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A 400,000 years old milestone of the Acheulian technocomplex in Central-Western France at Londigny (Charente).

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Abstract

In this paper, we present the results of a technological analysis of an unpublished Acheulian assemblage from Western-Central France from a preventive excavation at Londigny (Charente). The lithic pieces were found in an archaeological layer preserved at the bottom of the infilling of two karstic depressions on the Jurassic plateau. A large series of handaxes found during gravel quarrying in the Charente river valley and sparse assemblages from karstic cavities south of the large meander formed by the Charente river are amongst the main discoveries dating to the Lower Palaeolithic in Charente. In the Poitou region, Londigny is the first open air Lower Palaeolithic industry TL dated to MIS 11 recovered in a stratigraphic context age. Only a handful of sites date to this period in North-West Europe. Our study of this assemblage however allows us to describe in detail the lithic production that is characteristic of the Acheulian technocomplex. Despite of the unusual use of small Jurassic flint nodules, both bifacial shaping and flake production highlight a technical package shared by most of the Acheulian industries at that time from North-West Europe to South-West France. The Londigny site, located in a position between north and south, extends the geographical range of the Acheulian in France.

Keywords

Lower Paleolithic settlement; Central Western France; TL chronology; open air site; lithic industry

1. Introduction

In Western Europe, the development of Acheulean bifacial industries spans a long period from about 0,65 to 0,25 Ma (Antoine et al., 2019; Moncel et al., 2019), but settlement indices only become abundant during Marine Isotopic Stage (MIS) 13 to 11, in particular in the lowlands of northwestern Europe (Moncel et al., 2015). Then from MIS 10 onwards, bifacial industries spread all of Western Europe (fig. 1).

However, present knowledge of this period is limited due to significant geographical disparities, as data can be very incomplete depending on the region and the time range considered. The difficulties encountered in comparing archaeological records from Northern and Southern Europe for these periods have been underlined notably by Moncel et al. (2015, p. 322).

Most Acheulean occupations dating from MIS 13 to 10 are located in the United Kingdom and Northern France including the Paris basin (Ashton, 2016; Ashton and Lewis, 2012; Lamotte and Tuffreau, 2016; Moncel et al., 2015; Voinchet et al., 2015). These are characterised by archaeological levels mainly preserved within the alluvial deposits of the middle terraces of major rivers, and to a lesser extent, within slope deposits (Saint-Illiers-la-Ville: Blaser and Chaussé, 2016; and Etricourt-Manancourt: Hérison et al., 2016).

For the Early Paleolithic in southwest of France, Turq et al. (2010) distinguished industries with symmetrical bifaces similar to those of northwest Europe, and industries known as « Acheuléen méridional » (Bordes, 1971) typified by irregular bifaces. The latter, which come from various contexts (caves, open air, fluvial deposits), are not found prior to MIS 10/MIS 9 (Delpech et al., 1995; Turq and al., 2010) whereas the former, which are often found in secondary position in the fluvial deposits of the middle terraces of the Dordogne river and its tributaries, are dated between MIS 12 to 9 (Moisan, 1987; Texier, 1982; Turq and al., 2010). Further to the south in Quercy, biface industries do not predate 300 ka, i.e. MIS 8 (Jaubert, 2013). The particularities of the Acheulean in the Garonne river catchment (the so-called “Acheulean pyrénéo-Garonnais”) have been recently described but the industry has not been precisely dated (Brussels and al., 2003; Brussels and Jarry, 2001; Mourre and Colonge, 2007; Turq and al., 2010). The latest available data suggest that, as in the Quercy, these industries are no older than MIS 9/8 (Hernandez et al., 2012).

Between the north of the Paris basin and the southwest of France, Acheulean bifaces were collected from coarse-grained alluvial deposits in the Loir middle terraces, dated around 400

Ka (Despriée and al., 2010), and in those of the Charente river (Givenchy, 1933), yet undated.

This geographical disparity results from several factors. Firstly, research has for decades focused on two main areas, the Northwest of Europe and a vast peri-Mediterranean area, thus neglecting the middle part of France.

The distribution of the main sites reported by Bosinski (1996) highlights this research heterogeneity, linked to the geography of the researchers themselves (Rodier, 2006). A similar disparity also prevails for the Middle Paleolithic according to the maps published by Soriano (2005) and Jaubert (1999). This does not explain, however, the virtual absence of Acheulean sites firmly dated prior to MIS 9 in southwestern France.

Secondly, the chronostratigraphy of terrace systems in northwest Europe was the focus of several research projects during the last decades (Antoine, 1990; Antoine and al., 2003a, 2007; Bridgland, 1994; Bridgland and al, 2006; Cordier, 2006), whereas most of the studies in the Southwest occurred earlier (e. g. Moisan, 1987; Texier, 1982) and have not benefited from the development of numerical dating methods (OSL, ESR-U/Th...). The lack of precise chronological data does not allow definitive conclusions to be drawn on the age of many Lower Paleolithic assemblages collected in alluvial contexts in the latter region.

Finally, it seems that the fine-grained alluvial formations that enabled the preservation of Acheulean occupations in northern France and the United Kingdom, are much rarer and much less developed further south as suggested by observations on the middle Loire basin (Despriée 2012) and the Dordogne basin (Moisan, 1987; Texier, 1982). The lack of suitable sedimentary contexts could explain the relative scarcity of well-preserved Lower Palaeolithic sites able to deliver a representative assemblage and to be accurately dated by numerical methods.

The Londigny site is located in the "Seuil du Poitou", which lies at the junction of the Aquitaine basin to the south and the Paris basin to the north and is bounded by the Armorican Massif to the west and the Central Massif to the east. Because of its geographical position at the margins of the plains of northwest Europe where most studies of Acheulean sites took place, the site provides a rare opportunity to document the Acheulean technocomplex outside the region on which the research has historically focused.

The lower archeo-stratigraphic unit, dated to MIS 11 by thermoluminescence (TL), has a bifacial component and fits well into the Lower Palaeolithic as is currently understood and in particular into the Acheulean technocomplex of northwest France (Tuffreau, 2004 ; Antoine et al., 2003b ; Nicoud, 2013a, 2013b).

While there is implicitly the idea of a MIS 11 "Acheulean province" focused on the northwestern European lowlands where the bifacial shaping is widely present, some studies

suggest that diverse technical systems coexisted within the Acheulean on a European scale (Nicoud, 2013a, 2013b; Rocca, 2013). Londigny, located outside of the best-documented areas for this technocomplex, may bring new information about this issue.

Unlike most of the contemporaneous northwestern European sites, Londigny is located in a region typified by poor raw material availability (small Jurassic flint nodules). Such a pattern is not unusual for the Acheulean, however, as demonstrated by the Menez-Dregan site in Brittany (Ravon and Monnier, 2013; Ravon, 2017).

As pointed out by Tuffreau et al. (2008, p. 134) at Cagny La Garenne, there is a clear correlation between "the morphology, size, degree of shaping of the bifaces and the physical properties of the flint", which strongly suggests that Acheulean knappers did not necessarily search for or select the best quality flint even when available.

Did the raw material properties played a determinant role on the main characteristics of the industry as supposed by Villa (1981), or was it a factor that at most limited the expression of some techno-cultural traits (Jaubert and Servelle, 1996; Mourre, 2003), or else had they no significant effects? We will attempt here to determine whether the technical elements proper to the Acheulean of Northwest Europe can be identified in the industry of Londigny.

2. Geomorphological setting and methods

2.1 Context

The Londigny site was discovered in 2011 and excavated in 2012 before the construction of a new highway linking Tours to Bordeaux. According to the 1:50 000 geological map (Hantzpergue et al., 1997), the site is located on a vast Jurassic limestone plateau (j1, j2: Bajocian-Bathonian) covered by reddish weathering clay with abundant flint fragments (RCjs) (fig. 2). This plateau is dotted with many closed depressions probably of karstic origin (dolines). The site overlooks the Péruse valley, a small tributary of the Charente river, which flows about ten kilometres further east.

During the Pleistocene, the area had an almost null or deficit sedimentary budget (i.e. erosion prevailed upon sedimentation in the long term), which has restricted the possibilities of discovering buried, well-preserved ancient sites to few favourable contexts such as local sediment traps. This is the case of Londigny, where the remains of the Acheulean occupation lie at the base of the fill of two karstic depressions. This type of context is not unusual for the Acheulean in other French calcareous regions as evidenced by the examples of Gentelles (MIS 10/9; Tuffreau et al., 2001), Revelles (MIS 9; Guerlin et al, 2008), Clairly-Saulchois (MIS 9; Lhomme et al., 2002), Etricourt-Manancourt (MIS 9/8; Hérison et al., 2016) and

Gouzeaucourt (MIS 8; Tuffreau and Bouchet, 1985). For many years, surface finds have brought to light ancient occupations in the region (Façon et al, 1972; Germond, 1982; Patte, 1941, 1972; Petraglia and Potts, 2004; Russel, 1928, 1929; Texier, 1972). However, Londigny represents the first Lower Paleolithic site excavated in a secured stratigraphic and chronological context in the area and as such, it constitutes a unique data set for the understanding of the West European settlement during the Lower Paleolithic period.

The site includes three large stratified sub-zones covering an area of nearly 3,000 m². The excavation was heavily mechanized, allowing extensive exploration of the entire Pleistocene sedimentary sequence containing the remains, which in some places reaches 3 m in depth. The pieces were plotted in X, Y and Z coordinates using a theodolite and ascribed to the pedo-sedimentary units previously described from test trenches.

After manual cleaning and description of the sections, the sediments were sampled for analyses at the PACEA laboratory (University of Bordeaux). They comprise (1) grain-size analysis (N=10) with a Horiba LA-950 laser granulometer (fraction < 2 mm, suspension in sodium hexametaphosphate 5 g/l followed by 60 s ultrasonification to achieve optimal dispersion), (2) geochemical analysis (N=10) using Energy Dispersive X-Ray Fluorescence (ED-XRF) with a SpectroX-sort device (40 kV, 50 µA, calibration according to the methodology proposed by Lucas-Tooth and Price, 1961; elements lighter than Si are not detected), and (3) optical microscopy after preparation of thin sections from samples impregnated with resin under vacuum (N=5).

3. Stratigraphy and chronological data

3.1 Pedostratigraphy

The trenches made it possible to observe in detail the Quaternary sedimentary cover. The stratigraphy is quite homogeneous in the whole study area, although the thickness of the units may differ significantly. The following main units were distinguished, from the top to the base (fig. 3):

- Unit 1: Ploughed layer (Ap horizon). Humic silt with scattered gravel, dark brown (7.5YR 4/3), 30 cm thick.
- Unit 2: Argillic Bt horizon. Brown clayey silt (7.5YR 4/4), 40 cm thick. This unit penetrates into the underlying one along tongues or wedges arranged in plan view in a polygonal pattern half a meter in diameter. Some wedges reach up to 1 m in depth and are 20 cm wide at the opening. They are interpreted as former thermal contraction cracks in a

periglacial context (soil wedges, Washburn, 1979; Jetchick and Allard, 1990). At the microscopic scale, abundant yellow brown illuvial clay coatings are observed in the cavities.

- Unit 3: Homogeneous yellow brown (10YR 5/6) silt (C1 horizon), 35 to 50 cm thick. It exhibits a coarse platy structure due to former segregation ice lenses (Van Vliet-Lanoë, 1998). In thin sections, it shows silty intercalations (slaking crusts) (fig. 4) and few clayey coatings.
- Unit 4: Slightly more reddish (strong brown, 7.5YR 5/6) silt with scattered gravel (C2 horizon). It shows abundant fragments of clay coating (papules) coming from the reworking of an older argillic Bt horizon.
- Unit 5: Silt rich in gravel and rounded Fe-Mn concretions, 1 to 10 cm thick. This bed is discontinuous and overlies an erosional unconformity.
- Unit 6: Palaeoargillic (IIBt horizon). Strong brown (7.5YR 5/6) clayey silt 40 to 60 cm thick, with abundant black Fe-Mn concretions and coatings underlying a coarse platy structure. Bleached wedges cut through the horizon up to a depth of ca. 1 m. In thin sections, this unit shows abundant fragments of yellow-brown to brown humiferous clay coatings. The coatings are similar to those described in the Eemian-Early Glacial palaeosol in the Paris basin (Fédoroff and Goldberg, 1989; Antoine, 2002). The base of the horizon is richer in fragmented clay coatings, some of which are of red colour. The abundance and variety of illuvial features suggest that the horizon is polycyclic, i.e. it corresponds to the stacking of two or more argillic horizons.
- Unit 7: Mottled plastic clay with slickensides, 10 to 50 cm thick. This layer is locally deformed into involutions reaching 0.6 m in height. The clay contains some flint nodules and is interpreted as material derived from the weathering of the underlying limestone.
- Unit 8: Weathered limestone.

The limestone substrate is affected by abundant dissolution features, some of which being of large dimension (dolines), and the thickness of the sedimentary cover increases above. In the areas where the limestone is close to the ground surface (ca. 1.5 m), the Bt and IIBt horizons merge into a single argillic horizon.

3.2 Grain-size analysis and geochemistry

Overall, the sand fraction decreases from the bottom to the top of the sequence, whereas the silt fraction follows an opposite trend. The grain-size distribution is bimodal with a mode close to 70 μm (fine sand) and another close to 30 μm (coarse silt). Only the latter subsists in the upper part of the sequence (fig. 5). The silt mode is similar to that of loess from the Paris

basin (Lautridou, 1985) and suggests an aeolian origin. However, the fine-grained silt fraction (5-15 μm) is in much lower amount than in typical loess, possibly because of loess reworking and sorting by overland flow as indicated by the remnants of slaking crusts visible at the microscopic scale.

The geochemical analysis shows a regular trend in sample composition from the bottom to the top. Si, the main component of quartz, increases together with titanium (Ti) and zirconium (Zr), both hosted by strongly resistant minerals. To the contrary, the elements hosted by minerals sensitive to weathering (calcite, feldspars) such as calcium (Ca), potassium (K) and rubidium (Rb) decrease. A multivariate analysis (not shown here) involving the samples from Londigny, alluvium (Charente, Garonne) and loess from the Paris basin and southwest France allows the identification of three main discriminant elements, Ca, Fe and Zr. A triangular diagram using these elements (fig. 6) clearly shows that the Londigny samples spread between the pole of the material derived from the weathering of underlying limestone and the pole corresponding to decalcified loess (Sitzia et al., 2017).

3.3 Chronological data

Four heated flint artefacts have been dated by thermoluminescence at the Quaternary TL Surveys, Nottingham (Debenham, *in* Connet and al., 2014). They were chose from a selection of 10 flakes heated from the different sedimentary layers.

The gamma dose-rate was assessed by direct on-site measurement using a gamma spectrometer inserted into the burial sediments. The dose-rate due to cosmic rays was estimated from the depth of the flint below ground surface. The total dose-rates, from all four components of the radiation exposure, are shown in table 1.

The TL ages of the flints were obtained by combining the palaeodose evaluations with the total dose-rate assessments (table 1). Even if the heating was not caused by human action, it is clear that it must have occurred when the flints were on or very close to the ground surface. The dates refer to the most recent heating of the flint to a temperature of 400°C or higher. The error limits attached to the TL ages include random and systematic uncertainties in laboratory measurements and environmental factors, and represent the 68% confidence level.

3.4 Depositional history

The analytical data show that the sediments correspond to colluvium coming from the mixing of weathering clay and exogenous silt, probably of aeolian origin as suggested by the

topographic situation of the site. The aeolian inputs become dominant in the upper part of the sequence and have a grain-size and a geochemical composition close to the loess from the Aquitaine region studied by Sitzia et al. (2017). No loess cover is indicated on the 1:50 000 geological map in the area (*infoterre.brgm.fr*). The map of French aeolian deposits proposed by Bertran et al. (2016) using the LUCAS database (Ballabio et al., 2016) suggests, however, that a discontinuous sand and loess cover existed south of the Loire estuary up to the Charente area (fig. 7). As it is observed in the southern part of the Aquitaine basin, the loess is thin and decalcified. The dust source was probably the coversands that spread during the glacial period over the now immersed continental plateau.

The pedostratigraphic data together with the TL ages on flint artefacts allow a reliable chronological framework to be proposed. The main points are as follows:

- (1) The Bt horizon correspond to the Holocene luvisol. It developed upon silt layers (Units 2-4) of Weichselian age.
- (2) The IIBt horizon corresponds to a palaeoluvisol of interglacial rank. It underwent a complex history as shown by microscopic features, which suggests that it resulted from the stacking of at least two interglacials, the last being the Eemian. The silt layer upon which the palaeosol developed (Unit 6) was deposited during the Middle Pleistocene.
- (3) The TL ages of heated artefacts are in agreement with this hypothesis. The sample QTLS LON 23, found at the top of the Bt horizon (unit 2) ca. 55 cm deep, gave an age of 86.8 ± 7.4 ka, i.e. Early Weichselian. This piece is probably not in primary position but indicates that the upper silts cannot be older than 87 ka and thus belong to the Last Glacial. The other samples (QTLS LON 22 and 24) unearthed from the upper silts (Units 3-4) are significantly older and were obviously reworked from the lower units by colluviation. Their age (230 ± 54 and 307 ± 37 ka) shows that one or several occupations took place during MIS 6 to 9. The only sample (QTLS LON 26) coming from the IIBt horizon (Unit 6) yielded an age of 396 ± 66 ka, i.e. contemporaneous with MIS 10-12. This confirms the complex history of the palaeosol.

3.5 Archaeological levels

Three archaeological levels have been identified: (1) an upper level in Unit 2 (Bt horizon), (2) a median level in Units 3-4 (C1 horizon), and (3) a lower level in Unit 6 (IIBt horizon). The two upper levels, with 328 and 291 pieces respectively, extended over the entire excavated area. Both TL ages and archaeological evidence support the idea that these levels are

heterogeneous. The lower level (150 pieces) was preserved in two karstic depressions, for a total surface area of 200 m².

Of the three individualized archaeological units, only the oldest (IIBT) can be considered as a closed unit in the light of archaeological, stratigraphic and chronological evidences and thus justifies the detailed study presented here. For the two overlying complexes, colluviation and weak sedimentary accumulation contributed to the superposition of diachronic occupations and the remobilization of remains from older layers. This resulted in strong dispersion of the remains and the lack of well-preserved occupation level. Chronological and archaeological evidences support the idea that the upper and median units are heterogeneous.

Only the lower level is considered in this paper. The pieces were scattered in the whole unit 20 to 60 cm thick and do not show spatial groupings. On the edges of the depressions, the palaeosol merges with the upper Bt horizon and the artefacts remained impossible to ascribe to a specific level. The pieces showed no identifiable concentration within the level. The assemblage is homogeneous with regard to its techno-economic composition. Therefore, the TL age yielded by sample QTLS LON26, i.e. 396 ± 66 ka, centred on MIS 11, is considered to be representative of the age of the whole assemblage.

4. The Acheulean industry from unit IIBT of Londigny

4.1 Assemblage composition

The assemblage consists of 150 knapped flints artefacts and two quartz pebbles, which are possible hammerstones. The flint originates from the Middle Jurassic (Bajocian/Bathonian). It is an opaque flint, with an irregular structure, common in the weathering clay that covers the area. It is present on the Londigny plateau as more or less voluminous nodules (less than 30 cm), often rounded, sometimes broken by frost wedging. The clay also contains a few small quartz pebbles. The material used came probably from the site itself or from its immediate surroundings. A large proportion of the knapped material seems to be quite similar to the so-called "punctuated grey" Bajocian flint described in the Poitou area (Primault, 2003).

The lithic industry consists of 8 bifaces, rare shaping flakes (n=2), and 139 debitage products, 22 of which are retouched (table 2). More than half of the pieces show traces of post-depositional alterations. In most cases, it is a blunt edge or gloss related to the pieces' movement caused by pedo-sedimentary processes.

The techno-economic composition includes a flake production according to a single modality (strict unidirectional), which provided the exclusive blanks of retouched flake tools (of which

notches, denticulated and backpieces). These are found with bifaces that vary in their overall morphology but with edges arranged as scrapers and a rounded tip.

4.2 Bifacial shaping

Seven bifacial pieces, one of which is the conjoining of two fragments broken by frost, and only two shaping flakes illustrate bifacial shaping. The poor representation of shaping flakes is largely due to the mechanization of excavation and taphonomic processes, since a deficit in pieces less than 20 mm in width (fig. 8) affects the whole assemblage when compared with experimental data. However, this cannot be the cause of the deficit in large shaping flakes, which are represented by only two pieces 14-40 mm in width.

Three of the bifaces may have been shaped on blocks taken from the surroundings of the site according to their structure and technical characteristics (coarse flint, cleave planes, reduced dimensions). On the other hand, for three other entirely shaped bifaces, the very fine quality of the raw material and the initial size of the blocks are incompatible with the other materials used on the site, even if it is probably Jurassic flint. This difference in raw material quality, combined with the rarity of the shaping flakes, indicates that at least some of the bifaces were imported into the area. It appears that the lower level contained two different productions: *in situ* bifacial production, which corresponds to partially shaped bifaces, and the import of more extensively shaped bifaces produced on finer grain flint from outside the site.

Typologically, the two bifaces that are totally shaped are classified as oval bifaces. Their section is plano-convex and they have residual cortical surfaces that indicate a selection of blocks less than 50 mm thick, with, at least in one case, a regular shape (fig. 09). The volume is achieved by large flat and converging removals, detached from the entire perimeter of the blocks. The thickest section of the tool is then located in the middle part. Long flat removals link the apical portion with one of the tool edges, of convex delineation. This edge to tip portion supports a last level of short and oblique retouches. The opposite edge is slightly more open in section and the retouch is more concave.

At Londigny, as well as these totally shaped bifaces, there are also bifaces partially shaped on small sized blocks with natural surfaces and/or cleave planes. The block selection and the integration of natural surfaces/fracture planes into the final tool volume is the first construction stage of bifacial tools. For one of the pieces, the modification of the block is limited to the flattening of a surface in order to create, by bifacial retouch, a convex distal end

(fig 10 n° 398). In another case (fig 10 n° 738), a bifacial retouch, flat on one edge, more abrupt on the other, creates two straight edges with a sinuous cutting edge, converging in a tip. Since these bifaces were produced through shortened *chaîne opératoire* from blocks having shapes specific to the locally available raw material, they are difficult to compare with the bifaces of other assemblages.

These two groups of bifaces may meet different needs, both in terms of use and necessity, because of their morphological and dimensional differences. These, together with the morphology of their cutting edges, which vary in their delineation and angle (straight, slightly convex to very convex) or even their profile (sinuous, straight), induce different gripping modalities and therefore different use. It thus seems difficult to see Londigny's bifacial pieces as a specific group of tools but rather as varied tools, both in their morphology and construction and undoubtedly in their use.

4.3 Flake production

For flake production, blocks less than 15 cm in length were chosen, often with fracture planes (cleave planes, frost fractures) that create flat surfaces intersecting with an angle of about 70° (60° to 80°), used for the direct extraction of flakes. This pattern is observed for 17 out of the 32 entire cores taken into account. The proportion is even higher, almost exclusive, if we only take into account the lightly worked cores for which it is still possible to determine the initial volume. We can thus conclude that it is a matter of choice (15 cases out of 18). An almost exclusive production modality has been identified for the cores, namely a unidirectional production from a flat to convex surface, used as a striking platform. This simple algorithm can be repeated on the same core without the sequences appearing to be dependent on each other. The produced flakes often include a relatively abrupt edge created from the previous removal or a natural edge intersecting the flaked surface. Each sequence allows the extraction of 3 to 6 flakes.

Four kinds of cores can be distinguished according to the organization of the debitage sequences, their number and the desired flakes (fig. 11):

- Type A (unidirectional on short face of core) - A sequence of unidirectional removals in the thickness of the block (wide and short flaked surface) from a natural flat striking platform (11 pieces). The resulting flakes will be rather short (less than 80 mm), or even stocky, with a natural back and most often have a natural striking platform (19 pieces).
- Type B (unidirectional on long face of core) – A sequence of unidirectional removals along the length of the block (long flaked surface) from a natural or prepared striking platform (6

pieces). The resulting flakes are elongated but less than 86 mm in length, frequently with a natural back (12 pieces).

- Type C (polyhedral) - Several unidirectional removal sequences on several surfaces from a natural striking platform or previous flaked surfaces (13 pieces). The resulting flakes are often elongated (less than 80 mm), frequently have abrupt edges (back) and can be of various morphologies (29 pieces).

- Type D (bidirectional) - A sequence of opposite bidirectional removals from a natural or prepared striking platform (2 pieces). The resulting flakes are quadrangular, often with a natural back, and measure less than 60 mm (1 piece).

The observations made on the cores are confirmed by the analysis of the flakes assemblage, where, through types A to D (fig. 12), there is a certain consistence in the dimensions sought and the shape of the flakes, which mainly have an abrupt edge (table 3).

The flakes are extracted by hard percussion, away from the platform edge, the butts are wide (around 25 mm), often thick (10.5 mm on average), the impact points well marked. Except for the fragments and a few rare pieces, all the flakes fall within the production scheme that have been defined using the cores. They form a coherent assemblage where the elongated pieces do not exceed 86 mm in length and the most stocky 67 mm in length.

Type A and B flakes have a similar morphology (parallel edges, rectilinear profile) and only the elongation in the debitage axis creates the difference. Type C flakes represent a morphologically more heterogeneous group, with frequently converging edges and sometimes twisted or even sinuous profiles. This difference is the result of the lack of control of angulations between the exploited surface and the striking platform of type C cores during their working as well as the progressive superposition of the removals during the successive debitage sequences.

The proportion of retouched tools also reflects this difference, with a large majority of tools on flakes as blanks from unidirectional core (type A and B - 9 pieces) compared to only 4 for flakes from polyhedral core (type C), and this for groups of flakes of comparable quantity (31 and 29 pieces respectively). The retouch invests the flakes in their largest axis and is therefore frequently transverse for type A flakes (1 proximal and 4 distal). Except in one case, the retouch, when it is not abrupt and similar to a retouched back, is always opposed to an abrupt edge (previous negative, butt, cortical or natural surface).

Eighteen flake tools were identified: 10 flakes partially retouched with natural or retouched back, 6 denticulates and 2 notches. A core fragment, 2 debris and a block fragment with

retouch (2 denticulates, 1 piece with back, 1 notch) increase the number of potential tools (fig. 13 n° 343).

Partially retouched pieces consist of various, often thick, blanks that have on an acute edge, usually lateral but also sometimes distal or proximal, a short, irregular and often concave retouched section of edge always opposed a back (fig. 13 n° 849 and 681). While most of the time the regularity of retouch suggests they are intentional, in some cases result of tool using. The back opposed to the acute edge is retouched in four cases (fig. 13 n° 681). This combination- back/ sharp edge opposed- are essential parameters of Londigny tools construction.

The denticulates were selected from flakes of small length (less than 59 mm) but of variable thickness and type (A, B, C, D or cortical) (fig. 13 n° 850, 343, 797). The denticulation is obtained by a series of retouches with an angle from 60 to 90°, providing a generally rather straight edge.

The three notches are arranged on the longest edges of two short flakes (type A) and one chunk. They are single or double (fig. 13 n° 797), on an abrupt edge, and the retouch, hollow and concave, 1 to 3 cm wide, forms a notch with an inclination from 60 to 70°.

The two main tool groups, partially retouched pieces and denticulates, each display a certain consistency both morphometrically and technically, with a choice for thin flake with large dimensions for the first group and shorter and thicker flake for the second. A back opposed to the active part is the leitmotiv present in all tool categories. Potentially most of the un-retouched flakes with natural back could have been used as many tools. As the preservation of the material does not allow to perform use-wear analysis, this proposal cannot be fully validated.

5. Discussion

The discovery of the Londigny Acheulean assemblage firstly underlines the importance of karstic structures in the preservation of Middle Pleistocene sedimentary records and associated archaeological sites, particularly in calcareous regions without thick loess cover, slope deposits or fine-grained fluvial deposits. Preventive archaeology along major linear works (motorways, railways, etc.) is the main vector for the discovery and excavation of these contexts.

The Acheulean assemblage was recovered in a silty unit affected by a complex palaeosol, which reflects the stacking of two or more argilic horizon of interglacial rank. TL dating places the assemblage from MIS 12 to 10, with a central age in MIS 11 around 400 ka. This age fits perfectly the chronological framework of the Western European Acheulean, and is in

accordance with the technological standards of the period, in particular their northern expression (Nicoud, 2013a, 2013b).

At a regional level, Londigny fills a geographical gap for the Lower Palaeolithic between the Paris basin and southwest France. Within a radius of about fifty kilometres around the site, it is worth mentioning the bifaces collected at the beginning of the 20th century by J.T. Russel (1928, 1929) at La Croix-de-Chambe (Voulême, Charente), where the “limande” and oval types dominate (Petraglia and Potts, 2004) as is the case for Londigny. Unfortunately, these pieces were not found in a stratigraphic context.

The nearest occurrence prior to MIS 9 in the region is at the Artenac site at Saint-Mary (Charente) in a karstic cavity, about thirty kilometres southeast of Londigny. This is a small flake assemblage found in level 2 accumulated in the cavity probably earlier than 500 ka (Delagnes et al., 1999). In level 4 of the same site, a biface industry was found in a secondary position. It probably dates to the end of the Middle Pleistocene since U/Th dates between 182 ka and 255 ka were obtained for the fauna of the underlying level 3 (Delagnes et al., 1999; Delagnes and Tournepicche, 2010).

The Grande Vallée site in Colombiers (Vienne), located about 85 km northeast of Londigny, predates MIS 9. This open-air site yielded a sequence of paleolithic occupations, the lower (unit 5) having provided two groups of TL dates, i.e. around 450 ka and 650 ka, without possibility to favour one or the other group (Hérisson et al., 2012). The abundant lithic assemblage shows a corpus of tools composed of bifaces and tools on flakes knapped from a Turonian tabular flint present in the immediate surroundings of the site. At this research stage, it remains difficult to describe the design of the unit 5 bifaces. However, it can be noted that unlike Londigny, *in situ* bifacial production is accompanied by the production of scrapers of various types (sometimes convergent) on regular blanks resulting from the uni- or bidirectional knapping of large flint slabs (Hérisson et al., 2012).

Londigny's position, in between the Aquitaine and Paris basins, allows the lithic assemblage to be put into perspective with regard to both the Acheulean industries of northwest Europe and the contemporary industries of southwest Europe.

The flake production of Londigny's lower level was designed for the production of flakes with back, often short but also elongated of modest dimensions (< 80 mm), obtained using a basic algorithm of a sequence of unidirectional removals, which, when repeated on a core, is independent of the previous sequence(s). The search for an abrupt edge as opposed to the active edge of the flakes is a given for Londigny and can be observed almost systematically on all contemporary series (table 4).

At Londigny, the choice of the volume of the block to be worked is essential and depends on the presence of intersecting plane surfaces allowing the rapid obtention of the required

flakes. In this case, the initial phase of flake production begins with the selection of a volume offering the requirements for flake extraction without specific preparation. This process has been observed at many subcontemporary sites in Londigny (table 4 and fig. 1), particularly in areas where siliceous raw material is rare or absent and volumes are often small.

This is the case at Kärlich-Seufer for most of the debitage, but also for bifaces which are arranged on supports whose initial shape only required partial shaping (Rocca, 2013) and at Menez-Dregan (Ravon, 2017) where the fracture of pebbles offers a morphology close to the desired tool, thus requiring reduced shaping. This is also the case for the production of flakes from the Italian site of Torre in Pietra (Villa et al., 2016) and probably also from the Spanish sites of Aridos (Santonja et al., 2001) and Ambrona (Nicoud, 2011).

At Cagny-la-Garenne II (Tuffreau, 2001 and 2008; Lamotte, 2012), located in the Paris Basin where quality siliceous raw material is available, the flake production is obtained by sequences of unidirectional removals without specific volume preparation. A similar industry, attributed to MIS 10, has recently been discovered in the western part of the Paris Basin, in Saint-Illiers-la-Ville (Yvelines), in the S3N4 level (Blaser, 2012).

Only the English sites show a somewhat different process with the introduction of alternating unipolar production sequences on two secant surfaces (SSDA = Alternate Debitage Surface System; Ashton and al., 1992; Forestier, 1993; Boëda, 2013). This organization of unipolar sequences could be linked to the morphology of flint blocks, as it seems to be the case at Ferme de l'Épinette (Lamotte, 1999; Lamotte et al., 2001). This system includes a preparation stage by the first sequence of flakes, which aims to open a striking platform (Ashton, 1992, 1998).

However, regardless of the organization of the production processes, which are always unipolar, it seems that the search for backed blanks is a constant at MIS 11 sites. Even in Colombiers, in the Vienne region, where shaping provides the majority of tools on flakes, there is a constant search for a back (Hérisson et al., 2012). In a more recent Acheulean context (MIS 9) in Etricourt-Manancourt, HUZ and HUD levels, the search for thick cortically backed flakes has been highlighted (Hérisson et al., 2016).

While the production of flake tools always occurred on site, this is not necessarily the case for the production of bifaces. Thus, for southern and eastern Europe, at some sites such as Aridos (Santonja et al., 2001), the presence of shaping byproducts shows that bifaces were produced on site (table 4). However, at other sites, such as Torre in Pietra (Villa et al., 2016) and Ambrona (Nicoud, 2011), the absence of shaping byproducts shows that the few bifaces were imported onto the site, as at Londigny. Adaptation to specific raw material is a recurrent phenomenon in the Paleolithic, as for example demonstrated by the Kärlich-Seufer quartzite pieces for which the selection of flat pebbles and flat pebble fragments has enabled, through

partial shaping, to create bifacial pieces (Rocca, 2013). The importance of the raw material in the acheulean industries is not only marked for the bifaces, as the whole industry can have been concerned as for example in Atapuerca, where a strict relationship between the raw materials and the objectives aimed at by the hominins of the TD6 and TD10 units could be observed and can be related to the activities carried out on the site (Taradillos-Bernal et al., 2014).

Several different patterns are observed in the large sedimentary basins such as the Paris Basin and the Thames, where a quality siliceous raw material is abundant:

- A pattern similar to that observed in Londigny with the on-site production of flake tools and import of bifaces at Barnham Area I (Ashton, 1998) and Swanscombe LMG (Ashton in Conway et al., 1996).
- Concomitant on-site production of bifaces and flakes, this is the case of most English sites (High Lodge B C1 C2 D, Barnham Area IV, Swanscombe LL and Boxgrove 4c, Q2/C), of Cagny-la-Garenne II as well as Colombiers (table 4). The shaping flakes were used at Colombiers as blanks of retouched tools compensating for the rare debitage that took place on the site.

The quality of the raw materials available does not seem to be the only criterion leading to the spatial fractionation of bifacial production. At Londigny, it appears that the characteristics of the raw material used by the Acheulean knappers (medium to poor quality, small sized nodules) have only marginally constrained the flintknapping process. As for the Acheulean industries from MIS 13 to 9, it is more the techno-economic organization of knapping and use that, *de facto*, integrates the contingencies of raw materials through the high spatial mobility of bifaces produced on dedicated sites (workshops *sensu stricto* or residential sites on flint sources). These bifaces were produced on site with the available raw material when possible, or during movements relating to subsistence, often over short distances, as imported bifaces are usually shaped on local materials. At Londigny, bifacial tools made from less suitable local materials also perhaps replace imported bifaces.

The dichotomy between bifaces with elaborate shaping and bifaces resulting from a shorter *chaîne opératoire* where the initial morphology of the block is hardly modified has been observed at other Acheulean sites, even in areas where a quality siliceous raw material is abundant, such as Cagny-L'Épinette in level i1A (Lamotte and Tuffreau, 2001) or Gouzeaucourt in level G (Soriano, 2000).

Londigny's totally shaped bifaces appear to be similar to bifaces from Acheulean sites dating to the middle of the Middle Pleistocene, such as High Lodge E (Ashton and al., 1992) or Cagny-la-Garenne II (Lamotte, 2012). More rarely, the presence, although limited, of oval bifaces clearly imported into the sites is observed in geographical areas where the local raw material is less suitable for the production of such artefacts. This is the case, for example, at

Ambrona, in the S3 assemblage (Nicoud, 2011). At Notarchirico, Moncel and al. observe “a more intense shaping and more removals on flint or siliceous stones, due perhaps to the quality of the stone” even if the impact of the raw material is limited but nonetheless present (2019, p. 19). This hypothesis of a tool/raw material link can be proposed for some bifaces imported in Londigny: oval biface with long flat removals on the apical portion and one of the tool edges in continuity, of convex delineation with an opposite edge slightly more open in section and a retouch more concave.

The bifacial tool, on a straightforward concept of a tool arranged on two opposite surfaces, has many constructions and morphologies (pointed/rounded end, biconvex/plano-convex section). Within each site, one can observe constants that can be reflect in the construction methods as well as in the final morphology of bifaces, sometimes with several groups of tools (Moncel and al., 2018). The small number of sites in the Early Palaeolithic period compared to the long time and vast space, although confined to Western Europe, makes its analysis difficult. While it seems that the morphological differences of the bifaces over the long term are not due to a linear evolution (Moncel et al., 2018; Mac Nabb et al., 2015), they could be linked to various modalities of use (grasping, type and modality of action). Londigny's bifaces can have different morphologies but with identical cutting edges, such as a convex distal edge of comparable extent on two tools, one on a blank of which only the cutting edge is shaped, the other on a large totally shaped biface.

When the blank is slightly modified, the divergence of the handling parts necessarily leads to differences in the maintenance of the tool and therefore in the action and its result. The construction of the handling parts of tools allows them to be totally adapted to the desired morphology, which is decisive in terms of the modality of the tool's use. It seems that this aspect of bifacial tools is central to the question of the bifacial and can be a vector of identity. As data currently in territory studied, the plains of northwestern Europe have the largest number of sites characterized by totally shaped bifacial piece. Thus, from a bifacial point of view, Londigny could represent one of the most southern MIS 10/12 manifestations of an Acheulean who is now well document in the plains of northern Europe. Londigny is probably part of a larger territory, developed towards the southwest in particular, as suggested by acheulean industries recovered in secondary position in alluvial deposits in the southern half of France (Turq et al., 2010) and by several sites in northern Europe that contain bifaces totally shaped.

6. Conclusion

Londigny falls within the variability of the lithic industries of the Acheulean of Western Europe. This is firstly evidenced by flakes tools, which are composed by a cutting edge

opposed to a back. The organisation of the debitage in almost all industries from MIS 12 to 10 in area studied allows to produce series of blanks (flakes/elongated flakes) with this combination of predetermined technical features, ie. acute edge/abrupt-backed edge. Bifacial production seems to have a certain diversity. Thus, in the area studied, two major groups can be identified: the first one with a production of fully shaped bifacial pieces (transformative and prehensile components) and the second one with a production of bifacial pieces on selected natural blanks from which only the cutting edges are shaped (Nicoud 2011, 2013a, 2013b). The first is mainly located in the plains of northern Europe and the second is more frequently found in southern and eastern Europe. From the results exposed here, Londigny is clearly associated with the first group of Acheulean sites settled in the plains of northern Europe and is one of the southernmost described up to date with a reliable stratigraphic and chronological context. Acheulean occupation at Londigny was exceptionally preserved in a karstic depression suggesting that the initial geographic pattern of MIS 13-11 sites was so severely depleted that the spatial gap between Londigny and northern sites with similar industry appears now so large. Nevertheless this gap is paved with numerous surface finds of bifaces from dismembered sites together with old discoveries in stratigraphical context that have not yet been re-examined.

Raw materials selected at Londigny by Acheulean flintknappers differs from those usually encountered on sites settled in cretaceous basins from Northern Europe especially with more limited size and coarser grain but we demonstrate here that it had not induced any change in structure and objective of the lithic production, debitage or shaping. At the most, spatial organisation of lithic production through time and space was adjusted to fit with location of more suitable raw materials (quality, size) to allow the shaping of large bifaces which were thus more frequently moved from production place to use place. High mobility of bifaces might have been a mean to cope with spatial discontinuity of flint resources.

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TABLE

QTLS ref.	Site ref.	Palaeodose (Gy)	Total Dose-rate (Gy/ka)	TL Age (ka BP)
LON22	No.126, unit C	487 ± 46	1.585 ± 0.120	307 ± 37
LON23	No.189, unit BT	136.7±5.2	1.575 ± 0.120	86.8±7.4
LON24	No.237, unit C	382 ± 86	1.661 ± 0.110	230 ± 54
LON26	No.817, unit IIBT	630 ± 96	1.591 ± 0.105	396 ± 66

Table 1: Thermoluminescence dating measurements of the heated Londigny samples.

Technical description	Fragmentation		State of preservation					Unretouched piece	Retouched piece/tool	Total
	complete	broken	fresh	abraded	glossy	broken by frost	rounded			
Flake	64	36	31	26	28	4	11	80	18	101
Core	32	5	14	19		3	1	36	2	37
Debris		2		2					2	2
Shaped tool	2		1	1				2		2
Block tool	3	5	1	6		2			8	8
Hammer	2			2				2		2
Total	103	48	47	56	28	9	12	120	30	152

Table 2: Lithic material inventory, lower archaeological level.

Flake types	total no.	tool no.	Fragment no.	Whole pieces no.						
				no.	no.	maximum size (mm)	minimum size (mm)	back no.	tool no.	
A	19	7	6	13	*L/w<1	7	67	27	3	4
					L/w>1	6	80	31	6	
B	12	2	3	9	L/w<1					
					L/w>1	9	86	30	7	2
C	29	4	11	18	L/w<1	1	43	34	1	
					L/w>1	17	79	25	11	1
D	1		1		L/w<1					
					L/w>1					
cortical	16	4	4	12	L/w<1	5	55	27	4	2
					L/w>1	7	56	27	4	1
not included	18	4	12	6	L/w<1	1	33	26		
					L/w>1	5	75	23	4	1
Total	95	21	37	58			40		11	

Table 3: Debitage products according to the production methods identified through the cores (*L/w = length/width in the flaking axis).

	Sites	Total no.	Flake production system	Flake morphology	Main flake tools types	Main blank of retouched tools	Raw material	No. Biface	Spatial pattern of lithic production	Marin Isotopic Stage	Bibliographic references
Northwestern Europe											
ENGLAND	High Lodge E	462	SSDA	with natural back	side scrapers, notches and denticulates	backed blank	fine Cretaceous flint	14	<i>in situ</i> for debitage, reworked bifaces ?	13	Ashton et al., 1992
	High Lodge B C1 C2 D	1517	SSDA	with natural back	side scrapers, notches and denticulates	backed blank	fine Cretaceous flint	0	<i>in situ</i>	13	Ashton et al., 1992
	Barnham Area I	1596	SSDA	with natural back	notches, side scrapers and denticulates	backed blank	fine Cretaceous flint	2	imported bifaces	11	Ashton, 1998
	Barnham Area IV	718	SSDA	with natural back	notches, side scrapers and denticulates	backed blank	fine Cretaceous flint	2	<i>in situ</i>	11	Ashton, 1998
	Swanscombe LMG	151	SSDA and unipolar	with natural back	notches, side scrapers and denticulates	backed blank	fine Cretaceous flint pebble	3	imported bifaces	11	Ashton in Conway et al., 1996
	Swanscombe LL	153	SSDA and unipolar	with natural back	notches, side scrapers and denticulates	backed blank	fine Cretaceous flint pebble	0	<i>in situ</i>	11	Ashton in Conway et al., 1996
	Boxgrove	8277		with natural back	side scrapers, notches and denticulates	backed blank	fine Cretaceous flint	26	<i>in situ</i>	13-11	Roberts et Parfitt, 1999
Boxgrove 4c, Q2/C	1354	recurrent unipolar (not alternating) on natural blank and SSDA	with natural back	2 retouched knapped flakes	backed blank	fine Cretaceous flint	8	<i>in situ</i>	11	Nicoud, 2011	
FRANCE	Cagny-la-Garenne II	1348	unipolar recurrent (not alternating) on natural and prepared blank + Levallois like	with natural back	side scrapers, denticulates and notches	backed blank	fine Cretaceous flint	19	<i>in situ</i> and imported tools	13-11	Tuffreau 2001, Tuffreau et al. 2008; Lamotte 2012
	Menez Dregan I, c.8	5 300	unipolar on natural blank and SSDA	with natural back	side scrapers, denticulates and notches	pebble	flint (small pebble), quartz, sandstone, quartzite	2	<i>in situ</i> and export	11	Ravon, 2017
Centralwestern Europe											
FRANCE	Colombiers	18540	unipolar on natural blank	with natural back	side scrapers, denticulates and notches on knapped and debitage flakes	backed blank	Cretaceous flint (slabs and blocks)	64	<i>in situ</i>	12	Herisson et al., 2012
	Londigny	151	unipolar recurrent (not alternating) on natural blank	with natural back	side scrapers and denticulates	backed blank	Jurassic flint	6	imported and <i>in situ</i> bifaces	11	
South Europe											
FRANCE	Caune de L'Arago D	3019	unipolar and centripetal sequence on polyhedral core and anvil debitage	some with natural back	side scrapers, notches and end-scrapers	small size blanks	Quartz, quartzite, flint, lydian, limestone, sandstone, jasper and chert	13	<i>in situ</i> and imported	12	Barsky and al., 2019 De Lumley et Barsky, 2004
	Terra Amata	indet.	unipolar and SSDA	some with natural back	side scrapers, denticulates, notches, "hachereau"	small size blanks	flint, limestone, quartzite	rare	<i>in situ</i> and imported	11-9	Lumley dir., 2015
SPAIN	Aridos 1	333	unipolar recurrent (not alternating) on natural blank	with natural back	rare retouched flakes	tools on flake and pebble	flint, chert, quartzite	1	<i>in situ</i> and exported bifaces	11 ou 9?	Santonja et al., 2001
	Aridos 2	34	unipolar recurrent (not alternating) on natural blank	with natural back	back flakes used	tools on flake and pebble	flint, chert, quartzite	0	<i>in situ</i>	11 ou 9?	Santonja et al., 2001
	Cansladeta K	728	unipolar, SSDA, polyhedral	with natural back	denticulates, notches, "Epine"	tools on flake and pebble	quartz, schist, chert, basanite	0	<i>in situ</i>	11	Ollé and al., 2016
	Ambrona AS1	184	unipolar recurrent (not alternating) on natural blank	always with natural back	denticulates, back flakes and side scrapers	46 tools on pebble	quartz, quartzite and flint	4	imported bifaces	9 ou 11	Santonja y Pérez-González 2005
	Ambrona AS3	91	unipolar recurrent (not alternating) on natural blank	always with natural back	side scrapers and denticulates	backed blank	quartz, quartzite and flint	1	imported bifaces	9 ou 11	Santonja y Pérez-González 2005
ITALY	Torre in Pietra (m)	104	unipolar recurrent (not alternating) on natural blank	common with natural back	side scrapers, denticulates and irregular notches	tools on flake and pebble	small flint and limestone pebbles	32	?	10	Villa et al., 2016
Central Europe											
GERMANY	Kärlich-Seufer	146	unipolar recurrent (not alternating) on natural blank or after a short preparation of the core	with natural back	denticulates and used flakes	backed blank	quartz, quartzite, chert, radiolarite	3 shaped tools (morphological bifaces)	<i>in situ</i> , probably imported bifaces and denticulates	11	Rocca, 2013

Table 4: Techno-economic data from some Pleistocene Middle Pleistocene (SIM 11-13) Acheulean sites with bifaces and flakes with natural back, mainly on the western façade of Europe.

Figures

Figure 1: location of sites cited in the text.

Figure 2: A – Simplified geological map of France(infoterre.brgm.fr); the square indicates the location of B; B – geological map at 1:50 000 and location of the Londigny site

Figure 3: Cross-section of Londigny site with location of the samples. The stratigraphic units are indicated by numbers in brackets.

Figure 4: A - Microscopic view of unit 4 showing a laminated silty intercalation in the middle of the photo and yellow brown illuvial clay coatings in the cavities (Bt horizon); B – view of unit 6 showing fragmented multiphased clay coatings (IIBt).

Figure 5: Grain size distribution of the Londigny samples (see fig. 3 for sample location) compared to that of a typical loess from southwest France (Romentères, Sitzia et al., 2017).

Figure 6: Chemical composition of the deposits from Londigny compared to other Uaternary formations from southwest France on a calcium (Ca) – iron (Fe) – zirconium (Zr) diagram. The Ca pole corresponds to easily alterable minerals, the Fe pole to Fe oxides and the Zr pole to resistant minerals (mainly zircon).

Figure 7: Distribution of Pleistocene aeolian deposits in western France from Bertran et al. (2016) and location of Londigny site.

Figure 8: Width distribution of Londigny's flakes compared with an experimental shaping assemblage (after Bertran et al., 2012). Although the assemblages are not technically comparable, this graph points to a clear deficit in shaping flakes at Londigny.

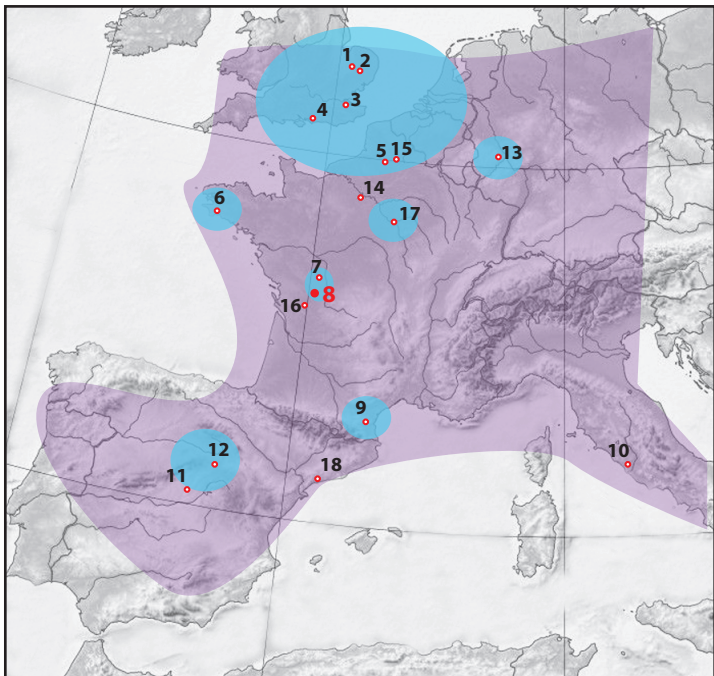
Figure 9: bifaces totally shaped.

Figure 10: bifaces partially shaped.

Figure 11: organisation of debitage sequences (type A to D) and examples of related core (n° 840 and 861 drawn by Pascal Rouzo).

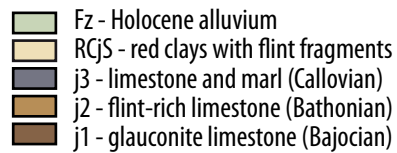
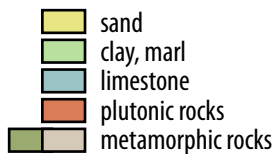
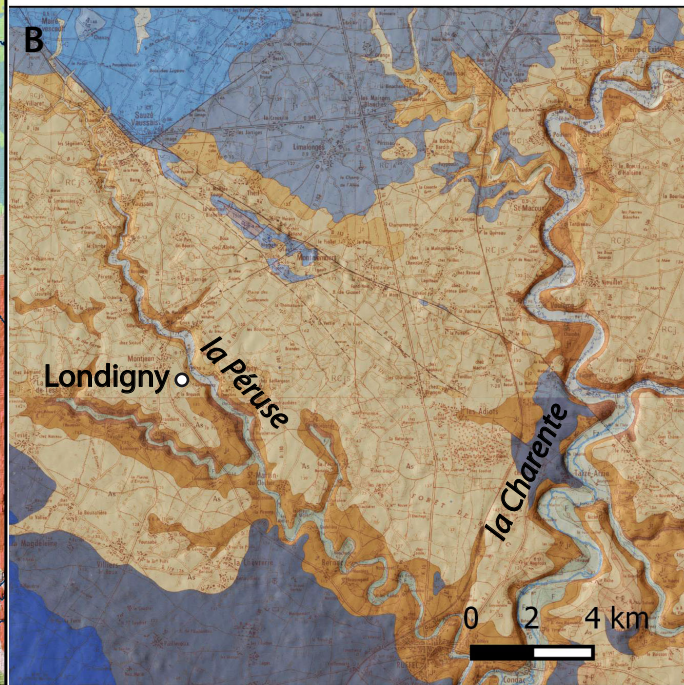
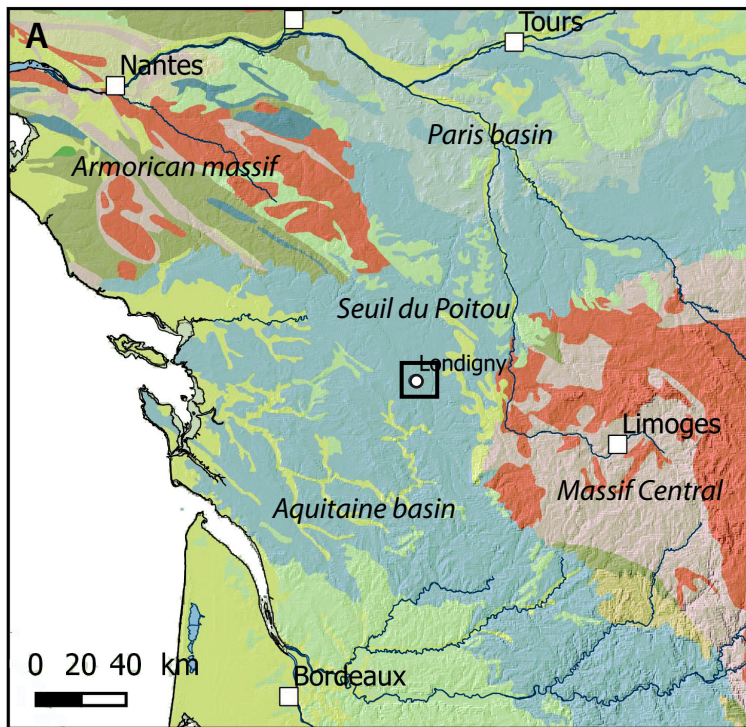
Figure 12: flakes type A to C.

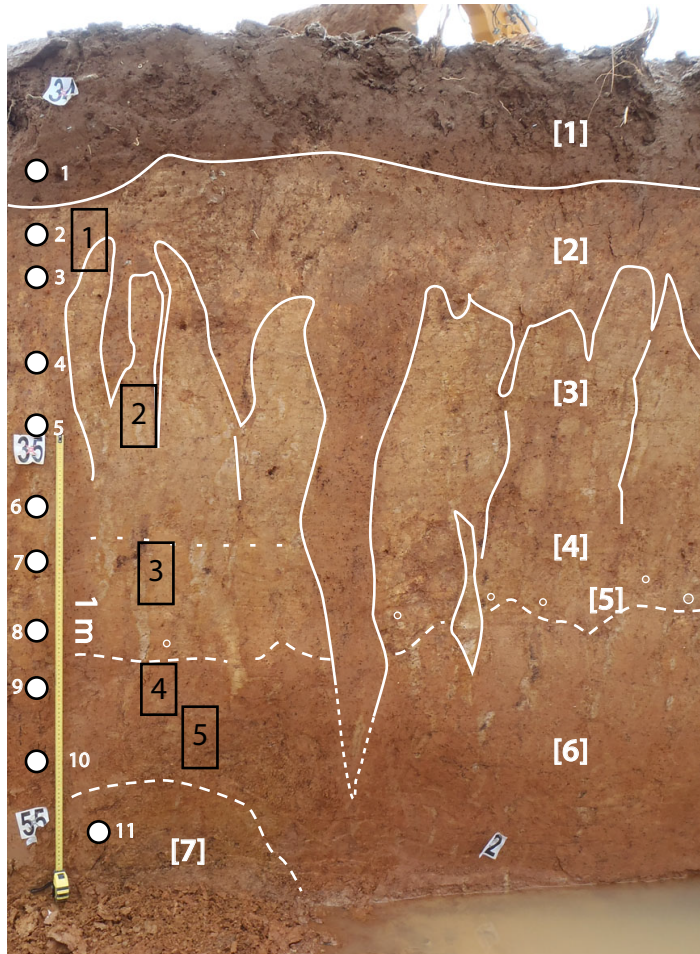
Figure 13: tools on flakes (1 to 4) and debris (5); 1 and 4 - partially retouched flake (1 with unretouched back, 4 with retouched back opposed), 2- denticulate/notch, 3 and 5- denticulate.



1-High Lodge; 2-Barham; 3-Swanscombe; 4-Boxgrove; 5-Cagny-la-Garenne, Cagny-L'EpINETTE, Gentelles, Revelles, Clairiy-Saulchoix; 6-Menez-Dregan; 7-Colombiers; 8-Londigny; 9-Caune de L'Arago; 10-Torre in Pietra ; 11-Aridos; 12-Ambrona; 13-Kärlich-Seufer; 14-Saint-Illiers-la-Ville; 15-Etricyourt-Manancourt, Gouzeaucourt; 16-Arténac; 17-La-Celle-sur-Seine; 18-Cansaladeta

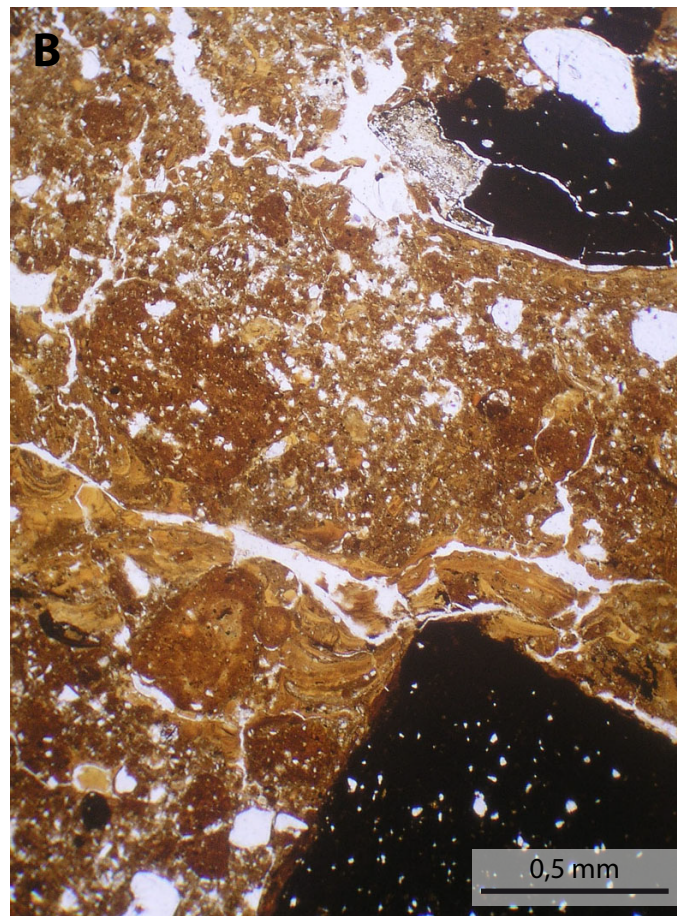
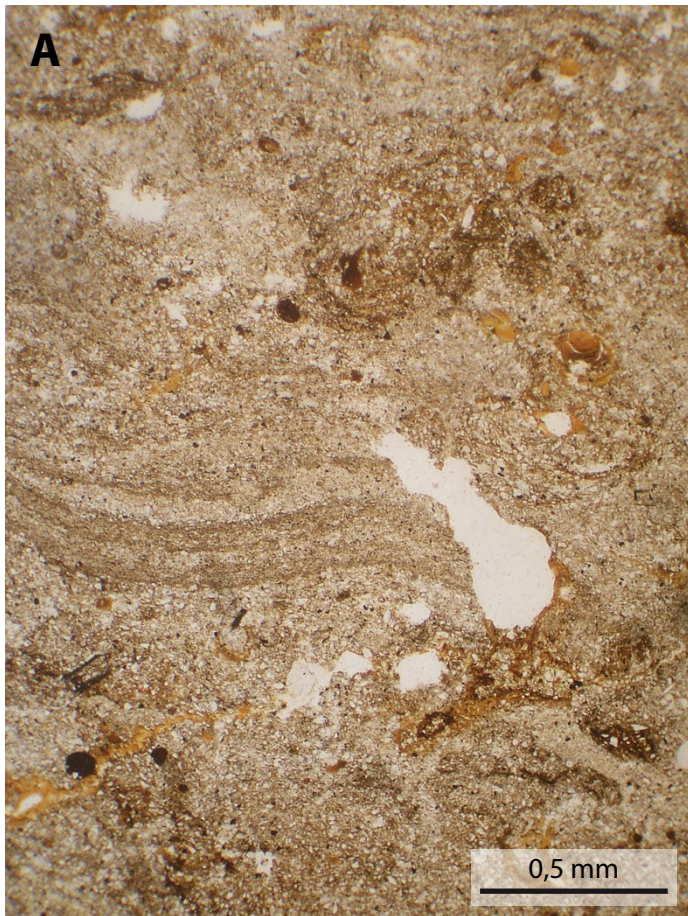
- sites with bifacial industry from MIS13 to MIS11
- extension of bifacial industry after MIS11

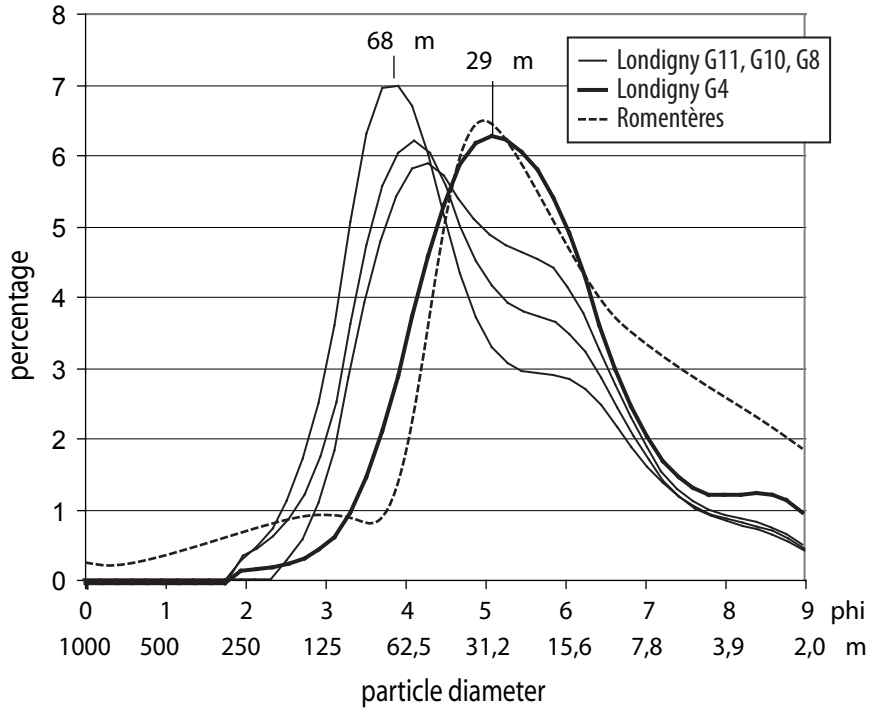


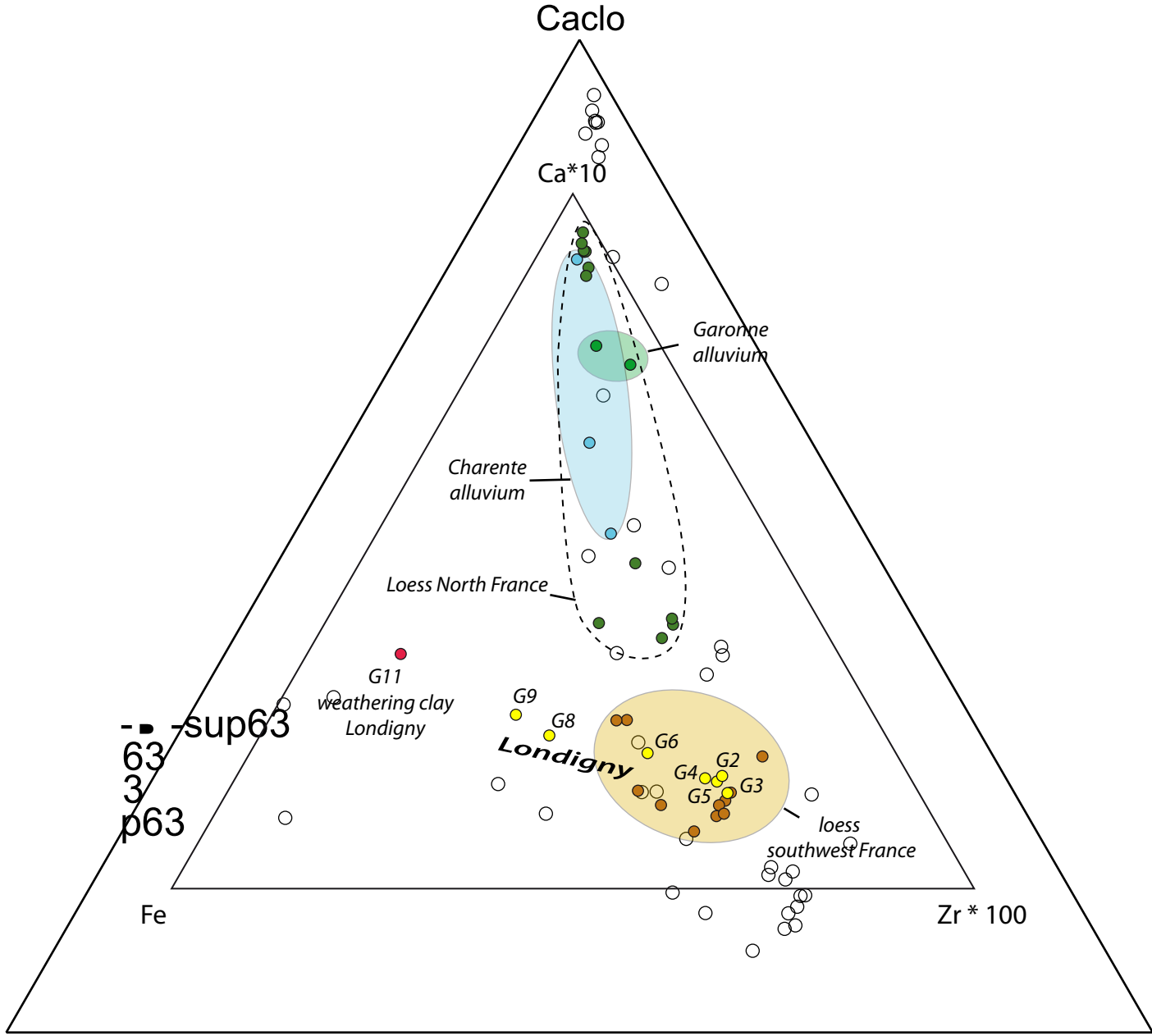


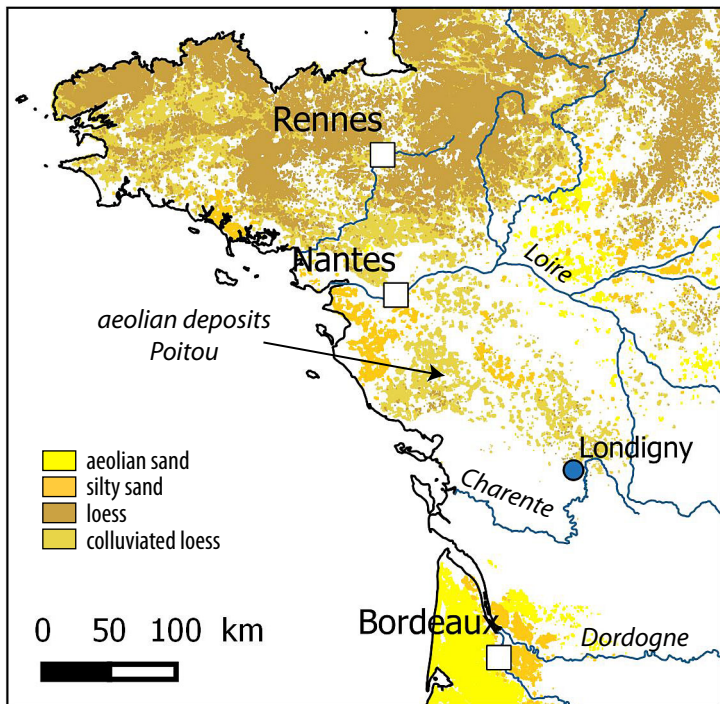
¹⁰ ○ sample (grain size, ED-XRF)

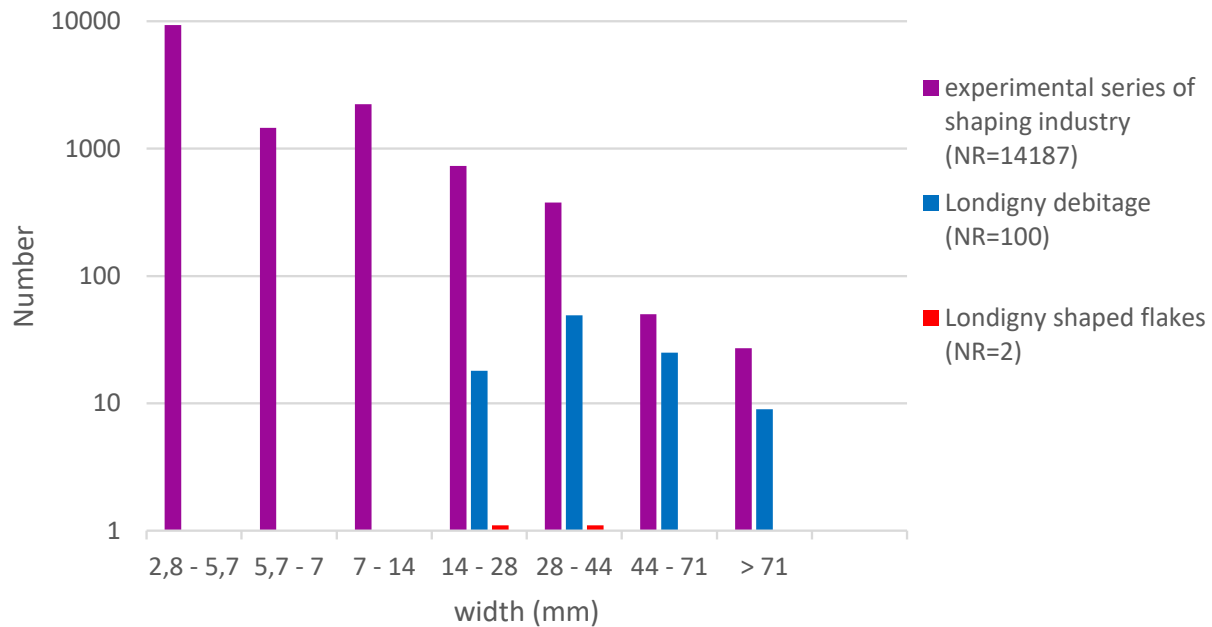
□ 4 thin section





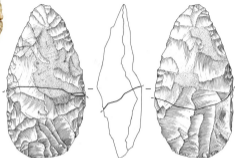






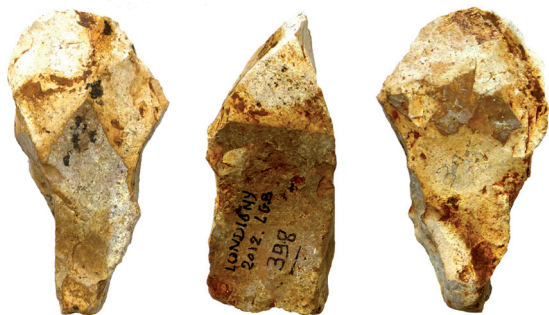


n° 350-352

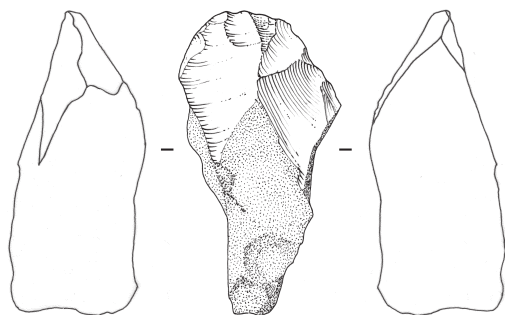


n° 737

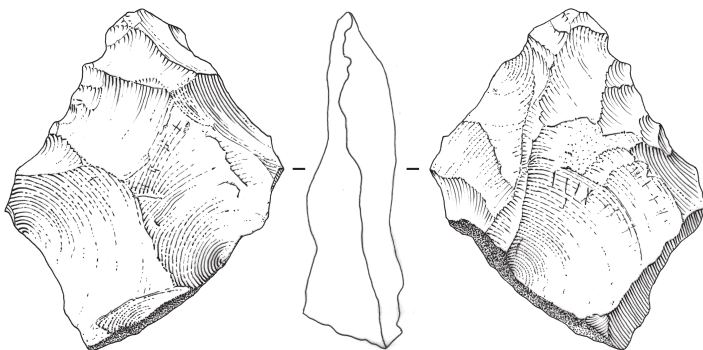


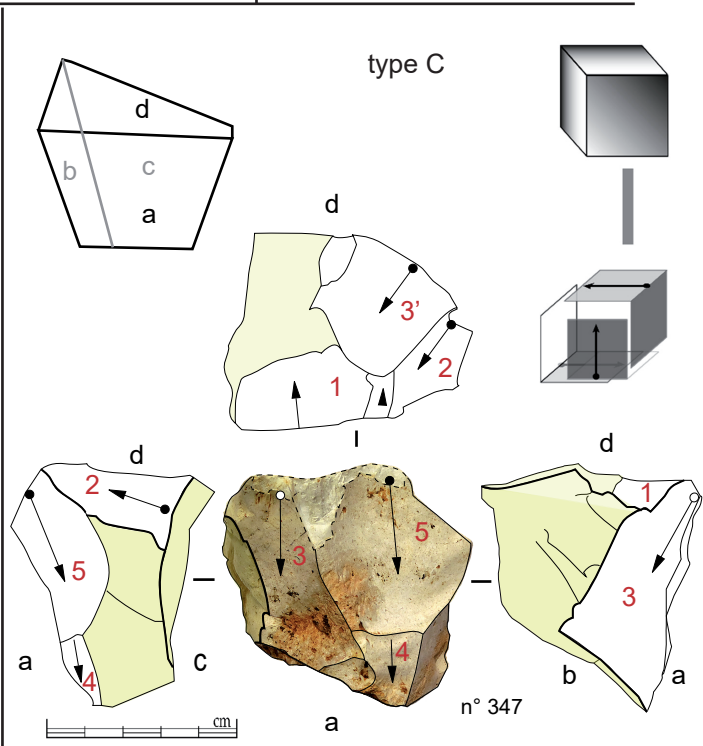
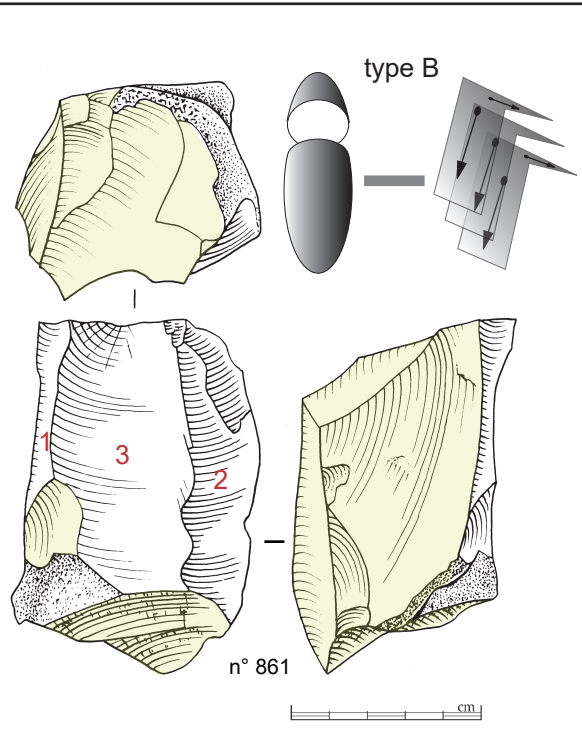
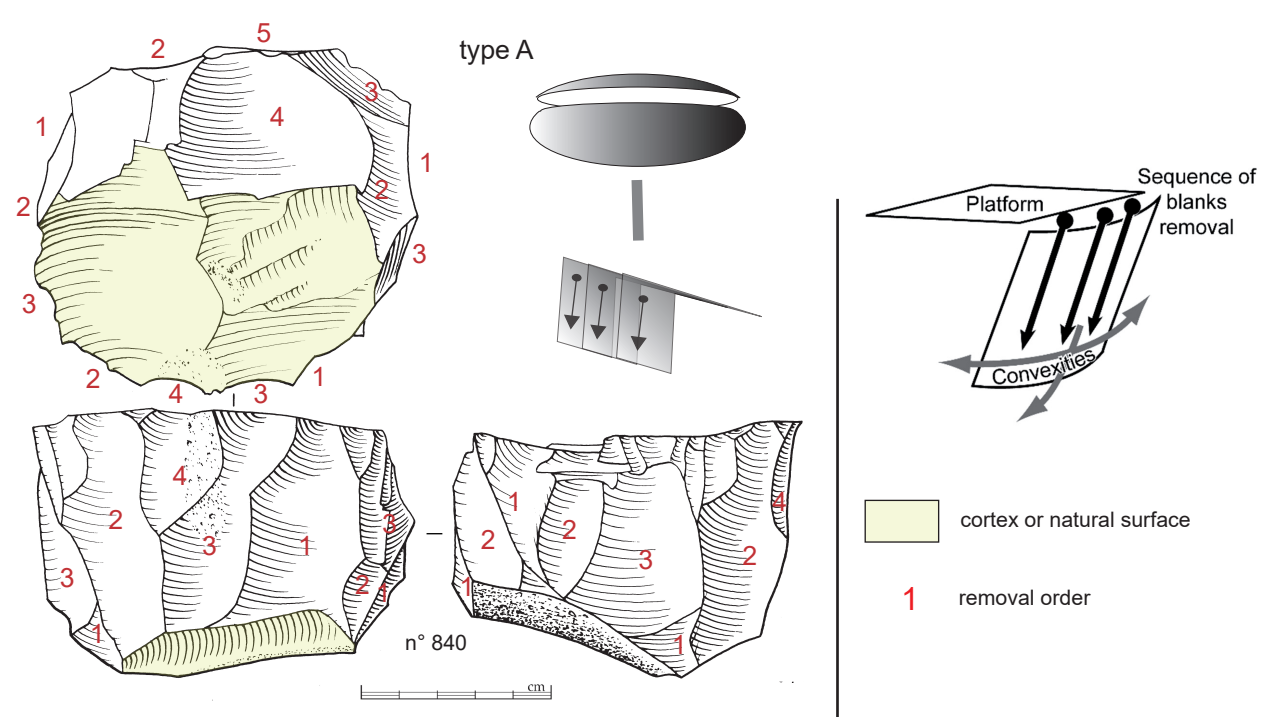


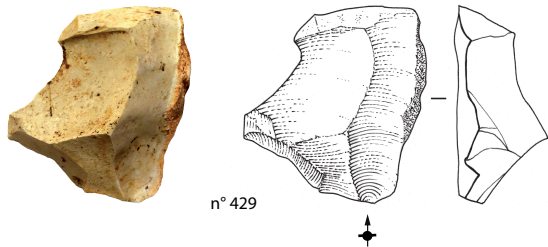
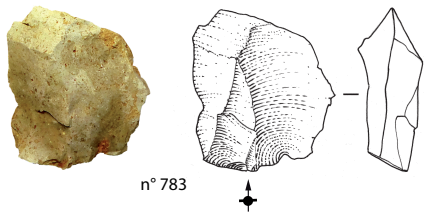
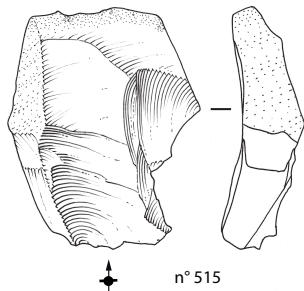
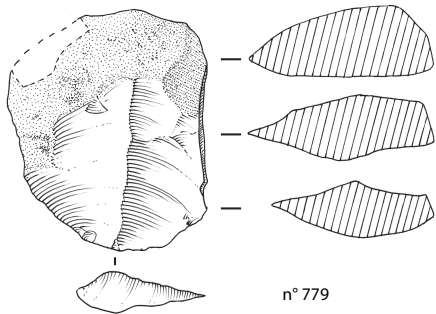
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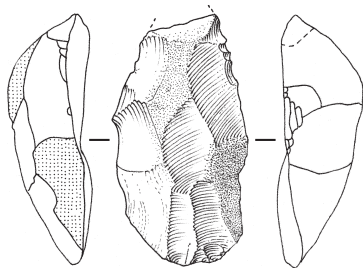


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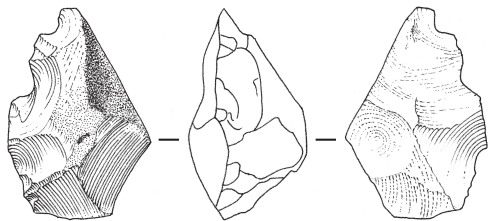
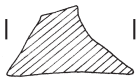




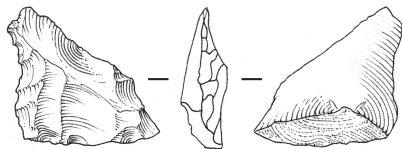




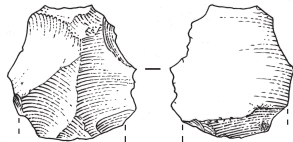
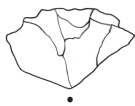
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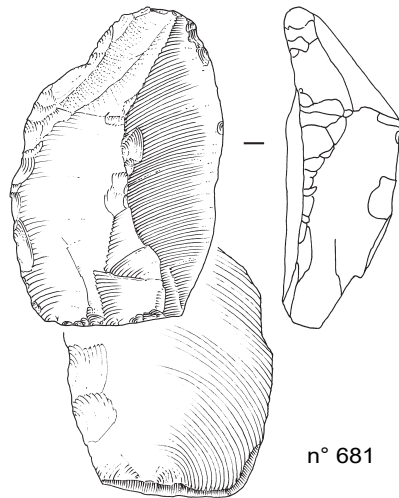
n° 343



n° 797



n° 850



n° 681