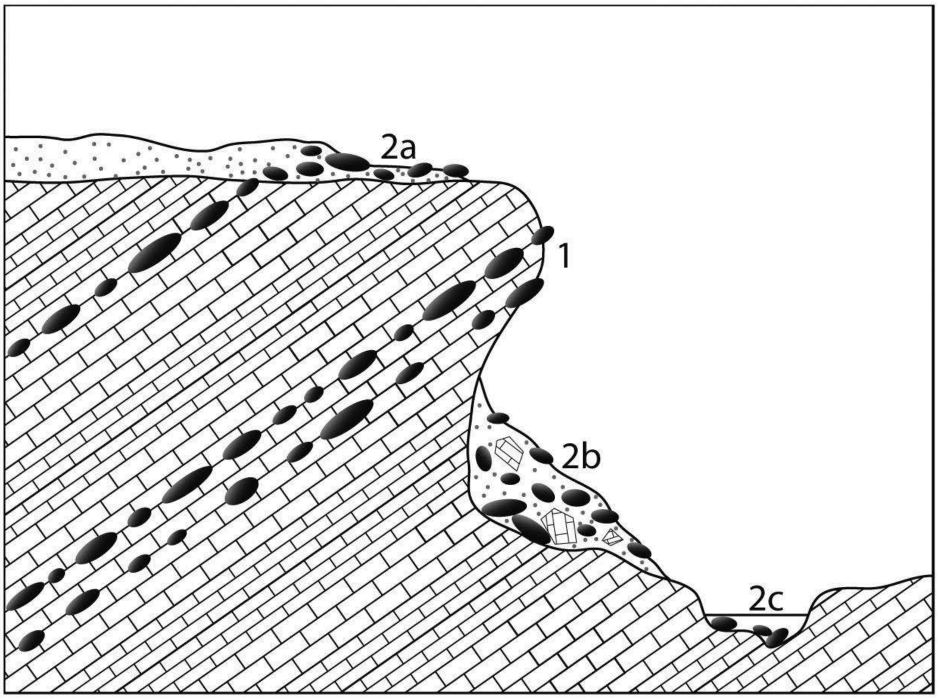
23 The limestones formed in marine environments during the Cretaceous are emerged today in the present-day Aquitaine Basin. The different geomorphological (folds, faults, erosion) and hydrographic processes resulted in different types of flint outcrops: primary deposits and secondary alterite type deposits, colluviums, alluvions (Turq 1992, 2000; fig. 6). The samples studied were collected from primary deposits and secondary alterite type deposits. These deposits are not representative of the whole distribution area of these resources: *a priori,* current access to the deposits does not allow for the exhaustive identification of all the potential Palaeolithic gathering places. In addition, the colluvium and alluvion zones were not prospected. We thus proposed a theoretical estimation of the Grain de mil outcropping areas and contexts. For that, the different samples were virtually placed in their geological (BRGM 1 / 50 000 map) and topographic context (IGN 1 / 25 000 map) using the ArcGis Geographic Information System. First of all, the stratigraphic and tectonic data were combined to infer the maximum area of flint outcrops in primary sites and alterite contexts. Then, the topographic data (namely the river system) were included, with the watersheds delimiting the catchment areas and the direction of the water courses to define the areas of flint diffusion by the alluvial network.

24 By extrapolation, we thus proposed hypotheses of Grain de mil flint gathering areas and methods during the Palaeolithic, at the scale of the catchment basin.

1.4 - Statistic test of the determination criteria: Factorial analysis of mixed data

25 In order to propose an identification key in archaeological contexts, the efficiency of the criteria used for the sedimentological description was tested using a factorial analysis of mixed data (Pagès 2004). This analysis enabled us to compare samples characterized by quantitative (proportions of grains, mode, sorting) and qualitative data (organization of the siliceous phase). These tests were carried out with the R software and the FactoMineR package (Husson *et al.* 2015). For each analysis, the following criteria were compared: the organisation of the siliceous phase, the overall proportion of grains, the mode and sorting of grains and the proportion of the different types of grains. Only the variables for which differences between at least two samples were observed were considered for each test.

Figure 6 - Geological context of primary and secondary flint outcrops.



1. Primary outcrops; 2. Secondary outcrops: 2.a. alterites; 2.b. colluvial deposits; 2.c. alluvial deposits.
Modified after Turq 2000.

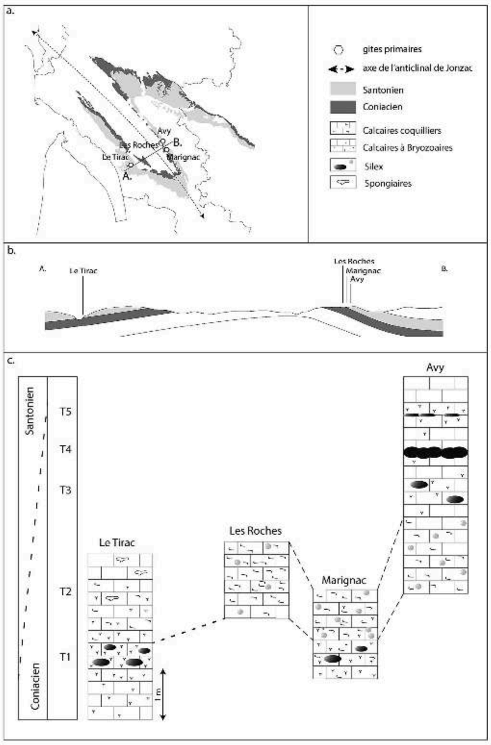
2 - Results and interpretations

2.1 - Study of samples from primary deposits

26 After prospections of the Coniacian and Santonian stages, four primary deposits were referenced (fig. 7). The comparison of the characterization of the surrounding limestones and the position of the deposits with the map and the geological notice (Moreau *et al.* 1976) allow us to attribute the studied silicification events to the

Coniacian – Santonian transition. The study of the limestones and flints established a correlation between the different stratigraphic logs: at Marignac and Roches, the lumachel with oysters, characteristic of the Upper Coniacian on the northern slope of the anticline of Jonzac, is visible. Five silicification events formed between the Upper Coniacian and the Lower Santonian were brought to light by the stratigraphic analysis.

Figure 7 - Location and stratigraphic logs of primary outcrops.



Geological profile modified after Moreau *et al.* 1976
Map modified after www.infoterre.fr (BRGM).

27 Twelve samples representing five different types, subsequently named T1 to T5, were collected from primary deposits (tab.1; fig. 8). Type T1 is related to a medium to high energy formation on account of the homogeneous organization of the siliceous phase, the high quantity of grains, good to medium sorting and the presence of fragmented erect Bryozoans. Types T3 and T5 also present fragmented erect Bryozoans but present a lower proportion of grains, medium to poor sorting and a heterogeneous organization of the siliceous phase (even volute deformation figures, mixing phase type): they can be related to medium energy deposit environments. Lastly, types T2 and T4 are related to low energy environments with deeper deposits: low quantity of grains, medium to poor sorting and rare, not very fragmented Bryozoans. Therefore, types T2 and T4 do not correspond to the definition of the Grain de mil flints. On the other hand, types T1, T3 and T5 are directly related to this definition. From a macroscopic viewpoint (tab.1), type T5 presents thin plaquettes forming a discontinuous bed of brown flint, whereas types T3 and T1 are regular blocks of brown to black flint in the centre, and can be over 20 cm long.

Table 1 - Description of flint types from primary outcrops.

Type	T1	T2	T3	T4	T5
Nombre d'échantillons	3	5	2	1	1
Blocs	nodules ; jusqu'à 30 cm	nodules ; moins de 20 cm	nodules ; moins de 20 cm	banc continu ; 20 cm de haut en moyenne	plaquettes en banc discontinu ; moins de 10 cm de haut en moyenne
Aspect macroscopique		gris clair, opaque		noir, semi-translucide	
Organisation	homogène	homogène	homogène à hétérogène	homogène	hétérogène à homogène
Proportion de grains	40 à 60 %	moins de 10 %	20 à 60 %	moins de 10 %	20 à 40 %
Mode	250 - 500 µm	125 - 250 µm	250 - 500 µm	125 - 250 µm	250 - 500 µm
Tri	bon à moyen	moyen à mauvais	bon à moyen	moyen	bon à moyen
Contenu	Bryozoaires présents à abondants très fragmentés ; rares foraminifères benthiques	Spicules de Spongiaires présents ; Bryozoaire présents à rares, peu fragmentés	Bryozoaires présents à abondants très fragmentés ; rares foraminifères benthiques	Spicules de Spongiaires présents ; Bryozoaire rares	Bryozoaires présents à abondants très fragmentés ; rares foraminifères benthiques
Environnement de dépôt	Haute à moyenne énergie	Moyenne à basse énergie	Moyenne à haute énergie	Moyenne à basse énergie	Moyenne énergie

28 First of all, it is important to note that the results from the analysis of the flint in primary deposits do not concur with the results from research into the local geology (Moreau *et al.* 1976). These latter works do not mention any silicification in the Coniacian levels. In addition, many siliceous accidents are mentioned in the Santonian complex, but this whole stage is characterized by fine limestones, rich in sponges, formed in deep low-energy environments. The high-energy facies of the “Grain de mil” flint are generally present in zones near the littoral (backwash), or in elevations along the platform (barrier, sand bank). The Coniacian-Santonian transition limestones of Saintes at Cognac, located upstream of the Jonzac anticline along the carbonated platform, prove the existence of low-energy environments in this zone (Moreau *et al.* 1976; Platel 1977; Bourgueil and Moreau 1967, 1969). The high and medium-energy limestones and flint (including Grain de mil flint) formed beside the anticline thus indicate a slope anomaly of this platform which could now be considered as a ramp platform (*e.g.* Platel 1987, 1996). This anomaly could be the consequence of minor marine transgression/regression events influencing the water level and thus the deposit environment of the sediments. But such events are not recorded elsewhere on the platform for the Coniacian-Santonian transition. It is thus more likely that these variations are directly imputable to the surrection of the anticline: the variation in the water level due to the formation of the fold would have resulted in a variation in energy and thus in limestone and flint formation conditions just below this tectonic structure.

2.2 - Study of the samples derived from alterites

29 In alterite contexts, 85 secondary deposits were referenced for which 94 samples corresponding to the “Grain de mil flint” definition were collected (cf. T1, T3 and T5 in

primary deposits) based on a first observation with the naked eye and a geologist's lens (x 20) of the organization and the quantity of grains. Among these samples, we distinguish a continuous variability between three types of sedimentary facies: high-energy facies ("HEF" hereafter), medium-energy facies ("MEF" hereafter) and volute facies (VF) (tab.2; fig. 9). These three facies, and in particular the high and medium-energy facies, are related to deposit environments presenting conditions varying gradually from one facies to another: the observed continuity in the flint samples is thus coherent from the point of view of the sedimentary analysis.

Figure 8 - Flint types from primary outcrops.

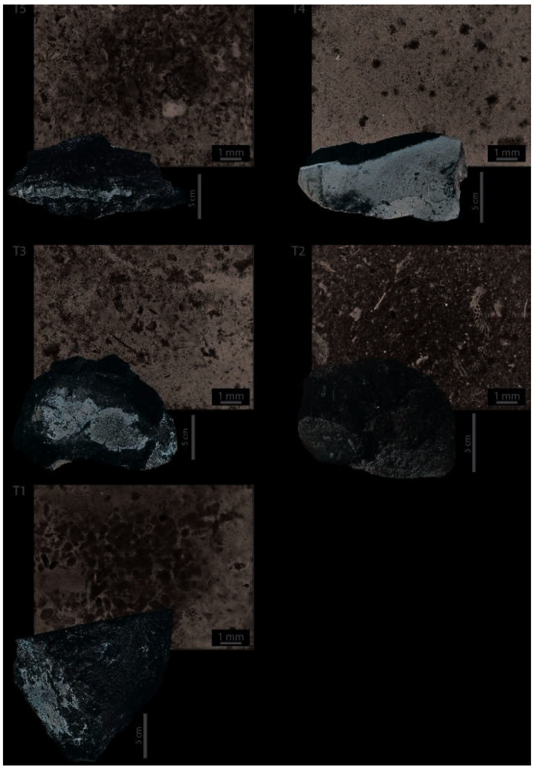
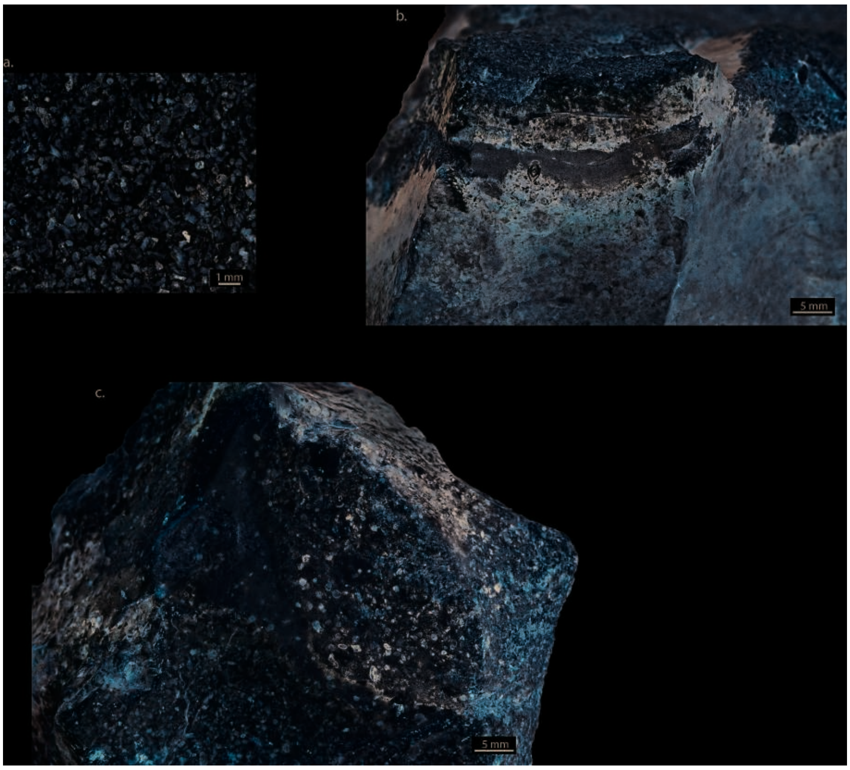


Tableau 2 - Description of flint types from secondary outcrops (alterites).

Groupe	Faciès de Haute Energie	Faciès de Moyenne Energie	Faciès à Volutes
Nombre d'échantillons	30	57	7
Organisation	Homogène	Homogène à hétérogène sans figure sédimentaire	Hétérogène à figures types volutes (mélange de phases)
Proportion de grains	40 à 60 %	20 à 60 %	20 à 60 %
Mode	250 – 500 µm	250 – 500 µm	250 – 500 µm (rarement dans la classe 125 – 250 µm)
Tri	Bon à moyen	Moyen à mauvais	Moyen à mauvais
Contenu	- Bryozoaires présents à abondants très fragmentés - Rares foraminifères benthiques (*Textulariidés*, *Nonionidés*, *Miliolidés*)	- Fragments de Bryozoaires présents à rares peu fragmentés - Rares foraminifères benthiques (*Textulariidés*, *Nonionidés*, *Miliolidés*)	- Fragments de Bryozoaires présents à rares peu fragmentés - Rares foraminifères benthiques (*Textulariidés*, *Nonionidés*, *Miliolidés*)

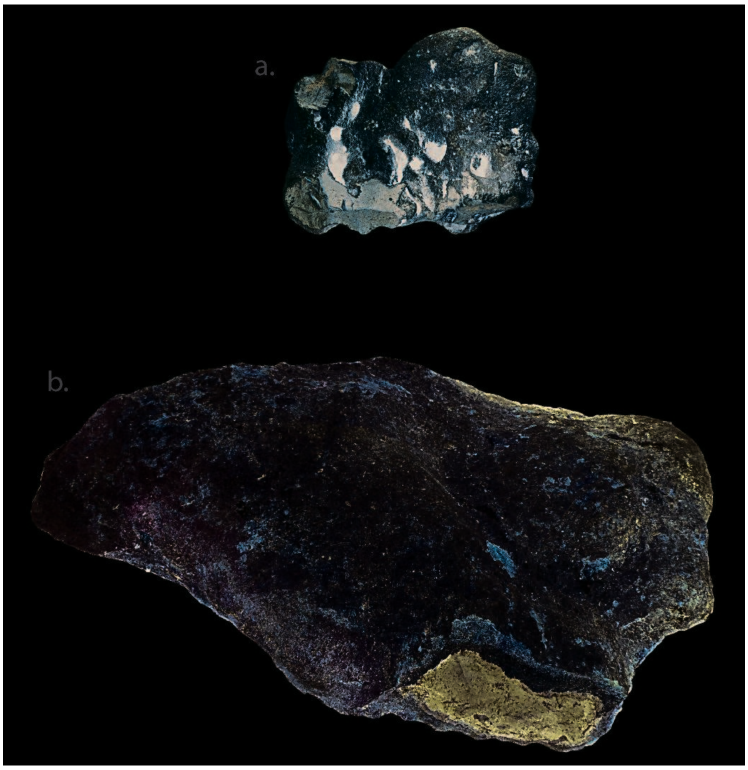
Figure 9 - Grain de mil flint variability.



a. homogeneous organization from middle to high energy deposit facies; b. and c. heterogeneous organization and volute-like figures.

30 Only 42 of the “Grain de mil” flint samples enabled us to evaluate the dimensions and the morphology of the blocks (fig. 10). We note high morphological variability, including slabs (with two subparallel surfaces) and regular nodules (with spherical to oblong shapes), as well as blocks with convolutions (block with no specific shape, with several folds indicating a complex silica/limestone interface). No branched blocks were observed, with shapes generally interpreted as burrow filling (Séronie-Vivien and Séronie-Vivien 1987). There is a clear correlation between the morphologies and the facies groups (fig. 11; tab.3). Group HEF is only represented by slabs and regular nodules, whereas the VF group is linked to blocks with convolutions. The samples from the MEF group (intermediary facies) are generally slabs and regular nodules, but can also contain several blocks with convolutions.

Figure 10 - Grain de mil nodule variability. a. volute facies: irregular nodule about 20 cm; b. high energy deposit facies: regular slab about 60 cm.



31 The dimensions of the “Grain de mil” flint sample blocks are also very variable (tab. 4; fig. 11). The dimensions were estimated by the classes: less than 20 cm / 20 to 40 cm / more than 40 cm. The samples from the VF group are mostly small and rarely medium-sized. The HEF and MEF are preferentially medium to large, although there are also several small blocks.

Figure 11 - Geographical distribution of Grain de mil nodules per size and facies.

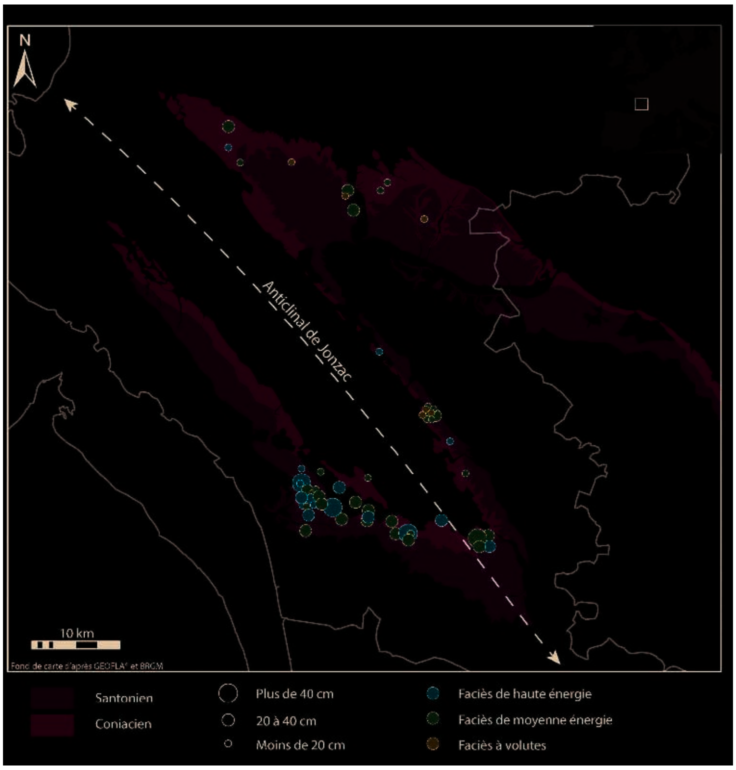


Table 3 - Grain de mil nodule count per shape and facies.

Groupe de faciès	Dalle et rognon	Circonvolution	Fragments indéterminés	TOTAL
FHE	12	0	18	30
FME	25	7	25	57
FV	0	5	2	7
TOTAL	37	12	45	94

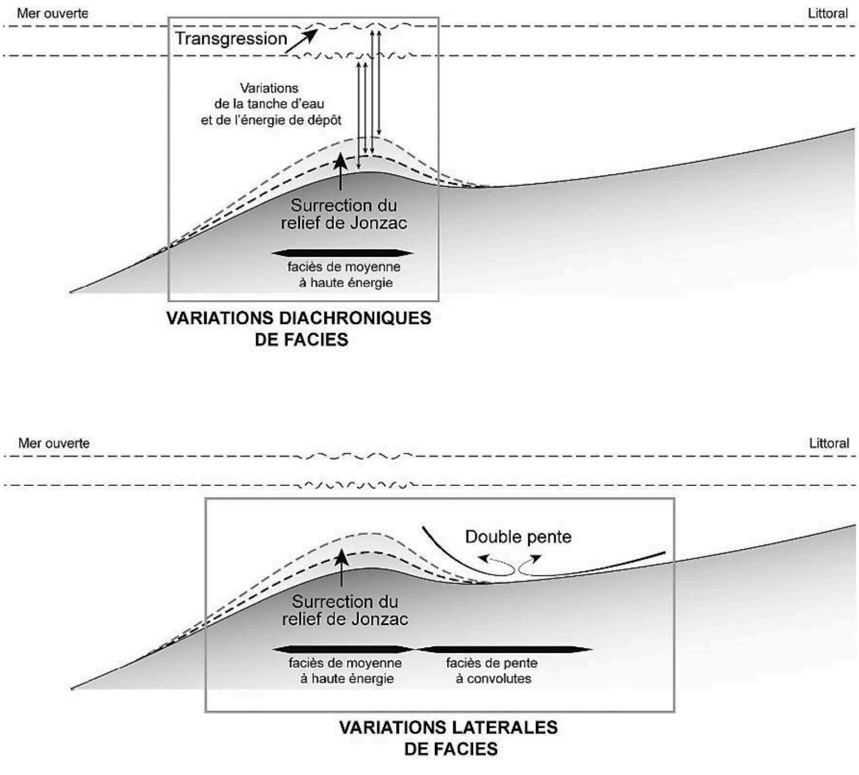
Table 4 - Grain de mil nodule count per size and facies.

Groupe de faciès	Moins de 20 cm	20 à 40 cm	Plus de 40 cm	Fragments indéterminés	TOTAL
FHE	7	7	3	13	30
FME	16	17	1	23	57
FV	6	1	0	0	7
TOTAL	29	25	4	36	94

32 The geographic distribution of the samples derived from alterites (fig. 11) shows that the samples from the VF group stand out as they all come from the northeast side of the Jonzac anticline, and to a lesser extent, from the northwest of the Saintes syncline. However, the distribution of the flints from the HEF and MEF groups is similar, extending over both sides of

33 the Jonzac anticline, and the extreme northwest of the Saintes syncline. This area thus partly overlaps that of the VF group. This geographic distribution may be the consequence of lateral facies variations, a once off silicification event resulting in the epigenization of the limestones of different facies along the platform. However, the analysis of the primary deposits shows that types T1, T3 and T5 all belong to "Grain de mil" flint groups and shows that there were at least three silicification events. The "Grain de mil" flints thus refer to different types of flint formation linked to the surrection of the Jonzac anticline. We can propose that the different types in this family present a continuous variability due, on one hand, to lateral facies variations along the slope, and, on the other hand, to diachronic facies variations directly imputable to the conjunction of tectonic movements (surrection of the fold) and the marine transgression (fig. 12). Indeed, the blocks with convolutions and volute facies are all located on the northeast side of the Jonzac anticline. In this area, the side of the fold shows a (very slight) inverse slope in relation to the general slope of the platform (fig. 12). It thus seems that even minor elevations in the ocean bed influenced the formation modes of silicification, creating volute figures indicating the mixing of phases.

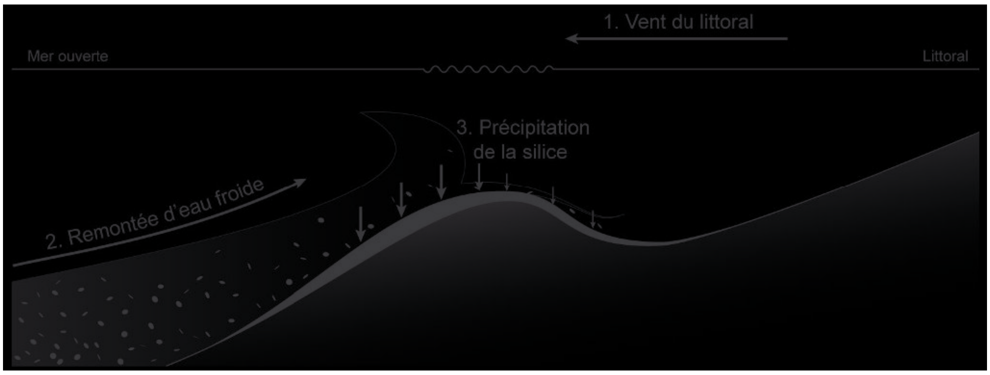
Figure 12 - Hypothesis for interpreting variations in Grain de mil flint facies from Charente-Maritime.



34 We also note that the geographic distribution of the samples from the HEF and MEF groups varies according to the dimensions of the blocks (fig. 11). The average and large-sized blocks are almost systematically situated on the southwest side of the Jonzac anticline, whereas only small, and rarely medium-sized blocks are present on the northeast side. This observation tends to confirm the hypothesis of the formation mode of marine flint in up-wellling zones (Séronie-Vivien and Séronie-Vivien 1987): the flint would result from the up-welling of cold water rich in silica, along the carbonated

platform where new pressure/temperature conditions would lead to the precipitation of silica (fig. 13). In the case of Grain de mil flint, the southwest side of the Jonzac anticline is directly exposed to the open sea and therefore to the upwelling of siliceous waters indispensable for the formation of flint nodules.

Figure 13 - Hypothesis for the formation of Grain de mil flints around the Jonzac anticline.



35 All of these observations (petrographic variability of facies groups, block dimensions and morphology, spatial distribution) enable us to subdivide the “Grain de mil” flint family into two types. The first type, the Jonzac Grain de mil, regroups middle and high-energy facies groups and is characterized by regularly-shaped blocks of medium and large dimensions, preferentially located on the southwest side of the Jonzac anticline. Experimental knapping provided more information on the qualities of the Jonzac Grain de mil: the homogeneous material and the fine grain allow for rigorous debitage control and produce sturdy cutting edges (J.-G. Bordes, A. Turq, M. Lenoir, P.-J. Texier, E. Claud, pers. com.). This is thus an excellent quality material. The second type, the Grain de mil from Saintes, corresponds to the volute facies group and is thus characterized by irregular blocks of small to medium dimensions, which are only present on the northeast of the anticline, at the Saintes syncline. From a macroscopic point of view, the siliceous part of the Saintes Grain de mil presents the same characteristics as that of the Jonzac Grain de mil: homogeneous fine-grained material (in spite of the mixing of phases and volutes). Nonetheless, the morphology of the block restricts the usable parts to very small volumes (less than 20 cm, even less than 10 cm on average).

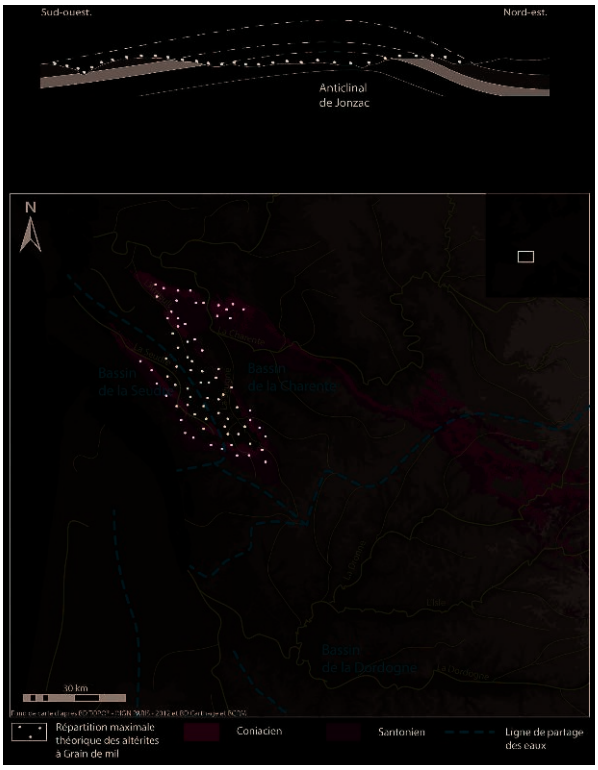
36 The distinction between these types is directly based on the shape and dimensions of the blocks. Yet, these two parameters could have been selection criteria during the Palaeolithic, particularly during the production of large blades. The observation of objects in Grain de mil flint in an archaeological context, and particularly in Magdalenian sites in the Pyrenees, led to a comparison of this material to the Bergeracois flint, based on block dimensions and knapping aptitude (Simonnet 1999). The characteristics of the Grain de mil flint, and especially the Jonzac type, seem to confirm this hypothesis.

2.3 - Outcrop context and Palaeolithic gathering area

37 The Jonzac anticline is now eroded, outlining the Charente-Maritime topography (fig. 14). Erosion hollowed out the anticline, leaving alterites made up of residues of limestone dissolution. Among these alterites are Grain de mil flints, potentially present

below the Lower Santonian, Coniacian and Turonian stages, outcropping in the centre of the anticline. The heart of the Saintes syncline is not eroded and potential Grain de mil flints could be buried deep down in the Coniacian-Santonian transition stages. The latter only outcrop on the edge: at the anticline/syncline limit (= northeast side of the anticline), on the northeast side of the syncline and the northwest end of the syncline (Bourgueil and Moreau 1969; Moreau *et al.* 1976; Platel 1977). The extent of the outcropping area of the alterites from the Coniacian-Santonian transition extends to Saujon; nonetheless, our prospection did not enable us to sample "Grain de mil" flints beyond Grézac. In this zone, Eocene sands cover the alterites (Berger and Ternet 1968; Marionnaud and Dubreuilh 1972), making the flint inaccessible today.

Figure 14 - Geological diffusion of Grain de mil flints in secondary outcrops: alterites, colluvial and alluvial deposits.



a. Jonzac anticline erosion and alterites and Grain de mil distribution; b. river system that could remobilize Grain de mil nodules from alterites.

Geological profil modified after Moreau *et al.* 1976.

38 These alterites were partly reworked by the river system of the different catchment basins. Considering the low overall elevation of the zone, the colluvium and alluvion contexts were assessed through a study of the catchment areas, based solely on the study of the river system (fig. 14). The sediments of the Jonzac anticline are mainly drained by the Seudre, along a southeast/northwest axis parallel to the fold. The river flows up to Saujon in the northwest, where it flows into the Atlantic Ocean. The southeast end of the anticline is drained by the Seugne at Jonzac, an affluent of the Charente, which reverses its course towards the north around Pons, and leaves the fold. In the centre of the Saintes syncline, the Charente and its affluents drain the sediments from east to west until Saintes where the course of the river is inversed and leaves the fold; it also flows into the Atlantic Ocean, around Rochefort. The northwest end of the

syncline is drained towards the northwest by the Arnoult, which joins the Charente at the northwest of the fold. Thus, we differentiate two main catchment areas: the Seudre basin draining the sediments from the southwest side of the Jonzac anticline, and the Charente basin including the northeast of the Jonzac anticline. The Seudre basin is limited to the Jonzac anticline. The Charente basin is wider and extends to the east and the north across the departments of Charente, Vienne and Haute-Vienne, where its source is located.

39 The study of the geological context brings to light a difference between two zones: The southwest side of the Jonzac anticline, which is part of the Seudre catchment basin, and the northeast side of the anticline, as well as the northwest end of the Saintes syncline, which is part of the Charente catchment basin. Around the Seudre, there are large zones of alterites containing Grain de mil flint from Jonzac, present as large slabs or regular nodules. The low relief of this zone does not allow us to infer accessible colluvium type deposits during the Palaeolithic. However, we note the presence of small water gaps through which the rivers cross the Santonian, then Coniacian stages, before joining the Seudre River (Moreau *et al.* 1976). These contexts are conducive to exposing blocks of flint. On the other hand, around Charente, the outcropping areas in alterite contexts are mainly located west of Saintes, and to a lesser extent at the limit of the two folds. In these deposits, there are two types of Grain de mil flint (Jonzac and Saintes) but they are only present as medium to small blocks with convolutions. These two zones thus denote very different outcropping modes in terms of geographic areas and the quality of the resources (dimensions and morphologies of the blocks).

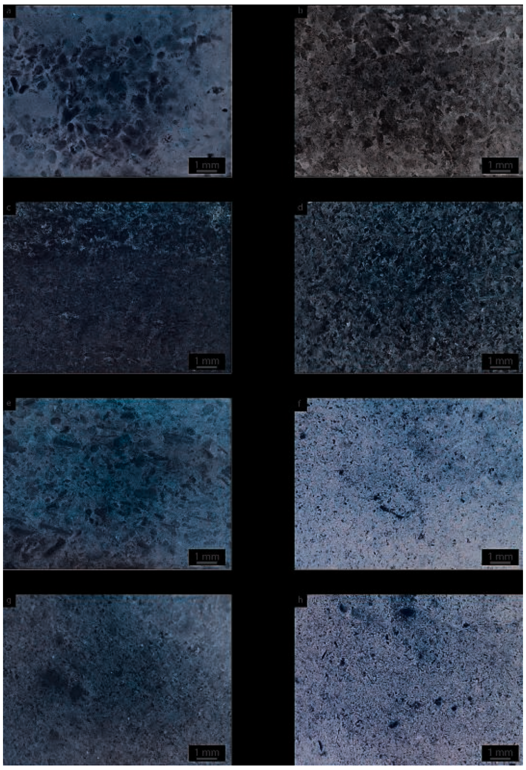
2.4 - Criteria for identifying the Grain de mil flint in archaeological contexts

40 The Grain de mil flint is thus characteristic of present-day Charente-Maritime. Nonetheless, similar flints may have formed in other environments along the north Aquitaine Cretaceous platform. Therefore, we compared the flints with similar facies to the Grain de mil flint. In order to do so, we studied the following types: Belvès, Bergeracois packstone, the Cenomanian from Charentes, Senonian blond from La Chapelle-Aubareil, Gavaudun, silicified sandstone from Mareuil and the Turonian from Angoulême (fig. 15). The petrographic analysis tends to prove that, for each type, one or several criteria from the sedimentological study enable us to differentiate the Grain de mil flint from the Charente-Maritime flints (tab.5). Statistical tests confirmed these results and therefore proved the validity of these criteria for the determination of the Grain de mil flint (fig. 16). Three discriminating criteria are recurrent:

- **organization**: volute type figures are characteristic of the Grain de mil from Saintes; several rare Grain de mil samples present oriented grains but never display stratification which is systematic for the Cenomanian and Turonian types from Angoulême;
- **mode**: the 250 – 500 µm mode seems to be characteristic of the Grain de mil flint; most often the other types present grains with a lower average diameter; the silicified grains from Mareuil can also present grains in this class (250 – 500 µm) but the type of the grains (frequent quartz grain) is also decisive;
- **absence of quartz**: quartz was observed in all the types in variable proportions (frequent to rare), apart from the Grain de mil type, and with variable shapes (detrital quartz grains

rounded or not from 125 to 500 µm). Nonetheless, very rare quartz grains were observed in the Grain de mil samples from the northeast side of the anticline.

Figure 15 - Grain de mil and other Cretaceous flint types from the north Aquitaine platform with convergent facies.



a. Grain de mil; b. Cenomanian flint; c. Turonian flint from Angoulême; d. silicified sandstone from Mareuil; e. Bergeracois packstone flint; f. black Santonian flint from la Chapelle-Aubareil; g. Gavaudun flint; h. Belvès flint.

Figure 16 - Factorial Analysis of Mixed Data showing the validity of the Grain de mil group.

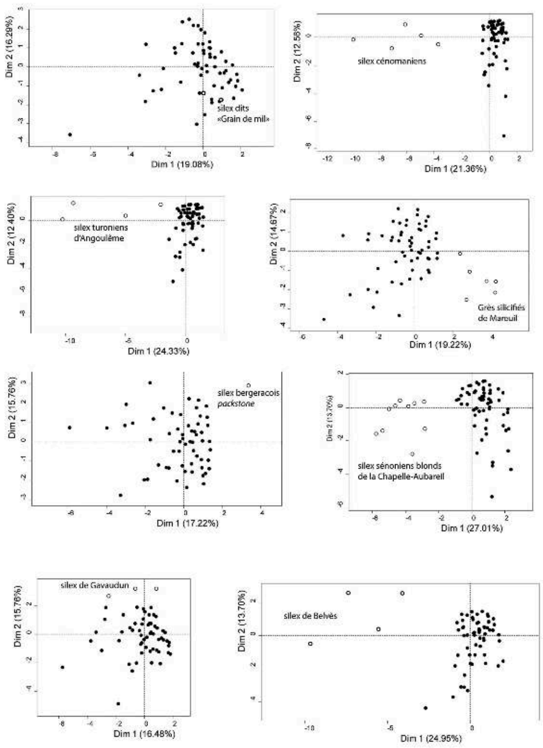


Table 5 - Petrographic description of Grain de mil and comparison with other Cretaceous flint types from the north Aquitaine platform with facies convergences. In red: the distinctive criteria for each group in comparison to the Grain de mil flint. The number of samples is indicated for each reference collection: S. Caux (SC), Poitou-Charentes (PCh) and PACEA (PACEA).

Groupe	Grain de mil Et dits « Grain de mil »	Cénomanien	Turonien d'Angoulême	Grès silicifié de Mareuil	Bergeracois « *packstone* »	Sénonien blond de la Chapelle-Aubareil	Gavaudun	Belvès
Nombre d'échantillons	94 (SC) Et 1 (PCh) + 1 (PACEA)	3 (SC) + 1 (PCh)	2 (SC) + 2 (PCh)	6 (SC)	1 (PACEA)	12 (SC)	3 (PACEA)	4 (PACEA)
Organisation	Homogène à hétérogène voire à figure de pente	Lité	Lité	Homogène	Homogène	Homogène	Homogène	Homogène
Proportion de grains	40 à 60 voire 20 à 40 %	20 à 40 voire 40 à 60 %	20 à 40 voire 40 à 60 %	40 à 60 % voire plus de 60 %	40 à 60 %	5 à 20 voire 20 à 40 %	40 à 60 % voire plus de 60 %	5 à 20 voire 20 à 40 %
Mode	250 – 500 µm	250 – 500 µm	125 – 250 µm	125 – 500 µm	125 – 250 µm	125 à 250 µm	125 à 250 µm	125 à 250 µm
Tri	Bon à mauvais	Bon à moyen voire mauvais	Bon	Moyen	Bon	Bon	Moyen voire mauvais	Bon à moyen voire mauvais
Contenu	- Fragments de Bryozoaires fréquents à présents voire rares (érigés rigides et articulés) - *Textulariidés* rares - *Nonionidés* rares - *Miliolidés* (*Nummofallotia cretacea*) rares	- Fragments de coquille de Mollusque présents - Grains de quartz détritiques rares à présents - Spicules de Spongiaires rares	- Grains de quartz détritiques présents à rares - Spicules de Spongiaires rares - Fragments de Bryozoaires rares (érigés rigides)	- Grains de quartz détritiques fréquents - Fragments de Bryozoaires rares (érigés rigides) - Fragments de coquille de Mollusque rares	- Grains de quartz détritiques présents - Fragments de Bryozoaires rares (érigés rigides)	- Quartz (125 µm) présents - *Miliolidés* rares à présents (tests peletonés, enroulement uni- et biloculaire) - Spicules de Spongiaires rares - Fragments de coquille de Mollusque rares	- Quartz (125 µm) fréquents - Fragments de Bryozoaires présents à rares (érigés rigides et articulés) - Fragments de coquille de Mollusque rares	- Quartz (125 µm) présents - Fragments de Bryozoaires rares à présents (érigés articulés) - Spicules de Spongiaires rares - *Rotalidés* rares - *Textulariidés* rares

41 The absence of detrital quartz in the Grain de mil seems to be characteristic whereas these grains are present in the majority of the other types from the platform, and particularly the Dordogne types. This can be explained by the proximity of the source rocks of these types to the Massif Central; on the other hand, the Grain de mil flints are a long way from the Massif Central and the Armorican Massif, which limits detrital inputs. Very rare quartz grains were observed in the Saintes type: this type is located

on the northeast of the anticline, i.e., on the littoral side. The southwest side, situated on the seaward side, would be protected from detrital inputs by the relief of the fold. The presence or absence of quartz could thus be a particularly effective criterion for identifying the Grain de mil quartz in an archaeological context.

3 - Discussion

3.1 - Determination of the Grain de mil flint

42 This study shows that the Grain de mil flint comprises a group of silicification events directly linked to the Jonzac anticline. The comparison between the Grain de mil flint from Charente-Maritime and the flint from the north Aquitaine Cretaceous platform with similar facies shows that the determination of the Grain de mil flint in archaeological contexts is statistically valid: based on characteristics observable with the stereomicroscope, we can distinguish this material from the other flints, namely those from Charente and Dordogne.

43 However, in spite of the different prospections, certain types of flint similar to the Grain de mil flint have not yet been discovered. In the same way, only several samples for each type have been studied, which does not reflect the overall variability of each type: some blocks on the fringes of the observed variability could present more similarities with the Grain de mil flint. Lastly, this study is based on siliceous rocks from the north Aquitaine Cretaceous platform; it is nonetheless probable that there are similar types of flint to the Grain de mil in the Jurassic stages, and/or in other carbonated platforms.

44 The study proposed here tends to prove that a detailed description based on sedimentological analysis can be sufficient to discriminate the Grain de mil flint in archaeological contexts. This has been brought to light in particular for the main types of flint used during the Palaeolithic in the Aquitaine Basin, such as the Senonian blond, the flint from Gavaudun and Belvès, the Turonian flint from Angoulême, as well as the Bergeracois packstone variety.

45 In spite of the continuous variability of the Grain de mil between three groups of sedimentary facies, the correlations between the shape and dimensions of the blocks and groups of facies bring to light tendencies distinguishing the Jonzac type and the Saintes type. Only the volute figures can distinguish the Saintes type with certainty. In archaeological contexts, these figures are not systematically observable, particularly on objects of small dimensions. In addition, the determination of sub-types is insufficient for inferring the provenance in terms of catchment areas (Seudre or Charente), as the outcropping area of the Jonzac type overlaps with the Saintes type. Nonetheless, this study shows that between the Seudre and Charente basins, the resources present different qualities in terms of block dimensions and morphology. The distinction between the Jonzac and Saintes types should thus enable us to discuss selection modes, provisioning areas and circulation during the course of the Palaeolithic.

3.2 - Methodological point

46 Our study of the Grain de mil flint was mainly based on the sedimentological study principles implemented for limestone rocks, and we discussed each methodological tool

in order to propose an analysis adapted to flint and to archaeological studies. We proposed an identification key of the Grain de mil flint; the criteria used are observable in archaeological contexts, including for the techno-economic study of procurement areas. This identification key is mainly based on objectively defined and quantifiable criteria. It should thus enable us to reduce the inter-observer identification variability for this material. The high proportion of grains and the frequency of Bryozoan fragments should allow for the almost systematic identification of objects more than 2 cm long.

47 Nonetheless, not all of the siliceous raw materials exploited during the Palaeolithic present as many observable elements: the sedimentological study alone is not adapted to materials with few grains such as flint from mudstone chalks. Other methods, such as sedimentological analysis, are used in petroarchaeology, but they are not adapted to the study of a collection: they are generally only applied to a selection of objects for specific analyses. The advantage of these studies is that they bring detailed information on procurement zones, nonetheless the observation of several objects restricts the study to the identification of a provisioning zone on the basis of the presence/absence of certain materials. Today, it is essential to combine petroarchaeological and techno-economic data in order to reconstruct selection modes, circulation, processing rates and modes of each resource. In order to process all the data from specific analyses as well as possible, the sorting carried out before these studies must be as rigorous as possible, based on objective criteria. It is thus essential to establish identification keys based on observation with the naked eye or with low magnification, in order to carry out techno-economic studies of the lithic collections.

Conclusion

Grain de mil flint: assessment of a resource

48 The petroarchaeological analysis of the Grain de mil enabled us to complete our understanding of the raw materials from the Aquitaine Basin, namely for Charente-Maritime, which had not been studied in detail up until now. This study showed that the formation of Grain de mil is linked to the Jonzac anticline as its formation is closely linked to the surrection of this structure during the Coniacian-Santonian transition. Two Grain de mil types can be differentiated: the Jonzac type, present as large slabs and regular blocks mainly on the southwest side of the fold, and the Saintes type, with smaller and irregular blocks only on the northeast side, at the limit of the Saintes syncline.

49 In an archaeological context, the observation of the siliceous phase allows for the identification of Grain de mil flint and differentiates it from the other materials from the north Aquitaine platform. The main discriminating criteria from the sedimentological analysis are the organization of the siliceous phase (homogeneous or with volute type figures, never stratified), grain dimensions (250 – 500 µm), the presence of Bryozoan fragments and the absence of detrital quartz. All of these criteria result in the determination of this material. The distinction between the Jonzac and Saintes types is mainly based on the organization of the siliceous phase, the Saintes type presents volute type figures whereas the Jonzac type shows homogeneous

organization. This macroscopic criterion is not always observable in archaeological contexts, particularly for small-sized objects.

50 Nonetheless, knowledge of the outcropping modes of this resource and of its variability (namely the variability of blocks: shape and dimensions) allows us to discuss procurement modes and the selection of Palaeolithic materials.

51 It is important to consider that the Grain de mil category should be limited to the objects and blocks fitting the criteria specified here. Consequently, formerly studied collections should be reassessed in order to clarify the counts of this material.

52 But regardless of this reassessment, we can confirm that the systematic presence of materials from Charente in the archaeological collections of sites all over the Aquitaine basin should be used as a basis to renew our analysis of the circulation of Palaeolithic groups in this region.

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NOTES

1. In the rest of this article, the term *Grain de mil* will be reserved for characterized flint types clearly identifiable in archaeological contexts. On the other hand, the term so-called *Grain de mil flint* will refer to all the flints corresponding to the present bibliographic definition of the type: abundant grains including Bryozoan fragments (Peybernès *in* Simonnet 1985). This term thus refers to geological samples included in this broad definition, as well as to archaeological samples identified up until now in the bibliography.

ABSTRACTS

Land use patterns are typically used to describe Palaeolithic hunter-gatherer nomadic groups. Due to the methodological development of petroarchaeology, in south-western France in particular, this region is one of the best documented European areas in terms of siliceous resources. But one major unknown still needs to be addressed: the characterization and origin of the so-called "Grain de mil" flint, a common raw material that has never been properly described and sourced even though it has been identified in archeological contexts over a very extensive area. In order to address this issue, we first approach the question of the lithic raw material analytical method: the sedimentary petrographic description remains the best approach to directly include petrological data in a petro-techno-economical study. We then present the results of the Grain de mil study: this material is typical of Charente-Maritime as its formation is linked to the Jonzac anticline. It forms a flint group comprising two types (Jonzac and Saintes), mostly differing with regard to outcrop location, and nodule size and shape. In archeological contexts, criteria observable with a binocular microscope are sufficient to distinguish the Grain

de mil from other north Aquitaine Cretaceous materials with abundant grains, particularly regarding their organization and pattern, and the absence of quartz grains.

INDEX

Keywords: Grain de mil flint, petroarchaeology, south-western France, sedimentological analysis

AUTHORS

SOLÈNE CAUX

Laboratoire PACEA - UMR 5199 B18, allée Geoffroy St-Hilaire, CS 50023 – FR-33615 Pessac Cedex - solene.caux@gmail.com

JEAN-GUILLAUME BORDES

Laboratoire PACEA - UMR 5199 B18, allée Geoffroy St-Hilaire, CS 50023 – FR-33615 Pessac Cedex