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New data on the exploitation of flint outcrops during the Middle Palaeolithic: the Mousterian workshop of Chêne Vert at Dirac (Charente, France)

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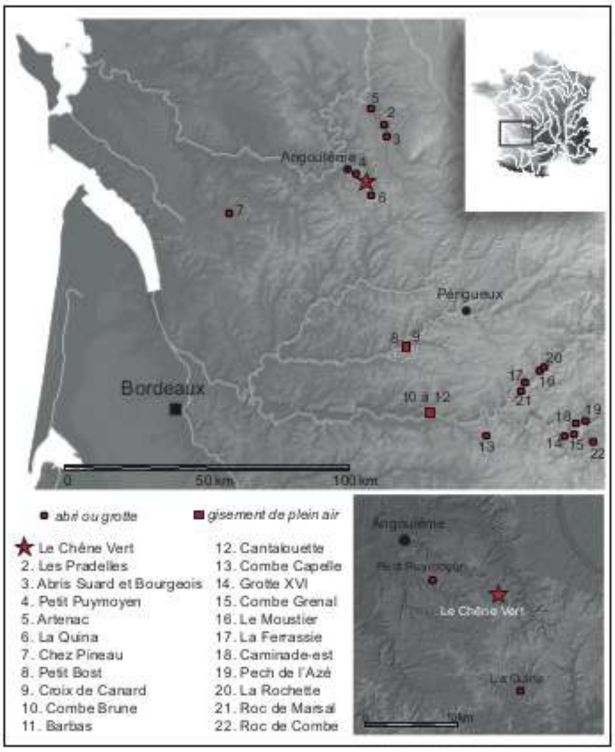
1 - Introduction

1 Although there are many known open-air Mousterian sites in the south-west of France (e.g., Jaubert 2010b and 2012; Vieillevigne *et al.* 2008), the occurrence of Middle Palaeolithic workshops located directly on raw material outcrops remains rare. The Charente has a considerable Palaeolithic record resulting from a long history of research in the region (*e.g.* Buisson-Catil & Primault (dir.) 2010). The Chêne Vert site at Dirac, in Charente, provides unique insights into raw material procurement strategies and modes of exploitation directly related to its accessibility and abundance, its nature or its morphological and dimensional characteristics. This paper presents preliminary results from the rescue excavation carried out in 2010 (Dawson *et al.* 2011).

Figure 1 - Figure 1 - Location of the Chêne Vert site at Dirac and the main Middle Palaeolithic sites of the region.

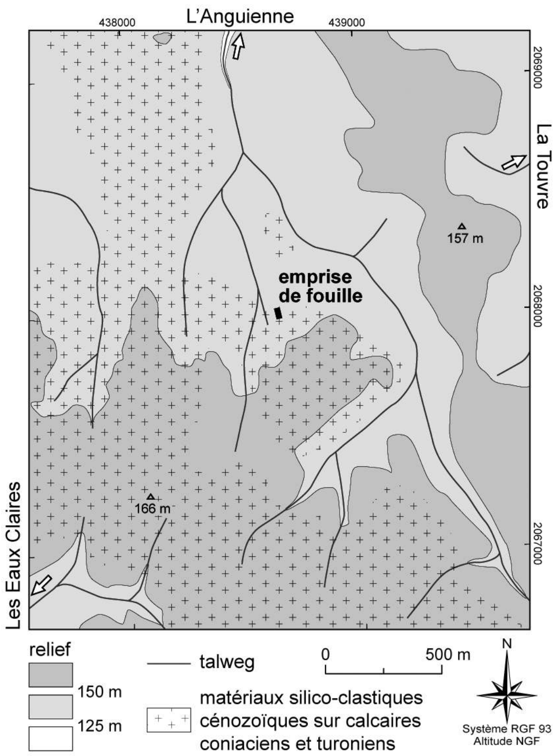


2 The site was discovered during the recent renovation of Angoulême's 1st Naval Infantry Regiment military school in Dirac forest, 12 km south-east of Angoulême, in the Anguienne catchment area (fig. 1 and 2). The significant archaeological context (a concentration of prehistoric sites and the presence of Cretaceous flint outcrops) of the site prompted the Poitou-Charentes Regional Archaeological Service (SRA) to call for an evaluation before any work was carried out on the site. Evaluation surveys were conducted in 2008 over a surface of 2,630 m^2 and brought to light a stony deposit with abundant Mousterian lithic objects, overlying a clayey decalcification level with Turonian flints (Prodeo *et al.* 2008). The rescue excavation was carried out by the company Paleotime for five weeks in September and October 2010 and aimed to identify the geoarchaeological context of the site over a surface of 1,000 m^2. The archaeological deposit (unit 3) was unearthed over a surface of 300 m^2 and was excavated for the most part with a mechanical digger (fig. 3). Three sectors with a total surface of 33 m^2 were manually excavated, which corresponds to 11% of the unearthed archaeological surface, and much less if we consider that the studied layer extends beyond the excavation zone. Given the high density of archaeological objects in these sectors and the restrictions associated with rescue excavations, objects were collected from quarter meter areas, in 5 cm spits, in accordance with the requirements set by the SRA. The main results of the lithic study presented here were obtained from an 8 m^2 sample zone in sector A (fig. 3). Micromorphological and granulometric analyses were carried out on the archaeological sequence, as well as field observations and two OSL dates (optically stimulated thermoluminescence). A taphonomic study was also conducted on some of the archaeological objects.

2 - Geoarchaeological approach

3 The Chêne Vert site is located on the Upper Cretaceous limestone plateau demarcating the northern extremity of the Aquitaine basin. This plateau is lined with narrow valleys along the left bank of the Charente River. The area studied is upstream of one of these valleys, on the eastern slope of a dry small valley extending towards the north (fig. 2). The excavated area lies at an altitude of 144.20 and 142.40 m, on a regular slope of about 2.5° towards the north-west. The nearest highest point is at an altitude of 166 m, and is located about 1 km south-west of the site.

Figure 2 - Geormorphological context of the area surrounding the site (M. Rué).



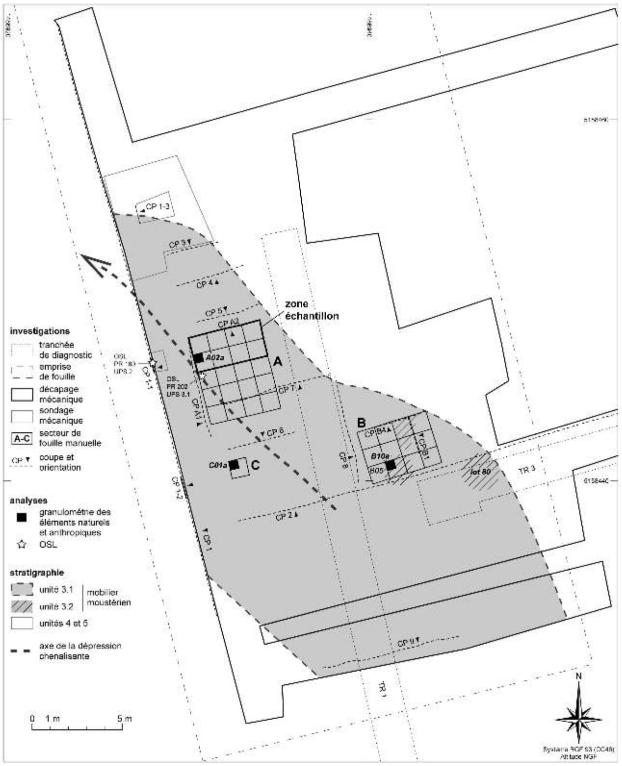
4 According to the geological map of Angoulême at a scale of 1/50000 (Bourgueil & Moreau 1970), the site is at the edge of a Cenozoic silico-clastic formation covering the limestone bedrock, which outcrops mainly at the highest points of the topography and reaches 10 m thickness in the Dirac forest where it is particularly well-represented (fig. 2). This formation is made up of heterogeneous materials, some of which derive from fluvial drift from the Massif Central. The age of this formation is believed to be Eocene to Pliocene (complex « e-p » on geological maps).

2.1 – Stratigraphy

5 Two large stratigraphic sections with a total length of 60 m (sections 1 and 2) enabled us to identify and characterize four main pedosedimentary units making up the site's sequence (UPS 1 to 4, maximum thickness 1.35 m). According to the geological map, these units are on a formation of "subcrystalline rudistid limestones" from the Upper

Turonian (UPS 5). However, this attribution has not yet been confirmed as the “e-p” formation masks the Cretaceous foundations (study in progress).

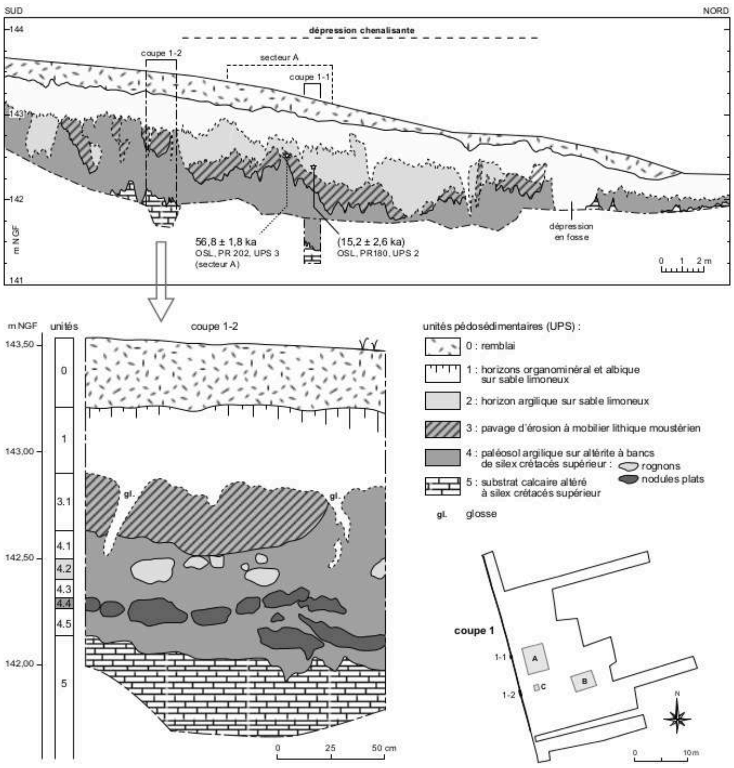
Figure 3 - Excavation plan (M. Rué, M.-C. Dawson and J.-B. Caverne).



Description of the units

6 The sequence is made up of the following lithostratigraphic units, from top to bottom (fig. 4):

Figure 4 - Stratigraphic context (M. Rué, G. Gazagnol, P. Tallet). Top: the whole of section 1 cutting tangentially through the depression and location of OSL samples (heights multiplied by 4). Bottom: section 1.2 showing the flint beds within the clay alterite (unit 4). The lower bed is affected by an overlapping deformation situated directly below a tongue.



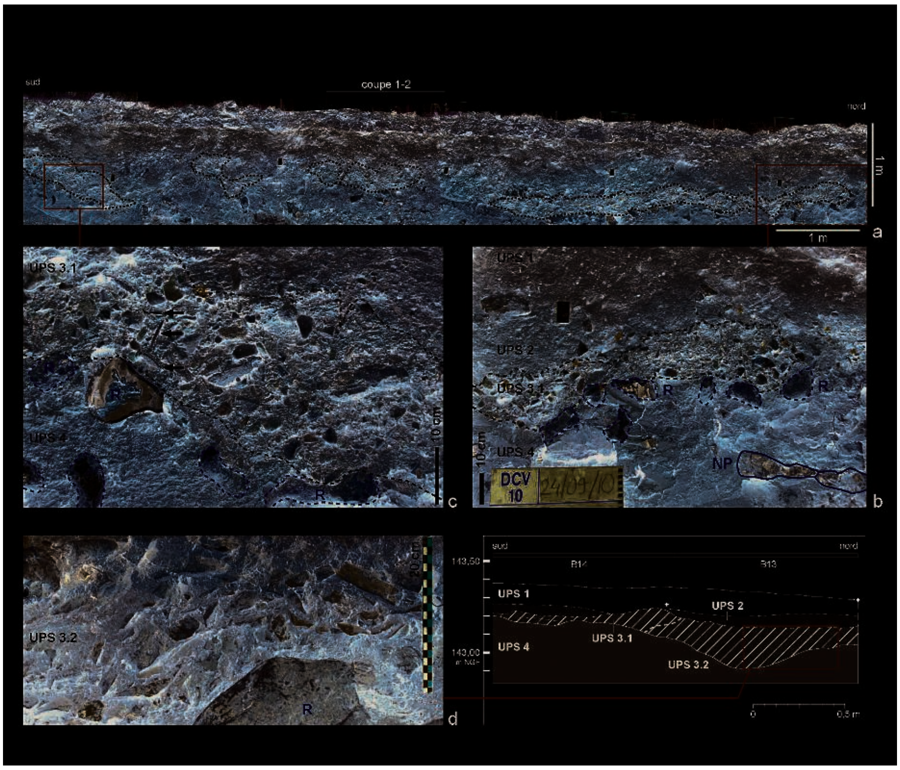
7 **UPS 0:** Heterogeneous brownish yellow to grey sandy material. Clear lower rectilinear limit. This unit corresponds to the backfill spread out during the construction of the military centre. Thickness of about 25 cm.

8 **UPS 1:** Silty sand, grey at the top (old surface horizon under the backfill), pale yellow further down (2.5 Y 7/1), with sparse coarse siliceous elements (gravel and stones). Low cohesion when dry. Massive structure. Diffuse, irregular lower limit with narrow, clearly delimited discoloured vertical tongues, filled with white sandy material, similar to that of UPS 1. Thickness of about 40 cm.

9 **UPS 2:** Compact silty sand with a yellowish red hue (5 YR 5/6), including rare Palaeolithic elements and a stony fraction (blunted to angular siliceous stones) defining two granulometric facies: UPS 2.1: facies with rare stones (< 5%); UPS 2.2: facies with more stones (> 5%). Massive structure. Diffuse lower limit, clearer on UPS 3, undulated. Thickness of about 35 cm.

10 **UPS 3:** Diamicton with clastic elements and a silty-gravelly brown matrix. The coarsest elements are made up of blunted to angular siliceous stones (up to 20 cm long), quartz pebbles (generally between 2 and 5 cm long) and Mousterian lithic objects which can represent up to a quarter of the total fraction over 2 mm. Clear and irregular lower limit. Average thickness 25-30 cm.

Figure 5 - Photographic documentation of unit 3 with Mousterian lithic artefacts (M. Rué).
a, b and c. Facies 3.1 (section 1). White and yellow lines indicate the location of, respectively, the archaeological layer and both flint beds within the alterite (R: nodules, NP. flat nodules/slabs). Note the omnipresent quartzose pebbles and the randomly organized elongated pieces (arrows). d. Facies 3.2 (section B1). Quartzose pebbles are rare and elongated pieces lie preferentially flat and follow the layer's dip.



11 Unit 3 presents two massive facies with diffuse extension limits:

12 UPS 3.1: dominant facies with a red brown matrix with gravels and pebbles and aggregates with black ferromanganese coating. The elongated elements have no preferential orientation (fig. 5a to 5c);

13 UPS 3.2: minor facies forming lenses or pockets, with a yellow brown clayey-gravelly matrix with rare black coatings. Elongated elements tend to lie flat, following the slope of the layer (fig. 5d).

14 **UPS 4:** Silty, compact, homogeneous clay with a dark red brown colour (7.5 YR 5/6), yellow brown in places, in which there are two residual flint beds: UPS 4.2 at the top (facies with nodules), UPS 4.4 at the base (facies with fragmented slabs). Clear irregular lower limit. Approximate thickness 55 cm.

15 **UPS 5:** Yellowish white crumbly limestone with a yellow patina. Clear layering (platelets of several centimetres). Unknown lower limit and thickness.

Interpretation of the sequence and formation of unit 3

16 The sequence contains two pedostratigraphic units separated by erosive contact:

- at the top, units 1 to 3 are made up of allochthonous siliceous materials from different slope inputs. These materials derive from Cenozoic formations and Coniacian sands. They underwent a long pedoclimatic history resulting in the formation of a leached, slightly podzolic soil profile, units 1 and 2 respectively make up the albic and argillic profile (Callot *et al.* 1975);

- at the base, unit 4 was formed by the *in situ* alteration of Cretaceous limestones (unit 5). The presence of this alterite partly explains the argilliturbation deformations of the overlying deposits and their episodic waterlogging (as happens with perched water tables) as indicated by the ferromanganese coatings.

17 This sequence is contained within a shallow channeling depression extending north-west, with a width of 10 to 15 m. Its limits at either end were not reached (fig. 3). Unit 3 is mainly located at the base of this depression (fig. 4) and follows an average slope of about 2.9° towards the north-west.

18 Below this depression, the two levels of alterite flint maintain the same inter-bed spacing and equally follow the same general morphology. This depression thus results from a general sinking of the sedimentary sequence, doubtlessly induced by the karstification of the Cretaceous limestones. The relatively constant thickness of unit 3 on either side of the depression proves that deposits did not accumulate within a channel but probably spread in sheet form along the slope before the formation of the depression.

19 The difference in composition and structure between facies 3.1 and 3.2 indicates a multi-phased deposition of the materials, although it is not possible to discern the chronology of the various sedimentary episodes because of the condensed and discontinuous nature of unit 3. The structure of facies 3.2 located at the edge of the depression evokes solifluction deposits (fig. 5d), whereas facies 3.1 may result from a more rapid flow such as a debris flow (fig. 5a to 5c). In plan, no diagnostic forms contemporaneous with the deposit allow us to support these interpretations. Moreover, the preferential orientation of elongated elements from facies 3.2, while visible on certain profiles (fig. 5d), was not confirmed by fabric measurements carried out for this unit (see 2.2 for a possible explanation).

20 In thin section, the matrix of unit 3 is characterized by an ovoid microstructure, probably of cryogenic origin and generally associated with phases of lateral soil displacement by periglacial solifluction (Bertran & Texier 1990). This microfacies is absent from overlying units. The flint from unit 3 and the upper surface of the nodules at the top of the alterite also present signs of frost. These observations thus suggest that the archaeological layer formed under periglacial influence.

21 Granulometric distributions demonstrate a predominance of the fraction over 2 mm (about 60% of the total mass) and a sand deficit. They reveal the progressive segregation of materials during the formation of unit 3. The archaeological level from Chêne Vert can thus be interpreted as a residual deposit. This type of context is not generally conducive to the preservation of archaeological assemblages (residualisation and possible mixing of several occupations).

Dates

22 Two OSL dates of the sequence were carried out by J. Lomax (Vienna Luminescence Laboratory) and G. Adamiec (Gliwice Absolute Dating Methods Centre) according to the single aliquot regeneration protocol (Murray & Wintle 2000; tab. 1, fig. 4). For unit 2, the age probability curve is spread out over the whole of isotopic stage 2. This dispersion may be caused by heterogeneous quartz grain bleaching which is a frequent

phenomenon during colluviation processes. The obtained age of 15.2 ± 2.6 ka corresponds to a possible phase of soil reworking. For unit 3, the results show a lesser age dispersion centred around 56.8 ± 1.8 ka, around the transition between isotopic stages 3 and 4. This date corresponds to the last exposure to light of the fine sand which filled the paving and therefore to its probable burial phase. Even though this sole result concords with pedostratigraphic observations, it must be interpreted with caution because of uncertainties linked to OSL dating of these residual coarse deposits. Moreover, the level is impermeable which makes it difficult to estimate possible water content variations.

Table 1 - OSL dating results.

Prélèvement	Unité	Date prélèvement	Laboratoire	Taille des quartz (µm)	Aliquotes (N)	Teneur en eau (%)	Paléodose (Gy)	Débit de dose (Gy/ka)	Age OSL (ka)
DCV10 PR. 180	UPS 2.1	14/10/2010	Vienna Luminescence Lab., Institute of Applied Geology, BOKU, Vienna (Austria)	100-200	39	15	(29,5)	1,95	(15,2 ± 2,6)
DCV10 PR. 202	UPS 3.1	21/10/2010	Luminescence Dating Lab., Institute of Physics, Silesian University of Technology, Gliwice (Poland)	125-200	12	12	64,6	1,14	56,8 ± 1,8

23 The study of thin sections led to the following pedoclimatic setting:

24 the base of unit 1 presents micro-organizations characteristic of alternating freeze/thaw action (silty caps and laminated structure). In the field, this level corresponds to the opening of tongues affecting the whole sequence (fig. 4). This indicates the development of a deep gelisol and could be linked to one of the permafrost episodes identified in Aquitaine during isotopic stages 2 or 3 (Lenoble *et al.* 2012);

25 units 2 and 3 bear slightly developed illuvial traits, in consistent position within pores or in the process of being integrated to the matrix. They indicate different phases of pedogenesis in a temperate forest context (Fedoroff & Courty 1987). The low complexity of these traits points to a recent, probably Holocene, evolution of these deposits, which occurs after the last interglacial (Eemian).

2.2 - Taphonomy

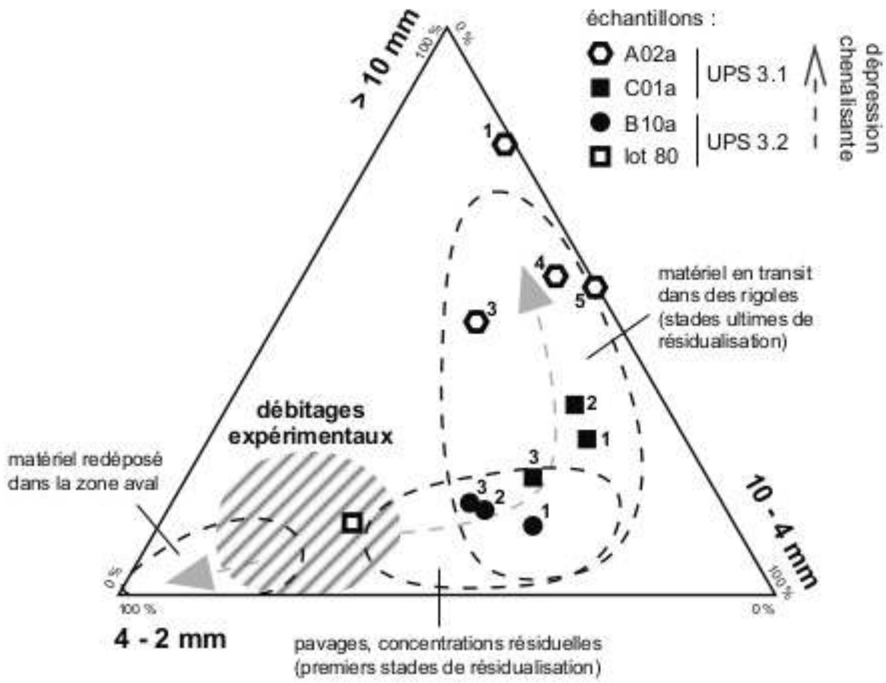
26 Due to the residual nature of unit 3 and the perceptible post-depostional processes (deformations of unit 3, absence of clearly marked concentrations of objects, many vertical pieces), a taphonomic study was undertaken to establish whether or not the lithic assemblage had been reworked in order to guide the techno-economic study.

Granulometric analysis of the archaeological objects

27 The study of the particle-size distribution of the Chêne Vert archaeological assemblage focused on four sample zones in order to determine whether or not taphonomic modifications had occurred (Bertran *et al.* 2006; Bertran *et al.* 2012): sectors A and C for unit 3.1, and sector B and lot 80 for unit 3.2 (fig. 3). These samples were wet sieved through a 2.5 mm mesh (apart from lot 80 which was sieved with a finer mesh of 2 mm), then dry sieved through a calibrated column with meshes of 2, 4, 5, 10 and 20 mm. The 2-4 mm fraction thus corresponds to a 2.5-4 mm fraction, probably slightly underestimating the quantity of the latter.

28 The results bring to light differential preservation depending on the sampling zone (fig. 6). Indeed, the granulometric spectrum is more complete in facies 3.2. However, we observe vertical granulometric homogeneity in the archaeological layer. The fine fraction is under-represented in relation to experimental reference collections (e.g., Schick 1986; Bertran *et al.* 2005; Bertran *et al.* 2006), indicating a secondary impoverishment of the site by natural processes, except for lot 80 located on the edge of unit 3 where the granulometric signal appears to be more complete. The ternary diagram for class dimensions (after Lenoble 2003) shows that all the sampling sites, apart from lot 80, are in the run-off residualisation zone. This diagram also shows the existence of a lateral and longitudinal ranking of the sampling sites in relation to the general morphology of unit 3: residualisation is more pronounced towards the heart of the sheet and towards the base of the slope (fig. 6). Run off therefore progressively reorganized the initial archaeological assemblage along the slope. The results from lot 80 may reflect a better preservation of unit 3.2 as they are close to those obtained for an integral assemblage. Nonetheless, we cannot exclude the possibility of bias related to the mesh used for sieving.

Figure 6 - Triangular diagram of artefact size distribution (after Lenoble 2003). Numbers 1 to 5 represent the different spits from the top to the base of layer 3. Sample location is indicated in figure 3.

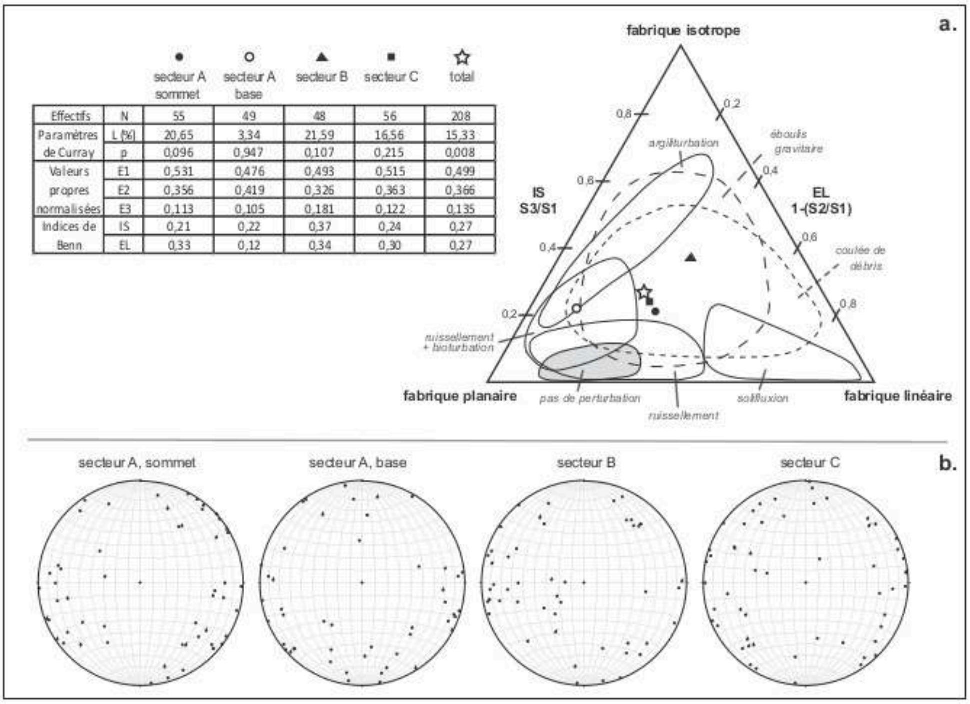


Fabric analyses

29 The study of the orientation and inclination of the elongation axis of archaeological objects can also provide details on the taphonomic processes involved in the formation (or deformation) of the archaeological level (Bertran 1994; Bertran & Texier 1995; Bertran & Lenoble 2002). We focused on three site locations: the 20 m^2 in sector A, sector C (two sub-squares) and square B05 (fig. 3). Overall, 208 measurements of

elongated pieces were taken during the excavation and exploited following a well-documented method (Bertran & Lenoble 2002).

Figure 7 - Fabrics of the archaeological level. a: Benn diagram (after Bertran and Lenoble 2002) and associated statistics. E1, E2 and E3: eigenvalues, L: intensity of preferential orientation, p: probability that orientation distribution is entirely random, IS: isotropy index, EL: elongation index. b: Schmidt diagrams of the base and top of sector A, of squares C1 and B05. The location of sample areas is indicated in figure 3.



30 The results bring to light an isotropic fabric for each of the three sectors (fig. 7). The intensity of the L preferential orientation (or vector magnitude; Curray 1956) is a long way off the significantly statistic threshold ($p < 0.05$ with the Rayleigh test, Bertran & Lenoble, 2002). The Benn diagram projection (1994) of the representative points obtained according to the Woodcock values method (1977) falls largely outside the characteristic range for sites affected by solifluction or run off (fig. 7a). On the other hand, it is close to projections obtained for debris flow (Bertran *et al.* 1997; Bertran & Lenoble 2002). However, the isotopic fabric is difficult to interpret at Chêne Vert as it also reflects deformation phases occurring after the fossilization of unit 3, particularly those induced by the shrinking-swelling of the underlying alterites. Three of the four samples are from the area of argilliturbated deposits (fig. 7a).

Surface states of the artefacts

31 The petroarchaeological analysis is based on macroscopic and stereomicroscopic observations of a sample of archaeological objects and geofacts (n= 412) in order to understand their depositional history. Fifteen discriminatory weathering criteria were observed on each piece for both types of Turonian flint (nodules and slabs) from the studied series.

32 Impact marks (subcircular or linear marks), with or without traces of crushing (n= 10), as well as friction striations on plane surfaces (n= 29) are rare. These observations suggest limited movement of objects.

33 Impact marks due to friction are more apparent on prominences. In fact most pieces bear impact marks on ridges and/or edge damage (n= 330 pieces or 80% of the sample). These marks are undoubtedly linked to displacement phases contemporaneous with the deposition of unit 3. Abrasion marks such as mirror sheen (of mechanical origin) are also visible on some pieces, but these are not frequent.

34 These observations indicate that objects remained close to the surface and were subjected to freeze-thaw cycles (several generations of thermal pitting separated by leaching phases). Most of the archaeological pieces and geofacts are polarized, with the side facing upwards bearing more alterations than the side facing downwards. This well-marked polarization points towards significant leaching phases after the formation of the unit.

35 The polarization of the objects, the fact that there are few signs of displacement, the position and intensity of sheen point to a series of transformations linked to migration on a gentle slope, in a heterogeneous and episodically saturated soil affected by periglacial morphodynamics.

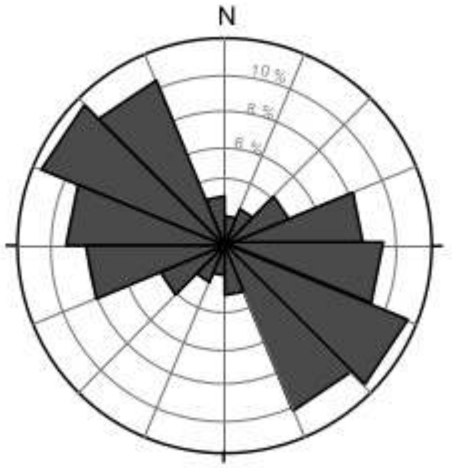
Lithic refits

36 The non-exhaustive search for refits and conjoins focused mainly on the 8 m^2 sample zone from sector A (fig. 3), which partly explains the low refit rate (2.3%). We believe that the actual refit potential is much greater, but more time would be necessary. This rate should therefore not be considered indicative of the degree of site preservation. Only the orientations of the refits are presented here.

37 Due to the way in which objects were recovered (in lots), processing the spatial refit data was a complex procedure as the exact location of each piece is unknown. Nonetheless, each refitted element can be assigned to a specific 0.25 m^2 sub-square and vertical spit which implies working with distance and orientation brackets. In order to work out all the location possibilities for each refit, the two poles of possible location acceptable are the outer limits of a sub-square. In this way, the orientation considered representative falls between two axes encompassing all location possibilities. The orientation is more accurate (with a reduced bracket) when the distance between sub-squares is greater.

38 Orientation brackets (33 altogether) are depicted on a rose diagram showing significant preferential refit orientation clustering around a NW-SE axis (fig. 8). The fact that this axis coincides with the general slope of the archaeological layer implies that colluvial dynamics were primarily responsible for the site's deformation.

Figure 8 - Orientations for refits from the sample area of sector A (n=33).



2.3 - Conclusion

39 Stratigraphic and taphonomic approaches to the site of Chêne Vert demonstrate:

40 the formation of unit 3 results from slope dynamics in a periglacial context, doubtlessly during the beginning of the last glacial cycle;

41 the collected objects are not representative of initial occupations which would have been located further up-slope, at a distance which remains difficult to estimate;

42 the siliceous raw materials contained in the alterites within the excavated zone were not directly accessible to Mousterians before the deposition of layer 3;

43 there is a high risk of reworking and subsequent mixing, thus complicating our understanding of the site.

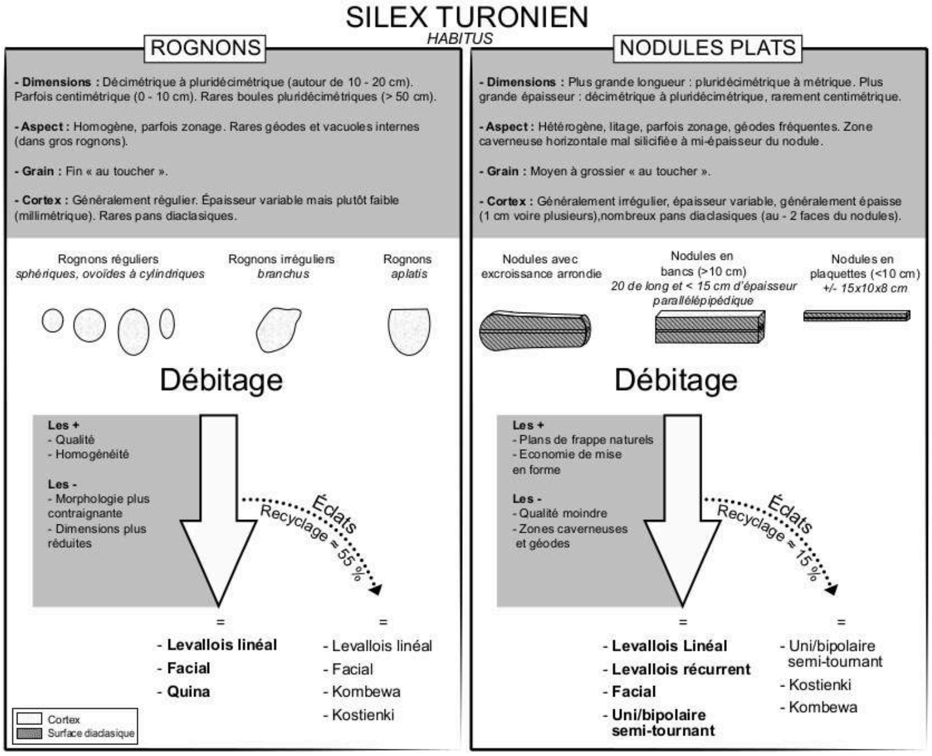
3 – The lithic industry of Chêne Vert

44 The study of the lithic industry concerned over 9,000 pieces recovered from 8 m^2 in the main manually excavated zone (sector A). In parallel, a succinct quantitative and/or very targeted approach was applied to the remaining objects (> 15 000 pieces).

Raw material

45 The crushing majority of the archaeological flints are local and come from the dismantling of the Dirac limestones. Two types of Turonian flint were used at Chêne Vert, distinguished by their habit and mineralogical composition (fig. 9 and 10): flat nodules or « lenses » in the form of parallelepiped slabs (thickness < 10 cm) or beds (thickness > 10 cm) with two cortical sides and two to four natural joint surfaces; generally ovoid decimetric nodules with a maximum length of 10-15 cm. Both types correspond to those identified in the underlying alterites (fig. 4 and 5a to 5c), demonstrating that these materials were exploited nearby.

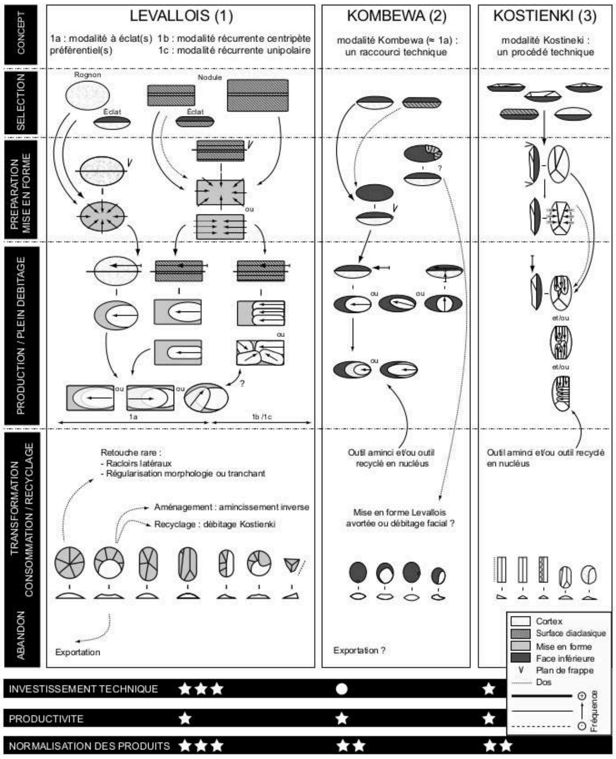
Figure 9 - Turonian flint from Dirac : reduction sequences and habitus (S. Bernard-Guelle and M. Dousse).



46 One of the major outcomes of the petrographic study is the identification of characteristics specific to the Turonian flint from Dirac, namely the presence of spicules, the relatively significant presence of detrital quartz which is not common to all Turonian flint, and especially the absence of *incertae sedis* (bioclasts corresponding to several types of organisms, radiolarian in this case). These bioclasts are present in most of the Turonian flints in Charente, except perhaps for the area around La Couronne and Chaix (Delagnes *et al.* 2006).

Debitage concepts: two distinct spheres

Figure 10a - Production schemes of the Levallois conceptual sphere (S. Bernard-Guelle and M. Dousse).



47 The dominant debitage system at Chêne Vert is Levallois (Boëda 1994). It is mostly represented by preferential flake modality (fig. 10a - 1) carried out on nodules and flakes from these nodules, occasionally on slabs and rarely on flakes obtained from slabs. The Levallois surface is generally shaped by peripheral centripetal removals, as shown by the high number of preferential Levallois flakes (fig. 11, no. 1 and fig. 19, no. 2 and 4), several blades (fig. 11, no. 4) and most of the cores.

Figure 10b -Other debitage concepts and production schemes identified at Chêne Vert (S. Bernard-Guelle and M. Dousse).

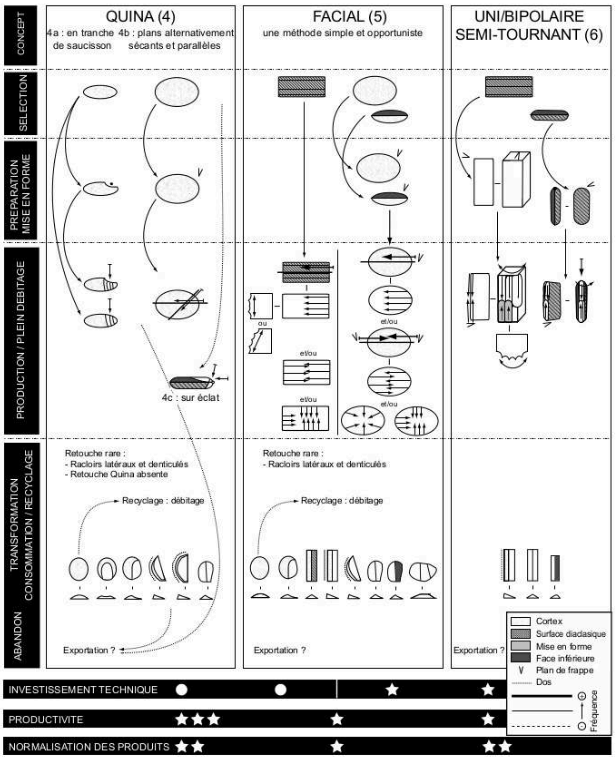
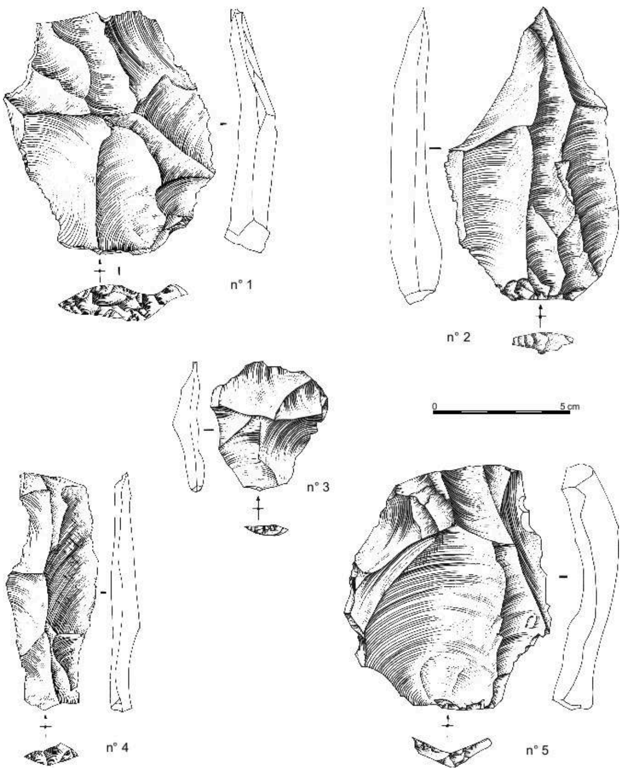
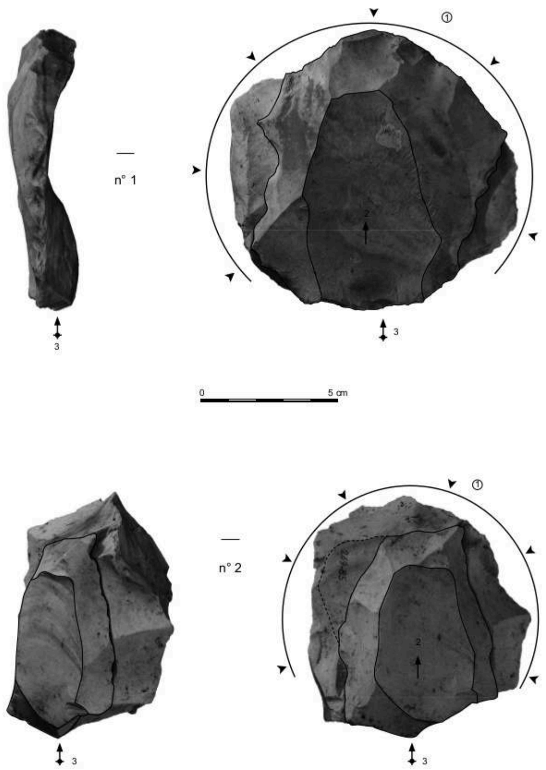


Figure 11 - Preferential Levallois flakes (no. 1-3) and blade (no. 4); overshot secondary preferential Levallois flake (no. 5) (R. Picavet).



48 The removal of the preferential flake is frequently followed by the detachment of another superimposed flake from the same pole (second preferential flake) (fig. 12 and fig. 11, no. 5). The superimposed second Levallois flakes are identifiable by the presence of a proximo-mesial concavity on the dorsal surface (to facilitate prehension, hafting?). Nonetheless, several cores illustrate the use of recurrent unipolar or centripetal modes. These seem to be used in parallel with preferential flake debitage and only involve slabs, which are technically less restrictive. As well as bigger dimensions and a longer exploitation cycle, these slabs represent the advantage of minimising shaping-out phases due to their morphology and natural striking platforms. Conversely, nodule flakes are preferentially reused as preferential Levallois cores, thus partly compensating for constraints linked to production objectives, i.e., significant technical investment and low core productivity. The products obtained are highly normalized from a morpho-dimensional viewpoint, and are rarely transformed by retouch, except for regularizing cutting edges and sometimes thinning.

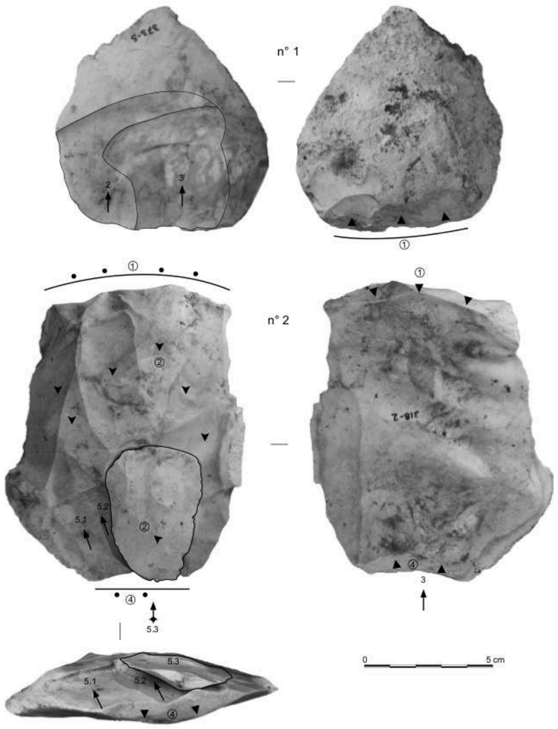
Figure 12 - no. 1: Levallois core with an overshot secondary preferential flake negative; no. 2: Levallois core with a negative of a secondary preferential flake. (S. Bernard-Guelle and M. Dousse).



49 In parallel, several flakes, in this case cortical and resulting from the reduction of nodules, were recycled with their ventral surface exploited according to a "Kombewa" type method (Owen 1938; Tixier et *al.* 1980; Tixier & Turq 1999) (fig. 10a - 2). They thereby confirm the presence of ramified *chaînes opératoires* (Bourguignon et *al.* 2004), which was already hinted at by the use of flake blanks for lineal Levallois debitage. In most cases, these cores exemplify preferential flake debitage, which can affect over half the blank's surface. At times, the preferential removal is reworked, generally from the same pole (fig. 13, no. 1) and only rarely from the opposite direction. This type of debitage does not seem to represent a separate concept in itself but rather forms an integral part of one of the previously described debitage modes.

"Kombewa" type cores are conceptually very similar to preferential flake Levallois debitage, with an added technical shortcut. Moreover, the reworking of the preferential flake is a common aspect of both production types. The blanks obtained are "Kombewa" flakes or more frequently "Kombewa" type flakes as their dorsal surface bears only a portion of the ventral surface of the flake-core. These products are smaller than the Levallois flakes and generally have a biconvex profile.

Figure 13 - no.1: redebited "Kombewa" type core; no. 2: "Kostienki" type core on an overshot Levallois flake. (Photos S. Bernard-Guelle and M. Dousse).

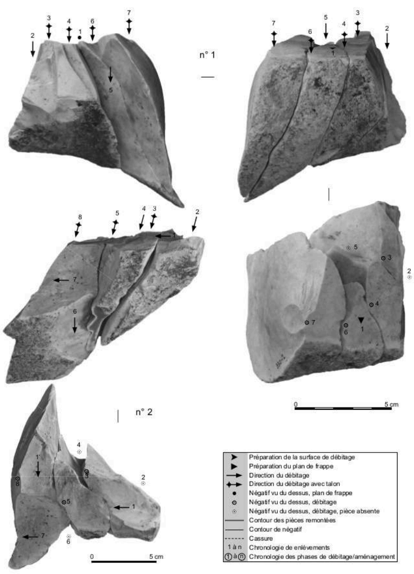


50 Kostienki type debitage (fig. 10a - 3) is also evidenced by several cortical and sometimes even Levallois products (fig. 13, no. 2). Inverse truncations are carried out on one or two extremities of the blank and followed by uni or bipolar debitage on the dorsal surface. Only one example provides evidence of a more elaborate preparation by direct bilateral removals prior to debitage. As is often the case, several retouched pieces are concerned by this "reshaping", rendering them difficult to interpret (tools recycled as a core or thinned pieces?). With this technical procedure (Efimienko 1958; Koslowski 1984), and unless in the case of a structured bladelet debitage (Slimak & Lucas 2005; Slimak dir. 2008), production is difficult to identify compared to that obtained from the ventral surface of a flake-blank. It involves, for example, simple cortical flakes or quadrangular flakes with uni or bipolar removal scars. They are generally of small size, but certain large flake-blanks can yield large products. This production mode can also produce Levallois-type flakes (fig. 13, no. 2). Thus, as is sometimes mentioned in the literature (e.g., Faivre 2008), reduction strategies carried out in the context of secondary Levallois production on flake-blanks could highlight two debitage modes which vary depending on which surface is exploited: Kombewa-type mode (on the ventral surface) and Kostienki-type (on the dorsal surface).

51 Alongside this first significant group ascribed to the Levallois conceptual sphere, several other debitage systems, notably Quina debitage, are clearly distinguishable. This production mode is characterized by a significantly different volumetric conception of core management compared to Levallois debitage (Bourguignon 1997). Several reduction methods adapted to the type of blank used have been identified (fig. 10b - 4):

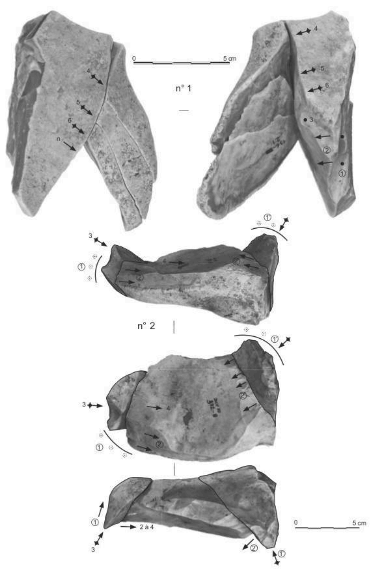
- "tranche de saucisson" debitge (Turq 1989) linked to the morphology of certain cylindrical flint nodules with less than 10 cm diameters. This seems to be the method best adapted to this type of habit and to the serial debitage of certain blanks (asymmetrical with a cortical back). The opening of the nodule varies depending on the initial morphology (regular shape, with knobby parts or with a flat side), taking place on cortical extremities (yielding a primary flake with a cortical butt) or exploiting a naturally flat side (primary flake with a natural butt), or by removing a primary flake from the width of the nodule to create a striking platform following the thickness of the nodule (primary flake with a plain butt) (fig. 14, no. 1). Unipolar debitage is then conducted in recurrent lateral series yielding a wide range of products with natural backs: flakes with a peripheral cortical back (*tranche de saucisson*), flakes with a more invasive cortical back (cortical back and distal end) and especially flakes with a cortical back and an asymmetrical cross-section. Butts are cortical or natural (joint surfaces) and primarily plain, wide, inclined (> 90°) or not (close to 90°). As suggested by Bourguignon (1997 - p. 141), the different production schemes proposed by Turq (1989) seem to have been carried out simultaneously on the same block leading to the production of the different blanks described above;

Figure 14 - Quina debitage ("tranche de saucisson" type for no. 1 and along alternate secant planes and parallel to the plane intersecting both surfaces for no. 2) (S. Bernard-Guelle and M. Dousse).



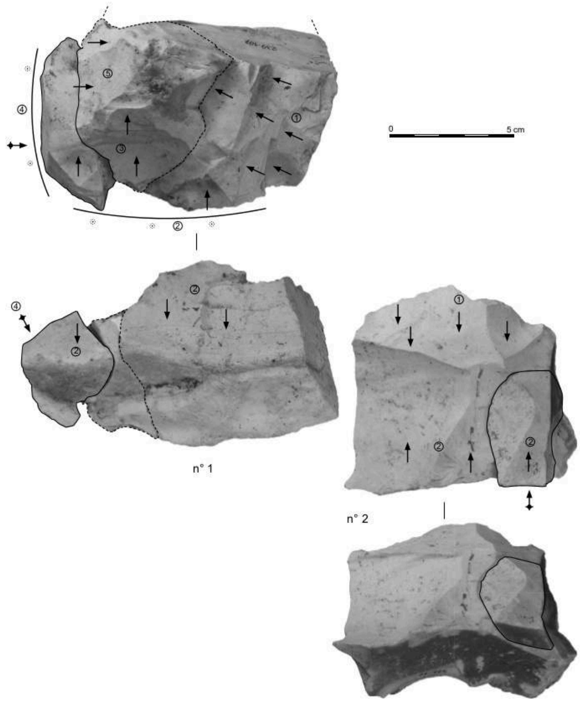
- Quina debitage, as defined by Bourguignon (1997), involved small, irregular ovoid nodules and especially larger nodules (tens of cm). The volume of the core is conceptually divided into two separate debitage surfaces, alternately exploited by secant debitage planes on one and subparallel removals on the other (fig. 14, no. 2, fig. 15, no. 2 and fig. 16, no. 1). This configuration differentiates it from the previous method which exploits a preferential surface. On the other hand, the resulting products from both methods are quite similar, although slightly more varied with the latter: primary flakes with natural or plain butts, partially cortical flakes with mostly unipolar scars, flakes with invasive cortical backs, flakes with cortical backs and asymmetrical cross-sections and non-cortical backed flakes (towards then end of the production sequence). The butts are generally plain and wide and appear to be more systematically inclined than with the *tranche de saucisson* method; asymmetrical dihedral or sectioned butts, described as markers of Quina debitage by L. Bourguignon, (1997 - p. 76 and 111), are present.

Figure 15 - Quina debitage (S. Bernard-Guelle and M. Dousse).



52 Quina debitage was identified just on nodules, the only exception being a large flake from a slab, initially exploited in its thickness from the ventral surface (reduced following a plane which is secant to the intersection plane of both surfaces of the flake-core), but debitage stopped after the flake-blank broke. This exploitation mode is similar to that described by L. Bourguignon in her doctoral thesis (1997- p. 123). As previously mentioned (Turq 1989; Bourguignon 1997; Bourguignon et *al.* 2006), Quina debitage is characterized by high productivity as the shaping-out of cores and technical investment are almost non-existent whereas production is recurrent and at times quite normalized (especially for the *tranche de saucisson* method). On the other hand, it is difficult to know which part of production was delocalized, if it all. Surprisingly, blanks are rarely transformed by retouch, which is uniquely of Quina type.

Figure 16 - no. 1: Quina core (the refitted flake bears a sectioned butt); no. 2: Bipolar facial core (S. Bernard-Guelle and M. Dousse).



53 Another type of reduction was identified through several cores and and refits, a (uni)facial debitage (fig. 10b - 5) characterized by a production carried out on a preferential debitage surface, which has not been prepared, and from one or several successive poles.

54 Depending on the chosen blank (nodule, slab or flake from a slab), the *chaîne opératoire* begins by setting up one or two striking platforms generally on the ends of nodules (or flakes) or, for slabs, on their smaller sides. For the latter, debitage can begin rapidly as joint surfaces constitute pre-existing striking platforms.

55 Debitage begins with a first series of unipolar removals which can continue along this same axis thanks to the removal of core management or *débordant* flakes which lower lateral convexities, especially on nodules, or by the removal of an overshot flake (on nodules or flakes) which leads to the reconfiguration of the core's distal convexity. On slabs, debitage can run over and even continue on an adjacent surface. Two modalities (bipolar and orthogonal) can also be carried out on the opposite pole or in an orthogonal manner, thereby inherently managing the core. These series may be further developed and adapted to the morphology of the core or progress around one side of the core (especially for nodules), ultimately producing cores with generally centripetal removals.

56 The reduction of slabs is generally carried out from a joint surface, along the slab's length and in a plane parallel to the slab's bedding, or in rarer cases in an orthogonal plane. The manner in which reduction is organized thus has a direct impact on the number of blanks with natural or cortical edges (the latter are predominant). Nevertheless, regardless of which side is debited, there is systematic production of pieces characteristic of this type of blank: products that tend to be elongated with two

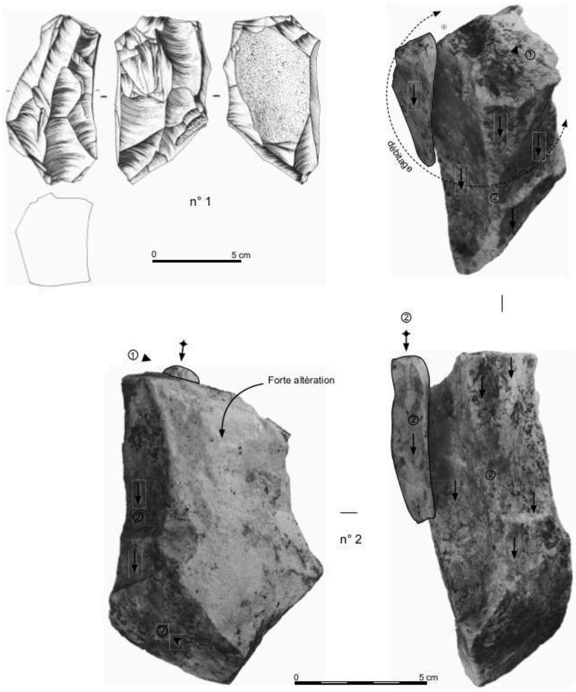
sides forming an angle close to 90°, one cortical the other natural (joint surface). Debitage may then proceed on an adjacent side, obliquely to the bedding. On rare occasions, it is carried out along the slab's thickness, but the presence of poorly silicified hollow zones, in the centre of the slabs, seems to have presented a hurdle.

57 This reduction mode produces blanks quite similar to those obtained by Quina debitage, albeit with fewer cortical backs (therefore less asymmetry) and less frequently inclined butts. In the case of slabs, products are often elongated as reduction generally follows the longest axis. These products frequently bear cortex or joint surfaces, have backs (cortical, natural or debitage surfaces), or even two joint surfaces (see above). When they are not entirely cortical, they present mostly unipolar scars (sometimes bipolar) and a triangular or trapezoidal section. The butts are natural or plain. For nodules, the products are similar, often with a cortical back but without joint surfaces.

58 This reduction system is simple and flexible as it can be adapted to the morphology of the blank being debited, but its productivity is relatively limited. The reduction sequences are often short and remnants of cortex are often still visible on the debitage surface. They are seldom recurrent; few cores with centripetal or orthogonal removals indicate a longer exploitation. In the same vein, several cores illustrate this with (bi)facial reduction carried out on two faces. In regards to the two main reduction systems described previously, this mode of production clearly differentiates itself from Levallois debitage, especially due to the lack of any prior shaping-out of the debitage surface and is distinguishable from Quina debitage by the exploitation of a preferential surface. Products are nonetheless quite similar to the latter.

59 Finally, a uni/bipolar *semi-tournant* debitage (fig. 10b - 6) was occasionally identified on slabs and large flakes detached from slabs. The volumetric conception of the core is unipolar (fig. 17, no. 2) or bipolar (fig. 17, no. 1) with a *semi-tournant* or even frontal debitage which can extend to a wide surface when it originates from along the blank's edge. Core maintenance is thus limited to optimizing the blank and the occasional removal of flakes that rework the core's longitudinal convexity. There is no management of the core's transverse convexity, production is low and relatively unstandardised in comparison to a genuine laminar volumetric exploitation. Comprehension of the technology involved is however rather difficult as several of the most characteristic pieces are heavily altered. The products obtained via this method are blades and elongated flakes which are quite large and thick with often asymmetrical cross-sections. This production seems to be secondary and possibly ramified.

Figure 17 - no. 1 : bipolar semi-tournant core ; no. 2 : unipolar semi-tournant core (R. Picavet, S. Bernard-Guelle and M. Dousse).

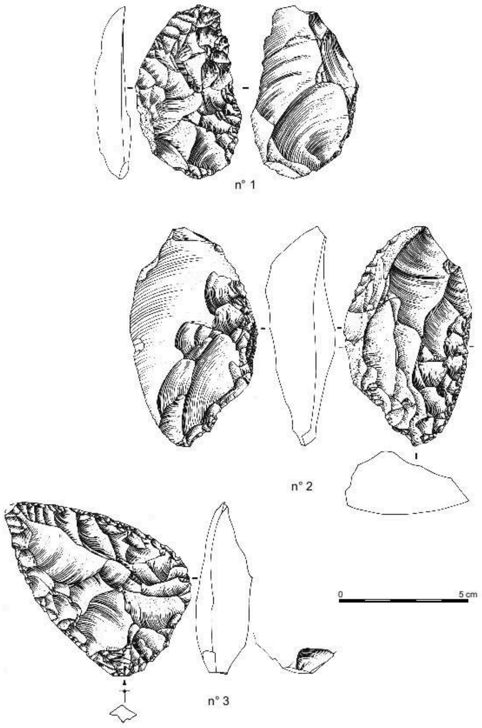


60 Figure 18 - no. 1: transverse scraper with a thinned back,

61 The technological deciphering of the industry highlights the fact that the Mousterians of Chêne Vert were able to perfectly adapt their objectives to the characteristics of both flint beds available at the site (dimensions, morphology and quality). It also raises questions concerning the homogeneity of the assemblage and the significance of the association between at least two debitage concepts which are hardly compatible within the same series: Quina and Levallois.

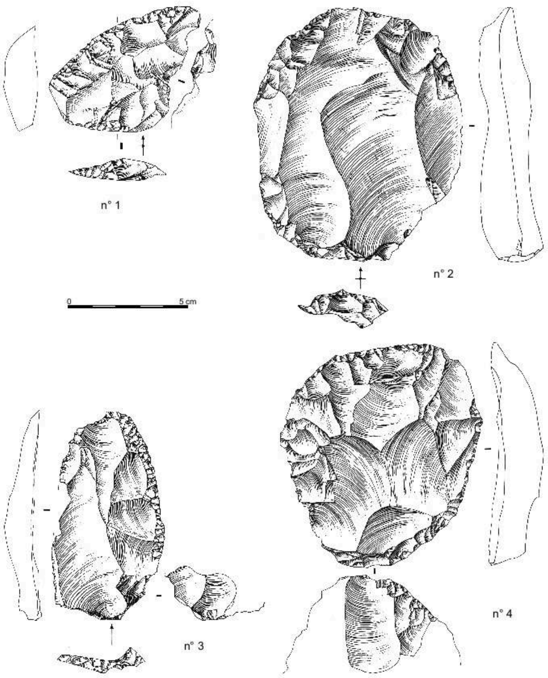
A rare retouched toolkit

Figure 18 - no. 1: transverse scraper with a thinned back, allochtonous flint; no. 2: retouched preferential Levallois flake; no. 3: simple convex scraper with a thinned back, allochthonous flint; no. 4: retouched and thinned preferential Levallois flake (R. Picavet).



The typological component is composed of 117 pieces including 27 in non-local flint. Blanks in local flint are more often derived from nodules than slabs, perhaps due to their finer grain, and are predominantly Levallois or cortical. The Mousterian group is the best represented with 54.1% of the retouched assemblage (n= 52), with a strong component of simple lateral sidescrapers (n= 26) which are sometimes thinned and generally convex (fig. 18, no. 3). The second most important component are convergent tools, made up of 14 convergent sidescrapers or Mousterian points, nine of which have been thinned (fig. 19, no. 1). Pieces in non-local flint are generally associated with this Mousterian group (n= 20), especially with convergent pieces (n= 11). The denticulate/notch group is only represented by 15 tools, as are more marginally retouched pieces encompassing those whose cutting edges were only lightly sharpened or for which the extent of retouch was extremely limited. Several Levallois flakes (fig. 19, no. 2 and 4) were slightly retouched, sometimes on the ventral surface, and even thinned. Lastly, the assemblage is completed by a group of very diverse and heterogeneous tools (n= 13), several retouched tool fragments (n= 21) and a single fragment of a bifacial piece. Retouch is mainly direct and scalar, the Quina variant is observed on only three sidescrapers with restricted stepped scalar retouch (1/2 Quina: fig. 18, no. 2). This type of retouch concerns only 2.5% of retouched pieces.

Figure 19 - no. 1: convergent scraper with a thinned back; no. 2: convex scraper with a thinned back and ½ Quina retouch, allochthonous flint; no. 3: déjeté scraper with a thinned back (R. Picavet).



62 Retouched pieces make up about 0.5% of the lithic industry, or even less if pieces in non-local flint are excluded. It is thus evident that blanks were not produced with the express purpose of being retouched on site, although some may have been exported and modified elsewhere.

Distinctive and ramified *chaînes opératoires*, carried out entirely on site

63 The techno-economic approach (Dawson dir. 2011) shows that this local flint industry presents all the characteristics of a workshop: large proportion of cortical pieces (nearly 60%) and of cores (3%), retouched toolkit accounting for less than 1% of the assemblage and scarcity of non-local flint (0.15%). Entire reduction sequences appear to have been carried out on site and the exportation, at least partial, of this production seems likely. Levallois debitage, mainly lineal (Boëda 1994), is characterized by a significant technical investment which is partly reduced by the selection of suitable blanks (flakes derived from decorticating nodules; rapidly exploitable slabs). The obtained products are highly normalized from a morpho-dimensional perspective and occasionally transformed by retouch. Their scarcity (around 2%) could indicate that part of this production was exported. Quina debitage was mainly identified on nodules debited according to different modalities. This type of debitage is characterized by an almost non-existent technical investment and high productivity. The blanks obtained are mainly cortical or with cortical backs, with an asymmetrical section and are rarely retouched. A third debitage system is highlighted by an opportunistic facial, uni or multipolar exploitation carried out on either slabs, nodules or flakes. Products are only slightly normalized, with similar morphological diversity to Quina debitage, but with lower productivity. Finally, the production of elongated pieces is evidenced by *semi-*

tournant uni or bipolar debitage, almost exclusively on slabs and flakes derived from slabs.

64 At Chêne Vert, ramification processes (Bourguignon *et al.* 2004) in the first phases of production are well evidenced: more than a third of the cores are on flakes. These flake blanks mainly consist of large cortical flakes (especially primary flakes) and seem to be selected on the basis of dimensional (dimensions of flake-cores are very close to those of blocks) and petrographic criteria (preferentially derived from shaping-out or reduction of nodules). They are predominantly exploited on their ventral surface via a preferential Levallois or assimilated ("Kombewa"), even frontal, debitage. Occasionally, exploitation concerns the dorsal volume (Kostienki), the thickness (frontal to *semi-tournant* debitage on the blank's edge) and exceptionally both sides (Quina). Most of the *chaînes opératoires* are thus ramified and production aims are identical between main and secondary *chaînes opératoires*. As primary and secondary productions do not have differentiated objectives (apart from perhaps on a dimensional basis), it is possible that ramification processes are linked to economic contingencies and allow productivity to be increased. The principal *chaînes opératoires* do however differ and most likely translate a chrono-cultural mixing (see below) and differentiated technical and functional requirements: oval and quadrangular Levallois products via different Levallois modalities including the Kombewa and probably Kostienki variants; asymmetrical and cortical products using different Quina modalities and facial debitage; and lastly, occasionally laminar products using *semi-tournant* uni(bi)polar debitage.

Immediate extraction and exploitation of raw material...

65 The function of the site appears to be clearly focused on the extraction of raw material in view of immediate exploitation (Geneste 1985), geared towards specialized Levallois or Quina production with high yield objectives. Debitage products were not, or seldom, retouched on site and were probably the object of a differed and/or delocalized use. Given the very specialized nature of the site and according to techno-economic data, part of the Levallois products were exported. Regarding other production modes, cortically backed pieces also seem underrepresented (7% of technologically identifiable products) and we may envisage, with caution, that parts of this corpus, characterized by a strong rejuvenation potential, were exported. In a context of Quina production, the main investment takes place mostly during transformation and rejuvenation phases (functional matrix, Faivre 2008) or recycling phases (production matrix) adapted to high mobility (Delagnes 2010). The absence of Quina sidescrapers associated with Quina debitage has previously been advanced as characteristic of a workshop facies (Bourguignon 1997 - p. 145). In this type of rarely seen case, of a site located directly upon an abundant source of raw material, we may expect to observe a production based on anticipated needs for tools, which are then exported in different forms (blanks, retouched tools, cores, mixed matrices) for deferred uses. However, in the absence of bone remains and use-wear analyses, other related or complementary activities at Chêne Vert cannot be ruled out. Finally, according to the taphonomic data presented above, we can reasonably assume that extraction/reduction activities were located a little further up slope from the excavated site.

...within a limited procurement territory

66 The main interest of Chêne Vert thus lies primarily in it functioning as a lithic workshop, which may tie into a larger network involving rock-shelters in the region. This aspect is all the more important given that Charente Turonian flint is systematically present in assemblages from this region (Delagnes & Meignen 2006), and is at times predominant as for instance at La Quina (Park 2007; Park & Féblot-Augustins 2010). At this site, located just ten kilometres south of Chêne Vert, Quina type Mousterians in layers G, L and M largely offset the absence of local good-quality flint by introducing Turonian flint blocks and products. Conversely, the rare non-local material identified at the site of Chêne Vert (0.15%) is drowned out by the sheer volume of local flint and may represent discarded items of personal gear (Binford 1980) left behind by passing hunters. These pieces are generally retouched and have sometimes been maintained, rejuvenated or recycled in various ways. These materials are the only indication of the Neanderthals' procurement territory prior to their arrival at Chêne Vert. It is rather limited, with flint having been collected from nearby Turonian and Coniacian levels (in the area of Angoulême) and circulation routes extending from neighbouring territories (< 20 km), to the east or northeast (Liasic and Jurassic formations) where several Mousterian sites are already known (e.g., Artenac, abris Suard and Bourgeois, Les Pradelles). Nearby excursions from the south-west (Santonian flint) are also possible; longer distance excursions are hinted at by the presence of two radiolarian flints which are not currently known in this part of the Aquitaine Basin. The relative distance of the sources seems consistent with the introduction of heavily retouched and/or recycled pieces, towards the end of their use-life, abandoned by Mousterians passing through Chêne Vert. Finally, it is surprising to find pieces in flint originating from Dirac that bear a level of transformation normally rserved for non-local flint pieces. This is the case, for example, of certain convergent or offset scrapers, occasionally thinned, which could be interpreted as evidence for Mousterians returning to the site.

Brief but regular visits according to raw material procurement needs

67 Regarding the site's status, in other words occupation modalities, available data is rather difficult to untangle. While the vast majority of artefacts are technologically coherent and of Levallois tradition, the more discreet presence of Quina type production seems to indicate that the flint outcrop was exploited by chrono-culturally distinct groups. It is hardly surprising that a good quality flint outcrop such as this should be exploited by different chrono-cultural groups, yet it remains impossible to define the number or the frequency of these stopovers. Petrographic and techno-economic approaches allow us to put forward several working hypotheses and to discern rather limited spatial movements, confined to the neighbouring environment of Dirac, mainly to the east and north-east. The exploitation of Santonian flint outcrops to the south and south-west has not been validated, but the possibility of circulation routes in that direction has not been ruled out. These observations tend to outline groups who operated within a constrained territory but whose precise movements remain unknown.

68 The Dirac outcrop seems to have been exploited at different periods during the Mousterian, as suggested by the technological analysis and the presence of distinctive

techno-complexes. Given the density of lithic objects, the diversity of non-local material and the presence of several pieces in local flint with a similar level of transformation/rejuvenation to that of allochthonous materials[1] it is also possible that Mousterian groups returned to Chêne Vert several times for periodic and regular raw material provisioning.

4 – What is the chronological framework of these occupations?

69 The taphonomic history of the site of Chêne Vert complicates our reading of the varying successive occupations. The technological study and refits clearly bring to light the presence of two technologically distinct spheres (Levallois/Quina) which seem to result from different Mousterian stopovers, which may have been separated by a significant interval. Indeed, these technical systems are generally not compatible within the same assemblage; their coexistence in a homogeneous level, from a sedimentary perspective, is therefore interpreted as indicating the mixing of the remains of diachronic occupations from further up slope and redistributed during the formation of the deposit. The status of Quina production at Chêne Vert remains problematic: Quina debitage is manifest, but the other identity marker, i.e. Quina retouch, is absent, which could however be tied to the site's function (see above). Nevertheless, it is worth noting the occurrence, albeit extremely rare, of techno-complexes associating Levallois and Quina, such as at Petit Bost where a Saalian Mousterian characterized by a partly Quina industry but a non Quina facies (with no Quina retouch) was identified (Bourguignon *et al.* 2008; Vieillevigne et *al.* 2008; Jaubert 2012). It thus raises the question of the chronological setting.

70 In the south-west of France, most of the Levallois techno-complexes cluster around MIS 8, 7, 6 and 5 (Delagnes & Meignen 2006). Quina techno-complexes, strictly speaking, tend to occur between MIS 4 and the beginning of MIS 3, which corresponds to a pleniglacial period (Discamps *et al.* 2011; Jaubert 2012). It would be tempting to classify the different occupations identified at Chêne Vert on this chronological basis, but the archaeo-sequences from Poitou-Charentes sometimes present exceptions. Certain Levallois techno-complexes occur after Quina facies, such as the denticulate Mousterian with Levallois debitage from Jonzac (49.7 ± 5 ka) (Jaubert 2010a) or that from La Quina (layer 7, between 44.5 ± 4.2 and 43 ± 3.6 ka) (Park 2007), or the late Levallois Mousterian with large sidescrapers from Rochers de Villeneuve (45.2 ± 1.1 ka) (Beauval *et al.* 2006). Moreover, the OSL date of 56.8 ± 1.8 ka obtained for layer 3 of Chêne Vert, which dates the probable burial of the archaeological level, is earlier than the last Mousterian occurrences with Levallois debitage, but much more recent than ante-Eemian Quina productions at Petit Bost. Ultimately, the hypothesis retained is that of a succession of Levallois and Quina occupations at Chêne Vert, loosely attributed to the recent Middle Palaeolithic, without being able to specify their exact order.

5 - Conclusion

71 The study of the site of Chêne Vert has brought to light a Mousterian site in secondary position highlighting several occupations by Neanderthal groups with technologically distinct traditions. The remains were mixed up during their transport, probably before

the isotopic stage 4 to 3 transition. In spite of taphonomic disturbances, the technological analysis and refits led to the identification of discrete occupations and to insights into Neanderthal techno-economic behaviour. They were able to, amongst other things, adapt their production objectives to the idiosyncrasies of both flint beds available in the underlying alterite.

72 One of the main interests of Chêne Vert lies in the primary function of the site, that of a knapping workshop on a flint outcrop. This type of site, whose economic status is certainly more nuanced than its designation as a workshop would suggest, undoubtedly played a major role in the socio-economic and spatial organization of Mousterian groups. The possibility of economic and territorial links and complementary relations between Dirac and other sites from this region, notably rock-shelters in the area, opens very promising prospects for future research. Furthermore, the petrographic study highlighted idiosyncrasies of the Turonian flint from Dirac which singles it out as a marker at the regional level. This specificity should thus eventually allow to directly identify which pieces from regional Mousterian assemblages were collected at Dirac.

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NOTES

1. Pieces made at Chêne Vert, which then circulated before being discarded at the place of original manufacture during return visit(s) by Mousterian to the site/outcrop...

ABSTRACTS

The ways in which Neanderthals exploited the landscape and raw material sources constitute a major aspect of the study of Middle Palaeolithic settlement systems. The Aquitaine Basin in the south-west of France, and more specifically the Charente, has been the object of numerous studies exploring open-air sites within the mineral environment (*e.g.* Park & Féblot-Augustins 2010). The recently discovered Mousterian workshop of Chêne Vert at Dirac, located on a flint outcrop and excavated in a rescue context, presents a rare opportunity for studying Neanderthal procurement strategies directly associated with a readily available raw material. The main excavation results presented in this article, through geoarchaeology, taphonomy, petroarchaeology and lithic techno-economy, shed light on site formation processes affecting the archaeological level, the assemblage's degree of integrity and technical behaviour and adaptations to the specific features of flint from Dirac, prior to the transition between MIS 4 and 3.

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Keywords: Middle Palaeolithic, Charente, workshop, flint outcrop, lithic industry, Levallois, Quina, taphonomy, geoarchaeology

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