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FROM THE FLAKE TO THE BLADE: THE TECHNOLOGICAL EVOLUTION OF THE MIDDLE PALEOLITHIC BLADE PHENOMENON

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To my family.

From the flake to the blade:
Technological evolution of the Middle Paleolithic blade phenomenon.

Abstract

The European Middle Paleolithic technocomplex shows some large chronological trends in the lithic industry changes, and also an internal technical diversity which is difficult to explain in a homogeneous framework.
We introduce a technological perspective to go through this technical diversity, based on the comparison of four Mousterian sequences: Bau de l'Aubesier and Payre in southern-east France, Riparo Tagliente in northern Italy and Grotta del Cavallo in southern Italy.

In the technological mosaic, which is the peculiarity of the European Middle Paleolithic, blade production assumes a not clear role. Technical analyses made on the sites mentioned above show a complex and discountinuos blade reduction strategies. In a comparative perspective, technical changes don't appear at the same rhythm in the four sequences. At Bau de l'Aubesier and Payre different technological features has been recognized. At Payre dominance of production of flakes is in contrast with the association of blade and flakes end-products recognized at Bau de l'Aubesier. This variability does not seem to be linked to external factors such as the raw materials or other activities.

Riparo Tagliente and Grotta del Cavallo share a combination of Levallois and laminar production aimed to produce distinct end products. Finally, a bladelets production recognized at Bau de l'Aubesier during the MIS 5 and later on at Grotta del Cavallo during the MIS 4-3 display a non-linear technological evolution through time and space.

We suggest that these different change modalities are the result of a deeper techno-cultural diversity of human groups populating the southern Europe during the Middle Paleolithic.

Keywords: *Southern Europe, Middle Paleolithic, Blade, Bladelets, Technological evolution.*

Resum

Des de l'ascla fins la làmina: L'evolució tecnològica de la tendència laminar del Paleolític Mitjà

El tecno-complex europeu del Paleolític Mitja mostra grans tendències cronològiques en els canvis de la industria lítica i una diversitat tècnica interna que és difícil d'explicar dins d'un marc homogeni.

Aquest treball introdueix una perspectiva tecnològica per entendre aquesta diversitat tècnica, basant-se en la comparació de quatre seqüencies mosterianes: Bau de l'Aubesier and Payre, al sud-est de França, Riparo Tagliente al nord d'Itàlia i Grotta del Cavallo al sud d'Itàlia.

Dins del mosaic tecnològic, que és el principal tret del Paleolític Mitja europeu, la producció laminar assumeix un paper poc clar. Les anàlisis tècniques dels complexos industrials recuperats a tots quatre jaciments mostren una discontinuïtat de les estratègies de reducció laminar. Des de un punt de vista comparatiu, però, els canvis tècnics no apareixen amb el mateix ritme a les quatre seqüencies.

A Bau de l'Aubesier i a Payre es van reconèixer diferents característiques tècniques. A Payre el predomini de la producció d'ascles contrasta amb l'associació de làmines i ascles com a productes finals reconeguts a Bau de l'Aubesier. Aquesta variabilitat no sembla estar relacionada amb factors externs com poden ser les matèries primes o altres activitats.

D'altra banda, els jaciments de Riparo Tagliente i de la Grotta del Cavallo comparteixen una combinació de la producció Levallois i laminar adreçades a la generació de productes finals diferents.

Finalment, una producció de laminetes reconeguda a Bau de l'Aubesier durant el MIS5 i més tard a la Grotta del Cavallo durant el MIS 4-3, presenta una evolució tecnològica no lineal a través del temps i de l'espai.

Proposem que aquestes diferents modalitats de canvi són el resultat de una profunda diversitat tecnològica dels grups humans que van poblar el sud del continent europeu durant el Paleolític Mitjà .

Paraula clau: Europa del Sud, Paleolític Mitja, Làmina, Evolució tecnològic.

De la lasca a la lámina:
Evolución tecnológica del fenómeno laminar del Paleolítico Medio

Resumen

Los tecnocomplejos Europeos del Paleolítico Medio muestran grandes tendencias cronológicas en los cambios de la industria lítica, y también una diversidad técnica interna que es difícil de explicar dentro de un marco homogéneo.

Para entender esta diversidad técnica, se ha introducido una perspectiva tecnológica basada en la comparación de cuatro secuencias musterienses: Bau de l'Aubesier y Payre, en el sudeste de Francia; Riparo Tagliente del norte de Italia y Grotta del Cavallo del sur de Italia.

En el mosaico tecnológico, que es la peculiaridad del Paleolítico Medio Europeo, la producción laminar asume un rol poco claro.

Los análisis tecnológicos de los cuatro sitios analizados, muestran una discontinuidad en la estrategia de reducción laminar.

Desde una perspectiva comparativa, los cambios tecnológicos no aparecen con el mismo ritmo en las cuatro secuencias: en Bau de l'Aubesier y Payre distintos rasgos tecnológicos se han reconocido.

En Payre el dominio en la producción de lascas, contrasta con la asociación de láminas y lascas como productos finales reconocidos en Bau de l'Aubesier. Esta variabilidad parece no estar asociada a factores externos, como materias primas u otras actividades.

Riparo Tagliente y Grotta del Cavallo presentan una combinación de Levallois y producción laminar, dirigida a la elaboración de diferentes productos finales.

Finalmente, una producción de laminetas es reconocida en Bau de l'Aubesier durante el MIS 5, y más tarde también, en Grotta del Cavallo durante el MIS 4-3, lo que muestra una evolución tecnológica no linear a través del tiempo y del espacio.

Se sugiere que estas distintas modalidades son el resultado de una profunda diversidad tecno-cultural de los grupos humanos que poblaban el sudeste europeo durante el Paleolítico Medio.

Palabra clave: Europa del sur, Paleolític Mitja, Paleolítico Medio, Lamina, Evolución tecnológico.

Contents

SUPPLEMENTARY FILE

Introduction

This work has been focused on the technological behaviours related to the appearance and development of the Middle Paleolithic blade productions in Southern Europe. Evidence of blade technology is confirmed in Northern Europe (France, Belgium), at least from the last part of the Middle Pleistocene (MIS 7). In MIS 5 these productions cover a larger area, which includes the North-Western Germany, central France, and occasionally the South of France. A third moment (MIS 4-3) shows us the reappearance of laminar productions in Southern Europe and more particularly in the South of France and the Italian peninsula. At the present state of research these three phases appear as on-and-off events without a clear evolutionary continuity. The reduction strategies used include a variety of production methods whose complexity cannot be explained simply with the dichotomy Levallois laminar production – Volumetric laminar production. The aim of this research project intends to examine, through a technological approach, the lithic assemblages of two sites located in the South of France (Payre and Bau de l 'Aubesier) and two in the Italian peninsula (Riparo Tagliente and Grotta del Cavallo). The main objective was to study the aspects connected with the laminar systems through a dual approach which takes into account the aspects related to the production of blades and their coexistence with other type of reduction strategies aimed to produce flakes.

Simplifying what is produced trough the lithic production, we can in fact identify three categories of possible products: flakes and blades, produced by knapping operations (débitage), and hand axes (*lato sensu*) by shaping operations (façonnage).

If the shaping operations contain a conceptual structure of modelling a morphology from a block of raw material, the dichotomy flake-blade, is, at a macroscopic scale, a double variant of the same theme, which is the separation of a support from a volume. The presence of a laminar production is now widely attested since the Middle Pleistocene and at several latitudes (Africa, the Near East and Europe). Since the beginning of its discovery, the Middle Paleolithic blade production has attracted the attention of scientific community for many reasons. The specific morpho-technical features of blade have acquired a double value; the role of cultural marker as technological innovation, and, approaching to the transitional and upper Paleolithic industries, of indirect evidence of biological status, i.e. the emergence of the AMH (anatomically modern human).

Despite the current difficulties in clearly defining the laminar phenomenon of the Middle Paleolithic, it is possible to draw a synthesis outline.

If we restrict our study to Europe, it is possible to identify at least three different and non-continuous presence of blade production.

The first evidences of laminar productions are found in Northern Europe at end of MIS 8 to the MIS 7 (RÉVILLION 1995), both resulting from volumetric débitage reduction syrategies (like in the sites of Coquelles, Saint Valery sur Sommes, Bapaume-les Osiers, Terdonne, Rissori), and from Levallois productions (like in the sites of Bagarre and Biache-Saint-Vaast). In the sites mentioned above, the laminar element assumes rarely a dominant role. On the contrary, we find it in conjunction with other production systems, including the most frequent Levallois concept débitage.

In the MIS 5 a second phase arises and the presence of blades in Northern France multiplies. Sites like Riencourt lès-Bapaume, Saint- Germain-des-Vaux, Seclin, Bettencourt-Saint-Ouen, Blangy-Tronville, Etouteville show a great variability in how to produce blades. This does not allow a specific grouping under a common name. The initial stage of the reduction systems can leverage on the preparation of a crested blade or using al long natural ridge of the block. The débitage can follow the unidirectional or bidirectional exploitation and raw materials utilized include pebbles, nodules or slabs.

In the same age (MIS 5) we find such productions spread over a larger area: in the North-West of Germany, in the sites of Tonchesberg, Reindhalen and Wallertheim and in central France, in the sites of Angé and Vinneuf.

The current explanation of the origin of these products is not unanimously accepted. In some specific cases, some authors have hypothesized a possible opportunistic answer motivated by optimizing the use of raw materials (CONARD 1990). However, this constraint cannot be valid in areas rich of flint, such as the North of France. Other authors have supposed the reason being the response to an environmental crisis (OTTE 1994). The duration and diffusion of the laminar phenomenon in different areas however suggest caution in giving a mono-factor explanation to its appearance and diffusion.

A third phase of blade production can be positioning during the MIS 4 and the beginning of MIS 3.

During this period the blade production shows a larger spread which includes the southern and the eastern Europe. In southern France, in fact, although this phenomenon would be first sporadically tracked in the final stages of MIS 5, it is in the MIS 4 and 3 that it actually takes on a certain consistency. Archaeological sites as Abris du Maras, Baume Flandin, Grand Champ, Tournal Caves, Grotte du Figuier are some of the most outstanding evidences of this third and last laminar insurgence before the rise of the Upper Paleolithic lithic industries.

As far as the Italian Peninsula is concerned, the laminar production does not show its evidence dating back to earlier periods of isotopic stage 4. On the other hand, in Italy the sites holding a laminar component seem to be concentrated in the later phases of the Middle Palaeolithic and especially in the first part of isotopic stage 3. At the present state of research, the laminar phenomenon in the Italian peninsula appears therefore with a certain delay compared to the south of France. The geographical distribution of these products does not seem to be confined to a territory or a specific environment. We find, in fact, volumetric laminar production in the Puglia region at the sites of Santa Croce and Grotta del Cavallo, in Lazio at Cave Breuil, in Molise at Grotta Reali, in Veneto at Fumane and Riparo Tagliente and in Liguria at Grotta di San Francesco.

In parallel to the emergence of the laminar volumetric systems, the Levallois concept seems to be redirected towards the production of elongated blanks at the expense of the flake modules. This phenomenon, as in the blade volumetric production, is found throughout the Italian peninsula: in Liguria, in the sites of Riparo Mochi and Barma Grande, in Veneto in the sites of Fumane, in Campania in the sites of Riparo del Poggio and Castelcivita, in Puglia in the site of Riparo dell'Oscurusciuto. In some cases, the coexistence of the two systems, Levallois and Laminar, seems to correspond to distinct production goals. At Grotta del Cavallo the Levallois production follows a unidirectional - bidirectional method for the production of sub-quadrangular flakes, while the volumetric system is dedicated to the production of blades.

Although the laminar production in the Middle Paleolithic is now proved, the production of bladelet seems to be a phenomenon confined to the final stages of the Mousterian cycle and numerically marginal. Some bladelet productions are found in Spain, in the site of El Castillo and Cueva Morin, in France, in the site of Grand Champ, in Italy in the site of Grotta Cavallo and Fumane and, in Germany, in the site of Balver Höhle.

More generally, we can observe that at the end of the Mousterian cycle the operational patterns shows a strong differentiation and the laminar production is one of the most evident expressions. The origin of this fragmentation is questionable. In a wider set of problems, the role of the blade takes in our opinion a key role, both in terms of its potential morpho-functional features and for the role it will plays in the subsequently transitional and Upper Paleolithic lithic assemblages.

Chapter 1

Aims of the project and Methodology

1.1 Structure of the thesis.

The present work is composed by five papers that correspond to the central chapters of this thesis (Chapter 2 to 6). Each paper can be considered as a finished work introduced by specific questions and methods. Detailed information about the questions and methods used can be found on each paper. To avoid the repetition of the references that would be partially overlapped and to facilitate its reading we decided to condense them at the end of the work. The final chapter of the thesis (Chapter 7) will be dedicated to resume the results for a final discussion.

1.2 General questions and objectives

Based on the current state of scientific knowledge description of the Middle Paleolithic, blades production is often identified using a binary pattern, which is the distinction between Levallois and non Levallois; the latter one is usually related to a volumetric reduction strategies. This dichotomy looks reductive compared to the complexity of the blade phenomenon. Furthermore, not to forget that the definition of blade substantially includes all the blanks that in an undifferentiated way correspond to a mainly morphologic character (Length> 2Width). This study is aimed to investigate the variability the blades reduction strategies and their related end products to better define the Mousterian blade production bypassing an hylomorphic approach.

Is the actual description of the Middle blade production exhaustive enough to show us the technological variability of the blade phenomenon?

The recurrent coexistence of blades and flakes reduction strategies open a question on the relation between these two blank categories. One of the main goals was to understand the dichotomy flake- blade in relation to their respective reduction strategies by a comparative analysis. Did the insurgence of the blades have an impact on the Middle Paleolithic flakes strategies? If the answer will be positive how did the introduction of blade inside a previous all-flake strategy work?

The laminar phenomenon in Europe spans more than 200,000 years of technological evolution. Nevertheless, the blades do not appear at the same time in all the regions. If northern Europe shows its presence at least since the MIS 7 is just during the MIS 5 that blades are attested in southern Europe. This second insurgence of blades seems to anticipate the same phenomenon that will recur in southern Europe just during the isotope stages 4 and 3. Are these three events part of a single macro-phenomenon or on the contrary, they spread from different techno-cultural identity with independent origins?
These set of issues and objectives have guided the preliminary choice of the collections according to two parameters: chronological and geographical. Four lithic assemblages have been analysed: Grotta del Cavallo and Riparo Tagliente located in the Italian peninsula and Bau de l'Aubesier and Payre located in the south-eastern France (Fig 1)

Figure 1 – Location of the sites studied.

Grotta del Cavallo is a coastal cave located in the south of Italy by the Ionian Sea located approximately 10 meters b.s.l. in the Apulia region (Fig 1).

This cave was first studied by Arturo Palma di Cesnola in 1961 (Palma di Cesnola 1963). In the years that followed other excavation campaigns were carried out, these highlighting the long Middle and Upper Paleolithic sequences present at the site (Palma di Cesnola 1964, 1965, 1967). In 1986 , under the direction of Lucia Sarti, the University of Siena re-opened the excavations on a larger surface (12 sq. m).

The site preserves a seven meters thick archaeological deposit, covering a time span ranging from MIS 5 to the final Upper Palaeolithic. The bottom layer is a marine interglacial beach conglomerate, layer O, MIS 5e (Sarti et al., in press) covered by Mousterian layers, approximately four metres thick, layers N-F (Sarti et al., 1998 – 2000 and 2002; Palma di Cesnola, 2001), Uluzzian layers, layers E-D (Palma di Cesnola, 1965a and 1966), a sterile tephra empirically related to the Campanian Ignimbrite eruption (layer C) and an Epigravettian layer (layer B). The laminar production analysed in this work comes from sub-levels FIIIe and FIIId and precede the rise of the Uluzzian. The base of the Uluzzian layers has been recently dated to 47,530 – 43,000 cal. BP, radiocarbon analysis on shell remains (Benazzi et al., 2011).

Riparo Tagliente is a rock shelter located in the Veneto region in northern Italy (Fig 1).

It was first excavated in the 1960s by the *Museo Civico di Storia Naturale di Verona* (Pasa & Mezzena 1964; Zorzi 1962; Zorzi & Mezzena 1963) and subsequently in collaboration with the University of Ferrara (Bartolomei *et al.* 1982, 1984). The Mousterian collection under examination comes from these excavations. Research at the site is still ongoing currently under the direction of Federica Fontana from the University of Ferrara. Sediment, macrofaunal, microfaunal and pollen analyses date the Mousterian sequence between MIS 4 and the beginning of MIS 3 (Arzarello *et al.* 2007; Cattani & Renault-Miskovsky 1989; Thun-Hohenstein & Peretto 2005). The stratigraphy, excavated by artificial layer, is composed of a Mousterian sequence and an Epigravettian sequence separated by erosion. The 1960s excavation procedures, which paid much attention to sedimentary details, have enabled us to determine light patterns of internal evolution of the lithic industry.

Bau de l'Aubesier is a large rock shelter located in the gorge de la Nesque, Vaucluse "South-eastern France" (Fig 1). The site, known since the beginning of the 20th century (Moulin 1903, 1904), has been extensively excavated starting the 1987 by an international team led by Sergey Lebel, then of the University of Quebec, Montreal, Canada (Lebel 2000 a, b).
The site contains a long sedimentation approximately 13 m deep and covering a time range from 100 Ka (thousands of years ago) to more than 200 ka approximately.
The entire sequence is composed by 14 archaeological levels, which were divided during the excavation into several sub layers corresponding to slightly difference in sedimentation.
Several radiometric dates and faunal analysis positioning the sequence from the end of the MIS 7 to the MIS 5 (Blackwell et al., 2001; Lebel et al., 2001; Fernandez, 2006).

Payre is a small cave located in the Rhône Valley (South-Eastern France) above the confluence of the Rhône and Payre Rivers (Moncel et al. 2002, 2008; Daujeard and Moncel 2010; Moncel and Daujeard 2012; Moncel et al., 2014). The 5m thick stratigraphic sequence yielded 8 occupation layers in 4 phases (units). The basal units G and F that we investigate here are dated from MIS 8-7, roughly 250,000 to 200,000 years before present (Grün et al. 2008; Valladas et al. 2008).

1.3 Methods

The first part of the research was addressed to collect the data set concerning the Middle Paleolithic European sites with evidence of blades reductions strategies.
The data set has been collected basing on the mains scientific publications including papers in journals, PhD thesis, volume and excavation reports.
During the data collection, qualitative and quantitative problems have emerged immediately. In fact, different methods used to analyse the lithic assemblages and dissimilar terminology used to describe the blade production have made it complicate to obtain an immediate comparison between the sites.
To reduce these discrepancies and homogenize the data sets we chose to organize the information with an appropriate database expressly built (Fig 2 and 3). When it was possible we tried to harmonise the terminology and to synthetize the information extracted by the different publication. The database's design is organized to recorder the information concerning all the sites that contain blade production evidence and it is structured in six mains parts that are linked to a single archaeological level of a site. The database incorporates the informations related to the chronology, the lithic raw material, the general information of the site, the main lithic industries information and the blade reduction process description (Fig 2).
The sites are subdivided by one or more records describing the information for each archaeological level which constitute the archaeological sequence of each sites (Fig 3).

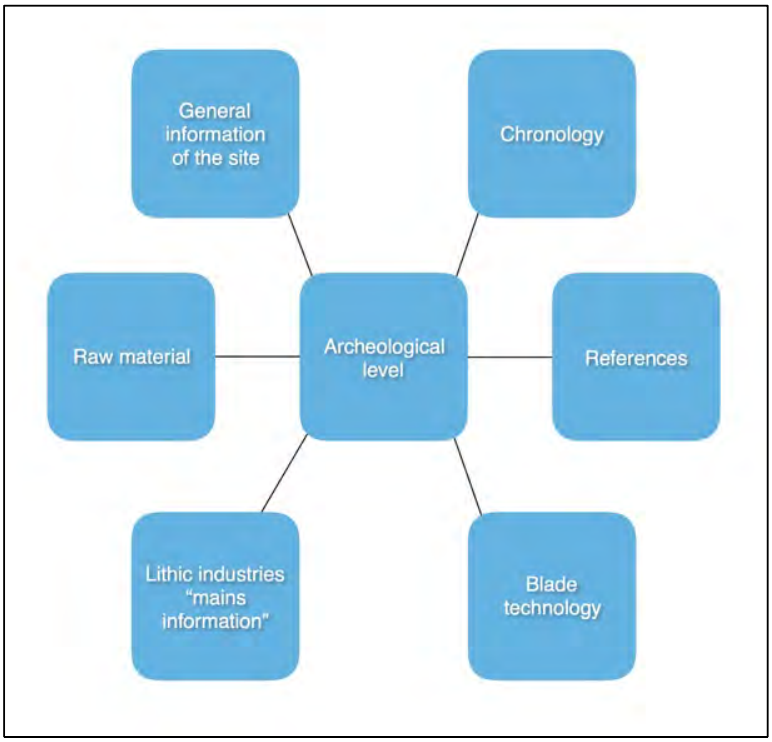

Figure 2 - Data base structures of the archeological sites

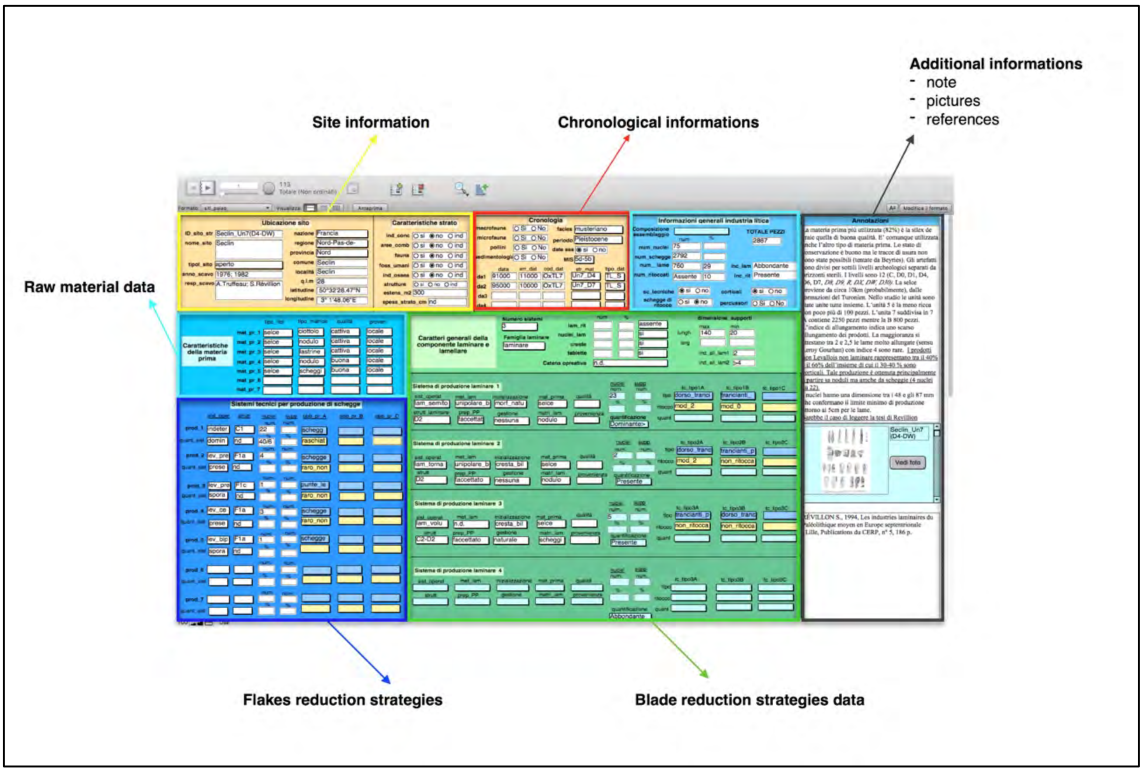

Figure 3 - Graphic interface of the data base of the archeological sites.

The second part of the work was addressed to implement the data concerning the lithic assemblages of the four sites studied in this work.

The lithic assemblages were analysed using a technological approach. All cores, core fragments, tools, tool fragments and all blades and blade fragments are selected regardless of their size. Technological analysis follows the chaîne opératoire approach based on the identification of the distinct phases of the process (Cresswell 1983, Pelegrin et al. 1988, Perlès 1991, Geneste 1991a, b). Percussion techniques, methods and concepts that underlie the reduction strategies have been analysed (Pelegrin 1991, 2000, 2005; Boeda et al 1990).

Diacritical analysis was applied to cores and blanks in order to identify the chronological order of the scars distinguishing the preparation phases to the main production phases (Dauvois 1973, Inizan et al. 1995).

The definition and the characterization of the lithic production have been also predated by a personal analytical approach. Further detailed information about the methodology used are described in the methodological part of each paper.

To improve the data collection of the lithic items, a specific database has been designed, structured in two separated section aimed to recorder the data set concerning the information of both the blanks and the cores (Fig. 4).

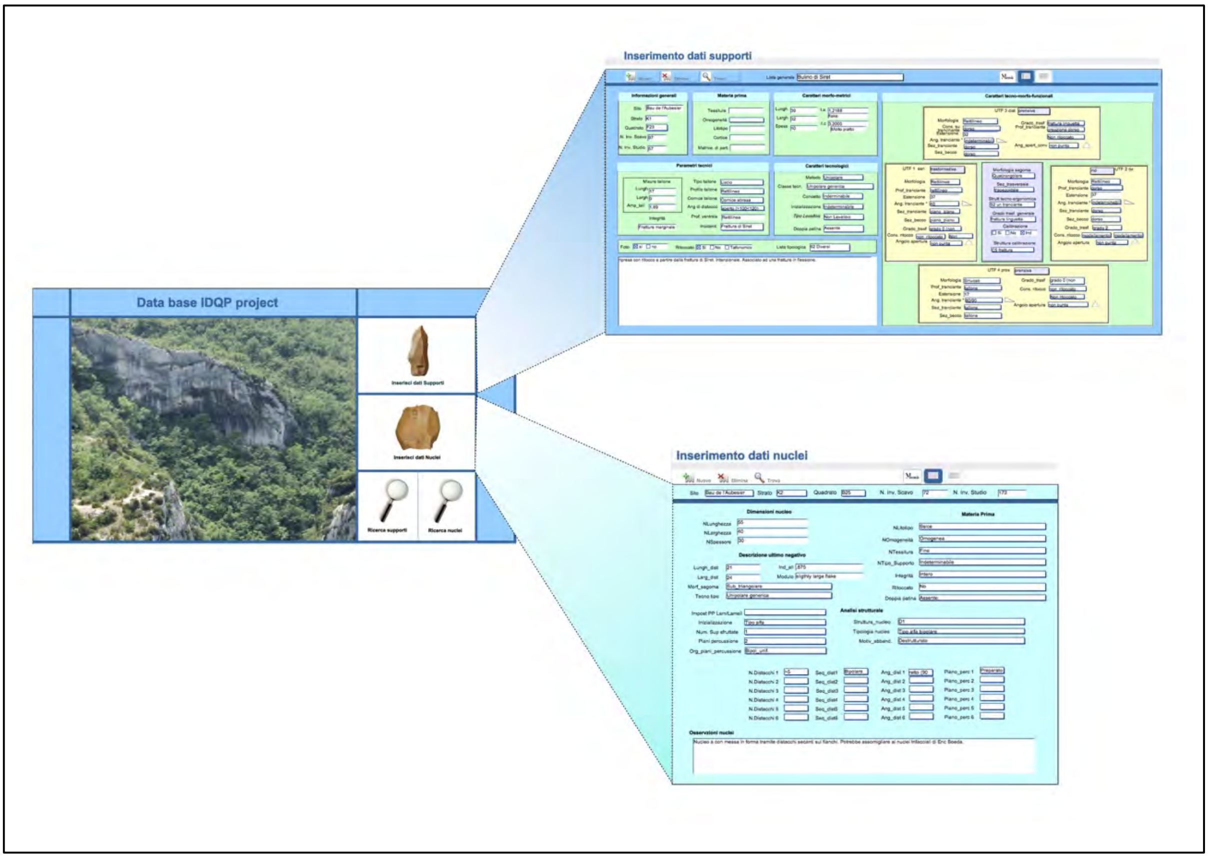

Figure 4 - Graphic interface of the lithic assemblages's data base.

Chapter 2

Technological variability during the Early Middle Palaeolithic in Western Europe. Reduction systems and predetermined products at the Bau de l'Aubesier and Payre (South-East France).

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Abstract

The study of the lithic assemblages of the Bau de l'Aubesier and Payre sites contributes to enlarging our knowledge of the earliest Neanderthal techno-cultural variability. In this pap er we present the results of a detailed technological analysis of Early Middle Palaeolithic lithic assemblages of MIS 8 and 7 age from two sites, Payre and the Bau de l'Aubesier, located on opposite sides of the Rhône Valley in the south-east of France. The MIS 9-7 period is considered in Europe to be a time of new behaviours, especially concerning lithic strategies. The shift from the Lower Palaeolithic to the Early Middle Palaeolithic is "classically" defined by an increase in the number of core technologies, including standardized ones, which are stabilized in the full Middle Palaeolithic (MIS 5-3), associated with the decline of the "Acheulean" biface. Applying a common technological approach to the analysis of the two assemblages highlights their technological variability with respect to reduction systems and end products. Differences between Payre and the Bau de l'Aubesier concerning raw material procurement and faunal exploitation only partially explain this multifaceted technological variability, which in our opinion also reflects the existence of distinct technological traditions within the same restricted geographic area.

1 Introduction

The MIS 9 to 7 time-span in Europe is considered to have recorded a behavioural change commonly described as the shift from the Lower to the Middle Palaeolithic or again as the threshold from Mode 2, including bifaces, to Mode 3, linked to the development of different core technologies (Clark 1969). From a general point of view the continuity in biface production and the increase in predetermined flaking systems, even if not generalizable, are recurrent features which are valid during all this period on a continental scale. Attribution of an assemblage to the Upper Acheulean (UA) or to the early Middle Palaeolithic (EMP) is often based on to the proportion of bifaces and/or pebble tools alongside flake production.

In this large chronological timespan, associated with new technological features, other changes regarding subsistence strategies are also documented, such as the wooden throwing spears discovered at Schöningen, Germany (Thieme 1997) and recently re-dated to the MIS 9, that provide evidence of specialized hunting (Richter & Krbetschek 2015).

Development of more complex flaking technology is emblematically represented by the rise of the Levallois concept. Early evidence of Levallois technology is largely documented in Western Europe at the end of MIS 9 (Adler et al. 2014; Alvarez-Alonso 2014; Delagnes and Meignen 2006; Dibble and Bar-Yosef 1995; Fontana et al. 2010; Fontana et al. 2013; Gamble and Roebroks 1999; Moncel et al. 2011; Moncel et al. 2012; Picin et al. 2013; Roebroeks and Tuffreau 1999; Soriano 2000; White and Ashton, 2003; Wiśniewski 2014; Moncel et al., 2016), even though the oldest records of the emergence of this concept are recognized, sporadically, in a few sites: in France at Cagny la Garenne and Cagny Cemetery dated to MIS 12-11 (Lamotte and Tuffreau, 2001; Lamotte, 1995; Tuffreau, 1995, 1987; Tuffreau et al., 2008), in the Iberian Peninsula at Grand Dolina TD10 and Ambrona dated to MIS 10-9 (Terradillos-Bernal and Rodríguez-Álvarez 2014; Terradillos-Bernal and Díez Fernandez, 2012; Olle et al., 2013; García-Medrano P. et al. 2015; Santonja et al., 2016;) and more recently in the Italian peninsula at Guado San Nicola dated to the end of MIS 11-beginning of MIS 10 (Peretto et al. 2016).

Another element of variability in reduction strategies that partially overlaps the rise of the Levallois concept during the EMP is the northern European blade production (Révillion 1995; Revillon, Truffeau 1994).

Early evidence of laminar production dates back to MIS 7 and the end of MIS 8 in the north of Europe, for instance at the sites of Saint-Valéry-sur-Somme (Heinzelin & Haesaerts 1983), Bapaume-les Osiers (Koehler 2008) and Therdonne (Loch et al. 2010) in France, and Rissori (Adam & Tuffreau 1973; 36 Adam 1991) in Belgium.

Unlike bifacial and Levallois production, that can be considered as a more global phenomenon, blade production is it limited to Nothern Europe for a long period.

By MIS 5 blade production covers a larger area including northeast Germany in the site of Tönchesberg (Conard 1990), and Wallertheim (Conard & Adler 1997) and in central and southern France, in the sites of Angé (Locht et al. 2008), Vinneuf (Gouédo 1994), Baume Flandin (Moncel 2005; Moncel et al. 2008 a,b), Cantalouette 4 (Blaser et al. 2012) Baume Bonne (Gagnepain et al. 2003, 2004) (Fig 1).

In all the sites mentioned above blades rarely assumed a dominant role but co-existed with various reduction systems (Levallois, Discoid, etc.) as well as with shaping systems, such as at the sites of Bapaume-les Osiers (Koehler 2008) and Vinneuf (Gouédo 1994).

In parallel to these new trends in the core technologies, bifaces persist throughout the EMP and into the late Middle Paleolithic, but in another form. In south-western France, the MTA industries record shaping processes as part of the Neanderthal techno-cultural equipment during the late Middle Paleolithic (MIS 4-3), although their features are not comparable to the Acheulian bifaces (Soressi 2002, 2004; Ruebens 2013, Brenet et al in press).

Even from this brief overview it is clear that it is extremely difficult to define a unique trend that can be valid at a large scale of analysis. Depending on the geographic scale of analysis and the choice of parameters used to describe the lithic industries, different scenarios can be created. The problems connected to the choice of the scale of analysis for the comprehension of material culture in prehistory has been underlined by several authors (see for example Koehler 2011; Chevrier and Koehler 2013).

Using as a primary technological parameter the distinction between shaping and flaking processes in assemblages during the EMP, we may recognize two variants: (1) industries only due to flaking technologies, and (2) industries where biface and flaking reduction systems co-exist in various proportions.

At the European continental scale these two categories are ubiquitous and are not linked to a specific geographic area. On the other hand, if we reduce our scale of analysis by taking into account more of the specificities of the reduction systems, it is possible to distinguish macro-areas, such as in the case of northern European blade production.

Over the last few years, new approaches in lithic studies, well-defined chronologies and new sites discovered have helped us with the recognition of specific technological features. Recently some authors have proposed to trace the onset of some regional differentiation in the technological behavioural changes starting from the Lower Palaeolithic (Rocca 2013; Aureli et al 2016; Baena et al. in press).

This complex scenario has generated widespread debates on the definition of the chronological limits between the Lower and the Middle Paleolithic as well as on the definition of the relevant archaeological data to be considered to be the marker of these behavioural changes (Monnier 2006, Moncel et al., 2011, 2012; Monnier & Missal 2014, Mathias in press, Richter 2011, in press).

If the evidence of technological variability during the Middle Palaeolihic is now commonly accepted the causes at the origin of this variability are still discussed.

This question, which originated in the transatlantic debate between Binford (1966, 1973) and Bordes (1961, 1970), has continued and is still one of the central topics in the understanding of material culture. Different explanations of the possible causes of technological variability have been proposed in the last decades: climatic change, raw material economy, subsistence strategy, demography, or mobility patterns.

To reduce the impact of external factors, the analysis of technological features needs to be tested in a small geographic area with a common environmental context. Furthermore, to identify the specificity of the technological features of the human groups, we have to go further than a macro-technological subdivision (i.e Levallois-Non Levallois; Biface-Non-Biface) especially if applied on a large geographical scale.

For all these reasons, the main aim of this paper is to discuss the technological turnovers that affect the EMP through a detailed technological analysis applied on a small regional scale.

The assemblages of the Bau de l'Aubesier and Payre, located in South-Eastern France on opposite sides of the Rhône corridor, are considered through a detailed comparative technological analysis. The choice of these two sites is motivated by geographical and chronological parameters:

(1) The two sites yielded layers dated to the MIS 8 and MIS 7, a crucial period of time for understanding the technological changes to the EMP in Western Europe; (2) secondarily they are located within the same region and in similar environments.

A basic question guides our analysis: Does technological variability on a regional scale exist in the EMP and if so, is it due to external factors and constraints, or is it evidence of diversification of the techno-cultural traditions of human groups as early as the EMP?

Figure 1. Location of the Bau de l'Aubesier and Payre and of the main sites cited in this paper.

2 Materials and methods

2.1 The sites of Payre and the Bau de l'Aubesier

2.1.1 Payre: Located in the Rhône Valley (South-Eastern France) (Fig 1), Payre is a small cave above the confluence of the Rhône and Payre Rivers at the intersection of various biotopes (Moncel et al. 2002, 2008; Daujeard and Moncel 2010; Moncel and Daujeard 2012; Moncel et al., 2014). The 5m thick stratigraphic sequence yielded 8 occupation layers in 4 phases (units). The basal units G and F that we investigate here are dated from MIS 8-7, roughly 250,000 to 200,000 years before present (Grün et al. 2008; Valladas et al. 2008). They are sub-divided into several levels including levels Ga, Gb and levels Fa, Fb, Fc, Fd. Unit G is composed of 6 lenses or sedimentological sub-layers. Level Ga is a dense concentration of artefacts related to lenses G4 and G5, 50 to 65 cm thick and composed of many small blocks. Unit F is composed of 7 lenses or sedimentological sub-layers. Level Fb is strictly related to the grey lens F3, 15-20 cm thick and free of limestone blocks. Unit G was excavated over 50 m^2 and unit F over 20 m^2. The lithic material found in units G and F is attributed to the Early Middle Paleolithic, with a discoidal and orthogonal core technology on flint and mainly scrapers and points (Baena et al. in press). Some heavy-duty tools, as well as bifaces and pebble tools, were made *in situ* or outside the site on local quartzite, limestone and basalt (Moncel et al. 2008). New evidence of use wear analysis on quartzite has been recently published (Pedergnana et al. 2016).

2.1.2 The Bau de l'Aubesier: The Bau de l'Aubesier is a large rock shelter located in the gorges of the Nesque river, Vaucluse (South-Eastern France) (Fig 1). The site, known since the beginning of the 20th century (Moulin 1903, 1904), was extensively excavated from 1987 to 2000 by an international team led by Serge Lebel, then of the Université du Québec à Montréal, Canada (Lebel 2000 a, b). The deposits in the site are complex, both laterally and vertically, and include more than 60 different sedimentological layers and lenses over a total thickness of more than 13 metres. The deposits also include at least a dozen archaeological levels, divided into more than 30 sub-layers, according to sedimentological, archaeological, or arbitrary depth criteria (Fig 2). Based on radiometric, faunal and stratigraphic results, it appears that the entirety of the deposits dates to between roughly 100,000 (or less) and 250,000 years ago (Blackwell et al., 2001; Lebel et al., 2001; Fernandez, 2006). The lower part of the site has been attributed to the later Middle Pleistocene, and the upper part to the Late Pleistocene (Trinkaus et al., 2000; Lebel and Trinkaus, 2002).

This present study concerns the lowest archaeological layers, J and K, which were divided during the excavation into J, J1, J2, J3 and J4, and K, K1 and K2 respectively. The lowest level, K2, is a layer of fine sediments with some larger rocks, probably reflecting accumulation during a temperate and relatively warm phase during MIS 7. This was followed by cooler phases during which more cryoclastic debris fell from the roof and walls of the rock shelter. During this time period, archaeological layers K1 through J also accumulated. These were later washed, reworked and eroded, forming a shallow basin or gully which later layers filled in and covered over. The total thickness of this phase of the deposits amounts to approximately 120 cm. There are very few traces of fire: only about 3% of remains in layer J and 5% of remains in layer K show any trace of having been burned, and there are no hearths or concentrations of burned material. The densest archaeological accumulations are in layers J4 and K2 (Fig. 2). One hominin tooth (an incisor) was found in layer J and has been described as pre-Neandertal, archaic Homo (79 Trinkaus et al., 2000). All together, layers J and K provided both lithic (almost entirely flint) and faunal remains attesting to significant use of the site by early Middle Palaeolithic hominins.

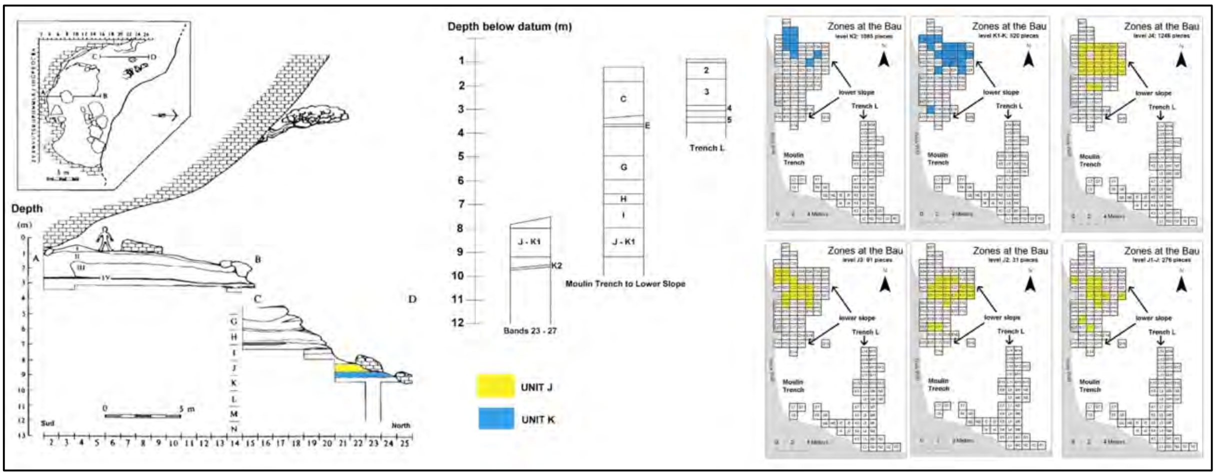

Figure 2. Simplified stratigraphy of the Bau de l'Aubesier: Drawings on the left after Lebel (2000a, Figure 9, p.22). On the left and in the center: simplified stratigraphy. In colour (yellow and blue), Units J and K. On the right the plan distribution of the lithic collection for each sub-unit considered in this study.

2.2 Methods

The comparison between the lithic collections uses both qualitative and quantitative parameters, describing the entire assemblages through an extensive technological analysis. A preliminary sorting procedure has been done dividing the lithic collection in two wide categories: undetermined and determined pieces. We classified as determined pieces all the removals that can be linked to a specif reduction strategies (e.g. Levallois, Discoid) or to a method (e.g. unidirectional, centripetal). Deeply patinated pieces or pieces with disorganized scars which did not allow us to associate them to a specific reduction strategy or method were classified as undetermined pieces.

The qualitative analysis follows the general principles of the *chaîne opératoire*, based on the identification of the distinct phases of the process (Cresswell 1983, Pelegrin et al. 1988, Perlès 1991, Geneste 1991a, b). Reconstitution of the *chaîne operatoire* is based on the identification of the percussion technique, methods and concepts that underlie the reduction processes (Pelegrin 2005; Boeda et al 1990). The percussion techniques were identified according to the criteria derived from experimental studies by Pelegrin (1991, 2000). Diacritical analysis was applied to cores and blanks in order to identify the chronological order of the scars distinguishing the preparation phases from the main production phases (Dauvois 1976, Inizan et al. 1995).

Due to the scarcity of refitting in the collections, the reduction sequences are described using the mental refitting method proposed by Pelegrin (1995).

The small number of cores in the assemblages did not allow us to quantify them in terms of ratio. A synthetic quantification of the technological systems through the sequence has been done by creating four groups based on the number of cores present in each layer: absent (0), rare (1-2); present (3-5); abundant (>5).

Identification of the Levallois concept follows the guidelines set out by Boëda (1994). In terms of Discoid production, we used the definition of Boëda (1993, 1991), and also took into account broader criteria (Peresani 1998, Slimak 2003).

Definition and characterization of the production techniques was preceded by a personal analytical approach which takes into account five technical parameters: the volumetric concept used, the striking platform organisation, the direction and the organization of the removals and the angle between the débitage surface and the striking platform.

The combination of these parameters allows us to preliminarily describe and identify the characteristics of the technological systems (Fig 3). Supporting Information for the terminology used in this work is provided in Supplementary File S1.

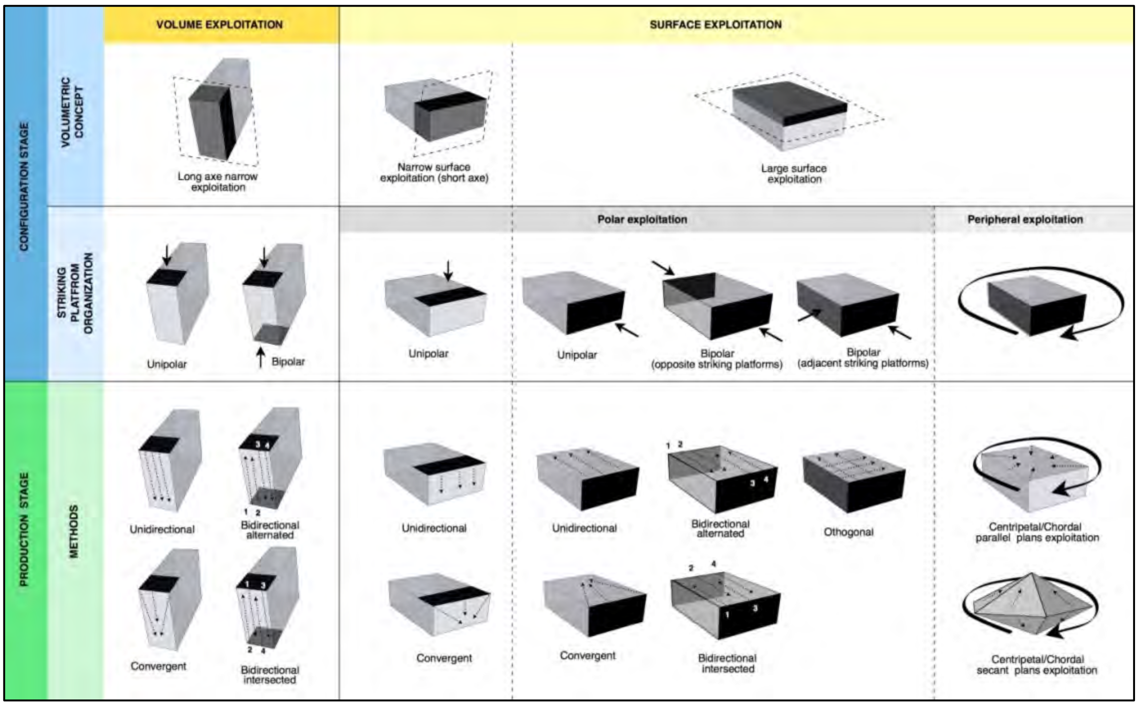

Figure 3. Schematic model of the reduction systems and the terminology used in this paper.

2.3 Composition of the lithic material assemblages

2.3.1 Payre: Units G and F yielded 8275 pieces including flakes, cores, pebbles and debris. The main density of pieces is in the sublevels Ga and Fa (Table 1). Small debris (<20mm) are in general abundant and attest to an intense flaking activity *in situ*. Undetermined flakes are also a significant part of the collection (Table 1). The ratio of undetermined flakes larger than 20 mm ranges from 23 % in sub-level Fc to 57.9 % for sub-level Gb. Determined flake ratios range from 20.4% in sub-level Gb to 2.4% in sub-level Fb. Cores are present in all of the sub levels, ranging from 3.1% of the assemblage in sub-level Gb to 0.2% in sub-level Fb.
Raw materials for flaking are largely dominated by a good quality flint (between 84% and 92%), with quartz or basalt secondary (Table 2). A small quantity of quartzite and limestone was used as well. The raw materials were collected in the form of cobbles, small nodules and flakes.

Table 1. Payre: Composition of the lithic assemblages of units G and F.

Assemblage composition	Gb		Ga		Fd		Fc		Fb		Fa		Total
	n	%	n	%	n	%	n	%	n	%	n	%	n
Undetermined Flakes<20mm	122	*20.1*	1253	*38,2*	284	*51.7*	330	*62.7*	*577*	*71.4*	1477	*59*	*4043*
Undetermined Flakes>20mm	352	*57.9*	1176	*35,8*	142	*25.9*	121	*23*	*203*	*25.1*	667	*26.7*	*2661*
Determined flakes	89	*14.6*	669	*20,4*	98	*17.9*	44	*8.4*	*19*	*2.4*	229	*9.2*	*1148*
Cores	19	*3.1*	47	*1.4*	17	*3.1*	9	*1.7*	*2*	*0.2*	44	*1.8*	*138*
Entire Pebbles	16	*2.6*	88	*2.7*	5	*0.9*	11	*2.1*	*6*	*0.7*	63	*2.5*	*189*
Broken Pebbles	8	*1.3*	49	*1.5*	3	*0.5*	11	*2.1*	*1*	*0.1*	21	*0.8*	*93*
Handaxes	2	*0.3*	-	*0*	-	*0*	-	*0*	-	*0*	1	*0.04*	*3*
Total	608	*100*	3282	*100*	549	*100*	526	*100*	*808*	*100*	2502	*100*	*8275*

Table 2. Payre: Raw material distribution in units G and F.

		Flakes<20mm	Flakes>20mm	Cores	Pebbles (Entire/Broken)	Handaxe	Total (n.)	Total (%)
Fa	Flint	1375	693(269)	40	-	-	2108	*84.3*
	Basalt	7	25	-	72(7)	-	104	*4.2*
	Quartz	91	121(10)	1	1	-	214	*8.6*
	Limestone	4	31	2	5(1)	-	42	*1.7*
	Quartzite	-	26(6)	1	6(6)	1	34	*1.4*
	Total	**1477**	**896**	**44**	**84**	**1**	**2502**	***100***
Fb	Flint	549	176(58)	2	-	-	727	90
	Basalt	8	17	-	7(1)	-	32	4
	Quartz	17	23(1)	-	-	-	40	5
	Limestone	-	2	-	-	-	2	*0.2*
	Quartzite	3	4	-	-	-	7	*0.9*
	Total	**577**	**222**	**2**	**7**	-	**808**	***100***
Fc	Flint	298	117(50)	9	-	-	424	*80.6*
	Basalt	6	15	-	18(2)	-	39	*7.4*
	Quartz	26	28(1)	-	1	-	55	*10.5*
	Limestone	-	4	-	2(1)	-	6	*1.1*
	Quartzite	-	1	-	1	-	2	*0.4*
	Total	**330**	**165**	**9**	**22**	-	**526**	***100***
Fd	Flint	271(1)	213(44)	17	-	-	501	*91.3*
	Basalt	3	9	-	8(2)	-	20	*3.6*
	Quartz	10	16	-	-	-	26	*4.7*
	Limestone	-	-	-	-	-	-	*0*
	Quartzite	-	2(1)	-	-	-	2	*0.4*
	Total	**284**	**240**	**17**	**8**	-	**549**	***100***
Ga	Flint	1253(4)	1482(515)	41	2	-	2778	*84.6*
	Basalt	-	173(3)	-	125(38)	-	301	*9.2*
	Quartz	-	132(21)	6	2	-	140	*4.3*
	Limestone	-	11(2)	-	4	-	15	*0.5*
	Quartzite	-	44(15)	-	4(3)	-	48	*1.5*
	Total	**1253**	**1845**	**47**	**137**	-	**3282**	***100***
Gb	Flint	120	422(83)	19	-	2	563	*92.6*
	Basalt	-	2	-	23(7)	-	25	*4.1*
	Quartz	-	13	-	-	-	13	*2.1*
	Limestone	-	1	-	1	-	2	*0.3*
	Quartzite	2	3	-	-	-	5	*0.8*
	Total	**122**	**441**	**19**	**24**	**2**	**608**	***100.0***

2.3.2 Bau de l'Aubesier: Units K and J yielded 3249 lithic pieces, including cores, flakes and debris. Lithic pieces were mostly concentrated in the sub-levels K2 and J4. Debris <20 cm (undetermined flakes and fragments) are the main part of the collection, residues of an intense flaking activity *in situ*. Determined flakes are more abundant than at Payre with a frequency ranging from 30.1% in the sub level J-J1 to 7.7% in K2 (Table 3). Cores are rare, between 0.8% in sub-level K-K1 and 4.4% in sub-level J3. A high ratio of cores (16.1%) characterizes the sub-level J2, but this has a total assemblage of only 31 lithic items (Table 3).

Flint was used almost exclusively in these levels: the only non-flint piece is a quartzite flake fragment from level J4. A large proportion of these pieces is heavily patinated, and can be identified only as flint. Combined with a very small proportion of flint types of unknown provenance, this means that all together 43.2% of the pieces in levels J-J4 are flint from unknown/unidentifiable sources, as are 51.7% of the pieces from levels K-K2. The sources of the remaining pieces have been identified, and (as will be discussed more fully below) are located within 15 km of the site, along an axis extending towards both the south-west and the north-east.

Table 3. Bau de l'Aubesier: composition of the lithic assemblages from the lowest part of the sequence.

Assemblage composition	K2		K-K1		J4		J3		J2		J-J1		Total
	n	%	n	%	n	%	n	%	n	%	n	%	n
Undetermined fragment<20	670	*61.8*	283	*54.4*	700	*56.2*	28	*30.8*	3	*9.7*	103	*37.3*	1787
Undetermined fragment>20	65	*6*	72	*13.8*	191	*15.3*	25	*27.5*	4	*12.9*	55	*19.9*	412
Undetermined flakes<20	180	*16.6*	42	*8.1*	97	*7.8*	1	*1.1*	5	*16.1*	19	*6.9*	344
Undetermined flakes>20	42	*3.9*	23	*4.4*	51	*4.1*	3	*3.3*	6	*19.4*	10	*3.6*	135
Determined flakes	84	*7.7*	107	*20.6*	185	*14.8*	30	*33*	8	*25.8*	83	*30.1*	514
Cores	13	*1.2*	4	*0.8*	22	*1.8*	4	*4.4*	5	*16.1*	8	*2.9*	57
Total	1085	*100*	520	*100*	1246	*100*	91	*100*	31	*100*	276	*100*	3249

3 Results

3.1 Reduction sequences and the aims of production at Payre

Knapping processes dominate in Units G and F. Shaping processes provide rare bifaces and pebble tools (Table 4). Different schemes of débitage, aimed at producing different types of end-products, have been recognized based on the analysis of the cores and determined blanks (Tables 4 and 5).

The core technologies are predominantly based on the exploitation of the large surfaces of the volume of the support. Depending on the organization and location of the striking platforms, the flaking follows either a peripheral or a polar management. A marginal volumetric exploitation was used to produce bladelets (Table 4).

Centripetal flakes are the most numerous recurrent products in the layers, varying from 46.2% in sub-level Fb to 21.2% in sub-level Fc (Table 5). The second most common category is unipolar flakes. Minor percentages are represented by bipolar, orthogonal, convergent and Kombewa flakes (Table 5).

Table 4 – Payre, numbers of the core types throughout the sequence.

Systems structure	Cores techno-type	Gb	Ga	Fd	Fc	Fb	Fa	Tot. Num.	Tot. %
Peripheral	**Secant plans cores "Discoid"**	1	2	-	3	-	8	14	10.1
	Secant plans cores "Partial exploitation"	7	9	1	2	-	4	23	16.7
	Secant plans "Trifacial cores"	3	5	-	-	-	-	8	5.8
	Parallels plans exploitation	-	10	2	2	-	8	22	15.9
Polar	**Unidirectional parallel plans**	-	3	2	-	-	4	9	6.5
	Unidirectional "short axe exploitation"	2	4	-	-	-	2	8	5.8
	Multidirectional (SSDA type)	3	5	1	2	-	6	17	12.3
	Bidirectional parallel plans	-	-	-	-	-	1	1	0.7
	Orthogonal parallel plans	-	-	1	-	-	-	1	0.7
	Convergent parallel plans	-	1	-	-	-	-	1	0.7
Volumetric	**Bladelet cores**	-	-	2	-	-	2	4	2.9
	Bipolar percussion core	-	1	-	-	-	-	1	0.7
	Large flakes cores	1	1	1	-	-	3	6	4.3
	Undetermined cores fragments	2	6	7	-	2	6	23	16.7
	TOTAL	19	47	17	9	2	44	138	100

Table 5 – Payre.: determined pieces. Numbers in brackets indicate retouched pieces

Techno-types	Gb		Ga		Fd		Fc		Fb		Fa	
	num	%	num	%	num	%	num	%	num	%	num	%
Centripetal flakes	37 (5)	*32.5*	337 (83)	*41.8*	33 (4)	*31.1*	14 (4)	*21.2*	12(2)	*46.2*	83(22)	*26.4*
Debordant flakes (chordal)	16 (5)	*14*	135 (48)	*16.7*	12 (1)	*11.3*	3	*4.5*	-	*0*	37 (4)	*11.8*
Pseudolevallois	-	*0*	1	*0.1*	1	*0.9*	1	*1.5*	1	*3.8*	3	*1*
Unipolar flakes	10 (1)	*8.8*	24 (3)	*3*	13	*12.3*	3 (1)	*4.5*	3	*11.5*	26 (8)	*8.3*
Debordant unipolar flakes	2	*1.8*	5 (1)	*0.6*	4	*3.8*	-	*0*	-	*0*	1 (1)	*0.3*
Bipolar flakes	1	*0.9*	2	*0.2*	-	*0*	2	*3*	-	*0*	-	*0*
Debordant bipolar flakes	-	*0*	1	*0.1*	-	*0*	2	*3*	-	*0*	-	*0*
Orthogonal flakes	1	*0.9*	5 (3)	*0.6*	-	*0*	2	*3*	-	*0*	-	*0*
Convergent/sub-convergent flakes	2 (1)	*1.8*	10	*1.2*	-	*0*	-	*0*	-	*0*	-	*0*
Bladelets	-	*0*	-	*0*	3	*2.8*	-	*0*	-	*0*	-	*0*
Blades	-	*0*	-	*0*	7	*6.6*	-	*0*	-	*0*	-	*0*
Kombewa	3	*2.6*	27 (5)	*3.3*	1	*0.9*	1 (1)	*1.5*	1	*3.8*	19 (1)	*6.1*
Kombewa debordant	1 (1)	*0.9*	4 (2)	*0.5*	-	*0*	-	*0*	-	*0*	3	*1*
Quina	3	*2.6*	10	*1.2*	-	*0*	-	*0*	-	*0*	2	*0.6*
Demi Quina	2	*1.8*	17	*2.1*	1	*0.9*	-	*0*	-	*0*	6	*1.9*
Wide flake (Demi Quina retouch)	1	*0.9*	1	*0.1*	14	*13.2*	-	*0*	-	*0*	2	*0.6*
Wide flakes	-	*0*	21 (7)	*2.6*	3 (1)	*2.8*	6 (3)	*9.1*	1	*3.8*	29 (9)	*9.2*
Bifaces	2	*1.8*	-	*0*	-	*0*	-	*0*	-	*0*	1	*0.3*
Macro-tools	1	*0.9*	4	*0.5*	1	*0.9*	-	*0*	-	*0*	5	*1.6*
Entire Pebble	16	*14*	88(41)	*10.9*	5(2)	*4.7*	11(3)	*16.7*	6(1)	*23.1*	63(14)	*20.1*
Broken Pebble	8	*7*	49	*6.1*	3	*2.8*	11	*16.7*	1	*3.8*	21	*6.7*
Striking platform flakes	2 (1)	*1.8*	1	*0.1*	-	*0*	7	*10.6*	-	*0*	2	*0.6*
Shaping/retouching flakes	4	*3.5*	43	*5.3*	1	*0.9*	3	*4.5*	-	*0*	10	*3.2*
Rejuvenation flakes	1	*0.9*	21 (14)	*2.6*	-	*0*	-	*0*	-	*0*	-	*0*
Crested flakes	1	*0.9*	-	*0*	4	*3.8*	-	*0*	1	*3.8*	1	*0.3*
Total	114	*100*	806	*100*	106	*100*	66	*100*	26	*100*	314	*100*

3.1.1 Pheripheral exploitation: The technological parameters of the flakes fit well with the analyses of the cores. The peripheral exploitation of the core is the main flaking process used at Payre, with an overall proportion of 48.6 % (Table 4). In this group are included cores with management of the periphery of the volume by centripetal and/or chordal removals. Based on the detachment angle of the removals, two different cases have been identified; a peripheral secant plans exploitation system and a peripheral parallel plans exploitation system (Fig 4).

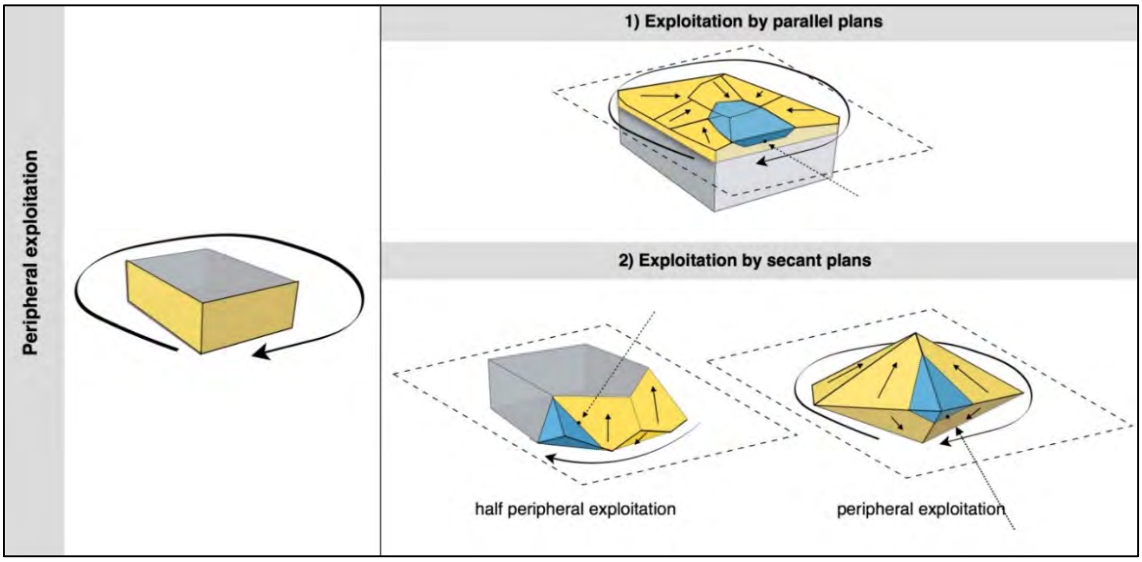

Figure 4. Model of peripheral plan exploitation: On the top right exploitation by parallel plans. On the bottom right the two variants of exploitation by secant plans.

In the secant plan exploitation systems the débitage starts without preparation, by a series of secant removals on the two opposite surfaces. The direction of the removal is alternatively centripetal and chordal. Each removal participates in maintaining the convexity and creates a new striking platform for the following removals. In relation to the mode of exploitation, two sub-types have been identified. In the first one, the removals of the platforms are around the core's entire periphery (Fig 5, n. 3, 4). This system can be fully ascribed at the classical Discoid systems. In the second modality, the removals are limited to one side of the core periphery, leaving the other part of the volume unexploited (Fig 5, n. 1, 2).

These two variants are present in both units G and F but in different amounts. Cores with a complete peripheral exploitation (Discoid) increase in abundance in unit F and especially in sub-level Fa (Table 4). Conversely, partial secant exploitation is more frequent in unit G (Table 4).

The sub-levels Ga and Gb differ from unit F by having produced 8 cores with a triangular cross-section, here called "Trifacial cores" (Fig 6). The flaking starts with a first series of secant removals without preparation. The second and the third series of removals repeat the same sequence on the two adjacent surfaces using the scars of the first series of removals as a striking platform. The sequence is repeated until the exhaustion of the core.

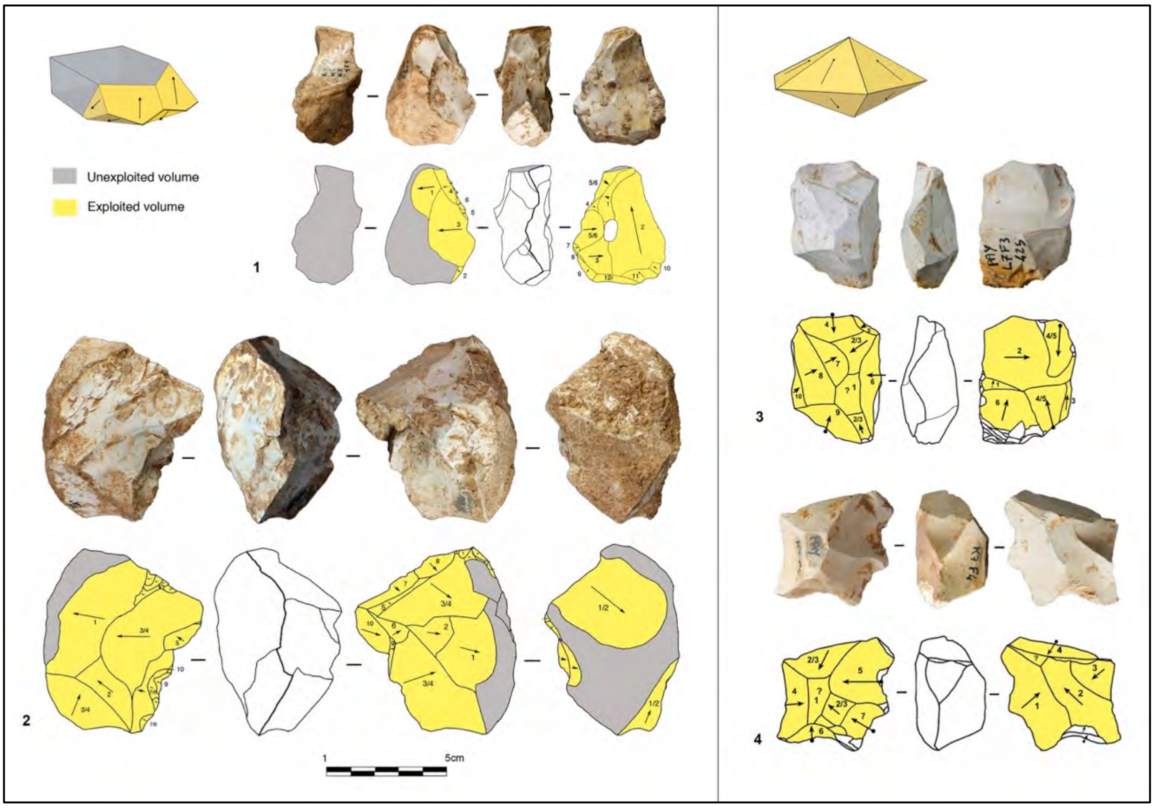

Figure 5. Payre. Peripheral secant plans cores: Cores of partial peripheral secant plans exploitation from sub-unit Gb (1, 2). Cores of complete peripheral secant plans exploitation from sub unit Fa (Discoidal) (3,4).

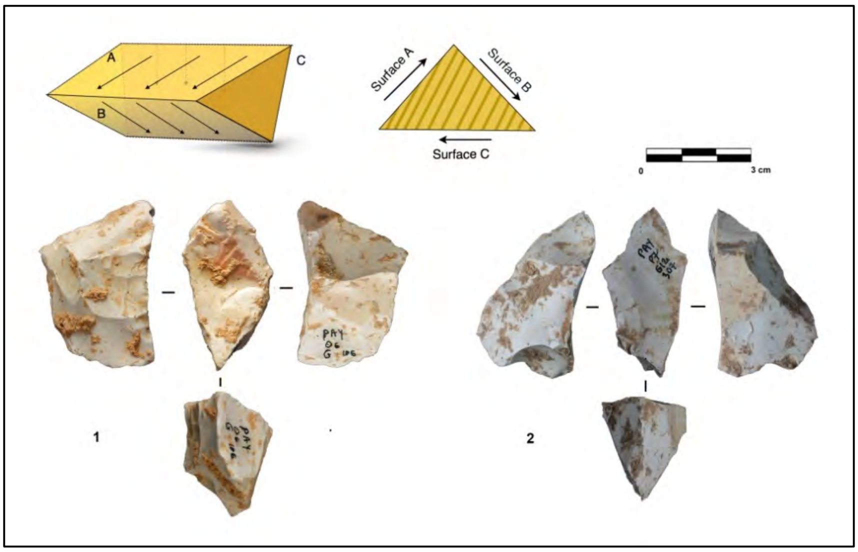

Figure 6. Payre. Trifacial cores: Trifacial secant plans exploitation cores from sub-levels Ga (n. 1) and Gb (n.2).

Twenty-two cores show a different exploitaion. Centripetal and chordal removals are strucked from the platforms around the core's entire periphery but the flaking surface is managed by parallel plans (Fig 7). These cores show some common features to the definition of Levallois proposed by Boëda (1993, 1994). They present asymmetrical convex surfaces (plane of intersection). However, we do not include them in the category of Levallois cores because they lack specific features that characterize this volumetric concept. These cores do not show any scars that would indicate a clear separation between the configuration phase of the débitage surface and the main production phase. The striking platforms are minimally prepared. A single centripetal series is obtained on the surface without evidence of preparation of the lateral and distal convexities (Fig 7). The flaking surface after a short series of centripetal removals is quickly abandoned. No rejuvenation flakes, suggesting a reconfiguration of the core, have been found. These kinds of cores are well represented in both units G (n = 10) and F (n = 12) (Table 4).

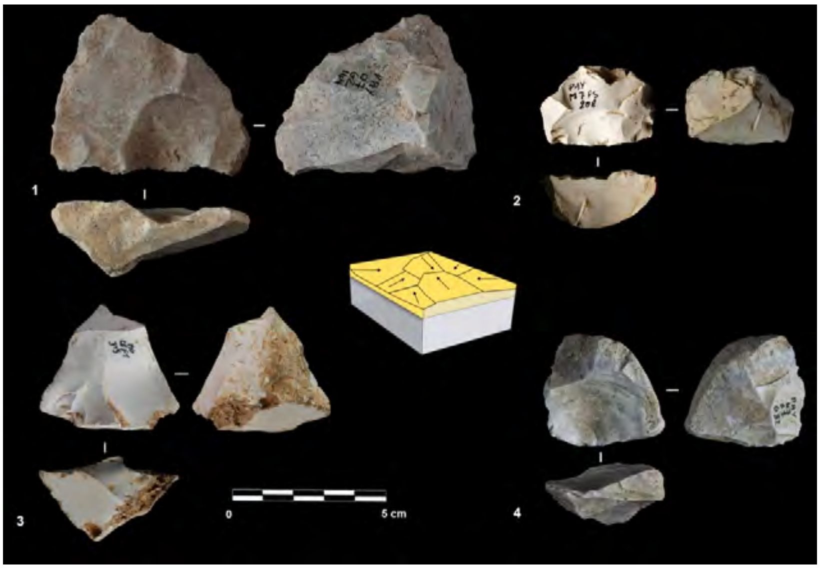

Figure 7. Payre. Peripheral parallel plans cores: Core with a peripheral parallel plans exploitation from sub-levels Ga (n. 1 and 2), Fb (n.3) and Fd (n. 4).

Product derived by peripheral exploitation show different features in function of the procedure applied (i.e. parallel and secant plan exploitation). For distinguishing products coming from peripheral secant exploitation and peripheral parallel exploitation, we take into account the angular degree of the dorsal scars and the angular degree between the platform and the ventral surface of the blanks.

The secant exploitation produces blanks with an inclined platform and the dorsal surface is characterised by secant centripetal scars (Fig 8). These flakes are short and thick with a robust cutting edge between about 40° and 60°. Centripetal and chordal directions of flaking produce respectively flakes with a peripheral cutting edge (type A1), and debordant flakes (type A2) (Fig 8).

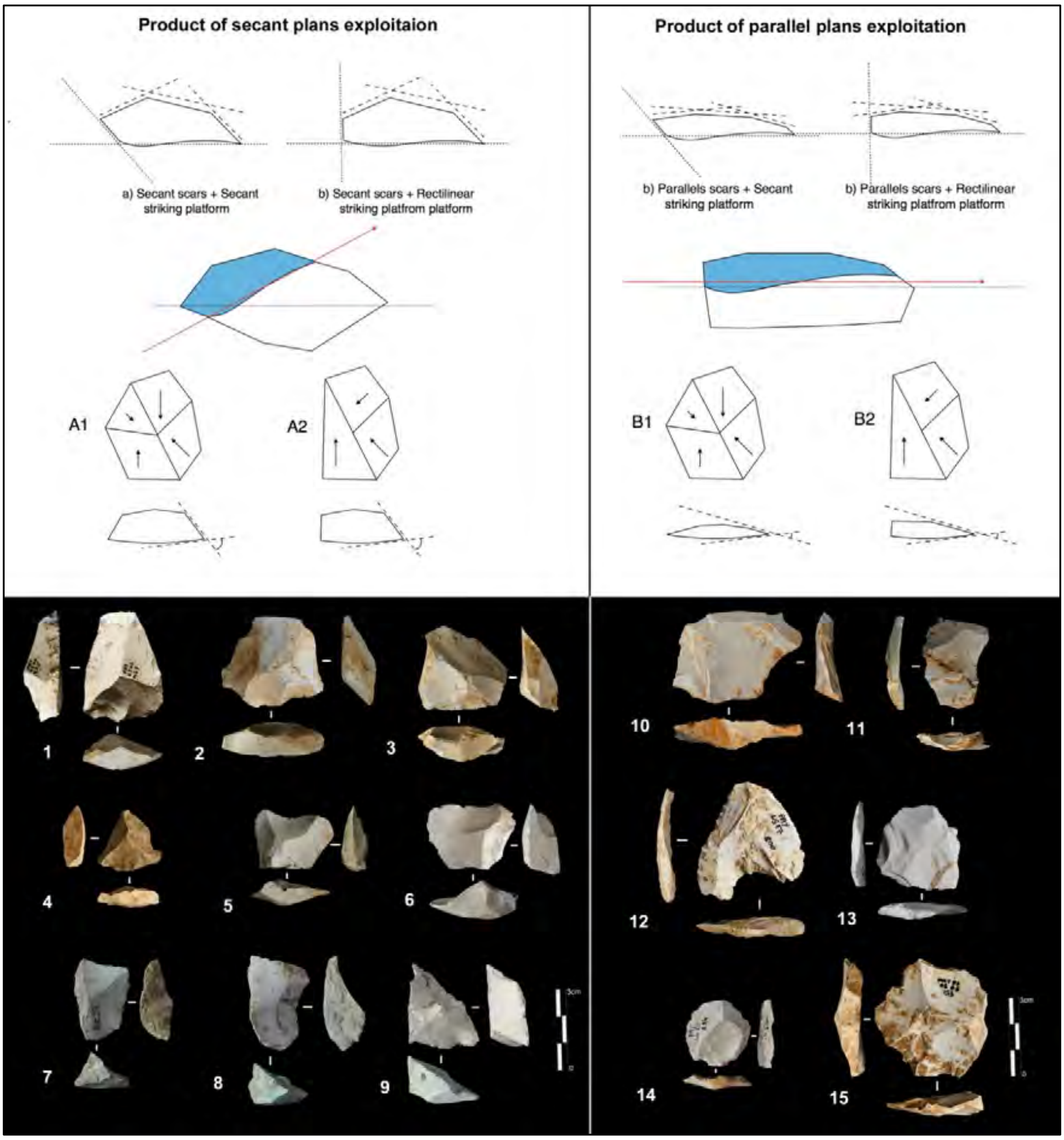

Figure 8. Payre. Peripheral exploitation blanks: On the top, sketch of products from a secant plan exploitation (top left) and from a parallel plan exploitation (top right). On the bottom left, blanks of secant plans exploitation: centripetal flakes (type A1) from sub-units Ga (n. 1 to 4), Fd (n. 5), and Fa (n. 6); debordant flakes (type A2) from sub-units Ga (n. 7 to 9). On the bottom right, products of parallel plans exploitation: centripetal flakes (type B1) from sub-units Ga (n. 10 to 13) and Fa (n.14); debordant flakes (type B2) from sub-unit Ga.

These products are diverse in shape. The cutting edge can be polygonal, sub-circular or convergent. Flakes with a convergent cutting edge are numerous in both units G and F (Chacon et al. 2016; Moncel et al 2009). Analysis of the dorsal scars rarely shows a convergent method. This data is confirmed by the cores. Just one core in sub-level Ga shows this type of method. Diacritical analysis of the dorsal scars of these convergent pieces shows that they are closer to a peripheral secant plans exploitation technique (Fig 6 n. 4, 9).

Products coming from parallel plans exploitation (Types B1 and B2) (Fig 8) differ greatly from those coming from the previous one. They are close to the typical Levallois flakes (Fig 8 n. 10 to 15). The platform is generally flat, but in some cases is carefuly prepared. The angle between the ventral surface and the platform of the flakes is between 95° and 115°. Scars on the dorsal surface are parallel or sub-parallel. Compared with the A1 and A2 flake types, B1 and B2 flake types are thinner, with a cutting edge of about 15° to 40 °.

Flakes with secant dorsal scars (Type A) are present in all of the sub-levels except Fd, (see Table A in Supplementary File S2). Among the flakes with secant dorsal scars (Type A), the majority are associated with an inclined platform, due to the secant plans exploitation. This is particularly clear in unit F where no rectilinear platform is related to flakes with secant scars (Table B in Supplementary File S2).

Six cores with secant plans were abandoned after a short series of removals. There is no evidence of preparation. Two of these cores come from unit G and three from unit F (Fig 9 n. 1 and 2). These cores can be related to large, wide flakes found in unit G (23 items) and unit F (55 items) with a flat or a cortical platform (Fig 9 n. 3 to 7).

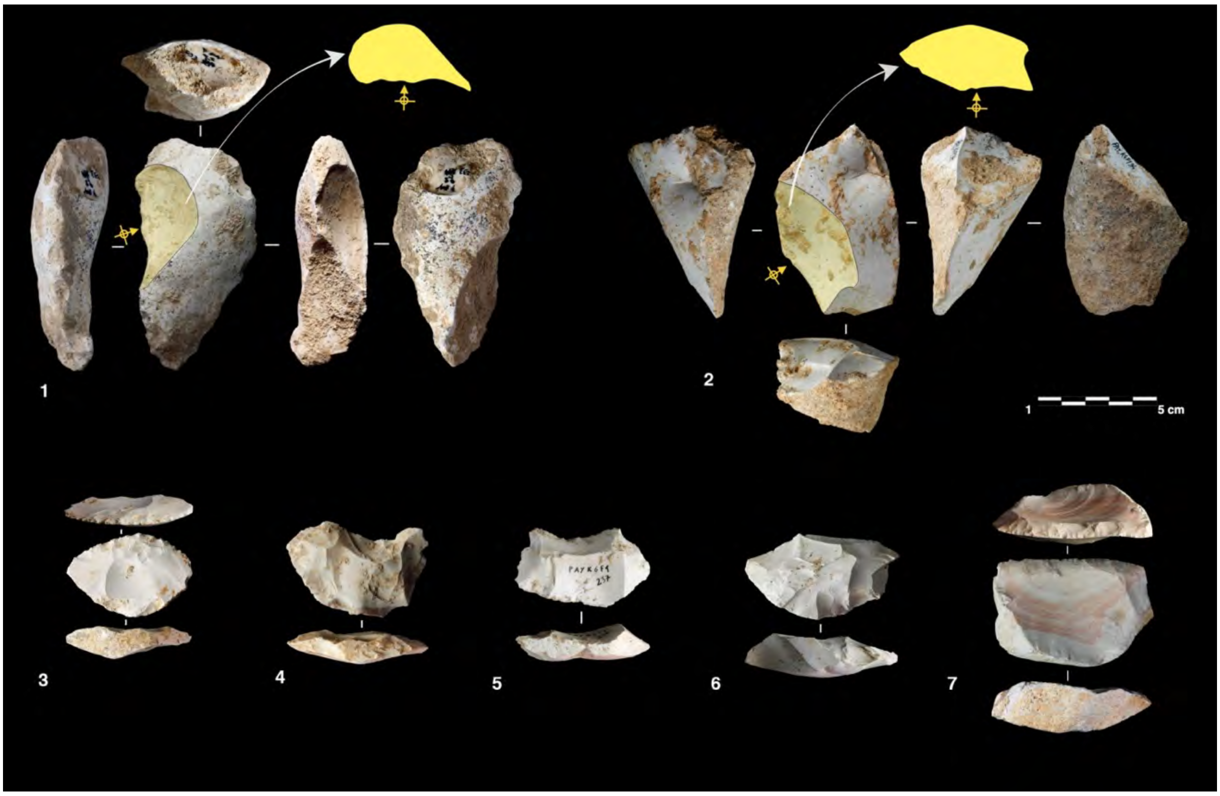

Figure 9. Payre. Wide flakes production: Large flakes cores (n.1, 2). Retouched wide flakes (n. 3 and 7). Unretouched wide flakes (n. 4 to 6).

3.1.2 Polar exploitation: This system is based on the exploitation of a surface with one or more striking platforms located on one or several sides of the cores. There are 56 such cores in unit F and 18 in unit G (Table 4). Based on the location of the striking platforms on the core, two different types are distinguished. The first modality is an exploitation of the narrowest surface of the core, while in the second the exploitation is applied to the largest surface of the core (Fig. 10).

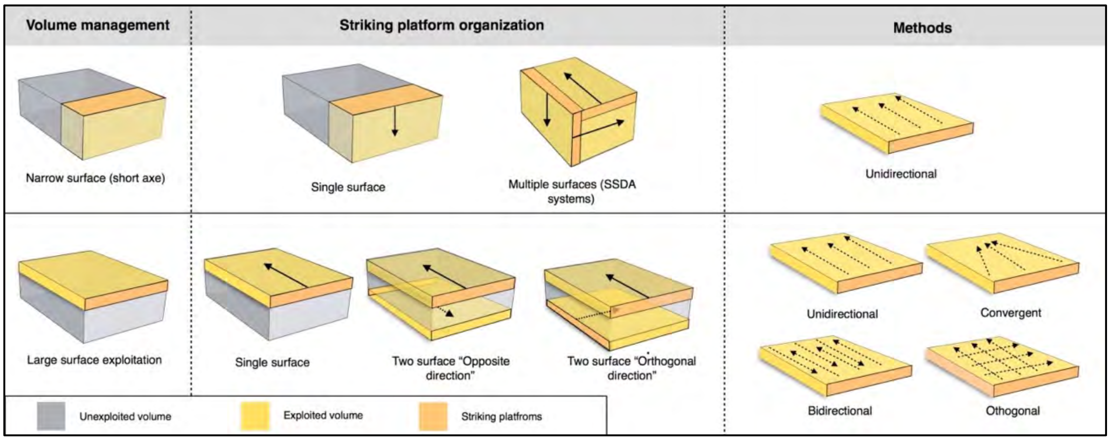

Fig 10. Payre. Polar exploitation variability: Model of the polar exploitation variability at Payre

The cores managed on the narrowest surface show only unidirectional removals. Six of these cores were found in unit G and two in unit F (Table 4).

The removals are directly struck on the core without preparation of the lateral and distal convexities. This does not allow a long exploitation of the surface. Several cores were quickly abandoned after a short series of removals, due to hinged fractures (Fig. 11 n. 1).

Repetition of a unidirectional series of removals on the same core can give various forms which can be interpreted erroneously as different reduction systems.

A group of 17 cores, 8 found in unit G and 8 in unit F, shown a multiple surfaces exploitation (Fig 11 n. 3). The final shape of these cores resembles the SSDA systems cores (Forestier 1993). In the case of Payre, these cores have to be described as an advanced phase of exploitation by unidirectional series managed on the same volume.

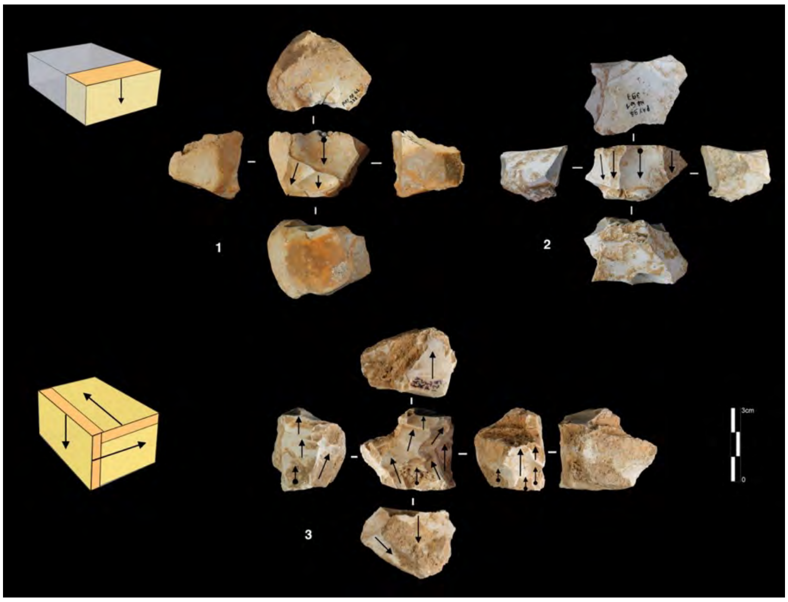

Fig 11. Payre: Unidirectional short axis cores.

The category of cores exploited on the large surface groups together various methods: unidirectional, bidirectional, convergent and orthogonal. The unidirectional method is the most frequent and is equally present in the two units (Table 4). Convergent, orthogonal and bipolar methods are less common. Selection of the appropriate volume allows for exploitation without the preparation of the lateral and distal convexity (Fig. 12 n. 2, 3). Just one core shows a partial preparation of the flaking surface (Fig 12 n.1). In this core débitage stopped due to hinged fractures and continued on the opposite surface with a second unidirectional series made in the opposite direction to the first (Fig. 12 n.1). In other cases, the second series of removals can be made in the same direction as the first one or orthogonally.

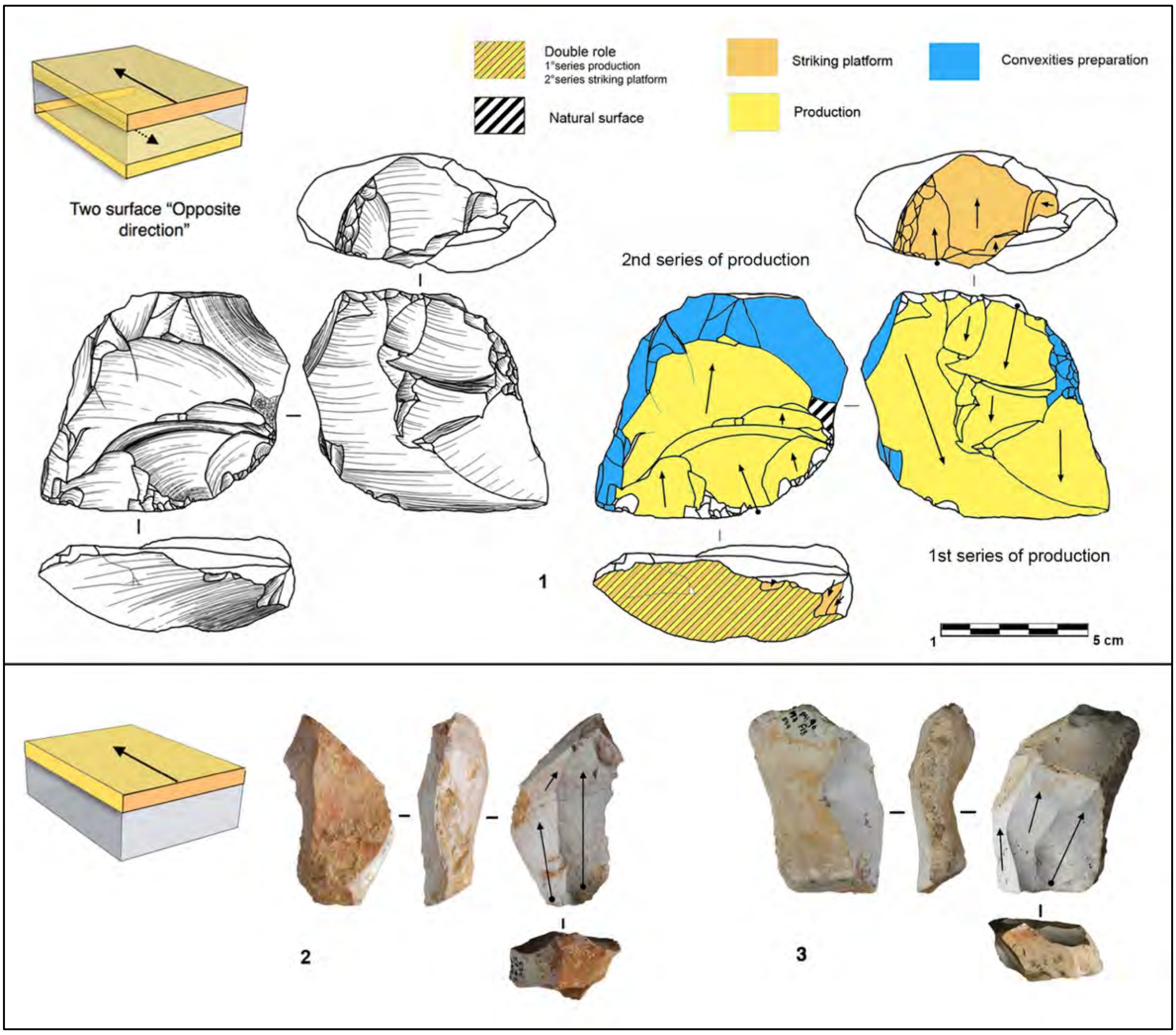

Fig 12. Payre: Unidirectional large surface cores.

The variability of end-products of polar exploitation is similar to what is observed in the cores. Unidirectional flakes are the most frequent, especially in sub-units Fa and Ga (Table 5). Triangular flakes coming from a convergent method are less frequent, and are more numerous in sub-levels Ga and Gb (Fig. 13, n. 8 to 10). Orthogonal and bipolar flakes are as rare as the cores.

Unidirectional methods produce quadrangular slightly elongated flakes with a peripheral cutting edge and debordant flakes (Fig. 13, n. 1 to 7). Products from unidirectional exploitation on the narrow surface and unidirectional exploitation on the large surface are similar.

Differences between the unidirectional flakes can however be detected in terms of the elongation. A group of unidirectional flakes shows a tendency to be more elongated and could be related to the exploitation of the largest surfaces (Fig. 13, n. 1 to 4). Conversely, the presence of short quadrangular flakes can correspond technologically to the exploitation of the shortest axis (Fig. 13, n. 5 to 7).

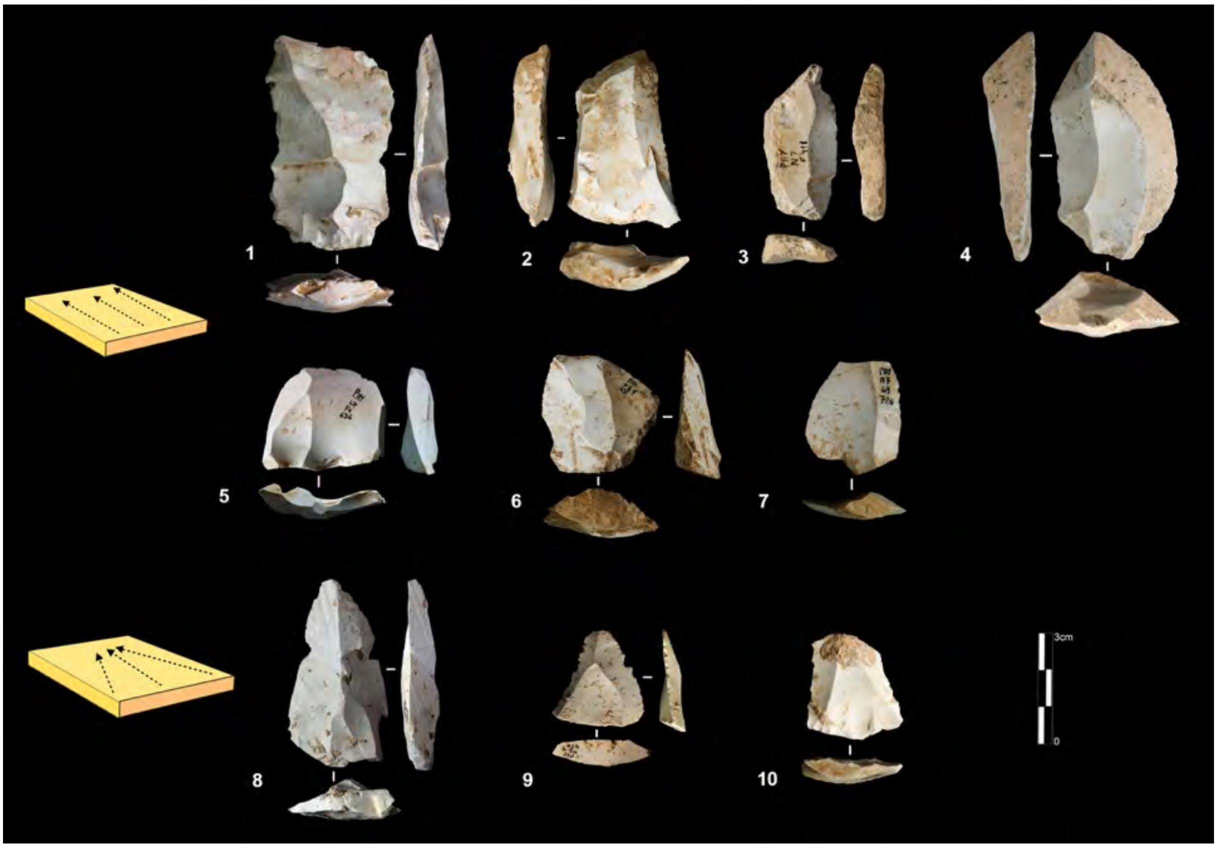

Fig 13. Payre: Elongeted unidirectional flakes from Unit F (n. 1 to 3) and Unit G (n.4); Unidirectional short flakes from Unit F (n. 7 to 9) and Unit G (n.10); Convergent flakes from Unit G (n. 8 to 10).

3.1.3 Volume exploitation Four small cores aimed at the production of bladelets were found in unit F (Table 4). There was minimal preparation of the cores. Partial preparation was made by rear lateral removals aimed at centering the flaking surface (Fig. 14). The striking platform was either left cortical or minimally prepared. Only 3 bladelets were found, in sub-level Fd. Despite the lack of these products, the scars on cores clearly indicate production of convergent/sub-convergent bladelets (Fig. 14). Export of the products outside of the site is possible, or the core may be a mobile piece since no products or by-products related to this reduction system have been observed in the series.

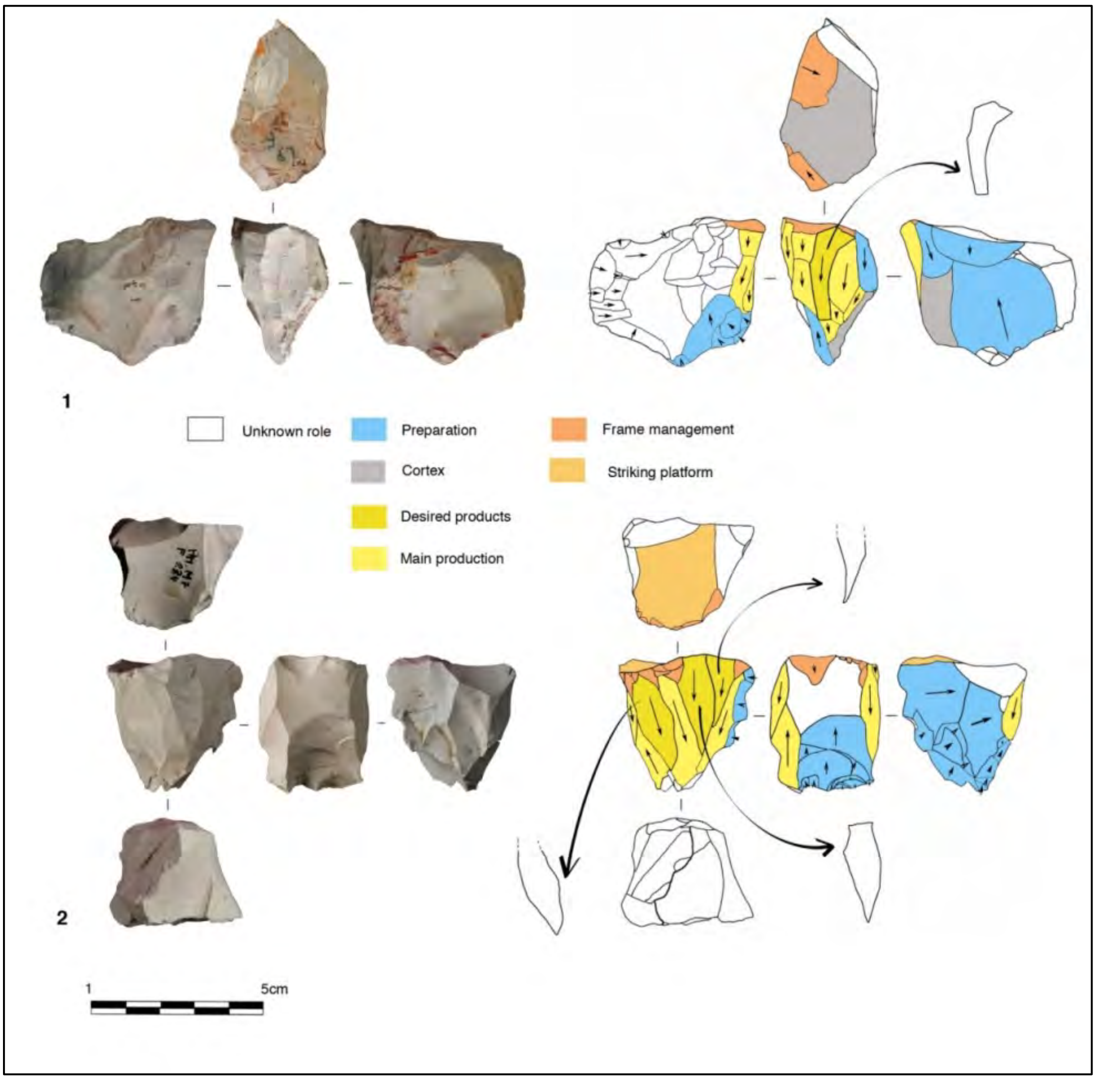

Fig 14. Payre: Bladelet cores from unit F.

3.2 Reduction sequences and the aims of production at Bau de l'Aubesier

The lithic assemblages of units K and J are entirely composed of products derived from flaking systems, with both surface and volumetric management occurring (Table 6). Surface exploitation was recognized on 42 cores and includes both polar and peripheral variants. Volume exploitation is indicated by 14 cores.

Table 6 – Bau de l'Aubesier, numbers of core types throughout the sequence.

Systems structure	Core techno-type	K2	K1	K	J4	J3	J2	J1	J	Total
Peripheral	Secant plans cores "Discoid"	3	-	-	-	-	-	-	-	3
	Secant plans cores "Partial exploitation"	1	1	-	-	-	-	-	-	2
	Centripetal parallel plans exploitation	1	-	-	2	2	2	-	4	11
Polar	Unidirectional parallel plans	-	-	-	1	1	1	1	-	4
	Bidirectional parallel plans	1	-	2	1	-	-	-	-	4
	Convergent parallel plans	1	-	-	1	-	1	-	-	3
	Orthogonal parallel plans	1	-	-	-	1	-	-	-	2
	Multidirectional (SSDA type)	-	-	-	5	-	-	1	-	6
Volumetric	Convergent semi-rotating	-	-	-	4	-	-	-	2	6
	Unidirectional semi-rotating	1	-	-	4	-	1	-	-	6
	Pyramidal cores	1	-	1	-	-	-	-	-	2
	Large flakes cores	1	-	-	4	-	-	-	-	5
	Undetermined cores fragment	2	-	-	-	-	-	-	-	2
	Total	**13**	**1**	**3**	**22**	**4**	**5**	**2**	**6**	56

3.2.1 Polar and Pheripheral Parallels plan exploitation systems. Levallois or not Levallois?

Secant plan exploitation is rare at the Bau de l'Aubesier and shows the same variability as at Payre. This modality is only present in unit K, with five cores. Three of them are knapped on their total periphery (Discoid Type) and two cores show a partial exploitation (Fig. 15).

Fig 15. Bau de l'Aubesier: Discoid cores from sub-level K2

Parallel plans exploitation is widely present. This category includes 24 cores from unit J and 6 cores from unit K. The methods employed are highly variable: centripetal, unidirectional, bidirectional, orthogonal and convergent. The bidirectional, convergent and orthogonal methods are found in both of the two units K and J (Table 6). Conversely, the unidirectional method is only present in unit J, with 4 cores with a single series of removals and 6 cores with a multipolar exploiation. The centripetal method is primarily found in unit J, with just one centripetal core found in sub-unit K2 (Table 6). Three different types of configuration are recognized: Levallois, a partial configuration and a direct exploitation (Fig. 16).

Among the 30 cores, 6 of them, in unit J, can be described as Levallois (Fig. 17). For the other 24 cores, two different processes in core management have been observed (Table 7). The first variant includes a preliminary phase that partially prepares the core by unidirectional removals that strike the two lateral surfaces. This operation gives the core a reversed trapezoidal cross-section (Fig 18). The aim is to create two lateral inclined striking platforms for the maintenance of the convexity on the flaking surface during exploitation. This particular process is mainly observed in unit K (Table 7). The methods are bidirectional, centripetal and orthogonal.

Table 7. Bau de l'Aubesier: parallel plan exploitation cores.

System configuration	Methods	K2	K1	K	J4	J3	J2	J1	J	Tot.
Direct exploitation	Centripetal	0	-	-	1	-	1	-	1	3
	Unidirectional	-	-	-	1	1	1	1	-	4
	Bidirectional	-	-	-	1	-	-	-	-	1
	Multidirectional "SSDA type"	-	-	-	5	-	-	1	-	6
	Convergent	1	-	-	1	-	1	-	-	3
	Orthogonal	-	-	-	-	1	-	-	-	1
	Partial total	***1***	***-***	***-***	***9***	***2***	***3***	***2***	***1***	***18***
Partial configuration	Centripetal	1	-	-	-	-	1	-	-	2
	Unidirectional	-	-	-	-	-	-	-	-	0
	Bidirectional	1	-	2	-	-	-	-	-	3
	Orthogonal	1	-	-	-	-	-	-	-	1
	Partial total	***3***	***-***	***2***	***0***	***0***	***1***	***0***	***0***	***6***
Levallois	Centripetal	-	-	-	1	2	-	-	3	6
	Total	**4**	**0**	**2**	**10**	**4**	**4**	**2**	**4**	**30**

Direct exploitation is based on the selection of a specific size and shape of raw materials, in order to avoid the first (configuration) phase. In this case, the exploitation of the core is preceded only by the preparation of the striking platforms. Exploitation is performed by unidirectional, bidirectional, centripetal, orthogonal and convergent methods. The convergent method is only used in the case of direct exploitation (Fig. 19).

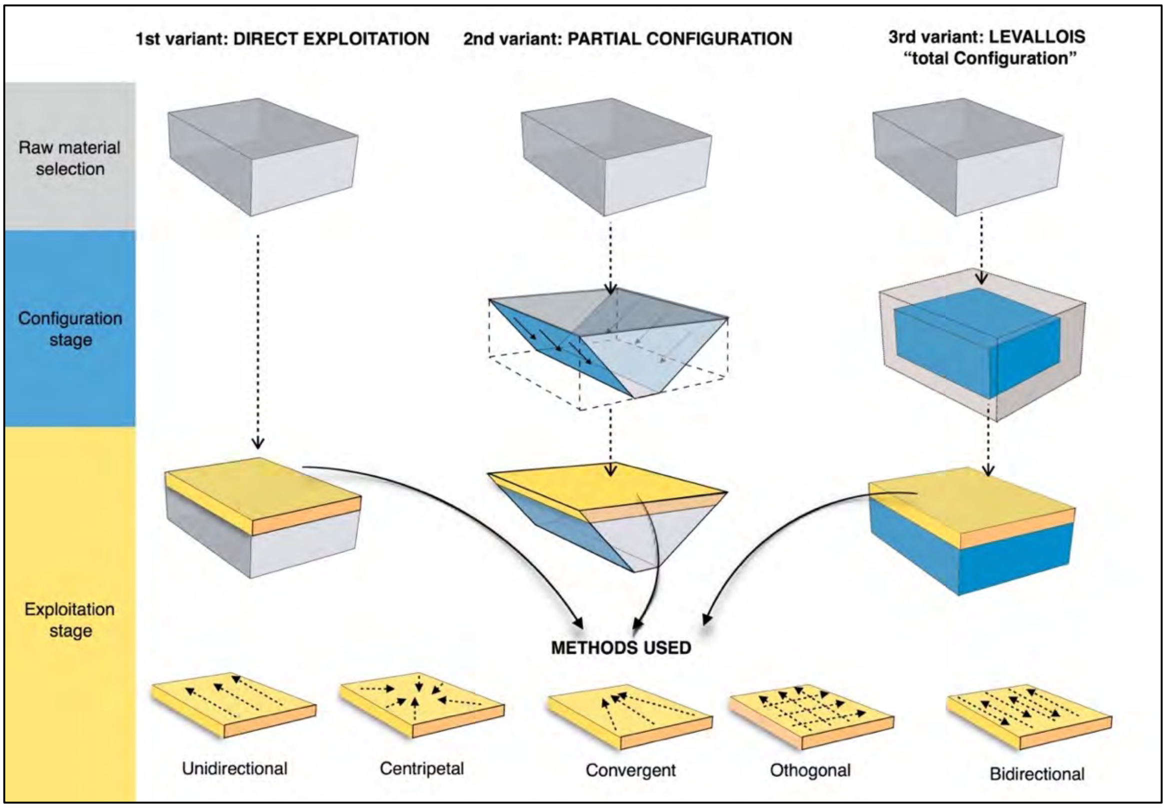

Fig 16. Bau de l'Aubesier: variability of reduction systems in parallel plan exploitation.

Fig 17. Bau de l'Aubesier: Levallois cores.

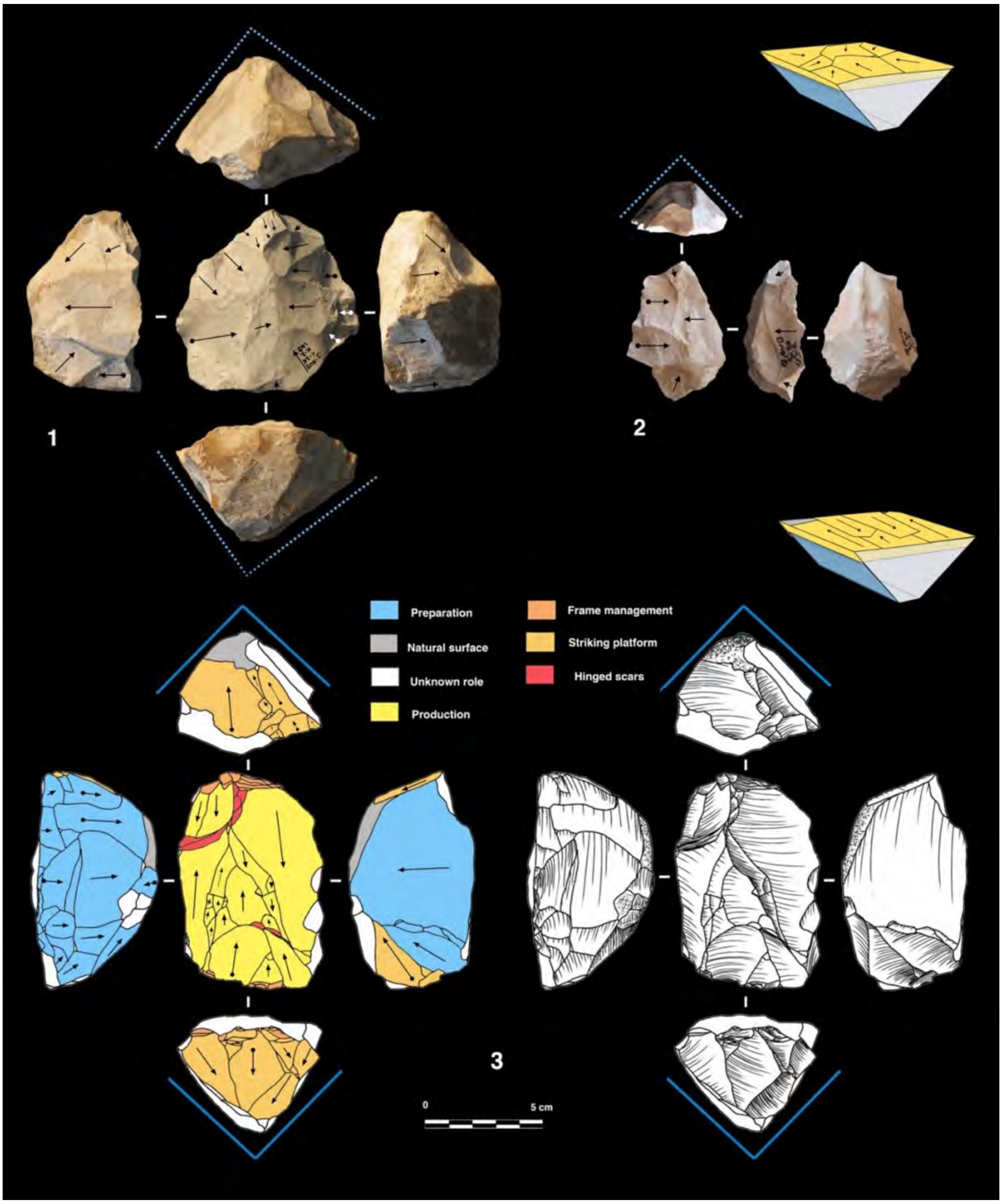

Fig 18. **Bau de l'Aubesier:** Cores with partial preparation.

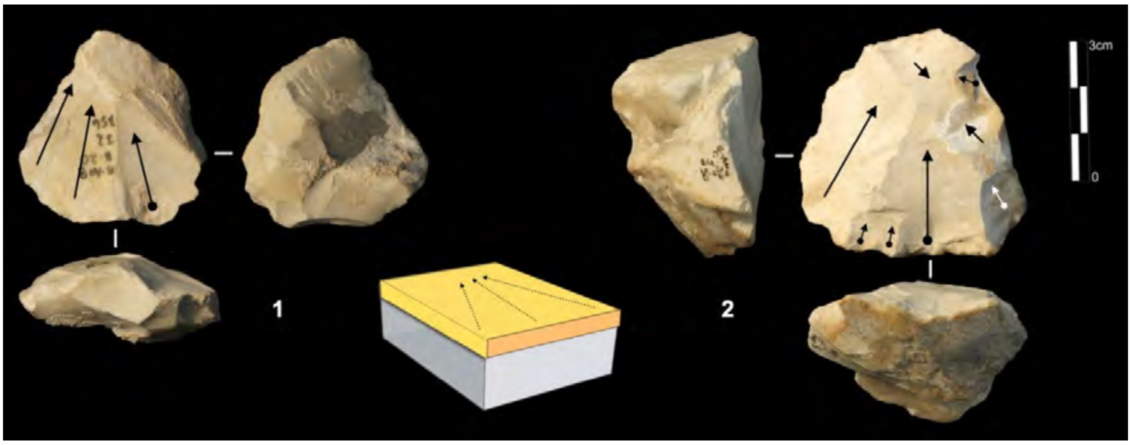

Fig 19. Bau de l'Aubesier: convergent cores without preparation from Unit J.

3.2.2 Volumetric exploitation systems.

Two types have been documented, for a total of 14 cores. Two cores are half-pyramidal cores and 12 cores are prismatic semi-rotating cores (Fig 20). The two half-pyramidal cores were found in unit K. Exploitation was carried out by convergent removals. In one case, the débitage starts from a cortical platform and shows a minimal phase of preparation in order to correct the distal convexity of the flaking surface (Fig 21 n.1). The second core shows a more elaborate re-configuration based on the re-centering of the flaking surface by lateral removals. After that, the core was abandoned after repeated hinged fractures (Fig. 21 n.2). The semi-rotating system comes primarily from unit J, with just one core out of 12 from sub-unit K2. The core volume is not completely shaped out before starting blade production. The management of lateral convexities is performed by debordant blades. In rare cases a second opposite striking platform is used in order to manage the distal convexity

Removals can cover one (Fig 21 n. 3) or both of the lateral surfaces (Fig. 21, n. 1, 2). The methods used are unidirectional and convergent.

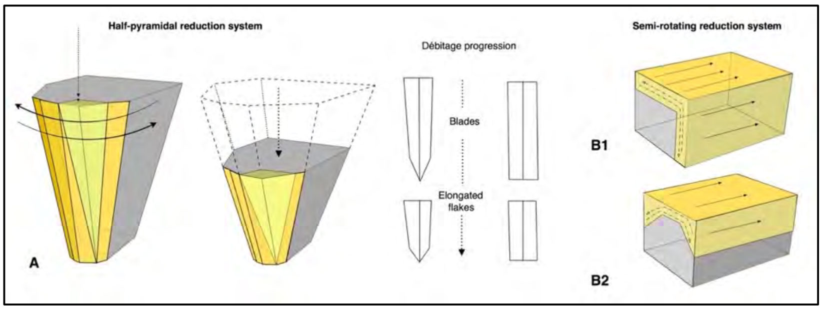

Fig 20. Bau de l'Aubesier: Variability in volumetric exploitation systems.

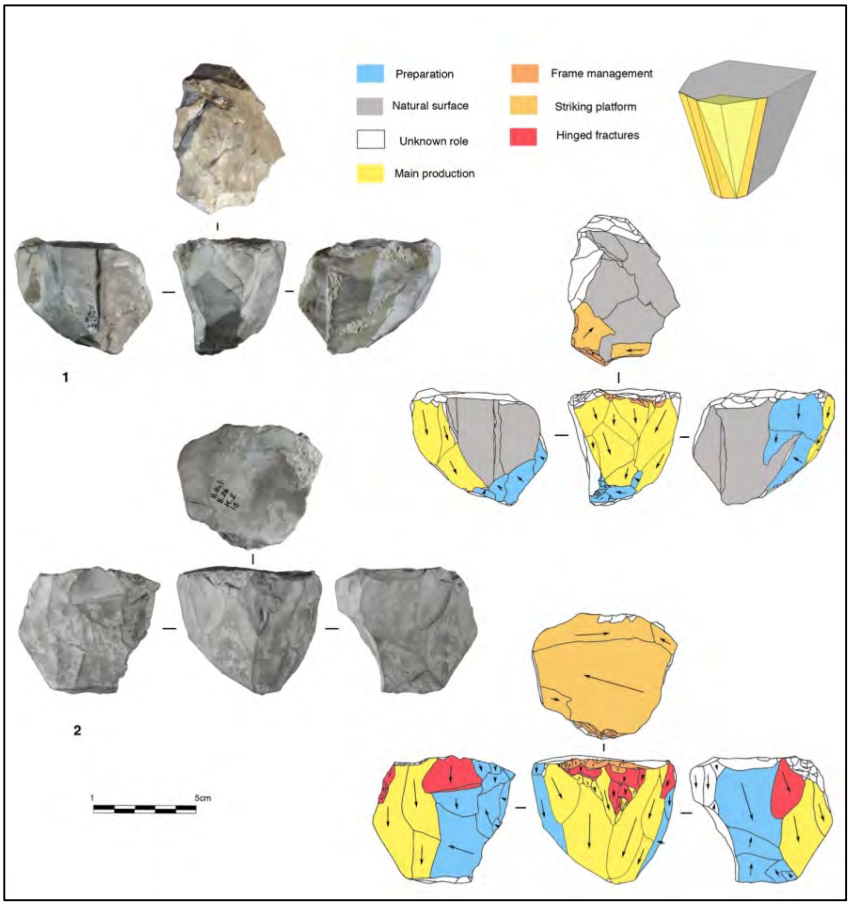

Fig 21. Bau de l'Aubesier: Half pyramidal cores.

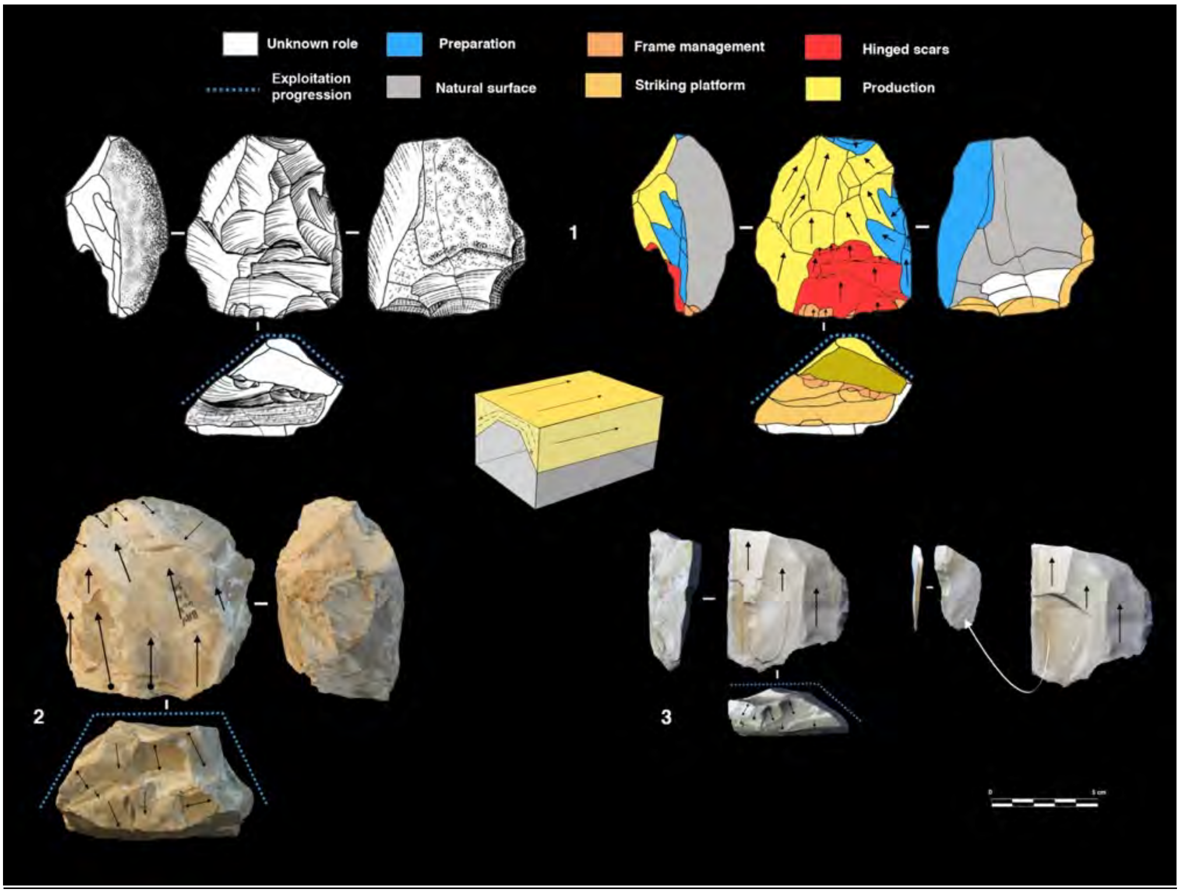

Fig 22. Bau de l'Aubesier: Semirotating cores. Sub-convergent core from sub-unit J4 (n.1); Unipolar core from sub-unit J4 (n.2); Refitting of unipolar semirotating core from sub-unit J2 (n.3).

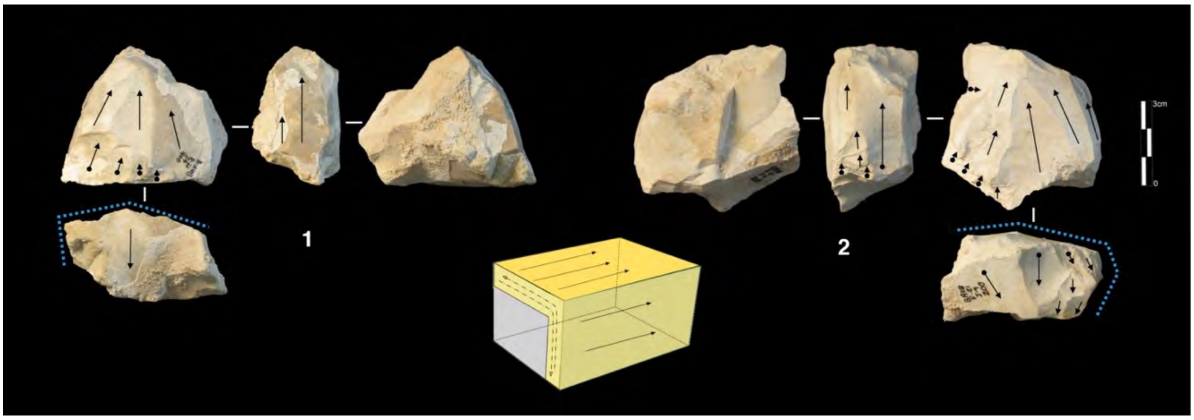

Fig 23. Bau de l'Aubesier: Convergent semirotating cores from sub-unit J4.

3.2.3 Volumetric and parallel plans exploitation end products: Core variability is similar to end-product variability. Centripetal flakes are the most frequent and are linked to the two main reduction processes (Table 8). Despite the low number of pieces, some observations can be suggested. Centripetal flakes with secant dorsal scars (type A) are present in units K and J but decrease over time (Supplementary File S1, Table C). Conversely, centripetal flakes with parallel dorsal scars (type B) increase in unit J, as do the equivalent cores. These products can be classified as Levallois-type flakes but can also be the results of three different processes: Levallois, direct exploitation, and partial preparation types (Fig. 16). The variability of methods for parallel plans exploitation is confirmed by convergent, unidirectional and bidirectional Levallois-type flakes (Fig. 24 n 1 to 9). Beside this dominant production of flakes, blades also exist in the two units; they are more numerous in the lower levels, with a proportion of 22.6%

in sub-unit K2 and 7.6% in sub-unit J4. The blades are triangular or rectangular, consistent with the pyramidal cores, and the rectangular blades can be linked to the semi-rotating unidirectional system (Fig 24 n 10 to 16).

Table 8 – Bau de l'Aubesier, determined pieces. Numbers in brackets represent retouched pieces.

Levels	**K2**		**K1-K**		**J4**		**J3**		**J2**		**J1-J**	
	num	**%**	**num**	**%**	**num**	**%**	**num**	**%**	**num**	**%**	**num**	**%**
Flakes (Cortex >50%)	5	*6*	4	*3.7*	12(1)	*6.5*	3	*10*	2	*25*	10	*12*
Flakes (Cortex<50%)	11	*13.1*	-	*0*	20(1)	*10.8*	4	*13.3*	-	*0*	40	*48.2*
Centripetal flakes	13(2)	*15.5*	16(1)	*15*	39(11)	*21.1*	13	*43.3*	1	*12.5*	7(2)	*8.4*
Debordant flakes (chordal)	5(2)	*6*	5(1)	*4.7*	12	*6.5*	-	*0*	-	*0*	5	*6*
Unipolar flakes	10(1)	*11.9*	22(4)	*20.6*	30(4)	*16.2*	6	*20*	2	*25*	13(2)	*15.7*
Debordant unipolar flakes	3(1)	*3.6*	5(2)	*4.7*	4	*2.2*	-	*0*	-	*0*	1(1)	*1.2*
Bipolar flakes	4(2)	*4.8*	6(4)	*5.6*	2(1)	*1.1*	-	*0*	-	*0*	-	*0*
Debordant bipolar flakes	1(1)	*1.2*	-	*0*	1	*0.5*	-	*0*	-	*0*	-	*0*
Orthogonal flakes	-	*0*	-	*0*	1	*0.5*	-	*0*	-	*0*	-	*0*
Debordant Orthogonal flakes	-	*0*	-	*0*	1	*0.5*	-	*0*	1	*12.5*	-	*0*
Convergent/sub-convergent flakes	4(2)	*4.8*	5(1)	*4.7*	28(6)	*15.1*	2	*6.7*	-	*0*	1	*1.2*
Bladelet	1	*1.2*	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*
Blades	19(4)	*22.6*	19(3)	*17.8*	14(5)	*7.6*	1	*3.3*	1	*12.5*	3(1)	*3.6*
Crested blade	2	*2.4*	1	*0.9*	-	*0*	-	*0*	-	*0*	1	*1.2*
Kombewa	-	*0*	3	*2.8*	1	*0.5*	-	*0*	-	*0*	-	*0*
Macro-outils	2 (2)	*2.4*	10(10)	*9.3*	1(1)	*0.5*	-	*0*	-	*0*	2(2)	*2.4*
Striking platform flakes	3	*3.6*	5	*4.7*	6	*3.2*	1	*3.3*	-	*0*	-	*0*
Shaping/retouching flakes	-	*0*	1	*0.9*	3	*1.6*	-	*0*	-	*0*	-	*0*
Rejuvenation flakes	-	*0*	2(1)	*1.9*	2(1)	*1.1*	-	*0*	-	*0*	-	*0*
Burin de Siret	1(1)	*1.2*	3 (2)	*2.8*	8	*4.3*	-	*0*	1	*12.5*	-	*0*
Total	84 (18)	*100*	107 (29)	*100*	185 (31)	*100*	30	*100*	8	*100*	83(8)	*100*

Fig 24. Bau de l'Aubesier end products: On the left, flakes from parallel plans exploitation: centripetal flakes (n. 1 to 3), convergent flakes (n. 4 to 6), unidirectional and bidirectional flakes (n. 7 to). On the right, blades: convergent blades from unit J (n. 10 to 12) and from unit K (n. 16), unidirectional blades from unit K (n. 13, 14 and 15).

3.3 Heavy-duty tools and retouched pieces at Payre

The lithic collections yielded denticulates, notches and sidescrapers. The assemblages also include tools derived from shaping processes (the heavy-duty component) and some Quina pieces (Fig 25).

The frequencies of tools in each assemblage range from 11.5% to 29.5% (Table 9). There does not seem to have been any specific choice of blank types from the débitage for any category of tool type (Supplementary File S2, Table E), except in unit G, where we observe more flake-tools from peripheral exploitation system blanks (centripetal flakes and debordant flakes).

Most of the Quina tools were found in sub-level Ga (27 pieces). Predetermined reduction systems devoted to the production of large blanks for Quina retouch have been identified in the Middle Palaeolithic elsewhere (Bourguignon 1996, 1997). According to Baena (Baena et al. in press), at Payre it is impossible to describe a Quina reduction process. The large and thick flakes used for Quina retouch can come from the first phase of secant parallel plans exploitation cores or from trifacial exploitation cores.

***Table 9** – Payre, proportions of retouched and unretouched pieces.*

Levels	Gb		Ga		Fd		Fc		Fb		Fa	
	n	%	n	%	n	%	n	%	n	%	n	%
Tools (flakes/handaxes/macro tools/pebbles)	26	22.8	238	29.5	10	9.4	12	18.2	3	11.5	73	23.2
Unretouched pieces (flakes/pebbles)	88	77.2	568	70.5	96	90.6	54	81.8	23	88.5	241	76.1
Total	114	100	806	100	106	100	66	100	26	100	314	23.2

Table 10 – Payre, proportions of types of retouched pieces

Levels	Gb		Ga		Fd		Fc		Fb		Fa	
	n	%	n	%	n	%	n	%	n	%	n	%
Tools on flakes	18	69.2	166	69.7	6	60	9	75	2	66.7	45	61.6
Quina	3	11.5	10	4.2	-	0	-	0	-	0	2	2.7
Demi Quina	2	7.7	17	7.1	1	10	-	0		0	6	8.2
Handaxe	2	7.7	-	0	-	0	-	0		0	1	1.4
Partial shaped tools	1	3.8	4	1.7	1	10	-	0		0	5	6.8
Retouched Pebbles	-	0.0	41	17.2	2	20	3	25	1	33.3	14	19.2
Total	26	100	238	100	10	100	12	100	3	100	73	100

Fig 25. Payre: Quina tools from Unit G.

Heavy-duty tools are rare. There are 3 handaxes, 2 in sub-level Gb and 1 in sub-level Fa (Fig 26). Eleven tools are characterized by a partial shaping operation, aimed at creating a trihedral morphology while leaving the main part of the piece unmodified (Fig 27).

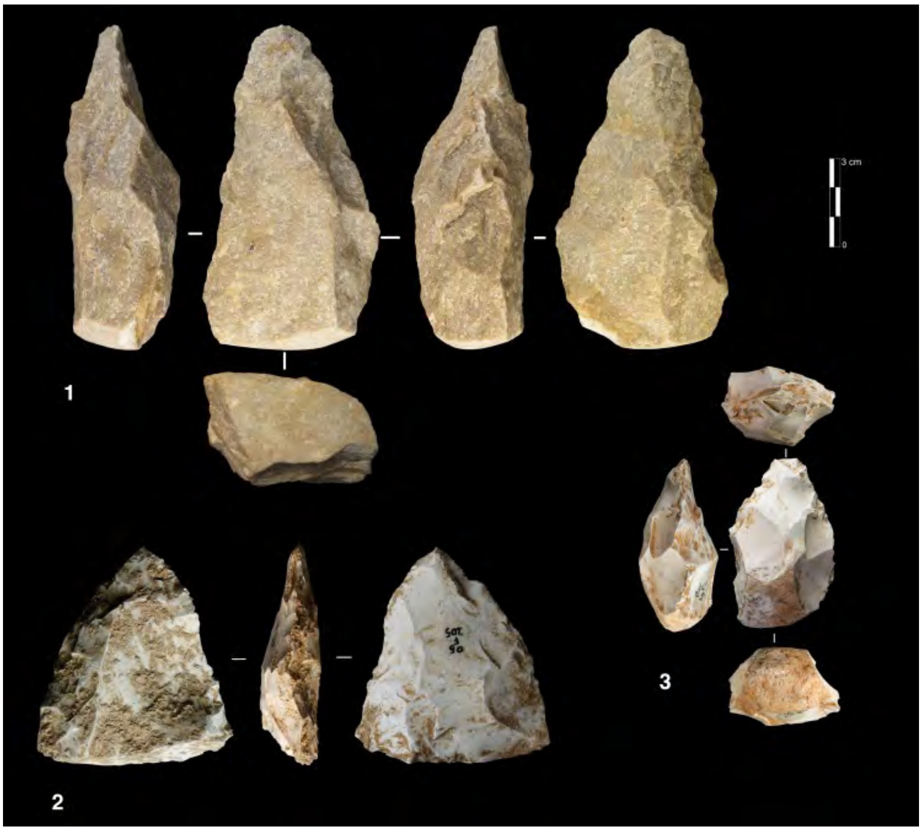

Fig 26. Payre: Bifaces from sub-unit Fa (n.1 and 2) and from Gb (n. 3).

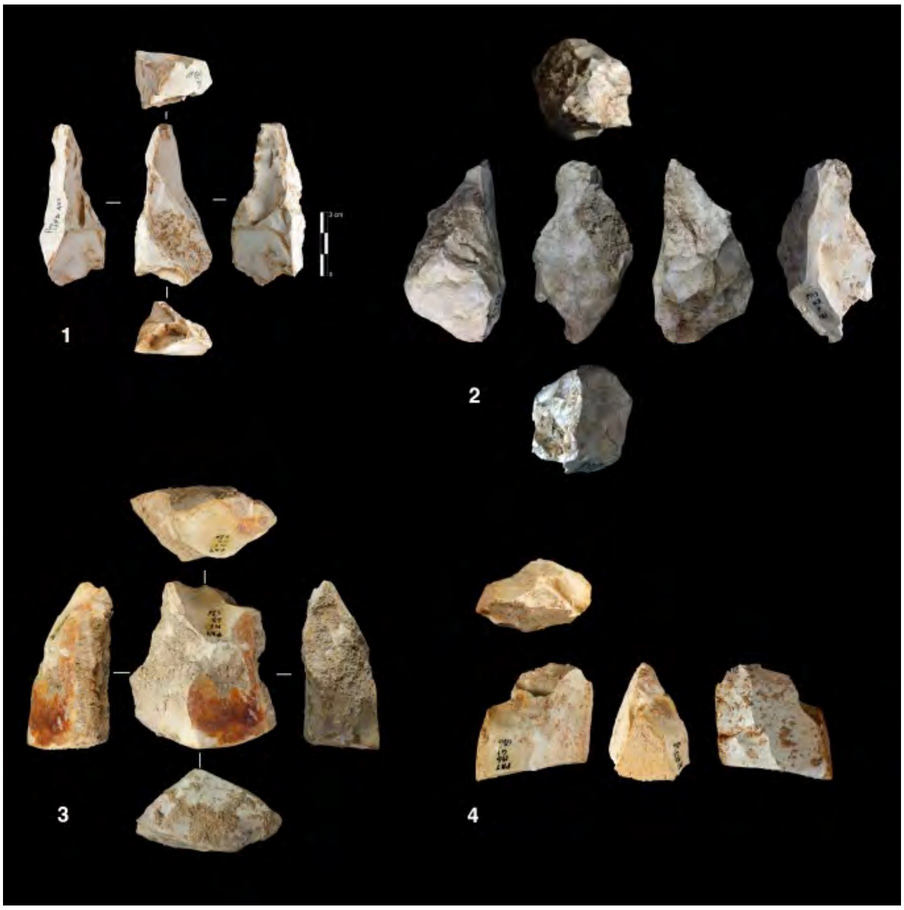

Fig 27. Payre: Partially shaped pieces from sub-units Ga (n. 1 and 2) and from Fa (n. 3 and 4).

3.3 Heavy-duty tools and retouched pieces at Bau de l'Aubesier

Retouched pieces are more frequent in units K (17.8%) and J4 (16.2%), but rare or totally absent in sub-levels J3 to J1-J. The retouch rarely modifies the form of the blanks, whether flakes or blades.

The only exception concerns 14 truncated pieces in unit K (12 pieces) and in sub-unit J4 (2 pieces) (Fig. 28). Fifteen pieces (12 from unit K and 3 from J) are characterized by partial shaping to build a rostrum (Fig. 29). The rest of the piece is unmodified, except in the case of one piece from sub-level K2 (Fig. 29 n. 3). Within the producution no specific blank type is selected to be retouched. (Supplementary File S2, Table D).

Table 11 – Bau de l'Aubesier, proportions between the retouched pieces and blanks excluded the undetermined removals.

Levels	**K2**		**K1-K**		**J4**		**J3**		**J2**		**J1-J**	
	num	**%**	**num**	**%**	**num**	**%**	**num**	**%**	**num**	**%**	**num**	**%**
Retouched flakes	14	*16.7*	19	*17.8*	30	*16.2*	-	*0*	-	*0*	6	*7.2*
Shaped pieces	2	*2.4*	10	*9.3*	1	*0.5*	-	*0*	-	*0*	2	*2.4*
Unretouched flakes	68	*81.0*	78	*72.9*	154	*83.2*	30	*100*	8	*100*	75	*90.4*
Total	84	*100*	107	*100*	185	*100*	30	*100*	8	*100*	83	*100*

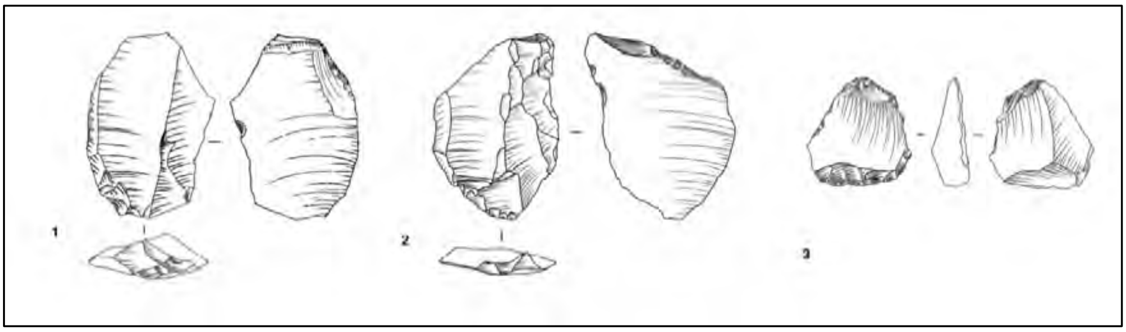

Fig 28. Bau de l'Aubesier: Truncated pieces from unit K (n. 1 and 2) and unit J4 (n.3).

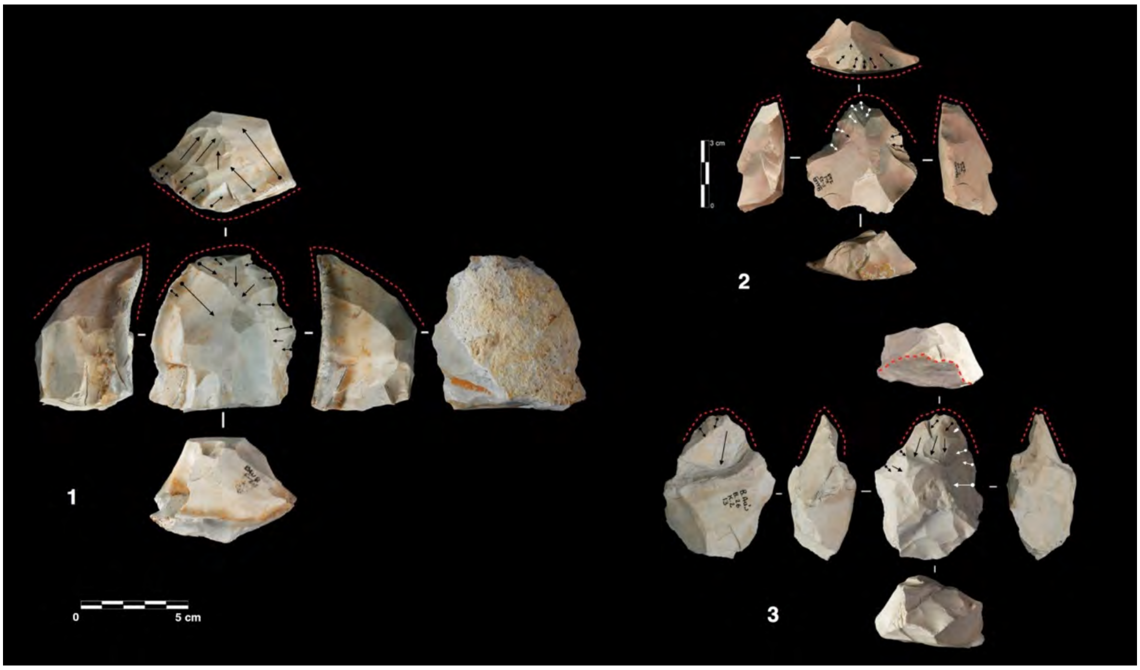

Fig 29. **Bau de l'Aubesier:** Partially shaped pieces from sub-unit K1 (n. 1 and 2) and sub-unit K2 (n. 3)

4 – Discussion and Conclusion

4.1 Similarities and differences in lithic production at Payre and the Bau de l'Aubesier.

The technological strategies performed at the Bau de l'Aubesier and Payre show both differences and common features over time. At the Bau de l'Aubesier the major differences between units K and J include the appearance of Levallois débitage in unit J, in parallel with the disappearance of Discoid production. The pyramidal system disappears in unit J, replaced by the development of a semi-rotating system and in particular by the convergent method, which is absent in unit K (Fig. 30). At Payre, the differences between the sub-levels seem to be less marked than at the Bau de l'Aubesier. The main shift over the time span from unit G to unit F is constituted by an increase of the Discoid system, associated with a decrease in the partial peripheral system and the disappearance of the trifacial cores. The shift also includes a marginal bladelets production and a decrease in the number of Quina pieces.

Comparing the lithic assemblages of the two sites, differences in terms of technological behaviours appear clearly at multiple levels: core management, reduction systems and tool kits. From a macroscopic point of view the Payre assemblages are the result of a double behaviour, with both knapping and shaping processes (Fig 30). Shaping processes are almost entirely absent at the Bau de l'Aubesier, represented only by core technologies and the partial shaping operation described for a few pieces. If we compare the core technologies between the two sites, strong and clear differences appear. At the Bau de l'Aubesier, reduction systems were performed on both the surface and the volume of cores, in order to produce both flakes and blades. Conversely at Payre, volumetric exploitation is absent except for a marginal but noteworthy bladelets production (Fig. 30).

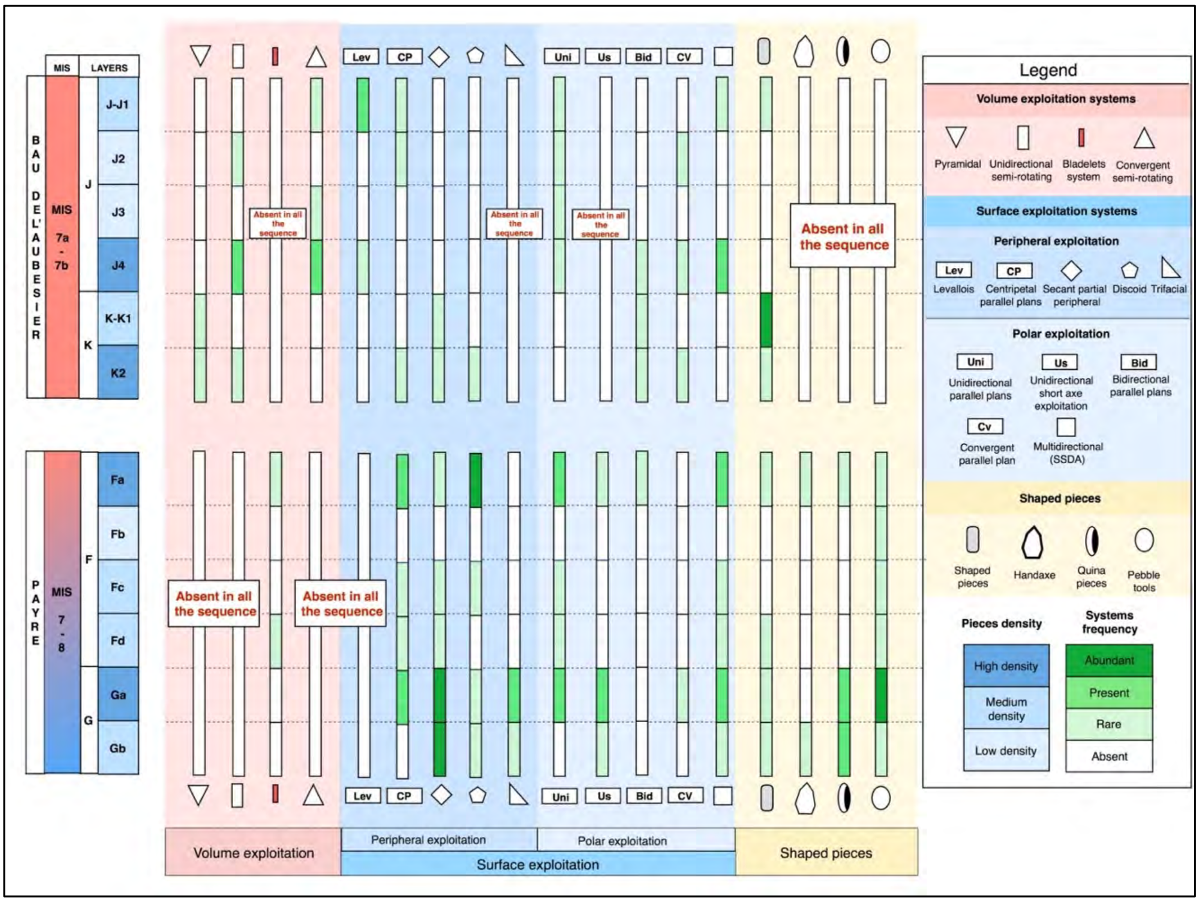

Fig 30. Summary of the reduction processes over the sequences at Payre and the Bau de l'Aubesier

If we compare the exploitation systems in detail, differences are again recognizable. The Levallois concept present at the Bau de l'Aubesier is totally absent at Payre. Flakes at Payre are mainly produced by secant plans exploitation, discoid systems, partial peripheral systems and trifacial cores.

At the Bau de l'Aubesier, variability in flake production is principally due to parallel plans exploitation systems, including Levallois, while exploitation by secant plans plays a minor role. Concerning tool composition and proportions, we again observe different trends at the two sites. Primarily, the tool kit proportion is higher at Payre than at the Bau de l'Aubesier, ranging from 11% to 29.5% at Payre, while at the Bau the l'Aubesier, tools represent between 7.2% and 17.8%, and in sublevels J3 and J2 they are totally absent. At Payre, the flake-tools are notches, denticulates and scrapers. Moreover, some Quina pieces, pebble-tools and some handaxes make up the heavy-duty component. At the Bau de l'Aubesier, the tools are on flakes and blades and are retouched by a marginal retouch that only slightly modifies the pieces, except for some truncated pieces and some partial bifacial tools (rostrum). This reduced importance of the tool kit at the Bau de l'Aubesier can be explained by the use of core technologies based on predetermined systems, such as Levallois, which produce a blank form that does not need to be modified. The common features between the sites are minor. The two sites share the use of unidirectional methods by parallel plans exploitation, even if at the Bau de l'Aubesier some types are absent. The main common features concern Payre units G and F and Bau de l'Aubesier unit K, where the Discoid system and the secant partial peripheral system were both found.

4.2 Possible reasons for the variability between the lithic assemblages of the two sites.

The two sites are located in a similar environmental setting, within the same region in South-East France, being (broadly speaking) located on opposite sides of the Rhône corridor. They are both in a more or less open cave or rock shelter, opening onto a slope of a narrow valley with a river, and close to low plateaus. Payre is closer to the Rhône Valley, while the Bau de l'Aubesier's environment is dominated by the nearby Mont Ventoux (1912 m elevation). Nonetheless, it is reasonable to assume that deposits that accumulated during the same time period (MIS 8 and 7, considered here) at the two sites would have accumulated under similar conditions of climate and floral and faunal resource availabilities.

Despite this environmental similarity, however, the technological strategies and tool kits differ greatly, and few common features can be observed between the occupations of the two sites. We also see that at each site, there are differences between the layers, showing change in technological approaches through time. This diversity of strategies is therefore clearly not only due to the particular site but also reflects variability in strategies employed by the human groups living in this part of France at that time. In order to better understand the variability of human behaviours during the Early Middle Palaeolithic (EMP) we can also examine the raw material availability and modes of procurement, and the subsistence strategies reflected in the site assemblages.

4.2.1 Raw material strategies at Payre and at the Bau de l'Aubesier.

Payre : Flint procurement patterns at Payre indicate differences in land use through time, perhaps due to differences in the duration of occupation between units G and F. Unit G is considered to have recorded long-term occupations while unit F reflects short-term occupations in a smaller cave (Rivals et al., 2009; Daujeard et al., 2011).

For instance, for sub-level Gb, 11 flint types have been described (Fernandes et al., 2008, 2010). Most of the flint came from the southern plateau along the Rhône River, following a North-South axis. Flint was collected mainly at surface (primary and secondary formations, 90%) or fluvial deposits, or at outcrops located from 5 to 15 km around the site, as fragments of nodules or large flakes. Some large flakes and nodules came from 30 km or small flakes from 60 km to the south of the site (reflecting partial reduction processes). The Rhône valley itself was rarely used for flint procurement.

Conversely, in Unit F most of flint was collected from alluvial deposits (90%). The exact location of the outcrops is therefore impossible to identify and only a maximum perimeter may be given. Ten types have been identified, some of which are also found in the unit G assemblage. Flint collecting was carried out more to the west of the site than is the case for unit G, but there was again some collecting in the southern area.

The basalt in the two basal units was collected at the foot of the site (from the remains of terraces on the slope) and introduced as pebbles of various sizes or large flakes. Primary sources of basalt are located upstream of the Payre River in the volcanic massif of the Coiron. Most of the pebbles were left whole. Despite the badly preserved superficial surfaces of the pebbles, some show percussion marks and could have been used as hammerstones.

The elongated and flat pebbles were shaped into unifacial pebble-tools and left numerous cortical flakes. Crushing marks and flakes from rejuvenation attest to their use *in situ*.

Local quartz arrived as rare pebbles and above all as flakes. The reduction processes are partial (Moncel et al., 2008). The rare cores have two secant or orthogonal surfaces. As was the case for the flint, flaking was mainly performed by a series of unipolar removals, rarely centripetal. Some large pieces could be modified cores (crush marks on the cutting edges) or are large tools on fragments of pebbles.

The flakes are thick and sometimes backed. Between 10 and 15% are retouched (one edge or convergent edges).

The marly and siliceous limestones were collected in the Payre or Rhône Rivers.

Some fragments of the cave limestone were collected and just retouched. Pebbles were broken or shaped. Flakes are numerous, thin, largely cortical and small, and imported, as for quartz. Few are retouched. Two cores in level Fa cannot be refitted with flakes. The flaking took place on small flat pebbles and cores with two secant surfaces.

Quartzite arrived as pebbles and above all as large and small flakes, collected possibly along the Rhône River. The large flakes, flaked from large cobbles outside, are unretouched or retouched as large unifacial or bifacial tools (peripheral, pointed or transversal). The large flakes are cortical or partially cortical. Crushing marks on edges support a use for heavy activities. Only one piece could be considered as a core or a re-used broken bifacial tool. Small flakes could come from the rejuvenation of the heavy-duty tools or have been imported for unknown reasons, as with the large basalt tools on flakes.

Bau de l'Aubesier: At the Bau de l'Aubesier, almost the entire assemblage is in flint, but it has been possible to distinguish many different types of flint and track them back to source areas throughout the region, as well as evaluate a variety of characteristics of each source area that would influence hominins' choice of whether or not (or how much) to use it (Wilson, 2007a, b, c; 109 Wilson, 2011; Browne and Wilson, 2011, 2013; Wilson and Browne, 2014). In all levels, a considerable proportion of the lithic assemblage has been patinated to such an extent that the pieces can only be identified as being flint, and no source can be attributed. There are also a few flint types for which sources have not been identified, but these account for a very small number of pieces. Taking these together with the patinated pieces, however, in levels J-J4 together, the sources of 43.2% of the pieces are either unidentified or unidentifiable; in levels K-K2 these account for 51.7% of pieces.

Once these unidentified pieces are excluded, the small numbers of remaining pieces in the sub-layers make it more reasonable to combine sub-layers and deal with an overall layer J and an overall layer K. These two assemblages have similar sizes: 830 pieces in J, and 880 in K. A variety of attempts has been made to try to detect whether the patination of such a large number of pieces has biased the remaining sample (e.g., with patination affecting some flint types more than others, thereby selectively removing them from the sample). No such effect has been found, so we consider these samples to be representative of the overall use of raw material sources for each assemblage.

In both layers, all of the material was obtained within 15 km of the site, with the bulk of it coming from source areas along a SW-NE trending axis (Fig. 31).

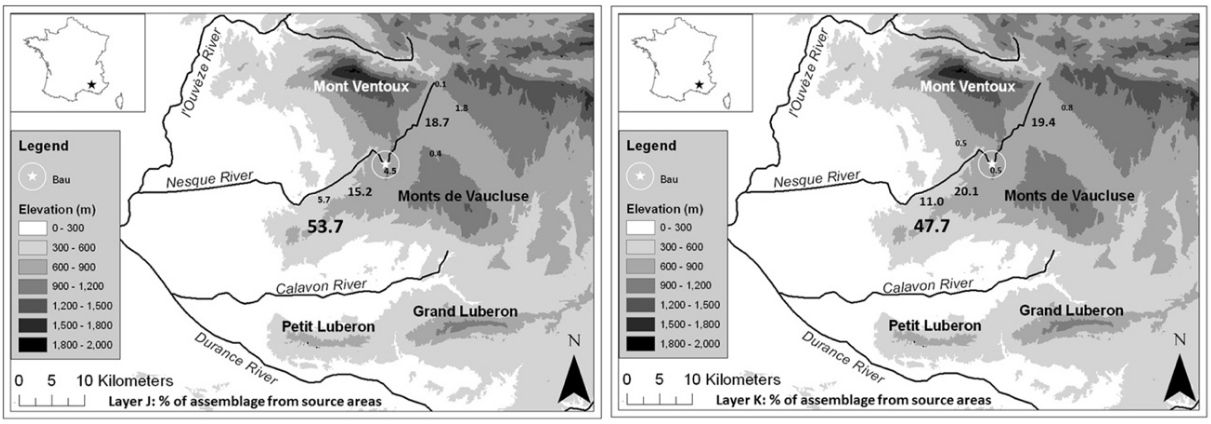

Fig 31. Bau de l'Aubesier: Map of sources of layer J (on the the left) and K (on the right)

In both layers, the assemblages are dominated by material from the Murs area, to the SW of the site, despite the fact that this is at the far end of the normal provisioning range (Table 12). Clearly, a distance-decay model, where raw materials would be less common the farther away their source is, does not apply in this case. There are some differences between the two layers in terms of the percentages of material from Murs among various typological categories, but in both layers all parts of the *chaîne opératoire* are present and common, suggesting that this raw material was imported as nodules or cores, and worked *in situ*.

Table 12 - Bau de l'Aubesier. Sources of raw material in the Bau de l'Aubesier assemblages.

		Layer J		Layer K	
Source Area	**Direction**	**n.**	**%**	**n.**	**%**
Nord Aurel	NE	1	*0.1*	-	*0*
St. Trinit	NE	15	*1.8*	7	*0.8*
Sault	NE	155	*18.7*	171	*19.4*
Nord des gorges	NW	-	*0*	4	*0.5*
St. Jean de Sault	E	3	*0.4*	-	*0*
Local	--	37	*4.5*	4	*0.5*
Faraud	SW	126	*15.2*	177	*20.1*
Méthamis	SW	47	*5.7*	97	*11*
Murs	SW	446	*53.7*	420	*47.7*
TOTAL	--	830	*100*	880	*100*

Raw material from other sources to the SW is also common in both layers, such that overall 74.6% of pieces in layer J, and 78.8% of pieces in layer K, are from the SW area. Use of sources off the SW-NE axis is extremely minor, and variable. Use of the source closest to the Bau de l'Aubesier is also minor, especially in layer K (only 4 identified pieces), and we have as yet no explanation to suggest for that.

The use of sources to the NE (which include the one piece of quartzite) does follow a distance-decay pattern, and the overall percentage of pieces from those sources is very similar in the two layers (20.6% in layer J, 20.2% in layer K), but there are some noteworthy differences in the use of these materials for different typological categories. In the lowest layers, K-K2 together, the material from the NE is distributed among tool categories in much the same way as the material from the SW, suggesting that it, too, was imported and knapped *in situ*. In layer J, however, the material from the NE is more common among the retouched flakes, large flakes and blades than it is in the debris, small flakes or cores, suggesting that it was imported in a more finished form, representing a more specialised or careful use of that material than the material from the SW. For example, taking retouched and shaped items together, raw material from the NE makes up 27.3% of such items in layer J, but only 13.7% of them in layer K. On the other hand, material from the NE accounts for only 4.9% of cores in layer J, but 13.6% of cores in layer K. We can therefore propose that strategies for use of the landscape, reflected in the lithic assemblages, varied through time at the Bau de l'Aubesier.

4.2.2 - Subsistence strategy at Payre and at the Bau de l'Aubesier

At Payre the spectrum of ungulates is mainly composed of red deer (*Cervus elaphus*), horse (*Equus mosbachensis*), bovines (*Bos primigenius and Bison priscus*) and rhinoceroses (*Dicerorhinus hemitoechus and D. kirchbergensis*). Carnivores are especially numerous in unit F. Among them, cave bear (*Ursus spelaeus*) is predominant, associated with other carnivores including some large predators such as wolf (*Canis lupus*), hyena (*Crocuta spelaea*) and cave lion (*Panthera (Leo) spelaea*) (Auguste 2008; Daujeard 2008; Patou-Mathis et al. 2008; Daujeard et al. 2011). This faunal list reveals a mildly cold climate and different biotopes, including forests, wooded prairie, steep rocky sides (Payre canyon), as well as open-steppe environments. The microfaunal remains indicate colder and steppic environments in units G and F (Desclaux et al. 2008). Possible disturbances in karstic deposits could explain this mismatch between macro- and micro-faunal remains (Moncel et al., 2015), such as by migration of small bones through the deposits.

The occupation types were different in units G and F. In F, carnivores commonly inhabited the site, suggesting that hominid occupations alternated with carnivore denning (Daujeard 2008; Daujeard et al. 2011). The study of the ungulate tooth microwear patterns attest to longer occupations in a larger cave in unit G than in unit F, where the cave's size and ceiling height were reduced, in agreement with the smaller number of lithic artefacts and the taphonomical study of the faunal remains. Unit F was mostly a carnivore den with shorter-term human occupations (Rivals et al. 2009; Daujeard et al. 2011). Unit G recorded longer-term occupations with a high anthropic impact on horses, deers and bovids, the three main hunted species (Patou-Mathis et al. 2008).

The anthropogenic activities left numerous sorts of evidence at Payre. Ungulate bones were intensively cut-marked, broken, and some were burned. Fire was used in each layer, but there are no clear hearth structures other than in unit G. The lithic residues and use-wear analysis show evidence, among other things, of fish processing in units Fa and D and of the use of avian resources (Hardy and Moncel 2011).

Similarities in the faunal corpus exist between units G and F (Dashek et al., et Auguste et al., in Moncel Dir., 2008; Daujeard, 2008; Daujeard et Moncel, 2010; Daujeard et al., 2011). The main species which characterize the assemblages are cervids, bovines, horses and rhinoceros. The rhinoceros include only young and old individuals, but the three main species are represented by adults, young, and young adults. In unit G, mortality curves indicate hunting all through the year. In unit F, conversely, hunting is more frequent in the autumn. In the two units, rhinoceros remains were mainly due to scavenging, although for unit F there is some evidence of occasional hunting of adults in the swamps of the Rhône Valley at the foot of the cave.

The difference between the two units is mainly due to the action of carnivores. In unit F, carnivore tooth-marks are present on between 2 and 6% of the NR > 5 cm, while in unit G, the value is around 1%. Except for cave lion and wild cat, the same species of carnivores exist in the two units. Unit F is moreover largely dominated by remains of *Ursus spelaeus*. Bears settled in the cave for winter, alternating with human occupations; these are followed in abundance by wolves, hyenas and big cats using the site. In unit G, cave bears are less numerous, as are foxes, hyenas and wolves.

Cut-marks on the different taxa of herbivores indicate that some small species were not brought by humans to the cave (roe deers, tahrs or boars). The middle and large herbivores attest conversely to human actions, which were more intense in unit F (cut-marks and bone breakage for marrow recovery). In both units, the anatomical proportions of ungulates and location of anthropic marks indicate primary butchery activities for cervids and secondary butchery activities for bovines, horses and rhinoceros (with the first skinning having taken place at the hunting location).

Burnt bones in the two units provide evidence of fire use, with the possible use of bones as the combustible. In unit G, one ash lens could be the remains of a fire place. Some bone retouchers attest to the use of bone.

In both units, faunal remains indicate the main anthropic accumulations. In unit F carnivores played a large role in the consummation of carcasses, and bear occupations were important: tooth marks indicate secondary occupations after the departure of humans. Human occupations took place in unit G during long-term phases all through the year, while in unit F there were short-term occupations mainly in the autumn.

At the Bau de l'Aubesier, Fernandez (2006) reports for layers J and K combined that he identified a minimum of 38 individual animals. Most of these were of large animals: 17 *Bos primigenius*, 12 *Equus mosbachensis*, 1 *Dicerorhinus hemitoechus*, and 1 *Megaceros giganteus*. There was also 1 *Cervus elaphus*, 2 *Capreolus capreolus*, 2 *Hemitragus cedrensis*, 1 *Dama dama*, and 1 *Rupicapra rupicapra*. From this, he suggests that these lowest levels are probably from MIS 7 or early 6, and that the climate was rigourous, with an open landscape. The two main species hunted, aurochs and horse, were both large animals but with very different behaviours, necessitating two separate hunting strategies (Fernandez, 2001; Fernandez et al., 1998, 2003, 2006).

4.3 Payre and the Bau de l'Aubesier in the MIS 9-7 European context. Traditions?

The comparison between Payre and the Bau de l'Aubesier does not show any significant divergence in terms of raw material strategies. At both sites, we see a local and semi-local provisioning with good quality flint, and some other local rocks. Raw materials were collected in the form of nodules, pebbles, flakes and slabs. At Payre, local stones (basalt and quartzite) were shaped to produce bifaces and pebble tools. These types of tools are absent at the Bau de l'Aubesier. Flint was largely employed for flaking at Payre even if a minor quantity of quartz was used as well. At Bau de l'Aubesier raw material used is flint excepting for one piece in quartzite. Procurement is obtained within 15 km of the site. At neither site do we see any undeniable relationship between changes in core technologies or tool kits and mode of flint procurement.

There are no signs of different specialized activities at either site. Subsistence strategies at both sites show that faunal resources were treated and consumed *in situ*. Herbivores were the main species hunted and each site is characterized by more or less long-term seasonal occupations.

Thus the raw material procurement and subsistence strategi suches observed do not account for the technological differences observed at Payre and the Bau de l'Aubesier.

The technical behaviour observed at Payre and the Bau de l'Aubesier must be seen in the context of the variability of the Western European EMP. The coexistence of some handaxes and dominant core technologies in the Payre sequence is a typical pattern of the EMP with persistence of bifacial tools. The presence of the Levallois core technology at the Bau de l'Aubesier is another technological feature shared by assemblages from the MIS 9.

Beside that, some specific technological features characterise each assemblage. The volumetric blade production at the Bau de l'Aubesier, dated to the end of MIS 7, provides evidence that this type of technology is older than previously shown in southern France, where until now it had been dated to the end of MIS 6 and the beginning of MIS 5 (Gagnepain et al 2004; Moncel et al., 2008, 2010; Blaser et al 2012). In a broader comparison, the only other site in southern Europe with a blade production earlier than MIS 5 is Cave dell 'Olio located in northern Italy, whichdates back to MIS 9 (Fontana et al. 2013, Fontana 2009). As at the Bau de l'Aubesier, at that site there is also early evidence of Levallois core technology. Moreover, the semi-pyramidal cores related to the blade production at Cave dall 'Olio and partially at the Bau de l'Aubesier are unusual for the EMP, where the most common reduction systems are linked to prismatic cores exploited by a rotating and semi-rotating rhythm.

The production of bladelets at Payre, even if occasional, is another noteworthy behaviour which is uncommon in the EMP. The intentional production of bladelets is recordered during the final phases of the Middle Palaeolithic (MIS 4 -3). It has been noted at the sites of El Castillo and Cueva Morin in Spain (Fernández et al. 2004), at Champ Grand (Slimak and Lucas 2005; 128 Slimak 1999) and Combe Grenal in France (Faivre 2012), at Fumane and at Grotta del Cavallo in Italy (Peresani 2012, 131 Peresani et al 2013, Carmignani 2010), and at Balver Höhle in Germany (Pastoors and Tafelmaier 2010). Recently, a bladelet production dated back to the MIS 5 has been described at the site of Riparo del Molare in southern Italy (Aureli and Ronchitelli *in press*).

Focusing our comparison on south-eastern France, where Payre and Bau de l'Aubesier are located, a more few sites can help us to propose a regional scenario. The presence of the Levallois in south- eastern France during the EMP is well known. The sequences of Orgnac 3, covering a span time from MIS 9 to 8, show a gradual development of Levallois technology with a decrease in bifacial tools (Moncel et al 2012, Moncel, 2005; Moncel 1995). The association of a few bifaces and bifacial tools and dominant core technologies brings together Orgnac 3 and Payre, except that the Levallois technology is lacking at Payre (except for some possible pieces introduced into the site in unit F).

The blade production observed at the Bau de l'Aubesier may be compared to what is described at Baume Bonne with both a Levallois and blade technologies dated to the MIS 6/5. The sequence of Baume Bonne, dated from MIS 10 to MIS 5, is long and complex, with changes in the technical behavior through time (Gagnepain and Gaillard, 2005; Hong, 1993). The early phases, units I and II (MIS 10 to 8), show a coexistence of bifaces and pebble tools with a production of flakes by discoid and SSDA technologies. In MIS 8, the Levallois is present and is associated with rare bifaces. During the MIS 6 and 5, the Levallois is stabilized and diversified in various methods including the production of blades (Gagnepain et al 2004). Lack of Levallois evidence associated with shaping processes in the earliest phase at Baune Bonne constitutes a trend comparable to what is recorded in units G and F at Payre. The development of the Levallois and blade technologies in the recent phases at Baume Bonne only partially correspond to what is recognized at the Bau de l'Aubesier.The Levallois core technology at Bonne Bonne is performed by various methods (convergent, centripetal, unipolar) while at the Bau de l'Aubesier only the centripetal method is employed. Moreover, at the Bau de l'Aubesier, the blade production is exclusively made by volumetric systems (pyramidal and prismatic) while at Baume Bonne, blades are obtained by both a volumetric and a surface management (Levallois). This is also the case for Baume Flandin, close to Payre and dated to the MIS 5e (Moncel et al., 2008, 2010), with blade debitage by a Levallois concept and directly on flint slabs. This debitage is associated with a Levallois flake technology in the same level.

5 – Conclusion

Technological behaviors recognized at Payre and the Bau de l'Aubesier shared features typical of the EMP such as, on the one hand, the presence of handaxes, and on the other the use of Levallois and laminar core technologies.
However, differences between the sites appear in the reduction systems employed (volumetric and Levallois concepts only observed at the Bau de l'Aubesier), types of end-products and tool kits. This variability does not seem to be linked to external factors such as the raw materials or other activities.
The two sites located within the same region, on opposite sides of the Rhône River valley, so their environments would have been similar, and we could expect more common features between the two sites. This particular geographical situation can be one of the reasons which contribute to maintaining distinct technological traditions even if the sites are contemporary.
The results at Payre and the Bau de l'Aubesier perfectly illustrate the diversity of technological strategies employed by human groups of the EMP. They demonstrate that the trajectory of behavioural changes in material culture is far from homogeneous and monolithic in time and space. Depending on the chronological and geographical scale, the classical subdivision between Lower and Middle Paleolithic must be revised to describe a complex and multifaceted archaeological reality with a rythm which remains to be described.

Supporting Information

S1 File Materials and Methods

S2 File Tables A, B, C, D

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Author Contributions

Conceptualization: L.C.

Data curation: Raw material analysis (L.W); Technological analysis (L.C.); Faunal analysis (P.F.)

Methodology: For technological analysis (L.C.) Raw material analysis (L.W and M.HM).

Technological variability during the MIS 9-7 in Western Europe. Reduction systems and predetermined products at the Bau de l’Aubesier and Payre (South-East France).

Leonardo Carmignani, Marie-Hélène Moncel, Lucy Wilson

Supporting Information

Supplementary File S1

Materials and Methods

This PDF file includes:
Lithic analysis terminology
References

To clarify the terminology used in this work we are going to describe it in the technological order used during the study of the lithic collection.

Volumetric concept: Volumetric and Surface exploitation were distinguished by means of the volumetric structure analyses (Boëda 1988, 1990, 2013). Supplementary differentiation was integrated to distinguish a surface exploitation applied on a large surface as in the case of the Levallois concept and a surface exploitation applied to a narrow surface but that exploits the core along its short axis. We limited the attribution to a volume exploitation just to the cores that are exploited on the narrow surface along its longer axis.

Striking platforms organization: In relation to the organization of the striking platforms and their positioning on the core the reduction process can follow two types of exploitation modality: polar and peripheral. The polar modality includes all of the reduction systems based on the extraction of a series of removals that are detached starting from a striking platform positioned at one of the poles of the core. In relation to the position of the striking platforms on the cores, three categories of polar exploitation can be identified: Unipolar, Bipolar with opposite striking platforms, and Bipolar with orthogonal striking platforms.
In this subdivision, we do not consider multipolar exploitation to be a valid variant, unlike SSDA systems. In fact, in that case the presence of more than two series of removals on different surfaces of the core can be the result of the repetition of the unipolar or bipolar modality on the same volume.
The peripheral modality includes the reduction systems where the removals were struck from platforms extending around the core’s periphery without a specific starting pole. In this category are include Discoid systems (unifacial and bifacial) and the partial peripheral exploitation systems.

Exploitation methods: After the choice of the volumetric concept and the positioning of the striking platforms (prepared or not), the exploitation method chosen is another technological variant, which serves to complete the reduction system. We defined the method as an algorithm that is a minimal sequence of detachment organized in relation to the direction of the removals and their combination. The direction of the methods can be convergent, unidirectional, bidirectional, centripetal, chordal, or orthogonal. On the basis of the combination of the

removals, the bidirectional method can follow an intersected or alternated rhythm. Various other combinations of removals are possible.
The organization of the detachments was identified by taking into account a previous diacritical analysis of both cores and flakes, distinguishing the initial stage from the main stage of the débitage. Based on this we attributed each piece to a specific method, taking into consideration just the scars that are correlated with the main stage of débitage.

Angle of exploitation: Whatever the reduction systems used the direction of the exploitation of the core can have just two variants: by secant plans and by parallel plans. Among the main reduction systems, exploitation by secant plans is common in the discoidal systems and partially used in Quina reduction systems. The exploitation of parallel plans is used for the majority of the reduction systems, including the Levallois concept. The inclination of the scars of the negatives of the removals has also been documented in order to distinguish whether the blanks come from a secant or parallel plans exploitation. Measurement of the angle degree for both cores and blanks was made with a profilometre.

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Leonardo Carmignani, Marie-Hélène Moncel, Lucy Wilson

Supporting Information

Supplementary File S2. Tables

This PDF file includes: Tables A-F

Table A. Payre, type A and type B flakes

Levels	Gb		Ga		Fd		Fc		Fb		Fa	
	N	%	N	%	N	%	N	%	N	%	N	%
A1 Centripetal flakes with secant dorsal scars	24	45.3	168	35.5	13	28.3	7	38.9	7	53.8	56	45.5
A2 Debordant flakes with secant dorsal scars	12	22.6	77	16.3	7	15.2	2	11.1	1	7.7	32	26
Subtotal (A type)	**36**	**67.9**	**245**	**51.8**	**20**	**43.5**	**9**	**50**	**8**	**61.5**	**88**	**71.5**
B1 Centripetal flakes with parallel dorsal scars	13	24.5	169	35.7	20	43.5	7	38.9	5	38.5	27	22
B2 Debordant flakes with parallel dorsal scars	4	7.5	59	12.5	6	13	2	11.1	-	0	8	6.5
Subtotal (B type)	**17**	**32.1**	**228**	**48.2**	**26**	**56.5**	**9**	**50**	**5**	**38.5**	**35**	**28.5**
Total	53	100	473	100	46	100	18	100	13	100	123	100

Table B. Payre, Type of platform of Type A and B flakes.

Type of platform	Gb		Ga		Fd		Fc		Fb		Fa	
	N	%	N	%	N	%	N	%	N	%	N	%
(A1) Inclined	16	*30.2*	102	*21.6*	13	*28.3*	6	*33.3*	7	*53.8*	56	*45.5*
(A1) Rectilinear	8	*15.1*	35	*7.4*	-	*0*	-	*0*	-	*0*	-	*0*
(A1) Punctiform/Linear	-	*0*	31	*6.6*	-	*0*	1	*5.6*	-	*0*	-	*0*
(A2) Secant	9	*17*	44	*9.3*	6	*13*	2	*11.1*	1	*7.7*	28	*22.8*
(A2) Rectilinear	1	*1.9*	12	*2.5*	-	*0*	-	*0*	-	*0*	2	*1.6*
(A2) Punctiform/Linear	2	*3.8*	21	*4.4*	1	*2.2*	-	*0*	-	*0*	2	*1.6*
(B1) Secant	4	*7.5*	70	*14.8*	5	*10.9*	2	*11.1*	-	*0*	5	*4.1*
(B1) Rectilinear	9	*17*	59	*12.5*	13	*28.3*	5	*27.8*	5	*38.5*	19	*15.4*
(B1) Punctiform/Linear	-	*0*	40	*8.5*	2	*4.3*	-	*0*	-	*0*	3	*2.4*
(B2) Secant	4	*7.5*	17	*3.6*	2	*4.3*	1	*5.6*	-	*0*	6	*4.9*
(B2) Rectilinear	-	*0*	30	*6.3*	4	*8.7*	1	*5.6*	-	*0*	2	*1.6*
(B2) Punctiform/Linear	-	*0*	12	*2.5*	-	*0*	-	*0*	-	*0*	-	*0*
Total	53	*100*	473	*100*	46	*100*	18	*100*	13	*100*	123	*100*

Table C. Bau de l'Aubesier, type A and type B flakes

Levels	K2		K1-K		J4		J3		J2		J1-J	
	N	%	N	%	N	%	N	%	N	%	N	%
A1 Centripetal flakes with secant dorsal scars	5	27.8	8	38.1	6	11.8	2	15.4	1	100	-	0
A2 Debordant flakes with secant dorsal scars	3	16.7	1	4.8	7	13.7	-	0	-	0	2	16.7
B1 Centripetal flakes with parallel dorsal scars	8	44.4	8	38.1	33	64.7	11	84.6	-	0	7	58.3
B2 Debordant flakes with parallel dorsal scars	2	11.1	4	19.0	5	9.8	-	0	-	0	3	25
Total	18	100	21	100	51	100	13	100	1	100	12	100

Table D. Bau de l'Aubesier, Type of platform of Type A and B flakes.

	K2		K1-K		J4		J3		J2		J1-J	
Type of platform	N	%	N	%	N	%	N	%	N	%	N	%
(A1) Secant	1	5,6	8	38,1	2	3,9	2	15,4	1	100	-	0
(A1) Rectilinear	3	16,7	-	0	2	3,9	-	0	-	0	-	0
(A1) Punctiform/Linear	1	5,6	-	0	2	3,9	-	0	-	0	-	0
(A2) Secant	1	5,6	-	0	7	13,7	-	0	-	0	-	0
(A2) Rectilinear	-	0	1	4,8	-	0	-	0	-	0	-	0
(A2) Punctiform/Linear	2	11,1	-	0	-	0	-	0	-	0	-	0
(B1) Secant	1	5,6	1	4,8	-	0	-	0	-	0	-	0
(B1) Rectilinear	-	0	-	0,0	18	35,3	5	38,5	-	0	3	25,0
(B1) Punctiform/Linear	7	38,9	7	33,3	15	29,4	6	46,2	-	0	4	33,3
(B2) Secant	-	0	1	4,8	-	0	-	0	-	0	-	0
(B2) Rectilinear	-	0	2	9,5	3	5,9	-	0	-	0	3	25,0
(B2) Punctiform/Linear	2	11,1	1	4,8	2	3,9	-	0	-	0	2	16,7
Total	18	100	21	100	51	100	13	100	1	100	12	100

Table E. Payre, Comparison of the flake techno-types with the incidence of retouch for each category. * Numbers in brackets indicate the number of retouched pieces for each category. The % ret column indicates the percentage of retouched pieces for each category.

Levels	**Gb**		**Ga**		**Fd**		**Fc**		**Fb**		**Fa**	
	N tot(ret)	*% ret*	N tot(ret)	*% ret*	N tot(ret)	*% ret*	N tot(ret)	*% ret*	N tot(ret)	*% ret*	N tot(ret)	*% ret*
Centripetal flakes	37 (5)	*13.5*	337 (83)	*24.6*	33 (4)	*12.2*	14 (4)	*28.5*	12(2)	*16.6*	83(22)	*26.5*
Debordant flakes (chordal)	16 (5)	*31.2*	135 (48)	*35.5*	12 (1)	*8.3*	3	*0*	-	*0*	37 (4)	*10.8*
Pseudolevallois	-	*0*	1	*0*	1	*0*	1	*0*	1	*0*	3	*0*
Unipolar flakes	10 (1)	*10*	24 (3)	*12.5*	13	*0*	3 (1)	*33.3*	3	*0*	26 (8)	*30.7*
Debordant unipolar flakes	2	*0*	5 (1)	*20*	4	*0*	-	*0*	-	*0*	1 (1)	*100*
Bipolar flakes	1	*0*	2	*0*	-	*0*	2	*0*	-	*0*	-	*0*
Debordant bipolar flakes	-	*0*	1	*0*	-	*0*	2	*0*	-	*0*	-	*0*
Orthogonal flakes	1	*0*	5 (3)	*60*	-	*0*	2	*0*	-	*0*	-	*0*
Convergent/sub-convergent flakes	2 (1)	*50*	10	*0*	-	*0*	-	*0*	-	*0*	-	*0*
Bladelets	-	*0*	-	*0*	3	*0*	-	*0*	-	*0*	-	*0*
Blades	-	*0*	-	*0*	7	*0*	-	*0*	-	*0*	-	*0*
Kombewa	3	*0*	27 (5)	*18.5*	1	*0*	1 (1)	*100*	1	*0*	19 (1)	*5.2*
Kombewa debordant	1 (1)	*100*	4 (2)	*50*	-	*0*	-	*0*	-	*0*	3	*0*
Wide flakes	1	*0*	22 (7)	*31.8*	17 (1)	*5.8*	6 (3)	*50*	1	*100*	31 (9)	*29*
Striking platform flakes	2 (1)	*50*	1	*0*	-	*0*	7	*0*	-	*0*	2	*0*
Shaping/retouching flakes	4	*0*	43	*0*	1	*0*	3	*0*	-	*0*	10	*0*
Rejuvenation flakes	1	*0*	21 (14)	*66.6*	-	*0*	-	*0*	-	*0*	-	*0*
Crested flakes	1	*0*	-	*0*	4	*0*	-	*0*	1	*0*	1	*0*
Total	82 (18)	*19.2*	638 (166)	*26*	96 (6)	*6.2*	44 (9)	*20.4*	19(2)	*15.5*	216 (45)	*20,8*

Table F. Bau de l’Aubesier, Comparison of the flake techno-types with the incidence of retouch for each category. * Numbers in brackets indicate the number of retouched pieces for each category. The % ret column indicates the percentage of retouched pieces for each category.

Levels	**K2**		**K1-K**		**J4**		**J3**		**J2**		**J1-J**	
	num	**%**	**num**	**%**	**num**	**%**	**num**	**%**	**num**	**%**	**num**	**%**
Flakes (Cortex >50%)	5	*0*	4	*0*	12(1)	*8.3*	3	*0*	2	*0*	10	*0*
Flakes (Cortex<50%)	11	*0*	-	*0*	20(1)	*5*	4	*0*	-	*0*	40	*0*
Centripetal flakes	13(2)	*15.4*	16(1)	*6.2*	39(11)	*28.2*	13	*0*	1	*0*	7(2)	*28.6*
Debordant flakes (chordal)	5(2)	*28.6*	5(1)	*20*	12	*0*	-	*0*	-	*0*	5	*0*
Unipolar flakes	10(1)	*10*	22(4)	*18.2*	30(4)	*13.3*	6	*0*	2	*0*	13(2)	*15.3*
Debordant unipolar flakes	3(1)	*33.3*	5(2)		4		-	*0*	-	*0*	1(1)	
Bipolar flakes	4(2)	*50*	6(4)	*66.7*	2(1)	*50*	-	*0*	-	*0*	-	*0*
Debordant bipolar flakes	1(1)	*100*	-	*0*	1	*0*	-	*0*	-	*0*	-	*0*
Orthogonal flakes	-	*0*	-	*0*	1	*0*	-	*0*	-	*0*	-	*0*
Debordant Orthogonal flakes	-	*0*	-	*0*	1	*0*	-	*0*	1	*0*	-	*0*
Convergent/sub-convergent flakes	4(2)	*50*	5(1)	*20*	28(6)	*21.4*	2	*0*	-	*0*	1	*0*
Bladelet	1	*0*	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*
Blades	19(4)	*21.1*	19(3)	*15.8*	14(5)	*35.7*	1	*0*	1	*0*	3(1)	*33.3*
Crested blade	2	*0*	1	*0*	-	*0*	-	*0*	-	*0*	1	*0*
Kombewa	-	*0*	3	*0*	1	*0*	-	*0*	-	*0*	-	*0*
Macro-outils	2 (2)	*100*	10(10)	*100*	1(1)	*100*	-	*0*	-	*0*	2(2)	*100*
Striking platform flakes	3	*0*	5	*0*	6	*0*	1	*0*	-	*0*	-	*0*
Shaping/retouching flakes	-	*0*	1	*0*	3	*0*	-	*0*	-	*0*	-	*0*
Rejuvenation flakes	-	*0*	2(1)	*50*	2(1)	*50*	-	*0*	-	*0*	-	*0*
Burin de Siret	1(1)	*100*	3 (2)	*66.6*	8	*0*	-	*0*	1	*0*	-	*0*
Total	84 (18)	*21,4*	107 (29)	*27,10*	185 (31)	*16,7*	30	*0*	8	*0*	83(8)	*9,6*

Chapter 3

Blade and bladelets in the Neanderthal techno-cultural baggage: Evolution of elongated product at the Bau de l'Aubesier rock shelter (France).

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Abstract

The insurgence of the blade phenomenon in Europe can be considered as one of the most remarkable facts that is related to a broader technological change which is the shift from the Lower to the Middle Paleolithic. The emergence of blades is inhomogeneous in time and space and can be detected in three different geographical areas that are Europe, Middle-East and Africa: in Africa around 500 ka, in Middle-East between 300-250 ka and in Europe between 250-200 ka.

In Europe, after the first phase of insurgence, which is concentrated in northern Europe, blade reduction systems reappear clearly during the MIS 5. Subsequently, at the end of the Middle Paleolithic (MIS 4 – 3) bladelets make their appearance while blade phenomenon spread also in the south and eastearn Europe.

Reduction strategies used to produce blades during this large span of time are constituted by a large variability that is not possible to fill it in a univocal model. The evolution of the Middle Paleolithic blade phenomenon shows a complex scenario that is not yet well defined.

In this paper, we report new evidences of blade and bladelets production found at Bau de l'Aubesier contributing to enlarge our knowledge about the rise and the evolution of production of elongated product during the Middle Paleolithic in the southern Europe. The lithic industries analysed by a technological approach put in evidence a long-term evolution of blade production covering a span time of 100 ka from the end of MIS 7 (marine isotopic stage) to the MIS 5. The blades and bladelets reduction strategies recognized allong the sequence show a high technological variability that evolved in parallel with a multiple type of flakes reduction systems. The meaning of this unexpected diversity will be discussed.

Introduction

Three macro-areas show the insurgence of the blade phenomenon during the Middle Pleistocene: Africa, Near East and Europe (Fig 1). The most ancient blade production which dates back to around 500 ka have been recognized in Kenya in the Kapturin formation (Johnson & McBrearty 2010) and in South Africa in the site of Kathu-Pan (Wilkins & Chazan 2012).
After these ephemeral traces, we have to wait at least 200.000 years before the reappearance of blade production that this time emerge in the Near East under the form of the so-called Amudian industries dating back to MIS 9 and MIS 8 (Mercier & Valladas 2003; Barkai *et al.* 2005).

In Africa, it reappears in the south, in the Howiesons Poort complex just after 70,000 years BP (Soriano et al. 2007). Blade production continue to be present in the Near East also in the final part of the Middle Pleistocene (MIS 7 and 6) covering a larger area and with different industries known by various names: the Hummalian (Le Tensorer 2005; Richter *et al.* 2011), Pre-Aurignacian (Bordes 1977), Hayonim (Meignen 2011), and Djruchula-Koudaro industries (Meignen & Tushabramishvili 2006, 2010).

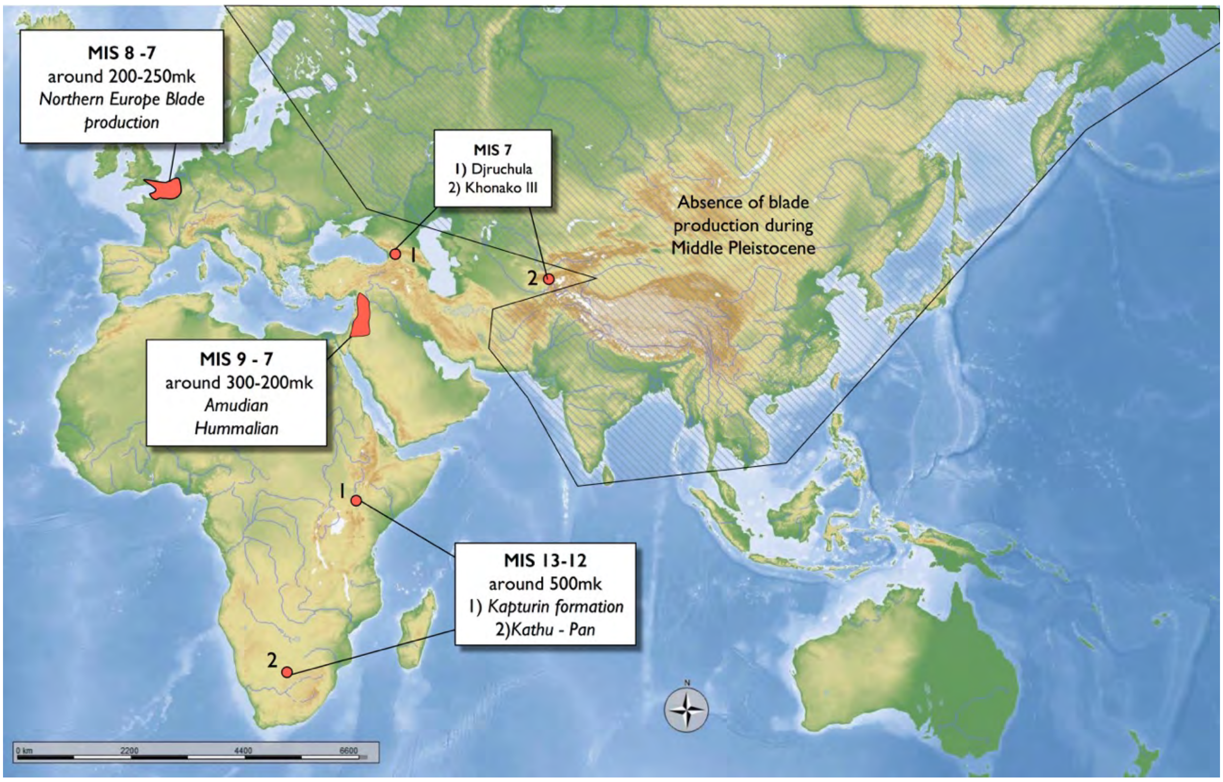


Figure 1 – Location of blades production during the Middle Pleistocene.

The third and last area of insurgence is northern Europe, where blade production has been found in several sites dating back to the end of MIS 8 and MIS 7 (e.g. Révillion 1995; Koehler et al. 2014); (Fig. 2).

In these sites, distinct reductions strategies are used to produce blades that in general we can divide in two mains group. The first group is based on a volumetric exploitation such as those of Saint-Valéry-sur-Somme (Heinzelin & Haesaerts 1983), Bapaume-les Osiers (Koehler 2008) and Therdonne (Locht *et al*. 2010) in France, Rissori (Adam 1991; Adam & Tuffreau 1973) in Belgium. The second group, less frequent, follows a surface exploitation or more specifically a Levallois concept, as noted at the site of Biache-Saint-Vaast in northern France (Böeda 1988).

In Europe, just one isolated case of blade production comes out from this chronological time span, which is the site Cave dall'Olio, located in the Italian peninsula and dating back to MIS 9 (Fontana et al. 2009; Fontana et al. 2013).

During the glacial pick of the MIS 6 there is lack of the archaeological evidence in the European northern plain (Fig 2). Just one site namely Cotte Saint Brelade in the island of Jersey "Great Britain" have yielded a lithic assemblage showing a production of elongated pieces made out by a volumetric system (Soriano 2002).

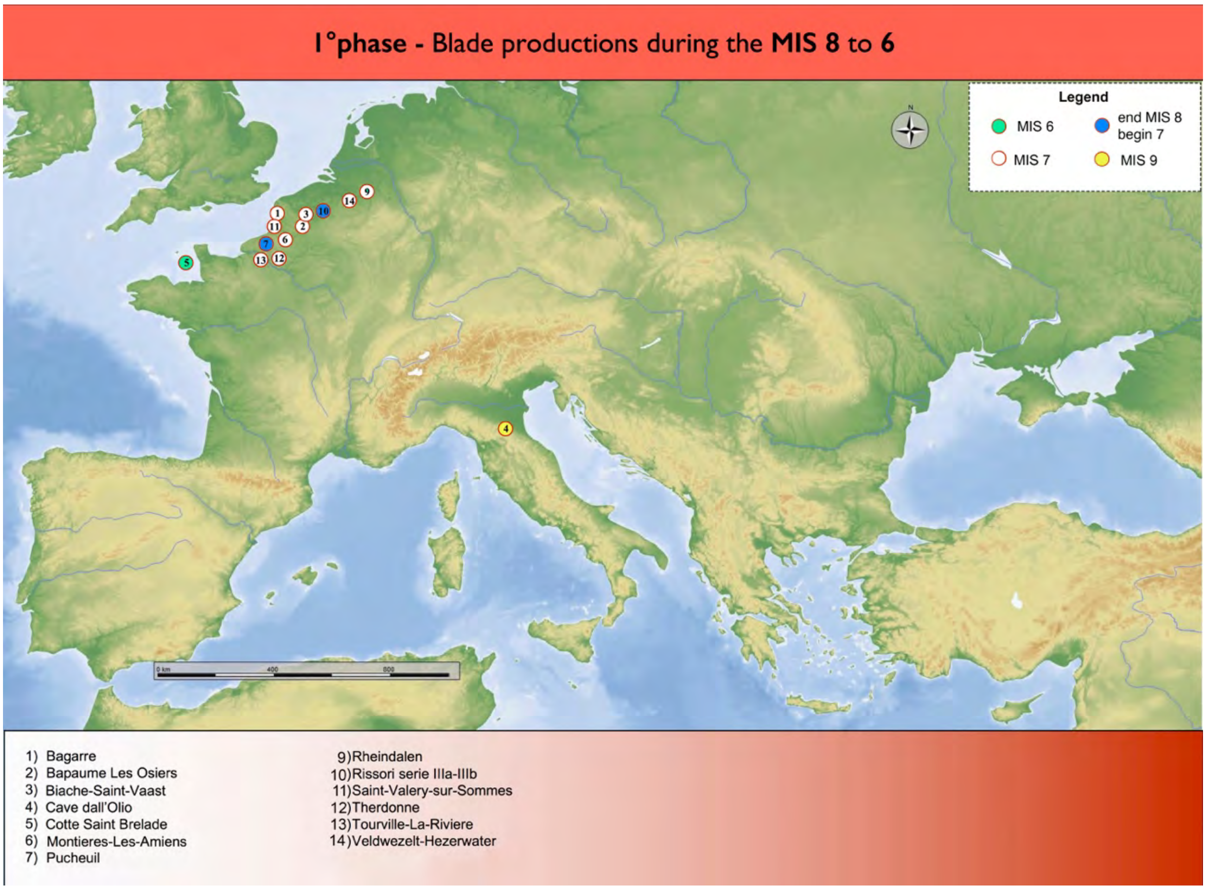


Figure 2 – Blade production during the MIS 8 to 6 in Europe.

New clear evidences of blade production come back to be present in the MIS 5 and this time with a more widespread including the central south of France and few site in eastern Europe (Fig 3).

During MIS 5 blade production continue to be abundant in northern Europe as exemplified by the sites of Riencourt lès-Bapaume (Ameloot-Van der Hejden 1993; Goval & Hérisson 2006), Saint-Germain-des-Vaux (Cliquet 1992; Révillion & Cliquet 1994), Seclin (Révillion & Tuffreau 1994), Bettencourt-Saint-Ouen (Loch 2002), Blangy-Tronville (Depaepe *et al.* 1999), and Rocourt (Otte 1994a).

Other areas in this period are touched by blades. In Germany blade production have been recognized in the site of Tönchesberg (Conard 1990) and Wallertheim (Conard & Adler 1997). In central and southern France in the sites of Angé (Locht *et al.* 2008), Vinneuf (Gouédo 1994), Baume Flandin (Moncel 2005; Moncel *et al.* 2008) Cantalouette 4 (Blaser et al. 2012) and Baume Bonne (Gaignepain and Gaillard 2005; Hong 1993).

Evidences of blade production during the MIS 5 are also been highlighted in eastern Europe such as in in the sites of Proniatin and Yezupil where blades are produced by a Levallois reduction strategies (Chabai et al 2006). Blades never played a dominant role in the European Middle Paleolithic but co-existed with various other reduction strategies (e.g. Levallois, Discoid) as well as with a number of shaping systems such as those noted at the sites of Bapaume-les Osiers (Koehler 2008) and Vinneuf (Gouédo 1994) in France.

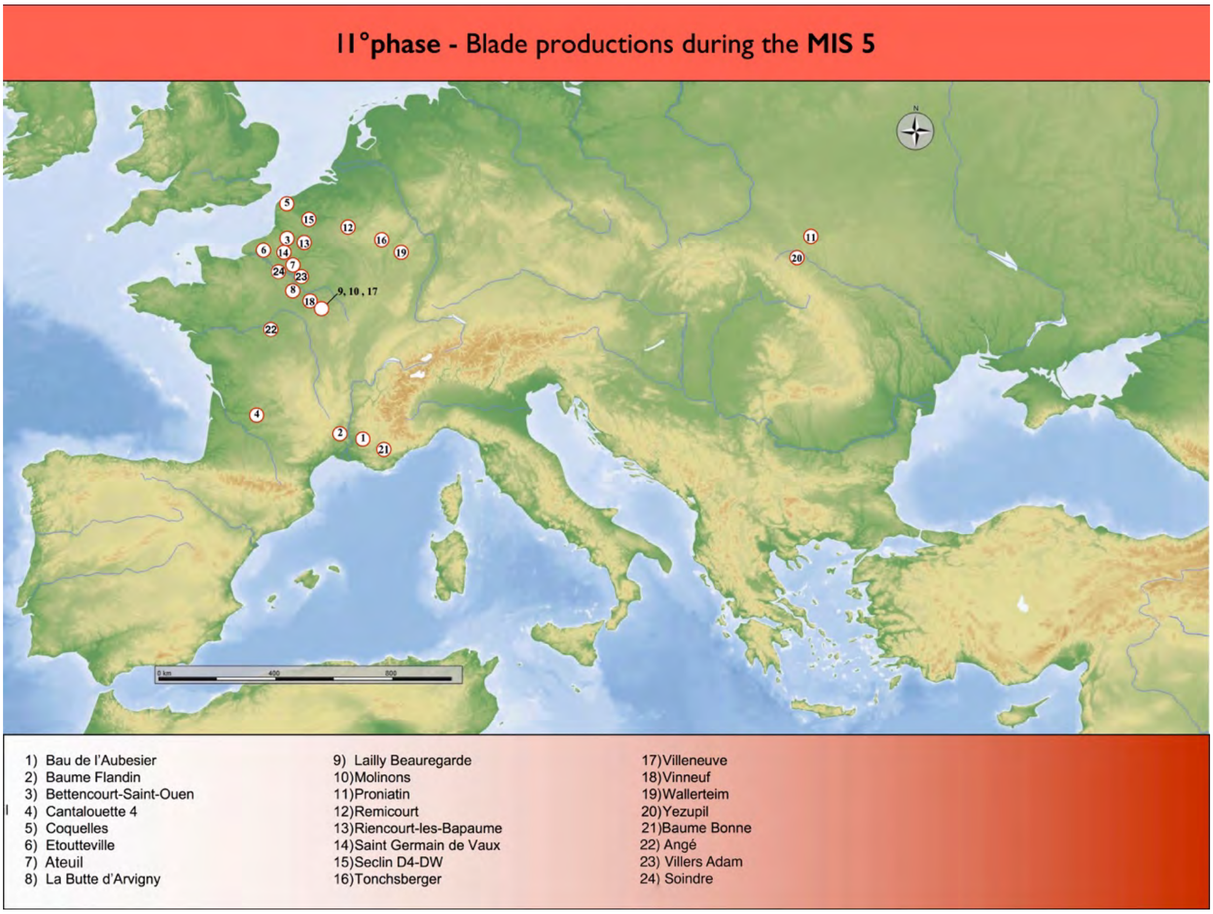


Figure 3 – Blade production during the MIS 5 in Europe.

The third and last phase of Middle Paleolithic blade production dates back to the MIS 4 and the beginning of the MIS 3. In this period blades reach the maximum expansion occupying areas not previously touched by this phenomenon (Fig 4).

This expansion recordered by many sites spread in the eastern European continent until the Crimean Peninsula such as in the site of Kabazi II and Karabi Tamchin and further at east in the Donbass-Asov region such in the site of of Kurdiumovka, Zvanovka (Chabai et al. Ed. 2006).

A second geographical spread follow the axis north-south penetrating all throughout the Italian peninsula such as in the sites of Fumane in Veneto region (Peresani 2012), Grotta Reali in Molise (Arzarello *et al.* 2004; Peretto 2012) and Grotta del Cavallo in the Apulia region (Carmignani 2010).

On the bases of the current state of the knowledge this spread seems not to involve others areas such as the Iberian Peninsula, Greece and the Anatolian region.

During the MIS 4-3 a more ephemeral but noteworthy phenomenon which is the production of bladelets partially overlap this blade expansion (Fig 4). Bladelets production has been noted at the sites of El Castillo and Cueva Morin in northern Spain (Maíllo Fernández 2001; Maíllo-Fernández *et al.* 2004), at Champ Grand (Slimak & Lucas 2005) and Combe Grenal in France (Faivre 2012), Fumane (Peresani *et al.* 2013) and Grotta del Cavallo in Italy (Carmignani 2010) and Balver Höhle in Germany (Pastoors & Tafelmaier 2010).

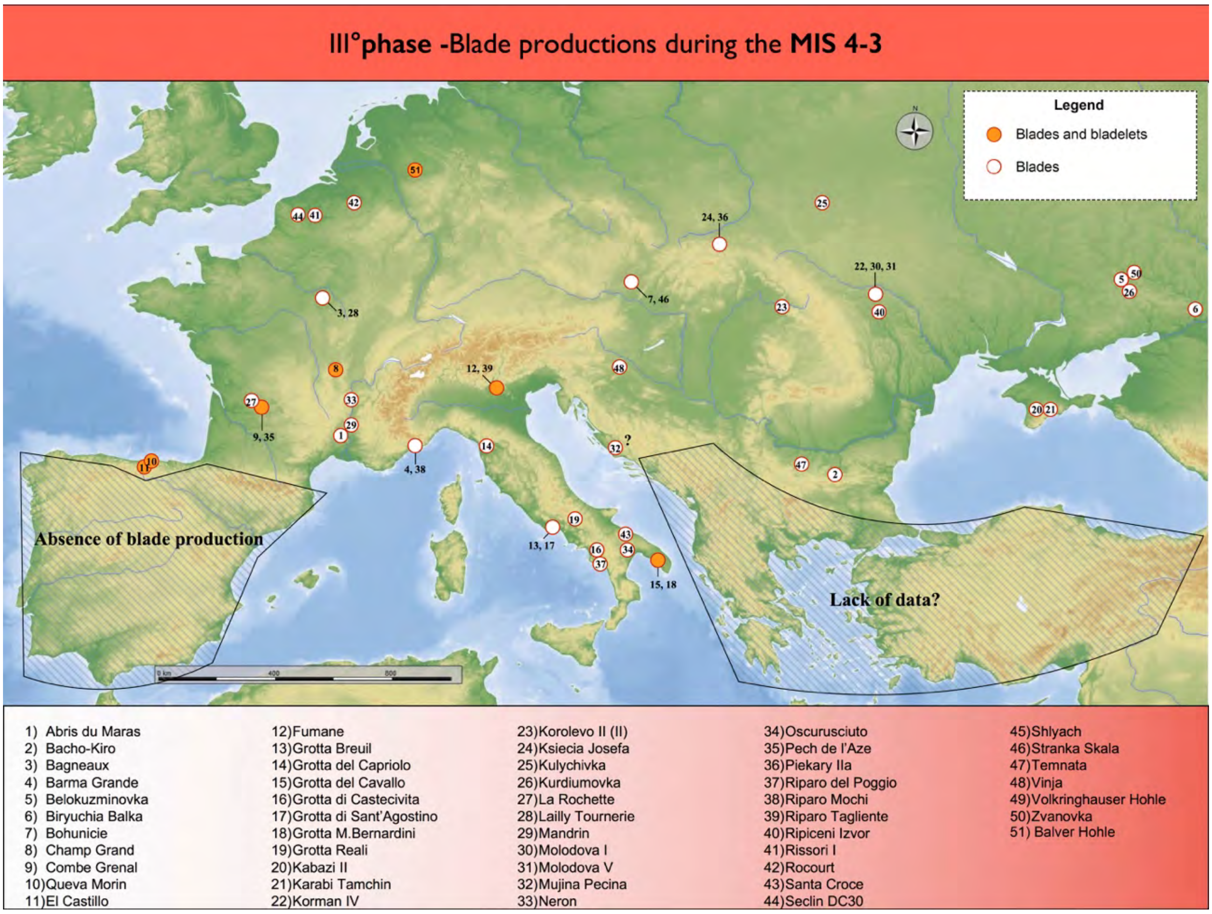


Figure 4 – Blade and bladelets production during the MIS 4-3 in Europe.

The Middle Paleolithic blade phenomenon does not fully fit in a univocal model. The three events of insurgence described above are discontinues in time and space and are composed by a multifaceted pattern of different blade reduction strategies.

On the basis of the current state of scientific knowledge, it is possible to draw a general scenario that shows how the first phase of blade production during the MIS 7 is circumscribed in northern Europe while during the second and third phase (MIS 5 to 3) the blade spreads in the central and south of France and later on in the whole European continent leaving however untouched some regions (Fig 4).

In this paper, we present the results of technological analysis of reduction strategies on the entire sequence of Bau de l'Aubesier located in the region of Vaucluse (South-eastern France). Bau the l'Aubesier is a key site because it is a long archaeological sequence covering a span time of 100 ka from the end of MIS 7 to the MIS 5 containing an uninterrupted presence of blade reduction systems.

Through a detailed analysis of the lithic assemblages and more specifically of the blade production, we will address the following questions:

1) The laminar phenomenon in Europe spans more than 200,000 years of technological evolution. Nevertheless, blades do not appear at the same time in all the regions. If northern Europe show its presence at least since the MIS 7 is just during the MIS 5 that blades are confirmed in southern Europe and specifically in southern France. Are these two events part of a single macro-phenomenon or do they rise from different techno-cultural identities with independent origins?

2) Bau de l'Aubesier dates back from the end of MIS 7 to the MIS 5 and shows a continuous presence of blades reduction strategies. Can we trace an internal evolution of the blade production during this time span?

3) Evidences of Middle Paleolithic bladelets production have been recognized until now during the MIS 4 and the beginning of MIS 3 in different parts of Europe.The unexpected evidence of bladelets reduction strategies recognized at Bau de l'Aubesier and positioned at the end of MIS 5 will be discussed.

2 Material

Bau de l'Aubesier is a large rock shelter located in the gorge de la Nesque, Vaucluse (Southeastern France). The site, known since the beginning of the 20th century (Moulin 1903, 1904), has been extensively excavated starting the 1987 by an international team led by Sergey Lebel, then of the University of Quebec, Montreal, Canada (Lebel 2000 a, b).

The site contains a long sedimentation approximately 13 m deep and covering a time range from 100 Ka (thousands of years ago) to more than 200 ka approximately (Fig 5).

The excavation was conducted on three distinct but contiguous areas named Moulin Trench, Lower Slope and Trench L (Fig 5). Moulin Trench area is 3 m^2 while the Lower Slope and the Trench L cover a larger area respectively of 63 and 50 m^2.

The entire sequence is composed by 14 archaeological levels which were divided during the excavation into several sub layers corresponding to a slight difference in sedimentation.

Several radiometric dates and faunal analysis positioning the sequence from the end of the MIS 7 to the MIS 5 (Blackwell et al., 2001; Lebel et al., 2001; Fernandez, 2006) (Fig. 5).

Just one discordance between the faunal and radiometric is present for the layer H.

The TL ages for layer H yielded a minimum age of 169 ± 17 ka and a maximum age of 191 ± 15 ka positioning the layer H to the OIS 6 to 7a (Lebel et al. 2001) while based on the faunal data, Fernandez (2006) positioned the layer H to the MIS 5e.

The excavation season conducted from 1987 to 2000 produced a large amount of lithic and faunal assemblages with a different concentration trough the sequence (Fig 5).

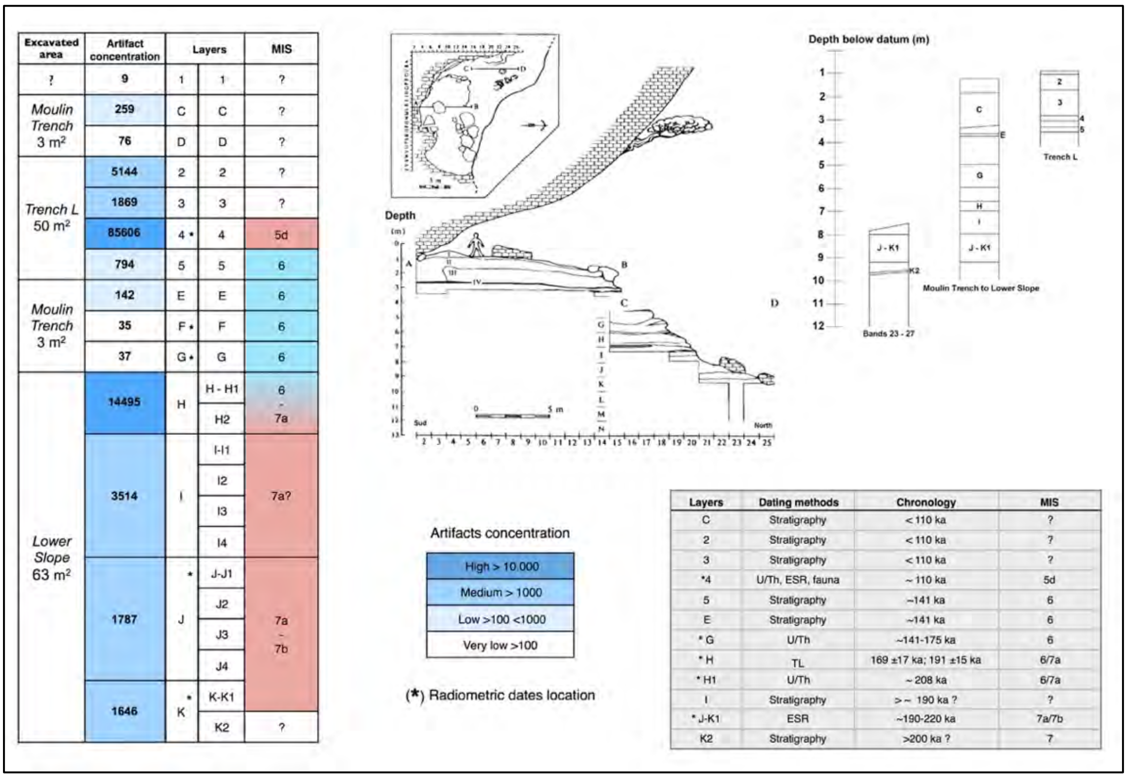
The lithic items that concerned this study are composed by 115413 pieces including flakes, cores, pebbles and debris. The main concentration of pieces is in the level IV and H. Levels C, D, E, G, F which correspond to the smaller excavated area have yielded few pieces mainly composed by undetermined fragments (Table 1 and Table A Supplementary File).

The entire assemblage is in flint and is collected within 15 km of the site (Wilson, 2007a, b, c; 109 Wilson, 2011; 110 e 111 Browne and Wilson, 2011, 2013; 112 Wilson and Browne, 2014).

In all levels, a considerable proportion of the lithic assemblage has been deeply patinated. Deeply patined pieces and pieces with disorganized scars were classified as undetermined flakes.

Along the entire sequence small debris (<20mm) are in general abundant and attest to an intense flaking activity *in situ*. This is particularly evident in the level IV in which the 74.7% of assemblages is composed by undetermined fragment <20mm. Undetermined flakes are also a significant part of the collection with a major concentration in the levels 3 and 2 (Table 1).

Determined removals ratio, excluding the few pieces found in the Moulin Trench, range from 3.7 % of the assemblages in level K to 24.9 in the level 5. Cores are present in all levels ranging from 0.5 % of the assemblages in the level IV to 2.6 % in the level 5.



Excavated area	Artifact concentration	Layers		MIS
?	9	1	1	?
Moulin Trench 3 m²	259	C	C	?
	76	D	D	?
Trench L 50 m²	5144	2	2	?
	1869	3	3	?
	85606	4 •	4	5d
	794	5	5	6
Moulin Trench 3 m²	142	E	E	6
	35	F •	F	6
	37	G •	G	6
Lower Slope 63 m²	14495	H	H - H1	6 - 7a
			H2	
	3514	I	I-I1	7a?
			I2	
			I3	
			I4	
	1787	J *	J-J1	7a - 7b
			J2	
			J3	
			J4	
	1646	K *	K-K1	
			K2	?

Layers	Dating methods	Chronology	MIS
C	Stratigraphy	< 110 ka	?
2	Stratigraphy	< 110 ka	?
3	Stratigraphy	< 110 ka	?
*4	U/Th, ESR, fauna	~ 110 ka	5d
5	Stratigraphy	~141 ka	6
E	Stratigraphy	~141 ka	6
* G	U/Th	~141-175 ka	6
* H	TL	169 ±17 ka; 191 ±15 ka	6/7a
* H1	U/Th	~ 208 ka	6/7a
I	Stratigraphy	> ~ 190 ka ?	?
* J-K1	ESR	~190-220 ka	7a/7b
K2	Stratigraphy	>200 ka ?	7

Figure 5 – Bau de l'Aubesier stratigraphy and chronology (after Wilson and Brown 2016 modified)

Table 1 - Overall composition of the lithic assemblages

Chronology	MIS 7b - 7a						MIS 7a-6	
Levels (Lower slope)	K		J		I		H	
	n	%	n	%	n	%	n	%
Undetermined fragment<20	953	*57,9*	834	*46,7*	1742	*49,6*	7606	*52,5*
Undetermined fragment>20	137	*8,3*	275	*15,4*	227	*6,5*	1595	*11*
Undetermined pieces<20	222	*13,5*	122	*6,8*	267	*7,6*	1151	*7,9*
Undetermined pieces>20	65	*3,9*	70	*3,9*	157	*4,5*	1164	*8*
Complete flakes/blades	191	*11,6*	306	*17,1*	825	*23,5*	2066	*14,3*
Fragmented flakes/blades	61	*3,7*	141	*7,9*	246	*7*	669	*4,6*
Cores (Entire and fragmented)	17	*1*	39	*2,2*	50	*1,4*	244	*1,7*
Total	1646	*100*	1787	*100,0*	3514	*100*	14495	*100*

Chronology	MIS 6						?			
Levels (Moulin Trench)	G		F		E		D		C	
	n	%	n	%	n	%	n	%	n	%
Undetermined fragment<20	8	*21,6*	16	*45,7*	49	*34,5*	46	*60,5*	131	*50,6*
Undetermined fragment>20	3	*8,1*	3	*8,6*	11	*7,7*	5	*6,6*	34	*13,1*
Undetermined pieces<20	6	*16,2*	4	*11,4*	14	*9,9*	11	*14,5*	12	*4,6*
Undetermined pieces>20	3	*8,1*	2	*5,7*	8	*5,6*	5	*6,6*	26	*10*
Complete flakes/blades	11	*29,7*	7	*20*	38	*26,8*	9	*11,8*	37	*14,3*
Fragmented flakes/blades	4	*10,8*	2	*5,7*	18	*12,7*	-	*0*	11	*4,2*
Cores (Entire and fragmented)	2	*5,4*	1	*2,9*	4	*2,8*	-	*0*	8	*3,1*
Total	37	*100*	35	*100*	142	*100*	76	*100*	259	*100*

Chronology	MIS 6		MIS 5d		?					
Levels (Trench L)	5		4		3		2		1	
	n	%	n	%	n	%	n	%	n	%
Undetermined fragment<20	256	*32,2*	63963	*74,7*	1188	*63,6*	2856	*55,5*	2	*22,2*
Undetermined fragment>20	86	*10,8*	5945	*6,9*	110	*5,9*	440	*8,6*	-	*0*
Undetermined pieces<20	84	*10,6*	4958	*5,8*	309	*16,5*	726	*14,1*	-	*0*
Undetermined pieces>20	52	*6,5*	3303	*3,9*	101	*5,4*	271	*5,3*	1	*11,1*
Complete flakes/blades	198	*24,9*	4996	*5,8*	108	*5,8*	475	*9,2*	3	*33,3*
Fragmented flakes/blades	97	*12,2*	2014	*2,4*	42	*2,2*	336	*6,5*	3	*33,3*
Cores (Complete and fragmented)	21	*2,6*	427	*0,5*	11	*0,6*	40	*0,8*	-	*0*
Total	794	*100*	85606	*100,0*	1869	*100*	5144	*100*	9	*100*

3 Methods

All cores, core fragments, tools, tool fragments and all blades and blade fragments are selected regardless of their size. The technological analysis follows the chaîne opératoire approach based on the identification of the distinct phases of the process (Cresswell 1983, Pelegrin et al. 1988, Perlès 1991, Geneste 1991a, b). Percussion technique, methods and concepts that underlie the reduction strategies has been analysed (Pelegrin 1991, 2000, 2005; Boeda et al 1990).
The identification of the Levallois concept follows the guidelines set out by Boëda (1994). In terms of the Discoid production, we used the definition by Boëda (1993, 1991) taking also into account broader criteria (Peresani 1998, Slimak 2003).
Diacritical analysis was applied to cores and blanks in order to identify the chronological order of the scars distinguishing the preparation phases to the main production phases (Dauvois 1973, Inizan et al. 1995).
The definition and the characterization of the blade production have been predated by a personal analytical approach that takes into account four technical parameters: the volumetric concept, the type of core configuration and the direction and organization of the removals. The combination of these parameters allows us to preliminary describe and identify the specificities of the blades technological systems (Fig. 6).
The parameters taken into consideration when defining blades and bladelets categories were: types of platform, knapping surface angles, cutting edge angles, transversal cross-section, longitudinal profile, length-width ratio and width-thickness ratio.
The maximum dimensions of each complete blades and bladelets were recorded using digital calipers. A supplementary classification has been used to define the elongation class of products (Fig 7).

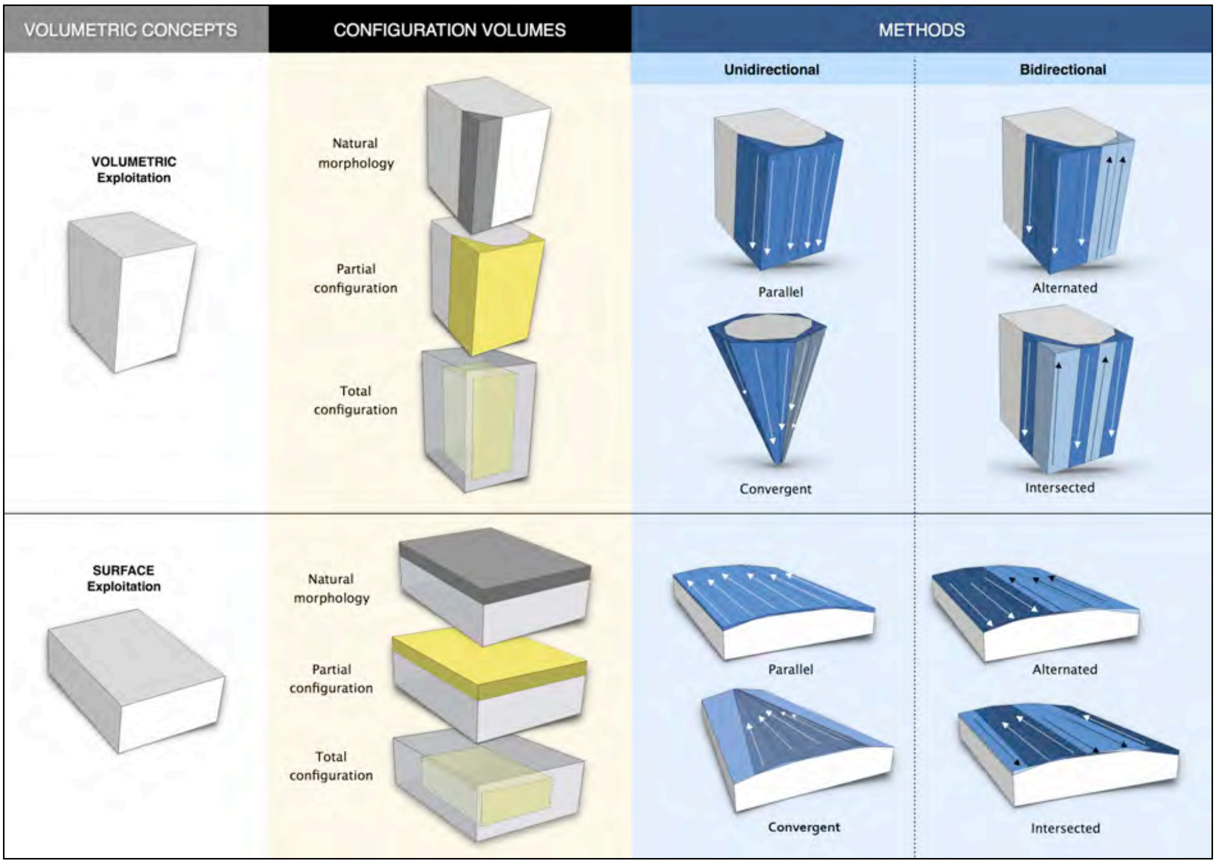


Figure 6 – Blade reduction strategies varibility and terminologies uses in this paper.

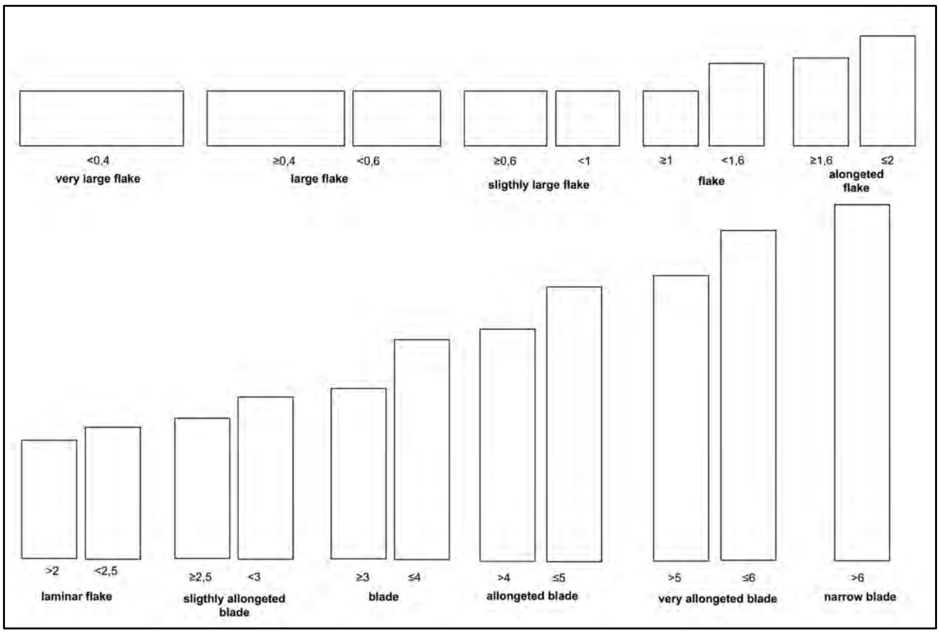


Figure 7 – Elongation parameters of blade and flake production.

3 - Results

3.1 Overall lithic assemblage composition

The whole sequence is dominated by cores aimed to produce flakes beside a minor presence of blade reduction strategies. The blade cores ratios range from 28.2% in level J to 3.3% for level IV (Table 2). The same tendency is recognizable also observing the end-products in which blades ratios range from 15.9% in level K to 3.3 % in level H (Table 2).
Bladelets cores are also present and are concentrated in level IV with 7.7% of the entire cores for this level. One bladelet core has been found in level 5 and two in the level 2.
Bladelets reduction strategies in level IV are also confirmed by the presence of 62 entire bladelets and 132 fragmented bladelets (Table A in Supplementary File). Bladelets are also present in level H and 2 with in a minor percentage (Table 3).

Table 2 - Cores and fragmented cores

Levels	MIS 7b - 7a						MIS 7a-6		MIS 6						?				MIS 6		MIS 5d		?			
	K		J		I		H		G		F		E		D		C		5		IV		3		2	
	N	*%*	N	*%*	N	*%*	N	*%*	N	*%*	N	*%*	N	*%*	N	*%*	N	*%*	N	*%*	N	*%*	N	*%*	N	*%*
Flakes cores	12	*70,6*	28	*71,8*	30	*60*	176	*72,1*	1	*50*	1	*100*	3	*75*	-	*0*	6	*75*	13	*61,9*	296	*69,3*	8	*72,7*	28	*70*
Blade cores	3	*17,6*	11	*28,2*	4	*8*	11	*4,5*	-	*0*	-	-	-	*0*	-	*0*	2	*25*	2	*9,5*	14	*3,3*	-	*0*	-	*0*
Bladelets cores	-	*0*	-	*0*	-	*0*	0	*0,0*	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*	1	*4,8*	33	*7,7*	-	*0*	2	*5*
Tested block	-	*0*	-	*0*	-	*0*	6	*2,5*	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*	2	*0,5*	1	*9,1*	1	*2,5*
Undetermined cores	-	*0*	-	*0*	4	*8*	11	*4,5*	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*	16	*3,7*	-	*0*	-	*0*
Core's fragments	2	*11,8*	0	*0*	12	*24*	40	*16,4*	1	*50*	0	*0*	1	*25*	-	*0*	-	*0*	5	*23,8*	66	*15,5*	2	*18,2*	9	*22,5*
Total	17	*100*	39	*100*	50	*100*	244	*100,0*	2	*100*	1	*100*	4	*100*	0	*0*	8	*100*	21	*100*	427	*100,0*	11	*100*	40	*100*

Table 3 - Blades and flakes products

Levels	MIS 7b - 7a						MIS 7a-6		MIS 6						?				MIS 6		MIS 5d		?					
	K		J		I		H		G		F		E		D		C		5		IV		3		2		1	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	*%*	N	*%*
Entire flakes	150	59,5	273	61,1	786	73,4	1960	71,7	10	66,7	7	77,8	35	62,5	-	0	33	68,8	190	64,8	4535	64,7	100	66,7	430	*53*	3	*50*
Fragm. flakes	55	21,8	120	26,8	198	18,5	633	23,1	3	20	2	22,2	11	19,6	-	0	10	20,8	86	29,4	1582	22,6	31	20,7	271	*33,4*	3	*50*
Entire blades	40	15,9	33	7,4	39	3,6	90	3,3	1	6,7	-	0	2	3,6	1	100	4	8,3	6	2	399	5,7	3	2	32	*3,9*	-	*0*
Fragm. blades	6	2,4	21	4,7	48	4,5	27	1	1	6,7	-	0	6	10,7	-	0	1	2,1	10	3,4	300	4,3	5	3,3	38	*4,7*	-	*0*
Bladelets	1	0,4	-	0	-	0	16	0,6	-	0	-	0	1	1,8	-	0	-	0	-	0	62	0,9	5	3,3	13	*1,6*	-	*0*
Fragm.bladelet	-	0	-	0	-	0	9	0,3	-	0	-	0	1	1,8	-	0	-	0	1	0,3	132	1,9	6	4	27	*3,3*		*0*
Total	252	100	447	100	1071	100	2735	100	15	100	9	100	56	100	1	100	48	100	293	100	7010	100	150	100	811	*100*	6	*100*

3.2 Technological analysis

3.2.1 Core reduction strategies

The study of the cores shows a wide variability in the reduction systems aimed to produce both flakes and blades. Inside this variability, three major changes, corresponding to three macrophases have been highlighted along the sequence that are the lower levels (K, J and I), the intermediate level H, and the upper level (IV to 2).

Levels G, F, E, D, C related to the Moulin Trench excavation area contain few cores that don’t allow a precise characterization of the reduction strategies (Table C in Supplementary File).

Lower level (K, J, I): The lower levels show similar macroscopic technological features that are constitute by a combination of flakes and blades reduction strategies. Flakes reduction strategies are dominated by non-Levallois processes that are represented by cores with no or minimal preparation of the flaking surface. These cores follow a parallel plans exploitation through differents methods: centripetal, orthogonal, unidirectional, bidirectional and convergent (e.g. Fig. 8 n. 2 and 4). The bidirectional method is the most used in level K with a cores percentage of 17.6 % while the centripetal method is the most employed in the levels J ranging from 17.9 % in the level J to 18 % in the level I. The unidirectional method is absent in level K and is present with one core in the level I and four cores in level J. Convergent and orthogonal methods are as well present with minor percentages (Table 4).

Table 4 - Cores tecno-type

	Levels	**MIS 7b - 7a**						**MIS 7a-6**		**MIS 6**		**MIS 5d**		**?**			
		K		J		I		H		**5**		**IV**		**3**		**2**	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Flakes cores	Levallois centripetal	-	0	3	7,7	3	6	78	32	5	23,8	51	11,9	1	9,1	4	10
	Levallois unidirectional	-	0	-	0	-	0	5	2	-	0	8	1,9	-	0	2	5
	Levallois bidirectional	-	0	-	0	-	0	2	0,8	-	0	1	0,2	-	0	1	2,5
	Levallois convergent	-	0	-	0	-	0	-	0	-	0	7	1,6	-	0	-	0
	Levallois lineal	-	0	-	0	1	2	2	0,8	-	0	3	0,7	-	0	-	0
	Levallois cores fragmented	-	0	-	0	-	0	13	5,3	1	4,8	5	1,2	-	0	-	0
	Centripetal	1	5,9	7	17,9	9	18	1	0,4	1	4,8	20	4,7	1	9,1	3	7,5
	Unidirectional	-	0	4	10,3	1	2	7	2,9	2	9,5	21	4,9	2	18,2	1	2,5
	Bidirectional	3	17,6	1	2,6	1	2	2	0,8	-	0	9	2,1	-	0	-	0
	Orthogonal	1	5,9	1	2,6	-	0	2	0,8	-	0	-	0	-	0	-	0
	Convergent	1	5,9	2	5,1	1	2	1	0,4	-	0	24	5,6	-	0	1	2,5
	Multidirectional	-	0	6	15,4	4	8	17	7	-	0	31	7,3	-	0	-	0
	Linear / Non Levallois	-	0	-	0	-	0	-	0	-	0	10	2,3	-	0	-	0
	Kombewa	-	0	-	0	3	6	16	6,6	3	14,3	51	11,9	-	0	5	12,5
	Kostienky	-	0	-	0	-	0	-	0	-	0	-	0	-	0	9	22,5
	Discoid bifacial	3	17,6	-	0	5	10	9	3,7	1	4,8	23	5,4	-	0	2	5
	Discoid unifacial	-	0	-	0	-	0	15	6,1	-	0	23	5,4	1	9,1	-	0
	Secant partial exploitation	3	17,6	4	10,3	2	4	1	0,4	-	0	9	2,1	3	27,3	-	0
	Trifacial core	-	0	-	0	-	0	5	2	-	0	-	0	-	0	-	0
Blades cores	Convergent on surface	-	0	-	0	-	0	-	0	-	0	4	0,9	-	0	-	0
	Unidirectional semi-rotating	1	5,9	5	12,8	3	6	8	3,3	2	9,5	7	1,6	-	0	-	0
	Unidirectional rotating	-	0	-	0	-	0	2	0,8	-	0	-	0	-	0	-	0
	Sub convergent semi-rotating	-	0	6	15,4	1	2	1	0,4	-	0	3	0,7	-	0	-	0
	Half pyramidal cores	2	11,8	-	0	-	0	-	0	-	0	-	0	-	0	-	0
Others	Bladelets cores	-	0	-	0	-	0	-	0	1	4,8	33	7,7	-	0	2	5
	Tested block	-	0	-	0	-	0	6	2,5	-	0	2	0,5	1	9,1	1	2,5
	Undetermined cores	-	0	-	0	4	8	11	4,5	-	0	16	3,7	-	0	-	0
	Core's fragments	2	11,8	-	0	12	24	40	16,4	5	23,8	66	15,5	2	18,2	9	22,5
	Total	17	100	39	100	50	100	244	100	21	100	427	100,0	11	100	40	100

Levallois cores are absent in level K while they are present in Level J (3 cores) and in the level I (4 cores). Except just one preferential levallois core found in level I the remains Levallois cores are made out of the centripetal recurrent method (Fig. 8 n. 1). Beside the Levallois and Non Levallois parallel plans exploitation a different group of cores are characterized by an exploitation by secant plans (Fig. 8 n. 3). This group includes cores in which the removals are strucked around the core’s entire periphery “Discoid cores” and cores with a partial exploitation in which the removals are limited to one side of the core periphery, leaving the other part of the volume unexploited.

Cores with this secant partial exploitation are present in levels K J and I with a progressive decreasing from the level K (17.6%) to the level I (4%). Discoid cores are found just in level K with 3 cores (17.6%) and in level I with 5 cores (10%) Level J and I also show a multipolar exploitation which are the results of a repeated unipolar series applied on different sides of the core (Table 4). Three Kombewa cores found in the levels I complete the technological variability of the flake strategies.

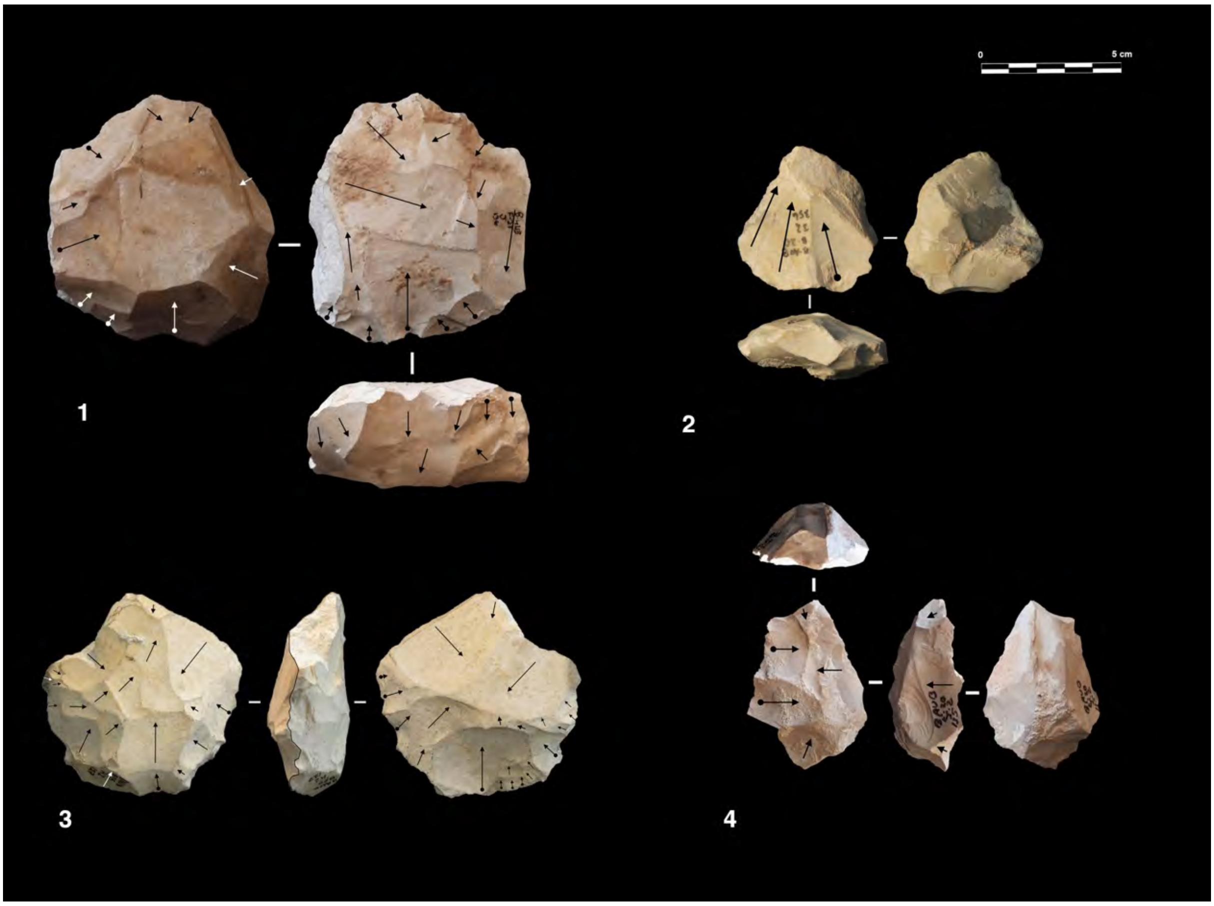


Figure 8 – Levallois centripetal core from level J (n.1); Discoid core from level K (n.3); Convergent and centripetal parallel plans exploitation from level J (n. 2 and 3).

Blade reduction strategies in the lower levels (K, J and I) are present with two main distinct modalities. The first modality is a half-pyramidal exploitation which is only present in the level K with two cores (Fig 9 n. 1). Exploitation in these cores was carried out by convergent intersected removals. The second modality is a semi-rotating exploitation system on prismatic cores following unidirectional and sub-convergent methods (Fig 9 n. 2). The removals on the semi-rotating cores are strucked laterally and on the center of the cores volume by the means of intersected sequences. The management of lateral convexities is performed by debordant blades. A second opposite striking platform is used in order to manage the distal convexity (Fig. 9 n. 2). Just one semi-rotating cores come from the level K. Sub-convergent cores are concentrated in level in level J and unidirectional exploitation is predominant in level I (Table 4).

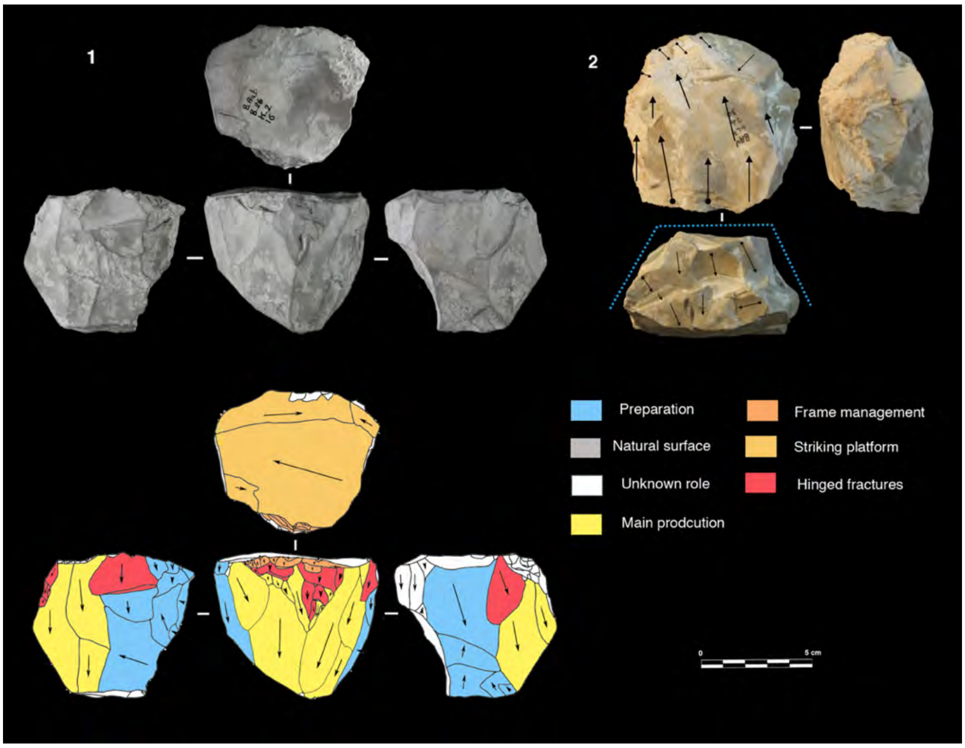


Figure 9 – Half pyramidal core from level K (n.1); Unidirectional semi-rotating core from level J (n.2).

<u>Intermediate level (H and 5)</u>: Cores in the level H are abundant and are composed by 11 blades cores and 182 flakes cores. The Levallois concept, that is sporadically present in the lower levels, becomes dominant in level H with a percentage of 40,9% of the cores of this level. The recurrent centripetal method is the most employed method with a 32 % of the entire cores (Table 4). Despite the over representation of the centripetal method the Levallois cores show a larger variability including the bidirectional and unidirectional methods (Fig 10 n. 1, 3, 4, 5). Non levallois exploitation by parallel plans continue to be present but in smaller percentages compared to the lower levels. The Discoid system constitutes another element of continuity with the lower level (Figure 10 n. 2).

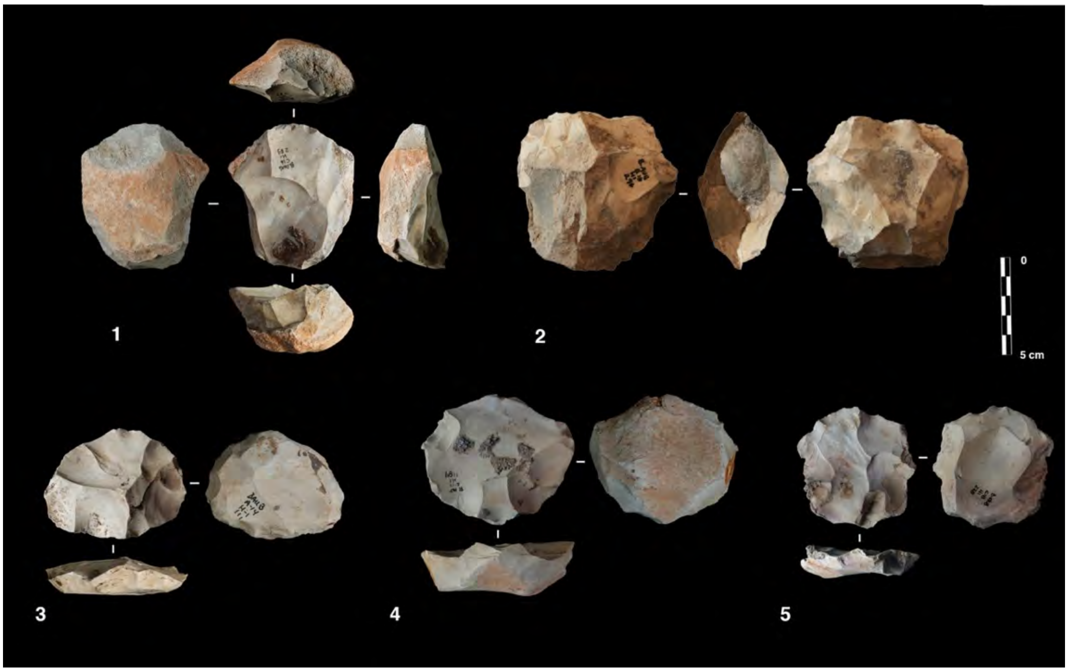


Figure 10 – Cores from level H: Unidirectional levallois core (n.1); Discoid core (n.2); Centripetal Levallois cores (n. 3 to 5).

The Kombewa core, already present in the level I, takes in this level more relevance with a percentage of 6.6% of the entire cores (Fig 11). Five cores that show a Trifacial exploitation, not recognized in the lower levels, are here present.

The eleven blade cores found in level H confirm a certain continuity in the blades reduction strategies with the levels J and I. The semirotating reduction strategies are mainly based on the unidirectional methods (8 cores) while the sub convergent methods count just one core. An element of divergence is represented by two rotating unidirectional cores which have not been recognized in the lower level (Fig. 12). The configurations of these cores are minimal and they are based on the exploitation of the natural convexity of a volume.

Level 5 contains 16 determined cores and 5 core's fragment (Table 4) . Despite the lower number of cores compared to the level H, similar technological features are highlighted. The Levallois cores continues to be prevalent and it is exclusively made out of the recurrent centripetal method. Presence of Kombewa cores constitute a second element of continuity with the level H. Blade core's strategies in level 5 is represented by two semirotating unidirectional cores.

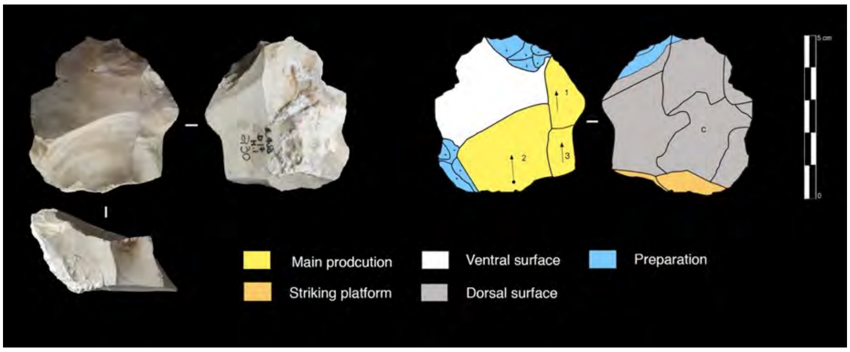


Figure 11 – Kombewa core from level H.

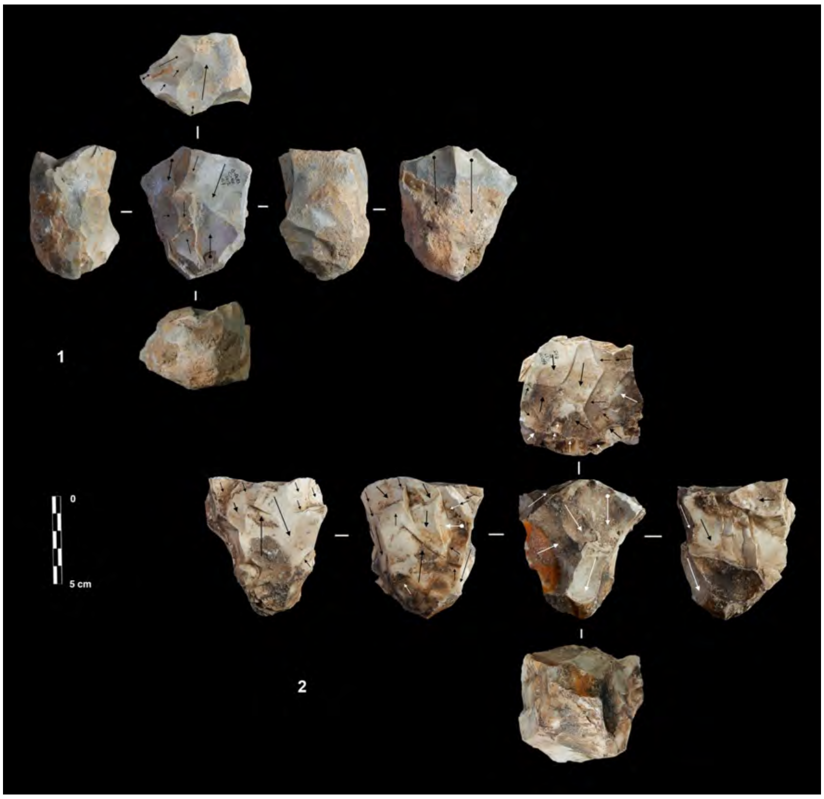


Figure 12 – Blades cores from level H: Semi-rotating core (n.1); Rotating core (n.2).

The upper Levels (IV, 3 and 2): The Upper levels of Bau de l'Aubesier contain a large amount of lithic industries mostly concentrated in the level IV in which there are 360 determined cores and 60 core's fragments (Table 4). Nine determined core are found in level 3 and 31 in level 2. Cores analysis of level IV confirm a consolidated presence of the Levallois concept with the predominance of the recurrent centripetal methods (Fig 13 n. 2 and 4). The presence of unidirectional and bidirectional methods continue to be present with similar percentage repeating the same trend highlighted in the level H. (Fig. 13 n. 1). This similarity in the Levallois variability is interrupted by the presence in the Level IV of a Levallois convergent method that is totally absent on rest of the sequence (Fig. 13 n. 3)

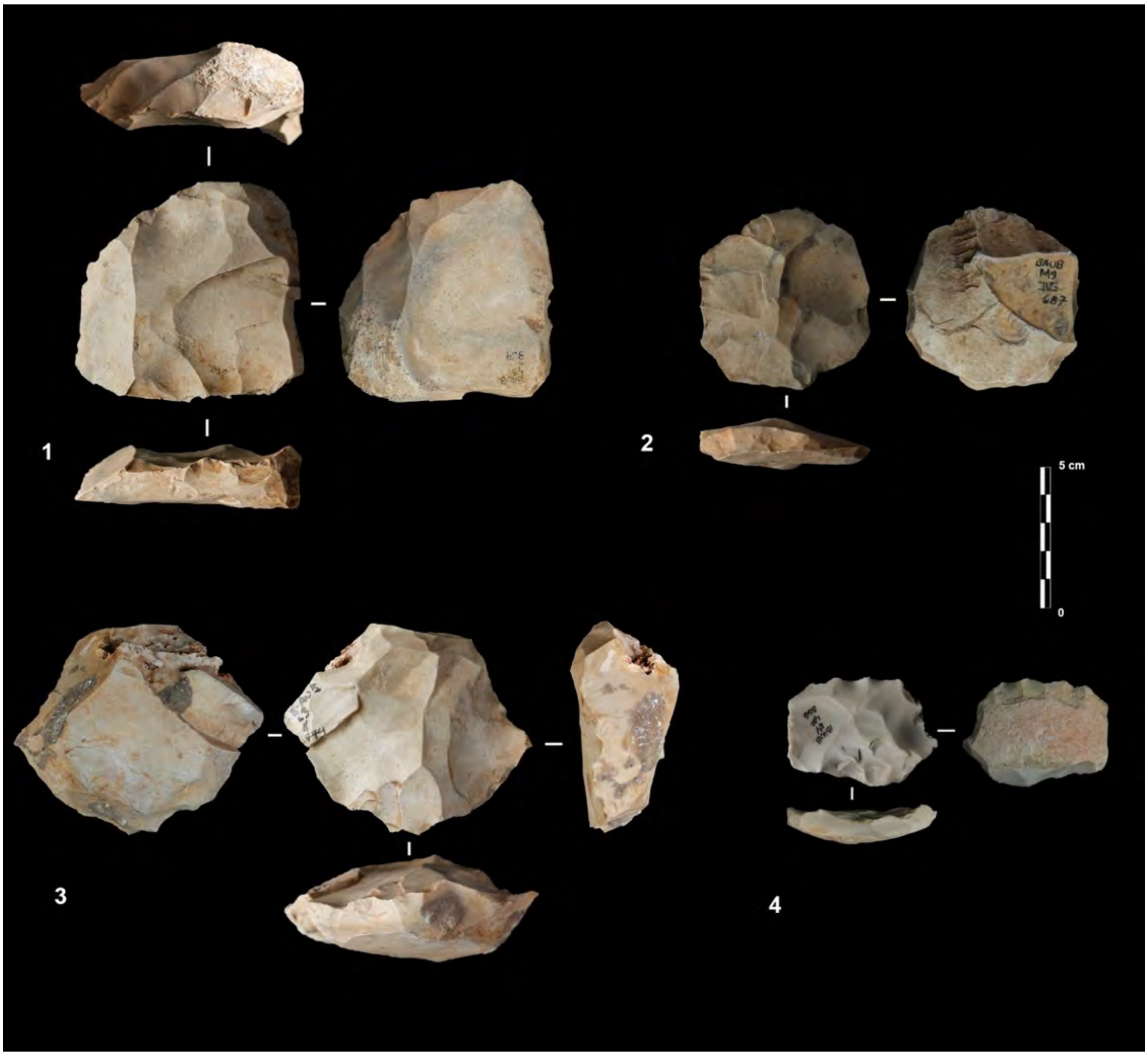


Figure 13 – Levallois cores from level IV: Bidirectional (n.1); Convergent (n.3); Centripetal (n.2 and 3).

Kombewa cores in the levels IV take a noteworthy role with a percentage of the 11.9 % of the core for this level. The major flexibility in methods recognized in the Levallois concept compared to level H seem to be repeated on the variability in methods for the Kombewa cores (Fig. 14). As observed for the Levallois cores, in fact, also in the Kombewa cores a divergence in methods between the level H and IV is recognizable by the lack of the convergent methods in the level H while in the level IV is well represented (Table 5). Unifacial and bifacial discoid cores are present with similar percentage (Table 4)

Table 5 - Kombewa cores variability

Levels	H		IV	
	N	%	N	%
Kombewa centripetal	1	*6,3*	13	*25,5*
Kombewa unidirectional	5	*31,3*	17	*33,3*
Kombewa bidirectional	1	*6,3*	5	*9,8*
Kombewa orthogonal	2	*12,5*	1	*2,0*
Kombewa convergent	0	*0,0*	6	*11,8*
Kombewa with a single scar	7	*43,8*	9	*17,6*
Total	16	*100*	51	*100*

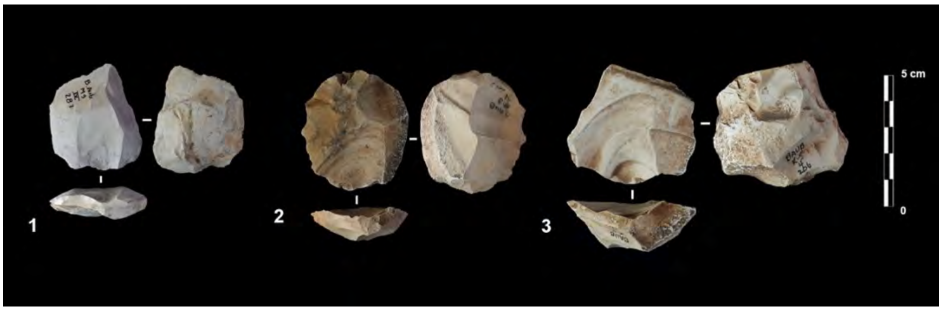


Figure 14 – Kombewa cores from level IV: Convergent (n.1); Centripetal (n.2); Unidirectioanl (n. 3).

Blade cores strategies in level IV are constituted by both elements of continuity and discontinuity compared to the level H and 5.
Semi-rotating reduction strategies are present with 6 unidirectional cores and 3 sub-convergent cores reflecting a similar variability observed in level H (Fig 15 n.1)
By contrast four core show a different exploitation based on a parallel plan exploitation of the flaking surface. These cores, that can be ascribed to the Levallois concept, are exploited by convergent removals from a single striking platform finely prepared. (Fig 15 n. 2).

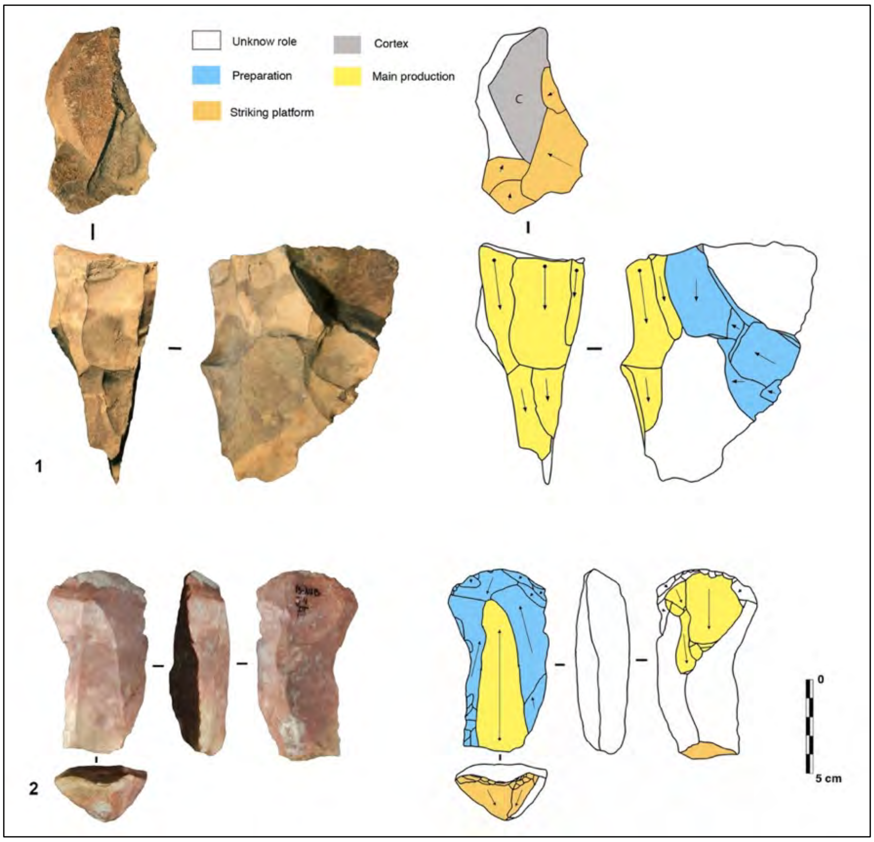


Figure 15 – Blades cores from level IV: Volumetric unidirectional blade core (n.1); Convergent on surface exploitation blade core (n. 2).

Beside the blade production an independent bladelets reduction strategy has been recognized on 33 cores (Table 4). Small blanks were selected in order to extract short series of bladelets. The initial stage of bladelet production usually entails a first removal that exploits one of the edges of the flake (Fig 16). However, preparation of two sided-crested bladelets prepared on the narrow surfaces is also attested by the presence of six crested bladelets (Fig 17 n. 4 to 6). Configuration of cores is also made out by the preparation of the distal convexity by short removals that strucked on the opposite direction of the main exploitation (Fig 16 n .3). The centring of the surface by lateral removals is also attested (Fig. 16 n. 1 and 2). Hinged fractures are solved through the extraction of a rejuvenation bladelet with the aim of reinitializing the knapping surface and allow a second series of detachments (Fig. 17 n. 1 to 3).

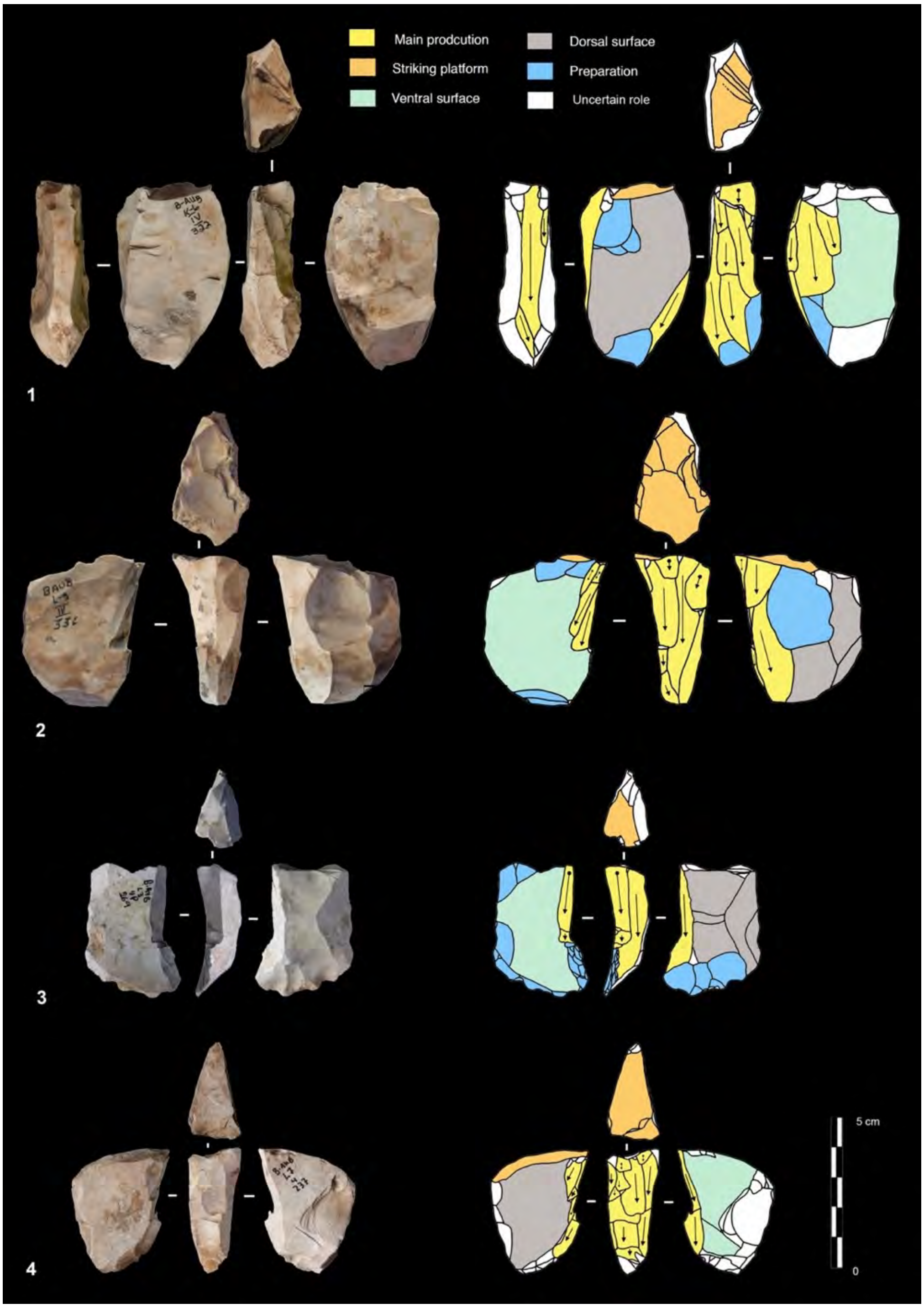


Figure 16 – Bladelet cores from level IV.

Figure 17 – Bladelets from level IV: Rejouvenation bladelets (n. 1 to 3). Crested bladelets (n. 4 to 6)

In level 3 just eight cores have been found that show a mixture of centripetal Levallois cores and Discoid (Table 4).

In Level 2 there are 31 determined cores that repeat the similar variability observed in the level IV which is the combination of a Levallois strategies and bladelets production (Fig. 18). Two bladelets cores with similar features are found in level 2 while blade cores are absent in this level. Core on flakes are represented by 5 Kombewa cores and 9 Kostienky type core characterized by an exploitation of the dorsal surface.

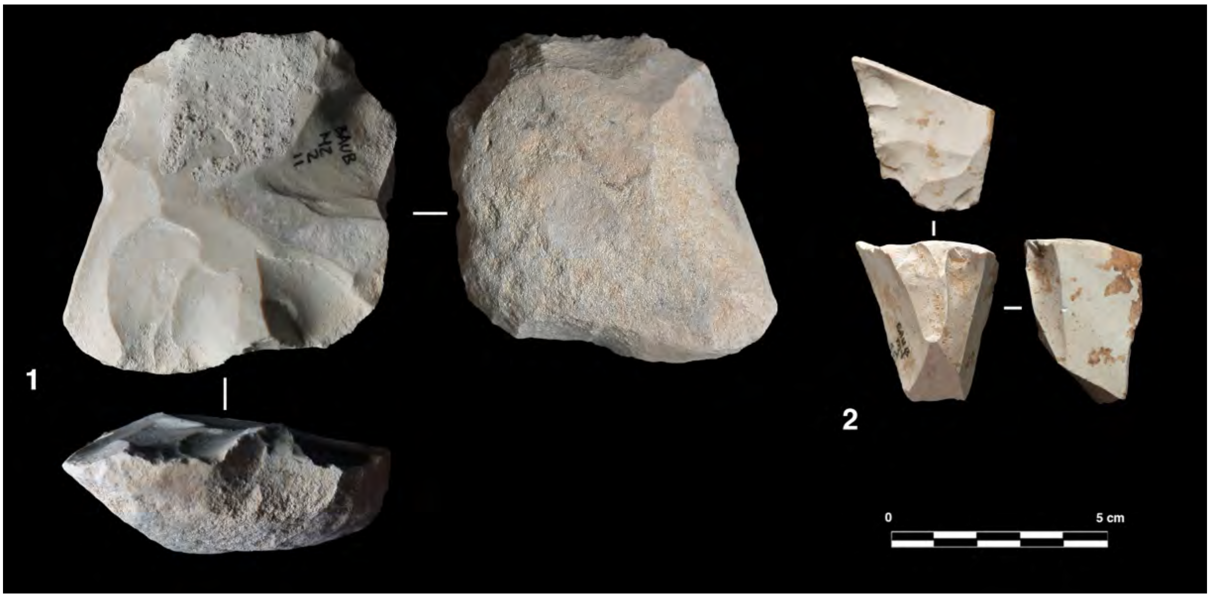


Figure 18 – Cores from level 2: Levallois centripetal core (n.1); Bladelets core (n. 2).

3.2.2 Flakes end-product

The high amount of small debris <20mm presents at Bau the l'Aubesier, that suggest an intense flaking activity made on the site, is confirmed by the presence of numerous cortical flakes present in the whole sequences (Table 6).

End-products are coherent as observed for the core reduction strategies. Level K, J, I show a large variability of end-products. (Fig. 19 and 20). The unidirectional method is the most present and is aimed to produce both flakes and blades. Unidirectional flakes ratios range from 16.7% in level J to 21.8 % in level I (Table 6).

Despite the reduce number of Levallois cores the removals close to the typical Levallois flakes are presents (Table 6). Nevertheless, the correlation of Levallois type flakes to a true Levallois reduction systems is not systematically possible. Other systems can in fact produce flakes with similar features to the levallois flakes. In the lower levels that is the case of the parallel plan exploitation cores (Fig. 8 n. 2 and 4).

The large variability of end-product observed in the level K, J and I is reduced in level H where the centripetal methods become dominant. The centripetal levallois flakes are present with a percentage of 13.1% and the non levallois centripetal flakes with 17.5 %.

Table 6 - Removals techno types

Levels	**MIS 7b - 7a**						**MIS 7a-6**		**MIS 6**		**MIS 5d**		**?**					
	K		J		I		H		**5**		**4**		**3**		**2**		**1**	
	n	*%*	n	*%*	n	*%*	n	*%*	n	*%*	n	*%*	n	*%*	n	*%*	n	*%*
Flakes (Cortex >50%)	6	*3,1*	27	*8,8*	77	*9,3*	264	*12,8*	13	*6,6*	429	*8,6*	10	*9,3*	25	*5,3*	1	*33,3*
Flakes (Cortex<50%)	15	*7,9*	51	*16,7*	127	*15,4*	389	*18,8*	32	*16,2*	771	*15,4*	14	*13*	83	*17,5*	-	*0*
Levallois type centripetal	10	*5,2*	27	*8,8*	95	*11,5*	270	*13,1*	30	*15,2*	389	*7,8*	6	*5,6*	17	*3,6*	-	*0*
Levallois type unidirectional	3	*1,6*	15	*4,9*	28	*3,4*	34	*1,6*	8	*4*	232	*4,6*	1	*0,9*	11	*2,3*	-	*0*
Levallois type bidirectional	-	*0*	-	*0*	7	*0,8*	7	*0,3*	4	*2*	8	*0,2*	0	*0*	1	*0,2*	-	*0*
Levallois type othogonal	1	*0,5*	4	*1,3*	1	*0,1*	2	*0,1*	0	*0*	1	*0*	0	*0*	1	*0,2*	-	*0*
Levallois type convergent	2	*1*	5	*1,6*	7	*0,8*	13	*0,6*	10	*5,1*	54	*1,1*	0	*0*	1	*0,2*	-	*0*
Debordant Levallois type flakes	6	*3,1*	8	*2,6*	24	*2,9*	42	*2*	7	*3,5*	58	*1,2*	1	*0,9*	3	*0,6*	-	*0*
Blades	40	*20,9*	33	*10,8*	40	*4,8*	90	*4,4*	6	*3*	399	*8*	3	*2,8*	32	*6,7*	-	*0*
Bladelets	1	*0,5*	-	*0*	0	*0*	16	*0,8*	0	*0*	62	*1,2*	5	*4,6*	13	*2,7*	-	*0*
Pseudolevallois	-	*0*	-	*0*	6	*0,7*	21	*1*	0	*0*	29	*0,6*	0	*0*	5	*1,1*	-	*0*
Centripetal flakes	13	*6,8*	9	*2,9*	88	*10,7*	362	*17,5*	26	*13,1*	733	*14,7*	22	*20,4*	58	*12,2*	1	*33,3*
Kombewa	3	*1,6*	1	*0,3*	9	*1,1*	22	*1,1*	7	*3,5*	101	*2*	5	*4,6*	10	*2,1*	-	*0*
Unidirectional flakes	32	*16,8*	51	*16,7*	180	*21,8*	196	*9,5*	16	*8,1*	553	*11,1*	10	*9,3*	72	*15,2*	1	*33,3*
Bidirectional flakes	10	*5,2*	2	*0,7*	4	*0,5*	22	*1,1*	2	*1*	38	*0,8*	1	*0,9*	3	*0,6*	-	*0*
Orthogonal flakes	-	*0*	1	*0,3*	7	*0,8*	3	*0,1*	2	*1*	48	*1*	2	*1,9*	20	*4,2*	-	*0*
Convergent flakes	9	*4,7*	31	*10,1*	33	*4*	83	*4*	11	*5,6*	484	*9,7*	7	*6,5*	37	*7,8*	-	*0*
Debordant flakes	13	*6,8*	17	*5,6*	45	*5,5*	116	*5,6*	9	*4,5*	241	*4,8*	11	*10,2*	32	*6,7*	-	*0*
Macro-tools	12	*6,3*	3	*1*	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*
Striking platform flakes	8	*4,2*	7	*2,3*	8	*1*	16	*0,8*	5	*2,5*	163	*3,3*	3	*2,8*	21	*4,4*	-	*0*
Shaping/retouching flakes	1	*0,5*	3	*1*	17	*2,1*	39	*1,9*	5	*2,5*	99	*2*	2	*1,9*	14	*2,9*	-	*0*
Rejuvenation flakes	2	*1*	2	*0,7*	10	*1,2*	18	*0,9*	2	*1*	44	*0,9*	2	*1,9*	5	*1,1*	-	*0*
Crested flakes	-	*0*	-	*0*	3	*0,4*	14	*0,7*	2	*1*	21	*0,4*	3	*2,8*	5	*1,1*	-	*0*
Siret accident	4	*2,1*	9	*2,9*	9	*1,1*	27	*1,3*	1	*0,5*	39	*0,8*	-	*0*	6	*1,3*	-	*0*
Total	191	*100*	306	*100*	825	*100*	2066	*100*	198	*100*	4996	*100*	108	*100*	475	*100*	3	*100*

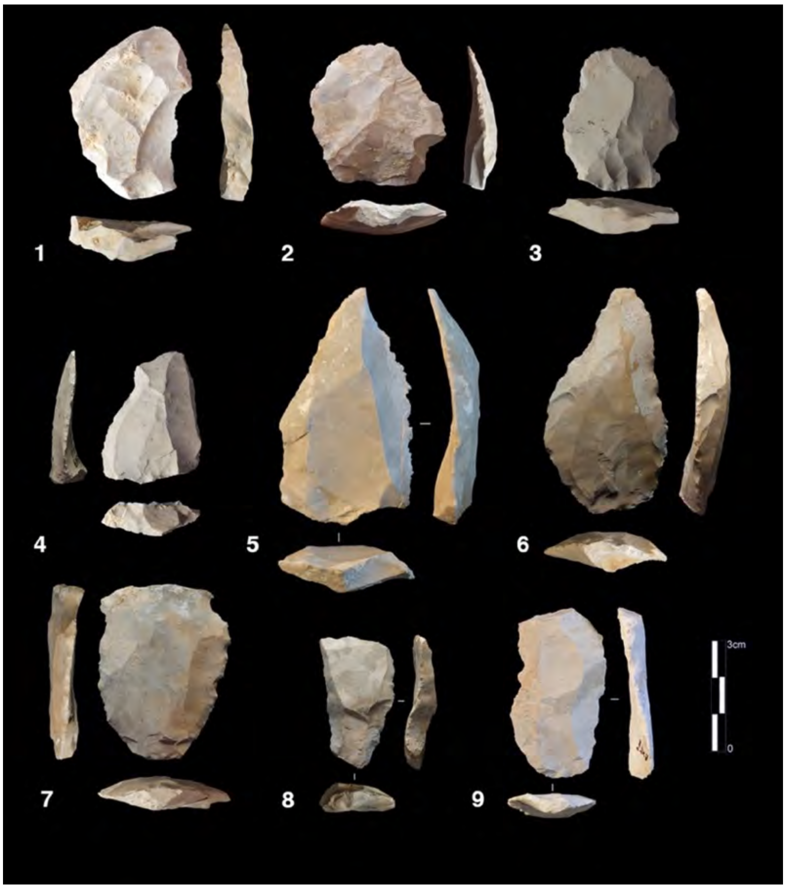


Figure 19 – Flakes end products from level K and J: Centripetal levallois types flakes (n.1 to 3); Sub convergent levallois type flakes (n.1

to 6); Unidirectional and bidirectional levallois type flakes (n.7 to 9).

The Levallois products in level H despite the predominance of the centripetal levallois flakes show a larger variability compared to the lower level that include the unidirectional, bidirectional, orthogonal and convergent Levallois flakes (Table 6) (Fig. 21).

This variability of Levallois flakes, observed in the levels H is confirmed also in the level IV (Fig 22 n 1 to 6). Kombewa flakes present in level H with 22 pieces (1.1%) increase in level IV with 101 pieces (2.2%) (Fig 22 n. 7 to 9). Level 2 shows a strict similarity with the level IV (Fig. 23).

Figure 20 – Flakes end - products from I. Centripetal levallois types flakes (n.1 to 3); unidirectional levallois type flakes (n. 2).

Figure 21 – Flakes end-products from H. Unidirectional levallois types flakes (n.1); Centripetal levallois type flakes (n. 2).

Figure 22 – Flakes end products from IV. Convergent levallois types flakes (n.1 to 3); Centripetal levallois type flakes (n. 4 to 6); Kombewa flakes (n.7 to 9).

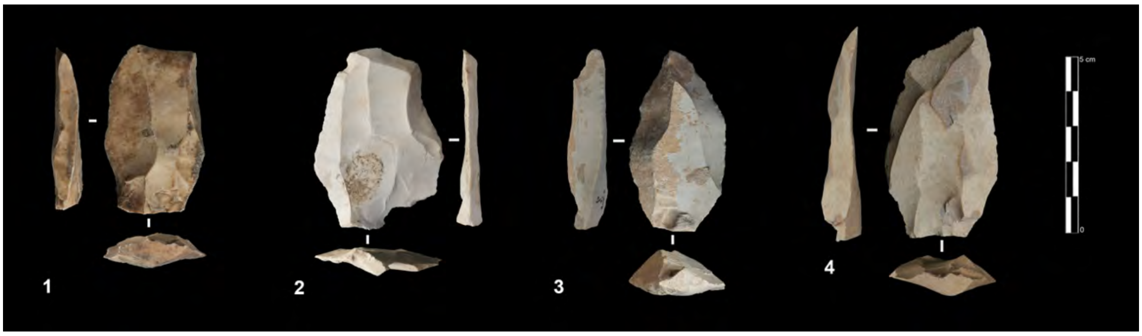


Figure 23 – Flakes end products from 2. Unidirectional flakes (n.1 and 2); Convergent flakes (n. 3 and 4).

3.2.3 Blades and bladelets end-products

Blades at Bau de l'Aubesier are constantly present beside a dominance of flakes. Considering just the entire pieces, blades ratios range from 20.9% in level K to 2.8% in level 3 (Table 7). Except for one single piece found in the level K, bladelets has been recognized just in level H and in the upper levels IV, 3 and 2. The major concentration of bladelets is in the level IV where 62 entire bladelets and 132 fragmented bladelets (Table 7 and Table A in suppl File) have been found. Presence of intentional bladelets production is supported by the presence of bladelets cores in the level 5, IV and 2. In the level H bladelets cores are totally absent. Presence of bladelets in level H can be the results of an advanced exploitation of the semi-rotating/rotating reduction strategies.

Table 7 - Blades and flakes removals excluding the fragmented pieces.

Levels	**MIS 7b - 7a**						**MIS 7a-6**		**MIS 6**		**MIS 5d**		**?**			
	K		**J**		**I**		**H**		**5**		**IV**		**3**		**2**	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Flakes	150	*78,5*	273	*89,2*	786	*95,3*	1960	*94,9*	190	*96,9*	4535	*90,8*	100	*92,6*	430	*90,5*
Blades	40	*20,9*	33	*10,8*	39	*4,7*	90	*4,4*	6	*3,1*	399	*8,0*	3	*2,8*	32	*6,7*
Bladelets	1	*0,5*	-	*0*	-	*0*	16	*0,8*	-	*0*	62	*1,2*	5	*4,6*	13	*2,7*
Total	191	*100*	306	*100*	825	*100*	2066	*100*	196	*100*	4996	*100*	108	*100*	475	*100*

The length-width ratio of blades show a similar elongation index in all the levels even if a slight difference exists between the lower and the upper levels. Elongated blades with length-width ratio > 4 ≤ 5 are in fact absent in level K, J and I, while they constitute the 4.4 % of laminar product in the level 2 and the 3.5% in the level IV (Table 8). Level IV contains also rare very elongated blades and narrow blades with a length-width ratio >5 (Table 8).
More in general two tendencies can be observed along the sequence from the lower to the upper levels which are the increase of the elongation of the blades and the presence of smaller product which is particularly clear in the layer IV. (Fig. 24)

Table 8 - Blades and bladelets elongation parameters

Layers	**k**		**J**		**I**		**H**		**5**		**4**		**3**		**2**	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
laminar flake (>2 <2.5)	19	46,3	17	51,5	19	47,5	54	50,9	4	66,7	212	46,0	2	28,6	22	48,9
short blade (≥2.5 <3)	15	36,6	11	33,3	16	40	32	30,2	2	33,3	153	33,2	1	14,3	15	33,3
blade (≥ 3 ≤ 4)	6	14,6	5	15,2	5	12,5	17	16	-	0	75	16,3	1	14,3	4	8,9
elongated blade (> 4 ≤ 5)	-	0	-	0	-	0	3	2,8	-	0	16	3,5	3	42,9	2	4,4
very elongated blade (> 5 ≤ 6)	1	2,4	-	0	-	0	-	0	-	0	2	0,4	-	0	1	2,2
narrow blade (> 6)	-	0	-	0	-	0	-	0	-	0	3	0,7	-	0	1	2,2
Total	41	100	33	100	40	100	106	100	6	100	461	100	7	100	45	100

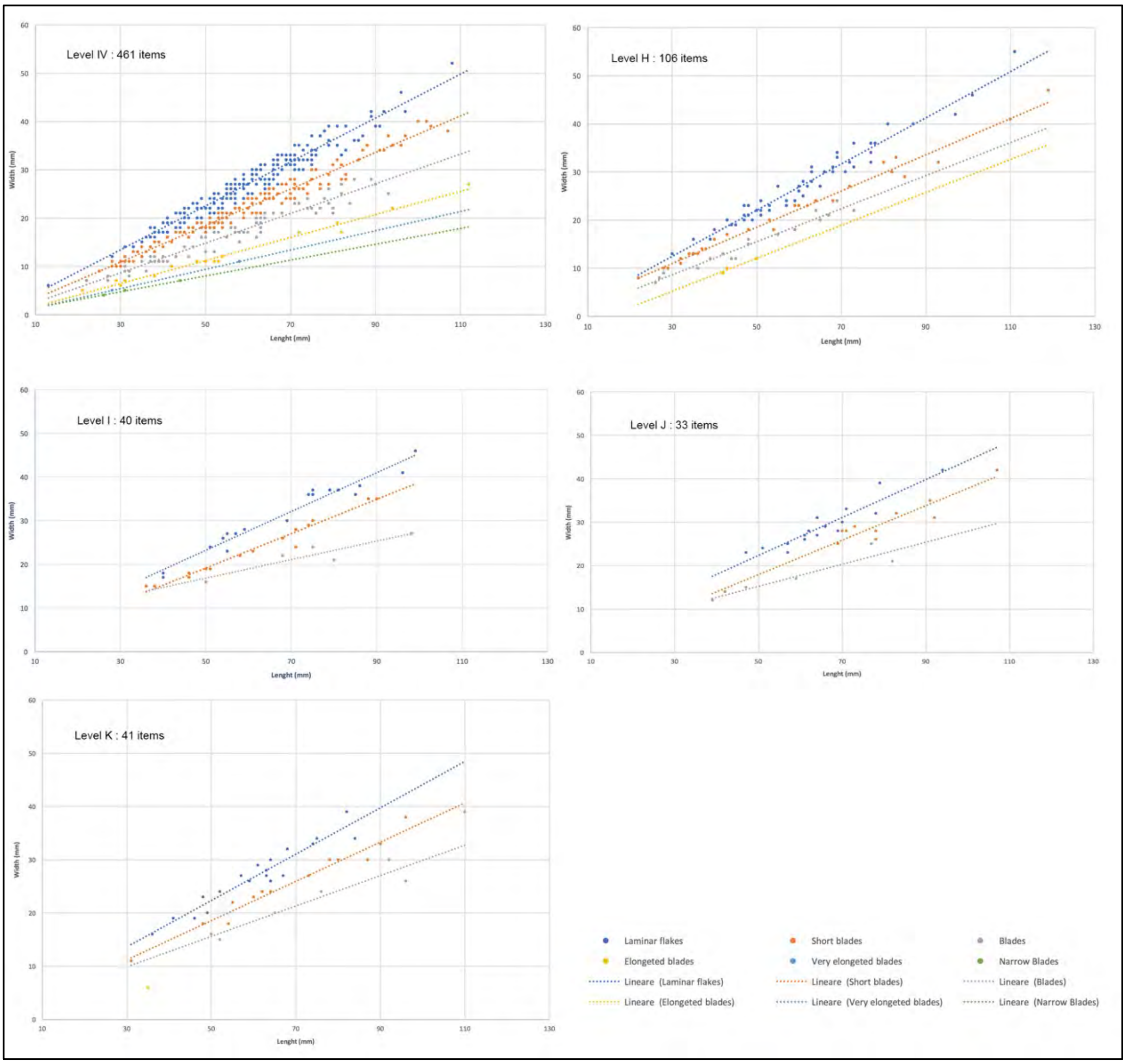


Figure 24 – Length-Width ratio of blades and bladelets across the sequence.

Blade core technologies at Bau de l'Aubesier follow two main different reduction strategies; a volumetric exploitation and a surface exploitation.

These two reduction strategies observed on the cores aimed to produce distinct end-products characterized by different morphological features which are the results of a different exploitation rhythm.

The semi-rotating or rotating rhythm that characterizes the volumetric concept is based on removals that are strucked alternately on the lateral edges and on the center of the flaking surface. Each removal has a double role at the same time, which is to produce blades and to maintain the lateral convexities all along the reduction process. The effect of this exploitation gives to the core a convex trapezoidal cross-section (Fig 25 A). The results of this operation have as consequence the production of thick blades characterized by a robustness cutting edge and a trapezoidal cross-section (Fig 25 n.1).

Conversely, in the surface exploitation, as in the case of the Levallois concept, the main production is mainly obtained on the center of the flaking surface. In this case debordant removals contribute to maintain the lateral convexity but without invading the laterals edges of the volume (Fig 25 B). Blades cores exploited on surface are characterized by a slightly convex rectangular cross section. The products derived from a surface exploitation are thin blades with a thin cutting edge (Fig 25 n.2). The differences between the volumetric and surface exploitation products emerge clearly comparing their thickness-thick ratio (Figure 26).

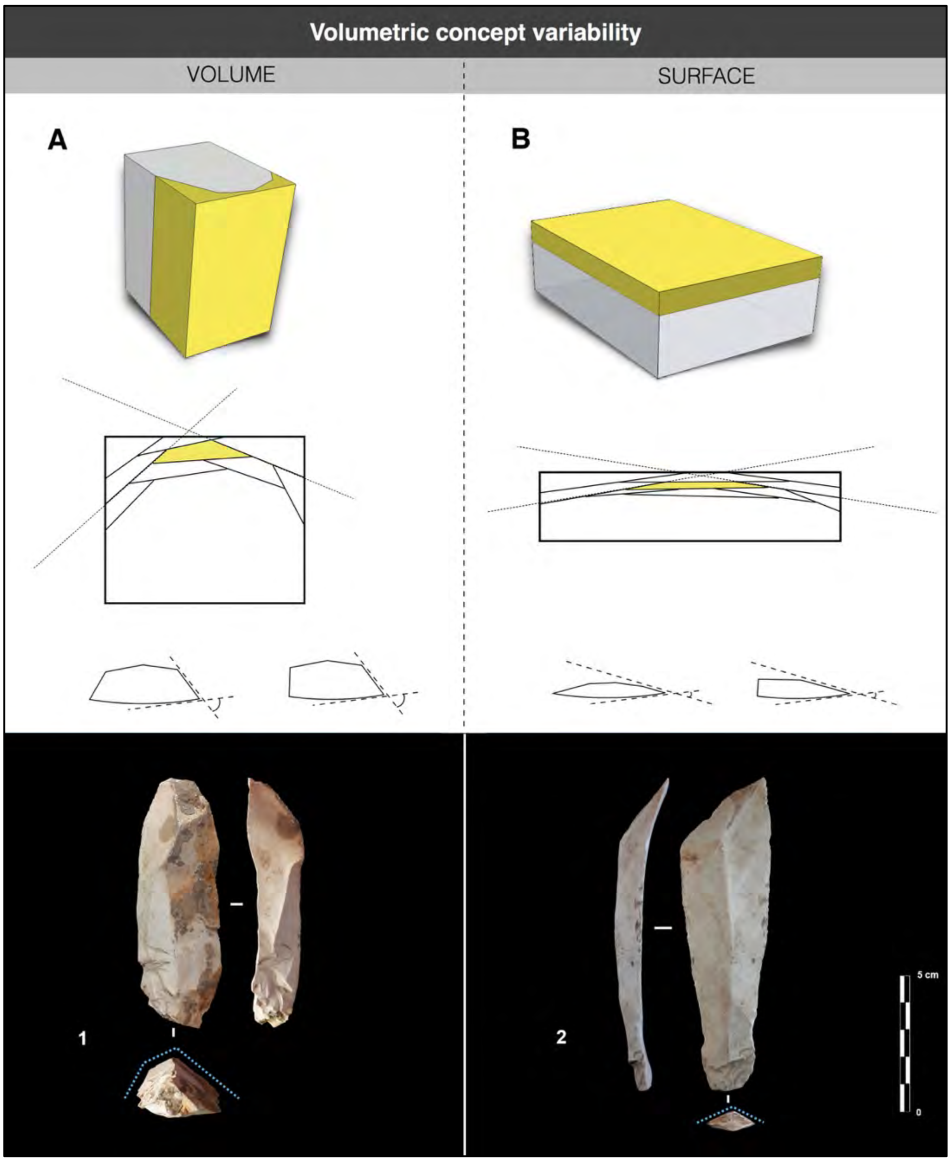


Figure 25 – Modeling of surface and volumetric blade reduction systems: Blade from volumetric exploitation from level IV (n. 1) Blade from surface exploiation from level IV (n. 2)

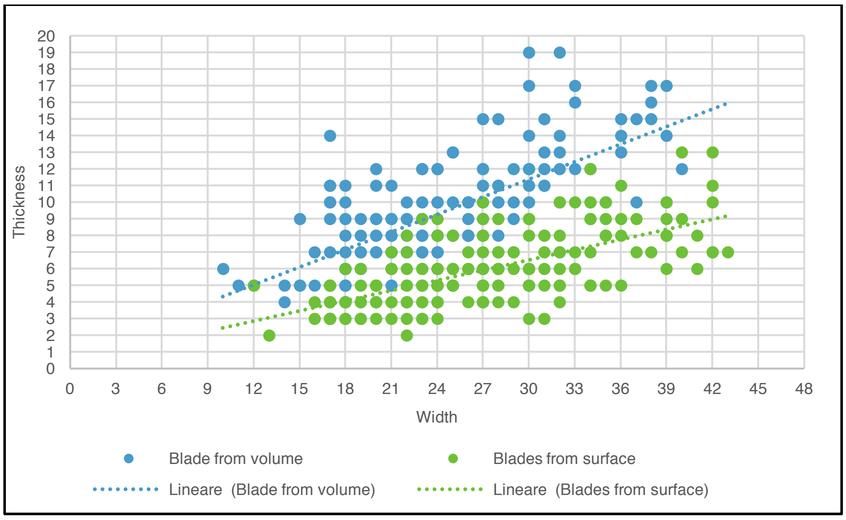


Figure 26 – Comparison between the Thickness-Width ratio of blades from volume and from surface.

Blades from surface and blade from volume are present in all the sequence but in different percentage depending on the layers. Most of the blades fell in the 'undefined blade' category that show mixed technological features. (Table 9).
Levels K and J show a major percentage of blades from volume while in levels I and particularly in levels H and IV blades from surface and blade from volume is equally represented (Table 9). Supplementary technological features show some differences between the blades from volume and the blades from surface. The platform of the blade from surface is frequently faceted or partially faceted showing a curated preparation of the striking platform (Table 10). By contrast, blades from volume show a major presence of plain or cortical platform (Table 10). Non-substantially differences emerge in the analysis of the preparation of the platform edge (Tab 11).

Table 9 - Volumetric and surface blades composition

Levels	K tot		J		I		H		5		IV		3		2	
	N	*%*	N	*%*	N	*%*	N	*%*	N	*%*	N	*%*	N	*%*	N	*%*
Blades from volume	17	*41,5*	13	*39,4*	8	*20*	28	*26,4*	3	*50,0*	116	*25,2*	-	*0*	5	*11,1*
Blades from surface	3	*7,3*	6	*18,2*	11	*27,5*	27	*25,5*	2	*33,3*	137	*29,7*	-	*0*	15	*33,3*
Undet. (mixed features)	20	*48,8*	14	*42,4*	21	*52,5*	35	*33,0*	1	*16,7*	146	*31,7*	2	*28,6*	12	*26,7*
Bladelets	1	*2,4*	-	*0*	-	*0*	16	*15,1*	-	*0,0*	62	*13,4*	5	*71,4*	13	*28,9*
Total	41	*100*	33	*100*	40	*100*	106	*100*	6	*100*	461	*100*	7	*100*	45	*100*

Table 10 - Platfrom modification

LEVELS	**K**		**J**		**I**		**H**		**5**		**IV**		**3**		**2**	
Blades from volume	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Completely Faceted	-	0	1	7,7	-	0	1	3,6	-	0	7	6,0	-	0	-	0
Partially Faceted	2	11,8	2	15,4	2	25,0	4	14,3	1	33,3	19	16,4	-	0	1	20,0
Dihedral	2	11,8	2	15,4	-	0	-	0	-	0	8	6,9	-	0	-	0
Unprepared (Plain)	7	41,2	5	38,5	4	50,0	19	67,9	2	66,7	61	52,6	-	0	3	60,0
Unprepared (Cortical)	1	5,9	1	7,7	-	0	2	7,1	-	0	2	1,7	-	0	-	0
Punctiform	2	11,8	-	0,0	-	0	1	3,6	-	0	5	4,3	-	0	1	20,0
Linear	-	0	1	7,7	-	0	-	0	-	0	6	5,2	-	0	-	0
Absent (fracture)	1	5,9	1	7,7	2	25,0	1	3,6	-	0	3	2,6	-	0	-	0
Absent (removed by retouch)	2	11,8	-	0	-	0	-	0	-	0	5	4,3	-	0	-	0
Total	17	100	13	100	8	100	28	100	3	100	116	100	-	0	5	100
Blades from surface																
Completely Faceted	2	66,7	3	50,0	7	63,6	9	33,3	1	50,0	23	16,8	-	0	6	40,0
Partially Faceted	-	0	-	0	3	27,3	7	25,9	-	0	31	22,6	-	0	3	20,0
Dihedral	-	0	-	0	-	0	3	11,1	-	0	8	5,8	-	0	-	0
Unprepared (Plain)	1	33,3	1	16,7	1	9,1	4	14,8	1	50,0	47	34,3	-	0	4	26,7
Unprepared (Cortical)	-	0	-	0	-	0	-	0	-	0	2	1,5	-	0	-	0
Punctiform	-	0	2	33,3	-	0	-	0	-	0	8	5,8	-	0	-	0
Linear	-	0	-	0	-	0	3	11,1	-	0	5	3,6	-	0	-	0
Absent (fracture)	-	0	-	0	-	0	1	3,7	-	0	10	7,3		0	2	13,3
Absent (removed by retouch)	-	0	-	0	-	0	-	0	-	0	3	2,2	-	0	-	0
Total	3	100	6	100	11	100	27	100	2	100	137	100	-	0	15	100
Undeter. (mixed features)																
Completely Faceted	1	5,0	1	7,1	5	23,8	3	8,6	-		6	4,1	-	0	0	0
Partially Faceted	2	10,0	3	21,4	1	4,8	2	5,7	1	100	27	18,5	-	0	3	25,0
Dihedral	2	10,0	-	0	1	4,8	2	5,7	-		4	2,7	-	0	-	0
Unprepared (Plain)	8	40,0	6	42,9	8	38,1	10	28,6	-		75	51,4	3	100	7	58,3
Unprepared (Cortical)	-	0	-	0	-	0	2	5,7	-		2	1,4	-	0	-	0
Punctiform	3	15,0	-	0	1	4,8	4	11,4	-		9	6,2	-	0	1	8,3
Linear	-	0	1	7,1	1	4,8	11	31,4	-		11	7,5	-	0	1	8,3
Absent (fracture)	2	10,0	3	21,4	3	14,3	1	2,9	-		10	6,8	-	0	-	0
Absent (removed by retouch)	2	10,0	-	0	1	4,8	-	0	-		2	1,4	-	0	-	0
Total	20	100	14	100	21	100	35	100	1	100	146	100	3	100	12	100

Table 11 - Edge platform modification

LEVELS	K		J		I		H		5		IV		3		2	
Blades from volume	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Edge Trimming	6	*35,3*	5	*38,5*	2	*25*	3	*10,7*	1	*33,3*	35	*30,2*	-	*0*	1	*20*
Edge abrasion	1	*5,9*	2	*15,4*	2	*25*	3	*10,7*	-	*0*	15	*12,9*	-	*0*	-	*0*
Unmodified	8	*47,1*	5	*38,5*	4	*50*	21	*75,0*	2	*66,7*	64	*55,2*	-	*0*	4	*80*
Undet. (partial fractured)	2	*11,8*	1	*7,7*	-	*0*	1	*3,6*	-	*0*	2	*1,7*	-	*0*	-	*0*
Total	17	*100*	13	*100*	8	*100*	28	*100*	3	*100*	116	*100*	-	*0*	5	*100*
Blades from surface																
Edge Trimming	-	-	1	*16,7*	2	*18,2*	4	*14,8*	-	*0*	44	*32,1*	-	*0*	3	*20*
Edge abrasion	-	-	-	*0*	3	*27,3*	2	*7,4*	1	*50*	31	*22,6*	-	*0*	1	*6,7*
Unmodified	3	*100*	5	*83,3*	6	*54,5*	21	*77,8*	1	*50*	62	*45,3*	-	*0*	11	*73,3*
Undet. (partial fractured)	-	-	-	*0*	-	*0,0*	-	*0*	-	*0*	-	*0,0*	-	*0*	-	*0*
Total	3	*100*	6	*100*	11	*100*	27	*100*	2	*100*	137	*100*	-	*0*	15	*100*
Undeter. (mixed features)																
Edge trimming	6	*30*	4	*28,6*	4	*19,0*	4	*11,4*	-	*0*	36	*24,7*	-	*0*	2	*16,7*
Edge abrasion	5	*25*	-	*0*	-	*0,0*	3	*8,6*	-	*0*	31	*21,2*	-	*0*	1	*8,3*
Unmodified	8	*40*	7	*50,0*	17	*81,0*	28	*80*	1	*100*	73	*50,0*	2	*100*	9	*75*
Undet. (partial fractured)	1	*5*	3	*21,4*	-	*0,0*	-	*0*	-	*0*	6	*4,1*	-	*0*	-	*0*
Total	20	*100*	14	*100*	21	*100*	35	*100*	1	*100*	146	*100*	2	*100*	12	*100*

A supplementary variability in blade production is originated by the exploitation methods used which are the convergent or the unidirectional/bidirectional methods. Height techno-type have been recognized in relation to the methods used and the position of the removal on the flaking surface (Fig. 27).

By cross-references these techno-type of blades with the volumetric and surface blades types some tendencies can be notice. (Table 12).

Blades from volume in level K J and I show a certain variability of tecno-type among which the convergent blades take a certain relevance (Tab 12), (Fig. 28 n. 1, 2 and 4). Blades with a peripheral cutting edge are also well represented in these levels (Fig. 28 n.3).

Blades on surface show contrarily a major representation of blades with a peripheral cutting edge “Type S0”. This tendency is particularly evident in level H where the S0 type is the 85.2% of the blades from surface. (Table 12).

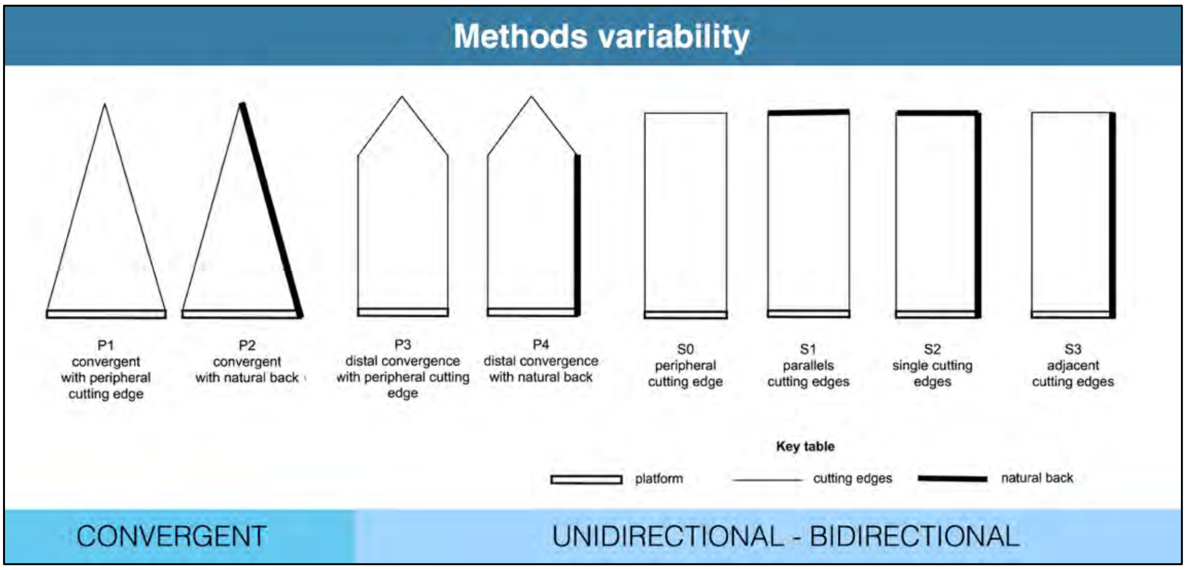


Figure 27 – Blades techno-types

Table 12 - Blades technotype

LEVELS	K		J		I		H		5		IV		3		2	
Blades from volume	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
P1 convergent	3	*17,6*	4	*30,8*	2	*25,0*	3	*10,7*	-	*0*	20	*17,2*	-	*0*	1	*20,0*
P2 convergent with natural back	1	*5,9*	-	*0*	-	*0*	-	*0*	-	*0*	1	*0,9*	-	*0*	-	*0*
P3 distal convergent	1	*5,9*	3	*23,1*	3	*37,5*	2	*7,1*	-	*0*	15	*12,9*	-	*0*	-	*0*
P4 distal convergent with natural back	2	*11,8*	-	*0*	-	*0*	2	*7,1*	-	*0*	1	*0,9*	-	*0*	1	*20,0*
S0 peripheral cutting edges	5	*29,4*	2	*15,4*	2	*25,0*	6	*21,4*	-	*0*	28	*24,1*	-	*0*	2	*40,0*
S1 parallels cutting edges	-	*0*	2	*15,4*	-	*0*	8	*28,6*	1	*33,3*	25	*21,6*	-	*0*	-	*0*
S2 single cutting edge	2	*11,8*	1	*7,7*	1	*12,5*	5	*17,9*	2	*66,7*	14	*12,1*	-	*0*	1	*20,0*
S3 adjacent cutting edge	3	*17,6*	1	*7,7*	-	*0*	2	*7,1*	-	*0*	12	*10,3*	-	*0*	-	*0*
Total	17	*100*	13	*100*	8	*100*	28	*100*	3	*100*	116	*100*	-	*0*	5	*100*
Blades from surface																
P1 convergent	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*	24	*17,5*	-	*0*	2	*13,3*
P2 convergent with natural back	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*	1	*0,7*	-	*0*	1	*6,7*
P3 distal convergent	1	*33,3*	1	*16,7*	2	*18,2*	3	*11,1*	-	*0*	11	*8,0*	-	*0*	3	*20,0*
P4 distal convergent with natural back	-	*0*	-	*0*	1	*9,1*	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*
S0 peripheral cutting edges	2	*66,7*	4	*66,7*	5	*45,5*	23	*85,2*	2	*100*	71	*51,8*	-	*0*	6	*40,0*
S1 parallels cutting edges	-	*0*	1	*16,7*	2	*18,2*	-	*0*	-	*0*	21	*15,3*	-	*0*	-	*0*
S2 single cutting edge	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*	3	*2,2*	-	*0*	1	*6,7*
S3 adjacent cutting edge	-	*0*	-	*0*	1	*9,1*	1	*3,7*	-	*0*	6	*4,4*	-	*0*	2	*13,3*
Total	3	*100*	6	*100*	11	*100*	27	*100*	2	*100*	137	*100*	-	*0*	15	*100*
Undeter. (mixed features)																
P1 convergent	3	*15,0*	0	*0*	2	*9,5*	1	*2,9*	-	*0*	25	*17,1*	-	*0*	5	*41,7*
P2 convergent with natural back	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*	2	*1,4*	-	*0*	-	*0*
P3 distal convergent	1	*5,0*	1	*7,1*	-	*0*	4	*11,4*	-	*0*	5	*3,4*	-	*0*	-	*0*
P4 distal convergent with natural back	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*	1	*0,7*	-	*0*	-	*0*
S0 peripheral cutting edges	6	*30,0*	3	*21,4*	10	*47,6*	23	*65,7*	-	*0*	40	*27,4*	-	*0*	6	*50,0*
S1 parallels cutting edges	10	*50,0*	3	*21,4*	5	*23,8*	4	*11,4*	-	*0*	25	*17,1*	1	*50*	-	*0*
S2 single cutting edge	-	*0*	6	*42,9*	3	*14,3*	2	*5,7*	1	*100*	36	*24,7*	1	*50*	1	*8,3*
S3 adjacent cutting edge	-	*0*	1	*7,1*	1	*4,8*	1	*2,9*	-	*0*	12	*8,2*	-	*0*	-	*0*
Total	20	*100*	14	*100*	21	*100*	35	*100*	1	*100*	146	*100*	2	*100*	12	*100*

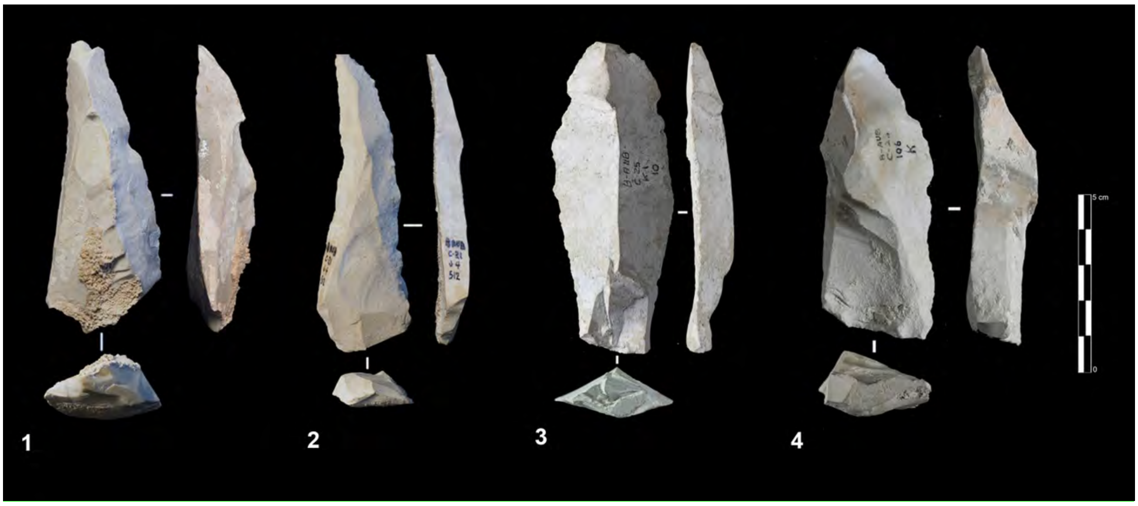


Figure 28 – Blades from level K and J. Convergent blades from volume (n. 1, 2 and 4); Non-convergent blade from volume (n. 3)

Passing on to analyse the level H a change can be notice in the representation of the techno-type of blades. Convergent blades from volume decrease and they are mostly associated with the type with a peripheral and parallel cutting edge "S0 and S1" type". At the same time debordant blades increase "type S2" (Table 12). However, despite the decrease of the convergent blades a wide variability in the techno-type continue to be present (Fig. 29 n. 2 to 5).

The increase of debordant blades in level H can be linked with the use of the rotating and semi-rotating reduction systems. Associated with the configuration of these reduction strategies 3 crested blades has been found (Fig. 29 n. 1).

Still associated with blade volumetric reduction systems, level H shows a high percentage of plunging blades “Type S1 and S2” (Table 12) (Fig. 29 n. 2 and 3).
In the upper levels and especially in level IV, techno-type of volumetric blades repeat the same variability observed in level H (Fig. 30). Convergent and non-convergent techno-type are both present with a major presence of the latter one (Table 12). Crested blades, as in the level H are present with 5 pieces (Fig. 30 n.2). Plunging blades (S1 and S2 types) continue to be presents with similar percentage to the level H (Table 12) (Fig. 30 n. 1).
If blades from volume in level IV share similar pattern with level H blades from surface differ greatly. In fact, even if blades from surface with parallel and peripheral cutting edge continue to be the most represented techno-type, at the same time a different techno-type, the convergent blades, appear. (Table 12) (Fig. 31). Non-convergent blades from surface also is well represented in level IV (Fig. 32).

Figure 29 – Blades from level H: Crested blade (n.1); Blade parallel cutting edge “S1 type” (n. 2 and 3); Blade with parallel cutting edge and distal convergence “ Type P3” (n. 4).; Blade with pheripheral cutting edge from surface “Type S0 (n. 5).

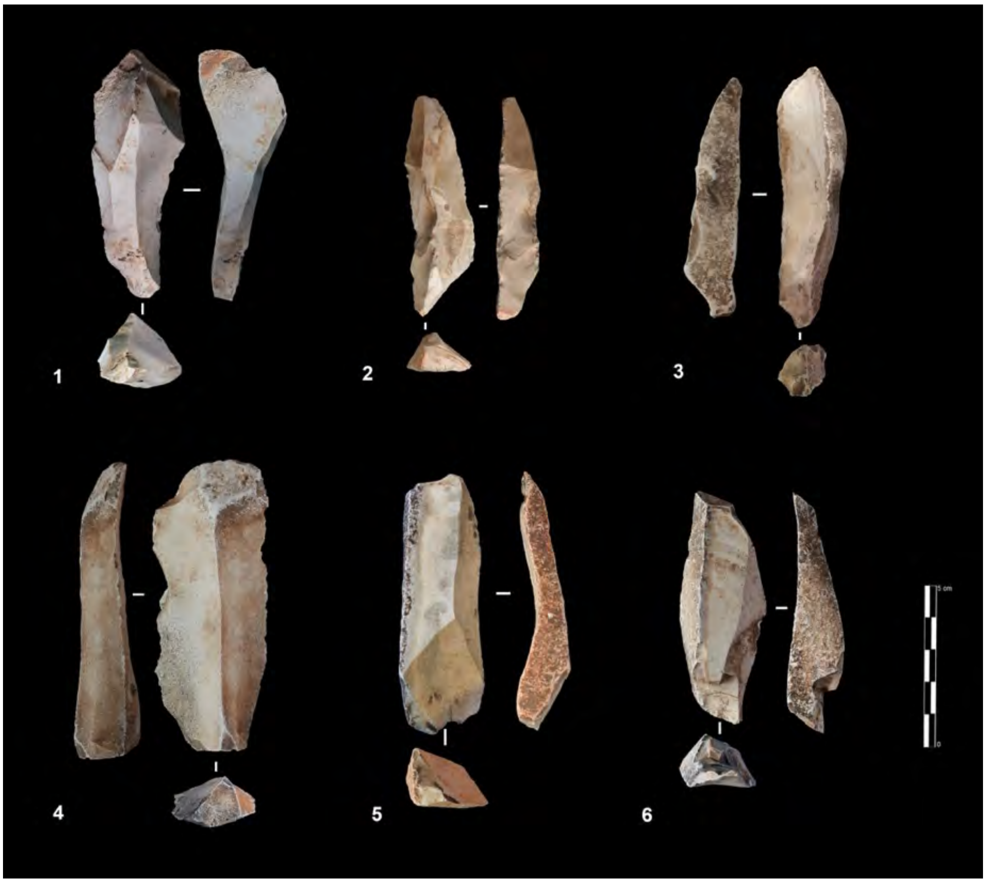


Figure 30 – Blades from volume (level IV):

Figure 31 – Level IV Convergent blades from surface.

Figure 32 – Level IV Non convergent blades form surface.

Blades from surface in level IV can be related to different reduction strategies. Convergent blades find a logical connection with the four blade convergent cores exploited by parallel plans. (Fig. 15 n.2). Non-convergent blades from the surface can be link with the unidirectional and bidirectional exploiation by parallel plans Levallois or not Levallois.

Concerning the bladelets, some differences emerge comparing the levels H and IV (Table 13). The most represented techno type in level H is constituted by bladelets with a peripheral cutting edge (S0 type) whereas in level IV a major variability can be observed that includes an increasing of convergent bladelets (Fig 33).

Table 13 - Bladelets techno type.

Levels	K		H		IV		3		2	
	N	%	N	%	N	%	N	%	N	%
P1 convergent	-	0	2	12,5	12	19,4	1	20	4	30,8
P2 convergent with natural back	-	0	1	6,3	2	3,2	-	0	2	15,4
P3 distal convergent	-	0	1	6,3	5	8,1	1	20	-	0
P4 distal convergent with natural back	-	0	-	0	1	1,6	-	0	-	0
S0 peripheral cutting edges	1	100	9	56,3	18	29,0	3	60	5	38,5
S1 parallels cutting edges	-	0	-	0	17	27,4	-	0	-	0
S2 single cutting edge	-	0	1	6,3	5	8,1	-	0	1	7,7
S3 adjacent cutting edge	-	0	2	12,5	2	3,2	-	0	1	7,7
Total	1	100	16	100	62	100	5	100	13	100

Percussion technique of bladelets is the direct percussion with hard hammer. Longitudinal profile of the bladelets is straight or slightly curved. Just a few items present a curve profile and a twisted profile (Table 14).

Platforms of bladelets are often flat with the percussion point located two or three mm from the platform edge (Table 15). Punctiform and linear platform are also present and can indicate an episodic use of the marginal percussion. Platform edge is mainly left unmodified. Trimming and abrasion of the platform edge is sporadically attested (Table 16).

Table 14 - Bladelets longitudinal profile

Levels	K		H		4		2	
	N	%	N	%	N	%	N	%
Straight	1	100	9	56,3	37	59,7	10	76,9
Slightly curved	-	0	4	25,0	10	16,1	2	15,4
Curved	-	0	3	18,8	4	6,5	-	0
Irregular	-	0	-	0	3	4,8	1	7,7
Twisted	-	0	-	0	8	12,9	-	0
Total	1	100	16	100	62	100,0	13	100

Table 15 - Bladelets platform

Levels	K		H		4		3		2	
	N	%	N	%	N	%	N	%	N	%
Completely Faceted	-	-	-	-	5	8,1	-	0	1	7,7
Partially Faceted	-	-	-	-	3	4,8	-	0	-	0
Dihedral	-	-	-	-	3	4,8	-	0	-	0
Unprepared (Plain)	1	100	9	56,3	24	38,7	4	80,0	7	53,8
Unprepared (Cortical)	-	-	1	6,3	2	3,2	-	0	-	0
Punctiform	-	-	1	6,3	12	19,4	1	20,0	4	30,8
Linear	-	-	5	31,3	10	16,1	-	0	-	0
Absent (fracture)	-	-	-	0	3	4,8	-	0	1	7,7
Total	1	100	16	100	62	100	5	100	13	100

Table 16 - Bladelets edge platform

Levels	K		H		4		3		2	
	N	%	N	%	N	%	N	%	N	%
Edge trimming	-	0	1	6,25	5	8,1	-	0	1	7,7
Edge abrasion	-	0	3	18,75	6	9,7	-	0	1	7,7
Unmodified	1	100	12	75	51	82,3	4	80	11	84,6
Undet. (partial fractured)	-	0	-	0	-	0,0	1	20	-	0
Total	1	0	16	100	62	100	5	100	13	100

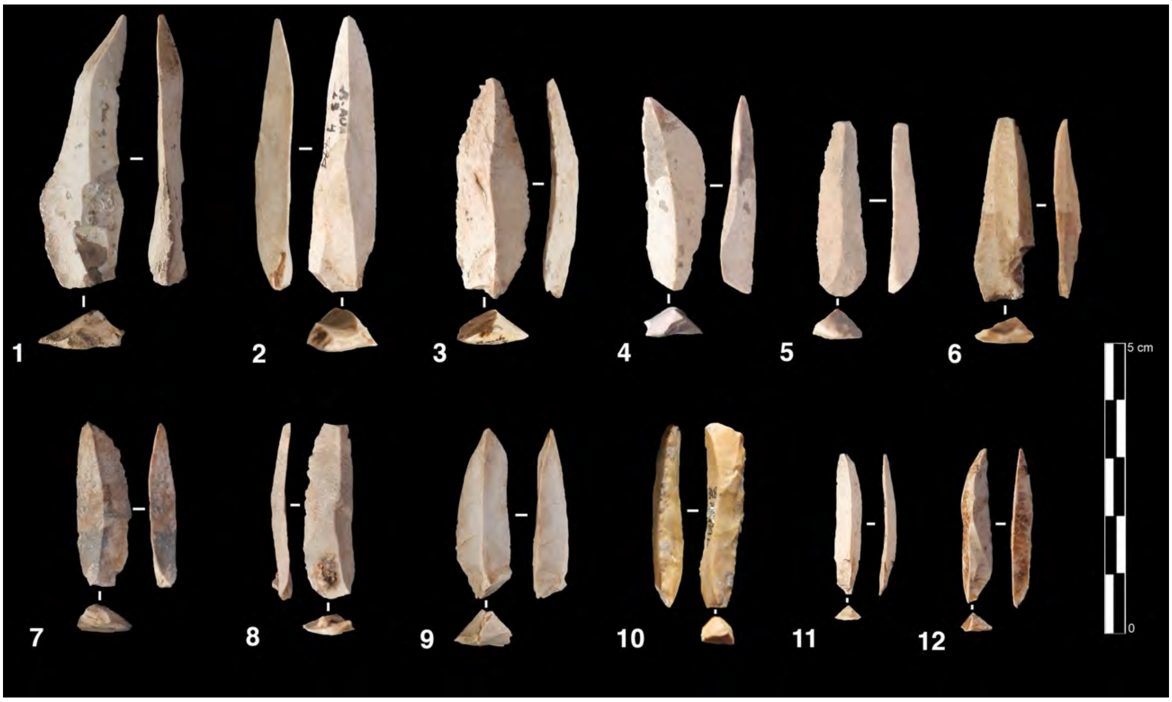


Figure 33 – Bladelets from the level IV.

3.2.4 Retouched elements.

Retouched tools are present along the sequence in different proportions (Table 17). Retouchments rarely modifies the form of the blanks, whether flakes or blades.

When it is presents, the retouchment seems to be focused to regularize the cutting edge of the blanks without changing the original structure of the flakes or blades (e.g. Fig. 32 n.1 and Fig 21). The only exception is represented by fifteen pieces (12 from unit K and 3 from J) that are characterized by partial shaping to build a rostrum (Fig. 34).

Blades are more frequently retouched than flakes except for the level K (Table 17). Retouched blades ratio range from 27.5% in level I to 12.5 % in level I while retouched flakes ratio range from 26.6 % in level K and 7.2 in level H (Table 6).

Bladelets are left unretouched except one single bladelet with a lateral retouch found in the level IV (Fig 33 n. 10).

Table 17: Incidence of the retouch on the flakes, blades and bladelets

Levels	**Blades**			**Flakes**			**Bladelets**		
	Total	Ret. N	*Ret %*	Total	Ret. N	*Ret %*	Total	Ret. N	*Ret %*
2	32	4	*12.5*	430	48	*11.1*	13	0	*0*
3	3	0	*0*	105	9	*8.5*	5	0	*0*
IV	399	95	*23.8*	4535	496	*10.9*	62	1	*1.6*
5	6	0	*0*	192	29	*15.1*	0	0	*0*
H	90	23	*25.5*	1960	143	*7.2*	16	0	*0*
I	40	11	*27.5*	785	72	*9.1*	0	0	*0*
J	33	6	*18.1*	273	33	*12.1*	0	0	*0*
K	39	7	*17.9*	150	40	*26.6*	1	0	*0*

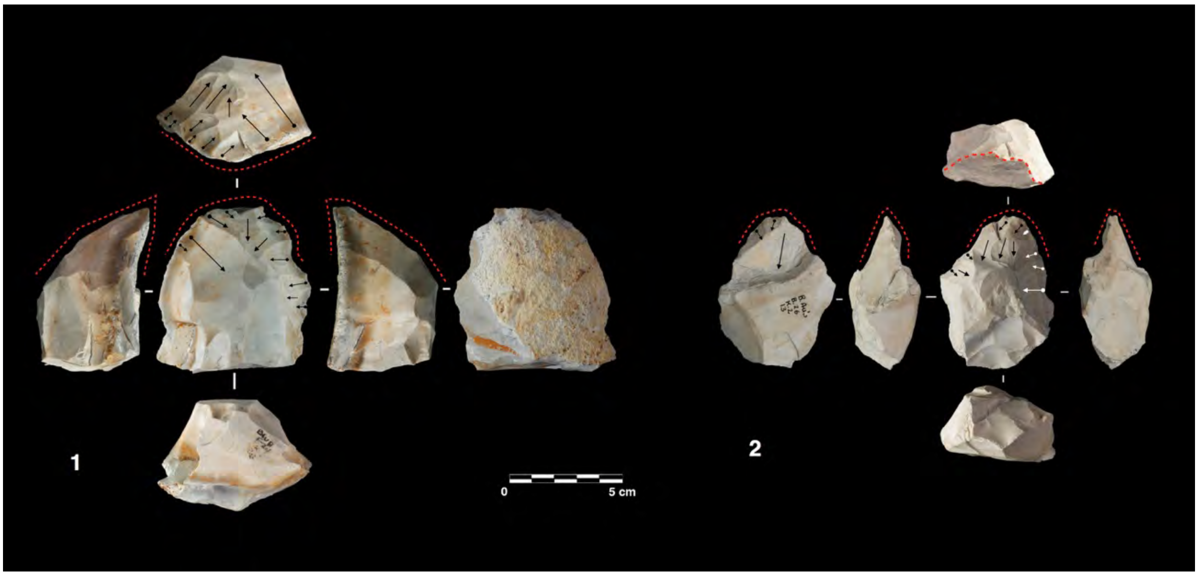


Figure 34 - **Bau de l'Aubesier:** Partially shaped pieces from level K.

3 – DISCUSSION

3.1 Flakes blades and bladelets at the Bau de l'Aubesier.

Over the sequence of Bau de l'Aubesier a complex variability in reduction processes has been detected. Differences and common features over time can be observed in both flakes and blades productions.

The blade production is made out of two main procedures that follow a volumetric and a surface exploitation. The technological flexibility of these two blade reduction process allows to produce a supplementary variability which is expressed along the sequence by the diversification in the methods used (Fig 35).

Starting from the bottom of the sequence, blade productions in the level K show a pyramidal system and a unidirectional rotating system aimed to produce convergent and non-convergent blades (Fig. 35). Levels J and I "lost" the pyramidal system, which is replaced by a semi-rotating sub-convergent system. In the subsequent level H the variability of blade reduction systems repeats in large part what has been seen in level J and I with slight differences that consist in the presence of a unidirectional rotating system and in a decrease of the sub-convergent semi-rotating systems.

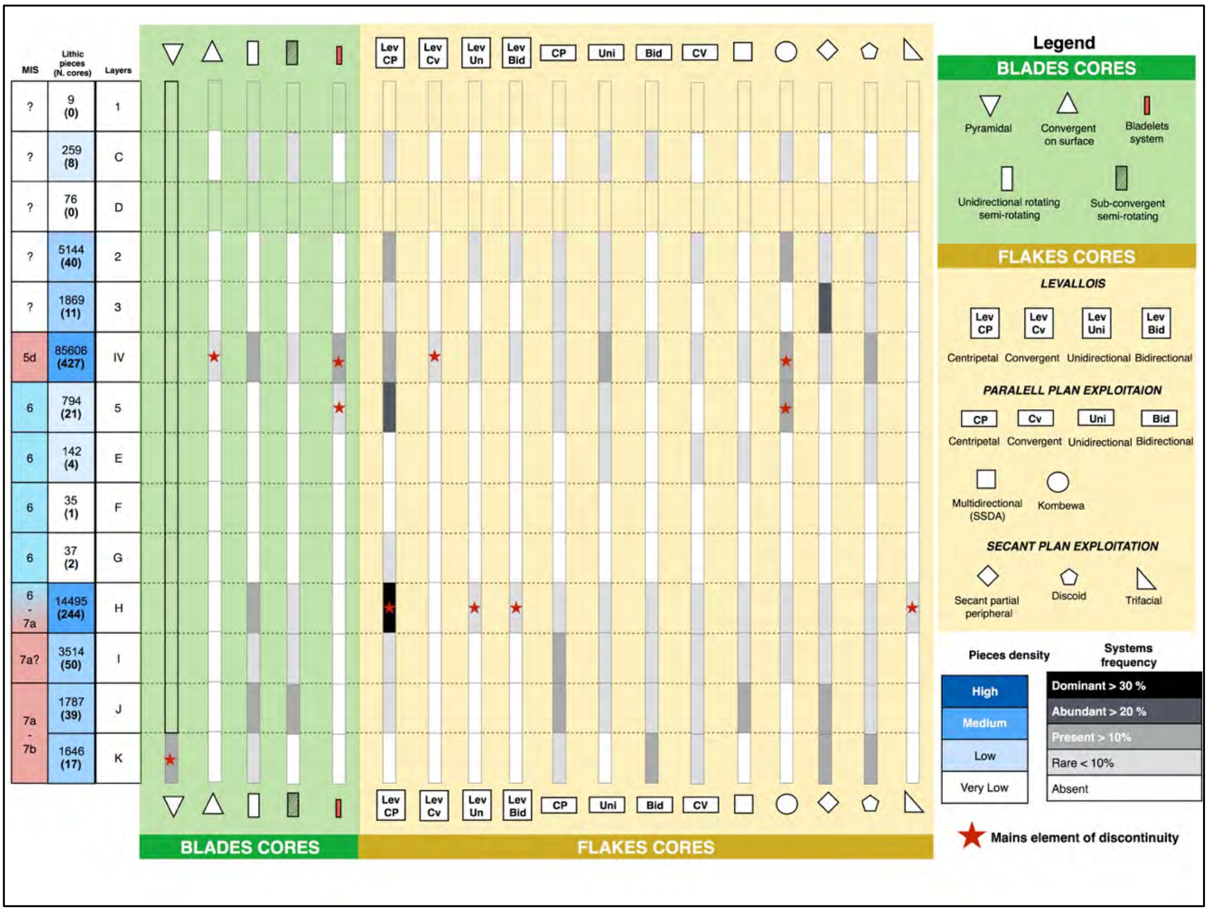


Figure 35 - Summary of the reduction processes over the sequences at the Bau de l'Aubesier

A clear element of discontinuity has been highlighted in the upper levels and more specifically in the level IV. In this level, beside the continuum of the volumetric blade production based on the unidirectional semi-rotating systems, a production of convergent blades reappears by the mean of a surface exploitation really close to the Levallois volumetric concept.

The second important technological change in level IV is constituted by the production of bladelets by independent reduction strategies which are clearly documented by bladelets, cores and by-product such us crested bladelets and rejuvenation bladelets (Fig 35). Less clear is the bladelet component found in the level H that could be the result of an advanced phase of a volumetric unidirectional exploitation. Level 2 at the top of the sequence also shows a bladelets production even if in minor quantity.

As well as for the blades reduction strategies, also flakes reduction strategies show elements of continuity and discontinuity over the sequence.

The lower levels (K, J and I) are characterized by the non-levallois parallel plans exploitation and by the secant plans exploitation. Levallois, which is absent in level K, appears sporadically in the level J and I in the form of the recurrent centripetal method (Fig 35).

Level H signs a technological break with the lower level concerning the flake production. This level is in fact dominated by the centripetal Levallois reduction system. Beside the dominance of the centripetal method the Levallois concept shows also a larger variability represented by the unidirectional and bidirectional methods.

Secant plan exploitation continue to be present and include a Trifacial exploitation not detected in the levels K J and I.

Level IV repeats to a large extent the variability observed in the level H but with some exceptions. The Levallois variability in this level includes in fact also the convergent method while the Kombewa exploitation already present in level H and I increases and repeats the same methods variability observed for the Levallois.

The technological variability observed on the core is reflected in the end-products differentiation. Over the sequence, change in blade and flake techno-type is observed. Concerning the blade production two main categories of blades are produced by the mean of two different distinct modalities that are the surface exploitation and the volumetric exploitation. Inside these categories, the use of different methods is aimed to produce two main types of blades that are the convergent blades and the non-convergent blades. Convergent blades in lower levels come from a volumetric exploitation that can be easily related to the sub-pyramidal cores found in levels K.

In the upper level (IV and 2) convergent blades are the result of a surface exploitation. These products are coherent with the elongated convergent core found in level IV. Non-convergent volumetric blades are present with different percentage all over the sequence in parallel with a continuous presence of the unidirectional volumetric exploitation cores.

The Non-convergent blades from surface exploitation are more difficultly linkable with specific reduction systems. These blades can be the results of a unidirectional or bidirectional exploitation on surface both Levallois and non Levallois. However, we can notice that the increasing of Levallois and in particular the unidirectional and bidirectional methods in level H and IV is correlated with an increase of this techno type of blades (Table 4).

Concerning the flakes, the differentiation in the Levallois method observed in level H with the insurgence of the unidirectional and bidirectional methods and in level IV with the convergent method fit well with an increase of the variability in the levallois end product in these levels.

To sum up a wide variability is obtained in blades and flakes end product due to a large differentiation in reduction strategies. This variability directly obtained during the débitage can explain the rare use of the retouchments that furthermore when used rarely modify the structure of the end product for both flakes and blades.

3.2 Blade and bladelets in the Middle Paleolithic.

Prior knowledge show how the most ancient blade production is concentrated in the northern European plain at the end of MIS 8 the MIS 7.

The blade production found in the lower level (K, J and I) at Bau de l'Aubesier, dating back to the end of MIS 7, and located in the southeast France contributes to mitigate this scenario.

The sub-pyramidal systems that characterise the blade production in the lower level at the Bau de l'Aubesier don't find any clear match with the northern plain blades reduction strategies which instead are based on a volumetric unidirectional or bidirectional reduction strategies such as at Saint-Valéry-sur-Somme (Heinzelin & Haesaerts 1983), Bapaume-les Osiers (Koehler 2008) and Therdonne (Locht *et al.* 2010) in France, Rissori (Adam 1991; Adam & Tuffreau 1973) in Belgium. The blades pyramidal core, prior the MIS 5 has been highlighted in the Italian peninsula at the site of Cave dall'Olio and dating back to MIS 9 (Fontana et al 2009).

Later on, during the MIS 5, evidence of pyramidal blades cores become more frequent such as in the sites of Angé in central-north of France (Koehler and Debenham 2009) or at Cantaluette IV (Blaser *et al.* 2012) in the southouest France even if semirotating and rotating systems continue to be the most reduction strategies used to produce blades as exemplified by the sites of Riencourt lès-Bapaume (Ameloot-Van der Hejden 1993; Goval & Hérisson 2006), Saint-Germain-des-Vaux (Cliquet 1992; Révillion & Cliquet 1994), Seclin (Révillion & Tuffreau 1994), Bettencourt-Saint-Ouen (Loch 2002), Blangy-Tronville (Depaepe *et al.* 1999), and Rocourt (Otte 1994a). In the level IV of Bau de l'Aubesier, dating back to the MIS 5, this type of reduction strategies are largely used but in the meanwhile the production of convergent blades by a surface exploitation is as well present. At the state of research this type of production doesn't find any clear match with the contemporaneous sites.

In general, we can observe how the blade production recognized at Bau de l'Aubesier shows both elements of convergence and divergence with the blade reduction strategies used from the MIS 7 to the MIS 5.

A second important element of divergence, which characterize the Bau de l'Aubesier, is the bladelets products recognized in the level IV.

Evidence of Middle Paleolithic bladelets production is a known phenomenon during the MIS 4 and 3 as noted at the sites of El Castillo and Cueva Morin in northern Spain (Maíllo Fernández 2001; Maíllo-Fernández *et al.* 2004), at Champ Grand (Slimak & Lucas 2005) and Combe Grenal in France (Faivre 2012), Fumane (Peresani *et al.* 2013) and Grotta del Cavallo in Italy (Carmignani 2010) and Balver Höhle in Germany (Pastoors & Tafelmaier 2010).

Prior to this period evidence of bladelets production are extremely rare. An ephemeral bladelets production dating back to the end of MIS 8 in the site of Payre has been recently highlighted by the author. Nevertheless, the few cores recognized at Payre and the total absence of product and by-products does not allow clarifying if we are facing a true intentional systematic production (Carmignani et al in this volume).

A second ancient evidence comes from the site of Bapaume les Osiers and dates back to the end of the MIS 7 that is constituted of one bladelet core and four bladelets (Koehler 2008). Evidences of bladelets production continue to be extremely rare and anecdotic also during the MIS 5. Production of small elongate elements removed by flakes has been recognized at the site of Angé. The author specifies however that in this case the reduction process of the bladelets is in continuity with a blade production and not can be considered as an independent reduction strategy (Koehler et al 2014). Another ephemeral presence of bladelets core dated at the MIS 5 has been recently recognized at the site of Riparo del Molare. No specific information about the end-product and the quantification are currently available (Aureli and Ronchitelli *in press*).

In contrast to these ephemerals evidences, at Bau the l'Aubesier all the chaine operatoire is present and leaving no doubt about the intentionality if this production.

CONCLUSION

The long-term evolution of the European Middle Paleolithic blade production spanning more than 200,000 years cannot be defined as a monolithic entity.

The large variability observed in blades techno-type suggests that the blade phenomenon cannot be related to a specific tool and probably neither to a specific function.

Although the blade variability recognized at the Bau de l'Aubesier share certain features with the contemporaneous reduction strategies present in northern Europe, original elements characterize the specific techno-cultural baggage of the Neanderthal group that occupied the site from the end of the MIS 7 to the MIS 5. The scenario that emerged at Bau de l'Aubesier is characterized by a complex internal technological evolution that affects both the reduction strategies and the end product.

The origin of this variability reflects in our opinion the existence of distinct technological traditions trough the time. Furthermore, even if the role of the Middle Paleolithic bladelets is still unclear its evidence largely documented at the Bau de l'Aubesier contributes to enlarge our vision about the complexity of the Neanderthal techno-cultural baggage.

Blade and bladelets in the Neanderthal techno-cultural baggage: Evolution of elongated product at the Bau de l'Aubesier rock shelter (France).

Leonardo Carmignani

Supporting Information

Supplementary File S1

Table A. – Determined fragmented pieces

	K		J		I		H		G-F-E-D-C		5		IV		3		2		1	
Levels	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Cortex >50 % dist	-	0	-	0	1	0,4	7	1	-	0	1	1	11	0,5	-	0	3	0,9	-	0
Cortex >50 % mes	-	0	-	0	-	0	1	0,1	-	0	-	-	1	0	-	0	-	0	-	0
Cortex >50 % prox	-	0	-	0	-	0	4	0,6	-	0	-	-	4	0,2	-	0	1	0,3	-	0
Cortex <50% dist	1	1,6	-	0	3	1,2	26	3,9	3	8,6	-	-	18	0,9	-	0	4	1,2	-	0
Cortex <50% mes	1	1,6	-	0	1	0,4	6	0,9	1	2,9	-	-	4	0,2	-	0	-	0	-	0
Cortex <50% prox	2	3,3	-	0	-	0	51	7,6	-	0	2	2,1	17	0,8	1	2,4	4	1,2	-	0
Levallois flakes Dist	2	3,3	5	3,5	12	4,9	17	2,5	-	0	3	3,1	33	1,6	-	0	5	1,5	-	0
Levallois flakes Mes	-	0	3	2,1	1	0,4	1	0,1	-	0	-	-	4	0,2	1	2,4	1	0,3	-	0
Levallois flakes Prox	1	1,6	8	5,7	36	14,6	46	6,9	1	2,9	7	7,2	166	8,2	1	2,4	20	6	-	0
Blades dist	2	3,3	10	7,1	23	9,3	17	2,5	1	2,9	4	4,1	112	5,6	-	0	15	4,5	-	0
Blades mes	2	3,3	3	2,1	6	2,4	3	0,4	4	11,4	4	4,1	64	3,2	4	9,5	4	1,2	-	0
Blades prox	2	3,3	8	5,7	19	7,7	7	1	3	8,6	2	2,1	124	6,2	1	2,4	19	5,7	-	0
Bladelets dist	-	0	-	0	-	0	7	1	-	0	-	-	50	2,5	3	7,1	9	2,7	-	0
Bladelets mes	-	0	-	0	-	0	-	0	-	0	-	-	35	1,7	1	2,4	8	2,4	-	0
Bladelets prox	-	0	-	0	-	0	2	0,3	1	2,9	1	1	47	2,3	2	4,8	10	3	-	0
Debordant flakes dist	-	0	-	0	2	0,8	2	0,3	-	0	-	-	1	0	3	7,1	2	0,6	-	0
Debordant flakes mes	-	0	-	0	-	0	-	0	-	0	1	1	4	0,2	-	0	1	0,3	-	0
Debordant flakes prox	3	4,9	-	0	4	1,6	1	0,1	-	0	2	2,1	17	0,8	-	0	8	2,4	-	0
Centripetal flakes dist	-	0	2	1,4	6	2,4	9	1,3	1	2,9	1	1	19	0,9	1	2,4	6	1,8	-	0
Centripetal flakes mes	-	0	-	0	4	1,6	2	0,3	-	0	-	-	2	0,1	-	0	-	0	-	0
Centripetal flakes prox	-	0	-	0	4	1,6	9	1,3	-	0	-	-	25	1,2	1	2,4	5	1,5	-	0
Unidirectional flakes dist	5	8,2	8	5,7	11	4,5	27	4	4	11,4	7	7,2	145	7,2	4	9,5	20	6	-	0
Unidirectional flakes mes	14	23	20	14,2	17	6,9	26	3,9	1	2,9	4	4,1	50	2,5	1	2,4	18	5,4	-	0
Unidirectional flakes prox	20	32,8	41	29,1	26	10,6	78	11,7	6	17,1	11	11,3	199	9,9	7	16,7	42	12,5	-	0
Bidirectional flakes dist	-	0	1	0,7	-	0	1	0,1	-	0	-	-	2	0,1	-	0	1	0,3	-	0
Bidirectional flakes mes	-	0	-	0	-	0	2	0,3	-	0	-	-	1	0	-	0	-	0	-	0
Bidirectional flakes prox	-	0	-	0	-	0	3	0,4	-	0	-	-	3	0,1	-	0	1	0,3	-	0
Convergent flakes dist	6	9,8	11	7,8	11	4,5	12	1,8	4	11,4	3	3,1	88	4,4	3	7,1	16	4,8	-	0
Convergent flakes mes	-	0	2	1,4	1	0,4	-	0	-	0	-	-	2	0,1	-	0	1	0,3	-	0
Convergent flakes prox	-	0	-	0	1	0,4	-	0	-	0	1	1	7	0,3	-	0	2	0,6	-	0
Undetermined flakes dist	-	0	3	2,1	15	6,1	86	12,9	-	0	7	7,2	196	9,7	-	0	18	5,4	-	0
Undetermined flakes mes	-	0	2	1,4	12	4,9	38	5,7	1	2,9	7	7,2	107	5,3	-	0	17	5,1	-	0
Undetermined flakes prox	-	0	14	9,9	30	12,2	178	26,6	4	11,4	29	29,9	456	22,6	8	19	75	22,3	3	100
Total	61	100	141	100	246	100	669	100,0	35	100	97	100	2014	100	42	100	336	100	3	100

Table B. – Entire determined removals from the Moulin Trench Area

LEVELS	G		F		E		D		C	
	N	*%*	N	*%*	N	*%*	N	*%*	N	*%*
Flakes (Cortex >50%)	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*
Flakes (Cortex<50%)	-	*0*	1	*14,3*	1	*2,6*	3	*33,3*	4	*10,8*
Levallois type centripetal	-	*0*	3	*42,9*	7	*18,4*	1	*11,1*	5	*13,5*
Levallois type unidirectional	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*
Levallois type bidirectional	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*
Levallois type othogonal	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*
Levallois type convergent	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*
Debordant Levallois type flakes	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*
Blades	1	*9,1*	-	*0*	2	*5,3*	1	*11,1*	1	*2,7*
Bladelets	-	*0*	-	*0*	1	*2,6*		*0*	1	*2,7*
Pseudolevallois	-	*0*	-	*0*	1	*2,6*		*0*	1	*2,7*
Centripetal flakes	4	*36,4*	1	*14,3*	7	*18,4*		*0*	6	*16,2*
Kombewa	-	*0*	-	*0*	3	*7,9*		*0*	3	*8,1*
Unidirectional flakes	3	*27,3*	2	*28,6*	6	*15,8*	1	*11,1*	6	*16,2*
Bidirectional flakes	1	*9,1*	-	*0*	-	*0*	1	*11,1*	2	*5,4*
Orthogonal flakes	-	*0*	-	*0*	4	*10,5*		*0*	2	*5,4*
Convergent flakes	-	*0*	-	*0*	3	*7,9*	1	*11,1*	1	*2,7*
Debordant flakes	1	*9,1*	-	*0*	1	*2,6*	1	*11,1*	3	*8,1*
Macro-tools	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*
Striking platform flakes	-	*0*	-	*0*	-	*0*	-	*0*	-	*0*
Shaping/retouching flakes	-	*0*	-	*0*	-	*0*	-	*0*	1	*2,7*
Rejuvenation flakes	-	*0*	-	*0*	1	*2,6*	-	*0*	-	*0*
Crested flakes	-	*0*	-	*0*	1	*2,6*	-	*0*	-	*0*
Siret accident	1	*9,1*	-	*0*	-	*0*	-	*0*	1	*2,7*
Total	11	*100*	7	*100*	38	*100*	9	*100*	37	*100*

Table C. – Cores from the Moulin Trench Area.

	Levels	G	F	E	D	**C**
Flakes cores	Levallois centripetal	1	-	-	-	2
	Unidirectional	-	-	1	-	2
	Bidirectional	-	-	-	-	1
	Multidirectional	-	-	1	-	-
	Kombewa	-	-	-	-	1
	Kostienky	-	1	-	-	-
	Discoid unifacial	-	-	1	-	-
Blades	Unidirectional semi-rotating	-	-	-	-	1
	Convergent semi-rotating	-	-	-	-	1
	Half pyramidal cores	-	-	-	-	-
	Core's fragments	1	-	1	-	-
	Total	2	1	4	0	8

Chapter 4

Between the flake and the blade: Associated systems of production at Riparo Tagliente (Veneto, northern Italy)

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Abstract:

The Riparo Tagliente site (Verona, Italy) shows three macro phases in which high technological variability can be observed. The aim of this study is to evaluate the specific role of the Middle Paleolithic blade production within this variability. Preliminary results show a complex scenario in which the role of the blade is strictly linked with flake production through mixed reduction systems.

Two different approaches were used for analysing the lithic assemblages from the site. The first analysis focused on the identification of the reduction systems by determining the techniques, methods and concepts underlying the entire *chaîne opératoire*. The second approach concentrated on analysing blade production in order to identify its variability.

Evidence of blade technology from the Middle Pleistocene (MIS 8-6) has been found in northern Europe (France, Belgium). Later, during MIS 5 blades can be found over a larger area, this time also including north-western Germany and the central-southern part of France. A third period (MIS 4-3) marks the appearance of laminar production in southern Europe, including in the Italian peninsula. Based on the present state of research these three phases appear to be on-and-off events wFithout clear evolutionary continuity.

By repositioning the sequence of Riparo Tagliente within the Italian context we can observe that at the end of the Mousterian period the technological patterns differ greatly, with laminar production being one of its most evident expressions. The origin of this fragmentation is questionable.

Keywords: Blades; Riparo Tagliente; Middle Paleolithic; Levallois; Reduction systems.

1. Introduction

By simplifying what is produced through lithic production, we can identify three possible categories of products: flakes and blades, both produced by knapping operations (*débitage*), and shaped tools (hand axes, choppers), the result of shaping operations (*façonnage*). If shaping operations involve a conceptual modelling structure of a block of raw material, the dichotomy flake-blade is, at the macroscopic scale, a double variant of the same theme, which entails the separation of a piece from its original volume. The Middle Paleolithic marks the emergence and development of a variety of knapping methods aimed at producing predetermined blanks within which the blade occupies a not-yet defined role.

This paper addresses the issue of the technological complexity that characterizes Middle Paleolithic reduction systems and investigates the role of elongated products within the Neanderthal techno-cultural baggage. In addition to Levallois production, the sequence of Riparo Tagliente shows the use of various reduction systems aimed at obtaining a mixture of flake and blade blanks. Because of this a comparison of the morpho-technical characteristics of Levallois and non-Levallois elongated products was carried out.

1.1 The blade phenomenon in the Middle Paleolithic

From a global point of view, blade production dates back to the Middle Pleistocene. The first evidence of blade production was found in Africa at two sites, Kathu Pan (Wilkins & Chazan 2012) and Kapturin (Johnson & McBrearty 2010), both approximately 500,000 years old (Figure 1).

The Amudian complex in the Middle East is the second oldest evidence of blade production and dates back to MIS 9 and MIS 8 (Mercier & Valladas 2003; Barkai *et al.* 2005).

Subsequently, in a second phase (MIS 7-6), the expansion and differentiation of blade production over a larger area took place, which included the internal part of Syria and the southern area of the Caucasus. This second phase gave rise to several other lithic industries known by various names: the Hummalian (Le Tensorer 2005; Richter *et al.* 2011), Pre-Aurignacian (Bordes 1977), Hayonim (Meignen 2011), and Djruchula-Koudaro industries (Meignen & Tushabramishvili 2006, 2010).

The third and final phase is that of the well-known case of the northern European blade production observed at several sites dating back to MIS 8 and MIS 7 (Révillion 1995).

By contrast, there is no evidence of blade tool production in Asia, at least during the Middle Pleistocene (Boëda *et al.* 2013; Li & Bodin 2013; Peng *et al.* 2014). The easternmost assemblages containing volumetric blade technology have been documented at Khonako in Tadjikistan and date back to around 170 ka (Schäfer & Ranov 1998; Schäfer *et al.* 1998, 2003).

All of these industries have in common the presence of blades, but differ strongly in the rest of their productions (Meignen 1994, 2007).

In short, during the Middle Pleistocene at least three blade production epicentres differentiated in space and time can be observed. As far as we know these spatial, chronological and technological differences suggest a convergence phenomenon (Figure 1).

We will now focus our attention on the European continent, where, as was already noted, the earliest evidence of laminar production dates back to MIS 8 and MIS 7 and is found in northern Europe. The reduction systems used were either volumetric, such as those of Saint-Valéry-sur-Somme (Heinzelin & Haesaerts 1983), Bapaume-les Osiers (Koehler 2008) and Therdonne (Locht *et al.* 2010) in France, Rissori (Adam 1991; Adam & Tuffreau 1973) in Belgium, or followed a Levallois concept, as noted at the site of Biache-Saint-Vaast in northern France (Böeda 1988) (Figure 1). We know these productions continued throughout MIS 7, but there is a lack of archaeological evidence for the glacial peak that was MIS 6. Further east, the sites of Kabazi, Molodova, and Kolorevo show blade production starting in MIS 7 (Chabai & Sitlivyj 1994; Chabai *et al.* 2004).

During MIS 5 blade production becomes, once again, abundant in northern Europe as exemplified by the French and Belgian sites of Riencourt lès-Bapaume (Ameloot-Van der Hejden 1993; Goval & Hérisson 2006), Saint-Germain-des-Vaux (Cliquet 1992; Révillion & Cliquet 1994), Seclin (Révillion & Tuffreau 1994), Bettencourt-Saint-Ouen (Loch 2002), Blangy-Tronville (Depaepe *et al.* 1999), and Rocourt (Otte 1994a).

At the same time, blade production also spread over a wider area including northeast Germany (Tönchesberg (Conard 1990) and Wallertheim sites (Conard & Adler 1997)) and central and southern France (Angé (Locht *et al.* 2008), Vinneuf (Gouédo 1994), Baume Flandin (Moncel 2005; Moncel *et al.* 2008) and Cantalouette 4 sites (Blaser et al. 2012)) (Figure 1).

In all of the above sites blades were rarely the predominant tool types, but instead co-existed with various other reduction systems (Levallois, Discoid, etc.) as well as with a number of shaping systems such as those noted at the sites of Bapaume-les Osiers (Koehler 2008) and Vinneuf (Gouédo 1994) in France. In the MTA B industries, the association of blade reduction systems with hand axe is also well documented (Soressi 2002, 2005).

The variability of the blade reduction systems used does not allow for these to be grouped based on a common denominator. Knapping can begin with the preparation of a crested blade or by exploiting the natural convexity of the raw material. Both unidirectional or bidirectional methods are applied for directing the removals. Exploitation can be applied to the narrow surface by means of a rotating or semi-rotating rhythm ('volumetric *latu sensu*') or to a configured large surface ('Levallois concept').

There is still ongoing debate concerning the origin of these production systems. Some authors have suggested that blade production could be an opportunist method leading to the optimisation of the use of the raw materials, which may have motivated the production of elongated removals (Conard 1990). However, this may not necessarily be the case in areas rich in raw materials, where these productions are equally present. Furthermore, the use of different raw material geometric structures such as pebbles, nodules, core-flakes or slabs does not appear to have been hindered or limited the production of blades. Other authors have suggested a relationship between blade production and environmental crises (Otte 1994b). However, the duration of the blade phenomenon and the diffusion in areas that differ greatly from one another suggest that it is impossible to provide a single explanation for it.

Figure 1. (A) Blade production during the Middle Pleistocene. (B, C, D) - Main sites with blade production in Western Europe during the Middle and Upper Pleistocene (MIS 8-3). (Adapted blank maps from Free Software Foundation (FSF), GNU General Public License).

This phenomenon only appeared in southern Europe at a later stage. Blades first appear in the south of France in MIS 5, as in the site of Cantaluette 4 (Blaser *et al.* 2012), but become more widespread during MIS 4 and MIS 3 such as in the site of Abris du Maras (Moncel 1996) and Champ Grand (Slimak 1999) (Fig 1).

This final phase of Middle Paleolithic blade production is also comparable to the lithic industries observed in central Europe such as the Bohunician (Svoboda & Skrdla 1995; Skrdla 2003).

In short, we can observe how the oldest expressions of the laminar phenomenon occurred within the northern borders for a long time (MIS 8-6) while the southern regions were still dominated by the production of flakes (Figure 1).

As far as the Italian peninsula is concerned, current studies report the first evidence of blade production in the final phases of the Middle Paleolithic, more specifically in MIS 4 and in the first part of MIS 3 (Figure 1). The geographic distribution of both non-Levallois and Levallois blade production does not appear to be linked to a specific area or environment. In fact, these productions can be found all throughout the Italian peninsula.

Non-Levallois productions were found in the Apulia region at the sites of Santa Croce (Arrighi *et al.* 2009) and Grotta del Cavallo (Carmignani 2010); in Lazio at Grotta Breuil (Grimaldi 1996); in Molise at Grotta Reali (Arzarello *et al.* 2004; Peretto 2012); in Veneto at Fumane (Peresani 2012); and in Liguria at Grotta di San Francesco (Tavoso 1988) and Madonna dell'Arma (Cauche 2007; Cauche & Lebègue 2008).

At the same time Levallois blade production is well represented both in northern Italy at Riparo Mochi (Grimaldi & Santaniello 2014; Yamada 2004) and Barma Grande (Yamada 1997) and in the south at Riparo del Poggio (Caramia & Gambassini 2006), Grotta di Castelcivita (Gambassini 1997) and Oscurusciuto (Boscato *et al.* 2011; De Stefani *et al.* 2012).

The only exception to this late appearance in the Italian peninsula is the site of Cave dell'Olio (Fontana *et al.* 2009; Fontana *et al.* 2013). This site is, at the present, the only one dating back to MIS 9, representing the only proof of blade production in the Italian Peninsula during the Middle Pleistocene.

While it is now certain that blades were produced during the Middle Paleolithic, the production of bladelets, obtained by means of an independent reduction system, is less evident and occurred just in the final phases of the Mousterian period. Some bladelets production has been noted at the sites of El Castillo and Cueva Morin in northern Spain (Maíllo Fernández 2001; Maíllo-Fernández *et al.* 2004), at Champ Grand (Slimak & Lucas 2005) and Combe Grenal in France (Faivre 2012), Fumane (Peresani *et al.* 2013) and Grotta del Cavallo in Italy (Carmignani 2010) and Balver Höhle in Germany (Pastoors & Tafelmaier 2010).

Some geographic areas, such as the Balkans and Greece, and the Iberian Peninsula, do not seem to be influenced by this phenomenon, both during its earliest and more recent phases, completing the fragmentary and irregular overview that emerges from the data in our possession. Although this absence can be attributed to a lack of research, especially for the Balkan region and Greece, this is certainly not the case for the Iberian Peninsula for which there is a much larger amount of available data.

The Riparo Tagliente site, which is presented in this paper, is part of the last phase of the Middle Paleolithic blade phenomenon and shows an articulated techno-cultural repertoire consisting of mixed flake and blade reduction systems.

2. Materials and methods

2.1. The site of Riparo Tagliente

Riparo Tagliente is a rock shelter located in the Veneto region in northern Italy (Figure 2).

It was first excavated in the 1960s by the *Museo Civico di Storia Naturale di Verona* (Pasa & Mezzena 1964; Zorzi 1962; Zorzi & Mezzena 1963) and subsequently in collaboration with the

University of Ferrara (Bartolomei *et al.* 1982, 1984). The Mousterian collection under examination here comes from these excavations. Research at the site is still ongoing currently under the direction of Federica Fontana from the University of Ferrara. Sediment, macrofaunal, microfaunal and pollen analyses date the Mousterian sequence between MIS 4 and the beginning of MIS 3 (Arzarello *et al.* 2007; Cattani & Renault-Miskovsky 1989; Thun-Hohenstein & Peretto 2005). The stratigraphy, excavated by artificial layer, is composed of a Mousterian sequence and an Epigravettian sequence separated by erosion. The 1960s excavation procedures, which paid much attention to sedimentary details, have enabled us to determine light patterns of internal evolution of the lithic industry.

The Mousterian sequences have been found in two different locations known as 'Internal shelter' and 'External shelter' (Figure 3). The Internal shelter comprises 18 layers (52 to 34) and extends over 8 m^2 while the External shelter comprises 13 layers (46 to 34) and a larger surface area ($16m^2$).

Figure 2. (A, B, C) Maps showing the position of Riparo Tagliente; (D) view of Riparo Tagliente (from Arzarello 2003).

2.2 Sorting procedure and methodology

In Medieval times the shelter has been used as a refuge. These occupations caused a partial destruction and reshuffle of the deposits on a quite large area both for the Epigravettian layers as well as for the Mousterian's ones.

For these reasons a preliminary check of the material and stratigraphy has been focused on eliminating the squares and the layers considered not reliable. After the check we have considered as being reliable just four squares coming from the Internal shelter (Q 614, 615, 634, 635) and four squares coming from the External shelter (Q 5, 6, 8, 9) (Figure 3). In the same way the layers 34 and 35, have been as well excluded from our analysis because of the presence of contamination coming from the Epigravettian layers. After the sampling, our analysis has been concentrated on the layers going from 52 to 36 on an area of 9 m^2. We have selected all flakes (complete or broken) bigger than 15 mm. All cores, core fragments, tools, tool fragments and all blades and blade fragments are selected regardless of their size. The distribution of the material across the sequence show different concentration of the material that has been possible to group in three macro phases called Lower layers, Intermediate layers and Upper layers (Figure 3). Five layers show a high density of stone artefacts (more than 200 pieces). Three layers contain less than 5 pieces and can therefore be considered as sterile (Figure 3).

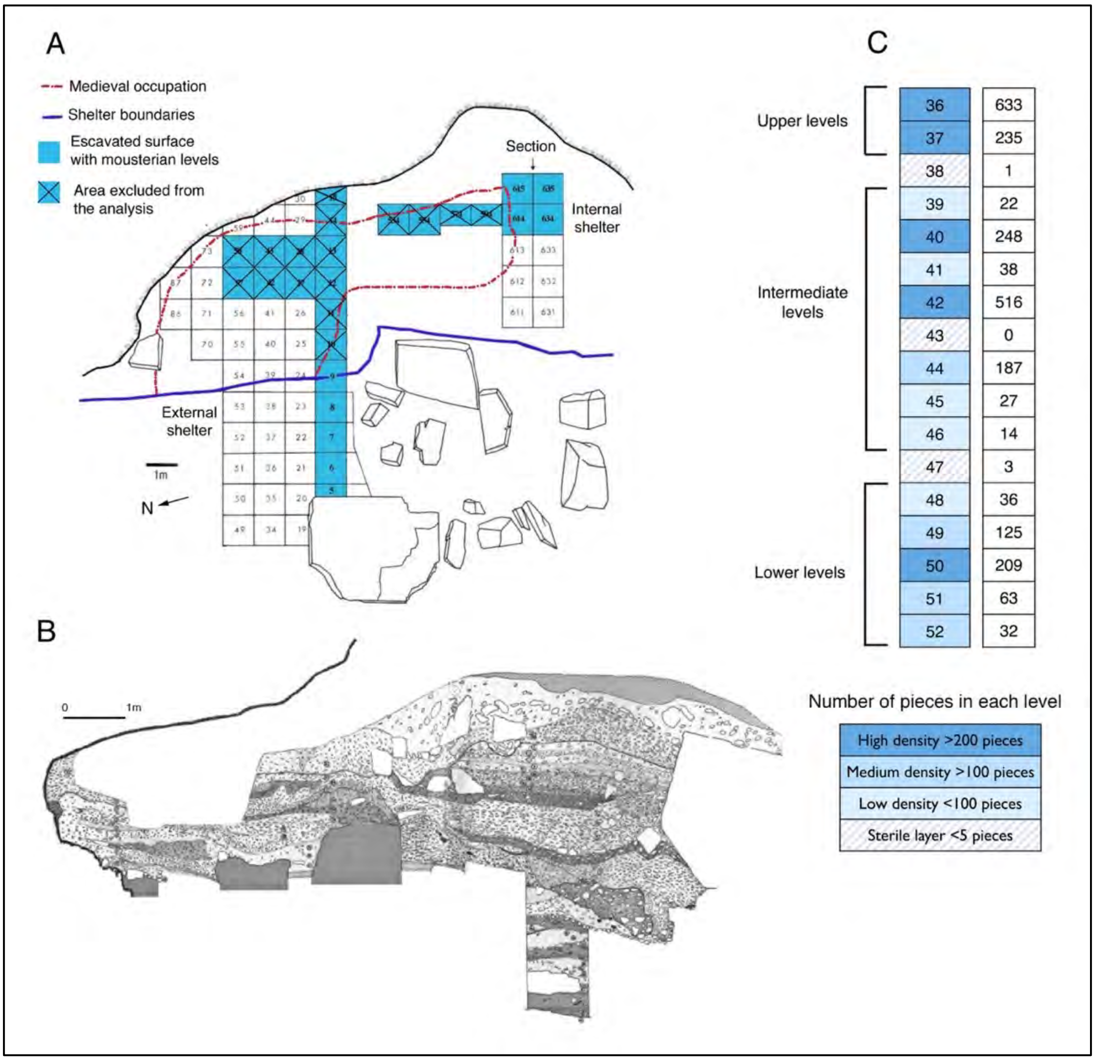

Figure 3. (A) Plan showing the excavation areas (Modified after Bartolomei *et al.* 1982). (B) Stratigraphic section between squares 5/15 and 505/515, and layers 43 to 31 (Modified after Arzarello 2003). (C) Lithic industry distributions across the sequence.

The lithic products of Riparo Tagliente were analysed using a technological approach. The knapping system analysis follows the same principles as those of the *chaîne opératoire* analysis, which is supported by the quantitative presentation of technological categories (Inizan et al. 1995). The definition suggested by Boëda (1994) was adopted for the Levallois concept. Given the absence of the refitting reconstruction of the reduction sequences we used the mental refitting method (Pelegrin 1995). The techniques were identified according to experimental studies carried out by Pelegrin (1991, 2000). Volumetric and Levallois blade productions were distinguished by means of volumetric structure analyses (Boëda 1990). In terms of the Discoid production, we used the definition put forward by Boëda (1993, 1991) as well as also taking in consideration broader criteria (Peresani 1998; Slimak 2003). Diacritical analyses were applied to cores and blanks as a means to reconstruct the chronological order of the scars (Dauvois 1976).

3 Results

3.1 Lithic technology

Our database contains a total of 2315 *débitage* removals and 75 cores. The raw material used is good quality flint from local sources (< 5km). The flint was collected mainly in secondary position in the form of pebbles and to a smaller extent in primary position as roundish nodules (Arzarello *et al.* 2007). Production mainly comprised flakes and to a lesser extent blades (Table 1).

Hard hammer direct percussion was the only technique used in all the reduction systems. The abundance of cortical flakes proves that the initial stage of knapping activities was carried out at the site (Table 1).

In terms of the knapping products, all the layers show a high degree of homogeneity as shown by the large number of Levallois flakes derived from centripetal and unidirectional methods (Table 1). Generic unidirectional and centripetal flakes are numerous. Unidirectional flakes, the number of which falls in the upper layers, represent the only element of discontinuity across the sequence. Blade production is distributed in similar percentages throughout the sequence and is composed of both Levallois and non-Levallois blades (Table 1). Production also includes convergent, orthogonal, bidirectional and Kombewa flakes that are present in small numbers throughout the sequence. The apparent homogeneity observed when analysing the knapping products will be partially invalidated when we turn our attention to the analysis of the cores.

Table 1. Riparo Tagliente. Frequencies of *débitage* classes and cores

LEVELS	**Lower layers**		**Intermediate layers**		**Upper layers**	
	from 52 to 47		**from 46 to 39**		**from 38 to 36**	
	n°	*%*	n°	*%*	n°	*%*
Levallois centripetal flakes	20	*4,3*	90	*8,6*	36	*4,1*
Levallois unidirectional flakes	22	*4,7*	36	*3,4*	16	*1,8*
Levallois orthogonal flakes	0	-	1	*0,1*	1	*0,1*
Levallois convergent flakes	1	*0,2*	7	*0,7*	4	*0,5*
Levallois flakes with a back	4	*0,9*	15	*1,4*	2	*0,2*
Centripetal flakes	51	*10,9*	96	*9,1*	74	*8,5*
Unidirectional flakes	48	*10,3*	83	*7,9*	26	*3,0*
Bidirectional flakes	4	*0,9*	10	*1,0*	2	*0,2*
Orthogonal flakes	0	-	11	*1,0*	3	*0,3*
Sub-convergent flakes	5	*1,1*	14	*1,3*	5	*0,6*
Convergent flakes	3	*0,6*	7	*0,7*	1	*0,1*
Debordant flakes (unspecified)	11	*2,4*	21	*2,0*	7	*0,8*
Debordant flakes (centripetal)	4	*0,9*	16	*1,5*	7	*0,8*
Debordant flakes (unidirectional)	4	*0,9*	7	*0,7*	0	-
Debordant flakes (bidirectional)	0	-	7	*0,7*	0	-
Pseudolevallois points	0	-	2	*0,2*	4	*0,5*
Kombewa 1°generation	9	*1,9*	17	*1,6*	5	*0,6*
Kombewa 2°generation	5	*1,1*	14	*1,3*	5	*0,6*
Levallois blades	3	*0,6*	18	*1,7*	7	*0,8*
Non Levallois blades	28	*6,0*	56	*5,3*	48	*5,5*
Crested blade	1	*0,2*	0	-	0	-
Cortical flakes	79	*16,9*	186	*17,7*	180	*20,7*
Striking platform flakes	11	*2,4*	5	*0,5*	6	*0,7*
Unspecified flakes	57	*12,2*	123	*11,7*	170	*19,5*
Undetermined fragments>15mm	73	*15,6*	165	*15,7*	256	*29,4*
Cores	25	*5,3*	45	*4,3*	5	*0,6*
Total	468	*100*	1052	*100*	870	*100*

3.1.1 Lower layer reduction systems

The Lower layers contain 468 lithic pieces of which 25 are cores. As is the case with the end product, the cores indicate that the Levallois is the main reduction system, which is predominantly expressed in the centripetal method and secondarily in the unidirectional method (Figure 4). The purpose of using the Levallois unidirectional system was to produce mostly flakes. Few blades are associated with this system.

The second most adopted system is based on the exploitation of cortical thick flakes by means of the Kombewa system (Table 2). The exploitation can be limited to a singular detachment or to a short sequence of detachments (Figure 6). The preparation of the cores is limited to a partial correction of the lateral convexities of the flaking surface.

Table 2. Riparo Tagliente. Core types.

LEVELS	Lower layers					Intermediate layers					Upper layers
	t52	t50	t49	t48	Total	t46	t44	t42	t40	Total	t36 (Total)
Levallois centripetal	-	3	3	-	6	-	-	16	-	16	3
Levallois unidirectional	-	1	-	1	2	-	-	3	-	3	-
Levallois bidirectional	-	-	-	-	-	-	-	1	1	2	-
Levallois preferential	-	-	-	-	-	-	1	5	-	6	1
Levallois initialized	-	-	-	-	-	-	-	3	-	3	-
Discoid	1	1	-	-	2	1	-	1	-	2	-
SSDA	-	1	2	-	3	1	-	2	-	3	-
Kombewa (single removal)	-	1	3	-	4	-	-	-	-	-	-
Kombewa (multiple removal)	-	2	1	-	3	-	-	-	-	-	-
Semi pyramidal	-	-	2	-	2	-	-	-	-	-	-
Unidirectional Type 1	-	1	1	-	2	-	-	-	-	-	-
Unidirectional Type 2	-	-	-	-	-	1	-	6	1	8	1
Bidirectional	1	-	-	-	1	-	-	2	-	2	-
Total	2	10	12	1	25	3	1	39	2	45	5

Two cores show a unidirectional reduction system composed of two different exploitation yet interconnected phases, which we termed Unidirectional Type 1 (Figure 5). The first phase exploits the larger surface of the volume through a short unidirectional sequence and has two complementary functions: to produce quadrangular, slightly elongated flakes and to reduce the thickness of the adjacent surface, which will be exploited by a second unidirectional sequence (second phase). The exploitation of the thinner side of the volume, already reduced in thickness during the first sequence, allows for the production of small blades (Figure 5). The configuration of cores is limited to a partial preparation of the lateral convexities carried out by means of a series of orthogonally-oriented detachments with regard to the main flaking direction. An isolated core shows a bidirectional exploitation starting from two opposite striking platforms. The variability of the production systems in this unit is also composed of two Discoid cores and two sub-pyramidal cores. The sub-pyramidal cores are aimed at producing thick convergent flakes (Figure 6). Four cores follow a reduction system based on the exploitation of orthogonal alternated surfaces that can be associated with a SSDA system (Forestier 1993) or with an opportunistic method, *sensu* Arzarello (2003).

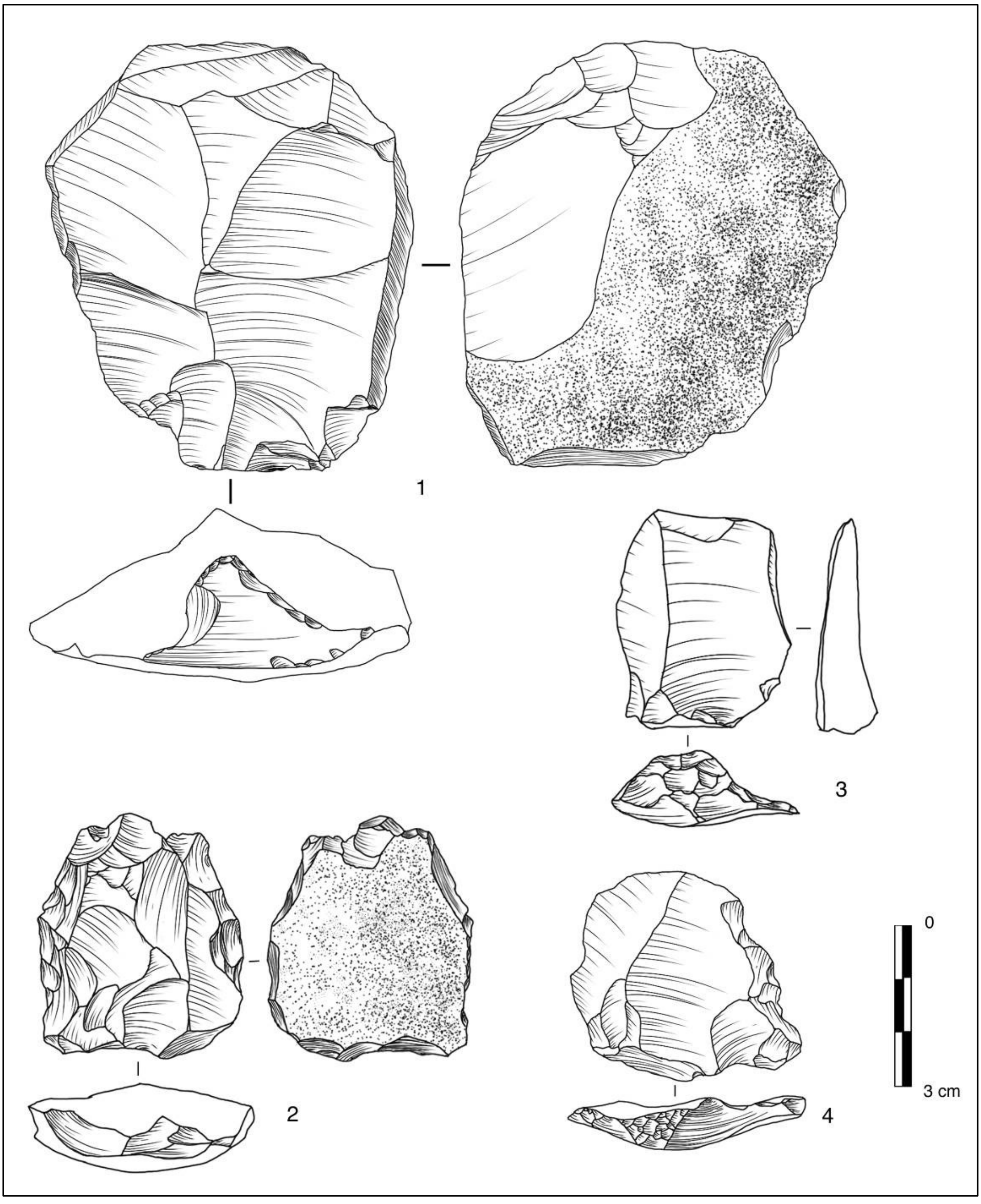

Figure 4. Riparo Tagliente. Lithic industries from the Lower Layers. (1) Levallois unidirectional core; (2) Levallois centripetal core; (3) Levallois unidirectional flake; (4) Levallois centripetal flake.

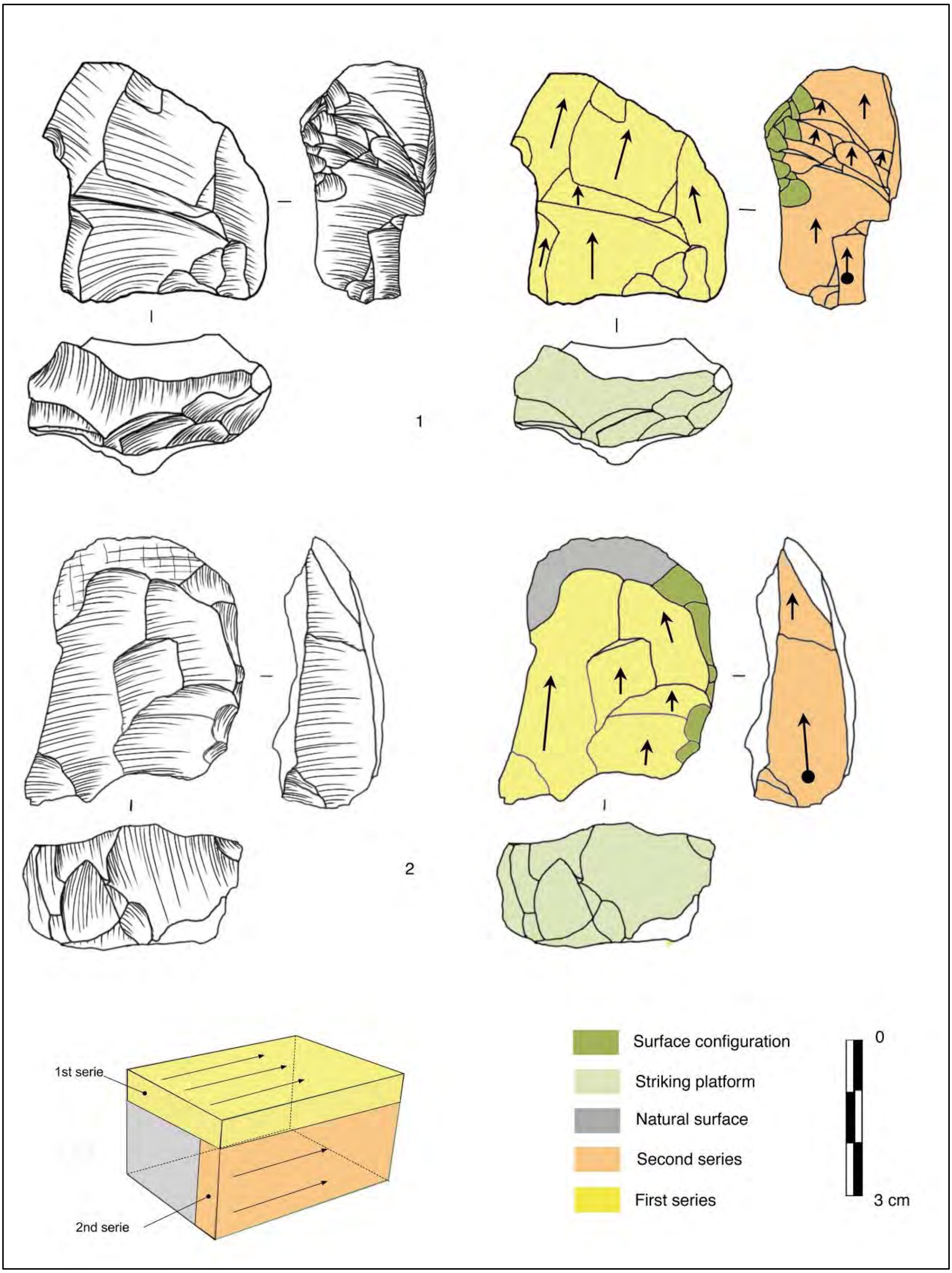

Figure 5. Riparo Tagliente. Lithic industries from the Lower Layers. Unidirectional system Type 1 cores.

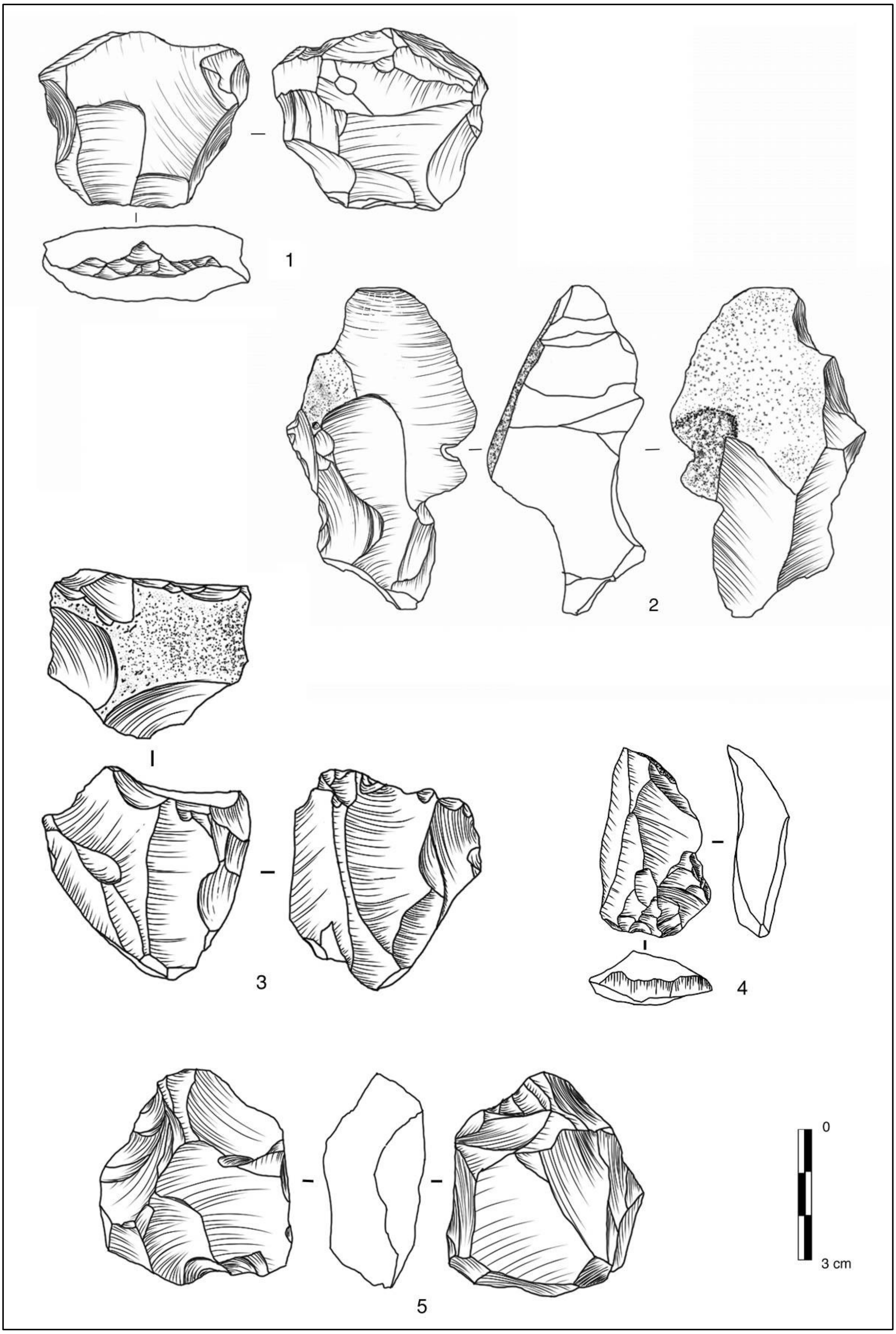

Figure 6. Riparo Tagliente. Lithic industries from the Lower Layers. (1, 2) Kombewa cores; (3) Half-pyramidal core; (4) Convergent flake; (5) Discoid core.

3.1.1 Intermediate layers reduction systems

The Intermediate layers of Riparo Tagliente show some elements of continuity with the Lower layers such as the persistence of the Discoid and SSDA systems. The centripetal Levallois continues to be the predominant reduction system, however, the plasticity of the Levallois concept finds greater variability here than it does in the Lower layers.

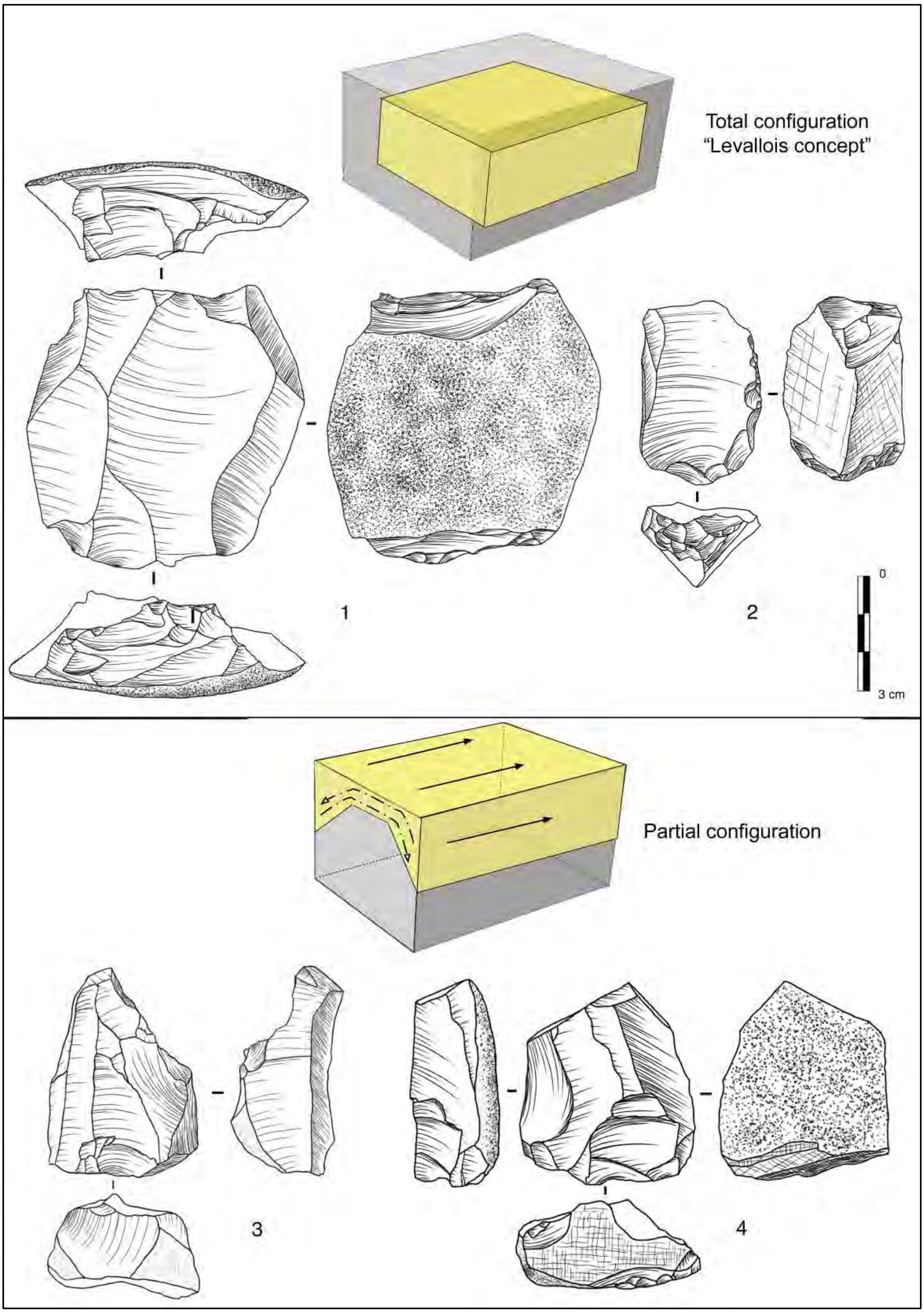

Figure 7. Riparo Tagliente. Lithic industries from the Intermediate Layers. (1) Levallois bidirectional core; (2) Levallois preferential core; (3, 4) Unidirectional system type 2 cores.

The centripetal and unidirectional methods are supported by a bidirectional exploitation while the use of the preferential method, totally absent in the Lower layers, is well represented here (Figure 7).

No Kombewa cores were noted in the Intermediate layers. The presence of Kombewa flakes in these layers could indicate the export of the cores outside the site or they could derive from other flaking operations such as the configuration of a Levallois surface based on the exploitation of the ventral face of a flake. The absence of pyramidal and unidirectional system type 1 methods is a further element of divergence compared to the Lower layers.

In the Intermediate layers the most common production system consists of a unidirectional system which tends to develop around the edge of the core following a semi-rotating rhythm (Unidirectional core type 2) (Figure 7). There is no or minimal flaking surface preparation. The maintenance of the core convexities is evident in some debordant blades and plunging laminar blanks. The end products consist of elongated thick blanks.

3.1.1 Upper layer reduction systems

The lack of cores roughly sums up the reduction systems in the Upper layers. However, based on the end products, we can see a certain continuity with the Intermediate and Lower layers represented by a large number of Levallois flakes. As for the Intermediate layers, the Levallois concept shows great variability expressed in the convergent, unidirectional and bidirectional methods (Figure 8). The unidirectional semi-rotating system (Unidirectional Type 2) is only observed in one core.

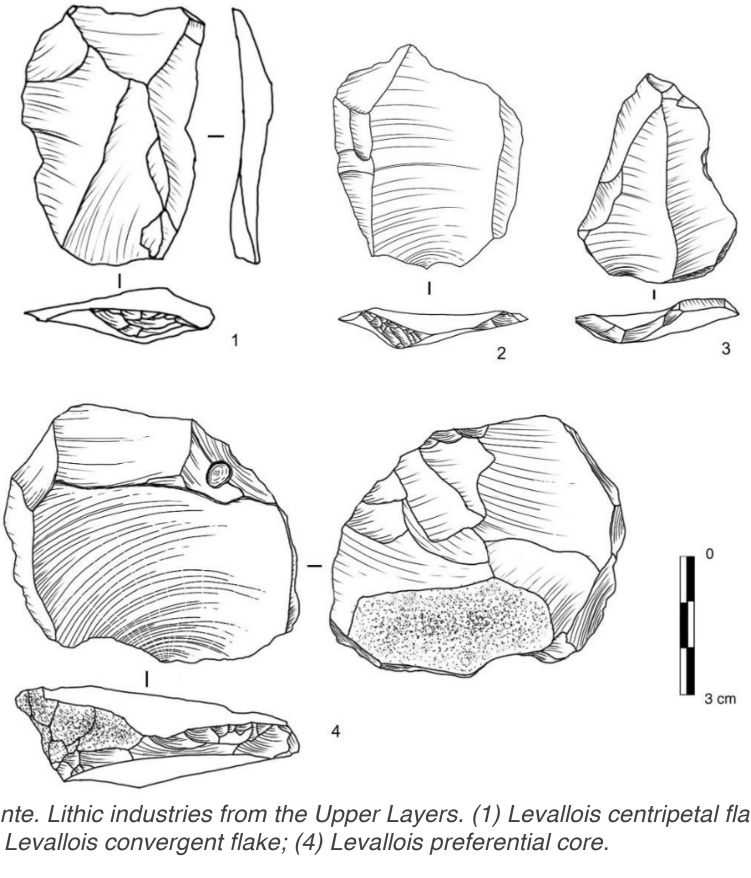

Figure 8. Riparo Tagliente. Lithic industries from the Upper Layers. (1) Levallois centripetal flake; (2) Levallois unidirectional flake; (3) Levallois convergent flake; (4) Levallois preferential core.

3.2 Retouched pieces

Three different categories were established in order to study the retouched pieces. Each of these categories corresponds to the number of transformation degrees undergone by the blanks: low, medium and high degrees (Figure 9).

The low degree describes a marginal retouch of the perimeter of the piece, which does not modify the cutting edge nor the morphology of the pieces in any way. The medium degree consists of a retouch that modifies the morphology of the cutting edges, but not the structure of the piece.

The high degree refers to the structural modification of the blanks, which completely or partially transforms their original morphology.

Transformation through retouching can be noted in all layers. The Lower layers show the highest percentage of transformation while the lowest percentages are observed in the Intermediate and Upper layers (Table 3).

The retouching phase shows different degrees of transformation in terms of the *débitage* classes. Besides a few rare exceptions, high levels of transformation are mainly observed in the cortical and generic flakes found in all three layer groups (Table 4). On the other hand, Levallois flakes only show slight modifications just like in the blade production (Figure 9).

Table 3. Riparo Tagliente. Frequencies of retouched and unretouched pieces.

LEVELS	Lower layers		Intermediate layers		Upper layers	
	n°	%	n°	%	n°	%
Unretouched	293	79,2	706	83,8	513	86,1
Retouched	77	20,8	136	16,2	83	13,9
Total	370	100	842	100	596	100

Table 4. Riparo Tagliente. Comparison between degree of retouch and *débitage* types.

LEVELS	Lower layers				Intermediate layers				Upper layers			
	Unret.	Low.	Med.	High	Unret.	Low.	Med.	High.	Unret.	Low.	Med.	High.
Levallois flakes	28	17	2	0	122	18	9	0	52	4	3	0
Centripetal flakes	34	2	12	3	86	9	1	0	66	4	2	2
Unidirectional flakes	35	6	7	0	65	8	7	3	22	1	2	1
Bidirectional flakes	3	1	0	0	8	1	1	0	2	0	0	0
Orthogonal flakes	0	0	0	0	9	1	1	0	3	0	0	0
Sub-convergent flakes	5	0	0	0	11	3	0	0	3	1	0	1
Convergent flakes	3	0	0	0	6	0	0	1	1	0	0	0
Debordant flakes	19	0	0	0	44	3	1	3	0	0	0	1
Pseudo-levallois	0	0	0	0	1	1	0	0	3	0	1	0
Kombewa	14	0	0	0	29	2	0	0	9	1	0	0
Levallois blades	1	1	1	0	13	2	3	0	6	1	0	0
Non Levallois blades	25	0	3	0	43	10	3	0	43	3	2	0
Crested blades	1	0	0	0	0	0	0	0	0	0	0	0
Striking platform flakes	11	0	0	0	5	0	0	0	6	0	0	0
Cortical flakes	69	1	6	3	158	9	10	9	146	7	11	16
Unspecific flakes	45	2	5	5	106	4	7	6	151	4	3	12
Total	293	30	36	11	706	71	43	22	513	26	24	33

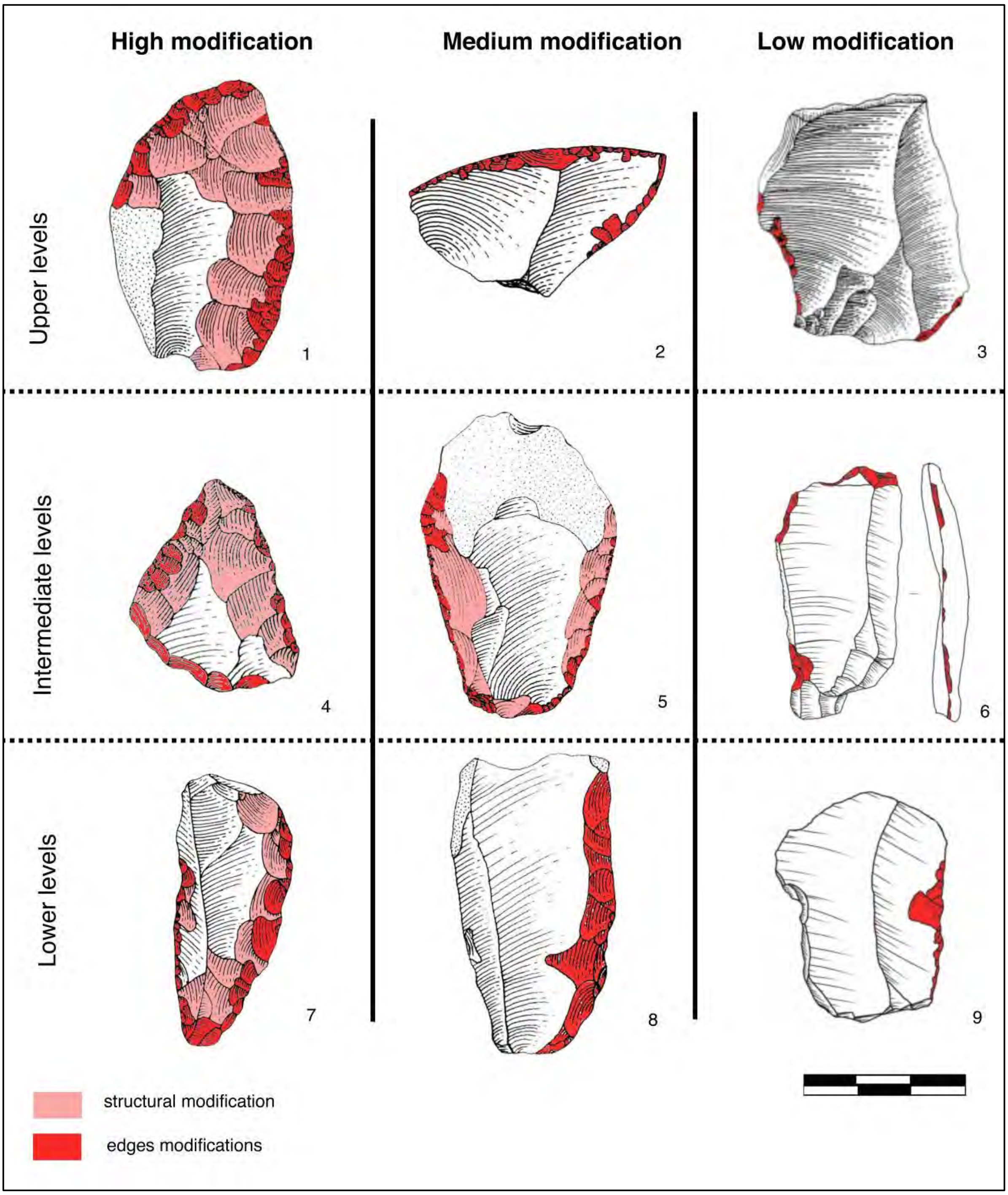

*Figure 9. Riparo Tagliente retouched pieces. (1, 5) Scrapers on cortical flakes; (4,7) Convergent scrapers on undefined flakes; (2, 3) Levallois retouched flakes; (6, 8, 9) Unidirectional retouched flakes. (*Drawings 1-3 and 4,5,7,8 modified after Arzarello 2003*).*

3.3 Blade tools across the sequence

Blade production is similar throughout the sequence with a slight increase in percentages in the Upper layers (Table 5). The blades can be described as being well preserved. Proximal fragments are the most numerous (Table 6).

Within the sequence different production systems can produce elongated blanks, both deriving from the unidirectional and bidirectional Levallois systems as well as from unidirectional non-Levallois systems (Unidirectional Type 1 and 2). Therefore the main aim of the study was to verify whether this variability was due to a predetermined intention to produce differentiated tools by using different reduction systems or whether this was only the result of opportunistic behaviour.

By observing the morphological characteristics of the blades and those of experimental representatives it was possible to distinguish two main blades categories: Levallois blades and non-Levallois blades. The blade fragments which could not be attributed to a specific category and blades with mixed characteristics that could have pertained to any category were placed in a third category termed 'undefined blades'.

Table 5. Riparo Tagliente - Frequencies of blades and flakes. Cores and undetermined fragments are excluded from the count.

Layers	Lower layers		Intermediate layers		Upper layers	
	n°	%	n°	%	n°	%
Flakes	337	91,6	768	91,2	541	90,8
Blades	31	8,4	74	8,8	55	9,2
Total	368	100	842	100	596	100

Table 6. Riparo Tagliente. Blade classes and distinction between fragmented and whole pieces.

Layers		Lower layers	Intermediate layers	Upper layers	Total
Undefined blades	Whole	14	17	18	49
	Apex absent	0	1	0	1
	Platform absent	0	1	1	2
	Distal fragment	2	1	9	12
	Mesial fragment	0	4	2	6
	Proximal fragment	6	8	3	17
	Partial total	*22*	*32*	*33*	*87*
Volumetric blades	Whole	5	16	5	26
	Apex absent	0	1	1	2
	Platform absent	1	1	0	2
	Distal fragment	0	1	1	2
	Mesial fragment	0	0	1	1
	Proximal fragment	0	5	7	12
	Partial total	*6*	*24*	*15*	*45*
Levallois blades	Whole	2	13	3	18
	Apex absent	1	2	0	3
	Platform absent	0	0	1	1
	Distal fragment	0	1	1	2
	Mesial fragment	0	0	0	0
	Proximal fragment	0	2	2	4
	Partial total	*3*	*18*	*7*	*28*
Total		*31*	*74*	*55*	*160*

The parameters taken into consideration when defining these categories were: types of platform, knapping surface angles, cutting edge angles, transversal cross-section, longitudinal profile, length-width ratio and width-thickness ratio.

Most of the blades fell in the 'undefined blade' category (Table 6). Levallois blades and non-Levallois blades are found in all layers in similar frequencies. From a morphometric point of view there is certain overlapping between the non-Levallois and Levallois productions in as far as the length-width ratio is concerned (Figure 10).

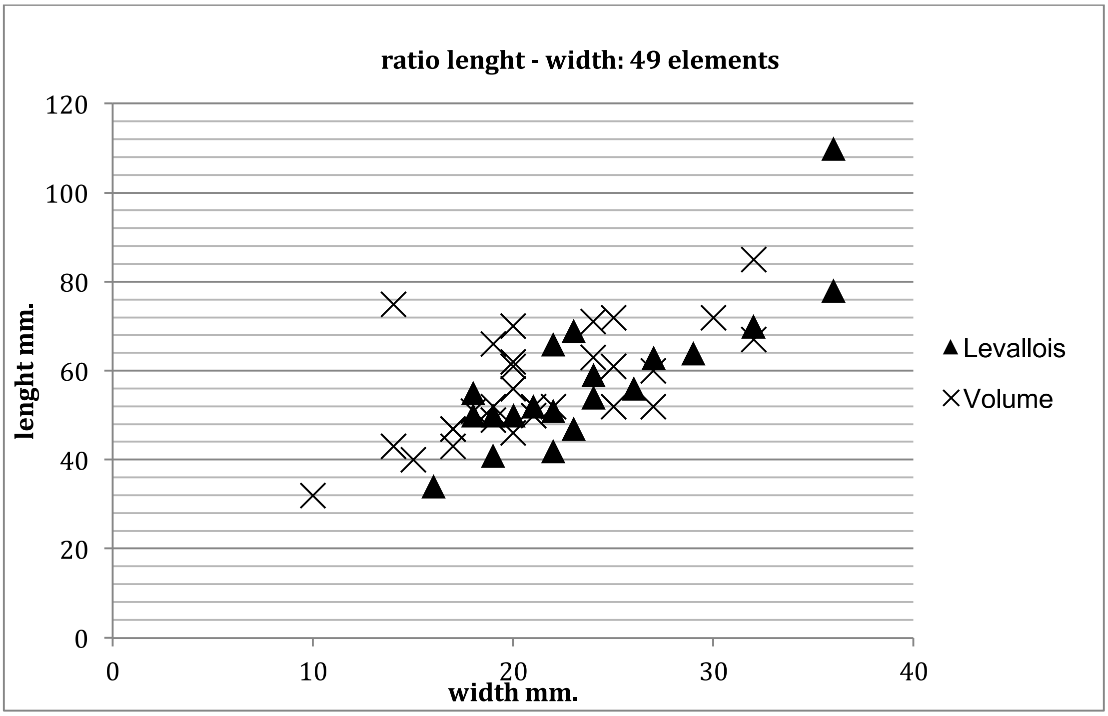

Figure 10. Riparo Tagliente. Levallois and Non-Levallois blade length-width ratios.

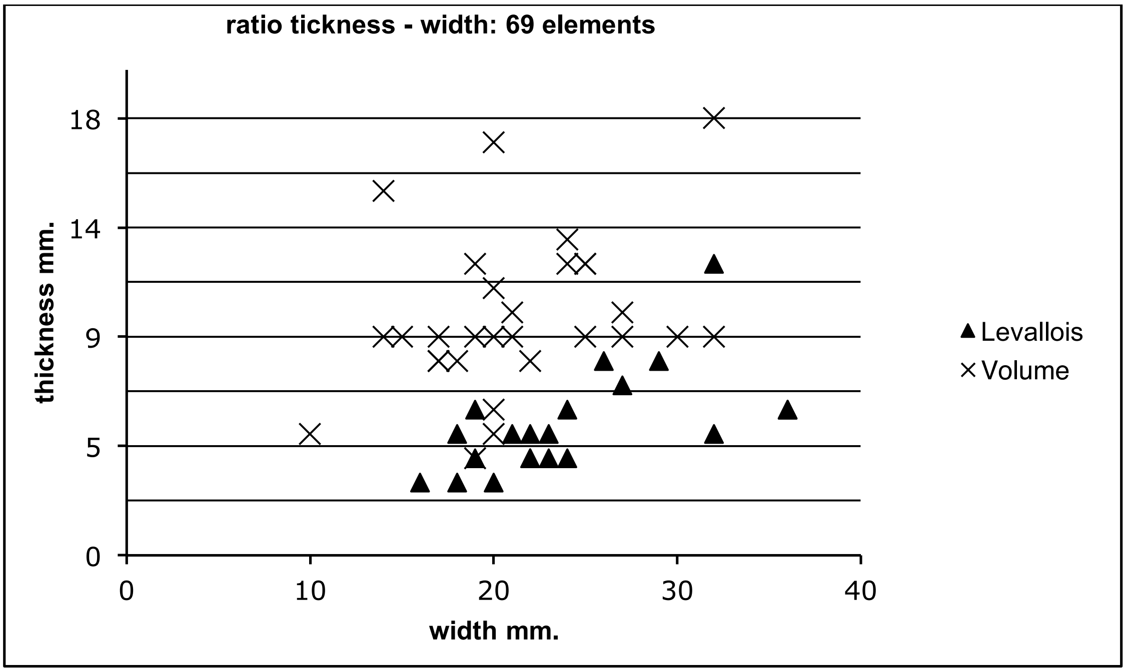

Figure 11. Riparo Tagliente. Levallois and Non-Levallois blade thickness-width ratios.

Conversely a significant difference is evident in their width-thickness ratios (Figure 11). This difference is also noticeable when we compare the angle of the cutting edges. In the Levallois blades the opening of the angles are concentrated between 10° and 35°, while the non-Levallois blades show wider angles of the cutting edges, ranging between 35° and 55° (Figure 12).

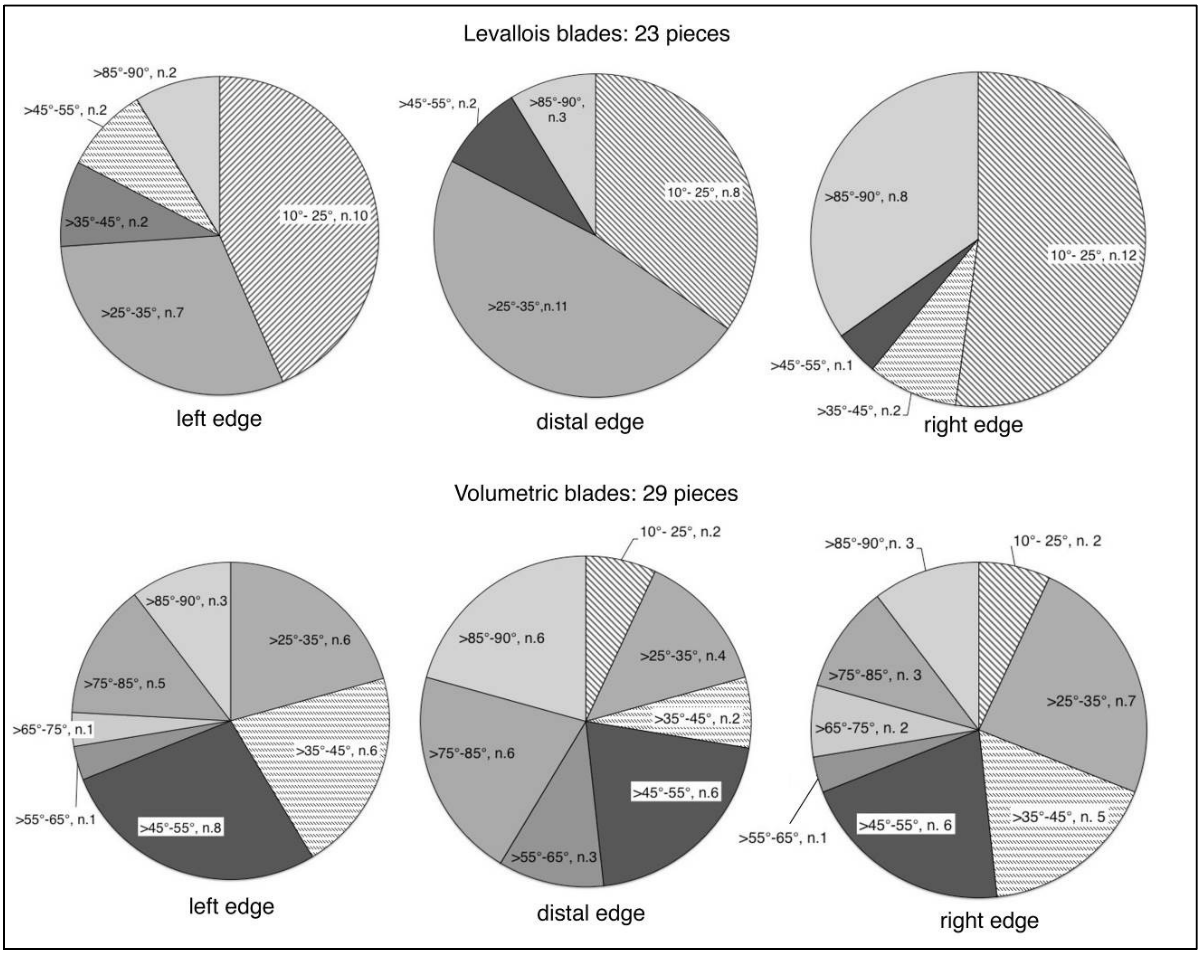

Figure 12. Riparo Tagliente. Cutting edge angle degrees of Levallois and Non-Levallois blades.

Both for the Levallois and non-Levallois productions, six techno-functional categories were observed, all based on the morphological structure and the organization of the cutting and non-cutting edges (Figure 13). Only completely intact blades were analysed; minimally fractured pieces were also excluded.

In general, we can observe how blade production at Riparo Tagliente focused on the production of objects with differentiated techno-functional characteristics rather than the making of a mono-tool (Figure 14).

By comparing the classes of blade we can see how blades with a peripheral cutting edge (S1 Type) are attributed mainly to Levallois blades. On the contrary, debordant blades (S3, S4 type) are more frequent among the Non-Levallois blades. Convergent blades (P1 type, P2 type) are rare in both categories. The undefined blade category does not show any specific tendency except for the scarce presence of convergent blades, as was the case in the Levallois and non-Levallois blades.

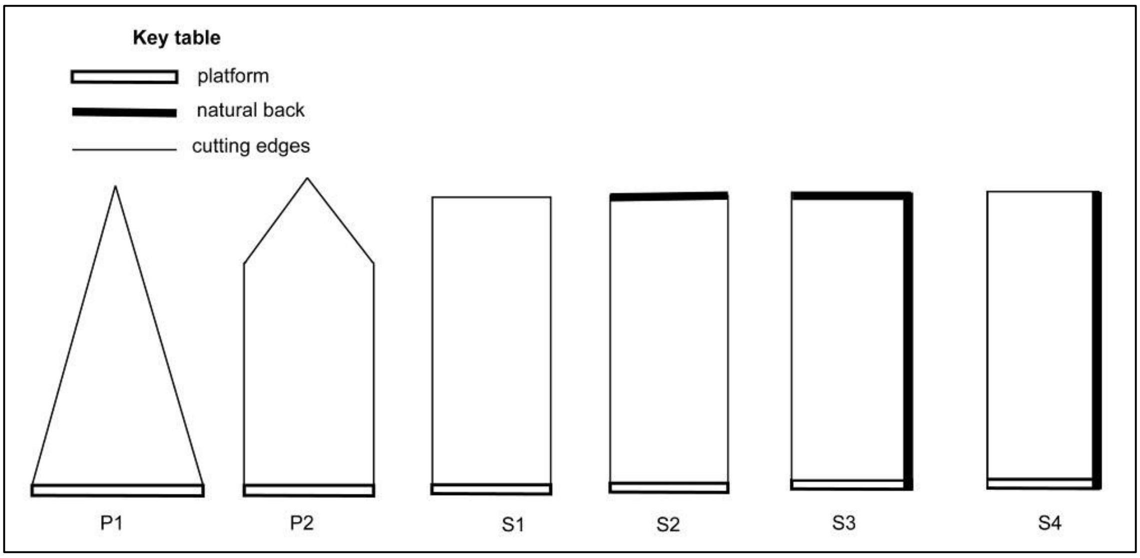

Figure 13. Riparo Tagliente. Blade types.

Table 7. Riparo Tagliente. Blade types.

		Lower layers	**Intermediate layers**	**Upper layers**
Undefinied blades	P1 type (convergent edges)	1	-	3
	P2 type (parallel edges)	-	3	2
	S1 pheriferal cutting edge	3	4	6
	S2 parallel cutting edge	6	5	2
	S3 single cutting edge	3	3	3
	S4 orthogonal cutting edge	1	2	2
	Partial total	*14*	*17*	*18*
Volumetric blades	P1 type (convergent edges)	1	-	-
	P2 type (parallel edges)	1	2	2
	S1 pheriferal cutting edge	-	3	-
	S2 parallel cutting edge	-	5	1
	S3 single cutting edge	-	2	-
	S4 orthogonal cutting edge	3	4	2
	Partial total	*5*	*16*	*5*
Levallois blades	P1 type (convergent edges)	-	-	1
	P2 type (parallel edges)	-	3	-
	S1 pheriferal cutting edge	1	7	2
	S2 parallel cutting edge	1	-	-
	S3 single cutting edge	-	3	-
	S4 orthogonal cutting edge	-	-	-
	Partial total	*2*	*13*	*3*
Total		21	43	27

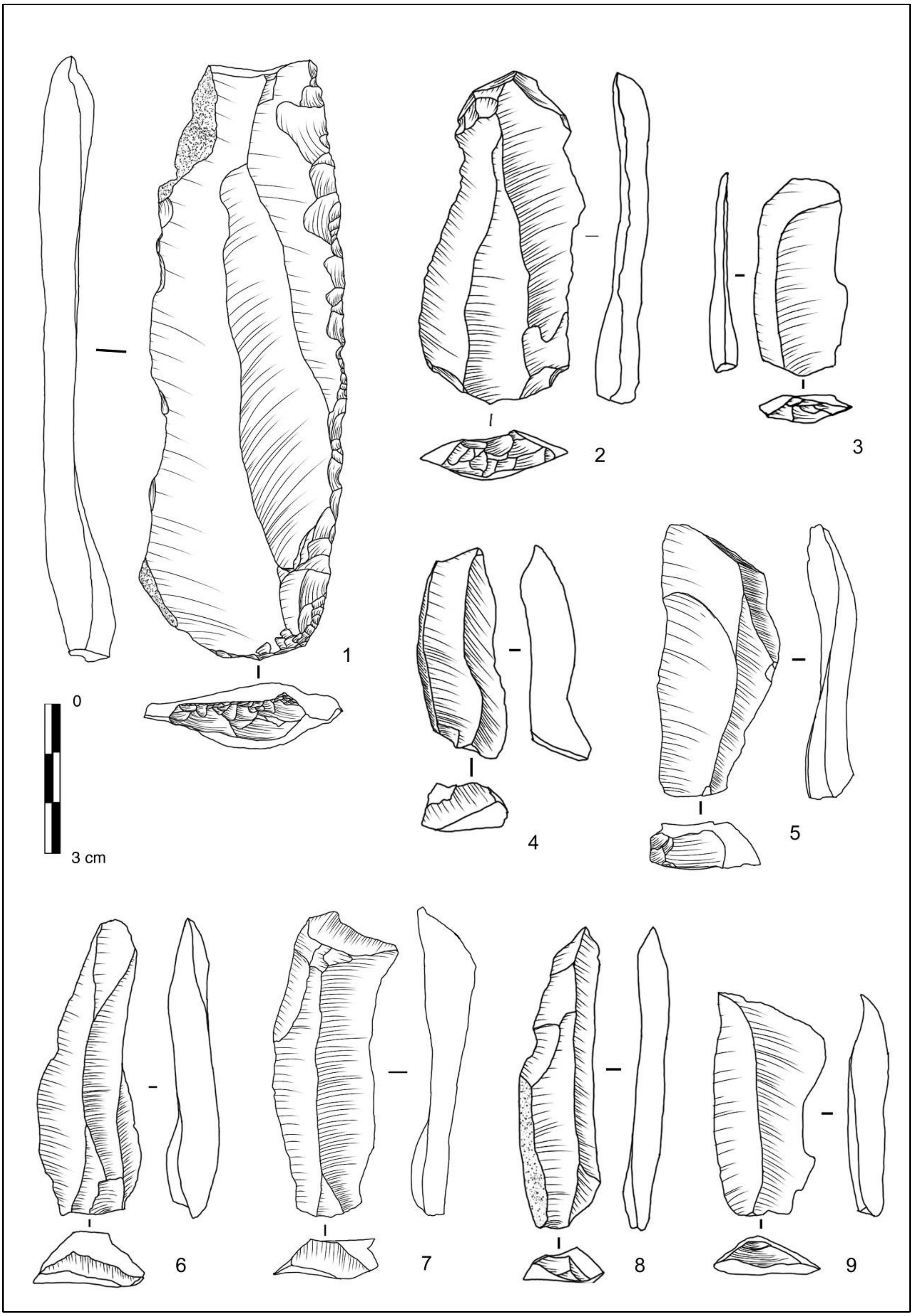

Figure 14. Blade production at Riparo Tagliente. (1) 'S1 type' Levallois blade from the Lower layers; (2) 'S2 type' Levallois blade from the Intermediate layers; (3) 'S1 type' Levallois elongated flake from the Upper layers; (4) 'S4 type' non-Levallois blade from the Lower layers; (5) 'S3 type' non-Levallois blade from the Intermediate layers; (6, 7) 'S1 type' non-Levallois blades from the Upper layers; (8) 'P1 and P2 type' non-Levallois blades from the Upper layers.

4 Discussion and conclusion

Despite the apparent substantial homogeneity of the Riparo Tagliente sequence, some differences can be observed in the reduction systems used. The main characteristics, common to the whole sequence, are the use of the Levallois concept and the production of elongated blanks. Other common features such as the presence, even though sporadic, of the Discoid and SSDA systems are shared by the Lower and Intermediate layers. This homogeneity, which is evident in the end-products, masks the presence of some differences, these mainly visible in the cores.

The greatest variability in the reduction systems used can be observed in the Lower layers (Figure15). In the Intermediate and Upper layers, the fall in the number of reduction systems is replaced by an increase of the variability of the Levallois concept, which is expressed by means of the centripetal method as well as the convergent, bidirectional and preferential methods (Figure 15).

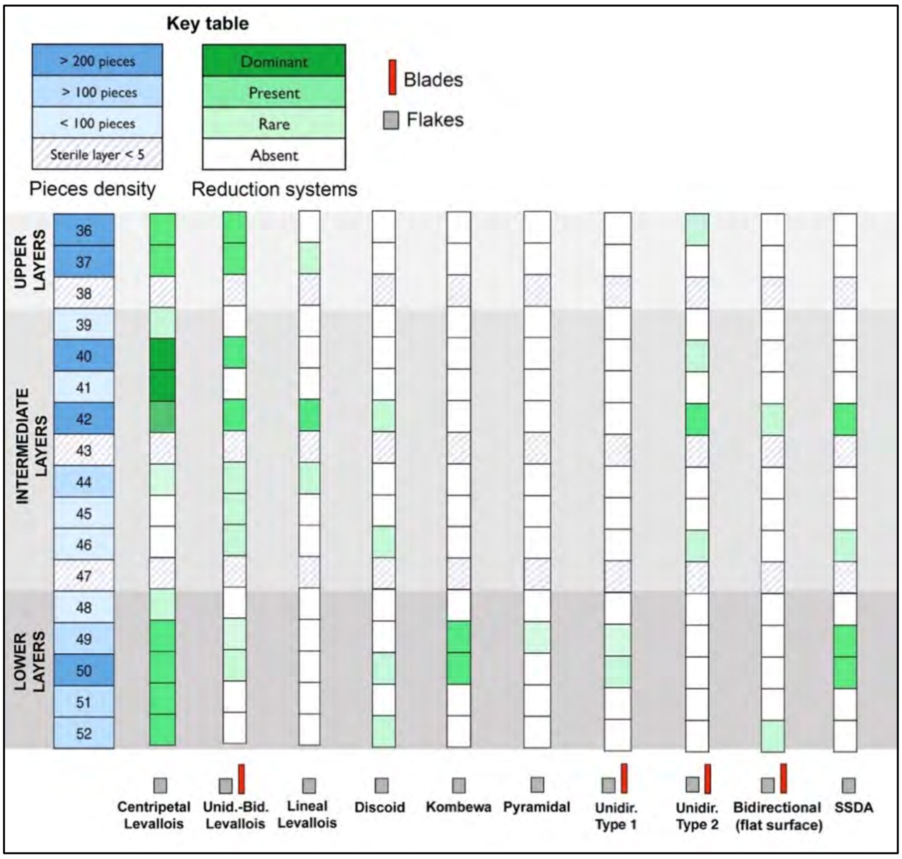

Figure 15. Riparo Tagliente. Frequencies of the reduction systems.

The retouched pieces only reveal minimal modifications of the cutting edges without altering the morphology of the flake nor the blade. Cortical flakes are the most affected and in this case underwent significant modification, while the products deriving from the main *débitage* phases were seldom retouched. This can be linked to the anticipation of the variability of the end products for flakes as well as blades already preconceived in the production systems. This aspect emphasizes the substantial difference with the more standardized blade productions of the Upper Paleolithic where differentiation of tools is usually mostly achieved during the retouching phase. Based on our data, at Riparo Tagliente, Levallois and non-Levallois reduction systems coexisted producing elongated blanks, different in their morphological and technological characteristics as a direct result of the different reduction systems used to obtain them. Both reduction systems are aimed at producing blades and flakes rather than blades in a systematic way. This differentiation in production can be observed in the Levallois unidirectional and bidirectional end products as well as in the unidirectional Type 1 reduction system. By observing the Riparo Tagliente sequence within the context of the Italian peninsula it is therefore possible to make a number of general observations (Figure 16).

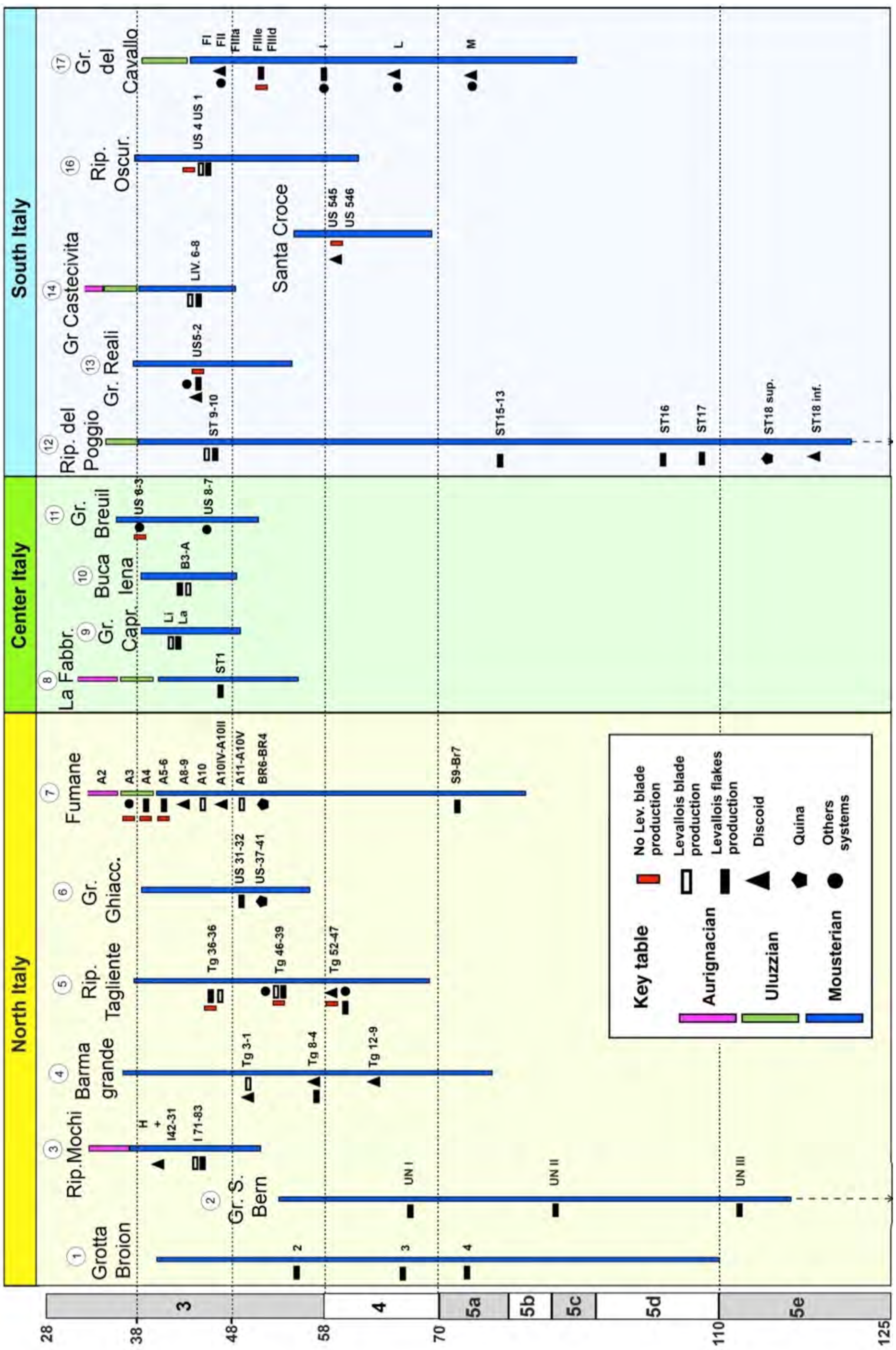

Figure 16. Reduction systems in the main Middle Paleolithic sites from MIS 5 to MIS 3 in the Italian peninsula. (1) Grotta del Broion (Peresani & Porraz 2004); (2) Grotta San Bernardino (Peresani 1995, 1996); (3) Riparo Mochi (Grimaldi & Santaniello 2014; Yamada 2004); (4) Barma Grande (Yamada 1997); (5) Riparo Tagliente (Arzarello & Peretto 2004, 2005); (6) Grotta Ghiacciaia (Bertola et al. *1999); (7) Fumane (Peresani 2012); (8) Grotta La Fabbrica (Dini* et al. *2007); (9) Grotta del Capriolo (Dini & Koehler 2009); (10) Buca della Iena (Dini & Koehler 2009); (11) Grotta Breuil (Lemorini 2000; Grimaldi 1996); (12) Riparo del Poggio (Caramia & Gambassini 2006); (13) Grotta Reali (Peretto 2012); (14) Grotta di Castelcivita (Gambassini 1997); (15) Santa Croce (Arrighi* et al. *2009); (16) Riparo Oscurusciuto (Boscato* et al. *2011); (17) Grotta del Cavallo (Carmignani 2010; Sarti* et al. in press*).*

The first observation is that the blade phenomenon in the Italian peninsula appeared at some point between MIS 4 and the beginning of MIS 3 and therefore later than in the south of France where blade production is first recorded as early as MIS 5 (Figure 16). The data from Riparo Tagliente fit will within this framework.

The second observation is that, as far as we know, there is no trace of local nor internal evolution. In fact, blade production seems to appear 'simultaneously' from north to south in the Italian peninsula and is always associated to other types of reduction systems of which the Levallois is the most common. (Figure 16).

As already noted for the rest of Europe, the production of blades did not entail a particular raw material preference. Blades were made from all types of raw materials (flint, chert, limestone, quartzite) and their different forms (pebbles, nodules, slabs, core flakes). Various reduction systems were used in the production of blades. Blades can be produced exclusively by means of a Levallois concept, as in the cases of Grotta di Castelcivita (Gambassini 1997), Riparo del Poggio (Caramia & Gambassini 2006), Barma Grande (Yamada 1997), and Riparo Mochi (Grimaldi & Santaniello 2014; Yamada 2004), or by ‘volumetric’ reduction systems, as is the case at the sites of Santa Croce (Arrighi et al. 2009), Grotta Reali (Arzarello et al. 2004; Peretto 2012), and Grotta del Cavallo (Carmignani 2010). Occasionally the two systems were used together as has been noted at Riparo dell’Oscurusciuto (Villa *et al.* 2009) and Riparo Tagliente (Arzarello & Peretto 2004, 2005).

In short we can observe how during the MIS 4 and MIS 3 there is widespread production of blades produced by means of original knapping systems or as in the case of the Levallois by a readjustment of this concept oriented towards the production of elongated products.

Given the current state of knowledge there is still much to be learnt concerning the causes of this technological change.

Middle Paleolithic blade productions cannot be considered as monolithic entities.

This ‘non universal’ phenomenon contrasts with other types of production systems such as the Levallois or the Discoid system, with which it coexisted and which contrastingly show a greater geographic diffusion and chronological continuity.

Understanding the role of blade production during Middle Paleolithic requires a systematic approach, which takes into account both the techno-functional aims and the evolution of the reduction systems.

Further research should be carried out on the following two issues:

- Concerning the appearance of blade production, are the diachronic differences noted between northern and southern Europe another case of a convergence phenomenon?
- Can we trace the origins of the Italian peninsula blade phenomenon in the oldest evidence found in southern France?

In order to provide answers to both these questions micro and macro regional comparisons of the various blade productions are urgently required in order to understand the blade phenomenon in both its wider and more local geographical context.

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Chapter 5

Grotta del Cavallo: Blade and bladelets reduction strategies and raw material procurements at the end of the Mousterian.

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Abstract

Evidence of the presence of blade tool technology has been confirmed in northern Europe from at least the latter part of the Middle Pleistocene (MIS 7-6). During MIS 5 these productions cover a larger area, which includes northwestern Germany, central France, and occasionally the south of France. It is only during MIS 4-3 that the blade production strategy begins to appear in southern Europe, including the Italian peninsula. Based on the present state of research these three phases appear as on-and-off events without clear evolutionary continuity. The FIIIe and FIIId levels of Grotta del Cavallo in Lecce (Italy) have yielded abundant lithic material predominated by two main reduction systems: the first originating from a Levallois concept by centripetal, unidirectional and bidirectional methods, and the second stemming from a blade volumetric reduction system. The presence of separate reduction systems aimed at obtaining bladelets complete the technological variability highlighted.

Key words: *Grotta del Cavallo, Blades, Bladelets, Middle Paleolithic.*

1. Introduction

In the European continent the oldest evidence of blade production is found in northern Europe within MIS 8/7. These productions are obtained by using primarily two reduction systems: a volumetric concept, such as that noted at the sites of Saint-Valery-sur-Sommes (Heinzelin & Haesaerts 1983), Bapaume-les Osiers (Koehler 2008), Therdonne (Loch et al. 2010) in France, and Rissori in Belgium (Adam 1991), and by a Levallois concept such as that observed at the site of Biache-Saint-Vaast in France (Böeda 1988). In the sites mentioned blade production is rarely the predominant kind; on the contrary, it is systematically associated with other

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production systems, among which the most frequent is the Levallois concept aimed to produce mainly flakes.

In MIS 5, following their prolonged disappearance, coinciding with the MIS 6 glaciation peak, these productions returned, occupying a wider area that now included north-west Germany with the sites of Tonchesberg (Conard 1990), Rheindhalen (Bosinsky 1986) and Wallertheim (Conard & Adler 1997), and central France, with the sites of Angé (Locht et al. 2008) and Vinneuf (Gouédo 1994). These productions are also found, albeit sporadically, in the south of France in sites such as that of Cantaluette 4 (Blaser at al. 2012).

At the same time in northern France and Belgium we see a return of blade productions at many sites: Riencourt-lès-Bapaume (Ameloot & Hejden 1993), Saint-Germain-des-Vaux (Révillion & Cliquet 1994), Seclin (Révillion & Tuffreau 1994), Bettencourt-Saint-Ouen (Locht 2002), Blangy–Tronville (Depaepe et al. 1999), and Etouteville in France (Delagnes & Ropars 1996), and Rocourt in Belgium (Otte1994a).

At all these sites we detect great variability in blade reduction systems, which prevents us from grouping them under a common denomination. The initial stages of the productions observed at the above industries entailed the preparation of a crested blade even if it is more common for the raw material's natural morphology to be exploited. Unidirectional or bidirectional methods can be applied to guide the removals. During the exploitation process the knapping can follow a *tournant* or s*emi-tournant* rhythm. The raw materials used can be pebbles, roundish nodules, slabs or flake-cores. In the same way, even if flint is the most common raw material noted, other lithotypes such as quartzarenites, limestones and jaspers were also used.

The debate on the emergence of these productions, which at present is thought to have taken place during the Middle Pleistocene, is still ongoing. Some authors have suggested that, in some specific cases, blade production could have been an opportunistic method leading to the use optimisation of the raw materials, which may have motivated the production of elongated removals instead of flakes (Conard 1990). This, however, may have not been the case in areas rich in raw materials, where the presence of these productions has also been noted. Other authors have suggested a relationship between blade production and environmental crises (Otte 1994b). The duration of the blade phenomenon and its diffusion to areas that differ greatly from one another suggests that single explanations to the origin and the spread of this phenomenon need to be treated with caution.

Unlike in northern Europe, the appearance of laminar productions in the south of France and the Italian Peninsula shows some delay. Even if in the south of France blades appear for the first time in MIS 5, such as at Cantalouette IV (Blaser et al. 2012), they become more visible during MIS 4 -3 such as at the sites of Abris Du Maras (Moncel 1996), Baume Flandin (Moncel 2005) and Champ Grand (Slimak 1999).

While it is now certain that blades were produced during the Middle Paleolithic, the production of bladelets, obtained by means of an independent reduction system, was much less common and occurred just during the final phases of the Mousterian period. In Europe some bladelet production has been noted at the sites of El Castillo and Cueva Morin in Spain (Maíllo-Fernández et al. 2004), at Champ Grand (Slimak & Lucas 2005) and Combe Grenal in France (Faivre 2012), at Fumane and at Grotta del Cavallo in Italy (Peresani 2011, Carmignani 2010), and at Balver Höhle in Germany (Pastoors & Tafelmaier 2010).

Recently, the presence of a bladelet production noted at the site of Riparo del Molare in Italy would date back its first presence to MIS 5 (Aureli and Ronchitelli *in press*).

The presence of laminar productions in the Italian peninsula has not been clearly confirmed prior to MIS 4. The chronologies of the sites where the use of blade technology has been noted are in fact concentrated around the final phases of the Middle Paleolithic and, in particular, the first part of MIS 3[3].

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[3] The only exception to this is the site of Cave dell'Olio dated to MIS 9 (Fontana, Peretto 2009).

In terms of their geographic distribution, blade production do not seem to be linked to a specific area or a specific environment. In Italy blade productions have been found in the south at the site of Santa Croce and at Grotta del Cavallo (Boscato et al. 2011, Carmignani 2010), in the center at Grotta Breuil (Grimaldi 1996), Grotta Reali (Peretto C. Ed. 2012, Arzarello et al. 2004), or again in the north at Riparo Tagliente (Arzarello & Peretto 2005, 2004), Fumane (Peresani 2011), Grotta di San Francesco and Madonna dell'Arma (Tavoso 1988, Cauche 2007)[4].

Generally speaking, towards the end of the Mousterian in the Italian peninsula there seems to be greater differentiation in the production systems, among these blade production is one of the most evident expressions. The origin to this differentiation is can be traced back to the wider issue concerning the key role the blade plays in relation to its morpho-functional peculiarity and the preponderant role it will have in the Upper Paleolithic.

2. The site

Grotta del Cavallo in the south of Italy is a coastal cave by the Ionian Sea located approximately 10 meters b.s.l. The site contains one of the most important Middle Paleolithic archaeological sequences of the Italian peninsula.

The cave was first studied by Arturo Palma di Cesnola in 1961, who carried out the first test pit which was followed, two years later, by the first excavation campaign (Palma di Cesnola 1963). In the years that followed other excavation campaigns were carried out, these highlighting the long Middle and Upper Paleolithic sequences present at the site (Palma di Cesnola 1964, 1965, 1967).

At the end of the 1970s new works had to take place at the site as in the interim illegal excavations had been carried out, thus disturbing the site. It was at this time that the University of Siena, in collaboration with the Soprintendenza ai Beni Archeologici della Puglia, closed the cave. Starting in 1986 L. Sarti re-opened the excavations and a larger surface (12 sq. m) was excavated. Although the sequence proposed by Palma di Cesnola was confirmed by the new excavations, these also allowed for the stratigraphy to be described in greater detail and the gathering of a greater amount of data (Sarti et al in press; Trenti et al in press).

Layer FIII, the subject of the present study, was, during its excavation, divided into five sub-levels (FIIIa, FIIIb, FIIIc, FIIId, FIIIe) based on the different concentrations of anthropic evidence.

The laminar production comes from sub-levels FIIIe and FIIId, which rest on a thick layer of tephra (Fig.1). At the top of level FIII, levels FII-FI mark the end of the Mousterian sequence (Sarti, Boscato, Lo Monaco 1998- 2000).

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[4] The chronology at the site of San Francesco remains uncertain.

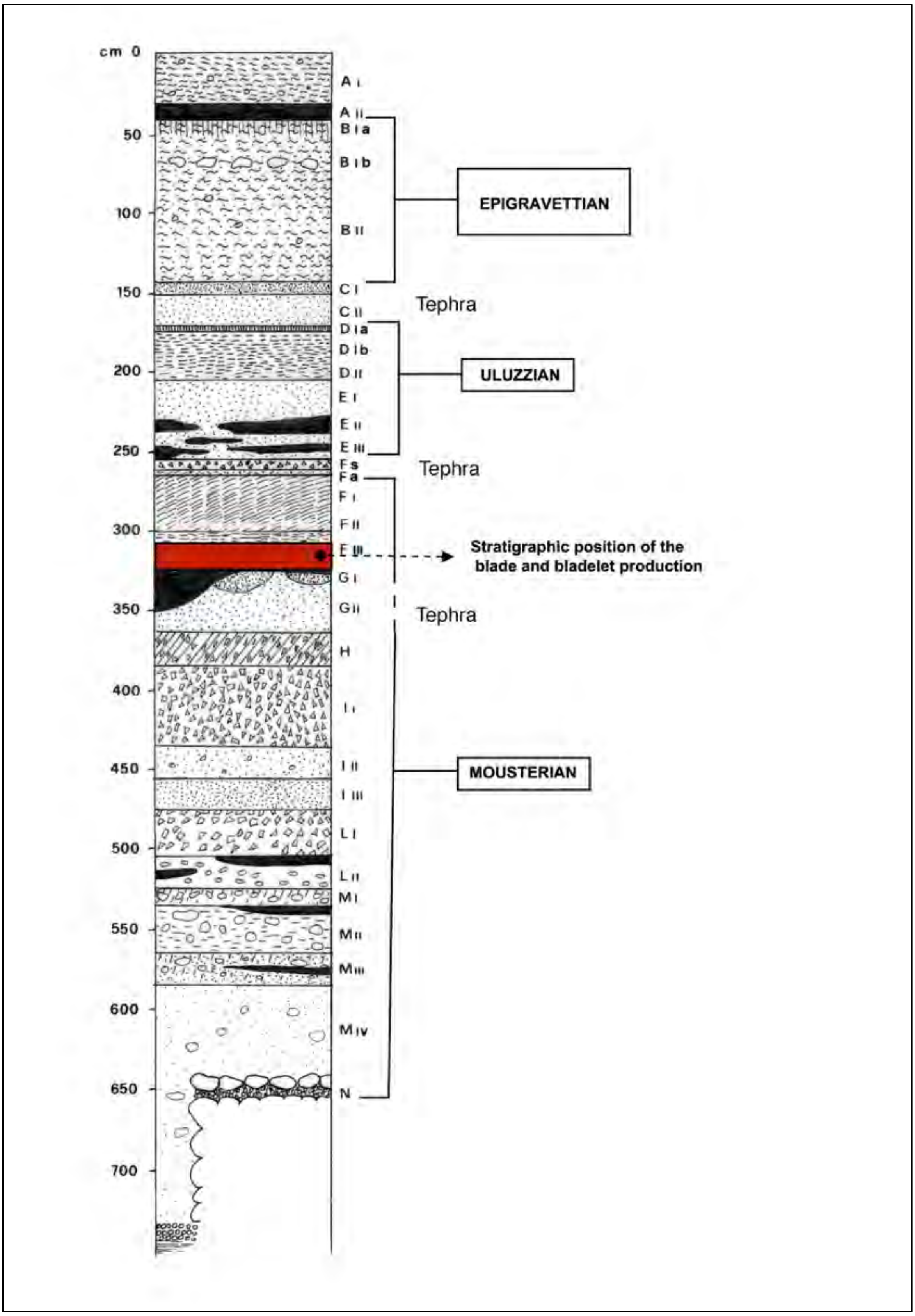

Figure 1. Grotta del Cavallo. Stratigraphic sequence.

3. Methods

The lithic products from Grotta del Cavallo were analysed using a chaîne opératoire approach following Pelegrin (1991), and supported by the quantitative presentation of technological categories (Inizan et al. 1995). The identification of the Levallois concept follows the guidelines set out by E. Boëda (1994). In terms of the Discoid production, we used the definition put forward by E. Boëda (1993, 1991), also taking into consideration broader criteria (Peresani 1998, Slimak 2003). Given the absence of the refitting reconstruction of the reduction sequences we used the mental refitting method proposed by Pelegrin (1995). The techniques were identified according to the experimental studies carried out by Pelegrin (1991, 2000). Volumetric and Levallois blade productions were distinguished by means of the volumetric structure analyses (Boëda 1988, 1990, 1991). Diacritical analysis was applied to cores and blanks in order to reconstruct the chronological order of the scars (Dauvois 1973).
Deeply patinated pieces on which the correct reading of the scars was not possible, and pieces with disorganized scars, the positioning of which did not allow us to reliably associate them to a specific reduction sequence were classified as generic flakes.

4. Reduction systems of level F of Grotta del Cavallo

4.1 Main technological patterns

Sub-levels FIIIe and FIIId produced a large amount of lithic industries mostly concentrated in the FIIIe sub-level (11192 pieces), with smaller numbers found in sub-level FIIId (1151 pieces). A large number of pieces are made out of undetermined fragments and generic flakes which cannot be linked to a specific reduction system. Leaving out the undetermined pieces, the diagnostic material amounts to 4908 pieces in FIIIe and 558 in FIIId (Table 1). The production in both the sub-levels is associated to three main reduction systems: a blade and bladelet volumetric systems, and a Levallois system. The Levallois system is present with the centripetal, unidirectional, bidirectional and convergent methods. Sub-layers FIIIc and FIIIb, although they had less pieces, they seem to show the same kinds of productions as do FIIIe and FIIId. The Mousterian sequence ends with levels FII-FI highlighting a clear techno-typological break compared to level FIII. In fact, FI-FII levels show the disappearance of blade production and the Levallois concept, which, in turn, are replaced by a Discoid system (Fig. 2). This break, which is visible in the reduction systems, is also accompanied by a different management strategy of the raw material (Romagnoli et al. 2016).

The lithic industry contains a large amount of retouched tools, which will not be discussed in detail in the present study. In general, the retouched pieces in FIIIe and FIIId mainly comprise Mousterian points and scrapers, while in levels FII and FI the presence of denticulated pieces is marked, followed by that of splintered pieces. The latter, it should be noted, are completely absent in the lower levels (Sarti et al. in press).

Table 1. Determined and undetermined pieces.

LEVELS	Level FIIIe		Level FIIId	
	n.	%	n.	%
Generic flake >20 mm.	619	*5,5*	64	*5,6*
Generic flake <20 mm.	1325	*11,8*	119	*10,3*
Undetermined fragments >20 mm.	1429	*12,8*	94	*8,2*
Undetermined fragments <20 mm.	2911	*26,0*	316	*27,5*
Determined pieces	4908	*43,9*	558	*48,5*
Total	11192	*100*	1151	*100*

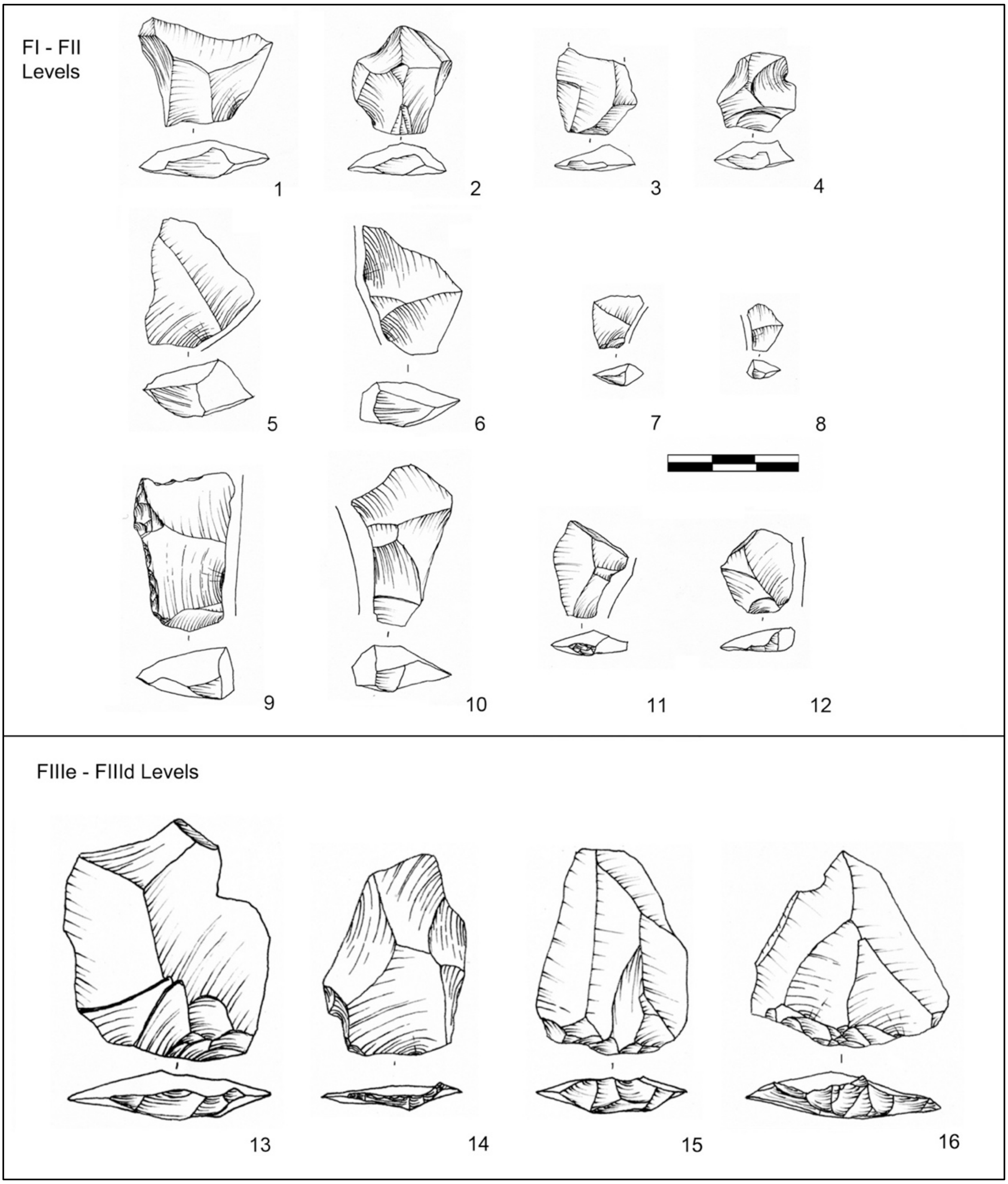

Figure 2. Flake production. (1-12) Discoid production from levels FI–FII, (13-16) Levallois production from the FIIIe-FIIId sub-levels (drawn by L. Carmignani).

4.2 Blade and bladelet production systems in sub-levels FIIIe and FIIId

The blade production found in sub-levels FIIIe and FIIId comprises 783 pieces in the case of the former and 64 pieces in the latter (Table 2). Ten cores associated to this production were found in level FIIIe whereas only two were recovered from FIIId. A large part of the blades are fragmented. Complete blades from level FIIIe amount to 254 pieces (32.4%) while 42 (65.5%) were found in FIIId (Table 3). Except for rare blades, which are over 7cm in length, the majority of the pieces indicate a small or medium-sized production (Fig. 3) (Carmignani 2010).

The raw materials used are limestone slabs collected locally a few hundred meters from the cave (Sarti et al. in press). The reconstruction of the chaîne opératoire suggests that all stages of the production were carried out at the site (Table 4). The technique employed during the whole production stages was direct percussion with hard hammer.

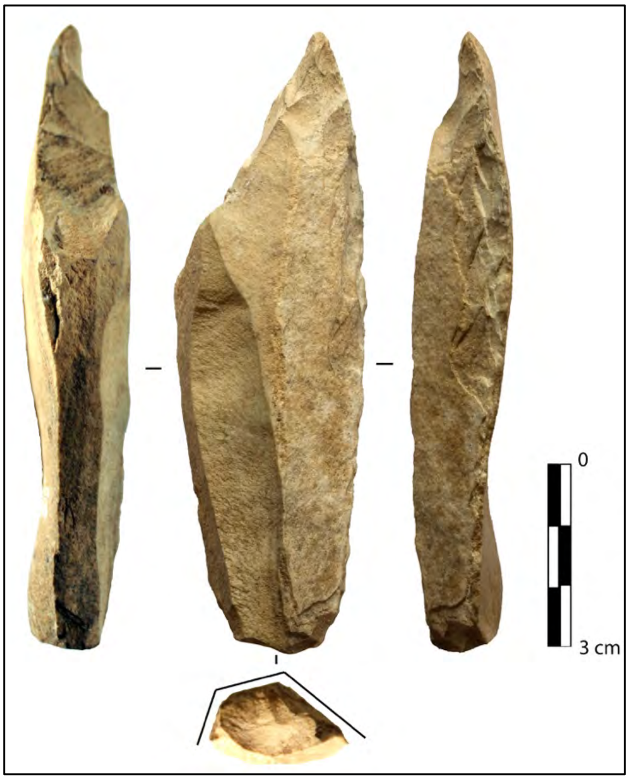

Figure 3. Large retouched blade from level FIIIe.

Table 2. Flake and blade production quantification.

LEVELS	Level FIIIe		Level FIIId	
	n.	%	n.	%
Blade production	783	*16,0*	64	*11,5*
Flake production	4125	*84,0*	494	*88,5*
Total	4908	*100*	558	*100*

Table 3. Integrity of blade production.

LEVELS	Level FIIIe		Level FIIId	
	n°	%	n°	%
Complete blades	254	32,9	42	67,7
Distal fragments	96	12,4	2	3,2
Mesial fragments	104	13,5	8	12,9
Proximal fragments	140	18,1	9	14,5
Apex broken	90	11,6	1	1,6
Base broken	86	11,1	0	0,0
Siret fracture	3	0,4	0	0,0
Total	773	100	62	100

Table 4. Blade production techno-types and cores. Excludes undetermined broken blades.

LEVELS	Level FIIIe		Level FIIId	
	n.	%	n.	%
Blades with cortex >50 %	57	*9,7*	2	*3,8*
Blades with cortex<50 %	92	*15,6*	10	*18,9*
Blades "*en tranche*"	9	*1,5*	0	*0,0*
Unilateral crested blades	14	*2,4*	0	*0,0*
Bilateral crested blades	12	*2,0*	2	*3,8*
Debordant blades	85	*14,4*	8	*15,1*
Blades	277	*47,0*	28	*52,8*
Rejuvenation blades	33	*5,6*	1	*1,9*
Cores	10	*1,7*	2	*3,8*
Total	589	*100*	53	*100*

The collected raw materials have a natural prismatic or sub-prismatic morphology that is suited to the direct knapping of blades without the need for a particular preparation of the core. When the configuration of the cores is present it does not show any standardization, but instead a wide range of technical solutions is used to correct the eventual imperfections of the block.

The presence of many cortical platforms indicates a direct extraction of removals using a natural striking platform. Preparation of the striking platform takes place just at the point when the natural angle does not fulfil the technical requirements.

In the majority of the cases the initial knapping phase is based on the direct extraction of a cortical blade that exploits the dihedral angle naturally present on the slabs (Fig. 4 no. 6).

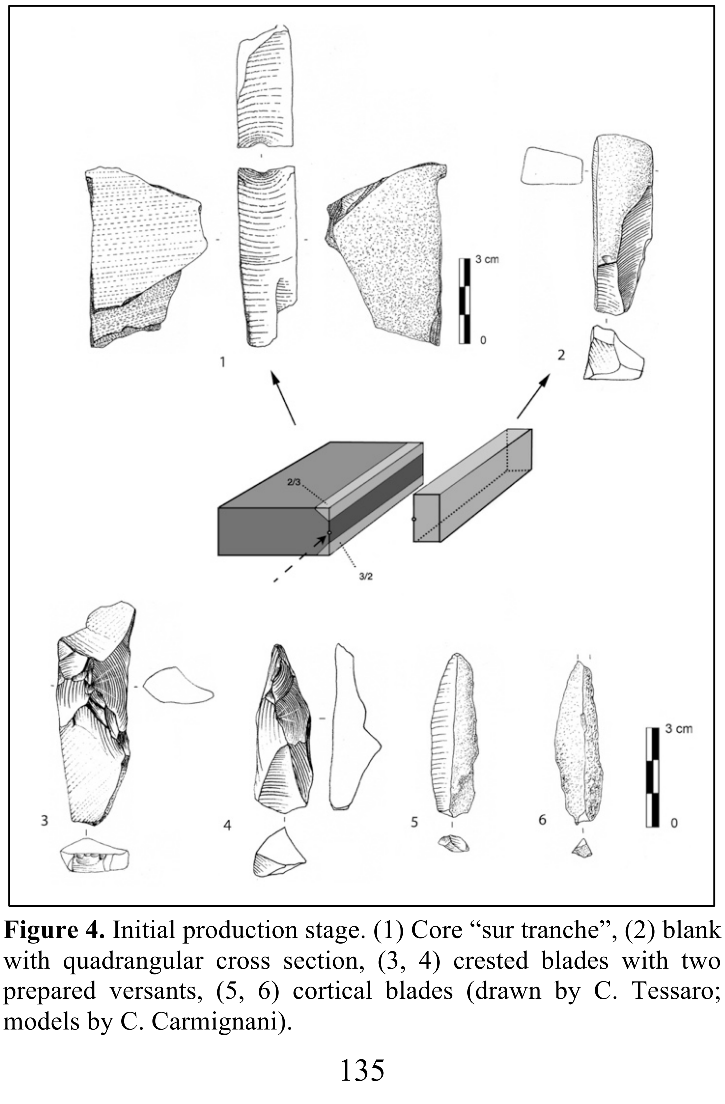

Figure 4. Initial production stage. (1) Core "sur tranche", (2) blank with quadrangular cross section, (3, 4) crested blades with two prepared versants, (5, 6) cortical blades (drawn by C. Tessaro; models by C. Carmignani).

A second option, very rare, consists in the preparation of a crested blade, which is used as a guide in the first detachment (Fig. 4 nos 3, 4).

Another method, used to initiate the slab exploitation process, is to remove a tranche creating two new dihedrals (Fig. 4 nos 1, 2). This technical solution is also employed to correct eventual accidents occurring during the débitage stage, making it possible to continue the exploitation.

The maintenance of the lateral convexities of the flaking surface is carried out through the extraction of débordant blades (pre-determinate/pre-determinant) which guide the exploitation following a semi-tournant rhythm. In rare cases the creation of a second striking platform opposite the main one is carried out in order to manage the distal convexity. The production system illustrated allows to the obtention of two techno-types of blade: blades with symmetrical cross sections and blade with asymmetrical cross sections or debordant blades (Fig. 5 nos 2, 3, 4).

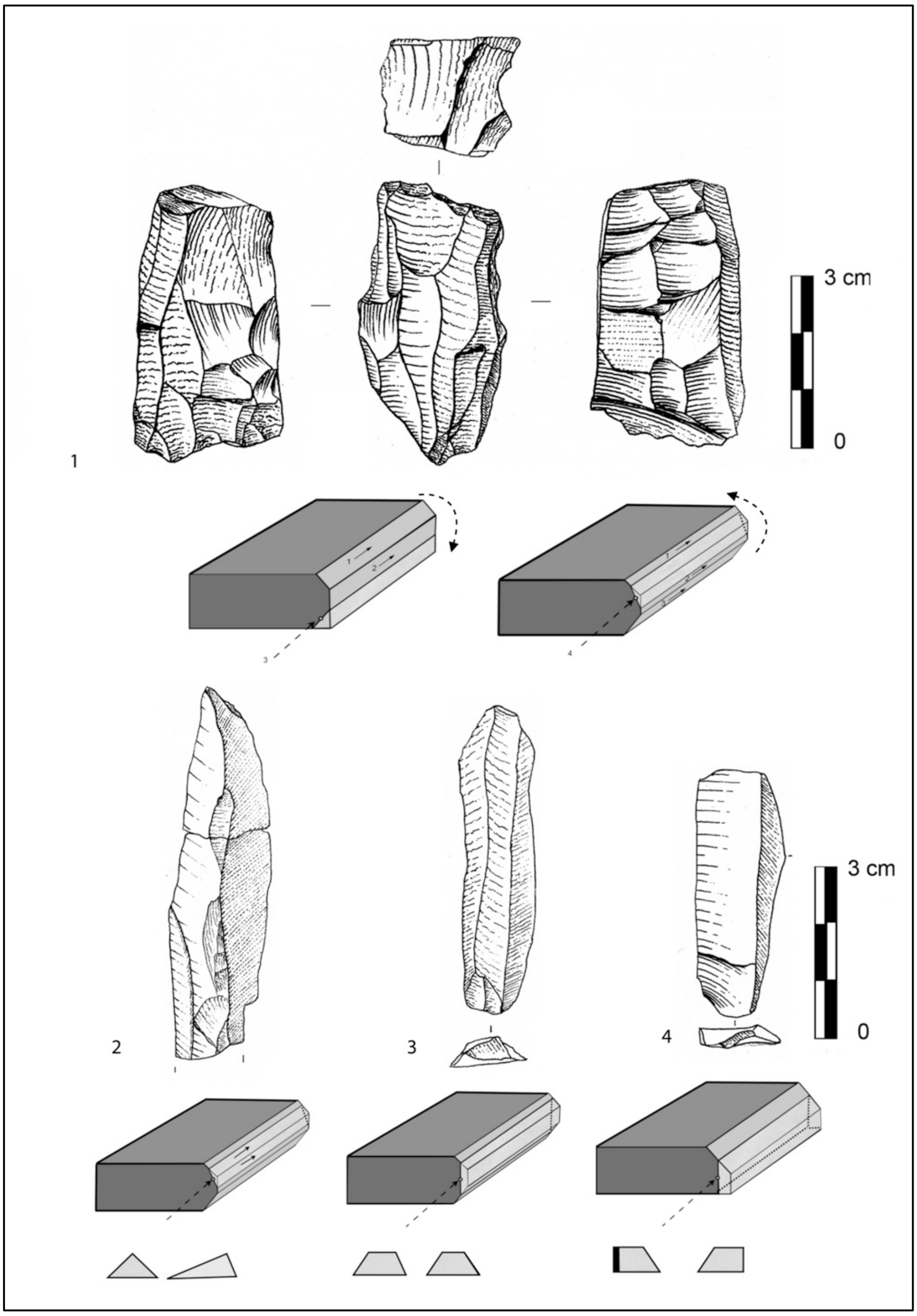

Figure 5. Main production stage. (1) core, (2, 3) blade with symmetrical cross section (4) blade with asymmetrical cross-section (drawn by C. Tessaro, models by C. Carmignani).

The blades have parallels edges and a straight profile. The direct production of blades with convergent edges is sporadic and can be considered as not predetermined. The convergence is instead often obtained through retouch, which in some cases modifies intensively the distal part of the blades (Fig. 3).

In sub-level FIIIe, of the 773 elements (intact and fragmented) that can be attributed to blade knapping, 160 have been modified through retouch with a transformation rate of 20.7%.

Besides laminar production, we also encounter the presence of an independent production kind aimed at producing bladelets through the exploitation of flake-cores. The exploitation of bladelet cores is carried out through a short series of unidirectional detachments. We can distinguish three types of volumes used as cores: simple flakes (Fig. 6 n. 2), flakes with a quadrangular cross section deriving from an exploitation "sur tranche" (Fig. 6 n. 1), and small number of slab fragments (Fig. 6 no. 3). As is the case in blade production, the configuration of the bladelet cores on flakes is based on the use of some technological expedients that require minimal preparation of the cores.

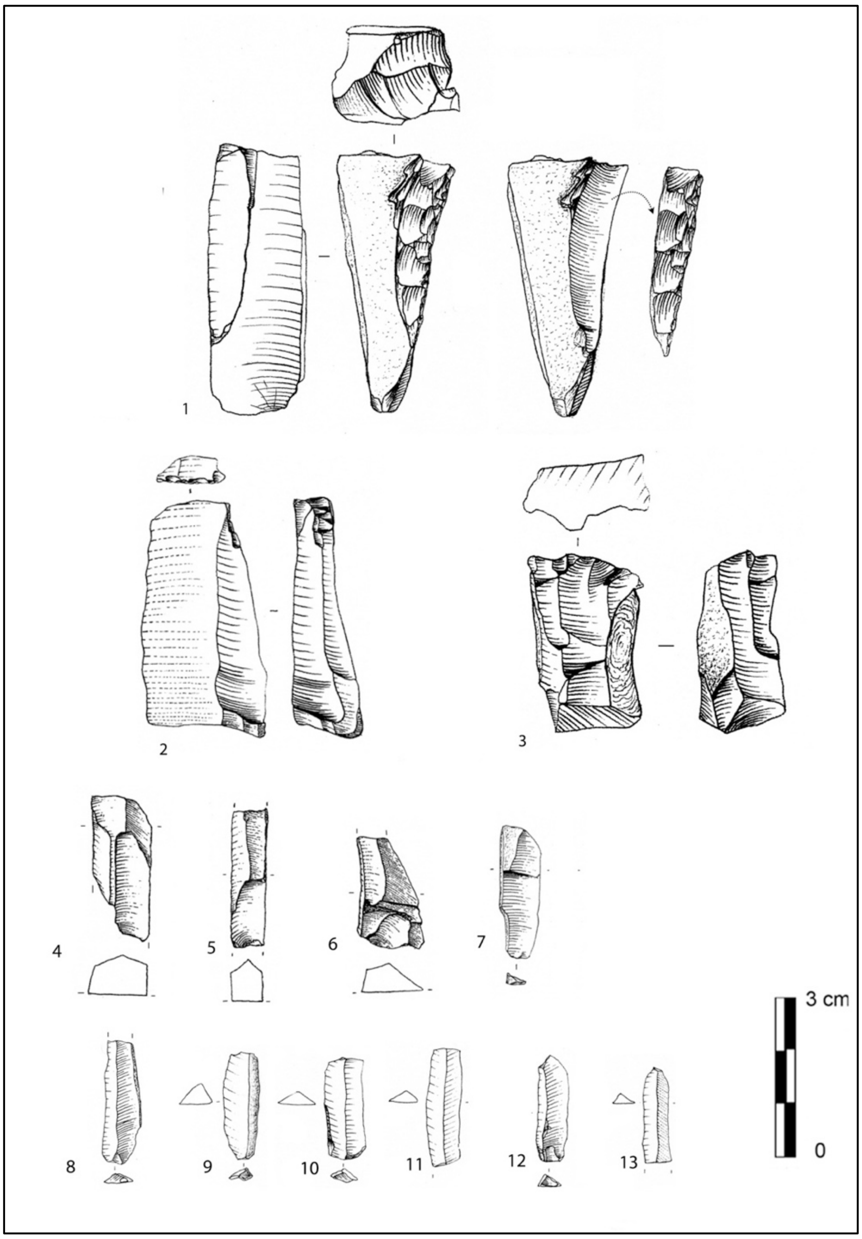

Figure 6. Bladelet production. (1) Core-flake with one refitted bladelet, (2, 3) Bladelet cores (4–7) rejuvenation bladelets, (8–13), bladelets (drawn by C. Tessaro).

The initial stage of bladelet production usually entails a first removal that exploits one of the edges of the flake. The preparation of a one-sided crested-bladelet has been noted, but this is a rare occurrence (Fig 6 no. 1).

The lack of a systematic management strategy of the core and, more specifically, a lack in the control of the distal convexity often leads to the abandonment of the bladelet cores after a short series of detachments. Flaking accidents are solved through the extraction of a rejuvenation bladelet with the aim of reinitializing the knapping surface and allow a second series of detachments (Fig. 6 nos 4, 5, 6, 7). Only one core shows a more elaborate management of the volume by rear-laterals removals aimed at the center of the flaking surface (Fig. 5 no. 1).

5 - Blade and bladelets on the Italian peninsula during the Middle Paleolithic: A possible summary?

It is important to being by noting that our attempt to carry out a precise comparison between the blade production of Grotta del Cavallo and other similar evidence present on the Italian peninsula turned out to be an arduous task for different reasons: lack of homogeneity among the data sets, methodological differences in the study of the lithic industries, and lack of a uniform terminology.

Generally, under the term 'blade' or 'bladelet' are gathered all the elements that in an undifferentiated way mainly correspond to a morphometric feature (length > 2width). According to us, this feature is not sufficient to attribute with certainty a group of elongated products to a real systematic and pre-determinate production of blades. A small number of elongated pieces can be obtained in a non-systematic way even through some reduction systems that are not specifically orientated towards the production.

In order to work with a corpus of data as homogeneous as possible and for a coherent comparison to be made we only considered reliable those lithic industries that have been analysed through a technological approach.

The blade production of Grotta del Cavallo is placed within a well-known kind of variability known from the production systems of the Middle Paleolithic. In Italy, from a geographic point of view, volumetric blade productions are present with no particular trends from north to south: in the Apulia region there are Grotta Santa Croce (Arrighi et al. 2009) and Riparo Oscurusciuto (Boscato et al 2011), Grotta Reali in Molise (Peretto 2012), Grotta Breuil in Lazio (Bietti & Grimaldi 1993, Grimaldi 1996, Lemorini 2000), and Riparo Tagliente (Arzarello & Peretto 2004, 2005) and Grotta Fumane (Peresani 2011) in the Veneto region.

The technique systematically used is that of direct percussion with a hard hammer. The main method used, with a few specific exceptions, is the unidirectional kind.

As observed in other parts of Europe the raw material used does not seem to neither hinder nor favour the production of elongated frames. In fact, volumetric laminar productions are found applied both on pebbles of different morphologies and dimensions, as well as on slabs, flakes-cores or nodules (Table 5). We can say the same thing concerning the lithology of the raw materials used, which include flints, jaspers, quartzarenites or limestones. The initial knapping phases exploit in almost the majority of cases the natural morphology of the blocks. Initial configuration of the volume seems to be based on the selection of the correct morphology of the available raw materials. Just in a few rare cases, such as at Grotta del Cavallo or again at Grotta Reali, the configuration phase can provide the preparation of a crested blade. The recourse to this technical expedient, when present, is, however, quantitatively minor and never assumes a standardized and systematic role. At Grotta del Cavallo, the construction of a crested blade is mostly applied in the advanced production phase to correct flaking accidents.

In terms of quantities, laminar productions are always in the minority and are consistently linked to flakes productions obtained by different production systems among which the Levallois, Discoid and the SSDA seem to be the most recurring (Table 5).

Table 5. Sites with blade production during the MIS 4/3 in the Italian peninsula.

Regions	Site name	Levels	Blade reduction systems	Raw material	Blade configuration systems	Blade methods	Mains flakes reduction systems associated	Chronology	MIS	References
Liguria	Barma Grande	I3-1	Levallois (blade)	Pebbles	-	-	Discoid	-	3	Yamada 1997
	Riparo Mochi	I sublevels 51-43	Levallois (blade)	Pebbles	-	-	Centripetal Levallois	-	3	Yamada 2004
	San Francesco	-	Volumetric (blade)	-	Crested blade	Unipolar?	-	-	?	Tavoso 1988
	Madonna dell'Arma	levels. I - II	Levallois (blade) + Volumetric (blade)	Pebbles	-	-	Centripetal Levallois	str.II 73100±4400 BP	4	Cauche 2007
Veneto	Riparo Tagliente	I 37-34	Volumetric (blade) - Levallois (blade)	Pebbles Nodule	Selection of natural morphology	Unipolar	Centripetal Levallois "Opportunistic" sensu Arzarello 2004"	-	3	Arzarello, Peretto 2004,2005
	Fumane	A5-A6	Volumetric (blade/bladelet)	Blocks Nodule Slabs	Selection of natural morphology	Unipolar	Centripetal Levallois	A5 14C 40.150±350 A5 14C 41.650±650 A5 14C 40.460±360 A6 U/Th e ESR 38.000±4000	3	Peresani 2011
Tuscany	Grotta del Capriolo	INF SUP	Levallois (blade)	Pebbles Blocks	-	Unipolar	Centripetal Levallois	39.000 U/Th BP	3	Dini,Koehler 2009
	Buca della Iena	A1+B1 B2 B3	Levallois (blade)	Pebbles Blocks	-	-	Centripetal Levallois	41.000 U/Th BP	3	Dini,Koehler 2009
Campania	Riparo del Poggio	9-10	Levallois (blade)	Pebbles	-	-	Centripetal Levallois	str.9 43800±3500 BP	3	Caramia,Gambassini 2006
	Grotta di Castelcivita	XIII-VI	Levallois (blade)	Pebbles	-	Unipolar	Centripetal Levallois	Liv XI 39.100±1300 BP 42.700±900 BP	3	Gambassini 1997
Lazio	Grotta Breuil	3,4,5,6	Bipolar percussion (elongated flakes /blade)	Pebbles	Selection of natural morphology	Unipolar Bipolar	Centripetal reduction systems	US 3-6 36.600 ± 2700 ka BP US 4-7 33.000 ± 4000 BP US 5 35.000 BP (non cal.)	3	Grimaldi 1996 Lemorini 2000 Grimaldi,Spinapolice 2010
Molise	Grotta Reali	2abc 2β/2γ 5	Volumetric (blade/bladelet) + Levallois (blade)	Slabs Pebbles Nodule	Selection of natural morphology + Crest (rare)	Unipolar	Discoid Levallois (Uni-Bip; Centr; Linear) "Opportunistic" sensu Arzarello 2004"	US 2γ 33.544 ± 540 BP (non cal.) US 5 35.650 ± 600 BP (non cal.) 36.620 ± 260 BP (non cal.) 40.040 ± 590 BP (non cal.)	3	Peretto 2012 Arzarello et. al. 2004
Apulia	Grotta di S.Croce	546 535	Volumetric (blade/bladelet)	Pebbles, Nodule	Selection of natural morphology	Unipolar	Discoid	-	4	Arrighi et.al. 2009
	Oscurusciuto	1,2,3	Levallois (blade)	Pebbles	Selection of natural morphology	Unipolare	Centripetal Levallois	US 1 38.500±800	3	Boscato et al. 2011 Villa et. al. 2009
	Grotta del Cavallo	FIIId FIIIe	Volumetric (blade/bladelet)	Slabs	Selection of natural morphology + Preparation of crested blades	Unipolar	Levallois (Uni-Bip; Centr; Conv.)	-	MIS 4 - 3	Carmignani 2010

In the Italian peninsula, during MIS 4 and MIS 3, the spread of blade productions by volumetric exploitation seems to coincide with a wider phenomenon, which can be summarised, in general terms, as a tendency towards searching for elongated products.

In fact, during this same time period, a tendency of the Levallois concept to produce blades by the unidirectional or bidirectional methods seems to emerge (Table 5). As was noted for the volumetric laminar production this aspect has also been noted for the whole Italian peninsula showing no clear patterns: in the Liguria region, at the sites of Riparo Mochi and Barma Grande (Yamada 1997, 2004), in the Veneto region at Fumane (Peresani 2011), in the Campania region at Riparo del Poggio (Caramia, Gambassini 2006) and Castelcivita (Gambassini 1997), and in the Apulia region at Riparo dell'Oscurusciuto (Boscato et al. 2011).

This apparent parallelism, which emerges as an interesting research theme, especially in terms of techno-functional aims, has not yet been fully explored.

In the case of Grotta del Cavallo the unidirectional and bidirectional Levallois methods, although present, is aimed at the production of quadrangular and sub-quadrangular flakes, which only sporadically reach an index of laminar lengthening. The systematic and predetermined production of blades has been attempted exclusively through the laminar volumetric system. At Grotta del Cavallo we seem to glimpse a clear distinction, in terms of techno-functional aims, between volumetric blade production and unidirectional-bidirectional Levallois methods. In others cases, as for instance at Riparo Tagliente, both the production systems, Levallois and volumetric, generate blades, but also, in this case, with distinct techno-functional structures (Carmignani in press).

Regardless of the production systems employed during MIS 4-3 a common macro phenomenon seems to take shape, which finds its uniqueness in creating blades using different reduction systems; in the case of the Levallois through a re-adaptation of the pre-existing volumetric concept, while, in the case of the volumetric systems, through completely innovative production systems.

In this respect it will be important in our opinion to compare, more in detail, the ephemeral bladelet production that appears during the last phase of the Middle Paleolithic with that of the Upper Paleolithic. A recent work that has highlighted a connection between the Châtelperronian and Pro-Aurignacian bladelets at the site of Quinçai (France) encourages future research to point in that direction. (Roussel 2016).

The last issue that we would like to discuss concerns the geographic setting of these productions. The Middle Paleolithic of the Italian peninsula is systematically found in cave or shelter sites. This differs to the blade productions of northern Europe, which are found in open-air sites (Table 5).

It remains to be verified whether this difference is the result of research bias or if instead these locality differences are actually linked to different population dynamics between the central-north and south areas of Europe.

The problems connected to the spread of the laminar phenomenon in the final Mousterian phases in the Italian peninsula need to be investigated, both in terms of the innovative element it represents and its relationship to the pre-existing techno-cultural substratum. Given the current state of research, and even if some general features are emerging, this overview does not allow us to frame the laminar phenomenon within a univocal model. The chronological delay that we see between the laminar production of the Italian peninsula, apparently concentrated in MIS 3, and those of the south of France, already present starting from MIS 5, leaves us with different possible scenarios. A comparison study between the laminar productions of southern Europe will clarify whether we are facing a phenomenon of technical convergence with different invention and spread centres or, if instead, this phenomenon can be tracked down to a single innovative centre from which it spread to other peripheral areas.

Chapter 6

Ressources lithiques, productions et transferts entre Alpes et Méditerranée
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Raw-Material Procurement and Productive Sequences in the Palaeolithic of Southern Italy: the Tyrrhenian and Ionian Areas

An Integrated Approach to the Reconstruction of Human Behaviour.

Francesca Romagnoli, Francesco Trenti, Lorenzo Nannini, Leonardo Carmignani, Giulia Ricci, Domenico Lo Vetro, Fabio Martini and Lucia Sarti

Abstract: The analysis of geological patterns has become a focus of research in European Palaeolithic archaeology in order to identify strategies in raw-material procurement and to interpret past technical behaviour. The reconstruction of past geological landscapes enables the correlation of archaeological assemblages with raw-material provenance and large-scale transport patterns. The evidence for procurement strategies and the patterns of raw-material exploitation and transport have been used to assess mobility and cognitive abilities among Palaeolithic groups, revealing differing strategies between Middle and Upper Palaeolithic hunter-gatherers. While Neanderthals seem to have organised their technology in a local or semi-local territory, modern humans have shown a more intense exploitation of distant sources. This scenario has been challenged over the last few years. Several studies have highlighted more complex environmental exploitation by Neanderthals through the catchment of distant lithic resources. The universities of Florence and Siena are engaged in a long-term project of geological survey that aims to identify lithic sources used during the Palaeolithic. Geological research has been carried out in parallel with technological analysis of archaeological lithic assemblages from the Mousterian layers of Grotta del Cavallo (Apulia, south-east Italy) and the Upper Palaeolithic layers of Grotta del Romito (Campania, south-west Italy). The project aims to answer specific questions regarding raw-material procurement: is it possible to predict human behaviour based on the distance between the settlement and the raw-material source? How did raw materials influence the variability of lithic assemblages? And, with regard to this latter question, which strategies were applied by hunter-gatherers regarding the use of the landscape and the available resources found within it? The integrated analysis of archaeological finds and ancient geological landscapes enables us to develop a complex scenario in which the rigid definition of the knapping concept and the economic strategies (e.g. curated and expedient behaviour) seems to be more strictly related to cultural constraints (shared knowledge, technical innovations and social and economic organisation) than to geophysical ones. We present here the methodology of geo-archaeological surveys and the preliminary results obtained for production sequences and procurement strategies at Grotta del Cavallo during the Middle Palaeolithic. At Grotta del Cavallo it could be evidenced that the human groups had great high mobility, which exceeded 50 km. Differences in techno-economy throughout the stratigraphical sequence of this site suggest that human strategies were influenced by several factors, including site use, demographic patterns and technical tradition, which generated various methods of adaptation to the available resources. The future implementation of this line of research, the integration of subsistence strategies and climate change analyses with that of stone tool assemblages and mobility, will make it possible to understand human behaviour and to explain the considerable variability of the archaeological record.

Keywords: Middle Palaeolithic, Upper Palaeolithic, techno-economy of lithic assemblages, mobility, human behaviour, Italy.

Résumé : L'analyse des ressources géologiques est devenue un thème central de recherche en archéologie paléolithique en Europe lorsqu'il s'agit d'identifier les stratégies d'approvisionnement des matières premières et d'interpréter les comportements techniques du passé. La reconstruction du paysage géologique des périodes étudiées permet de corréler les assemblages archéologiques avec l'origine des matières premières et les modes de transport à grande échelle. Les stratégies d'approvisionnement des matières premières ainsi que les modes de transport et d'exploitation ont été utilisés pour évaluer la mobilité et les capacités cognitives des groupes paléolithiques, montrant des stratégies qui différaient entre les chasseurs-cueilleurs du Paléolithique supérieur? et ceux du Paléolithique supérieur. Alors que les Néandertaliens semblent avoir organisé leur technologie sur un territoire local ou semi-local, les *Homo sapiens* semblent avoir été en mesure d'exploiter fortement des ressources éloignées au cours du Paléolithique moyen. Plusieurs exemples de transport sur de longues distances ont été présentés ces dernières années, apportant la preuve de l'existence de stratégies d'exploitation complexes du territoire par les Néandertaliens. Les universités de Florence et de Sienne ont initié un projet à long terme d'études géologiques visant à collecter et analyser des ressources lithiques utilisées pendant le Paléolithique. Les recherches géologiques ont été réalisées parallèlement à l'analyse technologique des assemblages lithiques archéologiques des niveaux moustériens de la Grotta del Cavallo (Pouilles, Sud-Est de l'Italie) et du Paléolithique supérieur de la Grotta del Romito (Campanie, Sud-Ouest de l'Italie). Les recherches visent à répondre à des questions spécifiques liées à l'approvisionnement en matières premières, comme par exemple: la distance à la source constitue-t-elle un indicateur du comportement humain? Comment la matière première conditionne-t-elle la variabilité des assemblages lithiques? Et, en rapport avec celle-ci, dans quelle mesure cette même variabilité a-t-elle été prise en compte par les chasseurs-cueilleurs dans leur utilisation des ressources disponibles et du paysage en général? L'analyse intégrée des découvertes archéologiques et le paysage géologique du passé nous permettent de comprendre un scénario complexe, dans lequel la définition rigide du concept de débitage et des stratégies économiques (par exemple, « comportement structuré et opportuniste ») semble être plus étroitement liée aux contraintes culturelles (connaissance partagée, innovations techniques et organisation sociale et économique) qu'aux contraintes géophysiques. Nous présentons ici la méthodologie des prospections géo-archéologiques et les résultats préliminaires sur des séquences de production et les stratégies d'approvisionnement à la Grotta del Cavallo au cours du Paléolithique moyen. À la Grotta del Cavallo, nous avons montré une grande mobilité des groupes humains sur des distances de plus de 50 km. Les différences techno-économiques observées tout au long de la séquence stratigraphique de ce site suggèrent que les stratégies humaines ont plusieurs causes, dont l'utilisation du site, les tendances démographiques et la tradition technique qui ont généré différentes adaptations aux ressources disponibles. La future application de cette ligne de recherche, avec l'intégration des stratégies de subsistance et les changements climatiques dans l'analyse des assemblages lithiques et de la mobilité permettra de comprendre le comportement humain en interprétant la grande variabilité des témoins archéologiques.

Mots-clés : Paléolithique moyen, Paléolithique supérieur, techno-économie des industries lithiques, mobilité, comportement humain, Italie.

FOR A LONG TIME archaeological studies on Palaeolithic hunter-gatherers have dealt with the mobility of human groups. In recent decades, raw-material economy has become a research focus in Europe and has led to the petrographic and geological identification of lithic resources in the landscape and of archaeological lithic remains (Geneste, 1989 and 1992; Féblot-Augustins, 1997; Féblot-Augustins et al., 2005; Turq, 2005; Fernandes and Raynal, 2006; Fernandes et al., 2007 and 2008; Riel-Salvatore and Negrino, 2009; Duke and Steele 2010; Browne and Wilson, 2011; Eixea et al., 2011; Aubry et al., 2012; Olivares et al., 2013, among others). The integrated analysis of geological and technological patterns makes it possible to correlate the archaeological assemblages with resources located in the environment and addresses raw-material provenance and large-scale transport patterns. Because raw materials are distributed throughout the landscape, their procurement implies the investment of time and energy (Bousman, 1993). Palaeolithic data suggest that these technological factors, including transport distance, influenced human economic strategies, while resource availability influenced technological strategies. Raw materials are usually divided into local and non-local based on their distance from the site. According to many authors, resources available within a radius of 5 km from the site are considered as local, while regional or semi-local resources are 6 to 20 km away, and exogenous resources are more than 20 km distant (e.g. Geneste, 1989; Féblot-Augustins, 1999 and 2009; Fernandes et al., 2008).

Raw-material procurement analysis revealed that the Middle Palaeolithic hunter-gatherers preferred local and semi-local lithic resources, which constituted at least 90% of the assemblages, although the exploitation of raw materials from sources located farther than 50 km away has been identified at several sites (e.g. Geneste, 1988; Roebroeks et al., 1988; Féblot-Augustins, 1993, 1999 and 2009; Chalard et al., 2007; Slimak and Giraud, 2007; Porraz, 2010). Since the beginning of the Upper Palaeolithic *Homo sapiens* experienced various strategies for the exploitation of environmental resources, as is attested by the increasing quantities of generally fine-grained and highly homogeneous raw materials originating from more distant sources (e.g. Soffer, 1989; Dobosi, 1991; Mellars, 1996; Demars, 1998; Kuhn, 2004; Tomasso et al., 2014).

Evidence for procurement strategies and patterns of raw-material exploitation and transport were used to assess mobility (Thacker, 1996; Blades, 1999; Andrefsky, 2009; Delagnes and Rendu, 2011) and cognitive abilities (Roebroeks et al., 1988; Stiles, 1998) among Palaeolithic groups. Most artefacts made from exogenous resources were retouched tools and show signs of long-term use and re-sharpening (Geneste, 1988; Féblot-Augustins, 1993; Bourguignon et al., 2006; Delagnes et al., 2006). This observation fits with the idea of procurement strategies that involved preliminary planning and the transport of finished tools or of specific raw materials not available in the places in which they were needed (Kuhn, 1992, 1995 and 2004).

Teams of the universities from Florence and Siena carried out studies on Palaeolithic raw materials in Southern Italy for several years (Martini et al., 2003 and 2006) in order to understand the technological and economical aspects of lithic production and to reconstruct the mobil-

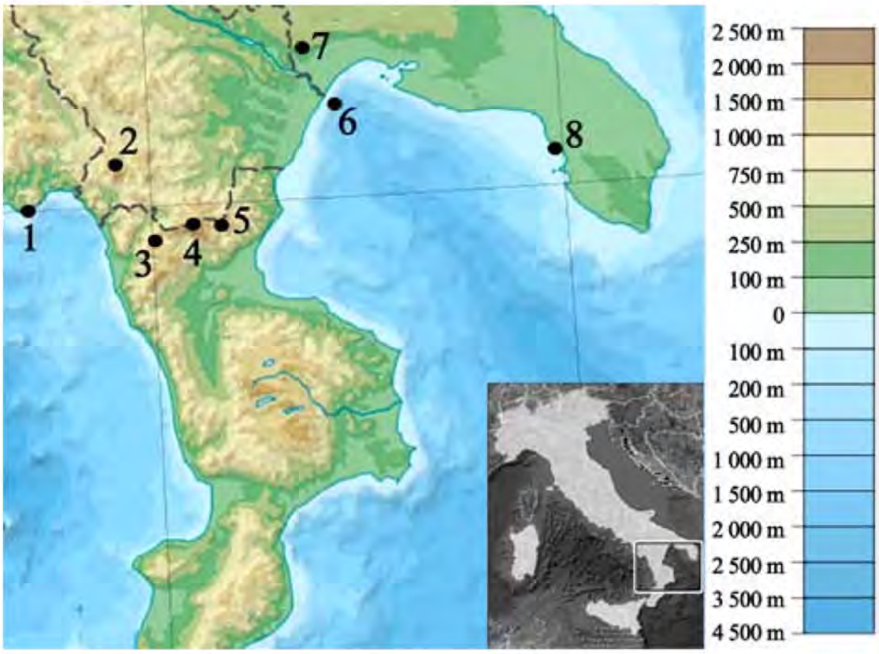

Fig. 1 – Study region and location of the main sites and geographic landmarks mentioned in the text. 1: Grotta della Serratura; 2: Sirino Mount; 3: grotta del Romito; 4: Pollino Mount; 5: Serra di Crispo; 6: mouth of Bradano river; 7: Ginosa; 8: grotta del Cavallo.

Fig. 1 – Région d'étude et localisation des sites et des principaux points géographiques mentionnés dans le texte. 1 : Grotta della Serratura ; 2 : Mont Sirino ; 3 : grotta del Romito ; 4 : Mont Pollino ; 5 : Serra di Crispo ; 6 : embouchure de la rivière Bradano ; 7 : Ginosa ; 8 : grotta del Cavallo.

ity patterns of hunter-gatherer communities. The research focused on two separate areas (fig. 1) and time periods: the Salento region of southern Apulia in the eastern part of Southern Italy, for the Middle Palaeolithic, and the Tyrrhenian coast of Calabria in the western part of Southern Italy, for the Upper Palaeolithic (Gravettian and Epigravettian).

Many studies have considered the transfer distances related to time, the energy input and the quality of the raw materials in relation to the task for which the tools were designed (e.g. Renfrew, 1977; Torrence, 1983 and 1989; Ataman et al., 1992; Elston, 1992; Kuhn, 1992, 1995 and 2004; Bamforth, 2006; Brantingham 2006). Clearly many factors have to be taken into account when we consider why humans collected a specific raw material in a specific place, and why they may have divided the operational sequence (chaîne opératoire) of this raw material within their environment, including landscape geography, subsistence strategies, level of human planning and, obviously, cultural decisions. Furthermore we must consider that lithic technology, subsistence strategies, resource procurement, processing and transport efforts have a dynamic interaction within the environmental setting and the technical traditions of human groups (e.g. Binford, 1980; Shott, 1986; Geneste, 1988; Wilson, 2007; Romagnoli, 2015). Our hypothesis is that the selection of raw materials depended on numerous factors, such as the duration of occupation of the site, technical traditions, the presence of specialised craftsmen, the social organisation of the groups, expedient behaviours, and social networks. Accordingly, judging only from the distance between the sites and the lithic sources would not be an adequate criterion to explain the variability of technical behaviour, for the relationships between raw materials, technical variability and hunter-gatherer mobility should also be taken into account. Could the distance from the source predict human behaviour? How did raw materials condition the variability of lithic assemblages? And, correlated with this latter question, what were the strategies used by hunter-gatherers for the exploitation of available resources and of the environment in general?

We therefore launched a long-term project of geological surveys that aimed at collecting and analysing the lithic sources (of both good and poor quality) in primary and secondary deposits. The previous technological analysis of the archaeological stone remains was the basis for the geological surveys. Our study aimed at correlating the geological environment with the mobility patterns, procurement strategies and technical traditions of the Palaeolithic hunter-gatherers and it was based on two main archaeological sites: Grotta del Cavallo (Middle Palaeolithic, Lecce, Apulia; fig. 1) and Grotta del Romito (Upper Palaeolithic, Cosenza, Calabria; fig. 1).

This article presents the methodology of the geological-archaeological surveys of the two areas analysed in our projects. The results concerning mobility patterns and productive strategies are described in detail for the Middle Palaeolithic sequence of Grotta del Cavallo, and the strategies of raw-material transport and use are discussed, as well as the relevance of the integration of raw-material analysis into the behavioural approach.

THE RAW-MATERIAL STUDIES CARRIED OUT IN SOUTHERN ITALY

The method implemented for this geo-archaeological study is based on a protocol previously tested in other studies carried out on lithic raw materials, mainly using accurate and extensive ground investigation surveys as well as petrologic analysis of geological and archaeological samples (Turq, 2005; Eixea et al., 2014; Soto et al., 2014; Tomasso et al., 2014; Wilson, 2014). As part of a major multidisciplinary research project on Palaeolithic human frequentation of Southern Italy, this method was used for the first time by the university of Florence in 2001 in order to characterise the lithic raw materials of Gravettian and Epigravettian assemblages stemming from Grotta della Serratura (Marina di Camerota), a coastal site in the Cilento region (southern Calabria; fig. 1). The geological surveys covered a wide area including the Cilento region and the Tyrrhenian reliefs of Basilicata (Mount Sirino and surroundings areas; fig. 1; Martini et al., 2003 and 2006). Geological investigations were later extended to the adjacent Tyrrhenian side of Northern Calabria with the aim of characterising lithic raw materials exploited during the Upper Palaeolithic at Grotta del Romito (Papasidero, Cosenza; Martini et al., 2006 and 2007). In 2009 a new season of surveys was carried out in Northern Calabria and Southern Basilicata based on the data stemming from the previous studies and including petrologic analysis of the geological samples collected and of the archaeological materials recovered from Grotta del Romito (Nannini, 2008–2009; Martini and Lo Vetro, 2011). In 2010 this method was used on the Apulian Ionian side to identify the lithic raw materials of the assemblages recovered from the Middle Palaeolithic layers of Grotta del Cavallo (Romagnoli, 2012 and 2015).

The method used consists of four main stages, as follows: 1) preliminary analysis of the geographic and geological context including the study of the geological literature on the archaeological data of the area under investigation; 2) geographical survey and sample collection; 3) macroscopic and microscopic analysis of the samples; 4) interpretation of the results.

The main goals are:

1) to reconstruct the mobility patterns of Palaeolithic hunter-gatherers;

2) to identify the technical processes and the economic strategies that led to the production of lithic assemblages;

3) to understand human behaviour and local resource exploitation strategies in relation to the regional setting and the diachronic changes in the environment.

In a first stage the analysis of geographical maps and geographical environments makes it possible to identify possible changes from prehistoric to present times (Rapp and Hill, 1998) and to classify the raw materials on the basis of the distances to the site and the displacement range. Numerous archaeological and ethnographical studies that focused on lithic procurement strategies suggest that the most appropriate area to be surveyed for raw material lies within a 30 km radius off the archaeological site (Binford, 1982; Turq, 1989; Geneste, 1992; Féblot-Augustins, 1999).

The formations containing exploitable flints were identified and mapped thanks to geological cartography and previous studies (Spinapolice, 2012). The daily displacement range depends on the difficulties related to the environment and the terrain (Wilson, 2007), which differs between the Salento and south Tyrrhenian areas. Salento is a flat peninsula with low hills in its southern portion that never rise above 200 m. By contrast the south Tyrrhenian area is characterised by a few coastal plains (restricted to the mouths of the rivers) and inland mountains over 1,000 m, some of which exceed 2,000 m in altitude, for example Mount Sirino, Mount Pollino, and Serra di Crispo (fig. 1).

Usually the local procurement area is based on the distance that can be covered during a one-day trip, taking into account an average rate of 5 km/h. According to the geographical features reported for Grotta del Cavallo, the limit between local and exogenous raw materials was fixed at 20 km in a straight line from the site, as it has been assumed that Palaeolithic people had a displacement rate of about 5 km/h for eight hours per day (Jarman and Webley, 1975). For Grotta del Romito this limit was fixed at 8 km in a straight line from the site. The limit, previously fixed at 10 km for Grotta della Serratura (Martini et al., 2007), was revised to adapt it to the geomorphological environment of Grotta del Romito. The inland of Calabria consists of a rough morphology with relevant physical obstacles. Taking into account the landscape, the limit between local and exogenous raw materials was assumed to coincide with the watershed of the Lao river valley, as well as with the routes along which the Palaeolithic hunter-gatherers roamed for hunting.

In a second research stage, surveys and samplings were carried out on the basis of the analysis of geological maps and literature. All the formations containing exploitable stone resources were sampled and the results were entered in a database in which geographical coordinates (GPS point), extent, slope and typology of the outcrops were recorded.

In a third stage both geological and archaeological samples were analysed macroscopically and microscopically, described, and compared with each other. Thin sections were cut for petrographical analysis. Macroscopic examination addressed the morphology of the support (block, nodule, pebble), the colour, the texture (showing the roughness of the surface to touch), the transparency, and the presence or type of internal structures (sedimentary structure, fissures and geodes, oxides or carbonates). Microscopic examination addressed particle size and microfossils content (Luedtke, 1992; Rapp and Hill, 1998; Fernandes et al., 2006). A stereomicroscope (SMZ-2T; Nikon, Tokyo, Japan) to analyse complete samples and a transmission microscope (C-4000Z BX51; Olympus, Tokyo, Japan) to observe thin sections were used. All the samples and thin sections were registered and classified in the rock collection of the Museo Fiorentino di Preistoria (Florence, Italy).

In a fourth stage the data gained from the previous three stages were combined to formulate a comprehensive process of raw-material procurement.

The geological study was carried out in combination with the technological analysis of the archaeological lithic assemblages, which was finalised to reconstruct past technical behaviour. The morpho-technical attributes of all the assemblages were analysed, reconstructing the life cycle of lithic artefacts from the discovery of the raw material to the discarding of the tools (Perlès, 1991; Inizan et al., 1995; Baena et al., 2010). The integrated approach combining geological and technological analysis aimed to evaluate human adaptation to the environment and to available resources, and to identify and interpret the technical strategies.

GEOLOGICAL CONTEXT

Ionian site of Apulia

Salento is a large plain without any obstacles for a long distance. The environment is geologically homogeneous and is composed of limestone units (Serre Salentine) outcropping in long ridges arranged north-west to south-east. These units are the result of tectonic events that occurred during the Cretaceous and the Early Pleistocene. The local limestone unit related to the Grotta del Cavallo area is called 'Melissano limestone' (Martinis, 1968; Largaiolli et al., 1969; Commissione Italiana di Stratigrafia, 2003). This formation is composed of a great variety of medium-fine grained microcrystalline limestone and dolomitic limestone. Occurring in joint sets, blocks of raw material are abundant throughout the formation. Chert is completely absent from the Salento formations, as attested to on the geological maps and confirmed by surveys carried out in 2010 across the whole Ionian side of Apulia. The cave opened onto a large plain during the last marine regressions (Siddall et al., 2003; Dorale et al., 2010), which have reached a maximum distance from the cave of approximately 12-15 km.

Geological sampling was carried out within a 30 km range off the cave. All the inter-formational varieties of lithotypes were sampled. The limestone lithotypes of the Melissano limestone formation are all abundant and easily available in the surroundings of the cave (< 5 km), both in primary and secondary position (fig. 2). The raw material was classified as follows: 1) limestone sensu stricto, 2) silicified limestone, and 3) laminated limestone with cleavages. Each lithotype exhibits a variety of colours and textures. To a varying degree of regularity all the lithotypes break with a conchoidal fracture. All the local lithotypes are attested to in the Middle Palaeolithic archaeological assemblages of Grotta del Cavallo and these raw materials were the most intensively exploited by Neanderthals at this site (Carmignani, 2011; Romagnoli, 2012 and 2015).

With the aim of identifying sources of fine-grained raw materials, sampling was extended from the south of the Salento peninsula to the border between Basilicata and Apulia (Fossa Bradanica), where, inside the alluvial deposits of the Bradano river, conglomerates with abundant Apennine siliceous pebbles have been found (chert and green radiolarites). The Bradano deposit consists of marine terraces that originated between the Late Pliocene and Middle Pleistocene. After the Upper Pleistocene marine regression, rivers began their erosion and accumulation activities that still characterise the Fossa Bradanica plain today (Lazzari and Pieri, 2002; Lazzari, 2008). The dimensions of the pebbles collected in the Bradano deposits vary from approximately 3 to 15 cm in diameter and all the pebbles evidence mechanical alteration on the rounded outer surface (fig. 3). The easy availability of this raw material also suggests that these deposits were possible procurement sources during the Pleistocene. Preliminary thin-section analyses have confirmed this hypothesis. The sources are located at a distance of 80–100 km from the cave. It is possible that in Palaeolithic times cobbles were collected at the mouths of the rivers or along the shores that were located closest to the cave. In any case, the small dimensions of the cobbles in the alluvial deposits near Ginosa suggest that the collection site was located nearby, given that the stone sizes usually decrease in parallel with the increase of the distance covered.

South Tyrrhenian side

The south Tyrrhenian area exhibits a great ecological variety, with several coastal plains (especially near the mouths of the rivers) with mountains reaching peaks up to 2,000 m (Mount Sirino and Mount Pollino) in the hinterland. Calabria displays a rough morphology with distinct natural barriers, in particular inland.

The archaeological assemblages recovered from the Grotta della Serratura and Grotta del Romito sites were usually made of high-quality flint. The geological context of the south Tyrrhenian side is varied and four formations have been identified as possible sources for raw material (Fogli 210 and 220, Carta Geologica d'Italia; fig. 4A): flint-bearing limestones (TsT4); siliceous shales containing radiolarites (G11Ts), grey flint-bearing limestone (MiE), and polygenic breccia containing black and grey chert (PCCs).

Fig. 2 – Grotta del Cavallo, Middle Palaeolithic. Variety of medium-fine grained microcristalline limestone and limestone *sensu strictu* sampled in the local Melissano limestone formation (photos F. Romagnoli).

Fig. 2 – Grotta del Cavallo, Paléolithique moyen. Variété de calcaire microcristallin et calcaire* sensu stricto *échantillonné dans la formation locale des calcaires de Melissano (clichés F. Romagnoli).

At Grotta del Romito (table 1) the lithic varieties primarily occurring in the archaeological assemblages are (fig. 4D, a-b) the following:

1) red and green radiolarites stemming from Mount Sirino (siliceous shale): these could be collected from the Noce river deposits as pebbles measuring 3 to 10 cm in diameter, at about 15–20 km directly from the cave. These raw materials were also widely exploited at Grotta della Serratura and were mainly collected close to the cave on the shores and in riverbeds (Martini et al., 2003, 2006 and 2007);

2) black chert, characterised by a poor quality and many fractures, which may have been collected from the Lao river deposits, near the cave (about 300 m away) and up to 5–7 km upstream. This kind of chert probably stems from polygenic breccias outcropping along the Lao valley, but we found it only in secondary deposits in the riverbed;

3) greyscale chert usually characterised by medium-poor quality, possibly from polygenic breccia outcrops.

Some high-quality chert lithotypes documented in the archaeological record were not localised in the local environment and perhaps came from a more distant source, possibly from Basilicata (about 50 km away). Indeed, preliminary surveys carried out in the Lucan Apennine outcrops and in their alluvial deposits, suggest possible procurement in this area (fig. 4D, c).

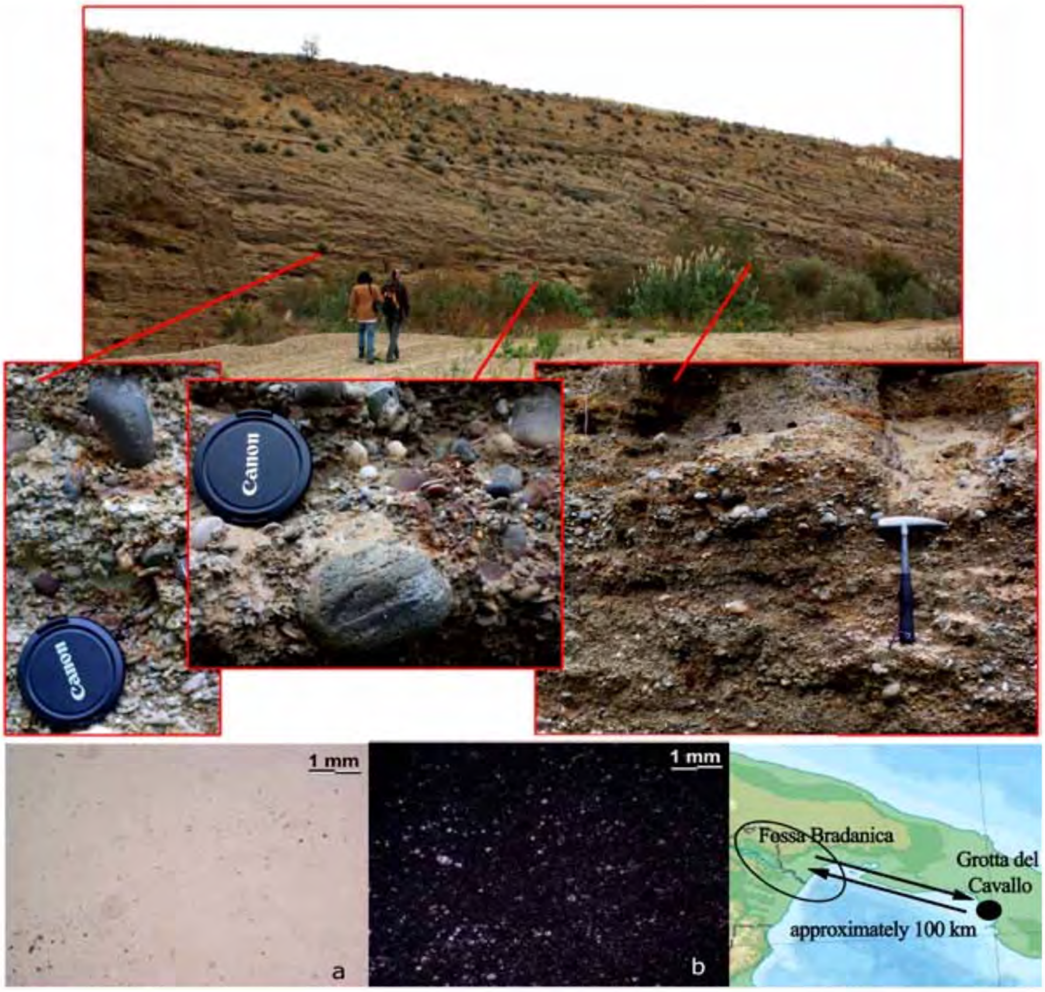

Fig. 3 – Grotta del Cavallo, Middle Palaeolithic. Chert and radiolarite cobbles sampled in the conglomerate of the 'Bradano trough' (paleodeposits originating from the hydrological system of the Bradano river). This procurement area is located approximately 100 km NW from the site. a: thin section of light microcrystalline flint, archaeological sample; b: thin section of green radiolarite, archaeological sample (photos F. Romagnoli and F. Trenti).

Fig. 3 – Grotta del Cavallo, Paléolithique moyen. Galets de silex et radiolarite échantillonnés dans le conglomérat de la « Fossa Bradanica » (paléo-dépôts du système hydrique de la rivière Bradano). Ce territoire d'approvisionnement est situé environ à 100 km au nord-ouest du site. a : lame mince de silex clair microcristallin, échantillon archéologique ; b : lame mince de radiolarite verte, échantillon archéologique (clichés F. Romagnoli et F. Trenti).

AN INTEGRATED APPROACH OF PRODUCTION STRATEGIES AND RAW MATERIALS: THE MIDDLE PALAEOLITHIC SEQUENCE AT GROTTA DEL CAVALLO

The site

Grotta del Cavallo is a karst cave located on the western coast of Salento in the southern part of Apulia (SE Italy). The cave opens onto the rocky coast of Baia di Uluzzo, about 15 m above the present day sea level, and consists of a single circular room, about 9 m in diameter (Palma di Cesnola, 1963). Archaeological investigations were directed by Arturo Palma di Cesnola during the 1960s (Palma di Cesnola, 1963, 1964, 1965a, 1965b and 1966) and then resumed in 1987 by the universities of Florence and Siena. The site preserves a seven metre-thick archaeological deposit, covering a time span ranging from MIS 5 to the final Upper Palaeolithic (fig. 5). The Middle Palaeolithic sequence (MIS 5 to MIS 3) is one of the most important in Southern Italy.

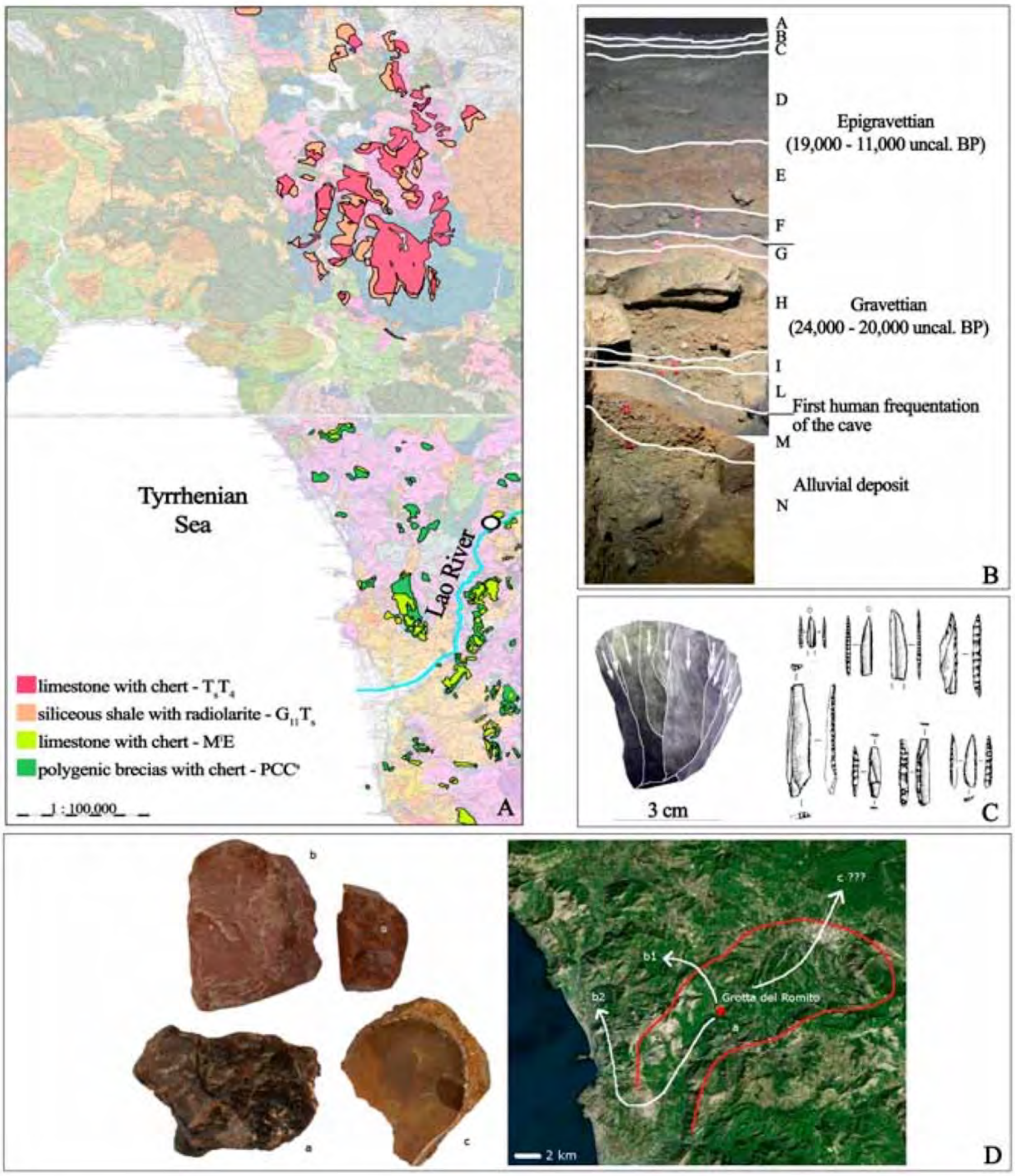

Fig. 4 – Grotta del Romito, Upper Palaeolithic. A: formations identified as possible raw-material sources (Carta Geologica d'Italia 1:100,000, sheets 210 and 220 http://193.206.192.231/carta_geologica_italia/default.htm, modified); B: stratigraphy of the cave (photos D. Lo Vetro); C: cores and backed tools, Late Epigravettian, layer C3 (photos D. Lo Vetro, drawings L. Baglioni); D: procurement area of the lithic raw materials, a: local black chert, b: radiolarite sampled from the Noce river valley, c: exogenous microcrystalline chert (photos F. Trenti).

Fig. 4 – Grotta del Romito, Paléolithique supérieur. A : formations identifiés comme possibles sources de matières premières (Carta Geologica d'Italia 1:100 000, feuilles 210 and 220 http://193.206.192.231/carta_geologica_italia/default.htm, modifié) ; B : stratigraphie de la grotte (clichés D. Lo Vetro) ; C : nucléus et outils à dos, Épigravettien final, couche C3 (clichés D. Lo Vetro, dessins L. Baglioni) ; D : territoire d'approvisionnement en matières premières lithiques, a : silex noir local, b : radiolarite échantillonnée dans la vallée du Noce, c : silex microcristallin exogène (clichés F. Trenti).

Sample code	Lab code	Layer	^{14}C BP uncal.	2σ cal. BP (Ox Cal V. 4.0)	Cultural phase
ROM 1	Beta-160295	C	11,060 ± 100	13,158-12,853	Late Epigravettian
ROM 2	Beta-160296	C2	11,090 ± 70	13,131-12,886	
ROM 3	Beta-160297	C3	11,380 ± 70	13,375-13,119	
ROM 4	Beta-160298	C4	11,250 ± 70	13,266-12,986	
ROM 5	Beta-160299	D	11,580 ± 70	13,617-13,278	
ROM 6	Beta-160300	D1	11,660 ± 70	13,695-13,345	
ROM 8	Beta-160302	D5a	12,060 ± 90	14,113-13,745	
ROM 9	Beta-160303	D5b	12,160 ± 50	14,148-13,866	
ROM 11	LTL234A	D8	12,170 ± 60	14,173-13,857	
ROM 14	LTL238A	D11	12,334 ± 75	14,749-14,015	
ROM 18	LTL607A	D13	12,258 ± 75	14,591-13,921	
ROM 23	LTL603A	D14	12,377 ± 95	14,875-14,051	
ROM 24	LTL608A	D15	12,331 ± 55	14,663-14,036	
ROM 25	LTL601A	D16	12,,369 ± 100	14,877-14,036	
ROM 26	LTL602A	D20	12438 ± 85	14,921-14,137	
R-33	LTL1050A	D29	12,494 ± 75	14,973-14,202	
R-31	LTL1052A	D35	12,970 ± 150	15,859-14,921	
R-37	LTL1046A	E2	13,650 ± 120	16,735-15,790	
R-36	LTL1047A	E5	13,646 ± 120	16,730-15,784	
ROM 38	LTL1590A	E8	14,373 ± 90	17,732-16,739	
ROM 39	LTL1591A	E10	15,273 ± 150	18,886-18,105	
ROM 40	LTL1592A	E16	16,129 ± 100	19,476-19,067	Evolved Epigravettian
ROM 41	LTL1593A	F1	17,376 ± 90	20,888-20,235	Ancient Epigravettian
ROM 20	LTL239A	F2	18,978 ± 130	22,846-22,230	
ROM 28	LTL606A	F3I	18,483 ± 95	22,326-21,518	
ROM 21	LTL236A	G1	19,351 ± 180	23,634-22,513	Evolved/Late Gravettian
ROM 22	LTL237A	G2	19,373 ± 90	23,450-22,635	
ROM 30	LTL604A	H4	20,210 ± 245	24,962-23,510	
R-35	LTL1048A	I	23,475 ± 190	27,926-27,357	

Table 1 – Grotta del Romito. Radiocarbon dates.
Tabl. 1 – Grotta del Romito. Datations radiocarbone.

The bottom layer is a marine interglacial beach conglomerate, layer O, MIS 5e (Sarti et al., in press) covered by Mousterian layers, approximately four metres thick, layers N-F (Sarti et al., 1998–2000 and 2002; Palma di Cesnola, 2001), Uluzzian layers, layers E-D (Palma di Cesnola, 1965a and 1966), a sterile tephra empirically related to the Campanian Ignimbrite eruption (layer C) and an Epigravettian layer (layer B). The base of the Uluzzian layers has been recently dated to 47,530–43,000 cal. BP, radiocarbon analysis on shell remains (Benazzi et al., 2011). Absolute chronometric data are currently not available for the Middle Palaeolithic sequence. As regards the Mousterian layers the faunal assemblages are dominated by *Cervus elaphus*, *Dama dama*, *Equus ferus*, and *Bos primigenius*, with different relative frequencies along the stratigraphy (Sarti et al., 1998–2000 and 2002; Cecchetti, 2003). All layers display several hearths and fireplace features. The lithic data presented here relate to the recent excavation directed by Lucia Sarti carried out on a surface of approximately 12 m^2.

Lithic technology

In the Middle Palaeolithic sequence of Grotta del Cavallo over 80% of the lithic artifacts were made from local raw material (table 2). The proportion of exogenous lithic resources changes during the sequence, suggesting different mobility patterns and probably different occupation strategies during the Middle Palaeolithic. Exogenous raw materials were flint, radiolarite, and in rare cases quartzite. The surveys have suggested that these raw materials were collected more than 50 km north-west of the site, between Ginosa and Ginosa Marina (fig. 3), as small fluvial cobbles and were invariably brought to the site as finished tools.

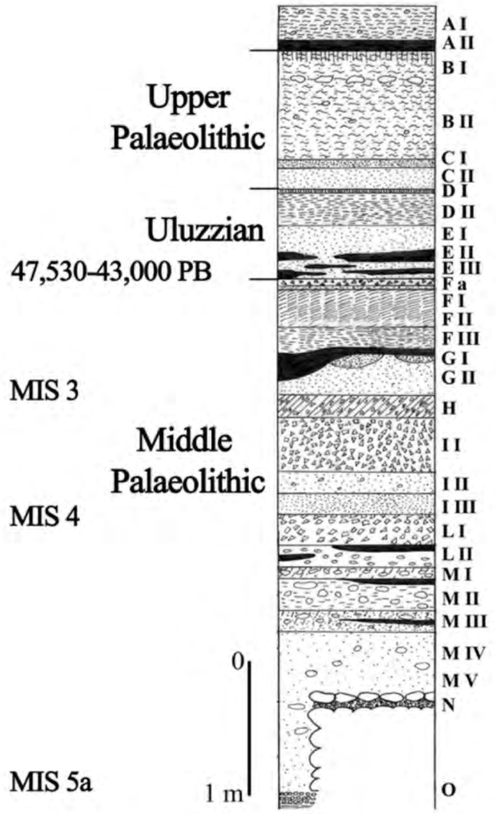

Fig. 5 – Archaeological sequence of Grotta del Cavallo (Palma di Cesnola 2001, modified).
Fig. 5 – Séquence archéologique de la Grotta del Cavallo (Palma di Cesnola 2001, modifié).

A great variability according to the layers was also observed for local stone resources. Neanderthals exploited different local raw materials during that time, although the procurement strategy remained unchanged. Local raw materials were collected from primary deposits by exploiting small sub-prismatic blocks occurring in joint sets. The variability of the raw-material economy and the exploitation techniques of local resources are related to differences in technical knapping methods and in the fragmentation of the operational sequences (chaînes opératoires). The layers M, L, and F are presented below.

Layer M: 3458 pieces (fig. 6a-b)

Exogenous raw materials were used in this layer only for a small number of remains (6.6%). Among local raw materials the most frequently used material was coarse-grained white limestone sensu stricto (45.4%) with irregular conchoidal fracture. Flat prismatic blocks of this material were exploited for unipolar adjacent reduction sequences with the aim of producing elongated flakes (fig. 6a, 3 to 4). The production sequences started from a lateral natural edge and continued on the largest surface of the block. Sequences were short for the greater part, characterised by the production of elongated flakes with an asymmetric triangular section and, in general, partially corticated.

Thick sub-prismatic blocks of coarse-grained limestone or grey laminated limestone were exploited for 'classical' discoidal sequences (*sensu* Boëda, 1993). The debitage was bifacial, with no hierarchical surfaces. Throughout the debitage both centripetal and chordal flakes (core-edge flakes (éclats débordants) and pseudo-Levallois points) were produced (fig. 6b).

Medium- to fine-grained laminated and silicified limestones were collected as flat prismatic blocks for a third method of debitage. Blocks with varying texture and internal structure were selected. All displayed natural flat surfaces on the margins, covered by a reddish patina. They were quite regular in shape, short and narrow, and were exploited on the largest surface. The production sequences were organised to establish a hierarchy between the two surfaces of the core and they were generally unipolar or

	Layer M		Layer L		Layer FIIIe-FIIId		Layer FIIIa-FI	
	N	%	N	%	N	%	N	%
Limestone *sensu stricto*	839	*45,4*	259	*27,5*	80	*1,5*	96	*9,2*
Laminated Limestone (Silicified)	359	*19,4*	297	*32,6*	5,226	*95,7*	592	*56,6*
Silicified Limestone	15	*0,8*	34	*3,6*	-	-	-	-
Quartzite	15	*0,8*	5	*0,5*	27	*0,5*	51	*4,9*
Chert	84	*4,6*	65	*6,9*	21	*0,4*	127	*12,1*
Radiolarite	9	*0,5*	25	*2,7*	65	*1,2*	90	*8,6*
Callista chione	-	-	126	*13,4*	-	-	-	-
Indeterminable	528	*28,5*	121	*12,8*	41	*0,7*	90	*8,6*
TOTAL	1,849	*100%*	941	*100%*	5,460	*100%*	1,046	*100%*

Table 2 – Grotta del Cavallo, Middle Palaeolithic. Distribution of the lithotypes in the layers that are presented in this paper.
Table. 2 – Grotta del Cavallo, Paléolithique moyen. Répartition des lithotypes dans les niveaux présentés dans le texte.

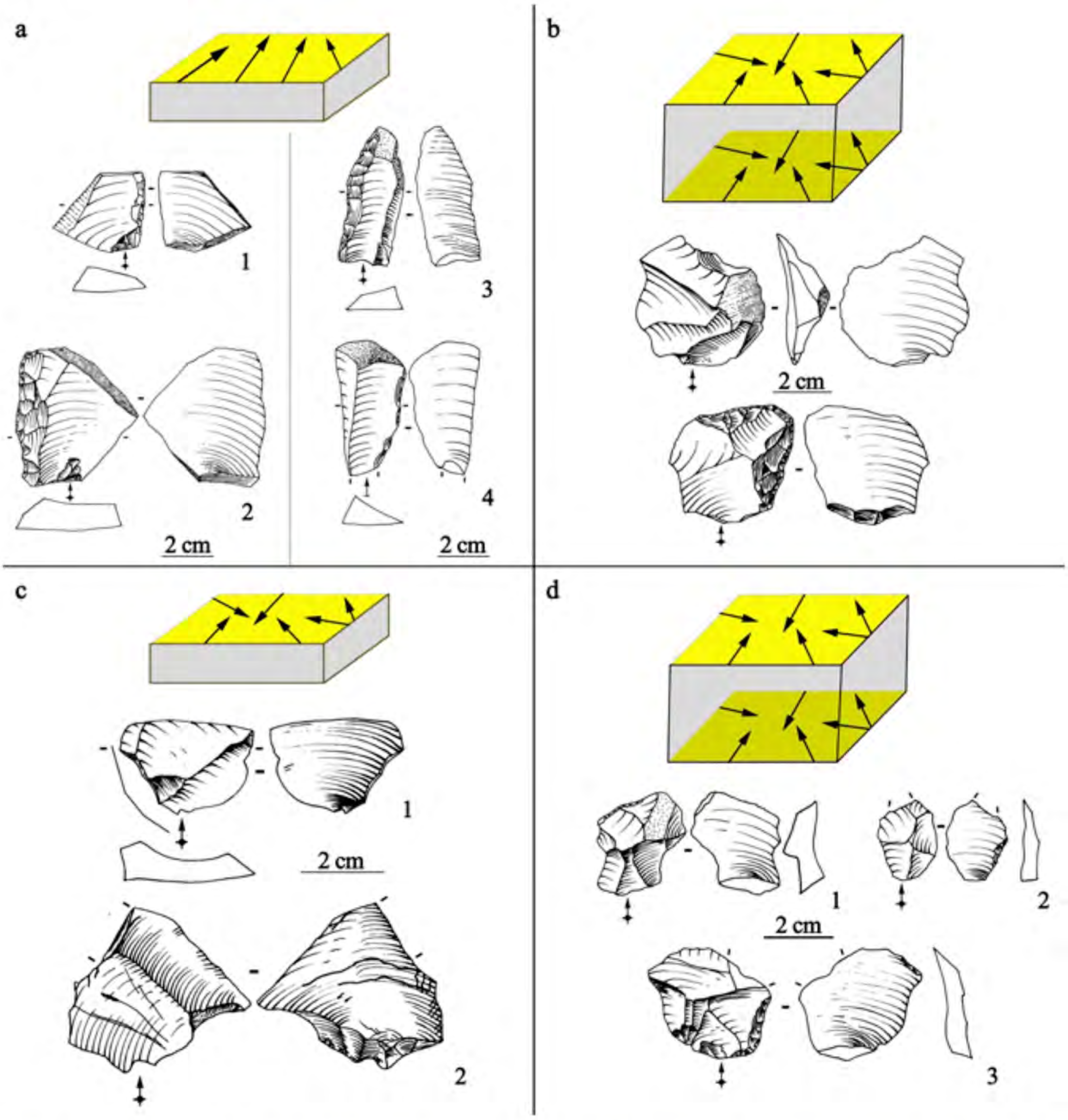

Fig. 6 – Grotta del Cavallo, Middle Palaeolithic. Production methods and selection of raw-material volumes in layer M (a–b) and layer L (c–d). a: unifacial unipolar debitage, reduction sequences aiming at the production of natural backed flakes (1–2) or elongated flakes (3–4); b: bifacial centripetal debitage, classical discoid; c: unifacial centripetal debitage, hierarchical discoid, 1-2: Pseudo-Levallois points; d: bifacial centripetal debitage, classical discoid, 1-3 centripetal flakes (drawings F. Romagnoli).
Fig. 6 – Grotta del Cavallo, Paléolithique moyen. Méthodes de production et sélection des volumes de matières premières dans les niveaux M (a-b) et L (c-d). a : débitage unipolaire unifacial, chaînes opératoires dédiées à la production d'éclats avec dos naturel (1-2) ou d'éclats allongés (3-4) ; b : débitage centripète bifacial, discoïde classique ; c : débitage unipolaire unifacial, discoïde hiérarchisé, 1-2 : pointes pseudo-Levallois ; d : débitage centripète bifacial, discoïde classique, 1-3 : éclats centripètes (dessins F. Romagnoli).

slightly convergent, with the debitage axis parallel to the shortest dimension of the core (fig. 6a, 1–2). This mode of production made it possible to obtain short core-edge flakes (éclats débordants), with an asymmetric transversal section and lateral cortical back, produced on the lateral portion of the exploited surface of the core.

Layer L: 1,911 pieces (fig. 6c-d)

The proportion of exogenous raw material in this layer is 13.2%, higher than in layer M (table 3). The lithic assemblage is characterised by shorter dimensions than that of layer M and in many cases the products were 'microlithic'. Reduction sequences had a fragmented spatio-temporal character and recycling behaviour was often attested to, regardless of the distance to the procurement sources (Romagnoli, 2015).

In this layer Neanderthals used all the lithotypes attested in the local formation of Melissano limestone. In addition to stones, valves of Callista chione, a large marine mollusc, were also exploited to produce retouched scrapers during this occupational phase at the site (Romagnoli et al., 2014 and submitted).

The main production methods were two types of recurrent centripetal debitage on the surface: without hierarchy (bifacial recurrent centripetal debitage: 'classical' discoid; fig. 6d) and with hierarchy (unifacial recurrent centripetal discoid; fig. 6c; Locht and Swinnen, 1994; Terradas, 2003; Wallace and Shea, 2006; Slimak, 2008; Vaquero et al., 2008; Baena et al., 2012). Each type of debitage was used to exploit distinct lithotypes characterised by specific volumes. Unifacial centripetal debitage was made on flat, sub-prismatic blocks of grey laminated limestone and produced abundant pseudo-Levallois points. Thick blocks of several lithotypes, with a variable degree of silicification, texture, and structural homogeneity, were exploited by bifacial centripetal production sequences leading to the extraction of both centripetal and chordal flakes (éclats débordants and pseudo-Levallois points).

Layer F

This layer was divided into three archaeological levels (FIII, FII, FI). FIII was further divided into five sub-levels, named by a letter and identified on the basis of ash concentrations. The levels and sub-levels were grouped together in three units based on the technological and typological features of the lithic remains: from bottom to top these are FIIIe–FIIId, FIIIc–FIIIb, FIIIa–FII–FI. The FIIIc–FIIIb unit yielded a small number of pieces which were difficult to analyse because of a high degradation of the raw material caused by desilication.

Artefacts made from exogenous materials are in a strict minority at the base of the layer (1.7% in FIIIe-FIIId), whereas they reach the highest value of the Mousterian series remains, although still in a minority, on top of the layer (18.2% in FIIIa–FII–FI; table 3).

FIIIe–FIIId: 12,343 pieces (fig. 7a-c)

The main flaking systems were the Levallois method as well as blade and bladelet volumetric reduction. The exploited raw material was almost exclusively silicified limestone, with a high degree of homogeneity (table 2). It was collected as flat sub-prismatic blocks. The Levallois methods used were mainly centripetal (fig. 7b) and, secondly, unipolar and bipolar debitage. The unipolar and bipolar Levallois debitage aimed to produce quadrangular flakes that rarely reached the size of a blade module (fig. 7a).

Volumetric reduction produced blades with a triangular cross-section with parallel edges, and backed blades with an asymmetrical triangular or quadrangular section (fig. 7c). The blade reduction system followed the unidirectional method. The blocks of raw material were not subjected to sophisticated preparation, although the sporadic configuration of a crest is attested. The technique used was invariably direct percussion with a hard hammer. Bladelets were produced during the advanced reduction phases of blade cores.

Independent, unipolar, bladelet volumetric reduction was based on the exploitation of small flakes that served as cores (fig. 7c, 1). As is the case for blade production, the natural edge of the core was usually exploited. Some remains revealed more accurate initialisation through the preparation of a crest, and the maintenance of the distal convexity of the core by small removals opposite the striking platform.

FIIIa-FII-FI: 2,388 pieces (fig. 7d)

Levallois and blade-bladelet production disappeared. The main production method was 'classical' discoid, with

	Local Raw Materials	Exogenous Raw Materials	Indeterminable
Layer M	65.6%	5.9%	28.5%
Layer L	77.1%	10.1%	12.8%
Layer F (FIIIe–FIIId)	97.2%	2.1%	0.8%
Layer F (FIIIa, FII, FI)	65.8%	25.6%	8.6%

Table 3 – Grotta del Cavallo, Middle Palaeolithic. Distribution of local and exogenous raw materials in the layers that are presented in this paper.

Tabl. 3 – Grotta del Cavallo, Paléolithique moyen. Répartition des matières premières locales et allochtones dans les niveaux présentés dans le texte.

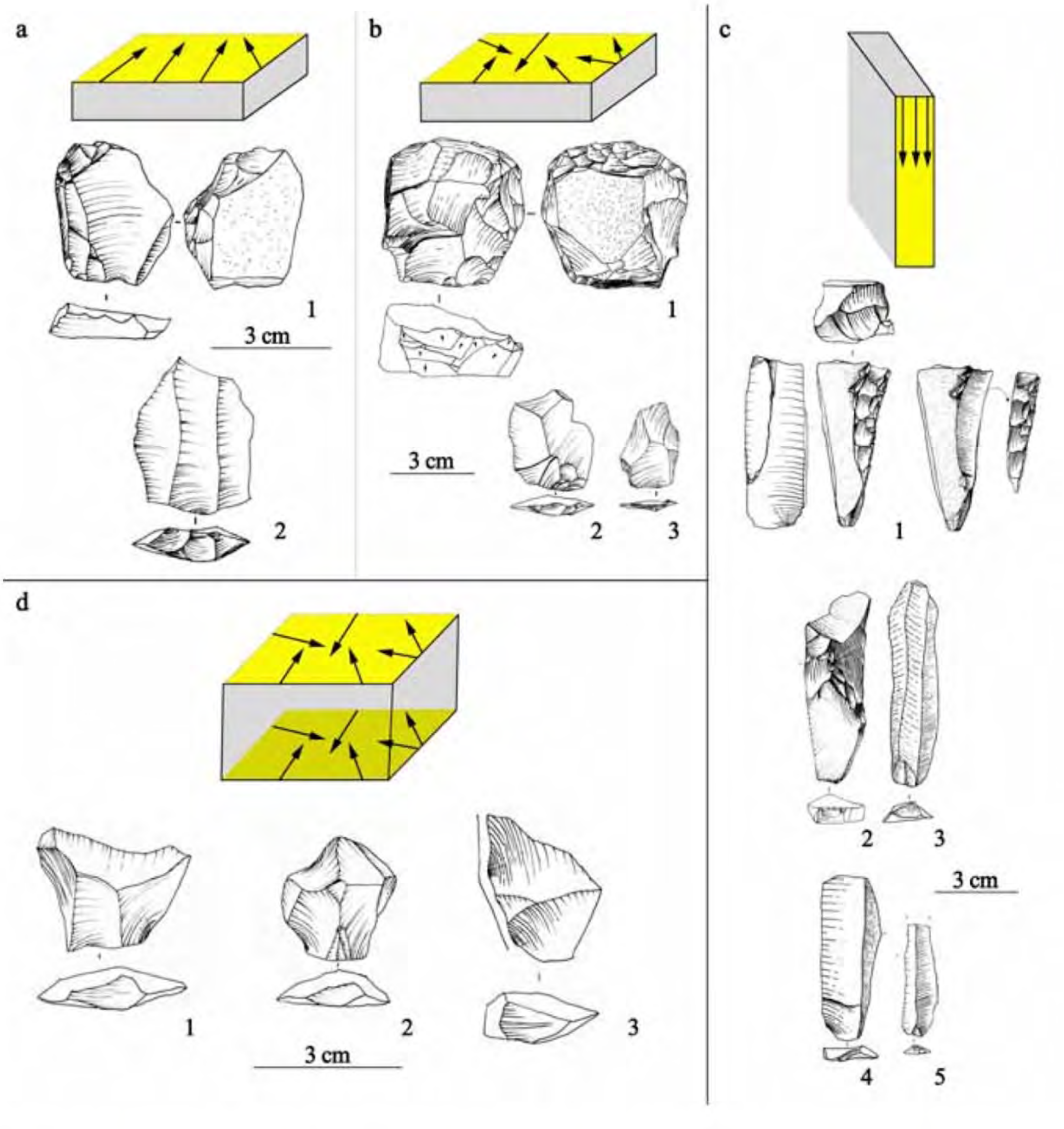

Fig. 7 – Grotta del Cavallo, Middle Palaeolithic. Production methods and selection of raw material volumes in level F, layers FIIIe–FIIId (a–c) and layers FIIIa–FI (d). a: unipolar Levallois debitage, 1: core, 2: unipolar flake; b: centripetal Levallois debitage, 1: core, 2–3: centripetal flakes; c: blade-bladelet volumetric debitage, 1: refitted bladelet core, 2: crest blade, 3–5: blades; d: bifacial centripetal debitage, classic discoid, 1–2: centripetal flakes, 3: pseudo-Levallois point (drawings L. Carmignani and C. Tessaro).

Fig. 7 – Grotta del Cavallo, Paléolithique moyen. Méthodes de production et sélection des volumes de matières premières dans le niveau F, couches FIIIe-FIIId (a-c) et couches FIIIa-FI (d). a : débitage Levallois unipolaire, 1 : nucléus, 2 : éclat unipolaire ; b : débitage Levallois centripète, 1 : nucléus, 2-3 : éclats centripètes ; c : débitage volumétrique laminaire et lamellaire, 1 : remontage de nucléus à lamelles, 2 : lame à crête, 3-5 : lames ; d : débitage centripète bifacial, discoïde classique, 1-2 : éclats centripètes, 3 : pointe pseudo-Levallois (dessins L. Carmignani et C. Tessaro).

bifacial centripetal removals that produced centripetal flakes, éclats débordants and pseudo-Levallois points (*sensu* Boëda, 1993; fig. 7d). It exploited thick sub-prismatic blocks of various lithotypes of local silicified limestones. The production of splintered pieces is also noted.

The change in production systems was associated with a significant increase in exogenous raw materials (table 3). The mainly exploited raw materials are local, silicified limestones, while the use of limestone slabs decreases considerably (table 2).

Reconstructing Neanderthal behaviour at Grotta del Cavallo

In the Middle Palaeolithic sequence of Grotta del Cavallo there is a clear predominance of local raw materials (tables 2 and 3). These were abundant and readily available in the surroundings of the site (> 5 km). They were always collected as small, sub-prismatic blocks occurring by joint sets. The exploitation of local raw material is a common behaviour throughout the European Middle Palaeolithic and is often related to differences regarding the quality of the available lithic resources.

Despite a stable availability of raw materials, the Mousterian sequence evidences a great variability of production methods over time, which were related to the selection of flat or thick volumes and indicate specific adaptations to the quality of the raw materials within different techno-complexes. In the same way, the selection of different local resources in the different layers attests to a great variability of these adaptations and reflects a wide knowledge of the territory by Neanderthals, as clearly expressed by the use of *Callista chione* valves (Romagnoli et al., 2014 and submitted). These tools were manufactured by selecting a complete valve on the beach, collected after the death of the mollusc, based on the typometric characters of the shells. The valves were indeed collected according to a standard size of 8 cm width, most likely in relation to the minimum thickness needed for the retouch. Experimentation has suggested that a thickness of the edge of less than 1.6 mm increases the risk of incidental ruptures during retouch. The valves were retouched on the external edge, invariably on the internal surface of the shell, using the same technical actions as for Quina and semi-Quina retouch, which is attested on 60% of all the retouched flint tools in this layer. These data, together with the operational sequence *(chaîne opératoire)* of Callista chione tools and the recycling behaviour within this chaîne opératoire suggest that this production was completely integrated into the technical traditions and was most likely related to mobility, economic strategy, and the Neanderthal capacity for innovation (Romagnoli et al., 2014 and submitted; Romagnoli, 2015).

Although the exogenous raw materials occurred invariably in a minority, their ratio changed along the sequence, with fluctuations apparently related to abrupt technical changes between layers rather than to a gradual evolution of a single technical and economic behaviour. Within this variability the import of retouched tools, ready to be used and made from high-quality material, appears as a constant feature of the site during the Middle Palaeolithic and suggests the existence of procurement strategies (Kuhn, 1992 and 1995) as well as of types of curated behaviour (Binford, 1979; Shott, 1996). The fragmented character of the operational sequences *(chaînes opératoires)* using local resources is well documented in layer L. The fragmentation of the production sequences across the territory has clearly been demonstrated in the Middle Palaeolithic context of Western Europe (e.g. Roebroeks et al., 1992; Bourguignon et al., 2006 and 2008; Brenet et al., 2008; Faivre, 2011; Turq et al., 2013), suggesting that tool mobility was a technical behaviour based not only on the quality of the raw material, but also on a more complex strategy across the territory. The organisation of the lithic technology is the result of a dynamic interaction between functional needs, the duration of the occupation of the site, the activities carried out at the site, the constraints arising from these activities, and the social organisation. In layer L the analysis of raw-material units (Roebroeks, 1988; Larson and Kornfeld, 1997), the morpho-technical analysis, and the reconstruction of the direction and chronology of each removal (diacritical approach, Inizan et al., 1995; Baena et al., 2010) suggest that the lithic assemblage is the result of multiple independent episodes carried out at the site by a group that was highly mobile across a large territory and that was probably present at the site for short-duration occupations. Furthermore the strategy of producing tools in advance, independently of the distance of the raw-material sources, and the recycling behaviour for reasons of expediency (Romagnoli, 2015) suggest, according to Torrence (1983), great time pressure during the organisation of the activities at the site.

The results of this study up to now suggest that exogenous, good-quality raw material was collected from the same area during the whole Middle Palaeolithic frequentation of the site, implying mobility over long distances, about 80 km NW-SE. The hypothesis of restricted mobility of Neanderthals is increasingly challenged as various examples have already shown regular, long-distance mobility, sometimes exceeding 100 km (e.g. Geneste, 1988; Roebroeks et al., 1988; Féblot-Augustins, 1993, 1999 and 2009; Chalard et al., 2007; Slimak and Giraud, 2007; Negrino and Starnini, 2010), leading to the assumption of the existence of extensive regional networks (Kaufman, 2002). In the Salento region high mobility would have been facilitated by the landscape, with a wide plain that extends up to the Taranto Gulf and to the Ionian coast of Basilicata.

The variations in exogenous raw-material procurement could be related to many factors such as different mobility patterns, different durations of frequentation of the site, different site use, and different cultural traditions of the human groups. These factors are not mutually exclusive and may well be the reason for the great variability of European Middle Palaeolithic industries as discussed since the 1960s. The highest fragmentation of the *chaîne opératoire* in layer L, for example, suggests that the human group that frequented the site during this phase had a high level of planning most likely related to social organisation, seasonal mobility and fragmentation of their activity within the landscape. This 'cultural dynamism' could have facilitated technical innovations, such as shell tools.

CONCLUSION AND PERSPECTIVES

It should be highlighted that the understanding of past human behaviour is a long process that requires interdisciplinary and multidisciplinary approaches. Strict interconnection between geology and archaeology is imperative for proposing hypotheses on human mobility and technological organisation. The differences identified by our studies for lithic remains along the Middle Palaeolithic sequence of Grotta del Cavallo suggest that cultural constraints (shared knowledge, technical innovations, and social and economical organisation) are more relevant than geophysical ones in determining the behaviour of humans in ancient times, as in present ones. Furthermore, the analysis of the organisation of technology on a large spatial scale (fragmentation of *chaîne opératoire*, recycling behaviour, mobility range of human groups) makes it possible to link these changes in mobility and land-use strategies with changes in stone tool manufacture and use. In this way we can perceive cognitive abilities and behavioural changes in past societies (Bamforth, 1986; Kelly, 1988; Andrefsky, 2009; Delagnes and Rendu, 2011; Romagnoli, 2015). From a technological perspective the combination of attributes that govern the lithic production determines the production and transportability of tools. According to P. Bleed (Bleed, 1986) the main attributes are 1) the complexity of the reduction sequence, 2) the tool's useful life, 3) the tool efficiency, and 4) the productivity of the knapping method that was used. This complexity also includes the time spent on raw-material procurement and on the volumetric construction of the core that was required to produce the desired tools. The Levallois technology is more time-consuming than unipolar or orthogonal methods and the volumetric constraints impose a more rigid selection of raw materials, with regard to both quality and volume. The production aimed at manufacturing tools with a high resharpening potential (e.g. Quina tools). These were a good choice to be transported because their long life cycle guaranteed the constant availability of functional tools. This tool efficiency implies a high technical investment in the preparation of the functional cutting edge, and it can be related to the high production input (the use of a complex production method increases the degree of control of the final product) or to the integration of retouch within the production sequence relating the volume of the flakes to retouch techniques that were used to manufacture the edge. The number of products obtained from a given raw-material volume makes it possible to reduce the effort invested in production and to obtain a greater number of functional products in less time. This may be favourable with regard to specific constraints of tasks and of mobility strategies.

This behavioural analysis has shown that the Middle Palaeolithic variability at Grotta del Cavallo is a multi-causal phenomenon, as highlighted in other regional studies in Europe (Delagnes and Rendu, 2011; Raynal et al., 2013; Turq et al., 2013; Lazuén and Delagnes, 2014; Moncel et al., 2014; Vaquero et al., 2015, among others). This behavioural approach does not consider the procurement strategy to be a simple local/exogenous dichotomy; rather the procurement distance was incorporated into a large-range scenario, in which the duration of occupation of the site, the social organisation, the economic strategies, and the expedient behaviour play a significant role in shaping human behaviour. Future research will focus on the detailing of the technological organisation in the entire sequence and on the linking of strategies of stone-artefact manufacture and raw-material exploitation to subsistence strategies and environmental changes. The top of the Middle Palaeolithic sequence attests to the association between Levallois and blade reduction technologies. Levallois and blade reduction technologies have been reported from several sites in South-Western France characterised by many different faunal associations (Delagnes and Rendu, 2011). Non-migratory species are the most abundant in these assemblages. In this respect it will be worth investigating if the same association occurred at Grotta del Cavallo and examining in more detail the fragmentation of the production sequences. This will make it possible to understand if the constraints imposed by the volumetric construction of the knapping methods played a role in mobility patterns and site location, instead of the animal resources that were probably available year-round in the same location, as is the case at the French sites.

With regard to the Tyrrhenian area the analysis of the lithic assemblage is still in progress and currently only limited data are available. The focus of the research in this area will be the definition of the technological behaviour along the Gravettian and Epigravettian sequence of Grotta del Romito, human mobility within the late Upper Palaeolithic climatic fluctuation, and the progressive creation of micro-regional original trends probably influenced by better adaptation to local resources, as is visible in subsistence strategies (Martini et al., 2007 and 2009; Palma di Cesnola, 2007; Craig et al., 2010).

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Authors' contributions: L. S. directed the archaeological excavation at Grotta del Cavallo. F. M. directed the archaeological excavation at Grotta del Romito; F. M. and L. S. identified the stratigraphic sequences and assumed responsibility for the financial support of the research at the sites. F. T., L. N., F. R., and L. C. carried out geological surveys and sampling; F. T. and L. N. performed the macroscopic and microscopic analysis of geo-archaeological samples; F.R. performed the macroscopic analysis of Apulian geological samples and studied the lithic assemblages of Grotta del Cavallo (layers M-L); L. C. analysed the morpho-techno attributes of the lithic assemblage from layer F of the same site; G. R. collaborated with D. L. V. in the technological analysis of lithic assemblages of Grotta del Romito, which were coordinated by D. L. V. and F. M.; F. R., F. T., D L. V. drafted the paper. The results were discussed by all of the authors.

Chapter 7

Discussion and conclusion

7.1 – The blade is coming? Which roots for the laminar technology?

The shift from the Lower Palaeolithic to the Early Middle Palaeolithic is “classically” defined by an increase in the number of core technologies, including standardized ones, which are stabilized in the full Middle Palaeolithic (MIS 5-3), associated with the decline of the “Acheulean” biface. Between these technological changes the Levallois concept is one of the most important marker to delimite this border.

The rise of blade production that dates back to the end of the MIS 8 to the MIS 7 can be also fully ascribed in this wider technological change which involves the European continent during second part of the Middle Pleistocene. The Levallois and Blade reduction strategies are not contemporaneous in their respective insurgence (Fig 1 and 2).

Even though the oldest records of the emergence of the Levallois are recognized, sporadically, in a few sites from the MIS 12 to MIS 10 such as in France at Cagny la Garenne and Cagny Cemetery dated to MIS 12-11 (Lamotte and Tuffreau, 2001; Lamotte, 1995; Tuffreau, 1995, 1987; Tuffreau et al., 2008) or in the Iberian Peninsula at Grand Dolina TD10 and Ambrona dated to MIS 10-9 (Terradillos-Bernal and Rodríguez-Álvarez 2014; Terradillos-Bernal and Díez Fernandez, 2012; Olle et al. 2013; García-Medrano P. et al. 2015; Santonja et al. 2016) it is just at the end of the MIS 9 that Levallois production becomes largely documented (Adler et al. 2014; Alvarez-Alonso 2014; Delagnes and Meignen 2006; Dibble and Bar-Yosef 1995; Fontana et al. 2010; Fontana et al. 2013; Gamble and Roebroks 1999; Moncel et al. 2011; Moncel et al. 2012; Picin et al. 2013; Roebroeks and Tuffreau 1999; Soriano 2000; White and Ashton, 2003; Wiśniewski 2014; Moncel et al., 2016).

During all this period the Levallois doesn’t seem to spread clearly in the Italian peninsula with the exception of the site of Guado San Nicola dated to the end of MIS 11-beginning of MIS 10 that nevertless does not seem to have left any trace behind him (Peretto et al. 2016).

Concerning the blade reduction system, excepted the isolated case of Cave dell’Olio dating back to the MIS 9 (Fontana et al 2009), the blade production will appear at end of the MIS 8 becoming more evident during the MIS 7 and is concentrated in northern Europe such as in the site of Saint-Valéry-sur-Somme (Heinzelin & Haesaerts 1983), Bapaume-les Osiers (Koehler 2008) and Therdonne (Loch et al. 2010) in France, and Rissori (Adam & Tuffreau 1973; 36 Adam 1991) in Belgium. The blade productions recongnized in the lower level of Bau de l’Aubesier are an isolated but nortworty exception.

Levallois production continues to be largely present from the MIS 8 to the MIS 6. (Fig 1) Except the case of Bau de l’Aubesier, blade production during this span of time continues to stay concentrated to the northern Europe while Levallois spreads in a larger area such as in Italy at San Bernardino (Picin et al 2013) Riparo del Molare (Ronchitelli et al 2010) Riparo del Poggio (Boscato eta la 2009); and also in eastern Europe such us at Korolevo (Haesaerts and Koulakovskaya 2006).

Just during the MIS 5 the blade production will penetrate more widely in the south of France and we have to wait the MIS 4 and 3 to see the first evidence of blade production in the Italian peninsula.

Based on the evidence here described two main observation can be made. The first one is that Levallois and Blade productions seems to repeat a similar trajectory north –south and west –

east but in different periods (Fig 1 and 2). The second is that the blade production does not follow the first Levallois spread from the MIS 8 to 6 and furthemore does not penetrate in the Iberian Peninsula.

Figura 1 -Levallois distribution in Europe from the MIS 9 to 6 (from Picin et al 2013)

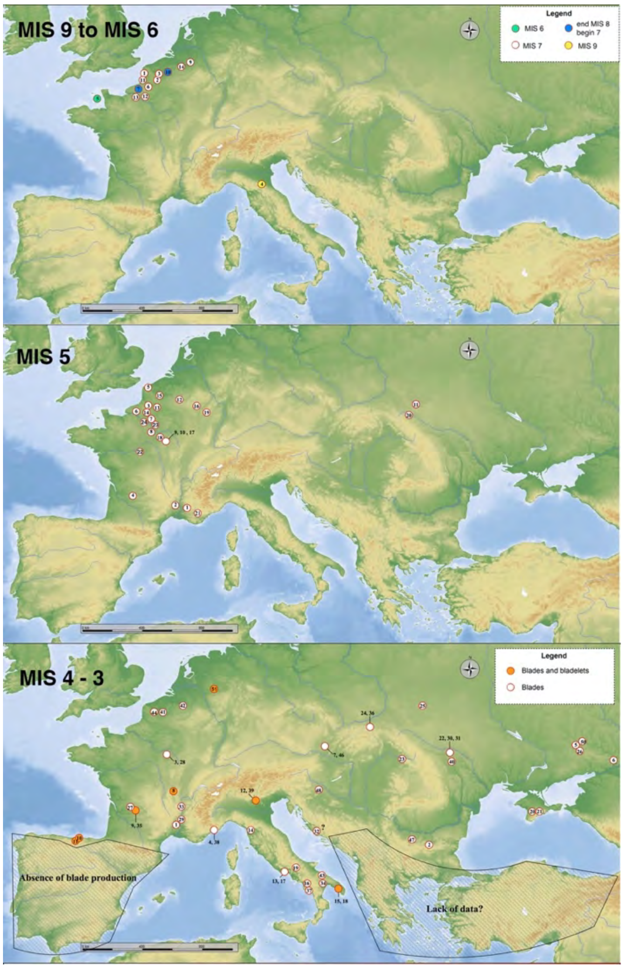

Figura 2 –Blades distribution in Europe from the MIS 9 to 3

The reason of this different and at the same time similar behaviour of the Blade and Levallois production is complicated to explain. Many factors can have contributed. Technology can spread in parallel with the displacement of the human group under the pressure of the envirromment and the climatic change but also by an indirect transmission of the techno cultural baggage without a direct contact of the human groups.

Another consideration is that when the laminar production arises in northern Europe the human group still has widely developed flaking technology in which the blades will come to join. A simple and at the same time complex question come out. How has this innovative technology been integrated in the previously all-flake substratum?

Considering the blade phenomenon as an introduction of a new concept of tool, which in that case consists of alongeted blanks, on a previous all-flake production we can distinguishing four possible schematic scenarios in relation to different integration modalities. (Fig 3).

Case number 1 – The blade production is integrated as an addition. In this case the previous flakes strategies remain unchanged and blades are produced by a reduction systems specifically dedicated.

Case number 2 - The introduction of the new blade reduction systems partially replaces the flakes strategies by new reduction strategy.

Case number 3 - The global concept of production doesn't change. In this case blades are produces by a reconversion of an operational systems which existed before such as the case of the Levallois blade production.

Case number 4 - There is a total substitution of the previous production. The blade becames the main desired product.

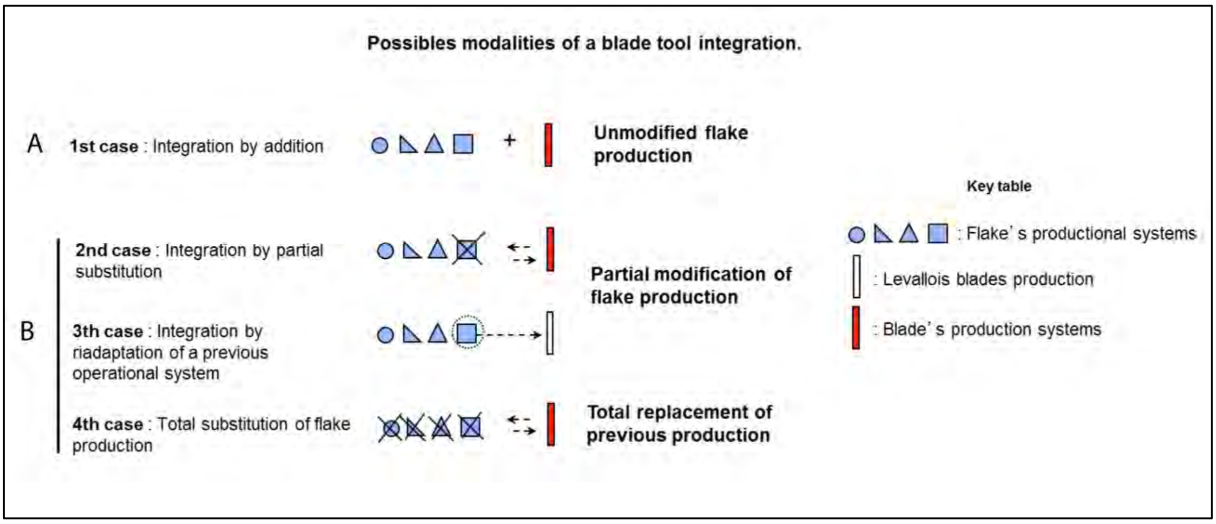

Figure 3 – Possible integration of the blade on the flake substratum.

The latter case (number 4) can be identified with the Upper Paleolithic industries in which blade and bladelets assume a predominant role although flakes production does not disappear completely. This case of figure does not exist in the European Middle Paleolithic where blade is always present in a small percentage compared to the flakes strategies.

Taking into consideration the state of the research, the first phases of blade production (MIS 8 to 6) are based on an independent reduction strategy based on a volumetric exploitation such as in the site of Saint-Valéry-sur-Somme (Heinzelin & Haesaerts 1983), Bapaume-les Osiers (Koehler 2008) and Therdonne (Loch et al. 2010) in France, Rissori (Adam & Tuffreau 1973; 36 Adam 1991) in Belgium.

The association with flake productions is variable in type although the most frequent is the Levallois concept that continues to produce flakes. In this first phase, Levallois blade production such as the case of Biache Saint Vaast is rare (Boeda 1988b).

Later on, during the MIS 5 to 3 blade reduction strategies assume a larger variability and the Levallois blade systems are largely employed such as for example at the site of Riparo del

Poggio (Caramia, Gambassini 2006), Grotta di Castelcivita (Boscato et al. 2011; Villa et. al. 2009) in Italy or at Baume Bonne in France (Gagnepain et al. 2003, 2004).

The "reconversion" of the Levallois concept to produce blades (case number 3) rarely assumes an exclusive role in the blade production that coexist with the volumetric exploitation systems. This scenario that seems to show a sort of duplication of the reduction systems aimed to produce the same product is actually wrong.

At the site of Bau de l'Aubesier and Riparo Tagliente the two systems are aimed to produce distinct end products with distinct morphological features. These differences recognized in the techno-type suggest also the possibility of distinct functions. The lack of specific use-wear analysis on the assemblages studied preventing us to go further these preliminary speculations.

The blade production of Bau de l'Aubesier, which is sub-contemporaneous of the northern blade production, shares similar features with the northern blade reduction strategies but at the same time it contains original elements such as the pyramidal cores and the production of convergent blades. These mixed characters of innovation and continuity suggest a local re-adaptation of the general concept of blade to a local substratum with its internal evolution and specificity.

7.2 - Middle Paleolithic bladelets and the rise of the transition.

The bladelets reduction systems recognize at Payre, Bau de l'Aubesier and Grotta del Cavallo cover a large span of time, from the end of the MIS 8 until the beginning of the MIS 3. These three evidences, far in time and space are plunged in distinct technological substratum and cannot be compressed in a univocal phenomenon.

If the ephemeral trace of bladelet cores found at Payre could be addressed to an opportunistic behaviour, that is not the case of the bladelet reduction systems recognized at Bau de l'Aubesier and dating back at the MIS 5. Nevertheless, these premature evidence of bladelets as also in the cases of Angé (Koehler et al 2014) and Bapaume les Osiers (Koehler 2008) don't seem to leave any trace in the following periods.

A different case is the bladelet production recognized at Grotta del Cavallo that is part of a wider phenomenon that affects the end of the Middle Paleolithic in different parts of Europe, such as at the sites of El Castillo and Cueva Morin in Spain (Maíllo-Fernández et al. 2004), at Champ Grand (Slimak & Lucas 2005) and Combe Grenal in France (Faivre 2012), at Fumane in Italy (Peresani 2011, Carmignani 2010), and at Balver Höhle in Germany (Pastoors & Tafelmaier 2010).

These last mousterian bladelets productions that are plunged in a classical mousterian substratum coincide also with the rise and the development of the so called transitional industries as the Châtelperronian and Uluzzian.

These transitional industries that partial overlapping the mousterian technocomplex contain evidence of blade and bladelets production in a more or less systematic way (Peresani et al; 2016; Roussel et al 2016).

At Grotta del Cavallo and Grotta di Fumane the end of the mousterian seems to anticipate a similar bladelets production that will be present in the Uluzzian layers (Carmignani in this volume; Peresani et al 2016).

Later on blade and bladelets will became one of the major marker of the first Upper Paleolithic industries. A recent work that highlighted a connection between the Châtelperronian and Pro-Aurignacian bladelets at the site of Quinçai (France) encouraging future research to point in that direction. (Roussel 2016).

In view of the above and basis on the results that coming out during my PhD motivated me to questioning about the role of the bladelets production on the shift form the end of the middle Paleolithic and the rise of the Upper Paleolithic industries.

The question of transitional culture between the Middle and Upper Paleolithic is rooted in anthropological and archaeological interests to explore how past cultures shifted on an evolutionary scale. The Uluzzian is an example of such transitional cultures from the Mediterranean Europe and the recent analysis of the human fossil established the association with anatomically modern humans at Grotta del Cavallo (Ronchitelli at al 2015).

7.3 Work in progress. The Mario Bernardini project.

These last considerations and questions motivate me in 2014 to plan as principal investigator the excavation project at the site of Grotta Mario Bernardini (Italy) in co-direction with Filomena Ranaldo from the University of Siena and in concession to the Comune di Nardò (Le), Italy.
Grotta Mario Bernardini is a coastal cave located in the south of Italy by the Ionian Sea located approximately 45 meters b.s.l. (Fig. 4).

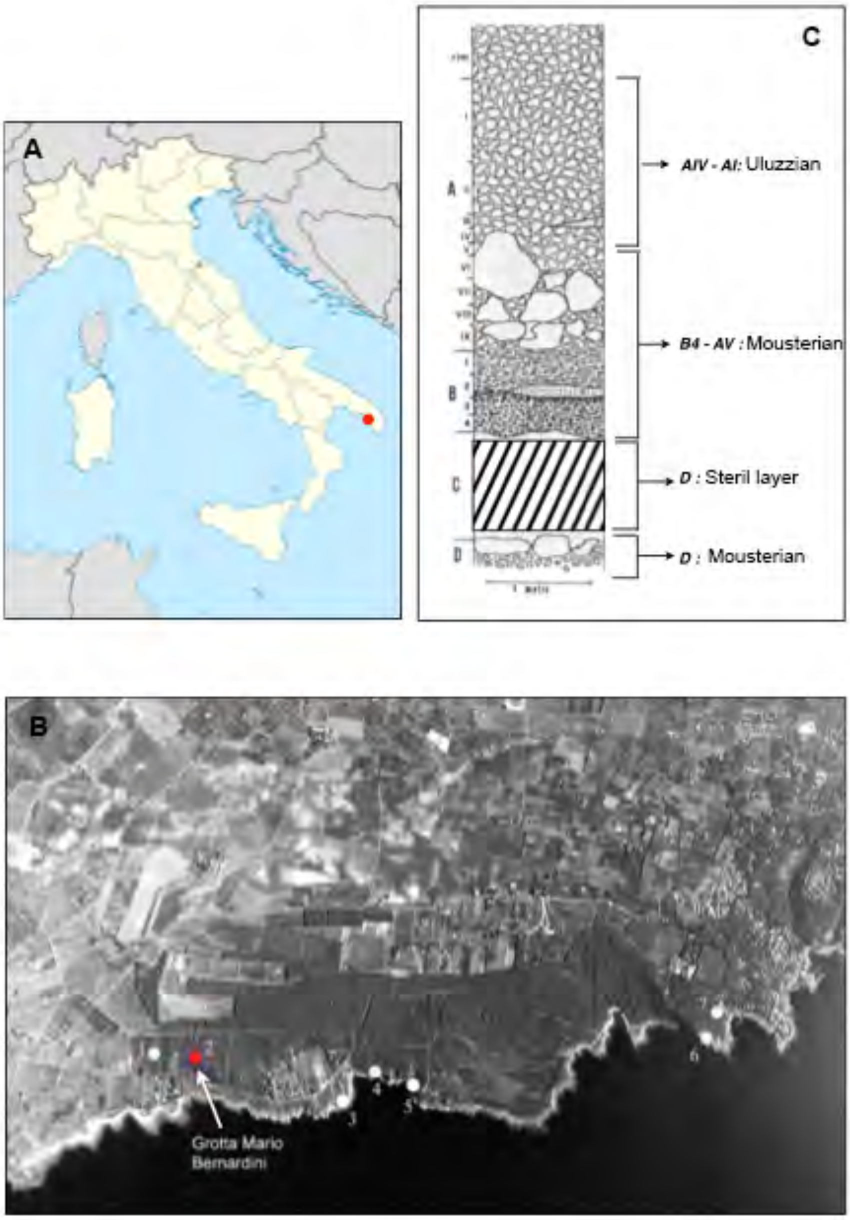

Figure 4 - Grotta Mario Bernardini: A and B – Location of the site; C Simplified stratigraphy of Grotta Mario Bernardini (Modified after Borzatti 1970)

The cave was discovered by Borzatti Von Löwerstern who carried out the first test pit which was followed, two years later, by the first excavation campaign (Borzatti 1970). In the years that followed other excavation campaigns were carried out highlighting a long sequences that yelded a succession of mousterian and Uluzzian industries present at the site (Borzatti Von Löwerstern E. 1971).

The main aim of the excavation project is to provide new data that address questions regarding the differences and similarities of Mousterian and Uluzzian cultures as well as the cultural shift through a multidisciplinary approach including technological analysis of lithics, zooarchaeological study, geoarchaeological study and dating using multiple chronometric techniques.

The research objective is to contribute new data to debates surrounding the behavioral adaptations of our closest relatives, Neanderthals, and modern humans, and address questions on transitional cultures, which chronologically followed the Middle Paleolithic occupations in Europe and Western Asia (Riel-Salvatore 2009; Ronchitelli et al. 2009; Roussel et al. 2016; Ruebens et al. 2015). New excavation at Grotta Mario Bernardini in the region of Apulia, southern Italy will enable us to better understand the Final Mousterian and Uluzzian cultures and to document the nature of the cultural transition. Using multidisciplinary approaches, we reconstruct the cultural and economic activities of hominins with better chronological control and stratigraphic contexts to test if the interaction of Neanderthal-modern human is a tenable scenario. Through the excavation and subsequent analysis of the archaeological material and documentation, we address the following questions.

Question 1: What are the stratigraphic contexts of the Final Mousterian and Uluzzian at GMB "Grotta Mario Bernardini"? Are other early Upper Paleolithic cultures such as the Aurignacian present? If so, what is the stratigraphic relationship between the technocomplexes? Further, what is the chronological framework of the Final Mousterian and Uluzzian?

The Final Mousterian and Uluzzian cultures have been identified at the site, but the geoarchaeological investigation has been limited to descriptive documentation of the sedimentological deposits (Borzatti von Löwenstern 1970, 1971). Detailed stratigraphic study that includes geochemical analyses will clarify the spatial contexts of the Final Mousterian and Uluzzian as well as explore the possible presence of early Upper Paleolithic cultures, such as the Aurignacian, which are rarely identified in southern Italy. Further, the chronometric dating with detailed stratigraphic analyses will be essential in determining the chronological framework of the cultures. We expect that the dates of the Mousterian-Uluzzian transition will range between 45 – 40,000 years ago (calibrated) (Douka et al. 2014). The series of date from GMB will be compared to the chronology from nearby sites with Middle to Upper Paleolithic sequence.

Question 2: Based on the lithic and organic industry, can we observe continuity or discontinuity between the Final Mousterian and Uluzzian cultures? Do the attributes of Uluzzian artifact assemblage from the site follow the characteristics that have been previously described? Can we trace the same technological interbreeding between the Uluzzian and the final Mousterian? What kind of similarity and inter-site variability do we observe? Do cultural patterns tie into the hunting activities and economic exploitation of animal resources?

The distinguishing characteristics of the Final Mousterian and Uluzzian lithic industries have been defined using the material from the previous excavation of Borzatti. This project will continue with the lithic analyses to increase the sample size of the Uluzzian and Late Mousterian artifact assemblages and study the spatial distribution of the artifacts. Lastly, zooarcheological study will be conducted on the faunal remains, which will initially focus on the species abundance and anthropogenic/non-anthropogenic modification to track patterns of processing activities.

Based on the results of Grotta Mario Bernardini excavation and analyses, we consider the following models to explain the Uluzzian culture and its relationship with the Final Mousterian Neanderthals.

Scenario 1: The Uluzzian was produced by Neanderthals. Here, the local Middle Paleolithic population has independently developed lithic technology with elements of the Upper Paleolithic cultures, drawing parallel technological development such as the Châtelperronian in southwestern France.

Scenario 2: The Uluzzian were produced by the modern humans. Modern humans that migrated into the region gave rise to the Uluzzian culture in the Mediterranean Europe. This scenario is currently supported by the bioarchaeological analyses of human fossils from the Uluzzian level of Grotta del Cavallo.

Scenario 3: This scenario considers that the Uluzzian resulted from both Neanderthal and modern human groups. The scenario of coexistence and interaction between the populations requires further consideration through the study of stratigraphic context in conjunction with the technological study of artifact assemblages.
Generating data addressing the above research questions will help us falsify or verify some of the scenarios which can be help explain the Uluzzian phenomenon and its relationship with the Late Mousterian in southern Italy

Transitional industries between the Middle to the early Upper Paleolithic that existed across various regions in Europe and the Near East pose one of the most interesting challenges for archaeologists, specifically in determining the identity of the makers (Davies et al. 2015; Hublin 2015; Moroni et al. 2013; Riel-Salvatore 2009; Riel-Salvatore and Barton 2004). Many archaeological phenomena are tied to the technological traditions, which serve to define and identify local and regional hunter-gatherer cultures. Further, lithic assemblages provide a broad but effective chronological control, which can be tested using chronometric dating techniques. The 'transitional' cultural phenomenon is puzzling, because elements of several cultures, one often associated with Neanderthals and the other to modern humans, are often present. Further, chronological studies can do little to provide concrete answers due to the limits in the precision and accuracy for most chronometric dating techniques, especially when the dates fall beyond the range of radiocarbon dating ~45 ka uncalibrated (Higham et al. 2014).

In the case of the Uluzzian technocomplex, which is found in Italy and Greece, the 'mix package' of continuity and innovation has been well studied and confirmed by lithic and artifact based analyses (De Stefani et al. 2012; Kaczanowska et al. 2010; Palma di Cesnola 1993, 1996, Peresani 2012; Peresani et al. 2013; Ranaldo in press; Ranaldo et al. in press). The most current dates suggest that its temporal range run between 45-39 ka cal BP (Douka et al. 2014). The paleoanthropological evidence places the Uluzzian in the hands of modern humans, based on the reinterpretation of isolated teeth from Grotta del Cavallo located in Porto Selvaggio in Apulia region of southern Italy, which makes it one of the oldest modern human fossils in Europe that is associated with cultural assemblages (Benazzi et al. 2011; 2014). However, some argue that the stratigraphic association between the cultural layer and hominin teeth is not solid, resulting in counterarguments to the proposed interpretation (Zilhao et al. 2015). Due to the limits of old documentation and excavation method, this counterargument remains speculative and has been refuted in some cases (Ronchitelli et al. 2016).

Recent research done at Grotta del Cavallo defined the technological patterns of the final Mousterian related to the level FI-FII and FIII and Uluzzian related to the levels E, EII-I and D (Carmignani 2010; Carmignani and Sarti in press; Palma Di Cesnola 1964; Sarti et al. 1998).
Final Mousterian layers have yielded abundant lithic material dominated by two main reduction systems: the first originating from a Levallois concept by centripetal, unidirectional and bidirectional methods, and the second stemming from a blade volumetric reduction system. The presence of separate reduction systems aimed at obtaining bladelets highlights the technological variability of the Final Mousterian.
Uluzzian layers has yielded large quantities of splintered/flaked tools from siliceous limestone blocks and pebbles, which have been obtained with the biopolar technique on anvil for flakes, small blades and bladelets and scrapers are made systematically on the plane level (Ranaldo et al. in press). Further the volumetric production of blades and bladelets are linked to the introduction of fine grained flint as the primary raw material (Ranaldo et al. in press).

The lithic technology from these two cultural phases shows gradual progression as well as abrupt changes, which does not lend itself to a simple interpretation, but the analyses of Uluzzian industry from excavations of the 1960's support a model suggesting that the Uluzzian industry represents technological break from the Final Mousterian. Further, the Uluzzian culture is characterized by the diversification of the raw material used for artifact productions, including bones and antlers, in addition to the production of seashell ornaments. The organic component of the cultural assemblage is rare in the Mousterian assemblage and sees greater parallel with other early Upper Paleolithic and transitional technocomplexes in Europe.
Grotta Mario Bernardini has been excavated by Borzatti von Löwerstern in the 1960’s but it has also experienced looting and undocumented excavation led by amateurs, showing recent disturbance of the site. The excavation will focus on the entrance area of the cave roughly covering ~ 20 m2, which likely has one of the highest density of undisturbed Paleolithic deposits (Fig 5).

Figure 5 – External shelter of Grotta Mario Bernardini. Geophysical prospections.

The new excavation will apply recovery techniques as well as a new focus on the excavation of large surface area, which will enable spatial analyses of archaeological objects. This will be one of the first Uluzzian sites where the spatial distribution of artifacts can be taken into account for understanding site formation processes and spatial organization of the inhabitants. Grotta Mario Bernardini's data will consider behavioral patterns produced through identification of occupational layers and the arrangements of artifacts and features for possible signatures of spatial organization, structure and activities.
Further, the stratigraphy exposed by Borzatti von Löwerstern will be investigated for detailed documentation and additional geoarchaeological and stratigraphic studies. The vertical profile of Borzatti from 60's has been rediscovered and will provide material for considering chronological evolution of the site added by chronometric dating. Borzatti von Löwerstern has documented in his previous study the presence of Uluzzian and Mousterian layers represented by one large deposit respectively but likely contain several discrete strata. Radiocarbon dating on charcoal, bone collagen and shell provides the most reliable techniques due to its accuracy. Further, TL dating, provided that burnt lithic tools are recovered, as well as ESR dating to test the validity of dates by comparing different chronometric dating. Lastly, the CI eruption, an ash layer found in many Italian archaeological sites with Middle and Upper Paleolithic occupations, is likely present at the site. The sampling and geochemical analysis of the ash in the layers will conducted which will also provide direct chronometric dates. The volcanic eruption, is dated from multiple sites to ~41 ka.

As one of the geoarchaeological investigations, micromorphological study sheds light on the nature of occupational layers and the depositional and post-depositional processes. By sampling of intact sediments and observing them through thin sections, the analyses allows for natural as well as anthropogenic signatures in the sediment that include presence of combustion features or identify discrete or continuous transition between separate geological/occupational layers. Here, the transition from the late Mousterian and Uluzzian will be identified not from artifacts but also from a micromorphological perspective, enabling us to consider whether the occupation of Uluzzian and Mousterian possible came in contact or if there is any evidence of erosion between the two cultural layers. This approach will combined with sedimentological and stratigraphic analyses to provide a comprehensive understanding of the depositional context and features.

Lithic analyses will be one of the key study that will inform the basis for characterizing the artifact assemblages and documenting any changes and continuity in the technological dimension of lithic production. The study will take on a technological approach and the knapping system analysis follows the same principles as those of the chaine opératoire analysis, which is supported by the quantitative presentation of technological categories (Inizan et al. 1995). The techniques will be identified according to experimental studies carried out by Pelegrin (2000). Additional analyses as macro and microwear study will be conducted to determine the function of the tools. It will be coupled by the study of organic artifacts, which is likely given the nature of the Uluzzian artifact assemblages.

Faunal analyses will mostly involve species composition and skeletal representation. Further, the taphonomic study will consider any physical, biological, carnivore as well as anthropogenic modification of faunal remains. This will enable us to study patterns of lithic production with economic activities, including hunting and exploitation of resources, and understand the economic behavior of Middle Paleolithic and Uluzzian inhabitants with a combined approach. It will consider previous studies in the region to see if similar patterns can be identified (Boscato and Crezzini 2006).

Subsequently, systematic comparison will be made between the data from the current site to GC, where recent research and reanalysis has led to major reinterpretation and appropriation of the understanding of makers of the transitional cultures in the region. The recent excavation of GC was limited in the surface area of excavation, placing greater importance on the diachronic patterns through vertical excavation. While the focus and the nature of the excavation slightly differs, these sites provide one of the comprehensive data which will also allow us to consider intersite variability. This project represents one of the case studies on the transitional studies on a local scale and then address the state of Uluzzian culture on a regional state by comparing the data will previous and subsequent research on this particular technocomplex

The research will contributes to the general discussion and topic on the cultural adaptation and behavioral repertoire of modern humans and the close relatives in Eurasia, Neanderthals. Of utmost interest is the causes and processes leading to their extinction, which has been linked to climatic fluctuations and ecological reasons, mostly framed in terms of competition between archaic and modern humans. Further, the research ultimately is driven and informed by 1) theoretical discussion on human uniqueness both in regards to their cognition and behavior, in other words our interest in understanding biological and cultural traits of Homo sapiens sapiens that led to our continued evolution to the present and 2) larger question on the relationship between the biological and cultural adaption of hominins. We have a better understanding of genetic and biological characteristics that differentiate Neanderthals and modern humans while the cultural and behavioral differences between the two hominin populations still probably can merit from additional research and new dataset. Through the study of Neanderthals, we shed light to notions of whether biological differences also manifest in cultural differences.

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Bau de l'Aubesier Report 2013 – 2015

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RÉPUBLIQUE FRANÇAISE

PREFET DE LA REGION PROVENCE-ALPES-COTE D'AZUR

Direction régionale des affaires culturelles

Service régional de l'archéologie

Aix-en-Provence, le 22 [illegible] 2015

№ 2457

Objet : CIRA Sud-Est / Session des 10, 11 et 12 mars 2015
Extrait du procès-verbal

Etude – 84 – MONIEUX – Bau de l'Aubesier
Demande d'autorisation de réaliser une étude documentaire 2015
Responsable : Léonardo CARMIGNANI (ETUD)
Rapporteur : Pierre-Jean TEXIER

Avis de la CIRA ***: Avis favorable à une étude du matériel qui permettra de compléter les connaissances sur les collections lithiques réunies dans le cadre des campagnes de fouilles réalisées sous la responsabilité de M. Serge Lebel.***

Pour le préfet et par délégation
Le Directeur Régional
P.O. Le Conservateur Régional de l'Archéologie

Xavier DELESTRE

Acte n° 2015-176
Dossier 11395

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RÉPUBLIQUE FRANÇAISE

№ 2 4 5 8

PREFET DE LA REGION PROVENCE-ALPES-COTE D'AZUR

VU le Code du Patrimoine et notamment son Livre V ;

VU le Code du Travail, et notamment sa quatrième partie (Santé et sécurité au travail) ;

VU le décret n° 94-422 du 27 mai 1994 modifiant la loi du 27 septembre 1941, portant réglementation des fouilles archéologiques et relatif à diverses dispositions concernant l'archéologie ;

VU le décret n° 2007-823 du 11 mai 2007 relatif au Conseil national et aux commissions interrégionales de la recherche archéologique ;

Après avis de la Commission Interrégionale de la Recherche Archéologique sud-est, en date du 10 mars 2015 ;

ARRETE

Article 1er :

Monsieur Léonardo CARMIGNANI est autorisé(e) à procéder, en qualité de responsable scientifique, à une étude documentaire à partir de la date du présent arrêté jusqu'au 31 décembre 2015

Concernant la région PROVENCE-ALPES-COTE-D'AZUR

Intitulé de l'opération : Bau de l'Aubesier

Département : 84

Commune : MONIEUX

Cadastre :

Lieu-dit :

Numéro(s) de site(s) :

Coordonnées Lambert : x = y =

Programme : 03 - Les peuplements néandertaliens l.s. (stades isotopiques 8 à 4 : 300 000 ans à 40 000 ans ; Paléolothique moyen l.s.)

Organisme de rattachement : ETUD

1

Article 2 : prescriptions générales

Les recherches sont effectuées sous la surveillance du conservateur régional de l'archéologie territorialement compétent, qui pourra imposer toutes prescriptions qu'il jugera utiles pour assurer le bon déroulement scientifique de l'opération.

A la fin de l'année le responsable scientifique de l'opération adressera au conservateur régional de l'archéologie, en quatre exemplaires papier plus un exemplaire numérique (cd-rom ou DVD), un rapport accompagné des plans et coupes précis des structures découvertes, et des photographies nécessaires à la compréhension du texte. Il donnera un inventaire de l'ensemble du mobilier recueilli et signalera les objets d'importance notable. Il indiquera les études complémentaires envisagées et le délai prévu pour la publication.

L'ensemble des documents relatifs à l'opération (notes, photographies, relevés, correspondances, etc.) sera remis au conservateur régional de l'archéologie.

Le responsable scientifique de l'opération tiendra régulièrement informé le conservateur régional de l'archéologie de ses travaux et découvertes. Il lui signalera immédiatement toute découverte importante de caractère mobilier ou immobilier et les mesures nécessaires à la conservation provisoire de ces vestiges devront être prises en accord avec lui.

Article 3 : destination du matériel archéologique découvert.

Le statut juridique et le lieu de dépôt du matériel archéologique découvert au cours de l'opération seront réglés conformément aux dispositions légales et réglementaires et aux termes des conventions passées avec les propriétaires des terrains concernés.

Article 4 : prescriptions particulières à l'opération.

Article 5 : le Directeur régional des affaires culturelles est chargé de l'exécution du présent arrêté.

Fait à Aix-en-Provence, le 2[illegible] [illegible] 2015

Pour le préfet et par délégation
Le Directeur Régional
P.O Le Conservateur Régional de l'Archéologie

Xavier DELESTRE

COPIES A :
[ ] Intéressé(e)
[ ] Organisme de rattachement
[ ] Propriétaire(s) du (des) terrain(s)
[ ] Préfet de région
[ ] Préfet(s) du (des) départements(s) concerné(s)
[ ] Direction régionale des affaires culturelles
[ ] Mairie(s)
[ ] Gendarmerie
[ ] Sous-direction de l'archéologie
[ ] Département des recherches archéologiques sous-marines et subaquatiques (si opération subaquatique)

RAPPORT D'ÉTUDE DE L'INDUSTRIE LITHIQUE DE BAU DE L'AUBESIER.

1 Encadrement du site et histoire des recherches.

Le site de Bau de l'Aubesier est un grand abri sous roche positionné dans le département de Vaucluse. La présence de nombreux vestiges archéologiques préhistoriques mais aussi romains démontre une importante continuité d'occupations humaine dans cette région.

En prennent en considérations seulement les occupations liées au Paléolithique Moyen ont été signalé plus de 30 sites (Buisson-Catil, 1994).

Cette concentration de sites dans un territoire relativement circonscrit est probablement justifiée aussi par le caractère karstique de cette région, que a permis la conservation des dépôts archéologique. De plus, la présence d'un environnement riche en sources d'eau et matières premières lithiques, a certainement rendu cette région favorable aux installations humaine pendant le paléolithique.

Cette région est en fait connue pour sa richesse en silex Crétacé et Oligocène de très bonne qualité que ont été exploité du paléolithique moyen jusqu'à au Néolithique.

Le site de Bau de l'Aubesier est positionné, ouvert vers Nord, à environ 100 mètre au-dessus de la rivière de la Nesque (Fig. 1A). L'abri préserve une sédimentation très important d'environ 13 m de profondeur sur une surface des plusieurs dizaines de mètres carre (Fig. 1B, 1C).

Fouillé pour la première fois au début du 20^{e} siècle (Moulin 1903, 1904) a été ensuite étudié brièvement par de Lumley dans les années 60' (de Lumley 1971).

Seulement dans le 1987 la fouille a été reprise avec un projet interdisciplinaire par l'équipe de Serge Lebel de l'Université du Québec du Canada. (Lebel, 2000; Wilson, 2007).

Les fouilles terminées dans le 2000 ont restitué un corpus archéologique composé par une industrie lithique et restes faunistiques très abondantes. Assez remarquable a été la découverte d'une fragmente de mandibule et treize dents tous attribué à Homo de Neandertal. (Trinkaus et al., 2000; Lebel et al., 2001; Lebel et Trinkaus, 2002; Fernandez, 2006).

Les premières fouilles, faites par Moulin, étaient limitées à quelques mètres carrés sur la sommité de l'abri pour une profondeur de 2 mètres environ (Moulin 1904).

Les restes archéologiques restant de cette fouille compte quelque dizaine de pièces et correspondent aux couches C, D, E, F de la séquence.

Les fouilles plus récents, dans un première temps, continueront dans la partie supérieur du dépôt sur une aère plus étendue et pour une profondeur de 2 mètres environ. Cette première intervention correspond à la fouille des couches 1, 2, 3, 4 et 5. Plus tard une deuxième intervention était mise en place dans la partie inferieur du site correspondent au couches G, H, I, J, K.

L'étude de la Faune et les datations absolue faits long de la séquence place les fréquentations humaines entre 200.000 et 100.000 ans environ.

Les couches de base, K et J, ont été attribué entre la fin du MIS 7 tandis que la couche supérieur se place au sein du MIS 5d. Les couches intermédiaires, H – I, sur la base de datation radiométriques serons placées entre la fin du MIS 7 et le MIS 6 lorsque les donnés faunistiques du couche H suggère une attribution au MIS 5e (Fig. 4).

La collection lithique de Bau de l'Aubesier a été étudiée à plus repris par différente chercheur. Notamment tout les aspect lié à l'identification des matières premières et aussi les aspects techno économique lié à leur circulation ont été amplement étudie par L. Wilson ((Wilson 2003, 2007, 2011). En ce que concerne les études techno typologique l'industrie à fait objet d'études beaucoup plus fragmentaire et ponctuelles.

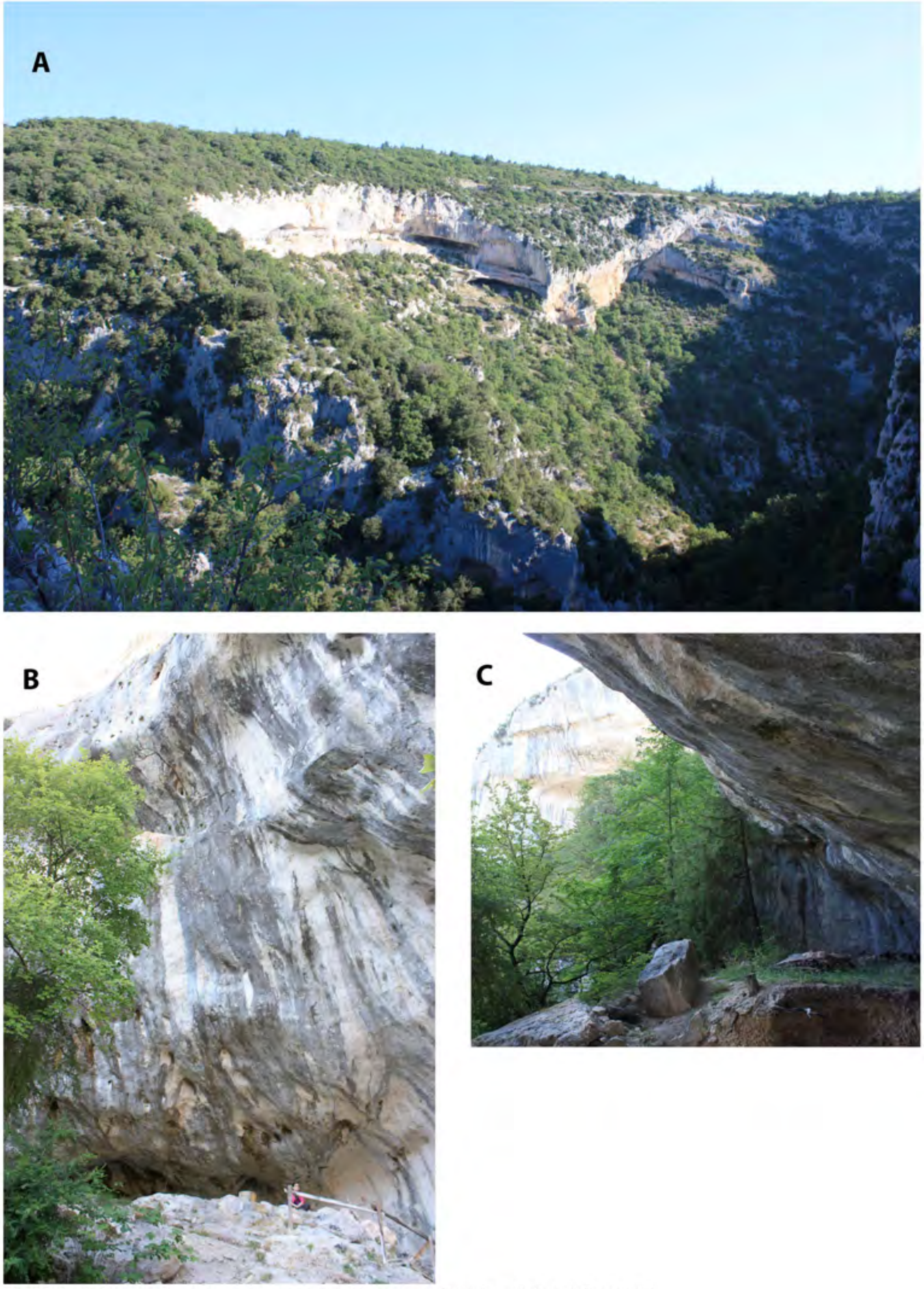

Figure 1 *- A: Vue panoramique de les gorge de la Niesque, B, C: L'abris de Bau de l'Aubesier.*

2 - Approche méthodologique à l'étude de l'industrie lithique.

A la lumière de précédentes études, que ont eu comme objective un caractérisation général de la collection par à travers un trie sélective du matériel, nous avons considère comme prioritaire un approche de type quantitative avec pour finalité un décompte complet de tous les pièces lithiques. Le but de cette approche quantitative a été aussi d'obtenir à posteriori un diagramme de dispersion le long la séquence par catégories technologiques et par carré de fouille.

En outre, les campagnes d'étude faite dans 2013 et 2014, en collaboration avec L. Wilson, avaient mis en évidence, lors de l'analyse d'un échantillon du débris provenant de la couche IV, le possible présence d'une production lamellaire. Cette découverte inattendue nous a motivé donc à étudier aussi toute la composante microlitique.

Nous avons donc procédé à examiner tous le sachet de tamis de tout la séquence en distinguent la fraction <20 mm et >20mm (Fig. 3). Tout le pièces non diagnostiques (fragments indéterminables et éclat ordinaire) ont été décompte et subdivise par couche et carré.

Dans une deuxième phase toutes les pièces diagnostiques (éclats et nucleus) ont été enregistrées dans une base de donnés informatisée.

Soi pour les nucleus que pour les supports nous avons tenue en compte les paramètres morphologique, dimensionnelles et technologiques. En outre les pièces le plus représentatifs ont eté photographié et dessiné.

Le décompte des pièces tant que leur identification dans le classes technologique est toujours en course d'ouvre. Au moment nous avons pu compléter l'étude globale des couches K, J et I.

Figure 2 *– Prix des mesures avec pie à coulisse électronique.*

2.1 - L'approche analytique-quantitative.

La dimension de la collection, estimé sur l'ordre de dizaine de millier de pièces, à requît une approche bien calibré soit en fonction du temps disponible que de la méthodologie.
La première subdivision à été fait par deux macro catégorie en subdivisant tout les pièces déterminable et les pièces pas déterminable (Fig. 2).
Les pièces déterminables sont tous ces pièces reconductible à la chaine opératoire et donc classifiable dans une catégorie technologique spécifique. A ce group appartiennent tous les éclats technique de mise en forme ou remise forme, les éclat corticaux, les objective de la production subdivisé par leur méthode de taille (centripète unipolaire etc.), les nucleus et fragment des nucleus et tout le fragment reconductible à une classe technologique spécifique.
Les pièces indéterminables sont ces pièces que nous ne pouvons pas attribuer à une catégorie technologique précis. Ces pièces ont été néanmoins décomptées en gardent leur colocation de couche et carré. Dans ce macro group nous avons distingué deux catégorie d'objet : les éclats ordinaire ou générique et le fragments indéterminables.
Les fragments indéterminables sont ces fragments ou c'est n'était pas possible d'orienter la portion fracturé et donc de le classé comme fragmente distale, mesial ou proximale.
Les éclats générique ou ordinaire sont des éclats, résultat d'une activité intentionnelle de taille, mais que pour différents motifs ne pouvant pas être reconduit à une catégorie technologique spécifique et par conséquent ne peuvent pas rattachez à une système de production précis.
Ces éclats peuvent être affecté par une patine très profonde, par une concrétion ou une exposition au feu que empêche la lecture de négatives de détachement. En outre peuvent être des éclats avec des négatives de détachement désorganisée. Les éclats que montrent une exposition au feu ont a fait l'objet d'une décompte séparée afin de détecter des éventuel concentration de aires de feu dans le diffèrent phases d'occupation. Soi les éclats générique que les fragment indéterminable ont été subdivise en deux catégorie dimensionnelle >20 mm et < 20 mm (Fig. 3).
Cette opération préliminaire nous a permis de « dépurer » l'industrie lithique de la fraction non diagnostique et de l'isoler de la composante diagnostique.

L'utilité d'enregistrer la présence des fragments indéterminables que les éclats ordinaire de toutes les catégories dimensionnelles nous a permis d'avoir des indications plus précises sur les zones présentent une plus forte concentration d'activité de taille (Fig. 16, 17).
Le travaille de décompte et de séparation des diffèrent classe technologique nous a prix 20 jour de travaille.
A l'état actuel de l'étude nous avons complété l'analyse des couches K, J, I, H et IV. Reste a compléter le décompte des couches couche 5, 3, 2 et 1 que toutefois représente la portion minoritaire de l'industrie. Nous avons décompté 99242 pièces lithiques (Tab 1). En lisant la séquence on a peut observer une différente concentration des artefact. Deux couches en particulière (H1, IV) montrent une quantité considérable des pièces tandis que d'outre couche, comme le couches J3 et J2, montrent des activité de taille plus ponctuelles, reliés probablement, à des fréquentations de plus court durée (Fig. 4).

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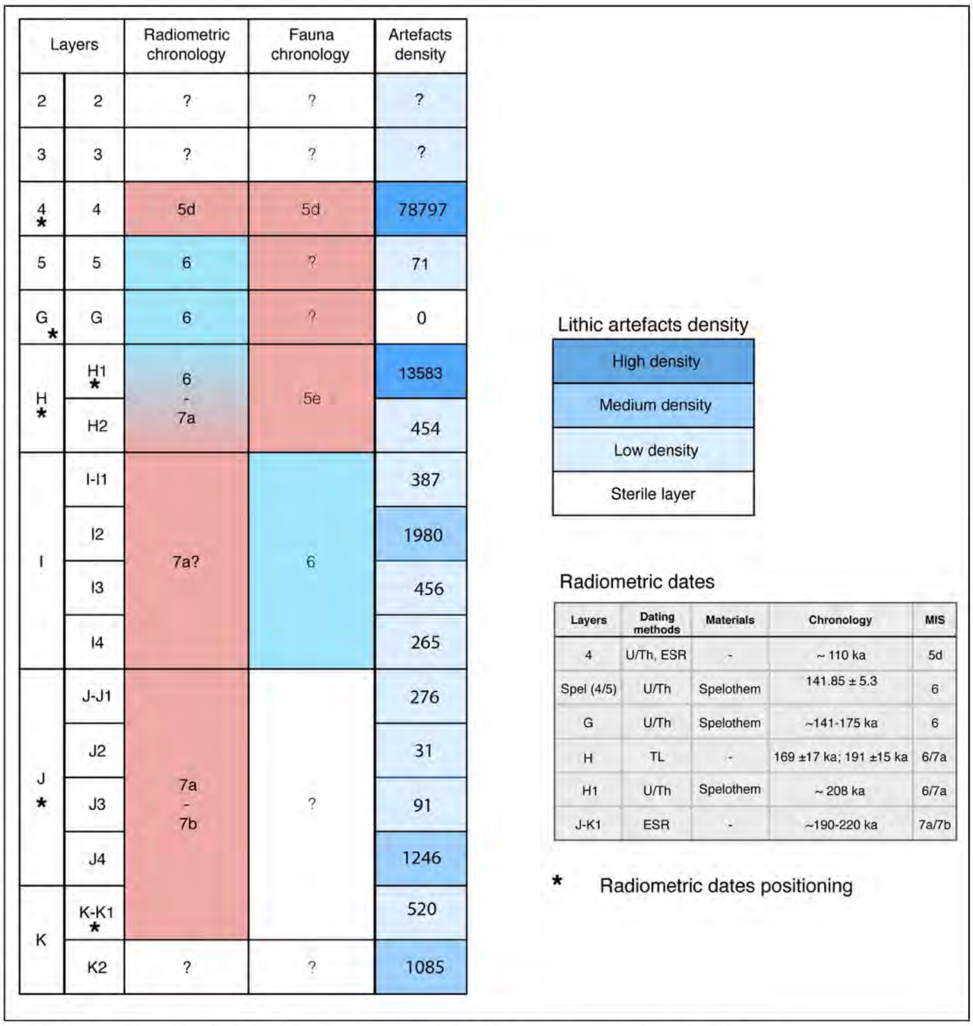
Figure 3 A) Éclats ordinaire > 20 mm ;. B) Fragmente indéterminables > 20 mm ;. C) Éclats ordinaires > 20mm D)Fragmentes indéterminables <20mm.

Couche	Éclats et fragmentes	Nucleus	Total	État de l'analyse
1	?	?	?	En cours
2	?	?	?	En cours
3	?	?	?	En cours
IV	78383	414	78797	En cours
5	71	-	71	En cours
H1	13326	257	13583	En cours
H2	454	-	454	En cours
I-I1	385	2	387	Terminé
I2	1946	34	1980	Terminé
I3	443	13	456	Terminé
I4	255	10	265	Terminé
J-J1	268	8	276	Terminé
J2	26	5	31	Terminé
J3	87	4	91	Terminé
J4	1224	22	1246	Terminé
K-K1	516	4	520	Terminé
K2	1071	13	1085	Terminé
Total	98455	786	**99242**	

Tableau 1 – Décompte complet à l'état actuelle de la recherche.



Layers		Radiometric chronology	Fauna chronology	Artefacts density
2	2	?	?	?
3	3	?	?	?
4 *	4	5d	5d	78797
5	5	6	?	71
G *	G	6	?	0
H *	H1 *	6 - 7a	5e	13583
	H2			454
I	I-I1	7a?	6	387
	I2			1980
	I3			456
	I4			265
J *	J-J1	7a - 7b	?	276
	J2			31
	J3			91
	J4			1246
K	K-K1 *			520
	K2	?	?	1085

Lithic artefacts density

- High density
- Medium density
- Low density
- Sterile layer

Radiometric dates

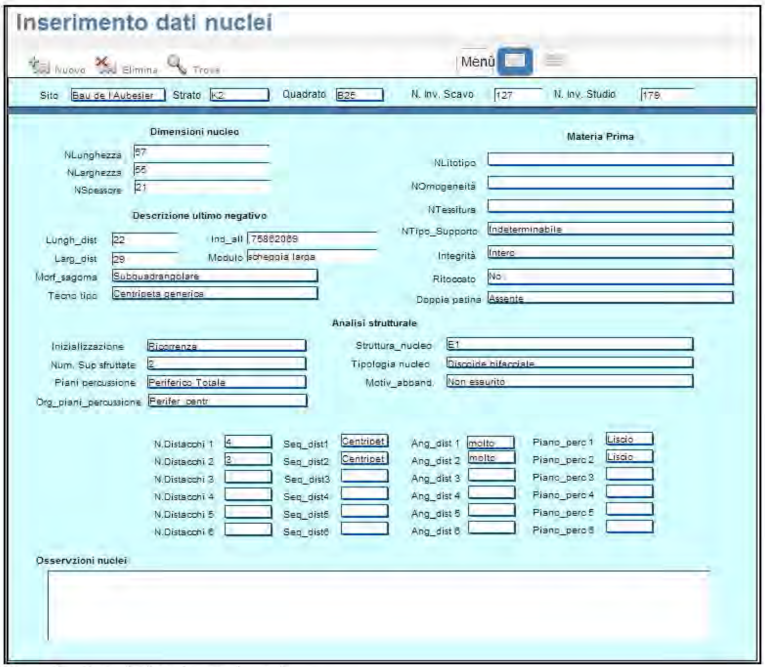
Layers	Dating methods	Materials	Chronology	MIS
4	U/Th, ESR	-	~ 110 ka	5d
Spel (4/5)	U/Th	Spelothem	141.85 ± 5.3	6
G	U/Th	Spelothem	~141-175 ka	6
H	TL	-	169 ±17 ka; 191 ±15 ka	6/7a
H1	U/Th	Spelothem	~ 208 ka	6/7a
J-K1	ESR	-	~190-220 ka	7a/7b

* Radiometric dates positioning

Figure 4 : Schéma chrono stratigraphique avec mis en évidence de la concentration des artéfacts lithiques.

2.2 - L'approche technologique-qualitative.

One fois isolé les éléments déterminable nous avons mise en place la deuxième phase de l'analyse dans le but de comprendre plus précisément les aspect techno-culturelle que régissent la production. Le but de cette étude a été principalement donc la reconstitution des traits techniques et l'identification des concepts technologiques sous-jacents.
En l'absence de remontages, l'identification des séquences de production à été basée sur la méthode déductive (Pelegrin, 1991) prennent en compte les nucleus, les éclats technique et les objective de la production.
Pour la représentation graphique du matériel, nous avons suivi les normes élaborées par M. Dauvois (Dauvois 1976). Pour la reconnaissance des méthodes, the techniques et de concepts de taille nous avons utilisé les procédures d'analyses élaborées par différents auteurs. (Inizan et al. 1995; Tixier 1967; Böeda 1991, 1994, 1997; Pelegrin 1995).
Tous les nucleus ont été enregistre dans une base de donné conçu en tenant compte des paramètres dimensionnelles et technologique. (Fig. 5).
La composent sur éclat à été enregistré dans une file Excel, subdivisé par couche et carré, et catalogué selon leur classe technologique d'appartenance.
Pour la composent laminaire individué long la séquence nous avons enregistré les informations dans une base de donnés spécifique (Fig. 6). Ce traitement de donnés différentié pour la composante laminaire trouve sa motivation dans la nécessité d'une analyse plus fine de la problématique liée au phénomène lamino-lamellaire que est le sujet de mon actuel projet de recherche doctorales.



Inserimento dati nuclei

Sito Bau de l'Aubesier
Strato K2
Quadrato B25
N. Inv. Scavo 127
N. Inv. Studio 179

Dimensioni nucleo

NLunghezza 57
NLarghezza 55
NSpessore 21

Descrizione ultimo negativo

Lungh_dist 22
Larg_dist 29
Ind_all 75862069
Modulo scheggia larga
Morf_sagoma Subquadrangolare
Tecno tipo Centripeta generica

Materia Prima

NLitotipo
NOmogeneità
NTessitura
NTipo_Supporto Indeterminabile
Integrità Intero
Ritoccato No
Doppia patina Assente

Analisi strutturale

Inizializzazione Ricorrenza
Num. Sup sfruttate 2
Piani percussione Periferico Totale
Org_piani_percussione Perifer_centr
Struttura_nucleo E1
Tipologia nucleo Discoide bifacciale
Motiv_abband. Non esaurito

N.Distacchi 1	4	Seq_dist1	Centripet	Ang_dist 1	molto	Piano_perc 1	Liscio
N.Distacchi 2	3	Seq_dist2	Centripet	Ang_dist 2	molto	Piano_perc 2	Liscio
N.Distacchi 3		Seq_dist3		Ang_dist 3		Piano_perc 3	
N.Distacchi 4		Seq_dist4		Ang_dist 4		Piano_perc 4	
N.Distacchi 5		Seq_dist5		Ang_dist 5		Piano_perc 5	
N.Distacchi 6		Seq_dist6		Ang_dist 6		Piano_perc 6	

Osservzioni nuclei

Figure 5 – Base de donnés pour le nucleus

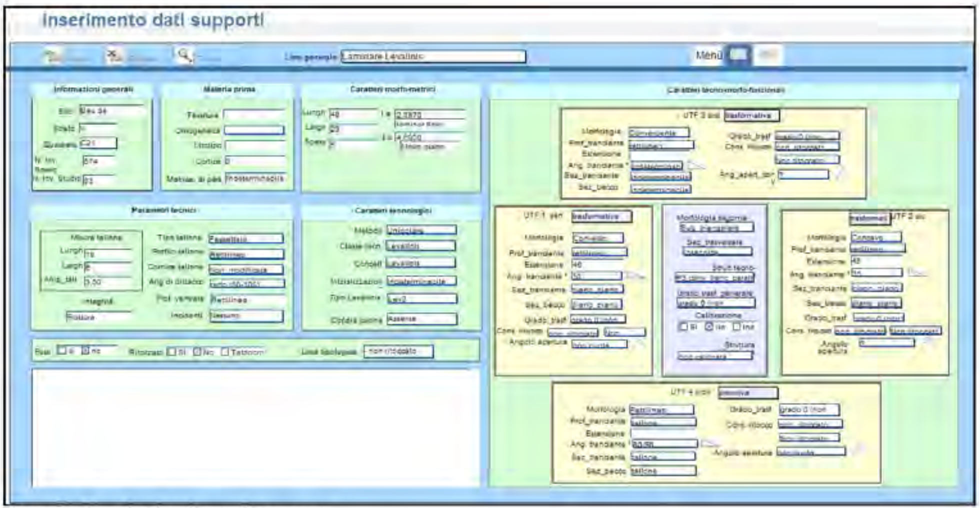


Figure 6 – Base des donnés pour les supports.

3 - Résultats préliminaires de l'étude de Bau de l'Aubesier

3.1 - Analyse technologique des couches à la base de la séquence. Couche K et J

La couche K et J situés à la base de la séquence de Bau de l'Aubesier sont composés par 1605 pièces pour la couche K et 1664 pièces pour la couche J (Tab. 2).

L'état de l'industrie est affecté par une patine blanchâtre due probablement à des phénomènes post-dépositionnelles de désilification que dans quelques cas a été d'obstacle pour la reconnaissance des schémas diacritiques des enlèvements.

En excluant les éléments indéterminables et les éclats ordinaires, les éléments déterminables se réduisent à 210 éclats et 18 nucleus pour la couche K et 304 éclats et 39 nucleus pour la couche J.

Classe Technologique			Total K		Classe Technologique	J4	J3	J2	J-J1	Total J	
	K-K1	K2	n°	%		n°	n°	n°	n°	n°	%
Fr_ind<20	283	670	953	59,4	Fr_ind<20	700	28	3	103	834	50,7
Fr_ind>20	72	65	137	8,5	Fr_ind>20	191	25	4	55	275	16,7
Éclats ordinaires<20	42	180	222	13,8	Éclats ordinaires<20	97	1	5	19	122	7,4
Éclats ordinaires>20	23	42	65	4,0	Éclats ordinaires>20	51	3	6	10	70	4,3
Pièces déterminables	96	114	210	13,1	Pièces déterminables	185	30	8	81	304	18,5
Nucleus	4	14	18	1,1	Nucleus	22	4	5	8	39	2,4
Total	520	1085	1605	100,0	Total	1246	91	31	276	1644	100,0

Tableau 2 – Décompte des classe technologique pour le couche K et J

Les premières phases du débitage sont marquées par la présence de nombreux éclats de décorticage. Cette présence est particulièrement évidente dans la couche J ou les éclats d'entame et les éclats semi corticaux constitue le 30 % environ des éléments déterminable (Tab. 8) .
Les nucléus, bien que peu nombreux, montrent une variabilité importante dans le système de débitage.
La couche K et J de Bau de l'Aubesier à mis en évidence une production orientée sur deux modalités de productions distinctes, une de débitage et une de confection (façonnage).
Le débitage majoritaire est basé principalement sur la production d'éclats unipolaires. La présence de 7 nucleus de méthode unipolaire semitournant peuvent être bien raccordé à ce type de production. En ce que concernent les classes d'allongement, cette production unipolaire montre majoritairement des modules à éclats. Néanmoins une partie non négligeable de la production se composé par des modules laminaires. Ces supports sont massifs avec un talon lisse et épais (Fig. 7).

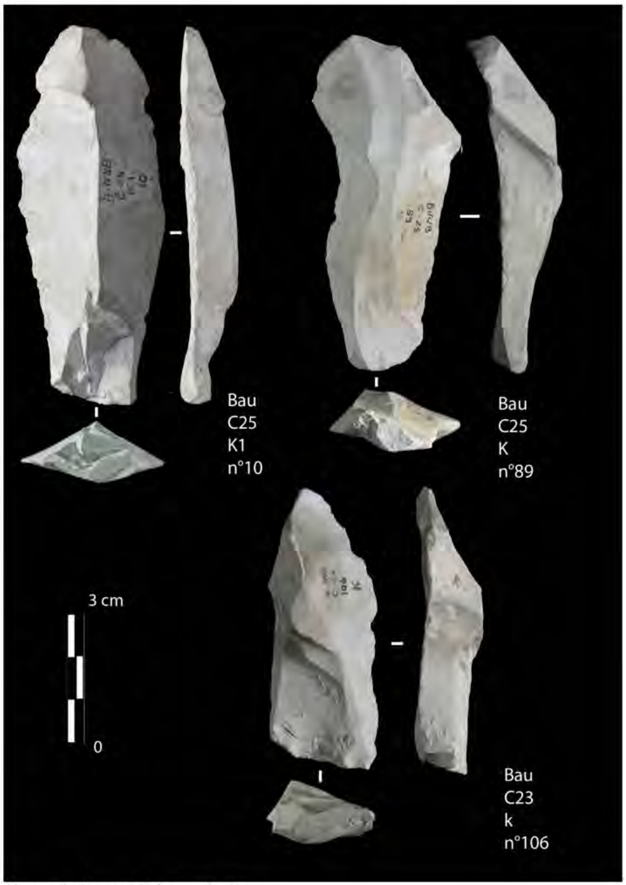


Figure 7 – Lames de la couche K.

Deux nucleus de type semi pyramidal de la couche K peuvent être connecté à ce type de production

Une débitage périphérique par plan sécant est orienté à la production d'éclats centripète et, plus rarement, d'éclats débordantes. On remarque inversement le manque des pointes pseudo-levallois.

Le couche J montre la présence d'une exploitation par plan parallèles majoritairement centripète. Cette type de production, que dans quelque cas peut suivre aussi une méthode unipolaire et bipolaire, donne une production d'éclats mince avec de talon parfois facetté, que peut rappelé des éclats de type Levallois. Néanmoins l'analyse des nucleus exclue la présence de ce type de concept volumétrique.

Le couche J se différencie du couche K aussi par d'une débitage unipolaire convergente de type volumétrique représenté par 6 nucleus. Les supports obtenus à travers ce type de débitage sont des éclats convergents à taon lisse plutôt épais.

Les outils retouchés comptent 34 pièces pour le couche K et 36 pièces pour le couche J (Tab 7, 8). Typologiquement les outils sont des racloir avec une très fiable transformation des bords tranchants. Une partie non négligeable de ces pièces (28 éléments) présentent est une troncature localisée sur une ou plusieurs bord de l'éclat. Le morphotype plus récurrent montre une structure constituée par deux aménagements opposés constitués par une troncature en partie distal souvent associé à un amincissement. Les supports sélectionnés pour la construction de ces outils sont majoritairement des éclats unipolaires ou des fragmentes de lames.

Enfin, un petit groupe d'outils de plus grandes dimensions (8 éléments), présentent un aménagement du volume pour le moyen d'une réduction par façonnage partiel du volume. Les matrices utilisées peuvent être indifférentement des nucleus réutilisée au des gros éclats.

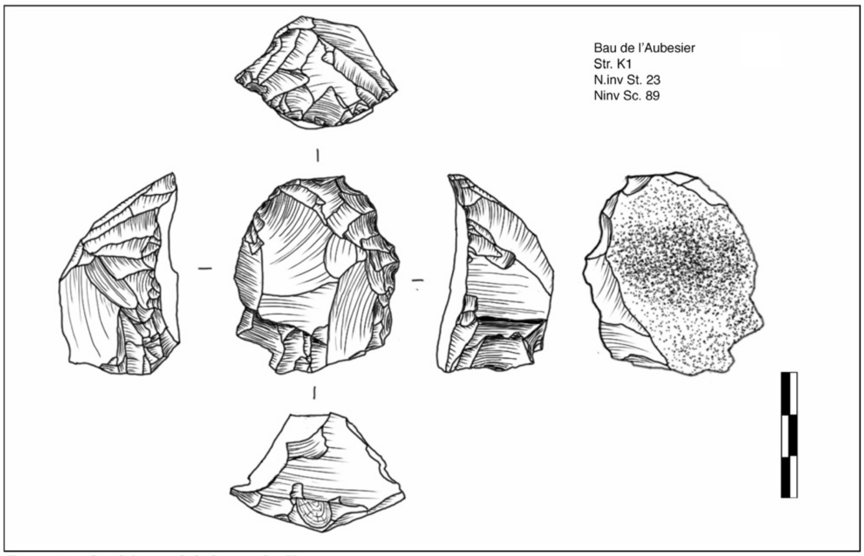


Figure 7 – Outil façonné de la couche K.

3.1 - Analyse technologique du couche I

La couche I compte 3088 pièces dont 666 éclats déterminables et 59 nucleus.
Dans cette couche nous retrouvons de similitude avec les couches K, J par la présence du débitage périphérique par plan sécant ici représenté par 8 nucleus. La production associé a ce système est également présent est se constitue par des éclats centripète présentent de négatives sécant et des talon lisse très incliné. La production d'éclats unipolaire à travers un system de type unipolaire demi-tournant continue dans ce niveau mais avec des pourcentages plus bas. Pour cette catégorie d'éclats on passe en fait du 17 % pour le couche K au 7% pour le couche I (Tab 7, 9). Les modules laminaires sont très rare (entre le 1 et 2 %) et peuvent être ici considéré comme anecdotique. Une similitude avec la couche J nous le retrouvons dans la production d'éclats convergents à travers le système unipolaire convergent de type volumétrique ici représenté par 4 nucleus. (Tab. 6).

Classe Technologique	I4	I3	I2	I-I1	Total	
	n°	n°	n°	n°	n°	%
Fr_ind<20	64	224	1190	264	1742	56,4
Fr_ind>20	43	56	106	21	226	7,3
Éclats ordinaires<20	34	37	163	32	266	8,6
Éclats ordinaires>20	23	20	76	10	129	4,2
Pièces déterminables	91	106	411	58	666	21,6
Nucleus	10	13	34	2	59	1,9
Total	265	456	1980	387	3088	100,0

Tableau 3 - Décompte des classe technologique de la couche I.

Le changement plus important relevé dans cette couche est représenté par la présence du débitage Levallois reconnaissable soit dans le produits que dans les nucleus. Nous avons compté 14 nucleus Levallois, pour la majorité de méthode centripète. La prédominance de ce méthode s'accord bien avec la présence des éclats Levallois centripète (Fig. 9).
Les pièces retouché compte 70 éléments constitués comme dans les couches K et J par des racloirs simples. Sont au contrarie absente le pièces tronquée et surtout le pièces façonné.

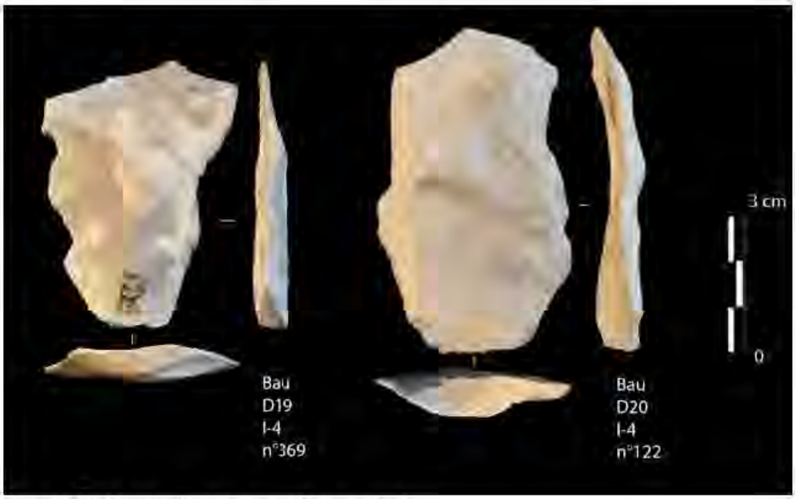


Figure 8 – Produits Levallois centripètes de la couche I.

3.2 - Résultat préliminaires des couche H et IV.

La partie supérieure de la séquence (Couche H et IV) est toujours en cours d'analyse mais nous pouvons déjà donner le traits plus essentiales.

La présence des nucleus, éclats corticaux, pièces brutes e pièces retouchées montrent que toutes les phases de la chaine opératoire ont eu lieux sur place.

Les principaux schémas opératoires attestés dans les deux niveaux principaux (couches IV-V et couche H), sont liés à un débitage de concept Levallois. Dans la couche H le débitage Levallois centripète est largement dominant (Fig.10 et 11). Cet aspect lui donne donc une certaine continuité avec le couche I.

La couche IV au contrarie montre une variabilité dans les méthodes beaucoup plus large comprennent aussi une débitage Levallois de type unipolaire et bipolaire est convergent.(Fig. 12). La présence d'un débitage Discoïde est attestée dans les couche H et IV d'une façon minoritaire.

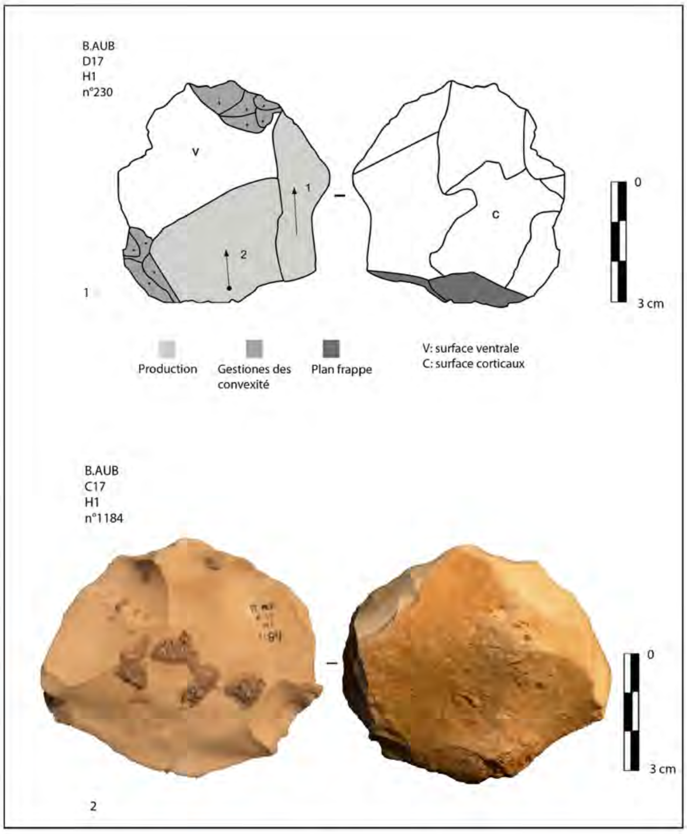


Figure 9 – n°1 nucleus Levallois centripète. N°2 nucleus Kombewa.

Figure 11 – Éclats Levallois de la couche H.

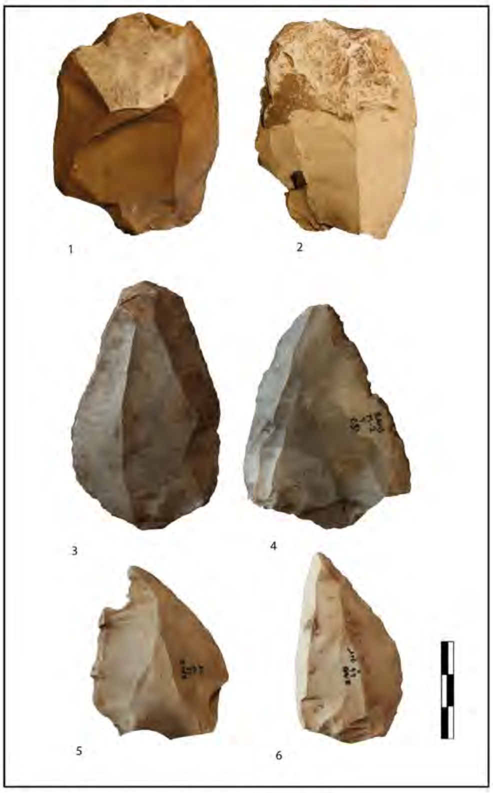


Figure 12 – Eclats Levallois de la couche IV.

La différence major entre la couche H et la couche IV est représentée par la présence, dans la couche IV, d'une production laminaire. Pour le moment nous avons distingué deux types de production. Une production laminaire convergente provenant d'un débitage par plan parallèles probablement de type Levallois et une production laminaire volumétrique (Fig 13, 14).
Ces dernières sont distinguable nettement d'une production de surface sur la base de diffèrent caractéristiques technologiques. Ces produits présentent une morphologie plus étroite et élancée avec un talon lisse. Les négatives visible dorsale sont très encline suggèrent un déroulement du débitage sur les flanc de nucleus avec un ritme de type tournant au demi-tournant.
En parallèles à la production laminaire nous signalons aussi une production lamellaire autonome
Les modules lamellaires présentent les mêmes caractéristiques morphologiques des lames volumétriques. La production lamellaire est fait à partir de la sélection d'éclats utilisés comme nucleus.
L'étude complète de la série nous permettra de mieux identifier la variabilité dans la production laminaire et lamellaire en ce que concerne la mise en forme et la gestion des nucleus.

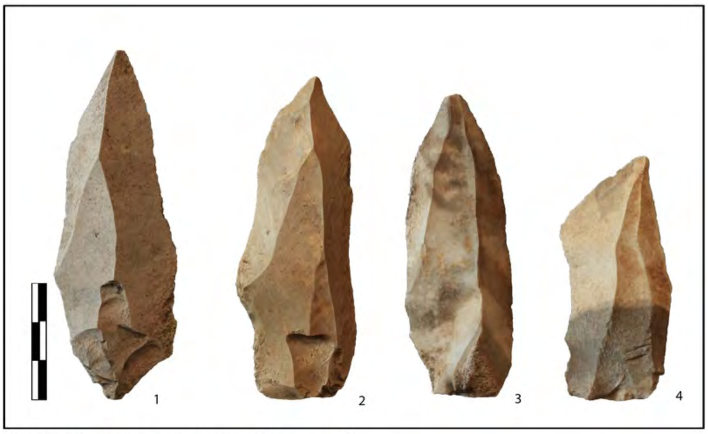


Figure 10 – Lames convergents de la couche IV.

Figure 11 – Produits laminaire de la couche IV.

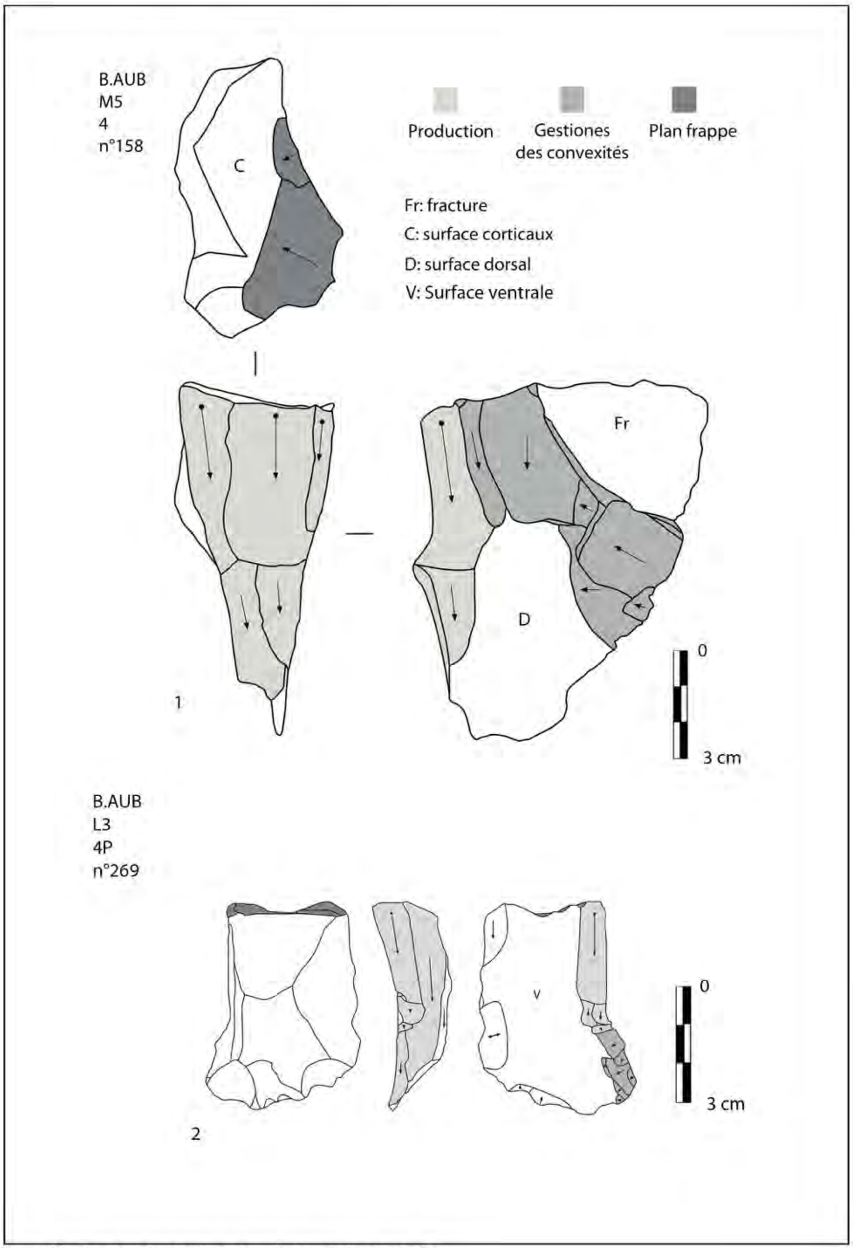


Figure 12 – Nucleus laminaire et lamellaires de la couche IV.

4 - Programmation campagne d'étude 2016

Cette étude préliminaire des systèmes de production de Bau de l'Aubesier montre, à travers la séquence stratigraphique certains caractères de continuité mais aussi de différences importante aussi bien dans les systèmes de production que dans les objectivés recherchées.
La mise en évidence d'une production laminaire dans les couches de base montre la présence d'une production laminaire. Cette présence dans le sud de la France, et plus en général dans le sud l'Europe, au sein du MIS 7 est un fait nouveaux et pas signalé auparavant. L'unique site comparable est le site de Cave dell'Olio en Italie ou c'est type de production s'atteste pendent le MIS 9 (Fontana et al. 2013).
Le couche I et H au contraire rentrent dans variabilité technologique classique pour le Paléolithique moyen de la région ou le débitage Levallois est présent à partir du Pléistocène Moyen.
La mise en évidence d'une production lamellaire dans le couche IV, daté au MIS 5, est elle aussi, pour cette période chronologique, une caractère inédite dans la région et plus en général en Europe.
A l'état actuel de la recherche nous avons terminé l'étude complet des couches K, K1, K2, J4, J3, J2, J-J1, I4, I3, I2, I-I1.
Dans le 2016,la prochaine campagne d'étude, serait dédiée au complètement de l'analyse de l'industrie lithique de Bau de l'Aubesier. L'étude prévue serait divisée en deux phases.
La première phase serait finalisée à l'étude des couches H2, H1 et IV en ce que concernent les éléments déterminables (nucleus et support).
La deuxième phase serais dédie à l'étude des restant couche (5, G, 3, 2, 1). Pour ces couche nous appliquerons la même méthodologie d'étude utilisée pour les outre couche et décrite dans ce rapport.
Le complètement de l'étude de Bau de l'Aubesier sera souhaitable afin de comprendre dans son intégralité l'évolution des systèmes techniques et des les dynamique techno-économiques que gère la production.
Le nécessaire temps estimé pour le complètement de l'analyse de l'industrie lithique de Bau de l'Aubesier est d'environ deux mois.

Remerciement

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ANNEXES

Tableau 4 – Nucleus de la couche K.

Nucleus	K2	K-K1	Total K
	n°	n°	n°
Centripète plan parallèles	1	0	1
Bipolaire plans parallèles	1	2	3
Orthogonaux plans parallèles	1	0	1
Convergente plans parallèles	1	0	1
Indéterminable plans parallèles	1	0	1
Discoïde	3	0	3
Plans sécantes bifacial	1	1	2
Pyramidaux unipolaire	1	1	2
Unipolaire demitournant	1	0	1
Fragment nucleus indéterminables	2	0	2
Totale	13	4	17

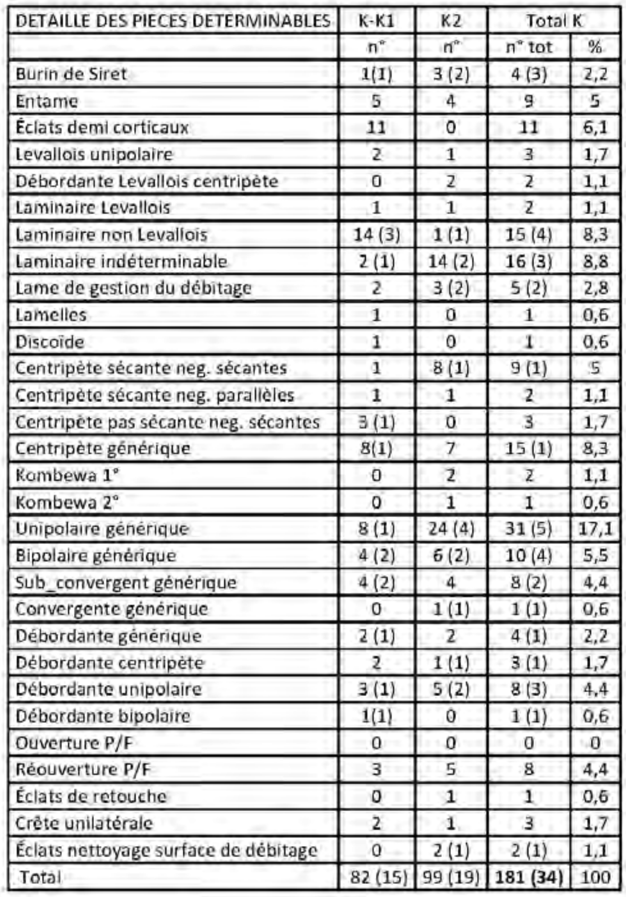
Tableau 5 - Nucleus de la couche J.

Nucleus	J1	J2	J3	J4	Total J
	n°	n°	n°	n°	n°
Centripète plan parallèles	3	2	2	2	8
Unipolaire plan parallèles	1	0	1	1	3
Bipolaire plans parallèles	0	0	0	1	1
Orthogonaux plan parallèles	0	0	1	0	1
Convergente plans parallèles	0	1	0	1	2
Convergente volumétrique	2	0	0	4	6
Unipolaire demitournant	0	2	0	4	6
SSDA	1	0	0	5	6
Fragments nucleus indéterminables	1	0	0	4	
Totale	8	5	4	22	39

Tableau 6 - Nucleus de la couche J.

Nucleus	I-I1	I2	I3	I4	Total
	n°	n°	n°	n°	n°
Centripète plan parallèles	0	0	0	2	2
Unipolaire plan parallèles	0	0	0	1	1
Orthogonaux plan parallèles	0	2	0	0	2
Convergente plans parallèles	0	1	0	1	2
Discoïde	0	0	3	0	3
Plans sécantes bifacial	1	2	1	0	4
Plans sécants unifacial	0	1	0	0	1
Convergent volume	0	2	1	1	4
Kombewa	0	1	0	0	1
Trifaciales	0	3	0	0	3
Unipolaire semi tournant	0	3	0	0	3
Levallois centripète	0	5	0	3	8
Levallois déstructuré	0	2	1	0	3
Levallois initialisée	0	1	0	0	1
Levallois linéale	0	1	0	0	1
Levallois unipolaire	0	0	0	1	1
Pièce esquillées	0	1	0	0	1
SSDA	0	1	1	0	2
Fragments nucleus indéterminables	1	8	6	1	16
Totale	2	34	13	10	43

Tableau 7 - Classes technologiques des pieces déterminables du couche K



DETAILLE DES PIECES DETERMINABLES	K-K1	K2	Total K	
	n°	n°	n° tot	%
Burin de Siret	1(1)	3 (2)	4 (3)	2,2
Entame	5	4	9	5
Éclats demi corticaux	11	0	11	6,1
Levallois unipolaire	2	1	3	1,7
Débordante Levallois centripète	0	2	2	1,1
Laminaire Levallois	1	1	2	1,1
Laminaire non Levallois	14 (3)	1 (1)	15 (4)	8,3
Laminaire indéterminable	2 (1)	14 (2)	16 (3)	8,8
Lame de gestion du débitage	2	3 (2)	5 (2)	2,8
Lamelles	1	0	1	0,6
Discoïde	1	0	1	0,6
Centripète sécante neg. sécantes	1	8 (1)	9 (1)	5
Centripète sécante neg. parallèles	1	1	2	1,1
Centripète pas sécante neg. sécantes	3 (1)	0	3	1,7
Centripète générique	8(1)	7	15 (1)	8,3
Kombewa 1°	0	2	2	1,1
Kombewa 2°	0	1	1	0,6
Unipolaire générique	8 (1)	24 (4)	31 (5)	17,1
Bipolaire générique	4 (2)	6 (2)	10 (4)	5,5
Sub_convergent générique	4 (2)	4	8 (2)	4,4
Convergente générique	0	1 (1)	1 (1)	0,6
Débordante générique	2 (1)	2	4 (1)	2,2
Débordante centripète	2	1 (1)	3 (1)	1,7
Débordante unipolaire	3 (1)	5 (2)	8 (3)	4,4
Débordante bipolaire	1(1)	0	1 (1)	0,6
Ouverture P/F	0	0	0	0
Réouverture P/F	3	5	8	4,4
Éclats de retouche	0	1	1	0,6
Crête unilatérale	2	1	3	1,7
Éclats nettoyage surface de débitage	0	2 (1)	2 (1)	1,1
Total	82 (15)	99 (19)	**181 (34)**	100

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Tableau 8 - Classes technologiques des pièces déterminables du couche J.

DETAILLE DES PIECES DETERMINABLES						
	J4	J3	J2	J-J1	n°	%
Entame	12(1)	3	2	9	26(1)	8,6
Éclat corticaux	20(1)	4	0	40	64(1)	21,1
Type Levallois centripète	18(3)	5	0	2	25(3)	8,2
Type Levallois unipolaire	9(1)	4	0	1	14(1)	4,6
Type Levallois orthogonaux	4	0	0	0	4	1,3
Type Levallois sub-convergent	2(1)	0	0	1	3(1)	1,0
Type Levallois convergent	0	1	0	0	1	0,3
Débordant Levallois centripète	3	0	0	3	6	2,0
Débordant Levallois unipolaire	2	0	0	0	2	0,7
Débordant Levallois orthogonaux	1	0	1	0	2	0,7
Laminaire type Levallois	1	0	1	0	2	0,7
Laminaire non Levallois	9(5)	1	0	2	12(5)	3,9
Laminaire indéterminable	2	0	0	1(1)	3(1)	1,0
Lame de gestion	2	0	0	0	2	0,7
Débordant sécante neg. sécantes	7	0	0	0	7	2,3
Centripète sécante neg. sécantes	2(1)	2	1	0	5(1)	1,6
Centripète pas sécante neg. sécantes	2(1)	0	0	0	2	0,7
Centripète générique	17(6)	6	0	5(2)	28(8)	9,2
Kombewa 1°ere	1	0	0	0	1	0,3
Unipolaire générique	15(3)	2	2	7	26(3)	8,6
Bipolaire générique	2(1)	0	0	0	2	0,7
Orthogonaux générique	1	0	0	0	1	0,3
Sub_convergent générique	17(5)	1	0	0	18(5)	5,9
Convergent générique	9	0	0	0	9	3,0
Débordant générique	2	0	0	2	4	1,3
Débordant unipolaire	2	0	0	1(1)	3(1)	1,0
Débordant bipolaire	1	0	0	0	1	0,3
Réouverture P/F	6	1	0	0	7	2,3
Crête deux versant	0	0	0	1	1	0,3
Éclats nettoyage surface	2(1)	0	0	0	2(1)	0,7
Réfléchie unipolaire	6	0	0	5(2)	11(2)	3,6
Réfléchie centripète	0	0	0	1	1	0,3
Burin de Siret	8	0	1	0	9	3,0
	185(30)	30	8	81(6)	304 (36)	100,0

Tableau 9 - Classes technologiques des pièces déterminables du couche I.

DETAILLE DES PIECES DETERMINABLES	I4	I3	I2	I-I1	Total K	
	n°	n°	n°	n°	n°	%
Burin de Siret	0	1	8(2)	0	9(2)	1,4
Entame	12	4(1)	56(2)	5	77(3)	11,6
Éclats demi corticaux	17(2)	14(1)	43(1)	9	83(4)	12,5
Levallois centripète	20(1)	8(1)	59(5)	1	88(7)	13,2
Levallois unipolaire	4	6	15(2)	0	25(2)	3,8
Levallois bipolaire	2	3(2)	3(1)	2	10(3)	1,5
Levallois orthogonales	0	1	0	0	1	0,2
Levallois sub_convergent	4	0	2(1)	0	6(1)	0,9
Levallois convergent	0	0	2(1)	1(1)	3(2)	0,5
Débordante Levallois centripète	1	6	5(1)	3	15(1)	2,3
Débordante Levallois unipolaire	0	1(1)	3(1)	0	4(1)	0,6
Débordante Levallois orthogonale	0	0	8(1)	1	9(1)	1,4
Laminaire Levallois	0	1(1)	8(1)	1	10(2)	1,5
Laminaire non Levallois	3	2	8(2)	0	13(2)	2,0
Laminaire indéterminable	1	0	5	1	7	1,1
Débordant sécante neg. sécantes	0	0	10	0	10	1,5
Débordante trasv_neg sécantes	0	0	3	0	3	0,5
Pseudolevallois	0	2(1)	4	0	6(1)	0,9
Centripète sécante neg. sécantes	2	5	7	0	14	2,1
Centripète pas sécante neg. sécantes	0	1	0	0	1	0,2
Centripète générique	7(2)	20	38(4)	5	70(6)	10,5
Kombewa 1°	0	0	2	0	2	0,3
Kombewa 2°	2	0	4	0	6	0,9
Kombewa débordante	0	0	1	0	1	0,2
Unipolaire générique	6(2)	6(1)	27(4)	8(2)	47(9)	7,1
Bipolaire générique	1	0	0	0	1	0,2
Orthogonales générique	0	0	1	6(2)	7(2)	1,1
Sub_convergent générique	2	2	11(2)	1(1)	16(3)	2,4
Convergente générique	2	3	8(1)	1	14(1)	2,1
Débordante générique	1	3(1)	7	0	11(1)	1,7
Débordante centripète	0	1	6	3	10	1,5
Débordante unipolaire	0	0	3(1)	1	4	0,6
Débordante bipolaire	1	0	0	0	1	0,2
Débordante transv_neg_sec	0	1	0	0	1	0,2
Débordante sécante neg sécantes	0	3(1)	0	0	3(1)	0,5
Réouverture P/F	0	4	4	0	8	1,2
Éclats de retouche	0	4	13	0	17	2,6
Éclat à crête	0	0	0	2	2	0,3
Éclat à crête transv.	0	0	0	1	1	0,2
Éclats nettoyage surface de débitage	0	0	7	2	9	1,4
Neo-crête	0	0	1	0	1	0,2
Réfléchie débordante	0	1	0	0	1	0,2
Réfléchie unipolaire	1	0	6	3	10	1,5
Réfléchie centripète	1	0	2	0	3	0,5
Réfléchie Levallois	1	0	1	0	2	0,3
Réfléchie générique	0	2	8	1	11	1,7
Pièces avec amincissement	0	1(1)	12(12)	0	13(13)	2,0
	91(7)	106(12)	411(45)	58(6)	666(70)	100,0

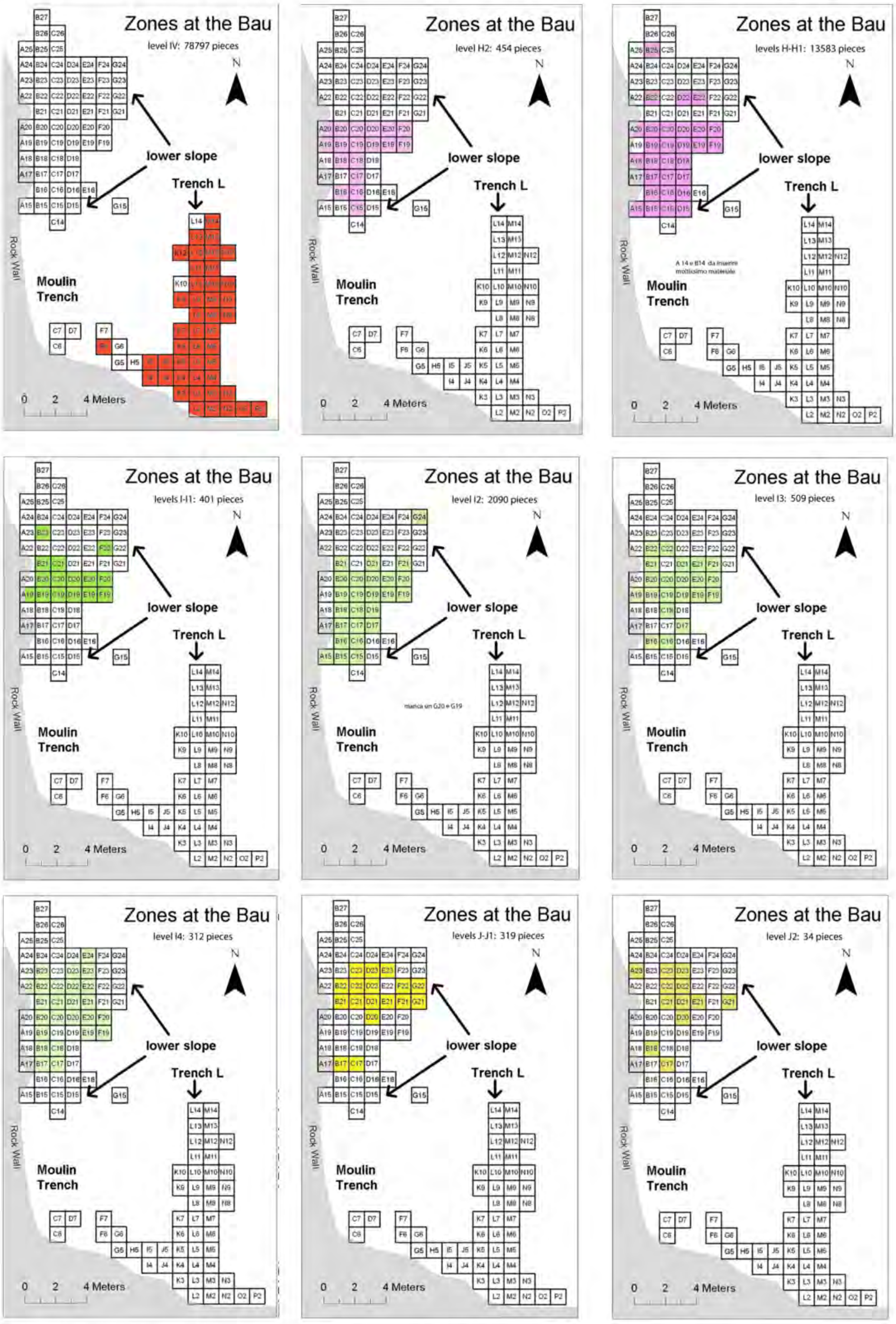

Figure 13 – Distribution de l'industrie lithique dans les couches IV, H, I, J-J1, J2.

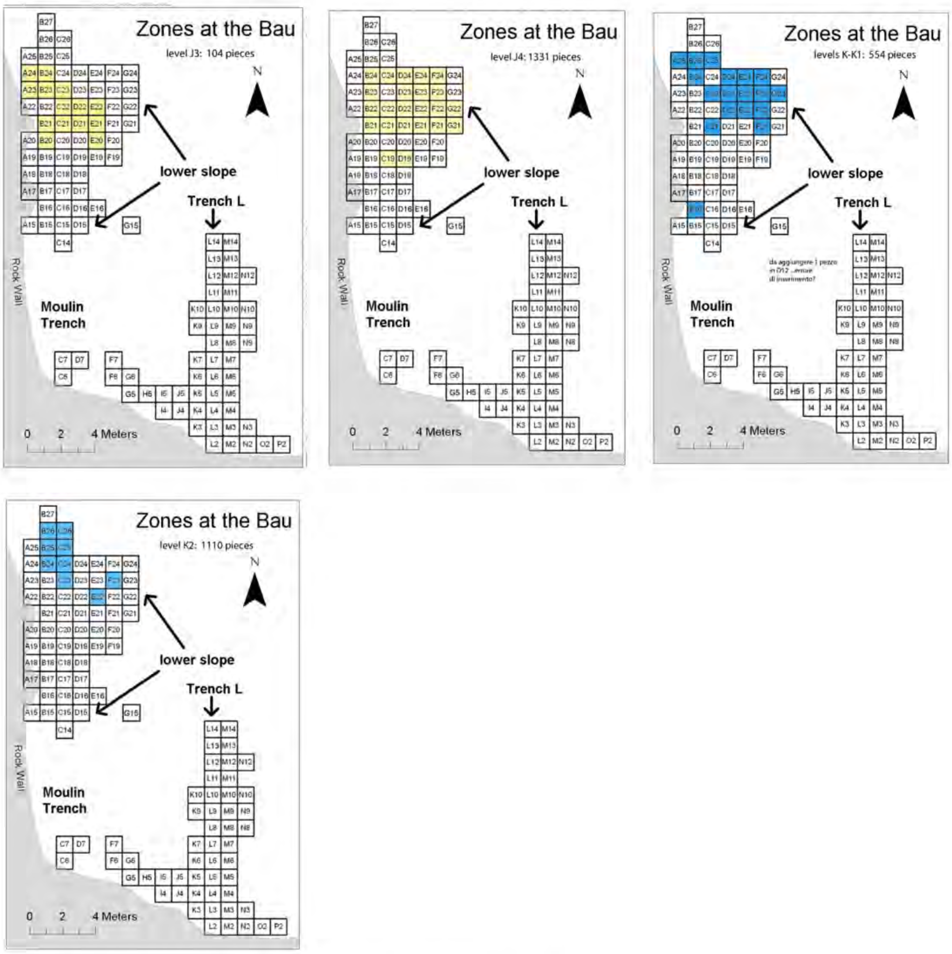

Figure 14 – Distribution de l'industrie lithique dans les couches J3, J4 et K.

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Rapport d'étude de l'industrie lithique de Bau de l'Aubésier (Vaucluse, France).

2014

L.Carmignani

Introduction

La production lithique des Néandertaliens du stade isotopique 5 au stade 3 du sud-est de la France est bien connu mais les séries lithiques avant le stade 5 ne sont pas très nombreuses et elles sont presque toutes issues de fouilles anciennes en grotte ou en abri. L'analyse des 207 pièces lithique provenant du couche K du site de Bau de l'Aubesier nous a permis de mieux comprendre les choix de production et les intentions techno-fonctionnelles de leur artisan pendent le stade isotopique 6.
Nous présentons ici le décompte technologique de cette série, puis une analyse des supports sélectionnés et des chaines opératoires mises en ouvre pour les produire.
Ensuite, nous mettons en ouvre une approche morpho-fonctionnelle adaptée au un petit groupe d'outils que présentent des caractères particuliers. Nous rappelons en préambule les principes d'analyse sur lesquels nous nous appuyons. Nous présentons ensuite les principaux systèmes opératoires présents ainsi que les principales objectives de productions. Les illustrations, les schémas diacritiques et les photos montreront qualitativement les pièces plus représentatives de l'étude fait.

1 - Critères d'étude de l'industrie lithique et méthodologie d'analyse.

Le but de cette étude a été principalement de reconstruire les schémas opératoires qui régissent la production et donc de comprendre les concepts technologiques sous-jacents.
En l'absence de remontages, l'identification des séquences de production repose sur la méthode déductive en s'appuyant principalement sur l'analyse des nucleus (Pelegrin, 1991). Pour la représentation graphique du matériel, nous avons suivi les normes élaborées par M. Dauvois (Dauvois 1976). Pour la reconnaissance des méthodes, the techniques et de concepts de taille nous appuierons sur la procédures d'analyses élaborées par différents auteurs. (Inizan et al. 1995; Tixier 1967; Böeda 1991, 1994, 1997; Pelegrin 1995).
Pour un petit groupe de pièces représenté par des outils des plus grand dimensions construits à travers des opération de façonnage ou demi-façonnage nous avons distingués des zones actives, en potentiel contact avec le matériel, et des zones passives, zones de réception en nous appuyant sur la conjonction de trois critères:

1) - un bord tranchant pour les zones actives alors que ce bord ne l'est pas ou peu pour les zones passives. C'est la méthode du tranchant d'abord, élaboré par M. Lepot (Lepot, 1993 : 32-37), qui vise rechercher en priorité les caractères tranchant des bords pour déterminer la position des zones actives par rapport a celle des zones passives (UTF T) (Fig 1).

2) - une opposition géométrique entre chaque zone active et la zone passive que l'on considère lui avoir servi de préhension (UTF P).

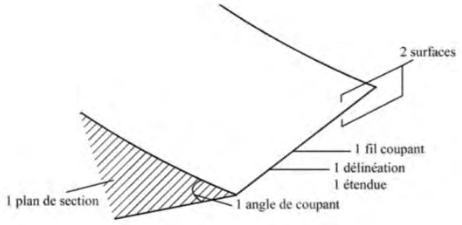
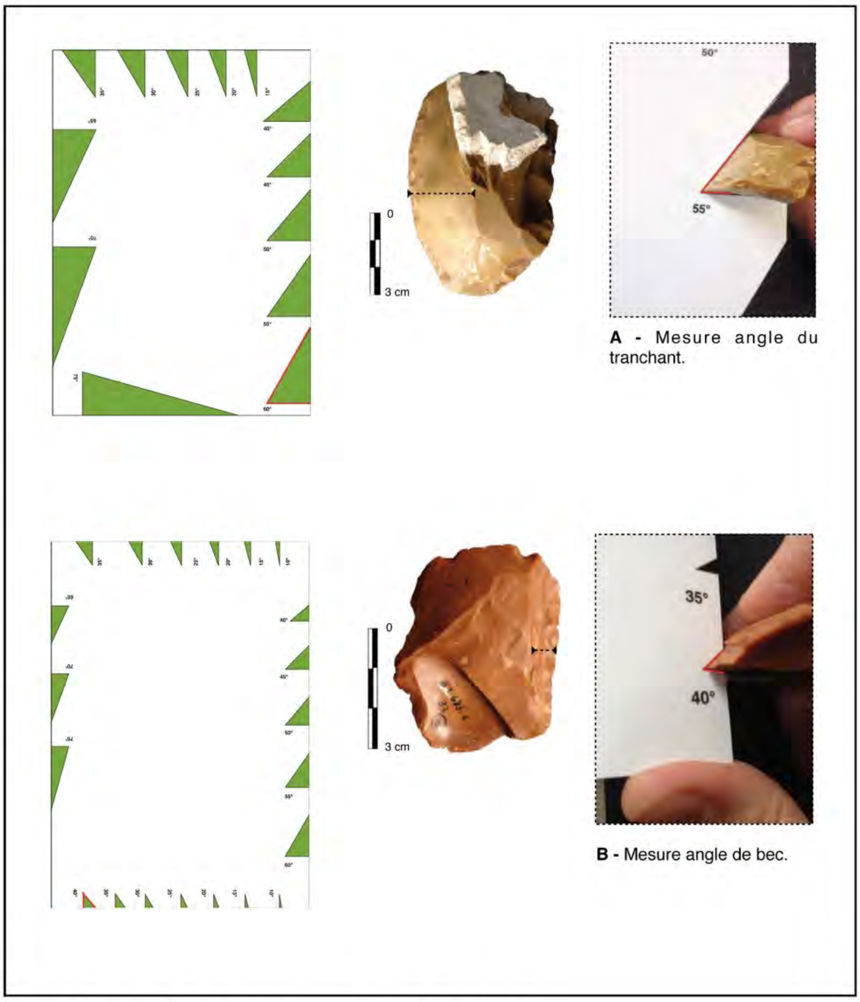


Figure 1 - Le dièdre de coupe (d'après Lepot, 1993)

3) - les deux zones, active et préhensive, tant suffisamment continues, de l'ordre de plusieurs centimètres (cf. Lepot, 1993 : 33).

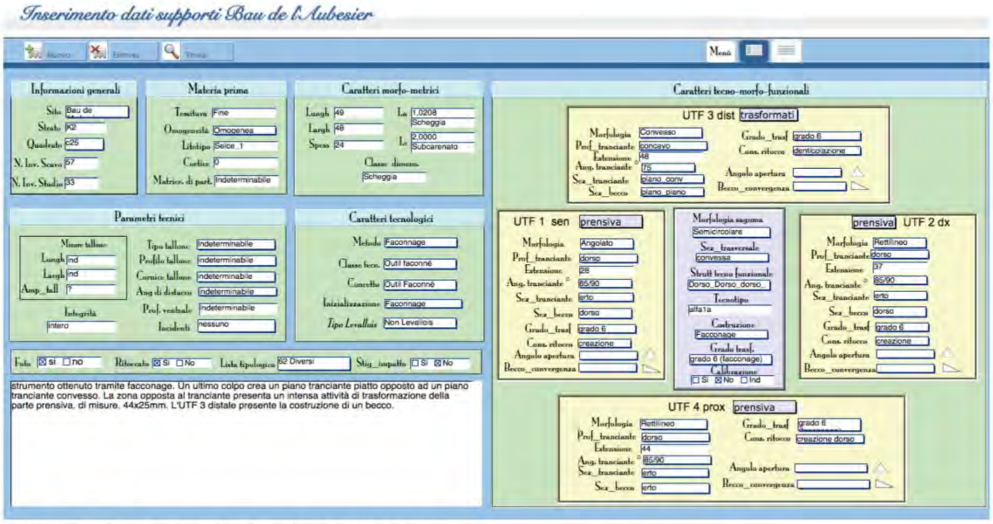
Pour cette analyse morpho-fonctionnel, nous avons travaillé uniquement sur les outils entiers. Toutes les mesures ont été prises au pied-coulisse Les dimensions ont été mesurées dans l'axe de débitage et perpendiculairement a l'axe de débitage.
La prix des angles des bords des pièces ont été prix pour le mien d'une profilométre avec une marge d'erreur de 5° (Fig. 2). Tout les données ont été ensuite systématiquement catalogués dans une base de donné conçu afin d'en permettre leur successive élaboration statistique (Fig 3).



A - Mesure angle du tranchant.

B - Mesure angle de bec.

Figure 2 - Modalité de prix des les mesure des angle du tranchant.



Informazioni generali
Sito: Bau de
Strato: K2
Quadrato: c25
N. Inv. Scavo: 57
N. Inv. Studio: 33

Materia prime
Tessitura: Fine
Omogeneità: Omogenea
Litotipo: Selce_1
Cortice: 0
Matrice di part.: Indeterminabile

Caratteri morfo-metrici
Lungh: 49
Largh: 48
Spess: 24
La: 1,0208 Scheggia
Ls: 2,0000 Subcarenato
Classe dimens.: Scheggia

Parametri tecnici
Misure tallone:
Lungh: ind
Largh: ind
Amp_tall: ?
Integrità: intero
Tipo tallone: Indeterminabile
Profilo tallone: indeterminabile
Cornice tallone: indeterminabile
Ang di distacco: indeterminabile
Prof. ventrale: indeterminabile
Incidenti: nessuno

Caratteri tecnologici
Metodo: Faconnage
Classe tecn.: Outil faconné
Concetto: Outil Faconné
Inizializzazione: Faconnage
Tipo Levallois: Non Levallois

Foto: ☒ si ☐ no
Ritoccato: ☒ Si ☐ No
Lista tipologica: 62 Diversi
Stig_impatto: ☐ Si ☒ No

strumento ottenuto tramite facconage. Un ultimo colpo crea un piano tranciante piatto opposto ad un piano tranciante convesso. La zona opposta al tranciante presenta un intensa attività di trasformazione della parte prensiva. di misure. 44x25mm. L'UTF 3 distale presente la costruzione di un becco.

Caratteri tecno-morfo-funzionali

UTF 3 dist: trasformati
Morfologia: Convesso
Prof_tranciante: concavo
Estensione: 48
Ang. tranciante °: 75
Sez_tranciante: piano_conv
Sez_becco: piano_piano
Grado_trasf: grado 6
Cons. ritocco: denticolazione
Angolo apertura:
Becco_convergenza:

UTF 1 sen: prensiva
Morfologia: Angolato
Prof_tranciante: dorso
Estensione: 28
Ang. tranciante °: 85/90
Sez_tranciante: erto
Sez_becco: dorso
Grado_trasf: grado 6
Cons. ritocco: creazione
Angolo apertura:
Becco_convergenza:

Morfologia sagoma: Semicircolare
Sez_trasversale: convessa
Strutt tecno funzionale: Dorso_Dorso_dorso_
Tecnotipo: alfa1a
Costruzione: Facconage
Grado trasf.: grado 6 (facconage)
Calibrazione: ☐ Si ☒ No ☐ Ind

UTF 2 dx: prensiva
Morfologia: Rettilineo
Prof_tranciante: dorso
Estensione: 37
Ang. tranciante °: 85/90
Sez_tranciante: erto
Sez_becco: dorso
Grado_trasf: grado 6
Cons. ritocco: creazione
Angolo apertura:
Becco_convergenza:

UTF 4 prox: prensiva
Morfologia: Rettilineo
Prof_tranciante: dorso
Estensione: 44
Ang. tranciante °: 85/90
Sez_tranciante: erto
Sez_becco: erto
Grado_trasf: grado 6
Cons. ritocco: creazione dorso
Angolo apertura:
Becco_convergenza:

Figure 3 – Base des données. Interface d'entrée de donnée

L'industrie lithique du niveau K.

La couche K est située à la base de la séquence de Bau de l'Aubesier. Sur la base des datations disponibles elle est placée entre le début du isotopique 6 et la fin du 7. Pendent l'excavation la couche K fut il subdivisé en trois sous ensemble (K2, K1, K). Cependant les trois sous niveaux peuvent être considéré absolument homogènes d'un point de vue sédimentologique et prive de discontinuité d'un point de vue archéologique. L'ensemble est composé par 215 pièces compréhensives des nucleus, éclats et débris (Tab. 1). Sur la base de cette homogénéité techno-typologique de l'industrie lithique, est d'une continuité sédimentologique du dépôt, nous allons à traiter ces différents sous niveaux comme un ensemble unique.

Figure 4 - Bau de l'Aubesier. Pièce patinée. Couche K1

L'intégrité de l'industrie peut être considéré bonne. Le 63% des éléments (131 pièces) sont entières. Une partie de l'ensemble montre des petites fracturation en partie distale (13 pièces) et proximale (17 pièces) que toutefois n'ont pas empêché une lecture correcte des pièces (Tab 2).

Entre les éléments cassé sont prédominant le fragment proximaux (28 élément). Les fragments distales et médiales comptent respectivement 6 et 7 éléments.

L'état de l'industrie est affecté par une patine blanchâtre due probablement à des phénomènes post-depositionélles de désilification que dans quelques cas spécifique a été l'obstacle pour la reconstitution précis des schémas diacritiques des enlèvements (Fig. 4). Tout fois, dans la majorités des cas, le dégrée de lecture a été suffisamment fiable pour l'identification du techno-type.

En excluant les éléments indéterminables, cette a dire, tous les éléments que ils ne peuvent pas être attribué à aucune catégorie technologique, la composition de l'assemblage lithique se compose de 172 enlèvements, 8 nucleus et 8 outils façonné. La présence de la phase de décortication est représente par 6 éclat d'entame et 10 éclat semi-corticaux (Tab. 4).

Niveaux	n°
K	76
K1	36
K2	103
Total	**215**

Tableau 1 – Distribution des pièces dans le différents sous-niveaux.

Intégrité	n°	%
Entière	131	*63,0*
Apex cassé	13	*6,3*
Base cassé	7	*3,4*
Fragment distal	6	*2,9*
Fragment médial	5	*2,4*
Fragment proximal	17	*8,2*
Fragment indéterminable	28	*13,9*
Total	**207**	***100***

Tableau 2 – Intégrité des enlèvements.

Lès nucléus, bien que peu nombreux (8 éléments) montrent une variabilité importante dans les méthodes de productions. Trois nucleus montrent une structure de débitage de type pyramidal, 4 nucleus sont de type discoïde d'exploitation bifaciale. Un seul nucléus montre une séquence convergente débitée sur la surface large de la surface de débitage (Tab. 3).

Les derniers détachements visibles sur la surface de débitage des nucléus indiquent un objectif dimensionnel minimum de production entre 20 et 30 mm de dimension maximum (Fig. 5).

En ce que concernent les supports obtenus la présence de nombreux éclats centripètes (24 pièces) et de 7 éclats débordantes centripète peuvent être reconnectés au débitage de type discoïde. On remarque inversement le manque des pointes pseudo-levallois que sont normalement un objet typique de la production discoïde. Cette absence peut dériver d'une exportation de cette partie de la production dehors du site ou au une absence du à la partialité de l'excavation.

Les enlèvements plus représentatifs sont constitués par des éclats courts de direction unipolaire (35 enlèvements) (Tab. 4). En ce que concerne le module d'allongement l'industrie est composé principalement par des modules à éclats mais une partie non négligeable de la production est composé par des modules laminaires. Sont des objets allongées de morphologie quadrangulaire (24 éléments) ou convergent (10 éléments). Ces supports sont massifs avec un talon lisse (Fig. 8). La recherche de l'allongement de ces produits est obtenue à travers un system de débitage récurrent de type semi pyramidal.

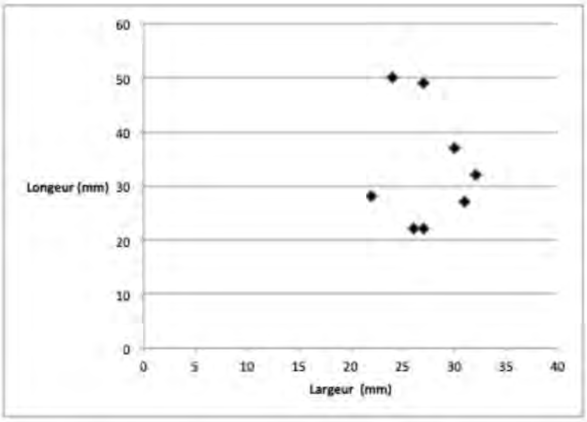


Figure 5 - Diagramme longueur-largeur du dernier détachement visible sur le nucleus.

Type de nucleus	n°
Pyramidal	3
Convergent	1
Discoïde	4
Total	**8**

Tableau 3 – Distribution des pièces dans le différents sous-niveaux

Techno type	n	%
Entame	6	*3,2*
Demi-corticaux	10	*5,3*
Centripète	24	*12,8*
Unipolaire	35	*18,6*
Bipolaire	4	*2,1*
Convergent	6	*3,2*
Sub-convergent	5	*2,7*
Orthogonaux	3	*1,6*
Kombewa	1	*0,5*
Débordant centripète	7	*3,7*
Débordant unipolaire	3	*1,6*
Lame	24	*12,8*
Lame convergent	10	*5,3*
Lame débordant	4	*2,1*
Éclat de nettoyage de surface	1	*0,5*
Crête unilatéraux	1	*0,5*
Éclat de façonnage	5	*2,7*
Éclat indéterminable	23	*12,2*
Outil façonné	8	*4,3*
Nucleus	8	*4,3*
Total	**188**	*100*

Tableau 4- Décompte de l'assemblage lithique exclu les fragmente indéterminable.

Les outils retouchés comptent 49 pièces dans la majorité représenté par des racloir (Tab 5). Une partie non négligeable de ces pièces (28 éléments) présentent des amincissements est une troncature localisée sur une ou plusieurs bord de l'éclat que va à détruire le fil du tranchant des support en créant des dos abruptes.

Cette morphotype de modification peut être rapproché en ce que on appelle en littérature pièce Kostienky ou Nahr-Ibrahim. Dans le cas présent cette type d'aménagement donne comme résultat

diffèrent structure techno-fonctionnel en fonction des l'organisations des parties transformatives (UTF T) e préhensive (UTF P) .
Le morphotype plus récurrent (15 éléments) montre une structure constituée par deux aménagements opposés constitués par une troncature en partie distal souvent associé à un amincissement (Fig. 6 n.4). Les supports sélectionnés sont principalement des éclats unipolaires ; plus rares les éclats centripètes (Fig. 6 n. 1, 3). Enfin, un petit group d'outils de plus grandes dimensions (8 éléments), présentent un aménagement du volume pour le moyen d'une réduction par façonnage (Fig. 8).

Elements retouché	**n**
Point moustérien	1
Racloir simple rect.	5
Racloir simple conv	2
Racloir simple conc.	1
Racloir double rect-conv	3
Racloir double biconv.	3
Racloir conv-rect.	2
Racloir trasv-rect.	1
Grattoir atypique	1
Burin	2
Perçoir atypique	3
Couteaux a dos	1
Couteaux a dos naturel	1
Encoche	1
Denticulé	5
Éclat abrupt	1
Divers	16
Total	49

Tableau 5 - Décompte des pièces retouché.

Conclusion.

La couche K de Bau de l'Aubesier a mis en évidence une production orientée sur deux modalités de productions distinctes, une de débitage et une de façonnage. La coexistence des ces deux types de production semble répondre a une nécessité de produire une gamme différentié d'outils finalisé à des taches fonctionnelles diversifié.
En ce que concerne le débitage la présence d'une production de support allongé de morphologie quadrangulaire et convergent se pose comme une évidence non négligeable. Bien que le module des supports soit faiblement allongé l'intention de la production est clairement de produire à travers un système de production spécifique de l'objet plus long que large. La mise en évidence d'une production laminaire dans le sud de la France avant le Pléistocène Supérieur se pose donc comme un fait remarquable.
Le second point à mettre en évidence est la présence d'une chaine opératoire finalisée à la production d'outils de plus grande taille a travers une opération de façonnage.
Les observations que nous avons pu faire l'année passé sur les ensembles lithiques plus récents de Bau de l'Aubesier montrerait un changement important dans la structure de production. Les niveaux J, H e IV de Bau de l'Aubier montrent en effet un développement du débitage Levallois au détriment du débitage pyramidal e discoïde présent dans le niveau K. En outre, alors que la structure de production dans le niveaux J,H,I,V est dominé exclusivement par le débitage le couche K comme nous l'avons précédemment dit s'exprime aussi à travers une production fait par façonnage.
Le suite de l'étude de la série de Bau de l'Aubesier nous permettra d'affiner l'étude des system techniques et comprendre donc les causes de ces changements dans les systèmes de productions. Une comparaison systématique entre les productions de la fin du Pléistocène Moyen du sud de la France nous permettra donc de remplacer le site de Bau de l'Aubesier dans son cadre régionaux pour comprendre l'extension géographique et chronologique de ces types de productions.

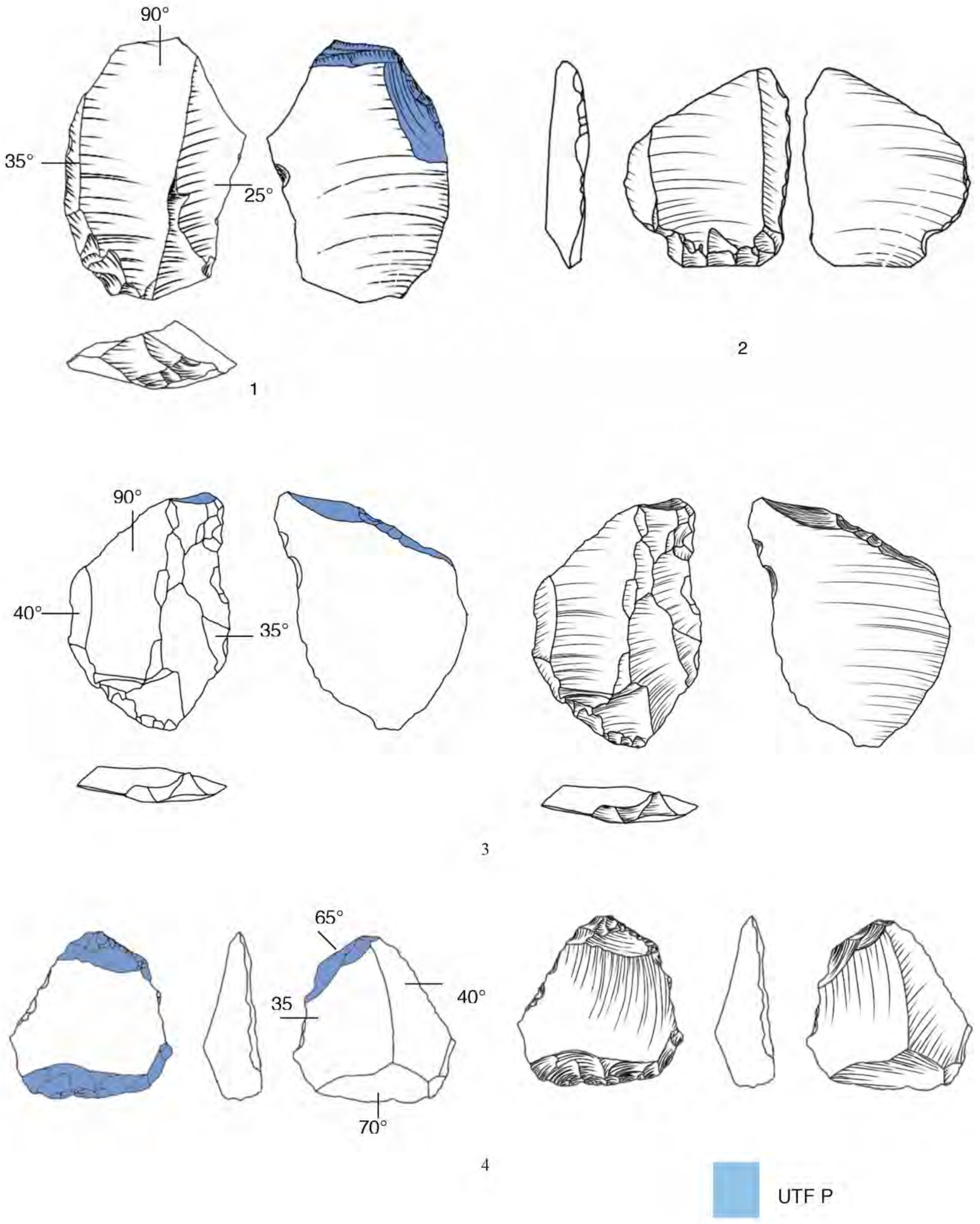


Figure 6 - n°1, 3 Éclats unipolaires avec troncature en partie distale; n° 2 éclat unipolaire; n°4 éclat centripète avec une double amincissement.

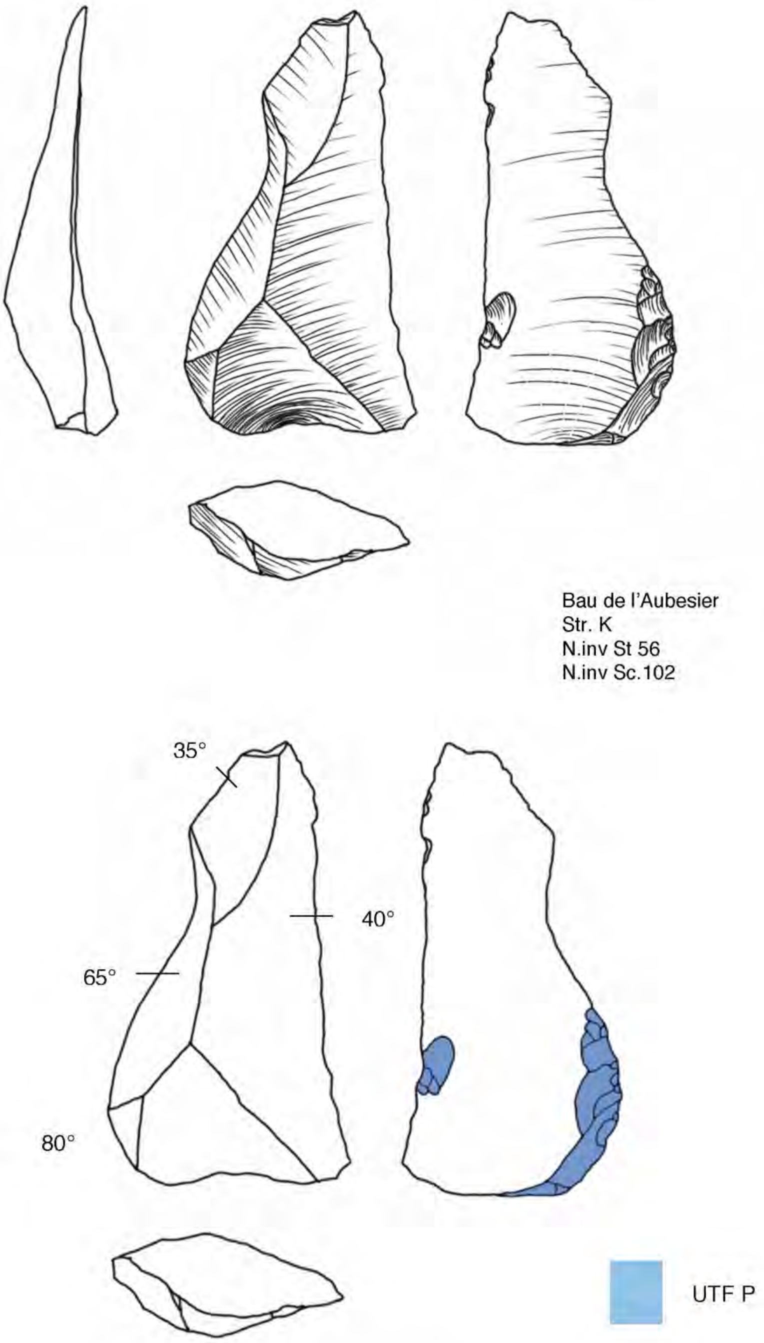
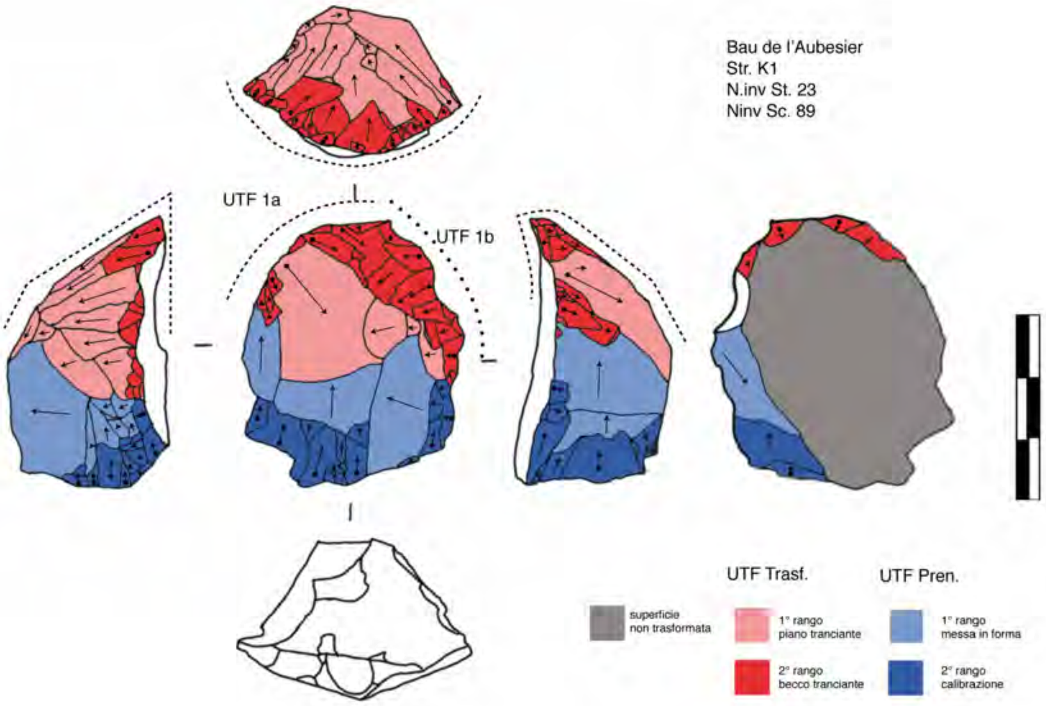


Figure 7 - Pièce allongé avec un aménagement de la UTF P dans la partie proximale.



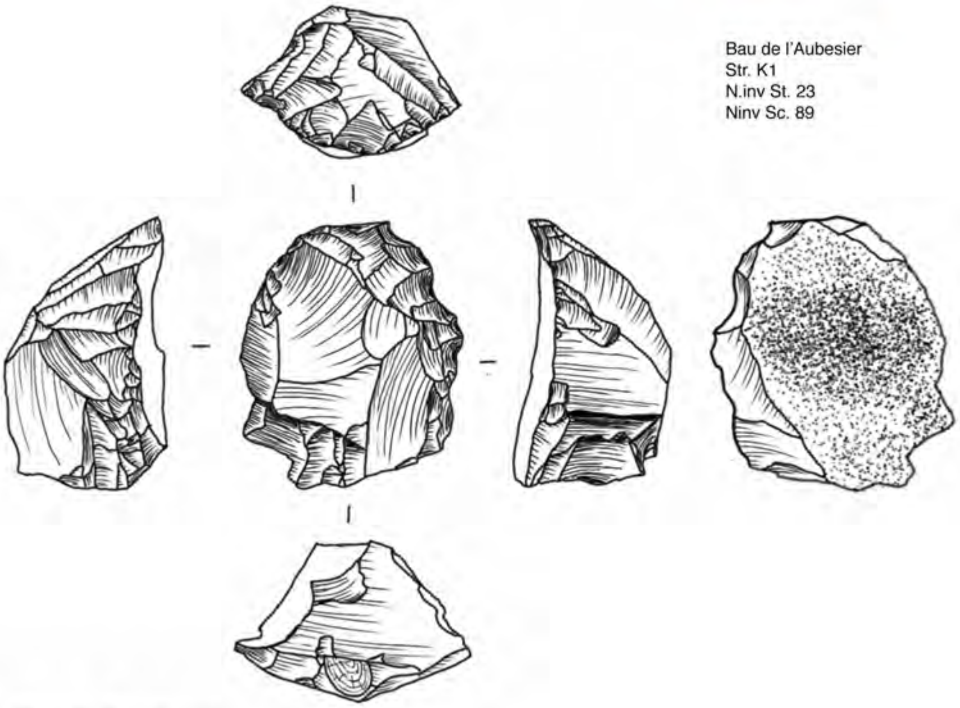


Figure 8 - Pièce façonné.

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Rapport d'étude de l'industrie lithique de Bau de l'Aubésier (Vaucluse, France)

2013

L.Carmignani

1 - Critères d'étude de l'industrie lithique et méthodologie d'analyse.

L'étude de l'industrie lithique de Bau de l'Aubesier est été effectué afin de comprendre dans ses lignes essentielles les principaux traits techniques que régissent la production.
Cette étude préliminaire a dû tenir en compte de l'impossibilité d'étudier, au moins dans cette première phase, la totalité l'industrie lithique. Pour cette raison a été nécessaire faire un trie préliminaire de l'industrie sur la base de deux critères principaux, d'une partie stratigraphique et de l'outre technologique.
L'échantillonnage a pris en compte tous les niveaux de Bau de l'Aubesier, au but de comprendre les différences techno-productionelle de l'entière séquence (**Fig. 1**). Le but de cette étude a été principalement de reconstruire les schémas opératoires qui régissent la production et donc de comprendre les concepts technologiques sous-jacents.
En l'absence de remontages, l'identification des séquences de production s'est basée sur la méthode déductive (Pelegrin, 1991) en se concentrant principalement sur l'analyse de nucleus. Pour la représentation graphique du matériel, nous avons suivi les normes élaborées par M. Dauvois (Dauvois 1976). Pour la reconnaissance des méthodes, the techniques et de concepts de taille nous appuierons sur procédures d'analyses élaborées par différents auteurs. (Inizan et al. 1995; Tixier 1967; Böeda 1991, 1994, 1997; Pelegrin 1995).

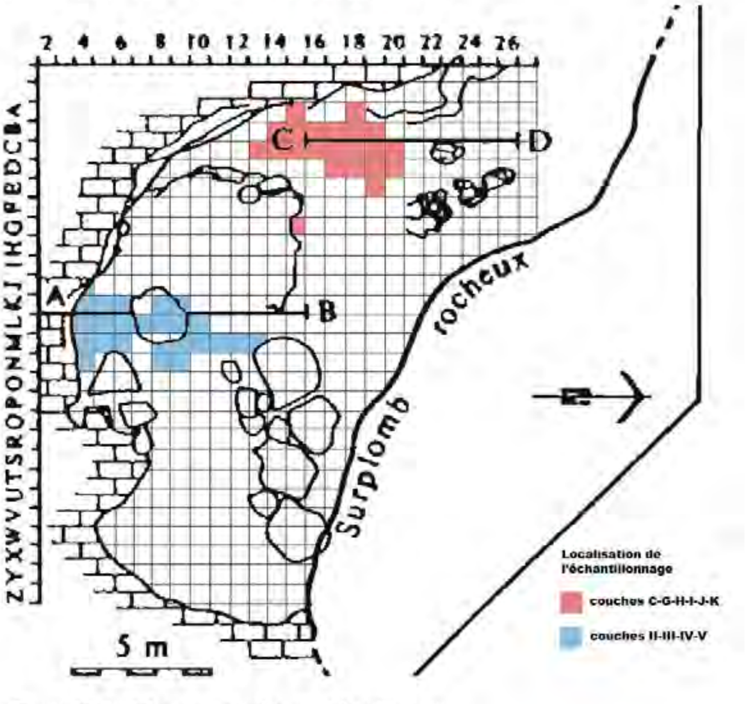

Figure 1 Détail des carrés touchés par échantillonnage.

2 - Caractères principaux de l'industrie lithique

Nous présentons ici le décompte de cette série, puis une analyse des supports sélectionnes. L'étude a pris en compte 217 nucleus et 436 enlèvements dont 123 retouchés (Tab 1, 2). En se basant sur l'homogénéité de la production, il a été possible de regrouper les niveaux étudiés de Bau de l'Aubesier en deux ensembles principaux : (couches IV-V) - (couche H), qui présentent une cohérence interne du point de vue des systèmes techniques identifiés. Les couches I et J situés à la base de la séquence prise en compte, ont livrés très peu pièces, comprenant des nucléus, des supports, des fragments non déterminés et des éclats ordinaire. Une situation similaire nous la retrouvions en ce que concerne les niveaux au sommé de la séquence (couches II-III). Compte tenu de la rareté des données des provenant de ces couches il n'était donc pas possible de donner une interprétation fiable des chaînes opératoires.

Couches	Nucleus	Brut	Retouché
II	2	10	2
IIIc	1	2	2
IV	74	113	40
IVP	20	42	14
V	2	2	3
C4	1	0	1
G6	1	2	0
H1	100	109	26
H2	7	14	11
I2	2	2	9
I3	1	8	13
I4	1	2	1
J2	1	1	0
J3	1	3	1
J4	2	1	0
K2	1	2	0
Tot.	**217**	**313**	**123**

Tab. 1 Quantification des pièces par niveaux.

Couches	Nucleus	Brut	Retouché
II-III	3	12	4
IV-V	96	157	57
C-G	2	2	1
H	107	123	37
I	4	12	23
J-K	5	7	1
Tot.	**217**	**313**	**123**

Tab. 2 Quantification des pièces par couches ou groupes de couches groupées sur la base d'une une cohérence interne du point de vue des systèmes techniques identifiés

3 - Description des schèmes opératoires.

Les principaux schémas opératoires attestés dans les deux niveaux principaux (couches IV-V et couche H), peuvent être attribués à un débitage de concept Levallois et à une production lamino-lamellaire issue d'un schéma opératoire indépendant (Tab 3). Le débitage Levallois est majoritairement de modalité centripète et uni-bipolaire. Les dimensions des supports de plein débitage provenant de ces deux modalités ne présentent pas de différences importantes. L'analyse des nucléus montre, que dans les deux modalités, centripète et uni-bipolaire, le niveau d'exploitation est très intense, puisque mené à exhaustion. La présence de nucleus, éclats corticaux, pièces brut e pièces retouchés montrent que tous les phases de la chaine opératoire on au lieux sur place. Les produits recherchés, éclats fins et allongés à tranchant parallèle pour la modalité unibipolaire, éclats fins sub-ovalaires et sub-quadrangulaires à tranchant périphérique issus de la modalité centripète, conservent les mêmes caractères au cours des étapes de réduction du nucléus. Ceci montre, contrairement à ce qui est attesté dans des situations comparables, qu'il n'y a pas ici d'exploitation centripète des nucléus uni-bipolaires proches de l'exhaustion. De façon très anecdotique, on note l'utilisation de la modalité convergente. Dans ce cas, les produits recherchés sont des éclats sub-triangulaires. La présence d'un débitage Discoïde est attestée, d'une façon minoritaire, dans tous les niveaux.

Dans les niveaux IV-V, parallèlement à la production de concept Levallois, un schéma de production autonome est attesté. Il est orienté vers la réalisation de supports étroits et allongés, de module lamino-lamellaire. La structure des supports recherchés se distingue nettement de la production Levallois uni-bipolaire au plan morphologique et dimensionnel. Les produits du système laminaire présentent au une morphologie étroite et plus élancée. La section de ces pièces est triangulaire ou quadrangulaire et les bords parallèles et rectilignes.

Couches	Techno-types des nucleus	n°
II-III	Levallois	1
	Kombewa	1
	Fragment indéterminable	1
	Tot_part	***3***
IV-V	Levallois	42
	Laminaire	6
	Lamellaire	8
	Kombewa	24
	Discoïde	4
	Unipolaire	3
	Convergente	5
	Bloc testé	3
	Fragment indéterminable	1
	Tot_part	***96***
C-G	Levallois	2
	Tot_part	***2***
H	Levallois	59
	Laminarie	2
	Lamellaire	2
	Kombewa	16
	Discoïde	8
	SSDA	8
	Trifacial	6
	Bipolaire	1
	Convergente	1
	Bloc testé	4
	Tot_part	***102***
I	Levallois	1
	Kombewa	1
	Discoïde	1
	Unipolaire	1
	Tot_part	***4***
J-K	Levallois	1
	Kombewa	1
	Trifaciale	1
	Bloc testé	2
	Tot_part	***5***
	Tot.	**217**

Tab. 3 Techno-types des nucleus.

Dans une moindre proportion, la production est orientée vers la recherche de lames à dos et à section sub-quadrangulaire. Les matrices utilisées pour la production laminaire sont systématiquement des éclats. La phase d'initialisation se limite généralement à l'exploitation d'un dièdre naturellement présent sur un de bords le plus longs de l'éclat. Si la préparation de crêtes est attestée, elle intervient seulement afin de régulariser le dièdre naturel du bloc. Le débitage, souvent abandonné très vite après un série très courte se poursuit en exploitant la surface étroite de l'éclat selon une modalité semi tournante.

Les modules lamellaires présentent les mêmes caractéristiques morphologiques que les modules laminaires. L'analyse des nucléus montre que des éclats de dimensions réduites ont été sélectionnés pour l'extraction de modules de petits calibres.

Dans toute la séquence un système technique original se distingue des précédents par une gestion particulière du volume initial. Ce système, s'il est différente dans la méthode et les objectifs ont néanmoins en commun le fait d'investir seulement une partie de la matrice initiale sélectionnée. La mise en application du même schéma opératoire au sein de ce système se fait indifféremment sur des blocs et sur des éclats.

Ce système se base sur l'association entre deux critères techniques de base. Le premier correspond à la préparation du plan de frappe pour obtenir un angle entre surface de plan de frappe et surface de débitage compris entre 95° et 115° environ. Le deuxième critère est l'application d'un algorithme de base, caractérisé par une série courte d'enlèvements à partir d'un plan de frappe précédemment préparé. Cet algorithme peut être appliqué une ou plusieurs fois sur la même matrice suivant un méthode unipolaire, bipolaire ou convergente. La gestion des convexités latérales et distales, lorsqu'elles sont présentes, ne concerne que la partie de la matrice utile à l'exploitation. À la différence d'un débitage de conception Levallois, où la récurrence des séries est prédéterminée dès le départ à travers une configuration totale du nucléus, dans ce cas, les séries d'enlèvement sont autonomes et indépendantes les unes des autres. La même séquence peut être appliquée plusieurs fois sur le même bloc selon des solutions variables en exploitant une ou plusieurs surfaces de la matrice.

4 - Conclusion

La sequence de Bau de l'Aubesier présent en partie des systèmes de production similaires en ce que concerne la présence majoritaire du débitage Levallois, Kombewa et in moins mesure Discoïde. Le système Levallois et la production laminaire sont absents que ce soit sous la forme de nucléus ou de supports. À l'inverse, le système majoritairement présent correspond à un débitage discoïde.

Dans les mêmes niveaux, on trouve parallèlement au système Levallois, un schéma de production autonome, orienté vers la production lamino lamellaire. Dans la phase successive, on voit au contraire la disparition du concept Levallois et du système laminaire au profit d'un débitage discoïde associé à des pièces esquillées issues d'une modalité de percussion bipolaire sur enclume.

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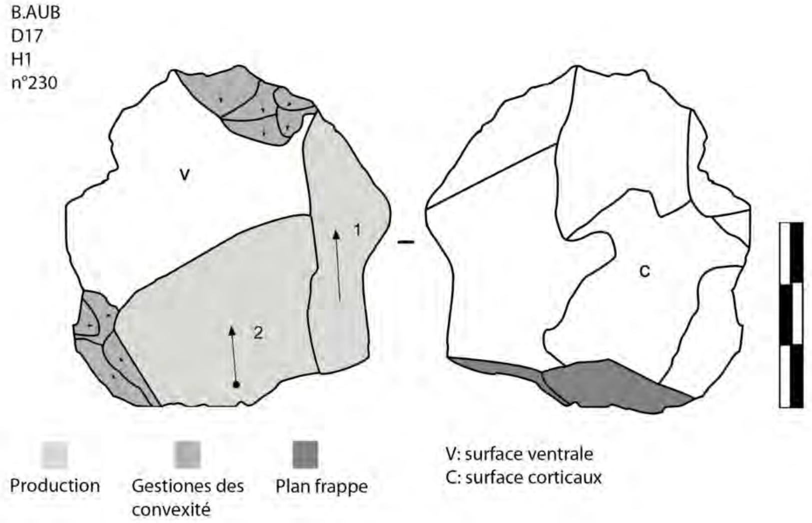
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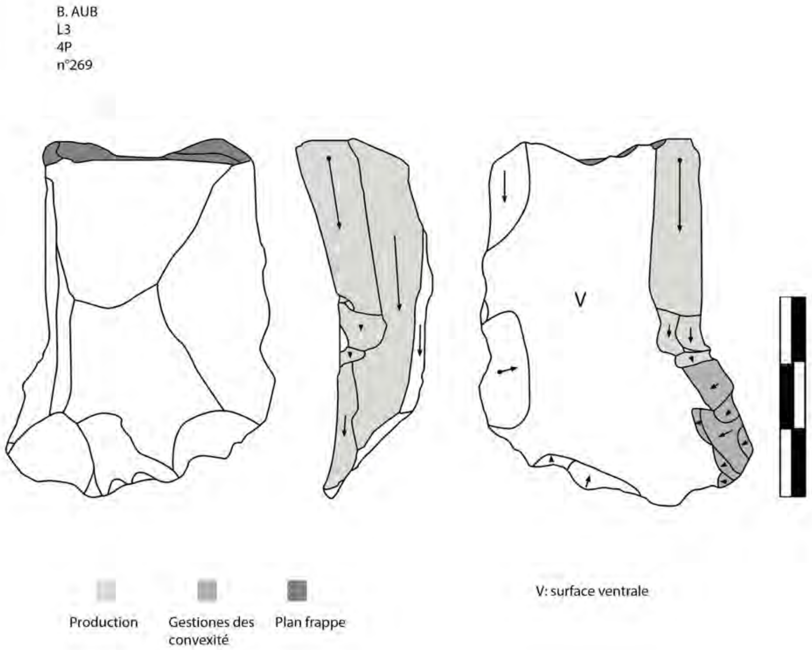
Plan frappe
V: surface ventrale
C: surface corticaux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Gestiones des convexité
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V: surface ventrale

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