Adaptation to raw materials intra-variability: Examples from three Middle Palaeolithic surface stations of the Hérault Valley, France (Les Geissières, Saint-Saturnin and Camillo)

Cyrielle Mathias [1], Laurence Bourguignon [2], Jérôme Ivorra [3], Déborah Barsky [4, 5], Sophie Grégoire [1], Cyril Viallet [1]

1. UMR 7194 - Histoire Naturelle de l'Homme Préhistorique (HNHP), avenue Léon Jean Grégory, 66720, Tautavel. France. Email: Cyrielle Mathias: cyrielle.mathias@gmail.com, Sophie Grégoire: sophie.gregoire@cerptautavel.com, Cyril Viallet: cyviallet@gmail.com
2. Institut National de Recherches Archéologiques Préventives (INRAP)/UMR 7041 Archéologies et Sciences de l'Antiquité (ArScAn), Anthropologie des Techniques, des Espaces et des Territoires (AnTET). Paris. France. Email: laurence.bourguignon@inrap.fr
3. Groupe de Recherche et d'Etude du Patrimoine Archéologique Méditerranéen (GREPAM), chemin du plateau d'Arnet, 34120, Pézenas. France. Email: jerome.ivorra@orange.fr
4. Institut Català de Paleoecologia Humana i Evolució Social (IPHES-CERCA), Zona Educacional 4, Campus Sescelades Universitat Rovira i Virgili, Edifici W3, 43007 Tarragona, Spain. Email: dbarsky@iphes.cat
5. Universitat Rovira i Virgili, Departament d'Història i Història de l'Art, Avinguda de Catalunya 35, 43002 Tarragona, Spain.

Abstract:

Up to now, little was known about the Middle Palaeolithic from the Hérault Valley (France). Recently, systematic surveys have led to the discovery of several surface stations on river terraces. Some of these have yielded stone tools made from unusual raw materials, such as, brecciated quartzites and jasper-like rocks, as well as quartz and rare flints. These rocks are found in primary position in the Montagne Noire area, and are also available in the alluvial deposits of the Hérault and its tributaries in the form of more or less rounded cobbles. These raw materials are very heterogeneous even within a single cobble. Their inter and intra-variability has been found to have induced specific knapping strategies as hominins adapted to - or took full advantage of - their special petrographic characteristics.

Here we present data from three Middle Palaeolithic open-air stations (Les Geissières, Saint-Saturnin and Camillo) to illustrate adaptive knapping strategies performed by Neanderthals. In addition to the technological analysis, experiments were also conducted to test some of the identified methods, such as bipolar-on-anvil, with the aims of: 1) evaluating flake production efficiency and 2) recognizing specific traces left on the products by this method. This enabled us to better identify archaeological artefacts in this particular alluvial context.

The study shows the use of stone reduction methods that allowed the knappers to adapt to the constraints posed by the raw materials: Discoid *sensu lato* (bifacial, unifacial, partial), Clactonian and bipolar-on-anvil. Methods more diagnostic of the Middle Palaeolithic, such as the Levallois and typo-

Journal of Lithic Studies (2021) vol. 8, nr. 2, 40 p. DOI: https://doi.org/10.2218/jls.4486

Published by the School of History, Classics and Archaeology, University of Edinburgh
ISSN: 2055-0472. URL: http://journals.ed.ac.uk/lithicstudies/

Levallois or various Kombewa methods were used on finer grained raw materials. There are a few retouched flake tools and some pebble tools (mainly choppers). These assemblages show us that, despite the influence of the raw materials (which is more of a constraint than a limit), Neanderthals achieved their goals through a variety of methods.

These surface stations make it possible to better perceive adaptive strategies in the Middle Palaeolithic in Languedoc-Roussillon, in a context where the Levallois techno-complexes prevail.

Keywords: Middle Palaeolithic; Neanderthals; surface stations; south-east France; raw material management; quartzite

1. Introduction

The Middle Palaeolithic of the Languedoc and, particularly, of the Hérault department, is poorly known in comparison with other areas, such as the Dordogne or Rhône Valley regions. Although the Languedoc has delivered major sites, these are scattered over a large area and local patterns are difficult to identify (Bourguignon & Meignen 2010; Chacón 2009: see endnote; Duran 2002: see endnote; Lebègue 2012: see endnote; Lebègue & Meignen 2014; Molès & Boutié 2009; Saos *et al.* 2020) (Figure 1). The sites are grouped together in eastern Languedoc and much less is known about the Middle Palaeolithic of central and southern Languedoc.

In this context, the Middle Palaeolithic from the Hérault area is only known by few sites: Aldène, Lunel-Viel, l'Hortus or Rothschild rockshelter (Ambert 1994; Bonifay 1981; Lebègue 2012: see endnote; Lebègue *et al.* 2010; de Lumley-Woodyear 1971: 129; 1972; see endnote; Rossoni-Notter *et al.* 2016), all of which are in karstic contexts. Only a few surface stations are documented, corresponding mainly to knapping workshops, such as Le Cadénas or Les Cours, where Levallois knapping strategies were largely employed on flint (Menras 2008: entire thesis). The Languedoc area was occupied from the Early and Lower Palaeolithic, as is attested by the sites of Bois-de-Riquet and Aldène, and evidence of Middle Palaeolithic occupations are perceptible from MIS 8-7, at Aldène, for example, and also at Lunel-Viel (Bonifay 1981; Bourguignon *et al.* 2016; Rossoni-Notter *et al.* 2016) (Figure 1).

New research has recently been undertaken in the middle part of the Hérault valley, with the aim of documenting and mapping Palaeolithic evidence from surface contexts. Since 2010, a systematic survey program has been conducted on the alluvial terraces of the Hérault, under the supervision of J. Ivorra (*Causses et terrasses alluviales du volcanisme des Baumes*). This program led to the discovery of numerous surface stations, from the Lower-Middle Palaeolithic up to the Neolithic. Within the Middle Palaeolithic occurrences, several sites yield lithic materials with archaic features, leading to their attribution to the Early Middle Palaeolithic. Here we present the results obtained from the lithic assemblages collected in the framework of this project, from three of these surface stations: Les Geissières, Saint-Saturnin (Neffiès), and Camillo (Caux). This study is part of larger project whose aim is to better understand the Middle Palaeolithic from the Hérault valley and its surroundings.

Figure 1. Main Middle Palaeolithic sites of the Languedoc. Green stars: studied sites.

2. Material and methods

2.1. Material: the Hérault Valley surface stations

The lithics studied were collected during the survey program directed by J. Ivorra *et al.* (2015: 1; 2018: 1). In this middle part of the Hérault Valley, twelve surface stations are attributed to the Middle Palaeolithic, two to the Upper Palaeolithic and six to the Mesolithic or Neolithic (Table 1). The survey area is delimited to the south by the Hérault River and to the east and west (respectively) by the Boyne and Peyne tributaries (Figure 2). The northern limit is formed by the Strombolian volcanic edifice of Les Baumes, positioned on the Cévennes fault. The latter played the role of a normal fault since the Oligocene, shaping the stepped landscape separating the surrounding hills from the middle valley of the Hérault, which was occupied by the sea during the Miocene. Following the marine withdrawal, a series of terrigenous deposits was accumulated successively up to the end of the Pliocene (Maurin 1983). The Hérault basin is bordered further to the east by the Nîmes fault. Consequently, it corresponds to the set of Languedoc fault, with a lacustrine or fluvial sedimentary filling, which may present a brecciated character near the fault edges (Serrano & Hanot 2005: see endnote).

Table 1. Middle Palaeolithic surface stations discovered during the survey, between 2014 and 2017. In bold, the sites presented in this paper.

Attribution	Name of the surface station	Cadastral landmark	Area	Nature of the discovery	Year of discovery
Middle Palaeolithic	Camillo	1307	Caux Nord	Lithics on Fv terrace	2014
Middle Palaeolithic	Paul Vidal de la Blache	87	Pézenas Nord	Lithics on Fya terrace	2014
Middle Palaeolithic	Clot des soeurs	782-785	Fontès Ouest	Lithics	2014
Middle Palaeolithic	Clot de Malibran	856	Nizas Ouest	Lithics	2014
Middle Palaeolithic	Les Croyes	68-69	Caux Nord	Lithics on Fv terrace	2015
Middle Palaeolithic	Saint-Jean-de-Bébian	249 and 254	Pézenas Nord	Lithics on Fv terrace	2015
Middle Palaeolithic	Sallèles	10-12	Caux Est	Lithics on Fv terrace	2015
Middle Palaeolithic	Clot de l'étang	126 and 131	Caux Nord-Est	Lithics	2015
Middle Palaeolithic	Garrigues	153-155	Caux Sud-Est	Lithics on Fv terrace	2015
Middle Palaeolithic	Arquinet	127 and 359	Pézenas Est	Lithics on Fx terrace	2015
Middle Palaeolithic	Les Geissières	501 and 678	Neffiès Ouest	Lithics on Fya terrace	2017
Middle Palaeolithic	Saint-Saturnin	12-14 and 17	Neffiès Sud	Lithics	2017

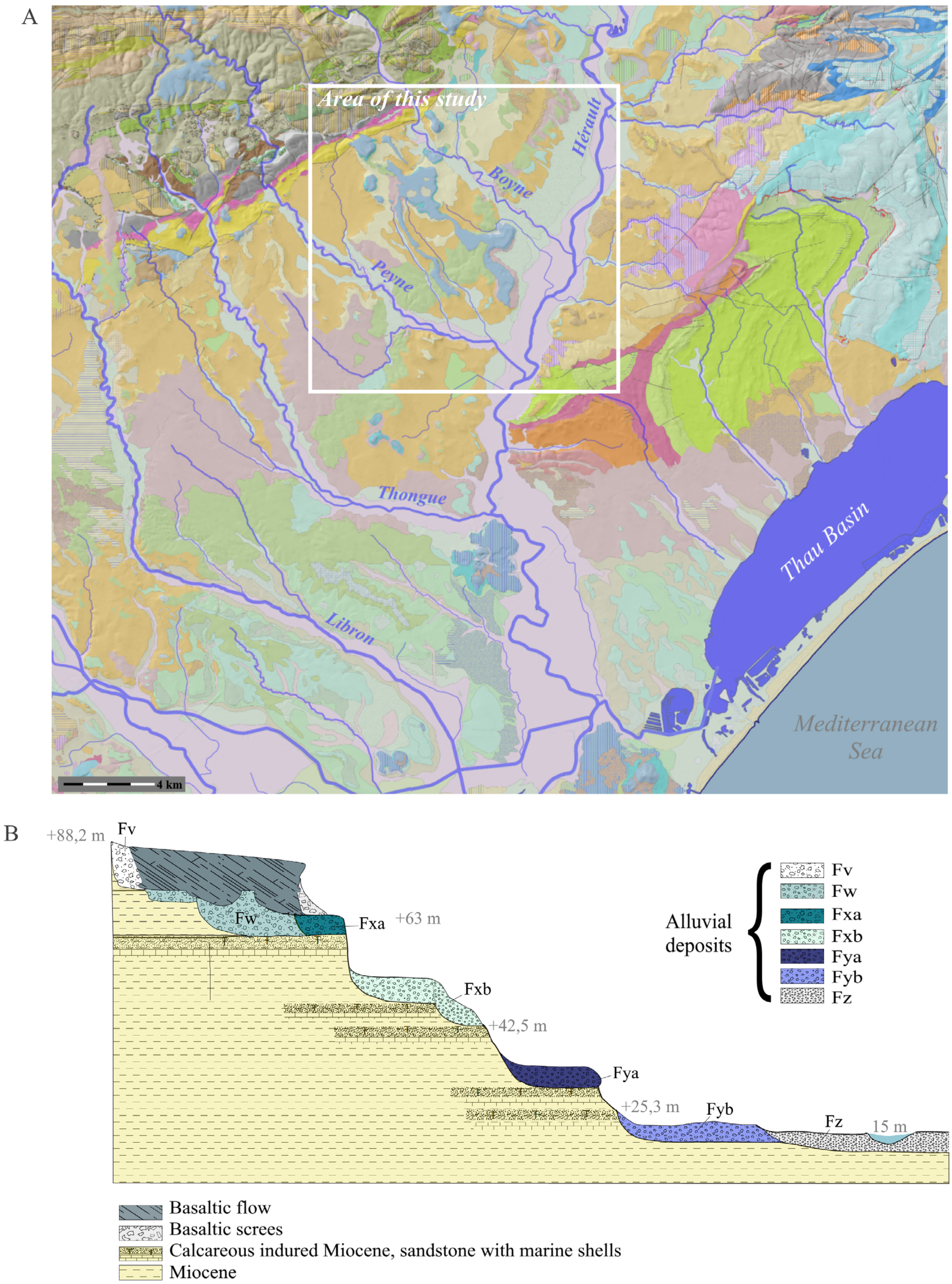

Figure 2. Synthetic view in section of the Hérault Valley terraces system. A: Location of the studied area on a geological map highlighting the hydrographic system (Vectorised 1:50 000 geological map, BRGM, caption available on infoterre.brgm.fr). B: Schematic cross-section of the Hérault Valley (after Ginouvez *et al.* 2016: see endnote).

The alluvial terraces of the Hérault River and its tributaries show a displacement and then a pivoting of the Hérault Valley after the Middle Pleistocene (Fx deposits). Successive volcanic episodes between the Lower and the Middle Pleistocene, following episodes of erosion and relief inversion, preserved portions of each alluvial terrace: 1) flushing flow released by the basalt quarry exploitation: 2) significant shreds protected between the volcanic constructions.

The ancient alluvial terraces have been preserved in a singular geomorphological context, linked to the setting up of a set of volcanic edifices which played a protective role against the erosion of the very high terraces which were much more eroded in other sectors of the Hérault Valley. In this favourable context, the presence of diverse mineral resources, including very fine-grained quartzite and flint nodules (sometimes in abundance), encouraged the settlement of human groups who came to exploit these raw materials.

The fluvial formations of the Hérault are correlated to different periods of the Quaternary Period (Berger *et al.* 1981; Ginouvez *et al.* 2016: see endnote; Ivorra *et al.* 2017: 28) (Figure 2):

The Fv alluvial accumulations are the oldest, and are attributed to the Lower Pleistocene (Villafranchian). These alluviums do not show any traces of volcanism. They remain only in the form of shreds (between +60 and +90 m above the current river level) and are clearly separated of the posterior alluviums.

The Fw sub-basaltic alluvium is attributed to the Lower Pleistocene, before the volcanic episodes. Their composition is similar to the Fv alluviums.

The Fx alluvium is attributed to the Middle Pleistocene. Its fragmentary distribution is observed in small discontinuous terraces of 3 to 4 metres in height (between +20 m and +30 m above the current river level). They are divided in two parts: Fxa and Fxb. The Fxa terraces are older than the Saint-Thibéry volcanism episode (around 680 ka ± 60 ka) (Ambert 1982; Semah 1979: see endnote), and the Fxb terraces correspond to a more recent phase of the Middle Pleistocene; probably between 560 ka and 480 ka.

The Fy alluvium is attributed to the end of the Middle Pleistocene and Upper Pleistocene. The terraces are well developed, especially on the right bank of the Hérault River. Between 4 m and 6 m in height, they contain raw materials from the Montagne Noire. The alluvium forms two terraces: Fya (middle terrace; between +10 m and +20 m) and Fyb (lower terrace; between +8 m and +10 m). The Fya terrace is only preserved between Paulhan and Pézenas. It can be distinguished by a morphological break where the Miocene bedrock appears.

The Fz alluviums correspond to recent alluvial deposits.

The dating of the terraces presented above makes it possible to assign a *terminus ante quem* for the lithic industries found on their surfaces, but not to date them. In any case, further geomorphological research and dating of the terraces is needed for this area, which has been little investigated for the Pleistocene period.

Three of the surface stations discovered yielded particular lithic assemblages knapped from metaquartzites, jaspoids and sometimes flint: Les Geissières, Saint-Saturnin, and Camillo (Figure 3; Table 1). These three stations are located near the Baumes volcano and the Lower Palaeolithic site of Bois-de-Riquet (Bourguignon *et al.* 2016). The characteristics of the raw materials used and the knapping systems identified have led to questions about the antiquity of these Middle Palaeolithic assemblages.

The lithic material from the three stations was collected in vineyard contexts, over an area of a few kilometres. Saint-Saturnin and Les Geissières are located at Neffiès. The site of Saint-Saturnin is located on the edge of a promontory that borders and dominates the Bayèle stream, while the second site is located on the high terrace of the river of the same name, crossing the nearby Triassic hills (correlation terraces Fya). The Camillo station, which yielded the most abundant Palaeolithic material, is located on the Fv terrace at Caux.

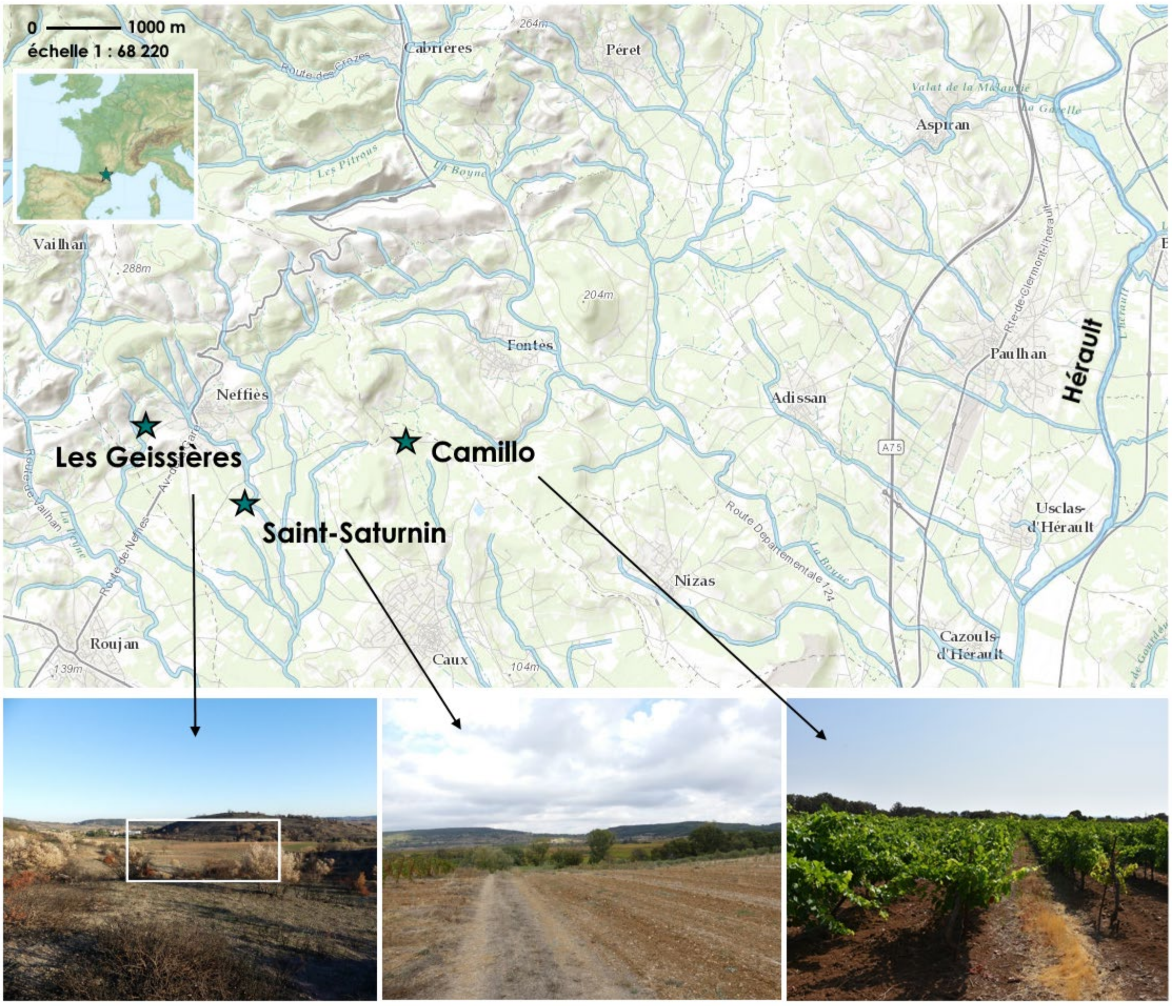

Figure 3. Geographical location and general views of the surface stations of Les Geissières, Saint-Saturnin and Camillo (Hérault, France).

2.2. Raw materials from the Neffiès basin

The Miocene marine deposits of the Neffiès basin contain pebbles and cobbles resulting from the dismantling of a metamorphic complex identical to that of the Montagne Noire (south of the Massif Central) with: vein quartz, quartzites and brecciated quartzites, jaspoids and sandstone. Vein quartz (xenomorphic) is more frequent compared to hyaline quartz (automorphic) (Mourre 1996). Some of these materials are highly heterogeneous, especially the brecciated quartzites and vein quartz (Figure 4). Some quartzites show large variation (grain size, homogeneity) and chalcedony inclusions are of excellent quality for knapping. Qualities of these raw materials are thus highly variable according to their homogeneity, grain size, or the presence of inclusions, fissures and joints.

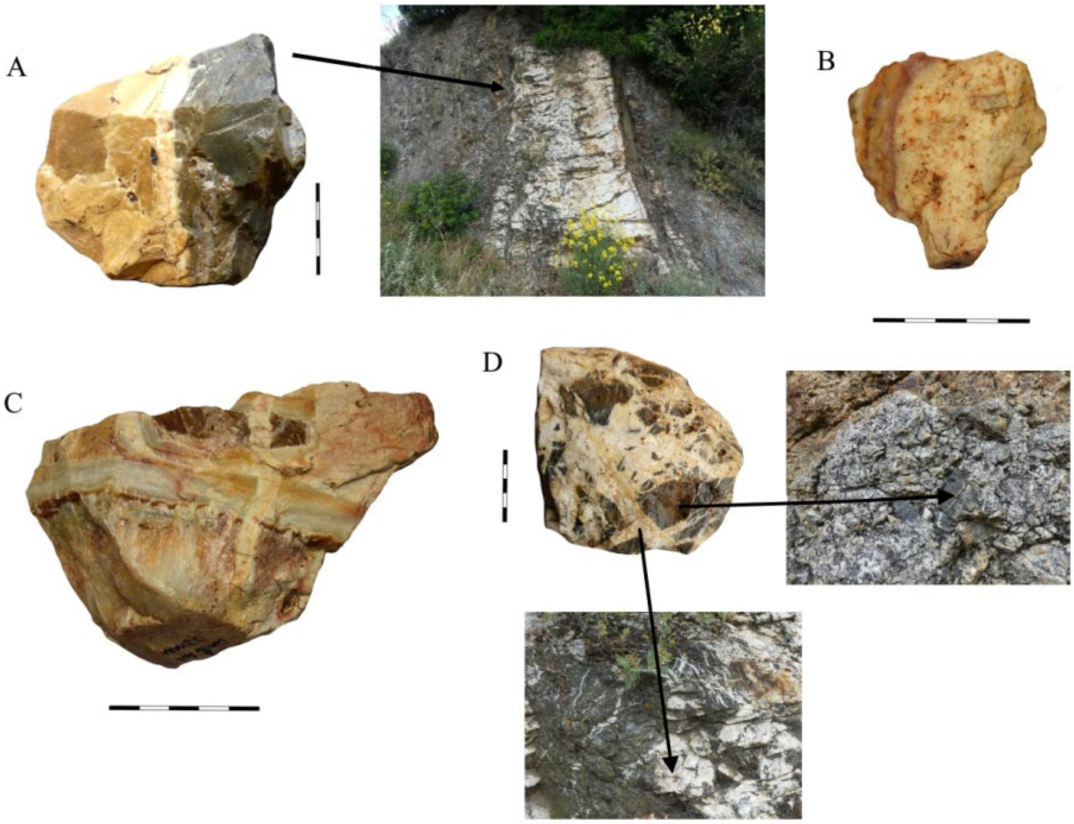

Figure 4. Examples of brecciated quartzites. A: Flake from Camillo and quartzite in primary position (Vailhan, Hérault). B and C: flakes of brecciated quartzite from Camillo. D: geological sample from the Fv terrace of Camillo and quartzite in primary position (Vailhan, Hérault). Scale bar: 5 cm.

So far, only 4 locations on the Fv, Fx and Fya alluvial terraces have delivered flint pebbles and cobbles in proportions exceeding 5% (Table 2). Flints from this area are integrated into the wider context of the Languedoc-Roussillon flint repository (Grégoire & Bazile 2009). On a macroscopic level, three *facies* are represented in our samples: these are more or less rounded and altered nodules whose external surfaces present some primary cortex mixed with patches of alluvial neocortex and natural fractures with double patinas. These external characteristics bear witness to brief fluvial transport, thus limiting the development of the alluvial neocortex on the surface of the rocks, which for the most part was not totally rounded into cobbles (suggesting proximity to primary outcrops). The double patinas bear witness to the long-term exposure of the nodules in the alluvial environment.

These three *facies* correspond to:

1) Translucent brownish flint, with more or less marked yellow or red concentric zones, which appear quite similar at the sampling points of Nizas (Figure 5, 2), Nézignan-L'Evèque, Saint-Jean-de-Bébian (Figure 5, 1), Chichéry and La Coustande. These flint types sometimes have partial or even total white patinas.

2) Flint type only identified on the Garrigue terrace. It could result from extreme alteration of the flints of the first *facies* or constitute a *facies* in its own.

3) Very homogeneous macro-crystalline flint, analogous to quartzite, with slightly rounded blocks showing regular parallel bedding. Only identified on two sampling points: Camillo and Sallèles 1 (Figure 5, 3).

Table 2. Description of the flint facies from samples collected in the terraces.

Collection locality	Position	Context	Texture	Matrix, Cement	Porosity	Constituents (in descending order)	Interpretation
Le Moulin-La Vierge (Nizas)	Secondary	Fv terrace	Grainstone to mudstone	Micritic caramel paste with a brecciated appearance	Low	Heterometric oolites, peloids, sponge spicules, foraminifers, iron oxide spots (hematite and goethite), automorphic quartz and quartz geodes,	Silicification of a clayey oolitic biomicrite, Secondary marine facies.
Chichéry (Pézenas)	Secondary	Fx terrace	Wackstone to packstone	Cryptocrystalline siliceous micritic	Low	Oolites, plant structures in fragments, echinoderm fragments, iron oxides (goethite) in zonation, Compression figures of included elements	Silicification of an oolitic biomicrite, Secondary marine facies
La Coustande (Pézenas)	Secondary	Fx terrace	Wackstone to packstone	Microsparite with caramel zonation, sometimes with a white patina	Low	Flaky elements, oolites, spicules and Sponge fragments, foraminifera, yellow oxide stains, glauconia	Silicification of an oolitic microsparite with glauconia, Secondary marine facies
Saint-Jéan-de-Bébian	Secondary	Fv terrace	Wackstone	Micritic caramel paste sometimes with a total white patina	Null	Heterometric ooliths, peloids, hematite inclusions, Sponge spicules	Silicification of a clayey oolitic micrite, altered Secondary marine facies
Sallèles, Camillo (Caux)	Secondary	Fv	Mudstone	Grey sparite (1 and 2) or cream (SL1)	Low	Yellow oxide spots	Indeterminate.
Garrigue	Secondary	Fv	Wackstone to grainstone	Microsparite with caramel zonation, sometimes with a white patina	Low	Oolites, peloids, flaky elements, spicules and fragments of sponges, foraminifera, yellow oxide spots	Silicification of an oolitic microsparite Secondary marine facies.

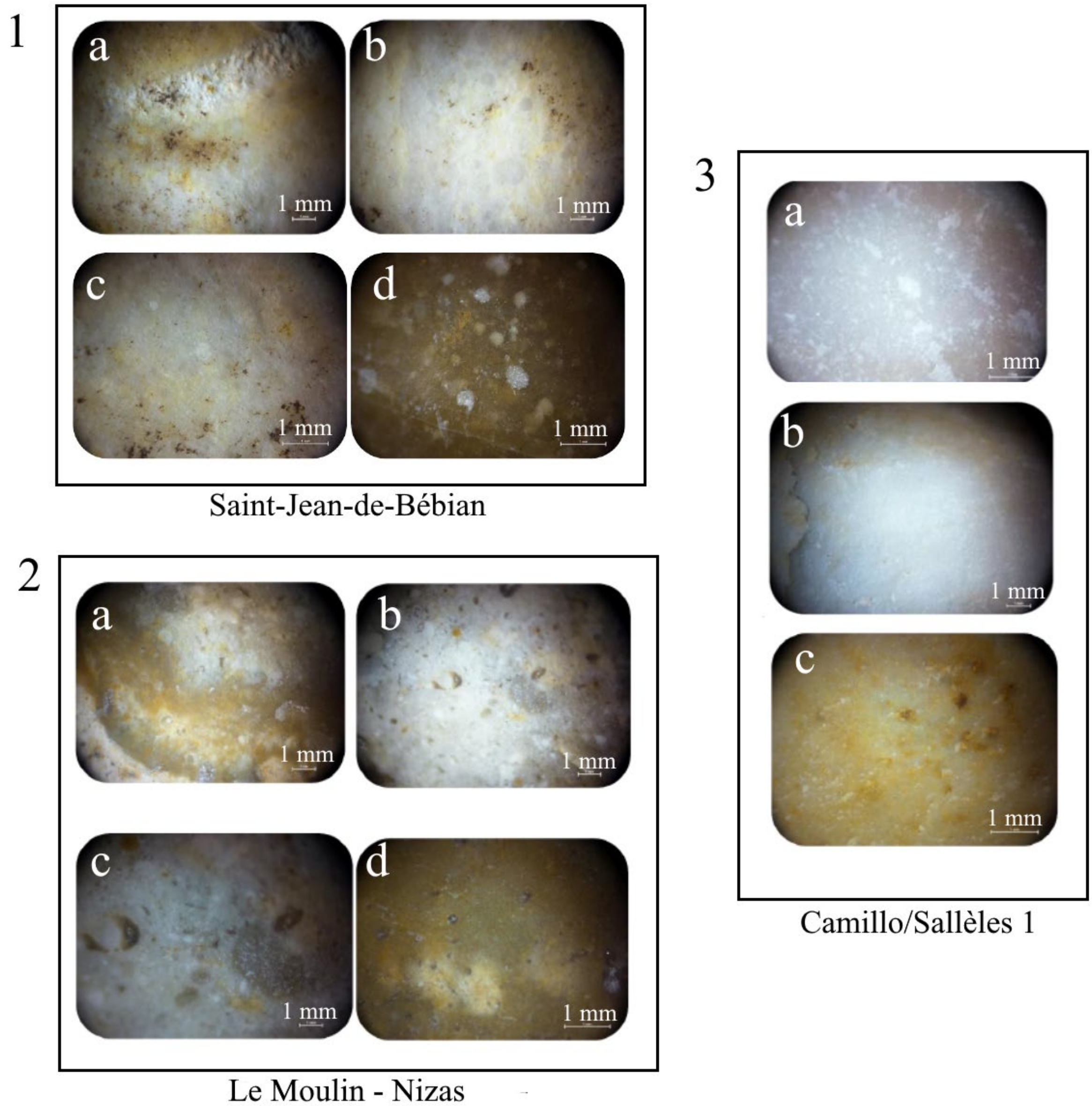

Figure 5. Flint facies. 1. Saint-Jean-de-Bébian, a: General view of the siliceous crystalline matrix with white patina and hematite inclusions, b: Heterometric ooliths, c: Non patinated part with flaky inclusions, d: Ooliths and hematite inclusions. 2. Le Moulin, Nizas, a: General view with yellow and white zonations, graphic patina, b: White zonations in details with numerous heteromorphic oolithis and foraminifers (coccolithophoridés), c: Debris and goethite, d: Yellow zonations with automorph quartz, geodes and peloids. 3. Camillo and Sallèles 1, a and b: General view of the grey sparite and iron oxides spots, c: Siliceous crystalline matrix and iron oxide impregnations.

Some Jurassic flint outcrops in primary or sub-primary contexts are found about 10 km to the north-northwest of the studied zone: the Bajocian flints from Puech Redon and Puech Pétou in the Fouzilhon area (Grégoire *et al.* 2007: 1; Ivorra *et al.* 2017: 51). These outcrops were exploited during the Middle Palaeolithic at the surface station of Les Cours (Plaissan) (Menras 2008: see endnote; 2009). These are the most common types in the terrace lithic assemblages.

2.3. Methods: Lithic analysis and experimental tests

A techno-typological analysis of the lithic material was carried out in order to identify the main knapping concepts (Boëda *et al.* 1990; Inizan *et al.* 1995: 59). As the material was collected from the surface of terraces, the first step consisted of a critical analysis of the collected material, taking into account taphonomic processes. Most of the materials in the collections have easily readable knapping marks (quartzites, jasper-like rocks, flints), making their anthropic origin easy to establish. On the other hand, more detailed work is necessary for the quartz items collected from surface contexts.

We based our quartz taphonomic analysis on the published literature, especially based on the visible traces of percussion (Driscoll 2011; Knutsson 1988; Mourre 1996; de Lombera-Hermida 2009; de Lombera-Hermida *et al*. 2011; de la Peña 2015), but also for specific experiments concerning the types of quartz found on the terraces.

Thus, numerous quartz items were present in the initial collections, which could correspond to cortical flakes produced by bipolar-on-anvil percussion. They were knapped from cobble edges along a longitudinal axis (greatest length). As this type of cortical flake did not seem appropriate to open quartz cobbles for knapping, we conducted an experiment to better understand the reaction of these quartz to percussion in relation to their size. Traces of bipolar-on-anvil knapping are diversified and sometimes difficult to observe (Donnart *et al.* 2009). The angle of flaking varies according to the morphology of the cobble flaked (Mourre *et al.* 2010).

We fractured meta-quartzites with bipolar-on-anvil percussion lengthwise and widthwise using quartz, quartzite and basalt hammerstones. The raw material was collected near the Saint-Saturnin and Les Geissières stations in Neffiès. Frequently, cores were broken without any link with the orientation of the percussion, following the natural fracture surfaces within the material (Figure 6, A and B; Table 3). In this case, the traces of bipolar-on-anvil percussion are not present (impacts from the blows and counter-blows, radial and transversal striations, *etc.*). Moreover, the longitudinal on-anvil opening of the cobbles proved to be very difficult to obtain, limiting these results. In the end, the flakes produced along this axis rarely showed the traces associated with bipolar-on-anvil knapping. As a result of this experiment, the choice was made to remove from the corpus the elongated cortical splinters from the anthropic material.

Table 3. Experimentation of bipolar-on-anvil (BoA*) knapping on quartz.

Experiment number	**Core or core-like (cobble fragment)**	**Flake with typical BoA* stigmata**	**Flake >2cm**	**Flake <2cm**	**Debris >2cm**	**Debris <2cm**	**Total**
1	1	-	2		8	4	15
2	2 parts (different orientation)	-	-	-	-	-	2
3	2 parts (different orientation)	-	-	-	-	-	2
4	1	2	2	-	-	-	5
5	3 parts (following diaclasis)	-	-	-	-	-	3
6	1	-	2	-	1	1	5
7	2	-	3	-	1	-	6
8	1	-	-	2	4	-	7
9	2 parts (longitudinal)	-	1	-	1	1	5
Total	**15**	**2**	**10**	**2**	**15**	**6**	**50**

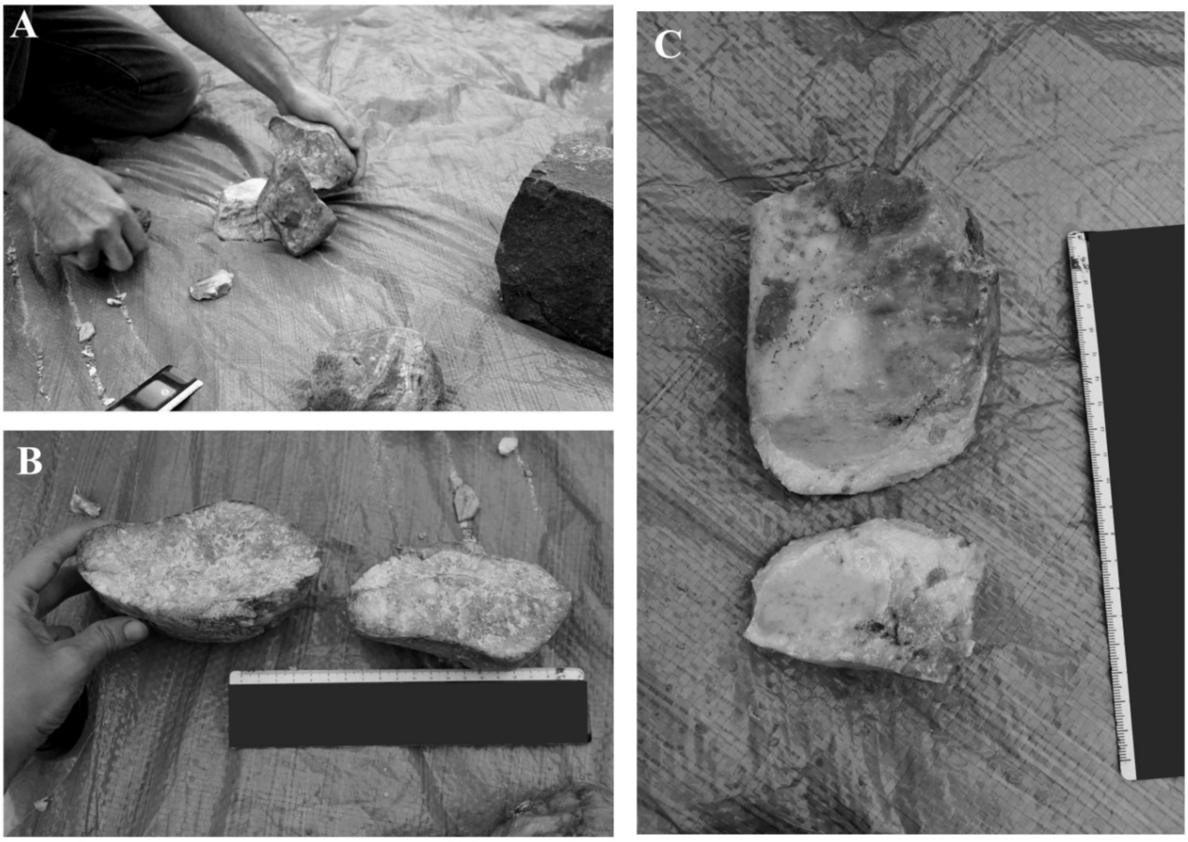

Figure 6. Experiment. A and B: perpendicular percussion on anvil; C: longitudinal percussion on anvil. Scale bar: 20 cm.

3. Results

3.1. Les Geissières (Neffiès)

The lithic assemblage from Les Geissières is essentially composed of quartzites. Brecciated quartzites are comparatively significant (42 on a total of 58 pieces of quartzite) (Table 4). Quartz, jaspoid and sandstone have also been used, but there are no flint pieces. A piece of (weathered) sandstone is also present.

The lithic assemblage yielded more flakes than cores (respectively N=43 and N=3) (Table 4). There are only five flake tools and cobble tools.

Table 4. Techno-typological main categories of Les Geissières station.

Techno-typological categories	Quartzite *sensu lato*	Quartz	Jaspoid	Sandstone	N total	%
Flakes	29	13	1	-	43	54.4%
Flake tools	4	-	-	-	4	5.1%
Cores	25	4	1	-	30	38.0%
Pebble tools	-	-	-	1	1	1.3%
Doubts, undet.	-	1	-	-	1	1.3%
Total	58	18	2	1	79	100%

Thirty cores were identified in the assemblage (Tables 4 and 5). S.S.D.A. methods (*Système par Surface de Débitage Alterné*) (Ashton 1992; Forestier 1993) are the most represented (N=13 - 43.3%). Cores with two, three or more surfaces are most common. Alternate surface methods conferring discoid morphology to the cores are represented (N=6;

e.g., Discoid *sensu lato*). The Levallois and typo-Levallois methods are not common (N=2) (Figure 7, B). The term typo-Levallois is used when all the criteria defined by Boëda (1993) are not observed, but the production objectives and the way of conceiving the surfaces are similar to the Levallois concept. We then speak of a Levallois with an additional structure and a Levallois with an integrated structure (Boëda 2013: 83). Some of these typo-Levallois cores have quite similar conformations, corresponding to convergent exploitations. Cores-on-flakes and combined matrices (that can be a tool and a core as well) are absent. A rotating or semi-rotating anvil method was also applied to metamorphic brecciated quartzite (N=3).

Table 5. Main types of cores identified at Les Geissières.

Type of cores	Quartzite *sensu lato*	Quartz	Jaspoid	N Total =	%
S.S.D.A. 1 surface	3	-	-	3	10.0%
S.S.D.A. 2 surfaces	5	-	-	5	16.7%
S.S.D.A. 3 surfaces and more	4	-	1	5	16.7%
Levallois and typo-Levallois	2	-	-	2	6.7%
Discoid *sensu stricto*	1	-	-	1	3.3%
Discoid *sensu lato* (partial bifacial, unifacial)	6	-	-	6	20.0%
Pebble tested, undet.	1	-	-	1	3.3%
Bipolar-on-anvil	-	4	-	4	13.3%
Rotating or Semi-rotating	3	-	-	3	10.0%
Total	25	4	1	30	100%

Bipolar-on-anvil knapping was applied on quartz, as is attested by the presence of both cores and flakes with recognizable traces of this method (Table 5; Figure 7, A). This is the only method identified on quartz.

Most of the flakes are poorly diagnostic of a knapping method, although a few could be the result of discoid *chaînes opératoires*. However, several pieces show the use of bipolar knapping-on-anvil (quartz). Considering cores and flakes, the production objectives are Discoid products (pseudo-Levallois and natural backed-flakes) and undifferentiated flakes, mainly from short production episodes (such as S.S.D.A. methods). However, when the raw materials allow it more standardized products were produced (Levallois and typo-Levallois).

A sandstone cobble seems to have been shaped on both surfaces. However, the alteration of the material impedes a clear technological lecture of the piece.

Only four retouched tools are present, exclusively in quartzite. These are: three scrapers and a scraper associated with a micro-denticulate (all on flakes excepting for the last one made on a fragment).

3.2. Saint-Saturnin (Neffiès)

From the point of view of raw material selection, pebbles or cobbles as well as angular fragments (especially quartzite) were used as cores. These are mainly metamorphic brecciated quartzites that have been used; they have a calcareous and opalescent inclusions (like for Les Geissières). Jaspoids, quartzites and quartz are present (in lesser proportions). Two Jurassic flint pieces have been identified, as well one that may be close to the Saint-Bébian type (Ivorra *et al.* 2017: 51). Finally, there is a sandstone piece with a significant alteration.

The lithic assemblage consists mainly of cores and flakes (N=49 and N=47, respectively) (Tables 6 and 7). Flake tools are rather rare (N=9) and only a shaped cobble is present. Five pieces, whose anthropic nature is not fully assured, have been set apart.

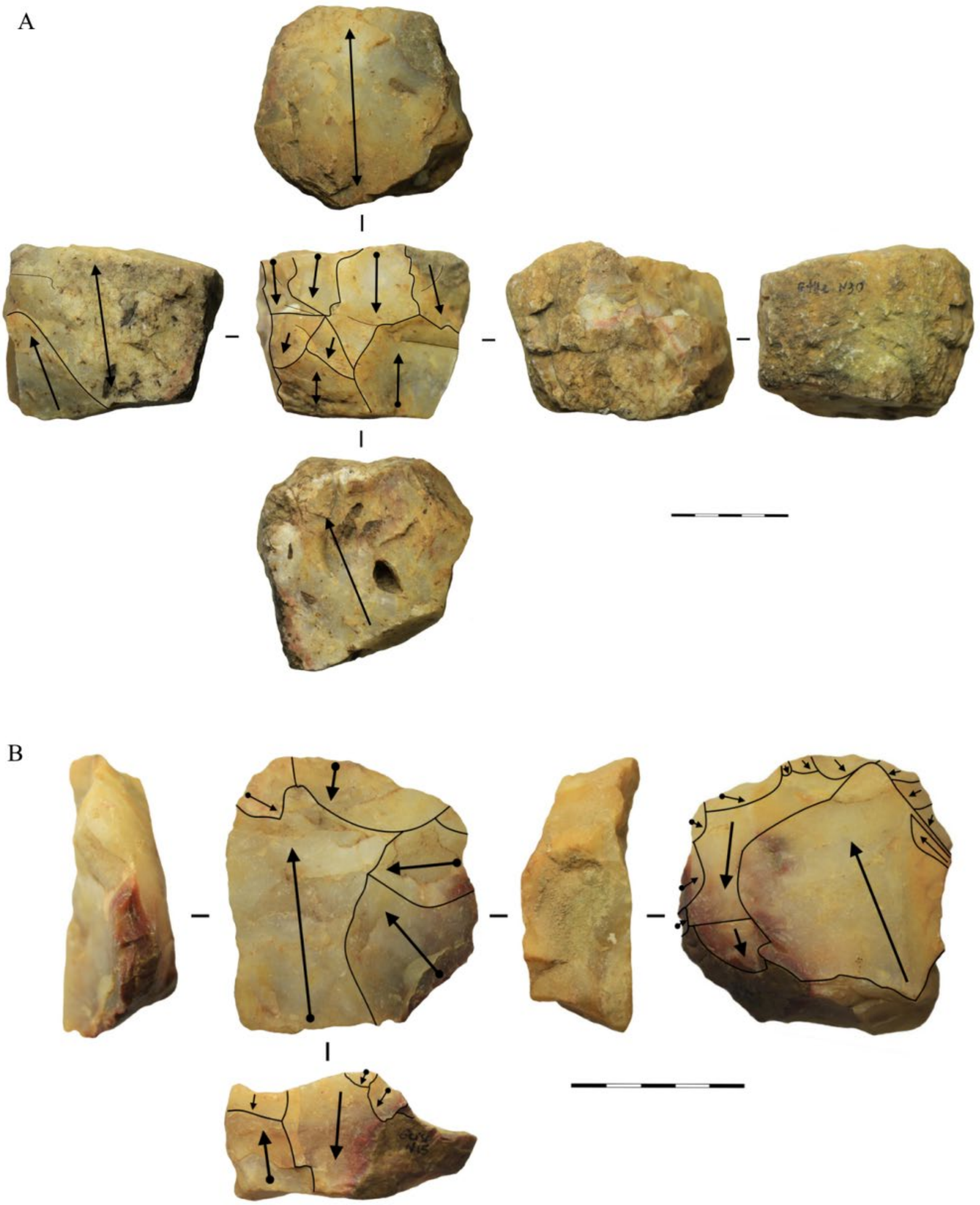

Figure 7. Cores from Les Geissières. A: bipolar-on-anvil on a small portion of good quality raw material. B: Levallois exploitation on a very good quality quartzite pebble. Scale bar: 5 cm.

Table 6. Techno-typological main categories of Saint-Saturnin station.

Techno-typological categories	**Quartzites *sensu lato***	**Quartz**	**Jaspoids**	**Flints**	**Sandstone**	**N =**	**%**
Flakes	38	6	2	1	-	47	42.1%
Flake tools	7	1	-	1	-	9	8.1%
Cores	38	8	2	1	-	49	44.1%
Pebble or Cobble tools	-	-	-	-	1	1	0.9%
Doubts	5	-	-	-	-	5	4.5%
Total	**88**	**15**	**4**	**3**	**1**	**111**	**100%**

Table 7. Main types of cores identified at Saint-Saturnin.

Type of cores	**N Quartzite *sensu lato***	**N Quartz**	**N Jaspoids**	**N Flint**	**N total**	**%**
S.S.D.A. 1 surface	7	1	-	-	8	16.3%
S.S.D.A. 2 surfaces	7	-	-	-	7	14.3%
S.S.D.A. 3 surfaces and more	3	-	-	-	3	6.1%
Levallois and typo-Levallois	6	-	1	-	7	14.3%
Discoid *sensu stricto*	2	-	-	-	2	4.1%
Discoid *sensu lato* (partial bifacial, unifacial)	7	2	1	-	10	20.4%
Kombewa recurrent	2	-	-	-	2	4.1%
Pebble or cobble tested, undet.	1	-	-	-	1	2.0%
Bipolar-on-anvil	1	5	-	-	6	12.2%
Combined matrices	2	-	-	1	3	6.1%
Total	38	6	2	1	49	

Forty-nine cores are present in the Saint-Saturnin series (Tables 6 and 7). The S.S.D.A. methods are the most represented (N=18 - 36.7%). One or two knapping surfaces were mainly exploited and cores with three surface exploitations are rare. Orientation of the negatives are very diverse (unipolar, bipolar, mixed) as well as the management of the knapping platform (cortical, prepared). The methods of production are not standardized.

The alternating methods, which lend the matrices a discoid morphology, are well represented (Figure 8, A). These methods are not strictly alternating and the products sought differ from conventional discoid methods (pseudo-Levallois points in particular) (Boëda 1993; 1995). The exploitation of these cores is mostly bifacial. Thus, if the detachment plan is secant, exploitation is often partial and the orientation of the removals is rarely *cordal* (which allows the obtaining of pseudo-Levallois points). Two classical discoid cores correspond to the initial definition (Boëda 1993). Note the presence of classical Middle Palaeolithic methods: Levallois and Levallois-like cores (typo-Levallois; Figure 8, B and Figure 9). Two cores-on-flakes are also present; they were exploited using recurrent Kombewa methods (Figure 8, C).

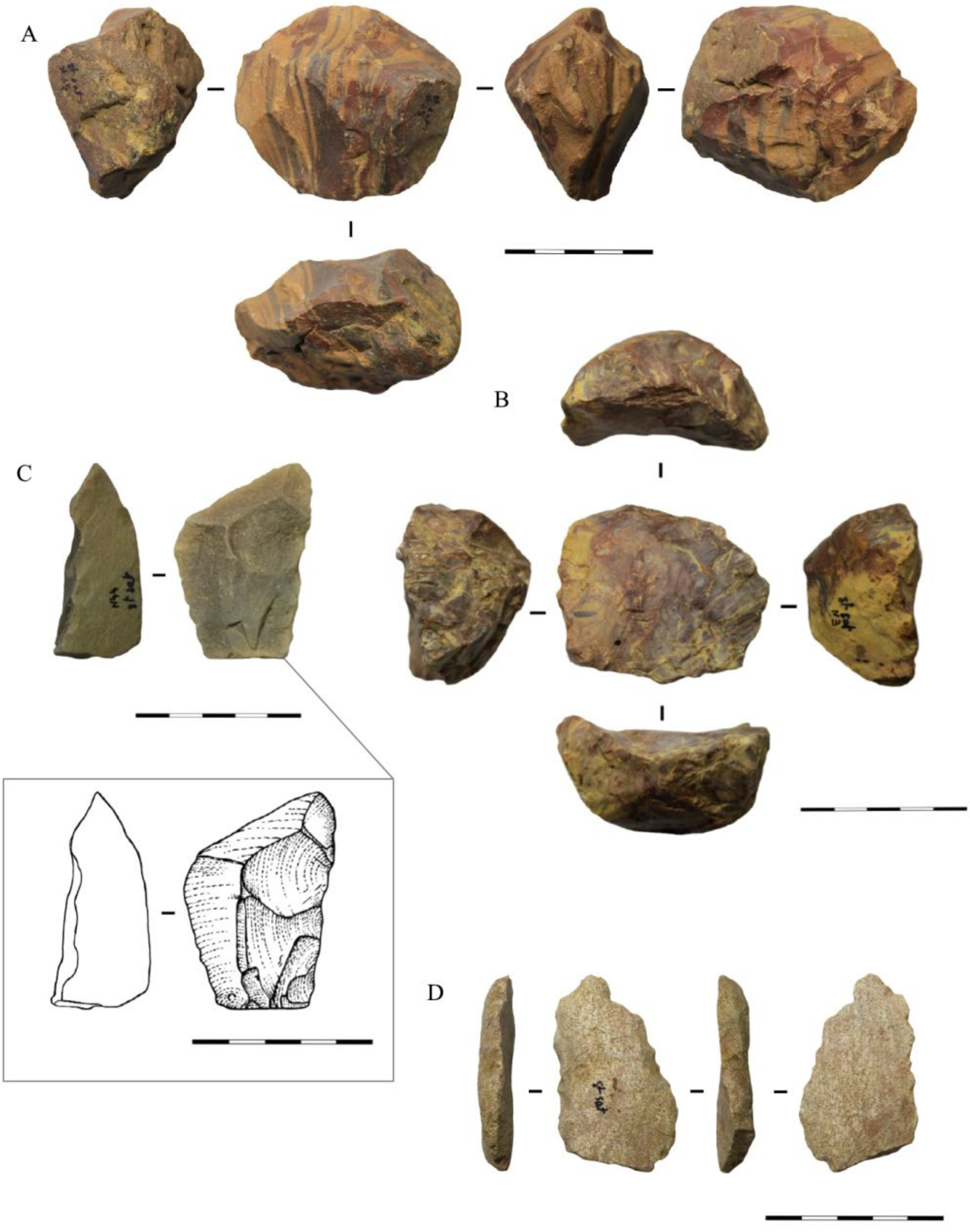

Figure 8. Lithic industry of Saint-Saturnin. A: Discoid core on jaspoid. B: typo-Levallois with preferential removal on quartzite. C: Recurrent Kombewa exploitation on a fine-grained quartzite. D: double denticulate on Jurassic flint. Scale bars: 5 cm.

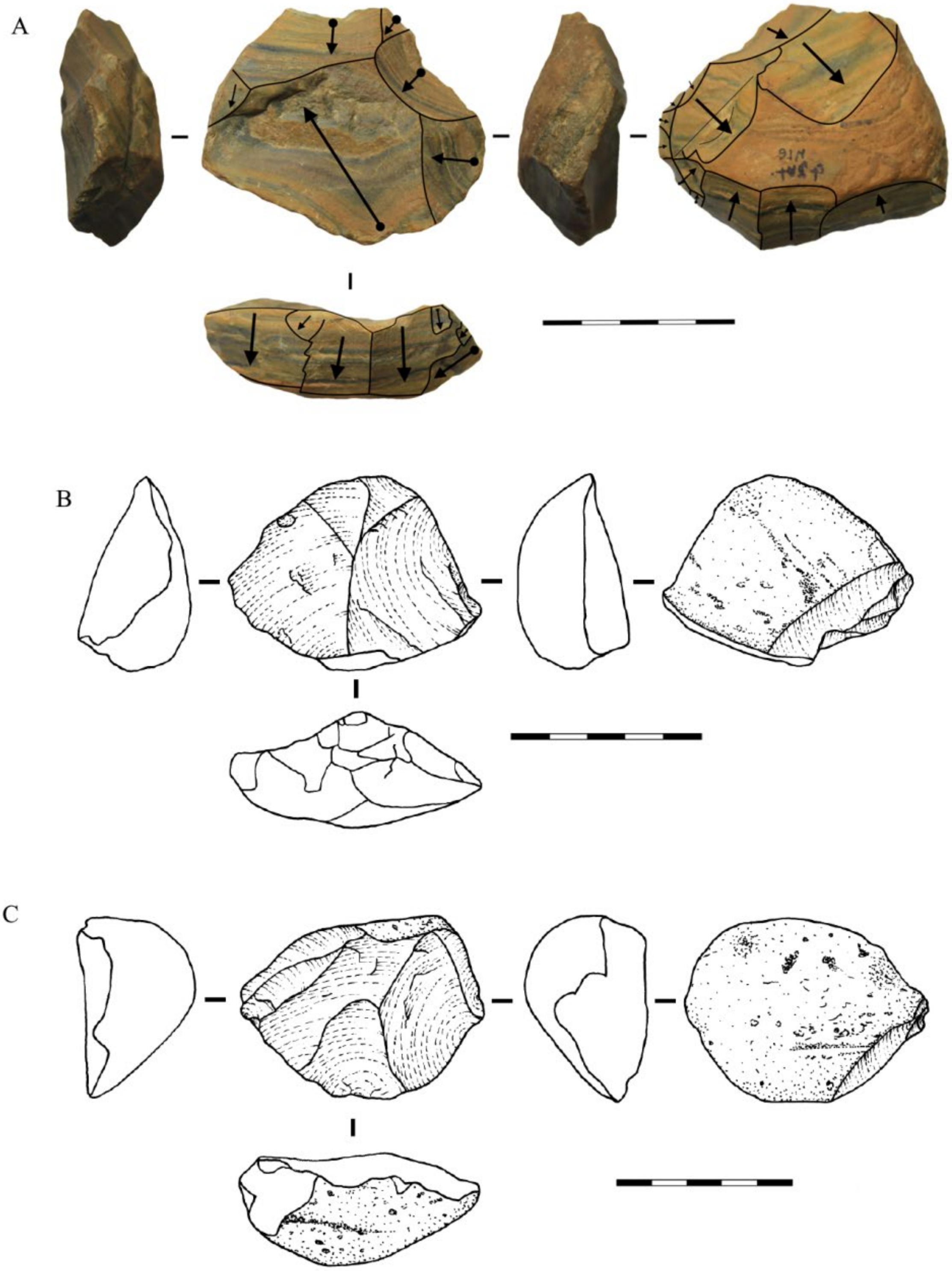

Figure 9. Levallois (A) and typo-Levallois (B and C) cores of Saint-Saturnin. A: Jaspoid; B and C: Quartzite. Scale bar: 5 cm.

For quartz, several cores have been identified (N=6) that attest a bipolar-on-anvil knapping.

Finally, an indeterminate modality is present, as well as three pieces that can correspond to combined matrices (*i.e.* that can be considered either as cores or as tools). One of these pieces corresponds to the only flint artefact that can be related to the type of Saint Jean de Bebian.

A cobble tool has been identified. It is made on a flat elongated sandstone cobble. The shaping of the cobble was carried out on a narrow edge, by non-invasive negatives. This is the only piece of this material in the series and it is highly weathered. The reading of its exploitation method is therefore complex and the counter-bulbs not very clear.

A few other tools have been identified, however they remain very rare. We have discarded all the pieces with irregular alternating notches, with a difference in patina, resulting most of the time from a taphonomic action. The flake tools, almost always made from brecciated quartzite (with the exception of one piece in quartz and one in flint) (Figure 8, D) correspond to scrapers, notches or micro-denticulates (one of which is convergent).

For the quartzite, flint and jaspoids, it is difficult to connect the flakes present in the lithic assemblage to a knapping concept. Their numbers are small and they are not diagnostic (often broken). On the other hand, some quartz flakes bear stigma of bipolar-on-anvil percussion (this method is also recognized on the cores). Considering both cores and flakes, the products sought are mainly peripheral-edged flakes (with a back corresponding to a back), pseudo-Levallois products and also ordinary flakes produced during short knapping sequences.

3.3. Camillo (Caux)

The surface station of Camillo yielded the most numerically rich lithic assemblage (N=543) (Table 7). Its raw materials are quite different, as brecciated quartzites are less common (total quartzites = 326 - 60%). The second raw material employed is quartz (milky and translucent; N=117 - 21.5%). The use of flint is also more significant: Jurassic flint, but also other diversified types, are represented by one or two pieces (respectively N=81 - 14.9% and N=16 - 2.9%). Other types of flint include one flake that can be attributed to the Saint-Jean-de-Bébian *facies*, and two flakes and one core attributed to the Camillo facies.

Another difference is that, compared to the other sites, there is a higher proportion of flakes (total of flakes = 267 - 49.2 % of the lithic assemblage) (Table 8). Pebble or cobble tools and flake tools are also more frequent than in the other assemblages (respectively, N=10 - 1.8% and N=39 - 7.2%). The shaped elements remain anecdotal, however, in proportion. Two hammerstones are present (one in quartzite and one in flint). They were both identified by a concentration of percussion traces on their surfaces (not isolated percussion traces).

Among these groups, S.S.D.A. methods were mostly employed (N=85 – 32.3%) (Table 9). One or two surfaces were generally exploited for the production of flakes, with unipolar removals (some unifacial cores can be considered as Clactonian, Ashton 1992). By-products are widely diversified and often cortical or semi-cortical, as knapping sequences are short. These methods allow an important adaptation to the cobble morphologies, taking advantage of the most homogeneous part of the raw materials. They were carried out on all of the raw materials; including flint.

Discoid *sensu lato* cores are the second most represented in the assemblage (N=75 – 28.5%) (Tables 7 and 8; Figures 10 and 11, 2). Their wide morphometric variability is largely due to the different modalities employed: unifacial, bifacial, partial peripheral, variant peripheral of a concept widely applied to quartzite materials, as, for example, in many regions of southern France (Quercy, Pyrenean Piedmont, and Catalonia). The production here is not oriented towards obtaining pseudo-Levallois points, but rather for backed-flakes (Table 8). Here we can also observe a succession on some discoid sequences with bipolar-on-anvil sequences within a same quartzite cobble (N=3) (Table 9).

Table 8. Main techno-typological categories in the Camillo lithic industry.

	Quartzite *sensu lato*	Quartz	Jurassic flints	Other flints	Lydien	Basalt	Total	%
Cores	151	68	40	4	-	-	263	48.4%
Flakes (undiferentiated)	43	10	19	1	-	1	74	13.6%
Cortical flakes	24	13	4	3	1	-	45	8.3%
Semi-cortical flakes	22	9	-	1	-	-	32	5.9%
Flakes with residual cortex	4	1	-	-	-	-	5	0.9%
Cortical backed flakes	23	8	8	-	-	-	39	7.2%
Other backed flakes	16	2	4	-	-	-	22	4.1%
Flakes from Discoid debitage	4	-	-	1	-	-	5	0.9%
Flakes from hierarchised debitages	3	-	-	1	-	-	4	0.7%
Kombewa flakes	1	-	-	1	-	-	2	0.4%
Combined matrices	-	-	-	1	-	-	1	0.2%
Cobble or Pebble tools	8	2	-	-	-	0	10	1.8%
Flake tools	26	4	5	3	1	-	39	7.2%
Hammers	1	-	1	-	-	-	2	0.4%
Total	326	117	81	16	2	1	543	100%
%	60%	21.5%	14.9%	2.9%	0.4%	0.2%	100%	

Table 9. Types of cores identified in the Camillo industry.

Type of cores	Quartzites *sensu lato*	Quartz	Jurassic flints	Other flints	N	%
S.S.D.A. 1 surface	21	6	6	1	34	12.9%
S.S.D.A. 2 surfaces	18	17	1	-	36	13.7%
S.S.D.A. 3 surfaces and more	9	5	1	-	15	5.7%
Unipolar elongated	1	-	-	-	1	0.4%
Levallois; typo-Levallois	14	-	3	-	17	6.5%
Discoid *sensu stricto*	13	6	2	-	21	8.0%
Discoid *sensu lato*	40	19	12	1	72	27.4%
Discoid + bipolar-on-anvil	3	-	-	-	3	1.1%
COFs -Kombewa, *etc.*	12	-	5	1	18	6.8%
Tested, undet.	20	4	10	-	34	12.9%
Bipolar-on-anvil	-	10	-	-	10	3.8%
Semi-rotating	-	1	-	-	1	0.4%
Combined matrices	-	-	-	1	1	0.4%
Total	151	68	40	4	263	100%
%	57.4%	25.9%	15.2%	1.5%	100%	

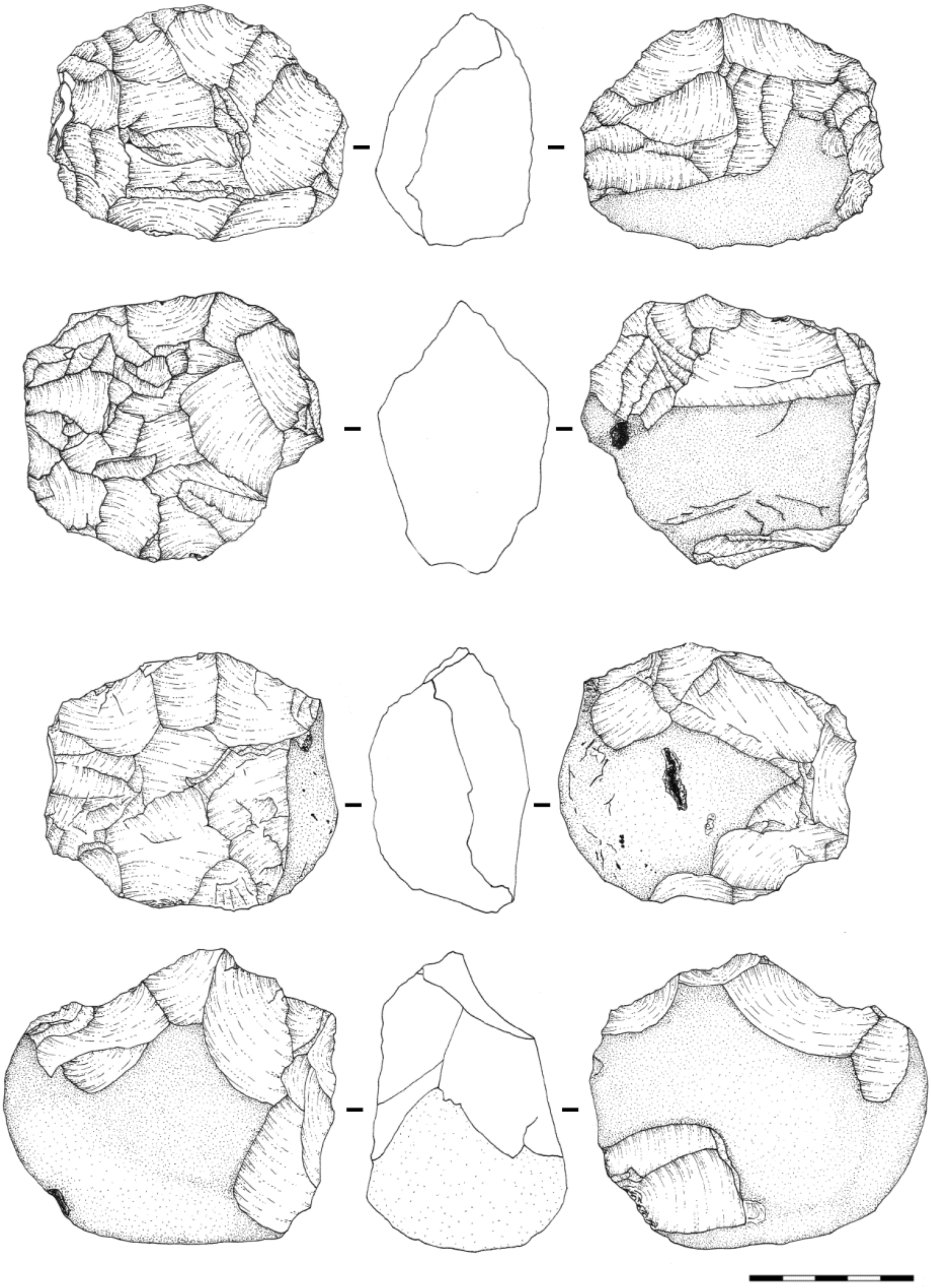

Figure 10. Discoid cores *sensu largo* (partial) of Camillo (drawings: Institut Català de Paleoecologia Humana y Evolució Social). Scale bar: 5 cm.

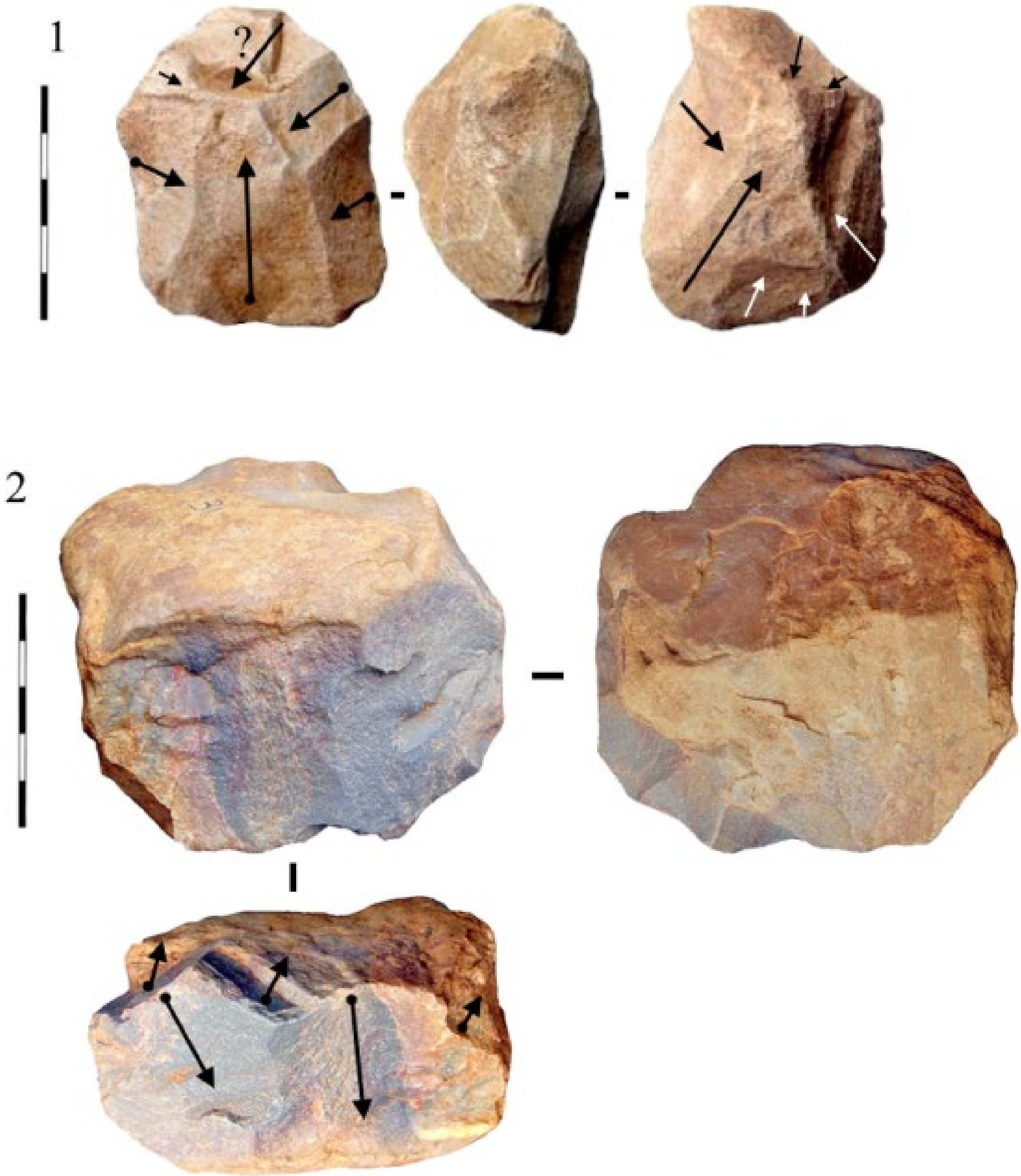

Figure 7. Cores of Camillo. 1: Lineal Levallois core on Jurassic flint. 2: Partial discoid core on quartzite. Scale bar: 5 cm.

Other methods were identified to a lesser extent in the series: Levallois and typo-Levallois methods (N=17 - 6.5%) (Figure 11, 1), but also debitage on flakes (COF; N=18 - 6.8%). Levallois and typo-Levallois cores show mainly recurrent unipolar or bipolar methods. The COFs are essentially Kombewa (both recurrent lineal) (Figure 12) and dorsal surface exploitations (*e.g.*, notch-like removals). These concepts were applied on almost all materials of good quality, excepting quartz.

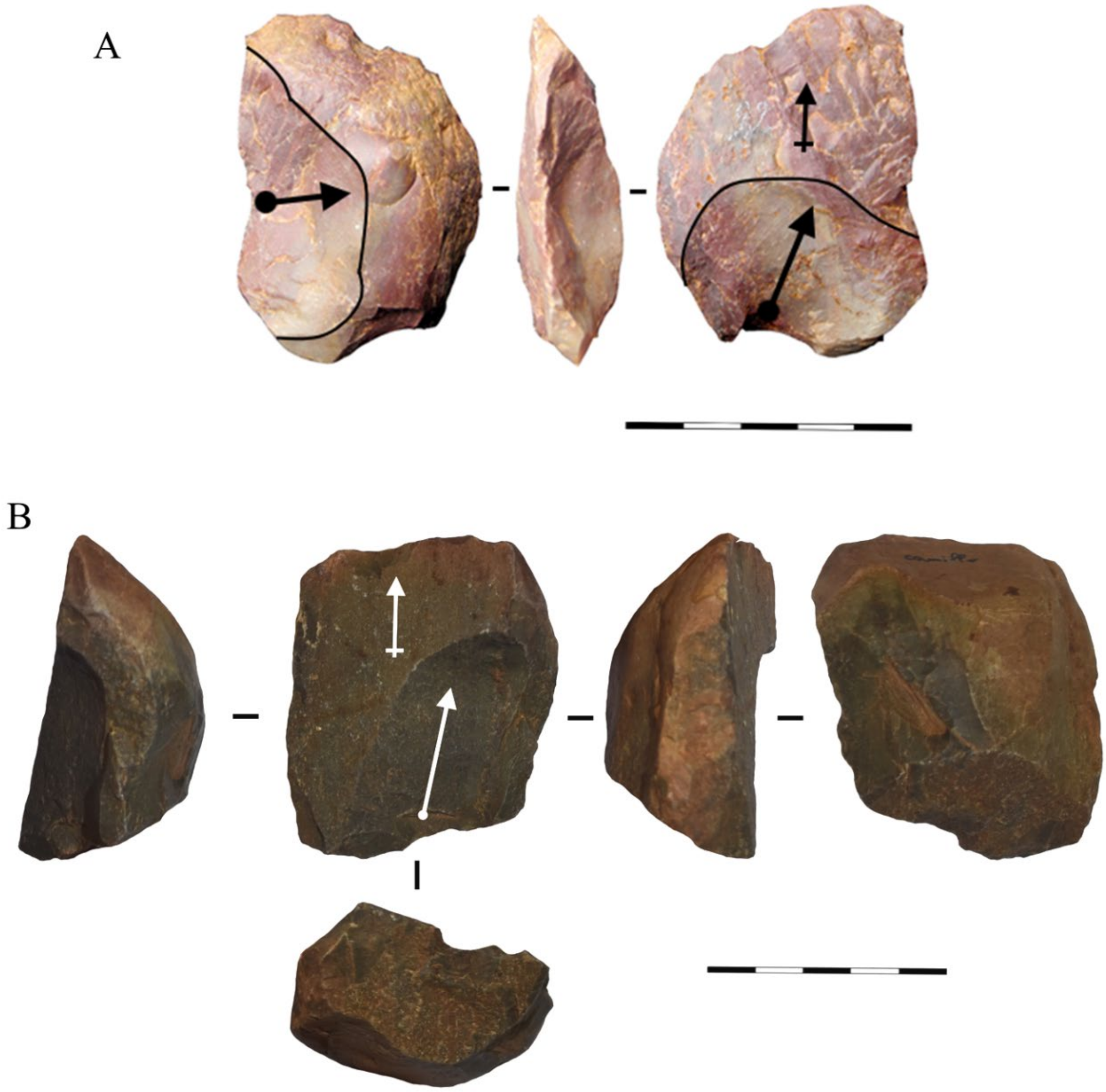

Figure 12. Cores-on-flakes on quartzite of Camillo. A: Ventral (Kombewa lineal) and dorsal (notch-like removal) exploitations; B: Kombewa lineal exploitation. Scale bar: 5 cm.

The set of large cutting tools (LCTs) from Camillo consists of 10 pieces, showing significant volumetric and dimensional variability (Figures 13, 14 and 15). All were produced on meta-quartzite cobbles with a more or less homogeneous matrix. Typologically, the series consists of 8 unifacial tools and 1 bifacially shaped cobble. In 6 cases, the shaping affects only on one edge of the cobble. In one case, the distal part and one edge (the mesio-proximal part) of the cobble was shaped. Finally, the last case of unifacial shaping is represented by a distal pick fragment.

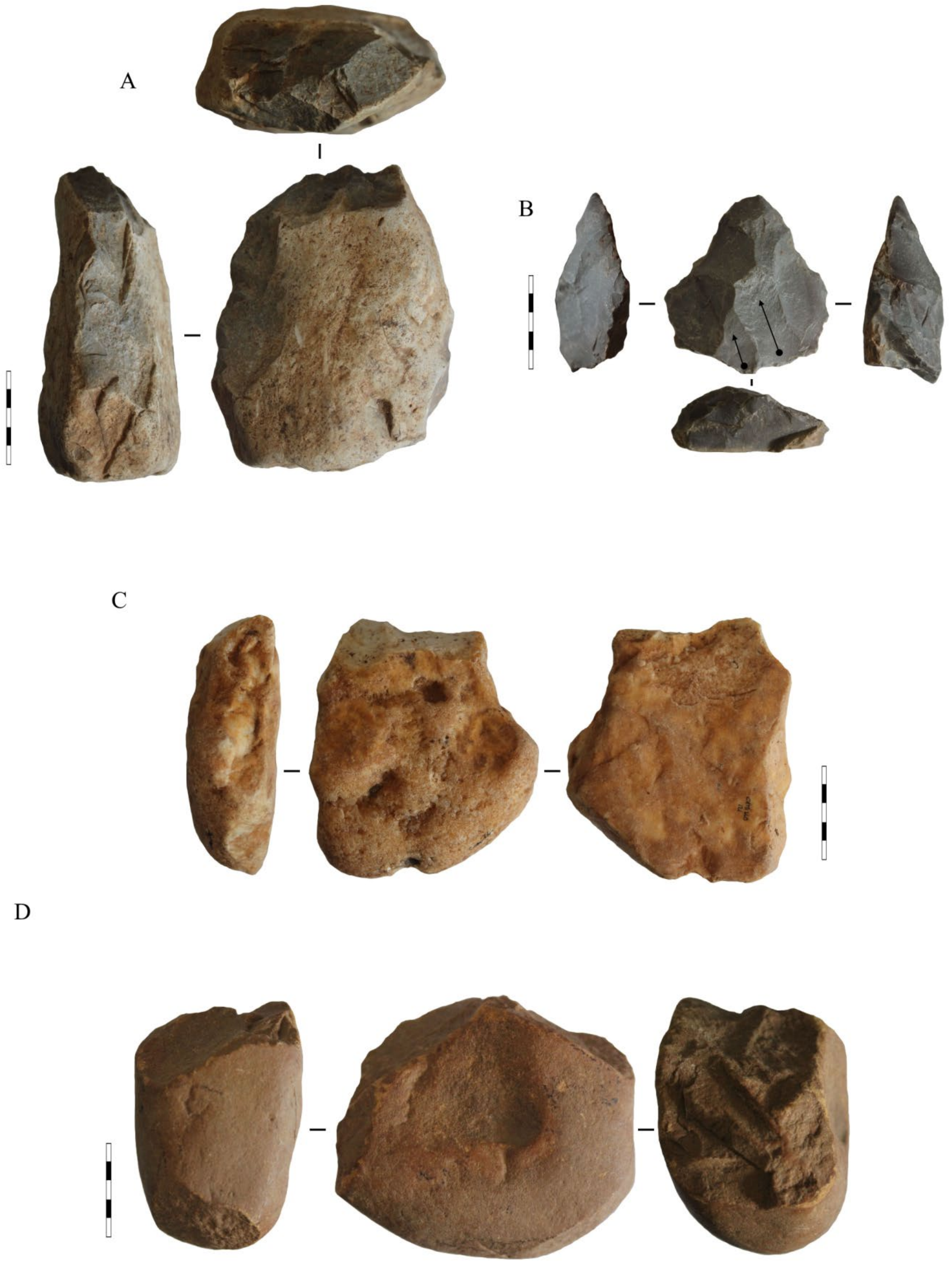

Figure 13. Large Cutting Tools of Camillo. A: Uniface. B: Pick in quartzite. C and D: Choppers. Scale bar: 5 cm.

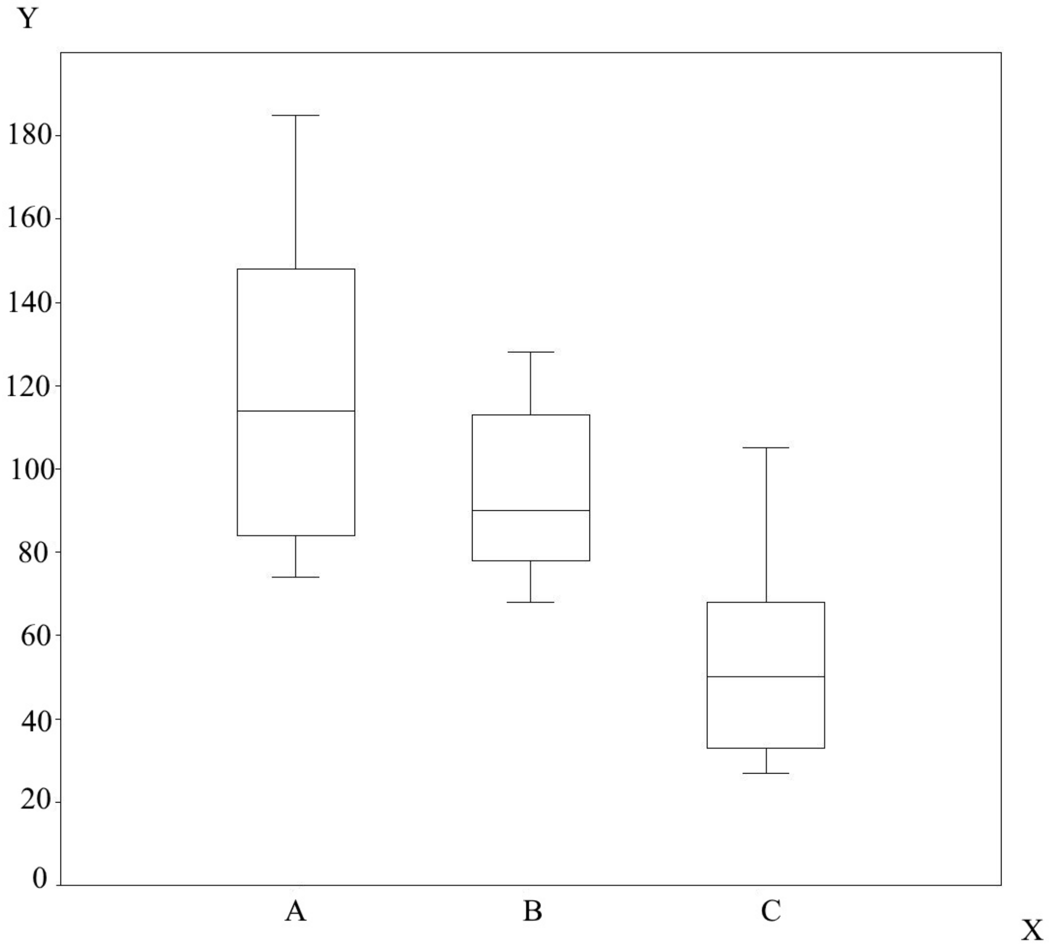

Figure 14. Boxplots of the lengths and widths of the cobble tools. Dimensions provided in Supplementary File 1.

Figure 15. Cobble with bifacial removals in quartzite, with macro-scars on the distal edge. Scale bar (main image): 5 cm.

The 7 cobbles with unifacial shaping represent two distinct volumetric structures (Figure 13):

1) The edge is shaped perpendicular to the axis of elongation of the support (N=5).

2) The edge is parallel to this same axis (N=2).

These two configurations imply different gestures of use. However, similarities exist for the shaping (few, long and rarely invasive removals) and their morphology (irregular in plan, most often concavo-plane in section and with an edge-angle comprised between 70° and 80°). Also, although the gestures may vary, there is a reasonable presumption that the category of operation was direct thrown percussion.

The uniface was made on a large quartzite cobble (Figure 13, A). The cutting edge of the distal end was shaped by a single, long, flat removal on the inverse side, followed by three long, concave removals on the upper side. The morphology is irregular in plan, set back in profile, and the edge-angle is 80°. It is situated in opposition to a transversal prehensile zone, which, associated with the type of cutting edge and the mass of the tool (1343 g.), implies its probable use for direct thrown percussion. The left edge of the cobble was also shaped by 4 short to long concave removals. The cutting edge is irregular in contour and profile, with an angle between 70° and 80°. Although it is morphologically similar to the distal edge, there is no morphological continuity between the two active areas of this tool. The hypothesis of direct percussion is also possible here, however, the lateral opposition between the active zone and the prehensile zone implies different gestures.

A quartz chopper was also made from a split cobble fractured in two by the bipolar-on-anvil method. The shaping was carried out using parallel, unipolar removals originating from the ventral-like surface (Figure 16). The edge is rectilinear and biplane in section.

Figure 16. Split-cobble of quartz (bipolar-on-anvil method), shaped subsequently with unipolar removals. Scale bar: 5 cm.

The pick fragment was produced on a very fine-grained quartzite. It corresponds to the distal end of the tool, shaped by 5 short to invasive removals. The fracture is accidental and may correspond to a knapping accident. The raw material is of good quality and thus, the tool was recycled as a core after the fracture, as shown by the two removals using the fracture as a striking platform (Figure 13, B).

The cobble with bifacial removals (*sensu* Nicoud 2011: 81) was produced on a thick meta-quartzite cobble (Figure 15). The shaping concerns only the mesio-distal part of the volume. It consists of invasive and flat removals on the lower face and long, concave or abrupt removals on the upper face. Short, concave and sharpening removals complete the functionalization. The active, convergent zone has an irregular profile and a generally biconvex cross-section with a high degree of angle (80° on average). Combined with a transverse opposition with the prehensile zone, the tool is designed for direct launched percussion operation. The bifacial macro-scars with reflected terminations present on the distal end may be evidence of use in this mode of action on hard material. Macro-scars of percussion are identified following experimental data and literature on this topic (Claud 2012; Claud *et al.* 2015; Viallet 2016a; 2016b: 106; Viallet *et al.* 2018).

The series of shaped tools at the Camillo site is therefore primarily associated with the range of percussive initiated activities. However, the diagnostic potential of these artefacts for chrono-cultural attribution is extremely limited.

Flake tools are quite frequent (N=39 - 7.2% of the lithic assemblage). Diverse raw materials were used: mainly quartzite *sensu lato* but also quartz, flints or lydian (Table 10). These tools are not really standardised, considering both blank selection and retouch type. Tool types are poorly diversified, and side-scrapers and notches are the most represented ones. Several flake-tools could not be assigned to a type because of their fragmentation (Table 10). The study of these tools does not allow us to know more from a technological point of view or in terms of chrono-cultural attribution.

Table 10. Flake-tools identified at Camillo.

Flake tool type	Quartzites *sensu lato*	Quartz	Jurassic flints	Other flints	Lydiens	N
Side-scrapers	6	-	3	2	1	12
Notches	8	1	1	-	-	10
Denticulates	4	2	-	-	-	6
Drillers	1	-	-	-	-	1
Retouch undet.	7	1	1	1	-	10
Total	26	4	5	3	1	39

4. Synthesis and discussion

4.1. Reduction processes identified and adaptation to raw materials

The S.S.D.A. knapping methods (Ashton 1992; Forestier 1993) and Discoid *sensu lato* dominate in the three sites. Bipolar-on-anvil knapping was mostly applied to quartz cobbles or sometimes on brecciated quartzites. Methods such as S.S.D.A., bipolar-on-anvil or discoid allowed the knappers to adapt as well as possible to the morphology and constraints of the raw materials during the knapping processes. When the raw materials are of better quality and homogeneous, more diagnostic Middle Palaeolithic knapping methods were used, such as Levallois (or typo-Levallois) and cores-on-flakes. It is interesting to note that the cores-on-flakes are represented by flint flakes but also by quartzite flakes, which is a rare (or unnoticed) phenomenon in ramification processes (Bourguignon *et al.* 2004).

Shaping is very rare, even for the station of Camillo, which yielded the most important assemblage of cobble tools, with choppers, chopping-tools and one cobble with bifacial removals.

It is interesting to note that there is a correlation between the knapping method employed and the quality of the raw materials (defined here by different criteria: homogeneity, grain size, presence of inclusions, fissures, *etc.*). Thus, longer and predetermined methods were used to knap better quality cobbles, whereas short and poorly standardized methods were applied on less homogeneous ones. This observation is not only based on the dichotomy flint or other rocks (as often observed): there are differences within a group of raw materials. This is the case for the brecciated quartzites and quartz in the three sites, but also (surprisingly) for flints at Camillo.

The raw materials are used as best as possible by the Middle Palaeolithic hunter-gatherers, and the types of raw materials are not an obstacle. Indeed, Levallois methods are frequently used on other materials than flint when they allow it: commonly quartzite, but also quartz, limestone and even basalt (Deschamps 2019; Eixea *et al.* 2016; Jaubert *et al.* 1990; Jaubert & Mourre 1996; Maroto *et al.* 2002; Santagata *et al.* 2017). In the Languedoc, we can cite the use of Levallois methods on fine-grained quartzites during the Middle Palaeolithic in Bize-Tournal Cave (Chacón 2009: see endnote; Lebègue 2012: see endnote; Tavoso 1987).

4.2. Site function

The site function of these surface stations is not determinable due to context and the heterogeneity of the lithic assemblages. The materials are found directly on the alluvial terrace (which provides the raw materials employed) and might indicate a knapping workshop. However, the presence of a few flake tools and cobble tools does not exclude another type of occupation, or at least the non-exclusive character of these knapping workshops.

4.3. Chrono-cultural attribution

These three surface stations had been attributed to an Early Middle Palaeolithic phase on the basis of their techno-typological composition: a combination of S.S.D.A. and predetermined knapping strategies, with a few shaped tools. While this composition may indeed correspond to the Early Middle Palaeolithic on the paper (Bourguignon *et al.* 2008; Brenet 2011: 341; Brenet *et al.* 2014; Hérisson *et al.* 2016; Jarry *et al.* 2007: 145; Mathias 2018: 553; Mathias *et al.* 2020; Moncel 1999), several elements lead us to be cautious in this specific context, particularly if we compare to other surface stations in the Hérault Valley (such as Le Clot des Sœurs) (Ivorra *et al.* 2017: 134):

1) Lack of chronology and effective association of archaeological material. Considering the diversity of manifestations of the Early Middle Palaeolithic in the South of France, it is impossible to make this attribution in the absence of a reliable chrono-stratigraphic context.

2) Adaptation to the raw material and its characteristics (nodule morphology and essentially quality). Indeed, in the series of Camillo, Les Geissières or Saint-Saturnin, when the raw materials were of better quality, show exploitation by typical Middle Palaeolithic concepts (Levallois, Discoid *sensu stricto*). If the raw material is not - strictly speaking - a constraint, it acts as a limiting factor.

These two arguments point towards an attribution to the Middle Palaeolithic in the broad sense. These elements show us how difficult the cultural attribution of industries where meta-quartzites are predominantly used can be. Similar observations have been made for many Upper Pleistocene industries, where the archaic appearance induced in part by the materials used may suggest earlier dates or appear unusual (Bracco 1993; Jaubert *et al.* 1990: 117;

Mourre 1994: 8; Soriano 2003; Tavoso 1978: see endnote). Finally, the reduction processes (Discoid *sensu lato* S.S.D.A.) identified at Saint-Saturnin, Les Geissières and Camillo are quite similar to those of the Middle Palaeolithic in contexts where meta-quartzites are dominant, such as in south-western France and Pyrenees (Colonge *et al.* 2008; Faivre *et al.* 2013; Mourre *et al.* 2008; Turq *et al.* 2017; Villeneuve *et al.* 2019). Once again, the technical solutions employed show us the great adaptation capacities of the Neanderthals to their environmental context (knowledge and resource management).

4.4. New data for the Middle Palaeolithic of the Languedoc

The three surface stations studied show us a new aspect of the Middle Palaeolithic in the Hérault and more widely in Languedoc-Roussillon regions. As specified above, the area has yielded scarce evidence of Lower and Middle Palaeolithic settlements; even if some important sites have been excavated. Within the same area, the sites presented here are to be added to those of Le Cadénas (Bédarieux) or Les Cours (Plaissan) about 20 km further north-east (Menras 2008: see endnote). These two open-air sites are quite different as flints represent the main raw material used and the Levallois knapping is dominant. On the other hand, for Le Cadénas station, where the raw materials are more diversified, there is an economy of raw materials with an adaptation of the knapping methods according to the materials used (Menras 2008: see endnote).

The Mousterian of the Languedoc thus differs from the techno-complexes identified in Aquitaine, in the northern Pyrenees or in the Rhone corridor. Thus, as several regional studies have pointed out, the Mousterian of the Languedoc is associated with the Levallois concept techno-complex, and variations seem to be mainly related to site functions and mobility patterns (Lebègue 2012: see endnote). Following the definition of the Quina type Mousterian and the re-examination of collections, certain entities initially defined in the region as Charentian or para-Charentian (de Lumley-Woodyear 1971: 60) thus fall within this regional variability (Bourguignon 1997; Bourguignon & Meignen 2010; Lebègue & Meignen 2014).

The study of the surface stations of the middle Valley of the Hérault thus provides nuance to this domination of Levallois methods within the series of the regional Middle Palaeolithic. These differences can be correlated with raw material properties. In this sense, the series are closer by some points to those found in crystalline contexts near the Pyrenees, such as: Caune de l'Arago (levels C, top stratigraphic complex), Montou, Le Portel, Mauran, Le Noisetier or other Middle Palaeolithic sites in the Garonne basin (Barsky 2013; Bruxelles *et al.* 2003; Duran 2002; Jaubert 1993; Lebègue & Wengler 2013; Mourre *et al.* 2008; Prince 2000: see endnote).

5. Conclusions and perspectives

The study of these three Middle Palaeolithic stations in the Hérault Valley allows us to learn more about this period in the region. Indeed, these series provide a better understanding of the variability of the manifestations of the Mousterian in Languedoc-Roussillon, where Levallois techno-complexes predominate (Bourguignon & Meignen 2010; Chacón 2009; Lebègue 2012: see endnote; Lebègue & Meignen 2014; Menras 2008: see endnote; Molès & Boutié 2009).

These surface stations thus present uncommon characteristics in comparison with the local Mousterian, considering the use of Discoid and S.S.D.A. reduction processes. If the raw material has an influence on the methods used to exploit it, we nevertheless find here some technical characteristics of the Middle Palaeolithic on good quality cobbles (*e.g.*, Levallois, typo-Levallois, COFs). This study thus also allows us to recognize once again the adaptability of Neanderthals to a variety of environments, making the most of the locally available raw materials. In most Neanderthal sites, local materials are in fact mostly exploited. This type of adaptation on non-flint materials from various mineral environments has now been recognized for several years in crystalline contexts (Colonge *et al.* 2008; Faivre *et al.* 2013; Lebègue & Wengler 2013; Mourre *et al.* 2008; Prieto 2018: 532; Villeneuve *et al.* 2019).

The continuation of fieldwork in this area (prospecting, archaeological survey, *etc.*) should, in future, enable us to better take into account the diversity of manifestations of the Middle Palaeolithic in the South of France.

Acknowledgements

This research was specifically funded by the SRA (*Service Régional d'Archéologie*) and the DRAC Occitanie (*Direction Régionale des Affaires Culturelles*), first as part of an inventory prospecting programme (dir. J. Ivorra), then as part of a thematic prospecting programme (dir. C. Mathias) on the Middle Palaeolithic of the Hérault Valley. These projects are also supported by the Hérault department and the CAHM (*Communauté d'agglomération Hérault Méditerranée*). Special thanks to L. Ledoux for his help to solve unsolvable name problems. DB is grateful for support from the Agència de Gestió d'Ajuts Universitaris i de Recerca (AGAUR) code 2017 SGR 859 and CERCA Programme of the Generalitat de Catalunya. The IPHES-CERCA has received financial support from the Spanish Ministry of Science and Innovation through the María de Maeztu program for Units of Excellence (CEX2019-000945-M). We would also like to thank the organizers of the 12th ISKM in Budapest, K. Biró and A. Markó, as well as the session organizers, L. Valenzuela and S. Sánchez-Dehesa Galán and the two reviewers that helped improve this paper.

Data accessibility statement

The authors confirm that the data supporting the findings is available within the article and supplementary file.

Endnote

The page numbers for these unpublished theses were not recorded during the initial draft of the paper. However, as the lead author has since moved country under pandemic restrictions and before the manuscript was finalised, the authors have been unable to return to obtain this information from the source library. Due to these difficult circumstances, the editors have permitted the inclusion of these references as they might still give the reader further information, even without the specific page numbers.

List of supplementary files

Supplementary file 1
MATHIAS ET AL - supplementary file 1 - cobble tool dimensions.xls
Dimensions of the cobble tools recovered from Camillo.

References

Ambert, P. 1982, Les reliefs pléistocènes anté-volcaniques du Languedoc central. *Bulletin de l'Association de géographes français*, 485-486: 83-89. (in French) ("The Pleistocene ante-volcanic reliefs of the central Languedoc")
URL: https://www.persee.fr/doc/bagf_0004-5322_1982_num_59_485_5316

Ambert, P. 1994, Témoins du Paléolithique moyen et supérieur du Languedoc Central (Hérault, Orb, Aude) dans leur contexte géologique. *Archéologie en Languedoc*, 18: 3-30. (in French) ("Witnesses from the Middle and Upper Palaeolithic of the Central Languedoc (Hérault, Orb, Aude) in their geological context")

Ashton, N. 1992, The High Lodge flint industries. In: *High Lodge. Excavations by G. de Sieveking, 1962-8, and J. Cook, 1988* (Ashton, N., Cook, J., Lewis, S. J. & Rose, J., Eds.), British Museum Press, London: p. 124-168.

Barsky, D. 2013, The Caune de l'Arago stone industries in their stratigraphical context. *Comptes Rendus Palevol*, 12: 305-325. doi:10.1016/j.crpv.2013.05.007

Berger, G., Feist, R., & Freytet, P. 1981, *Notice explicative de la feuille Pézenas à 1/50 000*. BRGM, Orléans: 42 p. (in French) ("Explanatory note of the Pézenas sheet at 1/50")

Boëda, E. 1993, Le débitage discoïde et le débitage Levallois récurrent centripète. *Bulletin de la Société Préhistorique Française*, 90(6): 392-404. (in French) ("Discoid and centripetal recurrent Levallois flaking") URL: https://www.persee.fr/doc/bspf_0249-7638_1993_num_90_6_9669

Boëda, E. 1994, *Le concept Levallois : variabilité des méthodes*. Archéo-éditions. CNRS, Paris, 280 p. (in French) ("The Levallois concept: variability of methods")

Boëda, E. 1995, Caractéristiques techniques des chaînes opératoires lithiques des niveaux micoquiens de Külna (Tchécoslovaquie). *Paléo*, 1(1): 57-72. (in French) ("Technical characteristics of lithic workings from the Micoquian levels of Külna (Czechoslovakia)") URL: https://www.persee.fr/doc/pal_1262-3075_1995_sup_1_1_1380

Boëda, E. 2013, *Techno-logique et technologie. Une paléo-histoire des objets lithiques tranchants*. Archéo-éditions, Prigonrieux, 266 p. (in French) ("Techno-logic and technology. A paleo-history of lithic cutting-edges")

Boëda, E., Geneste, J.-M. & Meignen, L., 1990, Identification de chaînes opératoires lithiques du Paléolithique ancien et moyen. *Paléo*, 2(1): 43-80. (in French) ("Identification of Early and Middle Palaeolithic lithic reduction processes") URL: https://www.persee.fr/doc/pal_1145-3370_1990_num_2_1_988

Bonifay, E., 1981, Les plus anciens habitats sous grotte découverts à Lunel-Viel (Hérault). *Archeologia Paris*, 150: 30-42. (in French) ("The oldest cave occupations discovered at Lunel-Viel (Hérault)")

Bourguignon, L. 1997, *Le Moustérien de type Quina : nouvelle définition d'une entité technique*. Doctoral dissertation at the Université de Paris X - Nanterre, Nanterre, tome I, 347 p. (in French) ("The Quina-type Mousterian: New definition of a technical entity")

Bourguignon, L., & Meignen, L. 2010, Ioton (Gard) 30 ans après : nouvelles considérations technologiques et techno-économiques sur l'industrie moustérienne. *Bulletin de la Société préhistorique française*, 107(3): 433-451. (in French) ("Ioton (Gard) 30 years later: new technological and techno-economic considerations on the Mousterian industry") URL: https://www.persee.fr/doc/bspf_0249-7638_2010_num_107_3_13944

Bourguignon, L., Faivre, J.-Ph. & Turq, A. 2004, Ramification des chaînes opératoires : une spécificité du Moustérien. *Paléo*, 16: 37-48. (in French) ("Ramification of the reduction processes: a specificity of the Mousterian")

Bourguignon, L., Djema, H., Bertran, P., Lahaye, C. & Guibert, P. 2008, Le gisement saalien de Petit-Bost (Neuvic, Dordogne) à l'origine du Moustérien d'Aquitaine ? In: *Les sociétés du Paléolithique dans un grand Sud-Ouest de la France : nouveaux gisements, nouveaux résultats, nouvelles méthodes* (Jaubert, J., Bordes, J.-G. & Ortega, I., Eds.), actes de la séance SPF (Talence, 24-25 novembre 2006), Société préhistorique française (Mémoire, 47), Paris: p. 41-55. (in French) ("The Saalian deposit of Petit-Bost (Neuvic, Dordogne) at the origin of the Mousterian of Aquitaine?")

Bourguignon, L., Crochet, J.Y., Capdevila, R., Ivorra, J., Antoine, P.-O., Agustí, J., Barsky, D., Blain, H.-A., Boulbes, N., Bruxelles, L., Claude, J., Cochard, D., Filoux, A., Firmat, C., Lozano-Fernandez, I., Magniez, P., Pelletier, M., Rios-Garaizar, J., Testu, A., Valensi, P. & De Weyer, L. 2016, Bois-de-Riquet (Lézignan-la-Cèbe, Hérault): a late Early Pleistocene archeological occurrence in southern France. *Quaternary International*, 393: 24-40. doi:10.1016/j.quaint.2015.06.037

Bracco, J.-P. 1993, Mise en évidence d'une technique spécifique pour le débitage du quartz dans le gisement badégoulien de la Roche à Tavernat (Massif Central, France). *Préhistoire Anthropologie Méditerranéennes*, 2: 43-50. (in French) ("Evidence of a specific technique for the cutting of quartz in the Benegoulian deposit of La Roche à Tavernat (Massif Central, France)")

Brenet, M. 2011. *Variabilité et signification des productions lithiques au Paléolithique moyen ancien. L'exemple de trois gisements de plein-air du Bergeracois (Dordogne, France).* Doctoral thesis at the Université de Bordeaux I, Bordeaux, 480 p. (in French) ("Variability and significance of lithic productions in the Middle Paleolithic. The example of three open-air sites in the Bergeracois (Dordogne, France)")

Brenet, M., Bourguignon, L., Colonge, D., Folgado, M., Jarry, M., Lelouvier, L.-A., Mourre, V. & Turq, A. 2014, Les techno-complexes du début du Paléolithique moyen en Aquitaine septentrionale : complexité, complémentarité des productions de débitage et de façonnage et implications comportementales. In: *Transitions, ruptures et continuité en Préhistoire 2 - Paléolithique et Mésolithique* (Jaubert, J., Ed.), Actes du XXVII Congrès préhistorique de France, Bordeaux-Les Eyzies, 31 mai-5 juin 2010, Société Préhistorique Française, Paris: p. 81-101. (in French) ("Early Middle Paleolithic techno-complexes in northern Aquitaine: complexity, complementarity of flaking and shaping productions and behavioural implications")

Bruxelles, L., Berthet, A.-L., Chalard, P., Colonge, D., Delfour, G., Jarry, M., Lelouvier, L.-A., Arnoux, T. & Onézime, O. 2003, Le Paléolithique inférieur et moyen en midi toulousain : nouvelles données et perspectives de l'archéologie préventive. *Paléo*, 15: 7-28. (in French) ("The Lower and Middle Palaeolithic in Midi Toulouse: new data and perspectives of preventive archaeology"). doi:10.4000/paleo.1193

Chacón, M.G., 2009, *The Middle Paleolithic in Southwestern Europe: Abric Romaní (Capellades, Barcelona, Spain) Payre (Rompón, Ardèche, France) and Tournal (Bize, Aude, France)*. Doctoral thesis at the Rovira I Virgili University (Tarragona, Spain) and Muséum National d'Histoire Naturelle, Paris, France, 607 p.

Claud, E. 2012, Les bifaces : des outils polyfonctionnels ? Étude tracéologique intégrée de bifaces du Paléolithique moyen récent du Sud-Ouest de la France. *Bulletin de la Société préhistorique française*, 109, 3: 413-439. (in French) ("Bifaces: polyfunctional tools? Integrated traceological study of Late Middle Palaeolithic bifaces from south-western France") URL: https://www.persee.fr/doc/bspf_0249-7638_2012_num_109_3_14169

Claud, E., Deschamps, M., Colonge, D., Mourre, V., & Thiebaut, C. 2015, Experimental and functional analysis of Late Middle Paleolithic flake cleavers from southwestern Europe (France and Spain). *Journal of Archaeological Science*, 62: 105-127. doi:10.1016/j.jas.2015.05.013

Colonge, D., Bruxelles, L., Jamois, M.-H. & Chevreuse, F. 2008, Périché (Verneuil-sur-Venne, Haute-Vienne), un gisement Paléolithique moyen en Limousin cristallin. In: *Les sociétés du Paléolithique dans un grand Sud-Ouest de la France : nouveaux gisements, nouveaux résultats, nouvelles méthodes* (Jaubert, J., Bordes, J.-G., Ortega, I.), actes de la séance SPF (Talence, 24-25 novembre 2006), Paris, Société préhistorique française (Mémoire, 47), Paris: p. 151-171. (in French) (“Périché (Verneuil-sur-Venne, Haute-Vienne), a Middle Palaeolithic site in the crystalline Limousin”)

de la Peña, P. 2015, A qualitative guide to recognize bipolar knapping for flint and quartz. *Lithic technology,* 40(4): 316-331. doi:10.1080/01977261.2015.1123947

Driscoll, K. 2011, Vein quartz in lithic traditions: an analysis based on experimental archaeology. *Journal of Archaeological Science*, 38(3): 734-745. doi:10.1016/j.jas.2010.10.027

Duran, J.-P. 2002, *Industries moustériennes en Languedoc, Roussillon et Catalogne au Würm ancien: la Combe, le Ratier, la Rouquette, les Anecs, Moutou-La-Joliette, la Caune de l'Arago, l'Arbreda*. Doctoral dissertation at the Université de Perpignan Via-Domitia, Perpignan, 796 p. (in French) (“Mousterian industries in Languedoc, Roussillon and Catalonia in the Early Würm: la Combe, le Ratier, la Rouquette, les Anecs, Moutou-La-Joliette, la Caune de l'Arago, l'Arbreda”)

Faivre, J.-Ph., Turq, A., Bourguignon, L., Colonge, D., Jarry, M., Jaubert, J., Bismuth, T. & Demars, P.-Y. 2013, Paléolithique moyen du Quercy : comportements techno-économiques et variabilité des productions lithiques. In: *Modalité d’occupation et d’exploitation des milieux au Paléolithique dans le Sud-Ouest de la France : l’exemple du Quercy* (Jarry, M., Brugal, J.-Ph., Ferrier, C., Eds.), Paléo supplément (4), Les Eyzies-de-Tayac: p. 231-270. (in French) (“Middle Palaeolithic of Quercy: techno-economic behaviour and variability of lithic production”)

Deschamps, M. 2019, Identification of Quina and Vasconian technocomplexes in Gatzarria Cave (north-western Pyrenees), based on the stratigraphic, taphonomic and technological revision of the Georges Laplace collections. *Comptes Rendus Palevol*, 18: 569-586. doi:10.1016/j.crpv.2019.04.001

Donnart, K., Naudinot, N. & Le Clézio, L. 2009**,** Approche expérimentale du débitage bipolaire sur enclume : caractérisation des produits et analyse des outils de production. *Bulletin de la Société préhistorique française*, 103-3: 517-533. (in French) (“Experimental approach to bipolar cutting on anvil: characterisation of products and analysis of production tools”) URL: https://www.persee.fr/doc/bspf_0249-7638_2009_num_106_3_13873

Eixea, A., Villaverde, J. & Zilhão, J. 2016, Not Only Flint: Levallois on Quartzite and Limestone at Abrigo de la Quebrada (Valencia, Spain): Implications for Neandertal Behavior. *Journal of Anthropological Research*, 72: 24-57. doi:10.1086/685265

Forestier, H. 1993, Le Clactonien : mise en application d’une nouvelle méthode de débitage s’inscrivant dans la variabilité des systèmes de production lithique du Paléolithique ancien. *Paléo*, 5: 53-82. (in French) (“The Clactonian: application of a new method of debitage within the variability of Early Palaeolithic lithic production systems”) URL: https://www.persee.fr/doc/pal_1145-3370_1993_num_5_1_1104

Ginouvez, O., Bourguignon, L., Gandelin, M., Ivorra, J. & Pardies, C. 2016, *Quartier Saint-Christol, Pézénas, Languedoc-Roussillon, Hérault*. Rapport de diagnostic, Inrap MED, Nîmes, 81 p.

Grégoire, S., Bazile, F., Boccaccio, G., Lebègue, F., Menras, C. & Pois, V. 2007, *Matières premières siliceuses en Languedoc-Roussillon*. Projet Collectif de Recherches, Rapport d’activité pour l’année 2007. (in French) (“Siliceous raw materials in Languedoc-Roussillon”)

Grégoire, S. & Bazile, F. 2009, La lithothèque des matières premières siliceuses en Languedoc-Roussillon. Un outil pour la reconstitution des territoires. In: *Els Pirineus i las arees circumdants durant el Tardiglacial. Mutacions i filiacions tecnoculturals, evolució paleoambiental (16000-10000 BP). Homenatge al professor Georges Laplace*, XIV Colloqui International d’Arqueologia de Puigcerdà, Institut d’Estudis Ceretans Editor, Puigcerda: p. 227-238. (in French) (“The lithotheque of siliceous raw materials in Languedoc-Roussillon. A tool for the reconstitution of territories”)

Hérisson, D., Brenet, M., Cliquet, D., Moncel, M.-H., Richter, J., Scott, B., Van Baelen, A., Di Modica, K., De Loecker, D., Ashton, N., Bourguignon, L., Delagnes, A., Faivre, J.-Ph., Folgado-Lopez, M., Locht, J.-L., Pope, M., Raynal, J.-P., Roebroeks, W., Santagata, C., Turq, A. & Van Peer, P. 2016, The emergence of the Middle Palaeolithic in north-western Europe and its southern fringes. *Quaternary International*, 411: 233-283. doi:10.1016/j.quaint.2016.02.049

Inizan, M.-L., Reduron, M., Roche, H. & Tixier, J. 1995, *Technologie de la pierre taillée.* Cercle de Recherches et d’Etudes Préhistoriques, Meudon, 199 p. (in French) (“Knapped stone technology”)

Ivorra, J., Bourguignon, L., & Ortega, I. 2015, *Causses et terrasses alluviales du volcanisme des « Baumes »*. Rapport annuel, prospection inventaire, SRA Occitanie. (in French) (“Causses and alluvial terraces of the "Baumes" volcanism”)

Ivorra, J., Bourguignon, L., Ortega, I., Capdevila, R. & Grégoire, S., 2017, *Causses et terrasses alluviales du volcanisme des « Baumes »*. Rapport de synthèse triennale 2015-2017, prospection inventaire, SRA Occitanie, 178 p. (in French) (“Causses and alluvial terraces of the "Baumes" volcanism”)

Ivorra, J., Mathias, C., Guillou, H., Nomade, S., Scao, V. & Voinchet, P., 2018, *Causses et terrasses alluviales du volcanisme des « Baumes »*. Rapport annuel, Prospection inventaire, SRA Occitanie. (in French) (“Causses and alluvial terraces of the "Baumes" volcanism”)

Jarry, M., Colonge, D., Lelouvier, L.-A. & Mourre, V. (Eds.) 2007, *Les Bosses 1, Lamagdelaine (Lot) : un gisement paléolithique moyen antérieur à l’avant-dernier Interglaciaire sur la moyenne terrasse du Lot*. Société Préhistorique Française, Travaux 7, 158 p. (in French) (“Les Bosses 1, Lamagdelaine (Lot): a Middle Paleolithic site predating the penultimate Interglacial on the middle terrace of the Lot”)

Jaubert, J. 1993, Le gisement paléolithique moyen de Mauran (Haute-Garonne) : techno-économie des industries lithiques. *Bulletin de la Société préhistorique française*, 90(5): 328-335. (in French) ("The Middle Paleolithic site of Mauran (Haute-Garonne): techno-economy of lithic industries")

Jaubert, J. & Mourre, V. 1996, Coudoulous, Le Rescoundudou, Mauran : diversité des matières premières et variabilité des schémas de production d'éclats. In: *Reduction Processes (« chaînes opératoires ») for the European Mousterian (*A. Bietti et S. Grimaldi, ed.), actes de la table ronde internationale, Rome, Istituto italiano di Paleontologia Umana, Quaternaria Nova, 6, Roma: p. 313-341. (in French) ("Coudoulous, Le Rescoundudou, Mauran: diversity of raw materials and variability of flaking production patterns")

Jaubert, J., Lorblanchet, M., Laville, H., Slott-Moller, R., Turq, A. & Brugal, J.-Ph. 1990, *Les chasseurs d'Aurochs de La Borde - un site du Paléolithique moyen (Livernon, Lot),* Paris, MSH, Documents d'Archéologie Française (27), 157 p. (in French) ("Aurochs hunters of La Borde - a Middle Paleolithic site (Livernon, Lot)")

Knutsson, K. 1988, *Making and Using Stone Tools: The Analysis of the Lithic Assemblages from Middle Neolithic Sites with Flint in Västebotten, Northern Sweden*. Societas Archaeologica Uppsaliensis, Uppsala, 206 p.

Lebègue, F. 2012, *Le Paléolithique moyen récent entre Rhône et Pyrénées : approche de l'organisation techno-économique des productions lithiques, schémas de mobilité et organisation du territoire (Les Canellettes, l'Hortus, Bize-Tournal, La Crouzade et la Roquette)*. Doctoral thesis at the Université de Perpignan and Université de Liège, Perpignan and Liège, 797 p. (in French) ("The late Middle Palaeolithic between the Rhône and the Pyrenees: approach to the techno-economic organisation of lithic production, mobility patterns and territorial organisation (Les Canellettes, l'Hortus, Bize-Tournal, La Crouzade and la Roquette)")

Lebègue, F. & Wengler, L. 2013, L'industrie moustérienne de la grotte de Montou (Corbère-les-Cabanes, Pyrénées-Orientales) : premiers résultats et perspectives concernant le peuplement néandertalien de la frange nord-est du contrefort pyrénéen. *Bulletin de la Société préhistorique française*, 110, 4: 747-750. (in French) ("The Mousterian industry of the Montou cave (Corbère-les-Cabanes, Pyrénées-Orientales): first results and perspectives concerning the Neanderthal settlement of the north-eastern fringe of the Pyrenean foothills") URL: https://www.persee.fr/doc/bspf_0249-7638_2013_num_110_4_14325

Lebègue, F. & Meignen, L. 2014, Quina ou pas ? Révision techno-économique d'un site moustérien charentien en Languedoc oriental : la grotte de la Roquette à Conqueyral (Gard, France). *Bulletin de la Société préhistorique française*, 11 (4): 603-630. (in French) ("Quina or not? Techno-economic review of a Charentian Mousterian site in eastern Languedoc: the Roquette cave at Conqueyral (Gard, France)") URL: https://www.persee.fr/doc/bspf_0249-7638_2014_num_111_4_14459

Lebègue, F., Boulbes, N., Grégoire, S. & Moigne, A.-M. 2010, Systèmes d'exploitation, exploitation des ressources et mobilité des néandertaliens de l'Hortus. In: *Settlement Dynamics of the Middle Paeolithic and Middle Stone Age* (Conard, N., Delagnes, A., Eds.), vol. III, Tübingen: p. 455-483. (in French) ("Exploitation systems, resource exploitation and mobility of Neanderthals in the Hortus") de Lombera-Hermida, A., 2009: The scar identification of lithic quartz industries. In: *Non-flint Raw Material Use in Prehistory. Old Prejudices and New Direction. Proceedings of the XV World Congress of the UISPP*, British Archaeological Reports International Series 1939, Archaeopress, Oxford, p. 5-11.

de Lombera-Hermida, H., Rodríguez, X.-P., Fábregas, R., Moncel, M.-H. 2011, La gestion du quartz au Pléistocène moyen et supérieur. Trois exemples d'Europe méridionale. *L'Anthropologie*, 115 (2): 294-331. (in French) ("The management of quartz in the middle and upper Pleistocene. Three examples from Southern Europe") doi:10.1016/j.anthro.2011.02.003

de Lumley-Woodyear, H. 1971, *Le Paléolithique inférieur et moyen du Midi méditerranéen dans son cadre géologique*. *Tome II Bas-Languedoc, Roussillon, Catalogne*. Editions du CNRS (Centre national de la recherche scientifique), Paris, 444 p. (in French) ("The Lower and Middle Palaeolithic of the Southern Mediterranean in its geological setting. Volume I Liguria - Provence") URL: https://www.persee.fr/docAsPDF/galip_0072-0100_1971_sup_5_2_2519

de Lumley-Woodyear, H. 1972, *La grotte de l'Hortus (Valflaunès, Hérault). Les chasseurs néandertaliens et leur milieu de vie. Elaboration d'une chronologie du Wurmien II dans le midi méditerranéen*, vol. 1, Etudes Quaternaires, Marseille, 668 p. (in French) ("The Hortus cave (Valflaunès, Hérault). Neanderthal hunters and their living environment. Elaboration of a chronology of the Wurmian II in the Mediterranean South")

Maroto, J., Ortega, D. & Sacchi, D. 2002, Le Moustérien tardif des Pyrénées méditerranéennes. *Préhistoires méditerranéennes*: 39-52. (in French) ("The Late Mousterian of the Mediterranean Pyrenees") URL: https://journals.openedition.org/pm/244

Mathias, C. 2018, *Les phases anciennes du Paléolithique moyen dans le Sud-Est et le Sud-Ouest de la France : étude des systèmes techniques lithiques*. Doctoral thesis at the Université de Perpignan Via-Domitia, Perpignan, 729 p. (in French) ("The ancient phases of the Middle Palaeolithic in the South-East and South-West of France: study of lithic technical systems") URL: https://tel.archives-ouvertes.fr/tel-01960322

Mathias, C., Bourguignon, L., Brenet, M., Grégoire, S., & Moncel, M.-H. 2020, Between new and inherited technical behaviours: a case study from the Early Middle Palaeolithic of Southern France. *Archaeological and Anthropological Sciences*, 12(7), 1-39. doi:10.1007/s12520-020-01114-1

Maurin, J.-C. 1983, Esquisse géologique de la moyenne vallée de l'Hérault. Etudes Héraultaises, 1-2: 31-40. (in French) ("Geological sketch of the middle valley of the Hérault") URL: https://www.etudesheraultaises.fr/publi/esquisse-geologique-de-la-moyenne-vallee-de-lherault/

Menras, C. 2008, *Les industries lithiques de trois occupations de plein air (étude techno-économique et typologique) et leur place dans le contexte Moustérien du Languedoc méditerranéen. Le Cadénas (Bédarieux, Hérault), Les Cours (Plaissan, Hérault) et le Serre du Coucouyon (La Capelle et Masmolène, Gard)*. Doctoral thesis at the Université Paul Valéry, Montpellier III, Montpellier, 466 p. (in French) ("Lithic industries of three open-air occupations (techno-economic and typological study) and their place in the Mousterian context of the Mediterranean Languedoc. Le Cadénas (Bédarieux, Hérault), Les Cours (Plaissan, Hérault) and Serre du Coucouyon (La Capelle and Masmolène, Gard)")

Menras, C. 2009, Les industries lithiques de trois occupations de plein air et leur place dans le contexte Moustérien du Languedoc méditerranéen : Le Cadénas (Bédarieux, Hérault), Les Cours (Plaissan, Hérault) et Le Serre du Coucouyon (La Capelle et Masmolène, Gard), *L'Anthropologie*, 113: 381-398. (in French) ("The lithic industries of three open-air occupations and their place in the Mousterian context of the Mediterranean Languedoc: Le Cadénas (Bédarieux, Hérault), Les Cours (Plaissan, Hérault) and Le Serre du Coucouyon (La Capelle and Masmolène, Gard)") doi:10.1016/j.anthro.2009.04.001

Molès, V. & Boutié, P. 2009, Contribution à la reconnaissance d'une microproduction au Paléolithique moyen : les industries de la grotte des Ramandils (Port-La Nouvelle, Aude, France). *L'Anthropologie*, 113: 356-380. (in French) ("Contribution to the recognition of a microproduction in the Middle Palaeolithic: the industries of the Ramandils cave (Port-La Nouvelle, Aude, France)") doi:10.1016/j.anthro.2009.04.002

Moncel, M.-H. 1999, *Les assemblages lithiques du site Pléistocène moyen d'Orgnac 3 (Ardèche, Moyenne vallée du Rhône, France)*. ERAUL, 89, Liège, 446 p. (in French) ("Lithic assemblages from the Middle Pleistocene site of Orgnac 3 (Ardèche, Moyenne vallée du Rhône, France)")

Mourre, V. 1994, *Les industries en quartz au Paléolithique moyen. Approche technologique de séries du Sud-Ouest de la France*. Master degree dissertation at the Université de Paris X - Nanterre, 2 vol., Nanterre, 111 p. (in French) ("Quartz industries in the Middle Paleolithic. Technological approach of series from the South-West of France")

Mourre, V. 1996, Les industries en quartz au Paléolihique. Terminologie, méthodologie et technologie. *Paléo*, 8: 205-223. (in French) ("Quartz industries in the Palaeolithic. Terminology, methodology and technology") URL: https://www.persee.fr/doc/pal_1145-3370_1996_num_8_1_1160

Mourre, V., Costamagno, S., Thiébaut, C., Allard, M., Bruxelles, L., Colonge, D., Cravinho, S., Jeannet, M., Juillard, F., Laroulanie, V. & Maureille, B. 2008, Le site moustérien de la grotte du Noisetier à Fréchet-Aure (Hautes-Pyrénées) - premiers résultats des nouvelles fouilles. In: *Les sociétés du Paléolithique dans un grand Sud-Ouest de la France : nouveaux gisements, nouveaux résultats, nouvelles méthodes* (Jaubert, J., Bordes, J.-G., Ortega, I. Eds.), actes de la séance SPF (Talence, 24-25 novembre 2006), Société préhistorique française (Mémoire, 47), Paris: p. 189-202. (in French) ("The Mousterian site of the Noisetier cave at Fréchet-Aure (Hautes-Pyrénées), first results of new excavations")

Mourre, V., Jarry, M., Colonge, D. & Lelouvier, L.-A. 2010, Le débitage sur enclume aux Bosses (Lamagdelaine, Lot, France). *Paléo*, numéro spécial(2009-2010): 49-62. (in French) ("Bipolar-on-Anvil flaking at Les Bosses (Lamagdelaine, Lot, France)") doi:10.4000/paleo.1894

Nicoud, E. 2011, *Le phénomène Acheuléen en Europe occidentale : approche chronologique, technologie lithique et implications culturelles*. Doctoral thesis at the Université de Provence & Università degli Studi di Roma « La Sapienza », Aix-en-Provence & Rome, 483 p. (in French) ("The Acheulean phenomenon in Western Europe: chronological approach, lithic technology and cultural implications")

Prieto, A. 2018, *Procurement and management of quartzite in the Cantabrian Region: The Middle and Upper Palaeolithic in the Deva, Cares and Güeña Valleys*. Doctoral thesis at the Universidad del País Vasco, Vitoria Gasteiz, 589 p.

Prince, G. 2000, *Contribution à l'étude des industries de la grotte du Portel-Ouest. Etude techno-typologique des industries moustériennes*. Doctoral thesis at the Université de Perpignan Via-Domitia, Perpignan, 214 p. (in French) ("Contribution to the study of the industries of the Portel-Ouest cave. Techno-typological study of Mousterian industries")

Rossoni-Notter, E., Notter, O., Simone, S. & Simon, P. 2016, Acheulean technical behaviors in Aldène cave (Cesseras, Hérault, France). *Quaternary International*, 409 (B): 149-173. doi:10.1016/j.quaint.2015.11.016

Santagata, C., Moncel, M.-H. & Raynal, J.-P. 2017, Neanderthals and volcanic rocks. Opportunistic behaviour or optimized management? *Comptes Rendus Palevol*, 16(4): 474-487. doi:10.1016/j.crpv.2016.12.001

Saos, T., Grégoire, S., Bahain, J. J., Higham, T., Moigne, A. M., Testu, A., Boulbes, N., Bachellerie, M., Chevalier, T., Becam, G., Duran, J.-P., Alladio, A., Ortega, M.I., Devièse, T. & Shao, Q. 2020, The Middle and Upper Palaeolithic at La Crouzade cave (Gruissan, Aude, France): New excavations and a chronostratigraphic framework. *Quaternary International*, 551: 85-104. doi:10.1016/j.quaint.2019.11.040

Semah, F. 1979, Etude chronostratigraphique de dépôts quaternaires du Massif Central et du Midi méditerranéen. Contribution du Paléomagnétisme. Doctoral thesis at the University of Provence, Marseille, 138 p. (in French) ("Chronostratigraphic study of Quaternary deposits in the Massif Central and the Mediterranean Midi. Contribution of Palaeomagnetism")

Serrano, O. & Hanot, F. 2005, *Le bassin Oligo-Miocène de l'Hérault : un exemlpe de rétrocharriage des structures pyrénéennes. Implications hydrogéologiques*. Rapport final BRGM/RP, 53733-FR, 22 p. (in French) ("The Oligo-Miocene basin of the Hérault: an example of retrocharriage of Pyrenean structures. Hydrogeological implications")

Soriano, S. 2003, Quand archaïque n'est pas ancien ! Etude de cas dans le pays dogon (Ounjougou, Mali). *Annales de la fondation Fyssen*, 18: 79-92. (in French) ("When archaic is not ancient! Case study in the Dogon Country (Ounjougou, Mali)")

Tavoso, A., 1978, *Le Paléolithique inférieur et moyen du Haut-Languedoc. Gisements des terrasses alluviales du Tarn, du Dadou, de l'Agout, du Sor et du Fresquel*. Université de Provence, Ed. du Laboratoire de Paléontologie Humaine et de Préhistoire, Études Quaternaires, 5, Marseille, 404 p. (in French) ("The Lower and Middle Palaeolithic of the Haut-Languedoc. Deposits on the alluvial terraces of the Tarn, Dadou, Agout, Sor and Fresquel rivers")

Tavoso, A. 1987, Le Moustérien de la grotte Tournal. *Cypsela*, VI: 61-173. (in French) ("The Mousterian of Tournal Cave")

Turq, A., Faivre, J.-Ph., Gravina, B. & Bourguignon, L. 2017, Building models of Neanderthal territories from raw material transports in the Aquitaine Basin (southwestern France). *Quaternary International*, 433: 88-101. doi:10.1016/j.quaint.2016.02.062

Viallet, C., 2016a, Bifaces used for percussion? Experimental approach to percussion marks and functional analysis of the bifaces from Terra Amata (Nice, France). *Quaternary International,* 409: 174-181. doi:10.1016/j.quaint.2015.08.068

Viallet, C., 2016b, *Potentiel fonctionnel des outils bifaciaux au Pléistocène moyen en contexte méditerranéen. Analyse de la structure et des macro-traces des séries bifaciales de la Caune de l'Arago, Terra Amata, Orgnac 3 et du Lazaret*. Doctoral thesis at the Université de Perpignan Via-Domitia, Perpignan, 398 p. (in French) ("Functional potential of bifacial tools in the Middle Pleistocene in a Mediterranean context. Analysis of the structure and macro-traces of the bifacial series of the Caune de l'Arago, Terra Amata, Orgnac 3 and Lazaret")

Viallet, C., Bourguignon, L., Mathias, C., Magniez, P., Ivorra, J. & Brugal, J.-Ph. 2018, Identify the launched percussion use of Lower Palaeolithic tools: The case of shaped pieces in limestone and basalt. *Buttletí Arqueològic*, V(40): 49-55.
URL: https://hal.archives-ouvertes.fr/hal-02541766

Villeneuve, Q., Faivre, J.-Ph., Turq, A. & Guadelli, J.-L. 2019, Etude techno-économique du Moustérien de Pradayrol (Caniac-du-Causse, Lot, France) : entre mobilité des ressources lithiques et adaptation aux matériaux locaux, un exemple de gestion complémentaire des quartz et silex au Paléolithique moyen récent en Quercy. *Comptes Rendus Palévol*, 18(2): 251-267. (in French) ("Techno-economic study of the Pradayrol Mousterian (Caniac-du-Causse, Lot, France): between mobility of lithic resources and adaptation to local materials, an example of complementary management of quartz and flint in the recent Middle Palaeolithic in Quercy") doi:10.1016/j.crpv.2018.10.002

Adaptation à la variabilité interne des matériaux : un exemple issu de trois stations de surfaces du Paléolithique moyen de la vallée de l'Hérault, France (Les Geissières, Saint-Saturnin et Camillo)

Cyrielle Mathias [1], Laurence Bourguignon [2], Jérôme Ivorra [3], Déborah Barsky [4, 5], Sophie Grégoire [1], Cyril Viallet [1]

1. UMR 7194 – Histoire Naturelle de l'Homme Préhistorique (HNHP), avenue Léon Jean Grégory, 66720, Tautavel, France. Email: Cyrielle Mathias: cyrielle.mathias@gmail.com, Sophie Grégoire: sophie.gregoire@cerptautavel.com, Cyril Viallet: cyviallet@gmail.com
2. Institut National de Recherches Archéologiques Préventives, 34420, Villeneuve-lès-Béziers, France (INRAP)/ UMR 7041 Archéologies et Sciences de Antiquité (ArScAn), team Anthropologie des Techniques, des Espaces et des Territoires au Pliocène et au Pléistocène (AnTET), Nanterre, France. Email: laurence.bourguignon@inrap.fr
3. Groupe de Recherche d'Etude du Patrimoine Archéologique Méditerranéen (GREPAM), chemin du plateau d'Arnet, 34120, Pézenas, France. Email: jerome.ivorra@orange.fr
4. Institut Català de Paleoecologia Humana i Evolució Social (IPHES-CERCA), Zona Educacional 4, Campus Sescelades Universitat Rovira i Virgili (Edifici W3), 43007 Tarragona, Spain. Email: dbarsky@iphes.cat
5. Universitat Rovira i Virgili, Departament d'Història i Història de l'Art, Avinguda de Catalunya 35, 43002 Tarragona, Spain.

Résumé :

Le Paléolithique moyen de la vallée de l'Hérault (France) reste jusqu'à aujourd'hui peu exploré, malgré la présence de plusieurs sites majeurs de cette période comme le Mas des Caves I (Lunel-Viel, l'abri Rothschild (Cabrières) ou encore l'Hortus (Valflaunès). Récemment, des prospections systématiques ont conduit à la découverte de plusieurs stations de surface attribuées au Paléolithique moyen sur des terrasses alluviales dans la moyenne vallée de l'Hérault, autour de Pézenas. Certaines d'entre elles ont livré des industries lithiques réalisées à partir de matières premières peu habituelles pour le Paléolithique de la région, telles que des quartzites bréchiques et des jaspoides, ainsi que du quartz. Si les silex sont également présents, ils sont utilisés en plus faible proportion. Ces roches (métaquartzites, jaspoïdes) se trouvent en position primaire en amont, dans la zone de la Montagne Noire. Elles se retrouvent dans les alluvions de l'Hérault et de ses affluents sous forme de galets plus ou moins roulés. Ces matières premières sont très hétérogènes (taille des grains, inclusions, diaclases), parfois y compris au sein d'un même bloc, pouvant leur réaction à la taille. Ces variations d'homogénéités internes ont ainsi induit des stratégies de taille spécifiques, les préhistoriques s'adaptant à ces caractéristiques pétrographiques particulières pour en tirer pleinement profit.

Nous présentons ici des données provenant de trois de ces stations de plein-air attribuées au Paléolithique moyen de la moyenne vallée de l'Hérault (Les Geissières, Saint-Saturnin et Camillo). Elles permettent d'illustrer les stratégies adaptatives des Néandertaliens face à ces matériaux locaux parfois très hétérogènes. Une analyse technologique du matériel a été

réalisée. Cette analyse est associée à des expérimentations qui ont été menées dans le but de tester certaines des méthodes identifiées dans les séries, comme que le débitage bipolaire sur enclume. Ces expérimentations ont été réalisées d’une part dans le but d'évaluer l'efficacité de la production d’éclats sur ces matériaux (métaquartzites, jaspoïdes) et d’autre part afin de mieux caractériser les traces spécifiques laissées sur les produits par cette méthode. Ceci nous a permis de mieux identifier les artefacts archéologiques dans ce contexte alluvial particulier.

L'étude de ces trois stations montre l'utilisation de méthodes de débitage qui ont permis aux tailleurs de s'adapter aux contraintes posées par les matières premières : débitage Discoïde *lato sensu* (bifacial, unifacial, partiel), Clactonien et débitage bipolaire sur enclume. Des méthodes plus diagnostiques du Paléolithique moyen ont également été identifiées, comme le débitage Levallois, principalement récurrent et le typo-Levallois ou des méthodes Kombewa. Ces concepts de production ont été appliqués sur des matières premières à grains plus fins. Quelques outils retouchés et façonnés ont également été identifiés dans les séries (principalement des *choppers* et *chopping-tools*). Ces assemblages nous montrent que, malgré l'influence des matières premières (qui est plus une contrainte qu'une limite), les Néandertaliens de l’Hérault ont atteint leurs objectifs grâce à des méthodes de production variées.

De manière plus générale, ces stations de surface permettent de mieux percevoir les modes de productions utilisés au Paléolithique moyen en Languedoc-Roussillon et attestent d’une diversité des systèmes techniques plus importante que supposée, dans un contexte où dominent les techno-complexes Levallois classiques.

Mots-clés : Paléolithique moyen ; Néandertaliens ; stations de surface ; Sud-Est de la France ; gestion des matières premières ; quartzite