



NON-FLINT RAW MATERIALS IN THE EUROPEAN MIDDLE PALAEOLITHIC: VARIABILITY OF LEVALLOIS AND DISCOID KNAPPING METHODS AND STUDY OF THE SUPPLY AREAS.

Sara Daffara

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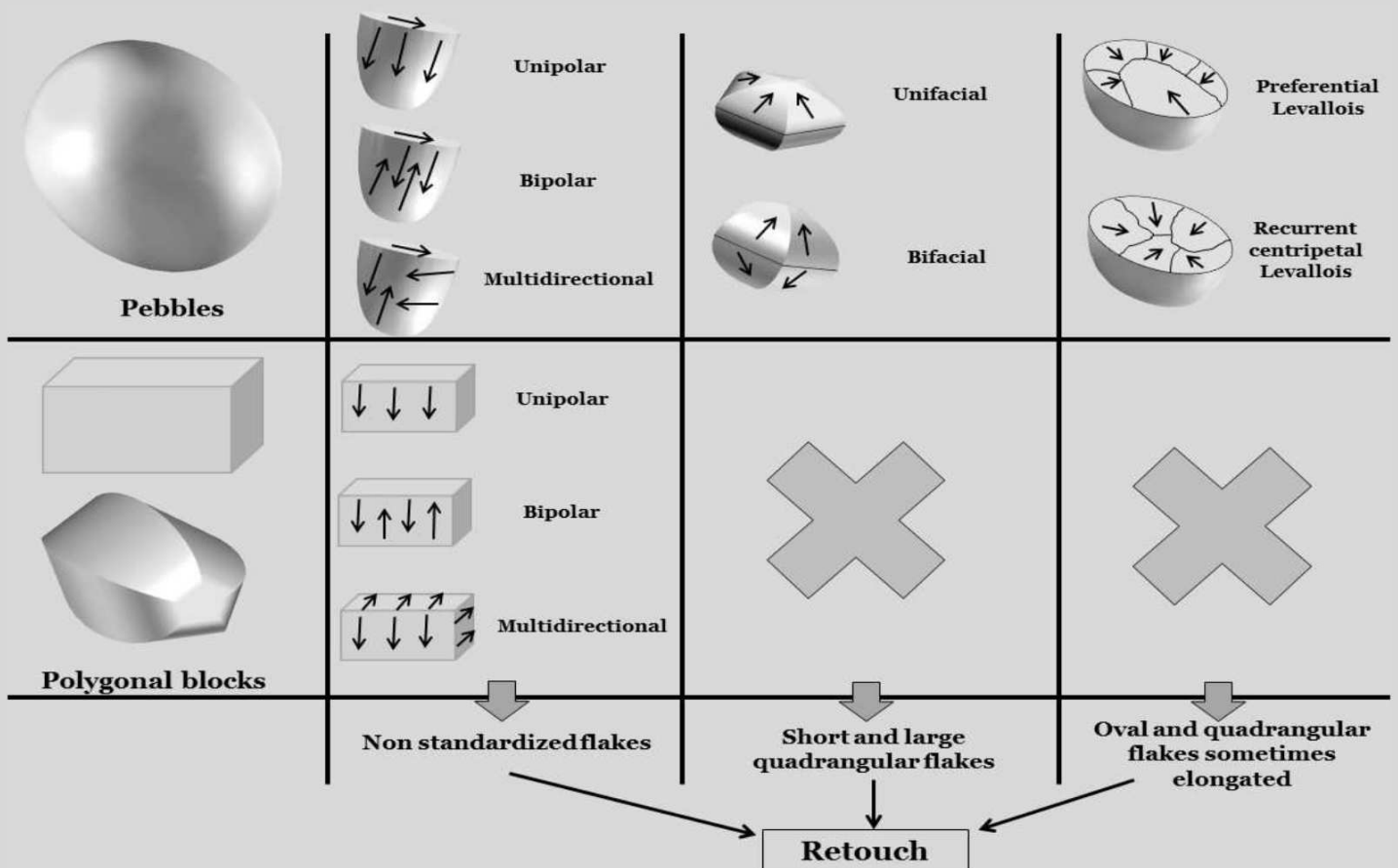
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Non-Flint Raw Materials In The European Middle Palaeolithic: Variability Of Levallois And Discoid Knapping Methods And Study Of The Supply Areas

SARA DAFFARA



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DOCTORAL THESIS

Supervised by
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**Tarragona
2018**

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Ferrara, February 14th, 2018

I STATE that the present study, entitled “Non-flint raw materials in the European Middle Palaeolithic: variability of Levallois and discoid knapping methods and study of the supply areas” presented by Sara Daffara for the award of the degree of Doctor, has been carried out under my supervision at the Department of Humanities of the University of Ferrara, at the Department of Prehistory of the Muséum national d’histoire naturelle de Paris and at the IPHES of the Universitat Rovira I Virgili. The thesis fulfils all the requirements to be eligible for the European Doctorate Award.

Doctoral Thesis Supervisor



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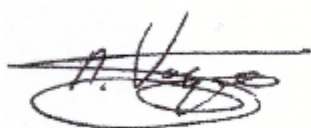


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SUMMARY

The proposed research focuses on the exploitation strategies of non-flint raw materials during Middle Palaeolithic in different European contexts. It is mainly aimed to observe how the Levallois and the discoid knapping methods have been applied and adapted to low quality raw materials.

Lithologies like vein quartz, quartzite, jasper, porphyry and other volcanoc, metamorphic and sedimentary rocks have always been considered as second-choice raw materials, used to produce lithic tools only where flint was missing or difficult to collect. Lithic industries realized on these kinds of raw materials have often been described as “primitive”, ascribing to a supposed technical inability of the knappers the results of a technological behaviour extremely adapted to the mechanical and petrographic characteristics of the lithic raw materials.

The research especially aims to point out any sort of adaptation to the physical and mechanical characteristics of the raw materials during the employment of the Levallois knapping method, both the lineal and the recurrent modalities, or of the discoid knapping method: i.e. the choice of pebbles with convexities suitable for this kind of exploitation or limited phases of shaping of the cores surfaces. The technological studies performed, also allow to make some considerations about the technological criteria defining Levallois and discoid knapping methods and the features that it is useful to consider distinguishing recurrent centripetal Levallois from discoid exploitation strategies.

To achieve the objectives of the present research, four Middle Palaeolithic European sites have been selected. All the sites share the presence in their lithic assemblages of vein quartz as main or complementary raw material and a significant presence of discoid and Levallois reduction sequences applied on different lithologies (vein quartz, quartzite, porphyry, syenite, flint and chert).

The first considered site is the Ciota Ciara cave, located in Piedmont, north-western Italy that present a huge lithic assemblage coming from four stratigraphic units (S.U. 13 – 892 artefacts; S.U. 103 – 430 artefacts; S.U. 14 – 4001 artefacts; S.U. 15 – 1787 artefacts). The main lithic raw material employed is vein quartz followed by a local variety of chert (spongolite) and by allochthonous good quality raw materials present just in some units and represented in the site mainly by finished tools. The upper level has already been subject to a

technological analysis and to the study of the supply areas of lithic raw materials. In the proposed research the entire lithic assemblage is considered both for the technological study and for the identification of the supply areas of raw materials not yet objects of the previous study. At today, the Ciota Ciara cave is the only Palaeolithic site of the region systematically excavated through a multidisciplinary approach while all the other evidence of a Middle Palaeolithic frequentation of the region come from unauthorized excavations and sporadic findings. For these reasons, the study of the lithic assemblage of the Ciota Ciara cave and the determination of the supply areas of lithic raw materials represents a fundamental starting point to understand the economic behaviour, the technical capabilities, and the modalities of land mobility of the Neanderthal groups that occupy the region during Middle Palaeolithic. Considering the lithic assemblage, the intense use of vein quartz not only for opportunistic reduction sequences but also to produce predetermined tools through Levallois and discoid methods, gives the chance to deeply analyse which adaptation strategies have been adopted for the exploitation of this raw material and also which technological criteria can be used to distinguish and identify these two knapping methods.

The second considered site is Payre, located in the middle Rhône valley and with a lithic assemblage that has been subject to several technological analyses which defined different aspects of the economic behaviour of the human groups that inhabited the site between MIS 8 and MIS 5. The present research focuses on the discoid reduction sequences on flint and vein quartz present in stratigraphic unit D (2315 artefacts), corresponding to the last phase of frequentation of the site. This is the only considered lithic assemblage where flint is the dominant raw material and vein quartz is the complementary one. In this way, we can not only make a comparison between the different raw materials at an intra-site level, but Payre level D also gives the chance to compare the discoid reduction sequences on flint to those of the lithic raw materials present in the other considered sites. Even if chronologically and geographically the considered sites are quite far from each other, a pure technological comparison can be made, and it is useful to better appreciate the technological variability caused by the employment of raw materials with so different petrographic and mechanical features.

Pedra Dreta and Can Garriga are two Middle Palaeolithic sites located in the Ter river valley, close to Girona and dated through the $^{230}\text{Th}/\text{U}$ method to OIS 5. Their lithic assemblages were studied through the Logical Analytical System soon after the end of the excavations, in the 90s. In this study we consider the lithic assemblages recovered during the systematic excavations that took place in 1991 (PD: 550 artefacts; CG: 283 artefacts) because the archaeological materials belonging to previous interventions lack a precise stratigraphic reference. In Can Garriga, the lithic assemblage analyzed corresponds to the artefacts coming from the archaeological Level 1. Level 2 and 3 are not considered since the lithic artefacts clearly referable to these archaeological levels are respectively 33 and 32. As for Payre level D, the focus of this new technological analysis are the Levallois and discoid reduction sequences that in Pedra Dreta and Can Garriga are applied on different lithologies: vein quartz, quartzite, porphyry and syenite. These lithic assemblages also give the chance to make some consideration on the concept of predetermination and on the technological criteria useful to identify the intention to produce predetermined tools in a context dominated by an opportunistic behaviour.

The technological analysis of the lithic assemblages from the Ciota Ciara cave (Italy), Payre – level D (France), Pedra Dreta and Can Garriga (Spain) is based on the concept of *chaîne opératoire*. For the technological analysis of each considered lithic assemblage an Access 2016 database has been realized, where, beside the general references of each piece (site name, stratigraphic unit, square, number), different technological features are considered. Concerning vein quartz, the subdivision in morpho-structural groups has been applied to see if a preferential choice was made for particular petrographic characteristics.

The study of the supply areas of lithic raw materials of the Ciota Ciara cave was performed in different phases: characterization of the lithologies present in the archaeological record through stereomicroscope observation, geological sampling, comparison between the geological samples and the archaeological materials through stereomicroscope observations and $\mu\text{-XRF}$ analysis. The results obtained for the Ciota Ciara cave allowed to determine the land mobility and the technological behaviour of the Middle Palaeolithic human groups that frequented the region. Beside an intense exploitation of local resources located

few hundred meters from the site, lithic raw materials were collected in a range of at least 30 km in a straight line from Monte Fenera.

The technological study performed on the considered lithic assemblages led to achieve interesting results concerning each context, the exploitation of non-flint raw materials and to general observations about the technological criteria useful for the identification of Levallois and discoid reduction sequences.

In the end of this study clearly appears that if it is undeniable that the quality of the raw materials and the morphologies of the natural blanks available strongly affect the choice of the knapping methods, it is evident that Middle Palaeolithic hunter-gatherers adapt technological concepts proper of their background to the resources available, showing great technological skills and the capability to practice complex adaptation strategies.

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INTRODUCTION

INTRODUCTION

The present research is the result of a three years' work carried out in different institutions: Universitat Rovira i Virgili and Institut Català de Paleoecologia Humana i Evolució Social (Tarragona, Spain), Università degli Studi di Ferrara (Ferrara, Italy), and Muséum national d'Histoire naturelle and Musée de l'Homme (Paris, France).

The aim of the proposed research is to deeply analyse one of the issues mainly discussed in the last years in the field of lithic technology: the modalities of exploitation of lithic raw materials different from flint, particularly for what concerns the application of the Levallois and the discoid technology, as defined by E. Boëda (1994, 1993), on vein quartz and other low-quality raw materials, thus evaluating the variability of these methods depending on technological expedients and adaptations to the raw material constraints. A consequent consideration is the identification of some technological criteria useful to define Levallois and discoid exploitation strategies and to distinguish between recurrent centripetal Levallois and discoid cores and products.

To fulfil the objectives of the research, four Middle Palaeolithic European sites have been selected: Ciota Ciara cave (Piedmont, Italy), Payre (Rhône valley, France), Pedra Dreta and Can Garriga (Girona, Spain). All the sites have lithic assemblages characterized by the exploitation of different lithic raw materials and only at Payre flint is dominant.

In Chapter 1 the objectives of the present research are presented in detail, followed by a state of the art concerning the definition of Levallois and discoid methods and the results of technological and experimental studies about vein quartz conducted in the last years to define reliable criteria for the analysis of vein quartz lithic artefacts.

In Chapter 2 are briefly described the main characteristics of the considered lithic assemblages and are exposed the reasons which led to the choice of that specific contexts. After the detailed description of the methodologies adopted for the technological analysis. As for the Ciota Ciara cave has been completed also a study about the supply areas of lithic

raw materials, part of chapter 2 is dedicated to the description of the laboratory analysis and of the field works conducted.

Chapter 3, 4 and 5 concern the technological study of the lithic assemblages from the Ciota Ciara cave, Pedra Dreta and Can Garriga, Payre – Level D. After each chapter a brief discussion of the results obtained has been included as well as an appendix with the diacritical scheme of Levallois and discoid cores. The study conducted on the lithic assemblage of the Ciota Ciara cave represents the first complete study of the site. Then the work presented here, beside focusing on the main aims of the research, also concerns the general technological study of the assemblage and presents the results of the analysis aimed at the identification of the raw materials supply areas. For the other considered sites, technological studies have already been completed, so in the present work attention was given to the Levallois and discoid component of the lithic assemblages. Chapter 4, concerning Pedra Dreta and Can Garriga, is structured as the paper recently submitted for publication to *L'Anthropologie* that includes also the results of the use-wear analysis performed on both the lithic assemblages (Berruti, 2017).

Chapter 6 concerns the discussion of all the results obtained from the different archaeological contexts considered and in Chapter 7 conclusive observations are reported. The last part of this work consists in two Appendix, the first showing the results of the laboratory analysis conducted on the archaeological and geological samples of the Ciota Ciara cave for the identification of the supply areas, the second presenting side-works conducted during this last three years.

CHAPTER 1

Objectives and State of the Art

CHAPTER 1

OBJECTIVES AND STATE OF THE ART

During the European Middle Palaeolithic, the use of several kind of lithic raw materials, other than flint, to produce tools is very well attested (e.g. Baena et al., 2012; Berruti et al., 2016; Berruti and Cura, 2016; Blaser et al., 2002; Carbonell et al., 2005; Cauche, 2007; Cologne et al., 2009; Cura, 2003; Cura and Grimaldi, 2009; de Lombera-Hermida et al., 2011; Degorce and Castel, 2006; Delagnes and Meignen, 2006; Delagnes and Rendu, 2011; Di Modica and Bonjean, 2009; Gibaja et al., 2002; Janot, 1988; Jaubert et al., 2005; Lamotte et al., 2014; Lazuén et al., 2011; Matilla, 2005; Menras, 2009; Moncel et al., 2014, 2013, 2008; Moncel and Daujeard, 2012; Moncel and Lhomme, 2007; Mora et al., 2004; Mourre et al., 2008; Mourre and Thiébaud, 2008; Nicoud, 2010; Ortega and Maroto, 2001; Rodríguez, 2004; Thiébaud et al., 2012; Tuffreau et al., 2009; Vallverdú et al., 2005). Even though, all the classical definitions in the field of lithic technology concerning knapping methods and techniques and tools' typology are mainly based on observations on flint lithic assemblages (e.g. Boëda, 1994, 1993; Bordes, 1961; Inizan et al., 1995; Tixier et al., 1980). So, since the dawn of the discipline, all the lithic raw materials different from flint were classified as “second rate raw materials”, and their technological study has been approached without considering their petrographic characteristics and their specific response to knapping (de Lombera-Hermida et al., 2011; de Lombera-Hermida and Rodríguez-Rellán, 2016; Mourre, 1996; Rodríguez-Alvarez, 2016). For example, the workability of vein quartz is limited by the presence of cleavage planes and internal flaws that determines its high rate of fragmentation and consequently the production of a lower quantity of suitable cutting edges per unit mass (Bordes, 1947; Tallavaara et al., 2010). For these reasons, the lithic assemblages where flint was absent or not predominant have been

described as rough or as belonging to underdeveloped cultures, i.e. the Alpine Mousterian (Battaglia, 1953; Lo Porto, 1957).

Just in recent years the attention of the researchers has been addressed toward raw materials different from flint to understand how they were exploited, which was their role in the techno-economic behavior of the Neanderthal groups and for which purposes they were exploited. This new attention is particularly evident concerning vein quartz and quartzite since they are raw materials widely diffused and employed in Middle Palaeolithic sites (e.g. Cologne and Murre, 2006; de Lombera-Hermida, 2009; Driscoll, 2011; Murre, 1996; Tallavaara et al., 2010).

Focusing the analysis on lithic assemblages where vein quartz and other raw materials different from flint are dominant or important complementary lithic resources, the main goals of the proposed research are: 1) to better understand how much and in which way their mechanical and petrographic properties affected the production of tools, especially in terms of organization and management of the reduction sequences; 2) when predetermined knapping methods (Levallois and discoid) are applied, the aim of the technological study is to understand how the traditional criteria defining these methods (Boëda, 1994, 1993; Peresani, 2003) are adapted to the raw material properties; 3) to contribute in the great current debate in lithic technology which concerns the existence or not of diagnostic criteria that could guarantee an unambiguous identification and distinction between discoid and Levallois cores and products, especially concerning the recurrent centripetal modality (e.g. Peresani, 2003). Indeed, unlike flint, vein quartz and other “second rate” raw materials are usually characterized by short reduction sequences (e.g. de Lombera-Hermida et al., 2011; Rodríguez-Alvarez, 2016), thus giving the chance to observe the entire exploitation of the cores, from the first removals to their abandonment. In other words, dealing with these raw materials and particularly focusing on vein quartz, we have the chance to observe in more detail which geometric and

volumetric criteria were looked for to obtain that products we classify as belonging to discoid or Levallois reduction sequences. Moreover, each of the considered assemblages, give the chance to make considerations about some important and debated concepts like predetermination and expedient or curated behaviour (e.g. Vaquero and Romagnoli, 2017)

1.1. Vein quartz and lithic technology

Quartz is one of the most diffused mineral on the earth and even if it is a very common raw material in several prehistoric site, it received just a few attention from the researchers (Bracco, 1997; de Lombera-Hermida et al., 2011). This is probably due to the general appearance of vein quartz lithic assemblages, typologically and morphologically less standardized than flint lithic industries for the tendency of quartz to fracture (de Lombera-Hermida and Rodríguez-Rellán, 2016; Driscoll, 2011; Mourre, 1996; Rodríguez-Alvarez, 2016). Moreover, stigma resulting from knapping are less visible on quartz flakes and cores, thus making the technological study more difficult, while the criteria based on the study of flint collections applied on quartz can create some confusion or uncertainties in classification (de Lombera-Hermida, 2009; Driscoll, 2011; Knutsson, 2014; Rodríguez-Alvarez, 2016).

The first technological studies on quartz lithic assemblages are those carried out in the 70s when the influence of the *New Archaeology* led to the development of studies based on “secondary” raw materials (Broadbent, 1973; Callahan, 1987; de Lombera-Hermida and Rodríguez-Rellán, 2016; Moloney et al., 1996; Sternke et al., 2009). Thanks to the studies conducted in those territories where quartz was dominant, like northern Europe or the north west of the Iberian peninsula, in recent years new technological and experimental approaches led to a better understanding of quartz lithic technology and technical criteria independent from those elaborated for flint are emerging (Bracco, 1997; de Lombera-

Hermida, 2009; de Lombera-Hermida et al., 2011; de Lombera-Hermida and Rodríguez-Rellán, 2016; Driscoll, 2011; Knutsson et al., 2015; Mourre, 1996; Rodríguez-Alvarez, 2016; Rodríguez-Rellán, 2016; Tallavaara et al., 2010). At today it is well-founded that the geological environment is not the only cause determining the use of quartz during Palaeolithic, but also other factors, like the general technological behaviour of the considered human groups, have to be taken into account (e.g. Bracco, 1997; de Lombera-Hermida et al., 2011; Martínez Cortizas and Llana Rodríguez, 1996; Mourre, 1996, 1994; Rodríguez-Alvarez, 2016)

A first important step in the understanding of quartz technology was made when it was no more considered as an homogeneous raw material, classified according to its appearance, opacity and colouring (de Lombera-Hermida et al., 2011; de Lombera-Hermida and Rodríguez-Rellán, 2016; Rodríguez-Rellán, 2016). This classification does not consider its petrographic characteristics and its modalities of formation and therefore it does not allow to gather any information about criteria of selection of the raw material depending on technological or functional needs (Ballin, 2008; de Lombera-Hermida et al., 2011; Llana Rodríguez, 1991). Moreover, these kind of classifications, still diffused among archaeologists, are subjective and difficult to replicate (Rodríguez-Rellán, 2016).

The most recent studies about quartz lithic industries are based upon a precise knowledge about quartz formation processes (temperature, pressure, host rock, chemical solution) that determine the presence of cleavage plans, the dimension of the crystals and therefore the response to knapping and the characteristics of the lithic tools (Bons, 2001; Collina-Girard, 1997; de Lombera-Hermida et al., 2011; de Lombera-Hermida and Rodríguez-Rellán, 2016; Driscoll, 2011; Knutsson, 2014; Martínez Cortizas and Llana Rodríguez, 1996). Thanks to this new approach, the variability and complexity of vein quartz lithic assemblages is known, and quartz is no more considered just as a secondary raw material used only in the absence of flint. The application on quartz of complex reduction

sequences (i.e. Levallois method), led to understand the high technological and behavioural complexity of the Palaeolithic human groups who had a great knowledge of the lithic raw materials, of their availability on the territory and who developed technical and adaptive strategies to the lithic resources and to the surrounding environment (de Lombera-Hermida and Rodríguez-Rellán, 2016).

1.2. The Levallois method

The appearance of the Levallois knapping method is considered to be the technological innovation that marks the beginning of Middle Paleolithic in Eurasia (Adler et al., 2014; Peretto et al., 2016). The first identification and definitions of this knapping method date back to the end of the XIXth and the beginning of the XXth century, when the term Levallois was introduced in the study of lithic assemblages at first to indicate “very long and wide flakes, ovoid in shape, nice pieces with clear ridges which are the largest of their epoch” (De Mortillet, 1883) and later to refer to cores with an accurate bifacial preparation and a faceted striking platform (Commont, 1909).

F. Bordes, in the 60s, is the first scholar who based his definition of the Levallois method on his own flintknapping experience and he is also the first one who refers to Levallois as a method for producing flakes with predetermined morphologies, even if he did not clearly define useful criteria for the identification of Levallois products (Bordes, 1961, 1947). Another technological perspective on Levallois *débitage* is that of H. Kelley who underlines the importance of the angle between the striking platform surface and the knapping surface (Kelley, 1954).

However, it is just in the 80s and in the 90s with the works of E. Boëda (Boëda, 1995, 1994, 1993, 1991; Boëda et al., 1990; Boëda and Pelegrin, 1980) that a precise technological definition of the Levallois method is achieved. He describes six criteria which are

characteristics of the Levallois method (Fig. 1.1) and that distinguish it from the other knapping methods (Boëda, 1995, 1994):

1. the volume of the core is conceived as two asymmetrical convex secant surfaces which intersection defines a plane;
2. the two surfaces are organized hierarchically: one is conceived to produce predetermined blanks; the other is conceived as a striking platform. During a single production sequence their roles cannot be reversed;
3. the flaking surface is prepared in such a way that the products obtained are predetermined. The technical criteria of predetermination consist in the maintenance of the lateral and distal convexities that serve to direct the shock wave of each predetermined blank;
4. the fracture plane of the predetermined blanks is parallel to the plan of intersection of the two surfaces;
5. the striking platform surface is prepared in such a way that the predetermining and predetermined blanks respond to fixed objectives; the maintenance of this surface depends on the method chosen for the detachment of predetermined blanks, but they always share one characteristic: the surface of the striking platform which is to receive the percussion for the removal of a predetermined blank is oriented, in relation to the flaking surface, so that the line created by the intersection of these two surfaces (hinge) is perpendicular to the flaking axis of the predetermined blank;
6. the only technique employed is the direct percussion by hard hammer.

According to E. Boëda (1994), even if the concept of predetermination is fundamental in the definition of the Levallois method, its originality in comparison with other knapping methods, relies in the synergy between predetermination and the other technical criteria listed above, typical of Levallois, that together define a specific volumetric conception of the core and imply particular rules in core management.

The Levallois method consists of different modalities of production of predetermined blanks, differentiated by the use of the exploitable volume to produce one or several flakes (Boëda, 1995, 1994). The goal of the preferential Levallois method (Fig. 1.2) is to produce a single predetermined flake for each prepared flaking surface. To produce another predetermined blank, it is necessary to restore the lateral and distal convexities of the flaking surface and to set up again the surface of the striking platform (Boëda, 1995, 1994).

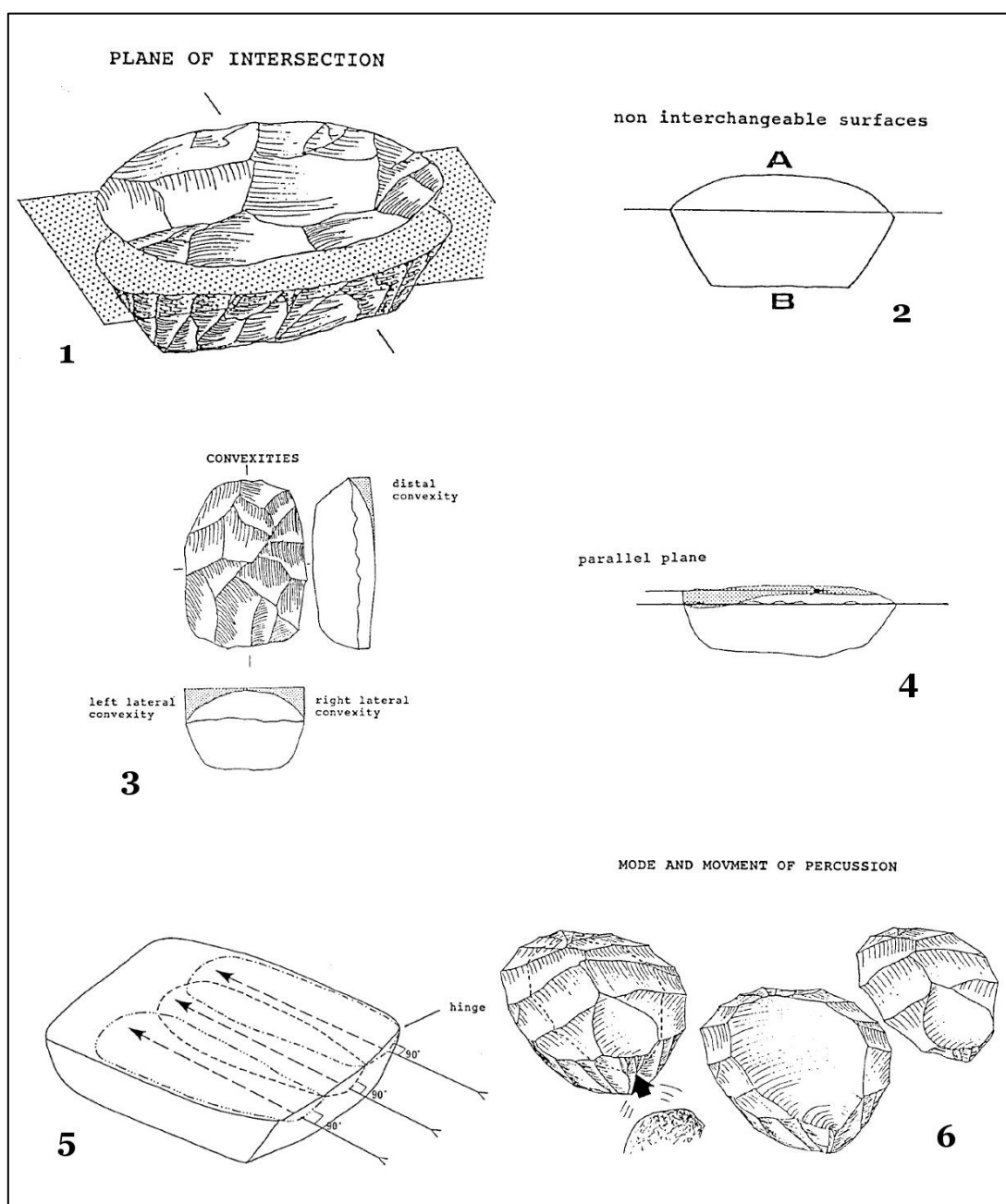


Fig. 1.1. Six technical criteria define the Levallois method: volume of the core shaped in two asymmetrical convex secant surfaces which intersection defines a plane (1); surfaces hierarchized (2); distal and lateral convexities of the flaking surface (3); fracture plan parallel to the plan of intersection of the two surfaces (4); axes of percussion perpendicular to the hinge (5); direct percussion by hard hammer (6). (Modified from Boëda, 1995)

The second modality includes the recurrent Levallois methods (Fig. 1.3 and 1.4) where the flaking surface is exploited to produce a series of predetermined blanks. In this case, each removal is predetermined and predetermining, since their detachment prepares the necessary convexities for the production of the next predetermined blank (Boëda, 1995, 1994). In the recurrent modality, depending on the wanted morphological features desired for the blanks, the flaking surface is managed in different ways, thus leading to the distinction of a recurrent unipolar modality (Fig. 1.4), a recurrent bipolar modality (Fig. 1.4) and a recurrent centripetal modality (Boëda, 1995, 1994) (Fig. 1.3).

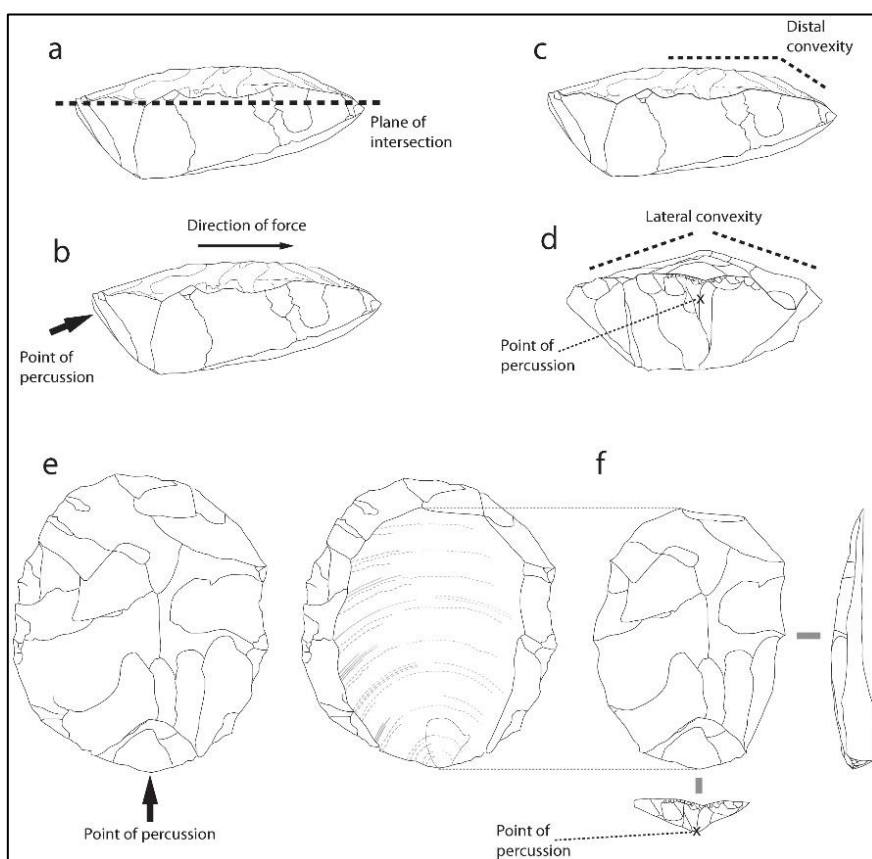


Fig. 1.2. Preferential Levallois (from Eren and Lycett, 2012)

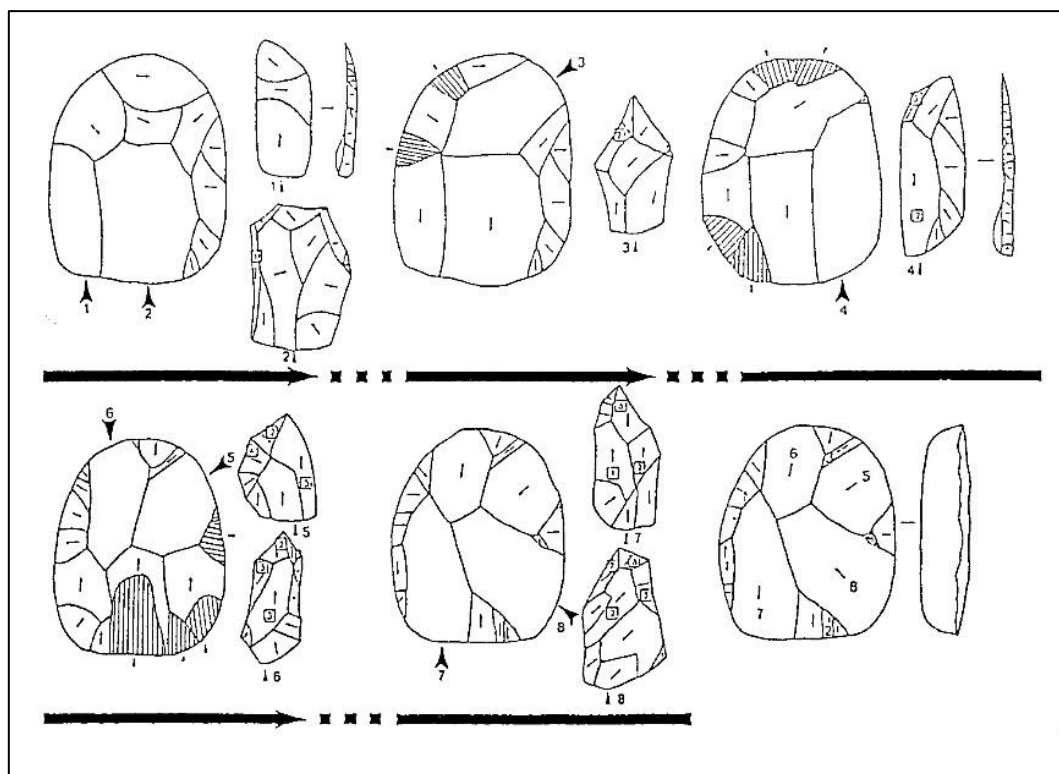


Fig. 1.3. Recurrent centripetal Levallois (from Boëda, 1994)

All the Levallois methods are characterized by a discontinuous rate of production of predetermined blanks, since both in the preferential and in the recurrent modalities, after the removal of one or of a series of predetermined flakes, the surface needs to be reshaped to restore the necessary convexities.

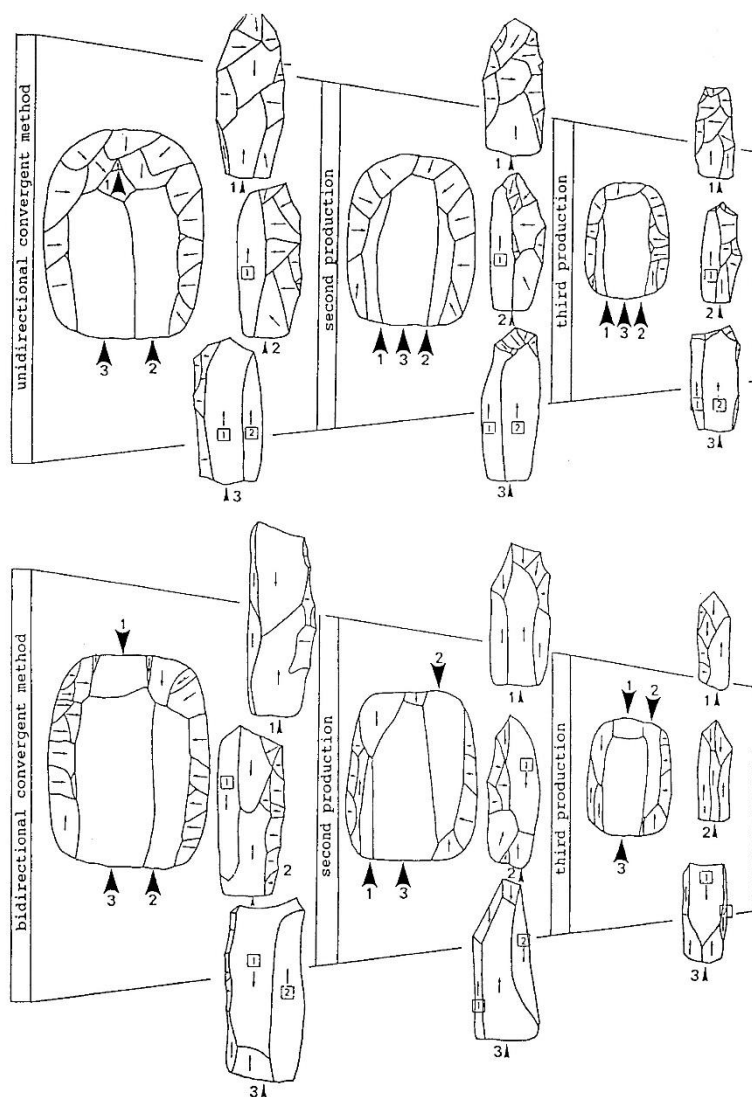


Fig. 1.4. Recurrent unipolar Levallois (top) and recurrent bipolar Levallois (bottom) (from Boëda, 1994).

Since the beginning of the studies about Levallois technology, great attention has been paid to the Levallois cores and to the identification of their modalities of exploitation and management of their volumetric criteria (Boëda, 1995, 1994, 1993; Bordes, 1980; Brantingham and Kuhn, 2001). To a lesser extent, the attention of the researchers has been focused on the problems of the identification of the Levallois products. In recent years, the development of geometric morphometrics studies seems to have helped in the definition of some general features specific of the Levallois predetermined products: in comparison to blanks obtained from other knapping methods, they appear to be characterized by a moderate thickness distributed across the cross-section and by a

greater general symmetry (e.g. Eren and Lycett, 2012). Even though, as E. Boëda already pointed out in his works (Boëda, 1995, 1994), products with similar morphological characteristics can be obtained through different methods and just a technological analysis conducted through a careful interpretation of the negatives visible on the dorsal face of the flakes and of all the other visible technological features permits to determine to which method the considered product belongs to.

The definition of the Levallois method and of the six technological criteria characterizing it, had a great impact on the researches in lithic technology, and shortly afterwards many debates arose concerning the discreteness of the method, the methodology of technological analysis and its variability (Chazan, 1997; Dibble and Bar-Yosef, 1995). Particularly interesting for the aims of the proposed research, is the issue raised by different scholars during the conference held in 1993 about “*The definition and interpretation of Levallois Technology*” and concerning whether a method that does not involve a shaping of the core, but where the cores are chosen among nodules that naturally have the shape of a Levallois core, fits under the definition of Levallois (Chazan, 1997; Dibble and Bar-Yosef, 1995). As it is known, when lithic raw materials different from flint are involved, the use of natural surfaces and convexities is much more frequent, even for predetermined methods, and avoiding phases of core preparation is a technical expedient often put into action to reduce the occurrence of knapping accidents (de Lomberra-Hermida and Rodríguez-Rellán, 2016; Moncel et al., 2008b; Mourre, 1996; Rodríguez-Rellán, 2016).

1.3. The discoid method: definitions and open issues

The discoid method owes its name to the shape of the cores and it was defined for the first time by F. Bordes (Bordes, 1961) who provided a brief description of its technical features defined in comparison with the Levallois method. According to his definition, the discoid

method is characterized by a continuous rate of production of predetermined products according to a centripetal *débitage* direction and obtained from one or both the core surfaces (Fig. 1.5). The discoid method was at that time conceived both as a separate operative scheme and as the final stage of exploitation of Levallois cores (Bordes, 1961) but there was not a clear distinction between the two methods, particularly concerning the recurrent modalities of the Levallois method that were considered to be as discoid reduction sequences (Boëda, 1993; Bordes, 1961).

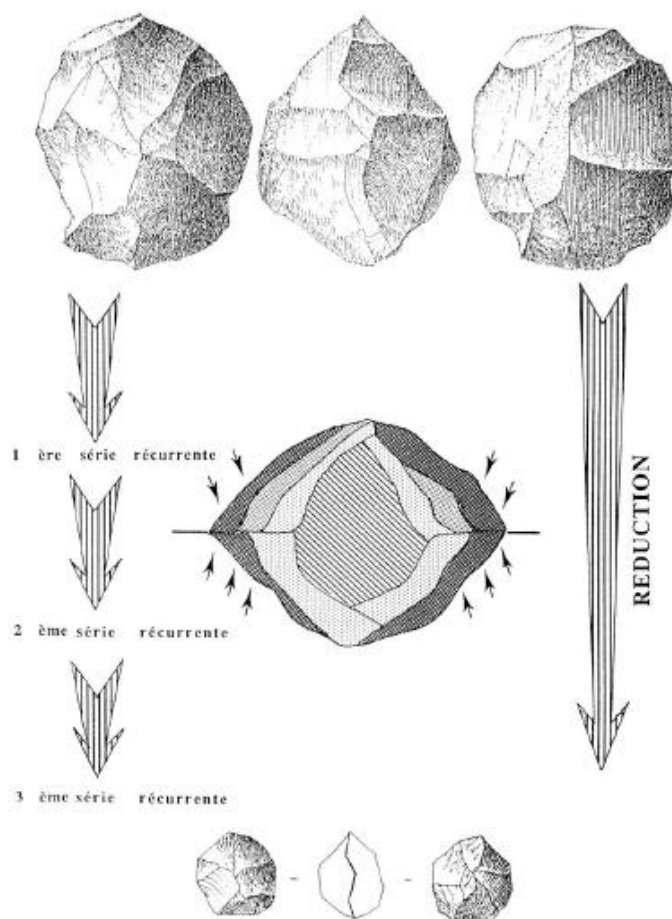


Fig. 1.5. Scheme of a discoid reduction sequence (Boëda, 1993).

Just in the 90s, E. Boëda recognizes the discoid method as a distinct flaking method with its own concept of volumetric predetermination (Boëda, 1993).

As for the Levallois method, E. Boëda lists six technical criteria that define the discoid method and underlines the differences between the Levallois and the discoid conception of exploitation (Fig. 1.6):

1. the volume of the core is conceived as two asymmetrical secant surfaces which intersection defines a plane;
2. the two surfaces are not hierarchized. During the reduction sequence, each of them can be the striking platform surface or the *débitage* surface;
3. the *débitage* surface is prepared in such a way that some of the obtained products are predetermined. The technical criteria of predetermination consist in the preparation of a peripheric convexity that is needed to control the lateral and distal removal of each predetermined blank;
4. the striking platform surface is prepared in such a way that the predetermined and predeterminant removals could correspond to the fixed objectives;
5. the plan of detachment of the predetermined and predeterminant products is secant as regard to the plan of intersection of the two surfaces;
6. the only technique employed is the direct percussion by hard hammer.

The great difference between Levallois and discoid methods is in the volumetric conception of the core: a discoid core is conceived as a volume able to provide an uninterrupted series of removals and the entire volume is exploitable; for a Levallois core, regardless the preferential or the recurrent modality chosen, the exploitable volume is limited to the volume included between the knapping surface and the plan of intersection of the two core surfaces. This is the reason E. Boëda proposes to refer to the Levallois method as a surface exploitation and to the discoid method as a volume exploitation (Boëda, 1994, 1993).

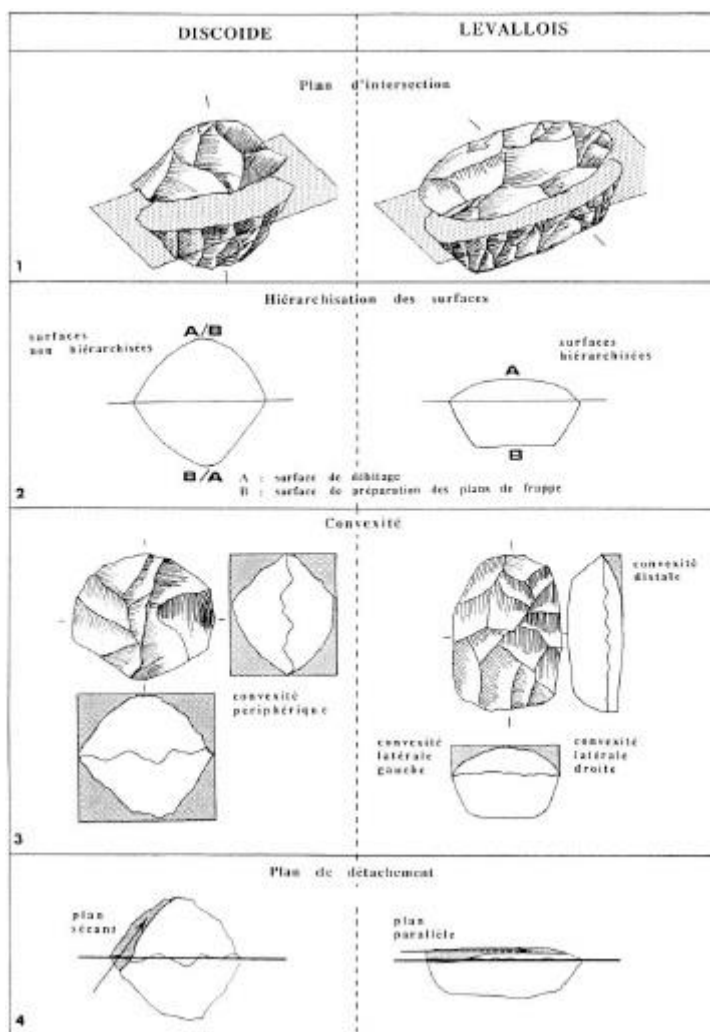


Fig. 1.6. Technical criteria defining the discoide and the Levallois reduction sequences (Boëda, 1993).

Discoide predetermined products are classifiable in four categories according to the direction of *débitage* (Fig. 1.7): pseudo-Levallois points and debordant flakes, issued from a cordal direction, and quadrangular flakes or flakes larger than long issued from a centripetal direction (Boëda, 1993). The removals in cordal direction are necessary for the maintenance of the peripheral convexity, while centripetal removals are needed to avoid the formation of a too pronounced convexity on the core surfaces (Boëda, 1993).

In general, all the obtainable products are characterized by an high average thickness and by a good aptitude for being handle (Lemorini et al., 2003).

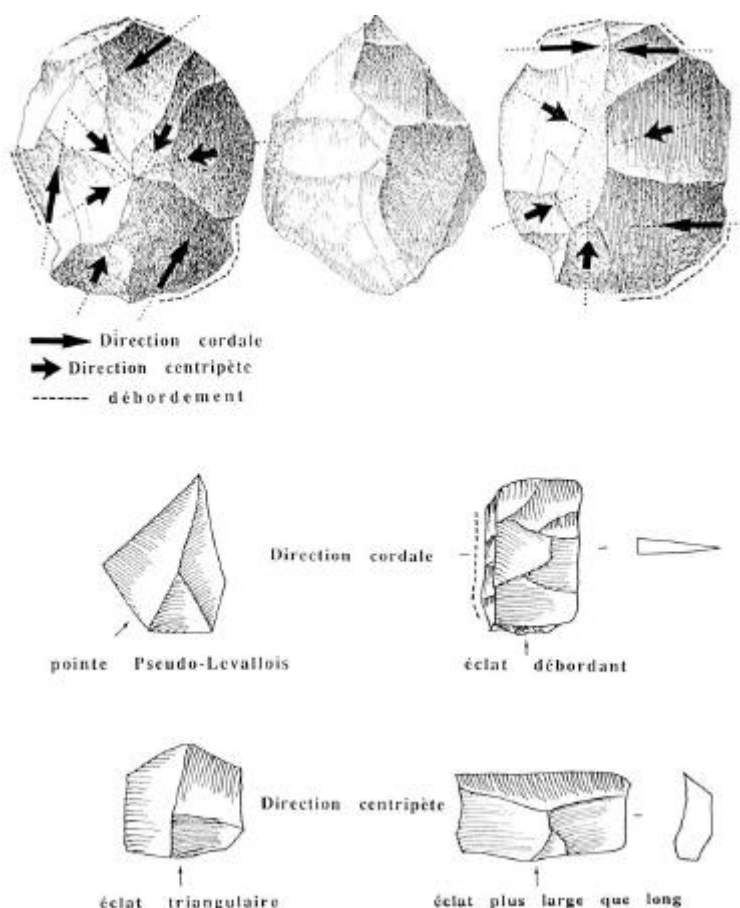


Fig. 1.7. Discoid products obtained from a centripetal or a cordal *débitage* direction (Boëda, 1993).

Even if E. Boëda (1994) strongly affirms that no confusion is possible between a discoid and a recurrent centripetal Levallois core since each core is the result of an operational scheme ruled by specific criteria and therefore it cannot present characteristics belonging to other operational schemes, a great debate arose concerning the variability of the discoid method and its distinction from the recurrent centripetal Levallois (e.g. Peresani, 2003). This debate is still an open issue and it concerns different aspects, from the technological definition of the methods to the economic and/or behavioral reasons that lead to the production of discoid rather than to Levallois flakes, more recently with the contribution of some use-wear studies focusing on the functional difference between Levallois and discoid products (Berruti, 2017; Brenet et al., 2013, 2009, Eren and Lycett, 2016, 2012, Kuhn, 1994, 1992; Lemorini et al., 2003; Mourre, 2003; Picin et al., 2014; Picin and

Vaquero, 2016; Slimack, 2003; Terradas, 2003; Vaquero et al., 2015, 2012; Vaquero and Carbonell, 2003).

The great variability observed in the archaeological record led to a strong criticism toward binding and strict definitions and the six criteria listed by E. Boëda (1993) have been object of several studies (Mourre, 2003; Slimak, 2003; Terradas, 2003). Generally, this kind of analysis reach the conclusion that just a few of the six criteria are diagnostic to distinguish between discoïd and recurrent centripetal Levallois reduction sequences and the effectiveness of each criteria depend on specific characteristics in each archaeological context (Peresani, 2003). As observed by Baena-Preysler et al. (2003), many factors can contribute to the variability of the discoïd method, such as site function, skills, composition of the human group, raw materials employed and many other inestimable elements together with the fact that in an exhausted core a great variety of technical intentions can converge.

For all these reasons, current studies in lithic technology include the discoïd knapping concept in the great group of centripetal *débitage* recognizing, in the variability of the method, some overlapping with the Levallois concept (Fig. 1.8) that can occur at different stages of the reduction sequence and for technical and behavioral reasons difficult to estimate (Mourre, 2003). To avoid misunderstandings, some scholars propose to distinguish two modalities in the discoïd method: *sensu lato*, in which the objectives are varied and *sensu stricto*, in which the reduction sequence focuses on the production of pseudo-Levallois points and core-edge removal flakes (Mourre, 2003; Picin and Vaquero, 2016).

In general, most of the researchers agrees upon the general conclusion that the identification of discoïd reduction sequences and the recognition of its variability has to be based not on a typological approach to each single core or flake, but on the study of the

entire lithic assemblages in the attempt to reconstruct all the reduction sequences applied (Boëda, 1993; Pasty, 2003; Slimak, 2003; Vaquero and Carbonell, 2003).

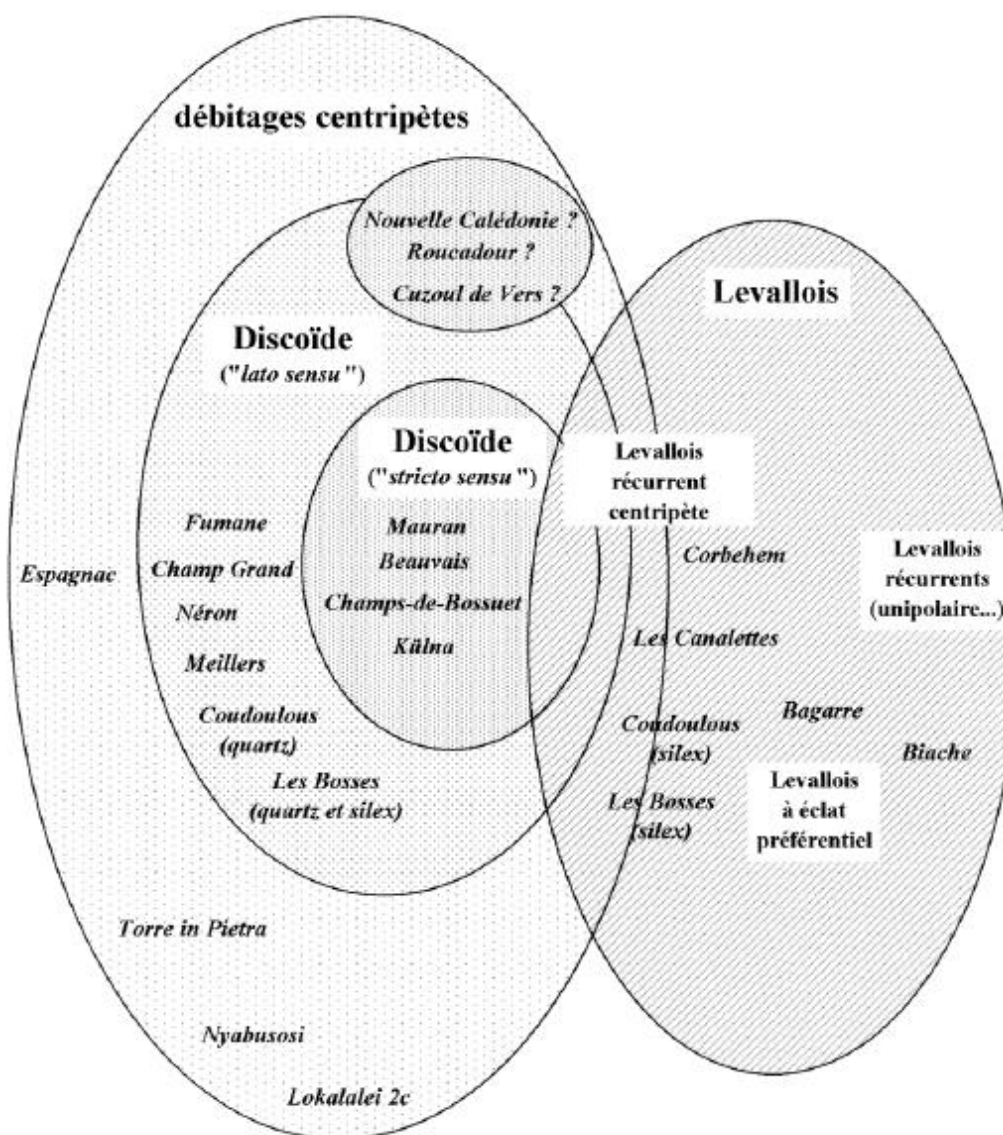


Fig. 1.8. Relationship between different kind of centripetal *débitages* (Mourre, 2003).

The present research is intended to be focused on one aspect of the debate about the discoïd *débitage* that concerns the respect and the application of the volumetric and technical criteria of the discoïd method defined by E. Boëda (1993) to different low-quality lithic raw materials (Arzarello et al., 2012a; Cura and Grimaldi, 2009; Daffara et al., 2014; Di Modica and Bonjean, 2009; Rosina and Cura, 2010), trying to understand if the

employment of the discoid method was an intentional choice or it was more likely an expeditive behaviour conditioned by the quality of the raw materials, their availability and by the dimension and morphology of the blanks collected to be discoid cores.

CHAPTER 2

Materials and Methods

CHAPTER 2

MATERIALS AND METHODS

To achieve the objectives of the present research, four Middle Paleolithic European sites have been selected (Fig. 2.1 and Tab. 2.1.). All the sites share the presence in their lithic assemblages of vein quartz as main or complementary raw material and a significant presence of discoid and Levallois reduction sequences applied on different lithologies (vein quartz, quartzite, porphyry, syenite, flint and chert).



Fig. 2.1. Sites locations: Ciota Ciara cave (1) – Piedmont, Italy; Payre (2) - Rhône valley, France; Pedra Dreta (3) and Can Garriga (4) – Ter river basin, Spain.

The first considered site is the Ciota Ciara cave, located in Piedmont, north-western Italy that present a huge lithic assemblage coming from four stratigraphic units (13 – 892 artefacts; 103 – 430 artefacts; 14 – 4001 artefacts; 15 – 1787 artefacts). The main lithic raw material employed is vein quartz followed by a local variety of chert (spongolite) and by allochthonous good quality raw materials present just in some units and represented in the site mainly by finished tools. The upper level has already been subject to a technological analysis and to the study of the supply areas of lithic raw materials.

(Arzarello et al., 2012a; Berruto, 2011; Daffara et al., 2014). In the proposed research the entire lithic assemblage is considered both for the technological study and for the identification of the supply areas of raw materials not yet considered by the previous study. At today, the Ciota Ciara cave is the only Palaeolithic site of the region systematically excavated through a multidisciplinary approach while all the other evidence of a Middle Palaeolithic frequentation of the region come from unauthorized excavations and sporadic findings. For these reasons, the study of the lithic assemblage of the Ciota Ciara cave and the determination of the supply areas of lithic raw materials represents a fundamental starting point to understand the economic behaviour, the technical capabilities, and the modalities of land mobility of the Neanderthal groups that occupy the region during Middle Palaeolithic. Considering the lithic assemblage, the intense use of vein quartz not only for opportunistic reduction sequences but also to produce predetermined tools through Levallois and discoid methods (Boëda, 1994, 1993), gives the chance to deeply analyse which adaptation strategies have been adopted for the exploitation of this raw material and also which technological criteria can be used to distinguish and identify these two knapping methods.

The second considered site is Payre, located in the middle Rhône valley and with a lithic assemblage that has been subject to several technological analysis (e.g. Baena et al., 2017; Bouteaux et al., 2008; Carmignani et al., 2017; Moncel et al., 2009, 2008; Moncel and Chacon, 2007) which defined different aspects of the economic behaviour of the human groups that inhabited the site between MIS 8 and MIS 5 (Masaoudi et al., 1997; Valladas et al., 2008). The present research focuses on the discoid reduction sequences on flint and vein quartz present in stratigraphic unit D (2315 artefacts), corresponding to the last phase of frequentation of the site. This is the only considered lithic assemblage where flint is the dominant raw material and vein quartz is the complementary one. In this way, we can not only make a comparison between the different raw materials at an intra-site level,

but Payre level D also gives the chance to compare the discoid reduction sequences on flint to those of the lithic raw materials present in the other considered sites. Even if chronologically and geographically the considered sites are quite far from each other, a pure technological comparison can be made and is useful to better appreciate the technological variability caused by the employment of raw materials with so different petrographic and mechanical features.

Pedra Dreta and Can Garriga are two Middle Palaeolithic sites located in the Ter river valley, close to Girona and dated through the $^{230}\text{Th}/\text{U}$ method to OIS 5 (Garcia Garriga, 2015; Giralt et al., 1995). Their lithic assemblages were studied through the Logical Analytical System (Carbonell et al., 1983; Eudald Carbonell et al., 1992; Carbonell and Rodríguez, 2002) soon after the end of the excavations (Rodríguez, 2004; Rodríguez et al., 1995). In this study we consider the lithic assemblages recovered during the systematic excavations that took place in 1991 (PD: 550 artefacts; CG: 283 artefacts) because the archaeological materials belonging to previous interventions lack a precise stratigraphic reference. In Can Garriga, the lithic assemblage analyzed corresponds to the artefacts coming from the archaeological Level 1. Level 2 and 3 are not considered since the lithic artefacts clearly referable to these archaeological levels are respectively 33 and 32. As for Payre level D, the focus of this new technological analysis are the Levallois and discoid reduction sequences that in Pedra Dreta and Can Garriga are applied on different lithologies: vein quartz, quartzite, porphyry and syenite. These lithic assemblages also give the chance to make some consideration on the concept of predetermination and on the technological criteria useful to identify the intention to produce predetermined tools in a context dominated by an opportunistic behaviour.

Site	Considered archaeological layers	Chronology	Raw materials	N° of lithic artefacts
Ciota Ciara cave (Piedmont, Italy)	SS.UU. 13, 14, 15, 103	debated chronology between ~ 100 and 300 Ka BP	Vein quartz Spongolite Flint Radiolarite Rhyolite Opal Jasper Milonite Metamorphic rock	7106
Can Garriga (Gerona, Spain)	Layer 1	between 103.5 ± 3.2 Ka and 87.7 ± 2.5 Ka	Vein quartz Quartzite Porphyry Syenite Hornfels Sandstone Metamorphic rock Granite Limestone Diorite Lydite Basalt	283
Pedra Dreta (Gerona, Spain)	Layer 1	between $88,2 \pm 4$ Ka BP and 92 ± 4 Ka BP	Vein quartz Syenite Quartzite Porphyry Flint Hornfels Limestone Basalt Gneiss Metamorphic rock Schist	550
Payre (Rhône valley, France)	Level D	OIS 5e	Vein quartz Flint	2315

Tab. 2.1. Archaeological sites considered in the proposed research with indication of archaeological layers analysed, chronology, lithic raw materials present, and number of lithic artefacts present in the lithic artefacts.

2.1. Technological study

The technological analysis of the lithic assemblages from the Ciota Ciara cave (Italy), Payre – level D (France), Pedra Dreta and Can Garriga (Spain) is based on the concept of *chaîne opératoire*, defined for the first time in France during the '50 and that includes all the technical procedures necessary to complete a single project, conceived to satisfy specific needs and implemented by the knapper according to its own skills (Geneste, 1991; Leroi-Gourhan, 1964; Pelegrin et al., 1988; Tixier, 1978). According to this approach, each step of production of the lithic tools is identified and positioned in time and space, from the collecting of the raw material to its discard after use. During the technological study of the considered lithic assemblages, a first level of analysis has been the technological interpretation of each object (core, flake, retouched tool, debris) to place it within the *chaîne opératoire*. A second and complementary level has been the identification of the relationships among the different objects of the *chaîne opératoire*.

Two more concepts are the basis of the present technological analysis: i.e. knapping technique and method, distinguished by J. Tixier in 1967 (Inizan et al., 1995; Pelegrin, 2000; Tixier, 1967). Technique is defined as the physical action that causes the detachment of a flake from the core and it includes: the way the force is applied, the kind of object employed, the gesture and body orientation, the core management. Each technique is recognisable thanks to diagnostic marks visible on the flakes (Inizan et al., 1995; Pelegrin, 2000; Tixier, 1967). The method is the organisation of the reduction sequence, the series of actions done to achieve the objective by applying a conceptual scheme (Tixier, 1967). The identification of the methods is based on the analysis of the entire lithic assemblage, focusing on diagnostic elements and skipping those that are ubiquitous and that can be generated by different methods (Inizan et al., 1995; Pelegrin, 2000).

For the technological analysis of each considered lithic assemblage an Access 2016 database has been realized (Fig. 2.2), where, beside the general references of each piece (site name, stratigraphic unit, square, number), different technological features are considered. At first for each artefact is determined the raw material, the presence or not of post-depositional alterations, the dimensions (length, width, thickness) and if it is a flake, a core, or a debris. For flakes the knapping technique has been identified through the analysis of the stigmata present on the butt and on the ventral face (impact point, ripples, hackles) even if, due to the raw materials employed, these stigmata are not always readable. Particularly for vein quartz, we referred to specific works about the identification of the knapping stigmata and on its rate and modalities of fragmentation (Cologne and Mourre, 2006; de Lomberra-Hermida, 2009; Di Modica and Bonjean, 2009; Driscoll, 2011; Manninen, 2016; Mourre, 1996, 1994; Tallavaara et al., 2010). The technological criteria and the methodology adopted for the study of vein quartz objects are detailed in the following paragraph. Concerning the other raw materials (porphyry and syenite in particular), since specific experimental works about the formation of knapping stigmata are not yet available, we referred to the general technical criteria listed above.

The screenshot shows an Access 2016 database window titled "Litica_monfenera : Database- C:\Users\admin\Documents\IDQP\Ciota Ciara\Litica_monfenera.mdb (formato file di Access 2002 - 2003) - Access". The main form is titled "Maschere" and "Litica monfenera". The form contains the following fields and options:

- ID: 7159
- Sito: Ciota Ciara Atrio
- Data: [Empty]
- US: [Empty]
- Qc: [Empty]
- N: [Empty]
- Tallone: [Empty]
- Bulbo: [Empty]
- Onde: [Empty]
- Integrità: [Empty]
- Direzione dei negativi: [Empty]
- Metodo: [Empty]
- Debordante:
- Tipo debordamento: [Empty]
- Scheggia riflessa:
- Scheggia sorpassata:
- Syret:
- Tipo di frattura: [Empty]
- Tipo strumento: [Empty]
- Materia prima: [Empty]
- Alterazioni di superficie: [Empty]
- Lunghezza: [Empty]
- Cortice: [Empty]
- Larghezza: [Empty]
- Tecnica: [Empty]
- Spessore: [Empty]
- SS:
- SN:
- Scheggia:
- Nucleo:
- Debris:
- NS:
- NN:
- descrizione ritocco: [Empty]
- Osservazioni: [Empty]

At the bottom, it shows "Records: 1 of 7144 of 7144" and "Nessun filtro".

Fig. 2.2. Access 2016 database. Example of worksheet for the record of the technological data of the lithic artefacts from the Ciota Ciara cave. The same procedure of data collecting has been used for all the sites considered in the present research.

Then, for each flake, have been considered the characteristics of the butt (natural, flat, dihedral, faceted, linear, pointed), the bulb pronounced or not, the integrity (complete/incomplete flake, proximal/distal/lateral/mesial fragment), the visibility of the ripples, the direction of the negatives on the upper face, the presence and the position of natural surfaces (cortex/neocortex), the presence and the kind of knapping accidents (siret knapping accident, fractures perpendicular to the *débitage* axe, hinged flake, plunging flake). The retouched tools have been classified according to the typological list developed by F. Bordes (1961) while the description of the retouch refers to the work of L.M. Inizan et al. (1995) and it is based on the criteria of position, localization, distribution, delineation, extent, angle and morphology.

The direction of the negatives on the upper face of the flakes and the presence and position of the cortex have been used to identify the knapping methods and the development of cores reduction. The definition of each method is based on the works of H. Forestier (1993) for S.S.D.A. (*Système par surface de débitage alterné*) reduction sequences and on the works of E. Boëda (1994, 1993) for the Levallois and the discoid methods. Concerning these last two methods other more recent works about their definition and variability have been taken into account (e.g. Di Modica and Bonjean, 2009; Peresani, 2003, 1998; Picin et al., 2014; Picin and Vaquero, 2016; Romagnoli et al., 2016).

For Levallois, discoid and centripetal cores (i.e. cores with few centripetal detachments not recognizable as discoid or Levallois cores) from each site, a diacritical scheme (Dauvois, 1976) has been realized to define all the steps of flake production and shaping of the core. Since for the Ciota Ciara cave the one proposed in this work is the first complete technological study, also the most representative opportunistic/S.S.D.A. cores have been drawn. As established, the representation of the different views is the orthogonal projection of the core's surfaces, rotated of 90° as regard to the main view. Diacritical drawings differ from realistic archaeological illustrations because they depict

the sequence of operations involved in manufacture rather than a simulacrum of the lithic tool.

2.1.1. Data processing

The data collected in the technological database described above have been processed through charts and tables aimed to highlight the technological features of each considered lithic assemblage. All the technological categories (flakes, cores, debris, unworked blanks) have been considered to evaluate the proportion of the different lithic raw materials identified in the assemblage and to give a general overview on the composition of the lithic industry and of its state of preservation. A comparison between vein quartz and the other raw materials present in the assemblage is present in all the analysis.

The rate of fragmentation of the *débitage* products has been evaluated considering the proportion of complete flakes, incomplete flakes, lateral, distal, proximal and mesial fragments. Excluding the category of complete flakes, among incomplete and fragmented flakes have been distinguished the different typologies of fractures, occurred during or after *débitage*. The reconstruction of the modalities of exploitation of all the lithologies and the identification of the different knapping methods is based on the criteria listed above and all the flakes (complete, incomplete and fragmented) have been taken into account in the analysis concerning the presence and the position of the cortex and the direction of the negatives on the dorsal faces.

Complete, incomplete flakes and proximal fragments were considered to distinguish the typology of the butts and to understand if natural, flat, or prepared surfaces have been used as striking platforms. The dimensional analysis concerns only complete products or incomplete flakes and, when significantly represented, cores were also included in this study to verify the consistency of their dimensional features with those of the products.

Specific analysis has been carried out when applicable, like the proportion of plunging flakes for each *débitage* method to see if the occurrence of plunging is a technological choice aimed to core management, or if it is due to the characteristics of the raw materials involved. Vein quartz flakes, cores and debris have then been divided, for each knapping method, according to the morphostructural groups methodology (see below).

2.1.2. Quartz properties and technological implications

As already mentioned in Chapter 1, quartz is one of the most frequent minerals on Earth, it is a component of sedimentary, metamorphic and intrusive rocks and its crystallization can occur at different stages of magmatic cooling and metamorphic processes (de Lombera-Hermida, 2009; Luedtke, 1992). Therefore, the term quartz indicates a huge variety of lithologies, different in their origin, colours, homogeneity, texture, and petrographic structure. Since the main factors influencing the mechanical properties of vein quartz are texture and presence of cleavages and since these features depend on temperature and pressure conditions during the formation of vein quartz, when considering a vein quartz lithic assemblage it is important to focus the attention first on these issues to understand the variability and the dynamics of vein quartz fracturing and its response to knapping (Bons, 2001; de Lombera-Hermida et al., 2011). For these reasons, in the present work the technological study of vein quartz (identification of knapping stigmata and fracture analysis) is based on those approaches that classify quartz according to its petrological characteristics (e.g. de Lombera-Hermida, 2009; de Lombera-Hermida et al., 2011; Driscoll, 2011; Manninen, 2016; Mourre, 1996; Rodríguez-Rellán, 2016; Tallavaara et al., 2010)

According to these approaches, two main groups can be distinguished within quartz (de Lombera-Hermida, 2009; de Lombera-Hermida et al., 2011; Mourre, 1996):

- **hyaline quartz** (authomorphic), when it displays its crystal structure and crystal faces can be identified. The presence of crystallization cores, constant environmental conditions, a great span of time and space are required for its formation and therefore it is present only in specific geological and magmatic contexts like subvolcanic formations of hydrothermal origin (de Lombera-Hermida, 2009; de Lombera-Hermida et al., 2011; Luedtke, 1992; Mourre, 1996);
- **vein quartz** (xenomorphic), when it is formed by the aggregation of different microcrystals. The dimension of the crystals determines the great polymorphism of this group and it depends on divergences in temperature, space, growing rates and core density during the formation process (de Lombera-Hermida, 2009; de Lombera-Hermida et al., 2011; Luedtke, 1992; Mourre, 1996). After its crystallisation, vein quartz is subject to the tectonics evolution of the wall rock, thus determining the presence and frequency of internal flaws that strongly affects its aptitude for knapping (Mourre, 1996).

Depending on differences in cooling rates, temperature and core density, different textures can be observed even in the same vein (Fig. 2.3): in the outer part of the vein the cooling rates are higher and impurities due to the wall rock are more frequent, thus determining the formation of small crystals and giving quartz a grainy texture; in the inner part of the vein, the cooling rates are slower and more space is available for the formations of bigger crystals, thus determining the formation of microcrystalline or automorphic quartz (Ballin, 2008; Bons, 2001; Collina-Girard, 1997; de Lombera-Hermida, 2009; de Lombera-Hermida et al., 2011). At the same time, tectonic forces, or inclusions can produce internal flaws (Bons, 2001; Collina-Girard, 1997; de Lombera-Hermida, 2009).

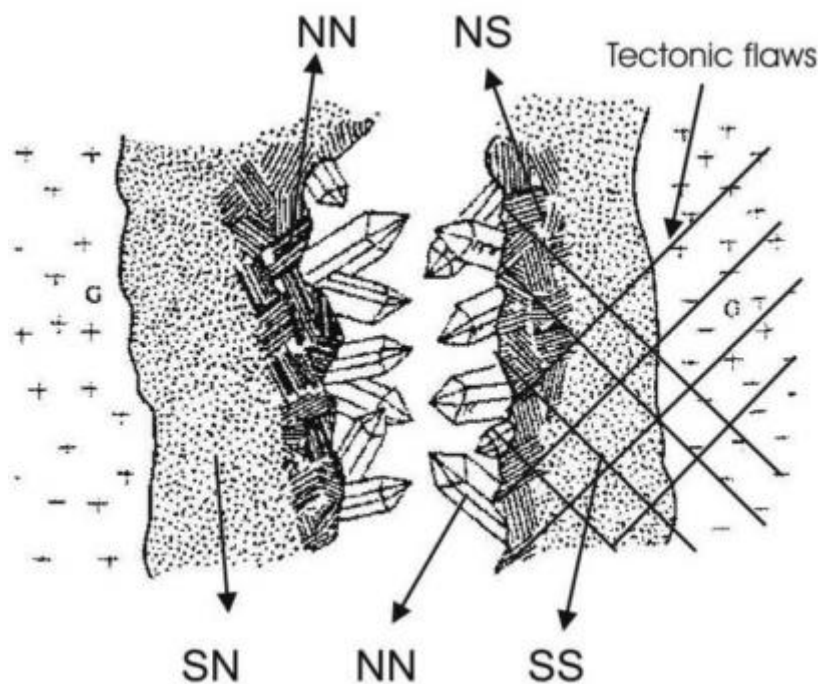


Fig. 2.3. Formation of vein quartz and morpho-structural groups (modified from de Lombera-Hermida, 2009)

Depending on the presence of big or small crystals and internal flaws, the mechanical properties of vein quartz change significantly (Collina-Girard, 1997; de Lombera-Hermida, 2009). For this reason, the technological study of vein quartz implements from the considered sites has been conducted through the methodology developed by Martinez Cortizas and Llana Rodriguez (1996), based on the macroscopic classification of quartz according to its morpho-structural variables (texture and homogeneity/continuity, i.e. internal flaws) and dividing it in four morpho-structural groups (Fig. 2.3): NN (no grainy, no planes); SN (grainy, no planes); NS (no grainy, planes); SS (grainy, planes) (Martinez Cortizas and Llana Rodriguez, 1996). In this way two main groups of xenomorphic quartz can be distinguished according to their macroscopic texture: quartz with a grainy texture and macrocrystalline quartz, this last representing quartzes that macroscopically do not have grainy in their texture even if they are not automorphic quartzes (de Lombera-Hermida et al., 2011; Martinez Cortizas and Llana Rodriguez, 1996). The subdivision in four morpho-structural groups is a useful methodology to understand the technological choices made by the prehistoric communities with regards to the geological environment

and to the availability and accessibility of the lithic raw materials (de Lombera-Hermida, 2009; de Lombera-Hermida et al., 2011).

The identification of knapping scars on the surfaces of vein quartz artefacts needs to take into account these petrological characteristics, since they determine the mechanical properties and therefore the quartz response to knapping (de Lombera-Hermida, 2009; de Lombera-Hermida et al., 2011). Indeed, the presence of internal flaws and of crystalline surfaces made quartz a non-homogeneous raw material and determines the occurrence of accidental and unintentional breakages. The other characteristic of quartz crystals is their anisotropy, due to the crystalline structure and its orientation (de Lombera-Hermida, 2009; de Lombera-Hermida et al., 2011; Mourre, 1996; Rodríguez-Rellán, 2016). It depends on two factors: cleavages and diaclases. The first is due to the crystalline structure debilities, evident in the existence of preferential fracture plans (oblique) on quartz crystals; diaclases is the presence of internal flaws due to internal impurities or tectonic forces and is related more to homogeneity than to anisotropy (Bons, 2001; de Lombera-Hermida, 2009; de Lombera-Hermida et al., 2011). Some recent studies show that the presence of cleavage plans in quartz, even causing a preferential breaking direction and interfering with the Hertzian fracture mode, do not affect knapping to a great extent; therefore it seems that the main limiting factors in quartz knapping are internal flaws and homogeneity (de Lombera-Hermida, 2009; de Lombera-Hermida et al., 2011; Rodríguez-Rellán, 2016). All things considered and looking at the morpho-structural groups, on NN and NS quartz (macrocrystalline) cleavage may be due to the absence of the typical Hertzian scars, i.e. bulbs and ripple marks, while on SN and SS quartz (grainy or microcrystalline) the anisotropy needs to be explained in a different way: in this case the fracture planes do not pass through the crystals but they follow their surfaces and therefore crystals anisotropic characteristics do not affect the fracture planes, determining what has been defined as *isotropie de compensation* (Mourre, 1996). During

knapping activities, grainy quartz can so develop some typical characteristics of the Hertzian fracture (de Lombera-Hermida, 2009; de Lombera-Hermida et al., 2011; Moure, 1996). Moreover, the grainy texture can better absorb the strength of the percussion force, thus increasing its elasticity (de Lombera-Hermida, 2009).

Specific works concerning these issues are just a few and in the present study we based the identification of knapping scars on vein quartz artefact on the experimental work conducted by A. de Lombera-Hermida (2009) and on the study conducted by V. Moure (1996). Starting from the consideration that quartz mechanical breakage, as flint, follows the Hertzian model but, due to the petrological characteristics of quartz, the force manifests itself in three-dimensional internal flaws (in the tangential and perpendicular planes), the author identifies several isolated or related scars or percussion marks (Fig. 2.4 and 2.5) that can be recognised on the negative and ventral faces (de Lombera-Hermida, 2009; Moure, 1996):

- radial fissures: result of the radial propagation of the force, their dimension depends on percussion angle, strength and quartz morphostructure;
- proximal fissures: transverse and subsurface fractures located close to the impact point that can cause proximal step fractures;
- striking platform fissures: concentric and radial fissures located beside the impact point and caused by partial Hertzian cones cracks created during hard hammer percussion;
- steps: due to the low elasticity and fracture propagation model of quartz. The impact point leads to a small removal that leaves a small scar behind;
- splintering: due to several radial and proximal fractures, it occurs on macrocrystalline quartz because of hammerstone impacts;

- edge battering: occurs on grainy quartz when the percussion point results in a whitish area caused by microstriae, quartz dust and partial Hertzian cones formed during hammerstone impacts;
- scales: micro-flakes that form on ventral and scar surfaces.

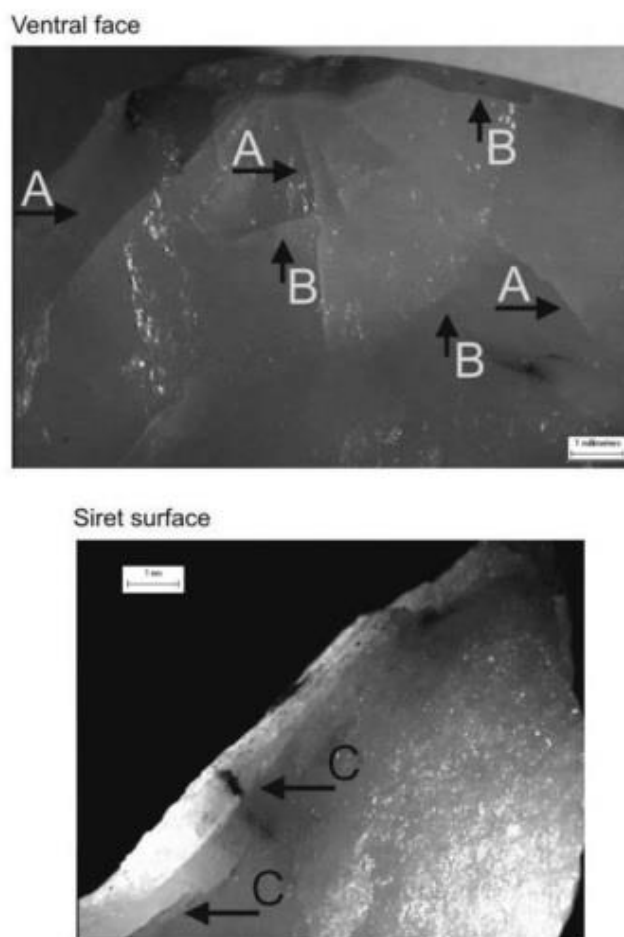


Fig. 2.4. Hertzian model observed on quartz: radial fissures (A); concentric fissures (B); subsurface and parallel fissures (C). (Modified from de Lombera-Hermida, 2009).

A strong relationship has been observed between these scars and quartz morphostructure since it determines the appearance and the association of some of them: in general grainy textures increase elasticity and decrease the formation of fissures and cracks, while they cause the appearance of scars related to specific fracture mechanics like Hertzian cones and micro flaking (de Lombera-Hermida, 2009).

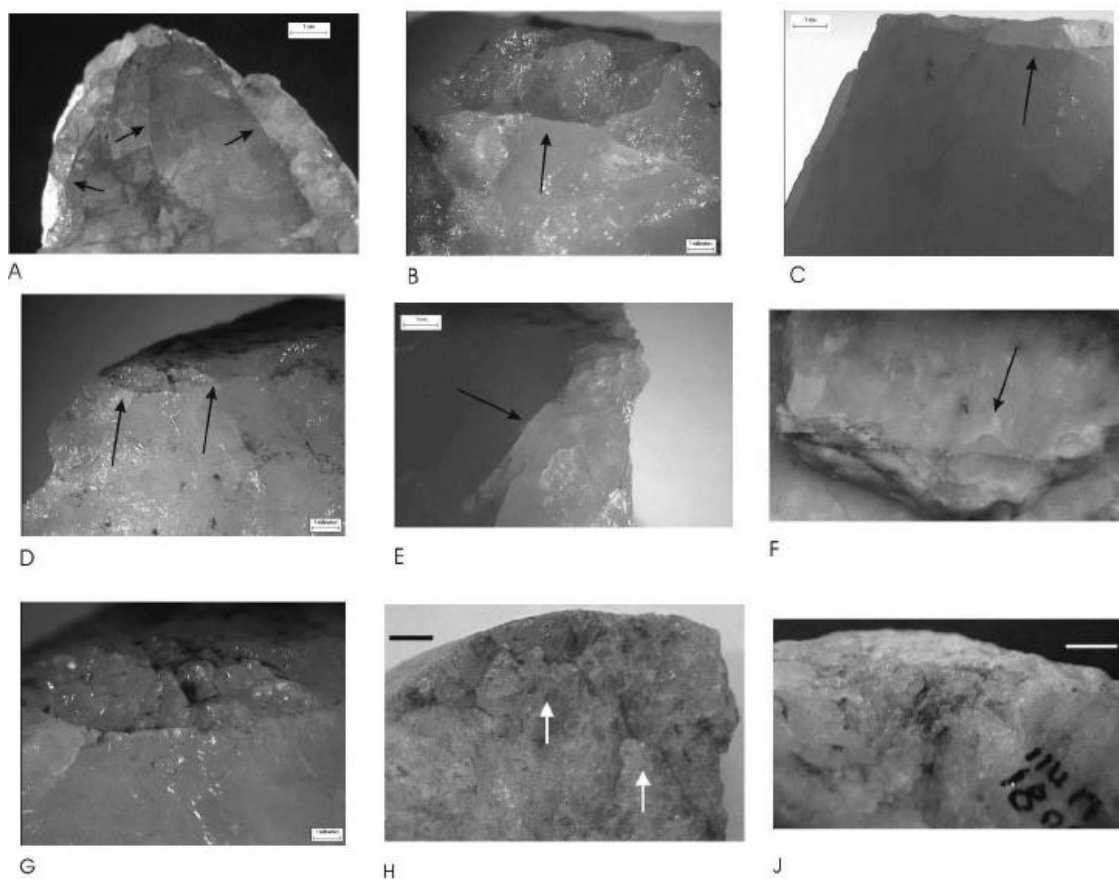


Fig. 2.5. Percussion marks on quartz experimental (A, B, C, E, F) and archaeological (D, G, H, J) artefacts: radial fissures (A); step (B); transverse fissures (C, D); striking platform fissures (E, F); splintering (G); scales (H); edge buttering (J). (modified from de Lomberra-Hermida, 2009).

As for the identification and interpretation of the knapping stigmata, also the analysis and classification of the fractures observed on quartz flakes is based upon specific studies (e.g. Driscoll, 2011; Manninen, 2016; Mourre, 1996; Tallavaara et al., 2010). Indeed, the tendency of quartz to shatter during knapping activities is one of the factors making the technological analysis more difficult, and to achieve good results in technological studies of quartz assemblages is necessary to carefully evaluate their rate of fragmentation. During the 80s and the 90s, archaeologists from Sweden and from the United States developed a method called “fracture analysis” which main assumption is that the proportion of different fragment types, including complete flakes, during a reduction sequence is fixed (Callahan et al., 1992; Tallavaara et al., 2010). Even though the predictability of quartz flakes fragmentation cannot be proved experimentally (Tallavaara et al., 2010) since it depends on several and invaluable factors (i.e. personal knapping

skills and style, flake dimensions and quartz morphostructure), the general principles of this method are still valid to understand the modalities of fragmentation of a considered quartz lithic assemblage. According to “fracture analysis”, the fragmentation of quartz is not random, but it follows the principles of material science and it is caused by different variants and by the combination of radial and bending fractures (Fig. 2.6): radial fracturing makes flakes to split radially from the point of percussion and occur depending on the applied force, while bending fractures, snapping flakes crosswise, form through vibrations developing in the flake during percussion (Tallavaara et al., 2010).

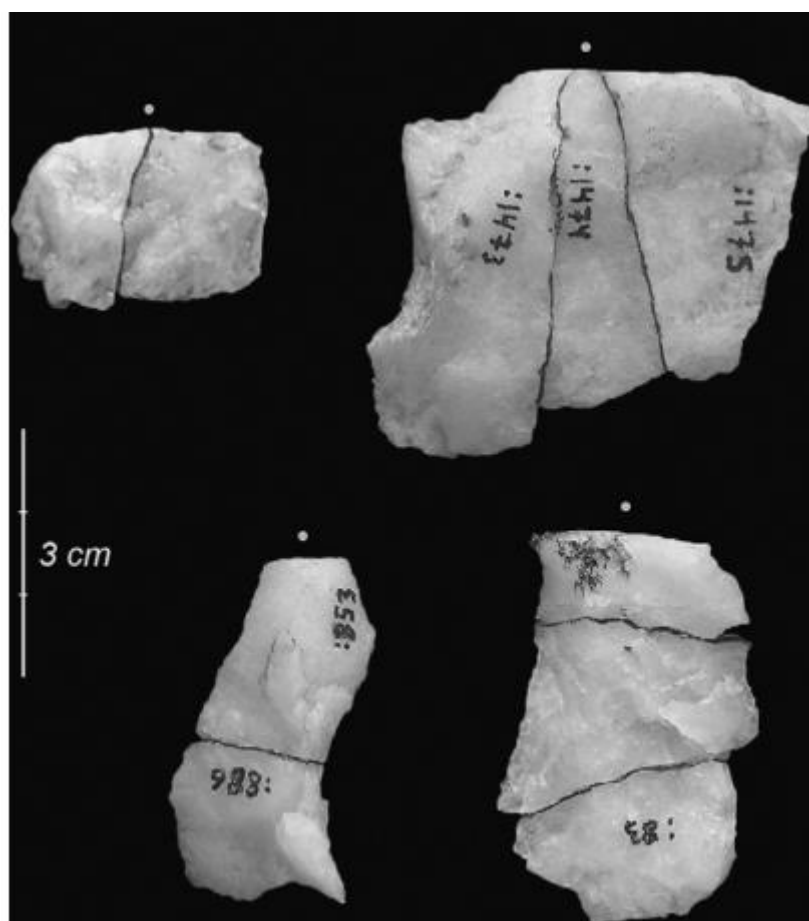


Fig. 2.6. Examples of radial (top) and bending (bottom) fractures on quartz flakes. (From Tallavaara et al., 2010)

Since in the analysis proposed by Tallavaara et al. (2010) the only distinction is between bending and radial fractures while no specific categories are provided for lateral fragments created through a siret break or a non-siret break, the analysis of quartz fragments also

considers the experimental work proposed by K. Driscoll (2011) where is also introduced the concept of sequential fracture, which occurs when a fracture had been initiated from a previous strike and subsequently the second strike removes the main flake and the previous incipient flake (Fig. 2.7) (Driscoll, 2011).

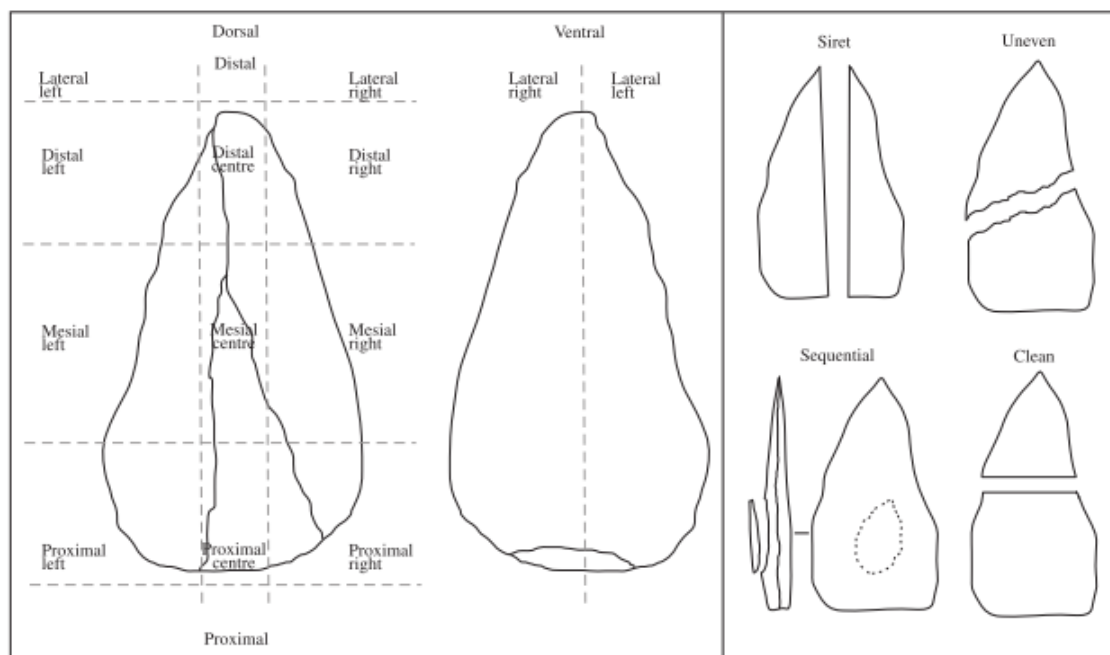


Fig. 2.7. Categories of flake fragments and breaks (from Driscoll, 2011).

For the identification of Siret accidents on quartz flakes, the work is based on the classification proposed by V. Mourre (1996). When considering a quartz lithic assemblage, the right identification of Siret accidents is very important, since they are very frequent and present with a certain number of variations. All of them share the development of an accidental fracture plan passing through the impact point (Fig. 2.8) (Mourre, 1996, 1994).

A further and last consideration must be done concerning the terminology used to indicate natural surfaces on quartz artefacts. When dealing with chert, the term cortex refers to an altered surface created by the physical and chemical phenomena typical of the depositional environment. These alterations made chert cortical surfaces not suitable for knapping activities, due essentially to their low efficiency in the propagation of the fracture

wave, and cortex removal is often the starting point for the exploitation of chert pebbles, nodules, or slabs. A different case is that of vein quartz natural surfaces, i.e. fluvial neocortical surfaces: they are the result of an alteration caused by transport which forms smooth and regular surfaces. It has been proved through experimental activities that the use of neocortical surfaces as striking platforms for vein quartz exploitation is one of the factors that contributes in reducing the occurrence of fractures and breakages (Mourre, 1996, 1994).

The methodology described above, that considers both quartz morphostructure and different criteria for the interpretation and classification of quartz fragments and fractures, is an efficient tool to gain an accurate technological analysis of quartz lithic assemblages and to understand technological choices, skills and behaviour of the considered Middle Palaeolithic human groups.

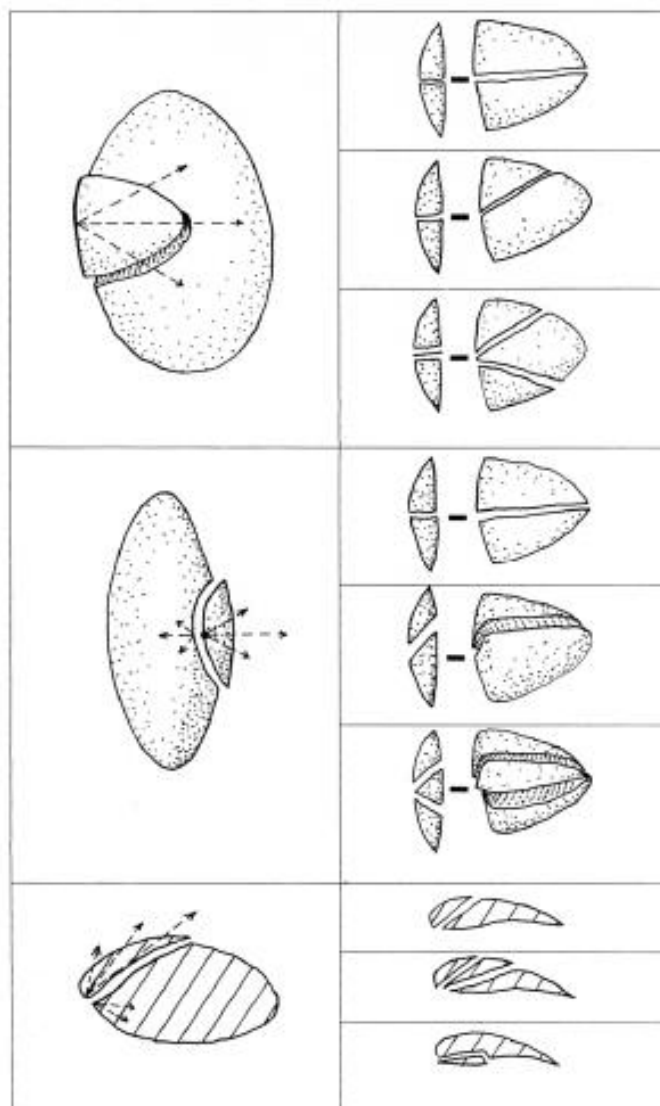


Fig. 2.8. Typology of silet accidents on quartz flakes. Top: accidental breakage along planes perpendicular to the fracture plane of the flake; middle: accidental breakage along planes secant to the fracture plane of the flake; bottom: accidental breakage along planes passing through the impact point and snapping the flake through its thickness. (From Mourre, 1996).

2.2. Raw materials supply areas

Starting from the 60's, the identification of the supply areas of lithic raw materials is a very important issue in prehistoric studies, since it allows to understand the relationship between the people frequenting an archaeological site and the surrounding environment and also to define the economic behaviour and the modalities of exploitation of the geological resources put into action by the prehistoric human groups on a specific territory (e.g. Binford, 1962; Martinez, 1991; Olivares et al., 2009; Steward, 1955; Vaquero, 2007)

The study of the supply areas of lithic raw materials has been carried out for one of the archaeological sites considered in the present work, the Ciota Ciara cave. A brief report of the results achieved by previous studies, conducted to define the probable primary and secondary sources of local lithic raw materials (Berruto, 2016, 2011), has been included in chapter 3.5 to give a complete outline of the land mobility of the Middle Palaeolithic human groups that inhabited the cave.

The present work is aimed to the definition of the supply areas of those good-quality raw materials present in the lithic assemblage of the Ciota Ciara cave mainly as finished tools, and that at first sight appeared to be of allochthonous origin. Their importance in the economy of the prehistoric groups varied through time (see chapter 3.6) and the proposed analysis concerns 171 lithic artefacts (flakes, debris, retouched tools and cores) coming from all the main archaeological levels of the Ciota Ciara cave.

As many other researches focused on the study of raw materials supply areas, the present work has been conducted in different phases and combining several approaches: the petrographic characterization of the lithic raw materials presents in the assemblage, the land survey based on the geological information available, and the comparison between the samples collected and the archaeological materials completed with the aid of geochemical analysis (e.g. Aubry et al., 2012; Fernandes et al., 2006; Gurova et al., 2016; Navazo et al., 2008; Nazaroff et al., 2013; Olivares et al., 2009; Spinapolice, 2012; Tarriño et al., 2015; Vallejo Rodríguez et al., 2017).

The characterization of the raw materials attested in the lithic assemblage has been carried out through a non-destructive methodology as not to damage the archaeological finds (e.g. Aubry et al., 2012; Barcelo, 1996; Bustillo et al., 2009; Navazo et al., 2008). The first observation of all the pieces was completed through

a stereomicroscope in reflected light Optika SZ6745TR with magnification between 0.6x and 4.5x, equipped with an USB camera Moticom 2500 with a 5-megapixel resolution, a lens providing a further 2x magnification and a LED-72T light ring (Fig. 2.9). This first phase of the analysis was carried out at the laboratories of the Department of Physics and Earth Science of the University of Ferrara.

The criteria considered in this first analysis were: texture, type of impurities, colour, presence and typology of micro-fossils (Luedtke, 1992).

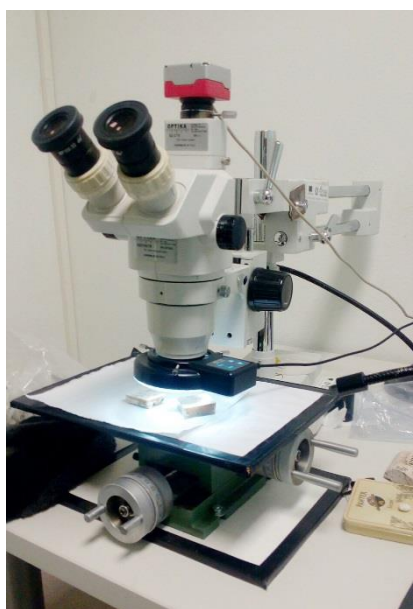


Fig. 2.9. Stereomicroscope used for the first characterization of the lithic artefacts and of the geological samples collected in the surveyed areas.

After the characterization of the raw materials present in the lithic assemblage a land survey based on the geological maps and on the data available in literature have been set up (e.g. Aubry et al., 2012; Fernandes et al., 2008, 2006; Gurova et al., 2016; Navazo et al., 2008; Spinapolice, 2012; Vallejo Rodríguez et al., 2017). Geological data concerning the immediate surroundings of Monte Fenara and the Sesia valley have been updated in the last years thanks to the institution of the UNESCO Sesia Valgrande Geopark and some recent works completed by Italian

and international researches have been used to acquire the necessary knowledge for the territorial survey (e.g. Quick et al., 2003; Sinigoi et al., 2010). The updated geological maps of the area available at <http://www.supervulcano.it/cartografia.html> have been consulted together with the digital version of Italian geological map 1:100.000 available on the web site of *ISPRA - Istituto Superiore per la Protezione e la Ricerca Ambientale* (<http://www.isprambiente.gov.it/it/cartografia>) (Fig. 2.10).

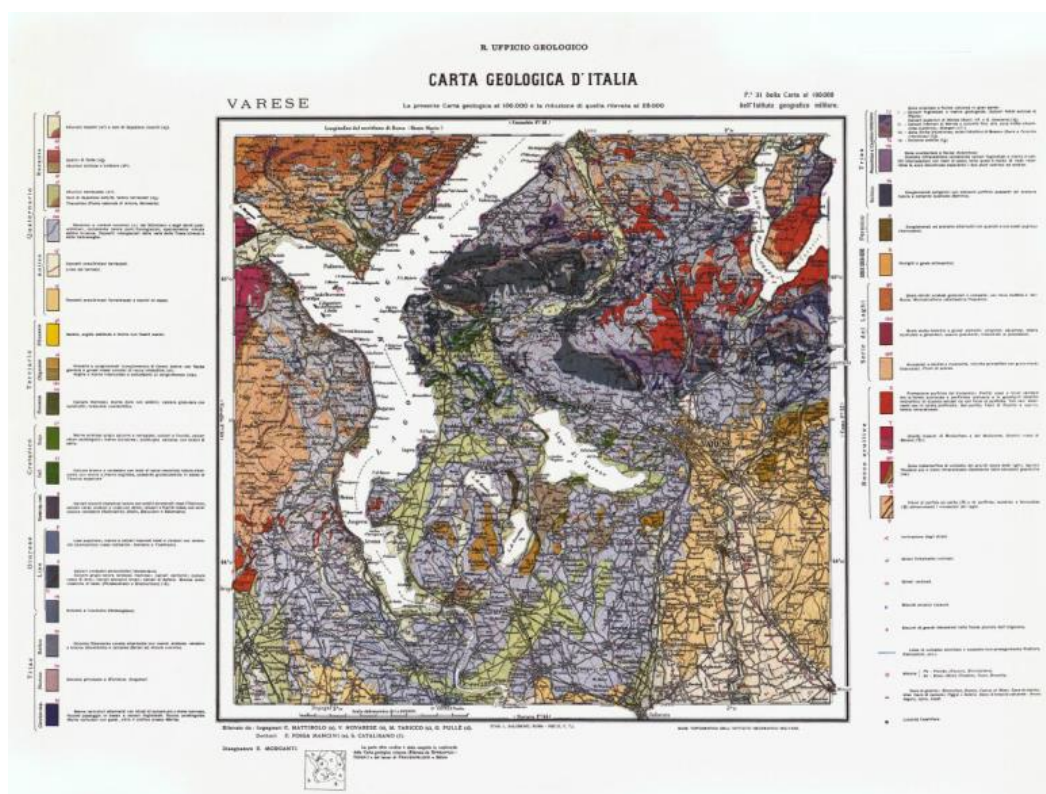


Fig. 2.10. Example of geological map used to identify the area to be surveyed (from <http://www.isprambiente.gov.it/it/cartografia>).

According to the information achieved from the study of the geological cartography and to the results of the microscopic observation of the raw materials of the lithic assemblage of the Ciota Ciara cave, outcrops and probable secondary deposits of lithic resources have been identified (e.g. Fernandes and Raynal, 2010, 2006; Huet, 2007). Another element considered in the choice of the area to be surveyed was that usually, during Middle Palaeolithic, the lithic resources

collected and brought to the site were those located as close as possible to the site (Bourguignon et al., 2006; Delagnes et al., 2006; Féblot-Augustins, 1993; Fernandes et al., 2008; Jaubert and Delagnes, 2007; Loch and Goval, 2004; Meignen et al., 2009).

During survey activities, samples of all the lithologies that at a macroscopic observation were consistent with those present in the archaeological record have been collected, both from the primary outcrops and from secondary deposits. Each surveyed area has been photographed and the primary outcrops were positioned through GPS technology.

All the samples collected have been observed through the stereomicroscope in reflected light available at the Department of Physics and earth Science of the University of Ferrara already employed for the characterization of the raw materials present in the archaeological record (Fig. 2.9). To confirm the microscopic observations, a qualitative X-ray fluorescence (XRF) spectroscopy was performed on a selected sample of the archaeological artefacts and on the geological samples that, after the microscopic study, showed characteristics consistent with those of the lithic finds (e.g. Nazaroff et al., 2013; Olivares et al., 2009; Skarpelis et al., 2017; Tarrío et al., 2015; West et al., 2012). This kind of analysis allow the characterization of the geochemical fingerprint of each lithic raw material regarding both its majority and minority components (Malyk-Selivanova et al., 1998; Milne et al., 2009; Tarrío et al., 2015). Indeed, during rocks' formation and diagenesis, inclusions incorporated from the surrounding environment, like clays, oxides or organic matter, may alter trace element geochemistry (Luedtke, 1992; Murray, 1994; Nazaroff et al., 2013). In this way, inclusions typical of a geographic area can be used to characterize particular

outcrops and deposits and can be very helpful in provenience studies (Nazaroff et al., 2013).

The XRF analysis has been carried out in the laboratories of the Department of Physics and Earth Science of the University of Ferrara through an ARTAX portable μ -XRF equipped with a He gas flush for the excitation and detection beam channel (West et al., 2012) (Fig. 2.11). The object to be examined is irradiated by a collimated X-ray beam between 200 and 1500 μm . This high-energy radiation incites element-specific X-ray fluorescence radiation in the sample. The intensity of this characteristic radiation is a measure of the quantity of the respective element in the sample. A cooled semi-conductor detector receives this characteristic X-ray radiation and converts it into current pulses which are amplified and digitised in the pre-amplifier and XSPV. The XDSP signal processor transfers the digital signals over the serial interface to the measurement computer where they are stored. The software computes the relative element composition of the sample considering the excitation energy, the detector effectiveness, and the spectral intensity distribution of the fluorescence lines. The principle of optical triangulation is used for the adjustment of the working distance between sample and measuring head (Fig. 2.12).

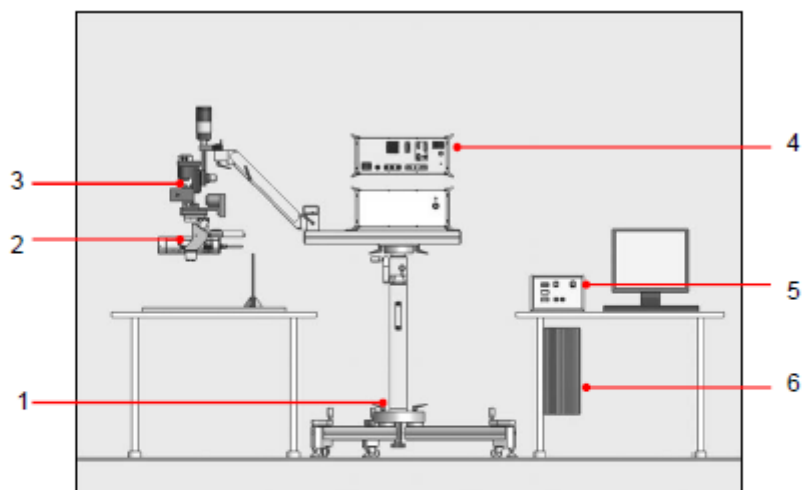


Fig. 6: ARTAX Main Components

- | | |
|--------------------|------------------------|
| 1 Tripod | 4 Electronics unit |
| 2 Measurement head | 5 Terminal |
| 3 XYZ adjustment | 6 Measurement computer |

Fig. 2.11. ARTAX portable μ -XRF with indication of the main components.

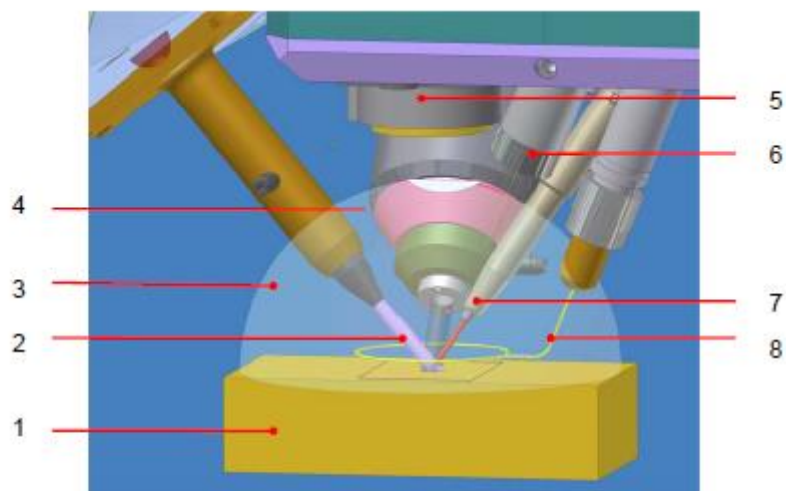


Fig. 7: Principle of operation of excitation and positioning

- | | |
|--|---------------------------------|
| 1 Sample | 5 CCD camera |
| 2 X-ray excitation beam | 6 Sample lighting |
| 3 X-ray fluorescence and scattered radiation | 7 Laser pointer for positioning |
| 4 Radiation registered by detector | 8 Collision sensor |

Fig. 2.12. Detail of the measuring head of ARTAX portable μ -XRF

The data from the microscopic observations and from the X-ray fluorescence analysis (Fig. 2.13) of the archaeological materials and of the geological samples

have then been compared, thus identifying the geological formations where the lithic raw materials exploited at the Ciota Ciara cave were collected. In this way the mobility of the prehistoric groups that inhabited the cave during Middle Palaeolithic has been assessed and for the first time an outline of the economic behaviour of the human groups frequenting Piedmont has been achieved.

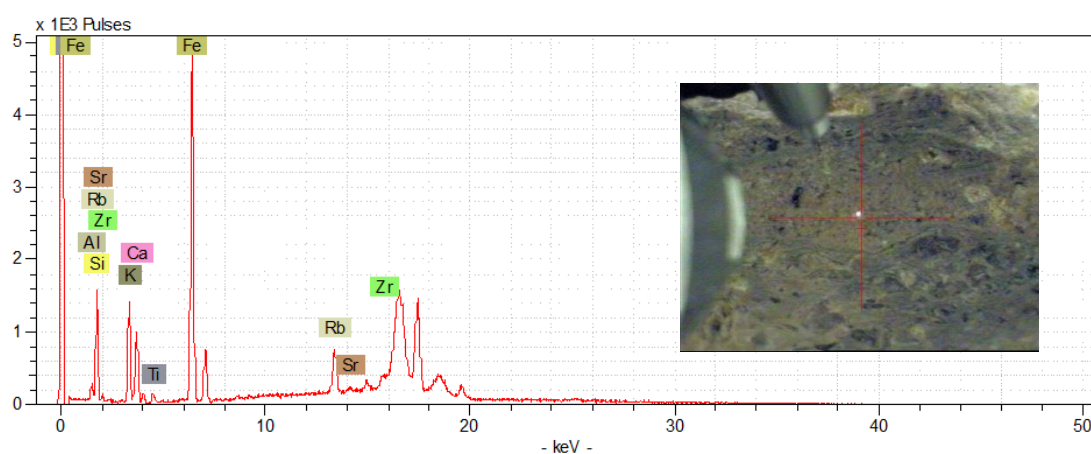


Fig. 2.13. Example of μ -XRF spectra obtained from the analysis of one of the archaeological samples.

CHAPTER 3

The Ciota Ciara Cave (north-western Italy)

Supply areas of lithic raw materials and technological analysis of a vein quartz Middle Palaeolithic assemblage

CHAPTER 3

THE CIOTA CIARA CAVE (north-western Italy) Supply areas of lithic raw materials and technological analysis of a vein quartz Middle Palaeolithic assemblage

The Ciota Ciara cave is located in Piedmont, Monte Fenera's karst, an isolated relief (899 m a.s.l.) in north-western Italy, in the municipality of Borgosesia, Vercelli district (Fig. 3.1). It is to date the most important Palaeolithic site of the region, the only one systematically excavated with a multidisciplinary approach and, together with the nearby *Ciùtarun*, the only Piedmontese Middle Palaeolithic site where human remains (*Homo neanderthalensis*) have been found (Mottura, 1980; Strobino, 1992a; Villa and Giacobini, 2005, 1995, 1993). The Ciota Ciara cave is situated on the west side of Monte Fenera at 670 m a.s.l. and it can be accessed both from a big triangular entrance, facing south-west (665 m a.s.l.), and from a secondary entrance facing west (670 m a.s.l.), originated by the collapse of the rock wall and enlarged by the removal of a big boulder blocking this entrance (Brecciaroli Taborelli, 1995; Fedele, 1972, 1966) (Fig. 3.1). It is a still active karst cave developed over more than 80 meters on its principal axe, with a positive difference in height of 15 meters from the main entrance to the bottom (Fig. 3.2). On the big main sector, straight and oriented NE-SW, is inserted a short branch going to the secondary entrance: the area where the two branches cross is a huge and wide space, enlarged during the years by dissolution and collapse of big boulders from the rock walls (Testa, 2005). A lateral and ascendant branch goes to the upper rooms, discovered and explored by *G.A.S.B. (Gruppo Archeologico Speleologico di Borgosesia)*, *Sala della Torre* and *Sala dei Pipistrelli* (Testa, 2005) (Fig. 3.2).

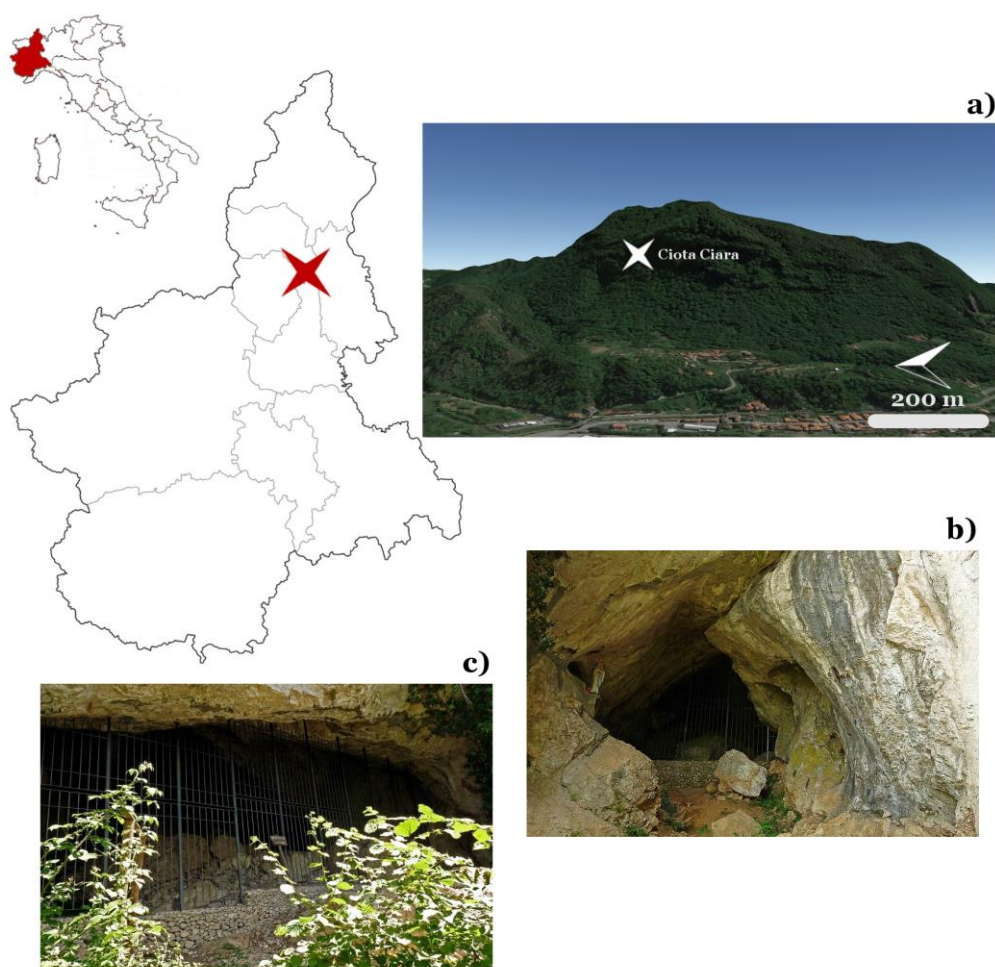


Fig. 3.1. Ciota Ciara cave. Geographic location (a), main entrance (b) and secondary entrance (c).

According to recent geomorphological studies, the internal deposit of the cave has a quite homogeneous matrix and it is the result of various different events such as debris flows and collapse episodes that alternate to phases with a more organized sedimentation with surface tractive flowing, probably linked to surface runoff processes outgoing the cave (Zambaldi, 2015). Another mechanism contributing towards the deposit formation is frost weathering, which caused degradation and collapse of the cave's walls (Fedele, 1966; Zambaldi, 2015).

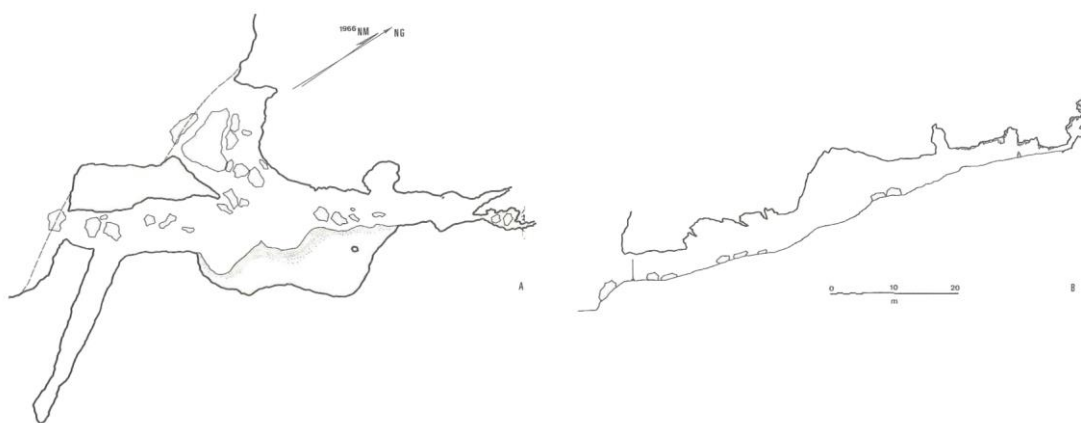


Fig. 3.2. Ciota Ciara. Planimetry (A) and section (B) of the cave (modified from Fedele, 1966).

3.1. Geological background

In the southern Alps, Monte Fenera represents the widest and stratigraphically most important portion of the Mesozoic sedimentary cover (Fig. 3.3): sedimentary portions are preserved where the presence of faults led to their displacement and subsequent protection against erosion (Bertolani, 1974; Fantoni et al., 2005b). This peculiarity was already highlighted by scholars and geologists in the end of the XIXth century but it was just in the 80s that Monte Fenera has been subject of monographic studies (Fantoni and Fantoni, 1991; Fantoni et al., 2005a).

The Oligocene – upper Miocene karstification, occurred within the carbonate rocks of the mount, originated several caves, that favoured a human frequentation of the area from the Palaeolithic to the Early Middle Ages (Bini and Zuccoli, 2005; Gambari, 2005).

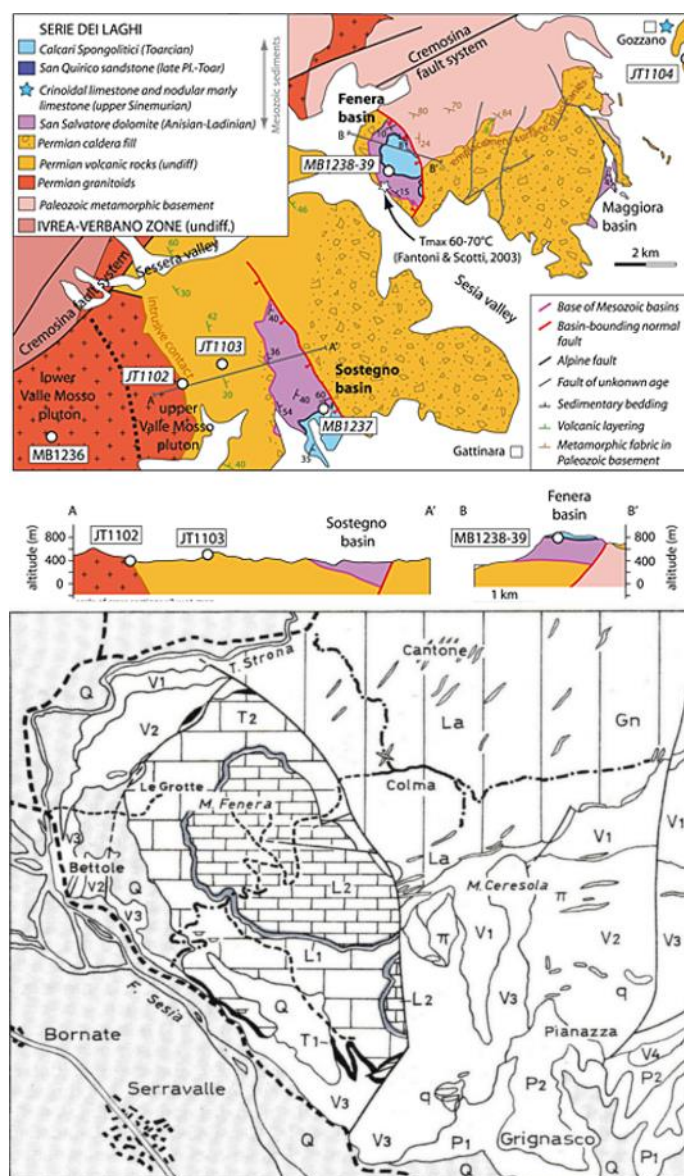


Fig. 3.3. Geological context of Monte Fenera. Geological map of the Cusio-Biellese area (top) (Beltrando et al., 2015); geological map of the Monte Fenera area (bottom) (Dal Pia, 1992): **Base of Serie dei Laghi:** Gn=rose-coloured orto-gneiss associated to para-gneiss; **Permian vulcanite:** V1= aphyric quartz-bearing latite and riolitic grey-greenish lavas; V2=reddish-brown felsic rhyolitic alkaline lavas; V3=yellowish ignimbrite; V4=reddish rhyolitic ignimbrite with flame-like structures and tuff; La=veins of lamprophyre; π=veins of granitic porphyry; q=hydrothermal quartz veins; **sedimentary cover:** T1=limestone-marl, calcarenite and sandstone (Lower Trias); T2=dolostone and dolomitic limestone (Middle-Upper Trias); L1=calcirudite, crinoid calcarenite and red sandstones (Middle Lias); L2=grey and black flinty limestone (Middle Lias); P1 and P2=Pliocene; Q=quaternary covers

The stratigraphic series of Monte Fenera (Fig. 3.4) (Fantoni and Fantoni, 1991; Fantoni et al., 2005a), from the bottom to the top, is made up of:

- *Scisti dei laghi*: metamorphic rocks belonging to the *Serie dei Laghi* sub-unit and emerging on the eastern side of the base of the mount and along the Strona valley;

- *Complesso vulcanico permiano*: volcanic and volcanoclastic units characterized at the base by reddish, brownish or greyish lava flows, covered by red-violaceous tuffs;
- *Arenarie grigie di Fenera Annunziata*: micro-conglomerates and sandstones with a grey or green dolomitic cement and clayish and silty intercalations, emerging on the west side of the mount;
- *Dolomia di S. Salvatore*: thick carbonate series that extends in the middle part of the mount;
- *Brecce del Monte Fenera*: Liassic deposits made up of breccias and mainly dolomitic clasts with reddish dolomitic cement, present only on the west side of the mount;
- *Arenaria di S. Quirico*: sequence made up of alternation of reddish coarse-grained sandstones, brownish fine-grained sandstones and grey or green sandstones;
- *Calcari spongolitici*: in the lower part, greyish flinty limestones, alternated to sandstones and brownish arenaceous limestones are prevailing; in the upper part the limestones become marly and blackish;
- Pliocene deposits: present only on the hills on the northern side of the Strona valley and on the hills in the north of Grignasco, these deposits have a lower portion made up of a discontinuous layer of polygenic conglomerates and grey sandstones that, going upwards, act as a transition to grey-bluish clays containing a rich fauna with molluscs and rare echinoderms; the upper part of the deposit is made up of yellowish sandstones.

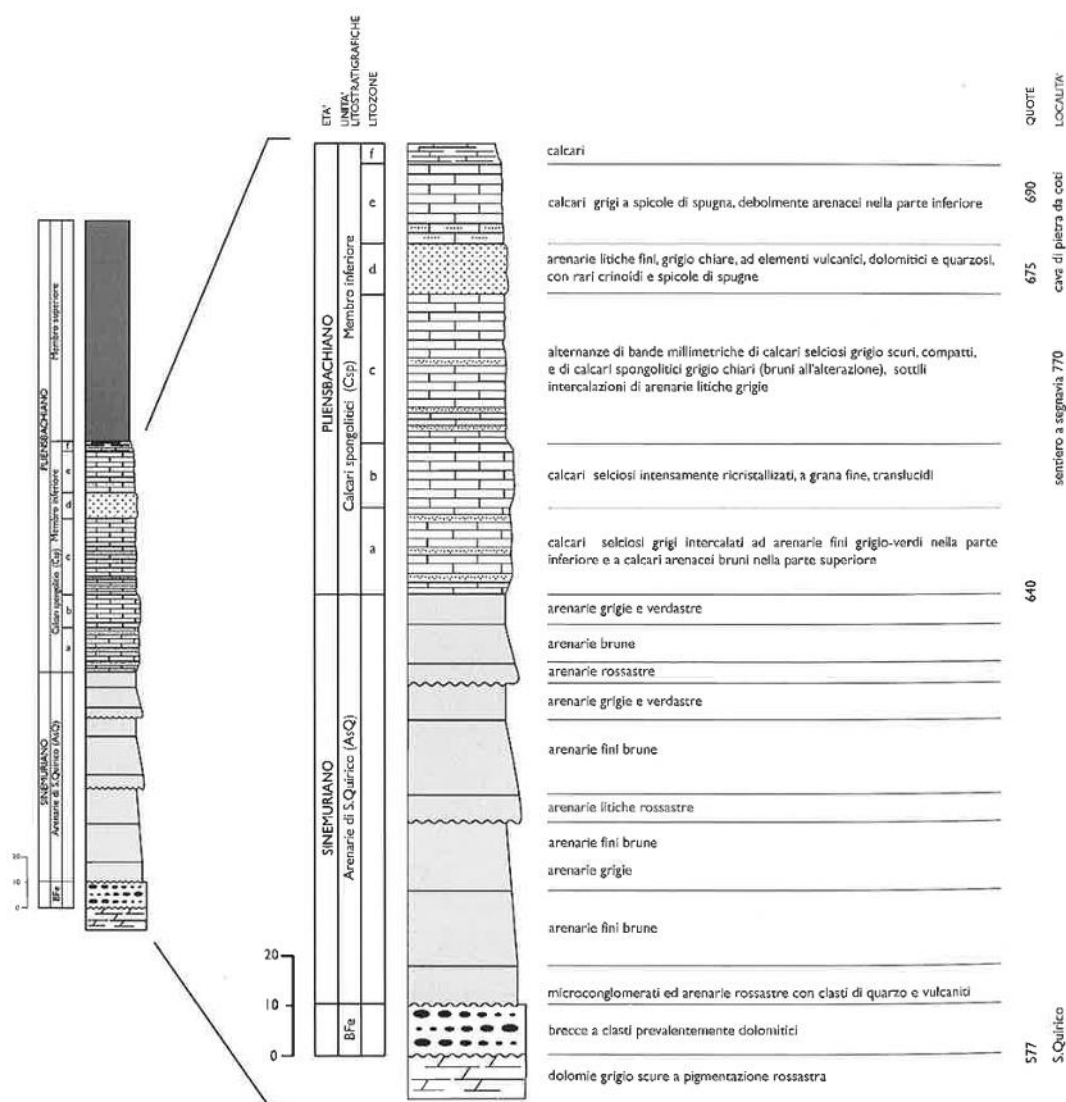


Fig. 3.4. Monte Fenera stratigraphic series (Fantoni et al., 2005b)

Looking at the Alpine geological background, Monte Fenera is close to the connection between the Po plain subsiding and the Alps rising (Fantoni et al., 2005a). Since the Oligocene, the most external areas of the alpine chain have been subject to compressive deformations, leading to a general high rate rising but it has to be bear in mind that it is since the Messinian that the western Southern Alps are deactivated, just like their continuation buried under the plain (Fantoni et al., 2005a). The last stage of the Alpine exhumation dates to 10 Mya for the penninic basement of the Rosa mount, while in the Sesia valley all the dates are

around 20 Mya, because little vertical movements continued to affect these areas connecting the Alpine chain and the subsiding basin, leading to the continuous dismantlement by erosion of the rising chain during Miocene and Pleistocene and transport of the sediments to the basin that will become the Po plain (Fantoni et al., 2005a).

Two main tectonic lineaments cross the considered area (Fig. 3.5): the *Linea della Colma (LCo)* and the *Linea della Cremosina (LCr)*, linked to the Mesozoic extensional cycle and to the Alpine compressional cycle respectively, and to which is connected a system of minor faults and diffused fracturing. The *LCo*, directed 150-170° N, marks the limit of the eastern side of Fenera's sedimentary portion. The *LCr* is a sub-vertical fault of a regional relevance, which follows locally the axis of the Strona valley (Fantoni, 1991; Fantoni and Fantoni, 1991; Fantoni et al., 2005b).

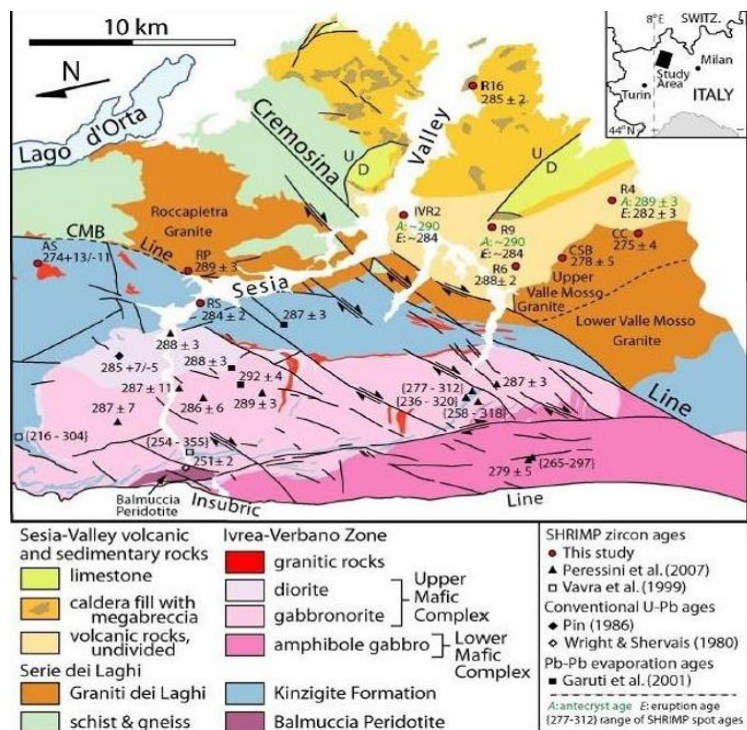


Fig. 3.5. Geological map of the Sesia valley with indication of the main tectonic faults (Sbisà, 2010)

3.1.1. Monte Fenera's karst

Monte Fenera's karst is linked to the tectonic lineaments mentioned above, and particularly to two systems of minor faults directed ENE – WSW and NNW – SSE, and parallel to *LCo* and *LCr* (Fantoni et al., 2005a). Their presence led to an intense fracturing of the carbonate units of the mount, thus causing secondary porosity and the increase of both water circulation inside the mount and of the dissolution phenomena responsible for karstification (Fantoni and Fantoni, 1991; Fantoni et al., 2005a). Seventy-two caves have been discovered and explored at today: all of them have an horizontal development and open on the west side of the mount, in the central part of that side and in its southern extremity, in Ara, in the *Dolomia di S. Salvatore* unit, except for the *Arenarie* cave, which opens in the *Arenarie di S. Quirico* (Fantoni and Fantoni, 1991; Fantoni et al., 2005a). The karst formed as a result of the rising of the Alpine chain, with a geomorphological and climatic context different from the present, which allowed a wider catchment basin and more intense precipitations. The development of the karst should then be dated to the warm and subtropical climate of the Miocene, thus justifying the karstification within not very soluble rocks such as the dolomite rocks (Fantoni and Fantoni, 1991; Fantoni et al., 2005a). Many authors hypothesize that the maximum development of the Fenera's karst took place during the Messinian crisis, even if we can't exclude that enlargement phenomena of the karst cavities could have took place due to the alternation of glacial and interglacial periods. In this area, the strong fracturing of the carbonate platform due to the Alpine tectonics, let us suppose a reshaping of the Fenera's karst, leading to the suspension of water circulation on a large scale, so that during Pleistocene it was already weak. Furthermore, from the upper Pliocene to Pleistocene, climatic changes lead to the erosion of the fluvial valleys with important slope collapses

and transport of detritus downstream, that, concerning carbonate lithologies, exposed the karst, thus causing the emerging of big cavities (Bini and Zuccoli, 2005; Fantoni and Fantoni, 1991).

3.2. History of the research and archaeological excavations

The first information about Monte Fenera's caves are in the historiographical works of local authors among which is worth to mention the one of G.P.F. Fassola that, in 1672, suggested their artificial origin, a belief that will be pass on by several authors until the XIXth century (Fedele, 1966).

In the half of the XIXth century, during the realization of the first geological map of the region, the first systematic surveys in the Monte Fenera area are carried out with a naturalistic and geological intent (Busa et al., 2005; Fedele, 1966). However, we have to wait until 1880, when Corrado Parona presented his observations and naturalistic discoveries during a trip from Colma, a small village on the eastern side of the mount, to the caves area and to the bottom of the Sesia valley, to have a first systematic geological report about the caves. During these years excavations took place in some of the caves leading to the recovery of paleontological remains that will be largely lost.

At the beginning of the XXth century there are both some information about the presence of archaeological remains on the mount, probably result of sporadic and unauthorized findings, of which we have no documentation, and writings about the caves, attraction for speleologists and fossils-diggers (Fedele, 1966). In the 30s, Carlo Conti from Borgosesia, keen on archaeology and palaeontology, starts to be interested in the Monte Fenera's deposits and publishes a monographic booklet (Conti, 1931). In 1936, Carlo Felice Capello, during his research about karst, mentions for the first time the presence of sporadic excavations in the Ciota

Ciara cave, with the discovery of bones and teeth referable to *Ursus spelaeus* and of pottery remains. The outbreak of World War II made suspend every kind of research (Fedele, 1966).

The post-war period is rich in new researches concerning Monte Fenera thanks to the foundation of *G.A.S.B. (Gruppo Archeologico e Speleologico di Borgosesia)* and to the personal initiative of Carlo Conti. In 1953, C. Socin from the Institute of Geology of the University of Turin, made a first test pit in the Ciota Ciara cave, bringing to light several paleontological and some archaeological remains. Probably in the same years has to be dated an excavation carried out by C. Conti near the secondary entrance of the Ciota Ciara cave (Fedele, 1966). The turning point for the Ciota Ciara cave is 1964, when some cranial bones, apparently human, together with some lithic artefacts were collected at the entrance of the cave next to an unauthorized excavation. After the discovery, Giuseppe Isetti, from the University of Genova, and Brunetto Chiarelli, from the Institute of Anthropology of the University of Turin, were contacted and the same year, in February, a survey was carried out with the participation of Francesco Fedele and Federico Strobino (Fedele, 1985, 1966; Strobino, 1992b). A test pit was realized in the atrial portion of the cave, close to the area where bones and lithics were found (Fig. 3.6). The trench was 1 x 2 m wide and 1 m deep and the stratigraphic sequence identified was divided in two main parts: the upper one yellow-reddish, sterile, and the lower part, orange-greyish, with lithic artefact (mainly made up of quartz) and faunal remains (95% referable to *Ursus spelaeus*) (Fedele, 1966). Francesco Fedele then hypothesized a seasonal human frequentation of the cave and the production *in situ* of the lithic tools (Busa et al., 2005; Fedele, 1966). In 1966, after G. Isetti's death, a systematic excavation took place under the direction of F. Fedele, who decided to open two excavations inside

the Ciota Ciara cave, thus revealing for the first time a stratigraphic sequence of the Quaternary deposits of Monte Fenera (Fig. 3.6). The so called “minor excavation” was located 20 m far from the entrance of the cave and was 1,20x1,40 m wide, while the main excavation was carried out in the eastern part of the hall, 35 m far from the entrance and was 3 m deep. Within the stratigraphic sequence of the main excavation, F. Fedele identified, under the present walking surface:

- stalagmite plate;
- yellow complex, made up of sandy sediments;
- orange complex, made up of sandy-silty sediments and with a small sized arenaceous and siliceous detrital component.

F. Fedele recognised ten levels, further subdivided in units (Fedele, 1972, 1966). From this excavation were recovered lithic artefacts made up of quartz and spongolite, summarily described by F. Fedele, and faunal remains of *Ursus spelaeus*.

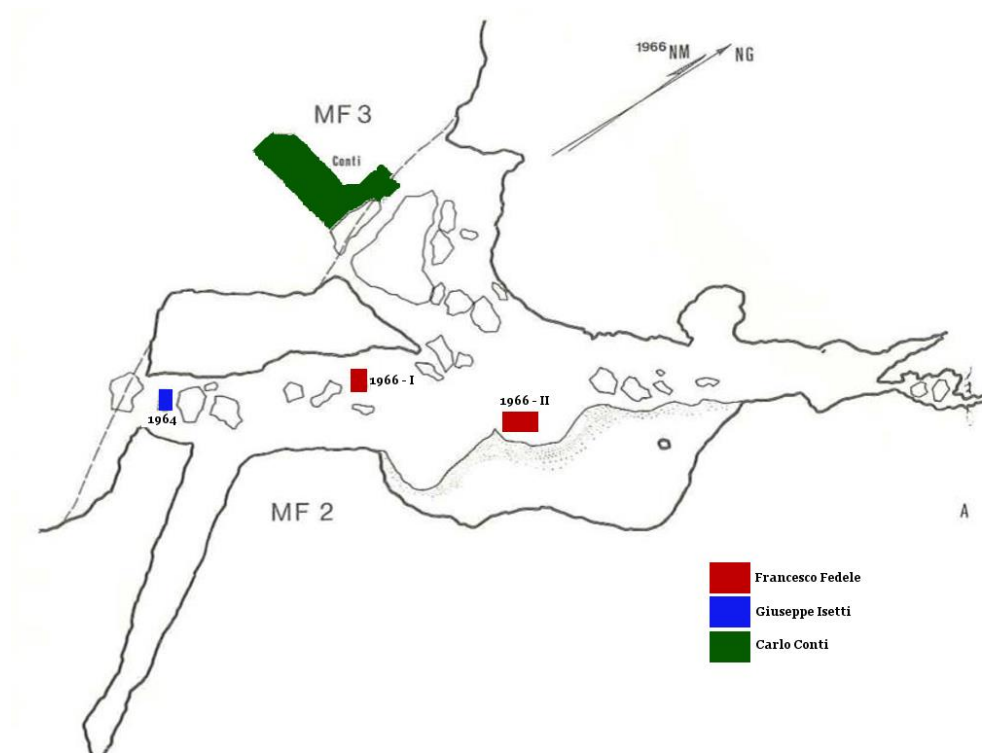


Fig. 3.6. Ciota Ciara cave. Planimetry of the cave showing the areas investigated during the 50s and the 60s (modified from Fedele, 1966).

Ten years later, in 1976, the move of a big boulder in front of the secondary entrance of the Ciota Ciara cave, led to an archaeological intervention carried out by *G.A.S.B.* under the direction of the archaeologist A. Freschi, which allowed the discovery of some Roman bricks belonging to a forge and to a small residential structure (Brecciaroli Taborelli, 1995; Busa et al., 2005; Gambari, 2005). In 1989, P. Gallo and F. Strobino found out two human teeth and a tooth of *Ursus spelaeus*, within sediments transported outside the cave by water. G. Giacobini, from the University of Turin, was charged with the study of the human teeth which were identified as belonging to *Homo neanderthalensis* (Busa et al., 2005; Villa and Giacobini, 2005, 1993) (Fig. 3.7).

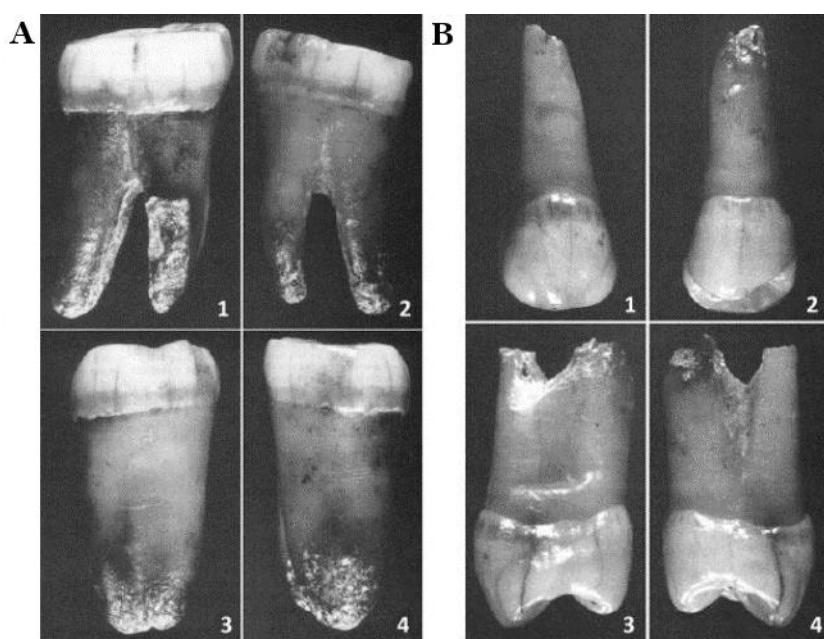


Fig. 3.7. Human remains from the Ciota Ciara cave found in 1989 within reworked sediments. A) right mandibular molar, M2 and B) right maxillary premolar P1 1) buccal view, 2) lingual view, 3) mesial view, 4) distal view (Villa and Giacobini, 1993)

In the 90s, new systematic researches were started at the Ciota Ciara cave by *Soprintendenza Archeologica del Piemonte*, under the direction of G. Giacobini and F.M. Gambari. The excavations were entrusted to the companies *CORA* (1991) and *Archeosistemi* (1992) and led to a first definition of the paleo-environment and of the archaeological deposit of the cave (Busa et al., 2005). They allowed the recovery of paleontological remains and of a quartz lithic

assemblage and they clarified the importance of the Late Ancient frequentation of the site (Brecciaroli Taborelli, 1995; Busa et al., 2005).

After seventeen years, systematic researches have been started again by the University of Ferrara in 2009 and they are still on-going (Angelucci et al., 2016, 2015; Arnaud et al., 2014; Arzarello et al., 2013, 2012b)

3.2.1. The University of Ferrara at the Ciota Ciara cave:

a new era of systematic excavations

In 2009 the University of Ferrara starts the first modern and systematic excavation at the Ciota Ciara cave after a gap of almost twenty years. The first campaign was directed to the restoration of the previous excavations both in the Ciota Ciara cave and in the nearby Belvedere shelter. Concerning the Ciota Ciara cave, three excavation areas have been opened, corresponding to Isetti's test pit, Fedele's MF2, and CORA's excavation. The first two excavations allowed to verify the stratigraphic sequences previously documented, while the third one, located in the atrium, led to the recovery of several Mousterian lithic artefacts in a good state of preservation. Due to the results obtained during the first campaign, in 2010 and 2011 the investigations at the Ciota Ciara cave were directed to the atrium (Fig 3.8), on an area of 5 m². During these excavations, S.U. 13 is completely removed and the subsequent S.U. 14 is exposed on the whole area. A huge quantity of materials has been recovered: faunal remains, mainly referable to *Ursus spelaeus*, micro-faunal remains, a huge lithic assemblage made up of local raw materials (quartz and spongolite) (Arzarello et al., 2012a, 2012b; Berruti and Arzarello, 2012; Berruto, 2011; Berto, 2012; Berto et al., 2016; Daffara, 2011; Daffara et al., 2014). Geophysical analysis have been carried out too (tomography

and georadar), allowing for the first time to make a correlation between the interior and the external levels of the cave deposit (Obradovic, 2011).

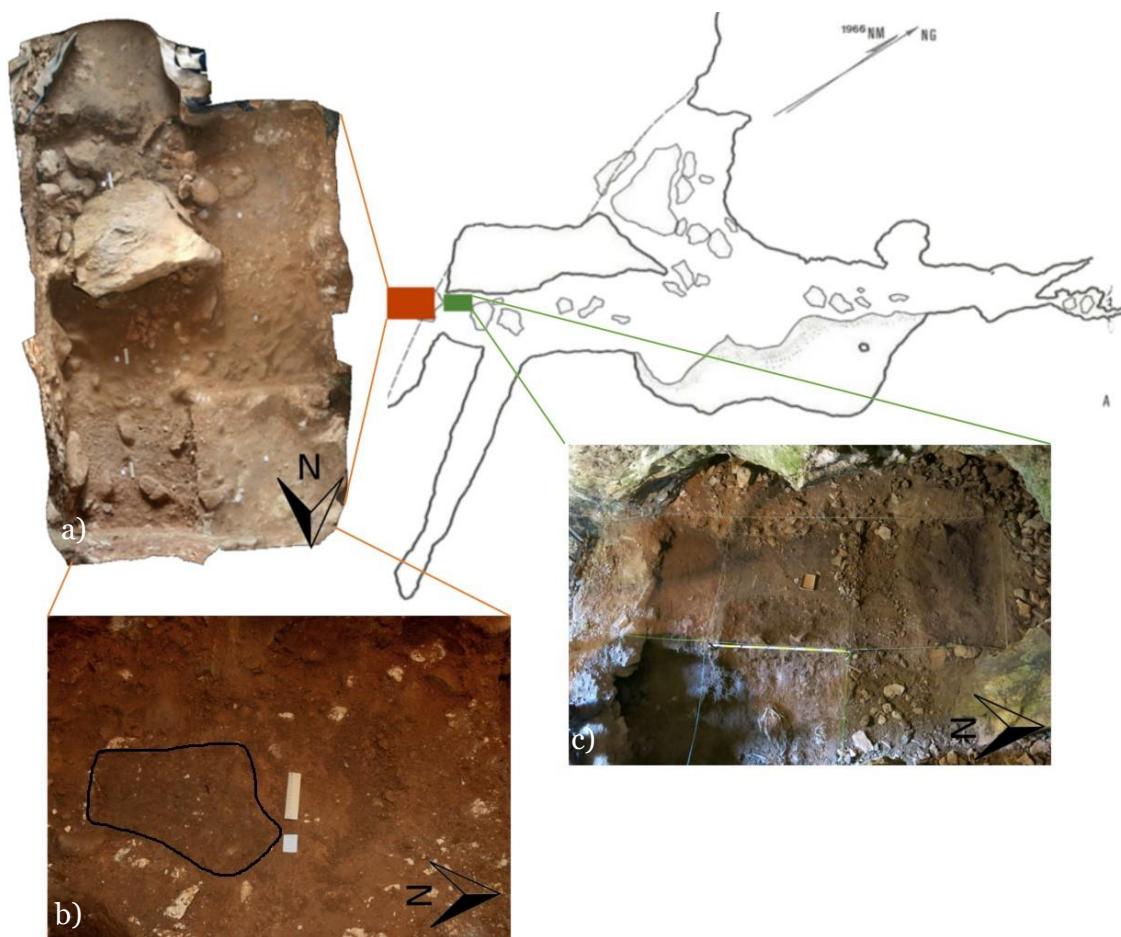


Fig. 3.8. Planimetry of the Ciota Ciara cave with location of the area excavated by the University of Ferrara in the atrium (orange) and in the internal part of the cave (green). a) 2012 excavation area; b) small fireplace found in 2013; c) internal excavation area opened in 2017.

During the following campaigns, the excavation area is enlarged of 2 m² thanks to the demolition of a big boulder and S.U. 14 started to be excavated. This unit is characterized by a more intense human frequentation of the cave, documented by a very huge lithic assemblage made up of a variety of raw materials, that seem to be mainly local with a small number of lithic artefacts made up of allochthonous raw materials, which characterization and definition of the supply areas is subject of the present work. A more intense human frequentation is also inferable by the increasing in the number of faunal remains referable to

herbivorous (*Rupicapra rupicapra*, *Cervus elaphus*, *Bos* sp.) and by the finding of a little fireplace in the south-western corner of the excavation area, close to the cave wall (Fig. 3.8) (Arnaud et al., 2014; Arzarello et al., 2013). During the campaigns of 2014 and 2015, the excavation area has been further enlarged of 2 m² and the removal of S.U. 14 has been completed (Angelucci et al., 2016, 2015), exposing the following S.U. 15 overall the investigated area. At the same time, a test pit was realized next to the entrance of the Ciota Ciara cave, where the dolomitic rock forms a wide sheltered area, to verify if also this area was involved in the Palaeolithic frequentation of the cave (Angelucci et al., 2016). Under reworked sediments, an individual burial was identified and, according to the modalities of the ritual and to the objects found, it has been defined as a Late Ancient burial (Fig. 3.9) chronologically placed between the IVth and the VIth century A.D. (Angelucci et al., 2016; Calandra, 2016). The burial was laying directly on the bed-rock, so this area was closed in 2016.



Fig. 3.9. Late Ancient burial identified in the test pit opened in 2015 in the sheltered area just outside the cave

In the last two excavation campaigns, S.U. 15 is removed, thus exposing on the entire area the following S.U. 16, archaeologically sterile and laying on the dolomitic bed rock. In 2017 the investigated area was further enlarged on 3 m²

and a test pit was opened inside the cave on 4 m² (Fig. 3.8), close to the Isetti's excavation, with the aim to remove the reworked sediments and to verify if parts of the stratigraphic sequence of the atrial area is preserved also inside the cave. During nine excavation campaigns, four main stratigraphic units (13, 14, 15 and 16) have been investigated with a multidisciplinary approach, leading to a detailed paleoenvironmental reconstruction, to the understanding of the function of the site, of the human activities that took place in the Ciota Ciara cave, of the technological behaviour and of the mobility of the Neanderthals in the surrounding territories (Arzarello et al., 2012a; Berruti, 2017; Berruti and Arzarello, 2012; Berruto, 2016, 2011; Berto et al., 2016; Buccheri et al., 2016; Daffara et al., 2014).

3.3. Stratigraphy and chronology

The stratigraphic sequence currently visible in the atrium of the Ciota Ciara cave represents the middle-lower portion of an original sequence which upper part has been removed during previous excavations (Busa et al., 2005; Zambaldi, 2015) (Fig. 3.10).



Fig. 3.10. Stratigraphic sequence of the Ciota Ciara cave (Angelucci et al., 2015).

Five main stratigraphic units have been identified: SS.UU. 13, 14, 15, 16 and 103.

- S.U. 13: silty unit, brown/dark-brown coloured, containing few centimetric stones, probably originally divided in several sub-units, with a horizontal disposition. It lays upon S.U. 14. The limit is mainly marked by chromatic variation and by a different organic matter, even if it is not always clear;
- S.U. 14: unit characterized by a silty matrix. It is made of a complex sequence of deposits linked to water circulation and resulting from the alternation between high energy phenomena, like debris flows, and low or medium-low energy tractive phenomena, going from the inside to the outside of the cave. According to chromatic changes, presence and dimension of stones, porosity, six sub-units have been identified: 14a, 14b, 14c, 14d, 14e, 14f. The lower limit with S.U. 15 is represented by decimetric dolomite rock boulders and by the sandy fraction resulting from the dolomitic rock itself;

- S.U. 15: it is a breccia deposit linked to a collapse phase of the cave walls. The silty matrix seems to be the same observed in S.U. 14. It is located just beneath S.U. 14 and the limit between these two SS. UU. is marked by the appearance of decimetric boulders of dolomitic rock. This unit shows vertical changing of the boulders' dimensions, maybe linked to different collapse phases;
- S.U. 103: it is located just in the western portion of the excavation area and it cuts SS. UU. 13 and 14. In the upper part it slopes to south, while to the bottom it becomes vertical. It is mainly dark brown coloured with scattered streaks. The filling is a clast supported breccia with the matrix that fills all the voids.
- S.U. 16: unit characterized by a clayey matrix with centimetric and decimetric sandstone and calcareous pebbles with a sub-vertical or vertical disposition. It lays upon the dolomitic cave floor and it is almost sterile (Angelucci et al., 2015; Zambaldi, 2015).

The ESR/U-series dating method has been applied on three samples collected in 2012 and belonging to S.U. 14 (Fig. 3.11): a lower third molar M₃ of *Rupicapra rupicapra*, an upper second molar M² of *Cervus elaphus* and a lower molar of bovid (*Bos* vel. *Bison*) (Vietti, 2016).

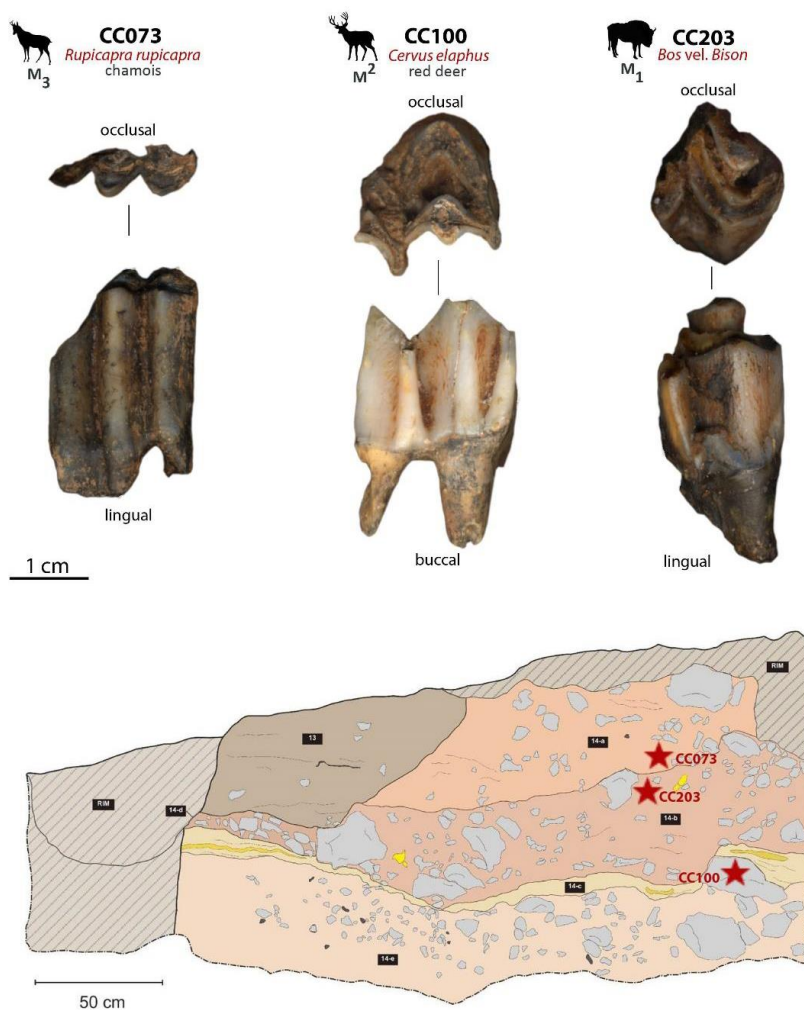


Fig. 3.11. Samples for combined ESR/U-series dating and their position in S.U. 14 (Vietti, 2016).

The age obtained from these samples are 310 ± 30 ka, 294 ± 32 ka and 281 ± 45 ka respectively, with a mean age of 289 ± 43 ka (weighted quadratic mean) (Vietti, 2016). These results are not consistent with the expected age of the human occupations of the Ciota Ciara cave related to S.U. 14, based on bio-chronological data: indeed, the enamel differentiation quotient (SDQ) of *Arvicola amphibius*, the general composition of the faunal assemblage and the presence of *Pliomys coronensis* placed the deposition of this level during MIS 5 (Berto, 2012; Berto et al., 2016). However, the homogeneity of the ESR/U-series dating is undeniable and suggests a correlation of the human occupation with the end of MIS 9 or the beginning of MIS 8 (Vietti, 2016). New dating are on-going and other

archaeological levels are involved to clarify the coherence of the previous dating and to obtain a radiometric dating for the entire sequence.

3.4. Faunal assemblage, paleoenvironmental reconstruction and archeozoological study.

The palaeo-environmental reconstruction has been achieved through the faunal analysis. The large-mammal assemblage of the Ciota Ciara cave (SS.UU. 13, 103 and 14) is mainly composed by carnivore remains: *Ursus spelaeus*, *Ursus arctos*, *Canis lupus*, *Vulpes vulpes*, *Meles meles*, *Martes martes*, *Lynx lynx*, *Panthera leo*, *Panthera pardus* and *Marmota marmota*. Herbivores are a minority within the faunal assemblage of all the SS.UU. but their importance grows considerably in S.U. 14. The following species have been identified: *Rupicapra rupicapra*, *Cervus elaphus*, cf. *Dama*, *Bos primigenius*, *Bos* sp., *Bos* vel. *Bison*, *Sus scrofa*, *Stephanorhinus* sp. (Angelucci et al., 2015; Arnaud et al., 2014; Arzarello et al., 2013, 2012a, 2012b; Berto et al., 2016). According to the M.N.I. calculated for the S.U. 14, the most represented taxa are *Ursus spelaeus* (18), *Cervus elaphus* (5) and *Marmota marmota* (3). All the other species are represented by just one or two individuals, indicating anyway a great biodiversity (Berto, 2012; Berto et al., 2016) (Tab. 3.1). New data on the macro mammals' assemblage concern the identification of *Stephanorhinus hemitoechus*, *Capra ibex*, *Capreoleus capreoleus* and *Castor fiber* (R. Cavicchi & B. Sala personal communication). After this new paleontological analysis, these data will contribute to a better understanding of the paleoenvironmental background of the human frequentation of the site.

Taxon	S.U. 103		S.U. 13		S.U. 14	
	NISP	MNI	NISP	MNI	NISP	MNI
<i>Ursus spelaeus</i>	33	5	232	9	989	18
<i>Ursus arctos</i>	15	1	24	2	17	2
<i>Panthera leo</i>	1	1			14	2
<i>Panthera pardus</i>					5	1
<i>Lynx lynx</i>			1	1	4	1
<i>Canis lupus</i>	1	1	8	1	11	2
<i>Vulpes vulpes</i>			2	2	3	1
<i>Meles meles</i>			6	1	2	1
<i>Martes martes</i>					1	1
<i>Rupicapra rupicapra</i>	3	1	9	2	26	2
<i>Cervus elaphus</i>			8	2	104	5
cf. <i>Dama</i>					1	1
<i>Bos primigenius</i>			1	1	1	1
<i>Bos vel Bison</i>			1	1	1	1
<i>Stephanorhinus sp.</i>					4	2
<i>Sus scrofa</i>					1	1
<i>Marmota marmota</i>					68	3
<i>Erinaceus europeus</i>			3	1	1	1

Tab. 3.1. Faunal remains from the Ciota Ciara cave divided by S.U. NISP = number of individual specimens; MNI = minimum number of individuals (modified from Buccheri et al. 2016).

Concerning the micro-mammal assemblage (SS.UU. 13, 103 and 14), the Ciota Ciara cave is the only Italian site with a so important presence of *Plyomis coronensis* and a so great biodiversity regarding bats species (Arzarello et al., 2012a; Berto, 2012; Berto et al., 2016). The most represented species is *Clethrionomys glareolus* that, together with *Apodemus (Sylvaemus)*, *Glis glis* and *Eliomys quercinus* and the bats, indicates a woodland environment, further validated by the presence of *Sciurus vulgaris* (Berto, 2012; Berto et al., 2016). Nevertheless, a climatic change has been observed between S.U. 13 and S.U. 14: during the formation of S.U. 14, the surroundings of the site were characterized by an open woodland environment with exposed rocks and within this unit are present different markers of cold climate, i.e. *Cricetus cricetus*, *Microtus cf. gregalis* and *Chionomys nivalis*.; S.U. 13 attests a lower presence of grassland species, like *Microtus arvalis* and *Microtus terricola*, together with the missing

of *Chionomys nivalis*, thus indicating a woodland environment (Angelucci et al., 2015; Berto, 2012; Berto et al., 2016).

An archaeozoological analysis has been conducted on the faunal remains of S.U. 14 (Buccheri, 2014; Buccheri et al., 2016): beside the identification of different taphonomic alterations (roots activities, cracking, carnivore intervention, deposition of manganese oxides, concretions, trampling marks, water abrasion), cut marks related to butchering activities have been identified on 35 bones.

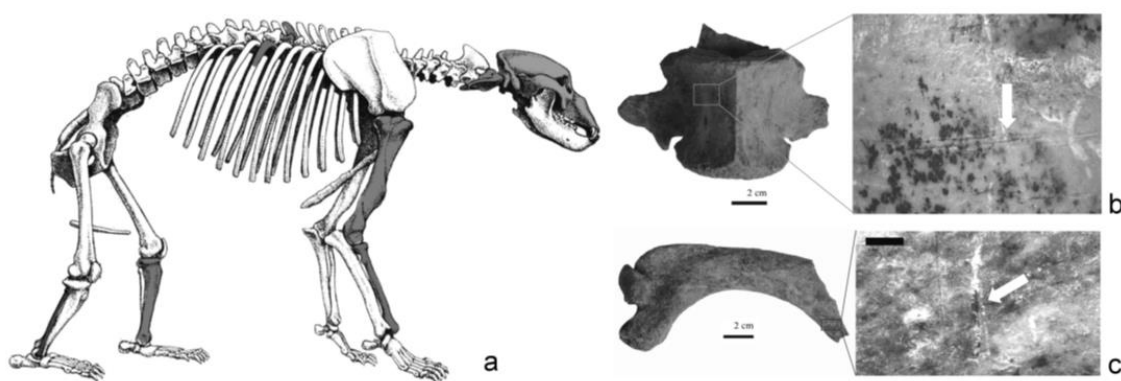


Fig. 3.12. Archaeozoological study on faunal remains of S.U. 14: (a) location of cut-marks on *Ursus spelaeus*; (b) fossil vertebra with cut marks; (c) fossil rib with cut marks (from Buccheri et al. 2016).

Half of the remains is undeterminable, while the others belong to large or medium-sized animals. An interesting result is the presence of 12 cut marks on bones of *Canis lupus* (1) and *Ursus spelaeus* (12) related to activities of both fur and flesh extraction (Fig. 3.12). The other cut marks identified belong to four different activities: flesh removal, evisceration, fur removal and disarticulation (Buccheri, 2014; Buccheri et al., 2016).

3.5. Supply areas of lithic raw materials

For the Ciota Ciara cave, the identification of the supply areas of lithic raw materials represents a very important step in the definition of the economic behaviour and of the land mobility of the human groups frequenting the site during Middle Palaeolithic. The results achieved during previous studies concerning local raw materials (Arzarello et al., 2012a; Berruto, 2016, 2011), and during the present work, focused on the allochthonous lithologies, become even more significant if we consider that, as mentioned before, the Ciota Ciara cave is the only Palaeolithic site in Piedmont object of systematic and multidisciplinary researches. The completion of the studies about the lithic industry of the Ciota Ciara cave for what concerns the raw materials supply areas, the technological and the functional study (Berruti, 2017) of the lithic assemblages belonging to the archaeological levels identified in the site, allow to provide here an exhaustive description of the modalities of frequentation of the Ciota Ciara cave and of the surrounding territories.

3.5.1. Previous studies

Since the beginning of the archaeological excavations at the Ciota Ciara cave in 2009, the importance of a detailed definition of the economic behaviour of the human groups that occupied the site during Middle Palaeolithic was clear.

At first, the research has been focused on the identification of the outcrops and of the secondary deposits of the raw materials most represented in the site, vein quartz and spongolite, and a first study was completed concerning levels 13 and 103 (Arzarello et al., 2012a; Berruto, 2011; Daffara et al., 2014). Later, due to the strong preponderance of vein quartz in all the archaeological levels, further

analysis have been conducted trying to define more precisely the deposits where this lithic resource was collected (Berruto, 2016).

Since during previous interventions in the caves of Monte Fenera (Fedele, 1966; Strobino, 1992a) no specific researches were aimed to the identification of the supply areas of lithic raw materials, the first step of the new analysis has been the development of a research protocol and the acquisition of a wide knowledge about the geological local environment (Berruto, 2011).

According to the data available, vein quartz is located within alteration structures of volcanic and volcanoclastic rocks, present at the base of Monte Fenera, while spongolite outcrops at the top of the mount, over the belt of carbonate rocks where the caves develop (Fantoni and Fantoni, 1991; Fantoni et al., 2005b; Reghellin, 2004).

Starting from the geological data, a fieldwork protocol was established: primary and secondary deposits of quartz and spongolite were identified, positioned through GPS technology and geological samples were collected (Berruto, 2011). Since the first technological analysis of the lithic assemblage of the Ciota Ciara cave (Daffara, 2011) highlighted that the natural surfaces present on quartz and spongolite artefacts were attributable to the collecting of lithic raw materials in secondary deposits, close attention was paid to the identification of vein quartz and spongolite in secondary deposition (Berruto, 2011). During the field works, also other lithologies, sporadically attested in the assemblage, were collected, revealing their local origin: grey/black flint, jasper, opal and milonite (Berruto, 2011).

The samples collected on the field and the archaeological artefacts have then been analysed and compared through observations conducted at the stereomicroscope in reflected light and a more precise characterization was achieved through the

analysis of some of the samples with SEM (Scanning Electron Microscope – ZEISS EVO40, 20 Kw, 90 Pa, at variable pressure and LaB₆ filament with a 20pA probe current), at the University of Ferrara (Berruto, 2011).

The microscopic analysis of the samples collected and of the archaeological assemblage, allowed to precisely locate the local lithologies exploited at the Ciota Ciara cave during Middle Palaeolithic. The results have been particularly exhaustive for spongolite, while, as mentioned before, vein quartz has been subject of further analysis (Berruto, 2016).

Outcrops of chert-like rocks have been identified between 720 and 899 m a.s.l., with vertical variations in the lithological characteristics indicating variations in the CCD (Carbonate Compensation Depth) during sedimentation (Berruto, 2011):

- spongolite, a sedimentary siliceous rock mainly composed by fossil remains of siliceous sponges (spicules), forms in open sea environments through slow accumulation of sediments rich in spicules on the seabed (D'Argenio et al., 2005). It is fine-grained and characterized by a homogeneous texture and by high hardness with conchoidal fracture (D'Argenio et al., 2005). In the archaeological record of the Ciota Ciara cave, two main kind of spongolite are present, characterized by a more or less pronounced porosity respectively (Berruto, 2011) (Fig. 3.13). Primary spongolite outcrops are located on Monte Fenara between 816 and 841 m a.s.l.: along the path called *Strada dei Buoi* are visible stratified spongolitic limestones with a considerable siliceous component; black and marly spongolitic limestones, with a lesser siliceous component, outcrop between a whetstone quarry and the top of the mount (Berruto, 2011). The same lithologies have been found in secondary deposition not far from the

Ciota Ciara cave, along the main current path and it is probable that the collecting of spongolite slabs and blocks took place in similar contexts (Berruto, 2011).

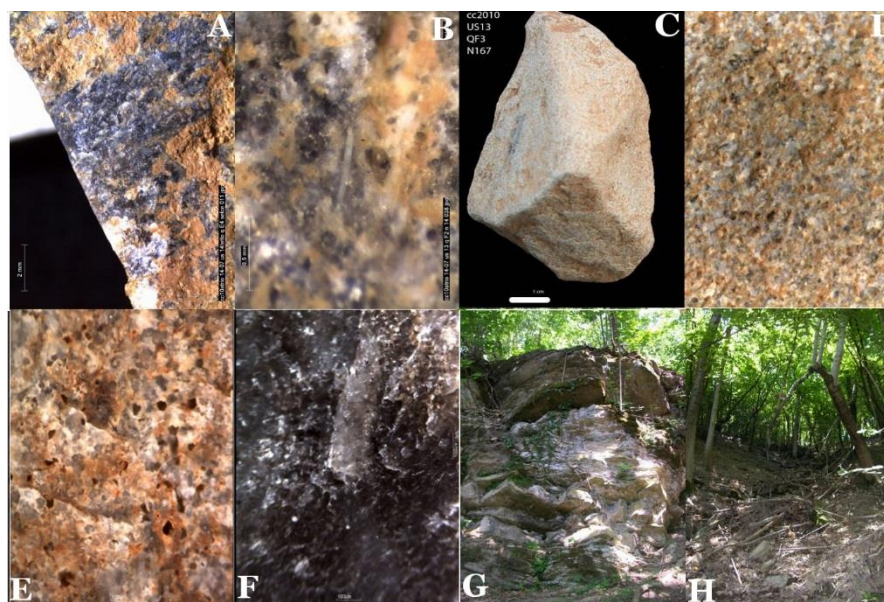


Fig. 3.13. (A, B, C, D) different varieties of spongolite present in the archaeological record; (E, F) detail of the surface of spongolite samples collected at Monte Fenera; (G) primary outcrop of spongolitic limestone; (H) path with spongolite slabs and blocks in secondary deposition (modified from Berruto, 2011).

- A better-quality variety of flint, barely present in levels 13 and 103 but more abundant in the other stratigraphic units (Fig. 3.32, 3.47, 3.61, 3.78), has been localized on Monte Fenera at 720 m a.s.l., under a whetstone quarry: it appears in the form of well-defined cryptocrystalline grey nodules with optimal conchoidal fracture, but its distribution area is limited (Berruto, 2011) (Fig. 3.14).



Fig. 3.14. Flint outcrops on Monte Fenera, close to a whetstone quarry (Berruto 2011).

As mentioned before, also other lithologies, barely attested in the lithic assemblage of the Ciota Ciara cave have been found during survey activities:

- milonite, a metamorphic rock compact and resistant, that usually is found in long and narrow belts along geologic faults: it is the result of a dislocation metamorphism along a fault at low temperature, consistent with the lithologies present in the Monte Fenera area (Berruto, 2011; D'Argenio et al., 2005). Along the same path where spongolite secondary deposits were identified, some milonite blocks were found and the microscopic analysis confirmed that the samples collected were consistent with the pieces present in the lithic assemblage (Berruto, 2011) (Fig. 3.15);

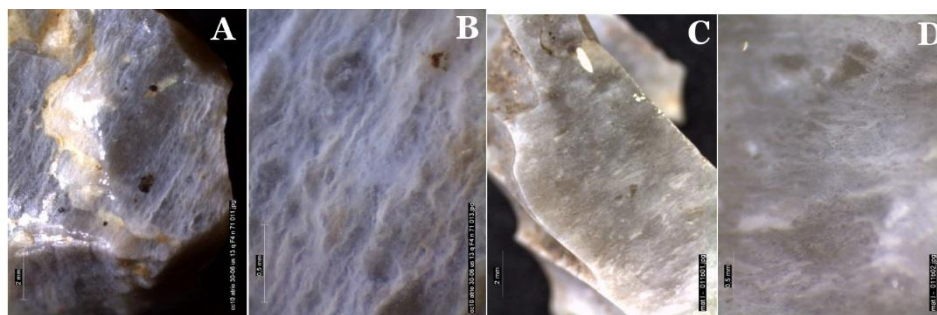


Fig. 3.15. microscopic observation of (A, B) milonite flake from S.U. 13 and (C, D) milonite collected in secondary deposition on Monte Fenera (modified from Berruto, 2011).

- hyalite, a variety of opal usually present in the form of patina or encrustations (Berruto, 2011). A small number of lithic tools (21) of the Ciota Ciara cave has been realized on a white and opaque raw material that at the microscopic analysis show an amorphous texture and that is consistent with the whitish crust present on a marly spongolite slab collected in a secondary deposit at 873 m a.s.l. (Berruto, 2011; Gottlicher et al., 1998) (Fig. 3.16);

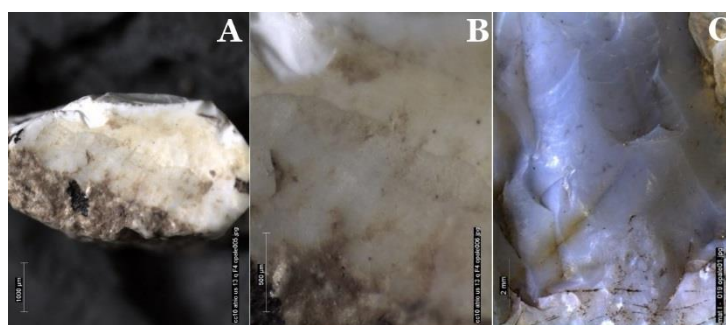


Fig. 3.16. (A, B) Detail of a hyalite flake from the Ciota Ciara cave and (C) hyalite collected on Monte Fenera (modified from Berruto, 2011).

- jasper, resulting from the combination between calcedony and clayey sediments or residual clays (D'Argenio et al., 2005), is present only in the lithic assemblage of level 14 (Fig. 3.47). A primary outcrop was found at the base of Monte Fenera in a former quartz quarry, at an altitude of 396-406 m a.s.l. (Berruto, 2011) (Fig. 3.17).



Fig. 3.17. (A) Primary outcrop of jasper and (B) detail of the surface (modified from Berruto, 2011).

Concerning vein quartz, the first analysis conducted were aimed to a precise characterization of this lithology, identifying all the elements useful to demonstrate the consistency between the lithic artefacts found in the site and vein quartz present in the primary outcrops and in the secondary deposits located at the base of the mount (Berruto, 2011).

The observation through the stereomicroscope in reflected light allowed to identify different elements useful for the comparison between archaeological vein quartz artefacts and the sample collected during survey activities. The presence, on some archaeological pieces, of minerals that according to their colour and morphology can be identify as chlorite and actinolite indicates the formation of vein quartz in an environment characterized by a low metamorphic degree (Fig. 3.18) (Berruto, 2011).

Other important elements for the definition of vein quartz sources is the presence of micas. Biotite and muscovite are visible on the neocortex of the archaeological vein quartz artefacts (Fig. 3.18), confirming that they have been obtained through the exploitation of vein quartz formed in metamorphic rocks and in an environment with low metamorphic degree, linked to geologic faults (Berruto, 2011).

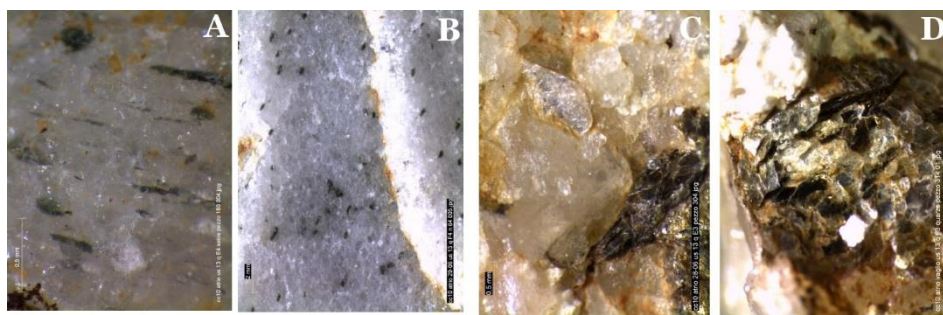


Fig. 3.18. Detail of the surface of vein quartz lithic artefacts from the Ciota Ciara cave: (A, B) detail of biotite and actinolite; (C, D) detail of biotite and muscovite (modified from Berruto, 2011).

The same minerals and micas have been found on the surface of the vein quartz samples collected at the base of Monte Fenera, in correspondence of veins formed

inside the igneous rocks of the Permian Volcanic Complex and in the hercynian metamorphic rocks, confirming the local origin of this raw material (Berruto, 2011) (Fig. 3.19).

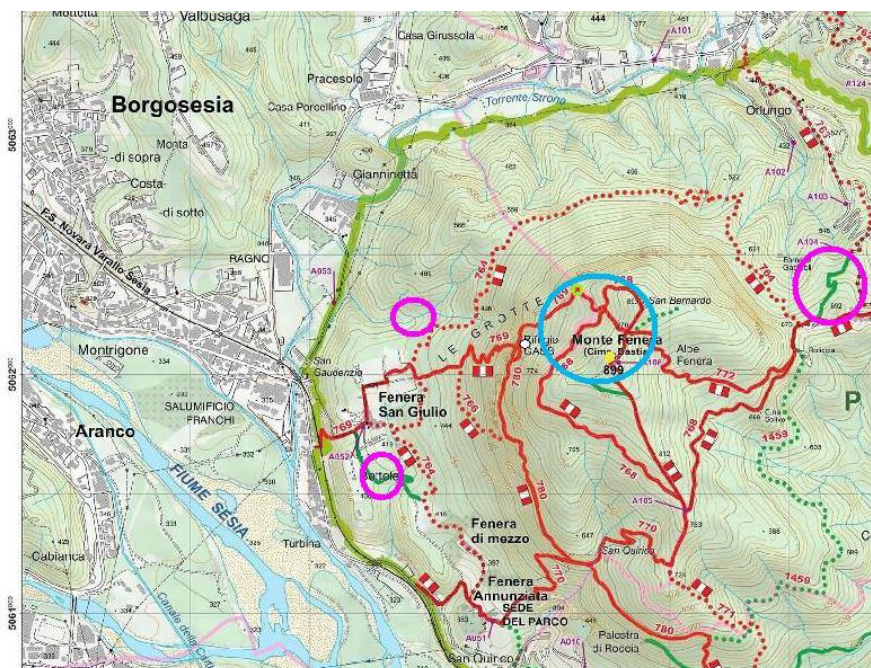


Fig. 3.19. Map with the location of the primary outcrops of vein quartz identified at the base of Monte Fenera (pink) and of primary and secondary deposits of spongolite and flint (blue) (modified from Berruto, 2011).

Since vein quartz was collected for knapping activities not from the primary outcrops but, as indicated by the frequent presence of fluvial neocortex, in secondary deposits, starting from the approach developed by P. Fernandes et al. (2007), a specific methodology was elaborated for a more precise identification of vein quartz secondary deposits. This analytical technique is based on the microscopic observation of flint cortex to identify pre-depositional processes, linked to specific features of the secondary deposits from where they were collected (Fernandes et al., 2007). This methodology was adapted to the particular characteristics of vein quartz, generally more resistant than flint to alterations (Venditti et al., 2016): through the microscopic and macroscopic observation of the neocortex present on the archaeological finds, an intense

survey activity and the comparison between archaeological data and those from the samples collected, interesting results have been achieved (Berruto, 2016).

Samples have been collected from different kind of alluvial deposits: current alluvial river deposits (i.e. Sesia river); current alluvial creek deposits (i.e. Strona creek); current alluvial stream deposits (i.e. Monte Fenera's streams); Pleistocene alluvial deposits (i.e. remaining portions of fluvial terraces linked to the Sesia riverbed) (Berruto, 2016).

The consideration of different parameters (lithology, presence of micas, neocortex morphology and appearance, colour, polish degree, presence and morphology of striations and scratches, pressure cones, impact traces, holes and fractures) led to the identification of the probable secondary deposits where the prehistoric human groups frequenting the Ciota Ciara cave collected vein quartz (Berruto, 2016). The comparison between the archaeological material and the geological samples collected, reveals that the vein quartz exploited at the Ciota Ciara cave comes from Pleistocene alluvial deposits (Fig. 3.20) and from current river alluvial deposits (Fig. 3.20), no neocortex referable to the collecting of vein quartz in creeks and streams have been identified (Berruto, 2016). This results show that vein quartz was probably collected in fluvial deposits linked to the Sesia river fluvial deposits at a distance of at least 750 m in a straight line from the Ciota Ciara cave (Berruto, 2016).



Fig. 3.20. Example of a Pleistocene alluvial deposit close to Fenera S. Giulio, at the base of Monte Fenera and of a current alluvial deposit (Sesia river). (Modified from Berruto, 2016).

3.5.2. Allochthonous raw materials

Some of the lithologies present in the archaeological levels of the Ciota Ciara cave are present in the assemblage mainly as finished tools or as small flakes with technological characteristics suggesting their belonging to the modification and rejuvenation of tools' edges (retouch flakes). For this raw materials, characterized by a homogeneous texture and by a good conchoidal fracture, has been hypothesise an allochthonous origin, both for their technological role in the lithic assemblage (Moncel, 2007) and for their petrographic characteristics. A first macroscopic observation led to the distinction between two different lithologies of sedimentary and volcanic origin respectively. This preliminary subdivision has then been confirmed by microscopic observations.

The present work is aimed to the identification of primary and/or secondary deposits of these raw materials thus completing the reconstruction of the economic behaviour and of the land mobility patterns of the Middle Palaeolithic human groups that inhabited the Ciota Ciara cave.

3.5.2.1. Radiolarites

Tools and retouch flakes realized on a very good quality raw material, characterized by a red/dark-red colouring, are present in all the main

stratigraphic units of the Ciota Ciara cave (13, 14 and 15) in different proportions (Fig. 3.32, 3.47, 3.61, 3.78). 97 lithic artefacts (flakes, retouched tools and retouch flakes) coming from the considered archaeological layers have been observed through a stereomicroscope in reflected light at different magnifications (for the technological characterisation see chap. 3.6.1, 3.6.2, 3.6.3 and 3.6.4) (Fig. 3.21).

The analysis highlights the presence, in all the 97 considered artefacts, of transversal sections of radiolarians, which skeletal material seem to have been substituted by calcedony (Fig. 3.21). The matrix is generally red, homogenous and do not present fissures or impurities (Fig. 3.21), thus confirming the good quality of this raw material for the production of lithic tools. According to the data obtained from the microscopic observation, the 97 artefacts have been identified as lithic tools made in radiolarite.

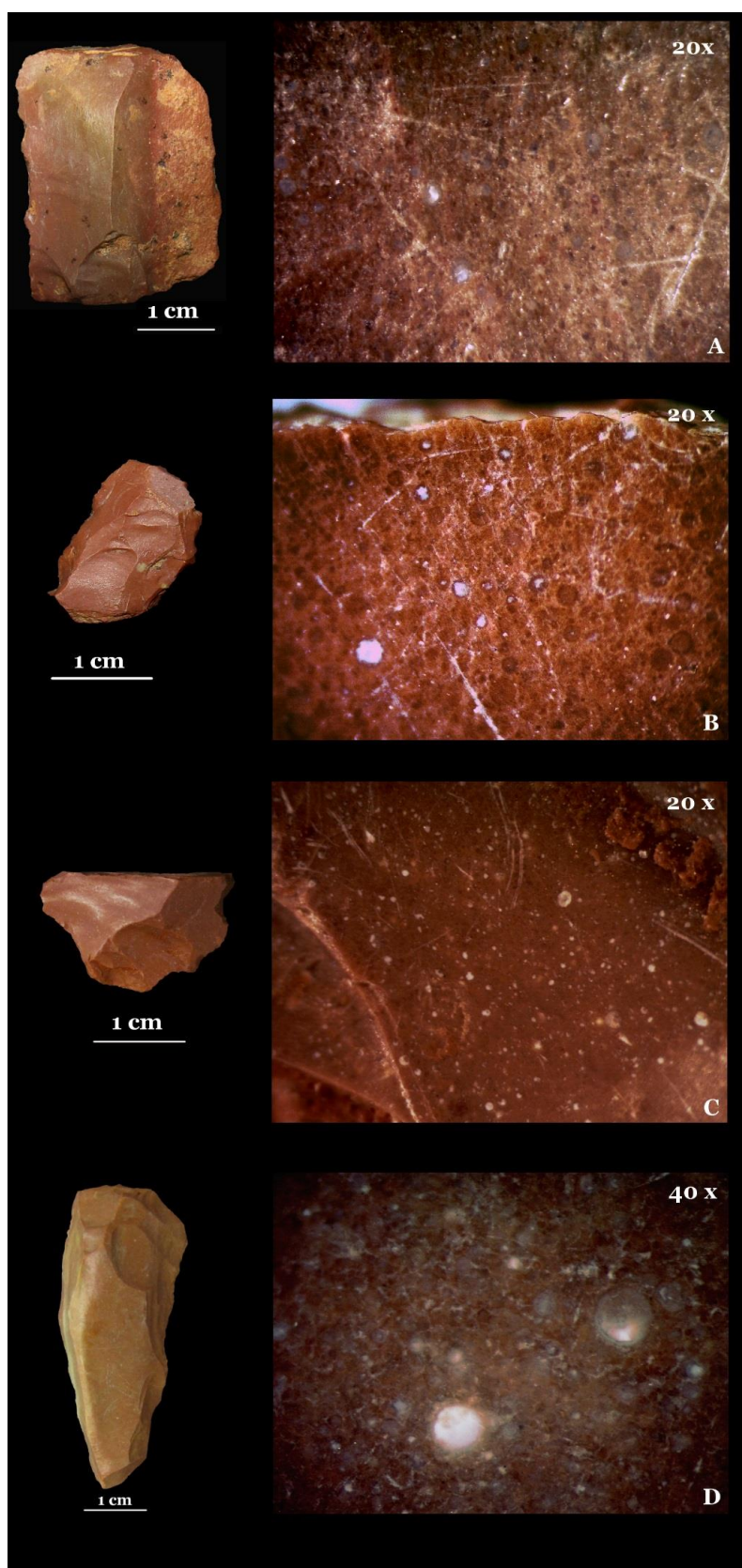


Fig. 3.21. Ciota Ciara cave, stereomicroscope observation of radiolarite artefacts belonging to S.U. 14 (A, B) and 15 (C, D). In all the pictures are well visible transversal sections of radiolarians, and the homogeneous texture that characterize this sedimentary biogenic rock.

The subsequent study of the geological maps (Fig. 3.22) revealed that the petrographic characteristics of the lithology present at the Ciota Ciara cave are consistent with those of the Lombardian Radiolarite Group, a Middle Jurassic formation which represent also the radiolarite outcrops nearest to the Ciota Ciara cave (~ 25-30 Km in a straight line) (Sciunnach, 2007a).

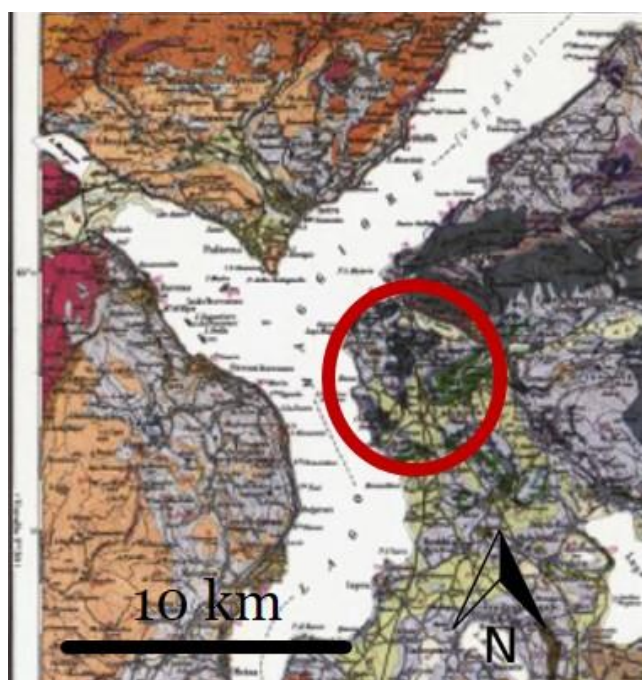


Fig. 3.22. Detail of the geological map 1:100.000 with indication of the surveyed area.

Radiolarites and siliceous limestones of the Lombardian basin consist of polychrome and well stratified flints, with intercalations of siliceous argillites, substituted in the upper part of the formation by red flint with radiolarians that can be found in layers or nodules within rose-coloured marly limestones or marls (Sciunnach, 2007a). From the bottom to the top, the Group is divided in two formations: Radiolarites of the Lombardian Radiolarite Group and Rosso ad Aptici (Sciunnach, 2007a). Its lateral boundaries are clear both eastward, in correspondence of the tectonic lineament of Valli Giudicatarie, and westward, in correspondence of the Lombard bank of Maggiore Lake (Sciunnach, 2007a). Within the Radiolarites of the Lombardian Radiolarite Group, two facies are

distinguished (Sciunnach, 2007b): the lower ribbon facies, formed by polychrome radiolarite slabs, and the upper knobby facies, formed by radiolarite nodules mainly dark-red coloured (Sciunnach, 2007b).

The field work for the collecting of geological samples to be analysed and compared with the archaeological materials, has then been set up. Considering that usually, during Middle Palaeolithic, is unlikely to hypothesize a distance of more than a few tens of kilometres from the site for the collecting of lithic raw materials (e.g. Moncel, 2007), the nearest area where outcrops of radiolarites are indicated on the geological maps, have been primarily object of survey activities. The selected area corresponds to a small mount located in the Sangiano municipality (Varese, western Lombardy), ~ 30 Km in a straight line from the Ciota Ciara cave, and close to the western bank of Maggiore Lake. In this area, at an altitude between 397 and 420 a.s.l., three samples, from the primary outcrop (Fig. 3.23) and from secondary deposits located near the outcrops, have been collected and observed at the stereomicroscope in reflected light. The raw materials collected in the Sangiano area show petrographic characteristics like those of the archaeological materials previously analysed, with abundant radiolarians in a homogeneous reddish matrix (Fig. 3.24).

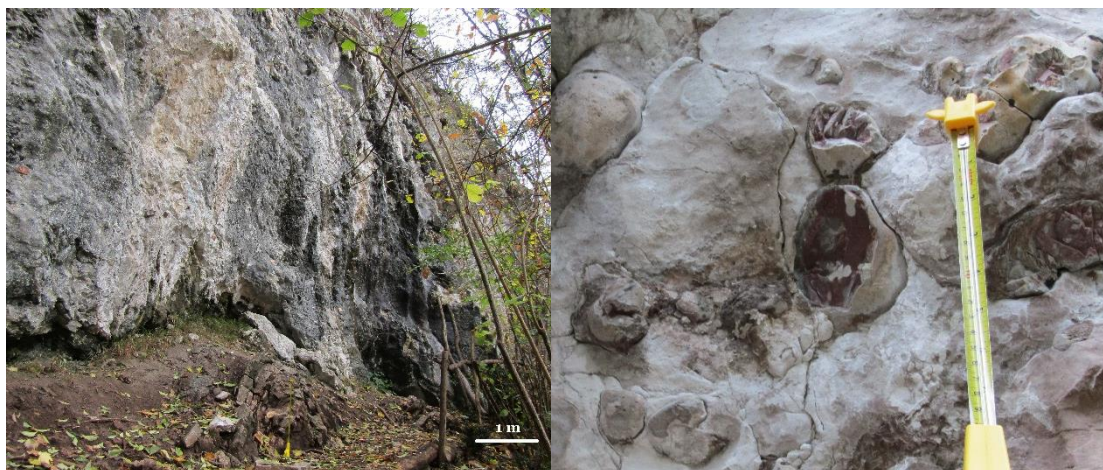


Fig. 3.23. Sangiano (VA – Lombardy). Primary outcrop of the Lombardian Radiolarite Group: within a thick layer of marly limestones are present abundant red flint nodules belonging to the formation of the Radiolarites of the Lombardian Radiolarite Group.

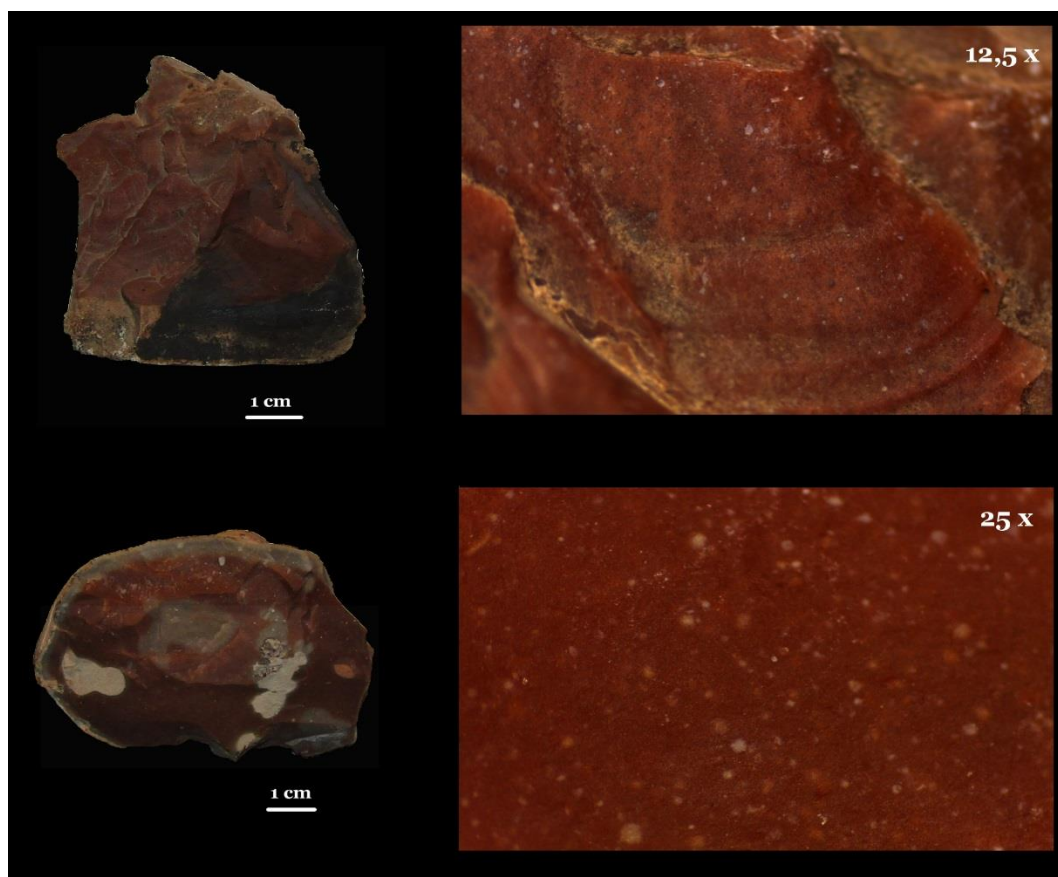
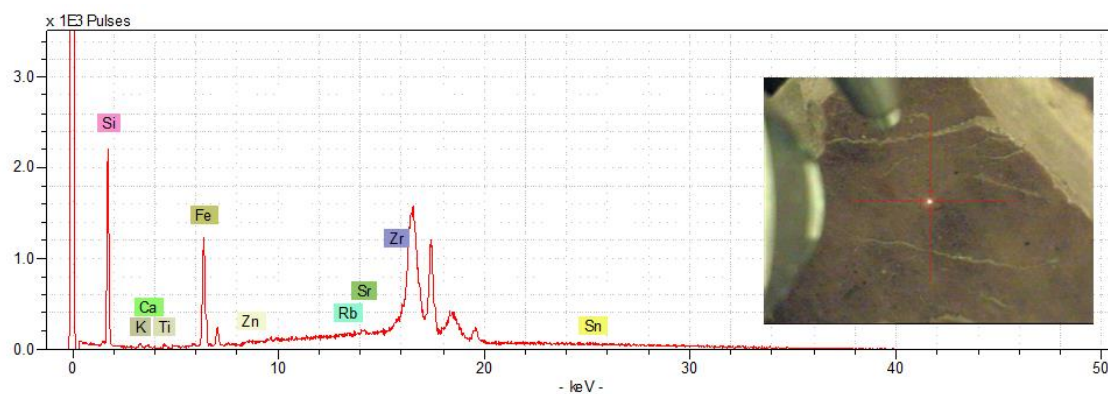
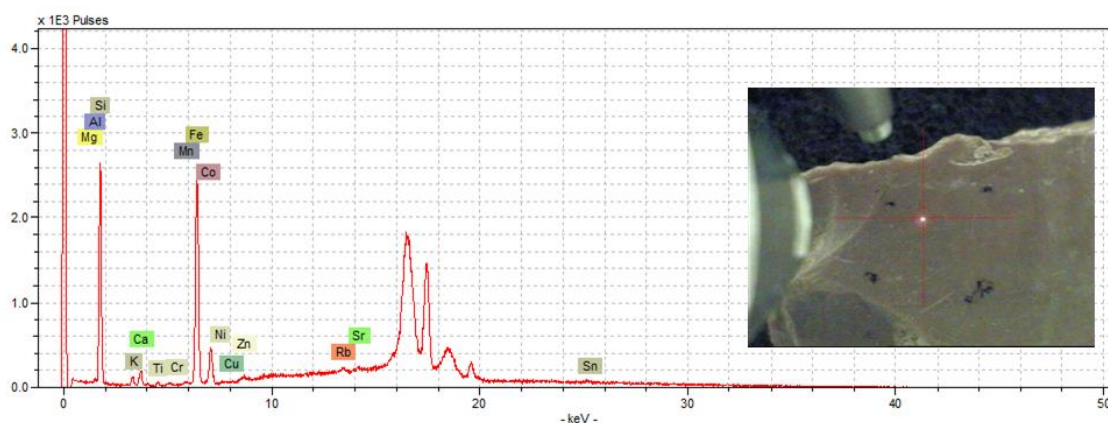


Fig. 3.24. Stereomicroscope observation of the samples collected at Sangiano. The samples are consistent with the archaeological materials of the Ciota Ciara cave. In both the pictures are well visible the homogenous reddish matrix and the radiolarians skeletal that characterize the Radiolarites of the Lombardian Radiolarite Group.

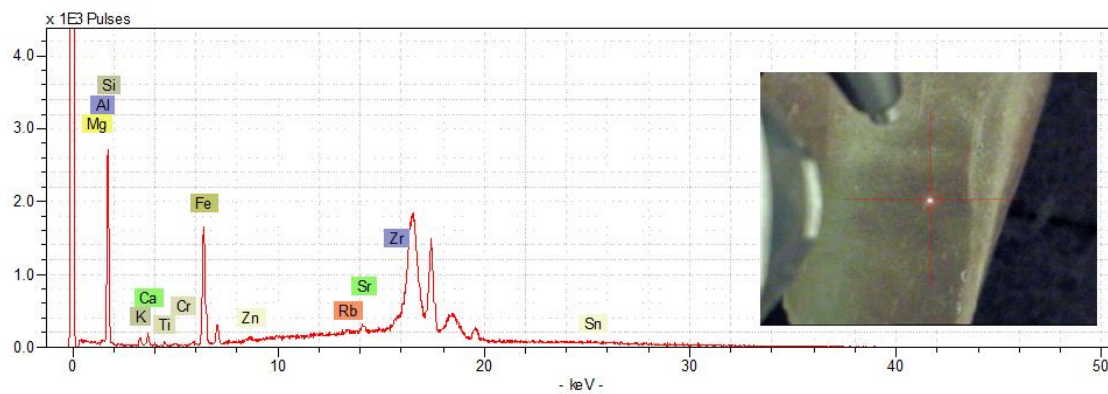
To verify the provenience of the radiolarites exploited at the Ciota Ciara cave from the formations belonging to the Lombardian Radiolarite Group, a μ -XRF analysis has been performed on a selected sample of four archaeological materials (14F317, 14F353, 15-11F326, 15-15D368) and on the three geologic samples from Sangiano. The spectra presented in Fig. 3.25 and in Appendix 1 show that the consistency between the radiolarite artefacts of the Ciota Ciara cave and the geologic samples collected, already highlighted by the petrographic observations, is confirmed by the geochemical analysis. The results obtained (Fig. 3.31) show that the radiolarite present in the Ciota Ciara cave was collected from outcrops or secondary deposits belonging to the Lombardian Radiolarite group, that today are located at about 25-30 Km from the site (Sciunnach, 2007a) (Fig. 3.29). The exploitation of this raw material took place in proximity of the outcrops or in places located along the path connecting the Ciota Ciara cave and other sites, still unknown and probably frequented during the year in the context of seasonal movements.



A



B



C

Fig. 3.25. μ -XRF spectra of a radiolarite sample from Sangiano (A), of the sidescraper 14 F3 53 (B) and of the limace (15-15 D3 68).

3.5.2.2. *Rhyolite*

Beside the group of artefacts realized on good quality radiolarites, a second group of artefacts is recognizable at the Ciota Ciara cave due to the good-quality raw material employed. At a macroscopic observation, the lithic artefacts belonging to this group seem to have been realized on a fine-grained volcanic rock with a light-red colouring and conchoidal fracture, providing a very good control of the results of knapping activities and the production of tools with sharp edges. This lithology is present in different proportion in all the archaeological layers of the Ciota Ciara cave (13, 14, 15 and 103) (Figg. 3.32, 3.47, 3.61, 3.78) and it is represented by retouched tools, flakes, small flakes referable to the modification or rejuvenation of the tools' edges, debris and, to a lower extent, by cores. A total of 73 artefacts has been observed at different magnification with a stereomicroscope in reflected light (Fig. 3.26). The analysis highlights the presence of several millimeter sized quartz and feldspar phenocrysts dispersed in an aphanitic reddish matrix, thus confirming the volcanic origin of this lithology, and allowing to refer it to a variety of rhyolite.

According to the geological data available, the petrographic characteristics observed on the lithic artefacts of the Ciota Ciara cave, are consistent with the rhyolites described by Quick et al. (2003) which primary outcrops are located on the opposite bank of the Sesia river, at a distance of about 2 km in a straight line from the Ciota Ciara cave (Fig. 3.27) (Quick et al., 2003).

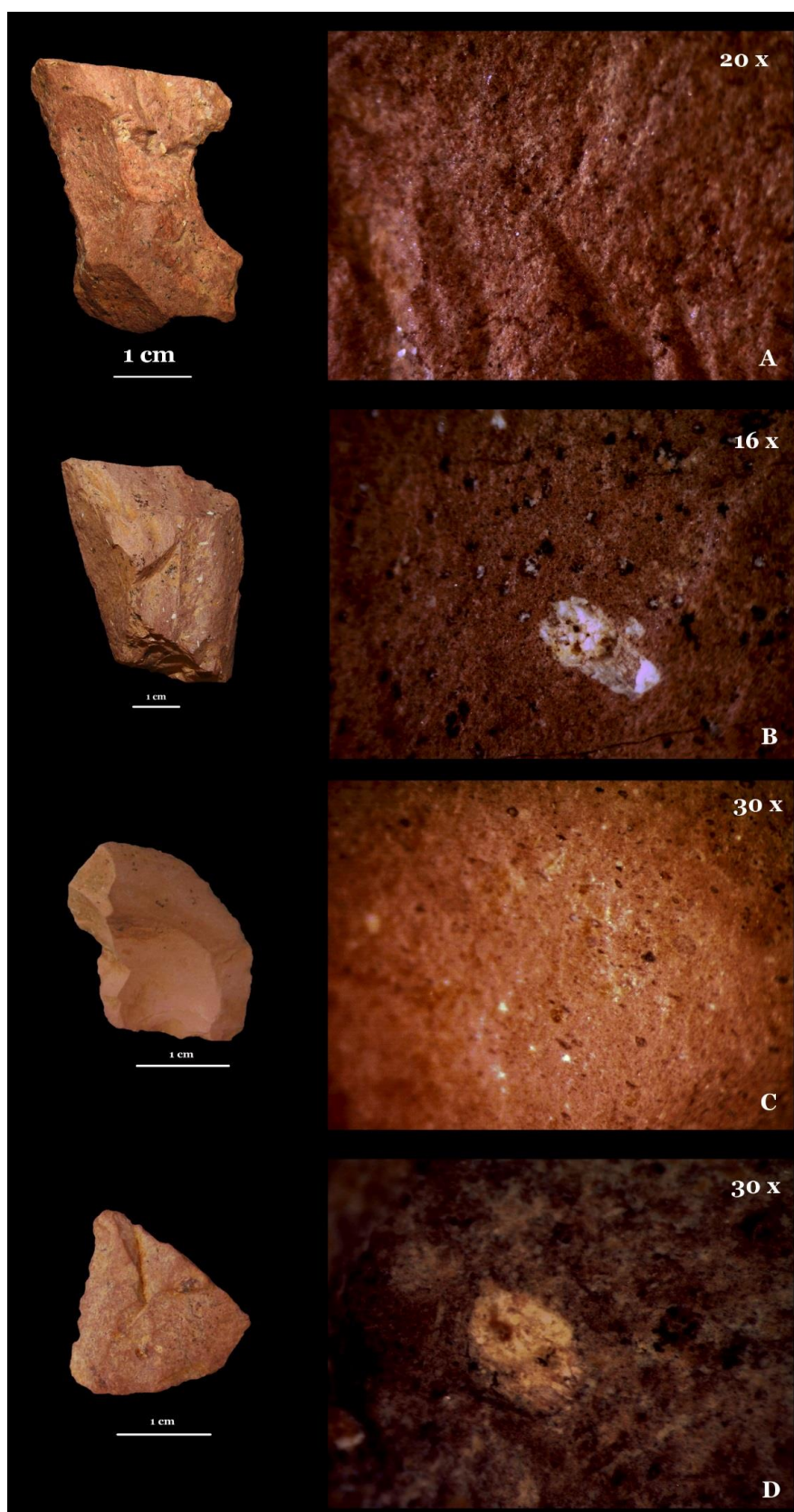


Fig. 3.26. Ciota Ciara cave, stereomicroscope observation of rhyolite artefacts belonging to S.U. 14 (A, B) and 15 (C, D). In all the pictures are well visible the millimeter-size quartz and feldspar phenocrysts.

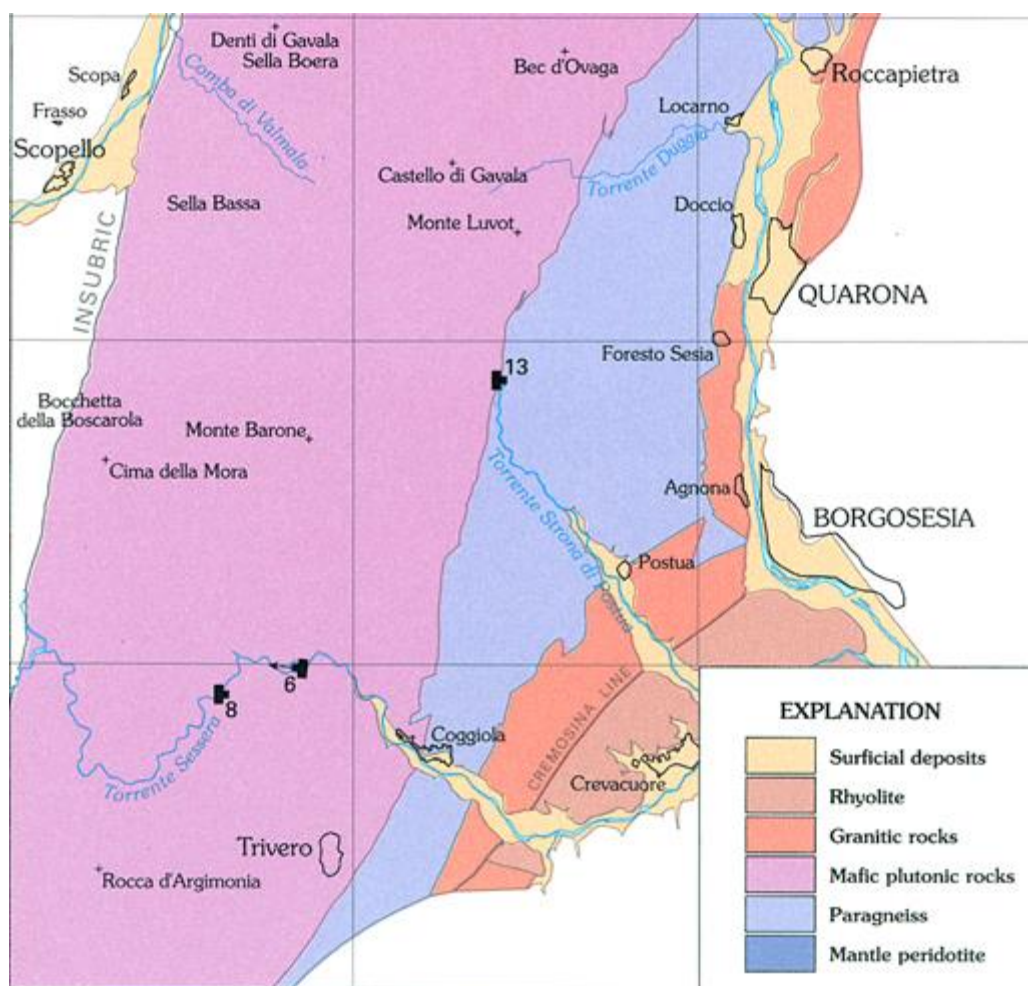


Fig. 3.27. Geologic map with geographic information of the left orographic side of the lower Sesia valley and surrounding territories (modified from Quick et al., 2003).

Since the characteristics of the smooth natural surfaces present on the rhyolite lithic artefacts of the Ciota Ciara cave show alterations consistent with a fluvial transport, i.e. fluvial neocortex, it is likely that rhyolite blanks for knapping activities were collected in secondary deposits.

For this reason, survey activities were carried out along the Sessera river and in correspondence of its confluence with the Sesia river (Fig. 3.28).



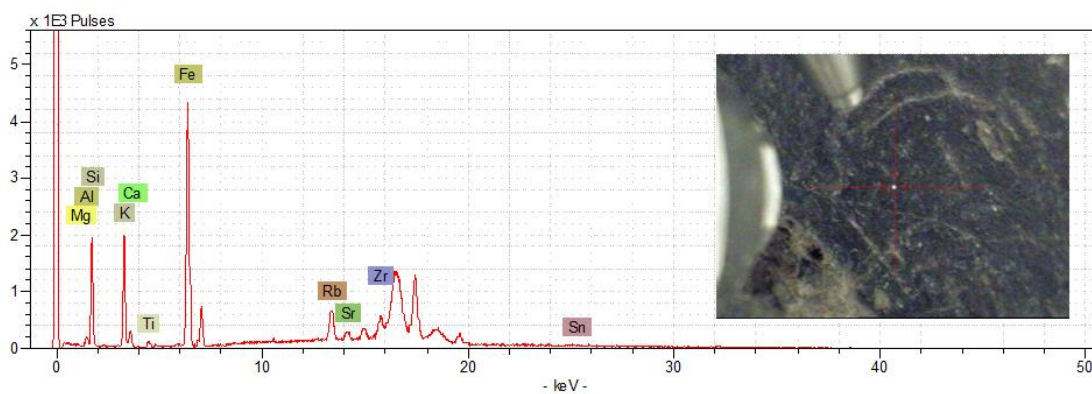
Fig. 3.28. Sessera valley (VC – Piedmont). Survey activities were carried out in this area to collect geological samples of rhyolite. Monte Fenera is visible on the background and reddish rhyolite pebbles are quite common along the Sessera river.

During survey activities were collected rhyolite pebbles that at a macroscopic observation had characteristics consistent with those of the archaeological artefacts in terms of texture and colour. The samples collected were observed at the stereomicroscope in reflected light showing the presence of quartz phenocrysts in an aphanitic matrix (Fig. 3.29). From a petrographic point of view the samples collected are comparable to the rhyolite knapped at the Ciota Ciara cave.

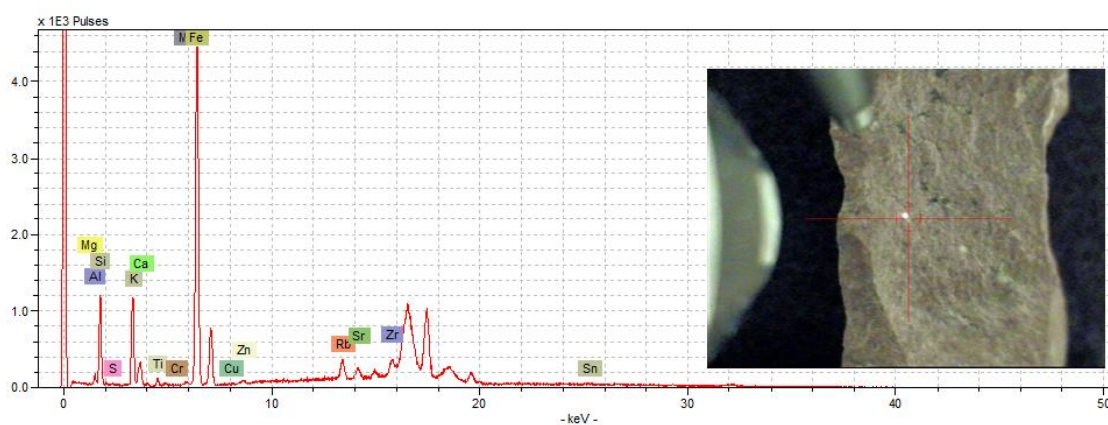


Fig. 3.29. Stereomicroscope observation of the samples collected along the Sessera river. In the aphyric matrix are well visible quartz and feldspar phenocrysts.

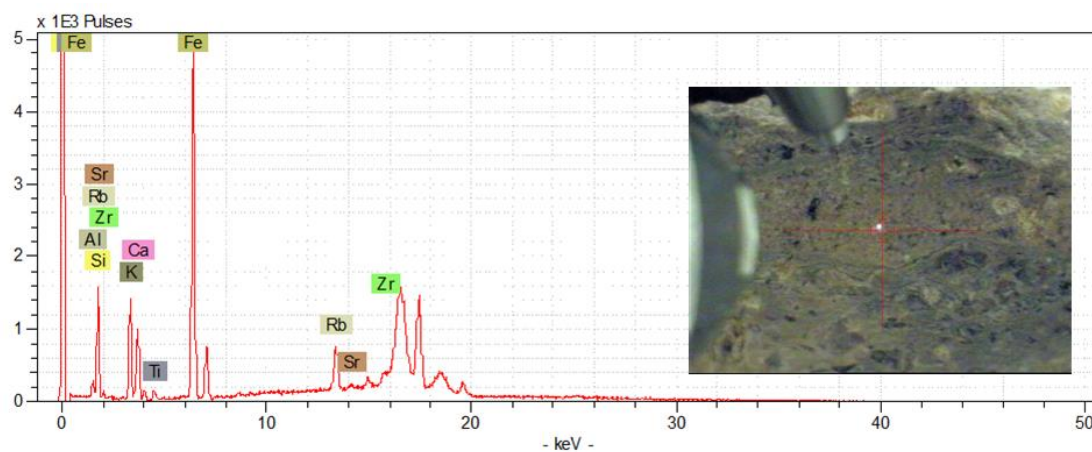
To confirm the provenience of the rhyolites knapped at the Ciota Ciara cave from the outcrops located close to the Sessera river, a μ -XRF analysis has been carried out on a selected sample of five archaeological materials (14D4121, 14E3260, 14E31276, 14F2825, 15-13F31527) and on the three geologic samples collected (Fig. 3.30). The spectra presented in Fig. 3.28 and in Appendix 1 show that the consistency between the rhyolites artefacts present in the lithic assemblage of the Ciota Ciara cave and the geologic samples, already highlighted by the petrographic observations, is confirmed by the geochemical analysis. The results obtained (Fig. 3.31) show that the rhyolite exploited at the Ciota Ciara cave during Middle Palaeolithic is of sub-local origin, it was collected in secondary deposits located at a distance of about 2 km from the site, probably during movements linked to other subsistence activities, and the production of tools took place mainly outside the cave, even if the presence of one core in S.U. 14 and of two cores in S.U. 15 suggest that occasionally rhyolite was knapped in the site.



A



B



C

Fig. 3.30. μ -XRF spectra of a rhyolite sample from the Sessera river (A), of the notch 14 E3 1276 (B) and of the flake 15-13 F3 1527.

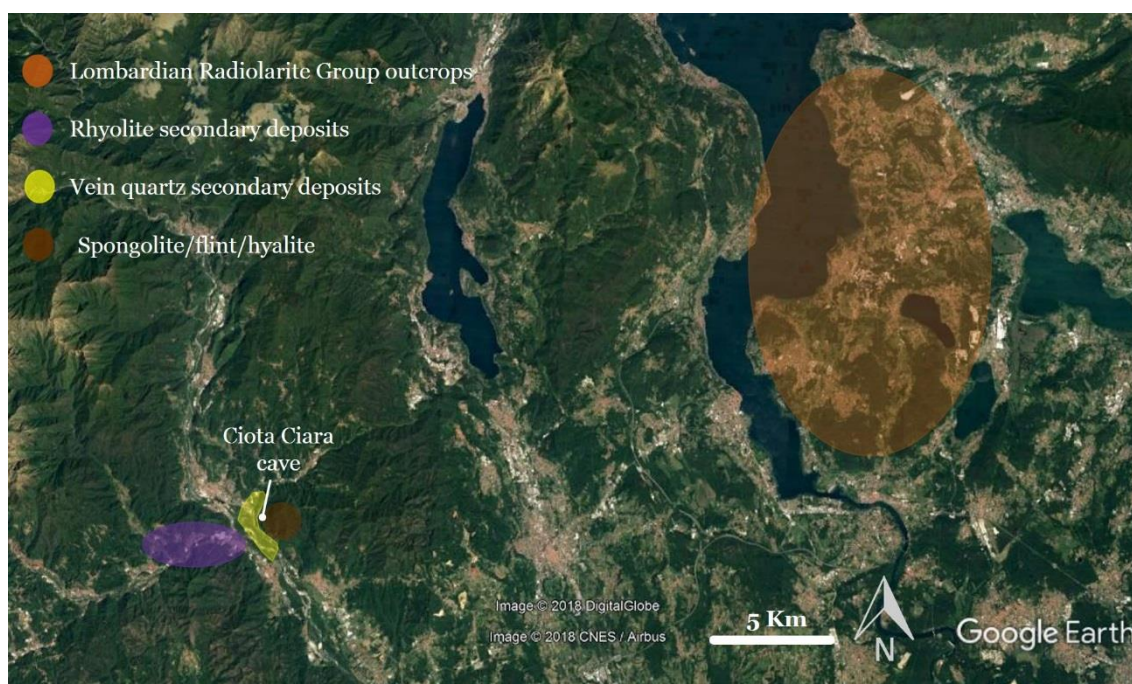


Fig. 3.31. Maps of the supply areas of the lithic raw materials of the Middle Palaolithic levels of the Ciota Ciara cave: spongolite, flint and hyalite outcrops and/or secondary deposits (brown) are located at the top of Monte Fenera, between 720 and 899 m a.s.l.; the vein quartz secondary deposits exploited (yellow) are located at the base of Monte Fenera at about 750 m from the site; rhyolite secondary deposits (purple) are present along the Sessera valley, close to the confluence with the Sesia river at ~2km from the site; outcrops of radiolarites of the Lombardian Radiolarite Group (red) are located between ~20 and ~30 km from the site.

3.6. Technological analysis

The technological analysis of the lithic assemblage of the Ciota Ciara cave has been partially completed in 2011 with the analysis of the lithic assemblage from S.U. 13 (Arzarello et al., 2012a; Daffara, 2011; Daffara et al., 2014). The present research deals with the analysis of the lithic assemblages of S.U. 14, 15, 103 and with an upgrade of the previous study on S.U. 13, further excavated in the last years after the enlargement of the investigated area (see chapter 3.2.1). The subdivision of vein quartz artefacts in morpho-structural groups has been performed for all the materials from S.U. 14, 15 and 103, while most part of the lithic artefacts belonging to S.U. 13, stored at Museo di Archeologia e Paleontologia “C. Conti” in Borgosesia (VC, Italy) has not been considered for this specific analysis.

Since the lithic industry of the Ciota Ciara cave is mainly realized on vein quartz of local origin and Levallois and discoid exploitation strategies are widely attested in the site on different raw materials, we had the chance to observe in detail the technological choices applied and to make some comparisons between raw materials with different petrographic features.

3.6.1. S.U. 13

Level 13 has been the first archaeological layer of the Ciota Ciara cave systematically investigated at the re-opening of the excavations in 2009 (Arzarello et al., 2012a, 2012b). As mentioned in section 3.3, the upper part of the stratigraphic sequence of the Ciota Ciara cave is missing due to previous excavations and to unauthorized interventions (Busa et al., 2005; Zambaldi, 2015): level 13 is partially preserved, but the general dynamics of the human frequentation of the site during its deposition are anyway understandable from

the palaeontological, technological and functional data collected (Arzarello et al., 2012a; Berruti, 2017; Berruti and Arzarello, 2012; Berto et al., 2016). All the studies carried out agree upon a general interpretation of this unit as a result of sporadic and brief frequentations of the cave by hunter-gatherers' human groups. Its lithic assemblage has already been object of a technological analysis (Daffara, 2011; Daffara et al., 2014) but the continuation of the researches in the site, with the extension of the investigated area, made increase the lithic assemblage belonging to this unit (Angelucci et al., 2016, 2015; Arnaud et al., 2014; Arzarello et al., 2013). The work presented here represents an upgrade of the data already published (Arzarello et al., 2012a; Daffara et al., 2014) focusing the analysis on vein quartz Levallois and discoid reduction sequences.

The lithic assemblage of S.U. 13 is composed by 891 artefacts issued from the exploitation of almost exclusively local raw materials (Fig. 3.32) (Angelucci et al., 2015; Berruto, 2016, 2011) among which vein quartz is, by far, dominant, representing 86,2% of the assemblage followed by spongolite and grey/black flint in similar proportions (6,6% and 5,8% respectively). Other lithic raw materials of local and allochthonous origin (opal, milonite, rhyolite and radiolarite) are sporadically attested and often represented just by one artefact (Fig. 3.32). A local metamorphic rock is also present in the assemblage as a hammer fragment.

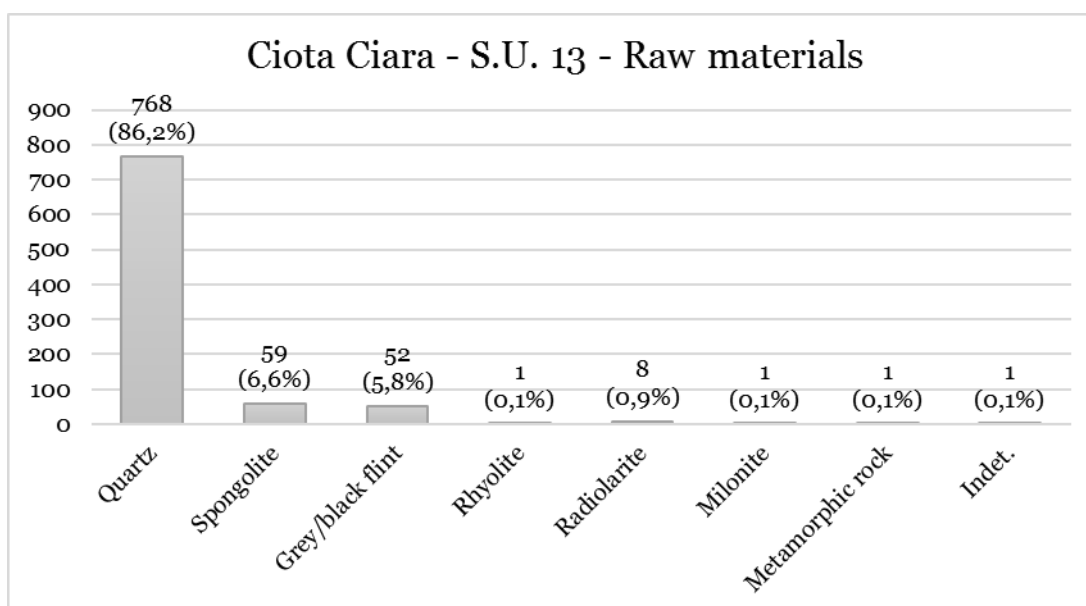


Fig. 3.32. Ciota Ciara cave, S.U. 13. Raw materials present in the lithic assemblage.

The state of preservation of the assemblage is generally good but not homogenous since vein quartz is less affected by chemical and mechanical alterations like white patina and rounding (Fig. 3.33). This diversity can not be interpreted as a consequence of different modalities of deposition but, as demonstrated by recent studies, it is caused by the different petrographic features of the considered raw materials that lead to a different response to mechanical and chemical post depositional agents (Venditti et al., 2016). Therefore, despite slight differences in the state of preservation, all the lithic artefacts of S.U. 13 can be considered part of a unique assemblage. No alterations linked to human activities (i.e. heat treatment) have been identified, thus confirming the interpretation of this level as a result of repeated but brief human frequentations (Arzarello et al., 2012a; Berruti, 2017; Berruti and Arzarello, 2012; Daffara et al., 2014).

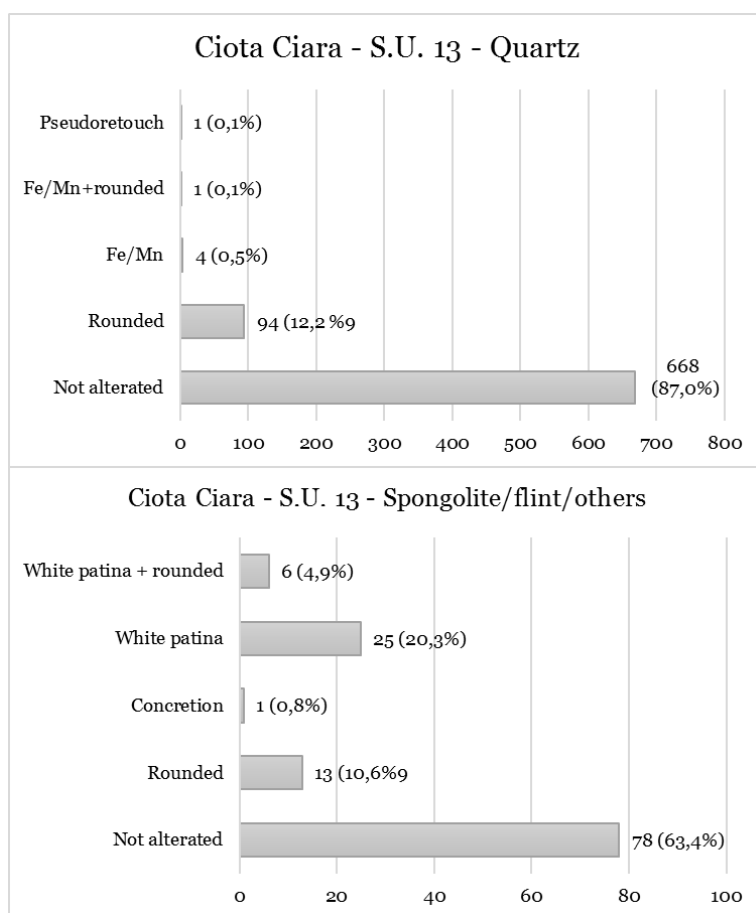


Fig. 3.33. Ciota Ciara cave, S.U. 13. Post depositional alterations identified on vein quartz artefacts and on all the other raw materials present in the assemblage.

The general composition of the lithic assemblage suggests that the reduction sequences are complete for quartz and spongolite with the presence of flakes, cores, debris retouched tools and 2 unworked blanks (Tab. 3.2). The presence of only unretouched flakes and debris in grey/black flint indicates that the exploitation of this raw material took place mainly out of the site. (Tab. 3.2).

Raw material	Flakes	Cores	Retouched tools	Debris	Unworked blanks	Total
Quartz	444	31	16	276	1	768
Spongolite	32	3	2	21	1	59
Grey/black flint	29	-	-	23	-	52
Other	6	1	1	4	-	12
Total	511	35	19	324	2	891
%	57,4%	3,9%	2,1%	36,4%	0,2%	100,0%

Tab. 3.2. Ciota Ciara cave, S.U. 13. Composition of the lithic assemblage

Rhyolite and radiolarite flakes are mainly linked to the rejuvenation of the edges of tools that were probably brought out of the site. Some/most part of pieces classified as debris could be linked to this kind of activity as well.

The rate of fragmentation is higher for quartz than for spongolite (Fig. 3.34) even if the petrographic characteristics of most part of the spongolite assemblage, i.e. the presence on several cleavages and internal flaws, significantly affect the response to knapping of this raw material in terms of a considerable occurrence of fractures, making the proportion of complete flakes generally low (Fig. 3.34).

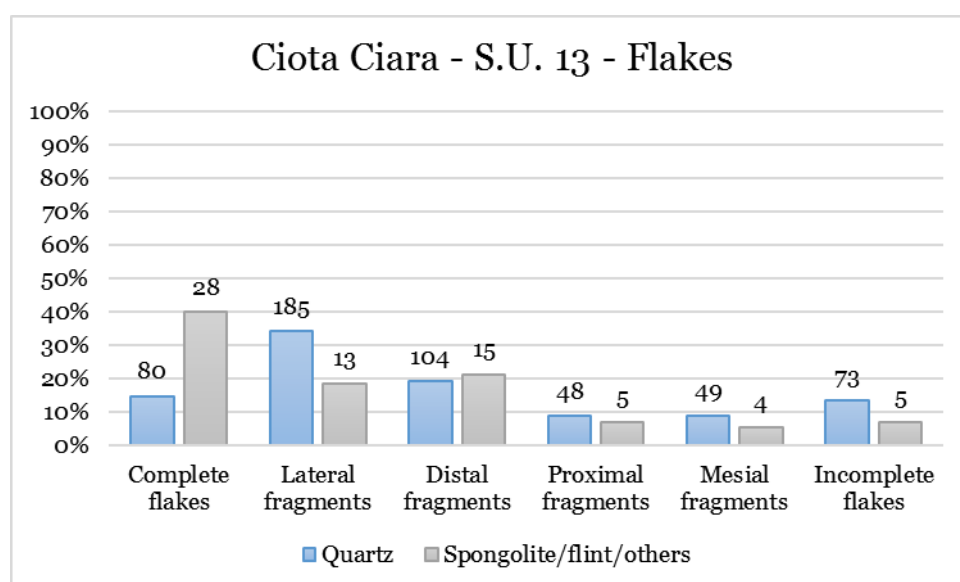


Fig. 3.34. Ciota Ciara cave, S.U. 13. Rate of fragmentation of vein quartz flakes compared to that of the other raw materials present in the assemblage (spongolite, grey/black flint, radiolarite, rhyolite, opal, milonite, indet. raw material).

This tendency to break during knapping proper of quartz and spongolite is one of the factors influencing both the dimensions of the products and the technological behaviour of the knappers for what concerns the choice of the blanks to be exploited and of the knapping method to be adopted (de Lomberra-Hermida et al., 2016; Driscoll, 2011; Tallavaara et al., 2010).

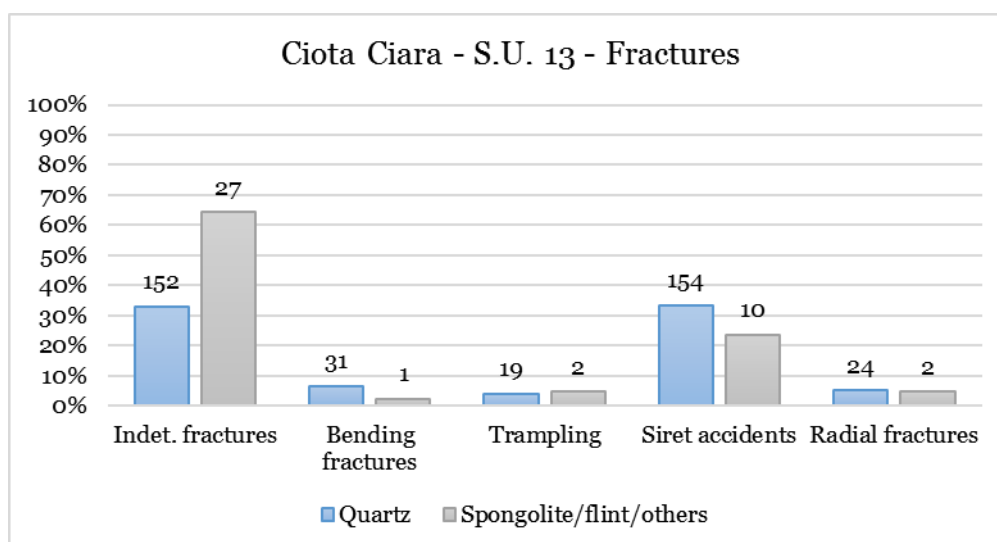


Fig. 3.35. Ciota Ciara cave, S.U. 13. Typology of the fractures identified on the flakes and comparison between vein quartz flakes and flakes obtained from the other raw materials present in the assemblage (spongolite, grey/black flint, radiolarite, rhyolite, opal, milonite, indet. raw materials). Tot. quartz fractures = 459; tot. spongolite/flint/other raw materials fractures = 42.

Looking at the typology of the fractures present on the products issued from the exploitation of the different raw materials present in level 13, it is evident the tendency of vein quartz to break according to radial planes, in most cases passing through the impact point of the flake and generating fractures classifiable as siret accidents according to the definition proposed by V. Mourre (1996). The great amount of cleavages and internal flaws in both the main raw materials, is the reason for the high number of fractures of undetermined origin, since breakages following natural fracture planes can occur during knapping and use or can be due to post depositional factors (Driscoll, 2011; Mourre, 1996; Tallavaara et al., 2010). Sometimes, the different intensity of post depositional alterations between the fracture surface and the remaining part of the flake made possible to attribute the cause of the breakage to post depositional factors, but the general scarce occurrence of strong post depositional alterations made it possible just in a few cases (Fig. 3.35).

Regardless the knapping method employed, the presence of cortex or, concerning quartz flakes, neocortex, is limited (Fig. 3.36). Rhyolite, radiolarite and opal

flakes do not show any portion of natural surfaces, thus supporting the hypothesis that their exploitation was performed out of the Ciota Ciara cave. Considering vein quartz flakes, when neocortical surfaces are present, they are located on one side of the flake (lateral position) or on the entire dorsal face (Fig. 3.36). More than 90% of the spongolite flakes do not have cortex visible on the dorsal face, but the slight presence of flakes with total, lateral and proximal cortex confirms that spongolite blanks were exploited in the site since the beginning of the reduction sequences (Fig. 3.36). Lateral cortex is associated to an opportunistic/S.S.D.A. exploitation (Forestier, 1993) and to unipolar removals for all the raw materials, thus suggesting that this kind of *débitage* starts directly from the natural surfaces of the cores, exploiting suitable convexities, and proceeds using the same striking platform until the convexity is exhausted.

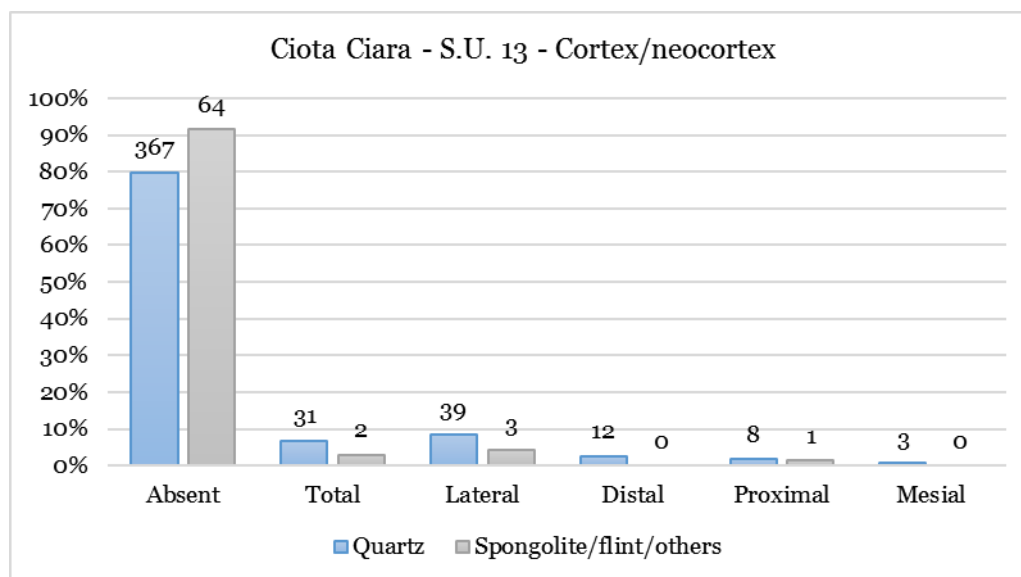


Fig. 3.36. Ciota Ciara cave, S.U. 13. Presence and position of neocortex on vein quartz flakes and of cortex on flakes obtained from spongolite, grey/black flint, radiolarite, rhyolite, opal, milonite and indet. raw materials. Tot. vein quartz flakes = 460; tot. spongolite/flint/other raw materials flakes = 70.

One of the elements involved in the identification of the different knapping methods is the direction of the negatives of previous removals on the dorsal faces

of the flakes (Fig. 3.37). The number of undetermined or unreadable negatives is higher for spongolite and flint than for vein quartz (Fig. 3.37) because they are more affected by post depositional alterations (Fig. 3.33). Concerning vein quartz, as already mentioned in Chapter 2, the registration of the knapping scars on its surface is not always as clear as for other raw materials and, together with the general high rate of fragmentation, it determines a scarce legibility of this technological feature (Fig. 3.37).

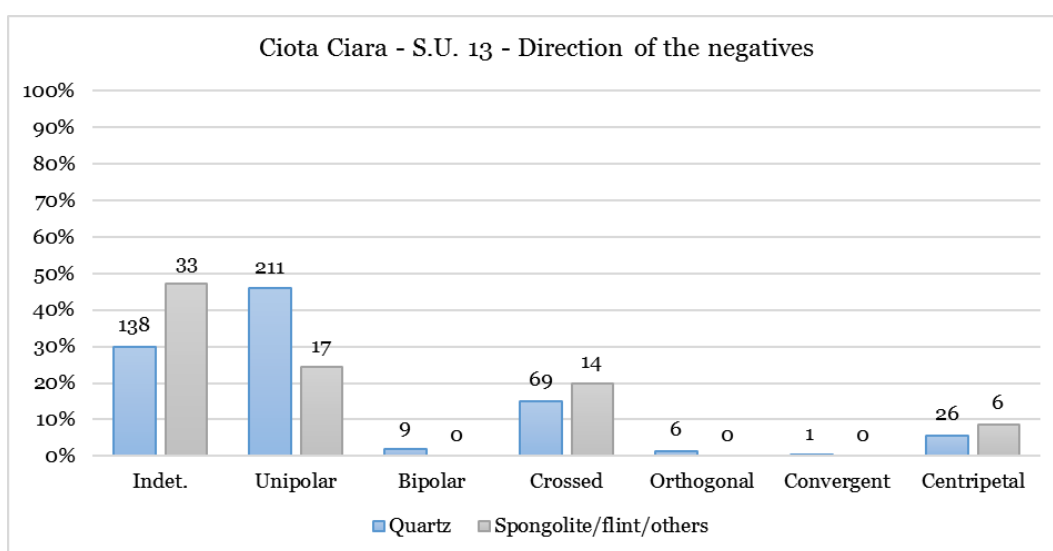


Fig. 3.37. Ciota Ciara cave, S.U. 13. Direction of the negatives of previous removals visible on the dorsal faces of the flakes. Tot. vein quartz flakes = 460; tot. spongolite/flint/other raw materials flakes = 70.

Unipolar, bipolar and orthogonal removals are associated to opportunistic/S.S.D.A. reduction sequences (Forestier, 1993) for all the raw materials, while convergent and centripetal scars belong to discoid and Levallois knapping methods (Boëda, 1994, 1993). Flakes with crossed negatives on the dorsal face are issued from opportunistic, Levallois or discoid exploitations. The attribution of this products to the different knapping methods is based on other technological characteristics such as the *débitage* direction and the consistency

between the technological characteristics observed on the cores and those of the products.

The knapping methods performed in S.U. 13 are those typical of Middle Palaeolithic lithic assemblages (Tab. 3.3): opportunistic/S.S.D.A., discoid and Levallois combined with a sporadic presence of a Kombewa *s.l. débitage* (Inizan et al., 1999; Tixier and Turq, 1999) that however is part of the opportunistic component of the considered lithic assemblage. The general good state of preservation of the lithic industry allowed to refer almost all the products to the knapping method from where they were issued. The attribution of some flakes to an undetermined reduction sequence is mainly caused by the occurrence of fractures that limited the chance to identify diagnostic technological features. Retouch flakes and debris have been included in Tab. 3.3 since they contribute in clarifying the role of each raw material in the lithic assemblage.

Raw material	Opp. S.S.D.A.	Discoid	Levallois	Kombewa <i>s.l.</i>	Indet.	Retouch flakes	Debr .	Tot.
Quartz	F. = 371 C. = 24	F. = 31 C. = 5	F. = 9 C. = 2	F. = 4 C. = -	F. = 28 C. = -			
Tot.	395	36	11	4	28	17	276	767
%	44,4%	4,0%	1,2%	0,4%	3,1%	1,9%	31,0 %	86,3%
Spongolite	F. = 9 C. = 1	F. = 7 C. = 2	F. = 1 C. = -	F. = - C. = -	F. = 4 C. = -			
Tot.	10	9	1	-	4	13	21	58
%	1,1%	1,0%	0,1%	-	0,4%	1,5%	2,4%	6,5%
Grey/black flint	F. = 25 C. = -	F. = - C. = -	F. = - C. = -	F. = - C. = -	F. = - C. = -			
Tot.	25	-	-	-	-	4	23	52
%	2,8%	-	-	-	-	0,4%	2,6%	5,8%
Others	F. = 1 C. = -	F. = - C. = -	F. = - C. = -	F. = - C. = 1	F. = 2 C. = -			
Tot.	1	-	-	1	2	4	4	12
%	0,1%	-	-	0,1%	0,2%	0,4%	0,4%	1,3%
Total	431	45	12	5	34	38	324	889
%	48,5%	5,1%	1,3%	0,6%	3,8%	4,3%	36,4 %	100,0%

Tab. 3.3. Ciota Ciara cave, S.U. 13. Raw materials and *débitage* methods. F. = flakes; C. = cores.

Considering vein quartz and spongolite, that are the most represented raw materials, no differences are present in their modalities of exploitation and all the reduction sequences were performed in the site, as confirmed by the presence of both cores and flakes and by the high frequency of debris (Tab. 3.3). The S.S.D.A./opportunistic exploitation (Forestier, 1993) is clearly predominant, representing 48,5% of the entire assemblage, with a certain frequency of discoid reduction sequences (Tab. 3.3). The Levallois method is barely represented in this unit and performed almost exclusively on vein quartz (Tab. 3.3). Grey/black flint and the other local raw materials are just sporadically exploited and present in the assemblage almost only as *débitage* products belonging to S.S.D.A./opportunistic reduction sequences (Tab. 3.3).

Given the dynamics of human frequentation of the cave during the deposition of unit 13 (Arzarello et al., 2012; Daffara et al., 2014) the incompleteness of some reduction sequences is probably due to the exploitation of a significative part of the lithic resources out of the cave, maybe during movements linked to hunting activities. A second hypothesis regarding grey/black flint is a different availability or access to this raw material during the periods of human presence at the Ciota Ciara cave linked to S.U. 13.

Allochthonous raw materials, rhyolite and radiolarite, are scarcely attested in the lithic assemblage but the presence of one retouched tool, of some debris (4) and of 4 small flakes referable to phases of maintenance or rejuvenation of the tools' edges, suggest their role of complementary lithic resources brought to the site as finished tools, strongly reshaped before being discarded (Tab. 3.3). The identification of retouch flakes is based on the consistency between their technological features (direction of the scars on the dorsal face, dimensions and

characteristics of the butts) and the characteristics of the retouch present on some of the products (see section 3.6.1.3).

In conclusion, in S.U. 13 just vein quartz and spongolite were intensively and systematically exploited in the site, while all the other raw materials, local or allochthonous have the role of complementary resources, exploited out of the cave, and occasionally introduced in the site as *débitage* products and retouched tools.

3.6.1.1. Opportunistic/S.S.D.A. technology

Opportunistic/S.S.D.A. reduction sequences (Forestier, 1993) are predominant in the lithic assemblage of level 13 and all the raw materials, local and allochthonous, have been exploited through these knapping methods (Tab. 3.3). The technological behaviour linked to these reduction sequences is however well understandable just for vein quartz and spongolite, since only for these raw materials both flakes and cores are represented (Tab. 3.3).

Considering vein quartz, the reduction sequences start with the choice of fluvial pebbles, decimetric blocks collected in secondary deposits or of big flakes with suitable convexities. The characteristics of the butts (Fig. 3.38) show a preferential use of flat or neocortical surfaces as striking platforms. Concerning the S.S.D.A modality of exploitation, are considered flat surfaces also those produced by previous removals. Dihedral and linear butts are present on products issued from the S.S.D.A. method.

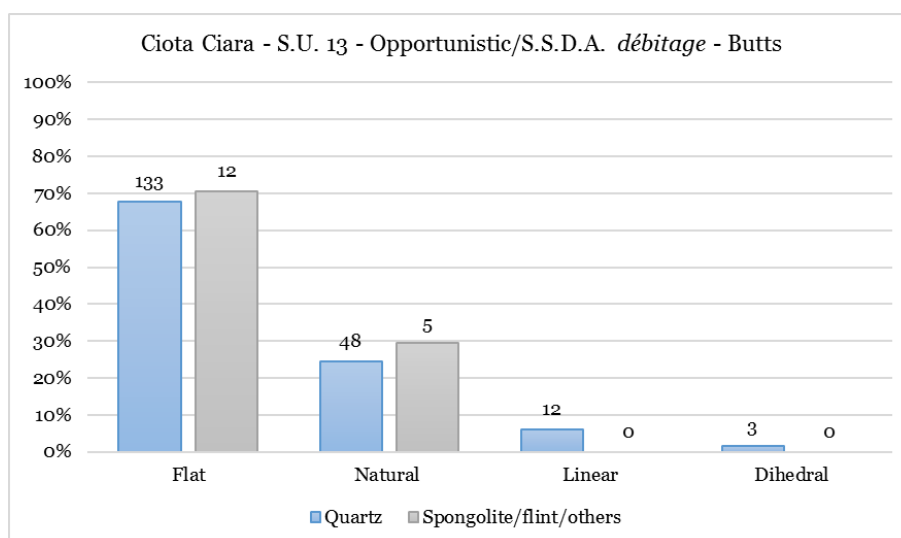


Fig. 3.38. Ciota Ciara cave, S.U. 13. Typology of the butts belonging to opportunistic/S.S.D.A. reduction sequences. Tot. vein quartz butts = 196; tot. spongolite/flint/other raw materials butts = 17.

Most of the cores are discarded before its complete exhaustion, sometimes due to fractures occurred during knapping activities, even if each core is usually quite intensely exploited, showing between two and four adjacent striking platforms (Fig. 3.39). Each of them is exploited until the exhaustion of the convexity which occurs after a short series of unipolar detachments, two or three. These data are consistent with the high frequency of unipolar negatives on the dorsal faces of opportunistic/S.S.D.A. products and with the rareness of bipolar and orthogonal scars (Fig. 3.37).

The desired vein quartz products are medium-sized flakes (Fig. 3.40), sometimes plunging or hinged due to inner flaws present in the cores which determine a bad propagation of the force in the raw material. The characteristics of the cores strongly influence their morphology and all the products are characterized by a considerable thickness.

Looking at the dimensional characteristics of the opportunistic/S.S.D.A. cores, a further consideration must be done: as it will be observed also for other units of the lithic assemblage of the Ciota Ciara cave, their dimensions are consistent with

but generally bigger than those of the products (Fig. 3.40). Thus, the smallest opportunistic/S.S.D.A. flakes are not referable to the last phase of exploitation of the cores, but their dimension are those desired by the knappers and the cores were generally discarded before their complete exhaustion.

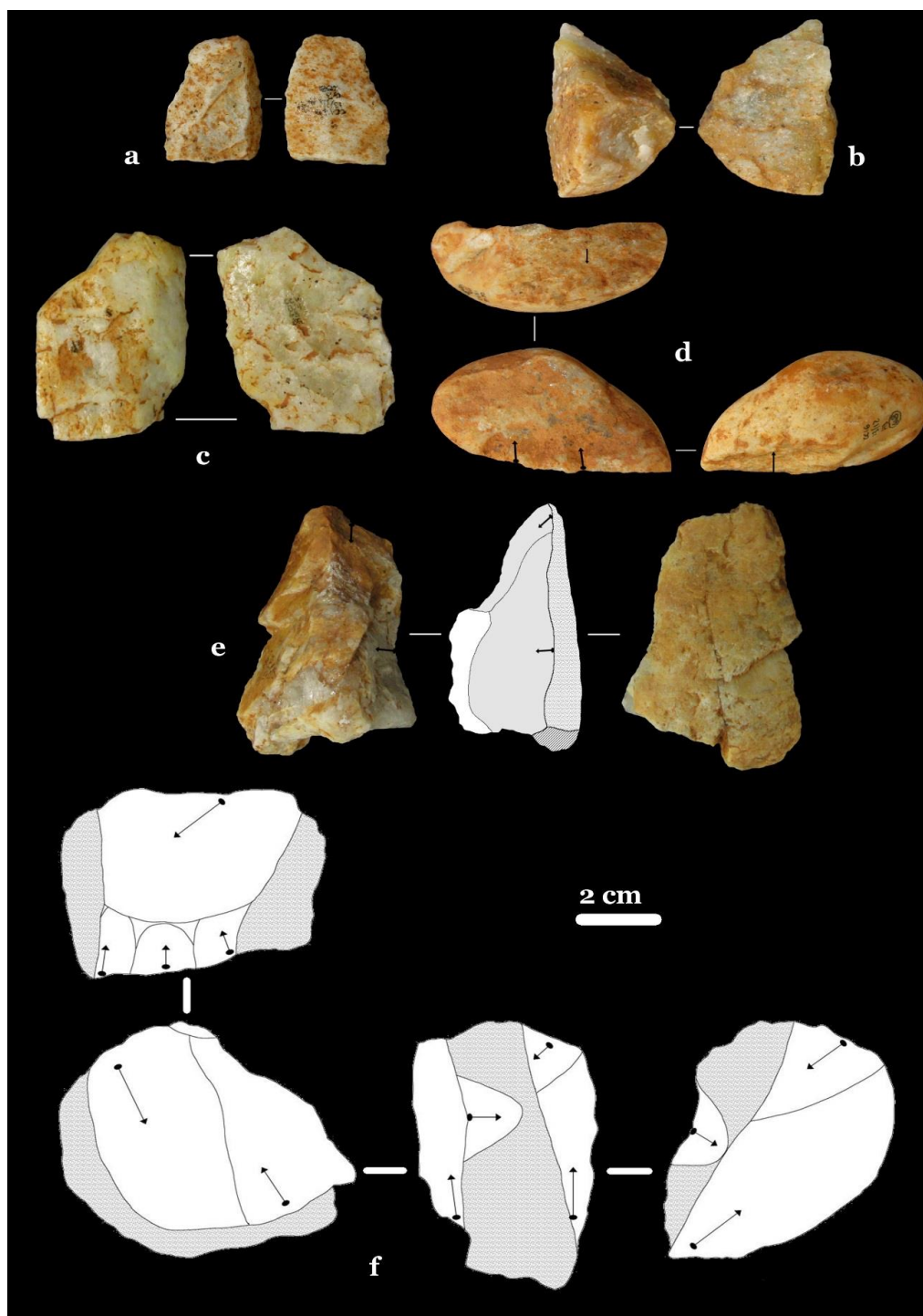


Fig. 3.39. Ciota Ciara cave, S.U. 13. Vein quartz opportunistic/S.S.D.A. cores and flakes: (a) opportunistic flake with neocortical dorsal face; (b) opportunistic flake with neocortical butt; (c) S.S.D.A. flake; (d, f) S.S.D.A. cores; (e) opportunistic core with neocortical striking platform.

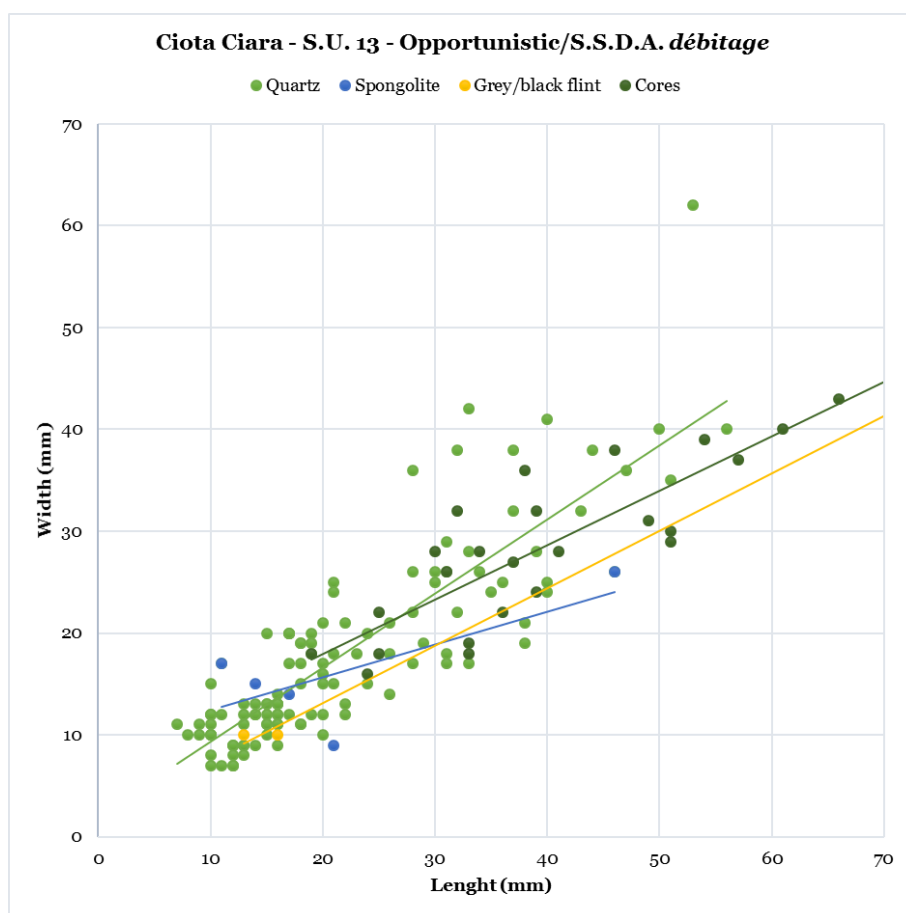


Fig. 3.40. Ciota Ciara cave, S.U. 13. Dimensional analysis of opportunistic/S.S.D.A. flakes and cores. Fragmented flakes are not included. The dimensions of the cores are consistent with those of the products obtained.

Spongolite and flint opportunistic/S.S.D.A. reduction sequences, even if complete, are represented only by one core and thirty-four flakes, of which the most part is fragmented and do not allow considerations about the objectives of the *débitage*. Even though, the products contemplated in the dimensional analysis suggest that for these raw materials the objective of the opportunistic/S.S.D.A. method were similar to those of vein quartz (Fig. 3.40). The spongolite opportunistic core found (Fig. 3.41) and the characteristics of the butts of spongolite and flint flakes show that flat surfaces were chosen as striking platforms (Fig. 3.38). These data, together with the absence of dihedral butts (Fig. 3.19), suggest that multidirectional reduction sequences as described by H. Forestier (1993) were probably rarely applied to spongolite and grey/black flint and that core exploitation was not intense. The characteristics of the products in

terms of dimensions suggest that, concerning spongolite, were exploited slabs collected in secondary deposits: they were knapped probably according to their thickness, perpendicularly as regard as the internal cleavage planes to limit the occurrence of fractures during *débitage*.

Both for quartz and for other raw materials, a small portion of the lithic assemblage on level 13 is referable to a Kombewa *s.l.* knapping method, i.e. to the use of big flakes issued from other knapping methods as cores (Tab. 3.3 and Fig. 3.41). A big spongolite flake issued from an opportunistic exploitation (Fig. 3.41) has been previously interpreted as indicative of the probable use of flakes as cores besides the absence of products issued from a *débitage-on-flake* and of any trace of percussion on the spongolite flake (Daffara, 2011). In the last years, the evidences emerged from the widening of the excavated area seem to support that hypothesis.

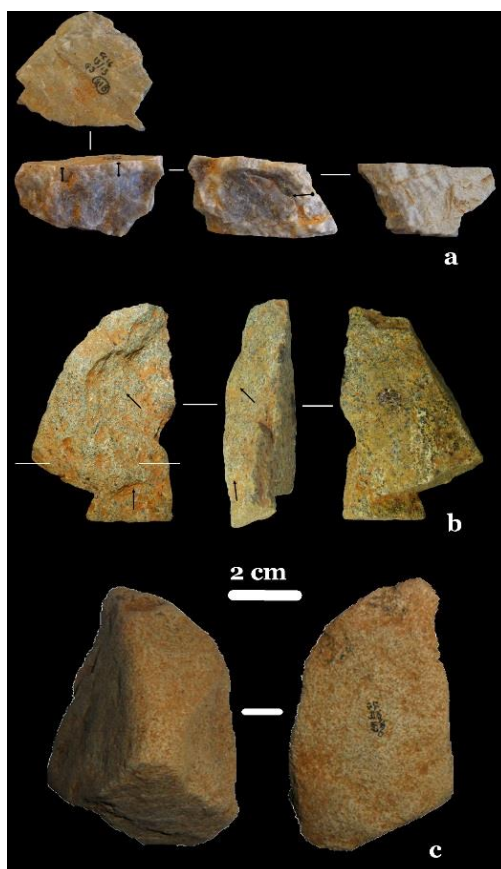


Fig. 3.41. Ciota Ciara cave, S.U. 13. (a) spongolite opportunistic core; (b) fragments kombewa *s.l.* core on undetermined raw material; (c) spongolite opportunistic flake.

3.6.1.2. *Levallois and discoid technology*

Levallois and discoid reduction sequences are attested just on vein quartz and spongolite and the Levallois ones are complete only for vein quartz (Tab. 3.3). Even if limited in number, Levallois and discoid products and cores allow to make some observations concerning the general organization of the reduction sequences, starting from the choice of the blanks to be exploited until the adaptation of the theoretical criteria defining these two methods (Boëda, 1994, 1993; Peresani, 2003) to the raw materials constraints.

Two vein quartz Levallois cores are present in the considered assemblage belonging to the recurrent centripetal Levallois and to the preferential modality respectively (Appendix A).

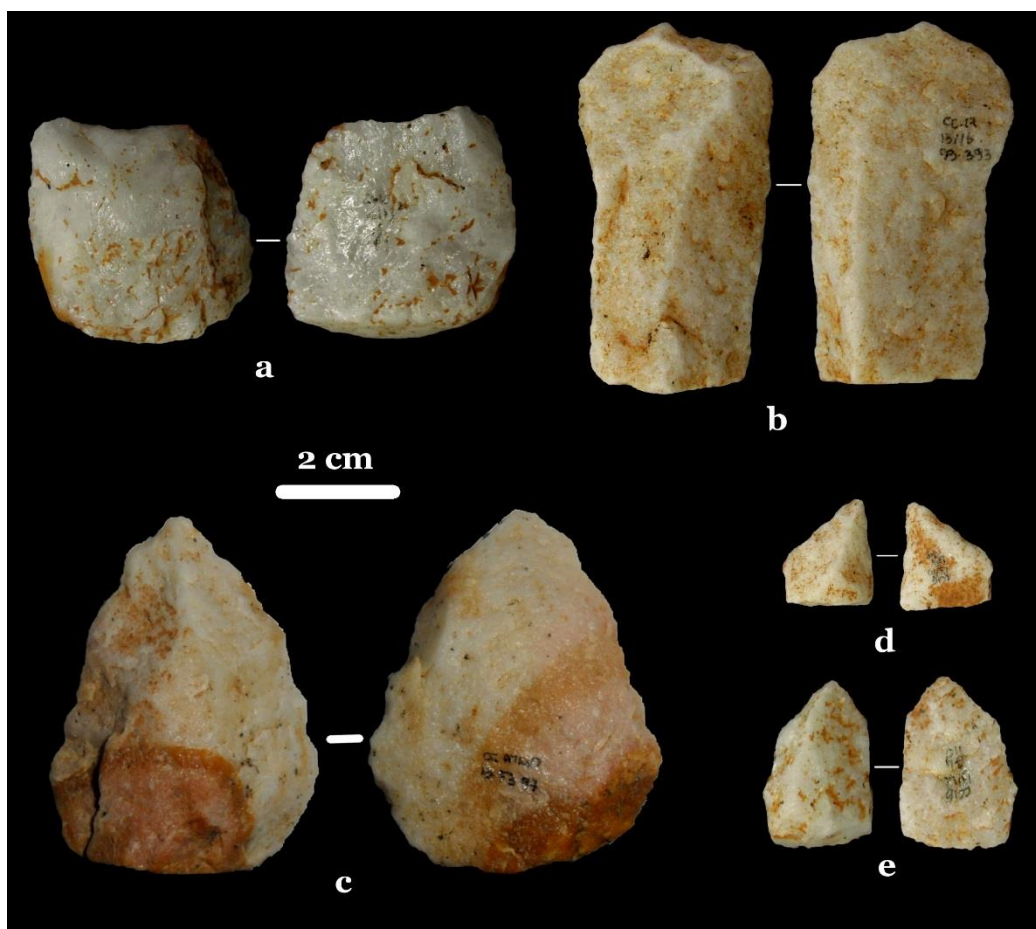


Fig. 3.42. Ciota Ciara cave, S.U. 13. Vein quartz Levallois and discoid flakes: (a, b) Levallois preferential flakes; (c) Mousterian point; (d, e) discoid flakes.

The recurrent centripetal core has a natural striking platform, part show a neocortical surface, the other consists in natural fracture planes; one of the lateral convexities of the knapping surface has been prepares through two short centripetal removals while the phase of *plein débitage* corresponds to the detachment of two oval medium-sized flakes (Appendix A).

The preferential Levallois core has a mostly natural striking platform with two removals perpendicular to the intersection plane of the two core surfaces preparing the surface in correspondence of the impact point of the predetermined flake. On the knapping surface one of the lateral convexities is natural while three centripetal removals prepare the distal and the other lateral convexity (Appendix A). The *débitage* direction is always parallel to the intersection plane between the core surfaces. The characteristics of these cores indicate that Levallois reduction sequences were performed only on pebbles with natural suitable convexities, thus leading to a great influence of the core morphology on that of the desired products. Both the cores have just one phase of exploitation, after which they have been discarded and do not have traces of further exploitations through different knapping methods, i.e. opportunistic or discoid.

Even if the products issued from the Levallois method are just nine, the dimensional analysis gives results consistent with the observations made on the cores regarding the general morphology of the predetermined products: oval, medium-sized flakes sometimes elongated (Fig. 3.43). In level 13, two findings attest the production of quartz points: a complete Mousterian point (Fig. 3.42) and a distal fragment of a Levallois point.

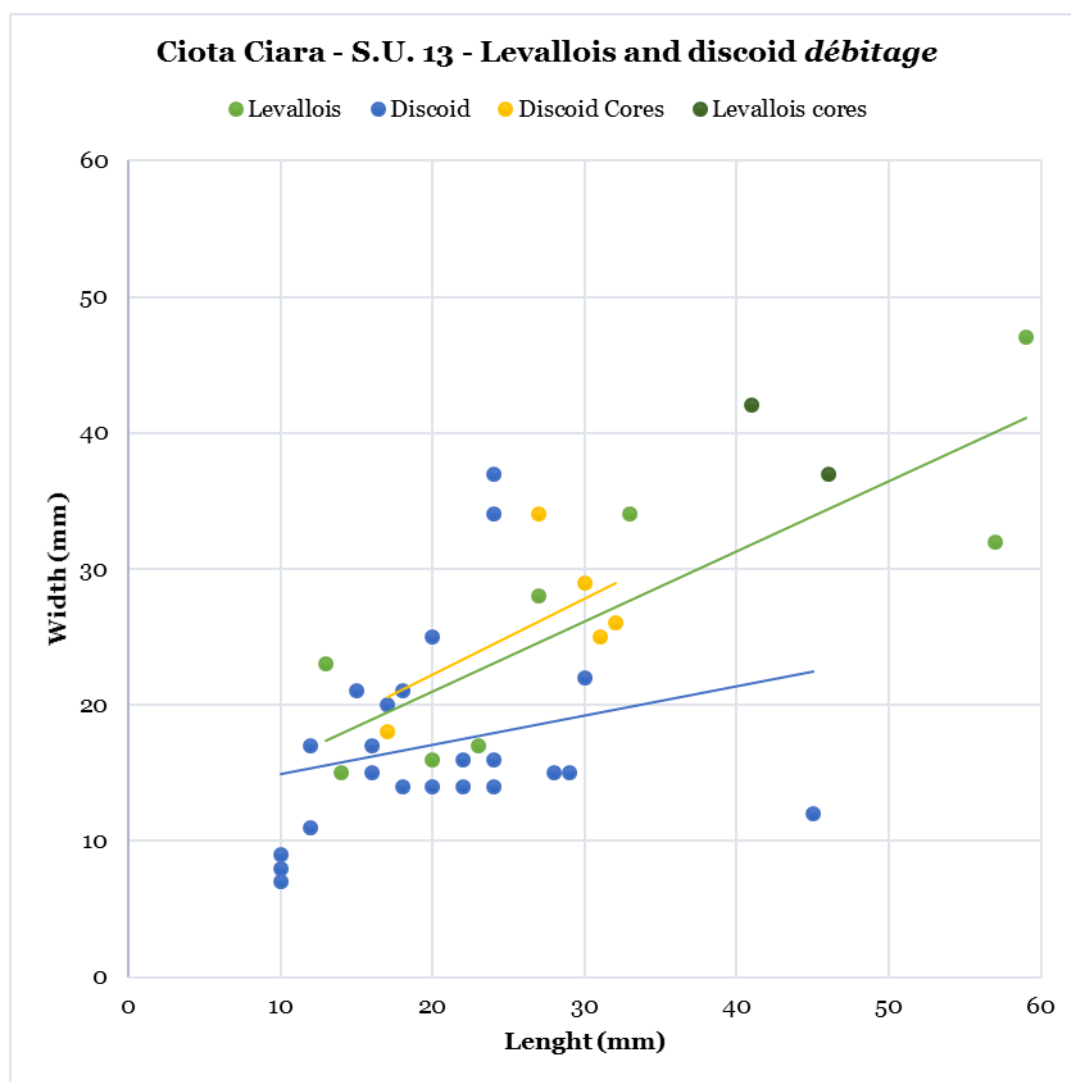


Fig. 3.43. Ciota Ciara cave, S.U. 13. Dimensional analysis of Levallois and discoïd flakes and cores. The morphology of the cores strongly influences the dimensions of the products. Fragmented flakes are not considered. Since no significant differences have been observed between Levallois and discoïd reduction sequences according to the raw material employed, for the dimensional analysis a subdivision just according to the knapping method has been done.

Discoïd reduction sequences are attested and complete only for vein quartz and spongolite (Tab. 3.3). Unifacial and bifacial modalities are present on these raw materials that have been exploited in a similar way through the discoïd method and in both cases, cores are represented by centimetric blanks with natural suitable convexities (Appendix A and Fig. 3.44). They are exploited with few centripetal removals with *débitage* direction secant to the plane of intersection of the two core surfaces. Usually they present just one phase of exploitation that is

enough to exhaust the core (Appendix A). The products obtained are small flakes (Fig. 3.43 and 3.44) sometimes with a lateral plunging.

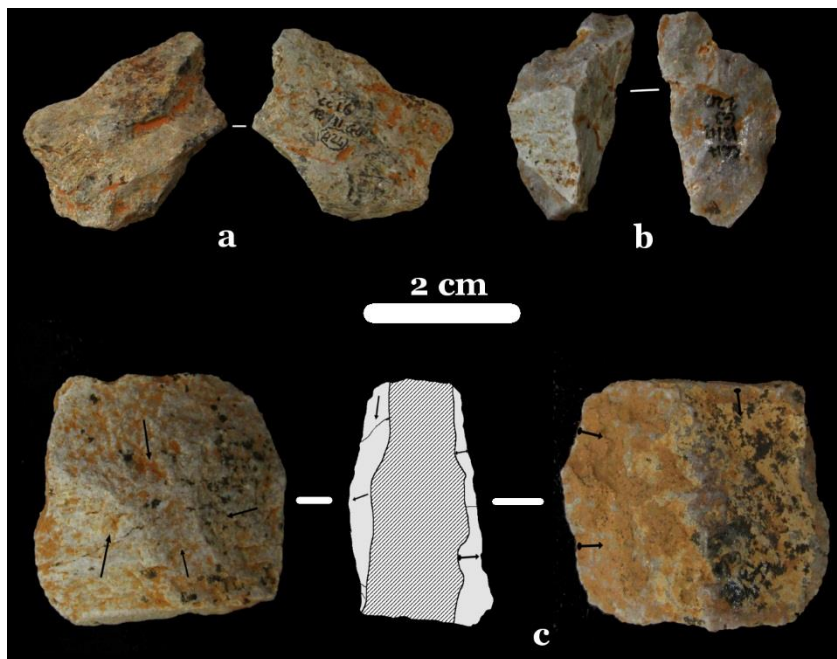


Fig. 3.44. Ciota Ciara cave, S.U. 13. Spongolite discoïd flakes (a, b) and core (c).

The typology of the butts belonging to Levallois and discoïd exploitation strategies confirm the observations made on the cores regarding the preferential choice of flat surfaces as striking platform and represented by neocortical surfaces or by fracture planes (Fig. 3.45).

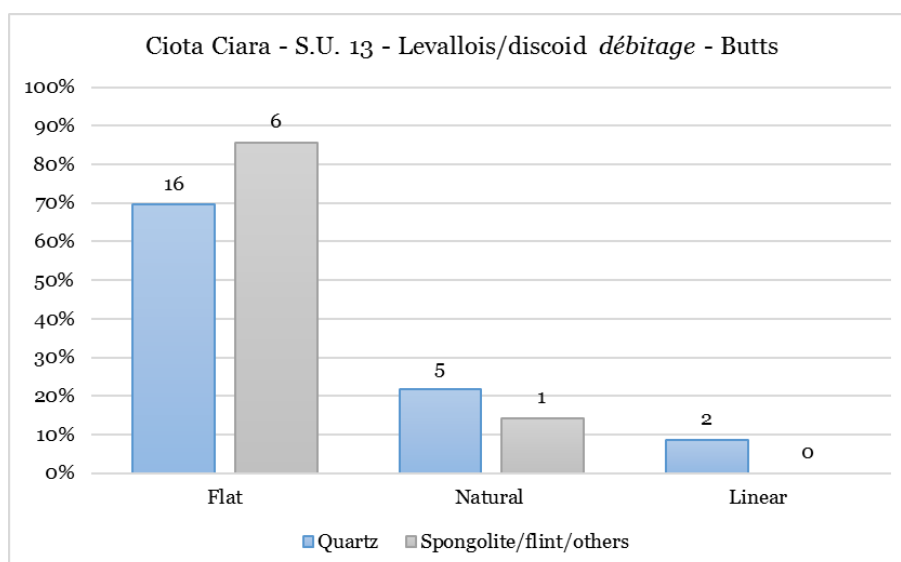


Fig. 3.45. Ciota Ciara cave, S.U. 13. Typology of the butts of Levallois and discoid products and comparison between vein quartz and spongolite. Tot. vein quartz butts = 23; tot. spongolite butts = 7.

The identification of discoid and Levallois products is mainly based on the direction of the negatives on the dorsal faces of the flakes and on the *débitage* direction, inferable from the angle between the butt and the ventral face, more pronounced for secant removals typical of a discoid knapping method (Boëda, 1993; Peresani, 2003).

Despite the low number of artefacts belonging to Levallois and discoid reduction sequences in level 13, some technological adaptation to the characteristics of the raw materials are however clear. The choice of blanks with natural suitable convexities together with the shortness of the knapping sequences, are expedient aimed to reduce the influence of the internal cleavages and flaws present in vein quartz, that increases going on with the knapping activities (Mourre, 1996). As already observed for opportunistic/S.S.D.A. reduction sequences, also the general pronounced thickness of vein quartz discoid and Levallois products is caused by an adaptation to the raw material properties (e.g. de Lomberra-Hermida et al., 2016; Driscoll, 2011; Tallavaara et al., 2010).

The data collected during this upgrade about the technological analysis the S.U. 13 confirm the scarce development of all the knapping sequences present in the lithic assemblage and support the hypothesis, already formulated and proved by the results of palaeontological and functional studies (Arzarello et al., 2012a; Berto et al., 2016; Daffara et al., 2014), of brief and sporadic human frequentations of the cave during the deposition of level 13.

3.6.1.3. Retouched tools

Retouched tools are only 19 in the lithic assemblage of S.U. 13 and are mainly realized on vein quartz flakes issued from opportunistic/S.S.D.A. knapping sequences (13) (Tab.3.2).

Retouch is always not invasive on vein quartz flakes; its inclination is abrupt or semi-abrupt and it is localized just on one side of the blank. The tools obtained are denticulates (5, of which 3 have a notch on the opposite edge), notches (2), simple or transversal scrapers (4) and convergent scrapers (2). Just for the Mousterian point retouch is more invasive, bifacial, and located on the lateral margins of the flake and on its distal part (Fig. 3.27).

Three more retouched tools are represented by a rectilinear convergent scraper in radiolarite, by a notch and a denticulate in spongolite (Fig. 3.46)

As already pointed out, radiolarite, even if sporadically attested in this level, was a complementary lithic resource for the human groups of the Ciota Ciara cave and it was brought to the site only as finished tools which edge were reshaped several times before the tool was discarded.

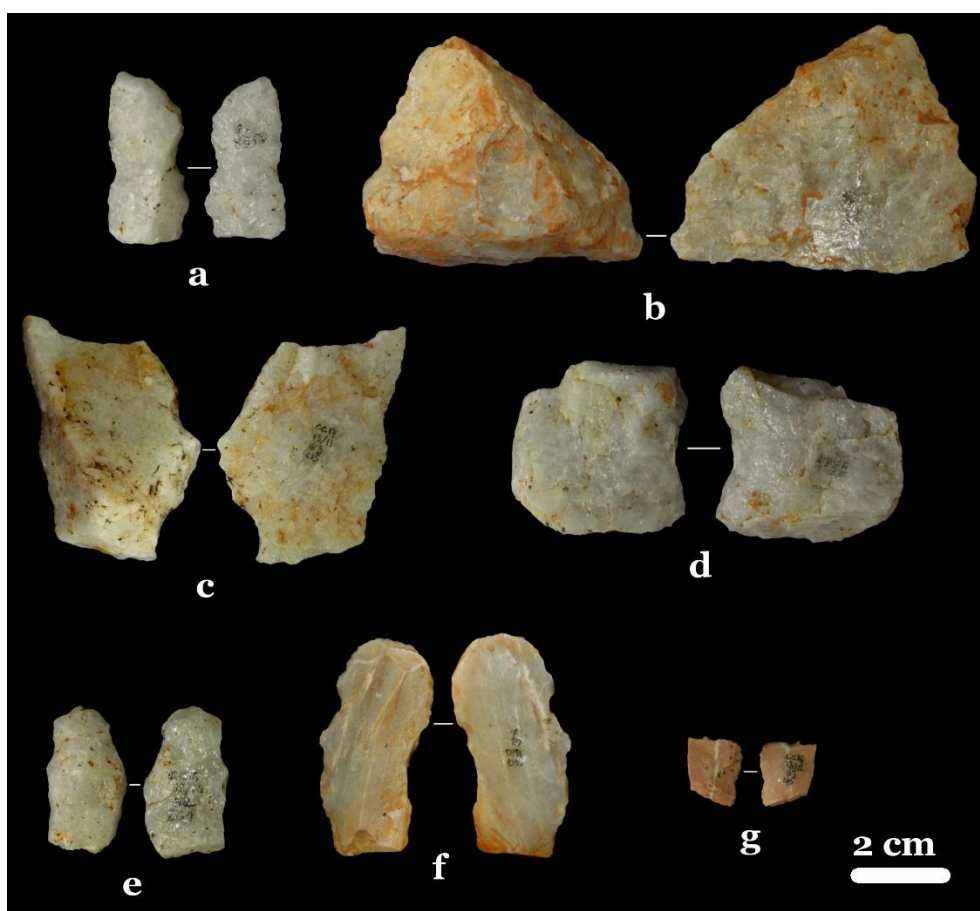


Fig. 3.46. Ciota Ciara cave, S.U. 13. Retouched tools: (a) denticulate + notch; (b, c, e) denticulates; (d) notch; (f) spongolite denticulate + notch; (g) radiolarite rectilinear convergent scraper.

3.6.2. S.U. 14

Archaeological level 14 of the Ciota Ciara cave corresponds to the periods of most intense frequentation of the site. As mentioned before, the increasing in the human presence in the site is attested by the greater number of herbivorous faunal remains, by the presence of a small fireplace found in the south-western corner of the excavated area (Fig. 3.8) and by the huge lithic assemblage characterized by the exploitation of various lithic resources (Arnaud et al., 2014; Arzarello et al., 2013).

Despite the problems linked to the chronology of this unit (see paragraph 3.3) (Berto et al., 2016; Vietti, 2016), the technological analysis of the lithic assemblage of S.U. 14, quantitatively the most abundant of the sequence, and the definition of the supply areas of lithic raw materials, represent the most

important steps to understand the technological behaviour of the human groups which inhabited the site during Middle Palaeolithic, especially regarding the employment of vein quartz for Levallois and discoid reduction sequences.

The considered lithic assemblage is composed by 3999 artefacts realized through the exploitation of different local and allochthonous raw materials (Fig. 3.47), among which vein quartz is the main lithology (78,0%) followed by local varieties of chert (spongolite – 12,7% and grey/black flint – 5,3%), opal (0,4%) and jasper (0,1%). The local metamorphic rocks, collected in the river beds close to Monte Fenara (0,2%) are present just in the form of hammers' fragments.

S.U. 14 is the archaeological level of the Ciota Ciara cave where allochthonous raw materials are more represented (radiolarite – 1,7% and rhyolite – 1,3%) (Fig. 3.47) and where their complementary role within the economy of the prehistoric human groups is better assessable.

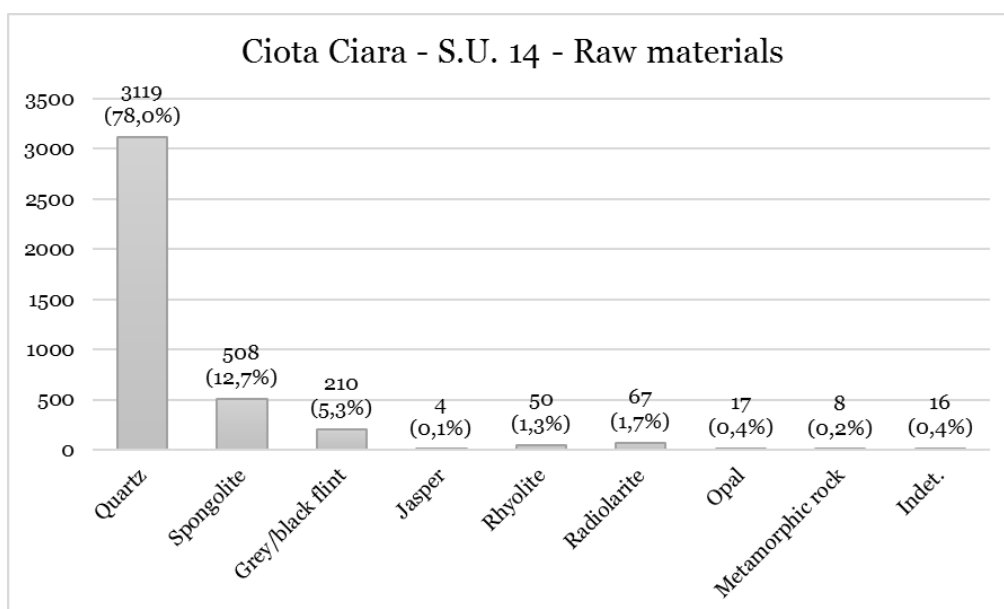


Fig. 3.47. Ciota Ciara cave – S.U. 14. Raw materials present in the lithic assemblage.

As already observed for S.U. 13, the state of preservation of the lithic assemblage is generally good but not homogeneous, because vein quartz artefacts are less

affected by post depositional alterations (Venditti et al., 2016) (Fig. 3.48). Since this diversity cannot be interpreted as a consequence of different modalities of deposition but, as demonstrated by recent studies, it is caused by the different petrographic features of the considered raw materials, all the lithic artefacts from S.U. 14 can be considered part of a unique assemblage. The presence of rounding and white patina on several of the spongolite and flint artefacts made sometimes difficult to read the knapping scars and to interpret the negatives on the upper faces of the flakes, thus not making possible the identification of the knapping method for some of the products.

Looking at the general composition of the assemblage of this unit, it is evident that the reduction sequences are not complete for all the raw materials (Tab. 3.4). The considerable presence of quartz and spongolite cores and debris let assume that the reduction sequences linked to these raw materials has been performed in the site. Concerning grey/black flint, of local origin as well, the presence of all the steps of the reduction sequences (flakes, cores, debris and retouched tools) let assume that the exploitation of this raw material took place in the site. Other local raw materials like opal and jasper are sporadically exploited and are present in this unit mainly as unretouched flakes.

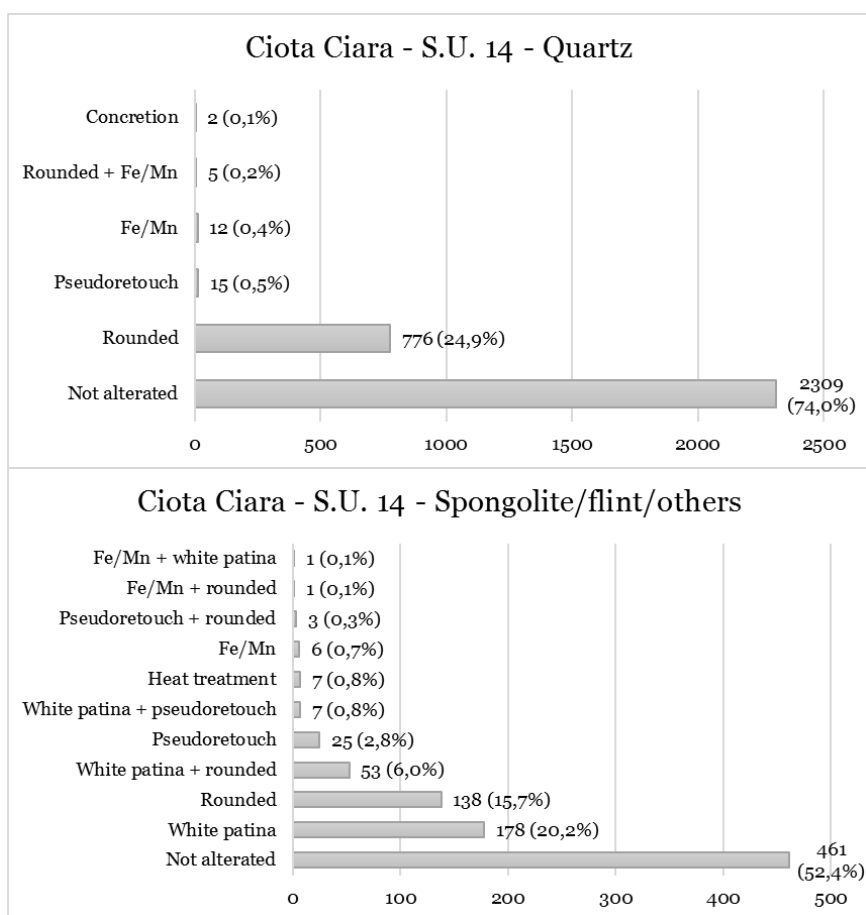


Fig. 3.48. Ciota Ciara cave. Post depositional alterations present on the lithic artefacts of S.U. 14.

Rhyolite and radiolarite have the same role in the assemblage, despite they were collected at distances significantly different one to the other. Both are present in S.U. 14 as retouched tools or unretouched flakes, often linked to the reshaping of the tools' edges (Tab. 3.4 and 3.5). Just one core in rhyolite is present and linked to the opportunistic component of the *débitage* (Tab. 3.5).

Raw material	Flakes	Cores	Retouched tools	Debris	Unworked blanks	Total
Quartz	2150	111	50	807	1	3119
Spongolite	280	17	9	191	11	508
Grey/black flint	139	3	5	63	-	210
Rhyolite	37	1	6	6	-	50
Radiolarite	50	-	3	14	-	67
Other	30	-	1	9	5	45
Total	2686	132	74	1090	17	3999
%	67,2%	3,3%	1,9%	27,3%	0,4%	100,0%

Tab. 3.4. Ciota Ciara cave, S.U. 14. Composition of the lithic assemblage.

As expected, the rate of fragmentation is higher for quartz than for all the other raw materials (Fig. 3.49) even if the high presence of inner flaws in spongolite blanks contributes to the increase in the occurrence of fractures during knapping activities, making the percentage of complete flakes generally low. Both in quartz and spongolite the tendency to break during exploitation through hard hammer percussion is one of the factors affecting both the technological choices of the knappers in terms of selection of the blanks and of the method and the final dimensions of the products (de Lomberra-Hermida et al., 2016; Driscoll, 2011; Tallavaara et al., 2010).

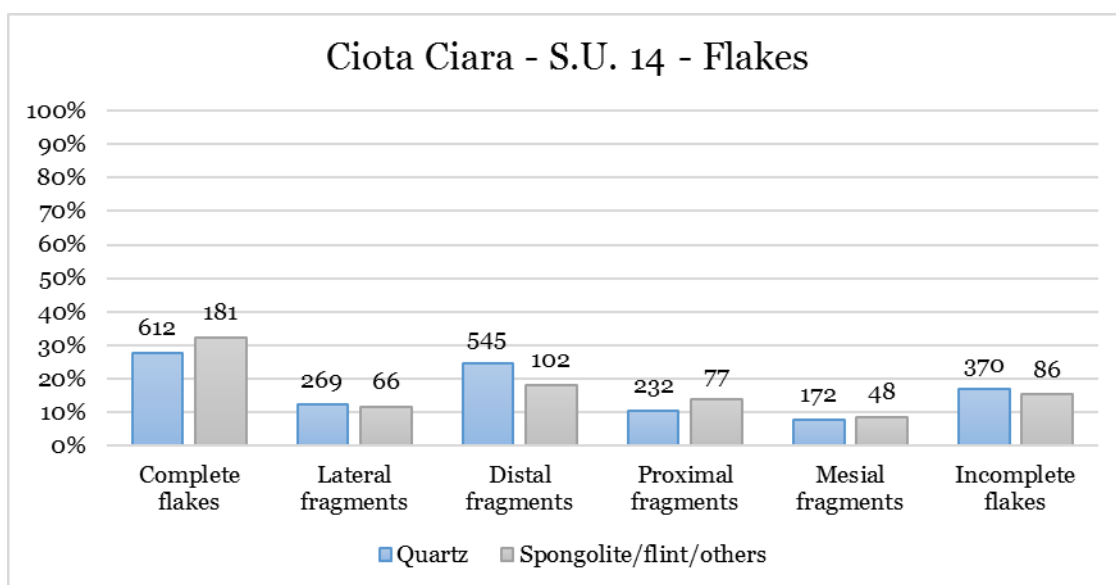


Fig. 3.49. Ciota Ciara cave, S.U. 14. Rate of fragmentation of vein quartz flakes compared to that of the other raw materials present in the assemblage (spongolite, grey/black flint, radiolarite, rhyolite, opal, jasper, indet. raw material).

Another consequence of the tendency to break during knapping of most of the raw materials present in level 14, is the great number of fractures of undetermined origin (Fig. 3.50): fractures following natural inner flaws can occur both during knapping and during use or can be due to post depositional mechanical factors (Driscoll, 2011; Mourre, 1996; Tallavaara et al., 2010). Quartz tends to fracture according to radial plans passing through the impact point of the flake and most of them correspond to Mourre's definition of sired accidents

(Mourre, 1996) while a significant part of the determinable fractures on spongolite, flint and rhyolite flakes is due to post depositional causes.

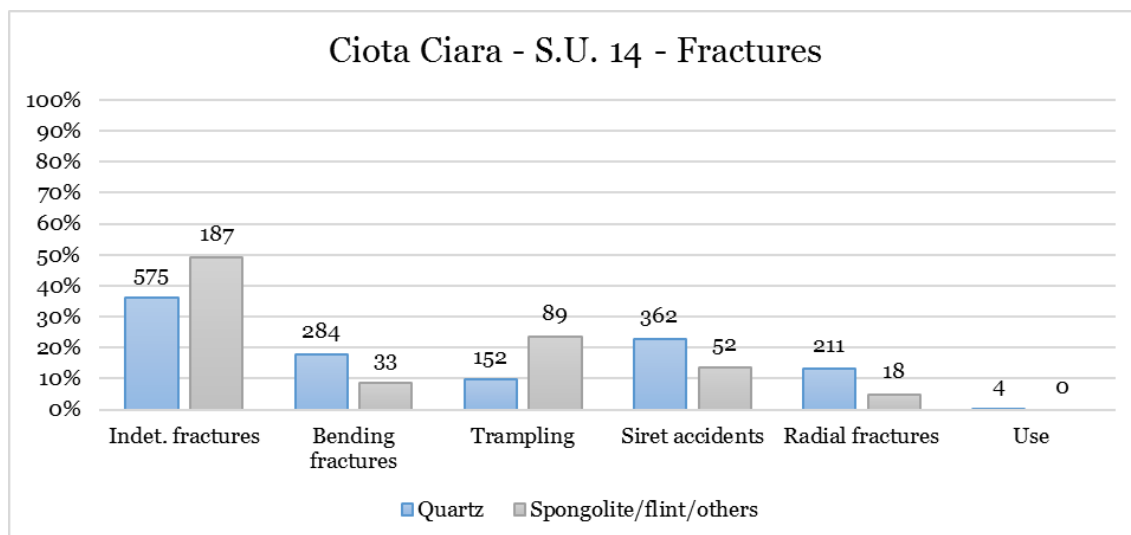


Fig. 3.50. Ciota Ciara cave, S.U. 14. Typology of the fractures identified on the flakes and comparison between quartz flakes and flakes obtained from the other raw materials present in the assemblage (spongolite, grey/black flint, radiolarite, rhyolite, opal, jasper, indet. raw materials). Tot. vein quartz fragmented flakes = 1588; tot. spongolite and other raw materials fragmented flakes = 379.

Regardless of the knapping method employed, surfaces with cortex or, concerning quartz flakes, neocortex, are reduced in number (Fig. 3.51). Flakes in rhyolite, radiolarite, jasper and opal do not show natural surfaces since they have been probably introduced in the site as finished tools or correspond to phases of rejuvenation of the tools' edges. Concerning vein quartz flakes, neocortex is mostly located on one side of the flake (lateral position) or on the entire dorsal face (Fig. 3.51), while when cortical surfaces are present on spongolite flakes, in most of cases they affect all the dorsal face. Lateral cortex is for both quartz and spongolite mostly associated to opportunistic/S.S.D.A. reduction sequences (Forestier, 1993) and to unipolar removals, thus indicating that this kind of *débitage* starts directly from the natural surfaces of the cores, exploiting suitable convexities, and proceeds using the same striking platform until the convexity is

exhausted. Some of the quartz flakes with a dorsal natural surface are small in size and could be linked to the initial phases of shaping of the cores' convexities in Levallois or discoid reduction sequences (Boëda, 1994, 1993), more articulated in this level than in the others of the sequence.

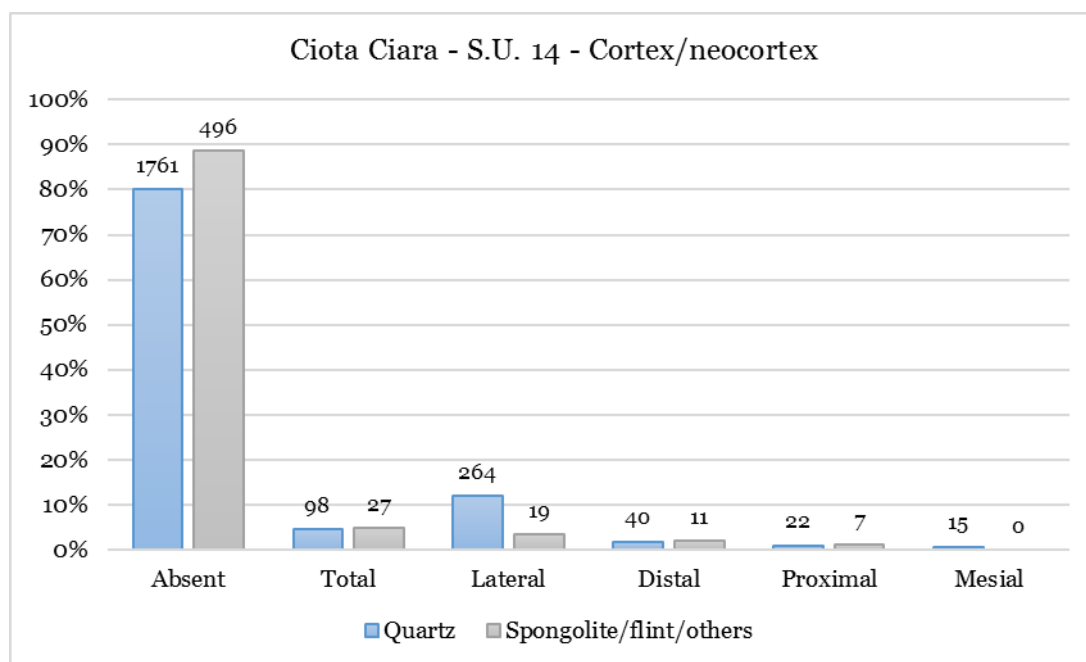


Fig. 3.51. Ciota Ciara cave, S.U. 14. Presence and position of neocortex on quartz flakes and of cortex on flakes obtained from spongolite, grey/black flint, radiolarite, rhyolite, opal, jasper, indet. raw materials. Tot. vein quartz flakes = 2200; tot. spongolite and other raw materials flakes = 559.

When visible, the direction of the negatives of previous removals on the dorsal faces of the flakes is one of the elements that allowed the identification of the different knapping methods employed level 14 (Fig. 3.52).

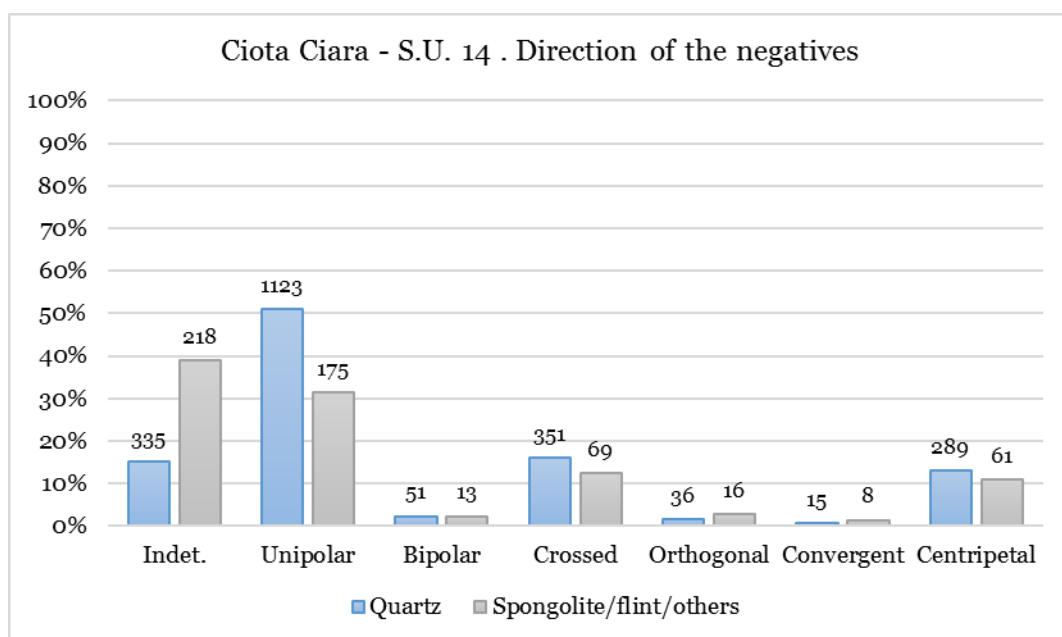


Fig. 3.52. Ciota Ciara cave, S.U. 14. Direction of the negatives of previous removals visible on the dorsal faces of the flakes. Tot. vein quartz flakes = 2200; tot. spongolite and other raw materials flakes = 559.

Being spongolite and flint artefacts more affected by post depositional alterations, the number of flakes with unreadable negatives is higher than for quartz (Fig. 3.52). For all the raw materials, unipolar, bipolar and orthogonal removals are exclusively associated with opportunistic/S.S.D.A. reduction sequences (Forestier, 1993), while crossed negatives can correspond also to a Levallois or to a discoid method (Boëda, 1994, 1993; Peresani, 2003). Convergent and centripetal removal are instead present only on Levallois and discoid products.

The reduction sequences identified in this level are those typical of Middle Palaeolithic lithic assemblages: opportunistic/S.S.D.A., Levallois and discoid, together with a sporadic presence of a *débitage*-on-flake classifiable as *Kombewa s.l.* (Inizan et al., 1999; Tixier and Turq, 1999) that however belongs to the opportunistic component of the *débitage* (Tab. 3.5). As mentioned before, due to post depositional alterations but also to the general high rate of fragmentation of the considered assemblage, for some flakes it was not possible to identify the

knapping method from where they are issued. The categories of debris and retouch flakes have been included in Tab. 3.5 since they contribute to better understand the general characteristics of the assemblage and the role played by each raw material.

Raw material	Opp. S.S.D.A.	Discoid	Levallois	Kombewa s.l.	Indet.	Retouch flakes	Debr.	Tot.
Quartz	F. = 1437	F. = 252	F. = 137	F. = 17	F. = 296			
	C. = 71	C. = 33	C. = 5	C. = 2	C. = -			
Tot.	1508	285	142	19	296	62	807	3119
%	37,9%	7,2%	3,6%	0,5%	7,4%	1,6%	20,3%	78,3%
Spongolite	F. = 141	F. = 24	F. = 12	F. = 4	F. = 59			
	C. = 15	C. = 2	C. = -	C. = -	C. = -			
Tot.	156	26	12	4	59	49	191	497
%	3,9%	0,7%	0,3%	0,1%	1,5%	1,2%	4,8%	12,5%
Grey/black flint	F. = 73	F. = 8	F. = 7	F. = 1	F. = 20			
	C. = -	C. = 2	C. = 1	C. = -	C. = -			
Tot.	73	10	8	1	20	35	63	210
%	1,8%	0,3%	0,2%	0,03%	0,5%	0,9%	1,6%	5,3%
Rhyolite/Radiolarite	F. = 30	F. = 14	F. = 15	F. = -	F. = 11			
	C. = 1	C. = -	C. = -	C. = -	C. = -			
Tot.	31	14	15	-	11	26	20	117
%	0,8%	0,4%	0,4%	-	0,3%	0,7%	0,5%	2,9%
Others	F. = 12	F. = 4	F. = 3	F. = -	F. = 3			
	C. = -	C. = -	C. = -	C. = -	C. = -			
Tot.	12	4	3	-	3	9	9	40
%	0,3%	0,1%	0,1%	-	0,1%	0,2%	0,2%	1,0%
Total	1780	339	180	24	389	181	1090	3983
%	44,7%	8,5%	4,5%	0,6%	9,8%	4,5%	27,4%	100 %

Tab. 3.5. Ciota Ciara cave, S.U. 14. Raw materials and *débitage* methods. F. = flakes; C. = cores.

Considering the two main raw materials, it is evident that no differences are present in the modalities of exploitation of vein quartz and spongolite (Tab. 3.5). On both these raw materials, all the knapping methods are employed with a clear preponderance of opportunistic/S.S.D.A. reduction sequences (Forestier, 1993). For quartz, the reliable number of debris, that represent about fifth of the entire

assemblage (20,3%), and the presence of cores linked to all the knapping methods identified, indicates that its exploitation took place in the site. A different interpretation is needed for part of the **spongolite reduction sequences**: while both cores and products belonging to the opportunistic/S.S.D.A. and the discoid methods are present, no Levallois core is attested. **Given the low number of spongolite Levallois flakes (12) it is realistic to suppose that this method has been barely employed on spongolite, but different hypothesis can be also done:**

- **Levallois cores have been not abandoned but further exploited through opportunistic methods and have not been recognized during the technological analysis;**
- **the Levallois flakes present in the spongolite assemblage suggest that only good quality spongolite blanks, characterized by a homogenous texture and without inner flaws or impurities, have been selected for this kind of *débitage* and it can be supposed that they were exploited directly where they were collected.**

Given the characteristics of the opportunistic/S.S.D.A. spongolite cores found, we are in favour of the second hypothesis, both for the modalities of exploitation of the opportunistic cores and for their textural features.

Concerning grey/black flint (Tab. 3.5), despite the number of cores is low, the presence of all the steps of the reduction sequences suggest that they could have been performed in the site. All the knapping methods are attested also on grey/black flint thus revealing that it was generally treated as quartz and spongolite. Other local raw materials like opal and jasper, quantitatively less available on Monte Fenera, were exploited sporadically but in the same way as all the other local raw materials, as attested by the presence of opportunistic, discoid and Levallois products in the assemblage. They were exploited out of the cave and

just finished tools were brought in the site. The presence of 9 retouch flakes (6 on opal and 3 on an undetermined raw material) suggests that phases of rejuvenation of the tools' edges were carried out in the site. The technological characteristics these flakes are consistent with an abrupt or semi-abrupt retouch and the presence of crossed negatives on their dorsal surfaces shows that the modification of the tools' edges was intense, and that more than one generation of retouch was present.

Rhyolite and radiolarite are instead complementary lithic resources, brought in the site as finished tools which margins have been intensively rejuvenated. In level 14 there is not any preferential choice of the raw material according to the knapping method and a selection is made just concerning the better quality raw materials (rhyolite and radiolarite): the tools obtained from their exploitation were not discarded till they were exhausted, differently from what observed on quartz and spongolite retouched tools that show always just one generation of retouch.

Quartz artefacts have been divided according to the morpho-structural groups methodology (e.g. de Lombera-Hermida et al., 2011; Martinez Cortizas and Llana Rodriguez, 1996) to see if any preferential choice was made according to the petrographic characteristic of this raw material (Tab. 3.6).

The data obtained indicate a predominance of the group NS (54,0%) on the others for all the considered knapping methods exception made for Levallois reduction sequences where the group SN is prevailing. In general, a texture with macro-crystal is preferred despite the presence of cleavages and internal flaws (Tab. 3.6). A certain conditioning of the geological environment in terms of presence and availability of the different categories of quartz has however also to be considered.

Method	Morphostructural groups			
	NN	NS	SN	SS
Opportunistic S.S.D.A.	Flakes = 42	Flakes = 712	Flakes = 631	Flakes = 17
	Cores = 3	Cores = 46	Cores = 18	Cores = 1
Tot.	45	758	649	18
Discoid	Flakes = 42	Flakes = 142	Flakes = 101	Flakes = -
	Cores = -	Cores = 16	Cores = 15	Cores = -
Tot.	42	158	116	-
Levallois	Flakes = 6	Flakes = 45	Flakes = 82	Flakes = -
	Cores = -	Cores = -	Cores = 5	Cores = -
Tot.	6	45	87	-
Indet.	Flakes = 10	Flakes = 127	Flakes = 123	Flakes = 1
	Cores = -	Cores = -	Cores = -	Cores = -
Tot.	10	127	123	1
Retouch flakes	4	25	32	-
Debris	20	514	230	4
Total	127	1627	1237	23
%	4,2%	54,0%	41,0%	0,8%

Tab. 3.6. Ciota Ciara cave, S.U. 14. Quartz morphostructural groups and knapping methods. NN = no grainy, no planes; NS = no grainy, planes; SN = grainy, no planes; SS = grainy, planes.

3.6.2.1. Opportunistic/S.S.D.A. technology

Opportunistic/S.S.D.A. reduction sequences (Forestier, 1993) are clearly predominant in the assemblage and all the raw materials, local and allochthonous, have been exploited in this way. Since a significative number of cores and flakes is present just concerning vein quartz and spongolite, the technological study will be focused on these two raw materials.

Vein quartz opportunistic/S.S.D.A. reduction sequences start with the choice of cores with suitable convexities, i.e. fluvial pebbles, decimetric blocks in secondary deposits or big flakes often with natural surfaces. The characteristics of the butts (Fig. 3.53) suggest that neocortical or flat surfaces (i.e. natural fracture surfaces occurred during fluvial transport) were preferentially chosen as striking platforms. In case of S.S.D.A. exploitation strategies flat surfaces correspond also to those obtained from previous removals. The reduction sequences are generally short, and the cores are discarded before their complete exhaustion. In most cases just two adjacent, orthogonal or, rarely, opposed striking platforms are exploited

and when the convexities suitable for knapping are exhausted the core is abandoned (Fig. 3.54). This data is consistent with the low frequency of bipolar scars on the dorsal faces of opportunistic flakes (Fig. 3.52). Otherwise, the core is discarded due to fractures occurred during knapping and caused by internal flaws or cleavages. For these reasons the cores belonging to the S.S.D.A. method as defined by H. Forestier (1993) are a minority in S.U. 14 lithic assemblage.

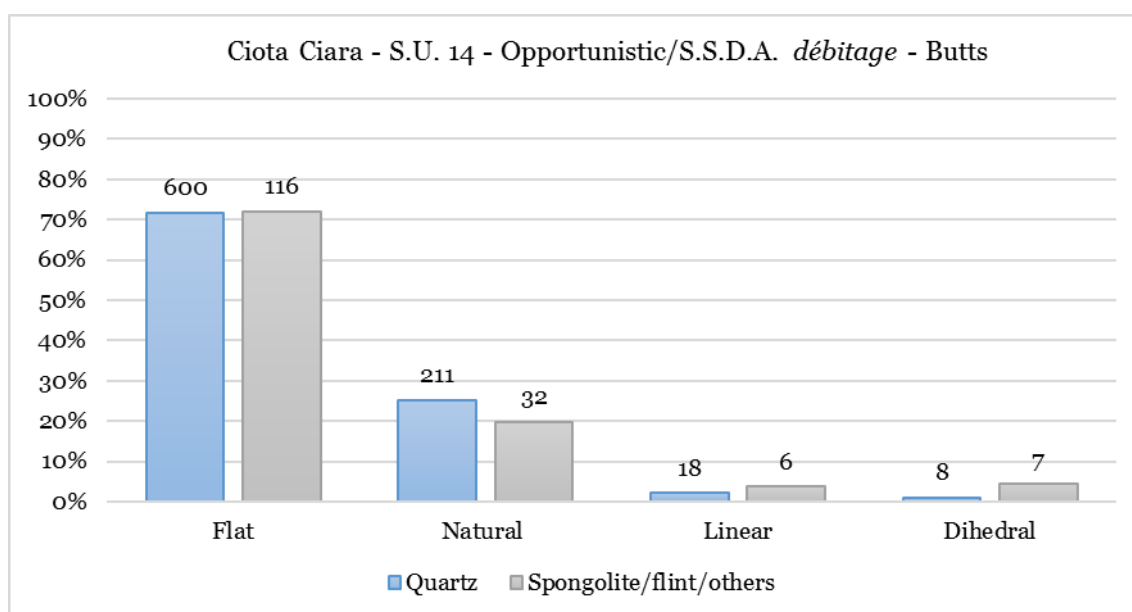


Fig. 3.53. Ciota Ciara cave, S.U. 14. Typology of the butts belonging to opportunistic reduction sequences. Tot. vein quartz butts = 837; tot. spongolite butts = 161.

Each striking platform is exploited to obtain a limited number of products (Fig. 3.54), usually no more than two or three, sometimes plunging, hinged or fragmented due to a bad propagation of the force in the raw material. The wanted products are medium-sized flakes (Fig. 3.55) which morphology is strongly conditioned by the characteristic of the core. Vein quartz opportunistic flakes usually have triangular section and pronounced thickness, that can be interpreted as an adaptation to the characteristic of the raw material: recent studies and experimentations demonstrate that increasing thickness is a good expedient to

avoid the occurrence of fractures during knapping activities (e.g. de Lomberra-Hermida et al., 2016; Driscoll, 2011; Tallavaara et al., 2010).

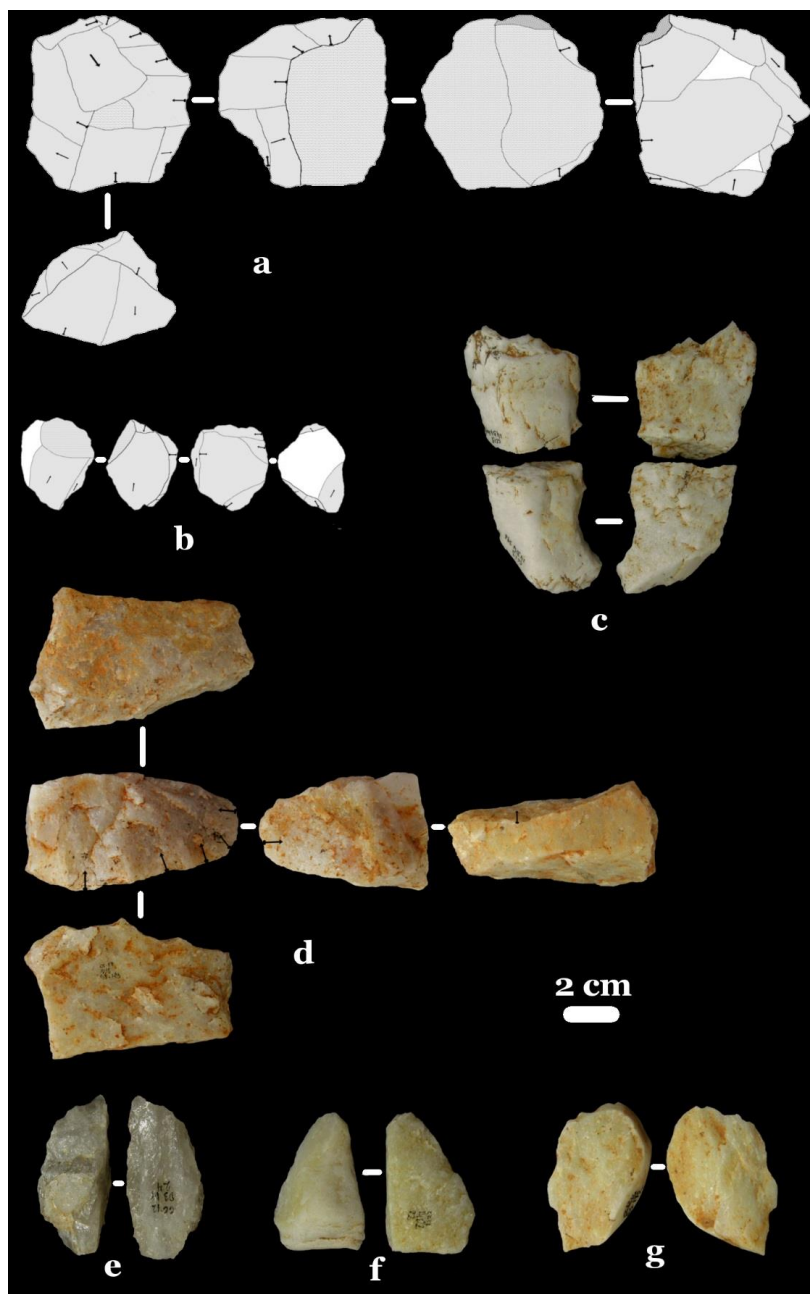


Fig. 3.54. Ciota Ciara cave, S.U. 14. Vein quartz opportunistic/S.S.D.A. cores and flakes: all the cores have been discarded before their exhaustion: (a) S.S.D.A. core on fluvial pebble; (b) opportunistic core; (c) connection between the proximal and the distal part of an opportunistic flake with natural dorsal face; (d) opportunistic core; (e) lateral fragment (siret accident) of S.S.D.A. flake with crossed negatives on the dorsal face; (f) opportunistic flake with natural dorsal face probably corresponding to the initialization of a vein quartz pebble; (g) opportunistic flake with lateral neocortex issued from the exploitation of a small quartz pebble.

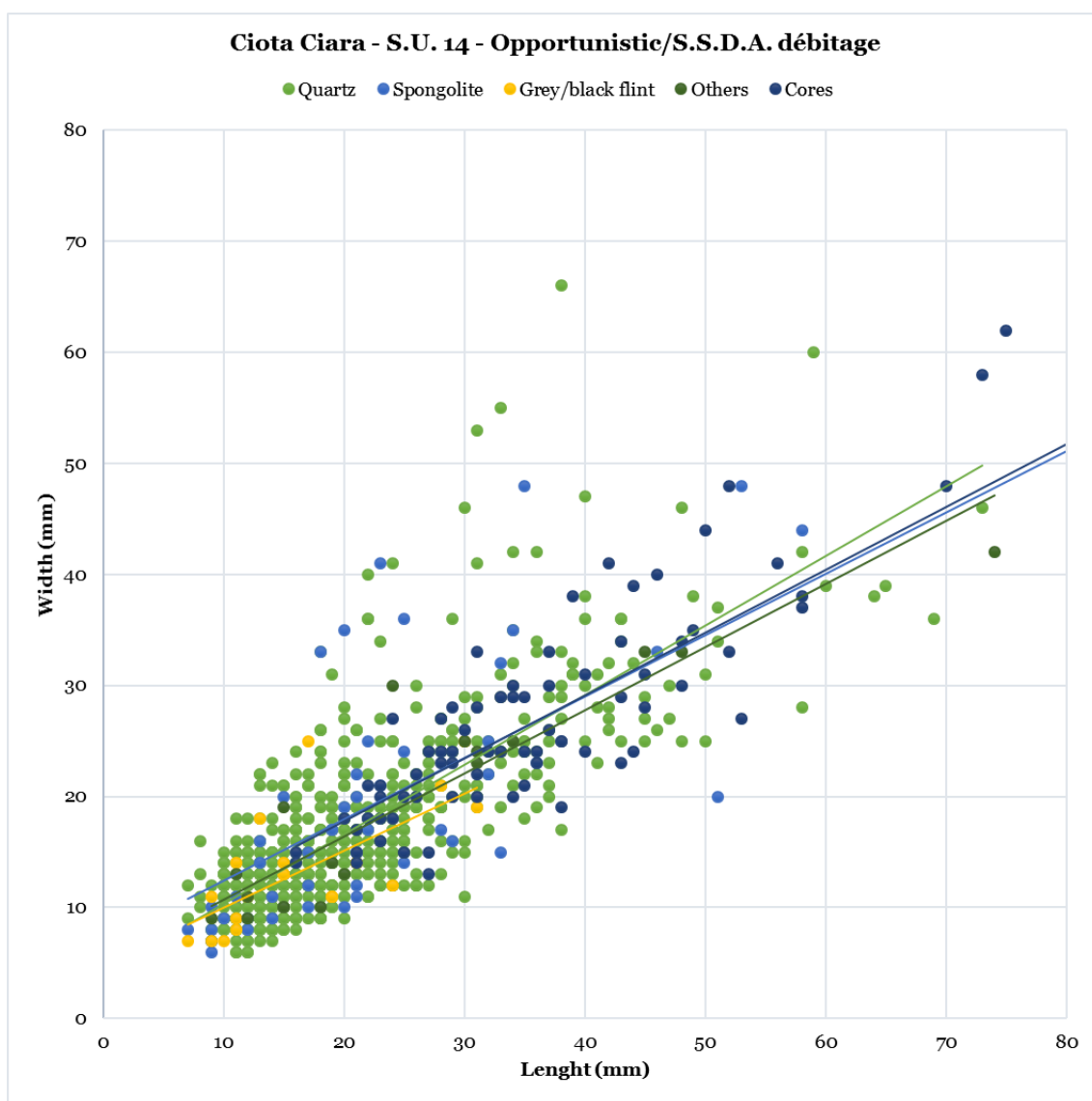


Fig. 3.55. Ciota Ciara cave, S.U. 14. Dimensional analysis of opportunistic/S.S.D.A. flakes and cores. Fragmented flakes are not included. No differences in the dimension of the wanted products are visible depending on the raw material employed and the dimensions of the cores are consistent with those of the products obtained.

Spongolite opportunistic reduction sequences are aimed to the production of flakes with dimensional features comparable to those of quartz and the sporadic presence of grey/black flint flakes issued from an opportunistic method suggest that even in this case the objectives of the knapping activity were similar (Fig. 3.55). The characteristics of the butts (Fig. 3.53) indicate that as well as for quartz, were preferentially chosen flat surfaces naturally present on the cores to start the *débitage*. There are however some differences in cores' exploitation between the two raw materials due to adaptations to the raw materials properties. Spongolite

cores are centimetric or, rarely, decimetric slabs rich in internal parallel cleavage plans that can strongly affect the characteristics of the final products. These slabs are usually exploited according to their thickness (Fig 3.56), perpendicularly as regard to the cleavage planes. Even if a specific experimental study has not been carried out yet, we can suppose that the systematic occurrence of this kind of expedient is due to an adaptation of the knapping sequences to the petrographic characteristics of this particular raw material. The initial morphology of the core strongly influences the dimensional properties of the final products. The thickness of the flake is generally high, further consequence of the cores' morphology: spongolite slabs presents knapping angles close to 90° thus forcing knappers to hit the striking platform far from the core's edges. Due to raw material constraints, most of the cores present just one or two opposite striking platforms, exploited till the exhaustion of the natural convexity to obtain a low number of finished products before their abandonment (Fig. 3.56). A last consideration must be made concerning opportunistic/S.S.D.A. cores of S.U. 14. The dimensional analysis (Fig. 3.55) indicates that their dimensions are essentially consistent with those of the products even if they are generally bigger. It means that the smallest opportunistic products do not correspond to the final phase of exploitation of the cores before their exhaustion, but their dimensions were desired, while, as already highlighted, the cores were discarded before their complete exhaustion.

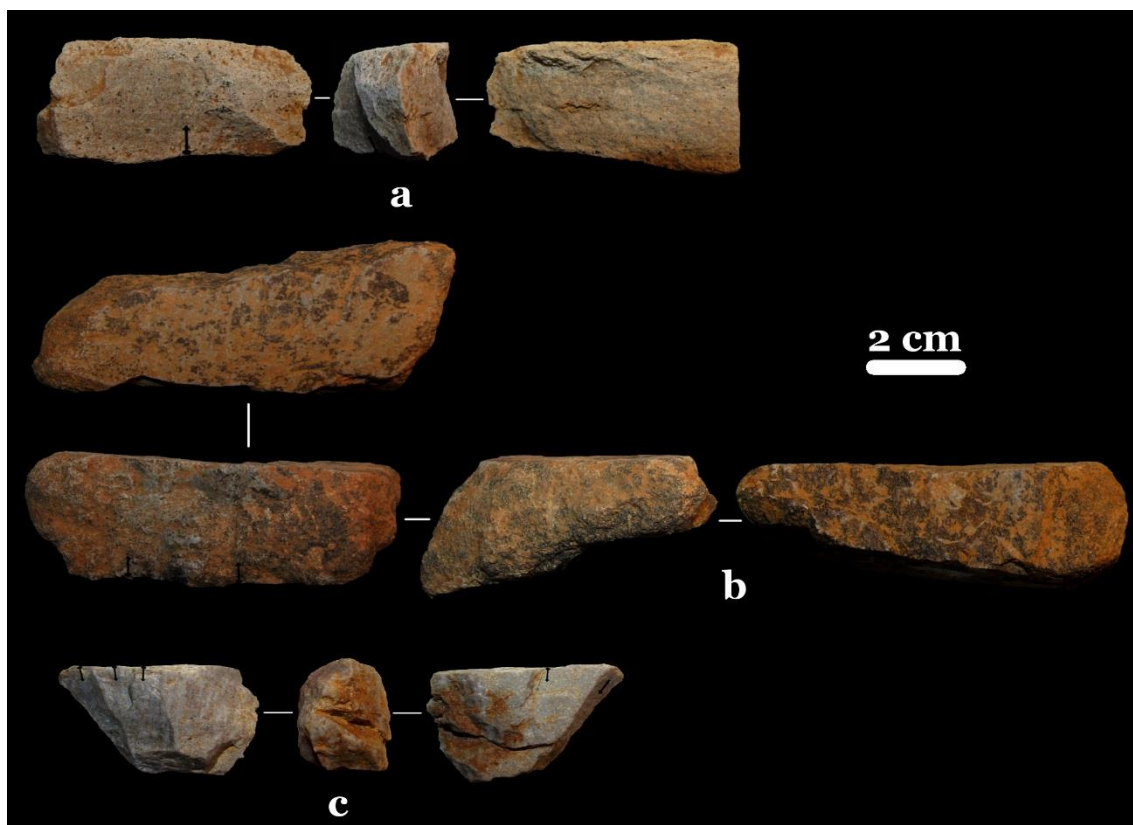


Fig. 3.56. Ciota Ciara cave, S.U. 14. Spongolite opportunistic cores where is clear the preferential exploitation of spongolite slabs according to their thickness as well as the abandonment of the cores before their exhaustion.

3.6.2.2. *Levallois and discoid technology*

Levallois and discoid reduction sequences (Boëda, 1994, 1993; Peresani, 2003) are largely attested in the considered lithic assemblage and are applied on all the raw materials, however just for vein quartz and grey/black flint they are complete, given the presence of both cores and products (Tab. 3.5).

The technological study of vein quartz Levallois and discoid cores (Appendix A) and flakes allow to make some considerations about the application of these two volumetric concepts to a raw material that do not guarantee the perfect control of the results of the knapping activity (e.g. de Lomberra-Hermida, 2009; de Lomberra-Hermida et al., 2011; Mourre, 1996).

Vein quartz Levallois cores present in the assemblage (Appendix A and Fig. 3.57) highlight the use of the preferential and of the recurrent centripetal modalities to

produce flakes with an oval/quadrangular morphology usually short and large even if some elongated flakes are sporadically attested in the assemblage (Fig. 3.58). Fluvial pebbles with natural suitable morphologies and convexities are chosen as cores, thus making the dimensions of the products strongly influenced by the morphological features of the core (Fig. 3.57). All the cores show just one phase of exploitation after which they are discarded. No evidences of further exploitation through discoid or opportunistic methods are attested in the end of the reduction sequence.

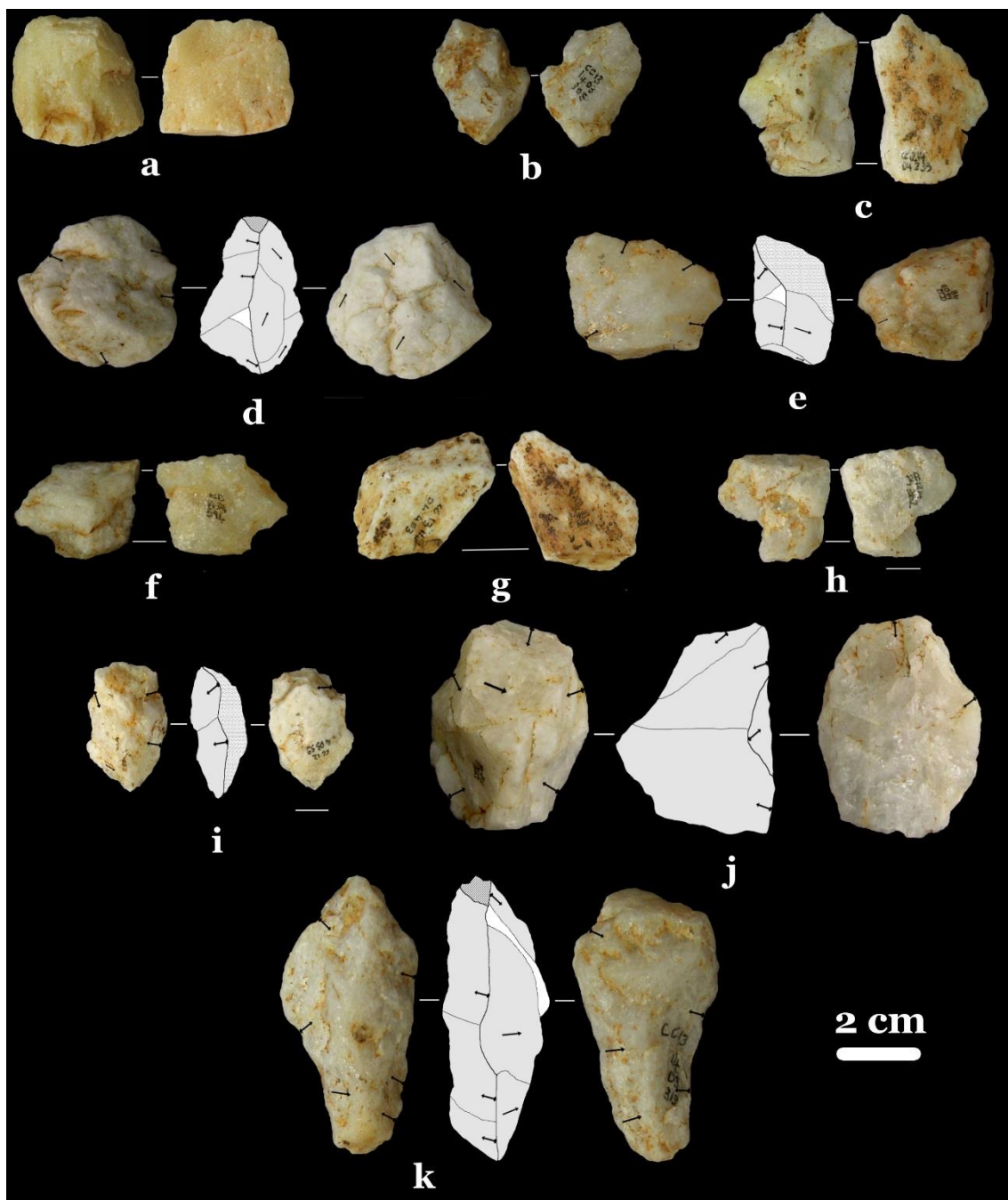


Fig. 3.57. Ciota Ciara cave, S.U. 14. Vein quartz Levallois and discoid cores and products: (a) preferential Levallois flake; (b, c) recurrent centripetal Levallois flakes; (d) recurrent centripetal Levallois core; (e) preferential Levallois core; (f, g, h) discoid flakes, (i) unifacial discoid core with a natural striking platform surface on a small quartz pebble; (j) bifacial discoid core on pebble; (k) bifacial discoid core on flake.

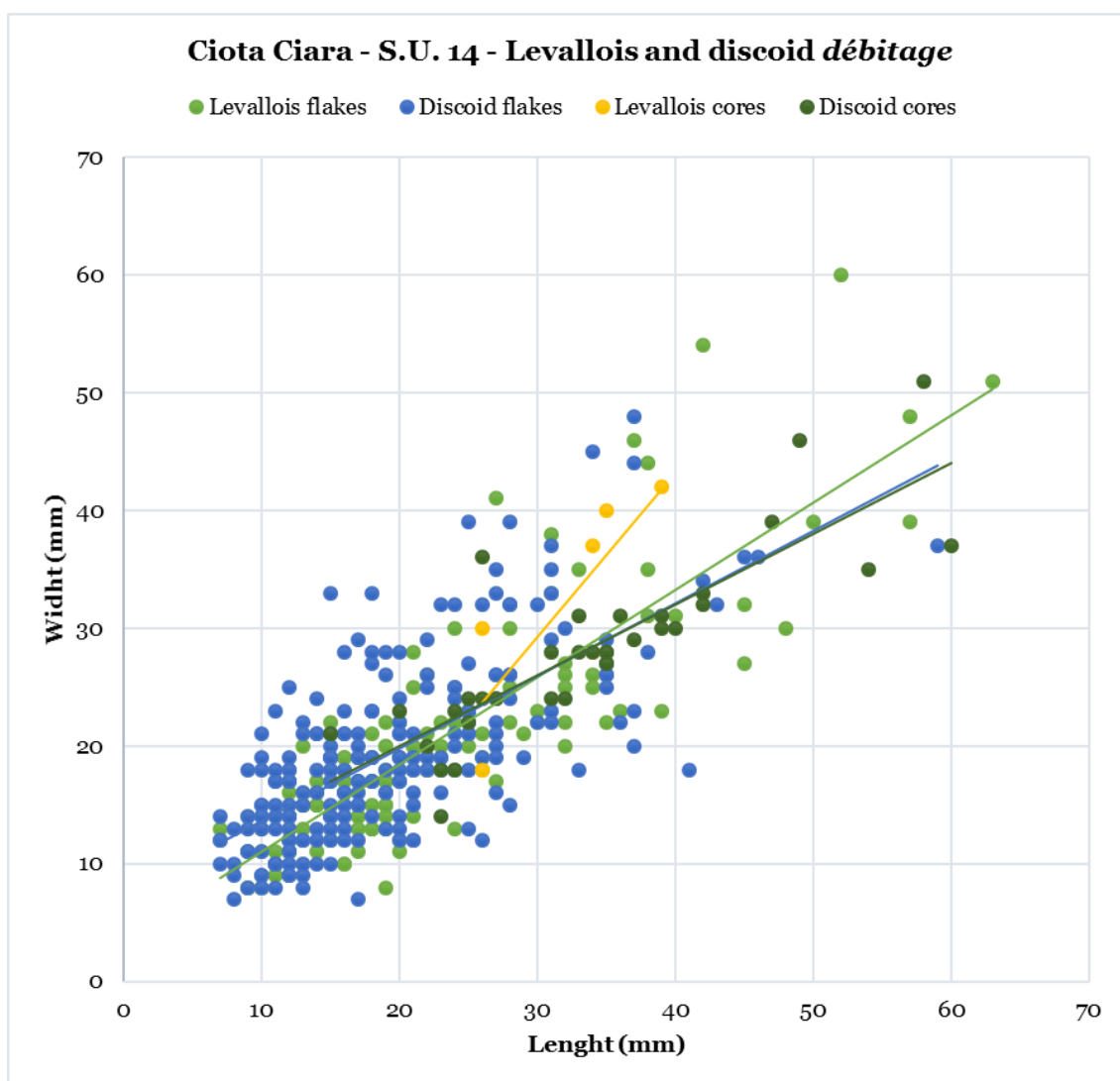


Fig. 3.58. Ciota Ciara cave, S.U. 14. Dimensional analysis of Levallois and discoid flakes and cores. The morphology of the cores strongly influences the dimensions of the products. Levallois and discoid reduction sequences seem to be aimed to the production of flakes with similar morphological features. Fragmented flakes are not considered. Since no significant differences have been observed between Levallois and discoid reduction sequences according to the raw material employed, for the dimensional analysis a subdivision just according to the knapping method has been done.

The core surfaces are barely prepared, being the striking platform surface completely natural or shaped through just a few detachments according to a centripetal direction (Fig. 3.57). In the preferential modality, a single removal, usually perpendicular to the plan of intersection of the two core surfaces, prepares the portion of the core to be hit through hard hammer percussion for the detachment of the preferential flake (Fig. 3.57). On the knapping surface two or

three removals, mainly centripetal, are needed to set the distal and the lateral convexities. After the detachment of the preferential flake the cores are discarded. Just one of the Levallois vein quartz core is referable to the recurrent centripetal modality (Fig. 3.57). Also in this case the convexities are naturally present on the core, but the striking platform surface is prepared through chordal and centripetal removals in correspondence of the impact points of the predetermined flakes. Four removals are present on the knapping surface corresponding to one phase of exploitation after which the core has been abandoned. The research for predetermined products is inferable from the use of both centripetal and chordal removals for the maintenance of suitable convexities even for a so short production phase (Fig. 3.57).

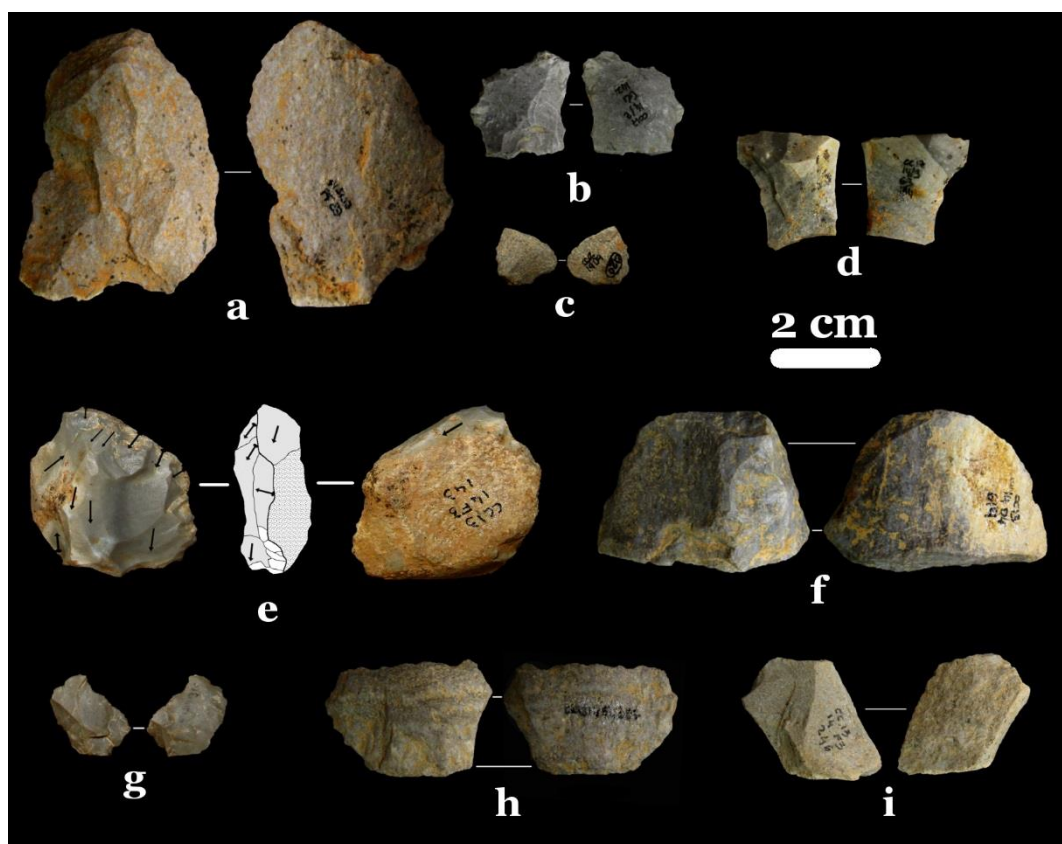


Fig. 3.59. Ciota Ciara cave, S.U. 14. Spongolite Levallois and discoide core and flakes. (a, c) recurrent centripetal Levallois flakes on good quality spongolite; (b) denticulate on a recurrent centripetal Levallois flint flake; (d) preferential Levallois flint flake; (e) flint recurrent centripetal Levallois core with natural striking platform; (f, g, h, i) discoide flakes on good quality spongolite.

No Levallois cores are attested for spongolite, while a recurrent centripetal core is present in the grey/black flint assemblage (Appendix A and Fig. 3.59). No significant differences are evident between this Levallois reduction sequence and those observed on vein quartz: the striking platform surface is natural with not any removal for the preparation of its convexity, thus confirming the choice of blanks with natural suitable convexities even in case of better quality raw materials. The main difference is the presence of more than one phase of exploitation on this flint core, that has been completely exhausted before being discarded. The researched products share the same morphological and dimensional characteristics observed on vein quartz cores.

The discoid method is well documented in the assemblage of S.U. 14 and the reduction sequences are complete for vein quartz, spongolite and grey/black flint (Tab. 3.5). On vein quartz, both the unifacial and the bifacial modalities are present (Appendix A and Fig. 3.57) with short reduction sequences aimed to produce short and large flakes, often quadrangular and characterized by a thickness generally higher than for products issued from Levallois reduction sequences (Peresani, 2003; Picin and Vaquero, 2016). The cores are discarded mainly before their complete exhaustion and after just one or two exploitation phases. Natural surfaces are often still present on the core surfaces and when an unifacial exploitation is employed the striking platform surface is usually neocortical or represented by a natural fracture plane (Fig. 3.57). Also for the discoid method the cores are chosen among blanks with suitable natural convexities and their morphology strongly influence the dimensions of the obtained products. Some discoid cores are realized on big flakes, probably issued from an opportunistic *débitage* (Fig. 3.57). The negatives of the removals visible on the cores usually follow a centripetal direction, while chordal detachments are

visible just when on the core are present two exploitation phases: the maintenance of the core convexities took place just in the longest discoid reduction sequences while when only one exploitation phase is completed the removals follow exclusively a centripetal direction (Fig. 3.57). No differences have been observed between the different raw materials in discoid reduction sequences concerning the selection of the cores, their modalities of exploitation or the wanted products. Also on spongolite, discoid reduction sequences are short and applied just on blanks with natural suitable convexities (Fig. 3.59). The cores are exploited through a few centripetal detachments to produce short and thick flakes (Fig. 3.58).

The *débitage* direction is always markedly secant to the intersection plane between the two core surfaces, thus showing a different volumetric conception of the core compared to those of the Levallois reduction sequences characterized by a parallel *débitage* direction.

The observations about Levallois and discoid reduction sequences made concerning cores are consistent with what can be noticed on the products (Figs. 3.57 and 3.59). The identification of Levallois and discoid products was based on the criteria listed in Chapter 2 and on the specific features of the considered assemblage: the direction of the negatives on the dorsal face, the *débitage* direction and the consistency between the technological characteristics observed on the cores and those of the products. Concerning fragmented flakes, the observation of just the direction of the negatives or of the typology of the butts was not considered to be sufficient to clearly assign them to discoid or Levallois reduction sequences, so the opportunistic component of the *débitage* could have been slightly overestimated. A good example is that of the negatives visible on the upper face of the flakes: considering the observations made on the cores, while

centripetal and convergent negatives for sure belong to a discoid or to a Levallois exploitation, crossed negatives could belong both to discoid or opportunistic methods.

The characteristics of the butts confirm the choice of natural or flat surfaces (i.e. prepared through a single removal) as striking platform surfaces (Fig. 3.60). A slight difference can be highlighted between vein quartz and the other raw materials when the Levallois and the discoid methods are applied, since on vein quartz, the choice of natural (i.e. neocortical) surfaces seems to be preferred. Prepared butts, dihedral and faceted, are attested just on the better quality raw materials and just in Levallois reduction sequences: radiolarite (2 faceted, 1 dihedral) and grey/black flint (2 faceted). So, even if the only grey/black flint Levallois core found in the assemblage show a natural striking platform, occasionally flint Levallois cores where more carefully prepared. Discoid products, on vein quartz and on the other raw materials as well, show exclusively flat or natural butts.

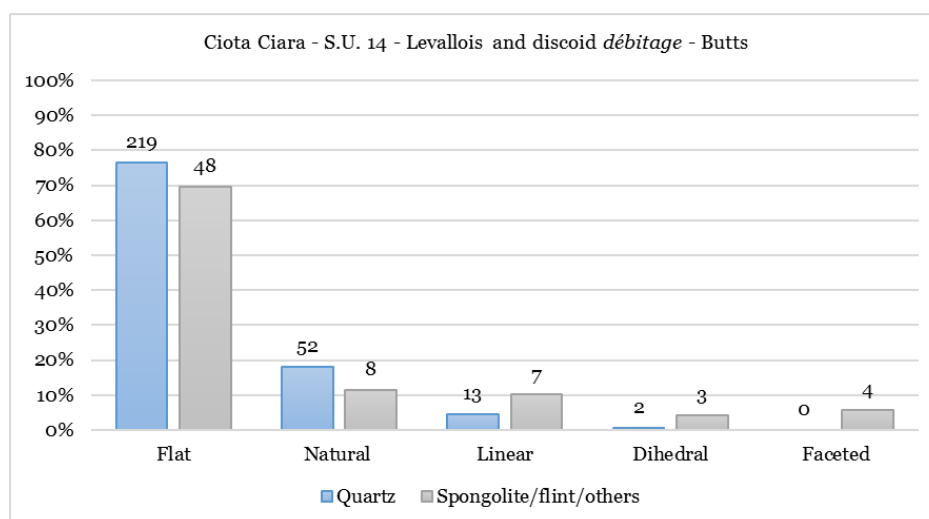


Fig. 3.60. Ciota Ciara cave, S.U. 14. Typology of the butts of Levallois and discoid products and comparison between vein quartz and the other raw materials present in the assemblage. Tot. vein quartz butts = 286; tot. spongolite and othe raw materials butts = 69.

Among Levallois and discoid products, plunging flakes are quite rare (Fig. 3.61). Considering the characteristics of the raw materials mainly employed (quartz and spongolite) in terms of presence of cleavages and inner flaws together with their textural features, the occurrence of plunging flake could be due more to a wrong propagation of the force rather than to a deliberate choice of the knappers with the aim of core maintenance. If we compare the proportion in the occurrence of plunging flakes in Levallois and discoid methods to those of opportunistic/S.S.D.A. reduction sequences (Fig. 3.61) we can see that for all the considered methods not-plunging flakes are clearly predominant and just lateral plunging flakes are proportionally more frequent in the discoid method. Indeed, discoid reduction sequences, even if short, are frequently longer than the Levallois and even than the opportunistic/S.S.D.A. ones and in this case a more important frequency of lateral plunging flakes could be related also to the maintenance of the cores convexities.



Fig. 3.61. Ciota Ciara cave, S.U. 14. Occurrence of plunging flakes according to the main reduction sequences present in the assemblage. Tot. vein quartz flakes = 252 discoid – 137 Levallois – 1437 opportunistic/S.S.D.A.; tot. Spongolite and other raw materials flakes = 50 discoid – 37 Levallois – 256 opportunistic/S.S.D.A.

The data obtained from the technological analysis of discoid and Levallois reduction sequences of S.U. 14 show some characteristics that can be linked to the adaptation of the technological criteria proper of these two knapping methods to the characteristics of the raw materials employed, particularly vein quartz and spongolite. These adaptations are evident first in the predominance of natural surfaces as striking platforms and in the choice of cores with natural convexities already suitable for these kind of exploitations, avoiding or strongly reducing the need of phases of shaping of the core. The systematic discard of the cores before their complete exhaustion, involving just the raw materials with the worst response to knapping (vein quartz and spongolite), cannot be explained just with the abundance of these lithologies in the surrounding of the site: the presence of cleavages and internal flaws, that distinguish vein quartz and spongolite, strongly affects the core exploitation and their effects increase going on with *débitage*, in terms of occurrence of knapping accidents (Mourre, 1996). Moreover, if we look at the better quality raw materials present in the assemblage (radiolarite, rhyolite, grey/black flint), even if cores are scarce, the technological features of the products, like the presence of prepared butts, let suppose that Levallois and discoid reduction sequences could have been longer and more articulated for these raw materials, with characteristics similar to the classical definitions of these two knapping methods (Boëda, 1994, 1993).

3.6.2.3. *Retouched tools*

Retouch is barely present in the lithic assemblage of level 14 (Tab. 3.4 and 3.5) but some observations can be made about the importance of retouch and of tool's edge rejuvenation depending on the raw materials involved.

Vein quartz flakes present a direct or inverse, marginal retouch which modify the flakes' edges to obtain simple scarpers (11), convergent or double scarpers (4) denticulates (21) and notches (13) (Fig. 3.62); flint, spongolite, rhyolite and radiolarite retouched tools have a more invasive retouch (direct, inverse or bifacial) and, even if the typology of the tools is not different from vein quartz (9 denticulates, 5 notches, 5 simple scrapers, 3 convergent or double scarpers and 2 Quinson points), the edges often show more than one phase of retouch, indicating that these tools were reshaped several times before being discarded (Fig. 3.62). As already mentioned, rhyolite and radiolarite have been brought to the site almost exclusively as finished tools and most of the unretouched flakes belonging to these lithologies refer to retouch and maintenance of the tools' edges (Tab. 3.5).

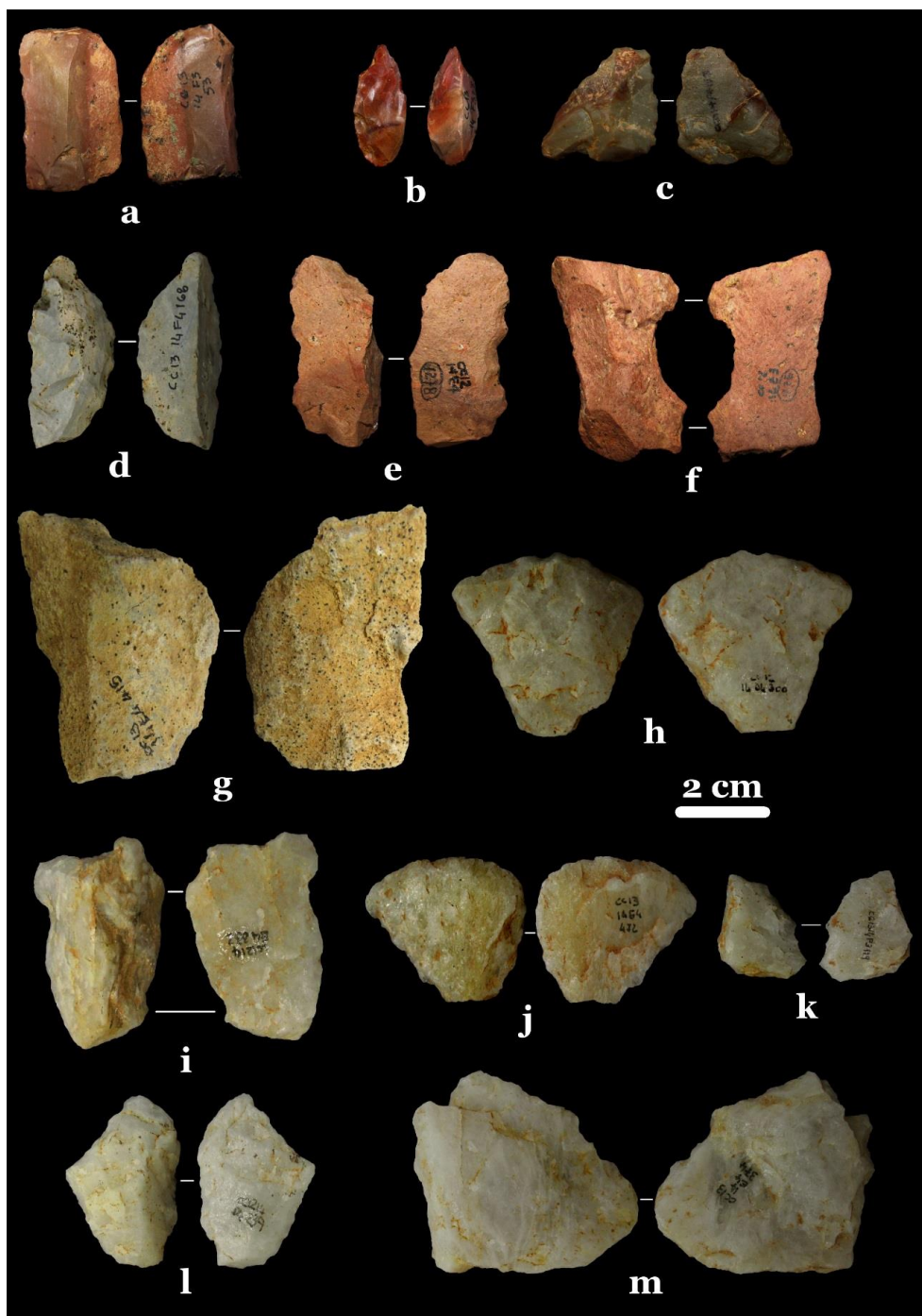


Fig. 3.62. Ciota Ciara cave, S.U. 14. Retouched tools: (a) radiolarite rectilinear side-scraper; (b) radiolarite Quinson point; (c) flint convex side-scraper on a preferential Levallois flake; (d) flint Quinson point; (e) denticulate on rhyolite; (f) rhyolite retouched notch; (g) notch on a spongolite flake; (h) transversal scraper; (i) notch; (j) rectilinear side-scraper; (k, m) denticulates; (l) concave side-scraper on a recurrent centripetal Levallois flake.

3.6.3. S.U. 15

Stratigraphic unit 15 is the last archaeological layer of the Ciota Ciara cave. It lays upon level 16, archaeologically sterile and placed upon the dolomitic bed rock (see paragraph 3.3).

The lithic assemblage belonging to this unit is composed by 1788 lithic artefacts realized on local and allochthonous raw materials (Fig. 3.63). Quartz is still the predominant lithology in the lithic industry (50,6%) followed by other local raw materials in different proportions: spongolite (44,4%), grey/black flint (1,6%) and opal (0,2%) (Fig.3.61). Allochthonous raw materials are represented by radiolarite (1,2%) and rhyolite (1,2%) (Fig. 3.63). A small percentage of the artefacts is undetermined for what concerns the raw material, due to post depositional surface modifications, and metamorphic rocks (0,3%) are present both as hammer fragment and as flakes belonging to opportunistic reduction sequences (Fig. 3.63).

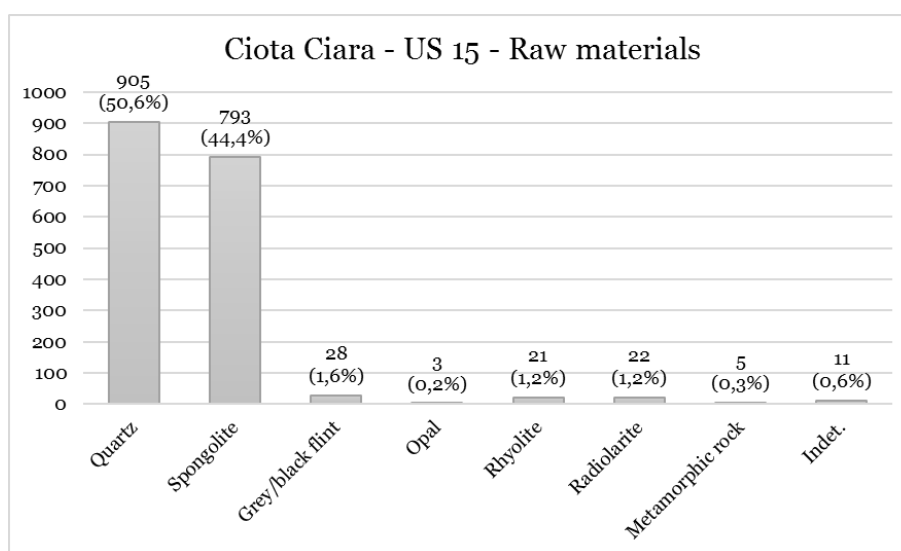


Fig. 3.63. Ciota Ciara cave – S.U. 15. Raw materials present in the lithic assemblage.

Looking at the proportion of the different raw materials identified (Fig. 3.63) and at the general composition of the lithic assemblage of level 15 (Tab. 3.7), it seems clear that in this stratigraphic unit the importance of spongolite is rather increased if compared with that observed in other archaeological levels.

Raw material	Flakes	Cores	Retouched tools	Debris	Unworked blanks	Total
Quartz	611	20	9	265	-	905
Spongolite	429	31	9	299	25	793
Grey/black flint	20	-	3	4	1	28
Rhyolite	12	2	1	6	-	21
Radiolarite	12	-	5	5	-	23
Other	10	1	-	6	2	18
Total	1094	54	27	585	28	1788
%	61,2%	3,0%	1,5%	32,7%	1,6%	100,0%

Tab. 3.7. Ciota Ciara cave, S.U. 15. Composition of the lithic assemblage.

Post depositional surface modifications, mainly of mechanical origin, strongly affect the lithic assemblage (Fig. 3.64). For what concerns mechanical post depositional alterations, contrary to what observed for the other archaeological layers, vein quartz artefacts are affected by post depositional alterations in a similar proportion than spongolite and other raw materials findings (Fig. 3.64). As already mentioned in the previous paragraphs, due to petrographic reasons, vein quartz is not affected by chemical post depositional surface modifications (Venditti et al., 2016), well attested in level 15 on all the other lithic raw materials (Fig. 3.64). The state of preservation of the lithic assemblage attests that after its deposition it was affected by quite intense post depositional phenomena, mainly linked to water circulation, in accordance with the results of the geoarchaeological studies recently completed (Angelucci et al., submitted paper; Zambaldi, 2015). The importance of post depositional surface modifications, made often difficult to identify knapping scars and to accurately define the

direction of the negatives on the dorsal faces of the flakes, especially regarding vein quartz and spongolite that even when their state of preservation is good do not show marked knapping scars on their surfaces (de Lomberra-Hermida, 2009). The consistency of the post depositional surface modifications, despite slight differences between the different raw materials, and the presence of a refitting (Fig. 3.65) between two opportunistic spongolite flakes, attests that all the artefacts belong to a unique lithic assemblage.

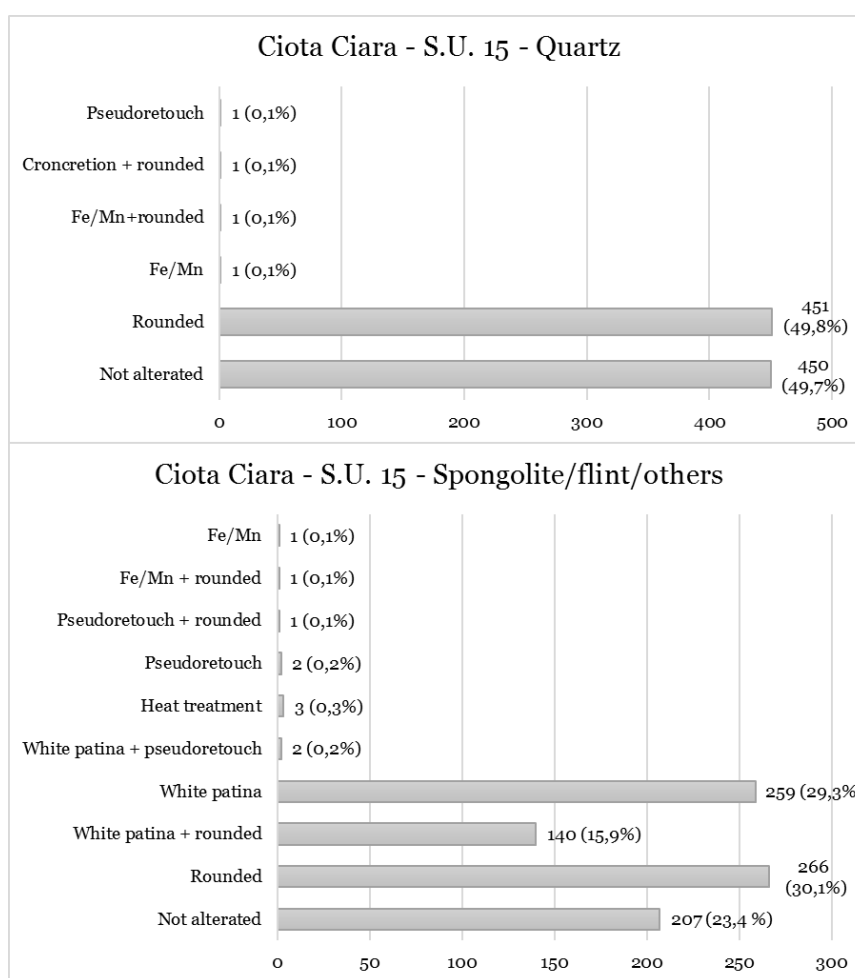


Fig. 3.64. Ciota Ciara cave. Post depositional alterations present on the lithic artefacts of S.U. 15.

The composition of the lithic assemblage (Tab. 3.7) indicates that the knapping sequences are complete for what concerns vein quartz and spongolite, both present as flakes, retouched tools, cores, and debris. The presence of two cores

suggests that occasionally also rhyolite pebbles were brought to the site to be exploited, while radiolarite and grey/black flint were introduced in the Ciota Ciara cave only as finished tools (Tab. 3.7). The technological characteristics of most of the radiolarite and grey/black flint unretouched flakes, indicate their belonging to the modification or rejuvenation of the tools' edges (Tab. 3.8). In the lithic assemblage of S.U. 15 there are several unworked spongolite blanks (25), most of them of decametric size and strongly affected by post depositional alteration (rounding), attesting that they were subjected to intense transport phenomena. Since the degree of post depositional alteration observed on them is stronger than that observed on the artefacts of level 15 and since the most altered and big of them belong to the lower portion of S.U. 15, a reliable hypothesis is their belonging to the interface between S.U. 15 and 16 rather than their intentional introduction in the site.



Fig. 3.65. Ciota Ciara cave, S.U. 15. Refitting between two opportunistic spongolite flakes.

As for the other archaeological levels, the rate of fragmentation is higher for vein quartz than for the other raw materials (Fig. 3.66). The frequent presence of

clevages and internal flaws in spongolite blanks makes however the rate of fragmentation quite elevated.

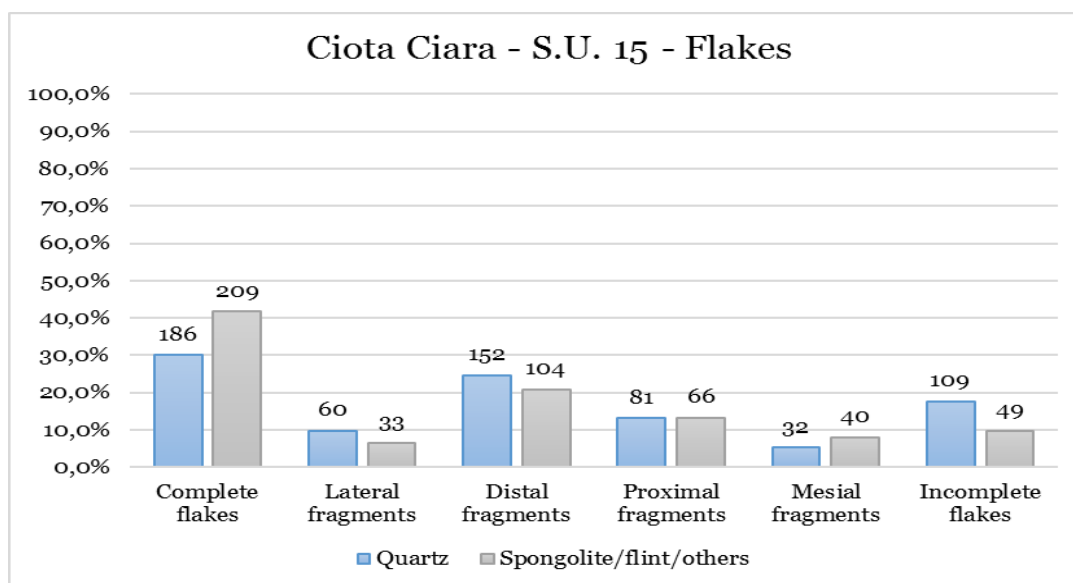


Fig. 3.66. Ciota Ciara cave, S.U. 15. Rate of fragmentation of vein quartz flakes compared to that of the other raw materials present in the assemblage (spongolite, grey/black flint, radiolarite, rhyolite, opal, metamorphic rock, indet. raw material).

The state of preservation of the lithic assemblage, together with the frequent occurrence of breakages following the internal fracture planes of vein quartz and spongolite, determines that a significant part of the fractures remains of unspecified origin (Fig. 3.67). This kind of fractures can indeed occur both during knapping activities or as a consequence of post depositional factors, like trampling (Driscoll, 2011; Mourre, 1996; Tallavaara et al., 2010).

Concerning fractures simultaneous to the *débitage*, vein quartz tends to fracture following radial planes, often passing through the impact point of the flake. These breakages are therefore classifiable as silet accident (Mourre, 1996). For the other raw materials, most of fractures is of post depositional origin (Fig. 3.67).

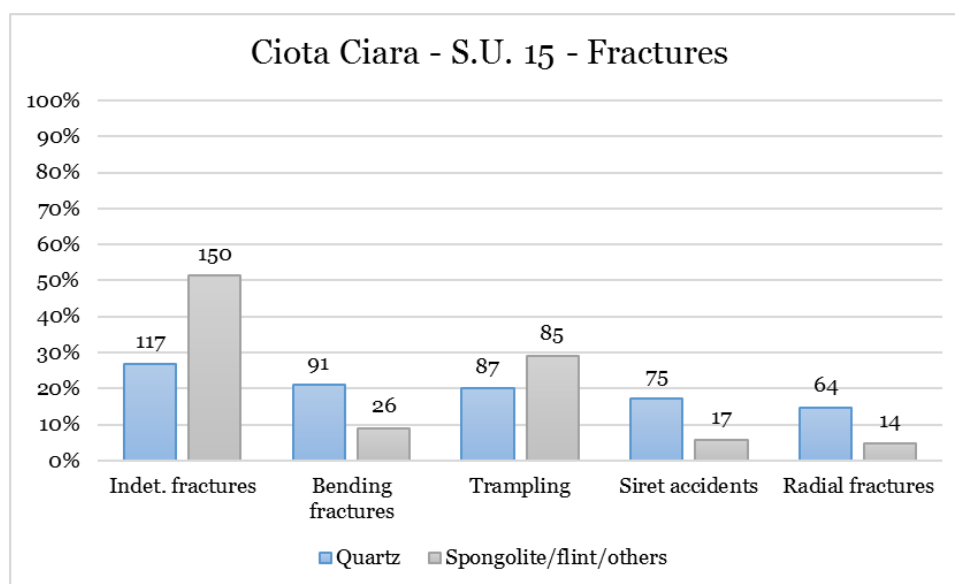


Fig. 3.67. Ciota Ciara cave, S.U. 15. Typology of the fractures identified on the flakes and comparison between quartz flakes and flakes obtained from the other raw materials present in the assemblage (spongolite, grey/black flint, radiolarite, rhyolite, opal, metamorphic rock, indet. raw materials). Tot. vein quartz fragmented flakes = 434; tot. spongolite and other raw materials fragmented flakes = 292.

Cortical and neocortical surfaces are rarely present on the dorsal faces of the flakes, regardless the knapping method employed (Fig. 3.68).

Flakes in radiolarite, opal and grey/black flint never show cortical surfaces, thus confirming the hypothesis that they were knapped elsewhere and transported up to the Ciota Ciara cave as finished tools. Concerning vein quartz, spongolite and, to a lesser extent, rhyolite, when neocortical/cortical surfaces are present, they are mostly visible on the lateral side of the upper faces of the flakes (Fig. 3.68). Lateral natural surfaces are mainly associated to unipolar negatives of previous removals and to opportunistic/S.S.D.A. reduction sequences (Forestier, 1993) which start directly from the natural surfaces of the selected blanks exploiting natural convexities and proceed until their exhaustion. Vein quartz and spongolite flakes with a natural dorsal face are both of big or very small dimensions: the firsts can be related to the opening of striking platforms in opportunistic/S.S.D.A. reduction sequences, the latter to the initial phases of shaping of core convexities in Levallois or discoid exploitation strategies.

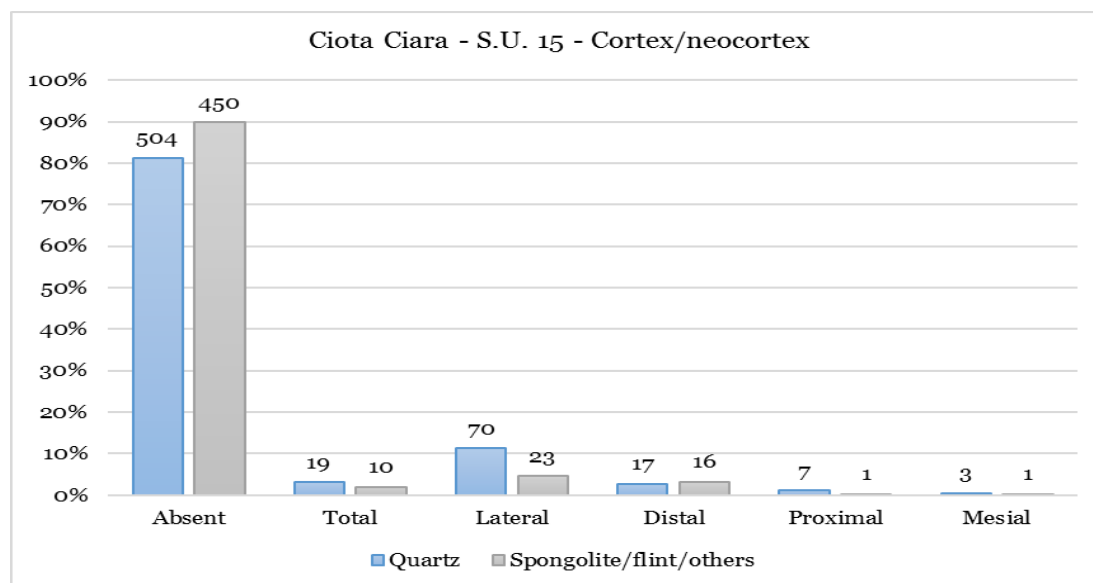


Fig. 3.68. Ciota Ciara cave, S.U. 15. Presence and position of neocortex on quartz flakes and of cortex on flakes obtained from spongolite, grey/black flint, radiolarite, rhyolite, opal, jasper, indet. raw materials. Tot. vein quartz flakes = 620; tot. spongolite and other raw materials flakes = 501.

The direction of the negatives of previous removals is one of the elements used to refer each flake to the knapping method it belongs to, but due to the quite intense post depositional surface modifications and to the general high rate of fragmentation of the considered lithic assemblage, for a significative number of spongolite flakes the direction of the negatives is undetermined (Fig. 3.69). When visible, unipolar negatives are predominant for all the raw materials and together with bipolar and orthogonal negatives they are exclusively associated to opportunistic/S.S.D.A. exploitations (Forestier, 1993). Convergent and centripetal scars are instead indicative of discoid or Levallois reduction strategies (Boëda, 1994, 1993; Peresani, 2003), while crossed negatives are visible on discoid, Levallois and also opportunistic/S.S.D.A. flakes.

The general scarce evidence of bipolar and orthogonal negatives suggests that multidirectional exploitation strategies (Forestier, 1993) were barely employed.

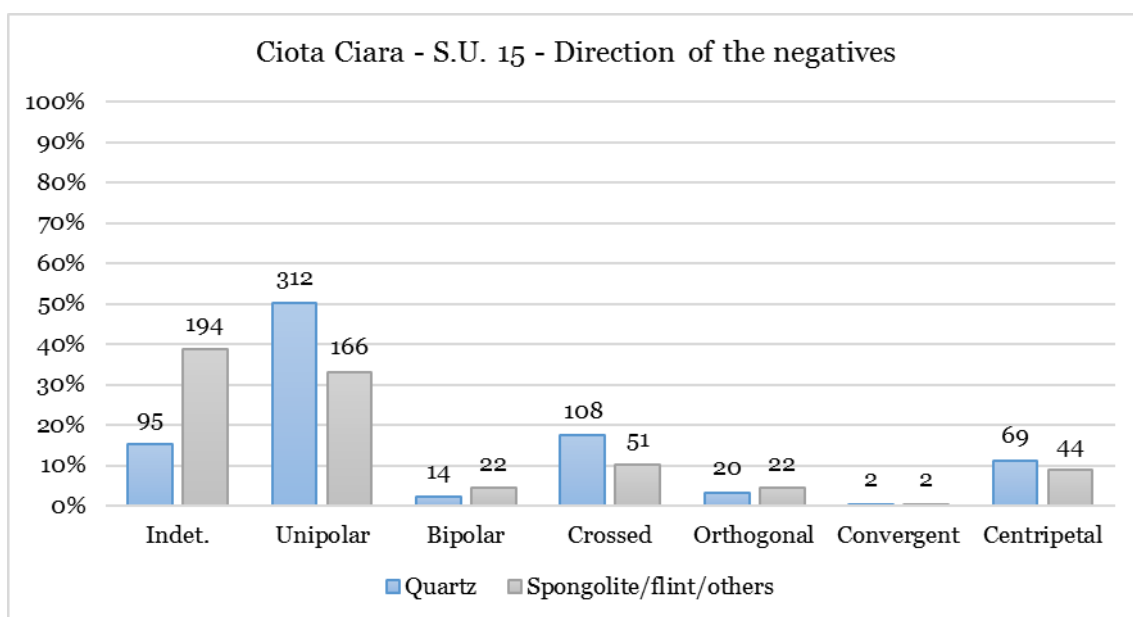


Fig. 3.69. Ciota Ciara cave, S.U. 15. Direction of the negatives of previous removals visible on the dorsal faces of the flakes. Tot. vein quartz flakes = 620; tot. spongolite and other raw materials flakes = 501.

The knapping methods identified in level 15 are the same present in the previous considered archaeological layers (13 and 14) (Tab. 3.8): opportunistic/S.S.D.A., discoid and Levallois, together with a sporadic presence of a *débitage*-on-flake classifiable as *Kombewa s.l.* (Inizan et al., 1999; Tixier and Turq, 1999) that is included in the opportunistic component of the *débitage*. Part of the knapping products, especially for vein quartz and spongolite, is undetermined concerning the knapping method: as already mentioned, this is due to the high rate of fragmentation of the lithic assemblage and to post depositional factors.

The categories of retouch flakes and debris have been included in Tab. 3.8 to better understand the general characteristics of the lithic assemblage of level 15.

Raw material	Opp. S.S.D.A.	Discoid	Levallois	Kombewa s.l.	Indet.	Retouch flakes	Debr.	Tot.
Quartz	F. = 410	F. = 64	F. = 41	F. = 4	F. = 84			
	C. = 13	C. = 5	C. = 2	C. = -	C. = -			
Tot.	423	69	43	4	84	17	265	905
%	24,1%	3,9%	2,4%	0,2%	4,8%	1,0%	15,1%	51,5%
Spongolite	F. = 205	F. = 31	F. = 17	F. = 5	F. = 84			
	C. = 26	C. = 4	C. = -	C. = -	C. = -			
Tot.	231	35	17	5	84	94	299	765
%	13,1%	2,0%	1,0%	0,3%	4,8%	5,4%	17,0%	43,5%
Grey/black flint	F. = 8	F. = 3	F. = 4	F. = -	F. = 3			
	C. = -	C. = -	C. = -	C. = -	C. = -			
Tot.	8	3	4	-	3	5	4	27
%	0,5%	0,2%	0,2%	-	0,2%	0,3%	0,2%	1,5%
Rhyolite Radiolarite	F. = 10	F. = 4	F. = 4	F. = -	F. = 4			
	C. = 2	C. = -	C. = -	C. = -	C. = -			
Tot.	12	4	4	-	4	7	11	43
%	0,7%	0,2%	0,2%	-	0,2%	0,4%	0,6%	2,4%
Others	F. = 7	F. = 1	F. = -	F. = -	F. = -			
	C. = -	C. = -	C. = -	C. = -	C. = -			
Tot.	7	1	-	-	-	4	6	17
%	0,4%	0,1%	-	-	-	0,2%	0,3%	1,0%
Total	681	112	68	9	175	127	585	1757
%	38,8%	6,4%	3,9%	0,5%	10,0%	7,2%	33,3%	100,0 %

Tab. 3.8. Ciota Ciara cave, S.U. 15. Raw materials and *débitage* methods. F. = flakes; C. = cores.

Vein quartz and spongolite have been exploited in the same way and the presence of abundant cores and debris confirms that their knapping sequences were performed in the site (Tab. 3.8). On these raw materials all the knapping methods are employed with a clear preponderance of opportunistic/S.S.D.A. reduction sequences (Forestier, 1993). Analogously to what already observed in level 14, a further consideration must be made concerning spongolite reduction strategies since cores and products are present for all the knapping methods identified exception made for the Levallois method, represented just by 17 flakes. **This low number of Levallois products suggest that the method was scarcely employed on spongolite by the absence of cores can be explained as already proposed for S.U.**

14:

- Levallois cores have been not abandoned but further exploited through opportunistic methods and have not been recognized during the technological analysis;
- Spongolite blanks selected for the Levallois method have been exploited out of the cave, maybe near the secondary deposits where they were collected.

Considering the characteristics of the opportunistic/S.S.D.A. cores present in the assemblage in terms of texture and exploitation modalities, in this case, we are in favour of the second hypothesis as well.

No cores and a reduced number of debris are present for grey/black flint, radiolarite and the other raw materials, suggesting that their exploitation took place elsewhere, while in the site were performed only the modification or rejuvenation of the tools' edges, as attested by the presence of small flakes technologically referable to this kind of activity (Tab. 3.8).

Two rhyolite opportunistic cores show that occasionally this raw material of sub-local origin was knapped in the site in the same modalities of the other lithologies present (Tab. 3.8).

The flakes classified as retouch flakes (Tab. 3.8) are those with technological characteristics consistent with the type of retouch visible on the tools: abrupt/semi abrupt, sometimes invasive. Mainly for radiolarite, the presence of crossed negatives on the upper faces of these small flakes confirm the continuous rejuvenation of the tools' edges before the discard of the tool.

Vein quartz artefacts have been divided according the morphostructural groups methodology (e.g. de Lombera-Hermida et al., 2011; Martinez Cortizas and Llana Rodriguez, 1996) to verify if there was or not a choice for specific characteristics depending on the knapping method (Tab. 3.9).

Method	Morphostructural groups			
	NN	NS	SN	SS
Opportunistic S.S.D.A.	Flakes = 9	Flakes = 154	Flakes = 231	Flakes = 7
	Cores = -	Cores = 8	Cores = 5	Cores = -
Tot.	9	162	236	7
Discoid	Flakes = 5	Flakes = 27	Flakes = 30	Flakes = -
	Cores = -	Cores = 2	Cores = 2	Cores = -
Tot.	5	29	32	-
Levallois	Flakes = 1	Flakes = 13	Flakes = 26	Flakes = -
	Cores = -	Cores = 1	Cores = 1	Cores = -
Tot.	1	14	27	-
Indet.	Flakes = -	Flakes = 33	Flakes = 49	Flakes = -
	Cores = -	Cores = -	Cores = -	Cores = -
Tot.	-	33	49	-
Retouch flakes	-	7	10	-
Debris	6	151	102	1
Total	21	396	456	8
%	2,4%	44,9%	51,8%	0,9%

Tab. 3.9. Ciota Ciara cave, S.U. 15. Quartz morphostructural groups and knapping methods. NN = no grainy, no planes; NS = no grainy, planes; SN = grainy, no planes; SS = grainy, planes.

The data obtained show a slight predominance of the group SN (51,8%) over the NS group (44,9%) concerning all the knapping methods attesting that the presence of grains was generally preferred to those of planes for the exploitation of vein quartz (Tab. 3.9). Conditioning in the raw materials choice due to the geologic environment have however always to be taken into account and the comparison between the different archaeological layer of the Ciota Ciara cave will help in making some hypothesis about this particular issue.

3.6.3.1. Opportunistic/S.S.D.A. technology

Opportunistic/S.S.D.A. exploitation strategies are clearly predominant in the lithic assemblage of S.U. 15 and they have been performed on all the lithologies attested in this level (Tab. 3.8). Even though, only for vein quartz and spongolite the reduction sequences are complete with the presence of flakes, cores and

retouched tools, so the overall characteristics of this kind of *débitage* can be deduced looking at these two local raw materials.

For vein quartz, the reduction strategy starts from the choice of fluvial pebbles and decimetric blocks collected in secondary deposits or of big flakes characterized by the presence of convexities suitable for knapping. The typologies of the butts identified in the assemblage (Fig. 3.70), suggests that both for vein quartz and spongolite the reduction sequence starts preferentially from flat surfaces that can be already present on the core or that formed during the development of the *débitage*. Given the low number of orthogonal, bipolar and crossed negatives (Fig. 3.69) referable to opportunistic methods, probably most of the flat surfaces were already present on the cores (i.e. fractures planes formed during fluvial transport) and multidirectional (S.S.D.A.) strategies (Forestier, 1993) were barely applied.

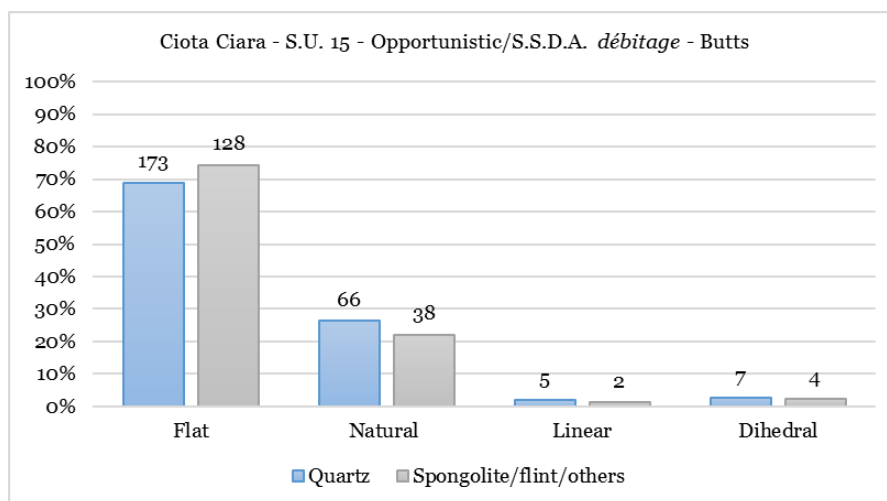


Fig. 3.70. Ciota Ciara cave, S.U. 15. Typology of the butts belonging to opportunistic reduction sequences. Tot. vein quartz butts =251; tot. spongolite/other raw materials butts = 172.

The technological analysis of vein quartz opportunistic cores confirms this observation: on most of them only one or two striking platforms are exploited and after the detachment of two or three flakes from each striking platform the core is discarded (Fig. 3.71). The wanted products are non-standardized flakes which dimensions are strongly influenced by the core morphology (Fig. 3.71 and 3.72).

Vein quartz opportunistic flakes usually have triangular section and pronounced thickness, that can be interpreted as an adaptation to the characteristic of the raw material (e.g. de Lombera-Hermida et al., 2016; Driscoll, 2011; Tallavaara et al., 2010).

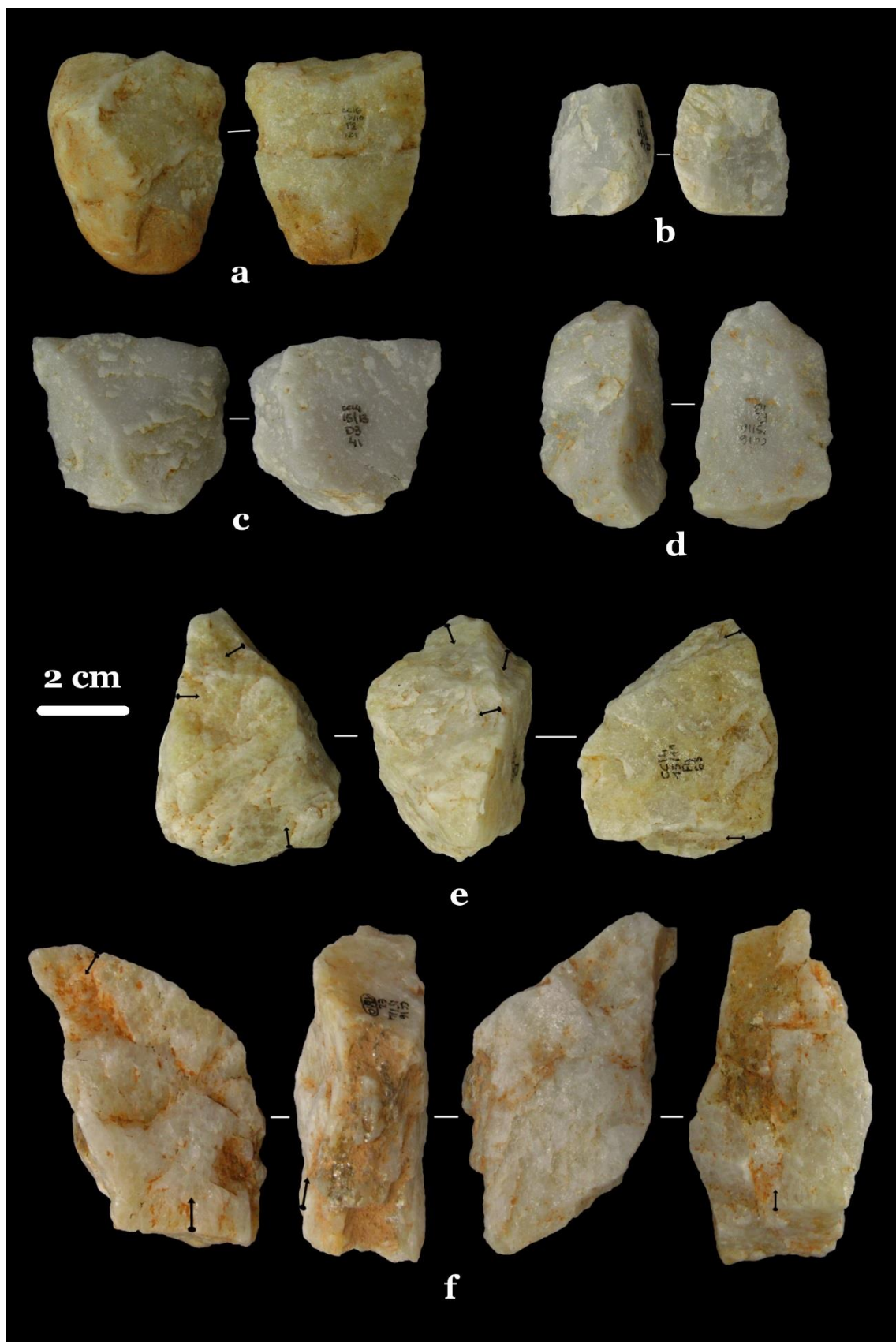


Fig. 3.71. Ciota Ciara cave, S.U. 15. Vein quartz opportunistic/S.S.D.A. cores and flakes: (a, b) flakes issued from the exploitation of a vein quartz pebble; (c, d) opportunistic flakes; (e, f) opportunistic cores on pebble (e) and on a vein quartz slab (f).

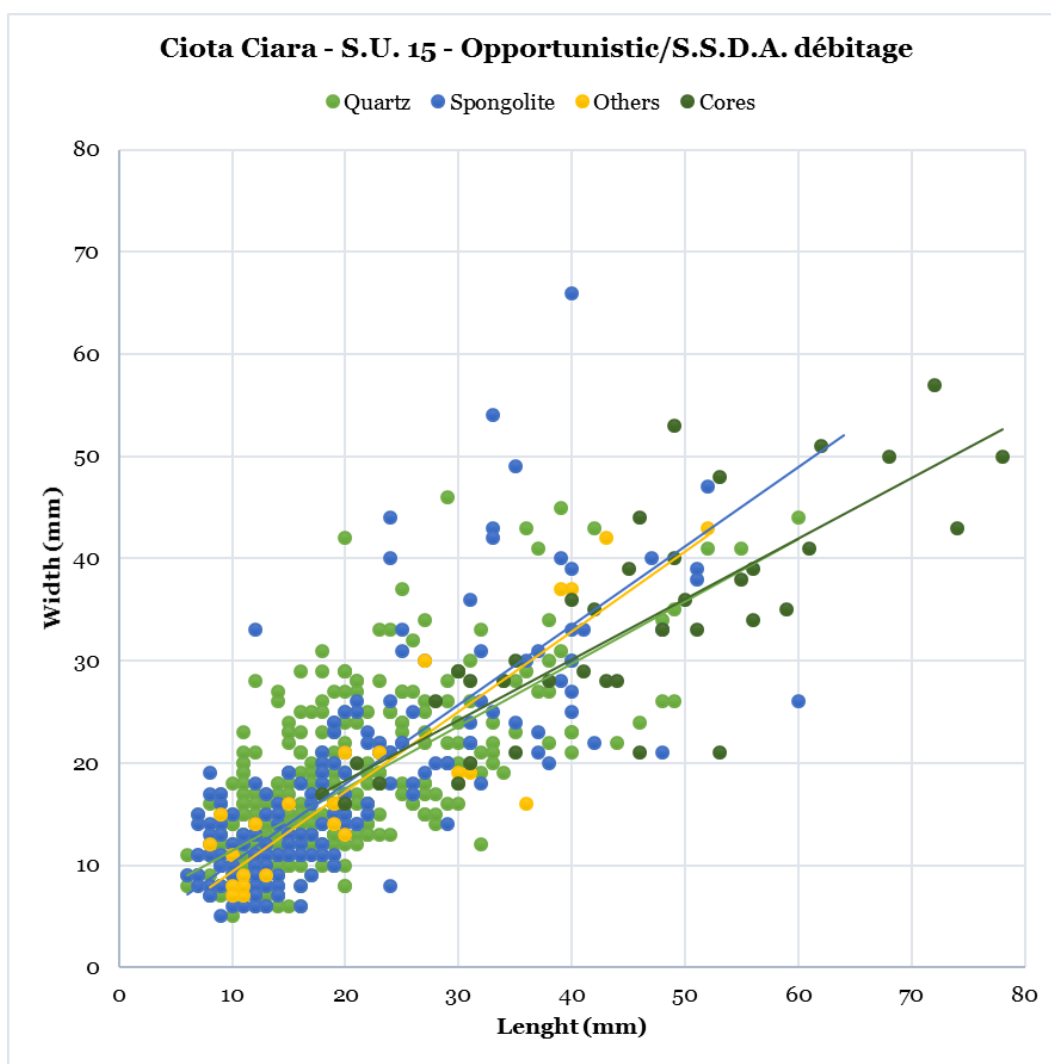


Fig. 3.72. Ciota Ciara cave, S.U. 15. Dimensional analysis of opportunistic/S.S.D.A. flakes and cores. Fragmented flakes are not included. No differences in the dimension of the wanted products are visible depending on the raw material employed and the dimensions of the cores are consistent with those of the products obtained.

Spongolite opportunistic/S.S.D.A. reduction sequences are aimed to the production of flakes with dimensional characteristics like those of vein quartz, and which morphology is strongly influenced by the characteristics of the core (Fig. 3.72). The exploitation of the other lithologies attested in S.U. 15 share the same objectives (Fig. 3.72). As for vein quartz the exploitation starts from flat surfaces naturally present on the core or, rarely, formed during the development of the *débitage*. The main difference between vein quartz and spongolite is in the natural blanks chosen for the opportunistic/S.S.D.A. method: collected in secondary deposits, spongolite cores are usually centimetric or decimetric slabs.

They are exploited according to their thickness, perpendicularly to the several cleavage planes present, an expedient that probably allow to better control the results of the knapping activity and helps in avoiding the occurrence of fractures. Due to core morphology, usually spongolite cores have one or two striking platforms, exploited through a reduced number of removals, and the cores are discarded before their exhaustion (Fig. 3.73).

The dimensional analysis of vein quartz and spongolite cores (Fig. 3.72) shows that their dimensional features are consistent with those of the products issued from opportunistic/S.S.D.A. *débitage* but they are generally bigger, confirming that they were usually discarded after short reduction sequences.

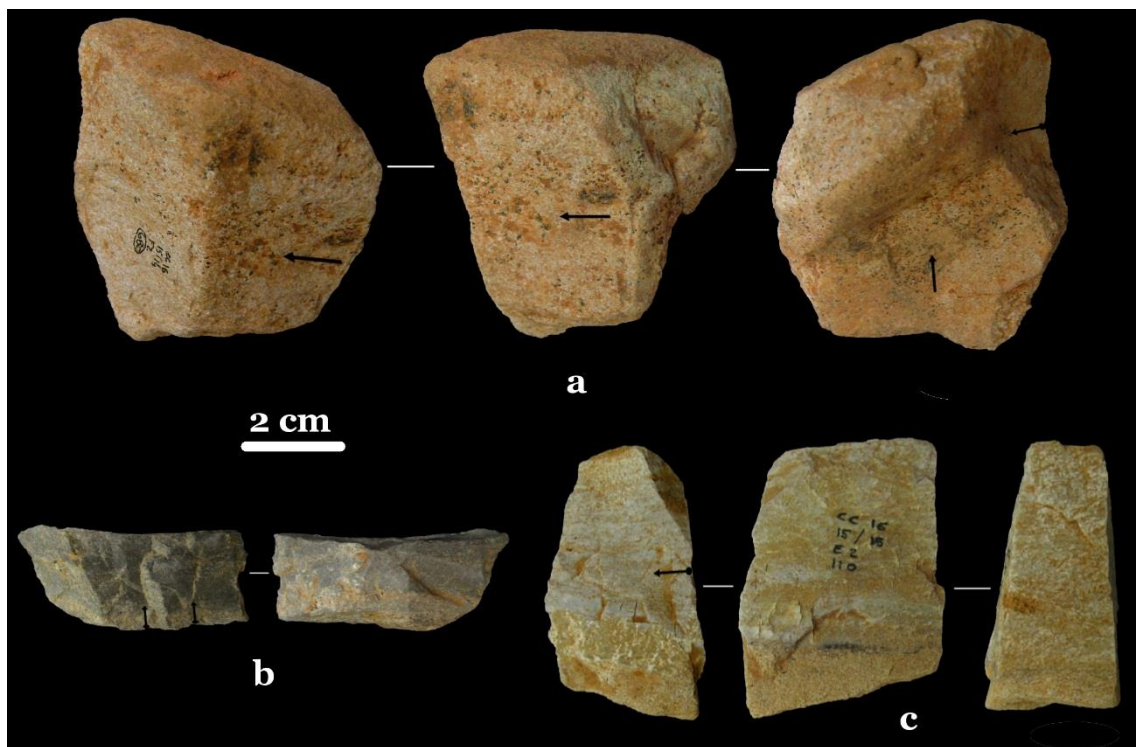


Fig. 3.73. Ciota Ciara cave, S.U. 15. Spongolite opportunistic cores showing the preferential exploitation of spongolite slabs according to their thickness as well as the abandonment of the cores before their exhaustion.

3.6.3.2. *Levallois and discoid technology*

Levallois and discoid exploitation strategies (Boëda, 1994, 1993; Peresani, 2003) are well attested in level 15 and are performed on all the main lithic raw materials even if only for vein quartz the knapping sequences are complete (Tab. 3.8).

Two vein quartz cores are present in the considered lithic assemblage and they belong to the preferential and to the recurrent centripetal modality respectively (Fig. 3.74 and Appendix A). The preferential Levallois core (Fig. 3.74 and Appendix A) is realized on a vein quartz pebble and has a neocortical striking platform with just one detachment in correspondence of the impact point of the preferential flakes that prepares that portion of the core; it has been abandoned after only one exploitation phase with nine centripetal and sometime plunging removals that prepare the latera and distal convexities of the knapping surface; after the detachment of the preferential flake the core is abandoned. The recurrent centripetal Levallois core (Appendix A) show two exploitation phases: first the convexity of the striking platform surface is prepared through three centripetal detachments and the knapping surface is exploited to produce four predetermined flakes; the second exploitation phase consists in the exploitation of a third surface through two removals which *débitage* direction is perpendicular to the intersection plane between the Levallois core surfaces. In this last phase the core is exploited according to an opportunistic modality. For both cores, during the production of Levallois flakes, the *débitage* direction is parallel to the intersection plane between the two core surfaces. The wanted products are oval and quadrangular medium-sized flakes, sometimes elongated, which dimensional characteristics are strongly influenced by those of the blanks chosen as cores (Fig. 3.75).

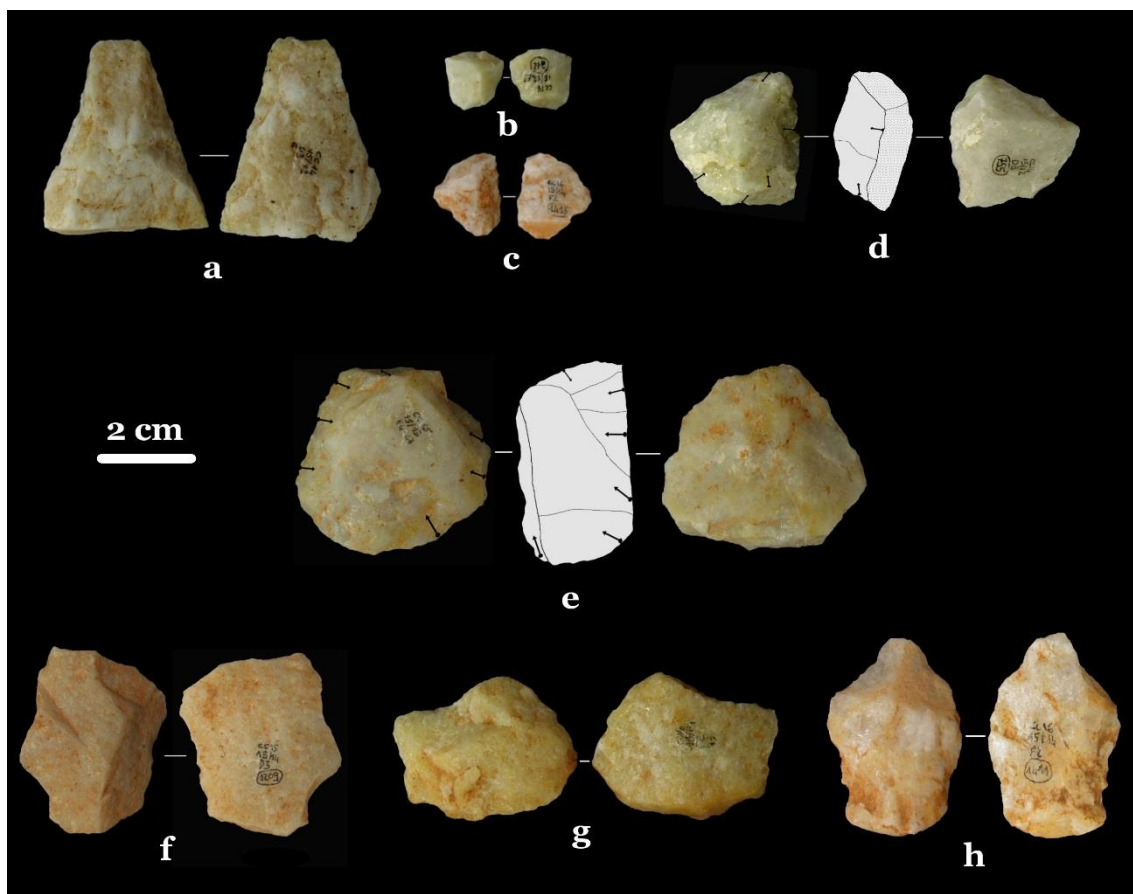


Fig. 3.74. Ciota Ciara cave, S.U. 15. Vein quartz discoïd and Levallois cores and products: (a, b, c) discoïd flakes; (d) unifacial discoïd core; (e) preferential Levallois core; (f, g) recurrent centripetal Levallois flakes; (h) preferential Levallois flake.

Discoïd reduction sequences are often attested in the lithic assemblage of S.U. 15 and cores are present both for vein quartz and spongolite (Tab. 3.8). No significant differences are evident comparing vein quartz and spongolite discoïd cores: for both the raw materials cores are chosen among centimetric pebbles or blocks collected in secondary deposits and presenting suitable convexities.

The exploitation starts directly from the natural surfaces of the cores and after the removal of a few discoïd flakes the cores are discarded even if not exhausted (Fig. 3.74, 3.76 and Appendix A).

For the unifacial exploitation strategy the striking platform is always neocortical or represented by a natural flat surface.

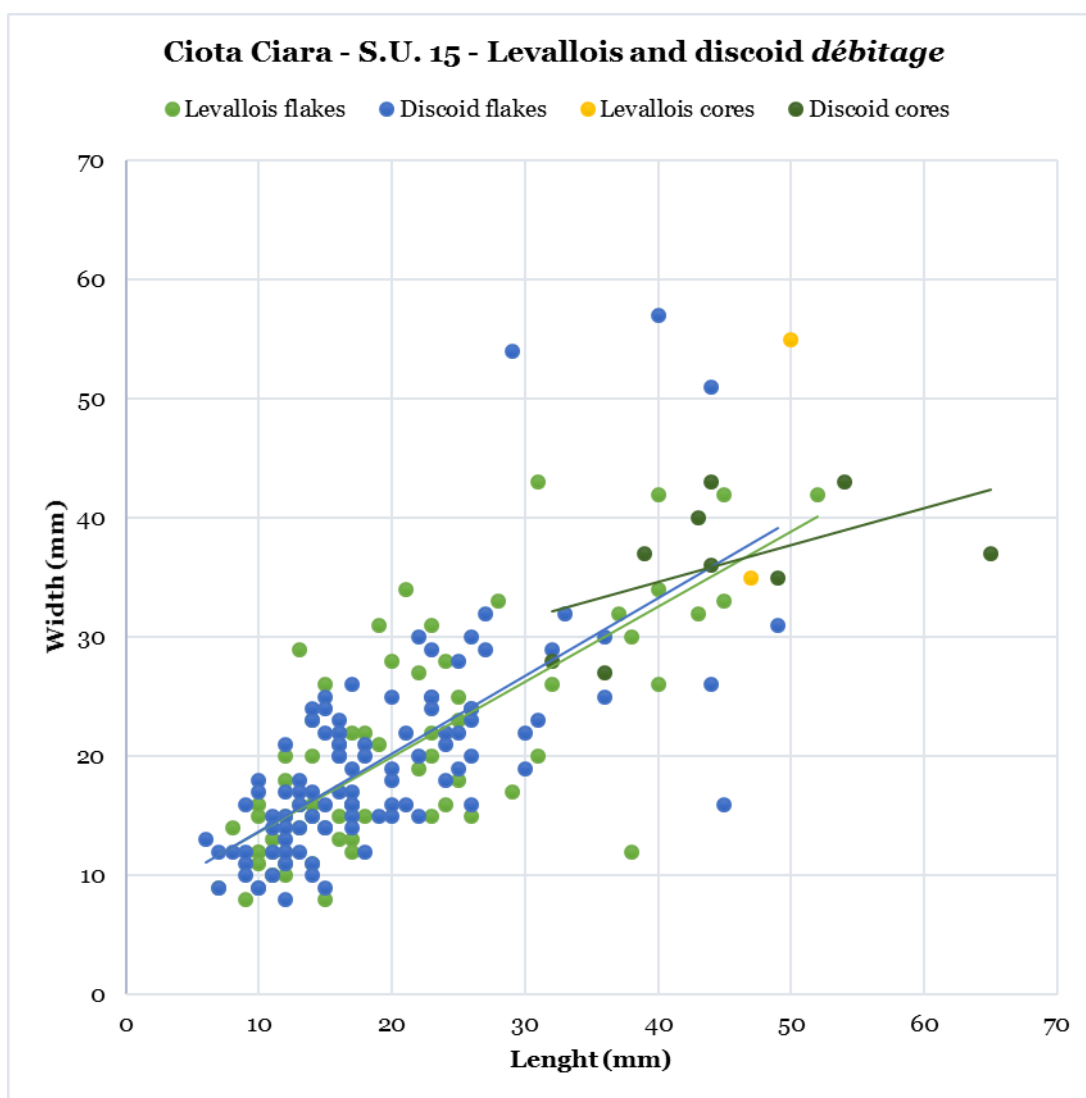


Fig. 3.75. Ciota Ciara cave, S.U. 15. Dimensional analysis of Levallois and discoïd flakes and cores. The morphology of the cores strongly influences the dimensions of the products. Levallois and discoïd reduction sequences seem to be aimed to the production of flakes with similar morphological features. Fragmented flakes are not considered. Since no significative differences have been observed between Levallois and discoïd reduction sequences according to the raw material employed, for the dimensional analysis a subdivision just according to the knapping method has been done.

Due to the shortness of the production phases, no great attention is paid to the management of the cores convexities that usually are exploited through only centripetal detachments. As shown in Fig. 3.75 and 3.76, the wanted products are short and large flakes, with dimensional characteristics similar to those of the Levallois reduction sequences and that are strongly conditioned by the cores' morphology. Regardless the raw material employed, discoïd flakes are generally characterized by a greater thickness if compared to the Levallois products

(Peresani, 2003; Picin and Vaquero, 2016). In the discoid method the *débitage* direction is always markedly secant to the intersection plane between the two core surfaces.

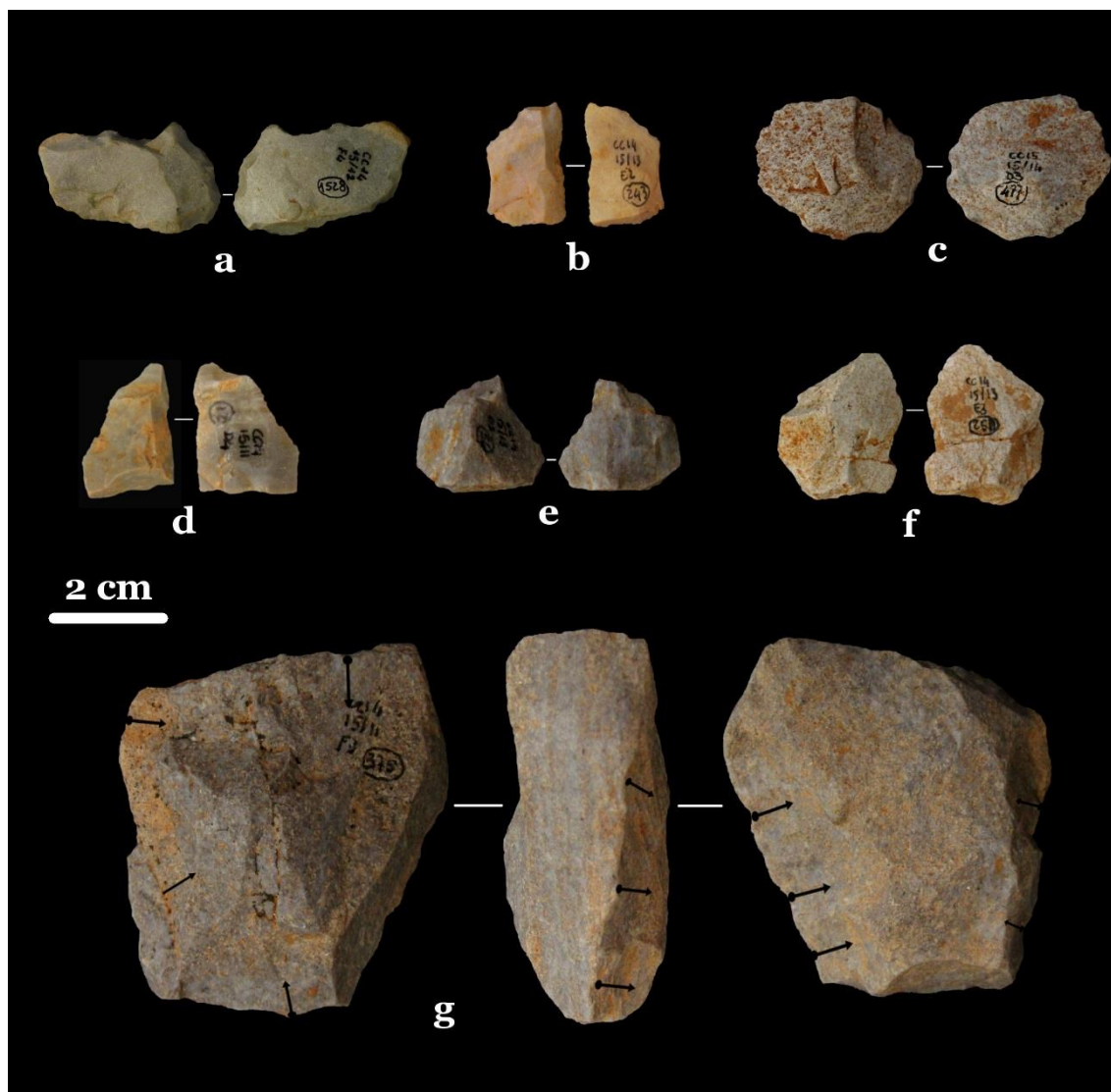


Fig. 3.76. Ciota Ciara cave, S.U. 15. Levallois and discoid technology on spongolite and other raw materials: (a, b) flint recurrent centripetal Levallois flakes; (c) spongolite recurrent centripetal Levallois flake; (d, e, f) spongolite discoid flakes; (g) spongolite discoid core.

The observations made on discoid and Levallois cores are consistent with those inferable from the products. The characteristics of spongolite Levallois flakes and of grey/black flint, rhyolite and radiolarite Levallois and discoid products, even in the absence of cores, show that these reduction sequences were applied in the same way on all the raw materials, although the presence of a faceted butt in the radiolarite assemblage (Fig. 3.77) indicates that for this lithology Levallois

reduction sequences could have been more complex than for the other low quality raw materials present in the assemblage. The presence of dihedral butts among Levallois products (Fig. 3.77) confirms that the preparation of the striking platform surface, when present, was performed through just a few detachments. In most cases natural or flat surface already present on the core were chosen as striking platform surfaces, thus determining the considerable presence of flat and natural butts (Fig. 3.77).

As for the other stratigraphic units, the identification of Levallois and discoid products is based on the combination of different technological criteria: the direction of the negatives on the upper faces of the flakes, the *débitage* direction, the consistency between the technological characteristics observed on the cores and those of the products, beside the general criteria listed in Chapter 2. For fragmented flakes and products strongly affected by post depositional alterations, the observation of just the direction of the negatives or of the typology of the butt has not been considered enough to assign them to discoid or Levallois exploitation strategies, therefore the opportunistic or undetermined component of the *débitage* could have been slightly overestimated.

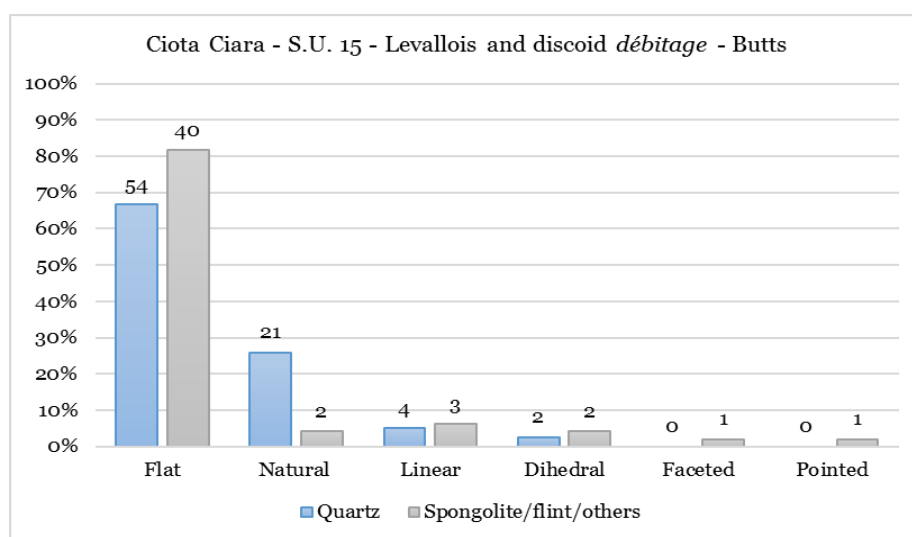


Fig. 3.77. Ciota Ciara cave, S.U. 15. Typology of the butts of Levallois and discoid products and comparison between vein quartz and the other raw materials present in the assemblage. Tot. vein quartz butts = 81; tot. spongolite and othe raw materials butts = 49.

Concerning Levallois and discoid reduction sequences, the occurrence of plunging flakes is not very frequent (Fig. 3.78). As already observed for stratigraphic unit 14, if we compare the proportion of plunging flakes of discoid, Levallois and opportunistic exploitation strategies we can see that for all the knapping methods not-plunging flakes are predominant. A reliable explanation could be that the occurrence of plunging is due more to the characteristics of the raw materials employed than to a deliberate choice of the knappers: as already observed, the technological characteristics of discoid and Levallois cores, suggest that due to the shortness of the reduction sequences, no attention was generally paid to the management of cores' convexities. Only for the discoid method the more frequent occurrence of lateral plunging can be explained as an expedient to maintain suitable convexities on the core until the end of the exploitation, while the occurrence of distal plunging for the Levallois products is more likely due to the scarce shaping of the core surfaces, thus determining a bad control on the knapping activities (Fig. 3.78).

The data obtained from the study of the discoid and Levallois reduction sequences of level 15 show that some expedients were systematically used as adaptation of these knapping methods to the characteristics of the raw materials. They are evident in the choice of blanks with suitable convexities and with flat or neocortical surfaces that permit to start the production of predetermined blanks avoiding or considerably reducing the shaping of the core surfaces. The technological features of Levallois and discoid products realized on better quality raw materials, like the presence of prepared butts, attests that on these lithologies the reduction sequence should have been more complex and long than on vein quartz and spongolite, for which the discard of the cores after only one phase of

exploitation is a further adaptation to the raw materials characteristics (Mourre, 1996).

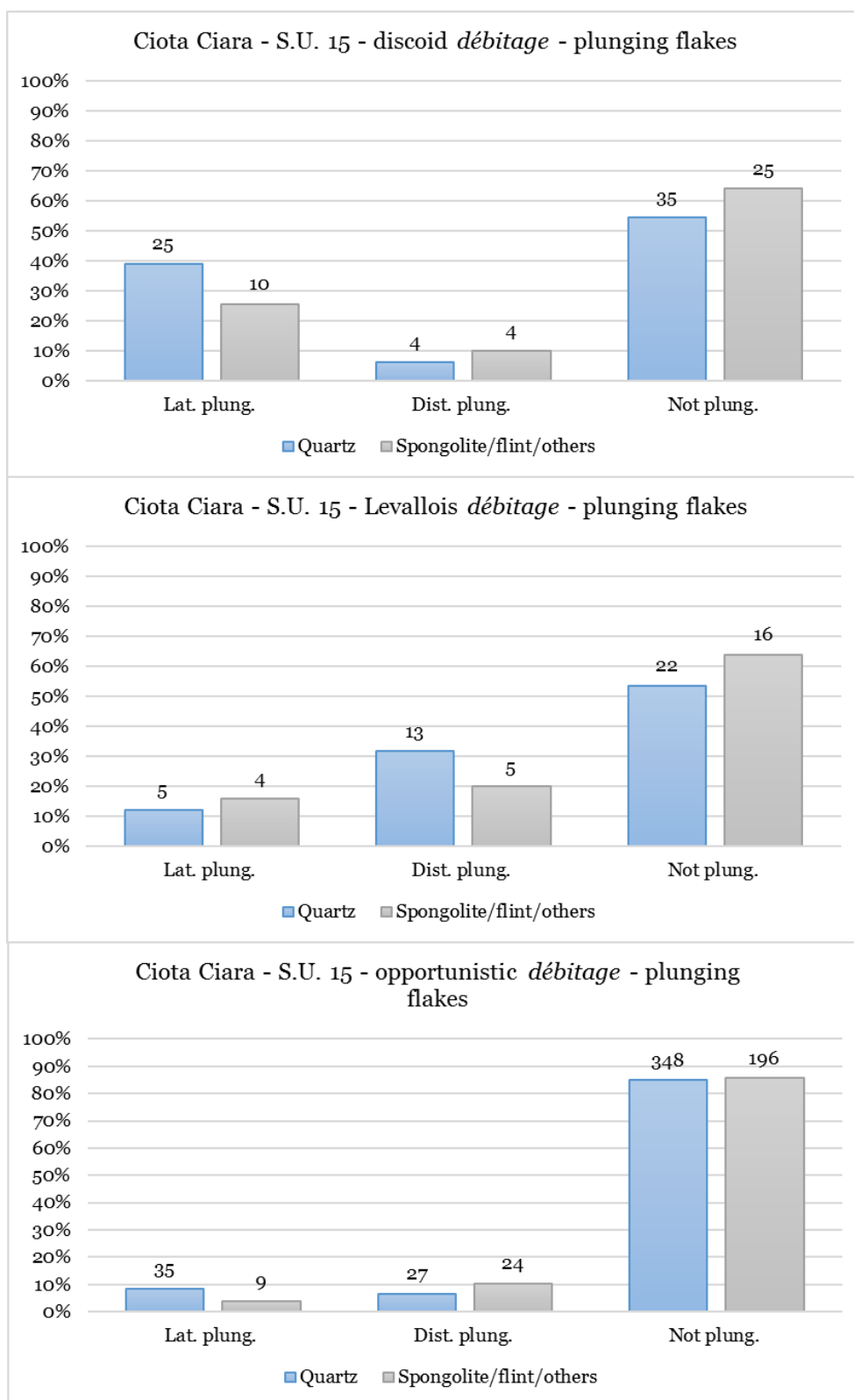


Fig. 3.78. Ciota Ciara cave, S.U. 15. Occurrence of plunging flakes according to the main reduction sequences present in the assemblage. Tot. vein quartz flakes = 64 discoïd – 41 Levallois – 410 opportunistic/S.S.D.A.; tot. spongolite and other raw materials flakes = 10 discoïd – 25 Levallois – 229 opportunistic/S.S.D.A.

3.6.3.3. *Retouched tools*

Retouched tools are generally not frequent in the lithic assemblage of S.U. 15 (Tab. 3.7 and Tab. 3.8) but some differences are evident between vein quartz and the other raw materials.

The edges of vein quartz flakes are in most cases unmodified and only nine flakes, issued from opportunistic (6) discoid (2) and Levallois (1) reduction sequences, attest the occasional use of a marginal retouch to shape the tools' edges. Retouch is always semi-abrupt, direct or inverse and usually located on only one of the flakes' edges. The tools obtained are denticulates (3), notches (2) and scrapers (a concave transversal scraper, a lateral rectilinear scraper, a concave lateral scraper and a double scraper) (Fig. 3.79).

Spongolite, grey/black flint, rhyolite and radiolarite retouched tools often show more than one generation of retouch on their edges (Fig. 3.79): it is more invasive and often located on both edges. Differently from what observed for vein quartz, the edges of better quality raw materials were continuously rejuvenated before the abandonment of the tool. In the lithic assemblage of level 15, eighteen retouched tools made in spongolite, grey/black flint, rhyolite and radiolarite have been found, realized on flakes issued from all the knapping methods attested in the assemblage. Typologically have been identified denticulates (9), notches (3), convex sidescraper (1), rectilinear sidescraper (2), a double bi-convex scraper, a double concave-convex scraper and a limace.

As already pointed out, better quality raw materials like radiolarite, were brought to the site as finished tools and the rejuvenation of the tools' edges in the site is attested by the presence of some small flakes technologically referable to retouch phases (Tab. 3.8).

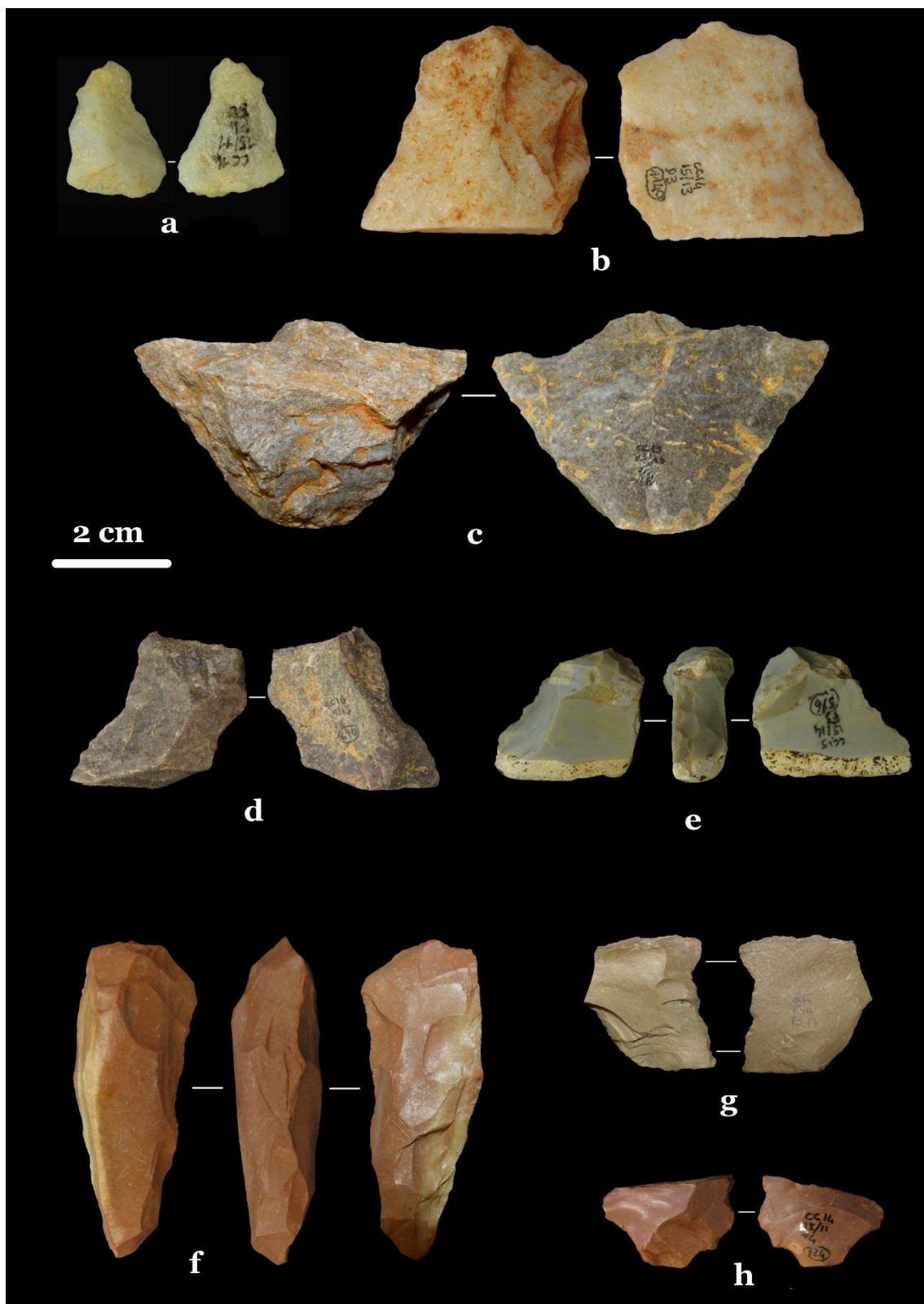


Fig. 3.79. Ciota Ciara cave, S.U. 15. Retouched tools: (a) vein quartz denticulate; (b) vein quartz concave sidescraper; (c) spongolite denticulate on a discoid flake; (d) spongolitenotch on a discoid flake; (e) double scraper on a spongolite patinated flake; (f) limace on a radiolarite flake; (g) double scraper on a Levallois flint flake; (h) fragmented radiolarite denticulate on a discoid flake.

3.6.4. S.U. 103

Stratigraphic unit 103 is localized in the south-western corner of the excavated area, close to the cave wall, and it represents the filling of a negative structure cutting levels 13, 14 and 15 (Angelucci et al., 2015; Zambaldi, 2015). According to the sedimentological and geochemical analysis carried out, despite its appearance is more chaotic than for the other archaeological levels and its lying becomes progressively vertical, its matrix do not differs from those of the other units (Angelucci et al., 2015; Zambaldi, 2015). As for the other levels, the deposition of level 103 is linked to gravitative, transport and alluvial phenomena directed from the inside of the cave towards the atrial area (Angelucci et al., 2015; Zambaldi, 2015). Since, as already mentioned, the upper part of the stratigraphic sequence is missing, it is not possible to clearly identify the exact geometry of this negative structure, neither to define more accurately its modalities of formation and its precise stratigraphic relations with the main archaeological levels of the Ciota Ciara cave (Zambaldi, 2015).

The lithic assemblage belonging to S.U. 103 is quantitatively less important than those described for levels 13, 14 and 15 but it shows technological features coherent with those already described for that units. The lithic assemblage is composed by 428 lithic artefacts realized on local raw materials (Fig. 3.80), with a clear predominance of vein quartz (53,0%) followed by the local varieties of chert, collected in secondary deposition close to the outcrops not far from the top of Monte Fenera (Berruto, 2011), and represented by spongolite (32,9%) and grey/black flint (13,3%). The other lithologies present in the assemblage, i.e. opal, quartzite and rhyolite, are each one represented by one piece, thus not permitting to make any technological consideration about their role within the considered lithic assemblage (Fig. 3.80).

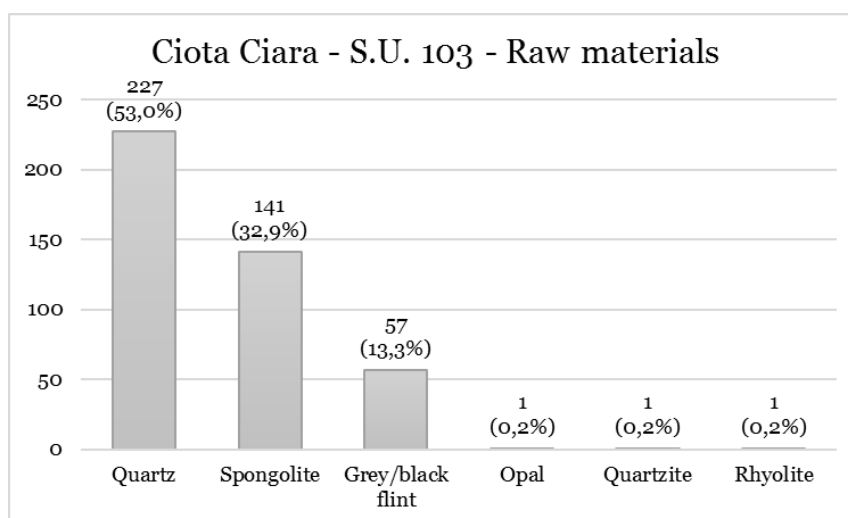


Fig. 3.80. Ciota Ciara cave, S.U. 103. Raw materials present in the lithic assemblage

The state of preservation of the lithic industry show that transport and selection phenomena have been more intense for this level and a consistent part of the assemblage is affected by rounding or, concerning spongolite and grey/black flint, by white patina (Fig. 3.81). These alterations, attested in all the stratigraphic units of the Ciota Ciara cave, are more intense on the lithic artefacts of S.U. 103, attesting that stronger transport phenomena are probably linked to its deposition. As already observed for the other levels, even in this case vein quartz is less affected than spongolite and grey/black flint by post depositional surface modifications (Fig. 3.81) due to its petrographic characteristics (Venditti et al., 2016).

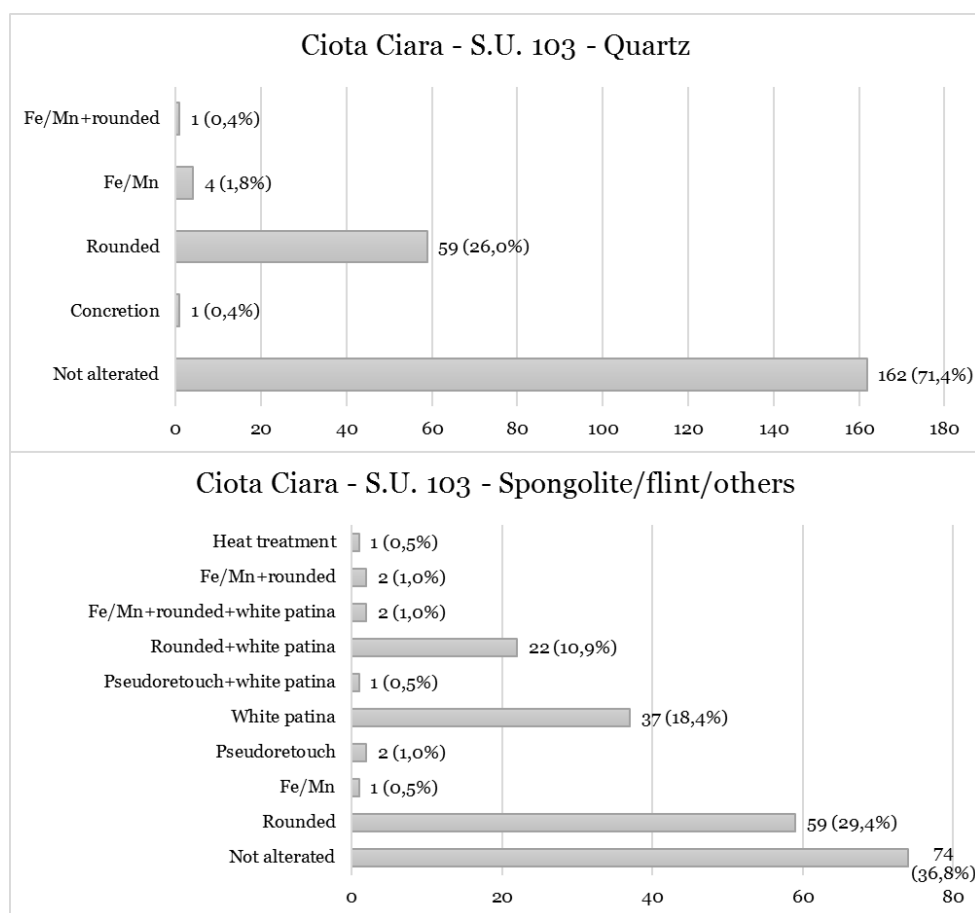


Fig. 3.81. Ciota Ciara cave. Post depositional alterations present on the lithic artefacts of S.U. 103.

The composition of the lithic assemblage of S.U. 103 (Tab. 3.10) show that the reduction sequences are complete for all the raw materials: flakes, cores, debris and retouched tools are present for vein quartz, spongolite and grey/black flint while, as mentioned above, other raw materials are present too sporadically to made reliable hypothesis about their exploitation modalities (Fig. 3.80)

Raw material	Flakes	Cores	Retouched tools	Debris	Unworked blanks	Total
Quartz	136	7	5	78	1	227
Spongolite	68	5	1	58	9	141
Grey/black flint	31	1	3	21	1	57
Other	3	-	-	-	-	3
Total	238	13	9	157	11	428
%	55,6%	3,0%	2,1%	36,7%	2,6%	100,0%

Tab. 3.10. Ciota Ciara cave, S.U. 103. Composition of the lithic assemblage.

The high number of debris, beside attesting that knapping activities were performed in the site, is also caused by the state of preservation of the lithic industry and by the high rate of fragmentation of the knapping products (Fig. 3.82). Vein quartz and the other raw materials are proportionally in the same way affected by fractures occurred during knapping or due to post depositional factors, even if it was not easy to distinguish between the different typologies of breakages and an important part of them remains of undetermined origin (Fig. 3.83).

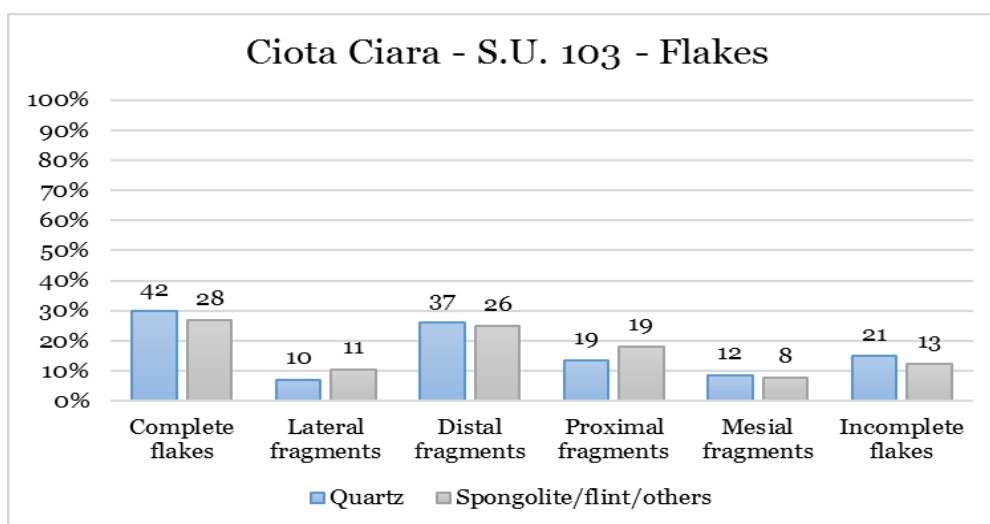


Fig. 3.82. Ciota Ciara cave, S.U. 103. Rate of fragmentation of vein quartz flakes compared to that of the other raw materials present in the assemblage (spongolite, grey/black flint, others).

One of the problems affecting the determination of the origin of fractures is that most of them follows the natural cleavage planes present in vein quartz and spongolite and therefore they could have occurred both during knapping or after deposition (Driscoll, 2011; Mourre, 1996; Tallavaara et al., 2010). The distinction has been possible just when different degrees of post depositional surface modifications affected the flakes and their fracture planes. As expected, radial fractures are more frequent for vein quartz artefacts and a considerable number of them is linked to siret accidents (Mourre, 1996).

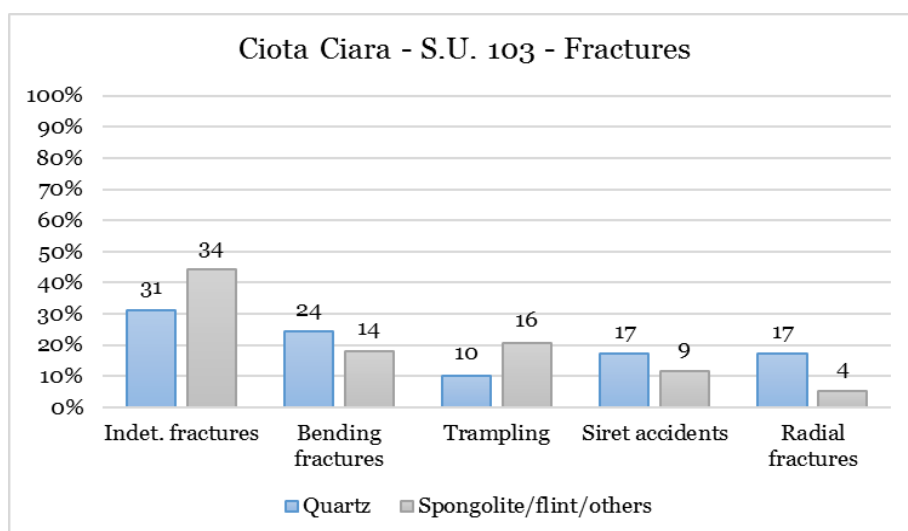


Fig. 3.83. Ciota Ciara cave, S.U. 103. Typology of the fractures identified on the flakes and comparison between quartz flakes and flakes obtained from the other raw materials present in the assemblage. Tot. vein quartz fragmented flakes = 99; tot. spongolite/grey black flint fragmented flakes = 77.

Natural surfaces are rarely present on the dorsal faces of the flakes for all the knapping methods, but the presence, for all the lithologies, of flakes with a complete or a partial natural upper face is another element in favour of the practice of knapping activities in the site (Fig. 3.84). As already observed for the archaeological levels previously considered, lateral cortex is always associated to unipolar negatives of previous removals on the upper faces of the flakes and to opportunistic/S.S.D.A. reduction sequences, attesting that they started directly from the natural surfaces of the cores exploiting the convexities already present until their exhaustion.

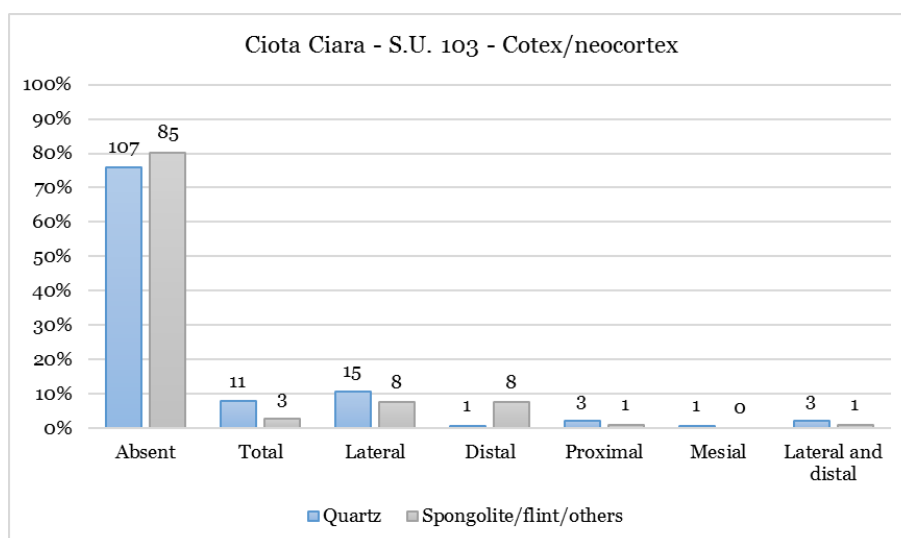


Fig. 3.84. Ciota Ciara cave, S.U. 103. Presence and position of neocortex on vein quartz flakes and of cortex on flakes obtained from spongolite and grey/black flint. Tot. vein quartz flakes = 141; tot. spongolite and grey/black flint flakes = 106.

Because of post depositional mechanical and chemical alterations and to the elevated rate of fragmentation of the considered lithic industry, the direction of the negatives of previous removals are not visible for a considerable portion of vein quartz and spongolite flakes (Fig. 3.85). Being spongolite and grey/black flint most affected than vein quartz by white patina and rounding, more than 50% of the flakes realized in these raw materials has unreadable negatives on its dorsal face (Fig. 3.85). For all the lithologies, unipolar and bipolar negatives are attributable to opportunistic reduction sequences while centripetal and convergent directions are linked to discoid and Levallois knapping methods. Crossed negatives do not seem to be diagnostic for the identification of the knapping method since they can be referred to opportunistic or to discoid and Levallois knapping sequences. As usual, the right attribution of each product to the method it belongs to depends on the combination of different technological criteria, like the characteristic of the butt and the angle between the butt and the ventral face.

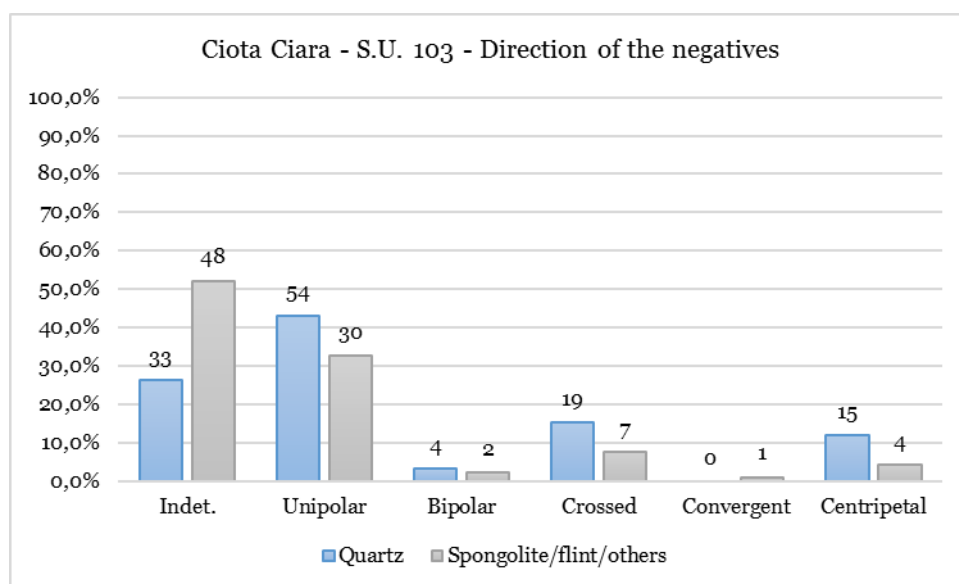


Fig. 3.85. Ciota Ciara cave, S.U. 103. Direction of the negatives of previous removals visible on the dorsal faces of the flakes. Tot. vein quartz flakes = 125; tot. spongolite and other raw materials flakes = 92.

The reduction sequences present in level 103 are the same already observed in the other archaeological layers (Tab. 3.11) and the modalities of exploitation linked to each knapping method are substantially like those of S.U. 13, 14 and 15. Opportunistic/S.S.D.A. and discoid reduction sequences are complete for vein quartz and spongolite while Levallois flakes and cores are both present only concerning vein quartz (Tab. 3.11). Grey/black flint, similarly to what already highlight for S.U. 13, is present in the site almost exclusively as *débitage* products, both retouched or unretouched (Tab. 3.10). A fragmented flint core is present in the lithic assemblage (Tab. 3.11), but its modality of exploitation cannot be determined because it is strongly affected by rounding. Anyway, it attests that occasionally also grey/black flint was knapped in the site even if to a less extent than vein quartz and spongolite. Retouch flakes have been identified according to their dimensional and technological characteristics in term of typology of the butt, direction of the negatives and consistency with the general features of the retouch phases observed on the tools. A general overview on Tab. 3.11 let us

suppose that no difference in raw materials exploitation is present in level 103 according to the knapping methods. Opportunistic/S.S.D.A. methods are preponderant for all the raw materials while discoid and Levallois knapping sequences are well represented for vein quartz while for the other raw materials their employment was probably less frequent (Tab. 3.11).

Raw material	Opportunistic S.S.D.A.	Discoid	Levallois	Indet.	Retouch flakes	Debris	Total
Quartz	F. = 87	F. = 13	F. = 2	F. = 23			
	C. = 3	C. = 2	C. = 1	C. = 1			
Tot.	90	15	3	24	16	78	226
%	21,6%	3,6%	0,7%	5,8%	3,8%	18,7%	54,2%
Spongolite	F. = 36	F. = 4	F. = 1	F. = 17			
	C. = 4	C. = 1	C. = -	C. = -			
Tot.	40	5	1	17	11	58	132
%	9,6%	1,2%	0,2%	4,1%	2,6%	13,9%	31,7%
Grey/black flint	F. = 27	F. = -	F. = 2	F. = 4			
	C. = -	C. = -	C. = -	C. = 1			
Tot.	27	-	2	5	1	21	56
%	6,5%	-	0,5%	1,2%	0,2%	5,0%	13,4%
Others	F. = 1	F. = -	F. = -	F. = -			
	C. = -	C. = -	C. = -	C. = -			
Tot.	1	-	-	-	2	-	3
%	0,2%	-	-	-	0,5%	-	0,7%
Total	158	20	6	46	30	157	417
%	37,9%	4,8%	1,4%	11,0%	7,2%	37,6%	100,0%

Tab. 3.11. Ciota Ciara cave, S.U. 103. Raw materials and *débitage* methods. F. = flakes; C. = cores.

Vein quartz flakes, cores and debris have been divided according to the morphostructural groups methodology to see if, according to the knapping method used, it is possible to see a deliberate choice for specific petrographic characteristic (de Lombera-Hermida et al., 2011; Martinez Cortizas and Llana Rodriguez, 1996) (Tab. 3.12).

Method	Morphostructural groups			
	NN	NS	SN	SS
Opportunistic S.S.D.A.	Flakes = 2	Flakes = 44	Flakes = 28	Flakes = 2
	Cores = -	Cores = 1	Cores = 2	Cores = -
Tot.	2	45	30	2
Discoid	Flakes = 1	Flakes = 8	Flakes = 4	Flakes = -
	Cores = -	Cores = 2	Cores = -	Cores = -
Tot.	1	10	4	-
Levallois	Flakes = -	Flakes = 1	Flakes = 1	Flakes = -
	Cores = -	Cores = 1	Cores = -	Cores = -
Tot.	-	2	1	-
Indet.	Flakes = -	Flakes = 15	Flakes = 7	Flakes = 1
	Cores = -	Cores = 1	Cores = -	Cores = -
Tot.	-	16	7	1
Retouch flakes	-	8	8	-
Debris	2	40	21	3
Total	5	121	71	6
%	2,5%	59,6%	35,0%	3,0%

Tab. 3.12. Ciota Ciara cave, S.U. 103. Quartz morphostructural groups and knapping methods. NN = no grainy, no planes; NS = no grainy, planes; SN = grainy, no planes; SS = grainy, planes.

The data obtained show that the presence of planes was generally more frequent than that of grains for all the knapping methods (59,6%). Groups NN and SN are barely present, as already pointed out for level 14 and 15, while the group SN is represented in all the reduction sequences identified (Tab. 3.12). Even if the subdivision in morphostructural groups underlines that the presence of planes was generally preferred for the exploitation of vein quartz, the presence of artefacts belonging to the SN group in all the reduction sequences, makes hypothesize that the preponderance of NS group could be due more to environmental causes than to a deliberate choice.

3.6.4.1. Opportunistic/S.S.D.A. technology

The prevalence of unipolar negatives on the dorsal faces of opportunistic flakes, together with the scarcity of bipolar and crossed negatives referable to this method and the absence of orthogonal negatives, allow to hypothesize that opportunistic cores were not intensively exploited and that a multidirectional reduction sequence (Forestier, 1993) was just sporadically performed. This is probably caused by raw materials constraints: concerning vein quartz, specific studies show that the most the *débitage* proceeds, the most increases the occurrence of knapping accidents (de Lombera-Hermida et al., 2011; Driscoll, 2011; Mourre, 1996); for spongolite, the morphology of the cores, i.e. centimetric slabs, do not provide useful angles and suitable convexities for a multidirectional exploitation (Fig. 3.86).

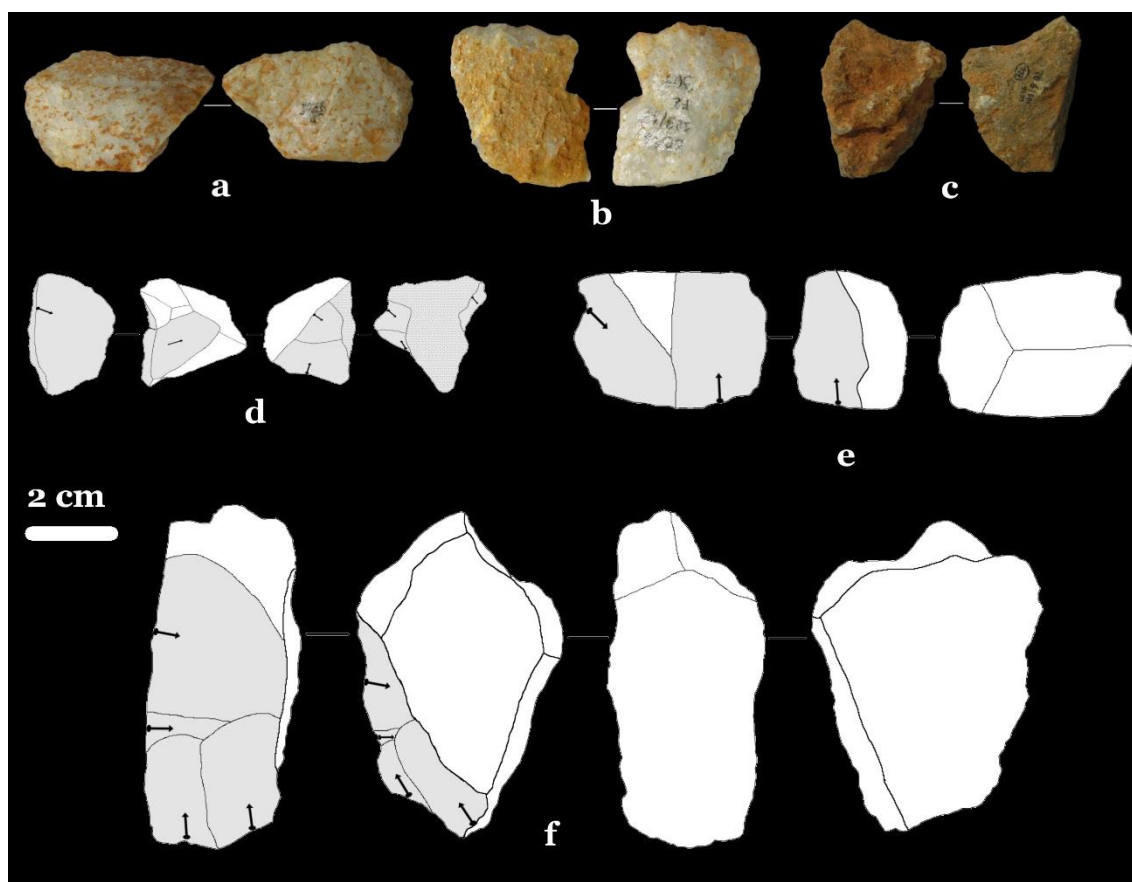


Fig. 3.86. Ciota Coara cave, S.U. 103. Opportunistic/SSDA flakes and cores on vein quartz and spongolite: (a, b) quartz flakes, b has a concretion on the dorsal face; (c) spongolite opportunistic flake; (d) vein quartz opportunistic core; (e, f) spongolite opportunistic cores.

The typology of the butts (Fig. 3.87) show that natural and flat surfaces, already present on the cores or produced by previous removals, were preferred as striking platforms, while the absence of dihedral butts is another element showing that S.S.D.A. reduction sequences were sporadically performed both on vein quartz and on spongolite and grey/black flint.

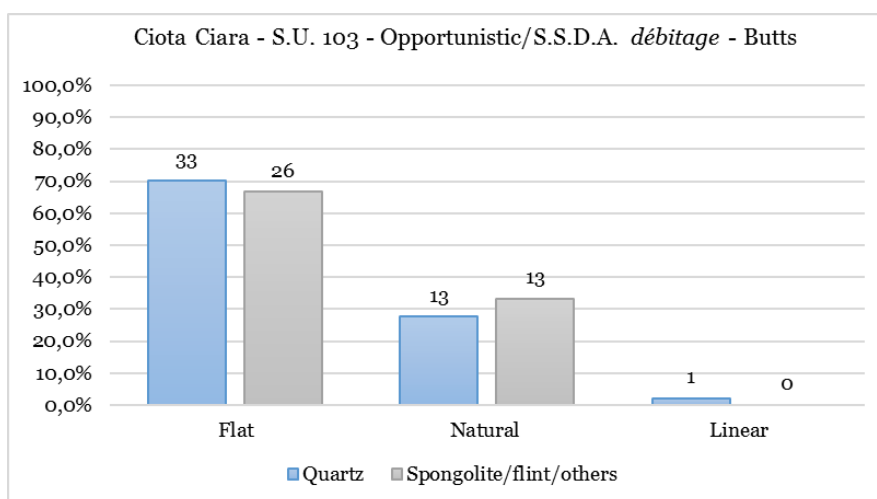


Fig. 3.87. Ciota Ciara cave, S.U. 103. Typology of the butts belonging to opportunistic/S.S.D.A. reduction sequences. Tot. vein quartz butts = 47; tot. spongolite and grey/black flint butts = 39.

Cores are frequently discarded before their exhaustion, sometimes due to fractures occurred during knapping and caused by internal cleavage planes or inner flaws. Vein quartz cores are represented by decimetric fluvial pebbles and blocks mainly exploited through unipolar removals: no more than two or three detachments are obtained for each striking platform (Fig. 3.86).

Spongolite cores are represented by slabs collected in secondary deposits (Fig. 3.86): their opportunistic exploitation starts from two opposite surfaces through detachment obtained according to the thickness of the slab, perpendicularly as regard to the internal cleavage planes.

Concerning grey/black flint, the absence of opportunistic cores does not permit to make precise considerations about how this knapping sequence was performed

on this raw material but the characteristics of the products (butts, direction of the negatives and dimensions) are consistent with those of vein quartz and spongolite. Then it can be supposed that grey/black flint was exploited through the same modalities of vein quartz and spongolite (Fig. 3.86 and 3.88).

The morphology of the products obtained through opportunistic/S.S.D.A. reduction sequences are strongly influenced by that of the cores and even their thickness, generally important, is to be interpreted as an adaptation to the characteristics of the raw materials (de Lomberra-Hermida et al., 2016; Mourre, 1996). The dimensional analysis of the opportunistic/S.S.D.A. products shows that the wanted products were medium sized flakes and, even if the spongolite products considered in the analysis are low in number, it is evident that the objectives of these knapping sequences were the same for all the other raw materials involved (Fig. 3.88). The dimensions of the seven cores found, as for the other archaeological levels, are consistent with, but slightly bigger than those of the products, confirming that the cores have been abandoned before their exhaustion (Fig. 3.88).

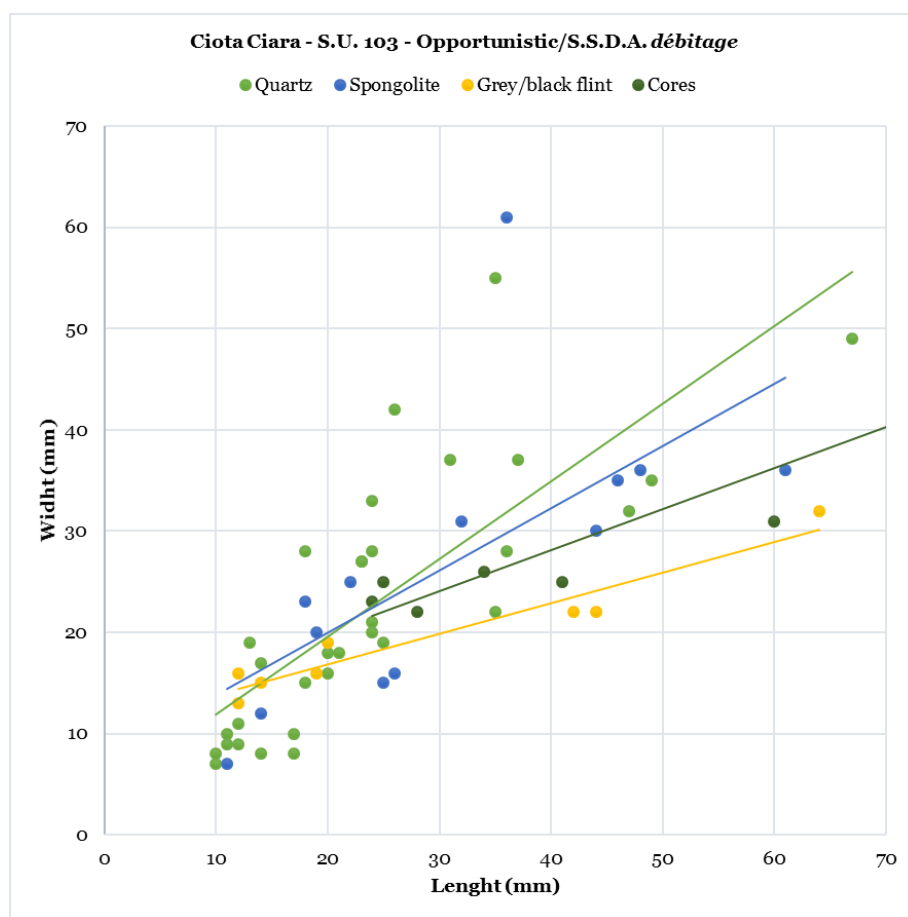


Fig. 3.88. Ciota Ciara cave, S.U. 103. Dimensional analysis of opportunistic/S.S.D.A. flakes and cores. Fragmented flakes are not included. The dimensions of the cores are consistent with those of the products obtained.

3.6.4.2. Levallois and discoid technology

The Levallois method is represented by a total of five flakes and by one core, so just a few technological considerations can be made about how it was performed on the different lithic raw materials. The reduction sequence is complete just for vein quartz since no cores have been found for spongolite and grey/black flint. All the artefacts are referable to the recurrent centripetal modality and the characteristics of the butts, together with those showed by the only one core present in the assemblage, suggest that flat or neocortical surfaces were chosen as striking platforms without shaping of the core convexities (Fig. 3.89, 3.90 and Appendix A). The core show just one phase of exploitation through five centripetal removals, after which it was discarded even if not exhausted. The

débitage direction is parallel to the intersection plane between the two core surfaces (Fig. 3.89 and Appendix A).

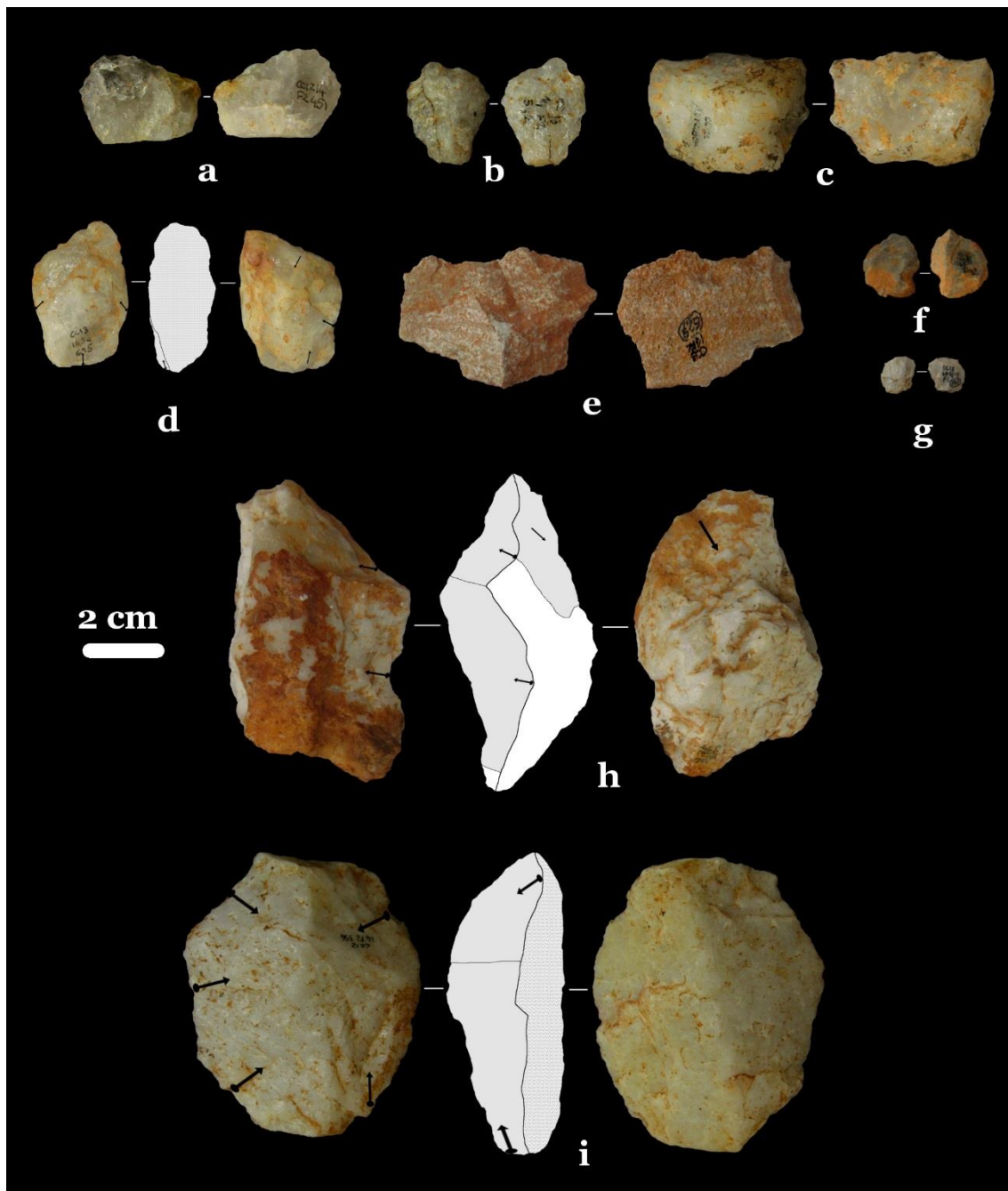


Fig. 3.89. Ciota Ciara cave, S.U. 103. Vein quartz and spongolite Levallois and discoid cores and flakes: (a, c) discoid flakes; (b, f, g) recurrent centripetal Levallois flakes; (d, h) discoid cores; (e) spongolite discoid flake; (i) recurrent centripetal Levallois core.

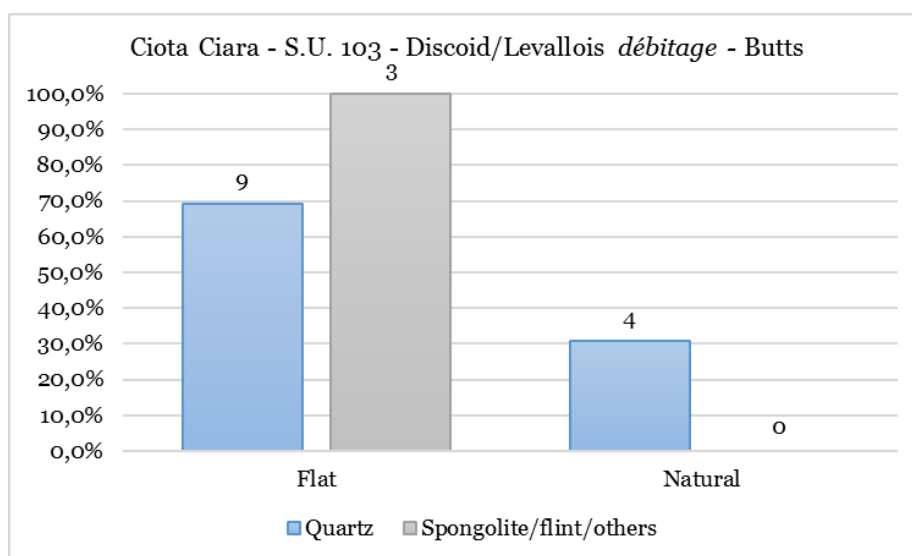


Fig. 3.90. Ciota Ciara cave, S.U. 103. Typology of the butts of Levallois and discoid products and comparison between vein quartz and spongolite. Tot. vein quartz butts = 13; tot. spongolite butts = 3.

Discoid reduction sequences are slightly better attested than Levallois but also in this case the low number of products (17) and cores (3) referable to these knapping method (Tab. 3.11) do not allow to achieve reliable data on how the different raw materials were exploited. The three cores found (Appendix A) attest that both the unifacial and the bifacial modalities have been employed. The two discoid quartz cores show just a few centripetal detachments with a *débitage* direction secant to the intersection plane between the two core surfaces. The discoid spongolite core show only two centripetal detachments on one of the surfaces, while the other is natural (Appendix A). It attests, also for this raw material, the use of blanks with suitable morphologies as cores to avoid the shaping of the core.

Since most of the discoid and Levallois products is fragmented, it was not possible to deal with a dimensional analysis. According to the characteristics of the discoid and Levallois flakes identified, and also to the removals visible on the cores, it seems that the wanted products are oval or quadrangular flakes, characterized by a general high thickness (Fig. 3.89). **Levallois flakes are generally longer and**

spongolite and flint Levallois and discoid products are generally smaller. This is due to the strong conditioning of the initial cores morphology on the final characteristics of the products since spongolite blanks with morphologies suitable for a discoid exploitation are usually of small dimensions.

3.6.4.3. Retouched tools

The typology of the nine retouched tools present in the lithic assemblage of level 103 is not different from the one of the other stratigraphic units.

The presence of small flakes with technological characteristics consistent with their belonging to the shaping or the rejuvenation of the tools' edges shows that this kind of activities were carried out in the site together with the production of the tools through the different knapping method described above.

Three denticulates, a transversal scraper and a rectilinear lateral scraper are the retouched tools realized on vein quartz discoid and opportunistic/S.S.D.A. flakes (Fig. 3.91). Retouch is direct or invers, always abrupt or semi-abrupt and no more than one generation is present on vein quartz tools. A convergent rectilinear scraper has been realized on a fragmented flint recurrent centripetal Levallois flake: since the patina present on the flake is not the same of the retouched surfaces, it means that this flake was collected and retouched after it was produced and discarded, and the fracture plane has been retouched too (Fig. 3.91). Other two retouched tools (a notch + deniculate and a convex sidescraper) are made on grey/black flint but retouch is invasive just for the convergent rectilinear scraper, while the other tools have a direct or inverse short retouch. Only a notch is part of the spongolite assemblage of level 103 (Fig. 3.91).

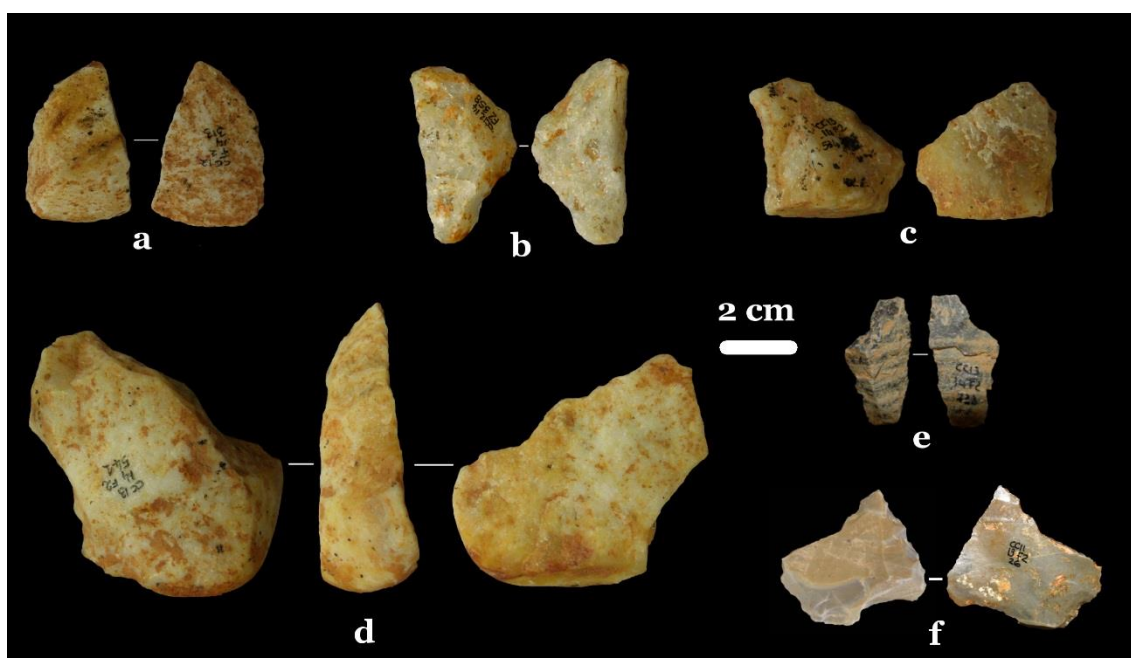


Fig. 3.91. Ciota Ciara cave, S.U. 103. Retouched tools: (a, c) sidescrapers; (b, d) denticulates; (e) notch; (f) convergent rectilinear scraper on a flint recurrent centripetal Levallois flake.

3.7. Discussion and conclusion

The studies carried out about the lithic assemblage of the Ciota Ciara cave allows to achieve significant data about the technological behaviour and the mobility patterns of the prehistoric human groups frequenting Piedmont and Lombardy, two territories where the researches about Middle Palaeolithic are quite underdeveloped. The data obtained from the definition of the supply areas of lithic raw materials and from the technological study are indicative of an articulated economic and technological behaviour that includes a great knowledge of the natural resources available, both in the immediate surroundings of the site and on a wider scale, and of the mechanical properties of the different lithologies involved in the production of tools.

Looking at the general composition of the considered lithic assemblages (Tabs. 3.2, 3.4, 3.7 and 3.10) and to the proportions of the different technological categories (flakes, cores, debris, retouched tools, retouch flakes) according to the raw materials employed (Tabs. 3.3, 3.5, 3.8 and 3.11) it is evident that the general

technological behaviour did not change significantly during the different phases of human frequentation of the cave. Slight differences among the archaeological levels are visible in the presence/absence of some secondary lithologies (jasper, opal, milonite) and in the completeness or fragmentation of the reduction sequences linked to grey/black flint of local origin (Tabs. 3.3, 3.5, 3.8 and 3.11). The role of the main exploited raw materials (vein quartz and spongolite) and that of the allochthonous lithologies (radiolarite and rhyolite) do not change all along the sequence. The characteristics of the lithic assemblages belonging to the different archaeological layers of the Ciota Ciara cave in terms of completeness and complexity of the reduction sequences, and of variety of lithic resources employed, seems to depend only on the intensity of the human frequentation of the site, probably linked to changing in the climatic and environmental conditions (Berto et al., 2016). In accordance with the results achieved by other studies (Arzarello et al., 2012a; Berruti, 2017; Buccheri et al., 2016), S.U. 13 and 15 attest repeated but brief occupations, probably linked to hunting activities, while S.U. 14 corresponds to long-term and repeated occupations with intense knapping activities performed in the site. S.U. 103 can correspond to frequentations like those of levels 13 and 15 but more realistic hypothesis could be made when its modalities of deposition will be precisely clarified (Zambaldi, 2015).

Even if geoarchaeological data confirm that the materials belonging to the different SS.UU. did not undergo important post-depositional phenomena (Zambaldi, 2015) and even if this data is confirmed by the technological coherence of each considered assemblage, no refitting have been found concerning vein quartz. It can be easily interpreted as a consequence of the response to knapping of this raw material that, when knapped through hard

hammer percussion, shatters producing a huge quantity of debris (e.g. de Lombera-Hermida, 2009; de Lombera-Hermida et al., 2016; Mourre, 1996), making the research of refitting quite unproductive.

Together with vein quartz, that is the predominant raw material in all the levels (Fig. 3.32, 3.47, 3.63 and 3.80), the most exploited lithology is spongolite: they are introduced as natural blanks and knapped in the site according to opportunistic/S.S.D.A. (Forestier, 1993), discoid (Boëda, 1993; Peresani, 2003) and Levallois (Boëda, 1994) exploitation strategies (Fig. 3.92 and 3.93). Looking at the characteristics of these raw materials, the preponderance of vein quartz in the assemblage cannot be explained only through its greater availability in the local environment (Berruto, 2016, 2011) but the petrographic features of these lithologies must be taken into account, as well as the dimensions and morphologies of the blanks available. According to the characteristics of the natural surfaces visible in the archaeological record, both were collected in secondary deposits; the surveys carried out (Berruto, 2016, 2011) show that vein quartz is available in different morphologies, rounded pebbles and polygonal blocks of different size, while spongolite is mostly available as centimetric slabs, while polygonal blocks are mostly of reduced dimensions. Moreover, spongolite always presents several internal cleavages that strongly condition its response to knapping. Therefore, vein quartz seems to be more attractive than spongolite for knapping activities. The subdivision in morphostructural groups of the vein quartz artefacts (Tabs. 3.6, 3.9 and 3.12), show that generally the presence of planes is preferred to those of grains, regardless the knapping method employed (e.g. de Lombera-Hermida et al., 2011). Even though, in level 15, a slight predominance of the SN group (grainy, no planes) is present: it could be ascribed to a deliberate choice of the knappers or to the collecting of vein quartz blanks in

secondary deposits different from those exploited in S.U. 13 and 14, as hypothesized by the recent study completed by G. Berruto (2016).

A further observation must be made concerning grey/black flint, the best quality lithic raw material present in the Monte Fenera area (see chapter 3.5.1.). Its limited use in all the SS.UU. is ascribable to the limited extension of the outcrops (see chapter 3.5.1.) where, on the other hand, it appears to be available in blanks with considerable dimensions. For this reason, even if the number of cores is scarce (Tabs. 3.2, 3.4, 3.7 and 3.10), the reduction sequences linked to this raw material can be considered as complete, since it is likely to hypothesize that a considerable number of products could have been obtained from the exploitation of a reduced number of blanks.

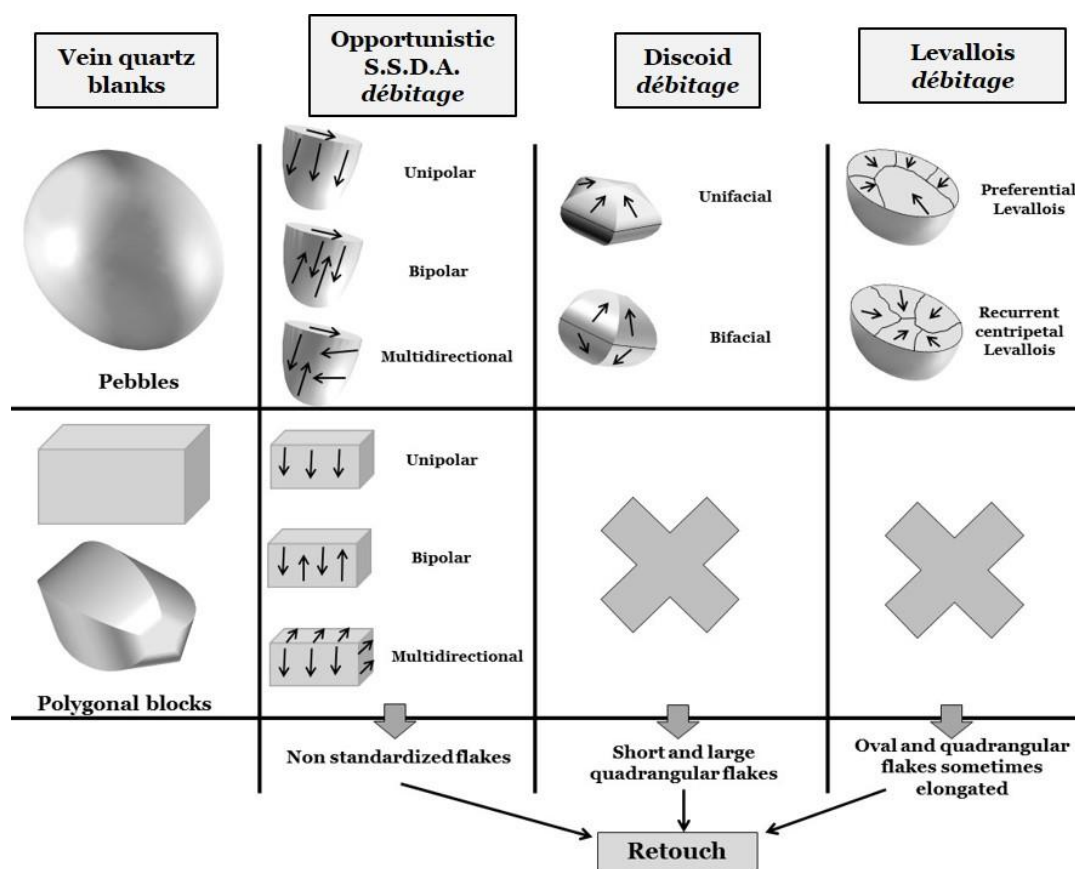


Fig. 3.92. Ciota Ciara cave. Schematic representation of vein quartz reduction sequences.

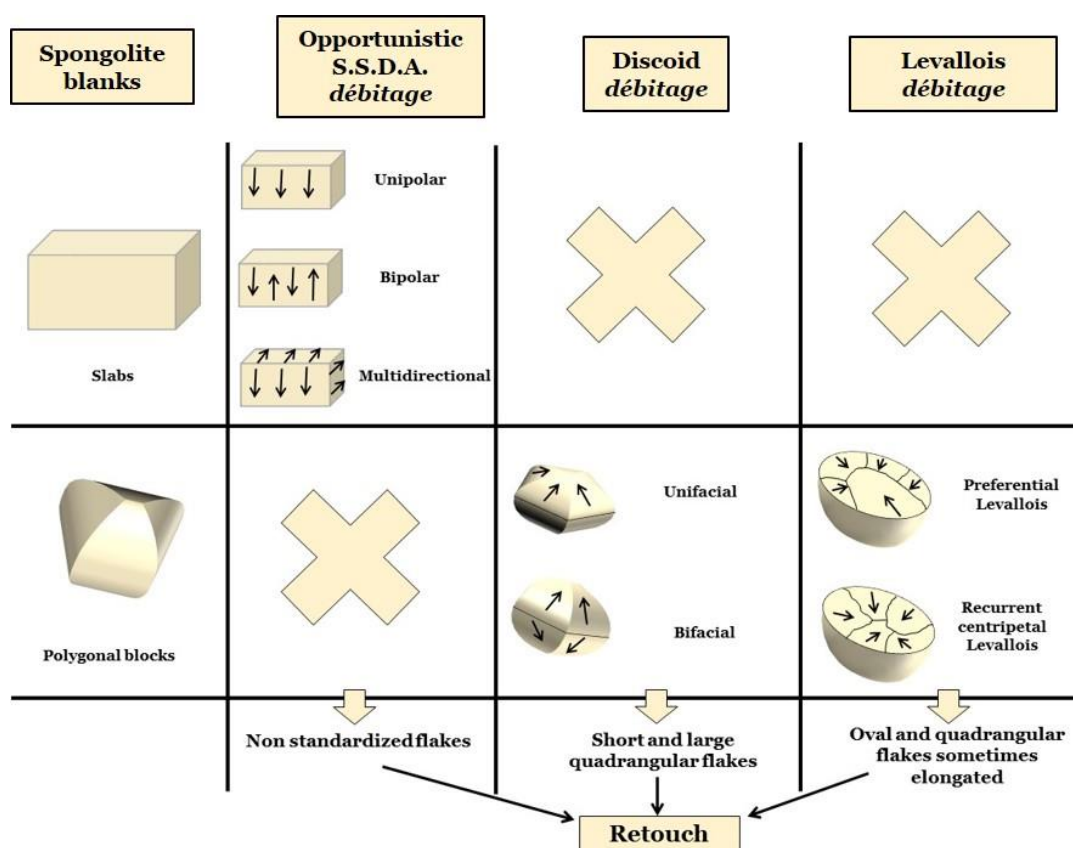


Fig. 3.93. Ciota Ciara cave. Schematic representation of spongolite reduction sequences.

The strong relation between the initial morphology of the cores and the knapping methods is evident looking at vein quartz and spongolite exploitation strategies (Fig. 3.92 and 3.93). While the opportunistic/S.S.D.A. method is applied on almost all the types of blanks collected (rounded pebbles, polygonal blocks and slabs), discoid and Levallois methods are employed exclusively on cores with suitable morphologies, i.e. vein quartz rounded pebbles and small spongolite polygonal blocks (Fig. 3.92 and 3.93). This implies that the final dimensions of Levallois and discoid products is strongly influenced by those of the natural blanks selected as cores (Fig. 3.40, 3.58 and 3.75).

Discoid and Levallois methods are well attested in the Ciota Ciara cave (Tabs. 3.3, 3.5, 3.8 and 3.11) and give the chance to make several considerations about the adaptation of their technological criteria to the characteristics of the raw

materials, particularly concerning vein quartz. A first adaptation to vein quartz petrographic features is visible in the general shortness of the reduction sequences: both discoid and Levallois exploitations start from the natural surfaces of the cores (neocortical surfaces or natural fracture planes) avoiding phases of shaping of the cores, as it appears evident from the typology of discoid and Levallois butts (Fig. 3.45, 3.60, 3.77 and 3.90) and from the characteristics of the cores (Appendix A). Only for preferential Levallois cores, few removals are realized to prepare the lateral and distal convexities of the knapping surface or to prepare the striking platform in correspondence of the impact point of the preferential flake (Appendix A). After one phase of exploitation the cores are discarded. While for spongolite this is due to the reduced dimension of the cores (Appendix A), for vein quartz the cores are discarded even when a re-shaping of the core would have permitted the production of other predetermined products (Appendix A): as demonstrated by experimental studies (de Lomberra-Hermida, 2009; Mourre, 1996; Tallavaara et al., 2010) the most the exploitation proceeds, the most the results of the knapping activity are unpredictable due to the formation of further inner fracture planes in vein quartz cores. A further adaptation to the mechanical characteristics of vein quartz is the frequent use of neocortical surfaces as striking platforms, that contributes in reducing the occurrence of knapping accidents and fractures (Mourre, 1996, 1994).

The development of discoid and recurrent centripetal production phases suggests that the intention to discard the core after the detachment of a reduced number of blanks was a usual technical behaviour at the Ciota Ciara cave. As observed in SS.UU. 14 and 15 (Fig. 3.61 and 3.78), where these reduction sequences are most developed, it is not visible an attention for the management of the core convexities: the removals are rarely plunging or directed toward a chordal

direction (Appendix A) as usually observed on cores with several production phases (Peresani, 2003).

All the elements presented above, typical of the discoid and Levallois reduction strategies at the Ciota Ciara cave, indicates that the general technical behaviour was strongly opportunistic, starting from the choice of the cores to be exploited till the exploitation of the natural convexities present on the cores and their abandonment after short production phases.

Despite the adoption of many technological expedients, vein quartz discoid and Levallois reduction sequences at the Ciota Ciara cave are conceptually fully consistent with the classical definitions of the methods (Boëda, 1994, 1993) and with the variability recognized for both methods by several scholars (e.g. Chazan, 1997; Di Modica and Bonjean, 2009; Dibble and Bar-Yosef, 1995; Eren et al., 2011; Eren and Bradley, 2009; Eren and Lycett, 2012; Holdaway and Douglass, 2012; Lycett and Eren, 2013; Menras, 2009; Peresani, 2003; Schlanger, 1996; Shimelmitz et al., 2016; Shimelmitz and Kuhn, 2017; Van Peer, 1992; Walker et al., 2013). The core volumetric concepts proper of the two methods are present (i.e. two non-hierarchized equally convex surfaces for the discoid method and two hierarchized differently convex surfaces for the Levallois method) together with a marked difference in the *débitage* direction, parallel to the intersection plane between the two core surfaces for Levallois, secant for discoid cores. When a unifacial centripetal exploitation is performed on a core, the distinction between the two methods becomes more difficult, since, as mentioned before, there are no great technological investments in the shaping of the core surfaces. In these cases, the main criteria used to distinguish between Levallois and discoid exploitations is the *débitage* direction (Peresani, 2003). The lack of phases of shaping of the cores made difficult also the identification of Levallois and discoid products,

especially when recurrent centripetal Levallois exploitations have been performed. Once again, the distinction of the recurrent centripetal Levallois products from the discoid ones is mainly related to the direction of the *débitage*. Another criterion is based on the general morphology of the products, shorter and thicker for the discoid, more elongated and thin for the Levallois method (Boëda, 1993; Eren and Lycett, 2012; Kuhn, 1994; Lemorini et al., 2003; Picin and Vaquero, 2016).

The demonstration that this low technological investment in Levallois and discoid reduction sequences is due to an adaptation to the characteristics of the lithologies involved and not to a supposed technological inability, as previously hypothesized (Lo Porto, 1957), comes from the Levallois and discoid products realized on allochthonous good-quality raw materials, radiolarite and rhyolite. Even if no Levallois or discoid cores are present for these lithologies, the technological characteristics of the products (i.e. faceted butts, number of negatives on the upper face of the flakes) let suppose that Levallois and discoid reduction sequences on this raw material were longer and more complex than those on vein quartz and spongolite, with a careful preparation of the core surfaces before the phase of *plein débitage*.

The use-wear analysis performed on the lithic assemblages of S.U. 13 and 14 are consistent with the technological study conducted, attesting the practise of activities mainly linked to the maintenance of wooden objects, probably linked to hunting activities, in level 13 and the practice of a wide range of activities in level 14, also linked to medium/long lasting workings, like hide processing (Berruti, 2017; Daffara et al., 2014).

A last observation must be made concerning these allochthonous raw materials, which supply areas are located at a certain distance from the site: ~ 30 Km for

radiolarite and ~ 2 Km in a straight line for rhyolite (see chapter 3.5). The presence of allochthonous good-quality raw materials is quite frequent in European Middle Palaeolithic sites and frequently in these contexts they are present only as finished tools with an high degree of edge rejuvenation (e.g. Bourguignon et al., 2004; Costamagno et al., 2006; Féblot-Augustins, 1999; Fernandes et al., 2006; Geneste, 1988; Hiscock et al., 2009; Jaubert and Delagnes, 2007; Kuhn, 1992; Meignen, 1988; Meignen et al., 2009; Porraz, 2005; Turq, 2000). The roles of rhyolite and radiolarite in the lithic assemblage of the Ciota Ciara cave is constant all along the sequence, testifying that, despite differences in the intensity of human presence in the site, the economic and technological behaviour of these human groups did not undergo significant changes. They were introduced in the site as finished tools and their edges have been rejuvenated several times before being discarded: according to Kuhn (1992) they can be interpreted as part of “personal toolkits”, versatile tools that could respond to any needs along the usual itinerary covered by the Middle Palaeolithic human groups and representing the capacity of predicting needs on a brief time-scale. The absence of evidence attesting the transport of cores or unworked blanks in the Ciota Ciara cave, seems to exclude the possibility of a long-term planning of future needs (Kuhn, 1992).

The Ciota Ciara cave is the evidence of the complex technological and economic behaviour of the Middle Palaeolithic human groups that frequented the site for brief or long-term seasonal occupations. The identification of raw materials supply areas located in the nearby Lombardy suggests that these territories have been frequented more intensely than it was thought during Middle Palaeolithic. These data, together with the results of recent researches conducted in the region (Rubat Borel et al., 2016, 2013), underline the necessity of further systematic

interventions aimed to the understanding of the Middle Palaeolithic settlement dynamics in this part of north-western Italy.

CHAPTER 4

The Ter River Basin:

Pedra Dreta and Can Garriga

CHAPTER 4

THE TER RIVER BASIN: PEDRA DRETA and CAN GARRIGA

The Ter river basin is composed of different geomorphological formations containing archaeological sites of different ages: the Ter fluvial terraces, the La Garriga stream, the volcanic context and the karstic complex of Cau del Duc de Torroella de Montgrí and Ullà (Garcia Garriga, 2015; Pallí, 1976). A human frequentation of the area dated to the OIS 5 is attested by the Middle Palaeolithic sites of Pedra Dreta and Can Garriga, subjects to different archaeological interventions from the 70s to the 90s and located on the left margin of the Ter river, at the right side of the Garriga tributary stream, in Sant Julià de Ramis, to the north of Girona (Canal et al., 1978; Canal and Carbonell, 1989; E. Carbonell et al., 1992; Mora et al., 1987; Rodriguez et al., 1995; Sala et al., 1992). From a geomorphological point of view, they are related to the Ter fluvial terraces and to La Garriga stream. Pedra Dreta is located at the confluence of La Garriga stream and the Ter river while the open-air site of Can Garriga is in the distal side of the promontory, on an ancient glacis above the Ter second terrace. Few kilometres far from Pedra Dreta is located the Can Guilana volcano, which eruptions are well represented and identifiable in the different layers of the Ter river valley, especially at Can Garriga (Garcia Garriga, 2015; Rodriguez et al., 1995). The travertine structure forming the substrate at these sites were dated by the $^{230}\text{Th}/\text{U}$ method, thus allowing their positioning within the OIS 5 (Garcia Garriga, 2015; Giralt et al., 1995). A new technological study of the lithic assemblages from Pedra Dreta and Can Garriga has been carried out, and it is mainly focused on the Levallois and discoid reduction sequences. The results of this study and of the

use-wear analysis are presented in the following paper recently submitted to
L'Anthropologie.

L'Anthropologie (xxx), submitted

**The use of “second rate” raw materials during Middle Palaeolithic.
Technological and functional analysis of two sites in north-eastern
Iberia.**

*L'utilisation de matières premières « mauvais » au Paléolithique moyen.
Analyse technologique et fonctionnelle de deux sites dans le nord-est de l'Ibérie.*

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Abstract

In recent years many issues arose regarding the technological and functional analysis of lithic assemblages dominated by “second rate raw materials” like vein quartz, metamorphic or volcanic rocks. Nevertheless, the technological study of this kind of assemblages and their consequent interpretation seems to be still based on the techno-typological criteria elaborated for flint artefacts, thus leading to the common inference that these lithic assemblages are archaic and mainly linked to opportunistic production systems. Pedra Dreta and Can Garriga, located in the north-east of the Iberian Peninsula, present two small lithic assemblages dominated by local raw materials (vein quartz, quartzite, porphyry, syenite, etc.) and by opportunistic reduction sequences but with the presence of Levallois and discoid *chaine operatoires*. The technological analysis is aimed to answer two main issues that emerged during the study and that can contribute to the study of non-flint lithic assemblages: 1. Which criteria should we adopt to distinguish

between discoid and recurrent centripetal Levallois products? and 2. Is it possible that the Levallois products are the result rather of the opportunistic and expedient reduction sequences that are dominant in these assemblages than of a real use of the Levallois method?

A use-wear analysis has also been conducted for the first time on Pedra Dreta and Can Garriga lithic assemblages. The peculiarities of the lithic raw materials employed made necessary the adoption of specific methodologies and the realization of a particular procedure for the analysis of porphyry's tools.

Keywords

Lithic technology, use-wear analysis, Levallois and discoid technology, quartz, porphyry, Iberian Peninsula.

Résumé

Depuis plusieurs années, l'analyse technologique et fonctionnelle des assemblages lithiques dominés par des matières premières de mauvaise qualité telles que le quartz filonien, les roches métamorphiques ou volcaniques a soulevé de nombreuses questions. Néanmoins, l'étude technologique et l'interprétation de ce type d'assemblage semblent toujours être basées sur des critères technotypologiques élaborés pour des artefacts en silex, ceci amenant fréquemment à une même conclusion : ces assemblages lithiques sont archaïques et principalement le fruit d'un système de production opportuniste. Les sites de Pedra Dreta et Can Garriga, situés au nord-est de la péninsule ibérique, présentent deux petits assemblages lithiques dominés par une matière première locale (quartz filonien, quartzite, porphyre, syénite etc...) et par une séquence de réduction opportuniste mais avec la présence de chaînes opératoires Levallois et discoïdes. L'analyse technologique a pour but de répondre à deux principales

questions qui se sont soulevées durant l'étude de ce matériel et qui peuvent contribuer à l'analyse d'assemblage lithique sans silex: 1. Quels critères doit-on adopter ici pour distinguer les produits du débitage Levallois de ceux du débitage Levallois récurrent centripète? et 2. Est-il possible que ces produits Levallois soient le résultat des chaînes opératoires opportuniste, qui semble être dominant dans ces assemblages, et non le fruit d'une réelle utilisation de la méthode Levallois ?

L'étude est complétée par une analyse tracéologique, effectuée pour la première fois sur les assemblages des sites de Pedra Dreta et Can Garriga. La particularité de la matière première implique l'utilisation de méthodologies spécifiques et la mise en place de procédures particulières pour l'analyse des instruments porphyriques.

Mots clés

Technologie lithique, analyse tracéologique, débitage Levallois et discoïde, quartz, porphyre, péninsule Ibérique.

4.1. Introduction

The use of raw materials different from flint, like vein quartz and quartzite, as raw materials to produce lithic tools is well attested in several European Middle Palaeolithic sites (e.g. Baena et al. 2012; Berruti and Cura 2016; Cologne et al. 2009; Daffara et al. 2014; Di Modica and Bonjean 2009; Jaubert et al. 2005; Lazuén et al. 2011; Márquez et al. 2016; Menras 2009; Moncel and Lhomme 2007; Mourre and Thiébaud 2008; Ortega and Maroto 2001) but, at today, works concerning the technological constraints linked to their exploitation, especially when predetermined knapping methods (i.e. Levallois methods) are employed, are still scarce (Clegg, 1977; Eren et al., 2011). Even if the interest toward vein

quartz and the role of raw materials properties in the final characteristics of the lithic assemblages increased in the last decades, the technological studies about quartz lithic industries and the resulting interpretations seem to be still based on the techno-typological criteria elaborated for flint artefacts, thus leading to the common inference that quartz lithic assemblages are archaic and mainly linked to opportunistic production systems (Knutsson, 2014; Rodríguez-Álvarez, 2016; de Lombera-Hermida & Rodríguez-Rellán, 2016). The same should be pointed out concerning use-wear analysis: although some years ago specific methodologies have been developed for the identification of wear traces on these kinds of raw materials, just in recent years a specific interest on this argument is born (e.g. Clemente-Conte et al., 2017; Clemente-Conte and Gibaja Bao, 2009; Driscoll, 2011; Knutsson et al., 2015; Moncel et al., 2008; Pereira, 1993; Sussman, 1988; Venditti et al., 2016).

The considered sites, Pedra Dreta (PD) and Can Garriga (CG) (Canal et al., 1978; Giralt et al., 1995; Mora et al., 1987; Rodriguez, 2004; Rodriguez et al., 1995; Rodriguez and Lozano Ruiz, 1999), show lithic assemblages composed of a mosaic of local raw materials where vein quartz is dominant, followed by quartzite, porphyry, syenite, hornfels, sandstone, metamorphic rocks, granite, limestone, diorite, lydite, schist and basalt. Levallois and discoid technologies are present on all the main raw materials, thus giving the chance to observe interesting expedients put into action by the knappers to face the constraints due to the mechanical and petrological properties of each raw material. Concerning use-wear analysis, one of the aims of this work was to test the effectiveness of the methodology chosen for the identification of wear traces on porphyry lithic artefacts.

4.2. Geomorphological setting, sites location and chronology

The Ter river basin is composed of different geomorphological formations containing archaeological sites of different ages: the Ter fluvial terraces, the La Garriga stream, the volcanic context and the karstic complex of Cau del Duc de Torroella de Montgrí and Ullà (Garcia Garriga, 2015; Pallí, 1976). A human frequentation of the area dated to the OIS 5 is attested by the Middle Palaeolithic sites of PD and CG, subjects to different archaeological interventions from the 70s to the 90s and located on the left margin of the Ter river, at the right side of the Garriga tributary stream, in Sant Julià de Ramis, to the north of Girona (Fig. 4.1) (Canal et al., 1978; Canal and Carbonell, 1989; E. Carbonell et al., 1992; Giralt et al., 1995; Mora et al., 1987; Sala et al., 1992). From a geomorphological point of view, they are related to the Ter fluvial terraces and to La Garriga stream. Pallí (1976) describes four asymmetrical terraces formed by alternating erosional-sedimentary fluvial activity: T4 (145 m a.s.l.) almost completely dismantled by erosive processes and composed of reddish-brownish clays soils; T3 (104 m a.s.l.), composed of carbonated brownish silt soils and restricted to the confluence interfluvium of the La Garriga stream and some other locations which were preserved from erosion; T2 (65 m a.s.l.), composed of dark brownish silt soils and representing the present plain going from Salt to Sant Julià de Ramis, passing through Girona; T1 (60 m a.s.l.), composed of silt and clays from the recent river bed (Garcia Garriga, 2015; Giralt et al., 1995). During the investigations of 1995, an intermediate terrace was identified (Giralt et al., 1995) between the third and the second terrace described by Pallí (1976) (Fig. 4.1).

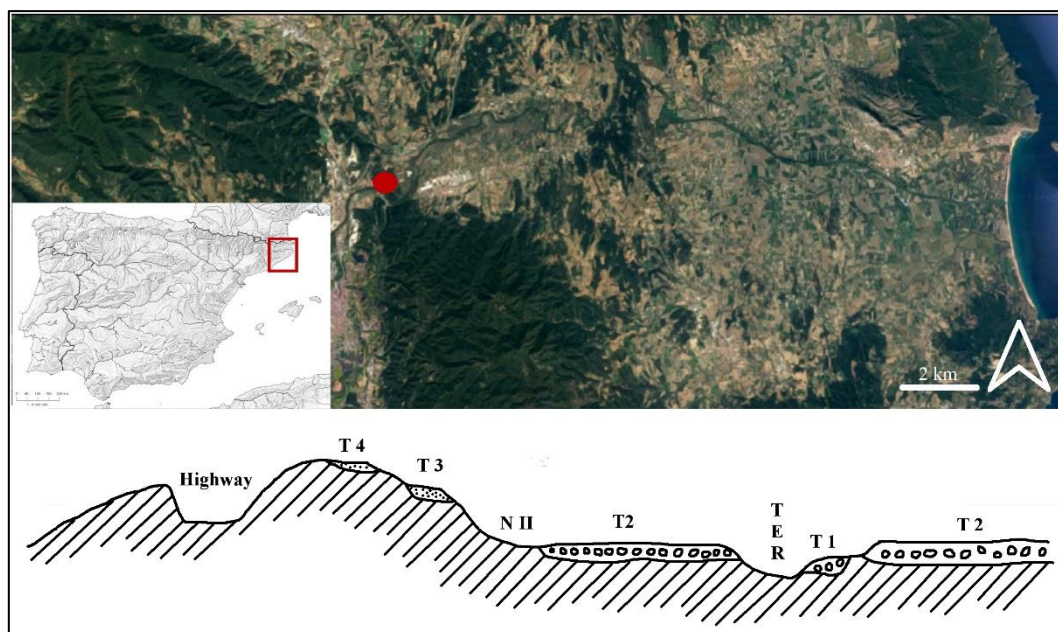


Fig. 4.1. Geographical location of the archaeological sites, Pedra Dreta and Can Garriga (top); longitudinal profile of the Ter terraces in Saint Julià de Ramis, modified from Giralt et al., 1995 (bottom).

Localisation géographique des sites archéologiques, Pedra Dreta et Can Garriga (en haut) ; profil longitudinal des terrasses du Ter à Saint Julià de Ramis, modifiées à partir de Giralt et al., 1995 (en bas).

PD is located at the confluence of La Garriga stream and the Ter river while the open-air site of CG is in the distal side of the promontory on an ancient glacis above the Ter second terrace (T2). Few kilometres far from PD is located the Can Guilana volcano, which eruptions are well represented and identifiable in the different layers of the Ter river valley, especially at CG (Garcia Garriga, 2015; Rodriguez et al., 1995). The travertine structure forming the substrate at these sites were dated by the $^{230}\text{Th}/\text{U}$ method, thus allowing their positioning within the OIS 5 (Garcia Garriga, 2015; Giralt et al., 1995).

4.2.1. Pedra Dreta

PD is located at the joining of the Garriga stream and the Ter river in the municipality of St. Julià de Ramis (Girona), on the National route II (Fig. 4.1). This area corresponds to the beginning of the gorge that the river Ter opens in the north-west of the Gavarres and it is the last plain of the Catalan pre-coastal

corridor before entering the marshlands of the Empordà and the lower Ter valley (Rodríguez et al., 1995). On the other side, few hundred meters away from PD, the Garriga stream goes deeper, dividing the PD area from the higher plain where is located the open air site of CG (Rodríguez et al., 1995).

During the archaeological intervention of 1991, two stratigraphic sequences were exposed in PD, one inside the rock shelter and one just outside, to identify its original width and to define the sedimentation dynamics (Giralt et al., 1995). In the north and in the west part of the investigated area, was identified a structure made by cobblestone, interpreted as an anthropic modification due to the construction of medieval routes. Nevertheless, the artefacts collected are all referable to the Upper Pleistocene and so, even if in these areas the spatial relationship among the objects is lost, intrusions of modern materials were not identified (Canal and Carbonell, 1989; Rodríguez et al., 1995).

The external sequence is composed of an alternation between conglomerates and coarse/fine grained sands at the base of the sequence, while the remaining part is composed of a layer of conglomerates and clays, followed by sands with travertine boulders characterized by a strong slope towards the exterior of the rock shelter (Giralt et al., 1995).

The interior stratigraphic sequence shows a different sedimentation dynamic. From the bottom to the top, it is composed of carbonate sands, alternation of travertine and stalagmitic crusts, an edaphic layer with two horizons, A and B, within which the archaeological level is located, and a travertine sheet that closes the assemblage. At the top of the sequence, a level composed of travertine boulders may be linked to the later collapse of the rock shelter (Giralt et al., 1995). Horizons A and B, above which the Middle Palaeolithic occupation took place, are clay levels originated from stream flooding and are located between two

travertine sheets: the lower is dated to 88.200 ± 4.000 BP, the upper to 92.000 ± 4.000 BP (Fig. 4.2). These data state that the sedimentation and collapse of the rock shelter were quite rapid, covering a time range of the hominin settlement of some 4.000 years (E. Carbonell et al., 1992; Garcia Garriga, 2015; Giralt et al., 1995; Sala et al., 1992).

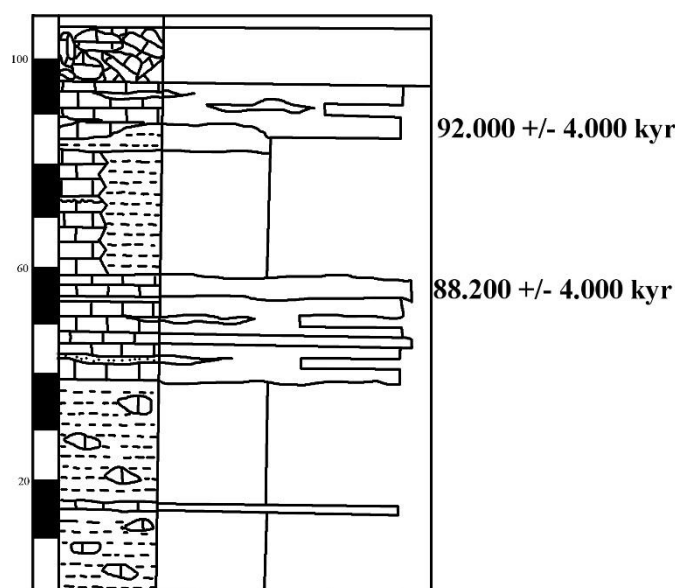


Fig. 4.2. Pedra Dreta. Interior stratigraphic sequence showing the $^{230}\text{Th}/\text{U}$ chronology (modified from Giralt et al., 1995)
Pedra Dreta. Séquence stratigraphique intérieure montrant les datations $^{230}\text{Th} / \text{U}$ (modifiée à partir de Giralt et al. 1995).

4.2.2. Can Garriga

Can Garriga is an open-air site located in the municipality of St. Julià de Ramis (Girona), on the left side of the Ter river and of the National route II and on the right side of La Garriga stream (Canal and Carbonell, 1989; E. Carbonell et al., 1992; Giralt et al., 1995; Mora et al., 1987; Rodriguez and Lozano Ruiz, 1999; Sala et al., 1992), few hundred meters from the site of Pedra Dreta (Fig. 4.1). The site is situated at the slope of a small hill, in the distal side of the promontory of an ancient glaciais, above the Ter second terrace, seventy meters above the sea level and twenty-two meters above the Ter river (Giralt et al., 1995; Rodriguez, 2004). In Can Garriga were identified four archaeological levels and its investigation

allowed for the first time the reconstruction of the stratigraphic sequence of the last phases of the Middle Pleistocene and of the beginning of the Upper Pleistocene in the region (Giralt et al., 1995).

In 1991, three stratigraphic sequences were exposed in Can Garriga, one to contextualise the archaeological levels and define the sedimentary dynamics (CG-1) (Fig. 4.3), two to identify possible lateral lithological changes (CG-2 and CG-3) (Giralt et al., 1995).

CG-1 consist in an alternation between carbonate sands and travertine levels while CG-2 and

CG-3 show an alternation between sands and travertine levels with a reduced lateral extension, showing an important lateral variability.

The analysis of these stratigraphic sequences led to the reconstruction of the sedimentation dynamics of the site, characterized by the alternation of glacial deposits, putting sands, and periods of stability, whereon little rafts appeared and generated travertines (Giralt et al., 1995; Rodriguez, 2004). As mentioned before, in Can Garriga were identified four archaeological levels, consequence of diverse occupations that took place in a moment of travertine regression (Fig. 4.3). The sedimentary dynamic of Can Garriga began with the formation of a travertine level on the second terrace (T2) of Ter river, dated in its downside in 128.8 ± 6.5 Ka and in its topside in 112.2 ± 7.5 Ka. Next there is a tractive level, or of alluvion, (archaeological level 4) formed by the action of the superficial streams of La Garriga's hill. On the top a travertine was localized, dated in 107.6 Ka. On the travertine lies the archaeological level 3, in paedogenic clays, with volcanic particles on its top, which analysis offered a magnetic inverse polarity, corresponding to the Blake episodes (118 Ka). Above this level of volcanic particles, the archaeological level 2 was deposited, in a deposit of clays and sands.

On its top, a travertine was dated in 103.5 ± 3.2 Ka, thus estimating the activity of Can Guilana volcano to about 100 Ka, simultaneous with the hominin settlement in the La Garriga stream valley (Garcia Garriga, 2015; Mora et al., 1987). Above these, is the archaeological layer 1, also in clays and sands. Finally, a travertine level dated in 87.7 ± 2.5 Ka appeared. Can Garriga can therefore be correlated with the OIS 5 (Garcia Garriga, 2015; Giralt et al., 1995; Mora et al., 1987; Rodriguez, 2004).

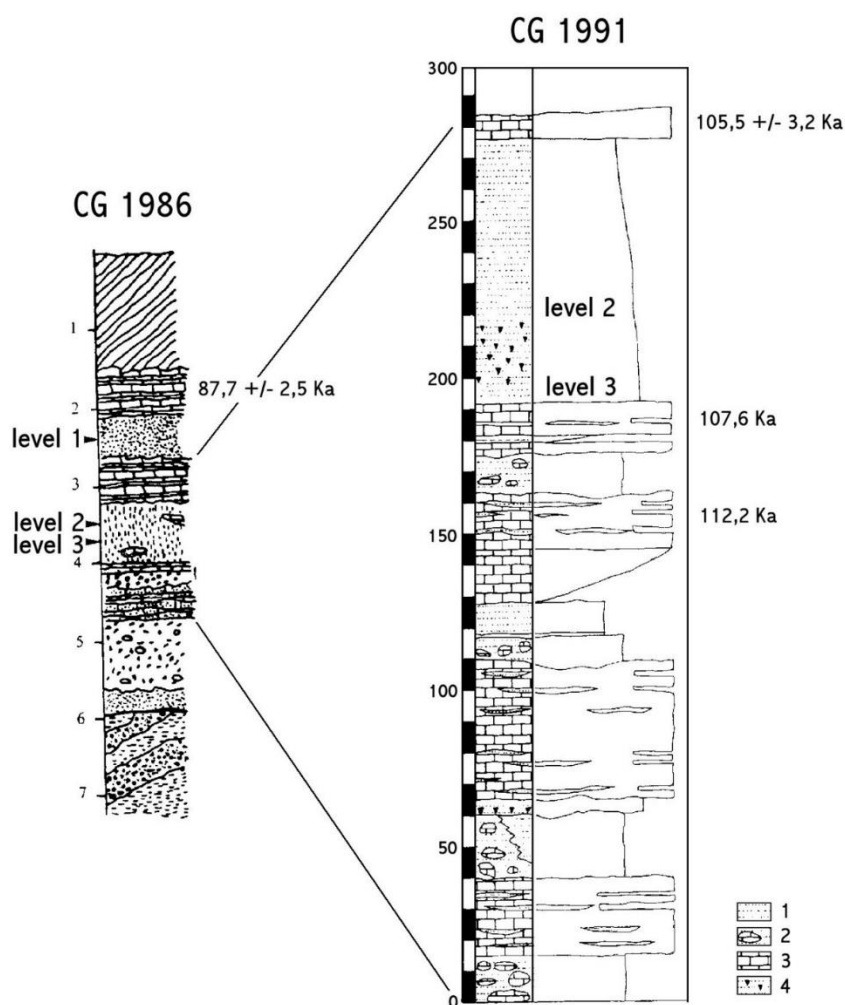


Fig. 4.3. Can Garriga. Stratigraphy and dates of Can Garriga sequence, indicating the archaeological levels. On the left the stratigraphic sequence drawn in 1986, and on the right the new stratigraphy drawn in 1991. In 1991 column do not appear the level 1 neither the travertine 1, indicated in 1986 column. Legend (for 1991 stratigraphy): 1: sands, 2: sands with travertine nodules, 3: travertine, 4: sands with volcanic particles (from Rodriguez, 2004).

Can Garriga. Stratigraphie et datations de la séquence de Can Garriga, indiquant les niveaux archéologiques. A gauche, dessin de la séquence stratigraphique réalisée en 1986 et à droite, stratigraphie dessinée en 1991. Dans la colonne de 1991, le niveau 1 et le travertin 1 n'apparaissent pas alors qu'ils sont indiqués dans celle de 1986. Légende (pour la stratigraphie de 1991) : 1 : sables, 2 : sables avec nodules de travertin, 3 : travertin, 4 : sables avec particules volcaniques (d'après Rodriguez, 2004).

4.3. Materials and methods

4.3.1. Technological study

A new technological analysis of the lithic assemblages from Pedra Dreta and Can Garriga was performed to reconstruct the knapping sequences and the core reduction strategies employed, with particular attention to the Levallois and the discoid knapping sequences applied on raw materials like vein quartz, porphyry and syenite. Technical criteria have been used to answer the objectives of these work (Boëda, 1994, 1993; Boëda et al., 1990; Inizan et al., 1995; Peresani, 2003). For flakes, different technological features have been considered. The knapping technique has been identified through the analysis of the stigmata present on the butt and on the ventral face (impact point, ripples, hackles) even if, due to the raw materials employed, these stigmata are not always readable on the flakes. Concerning vein quartz, we based the technological study on specific works about the identification of the knapping stigmata and on its rate and modalities of fragmentation (Cologne and Mourre, 2006; de Lomberra-Hermida, 2009; de Lomberra-Hermida et al., 2011; Di Modica and Bonjean, 2009; Driscoll, 2011; Manninen, 2016; Moncel et al., 2008b; Mourre, 1996, 1994; Tallavaara et al., 2010) while for other raw materials like porphyry and syenite no specific works have been published yet.

The presence and the position of the cortex and the direction of the scars on the upper face of the flakes have been used to identify the knapping methods and the development of core reduction. The definition of each knapping method is based on the works of Forestier (1993), Boëda (1993) and Boëda et al. (1990). For Levallois, discoid and centripetal cores (i.e. cores with few centripetal detachments not recognizable as discoid or Levallois cores) a diacritical scheme has been realized (Appendix B) in order to define all the steps of flake production

and shaping of the core. The typological attribution of the retouched blanks is based on Bordes (1961). Concerning quartz artefacts, we applied the subdivision in four morpho-structural groups developed by Martinez Cortizas and Llana Rodriguez (1996) and de Lombera-Hermida et al. (2011). According to this approach, vein quartz can be divided in four morpho-structural groups depending on the presence/absence of grains and planes (i.e. internal flaws or crystalline surfaces): NN (no grain, no planes), NS (no grain, planes), SN (grain, no plains), SS (grain, plains). The aim is to see if we can observe a clear relation between the mechanical features of each morpho-structural group and the knapping method chosen. In Pedra Dreta, the assemblage analyzed corresponds to the lithic artefacts collected during the 1991 excavation, since the materials coming from previous interventions do not have any stratigraphic indication. The assemblage is composed by 550 lithic artefacts characterized by a general good state of preservation. The raw materials are local and collected in the surroundings of the site. In Can Garriga, the lithic assemblage analyzed corresponds to the artefacts clearly referable to the 1991 excavation and it consists of 283 pieces coming from the archaeological Level 1 and characterized by a general good state of preservation. Level 2 and 3 are not considered since the lithic artefacts clearly referable to these archaeological levels are respectively 33 and 32. The raw materials are various but all local and collected in the surroundings of the site, in secondary deposition.

4.3.2. Use-wear analysis

The method employed for the use wear analysis is the integrated approach, which is the combination of two different methodologies: the Low Power Approach (LPA) (e.g. Odell, 1981; Semenov, 1964) and the High Power Approach (HPA)

(e.g. Keeley, 1980). Through the LPA approach, that requires the use of a stereomicroscope, it is possible to identify the type of action carried out with the lithic artefacts and the hardness of the material worked, while the HPA approach, that requires the use of a metallographic microscope, permits the identification also of the type of material worked. There are indeed some advantages working with the two methods together: the stereomicroscope (LPA) has a long working distance, wide depth of field and produces 3D images, it is less expensive in terms of time-consuming and large samples can be observed to verify the possible presence of use traces. However, due to the lower magnification, slight traces can be missed, but this can happen also with HPA. In the combined approach, the stereomicroscope analysis (LPA) represents an excellent tool for the screening of the material, for the selection of sample and for macroscopic observations (e.g. Lemorini et al., 2014; Wilkins et al., 2015; Moss, 1983; Beyries, 1987; Van Gijn, 2014; Berruti and Daffara, 2014; Cruz and Berruti, 2015). The use-wear traces identified with the LPA need to be further studied through the HPA. The integrated approach is applied by different scholars on lithic artefacts made in all the most common raw materials such as flint, chert, obsidian, quartz and quartzite (e.g. Clemente-Conte and Gibaja Bao, 2009; Lemorini et al., 2014; Plisson et al., 2008). To reduce the intensity of the fastidious glare, typical of quartz-rich raw materials like quartz and quartzite (e.g. Clemente-Conte and Gibaja Bao, 2009; Igreja, 2009; Lemorini et al., 2014) the metallographic microscope was equipped with a Differential Interference Contrast Microscopy (also known as Nomarski filter) (Igreja, 2009; Knutsson et al., 2015). For this study, the same methodology has been applied for all the lithic artefacts, even that in limestone, hornfels, porphyry and syenite.

4.3.2.1. Experimental collection

An experimental collection composed of about 50 artefacts obtained from the most abundant raw materials present in the archaeological sample (porphyry, quartz, syenite) was realized (Fig. 4.4). During the experimentation, the artefacts were used to perform different actions (cutting and scraping) on different materials (fresh and dry bone, dry and fresh wood, dry antler, fresh hide, meat and butchering activities) and monitored at different times (5-15-25 min.).

4.3.2.2. Selection of the sample for the use wear analysis

Among the 550 lithics composing the assemblage considered for the technological study of Pedra Dreta, a sample of 68 artefacts was selected for the use wear analysis: 10 of quartzite, 1 of limestone, 1 of hornfels, 10 of porphyry, 36 of quartz belonging to different morpho-structural groups (12 NS; 21 SN; 1 SS; 2 indet.), 1 of chert and the last 10 of syenite. Concerning Can Garriga, among the 283 lithic artefacts considered for the technological study, a sample of 32 was selected for the use wear analysis, of which 8 finds are made in quartzite, 1 in hornfels, 3 in porphyry, 19 in quartz belonging to various morpho-structural groups (1 NN; 2 NS; 14 SN; 1 SS; 1 indet.) and 1 in syenite. Five criteria were applied during the selection of the sample: completeness, presence of at least one functional edge (artefacts without potential functional edges were excluded from the analysis), morphology suitable for prehension or hafting, surface preservation (absence of marked post depositional alterations) and presence of removals and rounding localized on the edges of the artefacts and probably related to an ancient use (Berruti et al., 2016; Lemorini et al., 2014). This preliminary phase was divided in two parts. The first examination was carried out at the naked eye, followed by a second inspection with a stereo-microscope in reflected light. In

this way, it is possible to minimize the likelihood of confusing the modifications due to artefact's use rather than post-depositional processes.

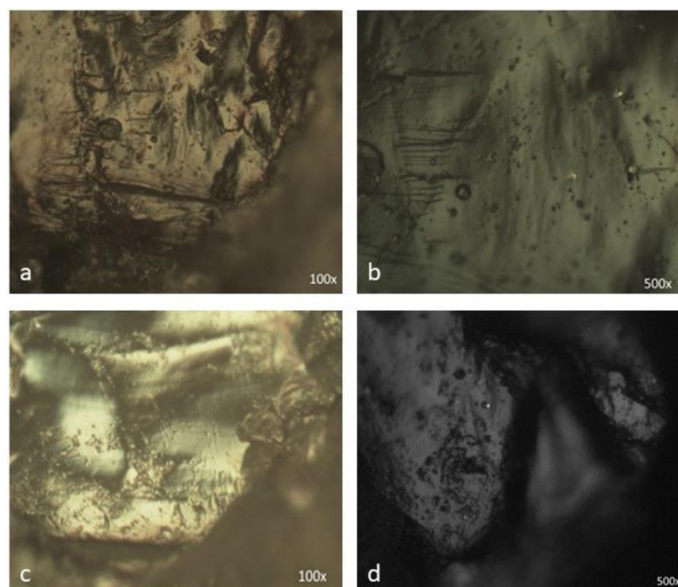


Fig. 4.4. Experimental collection: (a and b) natural marks on the edges of quartz unused flake (sper. 11); (c) wear traces on the edge of a quartz flake (exper. 13) used for bone-working (15 min); (d) wear traces on a quartz crystal on the edge rim of a porphyry flake (sper. 1) used for hide working (15 min).

Collection expérimentale: (a et b) traces naturelles sur les bords d'un éclat en quartz inutilisés (expér. 11) ; (c) traces d'utilisation sur le bord d'un éclat en quartz (expér. 13) utilisé pour le travail des os (15 min.) ; (d) traces d'utilisation sur un cristal de quartz sur le bord d'un éclat de porphyre (expér. 1) utilisé pour le travail de la peau (15 min.)

4.4. Results

4.4.1. Technological study

The lithic assemblage of Pedra Dreta (PD) is composed by 550 artefacts realized through the exploitation of local raw materials collected in the form of pebbles on the river banks close to the site. The most exploited raw material is vein quartz (64,5%), followed by syenite (20,0%), quartzite (6,5 %) and porphyry (6,2%). All the other raw materials, scarcely represented, are metamorphic or sedimentary rocks (hornfels, limestone, basalt, gneiss, schist) present near the site (Table 4.1). In Can Garriga (CG), the considered lithic assemblage is composed by 283 artefacts coming from archaeological level 1. As for PD, the most common raw

material is vein quartz (63,6%) followed by quartzite (12,4%), porphyry (6,4%), hornfels (3,5%) and syenite (3,2%). Other lithologies like sandstone, granite, limestone, diorite, lydite and basalt are sporadically attested and all of them are available near the site (Table 4.2). From a technological point of view PD and CG show significant similarities, so the sites will be dealt with together.

Raw material	Flakes	Cores	Retouched tools	Debris	Pebbles	Total	%
Quartz	238	19	3	92	3	355	64,5%
Syenite	84	4	-	15	7	110	20,0%
Quartzite	32	-	-	3	1	36	6,5%
Porphyry	24	3	1	5	1	34	6,2%
Flint	4	-	-	2	-	6	1,1%
Hornfels	2	-	-	-	-	2	0,4%
Limestone	2	-	-	-	-	2	0,4%
Basalt	-	1	-	-	-	1	0,2%
Gneiss	1	-	-	-	-	1	0,2%
Metamorphic rock	1	-	-	-	-	1	0,2%
Schist	1	-	-	-	-	1	0,2%
Indet.	-	-	-	1	-	1	0,2%
Total	389	27	4	118	12	550	100,0%

Table 4.1. Pedra Dreta. Raw materials and composition of the lithic assemblage.
Pedra Dreta. Matières premières et composition de l'assemblage lithique.

Raw material	Flakes	Cores	Retouched tools	Debris	Pebbles	Total	%
Quartz	123	14	9	32	2	180	63,6%
Quartzite	29	4	-	2	-	35	12,4%
Porphyry	11	3	-	2	2	18	6,4%
Syenite	9	-	-	-	-	9	3,2%
Hornfels	9	-	-	-	1	10	3,5%
Sandstone	5	-	-	-	1	6	2,1%
Metamorphic rock	4	-	-	2	-	6	2,1%
Granite	2	3	-	-	2	7	2,5%
Limestone	2	1	-	-	-	3	1,1%
Diorite	1	-	-	-	-	1	0,4%
Lydite	-	2	-	1	-	3	1,1%
Basalt	2	-	-	1	-	3	1,1%
Indet.	2	-	-	-	-	2	0,7%
Total	199	27	9	40	8	283	100,0%

Table 4.2. Can Garriga. Raw materials and composition of the lithic assemblage.
Can Garriga. Matières premières et composition de l'assemblage lithique.

The reduction sequences are generally short for all the raw materials and all the knapping methods and cores are usually discarded before their complete exhaustion. This could be due to the abundance of raw materials in the area, to the low quality of most of the raw materials, all characterized by the presence of several inner fractures or to the dimensions of the wanted products. A low number of cores is present in the lithic assemblages (PD: 27; CG: 27), therefore part of the production of lithic tools was probably done out of the site.

Considering the kind of raw materials employed, even the number of debris is low, thus supporting the hypothesis that the production of lithic tools was carried out in other areas even if the scarce presence of debris could be due to excavation modalities or to taphonomic causes. Another problem caused by raw materials is the frequency of fragmented products: most of the accidents occurred during the

reduction sequences, with a high frequency of radial and bending fractures (Tallavaara et al., 2010) (Fig. 4.5).

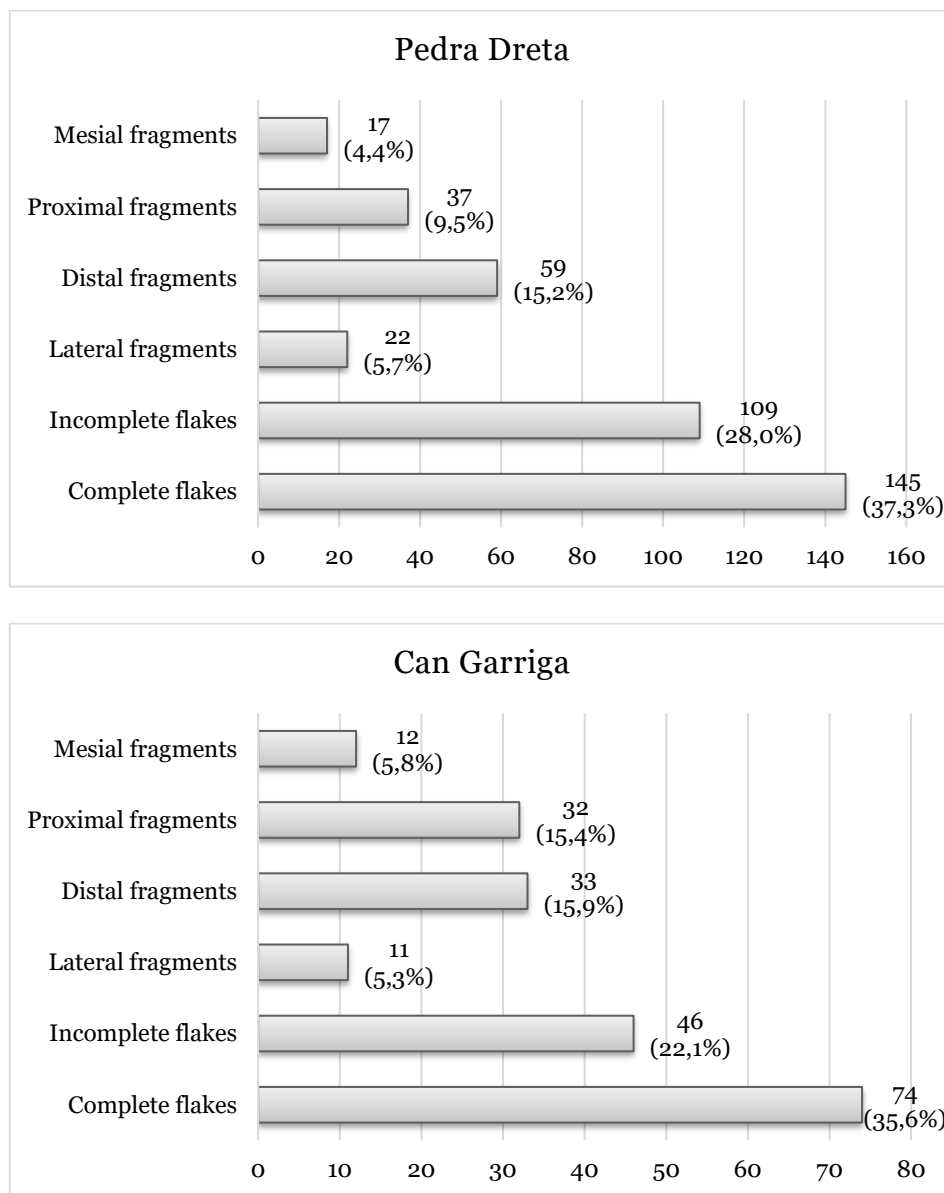


Fig. 4.5. Graphs showing the high rate of fragmentation of Pedra Dreta and Can Garriga lithic assemblages.

Graphiques montrant le taux élevé de fragmentation des ensembles lithiques de Pedra Dreta et Can Garriga.

The knapping methods are various and are those typical of Mousterian assemblages (opportunistic/S.S.D.A., discoid, Levallois) with a clear preponderance of opportunistic reduction sequences (PD: 81,7%; CG: 75,7%).

Débitage on flake, Kombewa *s.l.*, is also attested in PD by a quartz core and a

syenite flake but, considering the sporadic presence of this method, it can be related to the opportunistic component of the production (Table 4.3 and Table 4.4).

Raw material	Opportunistic	Discoid	Levallois	Centripetal	Kombewa s.l.	Indet.	Total
Quartz	Flakes = 205	Flakes = 18	Flakes = 5	Flakes = 2	Flakes = -	Flakes = 12	
	Cores = 14	Cores = 2	Cores = 1	Cores = -	Cores = 1	Cores = -	
Tot.	219	20	6	2	1	12	260
%	52,1%	4,8%	1,4%	0,5%	0,2%	2,9%	61,9%
Syenite	Flakes = 66	Flakes = 11	Flakes = 2	Flakes = -	Flakes = 1	Flakes = 3	
	Cores = 2	Cores = -	Cores = 1	Cores = 1	Cores = -	Cores = 1	
Tot.	68	11	3	1	1	4	88
%	16,2%	2,6%	0,7%	0,2%	0,2%	1,0%	21,0%
Quartzite	Flakes = 23	Flakes = 5	Flakes = 3	Flakes = -	Flakes = -	Flakes = 1	
	Cores = -	Cores = -	Cores = -	Cores = -	Cores = -	Cores = -	
Tot.	23	5	3	-	-	1	32
%	5,5%	1,2%	0,7%	-	-	0,2%	7,6%
Porphyry	Flakes = 20	Flakes = 4	Flakes = 1	Flakes = -	Flakes = -	Flakes = -	
	Cores = 2	Cores = -	Cores = 1	Cores = -	Cores = -	Cores = -	
Tot.	22	4	2	-	-	-	28
%	5,2%	1,0%	0,5%	-	-	-	6,7%
Others	Flakes = 10	Flakes = -	Flakes = -	Flakes = -	Flakes = -	Flakes = 1	
	Cores = 1	Cores = -	Cores = -	Cores = -	Cores = -	Cores = -	
Tot.	11	-	-	-	-	1	12
%	2,6%	-	-	-	-	0,2%	2,9%
Total	343	40	14	3	2	18	420
%	81,7%	9,5%	3,3%	0,7%	0,5%	4,3%	100,0%

Table 4.3. Pedra Dreta. Raw materials and *débitage* methods.
Pedra Dreta. Matières premières et méthodes de débitage.

The characteristics of the butts (mainly flat and cortical) and the considerable presence of cortical flakes and of flakes with lateral cortex on the dorsal face, let assume that the opportunistic *débitage* started with the opening of a striking platform on one side of the selected pebble and it continued through the detachment of flakes according to a unipolar direction. The low number of negatives visible on the dorsal faces (two or three) indicates that just a few flakes were produced for each striking platform. After this first production sequence, the core is usually discarded but sometimes the production continues according to a S.S.D.A. reduction sequence (Forestier, 1993). The products obtained

through this method are usually short and large and just sometimes elongated (Fig. 4.6) even if it cannot be explained as a deliberate choice, but more likely as the result of a conditioning due to morphology and dimension of the pebbles collected.

Raw material	Opportunistic	Discoid	Levallois	Centripetal	Indet.	Total
Quartz	Flakes = 105 Cores = 6	Flakes = 7 Cores = 5	Flakes = 4 Cores = -	Flakes = - Cores = 3	Flakes = 16 Cores = -	
Tot.	111	12	4	3	16	146
%	47,2%	5,1%	1,7%	1,3%	6,8%	62,1%
Quartzite	Flakes = 22 Cores = 3	Flakes = 2 Cores = -	Flakes = 3 Cores = -	Flakes = - Cores = -	Flakes = 2 Cores = 1	
Tot.	25	2	3	-	3	33
%	10,6%	0,9%	1,3%	-	1,3%	14,0%
Porphyry	Flakes = 7 Cores = 2	Flakes = 2 Cores = -	Flakes = 2 Cores = -	Flakes = - Cores = 1	Flakes = - Cores = -	
Tot.	9	2	2	1	-	14
%	3,8%	0,9%	0,9%	0,4%	-	6,0%
Syenite	Flakes = 6 Cores = -	Flakes = 1 Cores = -	Flakes = - Cores = -	Flakes = - Cores = -	Flakes = 2 Cores = -	
Tot.	6	1	-	-	2	9
%	2,6%	0,4%	-%	-	0,9%	3,8%
Others	Flakes = 21 Cores = 6	Flakes = - Cores = -	Flakes = 1 Cores = -	Flakes = - Cores = -	Flakes = 5 Cores = -	
Tot.	27	-	1	-	5	33
%	11,5%	-	0,4%	-	-	14,0%
Total	178	17	10	4	26	235
%	75,7%	7,2%	4,3%	1,7%	11,1%	100,0%

Table 4.4. Can Garriga. Raw materials and *débitage* methods.
Can Garriga. Matières premières et méthodes de débitage

Among the opportunistic component of the lithic assemblage, a centripetal exploitation that can't be related to a discoid or a Levallois reduction sequence it is attested in PD by two flakes and in CG by four cores and it consists in the exploitation of a peripheral natural convexity through a small number of detachments in centripetal direction.

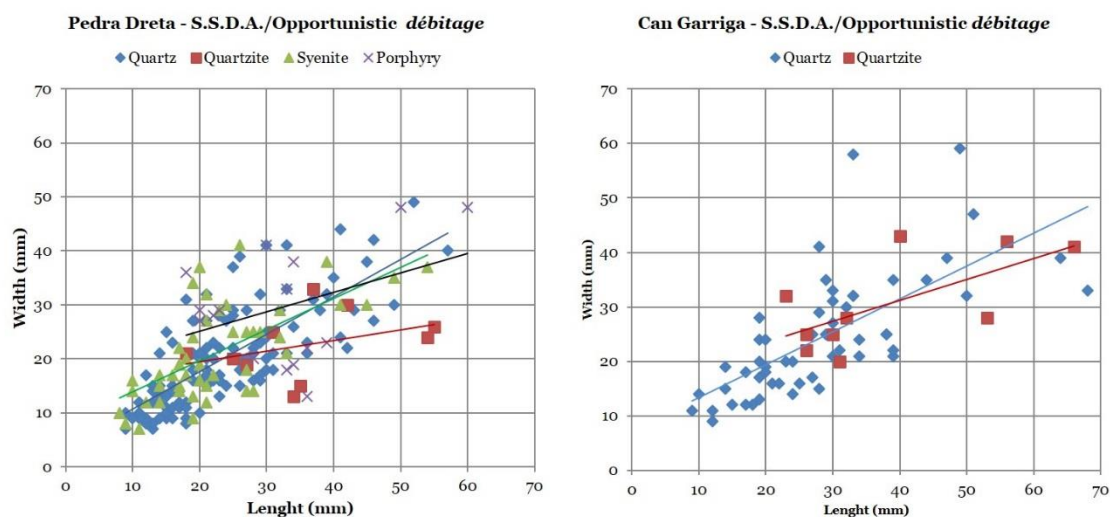


Fig. 4.6. Dimensional analysis of the flakes issued from an opportunistic/S.S.D.A. *débitage* in Pedra Dreta (left) and Can Garriga (right), fragmented artefacts are not included. The dimensions of the flakes are related to the initial dimensions of the collected raw materials.

Analyse dimensionnelle des éclats issus d'un système de débitage opportuniste / S.S.D.A. dans Pedra Dreta (gauche) et Can Garriga (droit), des éclats fragmentés ne sont pas inclus. Les dimensions des éclats sont liées aux dimensions initiales des matières premières collectées.

The Levallois method is attested just in the recurrent centripetal modality by 11 flakes and 3 cores (PD) made in quartz, quartzite, syenite and porphyry and by 10 flakes in quartz, quartzite, porphyry and hornfels (CG) (Table 4.3 and Table 4.4). Despite the exiguity of the sample, it is interesting to see how the criteria characteristic of the Levallois method (Boëda, 1994, 1993) have been adapted to the raw materials employed, thus indicating a great knowledge of the petrological and mechanical properties of the raw materials. The shaping of the core is minimized thanks to the choice of pebbles that already have suitable convexities for a Levallois exploitation. The convexity of the striking platform surface is prepared with a maximum of four centripetal detachments where necessary, while part of the surface is natural. No phases of shaping of the knapping surface are visible and the production of predetermined blanks starts with centripetal detachments parallel to the intersection plan between the striking platform and the knapping surface, exploiting the peripheral convexity sketchily prepared. The reduction sequences are short, and all the cores are discarded after just one

phase of exploitation. Levallois products are thin quadrangular flakes, often overflowing for the management of the production sequence and, as for the opportunistic products, their dimensions are strongly influenced by the morphology of the cores (Fig. 4.7-4.8).

The discoid method is attested by 38 flakes and 2 cores (PD) and by 12 flakes and 5 cores (CG), most of them in quartz, syenite and quartzite (Table 4.3 and Table 4.4). The discoid exploitation starts from the natural surfaces of the selected pebbles and the low number of negatives on the dorsal faces of the flakes suggests a short production sequence after which the cores are discarded (Fig. 4.8). The discoid method is employed to produce thick, short and large flakes and no differences in the characteristics of the products are visible depending on the raw material (Fig. 4.7).

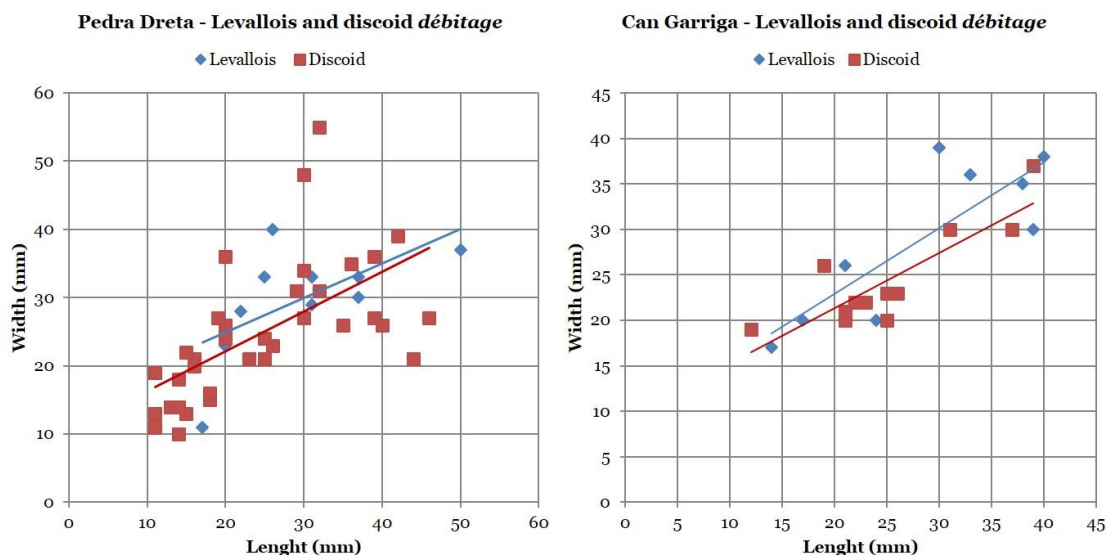


Fig. 4.7. Dimensional analysis of the flakes issued from Levallois and discoid *débitage* in Pedra Dreta (left) and Can Garriga (right), fragmented artefacts are not included.
Analyse dimensionnelle des éclats issus du débitage Levallois et Discoïde dans le sites de Pedra Dreta (gauche) et de Can Garriga (droit), les éclats fragmentés ne sont pas inclus.

Retouch is barely present in both sites: four retouched tools have been identified in PD (2 notches, 1 denticulate and 1 transversal scraper) and 8 flakes are

classifiable as retouch flakes; in CG nine quartz retouched tools are present (3 notches, 3 denticulate, 1 double scraper, 1 lateral scraper and 1 convergent scraper) while the presence of 12 retouch flakes let assume that part of the lithic tools was prepared or reshaped in the site. The scarcity of retouched tools could be explained as an adaptation to the characteristic of the raw materials or we can hypothesize that most of the retouched tools were used and discarded out of the site. We lean towards the first hypothesis since, as already observed in other sites and as tested through experimental activities (Berruti et al., 2016; Berruti and Arzarello, 2012; Clemente-Conte et al., 2017), for these kinds of raw materials the unretouched edges are more efficient than the retouched ones and in addition, due to the presence of inner fracture planes, retouch could cause the breakage of the lithic tools.

Concerning quartz, the subdivision in morphostructural groups (de Lomberra-Hermida et al., 2011; Martinez Cortizas and Llana Rodriguez, 1996) has been applied to understand if there was or not a choice of a certain kind of quartz according to the knapping method (Table 4.5 and Table 4.6). The most employed quartz is that referable to the SN group in CG and to the NS group in PD, while the categories SS and NN are barely represented in both sites. Nevertheless, no significant differences are visible in the choice of certain kind of quartz according to the knapping method, as opportunistic and predetermined methods are applied in both sites on all the most represented morphostructural groups. We just observed that if in PD the difference between the most represented groups, SN and NS, is minimal, in CG the presence of plans seems to have been avoided by the knappers, with a clear preponderance of the SN groups among the others.

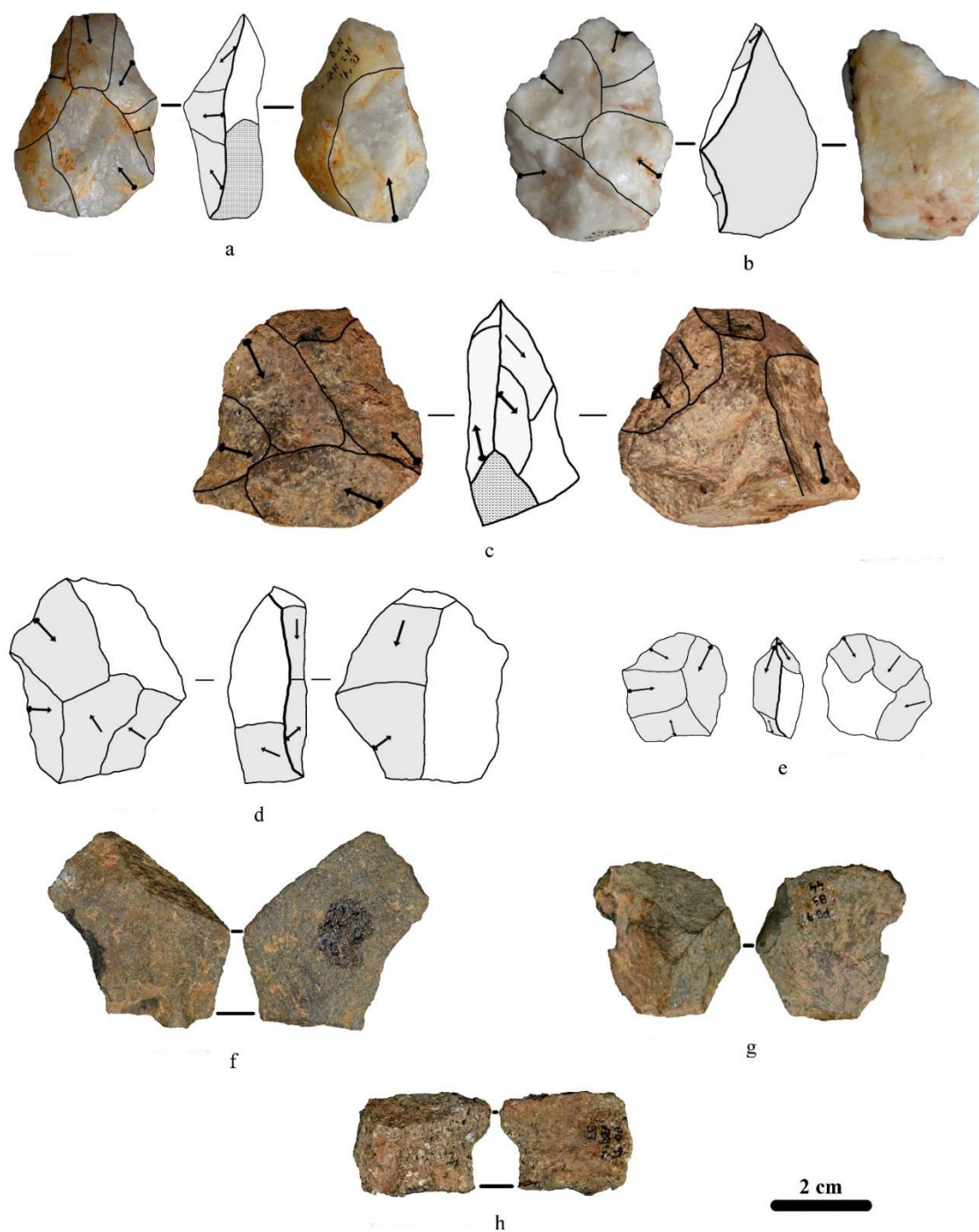


Fig. 4.8. Discoïd and Levallois cores and flakes from Pedra Dreta and Can Garriga. Quartz discoïd cores (a, b, d); quartz Levallois core (e); porphyry Levallois core (c); quartzite, syenite and porphyry discoïd flakes (f, g, h).

Nucl us et  clats disco ides et Levallois de Pedra Dreta et Can Garriga. Nucl us disco ide en quartz (a, b, d) ; nucl us Levallois en quartz (e) ; nucl us Levallois en porphyre (c) ;  clats disco ides en quartzite, sy n ite et porphyre (f, g, h).

Method	Morphostructural groups				
	SS	SN	NS	NN	
Opportunistic/S.S.D.A.	Flakes = 12	Flakes = 92	Flakes = 98	Flakes = 1	
	Cores = 3	Cores = 4	Cores = 6	Cores = -	
	Tot.	15	96	104	1
Discoid	Flakes = -	Flakes = 10	Flakes = 7	Flakes = 1	
	Cores = -	Cores = -	Cores = 2	Cores = -	
	Tot.	-	10	9	1
Levallois	Flakes = 1	Flakes = 4	Flakes = -	Flakes = -	
	Cores = -	Cores = -	Cores = 1	Cores = -	
	Tot.	1	4	1	-
Centripetal déb.	Flakes = -	Flakes = 1	Flakes = 1	Flakes = -	
	Cores = -	Cores = -	Cores = -	Cores = -	
	Tot.	-	1	1	-
Kombewa s.l.	Flakes = -	Flakes = -	Flakes = -	Flakes = -	
	Cores = -	Cores = 1	Cores = -	Cores = -	
	Tot.	-	1	-	-
Indet.	Flakes = -	Flakes = 4	Flakes = 8	Flakes = -	
	Cores = -	Cores = -	Cores = -	Cores = -	
	Tot.	-	4	8	-
Debris	3	18	66	6	
	Total	19	134	189	8
	%	5,4%	38,3%	54,0%	2,3%

Table 4.5. Pedra Dreta. Quartz lithic artefacts grouped by *débitage* method and morphostructural groups (SS = grainy/planes; SN = grainy/no planes; NS = no grainy/planes; NN = no grainy/no planes).
Pedra Dreta. Éclats et nucléus en quartz divisés par méthode de débitage et par groupes morphostructuraux (SS = grains/plans; SN = grains/sans planes; NS = sans grains/plans; NN = sans grains/sans plans).

Method	Morphostructural groups				
	SS	SN	NS	NN	
Opportunistic/S.S.D.A.	Flakes = 6	Flakes = 73	Flakes = 20	Flakes = 1	
	Cores = -	Cores = 1	Cores = 3	Cores = 1	
	Tot.	6	74	23	2
Discoid	Flakes = 1	Flakes = 4	Flakes = 1	Flakes = 1	
	Cores = -	Cores = 1	Cores = 3	Cores = 1	
	Tot.	1	5	4	2
Levallois	Flakes = -	Flakes = 4	Flakes = -	Flakes = -	
	Cores = -	Cores = -	Cores = -	Cores = -	
	Tot.	-	4	-	-
Centripetal déb.	Flakes = -	Flakes = -	Flakes = -	Flakes = -	
	Cores = -	Cores = 1	Cores = 2	Cores = -	
	Tot.	-	1	2	-
Indet.	Flakes = 1	Flakes = 12	Flakes = 2	Flakes = -	
	Cores = -	Cores = -	Cores = -	Cores = -	
	Tot.	1	12	2	-
Debris	3	11	13	5	
	Total	11	107	44	9
	%	6,4%	62,6%	25,7%	5,3%

Table 4.6. Can Garriga. Quartz lithic artefacts grouped by *débitage* method and morphostructural groups (SS = grainy/planes; SN = grainy/no planes; NS = no grainy/planes; NN = no grainy/no planes).
Can Garriga. Éclats et nucléus en quartz divisés par méthode de débitage et par groupes morphostructuraux (SS = grains/plans; SN = grains/sans plans; NS = sans grains/plans; NN = sans grains/no plans).

4.4.2. Use-wear analysis – Experimental collection

The study of the experimental collection led to interesting observations concerning porphyry, that has a reaction to use similar to that of quartzite (Clemente-Conte and Gibaja Bao, 2009; Gibaja et al., 2009, 2002; Igreja, 2009; Lemorini et al., 2014). The experimentation carried out show that the edges of porphyry tools get rounded and broken very quickly, especially when used on hard materials. This is due to the porphyry structure which leads to a rapid detachment of the grains from the matrix. Edge removals are however present and permit to identify the hardness and the direction of the gesture. Micro-traces are identifiable on the quartz crystals (Fig. 4.4), when they are present on the active edges of the tools. In these cases, it is possible to identify of the material worked following the same procedure used for the quartz crystals in quartzite lithic tools (Clemente-Conte and Gibaja Bao, 2009; Gibaja et al., 2002; Igreja, 2009; Lemorini et al., 2014). The crystals of quartz can be identified because they usually have vitreous lustre, colourless or milky\grey with crystalline habitus usually prismatic or massive (Rogers, 1935). The other raw materials analysed show a different pattern. At a low magnification (LPA), the analysis of the edges shows marked and widespread use-wear traces that lead to a rapid dulling of the blanks, thus attesting their lower efficiency compared to flint, chert, quartz and quartzite. The characteristics of the surfaces of these blanks have not allowed any profitable analysis with a metallographic microscope and no diagnostic features for identification and description of micro-polishes could have been detected.

4.4.3. Pedra Dreta

The state of preservation of the assemblage is generally good. Three types of post depositional alterations were found on the lithic artefacts (white patina,

concretion, and edge crumbling) but in all the cases, the development of the alterations is modest or scarce, and did not preclude the use wear analysis. The study of the selected sample allowed to identify 24 artefacts with use-wear traces: 17 of them are made in quartz, 3 in porphyry, 2 in syenite, 1 in quartzite and the last one in hornfels. All of them have only one zone of use (Table 4.7).

Square	N.	Raw Material	Method	Tool	MS group	Action	Hardness	Material
B3-C	69	Quartz	SSDA		SN	T	MS	?
B3-B	46	Porphyry	SSDA		/	L	MH	Bone
B3-C	68	Quartz	SSDA		SN	L	MS	?
B3-C	53	Quartz	Lev.		SN	T	MS	wood
B3-C	71	Quartzite	Disc.		/	Mix	S	Butch.
E4	7	Quartz	Opp.		NS	T	MH	?
A4	19	Quartz	Disc.		SN	L	S	Butch.
A2	2	Quartz	Disc.		SN	T	MS	Hide
A2	2/	Quartz	SSDA		/	L	MS	Butch.
E5	31	Quartz	SSDA	S.S.	SN	T	MH	Butch.
E5	41	Quartz	Centr.		SN	T	MH	Wood
C5	73	Syenite	SSDA		/	L	S	?
B2	2	Quartz	SSDA		SN	L	MS	Butch.
A4	7	Quartz	SSDA		SN	L	MS	Butch.
A3-A	45	Hornfels	SSDA		/	L	MH	?
B2	18	Quartz	SSDA		SN	L	MS	Butch.
C4-A	81	Porphyry	SSDA		/	T	MH	Wood
C4	78	Quartz	SSDA		SN	L	MS	?
D5	27	Quartz	Disc.		NS	L	MH	Bone
D4	43	Porphyry	Lev.		/	L	MS	?
D4	102	Quartz	SSDA	D.	/	T	MS	Hide
D4	72	Quartz	SSDA		SN	T	MS	Butch.
D4	44	Quartz	SSDA		/	MIX	MH	Wood
B5-D	4	Syenite	Disc.		/	L	MS	?

Table 4.7. Pedra Dreta. Use-wear traces identified grouped by action, *débitage* method and worked material. (T = transversal action; L = longitudinal action; Mix = mixed action; MH = medium hard material; H = hard material; MS = medium soft material; S = soft material; Butch. = Butchering activity; S.S. = sidescraper; D. = denticulate).

Pedra Dreta. Traces d'utilisation identifiées, regroupées par geste, méthode de débitage et matière travaillée. (T = geste transversal; L = geste longitudinal; Mix = geste mixte; MH = matière moyennement dur; H = matière dure; MS = matière moyennement tendre; S = matière tendre; Butch. = dépeçage; S.S. = raclage latéral; D. = denticulé).

Traces referable to transversal actions have been recognized on 9 finds and for 8 of them it was possible to identify the worked material (3 wood, 1 dry wood, 2 hide, 1 butchering, 1 bone or antler); in the last case, it was identified only the hardness of the worked material (medium hard). Most part of these artefacts are made of quartz except one (linked to dry wood working activities) that is made of porphyry. Traces referable to longitudinal actions have been recognized on 13 finds and concerning 7 cases it was possible to identify the worked material (5 butchering, 2 bone); in all the other cases, only the hardness of the worked material is known (1 medium hard, 4 medium soft and 1 soft). The artefacts with traces that allowed the identification of the worked material are made on quartz (Fig. 4.9) (5 butchering and 1 bone) and porphyry (1 bone) (Fig. 4.10).

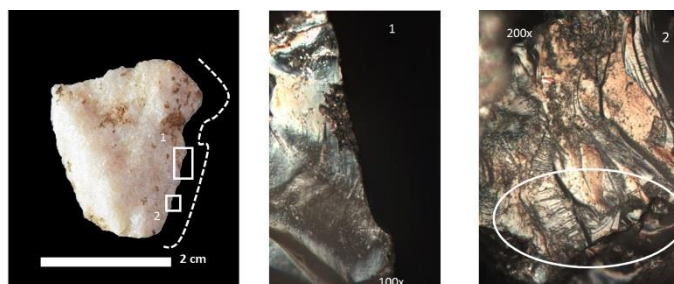


Fig. 4.9. Petra Dreta. Quartz flake (A4 19) with traces interpreted as butchering. (1) striae, micro hole, micro scars; (2) edge rounding (in the circle), polish with rough appearance.
Petra Dreta. Éclat de quartz (A4 19) avec traces d'utilisation interprétées comme dépeçage. (1) stries, micro-trou, micro-écailllements ; (2) arrondissement du bord (cercle), polissage rugueux.

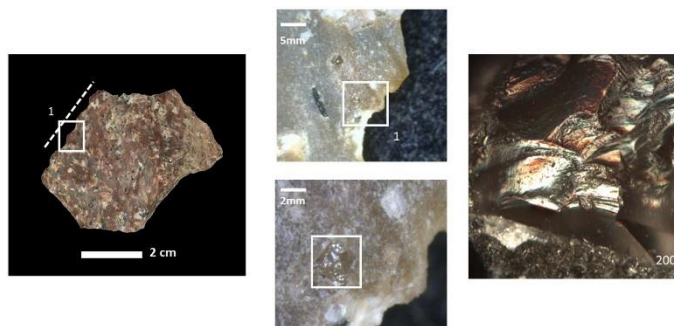


Fig. 4.10. Petra Dreta. Porphyry flake (B3-B 46) with edge removals typical of a longitudinal action, domed polish, micro holes and striae caused by bone working; note the striations oblique to the edge.
Petra Dreta. Éclat de porphyre (B3-B 46) avec écailllements caractéristique d'une action longitudinale, polissage en dôme, micro-trous et strie dus au travail de l'os ; notez les striations obliques au bord.

The other 6 artefacts of this group have traces that allow only the individuation of the hardness of the worked material, and are divided as follows: 1 artefact made in hornfels with traces of medium hard material working; 2 artefacts made in quartz, 1 made in syenite and 1 made in porphyry with traces referable to medium soft material working; 1 artefact made in syenite with traces of soft material working. Traces referable to mixed actions were identified on 2 quartz artefacts and are linked one with the working of soft animal tissue and the other with dry wood working. In the sample of artefacts with traces of use there are only two formal tools both made in quartz, one is a side scraper with traces of a transversal action on bone and the other one is a denticulate with traces of transversal work on hide.

4.4.4. Can Garriga

At the macroscopic level, the state of conservation of the lithic industry of Can Garriga level 1 is generally good and three types of post depositional alterations were found on the lithic artefacts: white patina, concretion and abrasion. The analysis of the selected sample highlighted an elevated presence of widespread abrasion of the surfaces and of the edges of the lithic tools (85% of the considered sample) (Asryan et al., 2014; Mazzucco et al., 2013) (Table 4.8).

Square	N.	Raw Material	Method	Tool	MS group	Action	Hardness	Material
G21	22	Quartz	Discoïd		SN	Mix	MH	Dry bone
K21	10	Quartz	SSDA	N.	SN	T	H	Indet. pol.
G22	1	Porphyry	SSDA		/	L	MS	Fresh wood
K21	5	Quartz	SSDA	S.	SS	T	MH	?
G22	22	Quartz	Levallois	D.	SN	T	MS	Fresh wood
G21	24	Quartz	Opp.	D.	SN	T	MH	Indet. pol.
	R22	Quartz	SSDA		SN	L	MS	Hide
J21	16	Quartz	Discoïd		SN	T	MS/ MH	?
K20	13	Quartz	Levallois		SN	T	MS	Bone

Table 4.8. Can Garriga. Use-wear traces identified grouped by action, *débitage* method and worked material. (T = transversal action; L = longitudinal action; Mix = mixed action; MH = medium hard material; H = hard material; MS = Medium soft material; S = soft material; D. = denticulate; S. = scraper; N. = notch).

Pedra Dreta. Traces d'utilisation identifiées, regroupées par geste, méthode de débitage et matière travaillée. (T = geste transversal; L = geste longitudinal; Mix = geste mixte; MH = matière moyennement dur; H = matière dure; MS = matière moyennement tendre; S = matière tendre; Butch. = dépeçage; S.S. = racloir latéral; D. = denticulé; N. = encoche).

The study of the archaeological sample allowed to identify 9 artefacts with traces of use. Among them, 8 are made in quartz (Fig. 4.11) and 1 in porphyry (Fig. 4.12). All the finds with wear traces have only one zone of use. A transversal action has been recognized on 6 quartz finds and, in 2 of these cases, the worked material (1 wood and 1 dry bone) was identified, while in 2 cases were detected only indeterminate micro-polish on the artefacts edges but it was possible to identify the hardness of the worked material (middle hard and hard). In the last two cases, only the hardness of the worked material (medium hard) is known. A longitudinal action has been recognized on 2 finds, one made in quartz and one made in porphyry and in both cases, it was possible to identify the worked material (1 fresh wood, 1 hide). Mixed actions were identified on 1 quartz artefacts and they are linked to dry bone working.

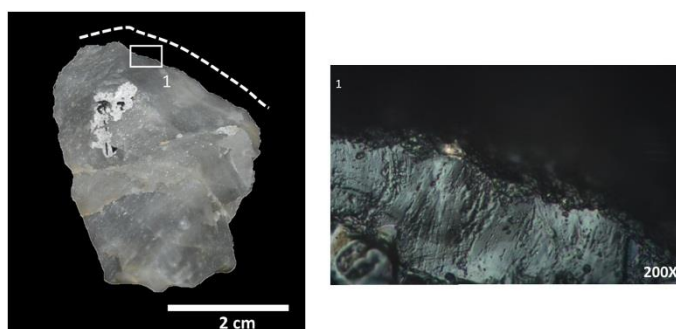


Fig. 4.11. Can Garriga. Quartz flake (G21 22). Troughs and sleeks oriented perpendicularly to the edge. In line with the edge, deep surface cracks and micro holes typical of bone working.
Can Garriga, éclat de quartz (G21 22). Dépressions et lissages orientés perpendiculairement au bord. Parallèles au bord, des fissurations de la surface et des micro trous typiques du travail de l'os.

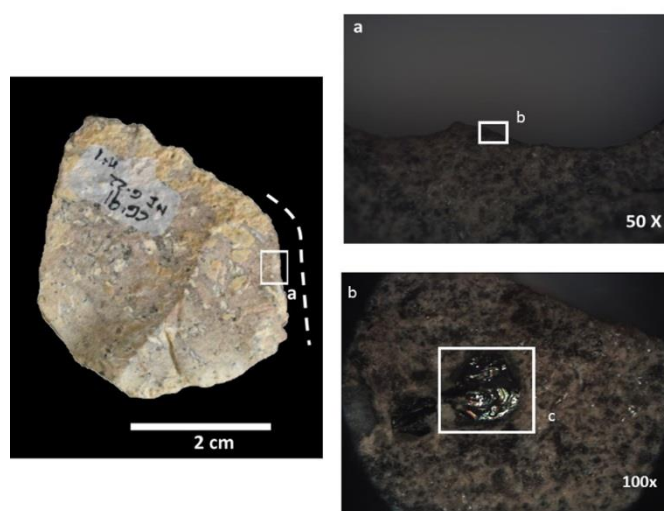


Fig. 4.12. Can Garriga, porphyry flake (G22 1). a) edge removal typical of a longitudinal action; b) quartz crystal near the edge; c) detail of the quartz crystal with traces of woodworking.
Can Garriga, éclat de porphyre (G22 1). a) écailllements caractéristiques d'une action longitudinale ; b) cristal de quartz sur le bord de l'éclat ; c) détail du cristal de quartz avec des traces de travail du bois.

4.5. Discussion

The technological analysis of the lithic assemblages from Pedra Dreta and Can Garriga permits on one hand to observe Neanderthals capabilities in adapting their technology to the available raw materials, on the other to make some considerations about the criteria traditionally defining Levallois and discoid technologies (Boëda, 1994, 1993).

If we look at these two assemblages, their main feature is the dominant opportunistic component of the *chaînes opératoires* (Table 4.3 and Table 4.4), starting from the choice of the raw materials, strongly affected by the local environment, with the collection of fluvial pebbles in the proximity of the sites and within which quartz was the most suitable one. As shown, the knapping sequences are short and characterized by uni- or multidirectional exploitation strategies (S.S.D.A.) (Forestier, 1993). Opportunistic reduction sequences are the easiest and most simple way to obtain tools with sharp edges, especially if the quality of the raw materials is low; for this reason several Middle Palaeolithic lithic assemblages where low quality raw materials are prevailing show as a common characteristic the preponderance of opportunistic knapping sequences (e.g. Berruti and Cura, 2016; Carbonell et al., 2005; Cologne et al., 2009; Daffara et al., 2014; de Lombera-Hermida et al., 2011; Lazuén et al., 2011; Menras, 2009; Modica and Bonjean, 2009; Tuffreau et al., 2009). The use of opportunistic methods on this kind of raw materials also helps in avoiding knapping accidents due to the presence of impurities or cleavages, even if the rate of fragmentation remains high (Cologne and Mourre, 2006; Mourre, 1996; Tallavaara et al., 2010). Nevertheless, Levallois and discoid technologies are often applied on these raw materials, even in contexts where they are not predominant (e.g. Matilla, 2010; Moncel et al., 2014, 2008; Moncel and Lhomme, 2007; Ortega and Maroto, 2001; Santagata et al., 2017; Thiébaud et al., 2012).

When lithic assemblages with raw materials other than flint are considered, it is quite difficult to analyze the discoid/Levallois component, since, beside the traditional criteria proposed by Boëda (1994, 1993), we have to take into account how the Levallois or the discoid concept were adapted to the constraints of the raw material. In Pedra Dreta and Can Garriga the discoid exploitation starts

directly from the natural surface of the selected pebble (Fig. 4.8), as testified by natural butts and by the presence of neocortex on the upper faces of the products. The aim of these knapping sequences are short and large centripetal flakes, but a clear standardization of the products is not visible. The Levallois method is present just in the recurrent centripetal modality and even in this case the shaping of the core is minimal. Two issues then arise: 1. Which criteria should we adopt to distinguish between discoid and recurrent centripetal Levallois products? and 2. Is it possible that the Levallois products are the result rather of the opportunistic and expedient reduction sequences that are dominant in these assemblages than of a real use of the Levallois method?

The problem of the distinction between recurrent centripetal Levallois and discoid has been longer debated (e.g. Boëda, 1993; Mourre, 2006, 2003; Picin and Vaquero, 2016; Vaquero and Carbonell, 2003) as well as the factors that led to the adoption of one method rather than another (Brenet et al., 2013, 2009; Mourre, 2003; Picin et al., 2014; Picin and Vaquero, 2016; Slimack, 2003; Vaquero et al., 2012) but if several observation and analysis have been done concerning chert assemblages, a lack concerning all the other raw materials is evident. In PD and CG, quartz, quartzite, or porphyry cores are not shaped before the phase of *plein débitage* so the characteristics of the butts, prepared/not prepared, are not considerable as distinctive features. So, considering the characteristics of the lithic assemblages analyzed, the main criteria that we can apply for the distinction of the recurrent centripetal Levallois products from the discoid ones is related to the direction of the *débitage*, parallel to the intersection of the core surfaces for the Levallois, secant for the discoid (Boëda, 1993). Another criterion is based on the general morphology of the products, shorter and thicker for the discoid, elongated and thin for the Levallois method (Boëda, 1993;

Eren and Lycett, 2012; Kuhn, 1994; Lemorini et al., 2003; Picin and Vaquero, 2016). Even concerning cores, when the exploitation of the surfaces is minimal it is not possible to distinguish between discoid and recurrent centripetal Levallois cores and we preferred to refer this kind of artefacts to a general centripetal *débitage*. After the observation of the considered lithic assemblages and the comparison with other contexts where low quality raw materials are dominant (i.e. Daffara et al., 2014), it seems that in these cases the “grey zone” between discoid and recurrent centripetal Levallois is wider than traditionally observed in chert assemblages (Mourre, 2003), since some parts of the reduction sequences (shaping of the cores, preparation of the convexities) considered to be diagnostic for the distinction between the two methods are lacking or barely present.

Another interesting issue arose from the technological analysis concerns the real existence or not of predetermined knapping sequences (recurrent centripetal Levallois) in a context where the opportunistic behavior is dominant. As shown before, especially concerning flakes, when butts are not prepared and when no products linked to core shaping and management are present, we have just a few elements for the identification of the recurrent centripetal Levallois. In a context of markedly expedient behavior it is realistic to imagine that the unifacial centripetal exploitation of a pebble could give results like those of recurrent centripetal Levallois.

Levallois is a concept that, as defined by Boëda (1994), relies on six criteria concerning core geometry, direction of the flaking axis and of the detachment plane. Boëda (1994) and several other studies (Bar-Yosef and Van Peer, 2009; Boëda et al., 1990; Chazan, 1997; Di Modica and Bonjean, 2009; Dibble and Bar-Yosef, 1995; Eren et al., 2011; Eren and Bradley, 2009; Eren and Lycett, 2012; Fontana et al., 2013; Holdaway and Douglass, 2012; Lycett and Eren, 2013;

Menras, 2009; Peresani, 2011, 2001, Sandgathe, 2006, 2004; Schlanger, 1996; Shimelmitz et al., 2016; Shimelmitz and Kuhn, 2017; Van Peer, 1992; Walker et al., 2013) recognize a great variability within the Levallois concept and even the significance of some of the six criteria is not considered to be distinctive when we have to distinguish between the recurrent centripetal modality and the discoid method (Peresani, 2003). In PD, just three Levallois cores are present but some observations can be made concerning core geometry: both the surfaces are convex but one (the knapping surface) is less convex than the other (striking platform); the two surfaces are hierarchized; the detachment plane is parallel to the intersection between the two surfaces; the convexity of the striking platform is roughly prepared. So, even if the exploitation of these cores is clearly expedient considering in particular the choice of pebbles with suitable morphologies, it is equally evident that the Levallois concept is well present in the knappers' mind, as already observed in Scladina cave, where a unifacial *débitage* is considered to be a much expanded version of Levallois (Di Modica and Bonjean, 2009). A small part of the lithic assemblages can then be referred to a predetermined way of flake production even if part of these *chaînes opératoires* stays within the general expedient behavior that characterize both the sites.

In Pedra Dreta, the exploitation of animal carcasses is the most represented activity with 11 different finds (with traces referable to: butchering, fresh bone and fresh hide working); the presence of woodworking is testified by 4 finds (with traces referable to: dry wood and fresh wood or non-woody plants) (Table 4.7). The presence of these activities, with this proportion, falls in the normal scenery of the Middle Palaeolithic sites (e.g. Berruti and Arzarello, 2012; Lemorini, 2000; Martínez et al., 2005). The presence of woodworking activities, not prevalent throughout the lithic assemblage is well documented in many sites, (e.g.

Lemorini, 2000; Martínez et al., 2005) and it can be explained with the necessity of sharpening spears or manufacturing other wooden tools. As shown in Table 4.7, the animal carcasses processing includes different phases: butchering, work of fresh and dry hide, bone and soft animal tissue working. In the group of artefacts classified as butchering tools are placed artefacts with traces of contact with fleshy tissues in association with traces of contact with bone or fresh hide that are linked to activities such as skinning, evisceration, disarticulation and defleshing of carcasses (Lemorini et al., 2006). The traces referable to transversal work on bone can be related to periosteum removal for the extraction of marrow (Grayson, 1984; Longo, 1994). The results of the use wear analysis allow to hypothesize the site function. The presence of only two groups of activities suggests a specialization of the site and the high presence of traces principally linked to the exploitation of animal carcasses supports the interpretation of the site as a hunting or killing camp (Stiner, 2013). Despite the spatial relationship between the finds had been lost due to the construction of medieval routes (Canal and Carbonell, 1989; Rodriguez et al., 1995), the density of the instruments with traces of exploitation of animal carcasses in squares B3, B2, A4, A2, does not follow the general density of the lithic artefacts of Pedra Dreta. This can suggest the presence of a specialized butchering area not destroyed during the construction of medieval route.

The analysis of the morpho-structural groups of quartz, shows that the group SN is the most present in the assemblage but, as for Can Garriga, this data is consistent with the percentage of the lithic industry made with this morpho-structural group.

On the edges of the lithic artefacts of level 1 of Can Garriga were found traces linked with different activities: wood, hide and bone working, while butchering

activities have not been identified (Table 4.8). The presence of these activities falls in the normal scenery of activities carried out in Middle Palaeolithic sites (Stiner, 2013). The presence of woodworking activities, although usually scarce, is documented in many sites, as well as the processing of bone and hide (e.g. Berruti and Arzarello, 2012; Lemorini, 2000; Martínez et al., 2005). In all these sites, the tools with traces of these activities are accompanied by other tools with traces linked to butchering. The absence of butchering traces in Can Garriga can be explained through the difficult "registration" of these traces on quartz and quartzite tools, as asserted by some scholars (Clemente-Conte and Gibaja Bao, 2009; Gibaja et al., 2002). These traces are so labile and may have suffered a process of removal or of overlay due to the post-depositional alterations recorded in the sample (Venditti et al., 2016). The same post depositional alteration have probably destroyed most part of the faunal remains (Rodriguez, 2004). Anyway, it is possible to deduce the presence of this type of activities thanks to the presence of traces linked to other animal carcass processing activities, as bone and hide working. Especially, the traces referable to transversal work on bone can be related to periosteum removal for the extraction of marrow (Grayson, 1984; Hardy, 2004; Longo, 1994). This conclusion is also supported by the presence, in level 1, of several large sized cobbles with scars that testify that they were used like anvils, probably employed to break up the bones after the periosteum removal (Rodriguez, 2004; Rodriguez et al., 1995). However, analyzed as a whole, including the traces of indeterminable materials, the use wear traces found on the edges of the lithic tools of Can Garriga seem to indicate that the site was specialized in the manufacturing of materials with a high or medium high hardness, comparable with bone working (Odell, 1981). Unfortunately, the small number of finds with use wear traces makes impossible to put in relation the use

wear analysis results with the technological and morphological features of the lithic industry.

4.6. Conclusions

The lithic assemblages from PD and CG show that the Neanderthal groups living in the area, during OIS 5, adopted expedient technological behaviors as adaptation to the raw materials present close to the site. This adaptation is clearly visible in the shortness of the reduction sequences and in the great predominance of opportunistic/S.S.D.A. knapping sequences. Even when predetermined knapping methods are employed (recurrent centripetal Levallois, discoid), the general behavior is expedient since just pebbles with suitable convexities are chosen to minimize or avoid the shaping of the cores. Nevertheless the exploitation of these cores follows the general criteria proper of the Levallois and the discoid methods (Boëda, 1993), thus underlining that even in a clearly opportunistic context these concepts were part of the technological expertise of these groups.

The results of the use wear analysis can be used to hypothesize the function of the site. The predominance of activities linked to the animal carcass processing, suggests the interpretation of Pedra Dreta as a specialized settlement, linked to hunting activities, probably a hunting or killing camp where the preys were slaughtered to transport meat to the base camps (Stiner, 2013). Furthermore, the site is probably the result of one or of a series of ephemeral occupations. This hypothesis is consistent with previous studies and with the results of the technological analysis, which came at the same conclusions observing the shortness and the incompleteness of the *chaînes opératoires* (Canal and Carbonell, 1989; Rodriguez et al., 1995).

Concerning Can Garriga, the presence of different type of activities on different materials, especially bone and hide, and despite the absence of traces of meat processing, suggests the interpretation of the site as a specialized settlement, linked to animal carcass processing (Stiner, 2013), probably linked to the early stages of butchering, especially because marrow is one of the more perishable products of carcasses processing (Hurcombe, 2014). This hypothesis is consistent with previous studies which highlighted a spatial organization of the area and the presence of stone anvils used to break bones (E. Carbonell et al., 1992; Giralt et al., 1995; Rodríguez et al., 2004).

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CHAPTER 5

Payre – Level D

CHAPTER 5

PAYRE – LEVEL D

The Middle Palaeolithic site of Payre is located on the right edge of the middle Rhône valley (Fig. 5.1) and it represents one of the rare archaeological contexts dated between the end of OIS 8 and the beginning of OIS 5 in the area (Moncel, 1993; Moncel et al., 2008a, 2002; Moncel and Chacon, 2007; Valladas et al., 2008).

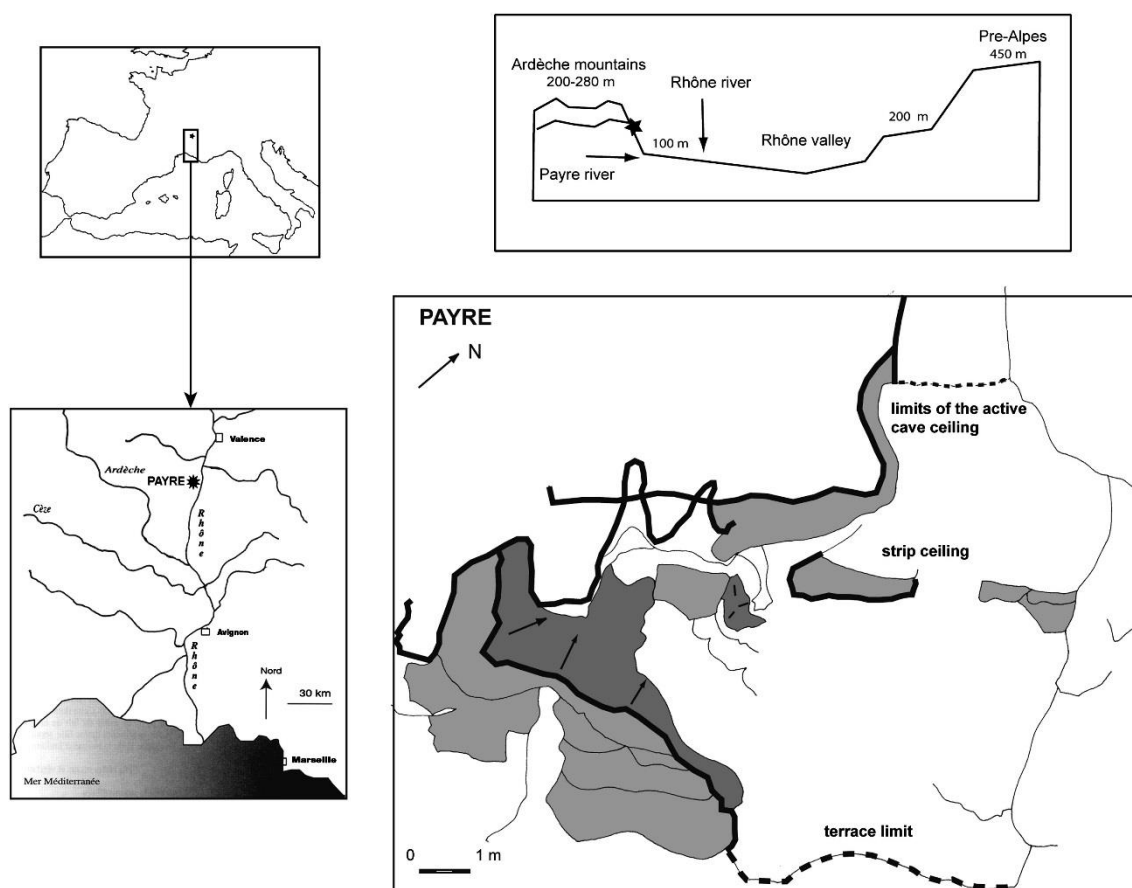


Fig. 5.1 Geographical location of Payre on a plateau in the middle Rhône valley. Grey=limestone; dark grey=stalagmitic floor; black line=limits of the cave (Moncel et al., 2009)

The cave is part of an active karstic system, it opens to south-east, on a cliff 60 m above the Payre river, close to a plateau, and since 1990 till 2002 systematic excavations took place in the site, leading to the identification of different levels

of human occupation, associated to a huge assemblage of lithic artefacts, fauna and some human remains (Baena et al., 2017; Bouteaux et al., 2008; Carmignani et al., 2017; Ecker et al., 2013; Hardy and Moncel, 2011; Moncel et al., 2008a, 2008b, 2002, 1993; Moncel, 1993; Moncel et al., 2009; Moncel and Chacon, 2007; Moncel and Condemi, 1997, 1996; Rivals et al., 2009; Rufà et al., 2016; Valladas et al., 2008). The position of the site, in a convergence of different environments, made it a strategic point for the exploitation of different ecosystems despite the changing morphology of the cave that, at the end of OIS 6, mainly collapsed, thus becoming a rock shelter (Ecker et al., 2013; Moncel et al., 2008a, 2002, 1993; Moncel and Chacon, 2007; Rivals et al., 2009).

The lithic assemblage from level D has already been subject to different analysis (Bouteaux et al., 2008; de Lomberra-Hermida et al., 2011; Hardy and Moncel, 2011; Moncel et al., 2009, 2008b; Moncel and Chacon, 2007), it is characterized by the exploitation of different raw materials and dominated by opportunistic and discoid reduction sequences. The present study focuses on the discoid component of Payre – level D lithic assemblage since it gives the chance to observe how the concept of discoid *débitage* was applied and adapted to the characteristics of the different raw materials.

5.1. Geomorphological setting

Payre belongs to a karstic complex of the Jurassic and Cretaceous formations which covers a large part of the right bank of the middle Rhône valley (Debard, 1988) and it is located on the edge of a limestone plateau which represents one of the western borders of the Rhône valley (Fig. 5.1) (Moncel et al., 2002). The site is on the limit of two geological formations: the Tithonian-Portlandian formation, which represents the top of the cliff and the Grads plateau above the site, and the

upper Kimmerdgian formation visible at the bottom of the slope. By tectonic faults, north to the Grads plateau, are visible volcanic and metamorphic grounds and in the area are also present evidences of Tertiary volcanism, like Miocene basaltic flows (Moncel et al., 2002).

Oriented to south-east, the Payre site is located 60 m above a small river, the Payre, just a few kilometers from its confluence with the Rhône. This river is part of a fluvial system, oriented west-east from the foothills of the Massif Central to the Rhône valley. The Payre valley enlarges near the site, before its confluence with the Rhône and after a canyon more than 2 km long. The cliff where the archaeological site is located has stepped slopes, consisting in limestone banks, more frequent towards the top of the cliff, and it is in this part that the karstic system of Payre develops (Moncel et al., 2002). Several cavities and rock shelters are present all along the Payre canyon, but due to the exploitation of the slopes through quarrying activities, it is impossible to know which topography the Neanderthals found and how they have had accessed the cave (Moncel et al., 2002). The karstic complex to which the Payre site belongs is made of two caves and three fissures, articulated around a huge limestone terrace that occupies an area of about 180 m². A cave and a fissure open in this terrace and at first, they were considered to be two different sites (Payre II and Payre I respectively) (Fig. 5.2) but geological studies indicate that the cave, composed by two chambers with a narrow entrance, became a rock shelter after erosion on the valley side caused a roof collapse. Therefore, Payre I and Payre II are now considered as a single site (Moncel et al., 2002; Valladas et al., 2008).

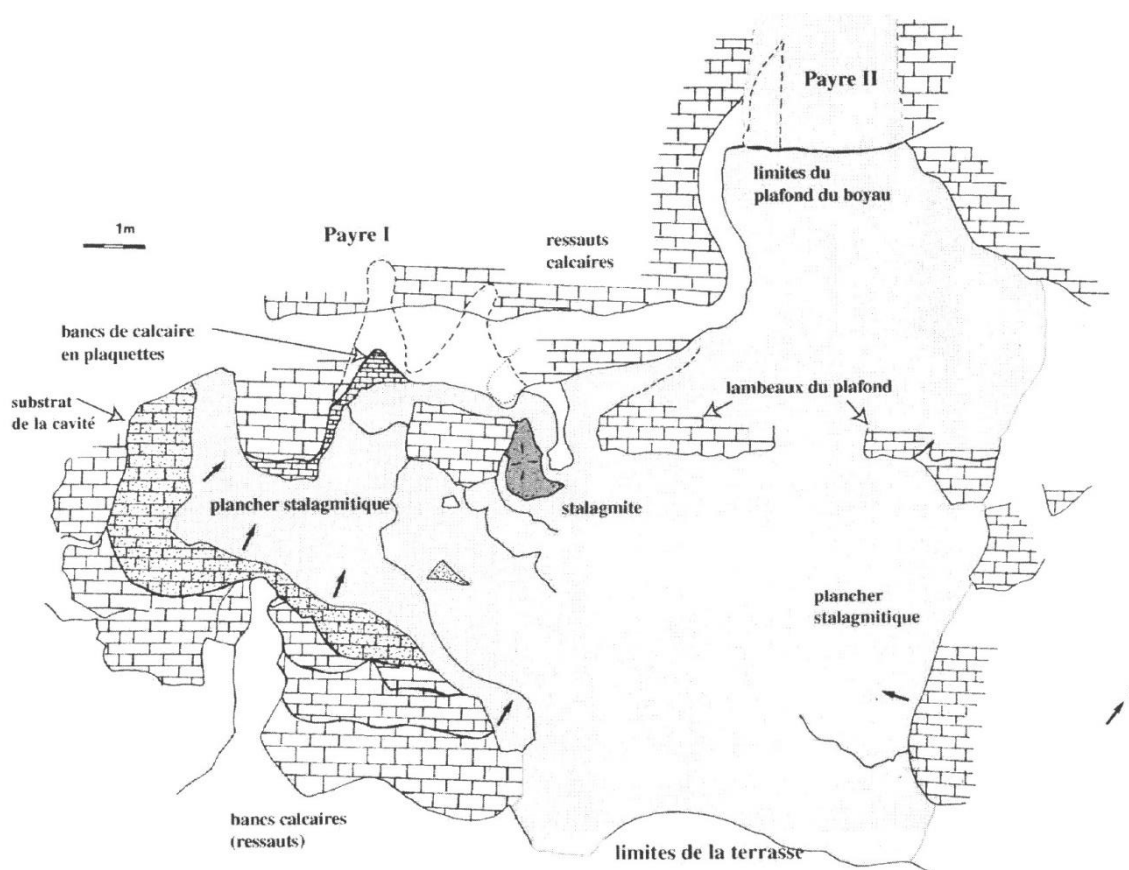


Fig. 5.2. Plan of the Payre site (Moncel et al., 2002)

5.2. Archaeological excavations, stratigraphy and chronology

The archaeological interest of the Payre area is known since 1950 when some test pits were opened in the western part of the terrace by J. Combier, E. Beaux, M. Sierra-Salvado and L. Taupenas who identified an archaeological level with lithic industries and a huge faunal assemblage (Combier, 1977, 1972, 1967, 1957; Moncel et al., 2002; Moncel and Chacon, 2007).

In 1990 systematic excavations started in the area, at first concentrated in Payre II and subsequently extended towards Payre I (Fig. 5.2). The investigation of the area led to a precise understanding of the sedimentation dynamics and of the site formation processes, exposing a 5 m thick stratigraphic sequence divided, from the bottom to the top, in five units (G, F, E, D-C and A-B), each of them including

some sub-layers (Moncel et al., 2008a, 2002; Moncel and Chacon, 2007; Rivals et al., 2009; Valladas et al., 2008) (Fig. 5.3).

At the bottom of the sequence are the remnants of the stalagmitic floor (H7-H2), deposited on both sides of the cave on the limestone substratum and dated by ESR and TIMS to OIS 8-7 (Valladas et al., 2008). The overlaying level G, composed of orange clays with pebbles and blocks, lies on the stalagmitic floors in the Eastern part of the site and directly on the substratum in the center of the site. The top portion of the sediment is eroded and partially brecciated. It contains two main occupation phases, yielding most of the human remains (eight teeth and a fragment of a left parietal bone) all scattered on a small area and concentrated in a unique layer. They belong to three or four Neanderthal individuals, from both children and adults (Moncel and Condemi, 1997, 1996). This deposit is dated to MIS 8-7 by U/Th, ESR and TL dating processed on bones and teeth (Masaoudi et al., 1997; Valladas et al., 2008). Level F corresponds to seven cyclic deposits of grey sediment and beds of rubble and clay. It contains four human occupations alternating with cave bear occupations. The U/Th, ESR and TL dates indicate that it belongs to MIS 8-7. The subsequent Level E corresponds to the collapse of the cave roof and to the enlarging of the cave entrance at the beginning of MIS 5 (U/Th and ESR dating) and it is rich in stones and large blocks. After the collapse of the cave ceiling, the covered surface tended to reduce progressively and the last human occupations (Level D and C) took place in open air within sheltered area during OIS 5 (U/Th and ESR dating). Layers B and A are composed of sediments from the active karst and do not contain any archaeological remains. In general, the stratigraphic sequence of Payre is characterized by the alternation between sedimentation layers and

erosional phases, probably linked to the collapse of the cave ceiling (Moncel and Chacón, 2007; Valladas et al., 2008).

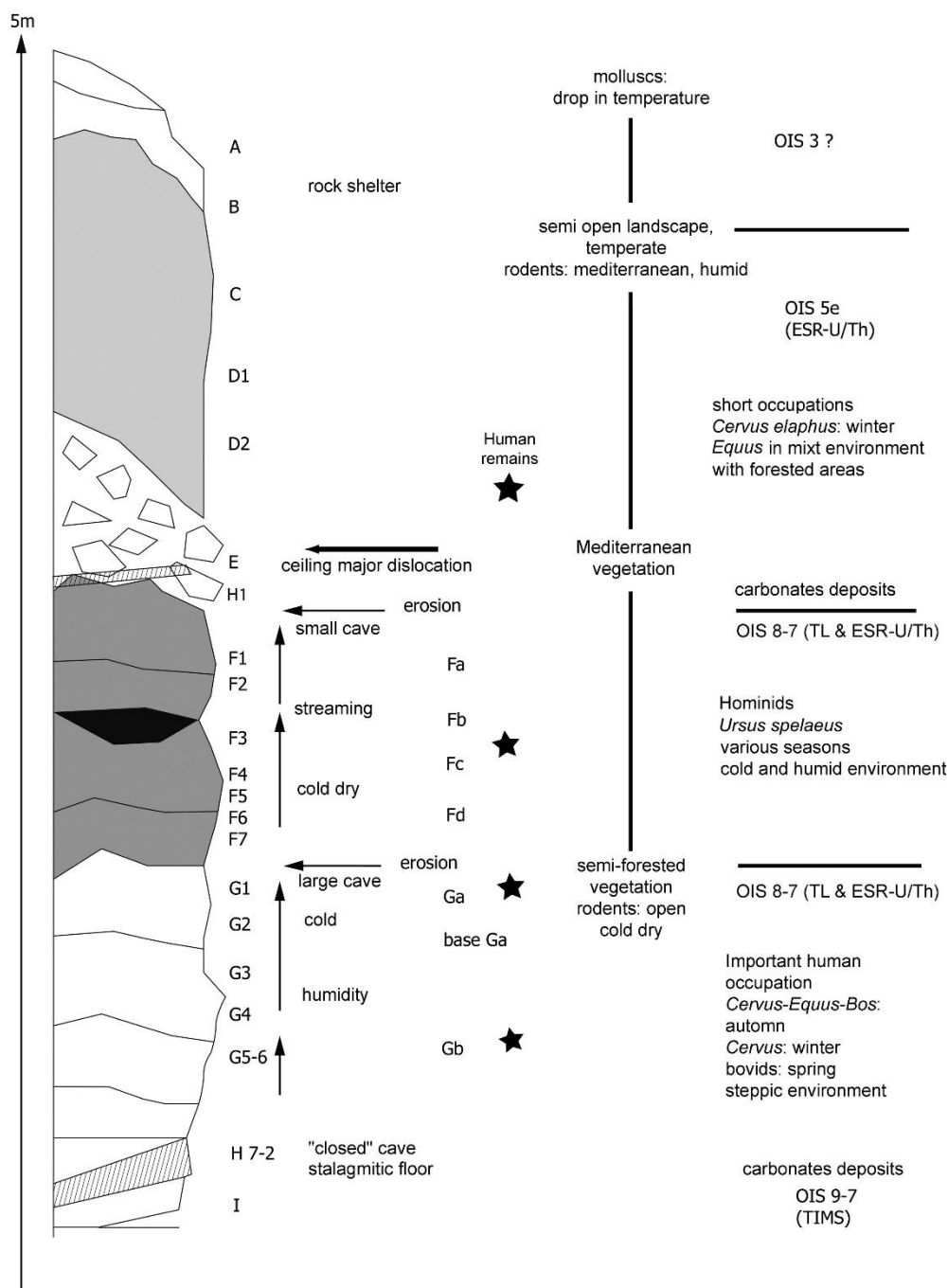


Fig. 5.3. Payre stratigraphic sequence with indication of the levels of human occupation, chronology and paleoenvironmental data (Rivals et al., 2009).

5.3 Paleoenvironmental reconstruction and human occupation dynamics

The paleoenvironmental reconstruction of the different phases of human occupation of the Payre site is the results of several studies on the faunal remains, on the micromammals assemblage and of biochemical and pollinic analysis that suggest an environment composed of highly developed forestal areas and open spaces which favoured a great diversity of taxa in several ecological compartments (Kalai et al., 2001; Moncel et al., 2008a, 2002; Moncel and Chacon, 2007; Rivals et al., 2009; Rufà et al., 2016).

The data obtained indicate that the three main occupation levels (units G, F and D) correspond to temperate and humid interstadial phases (Fig. 5.3) with some differences in the composition of the faunal assemblage between levels (Moncel et al., 2008a, 2002; Moncel and Chacon, 2007), all dominated by herbivore species. The mammal species are: *Dicerorhinus hemitoechus*, *Stephanoinus kirchbergensis*, *Equus cf. mosbachensis*, *Bos primigenius*, *Bison* sp., *Cervus elaphus* sp., *Capreoleus capreoleus* sp., *Megaloceros* sp., *Capra ibex*, cf. *Hemitragus* sp., *Rupicapra* sp., *Sus scrofa* sp., *Ursus deningeri-spelaeus*, *Ursus arctos*, *Canis lupus* sp., *Vulpes vulpes*, *Panthera* (Leo), *Panthera pardus*, *Crocota crocota* sp., *Meles meles*, *Martes martes*, *Castor fiber*, *Lepus* sp., and unspecified herbivores (*Elephas*). Macro-fauna and avian remains suggest a temperate climate with a rather open and rocky landscape (Moncel, 2008; Moncel et al., 2008a, 2002; Moncel and Chacon, 2007; Rivals et al., 2009).

In the sequence were found twenty-three micro mammals species. Looking in particular at Unit D, the micromammals association (*Pliomys lenky*, *Microtus brecciensis* (*Iberomys*), *Arvicola terrestris* and *Arvicola sapidus*) indicates an open humid environment corresponding to the end of the Middle Pleistocene and

the beginning of the Upper Pleistocene (Moncel, 2008; Moncel et al., 2002; Rivals et al., 2009).

All the biostratigraphic data set that the base of the sequence deposited in a temperate period, drier in level G than in level F, while level D deposited during a milder climatic phase. According to pollen analysis, this unit has to be assigned to a sub-stage of MIS 5, probably MIS 5d (Kalai et al., 2001; Moncel et al., 2008a; Moncel and Chacon, 2007).

Faunal and zooarchaeological studies indicate that human occupations alternated with carnivores and they were more intense at the lower levels, as attested by the evidence of human modifications on bones (cut marks, burnt bones, etc.) and of abundant lithic industries and hearths (level Ga) (Rivals et al., 2009; Rufà et al., 2016). In all levels, the Neanderthal subsistence strategies were based upon the hunting of bovids (*Bos primigenius* and *Hemitragus bonali*), cervids (*Cervus elaphus* and *Capreolus capreolus*) and *Equus ferus* and the scavenging of rhinoceros and elephant (Bouteaux, 2003; Moncel et al., 2008a, 2002, 1993; Moncel and Patou-Mathis, 2008; Rivals et al., 2009). Seasonality was assessed for each level through zooarchaeological studies (Moncel and Patou-Mathis, 2008): in level G, were hunted equids, cervids and bovines even if equids were not hunted in summer and cervids and bovines not in winter; in level F, hunting of bovines and equids, according to the age-at-death estimated, took place from summer to autumn; in level D, *Cervus elaphus* was hunted during winter combined with an opportunistic predation of other herbivores (Bouteaux, 2003; Moncel, 1997; Moncel et al., 2002; Moncel and Chacon, 2007). G and F seem to correspond to short or annual occupations focused on the hunting of different species in various environment, while level D probably correspond to a specialized hunting on *Cervus elaphus* (Moncel, 2008; Moncel et al., 2008a;

Moncel and Patou-Mathis, 2008). The study conducted by Rivals et al. (2009) concerning dental wear analysis led to a more precise definition of the seasonality bringing some evidence on the relative duration of occupations. According to these analysis, level G is the one where human impact on the faunal assemblage is stronger, thus suggesting repeated seasonal human settlement in the cave in relation to game availability; level F correspond to short settlements during the warm season; level D would represent longer occupations, while humans inhabited shelters at that time (Moncel and Patou-Mathis, 2008; Rivals et al., 2009; Rufà et al., 2016). Probably, the changing morphology of the cave, just a rock shelter during the deposition of level D, influenced the modalities and the frequency of human settlement in the cave (Rivals et al., 2009; Rufà et al., 2016): the smaller morphology of the cave after the collapse of the ceiling during the deposition of level F is considered to be one of the factor determining a better environment for the establishment of carnivore dens, thus accentuating the sporadic character of human occupation (Rufà et al., 2016).

5.4. The lithic assemblage of Payre level D

The lithic assemblage of Payre level D is composed by 3044 artefacts made of different kind of raw materials (flint – 77,8%, basalt - 11,6%, quartz – 8,2%, quartzite – 1,5%, limestone – 0,8%, others – 0,6%) gathered on the plateaus and along the sides of the valley southwards and eastwards around the site (Moncel and Chacon, 2007). Quartz, basalt and limestone pebbles (grey, black, marly or siliceous) were collected downhill in the Payre river while quartzite and flint pebbles are from the Rhône valley, less than 1 km from the site. Most of the flint knapped in level D was however collected in nodules from the plateau located 10 km south, in Barremian/Bedoulian formations, while a small number of flint

nodules is from the Tithonian-Portlandian limestone of the cave (Moncel and Chacon, 2007).

Many of the raw material was introduced in the site as whole or tested pebbles/nodules. Just basalt, quartzite, limestone and rarely quartz were occasionally introduced in the form of big flakes (Bouteaux et al., 2008; Moncel and Chacon, 2007).

Concerning basalt and local/semi-local flint, the *châines opératoires* are complete but as flint was mainly knapped for the production of different kind of flakes, often retouched to obtain mainly scrapers and convergent tools (Fig. 5.4), basalt was sometimes shaped into choppers with some pebbles used as hammers (Fig. 5.5) (Bouteaux et al., 2008; Moncel et al., 2009; Moncel and Chacon, 2007). Quartzite is found in the site as unretouched flakes, originated from shaping or rejuvenation of unifacial tools on large cortical flakes produced out of the site through simple *débitage* methods (Fig. 5.6) (Bouteaux et al., 2008; Moncel et al., 2008b; Moncel and Chacon, 2007).

Limestone flakes were obtained from either knapping large pebble or shaping, which took place outside the excavated area (Fig. 5.7) (Bouteaux et al., 2008; Moncel and Chacon, 2007).

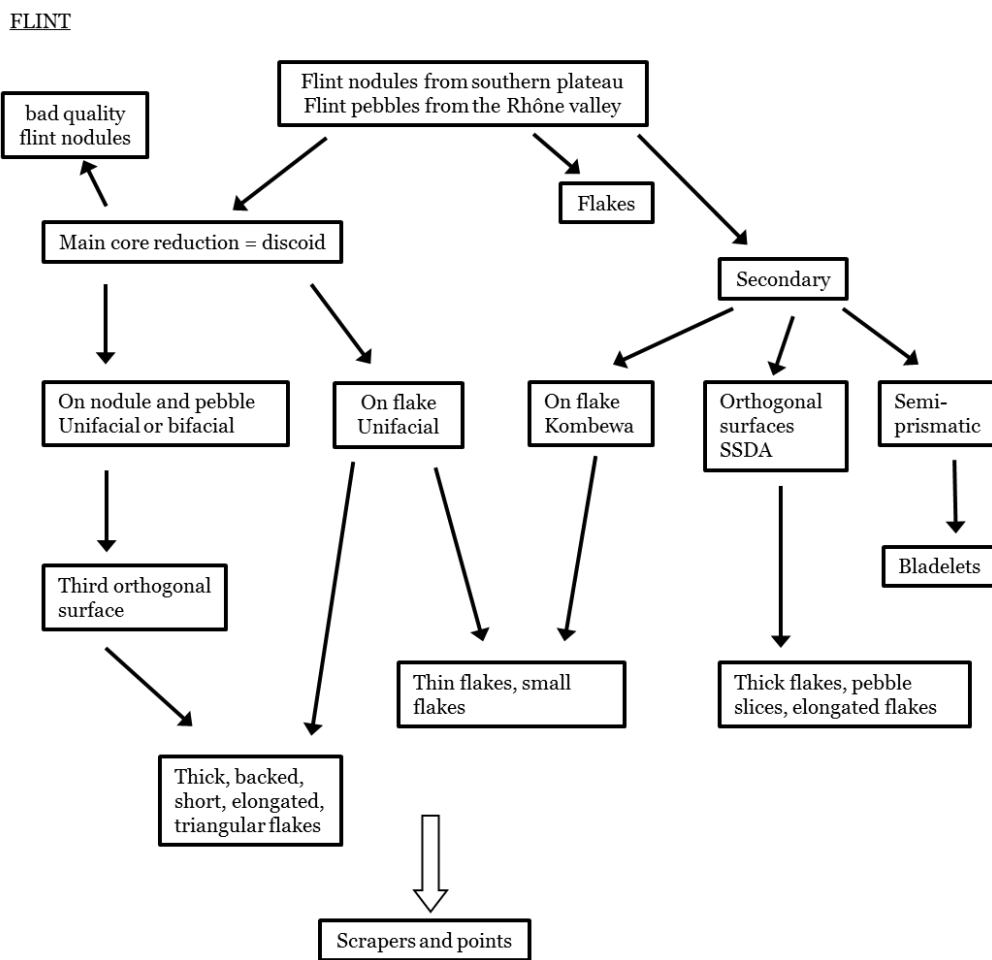


Fig. 5.4. Payre – Level D. Processing system of flint (modified from Moncel and Chacon, 2007)

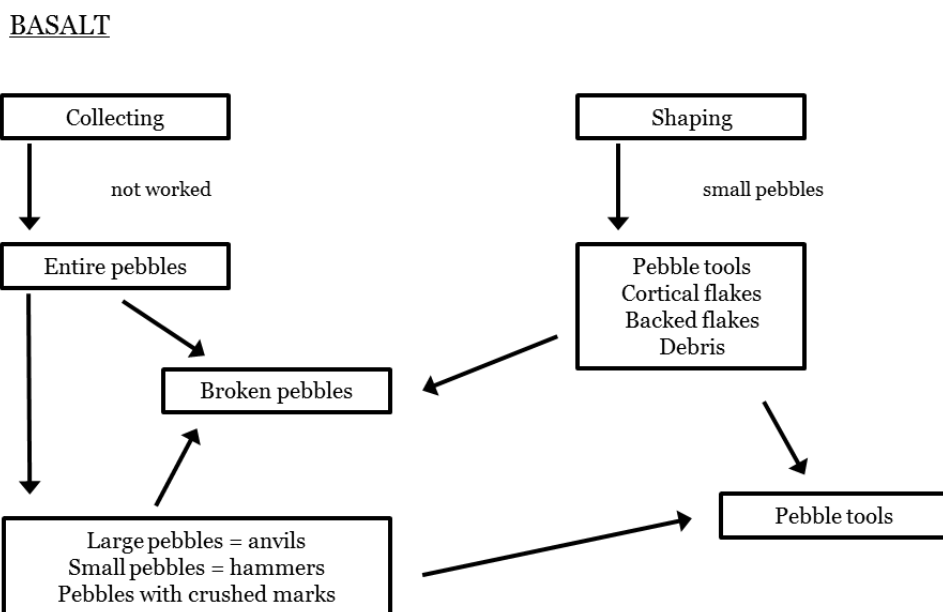


Fig. 5.5. Payre – Level D. Processing system of basalt (modified from Moncel and Chacon, 2007)

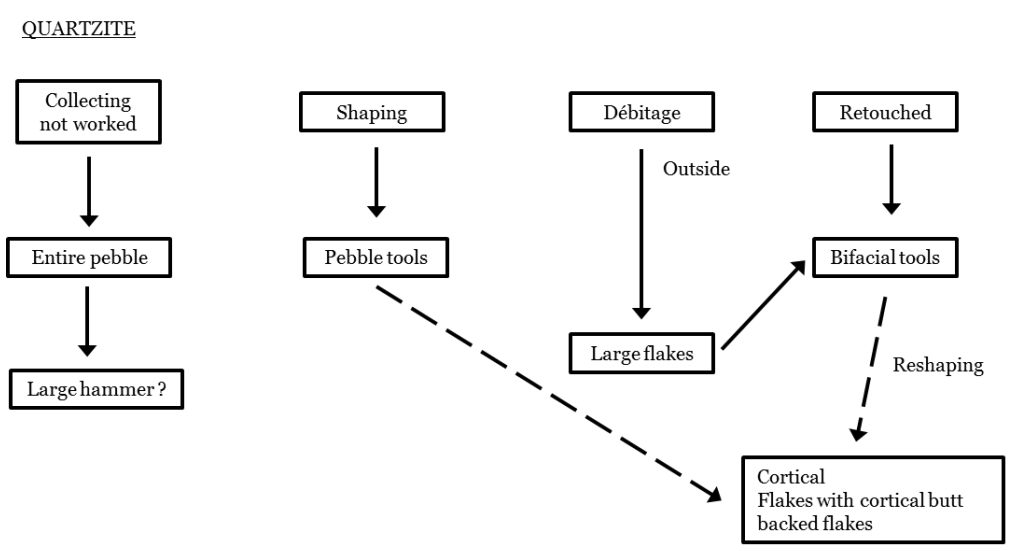


Fig. 5.6. Payre – Level D. Processing system of quartzite (modified from Moncel and Chacon, 2007)

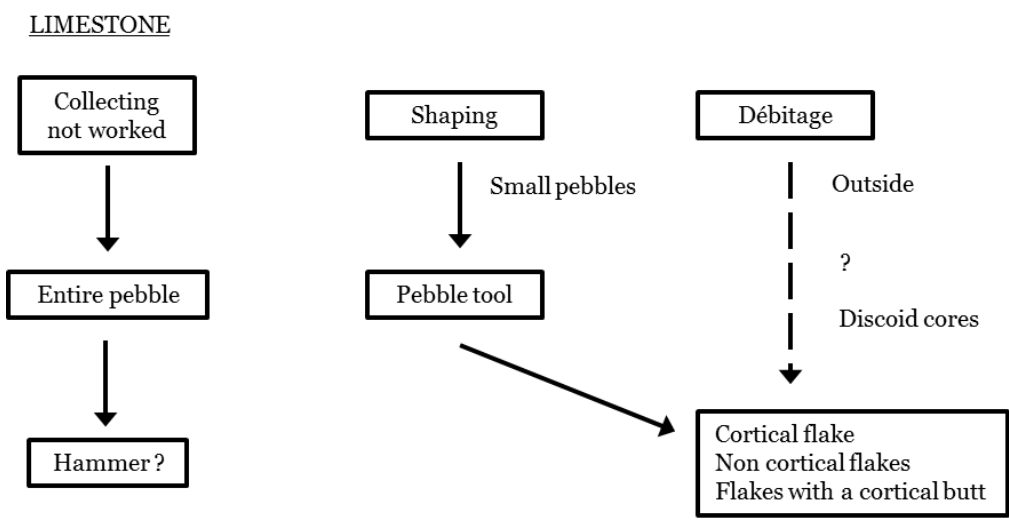


Fig. 5.7. Payre – Level D. Processing system of limestone (modified from Moncel and Chacon, 2007)

Quartz artefacts are mostly made from thick flakes with discoidal and opportunistic/multidirectional cores (Fig. 5.8). The low number of cores and debris indicate that it was partially knapped out of the site. According to the characteristics of the cortex, two kinds of blanks were collected: medium-sized rounded pebbles and big flakes or tabular fragments obtained from big pebbles.

Just a few pieces are retouched such as sidescrapers and convergent tools (Bouteaux et al., 2008; Moncel et al., 2008b; Moncel and Chacon, 2007).

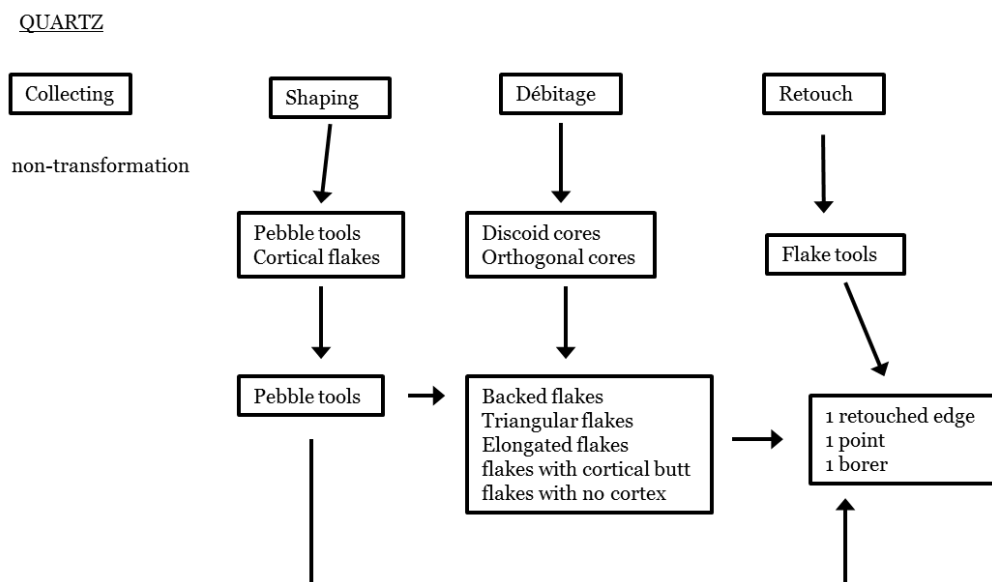


Fig. 5.8. Payre – Level D. Processing system of quartz (modified from Moncel and Chacon, 2007)

The lithic assemblage from Payre – level D is not very different from those of the other levels of human frequentation of the site. Local and semi-local flint are the most exploited raw materials through mainly a unifacial *débitage* on a surface secant to a cortical surface, not prepared. The *débitage* develops according to the morphology of the core, thus leading to the great variability in the management of flint and quartz cores (Bouteaux et al., 2008). The exploitation of each raw material is organized depending on their mechanical features. In particular, quartz and flint products have similar modules, thus leading to the interpretation of quartz both as a supplementary raw material used in the same ways as flint, and as a raw material used in a different way due to its petrographic features (Bouteaux et al., 2008; Moncel et al., 2008b). On the other hand, quartzite, considering the *châines opératoires* and the characteristics of the products, is for sure a raw material with a specific function (Moncel et al., 2008b).

5.5. New insight on discoid technology in Payre – level D

Discoid *débitage* (Boëda, 1993; Peresani, 2003) in Payre – level D is extensively employed together with opportunistic/S.S.D.A. (Forestier, 1993) reduction sequences. Among the different raw materials present in this archaeological level, just on quartz and flint this method is regularly used. The huge number of discoid cores and products gives the chance to observe how this method was applied on flint and quartz, two raw materials with very different petrographic and mechanical characteristics. The present study focuses in particular on the analogies and differences in discoid cores management depending on the raw material used and on the technological criteria that allow the identification of discoid cores and products.

To pursue the proposed objectives, all the flint and quartz artefacts from Payre level D available at *Institut de Paléontologie Humaine (IPH)* in Paris were considered, for a total of 2315 lithic artefact (Tab. 5.1). For a better understanding of the discoid technology of the considered level, for quartz and flint discoid cores, a diacritical scheme has been realized (Appendix C). The identification of discoid reduction sequences is based on the general criteria listed in Chapter 2 while the identification of discoid products takes into account criteria linked to the peculiarities of the considered lithic assemblage: according to the characteristics of the discoid *débitage* development and management observed on the cores, just the products with technological features (i.e. the direction of the negatives on the dorsal face and the *débitage* direction) fully in compliance with those characteristics have been considered as discoid products.

Raw material	Flakes	Cores	Retouched tools	Debris	Total	%
Flint	1552	102	227	251	2132	92,1%
Quartz	130	24	12	17	183	7,9%
Total	1682	126	239	268	2315	100%

Tab. 5.1 Payre - Level D. Composition of the considered lithic assemblage.

The state of preservation of the considered assemblage is not homogeneous, since quartz artefacts show a general good state of preservation while several post depositional surface modifications affect flint artefacts (Fig. 5.9 and 5.10). As already pointed out by recent researches (i.e. Venditti et al., 2016), quartz can better survive mechanical and chemical attacks, while flint is much more inclined to be affected on its surface by post-depositional processes. This is due to the different internal structure and to the different processes that lead to the formation of surface modifications on these raw materials, even under the same conditions (Venditti et al., 2016). So, despite these differences in the state of preservation, quartz and flint artefacts of Payre level D are part of a unique assemblage.

The strong presence of white patina and rounding on flint artefacts made sometimes difficult the reading and the interpretation of the knapping scars and for this reason some products have been classified as “indeterminate” concerning the knapping method (Tab. 5.2).

The rate of fragmentation is higher for quartz than for flint products (Fig. 5.11). As for the formation of post depositional surface modification, the internal structure of the raw materials plays a determining role, especially during the production of the tools through knapping. Bending and radial or Siret accidents are very common for quartz artefacts and are due to the presence of internal flaws and to properties like its relatively low tensile and compressive strength (Cotterell

and Kamminga, 1990; Domanski et al., 1994; Mourre, 1996; Tallavaara et al., 2010).

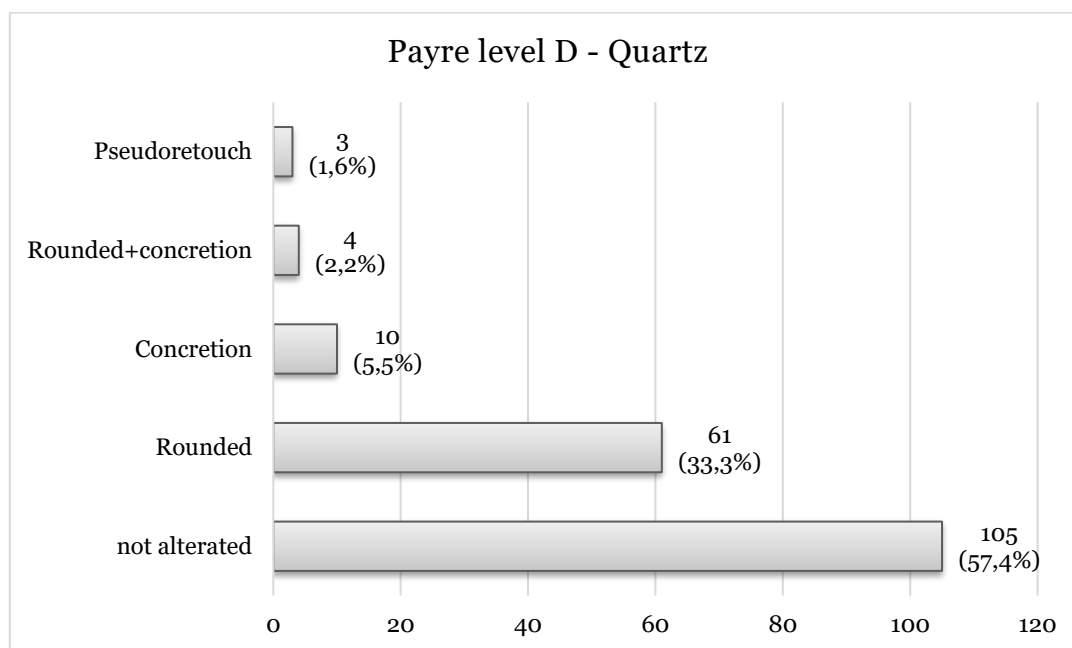


Fig. 5.9. Payre – Level D. Post depositional surface modifications observed on quartz artefacts.

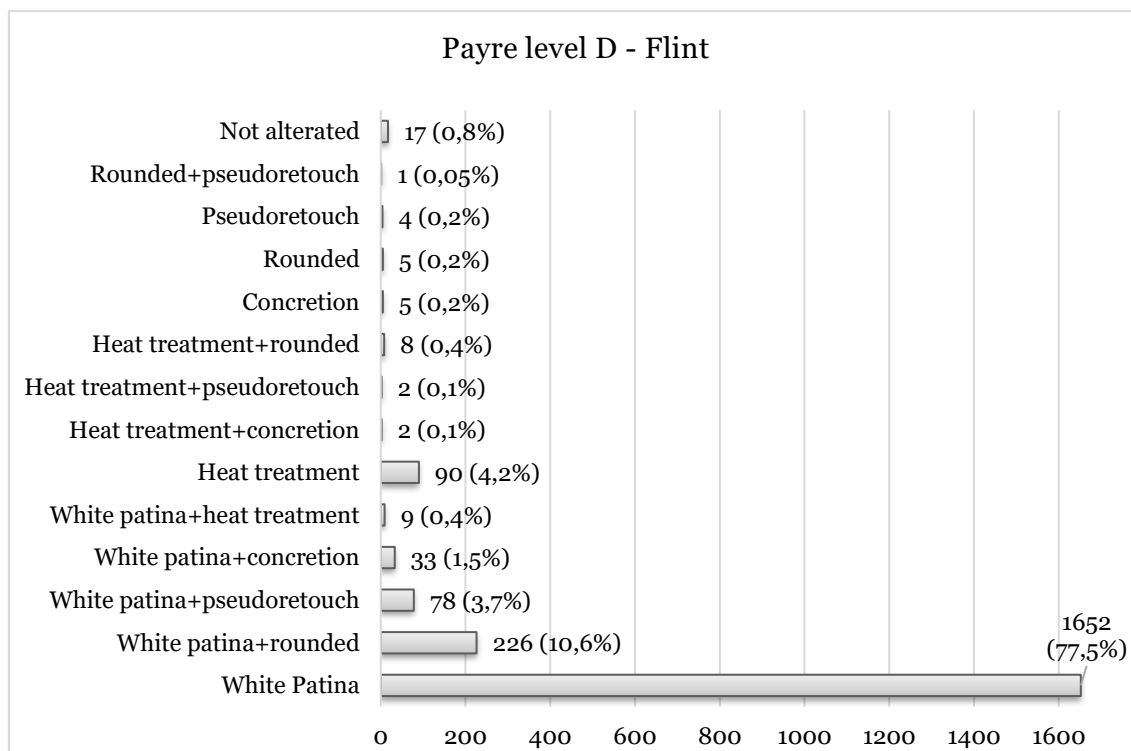


Fig. 5.10. Payre – Level D. Post depositional surface modifications observed on flint artefacts.

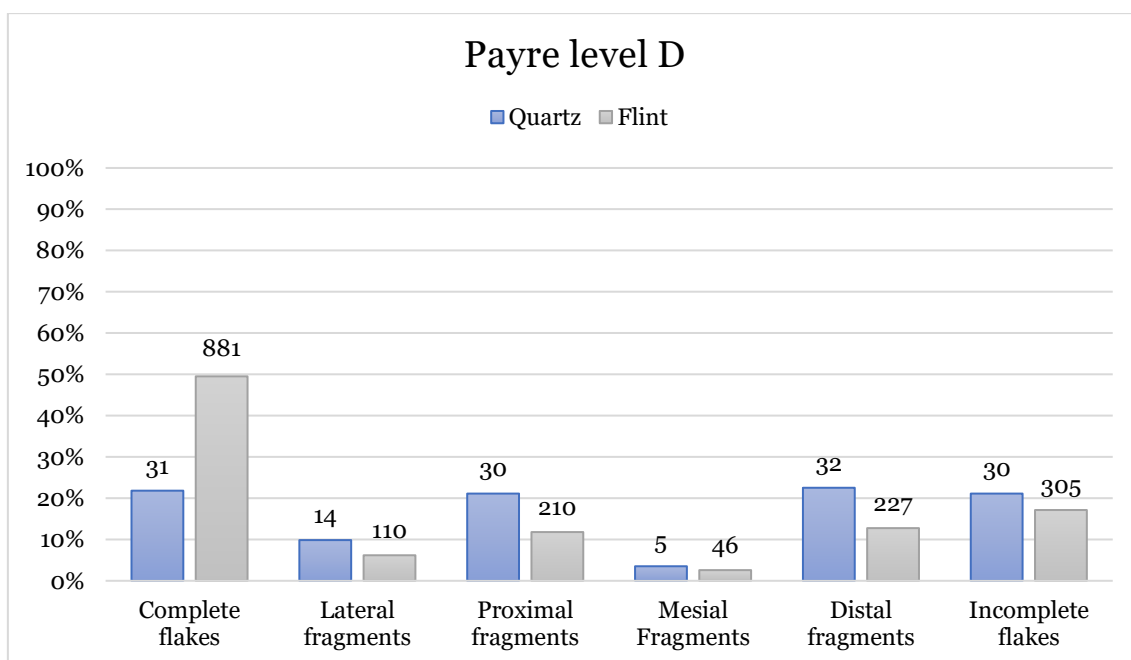


Fig. 5.11. Payre – Level D. Rate of fragmentation of quartz and flint flakes.

As mentioned before, quartz and flint have similar reduction sequences and on both these raw materials opportunistic/S.S.D.A. and discoid methods are mainly applied, followed by a negligible presence, only on flint, of a *débitage*-on-flake classifiable as *Kombewa s.l.* but, given its sporadic nature and the common exploitation of large flakes as cores for multidirectional or centripetal *débitage*, this products and cores have later been included in the opportunistic component of the lithic assemblage (Tab. 5.2).

Raw material	Opportunistic S.S.D.A.	Discoid	Kombewa s.l.	Indet.	Total
Quartz	Flakes = 96 Cores = 11	Flakes = 28 Cores = 13	Flakes = - Cores = -	Flakes = 18 Cores = -	
Tot.	107	41	-	18	166
%	5,3%	2,0%	-	0,9%	8,3%
Flint	Flakes = 1336 Cores = 53	Flakes = 230 Cores = 46	Flakes = 4 Cores = 2	Flakes = 170 Cores = 1	
Tot.	1389	276	6	171	1842
%	69,2%	13,7%	0,3%	8,5%	91,7%
Total	1496	317	6	189	2008
%	74,5%	15,8%	0,3%	9,4%	100,00%

Tab. 5.2. Payre - Level D. Raw materials and *débitage* methods.

Concerning quartz, the subdivision in morpho-structural groups has been applied (de Lombera-Hermida et al., 2011; Martinez Cortizas and Llana Rodriguez, 1996) (Tab. 5.3). According to this approach vein quartz can be divided in four different groups depending on the presence/absence of grains and plains (i.e. internal flaws or crystalline surfaces) that determines its mechanical characteristics and therefore its aptitude and response to knapping activities (NN: no grain/no planes; NS: no grain/planes; SN: grain/no planes; SS: grain/planes). This approach is useful to see if there was or not a choice for particular characteristics of the lithic raw material according to the knapping method employed and it was already applied to the entire sequence of Payre (de Lombera-Hermida et al., 2011). Its application just at level D allows to appreciate the peculiarities of this level.

Method	Morpho-structural groups			
	NN	NS	SN	SS
Opportunistic S.S.D.A.	Flakes = -	Flakes = 50	Flakes = 33	Flakes = 2
	Cores = -	Cores = 8	Cores = 2	Cores = -
Tot.	-	58	35	2
Discoid	Flakes = 1	Flakes = 14	Flakes = 13	Flakes = -
	Cores = -	Cores = 9	Cores = 4	Cores = -
Tot.	1	23	17	-
Indet.	Flakes = -	Flakes = 11	Flakes = 3	Flakes = -
	Cores = -	Cores = -	Cores = -	Cores = -
Tot.	-	11	3	-
Debris	-	9	4	-
Total	1	101	59	2
%	0,6%	62,0%	36,2%	1,2%

Tab. 5.3. Payre - Level D. Quartz morpho-structural groups and knapping methods.

The data obtained show that a choice has not been made according to the knapping method, but a general and clear prevalence of the NS group is evident (62%) (Tab. 5.3). As for the lower levels, the grainy types of quartz are barely

present in the assemblage reflecting the scarcity of this kind of quartz in the surroundings of the site (de Lombera-Hermida et al., 2011). Nevertheless, in Payre - level D the presence of inner flaws and crystalline surfaces does not preclude the use of more complex reduction sequences (i.e. discoid method) even on vein quartz.

The analysis of the discoid reduction sequences of Payre – level D led to some interesting observations on the variability of the method and on the adaptation of its technical criteria to the raw materials employed, even if it is applied on quartz and flint both in the unifacial and in the bifacial modality with no significant differences between the two raw materials (Fig. 5.12).

Discoid flint cores always have more than one phase of exploitation and are often completely exhausted (see Appendix C). Infrequently, the core is discarded before its complete exhaustion and it seems to happen when a shaping of the core is needed to restore the convexities. In this way the following exploitation would have been characterized by the production of flakes with dimensional and morphological characteristics different from those wanted during the previous phases.

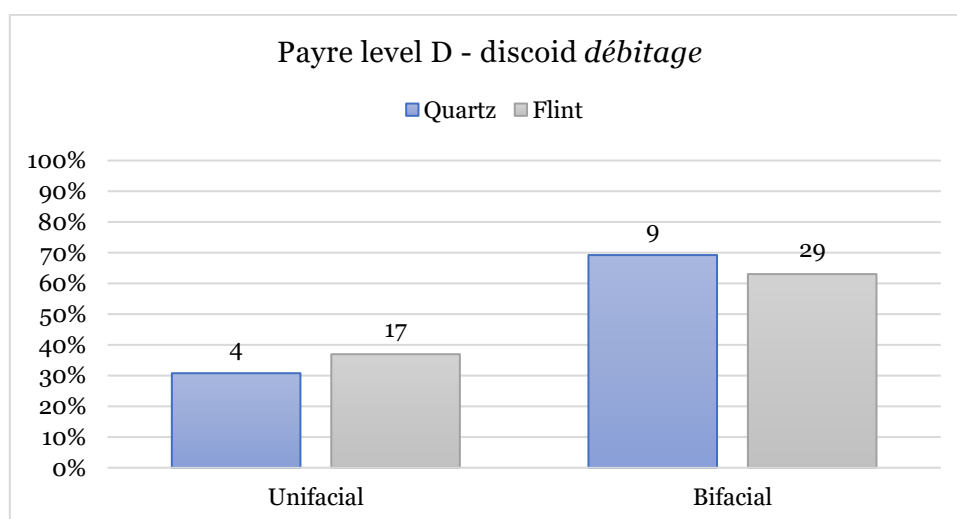


Fig. 5.12. Payre – Level D. Unifacial and bifacial discoid *débitage* on quartz and flint.

The management of the core convexities, aimed to assure a continuous production of flakes with the wanted dimensional and morphological characteristics, is pursued during the production phases, through the detachment of debordant flakes, often according to a chordal direction, or through the detachment of a centripetal, invasive flake that removes the central convexity when it becomes too pronounced (Fig. 5.13). The production phases correspond to series of centripetal detachments with a *débitage* direction always secant regarding the plan of intersection of the core surfaces. The products obtained are short and wide flakes, often debordant to assure a good management of the core convexities and with convergent edges (Fig. 5.13). Discoid bifacial cores on flint show no hierarchization of the two surfaces, since both are used as striking platform surface and as knapping surface. Even that, in the last phase of exploitation of these cores, the surfaces are sometimes not equally convex and the *débitage* direction becomes more parallel to the plan of intersection of the two surfaces (see Appendix C). In this last production phase, the two surfaces seem to be hierarchized, since flakes are obtained only from one of the surfaces that progressively becomes flatter than the other. The result is a core with one surface more convex than the other and with a clear distinction between knapping surface and striking platform surface. Sometimes a third surface, perpendicular to the others, is exploited with the detachment of an elongated flake (Fig. 5.14). Despite the intensive exploitation of these cores makes it difficult to observe, the presence of some natural surfaces let assume that for the bifacial discoid *débitage*, pebbles/big flakes with suitable convexities are chosen, thus reducing or avoiding the shaping of the core convexities.

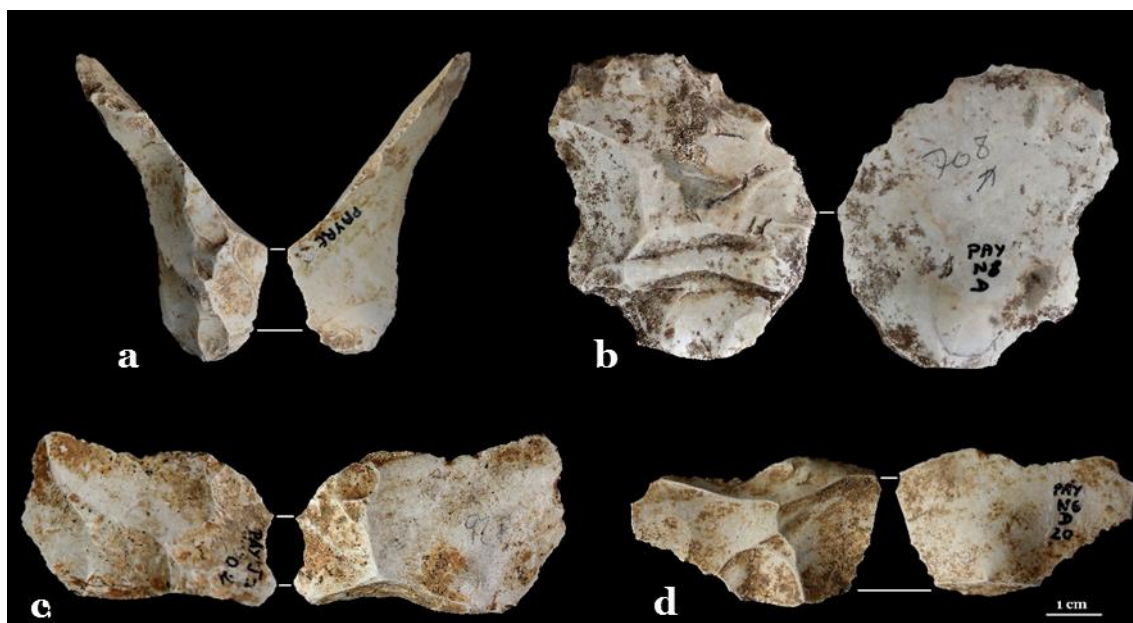


Fig. 5.13. Payre – Level D. Discoïd flint flakes. (a) core management flake; (b) discoïd centripetal invasive flake removing the central convexity of the core; (c, d) discoïd debordant flakes.

Unifacial flint cores are very frequent in the considered assemblage (Fig. 5.12) and are often realized on the ventral face of big flakes. The surfaces of the core are always hierarchized and in the end of the exploitation the core shows one surface more convex than the other. As for the bifacial cores, the exploitation is aimed to the production of short and thick flakes mainly through a centripetal direction. The flakes are often debordant, thus helping in the management of the surface convexity. The striking platform is prepared through small and not invasive centripetal detachments but sometimes it is completely natural (Fig. 5.14). Even in this case, a choice of blanks with suitable convexities is evident to immediately start the phase of production of flakes with the researched morphology.

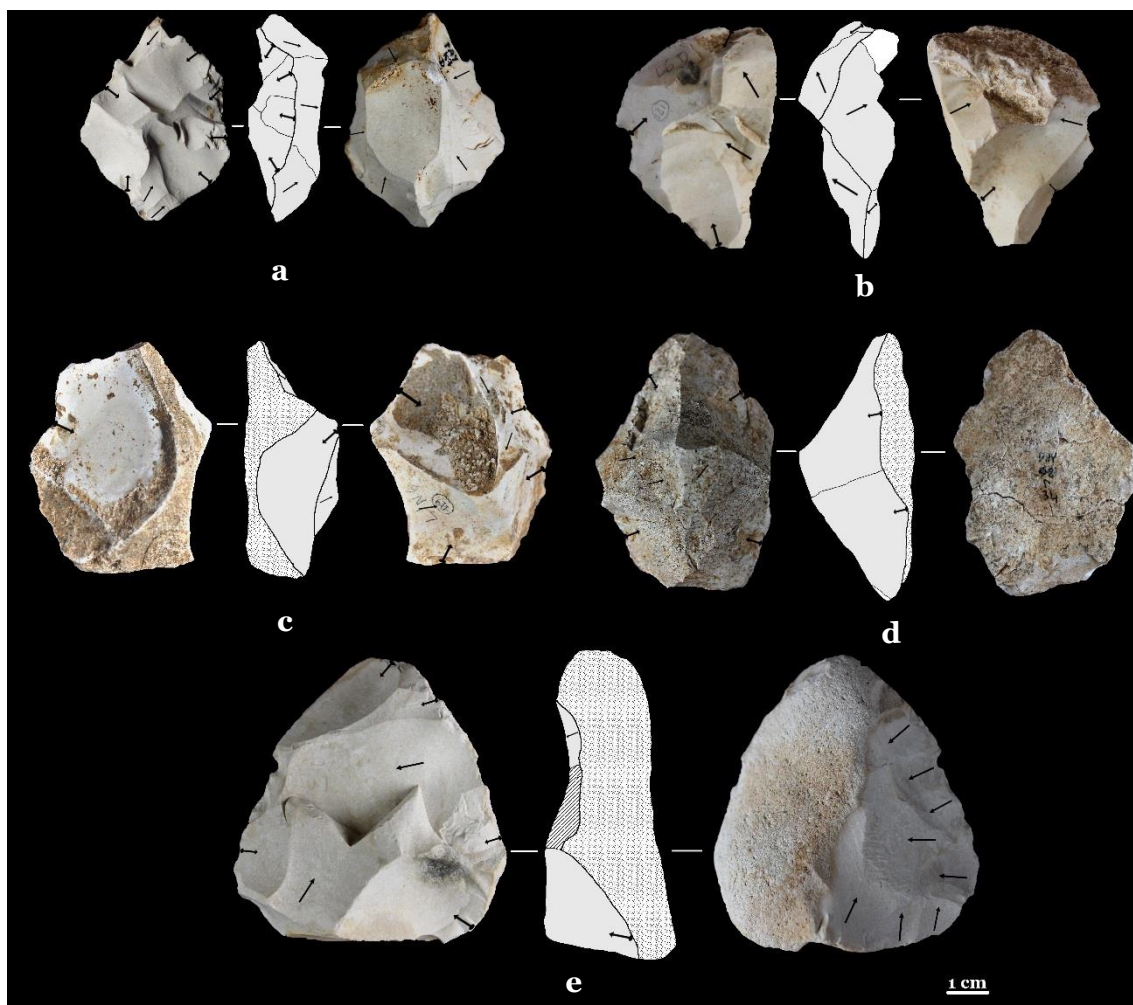


Fig. 5.14. Payre – level D. Discoid flint cores. (a, b) bifacial cores; (c) exhausted bifacial core with a third surface exploited in the last phase of flake production; (d) unifacial core with a natural striking platform surface; (e) unifacial core with a striking platform partially prepared with centripetal detachments.

Quartz discoid cores show just one phase of exploitation, exception made for one case, and short reduction sequences (Fig. 5.15). All the cores are discarded before their complete exhaustion probably because the presence of inner flaws and crystalline surfaces makes very difficult the management of the core convexities and the control of the knapping activity (de Lomberra-Hermida et al., 2011; Driscoll, 2011; Mourre, 1996). Natural surfaces, i.e. neocortex, are often still visible on the cores thus attesting the collecting of pebbles with a suitable morphology for a discoid exploitation. As for flint, both bifacial and unifacial discoid exploitation are present. The production phase starts directly from the natural surface of the pebbles and proceeds with centripetal detachments,

sometimes debordant and often not very invasive. Considering the shortness of the reduction sequences on quartz, the presence of debordant detachments could have a different meaning than for flint. As described before, on flint discoid cores the detachment of debordant flakes is useful for the core managements and is aimed to guarantee a continuous production of flakes without need for a shaping of core convexities; on quartz cores, where the exploitation is for the overwhelming majority limited to a single series of flake production, the presence of debordant detachments seems to be due more to quartz inner flaws than to an intentional gesture. The products obtained are short and thick flakes with morphological characteristics not significantly different from the flakes obtained from flint (Fig. 5.16).

As mentioned before, quartz and flint discoid products, have been identified depending on the compliance of their technological features with those observed on the cores in terms of direction of the negatives, *débitage* direction and dimensions. Concerning complete and uncomplete flakes, all these criteria have been applied, while for fragmented flakes it was clearly more difficult to identify discoid products based on just the direction of the negatives or the characteristics of the butts. So, for fragmented products the opportunistic component could have been overestimated. As observed on discoid cores, the centripetal direction was the preferred to produce short and thick flakes, while very rare are detachments consistent with the presence of orthogonal negatives (Fig. 5.17) that should be better referred to a multidirectional exploitation of the core surfaces. The *débitage* direction of discoid cores is almost exclusively secant as regard for the plan of intersection of the two core surfaces and just in a few cases, in the end of the core exploitation, it becomes parallel.

This technological feature is recorded on the discoid flakes by the morphology of the butts which angle with the ventral face is more inclined than that formed by a parallel *débitage* direction. Only the complete/uncomplete products consistent with both these criteria and the fragmented products consistent with one of them have been identified as discoid flakes.

The results obtained show that flint and quartz cores were exploited in similar ways even if flint was exploited more intensively than quartz cores, as confirmed by the number of negatives visible on the flakes (2 or 3 for quartz, usually more than 3 on flint) (Fig. 5.17).

The differences between quartz and flint in core shaping and management are on the other hand visible in the characteristics of the butts of the discoid flakes, since just on flint flakes are present, even if sporadic, faceted and dihedral butts (Fig. 5.18), index of a preparation of the striking platform or of the presence of more than one phase of exploitation. For both quartz and flint products the butts are mainly flat (Fig. 5.18), confirming that the exploitation starts mostly from surfaces already present on the core.

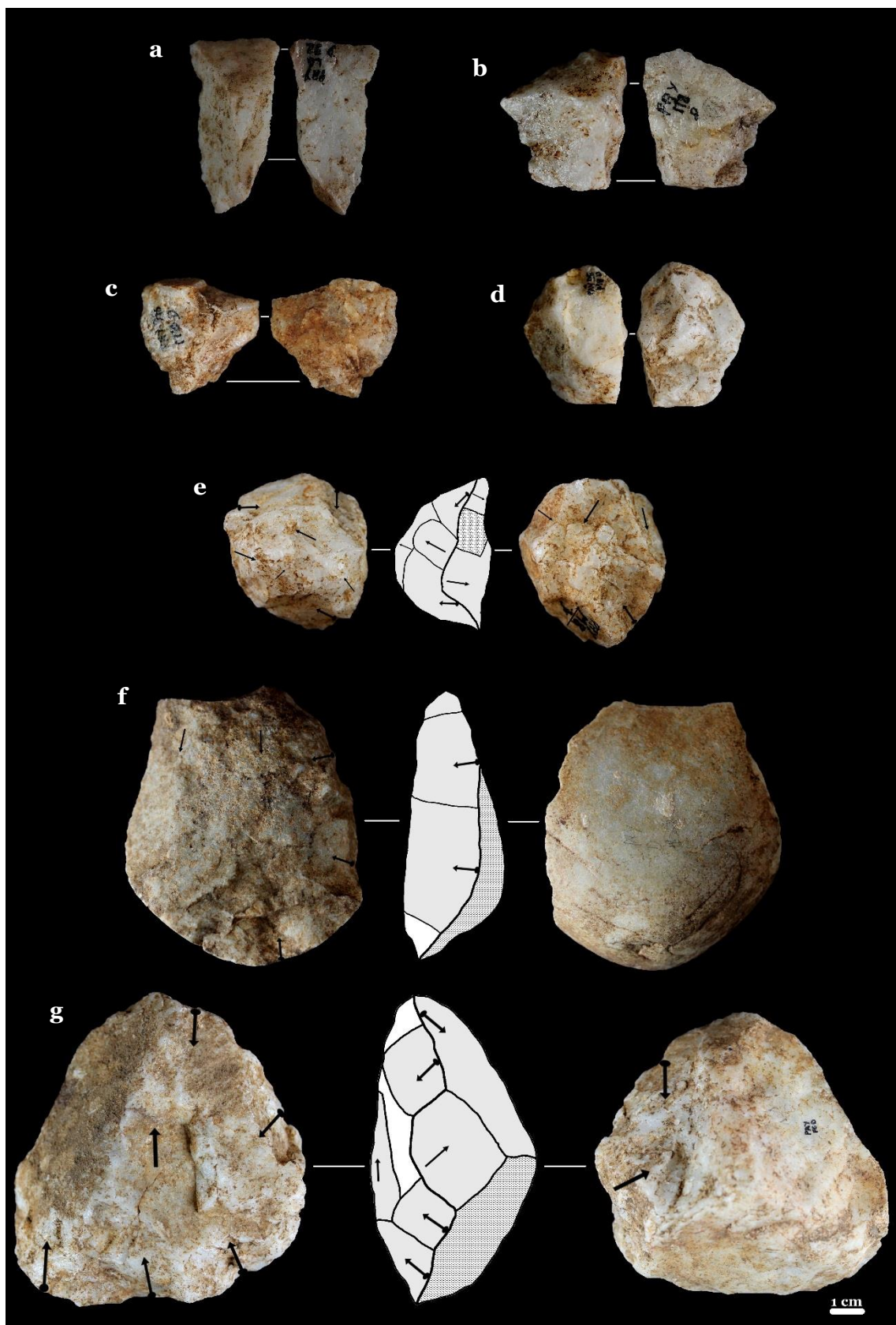


Fig. 5.15. Payre – level D. Quartz discoïd flakes and cores. (a-d) discoïd flakes with centripetal negatives on the dorsal face; (e) bifacial core; (f) unifacial core with natural striking platform; (g) unifacial core, two centripetal detachment prepare the striking platform.

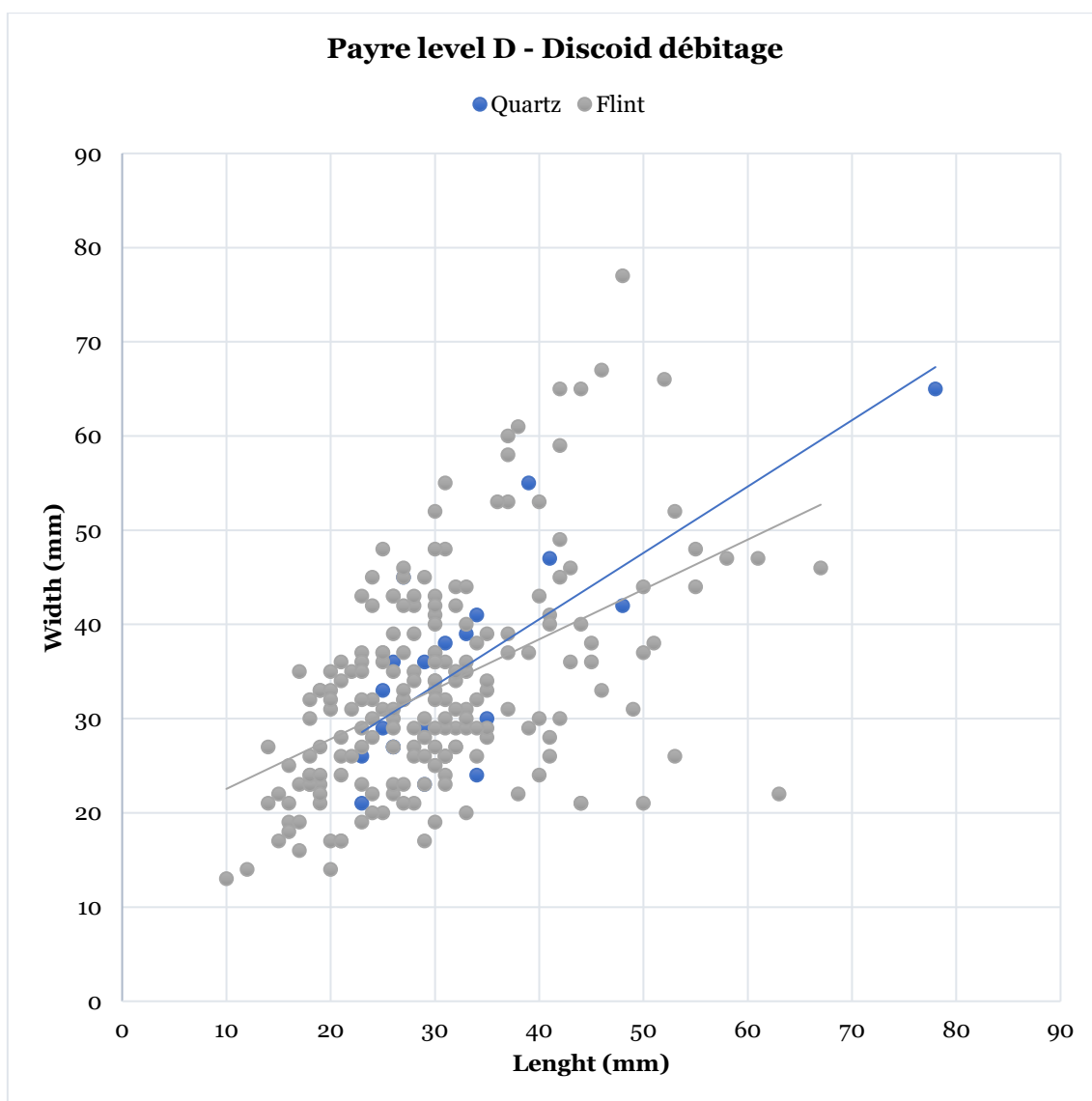


Fig. 5.16. Payre – level D. Dimensional analysis of quartz and flint discoid products, fragmented flakes are not included. The wanted products are short and large flakes and no differences are visible between the two raw materials. Blanks with suitable dimensions were chosen to obtain flakes with the wanted dimensions. Elongated flakes are related to core management or to the exploitation of a third surface during the final stage of exploitation.

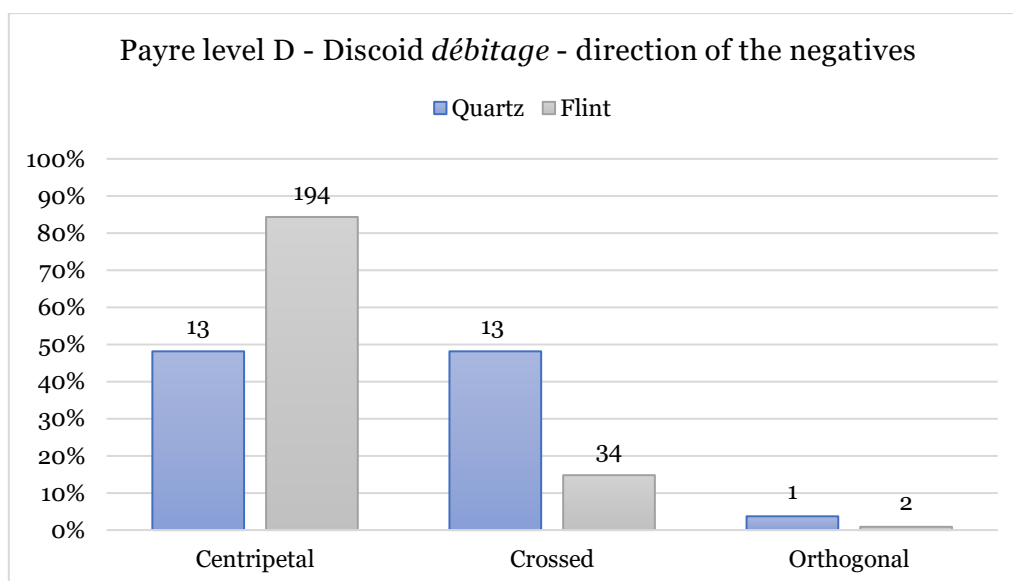


Fig. 5.17. Payre – level D. Direction of the negatives visible on the upper face of quartz and flint discoid flakes.

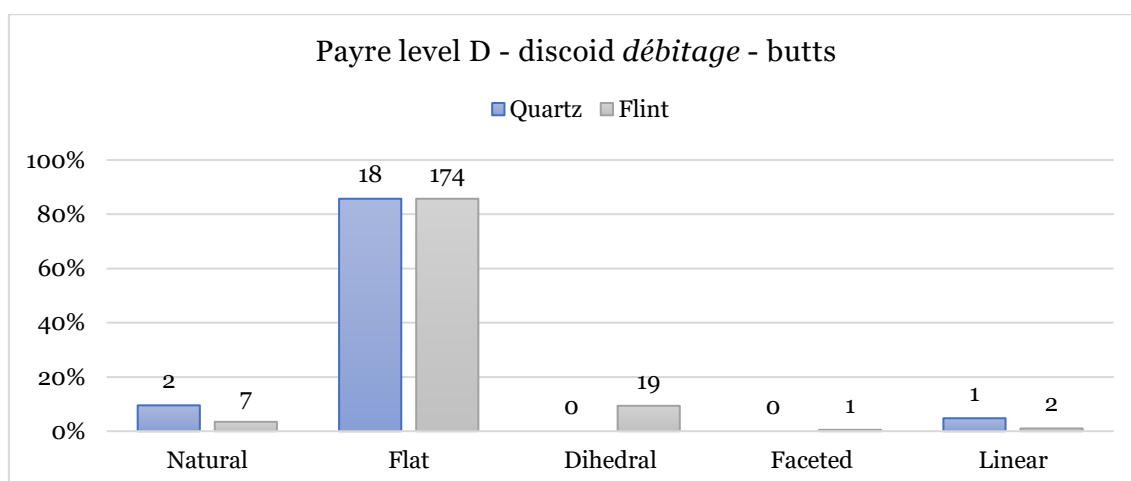


Fig. 5.18. Payre – level D. Typology of the butts of quartz and flint discoid flakes.

Considering the dimensional features of the discoid products (Fig. 5.16) compared with those of the products issued from opportunistic/S.S.D.A. reduction sequences (Fig. 5.19) we can suppose that the discoid method was employed to produce flakes with specific morphological features, generally shorter and wider than the opportunistic/S.S.D.A. products. The characteristics of the products are in both cases clearly influenced by the morphology of the pebbles and flakes selected as cores, but according to the characteristics of the

considered lithic assemblage it seems that the method influenced the choice of the raw materials to be collected and not the opposite. A final observation has to be made concerning quartz opportunistic/S.S.D.A. products: while for flint artefacts is evident the research of given morphological characteristics, quartz artefacts show very irregular dimensional features, thus attesting a stronger influence of the raw material initial morphology (Fig. 5.19).

Retouch is often used in Payre level D to modify or rejuvenate the edges of tools issued from the different knapping methods present in the assemblage (Fig. 5.20), particularly to obtain or modify convergent edges, i.e. convergent scarpers (Moncel et al., 2009; Moncel and Chacon, 2007) with a sporadic evidence of denticulates and notches (Fig. 5.21). Retouch was partially carried out in the site as confirmed by the presence of 34 small flakes linked to rejuvenation or modification of tools' edges.

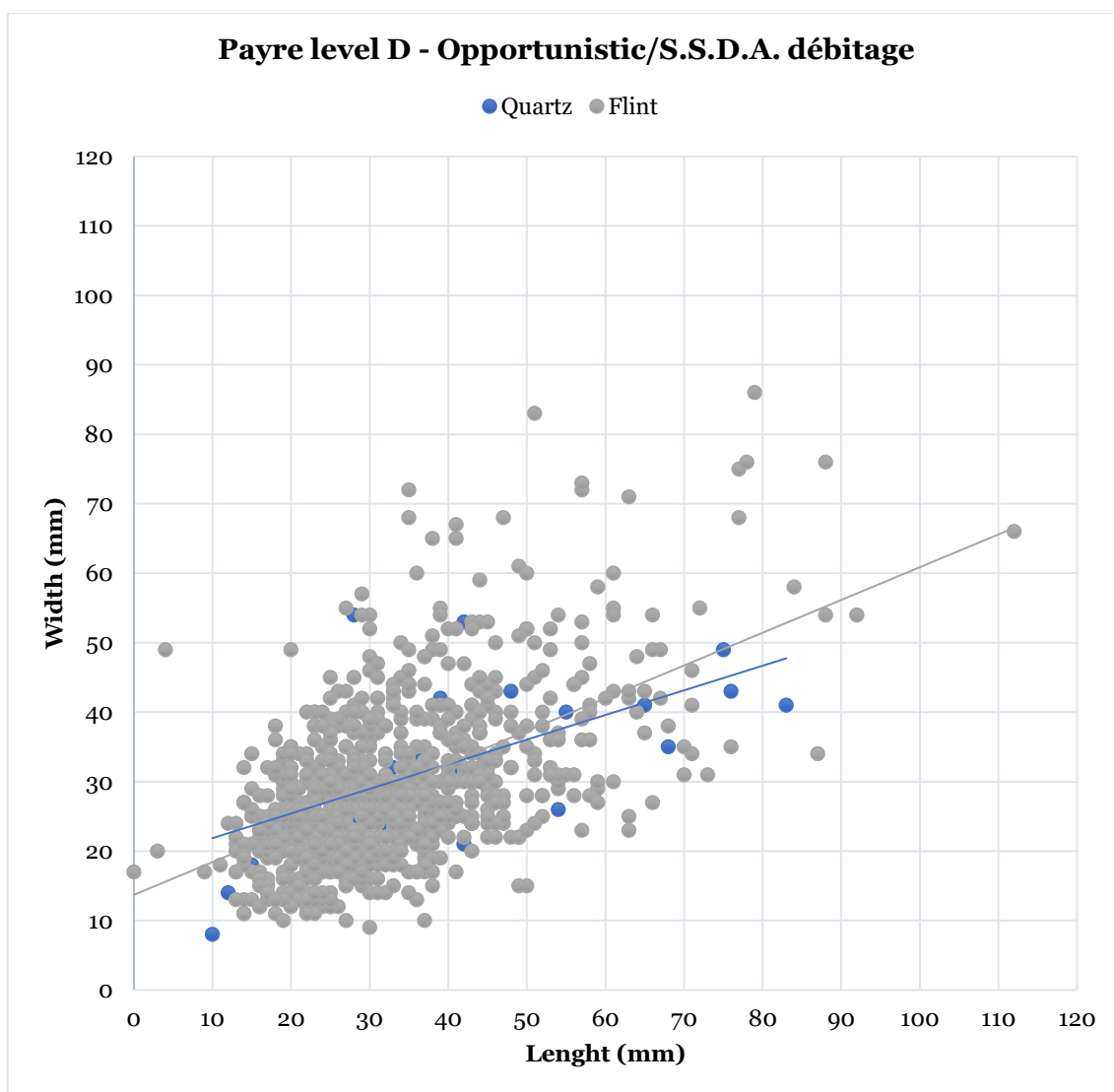


Fig. 5.19. Payre – level D. Dimensional analysis of quartz and flint opportunistic/S.S.D.A. products, fragmented flakes are not included. The wanted products are mainly elongated flakes. The morphology of the products is also related to the initial morphology of the raw materials collected.

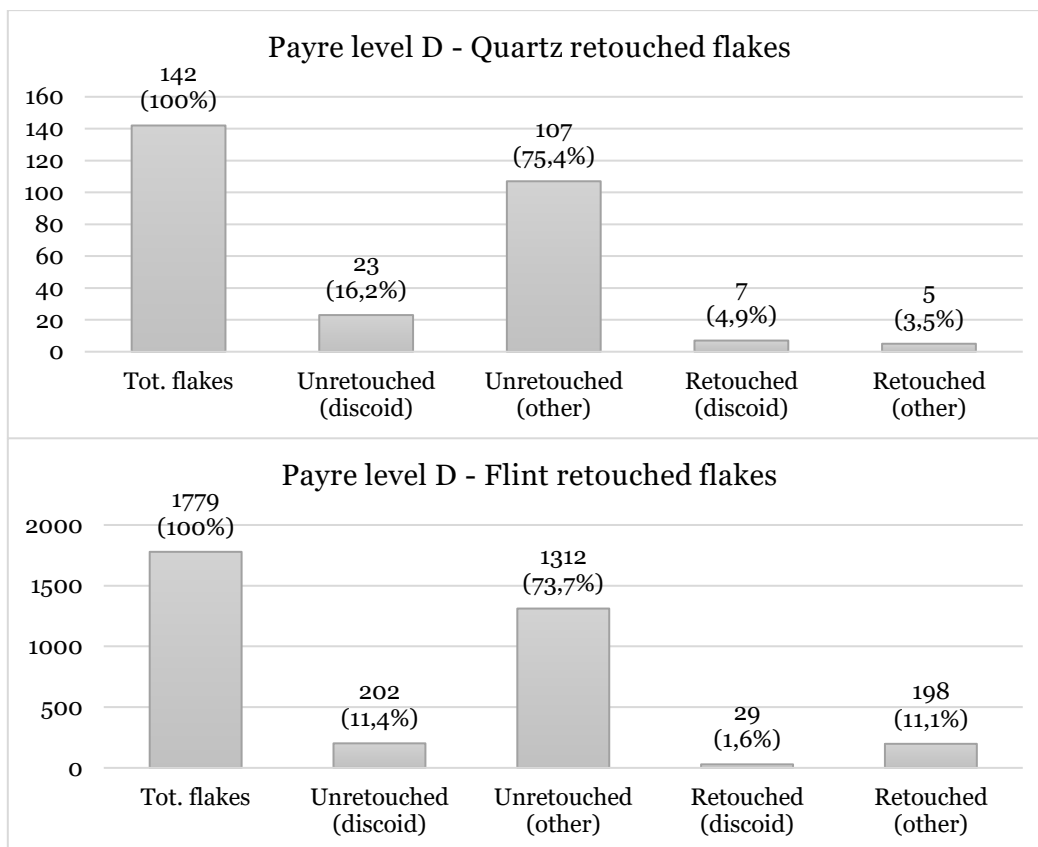


Fig. 5.20. Payre – level D. Relationship between retouched and unretouched flakes divided by knapping method.

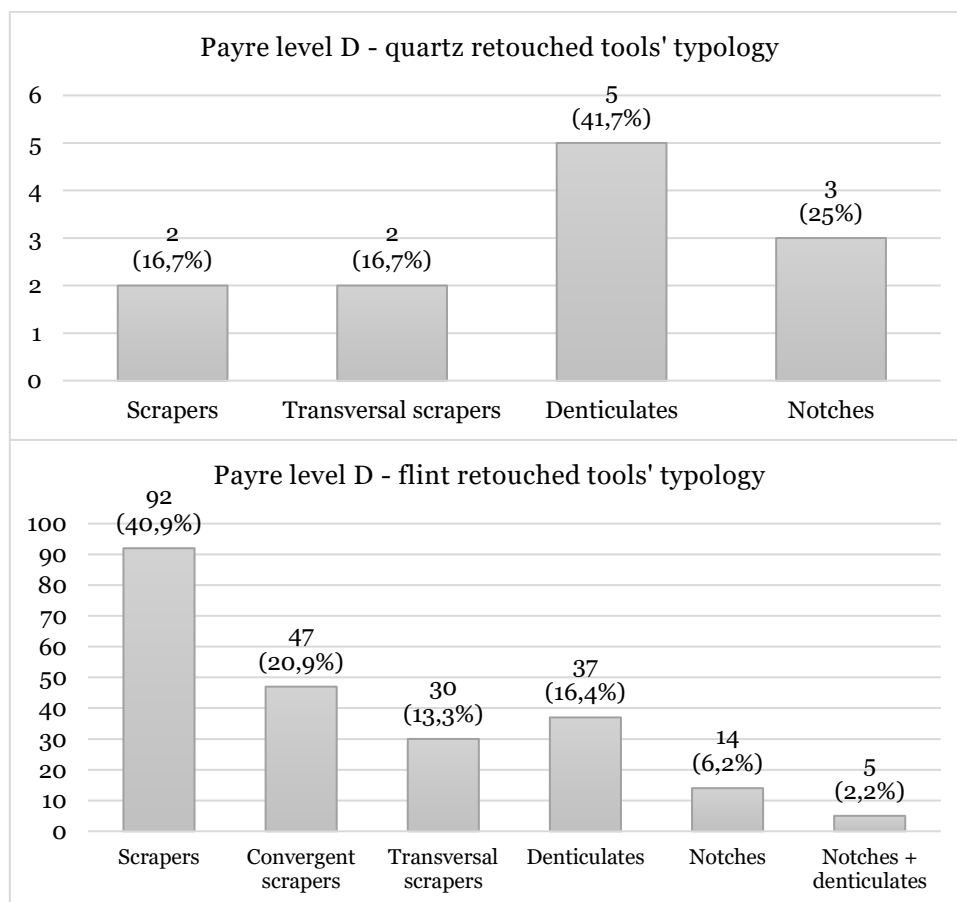


Fig. 5.21. Payre – level D. Typology of quartz and flint retouched tools.

5.6. Discussion and conclusion

Level D represents the last and more recent phase of human frequentation of the site of Payre and it gave back a huge lithic assemblage characterized by using different local and semi-local raw materials and by a technological variability that allow to make some considerations on the definition of discoid *débitage*.

Even if from the point of view of the lithic raw materials exploited and of the supply areas, no significant differences have been observed in comparison with the lower levels of the sequence (units F and G) (Fernandes et al., 2008, 2006; Moncel et al., 2002), from a technological perspective some remarks have to be made.

The lithic assemblages from levels F and G (e.g. Moncel et al., 2008b, 2009; Baena et al., 2017) have recently been subject to a new technological analysis (Carmignani et al., 2017) which highlights the peculiarities of the reduction sequences adopted. Quartz cores are very sporadic in these levels, one from level Fa and six from level Ga (Carmignani et al., 2017), so a comparison can be made just considering flint. In the lower levels of the Payre's sequence, the centripetal exploitation of the cores surfaces is widely attested and it is mainly conducted through centripetal and chordal removals each of them participating in the maintenance of the core convexities as well as observed in level D (Baena et al., 2017; Carmignani et al., 2017). Two main differences are evident between level D and the lower levels and they concern the presence, in levels G and F, of a peripheral parallel planes exploitation strategy and the presence of some cores with secant centripetal removals limited to one side of the core, thus causing some uncertainties in the attribution of this exploitation strategies to a discoid conception (Carmignani et al., 2017). In level D, the centripetal exploitation of flint cores falls clearly inside the classical discoid concept defined by E. Boëda

(1993) with a *débitage* conducted through mainly centripetal removals in a direction always secant as regard to the plan of intersection of the two core surfaces (Fig. 5.14; Appendix C). Flint cores are intensely exploited and even when they are discarded before their complete exhaustion no part of their volume appears unexploited. Just in the final phase of exploitation the *débitage* direction becomes almost parallel to the plan of intersection of the two core surfaces, that now seem to be hierarchized (Fig. 5.14), since one of them is used as striking platform while the other becomes the knapping surface. In these cases, the attribution of the cores to the discoid method is more difficult since at first they seem to belong to a Levallois reduction strategy (Boëda, 1994). Even though, the absence of phases of shaping or re-shaping of the core convexities, the *débitage* direction still generally secant and the absence, in the considered assemblage, of products with unquestionable Levallois features (Boëda, 1994), lead to be in favor of an attribution to a final phase of a discoid reduction strategy. According to the criteria listed by E. Boëda (1993) for the identification and definition of discoid reduction sequences, discoid cores should respect six criteria defining core geometry and shaping, the hierarchization of the surfaces, the *débitage* direction and the technique of percussion. The debate about the effectiveness of these criteria is currently ongoing and within the discoid method a high variability has been recognized, even questioning its status of predetermined method (e.g. Peresani, 1998, 2003; Pasty, 2000; Bourguignon et al., 2004; Martínez Molina et al., 2006; Faivre, 2011; Thiébaud et al., 2012; Turq et al., 2013; Martinez Lorenzo et al., 2014; Picin et al., 2014; Romagnoli et al., 2016; Carmignani et al., 2017; Delpiano and Peresani, 2017). The analysis of the lithic assemblage of Payre level D give the chance to contribute to one particular aspect of this wide debate: the concept of hierarchization of the core surfaces., i.e. when should we consider two

surfaces as hierarchized? In the Levallois method we have a clear distinction between the striking platform surface and the knapping surface, which deeply differ from each other also in their geometry and general morphology (Boëda, 1994). In the discoid *débitage* the two surfaces are not hierarchized, and both are in turn knapping surface and striking platform surface (Boëda, 1993; Peresani, 2003). Nevertheless, in the considered assemblage, in the end of the core exploitation it happens that each of the surfaces gets a precise role. In these cases, we talk about hierarchization of the core surfaces, as well as we do when unifacial discoid cores are considered, thus making difficult the attribution of these cores to discoid or Levallois reduction sequences. The hierarchization of the core surfaces is in fact one of the most diagnostic criteria for the distinction between the two methods (Peresani, 2003). Considering the lithic assemblage of Payre level D, the concept of hierarchization of the core surfaces seems to be completely absent: beside an opportunistic/S.S.D.A. exploitation, the flint cores are exploited according to a discoid scheme with centripetal and chordal removals obtained from a peripheral striking platform. When the cores are almost exhausted it happens that all the flakes start to be detached just from one of the core surfaces. Since this kind of hierarchization of the surfaces is not intentional but due to the maximization of the raw material exploitation, we should not talk of hierarchized surfaces when describing these cores. The same has to be said concerning unifacial discoid cores, where the exploitation of just one surface through centripetal or chordal removals can be considered as an opportunistic behavior conditioned by the raw material characteristics, morphology and dimensions (Peresani, 2003). Within a discoid reduction sequence, the exploitation of just one of the core surfaces during the entire reduction sequence or just in its last phase, conceptually, is not different from the opening of a third

débitage surface perpendicular to the others as last phase of exploitation (Fig. 5.14), since all these expedients are aimed to obtain as much flakes as possible from a single core. Two surfaces should then be considered as hierarchized just when their roles are clear since the beginning of the core exploitation, which correspond to the chance to observe on the core the configuration of their geometric features.

Different considerations have to be made about quartz cores, since the knapping methods employed are strongly conditioned by its response to knapping, which is determined by its petrographic features (Arzarello et al., 2012a; G L F Berruti et al., 2016; Cologne and Mourre, 2006; Daffara et al., 2014; de Lombera-Hermida and Rodríguez-Rellán, 2016; Degorce and Castel, 2006; Driscoll, 2011; Manninen, 2016; Martinez Cortizas and Llana Rodriguez, 1996; Mourre, 1994, 1996). Discoid quartz cores in Payre level D show just one phase of exploitation, exception made for one core (Fig. 5.15; Appendix C), thus giving the chance to observe the entire exploitation of these cores, differently from what happens with flint cores that are intensively exploited. The shortness of the discoid reduction sequences, together with the frequent presence of natural surfaces highlights that, for quartz, the choice of blanks with a suitable morphology was far away more important than for flint. Moreover, the dimensional and morphological characteristics of the products are more determined by the core natural convexities than by the previous removals, which is the greater difference between quartz and flint discoid reduction sequences observed in Payre level D. On the other hand, the general characteristics of the discoid reduction sequences on quartz, allow to refer them, together with flint cores, to the classical discoid concept (Boëda, 1993) since we observe a bifacial or unifacial exploitation of cores with two surfaces, equally convex, through removals secant with regards to the

plan of intersection of the two surfaces and directed toward the middle of the core.

In conclusion, the main differences between flint and quartz discoid reduction sequences in Payre level D are determined by the petrographic characteristics of the raw materials but a differential exploitation between them is not attested: in this lithic assemblage quartz is a complementary raw material, used in the same way as flint for the production of flakes with the wanted dimensional and morphological characteristics and with some adaptation (shortness of the reduction sequences, frequent exploitation of natural surfaces) necessary for the application of the discoid concept to this lithic raw material. If compared to the lithic assemblages of the lower levels (units G and F), we observe, all along the sequence, the acquisition of a discoid concept, going from partial centripetal exploitation of the core volume to the bifacial and intense exploitation of the entire core. In addition, in level D the discoid method is systematically applied also on vein quartz through some expedients which testify the great knowledge not only of the raw material properties but also of the discoid method itself.

CHAPTER 6

Discussion

CHAPTER 6

DISCUSSION

The proposed research is aimed to deeply investigate the modalities of exploitation of non-flint lithic raw materials during Middle Palaeolithic, with particular attention to vein quartz exploitation strategies, a matter that in the last years became one of the main issues in the field of lithic technology (e.g. Blaser et al., 2002; Bracco, 1997; de Lomberra-Hermida, 2009; de Lomberra-Hermida et al., 2016, 2011; de Lomberra-Hermida and Rodríguez-Rellán, 2016; Degorce and Castel, 2006; Driscoll, 2011; Driscoll and Menuge, 2011; Janot, 1988; Knutsson et al., 2016; López-Ortega et al., 2017; Moncel et al., 2008; Moncel and Lhomme, 2007; Rodríguez-Rellán, 2016; Venditti et al., 2016).

It is known that the mechanical properties of a lithic raw material affect its response to knapping, the way in which the reduction sequences are performed and the characteristics of the products for what concerns integrity, dimensions and general morphology (e.g. Cologne and Mourre, 2006; de Lomberra-Hermida and Rodríguez Rellán, 2010; Mourre, 1996, 1994). The focus of this research were the modalities of exploitation of different kind of raw materials for what concerns discoid and Levallois reduction sequences, in order to understand which technological expedients were applied to adapt those concepts to the raw materials characteristics and the technological variability originated by such expedients.

Three of the considered archaeological contexts (Ciota Ciara cave, Pedra Dreta and Can Garriga) share some characteristics, like the predominant exploitation of vein quartz and of local low-quality raw materials like volcanic, sedimentary, and metamorphic rocks, with Levallois and discoid reduction sequences attested

on almost all the main lithologies employed (Tabs. 3.3, 3.5, 3.8, 3.11, 4.3, 4.4). Payre – level D is the only lithic assemblage where a good-quality flint is the predominant raw material followed by vein quartz: discoid reduction sequences are widely attested, thus giving the chance to observe analogies and differences between the two lithologies (Tab. 5.2).

During this analysis, different issues arose, linked not only to the specific object of the research but more broadly to the criteria defining the Levallois and the discoid method and to the concept of predetermination. The results obtained also allow to make some considerations in the debate concerning if and how much the raw materials exploited and available in the environment affect the choice of the knapping method (Bar-Yosef et al., 1992; Delagnes and Rendu, 2011; Meignen et al., 2007; Moncel et al., 2008c; Otte, 1991; Picin and Carbonell, 2016; Picin and Vaquero, 2016; Wengler, 1990).

6.1. Technological adaptations to the raw materials properties

The conditioning of the mechanical properties of the lithic raw materials exploited in an archaeological site on the characteristics of the reduction sequences is known, but the description of the technological adaptations applied is often inaccurate, thus attributing to non-flint reduction sequences the character of archaic, rough or not accurate production systems (de Lomberra-Hermida and Rodríguez-Rellán, 2016; Mourre, 1994; Rodríguez-Alvarez, 2016; Rodríguez-Rellán, 2016). This is a great limit in the field of lithic technology, since raw materials like vein quartz have been widely employed during Middle Palaeolithic and the accurate study of the reduction sequences on this kind of raw materials permits to appreciate the technological effort and the expertise necessary to control the results of the knapping activities. In other words, the

exploitation of such raw materials seems to demand great knowledges of the lithologies and greater adaptation capabilities than the exploitation of flint to obtain the wanted products.

In different European Middle Palaeolithic contexts a differential use of the lithic raw materials collected has been observed (e.g. Delagnes and Meignen, 2006; Faivre et al., 2014; Jaubert and Farizy, 1995; Rios-Garaizar et al., 2015; Romagnoli et al., 2016): according to their better or worse aptitude for knapping, they have been used for Levallois or for discoid/opportunistic reduction sequences, driving some authors to suppose a strict correlation between Levallois knapping sequences/good-quality raw materials (i.e. flint) and between discoid knapping sequences/low-quality raw materials.

The results of the study carried out suggest that if a strong conditioning of the quality of the raw materials on the development of Levallois and discoid reduction sequences is undeniable, generalize such kind of correlations is quite misleading. In Payre – level D, the main reduction sequences are referable to opportunistic/S.S.D.A. and discoid exploitation strategies (Tab. 5.2), equally applied on flint and vein quartz. The two raw materials have been treated in the same way, with differences linked only to technological adaptation to the raw materials characteristics. At the Ciota Ciara cave, the good-quality raw materials introduced in the site (i.e. radiolarite and rhyolite) are exploited in the same way as all the other lithologies, according to opportunistic, Levallois and discoid exploitation strategies (Tabs. 3.5 and 3.8). As well as in Payre – level D, the differences in the reduction sequences are due to technological adaptation to the raw material properties. As already observed by Meignen et al. (2009), the Western European Middle Palaeolithic show an high degree of variability that scarcely fits with the rigidity of our habitual classifications. Therefore, if a

differential use of the raw materials is observable in specific contexts, this can't be generalized and assumed as a constant behaviour, as already pointed out by F. Romagnoli et al. (2016).

The technological analysis of the lithic assemblages from the Ciota Ciara cave, Pedra Dreta, Can Garriga and Payre – level D, highlights the presence of some common technological behaviour that can be interpreted as adaptations to the raw materials mechanical and petrographic characteristics. The following considerations mainly descend from the study of vein quartz artefacts, since it is quantitatively the most exploited raw material, but some technological characteristics are shared by all the raw materials different from flint present in the considered assemblages.

The adaptation to the raw materials starts from the beginning of the *chaînes opératoires*: all the considered sites share the collecting of natural blanks with suitable convexities in order to start the production of flakes directly from the natural surfaces of the cores.

According to the results obtained from all the considered lithic assemblages, the morphology of the core is the main element influencing the choice of the knapping method to employ, more than the raw material characteristics. This is particularly evident at the Ciota Ciara cave and at Payre – level D (Fig. 3.92, 3.93, 5.15), while for Pedra Dreta and Can Garriga the limited number of cores do not allow to make thorough considerations (Tabs. 4.3 and 4.4). Opportunistic/S.S.D.A. exploitation strategies are applied to all the blanks morphologies, i.e. rounded pebbles, polygonal blocks, slabs and flakes, while discoid and Levallois reduction sequences are always applied only on rounded pebbles and, at the Ciota Ciara cave, also on spongolite small polygonal blocks (Fig. 3.93). The aim is clearly to reduce the need of shaping the core surfaces

before the phase of *plein débitage*. As observed by different authors (de Lomberra-Hermida, 2009; Mourre, 1994; Tallavaara et al., 2010), when raw materials like vein quartz are knapped, the most the *débitage* proceeds, the most the results of the knapping activity are unpredictable because of the formation of further inner fracture planes that strongly affect the continuation of the exploitation. After the choice of pebbles with suitable morphologies, the general shortness of the reduction sequences on vein quartz (and in general on raw materials rich in internal cleavages and internal flaws), is a second expedient to control the results of knapping activities.

Most of the cores analysed show no more than one phase of exploitation or the detachment of a very reduced number of flakes (two or three) after which the core is discarded. Concerning the Levallois method, adaptations linked to the need of short reduction sequences is evident in the low technological investment in the shaping of the core convexities: the striking platforms are in most cases neocortical surfaces and the convexities on the knapping surfaces are already present on the collected natural blank or roughly prepared through a limited number of centripetal detachments (Appendix A, B, C). Levallois cores, regardless the preferential or recurrent modality employed, are abandoned after one phase of exploitation, no reshaping of the core has been observed in all the contexts studied. Analogously, for discoid reduction sequences, the production starts directly from the natural surfaces of the core and the intention to discard it after a limited number of detachments is evident in the generally scarce presence of removals linked to the management of the core convexities, like chordal or plunging removals (Peresani, 2003). The adaptation of discoid exploitation strategies to vein quartz properties is particularly evident in Payre – level D: flint discoid cores are usually exploited till their exhaustion, showing several

exploitation phases and the removal of plunging flakes or of invasive flakes removing the central convexity of the core; quartz discoid cores are abandoned after only one phase of exploitation and neocortical surfaces are often still present on the core surfaces. The case of Payre – level D clearly shows that the scarce exploitation and maintenance of vein quartz core is not caused by scarce technological skills, but, on the contrary, by a good knowledge of the lithologies and of the possibility that each of them has in terms of production of blanks with the wanted characteristics.

The common use of neocortical surfaces as striking platforms is another adaptation to vein quartz features, since, as demonstrated by experimental studies, this expedient helps in reducing the occurrence of fractures during knapping activities (Mourre, 1996).

On the products, the results of the technological expedients listed above are visible in the characteristics of the butts, mainly flat or natural even concerning discoid or Levallois exploitation strategies, in the reduced number of negatives visible on the dorsal faces, that together with the frequent presence of natural surfaces confirm the shortness of the reduction sequences, and in the general high thickness, another expedient adopted to reduce the occurrence of fractures (de Lomberra-Hermida et al., 2016; Mourre, 1996).

The proportion of the different knapping methods in the considered assemblages shows that when vein quartz and other non-flint raw materials are dominant, opportunistic/S.S.D.A. reduction sequences seem to prevail, another element that contributes in the description of these lithic assemblages like archaic or belonging to human groups with scarce technological skills. In our opinion, this predominance of opportunistic knapping methods, has to be read just as a further adaptation to the raw material characteristics. Being the employment of Levallois

or discoid reduction sequences strictly subject to the availability of natural blanks with suitable morphologies, the easiest way to obtain lithic tools is to exploit all the type of natural blanks available through simple reduction strategies (e.g. Matilla, 2010; Moncel et al., 2014, 2008; Moncel and Lhomme, 2007; Ortega and Maroto, 2001; Santagata et al., 2017; Thiébaud et al., 2012).

A last consideration must be made concerning the subdivision of vein quartz artefacts in morpho-structural groups (de Lombera-Hermida et al., 2011; Martinez Cortizas and Llana Rodriguez, 1996). The results of this analysis show that in Pedra Dreta, Payre – level D and Ciota Ciara levels 14 and 103, the group NS (no grainy/planes) is predominant in the lithic assemblage while in Can Garriga and in Ciota Ciara level 15 the group SN (grainy/no planes) is preferred for knapping activities (Tabs. 3.12, 3.9, 3.6, 4.5, 4.6, 5.3). Some recent works applying this methodology show that, generally, the presence of planes affects the results of knapping activities to a lesser extent than the presence of grains, and therefore the group NS is preferred especially concerning complex reduction sequences, i.e. Levallois (e.g. de Lombera-Hermida et al., 2011). In the considered assemblage the predominance of one of the morpho-structural groups is never linked to the knapping method. This element, together with differences observed in the same sequence (Ciota Ciara cave) or between sites located in the same geographic context (Pedra Dreta and Can Garriga), let us suppose that the predominance of one group over the others could be due more to its predominance in the secondary deposits where the blanks were collected than to a deliberate choice of the knappers. Moreover, the choice of the blanks for Levallois and discoid exploitations seems to be linked more to their morphology than to the morpho-structural group. Even though, to confirm or deny this hypothesis a more precise knowledge of the geologic environment and of the

proportion of the different morpho-structural groups in the environment is necessary.

6.2. Levallois and discoïd technological criteria

The Levallois and the discoïd methods have been clearly defined in the '90s thanks to the works of E. Boëda (1994, 1993), who identified the six technological criteria proper of each method and highlighted the main conceptual differences between the Levallois and the discoïd exploitation (see Chapter 1). Soon after, different problems related to the effectiveness of those criteria in describing the technological variability observed in the archaeological record, opened a great debate about these two *débitage* methods that is still ongoing (e.g. Chazan, 1997; Dibble and Bar-Yosef, 1995; Eren et al., 2011; Eren and Bradley, 2009; Peresani, 2003; Shimelmitz et al., 2016). One of the main issues in this debate is the distinction between the recurrent centripetal Levallois and the discoïd method (Mourre, 2003; Pasty, 2003; Terradas, 2003), especially when the cores are intensively exploited. During the development of this research it became evident how much the definitions of the different knapping methods are based on observations linked to flint exploitations, and just a slight attention has been paid to the modalities of application of the Levallois and the discoïd concepts on non-flint raw materials (Chazan, 1997; de Lomberra-Hermida and Rodríguez-Rellán, 2016; Dibble and Bar-Yosef, 1995; Moncel et al., 2008b; Mourre, 1996; Rodríguez-Rellán, 2016).

After the study of the lithic assemblage of the Ciota Ciara cave, Payre – level D, Pedra Dreta and can Garriga and the observation of a significative quantity of discoïd and Levallois cores and products realized on various raw materials (Tab.

6.1), some considerations can be made about some of the fundamental concepts defining the two knapping methods.

Site	Levallois cores	Levallois flakes	Discoid cores	Discoid flakes
Ciota Ciara cave	vein quartz = 11	vein quartz = 189	vein quartz = 43	vein quartz = 360
	flint = 1	spongolite = 31	spongolite = 9	spongolite = 67
		flint = 13	flint = 2	flint = 10
		radiolarite = 17	others = 1	radiolarite = 9
		rhyolite = 2		rhyolite = 9
	others = 3		others = 5	
Pedra Dreta	vein quartz = 1	vein quartz = 5	vein quartz = 2	vein quartz = 18
	syenite = 1	syenite = 2		syenite = 11
	porphyry = 1	porphyry = 1		porphyry = 4
		quartzite = 3		quartzite = 5
Can Garriga		vein quartz = 4		vein quartz = 7
	-	quartzite = 3	vein quartz = 5	quartzite = 2
		porphyry = 2		porphyry = 2
		others = 1		
Payre - level D	-	-	flint = 46	flint = 230
			vein quartz = 13	vein quartz = 28

Tab. 6.1. Levallois and discoid cores and products present in the considered sites divided according to the raw material employed.

The concept of predetermination, i.e. the production of flakes with specific characteristics for what concerns shape and dimensions, in Middle Palaeolithic lithic assemblages is traditionally linked to Levallois exploitation strategies and to the specific core configuration proper of this method, where the preparation of the lateral and distal convexities on the knapping surface gives the knapper a good degree of control over the results of the knapping activity (Boëda, 1994; Boëda et al., 1990; Picin et al., 2014; Shimelmitz and Kuhn, 2017). The problems linked to the identification of Levallois reduction sequences on cores that do not show phases of core configuration has already been highlighted (Chazan, 1997; Dibble and Bar-Yosef, 1995) but never deeply investigated, being the most of the technological definitions linked to flint lithic assemblages. The study of the

Levallois cores and products present in the four considered lithic assemblages, and particularly at the Ciota Ciara cave, where this *débitage* method is well represented on vein quartz, let us suppose that looking just at the presence of phases of core configuration to define predetermination is quite oversimplifying. According to the criteria listed by E. Boëda (1994), the Levallois method is defined by the presence on the core of two hierarchized surfaces not equally convex and the production develops according to the exploitation of surfaces through a *débitage* direction that is parallel to the plan of intersection between the striking platform and the knapping surface. As already mentioned, especially when vein quartz is involved in the production of tools, the reduction sequences needs to be short to assure the maintenance of good control on the knapping activity (Mourre, 1996). This could be the reason determining the application of Levallois knapping strategies exclusively on natural blanks that already have suitable morphologies and that allow to start the production of Levallois flakes without a great technological investment in core configuration. Vein quartz, porphyry and syenite cores have been recognized as Levallois cores when their volumetric characteristics were consistent with the definition of the method. The exploitation of natural convexities is not automatically related to opportunistic exploitation strategies, but it is the result of the adaptation of a volumetric concept clearly present in the knappers' mind to the constraints due to the mechanical and petrographic characteristics of the raw materials employed. All the Levallois cores studied at the Ciota Ciara and at Pedra Dreta share some characteristics: the dimensions of the blanks collected (mainly rounded pebbles) often determines that no more than one exploitation phase can take place for each core, but even when a reshaping of the convexities would have permitted the production of further predetermined flakes, the cores are discarded; when a slight

modification of the natural convexities present on the core is necessary, this is obtained through a few, usually two or three, centripetal removals, while the striking platform is in most cases represented by natural surfaces; the *débitage* direction is always parallel to the plan of intersection between the core surfaces; the Levallois method is present in two modalities, preferential and recurrent centripetal, no recurrent unipolar or bipolar modalities are attested.

What is constant in all the considered lithic assemblages, is that the performing of Levallois reduction sequences is more influenced by the morphology of the blanks chosen as cores than by the raw material. All the elements traditionally considered to be essential for the method should be considered as factors strictly dependent on the lithic raw materials exploited in the site: what seems to be important in the identification of Levallois reduction sequences is the way in which the volume of the core is perceived. Since flint allow to maintain a good control of the knapping results also along articulated reduction sequences, blanks with various morphological characteristics can be used as Levallois core and their convexities shaped to obtain the wanted volume. With raw materials like vein quartz or porphyry the shaping of the core could compromise the results of the knapping sequence, therefore it is necessary to look for cores that naturally accomplish the volumetric parameters of a Levallois reduction strategy.

One more issue needs to be debated concerning the Levallois method: if the production of Levallois flakes with low-quality raw materials is so strongly affected by the initial morphology of the cores, where is predetermination? i.e. the exploitation of rounded pebbles through reduction sequences that accomplish the volumetric criteria proper of the Levallois method, was aimed to the production of predetermined tools or was it just the easiest way to exploit that natural morphologies? It is not easy to answer this question, since several of the

Levallois cores present in the considered lithic assemblages show that the phase of *plein débitage* starts directly from the natural surfaces of the pebble; on the other hand, especially concerning Levallois preferential cores, the presence of centripetal removals on the knapping surface arranging the natural lateral and distal convexities before the detachment of an invasive flake, suggest that the choice of pebbles with that characteristics was intentionally aimed to the production of Levallois flakes, which morphologies were clearly predetermined. Concerning discoid technology, the concept of predetermination has been widely debated between scholars that recognize to this knapping method a high degree of predetermination, basing their observations on the presence of certain blank-morphologies like pseudo-Levallois points (Boëda, 1993; Loch and Swinnen, 1994; Mourre, 2003), and those considering discoid as an expedite method used to reduce efficiently the core volume through series of recurrent centripetal removals and considering pseudo-levallois points or core edge removals as by-products used to maintain the core convexities (Vaquero et al., 2012). The great variability recognized in the discoid method concerning core morphologies and modalities of core exploitation, made this knapping method more flexible than Levallois, thus generating a huge quantity of variables compared to the classical definition of the method (Boëda, 1993; Peresani, 2003).

When low-quality lithic raw materials are employed, the shortness of the knapping sequences allows to avoid all the problems in the identification of discoid exploitation strategies connected to the intense exploitation of the cores. All the discoid cores realized in vein quartz, porphyry or syenite are characterized by just one phase of exploitation (Appendix A, B, C) with the removal of only one series of centripetal flakes. As mentioned before, this is particularly evident in the lithic assemblage of Payre – level D where discoid flint cores are mostly exhausted

while vein quartz discoid cores have been discarded after one exploitation phase (Appendix C): concerning flint some of the core show characteristics that can generate confusion in their attribution to a discoid or to a recurrent centripetal Levallois reduction sequence, while for vein quartz discoid core the modalities of exploitation of the core volume clearly fit with a discoid conception of the *débitage* (Boëda, 1993; Peresani, 2003). Beside the shortness of the reduction sequences, another great difference between flint and low-quality raw materials discoid reduction strategies is the general morphology of the products obtained: in all the considered lithic assemblages, low-quality raw materials discoid products are obtained almost exclusively through centripetal removals producing short and large quadrangular flakes, while in Payre – level D the intense exploitation of flint discoid cores generates a greater variety of discoid products, like elongated flakes removing the central convexity of the core or core-edge removals (Fig. 5.13) (Peresani, 2003; Picin et al., 2014). The absence of detachments aimed to the management of the cores convexities, highlights that the intention to discard the cores after a short production phase was clear since the beginning of the discoid exploitation, as already observed for the vein quartz discoid cores of the Ciota Ciara cave (see Chapter 3.7).

As for the Levallois method, discoid knapping strategies are applied only on natural blanks with suitable morphologies and the discoid exploitation starts directly from the natural surfaces of the cores. Cores are exploited through centripetal removals with a *débitage* direction always secant to the plane of intersection of the core surfaces. Dimensions and morphology of the products are strongly influenced by those of the cores, leading to the hypothesis that the discoid method could represent, in the considered contexts, just and expeditive core exploitation (Picin et al., 2014; Picin and Vaquero, 2016; Vaquero and

Carbonell, 2003). The discoid method is applied, in all the sites, on natural blanks that have the same morphological characteristics of those exploited through Levallois methods. The choice of exploiting that volume according to a discoid conception can then be interpreted as intentional, with knapping sequences aimed to the production of flakes with morphological characteristics different from those issued from Levallois reduction strategies.

Even if the general technological behavior observed in the considered sites can be defined as opportunistic (exploitation of natural convexities, reduction sequences strongly influenced by the characteristics of the raw materials) predetermination is evident in the adaptation of Levallois and discoid concepts to the natural convexities present on the core. The same natural convexities can be exploited to obtain predetermined Levallois or discoid products, highlighting the intentional choice made by the knapper. The volumes of the rounded pebbles collected are exploited according to plans secant or parallel to the plan of intersection between the core surfaces, thus determining the main difference between a Levallois and a discoid exploitation strategy. Another issue widely debated is in fact that of the technological criteria useful to distinguish between discoid and recurrent centripetal Levallois reduction strategies (Boëda, 1995, 1993, 1991; Boëda et al., 1990; Chacón et al., 2012; Chazan, 1997; Delpiano and Peresani, 2017; Dibble, 1991, 1985; Dibble and Bar-Yosef, 1995; Eren et al., 2011; Jaubert and Farizy, 1995; Kuhn, 1992; Peresani, 2003, 1998; Picin et al., 2014; Picin and Vaquero, 2016; Romagnoli et al., 2016; Shimelmitz et al., 2016; Shimelmitz and Kuhn, 2017; Vaquero and Carbonell, 2003). It is well-founded that not all the six criteria listed by E. Boëda (1993) can be considered to be diagnostic to distinguish between the two methods, and several considerations have been made concerning flint assemblages, leading to the conclusion that the characteristics of discoid and

Levallois reduction sequences are very different from one archaeological context to the other and that generalizations are hard to be done (Baena-Preysler et al., 2003; Mourre, 2003; Slimack, 2003; Terradas, 2003; Vaquero and Carbonell, 2003).

Dealing with raw materials different from flint, characterized by a scarce aptitude for knapping and by short reduction sequences often reduced to only one phase of exploitation, gives the chance to observe the totality of the knapping sequence (Appendix A, B, C). As mentioned before, no phases of shaping of the core convexities are present and just in the preferential Levallois modality the natural convexities can be slightly adapted to the knapper's needs, i.e. slight modifications of the natural convexities of the knapping surface are achieved through a limited number of centripetal removals. Often the discoid method is attested in the unifacial modality, with surfaces hierarchized since the beginning of the exploitation. After the analysis of the discoid and the Levallois cores present in the considered assemblages, it seems that a clear distinction between a Levallois and a discoid conception of the *débitage* relies in how the volume of the core is perceived: starting from similar natural morphologies (i.e. rounded pebbles) the different conception of the core volume determines differences in its exploitation that are mainly evident in the *débitage* direction, secant to the plane of intersection between the core surfaces for the discoid method, parallel for the Levallois. The general volume of the exploited core and the *débitage* direction, concerning low quality raw materials, are the only technological criteria that allow to clearly distinguish between discoid and recurrent centripetal Levallois exploitation strategies.

The choice of one method rather than to the other, always considering low quality raw materials, don't seem to have been determined by reasons linked to

productivity (e.g. Eren and Lycett, 2012; Lycett and Eren, 2013; Picin and Vaquero, 2016) since recurrent centripetal Levallois and discoid cores show one phase of exploitation that lead to the production of a limited number of flakes (Appendix A, B, C). The great differences in the development of Levallois and discoid knapping sequences between flint and other raw materials, due to the mechanical and petrographic properties of the lithologies employed, made the results of experimental studies conducted on flint (e.g. Eren et al., 2014, 2011; Eren and Bradley, 2009; Eren and Lycett, 2016, 2012; Lycett and Eren, 2013) not completely applicable to raw materials like vein quartz, where the choice of the discoid or of the Levallois method seems to be linked more to the characteristics of the products that can be obtained, than to productivity requirements.

In conclusion, if it is undeniable that the quality of the raw materials and the morphologies of the natural blanks available strongly affect the choice of the knapping methods and it can be the reason why in low-quality raw materials lithic assemblages opportunistic reduction sequences are predominant, it is evident that Middle Palaeolithic hunter-gatherers adapt technological concepts proper of their background to the resources available, showing great technological skills and the capability to practice complex adaptation strategies.

CHAPTER 7

Conclusions

CHAPTER 7

CONCLUSIONS

The technological study performed on the lithic assemblages of the Ciota Ciara cave, Pedra Dreta, Can Garriga and Payre - level D led to achieve interesting results concerning the single considered contexts, the exploitation of non-flint raw materials and to general observations about the technological criteria useful for the identification of Levallois and discoid reduction sequences. At the Ciota Ciara cave, the location of the supply areas of lithic raw materials allowed for the first time to make reliable hypothesis about the economy and land mobility of the Middle Palaeolithic hunter-gatherers frequenting Piedmont (north-western Italy) (see Chapter 3.5), opening significative research perspectives in territories where the knowledge about Palaeolithic are extremely sketchy and linked to sporadic findings (Berruti and Viola, 2011; D'Errico and Gambari, 1983; Giacobini, 1976; Guerreschi and Giacobini, 1998; Mottura, 1990, 1980, Rubat Borel et al., 2016, 2013).

The technological study of the lithic assemblages from the different SS.UU. of the Ciota Ciara cave contributes in the interpretation of the modalities of frequentations of the cave: in accordance with the results of the functional, palaeontological and archaeozoological analysis recently performed (Berruti, 2017; Berto et al., 2016; Buccheri et al., 2016; Daffara et al., 2014), S.U. 13 and 15 correspond to short-terms occupations probably linked to hunting activities, while for S.U. 14 the cave was used as a base-camp with repeated medium or long term frequentations characterized by the intense exploitation of animal resources, with long lasting processes, as hide treatment, combined with a marginal exploitation of vegetal resources (Berruti, 2017; Buccheri et al., 2016).

In a context like Piedmont, where no sources of good quality raw materials are present (Gabriele L.F. Berruti et al., 2016; Guerreschi and Giacobini, 1998), the lithic assemblages found in all the archaeological layers of the Ciota Ciara cave are a very good example of the strategies put into action as adaptations to the local resources. Vein quartz, very abundant in the local environment (Berruto, 2016, 2011) and available with different blank morphologies (rounded pebbles or polygonal blocks of different size) has been adopted as main lithic resource. The technological study revealed that the morphology of the blanks collected was the main factor influencing the choice of the knapping method, more than the petrographic characteristics of the raw material, i.e. morpho-structural groups. While opportunistic reduction sequences were applied to all the natural blanks available, Levallois and discoid knapping strategies were performed exclusively on rounded pebbles with suitable convexities, with a production of predetermined flakes that starts directly from the natural surfaces of the core, with some adjustments of the natural convexities only when a preferential Levallois exploitation was chosen (Appendix A). Such technological behaviour reveals that what we recognize as Levallois and discoid exploitation strategies correspond to different volumetric conceptions that were clearly part of the technological skills of these hunter-gatherer's groups and that remain discernible one to the other, in the absence of intense phases of shaping of the core, just on the base of how the volume of the core has been reduced. Other local raw materials were exploited at the Ciota Ciara cave as complementary lithic resources, especially spongolite, collected near the site but with petrographic characteristics that made very hard the control of the knapping activities, i.e. presence of frequent inner fracture planes (see Chapter 3.5). As for vein quartz, we observed that the morphology of the blanks collected influenced the choice of

the knapping method more than other factors: slabs were exploited through opportunistic reduction sequences, while small polygonal blocks with suitable convexities were employed for discoid and Levallois reduction strategies. Other local raw materials are more sporadically attested, and it is interesting the presence of finished tools and retouch flakes realized on radiolarite (~ 30 km from the site) and rhyolite (~ 2 km from the site). This good-quality raw materials have been exploited through the same strategies applied on vein quartz and spongolite but, as previously pointed out (see Chapter 3.7) some elements like the presence of Levallois flakes with faceted butts, let us suppose that on these raw materials such reduction sequences were more articulated and that quite intense phases core configuration were performed. This difference in Levallois reduction strategies between low and better-quality raw materials confirms that the roughness of vein quartz and spongolite exploitation strategies is due to adaptations to the raw materials properties.

The revision of the lithic assemblages from Pedra Dreta and Can Garriga (Canal et al., 1978; Garcia Garriga, 2015; Giralt et al., 1995; Mora et al., 1987; Rodriguez et al., 1995; Rodríguez et al., 2004), shows that the Middle Palaeolithic human groups frequenting the Ter river exploited a great variety of local lithic resources: vein quartz, quartzite, syenite, porphyry, schist, basalt, metamorphic rocks, limestone, hornfels, gneiss, sandstone, granite, lydite and diorite (see Chapter 4). All these lithologies were available near the site as fluvial pebbles. The characteristics of the reduction sequences of the most exploited raw materials (vein quartz, syenite and porphyry) revealed that, like the Ciota Ciara cave, the morphology of the natural blanks collected was the main factor affecting the choice of the knapping method. Levallois and discoid exploitation strategies are adapted to those morphologies with the aim to produce predetermined flakes

taking advantage of the convexities already present on the core surfaces and lightly modifying them when necessary (Appendix B).

Concerning Payre – level D, different technological studies have already been performed on this lithic assemblage (Bouteaux et al., 2008; Moncel, 2008; Moncel et al., 2009, 2008b; Moncel and Chacon, 2007; Moncel and Patou-Mathis, 2008; Rivals et al., 2009) but the present work focuses for the first time on the characteristics of the discoid technology present in this layer and on the differences in discoid reduction sequences depending on the raw materials employed. The results obtained highlight that those differences strictly depend on the raw material properties: flint allows to manage long and articulated reduction sequences while the results of knapping activities are more controlled on vein quartz only reducing the intensity of the core exploitation. Like at the Ciota Ciara cave, in Payre – level D is evident that the roughness of vein quartz discoid reduction sequence is only due to adaptations to the raw material properties.

All the considered lithic assemblages are the result of technological behaviours clearly opportunistic that takes advantage from the natural morphologies of the cores to produce flakes with the wanted characteristics. The general low investment in the shaping of the cores' convexities and the shortness of the reduction sequences emphasize the problem of identifying useful criteria for the identification of Levallois and discoid reduction strategies. This issue has been longer debated but almost the totality of the observations have been made concerning flint (Bargallò Ferrerons, 2008; Boëda, 1993; Delagnes, 1995; Delpiano and Peresani, 2017; Eren et al., 2011; Eren and Bradley, 2009; Eren and Lycett, 2012; Goval et al., 2016; Jaubert and Farizy, 1995; Peresani, 2001, 1998, 2003; Picin and Vaquero, 2016). Flint often shows long and articulated reduction

sequences, with phases of reshaping of the core, and with several technological expedients used to maintain the core convexities (e.g. Brantingham and Kuhn, 2001; Eren and Bradley, 2009). The presence of numerous variables in Levallois and discoid flint reduction sequences led to a huge variety of interpretations about the criteria defining this two knapping methods, creating a sort of typological classification of the variations observed in each context (e.g. Conard et al., 2004; Eren et al., 2014; Lycett and von Cramon-Taubadel, 2013). The technological analysis of non-flint raw materials highlights that some criteria considered to be diagnostic and distinctive for the identification of Levallois or discoid reduction sequences are not applicable to non-flint assemblages: presence of more or less intense phases of shaping of the core surfaces, preparation of the striking platform, and presence and the characteristics of the products referable to core maintenance (Boëda, 1994, 1993; Chazan, 1997; Peresani, 2003). All these elements are absent in the considered lithic assemblages and, in our opinion, the modalities of core shaping and maintenance, as well as the exploitation of one or two core surfaces in discoid knapping strategies, depend on a combination of different elements that are not detectable in the technological analysis, like the ability of the knappers, the contingency that determined the production of flakes and the span of time dedicated to flake production. Each of these factors can determine different core shaping and morphologies: elements depending on such unpredictable factors cannot be assumed as diagnostic elements for the identification of a knapping method. The only constant characteristics observed on the considered cores (Appendix A, B, C) are the *débitage* direction, parallel to the plane of intersection between the core surfaces for the Levallois method, secant for the discoid, and, to a greater extent, the way in which the volume of the core is perceived. As

mentioned before, non-flint raw materials give the chance to observe all the knapping sequence performed on a core, and in all the lithic assemblages analysed, starting from the same natural morphologies, two volumetric conceptions are clearly visible, attributable to the definition of the Levallois and the discoid methods (Boëda, 1994, 1993), and the variability observed in each assemblage in terms of intensity of exploitation and core configuration are due to adaptation strategies to the mechanical properties of the different raw materials employed, put into action by knappers with different knapping *savoir faire* and probably different needs (Slimak, 2003).

The aim of lithic technology is to understand the technological behaviour of the human groups that based part of their subsistence on the production of lithic tools (Bar-Yosef and Van Peer, 2009; Geneste, 1991; Leroi-Gourhan, 1964; Pelegrin et al., 1988; Slimak, 2003; Tixier, 1978). Classifications and categories are needed, i.e. Levallois and discoid, but they must be intended in their general meaning: they substantially correspond to two different ways of raw material exploitation, depending on how the volume of the core is perceived. Focusing on aspects linked more to contingencies proper of each specific context than to the essential definition of the methods makes us focus on aspects that are not significant for the aims of technological studies that, considered all together, should be able to broadly reconstruct the technological and economic behaviour of the Middle Palaeolithic European hunter-gatherers. To achieve this objective non-flint raw materials cannot be left behind, since as the present study highlights, they represent a significant portion of the hunter-gatherers' economy, they provide interesting information and give rise to several considerations about the technological strategies and skills of Middle Palaeolithic knappers.

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APPENDIX A

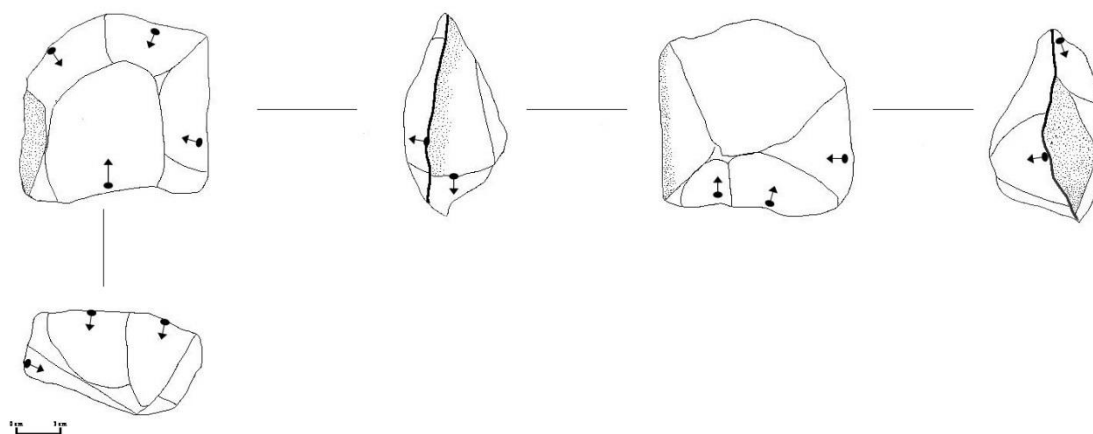
Ciota Ciara cave:

discoid and Levallois cores

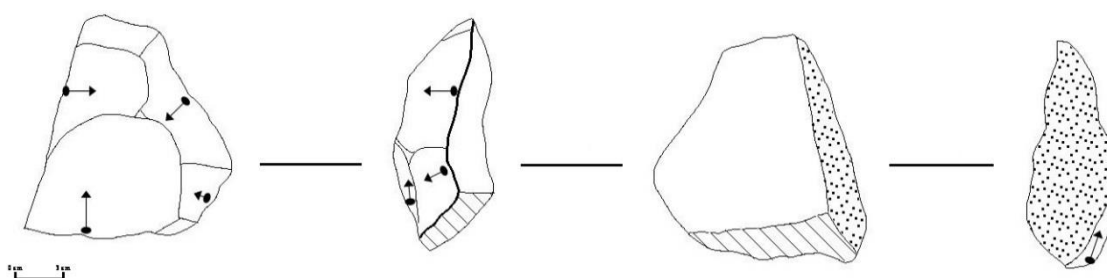
APPENDIX A

Ciota Ciara cave: discoid and Levallois cores

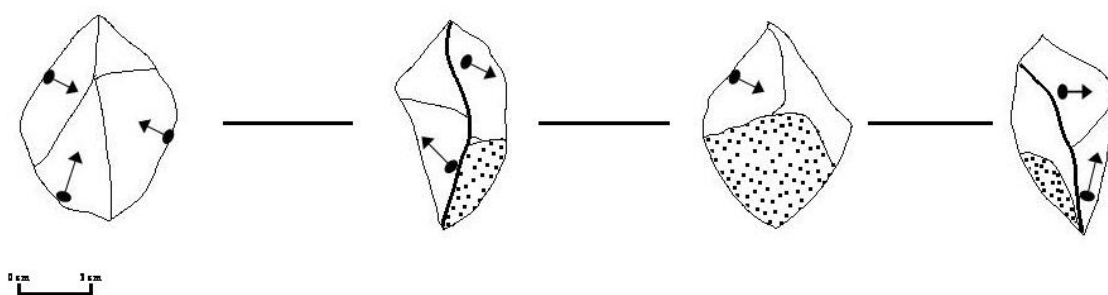
1. S.U. 13 - Vein quartz cores



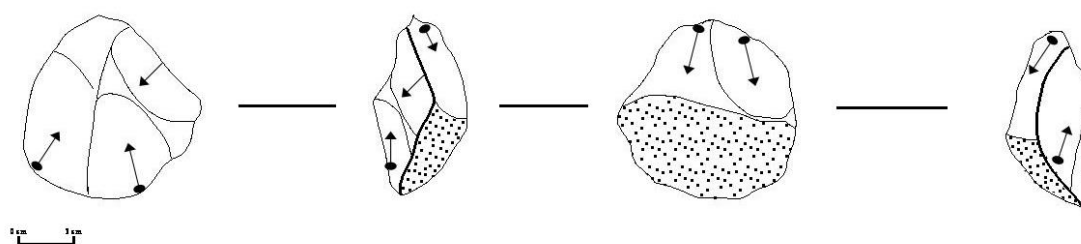
CC 13 E3 14. Vein quartz preferential Levallois core on pebble. One phase of exploitation; the core has been discarded before its exhaustion; three centripetal detachments prepare the distal and one of the lateral convexities of the knapping surface; the other lateral convexity is natural; three centripetal detachment prepare the striking platform surface in correspondence of the impact point of the preferential flake. The wanted product is an elongated medium sized flake. (from Daffara, 2011).



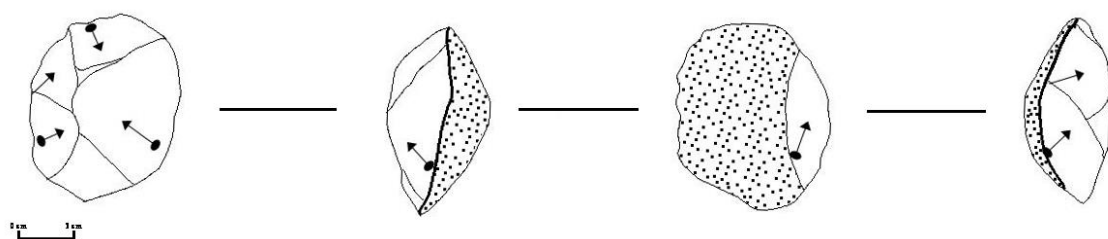
CC 13 F3 172. Vein quartz recurrent centripetal Levallois core; one phase of exploitation; the core is exhausted; the striking platform surface is natural, and no preparation of the knapping surface is present; the wanted products are short and large oval flakes. (From Daffara, 2011)



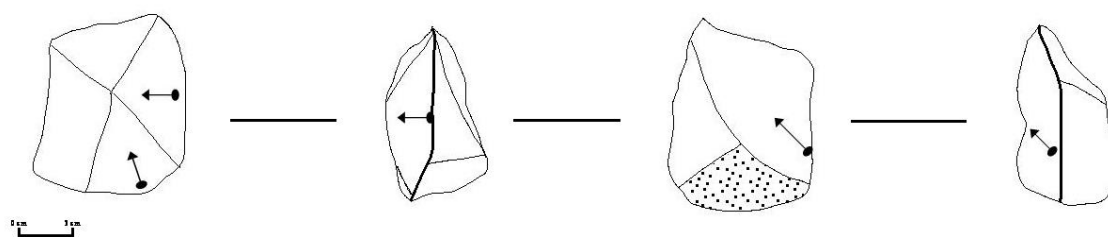
CC 13 F3 79 n.c. Vein quartz discoid bifacial core on small pebble; one phase of exploitation; one of the surfaces is partially natural; the core has been discarded before its exhaustion; the wanted products are small short and large flakes obtained through centripetal removals. (From Daffara, 2011)



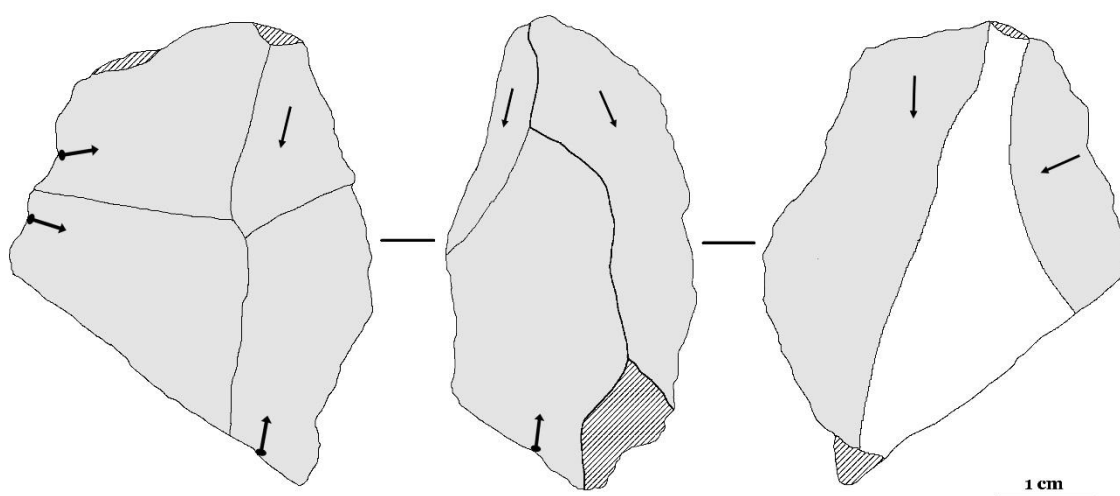
CC 13 F3 185. Vein quartz discoid bifacial core on small pebble; one phase of exploitation; one of the surfaces is partially natural; the core has been discarded before its exhaustion; the wanted products are small flakes obtained through centripetal detachments. (From Daffara, 2011)



CC 13 F4 5. Vein quartz discoid unifacial core on a small pebble; one phase of exploitation; the core is exhausted; the striking platform surface is natural; the wanted products are small short and large flakes obtained through centripetal detachments. (From Daffara, 2011)

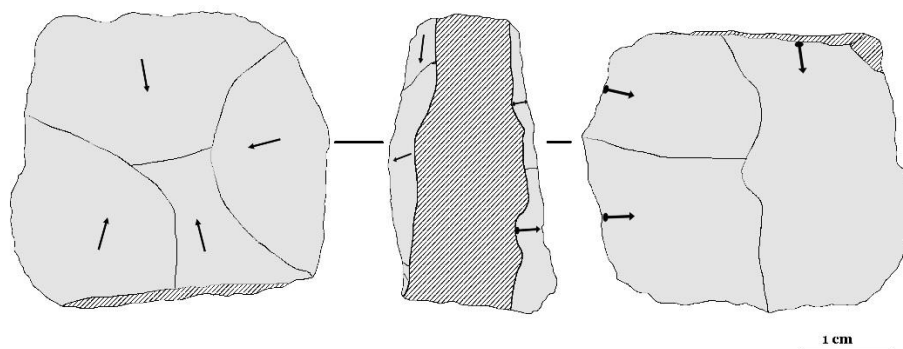


CC 13 F4 4. Vein quartz discoid bifacial core on a small pebble; one phase of exploitation; the core is exhausted; both the surfaces are partially natural; on the first knapping surface the wanted products are small flakes obtained through centripetal detachments; on the second knapping surface an elongated plunging flakes is obtained through a chordal removal. (From Daffara, 2011).



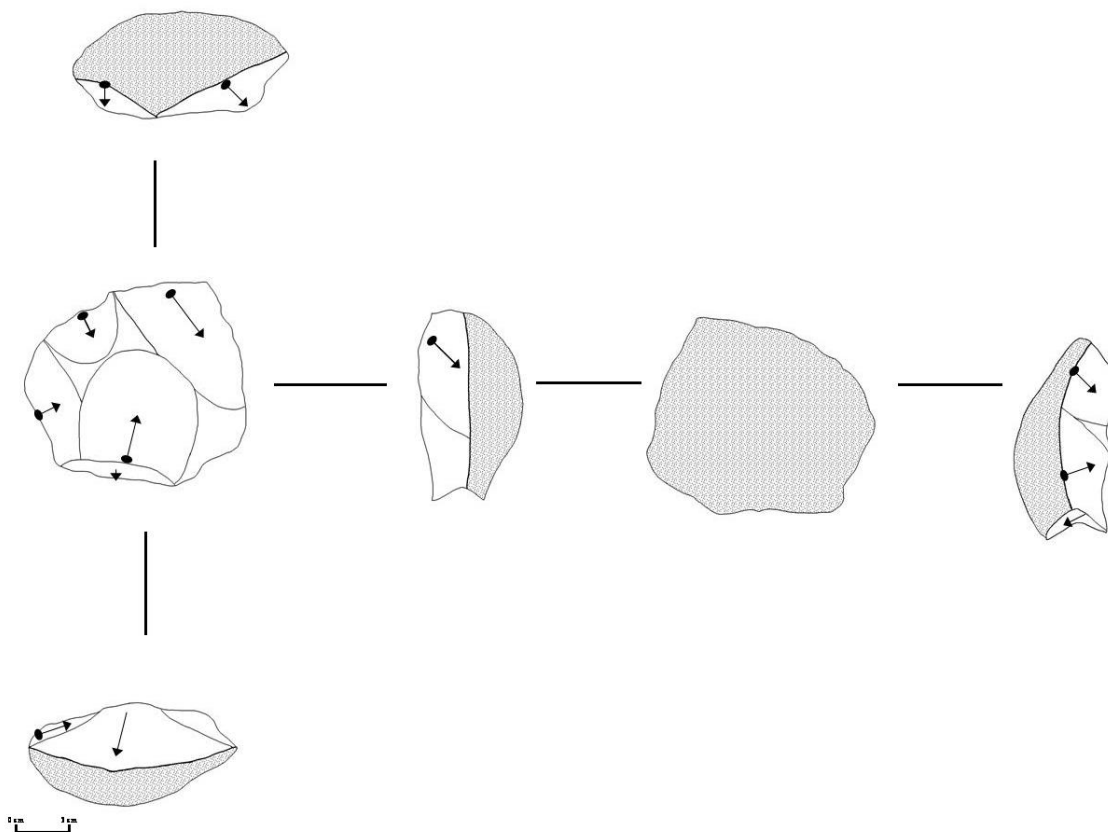
CC 13-12 G3 153. Vein quartz bifacial discoid core; one phase of exploitation; the core has been discarded before its exhaustion; the wanted products are medium-sized large and elongated flakes obtained through centripetal and chordal removals.

2. S.U. 13 Spongolite core

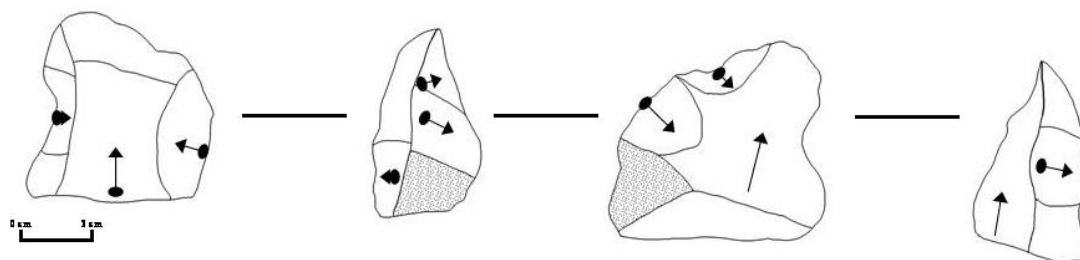


CC 13-14 G4 259. Spongolite discoid bifacial core; one phase of exploitation; the core has been discarded before its exhaustion; fractures occurred during *debitage*; the wanted products are medium sized large and short flakes obtained through centripetal and chordal removals.

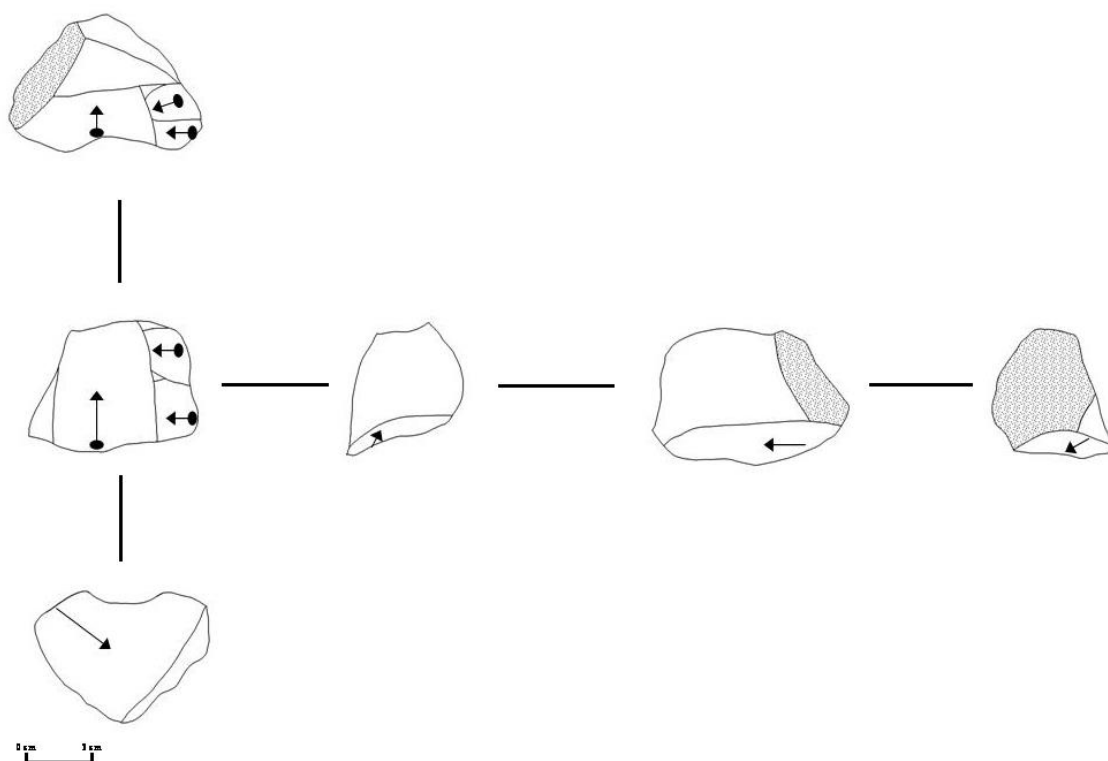
3. S.U. 14 Vein quartz cores



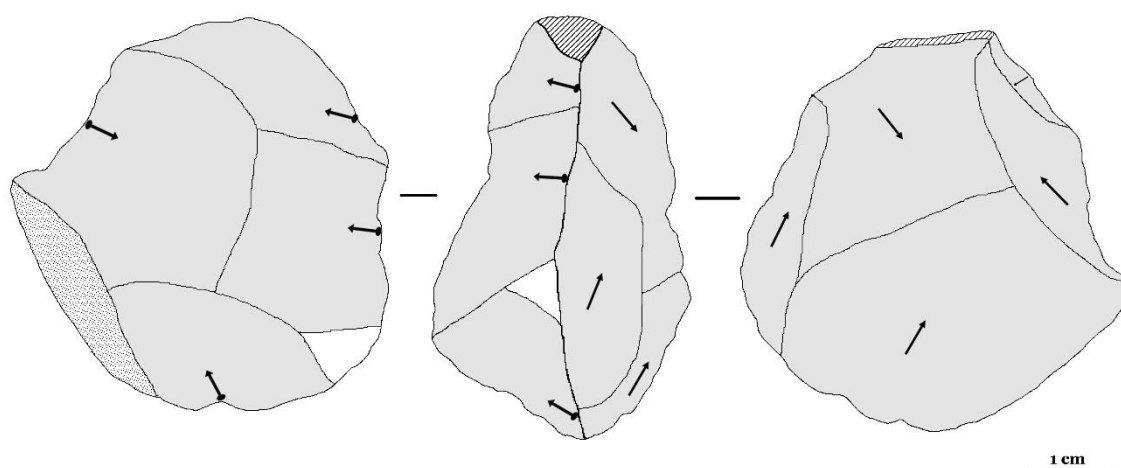
CC 14 F4 117. Vein quartz preferential Levallois core on pebble (SN group); one phase of exploitation; the core is exhausted; the striking platform surface is natural; one removal perpendicular to the intersection between the two core surfaces prepares the portion of the striking platform surface in correspondence of the impact point of the preferential flake; the lateral and distal convexities on the knapping surface are prepared through two centripetal and one chordal detachment.; the wanted products is an oval medium-sized flake. (From Daffara, 2011).



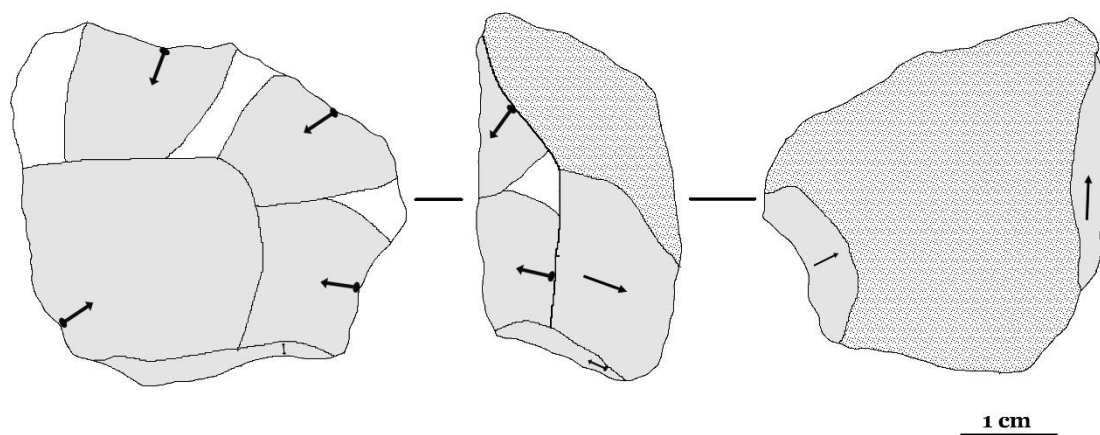
CC 14 F4 16. Vein quartz preferential Levallois core on small pebble (SN group); one phase of exploitation; the core is exhausted; the convexity of the striking platform surface is prepared through three removals; the lateral convexity on the knapping surface are prepared through two centripetal detachments while the distal convexity is natural; the wanted product is a small quadrangular flake. (From Daffara, 2011).



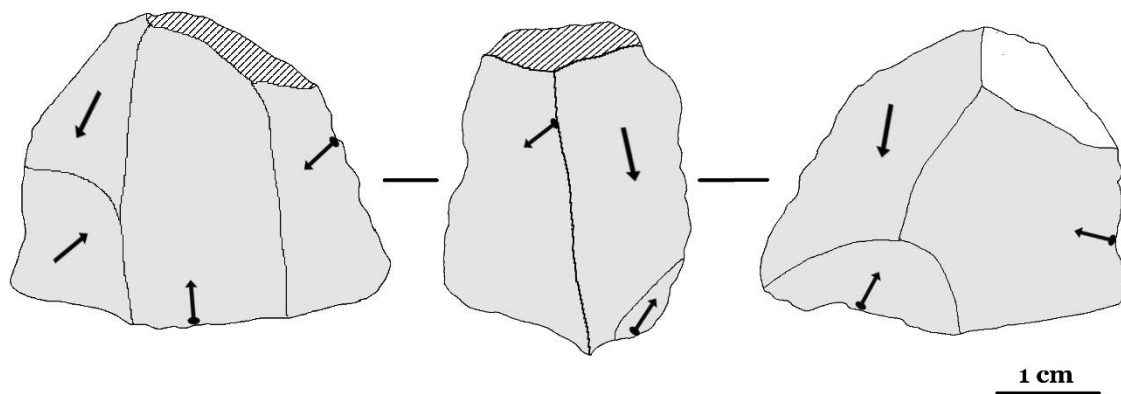
CC 14 F4 89. Vein quartz preferential Levallois core on small pebble (SN group); one phase of exploitation; the core is exhausted; the striking platform surface is natural; one removal perpendicular to the intersection between the two core surfaces prepares the striking platform in correspondence of the impact point of the preferential flake; the wanted product is a small elongated flake. (From Daffara, 2011).



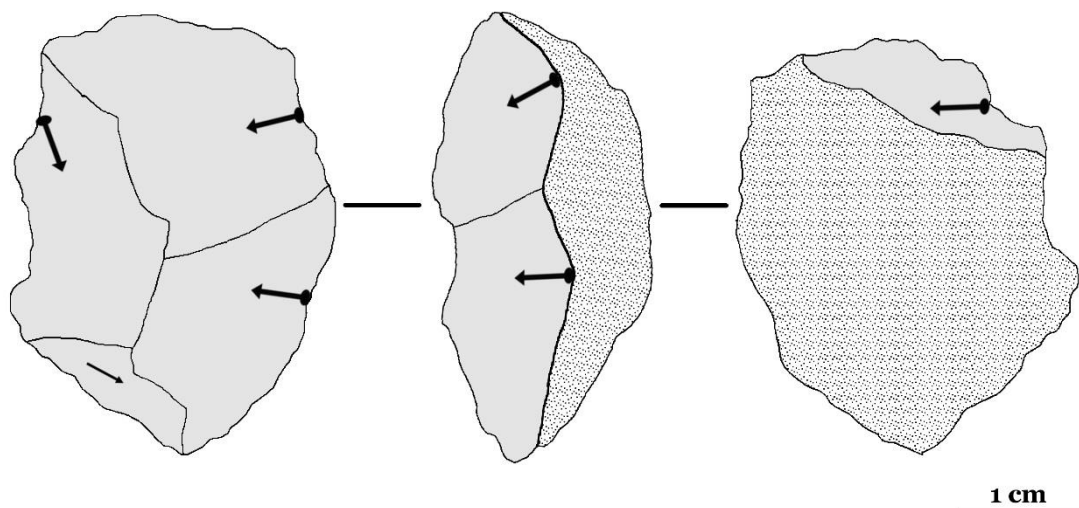
CC 14 D3 101. Vein quartz recurrent centripetal Levallois core on pebble (SN group); one phase of exploitation; the core has been discarded before its exhaustion; the striking platform surface is prepared through four removals; no shaping of the convexities is present on the knapping surface; the wanted products are mediu-sized short and large flakes obtained through centripetal and chordal detachments, sometimes plunging.



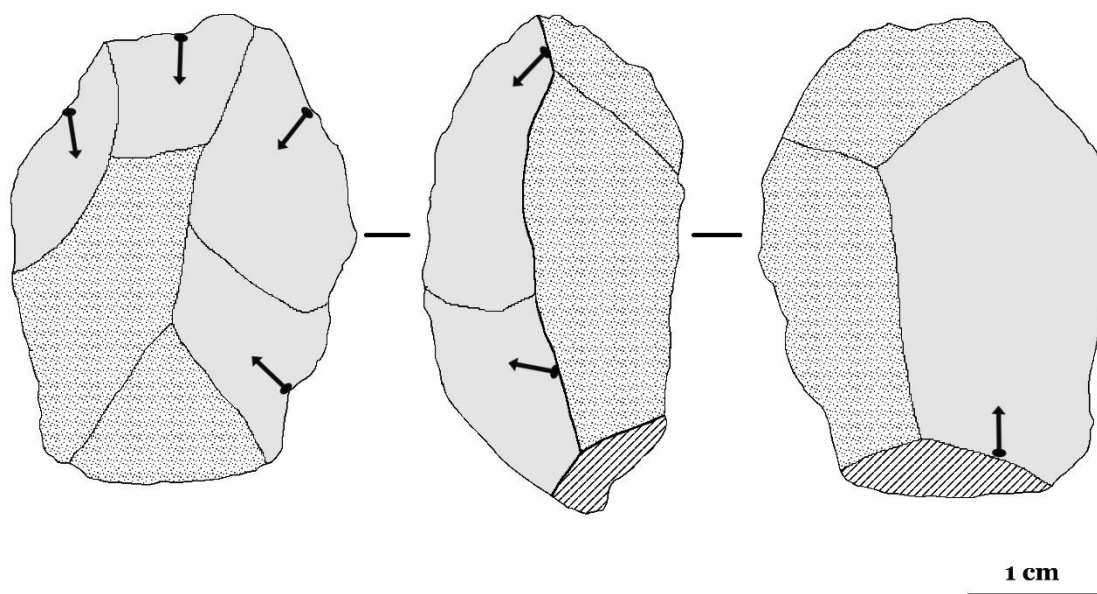
CC 14 D3 48. Vein quartz preferential Levallois core on pebble (SN group); one phase of exploitation; the core has been discarded before its exhaustion; the striking platform surface is almost completely natural; the lateral and distal convexities of the knapping surface are prepared through three centripetal detachments; the wanted product is a medium-sized quadrangular flake.



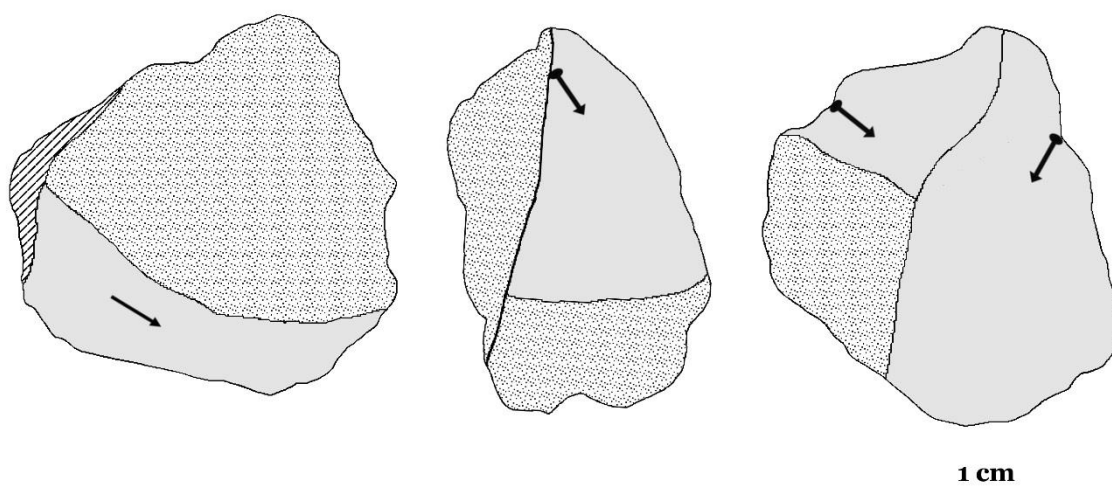
CC 14 D3 141. Vein quartz bifacial discoïd core (SN group); one phase of exploitation; the core has been discarded before its exhaustion; the wanted products are short and large, in one case elongated, medium sized flakes obtained through centripetal and chordal detachments.



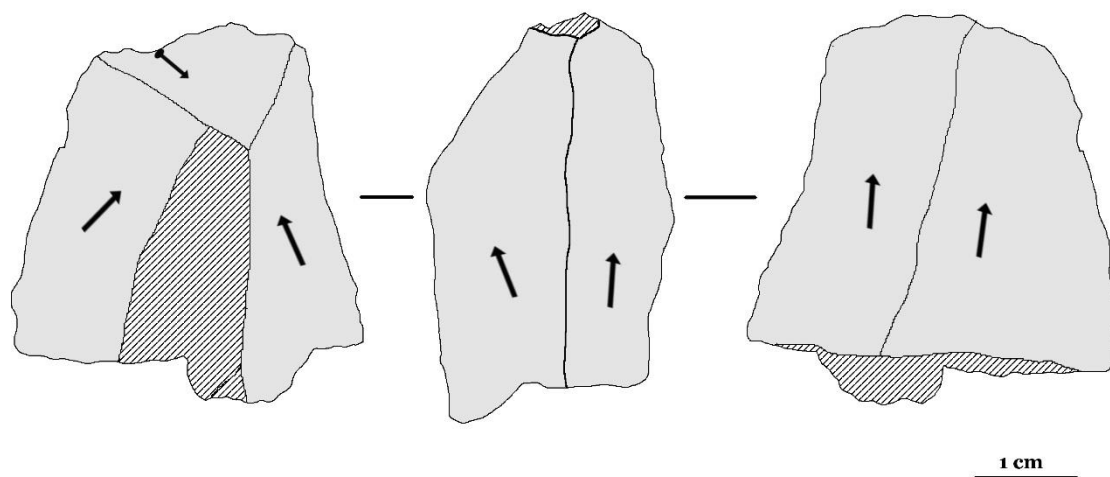
CC 14 D3 59. Vein quartz unifacial discoid core on pebble (NS group); one phase of exploitation; the core has been discarded before its exhaustion; the striking platform is natural; the knapping surface has been exploited through four centripetal removals to obtain short and large flakes.



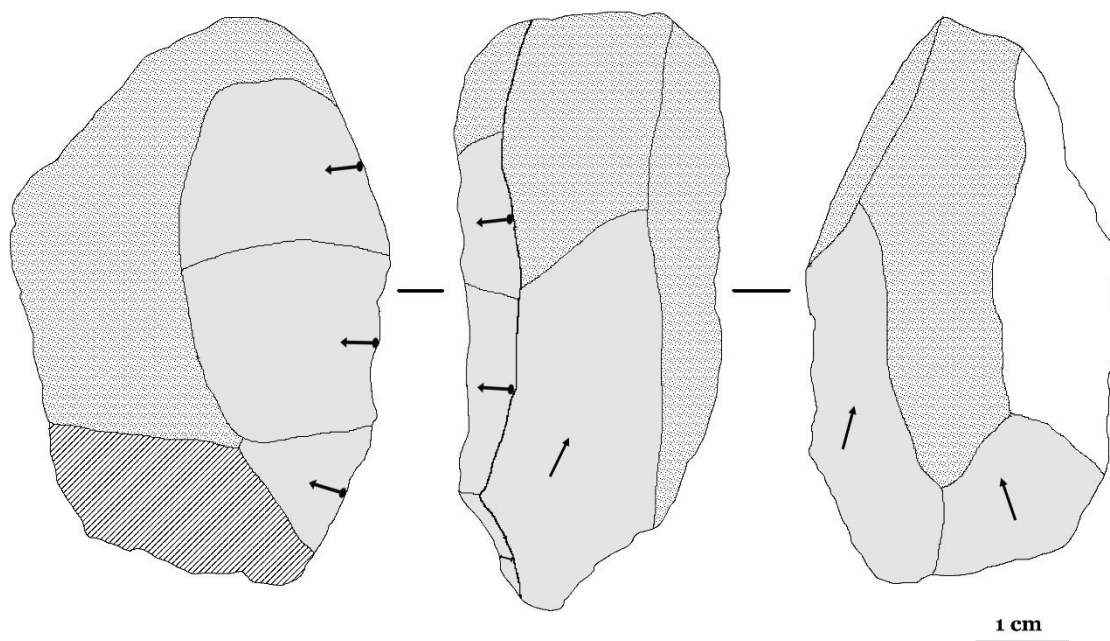
CC 14 D3 22. Vein quartz discoid core on pebble (NS group); one phase of exploitation; the core has been discarded before its exhaustion; both the surfaces are partially natural; the wanted products are medium-sized flakes, sometimes plunging, obtained through centripetal removals.



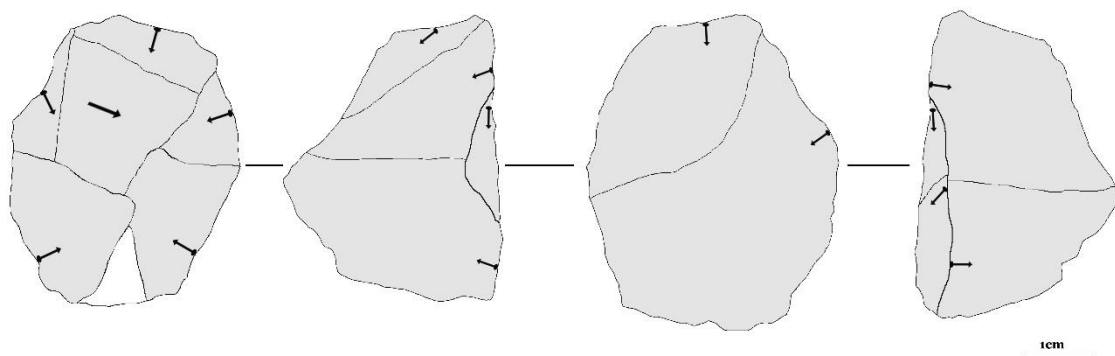
CC 14 D3 221. Vein quartz discoid core on pebble (NS group); the core has been just partially exploited through centripetal and chordal detachments; both surfaces are partially natural; the core has been discarded before its exhaustion; the wanted products are medium-sized plunging flakes.



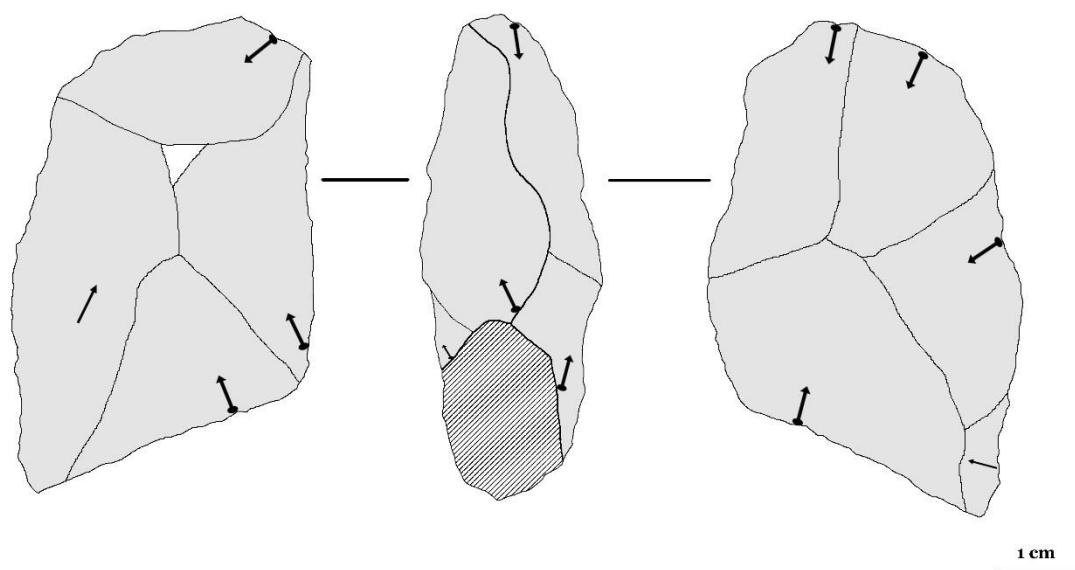
CC 14 D3 232. Vein quartz fragmented discoid core (SN group); one phase of exploitation; the core is exhausted; the wanted products are small elongated quadrangular flakes obtained through centripetal detachments.



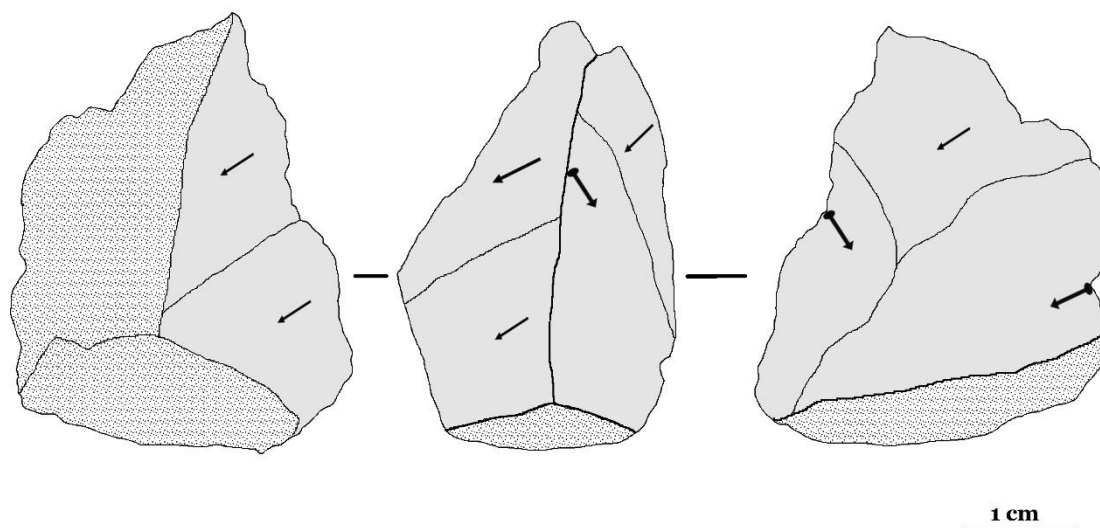
CC 14 D4 232. Vein quartz discoid core on small block (NS group); both surfaces are partially natural; the wanted products are medium-sized flakes obtained through centripetal detachments.



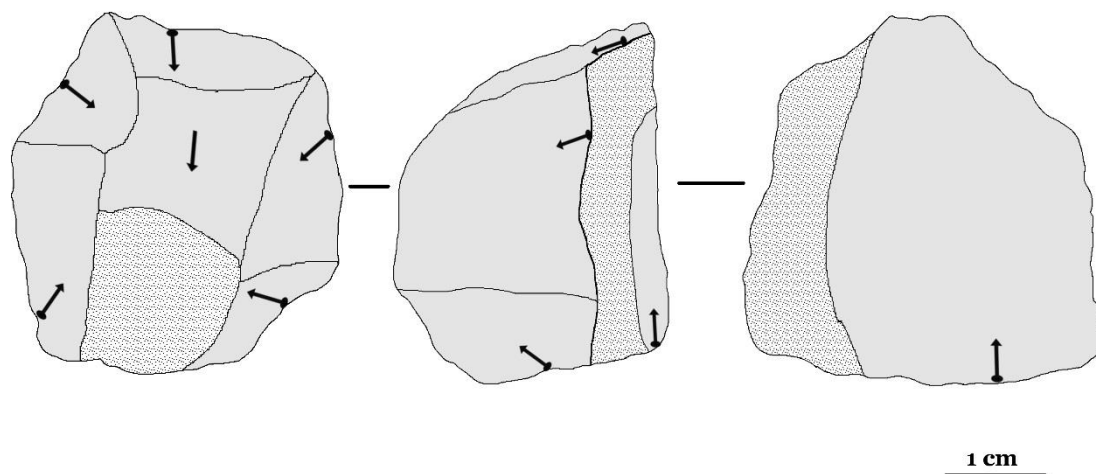
CC 14 D4 83. Vein quartz bifacial discoid core on pebble (NS group); two phases of exploitation are visible on one of the surfaces; the core has been discarded before its exhaustion; the wanted products are medium sized short and large flakes, sometimes plunging, obtained through centripetal detachments.



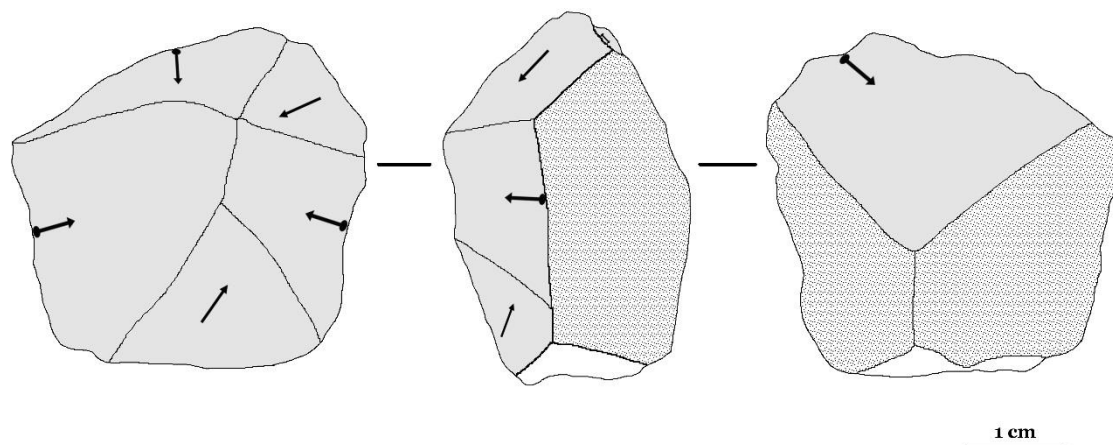
CC 14 D4 116. Vein quartz bifacial discoid core (NS group); one phase of exploitation; the core is exhausted; the wanted products are medium sized flakes, sometimes plunging, obtained through centripetal and chordal removals.



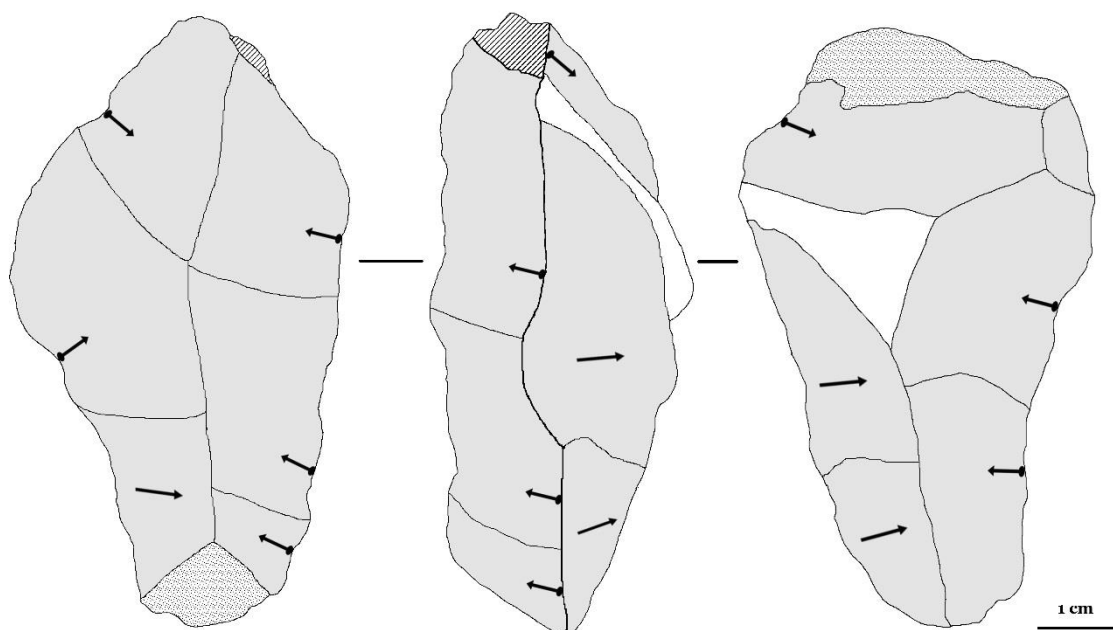
CC 14 E3 98. Vein quartz bifacial discoid core on pebble (NS group); one phase of exploitation; the core has been discarded before its exhaustion; one of the surfaces is partially natural; the wanted products are short and large flakes obtained through centripetal detachments.



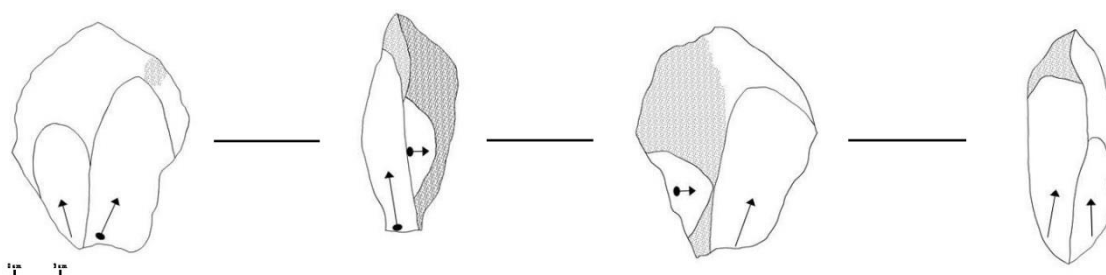
CC 14 D3 278. Vein quartz unifacial discoid core (NS group); two exploitation phases; the core has been discarded before its exhaustion; one of the surfaces is partially natural and a big removal prepares the striking platform; the wanted products are small and short flakes obtained through centripetal detachments.



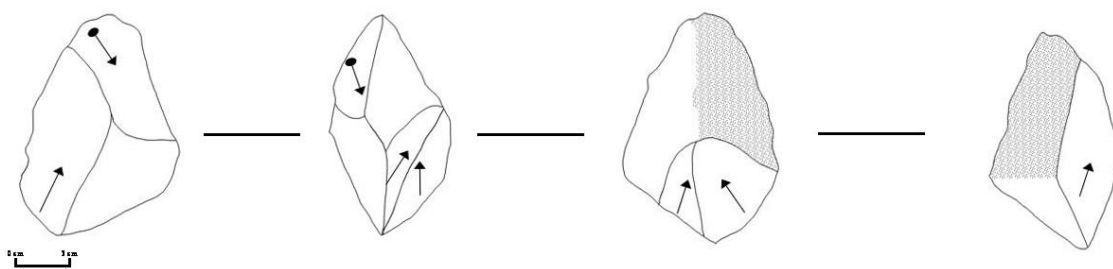
CC 14 E4 435. Vein quartz bifacial discoid core (SN group); one phase of exploitation; the core has been discarded before its exhaustion; one of the surfaces is partially natural; the wanted products are small flakes, sometimes plunging, obtained through centripetal detachments.



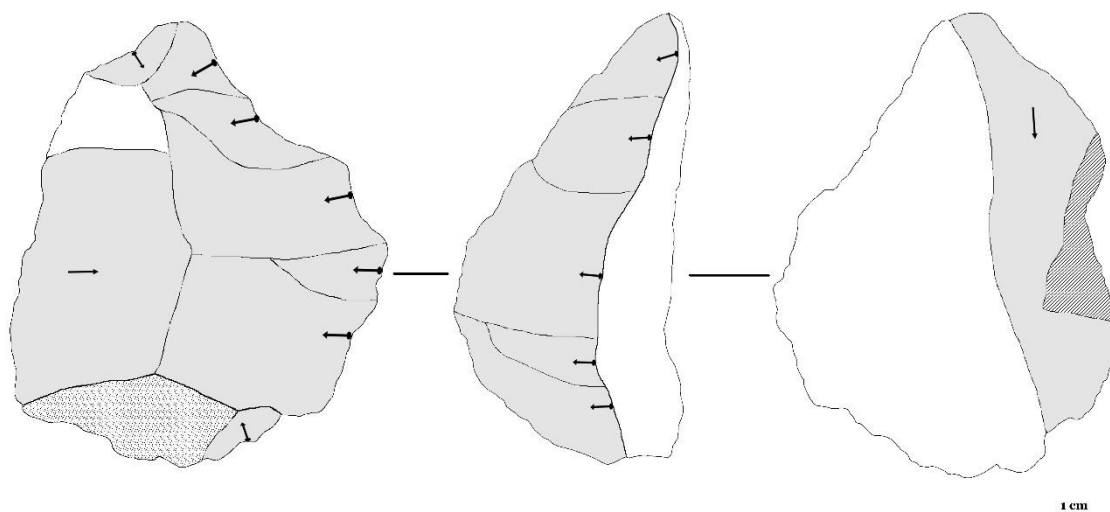
CC 14 D3 313. Vein quartz bifacial discoid core on flake (SN group); one phase of exploitation; the core has been discarded before its exhaustion; the wanted products are medium sized quadrangular flakes, sometimes plunging, obtained through centripetal detachments.



CC 14 E4 29. Vein quartz discoid core on pebble (NS group); after few detachments in a centripetal direction the core has been discarded; both the surfaces are partially natural; the wanted products are medium-sized elongated flakes. (From Daffara, 2011).

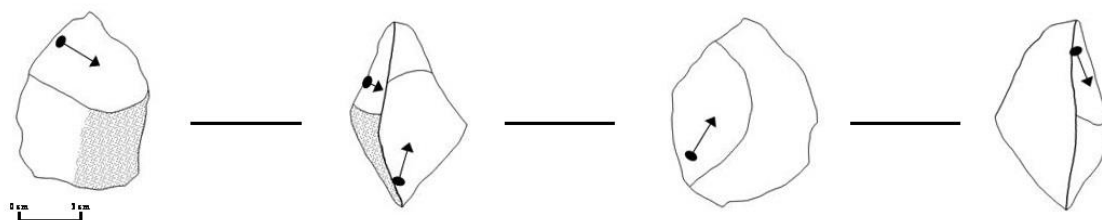


CC 14 F3 116. Vein quartz discoid core on small pebble (SN group); one phase of exploitation; the core has been discarded before its exhaustion; the wanted products are small elongated flakes obtained through centripetal detachments. (From Daffara, 2011).

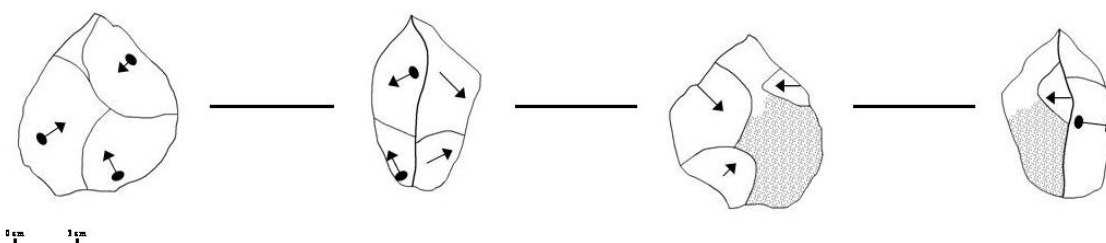


CC 14 D3 281. Vein quartz unifacial discoid core (SN group); one phase of exploitation; The core has been discarded before its exhaustion; the striking platform surface has been prepared through a removal in chordal direction; the wanted products are medium-sized quadrangular flakes obtained through centripetal detachments.

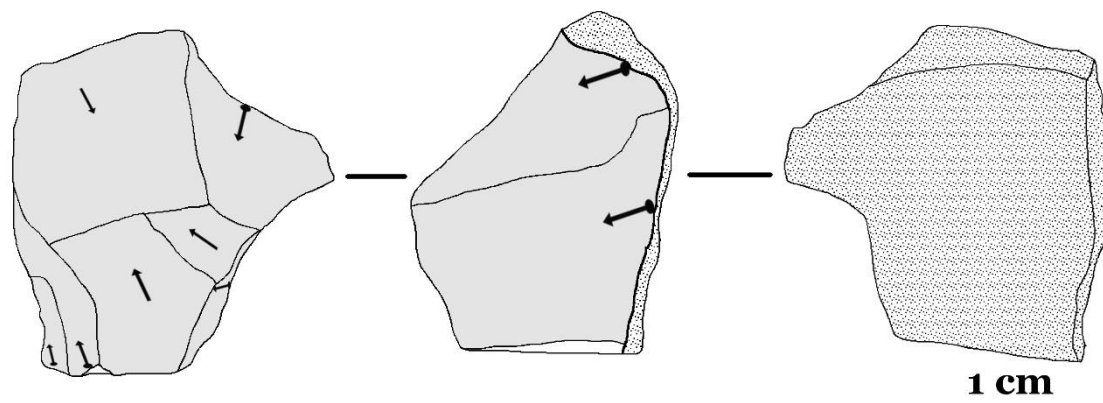
4. S.U. 14 Spongolite and flint cores



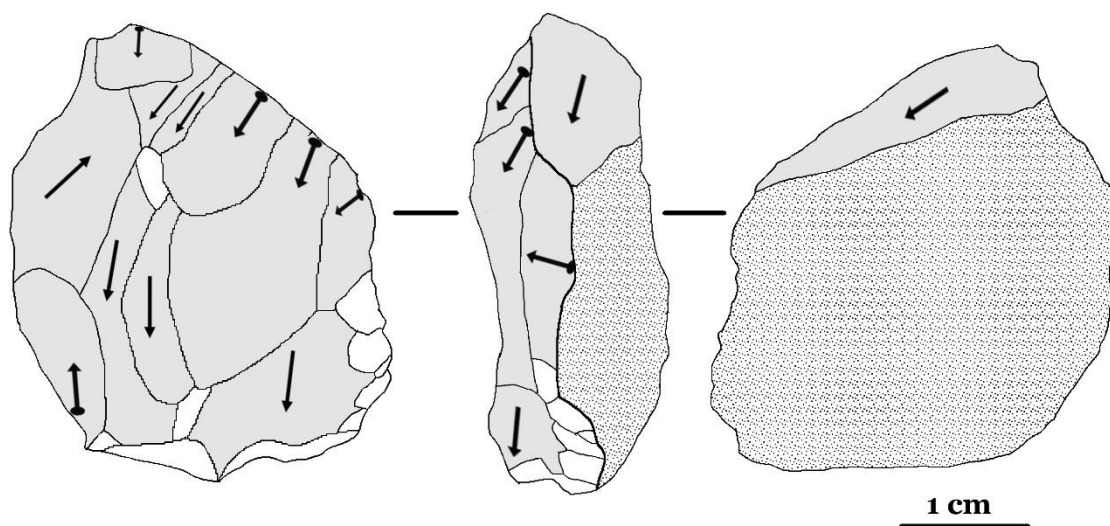
CC 14 E3 485. Spongolite discoid core on a small polygonal block; the core has been discarded before its exhaustion; the wanted products are small flakes obtained through centripetal detachments. (From Daffara, 2011).



CC 14 E4 522. Spongolite bifacial discoid core on a small polygonal block; one phase of exploitation; the core is exhausted; one of the surfaces is partially natural; the wanted products are small short and large flakes obtained through centripetal detachments. (From Daffara, 2011)

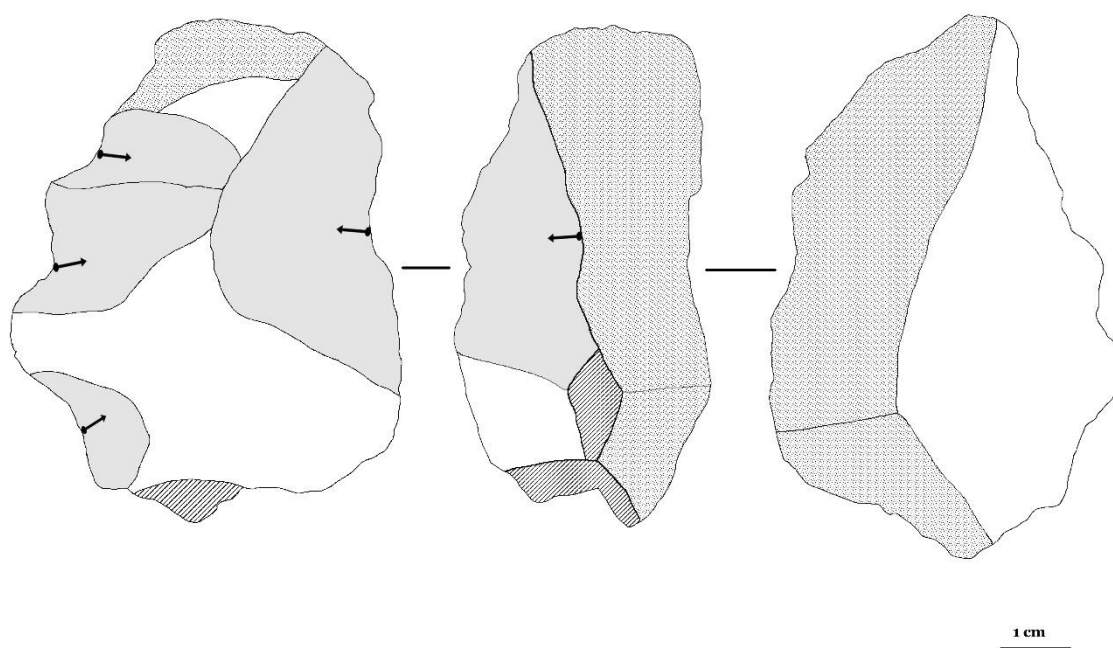


CC 14 D2 123. Fragmented flint unifacial discoid core; two exploitation phases are visible; the core is exhausted; the striking platform surface is natural; the wanted products are small short and large flakes obtained through centripetal detachments.

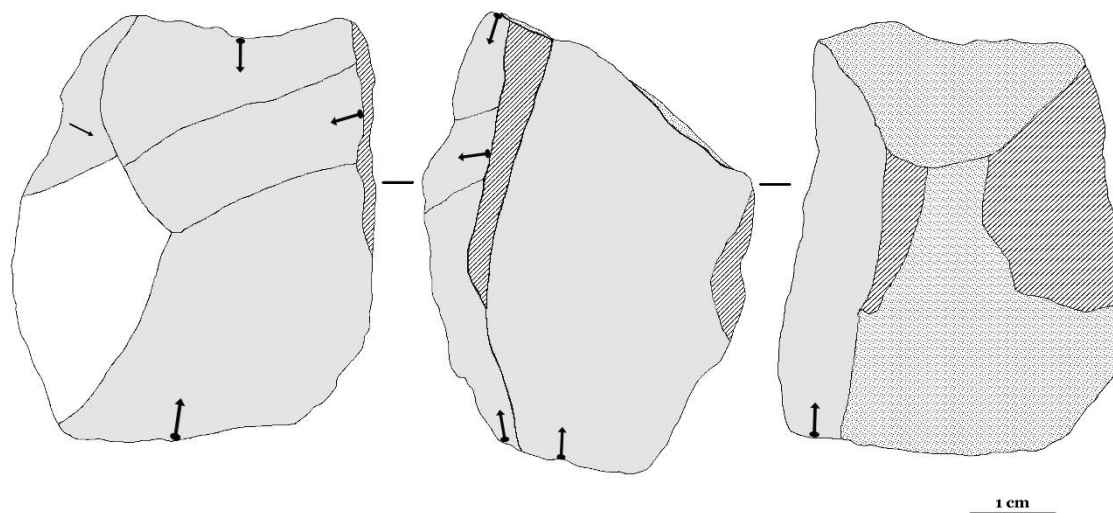


CC 14 F3 143. Flint recurrent centripetal Levallois core; two exploitation phases are visible; the core is exhausted; most of the striking platform surface is natural; the wanted products are small elongated flakes sometimes plunging.

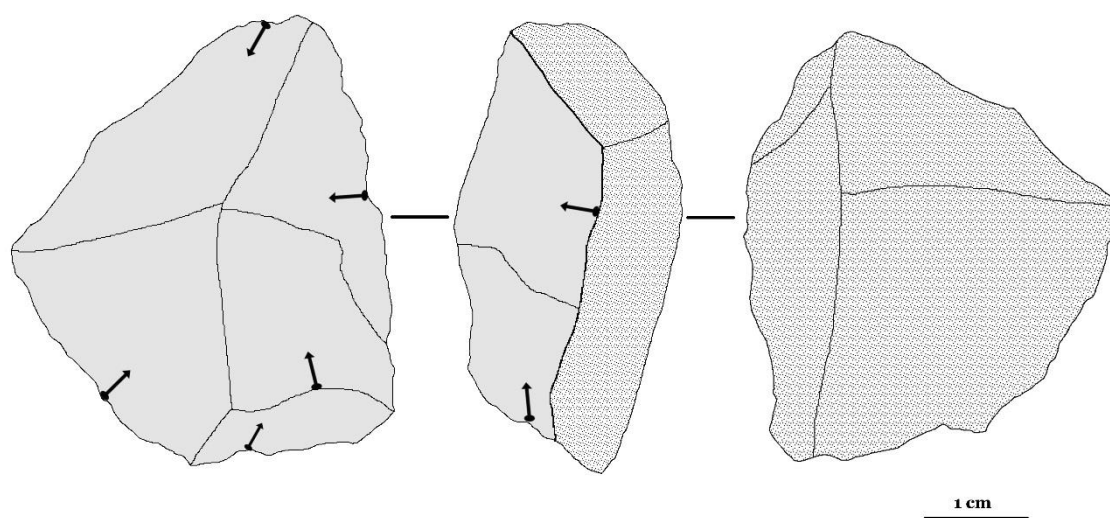
5. S.U. 15 Vein quartz cores



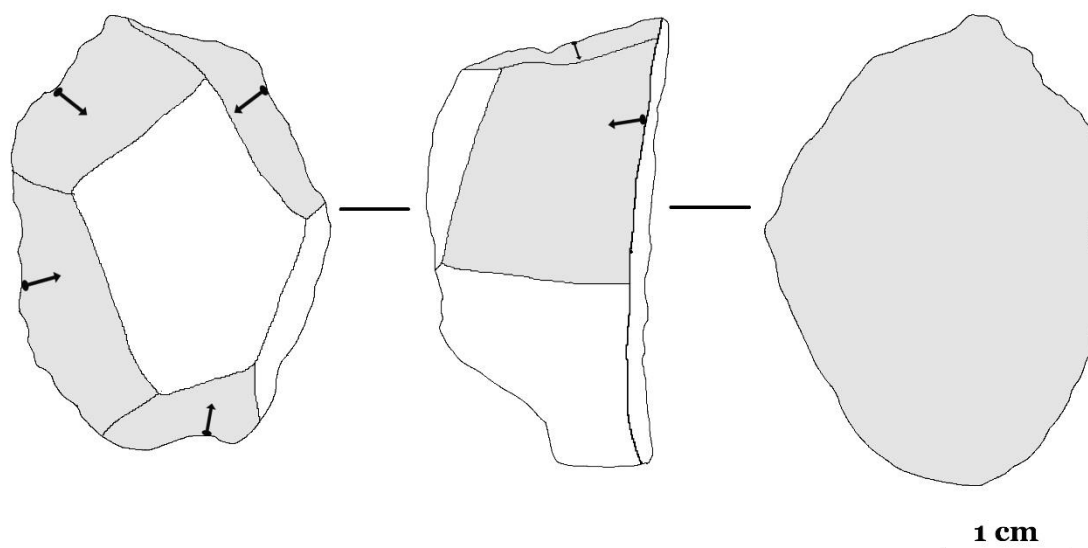
CC 15-12 F3 141. Vein quartz unifacial discoid core (NS group) ; one phase of exploitation; the core has been discarded before its exhaustion; the striking platform surface is natural; the wanted products are medium-sized short and large flakes.



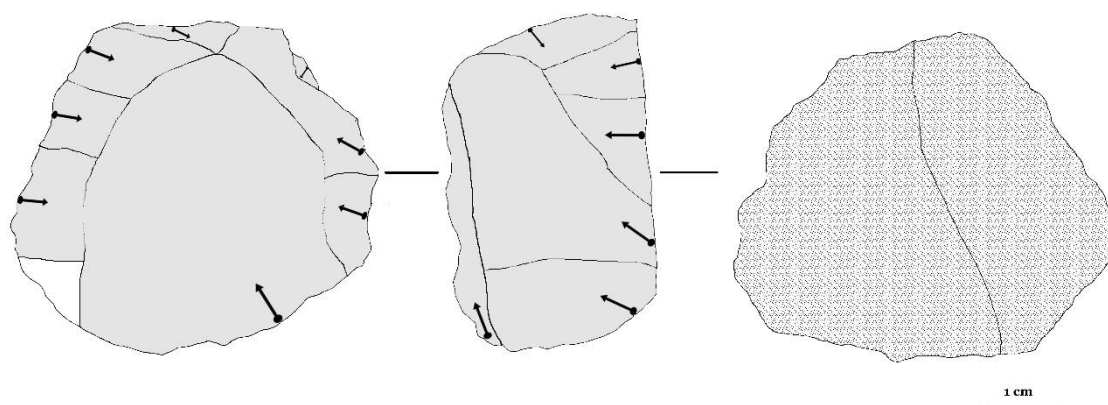
CC 15-13 E2 60. Vein quartz unifacial discoid core on pebble (NS group) ; one phase of exploitation; the core has been discarded before its exhaustion; the wanted products are medium-sized flake with a not-standardized morphology; a third surface, perpendicular to the others, has been exploited before the abandonment to obtain an elongated flake.



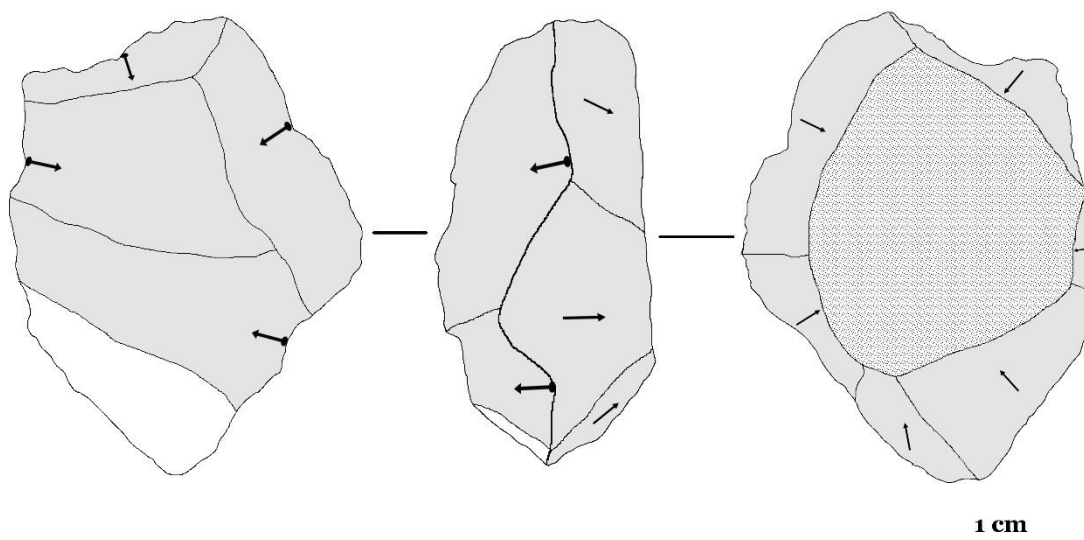
CC 15-12 D3 755. Vein quartz unifacial discoid core on pebble (SN group); one phase of exploitation, the core has been discarded before its exhaustion; the wanted products are medium-sized short and large flakes.



CC 15 D3 1203. Vein quartz unifacial discoid core on flake (SN group) ; one phase of exploitation; the core is exhausted; the striking platform is the ventral face of a flake; the wanted products are small short and large quadrangular flakes obtained through centripetal detachments.

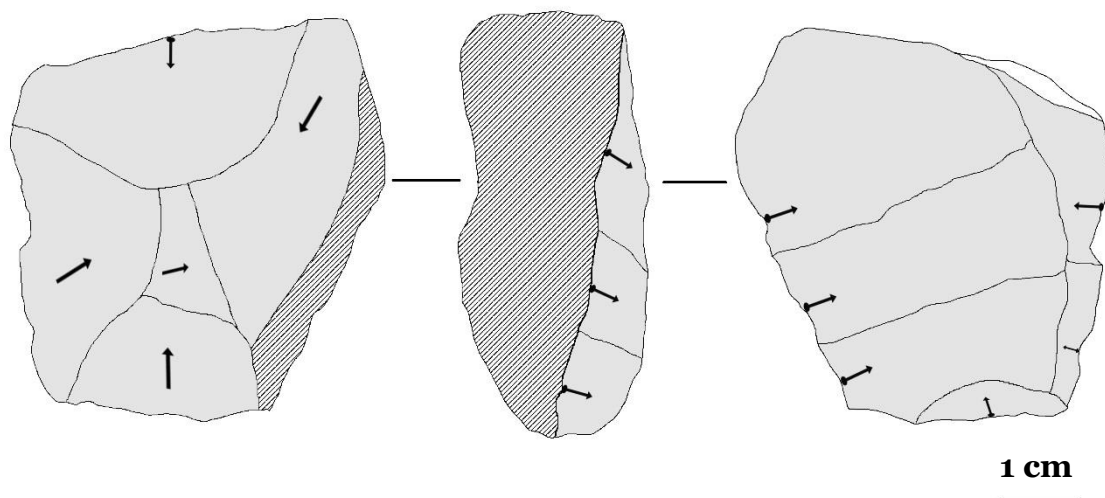


CC 15-13 E4 47. Vein quartz preferential Levallois core on pebble (NS group); one phase of exploitation; the core has been discarded before its exhaustion when a new phase of shaping of the striking platform surface would have been necessary to produce another Levallois flake; the striking platform surface is natural, the lateral and distal convexities of the striking platform surface have been prepared through eight centripetal and chordal removals.

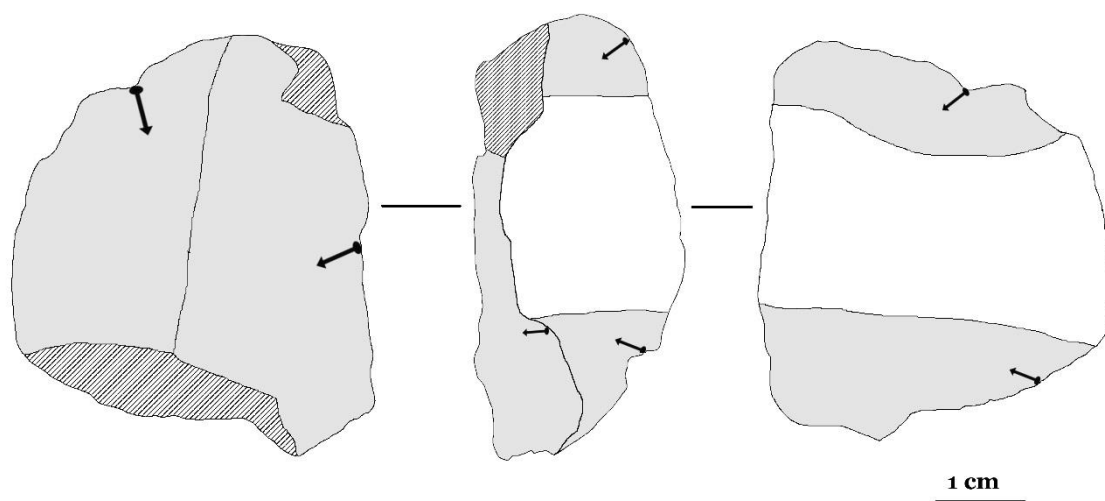


CC 15-13 D2 1300. Vein quartz recurrent centripetal Levallois core (SN groups) ; one phase of exploitation ; the core is abandoned before its exhaustion; the striking platform surfaces is prepared through six centripetal removals and it is partially natural; The wanted products are medium-sized quadrangular flakes; one of the removal has a distal plunging.

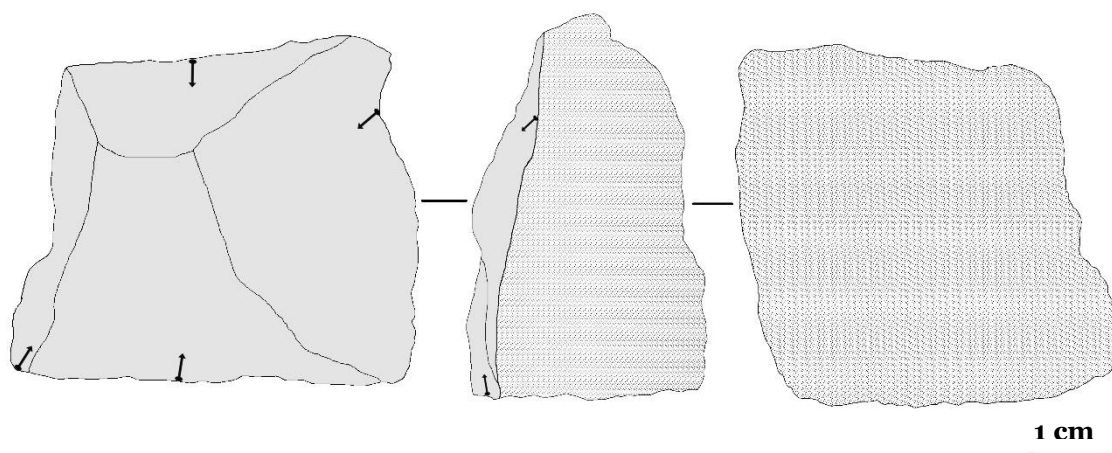
6. S.U. 15 Spongolite cores



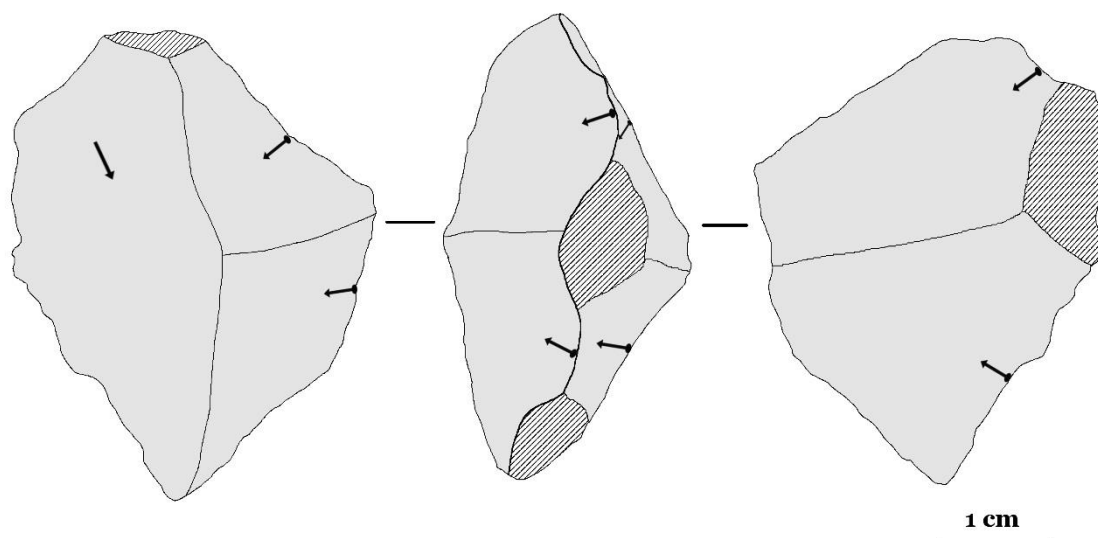
CC 15-11 F3 375. Spongolite bifacial discoid core; two exploitation phases; the core has been discarded before its exhaustion; the wanted products are medium-sized flakes obtained through centripetal detachments.



CC 15-13 F3 183. Spongolite fragmented discoid core; one phase of exploitation; the core is exhausted; the wanted products are small quadrangular flakes, sometimes plunging.

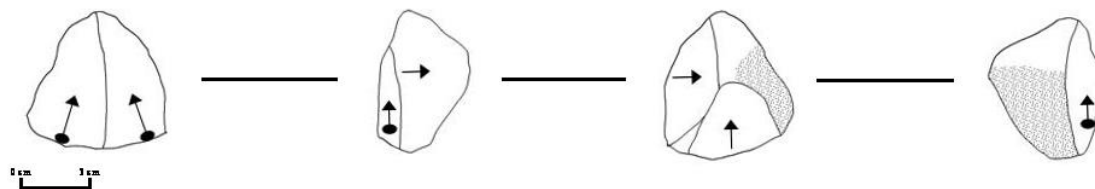


CC 15-14 E2 83. Spongolite unifacial discoid core; one phase of exploitation; the core has been discarded before its exhaustion; the wanted products are medium-sized flakes, sometimes plunging, obtained through centripetal detachments.

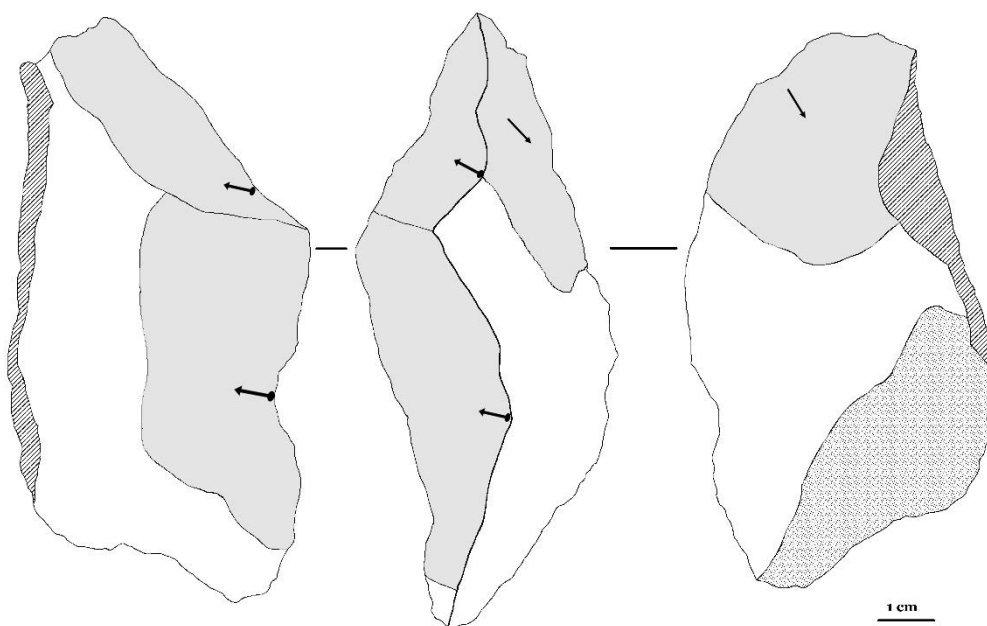


CC 15-13 F2 429. Spongolite bifacial fragmented discoid core; the core is exhausted; the wanted products are small short and large flakes.

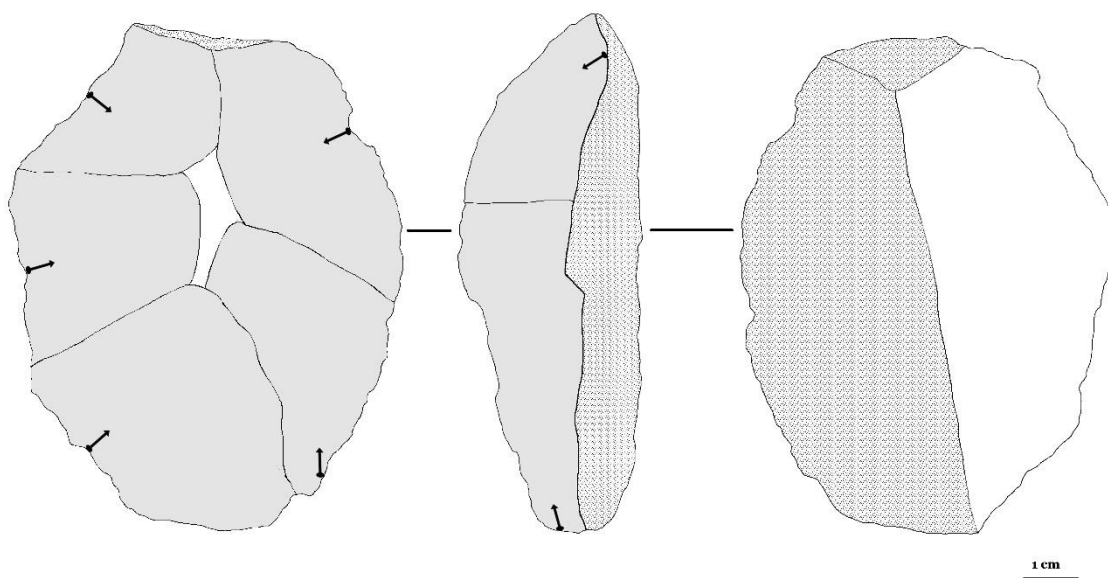
7. S.U. 103 Vein quartz cores



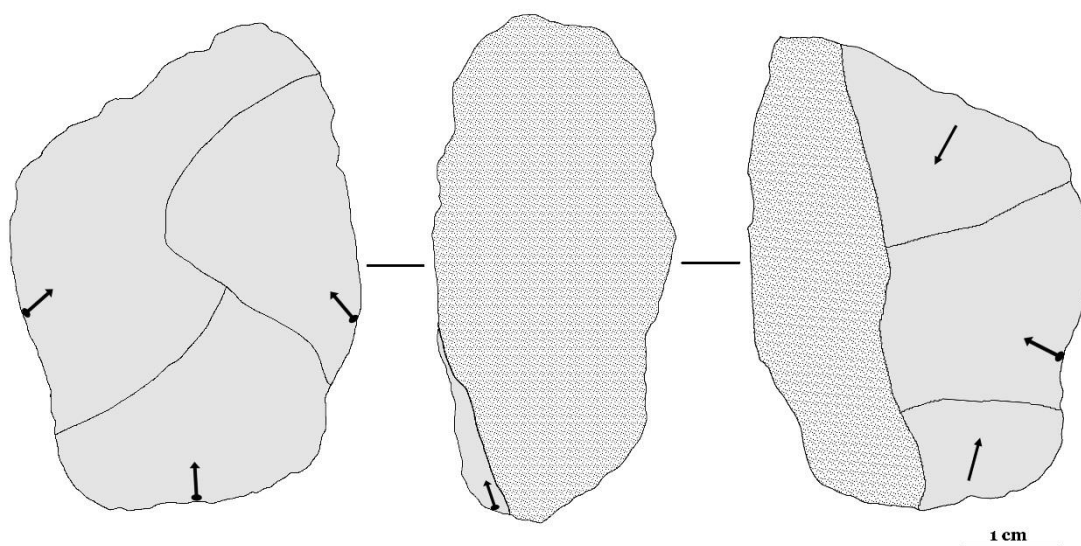
CC 103 F2 313. Vein quartz bifacial discoid core (NS group); one phase of exploitation; the core has been discarded before its exhaustion; one of the surfaces is partially natural; the wanted products are small short and large flakes. (From Daffara, 2011).



CC 103-15 F2 83. Vein quartz discoïd core (NS group) ; the core has been abandoned before its exhaustion; the presence of a concretion do not allow to read all the negatives present on the core; the wanted products are medium-sized short and large flakes, sometimes plunging.



CC 103 F2 354. Vein quartz recurrent centripetal Levallois core on flake (NS group) ; one phase of exploitation; the core has been discarded before its exhaustion; the striking platform surface is partially natural; no evidence of shaping of the core surfaces is present; the wanted products are medium-sized short and large flakes, sometimes plunging.



CC 103 F2 638. Vein quartz recurrent centripetal Levallois core on a small pebble (NS group); one phase of exploitation; the core is exhausted; the striking platform surface is partially natural; the wanted products are medium-sized short and large flakes, sometimes plunging.

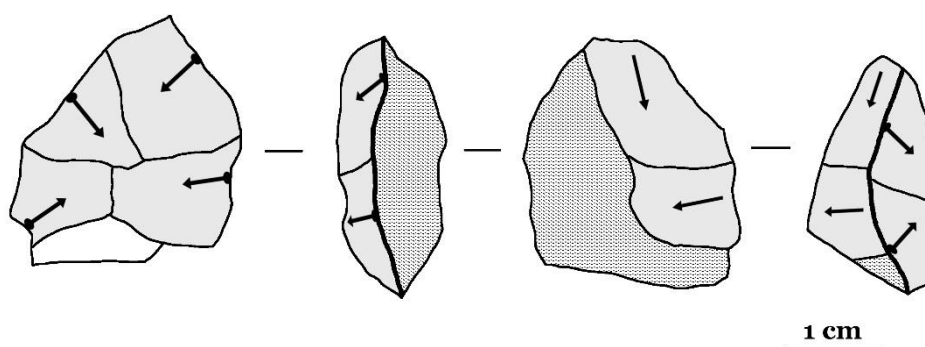
APPENDIX B

Pedra Dreta and Can Garriga: discoid, centripetal and Levallois cores

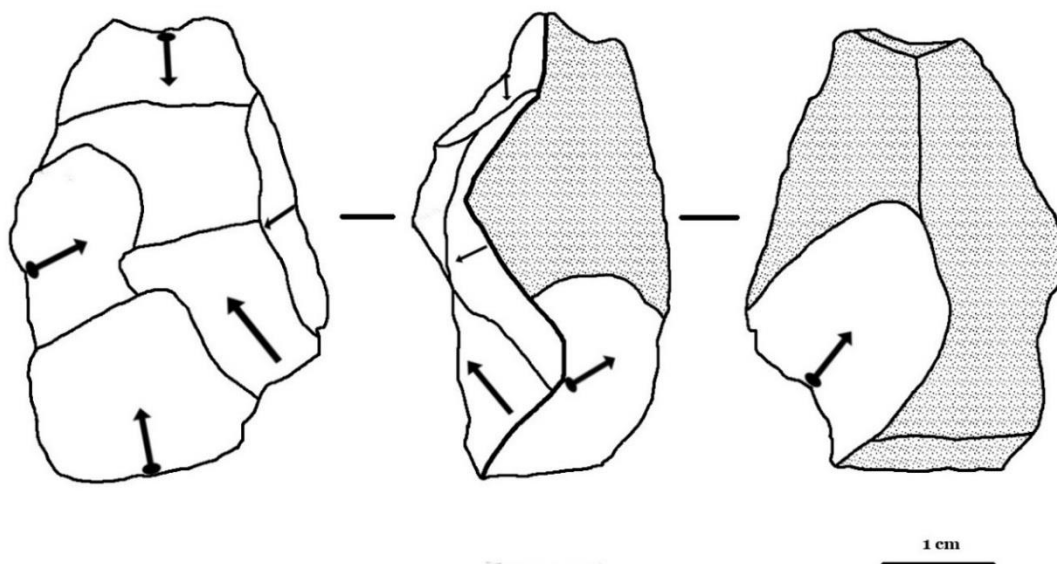
APPENDIX B

Pedra Dreta and Can Garriga: discoid, centripetal and Levallois cores

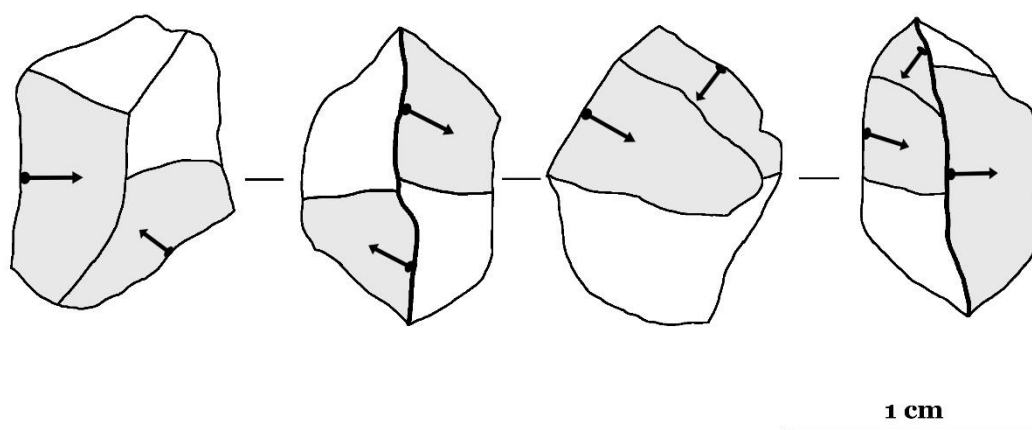
1. Pedra Dreta



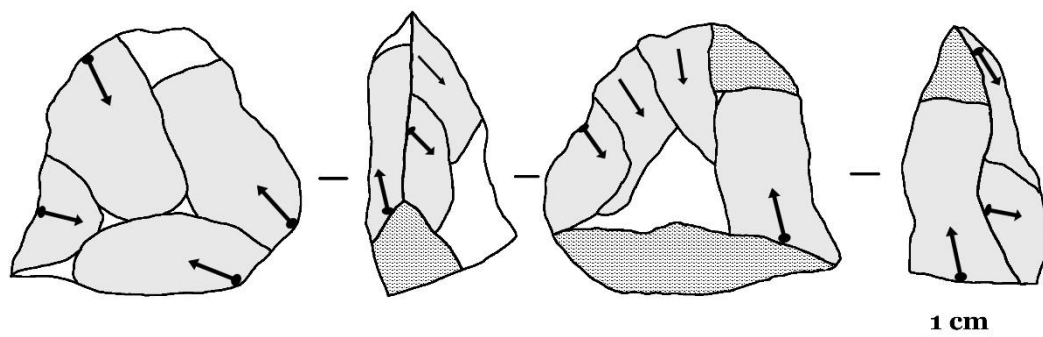
PD A2-B 28. Syenite pebble – Unifacial discoid core: one phase of exploitation; the surfaces are hierarchized; the striking platform is partially natural (neocortex) and roughly prepared with two detachments; the *débitage* surface is exploited through four centripetal detachments to produce short and large flakes; the *débitage* direction is secant regarding the intersection plane of the two surfaces.



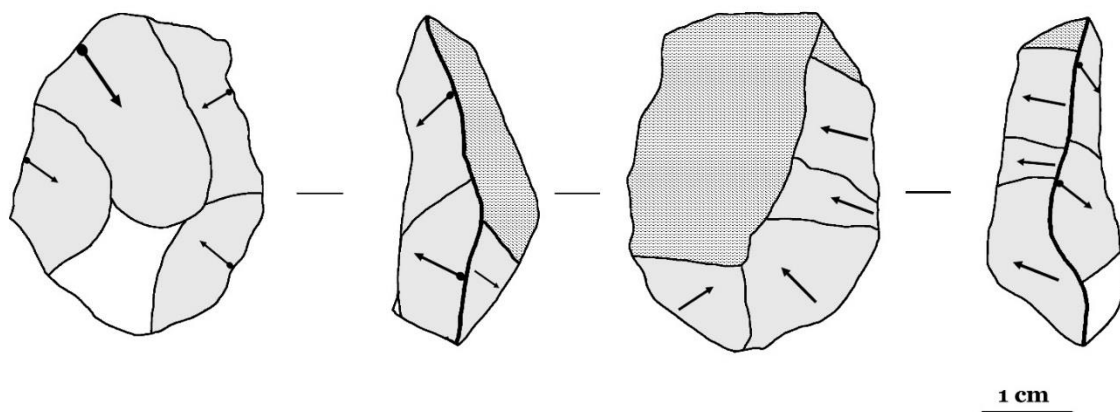
PD RC A2 1. Quartz pebble (NS) – Unifacial discoid core: one phase of exploitation; the surfaces are hierarchized; the striking platform is partially natural (neocortex) and roughly prepared with one detachment; the *débitage* surface is exploited through five centripetal detachments to produce short and large flakes; the *débitage* direction is secant regarding the intersection plane of the two surfaces.



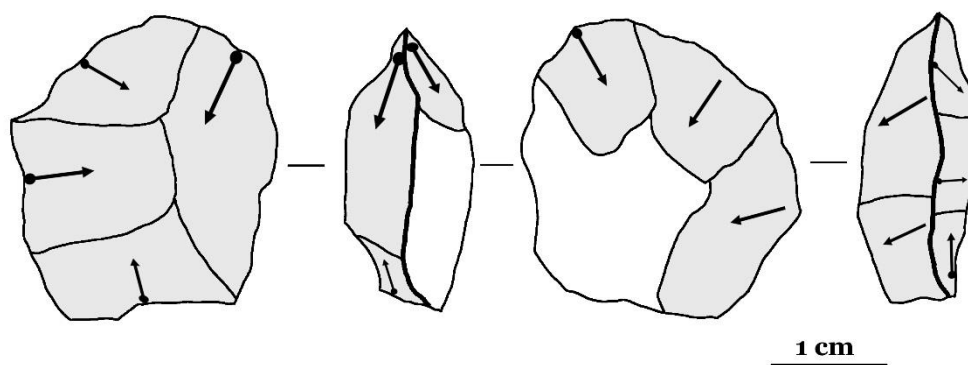
PD A2-D 69. Quartz pebble (NS) – Centripetal core: one phase of exploitation; the surfaces are not hierarchized; natural surfaces (fracture plans) are present on both side of the core; the production of centripetal flakes starts directly from the natural surfaces of the core; the *débitage* direction is secant regarding the intersection plane of the two surfaces.



PD B3-C 48. Porphyry pebble – Recurrent centripetal Levallois core: one phase of exploitation; the surfaces are hierarchized; the striking platform, partially natural (neocortex), is more convex than the *débitage* surface; the convexity of the striking platform is prepared through four detachments; the *débitage* surface is not prepared and it is exploited through four centripetal detachments to produce elongated flakes, three of which are debordant; the *débitage* direction is parallel regarding the intersection plane of the two surfaces.

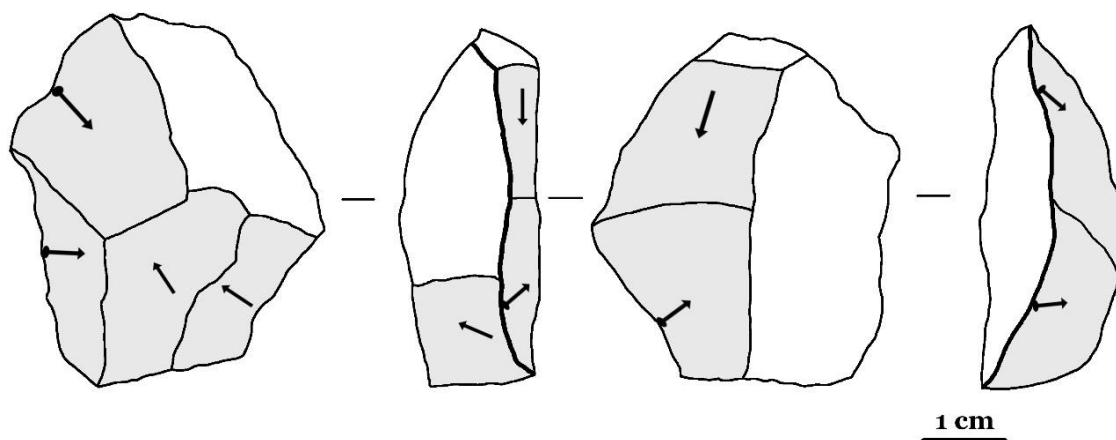


PD B3-C 56. Syenite pebble – Recurrent centripetal Levallois core: one phase of exploitation; the surfaces are hierarchized; the striking platform, partially natural (neocortex) is more convex than the *débitage* surface; the convexity of the striking platform is prepared through four centripetal detachments; the *débitage* surface is not prepared and it is exploited through four centripetal detachments to produce elongated flakes or short and large flakes; the *débitage* direction is parallel regarding the intersection plane of the two surfaces.

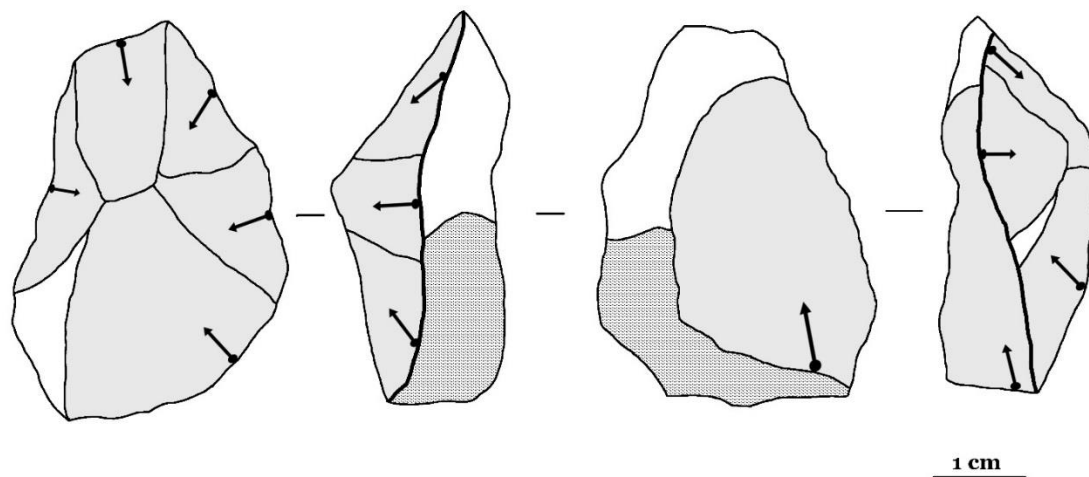


PD D4 83. Quartz pebble (NS)– Recurrent centripetal Levallois core: one phase of exploitation; the surfaces are hierarchized; the striking platform, partially natural (neocortex) is more convex than the *débitage* surface; the convexity of the striking platform is prepared through three centripetal detachments; the *débitage* surface is not prepared and it is exploited through four centripetal detachments to produce short and large debordant flakes; the *débitage* direction is parallel regarding the intersection plane of the two surfaces.

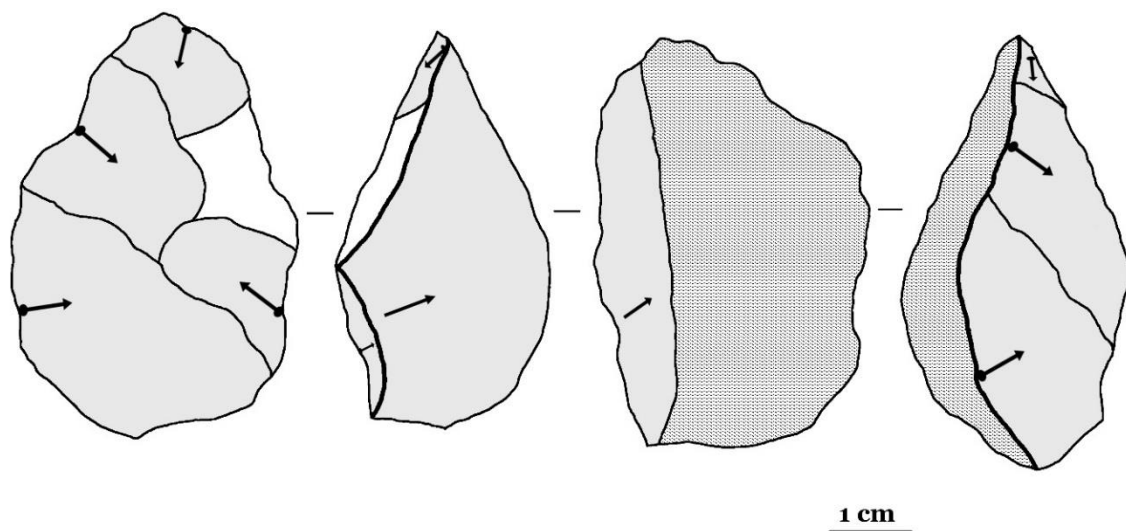
2. Can Garriga



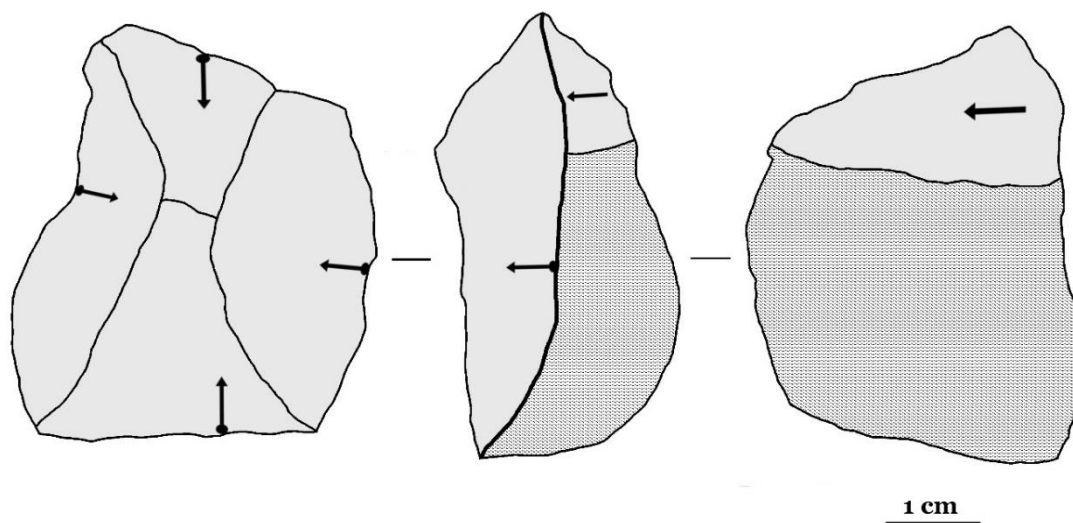
CG K22 9. Quartz pebble (SN) – Discoid core: one phase of exploitation; the surfaces are not hierarchized, and both are partially natural (fracture planes); the surfaces are exploited through four and two centripetal detachments respectively to produce short and large flakes; the *débitage* direction is secant regarding the intersection plane of the two surfaces.



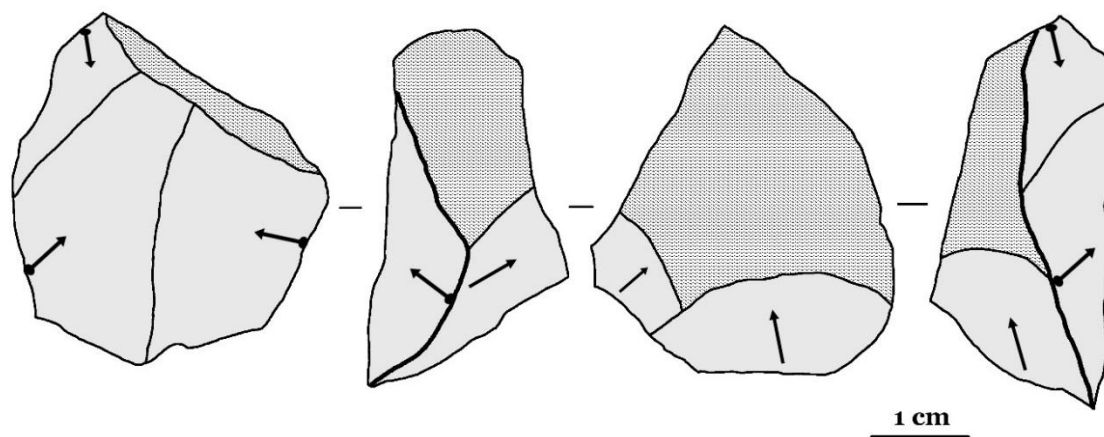
CG H21 9. Quartz pebble (NS)– Unifacial discoid core: one phase of exploitation; the surfaces are hierarchized, and both are partially natural (neocortex and fracture planes); the *débitage* surface is exploited through five centripetal detachments to produce short and large flakes; the *débitage* direction is secant regarding the intersection plane of the two surfaces.



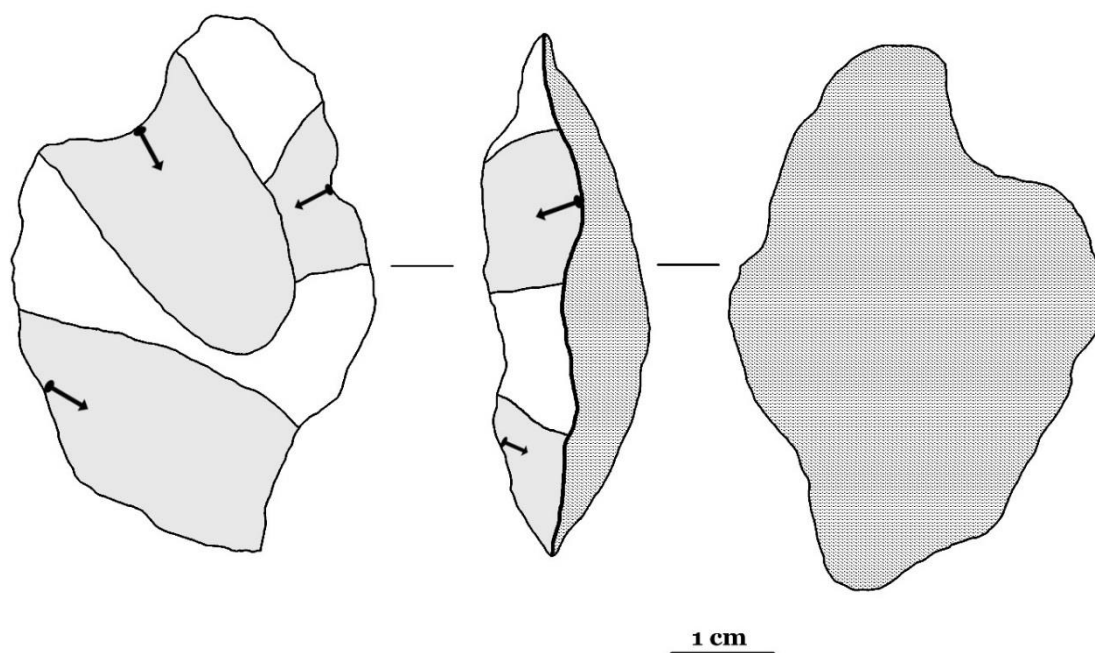
CG H21 21. Quartz pebble (NN) – Unifacial discoid core: one phase of exploitation; the surfaces are hierarchized, and both are partially natural (neocortex or fracture planes); the *débitage* surface is exploited through four centripetal detachments to produce short and large flakes; the *débitage* direction is secant regarding the intersection plane of the two surfaces.



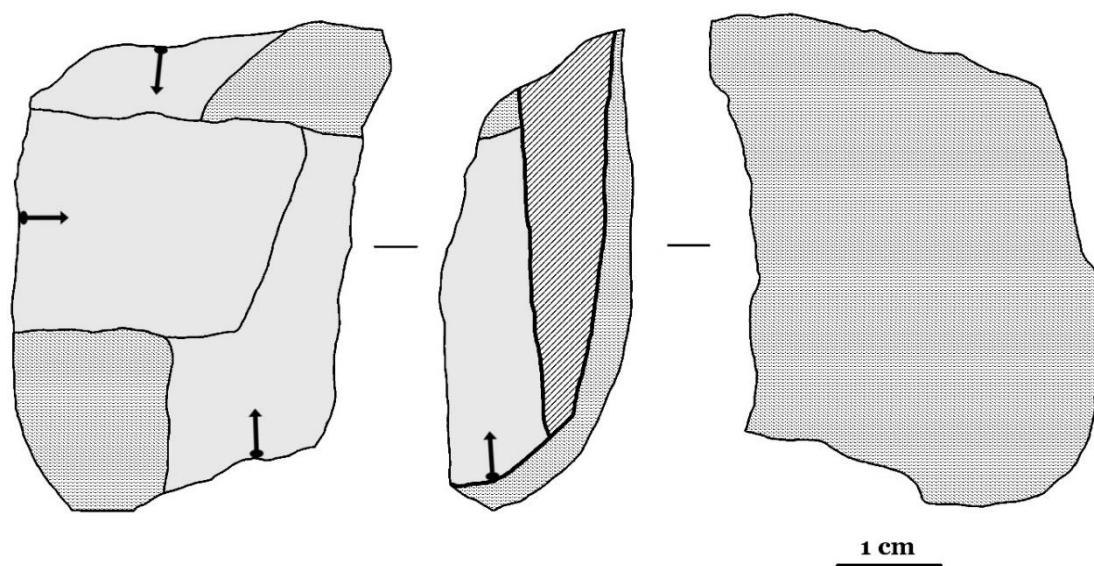
CG H21 25. Quartz pebble (NS) – Unifacial discoid core: one phase of exploitation; the surfaces are hierarchized, and one is partially natural (neocortex); the *débitage* surface is exploited through four centripetal detachments to produce short and large flakes; the *débitage* direction is secant regarding the intersection plane of the two surfaces.



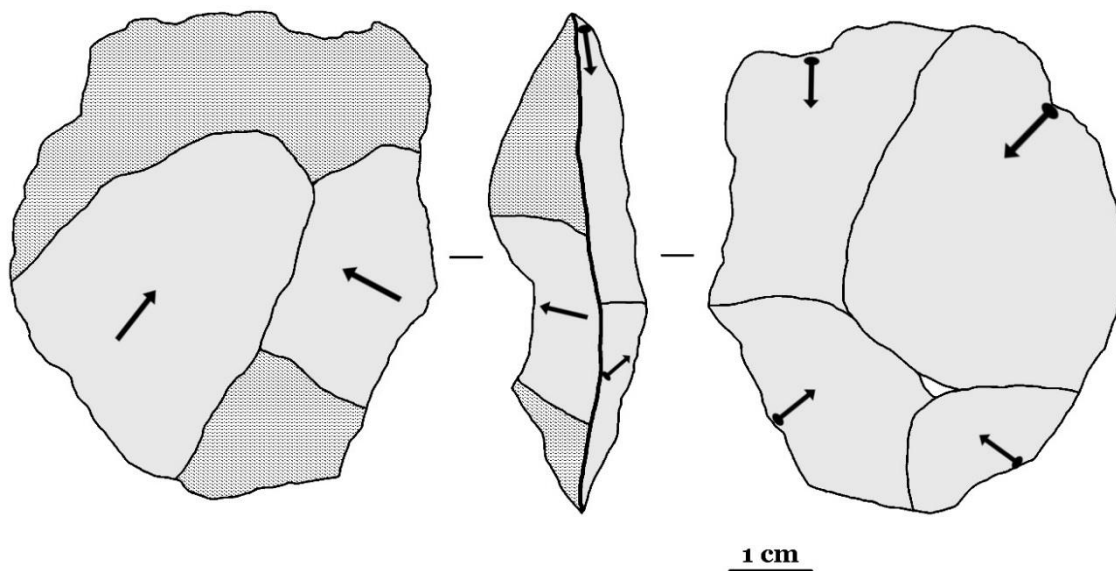
CG I 21 4. Quartz pebble (NS) – Unifacial discoid core: one phase of exploitation; the surfaces are hierarchized, and one is partially natural (neocortex); the *débitage* surface is exploited through three centripetal detachments to produce large flakes; the *débitage* direction is secant regarding the intersection plane of the two surfaces.



CG H21 7. Quartz pebble (NS) - Centripetal core: one phase of exploitation; the surfaces are hierarchized; the striking platform is natural (neocortex); the *débitage* surface is exploited through three detachments, two centripetal and one chordal respectively; the *débitage* direction is parallel regarding the intersection plane of the two surfaces that are equally convex.



CG R 50. Quartz pebble (NS) – Centripetal core: one phase of exploitation; the surfaces are hierarchized; the striking platform is natural (neocortex); the *débitage* surface is partially natural (neocortex) and exploited through three centripetal detachments; the *débitage* direction is secant regarding the intersection plane of the two surfaces that are equally convex.



CG J21 13. Porphyry pebble – Centripetal core: one phase of exploitation; the surfaces are not hierarchized; one surface is partially natural (neocortex) and exploited through two centripetal detachments; the other surface direction is exploited through four centripetal detachments; the *débitage* direction is secant regarding the intersection plane of the two surfaces that are equally convex.

APPENDIX C

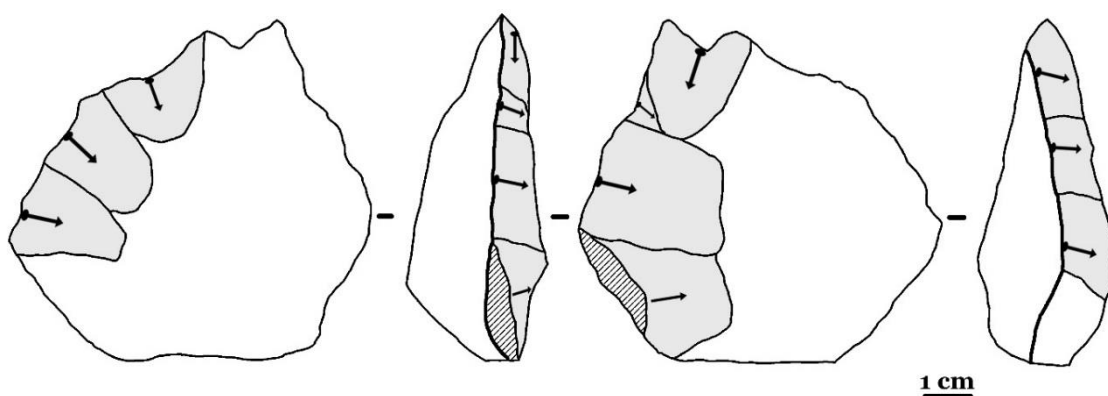
Payre – Level D :

discoid cores

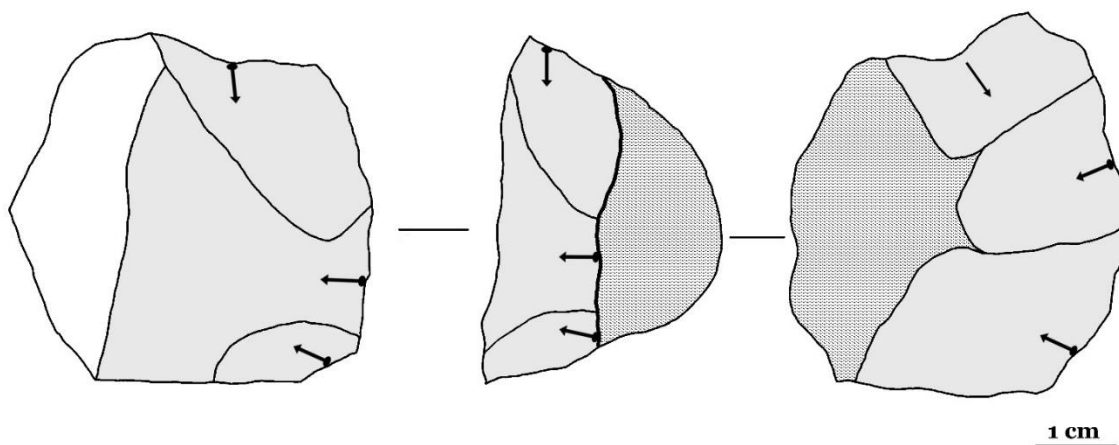
APPENDIX C

Payre – Level D: discoid cores

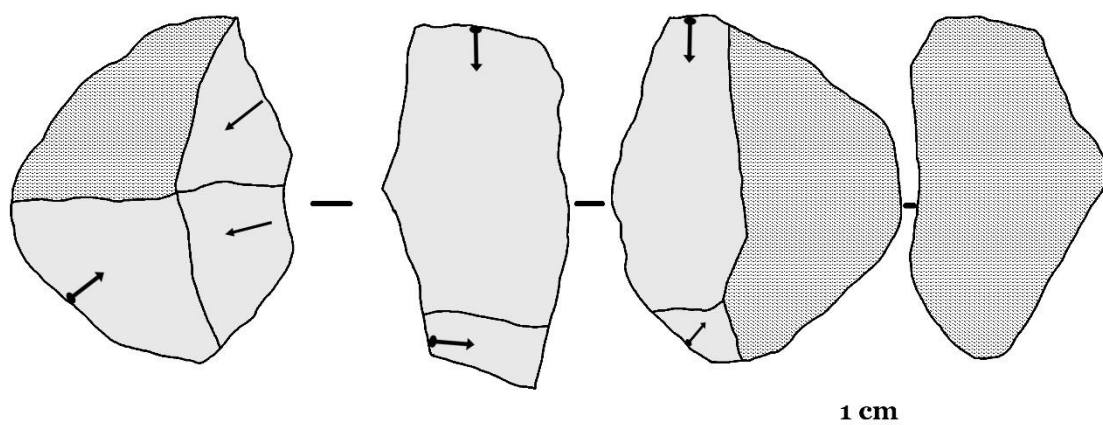
1. Vein quartz discoid cores



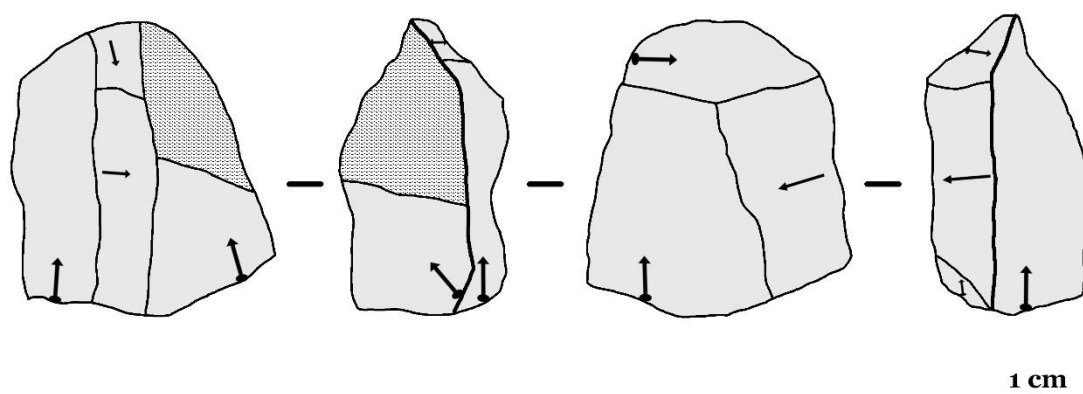
Payre D 103. Discoid core on quartz (NS group) flake: one phase of exploitation; the core was discarded before its complete exhaustion; a partial shaping of the core would have been necessary to proceed with the exploitation; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces; according to the seven visible detachments, the wanted products are large and short centripetal flakes.



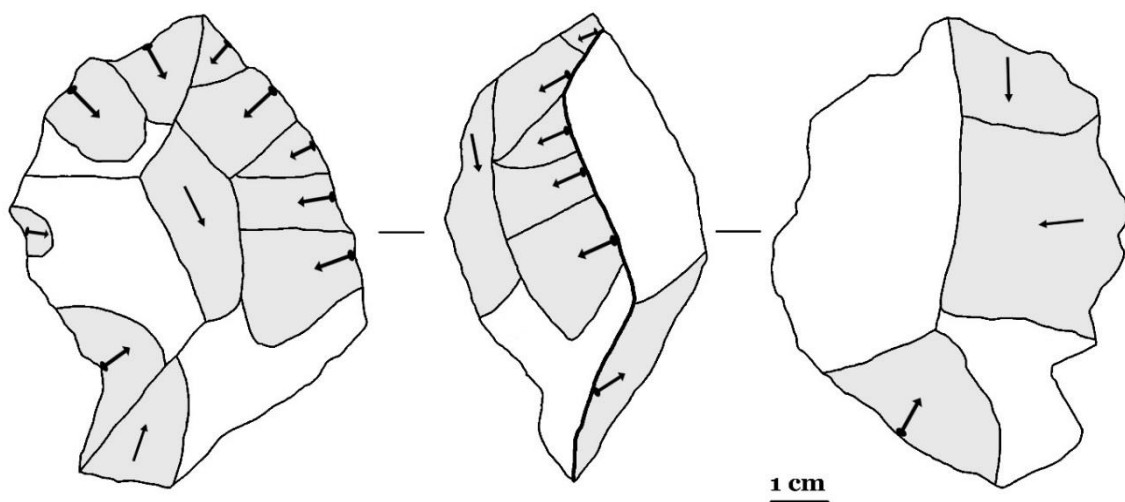
Payre D L6 98. Discoid quartz (SN group) core on pebble: one phase of exploitation; the core is exhausted; the exploitation started directly from the natural surface of the pebble; one of the surfaces is still partially natural; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces; according to the six visible detachments, the wanted products are short, large and debordant flakes.



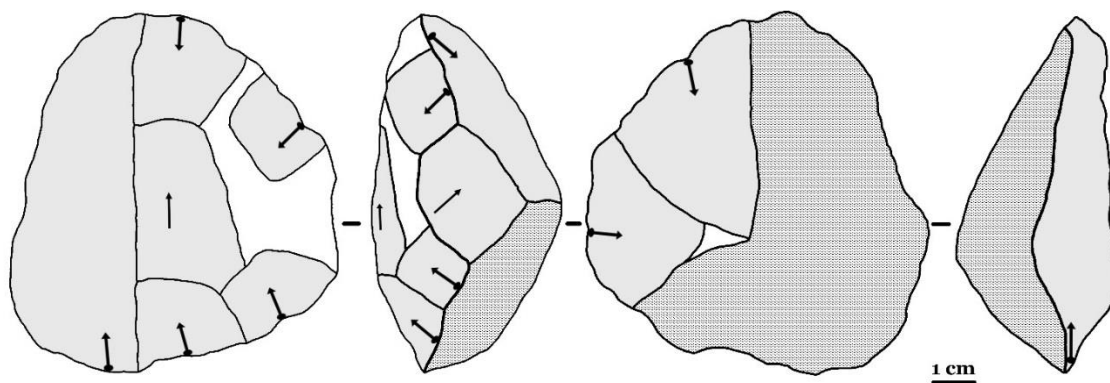
Payre D J11 D3 53. Discoïd quartz (NS group) core on pebble: one phase of exploitation; the core is exhausted; the exploitation started directly from the natural surface of the pebble; both the surfaces are still partially natural; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces; the last detachments are obtained through the exploitation of a third surface; according to the 5 visible detachments, the wanted products are short and large centripetal flakes; on the third knapping surface the wanted products are elongate flakes.



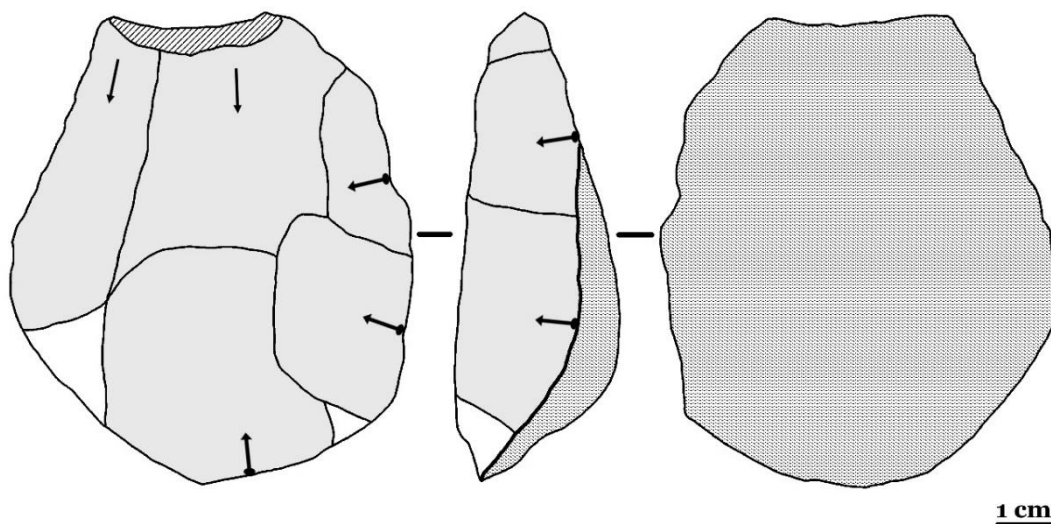
Payre D P5. Discoïd quartz (SN group) core on pebble: one phase of exploitation; the core is discarded before its complete exhaustion; a partial shaping of the core would have been necessary to proceed with the exploitation; one of the surfaces is still partially natural; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces; according to the 7 visible detachments, the wanted products are elongated flakes obtained through centripetal and chordal detachments.



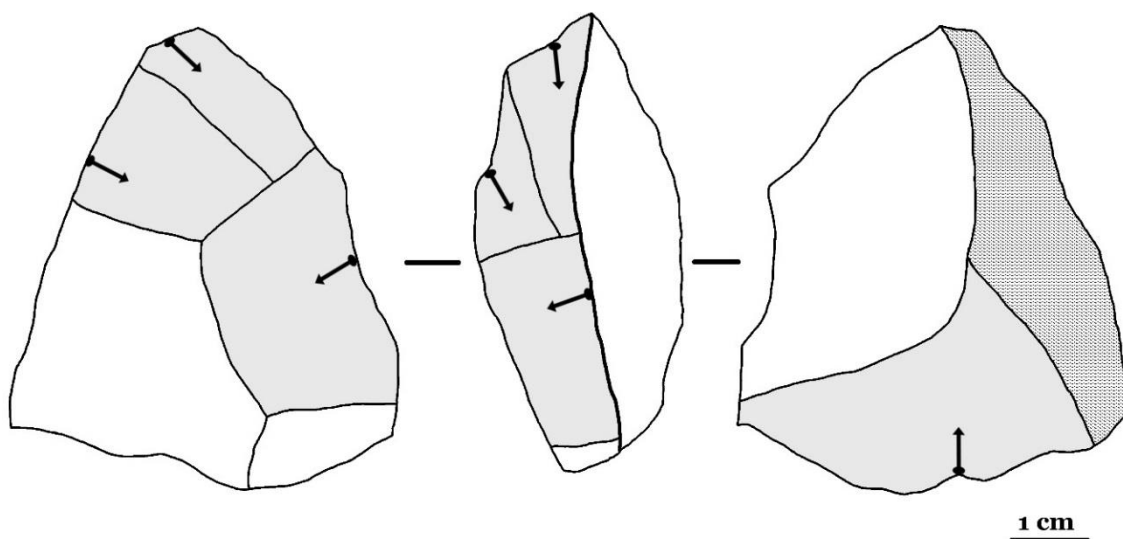
Payre D 108. Discoïd quartz (SN group) core: one phase of exploitation; the core is discarded before its complete exhaustion; a partial shaping of the core would have been necessary to proceed with the exploitation; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces; according to the 14 visible negatives, the wanted products are short and large flakes.



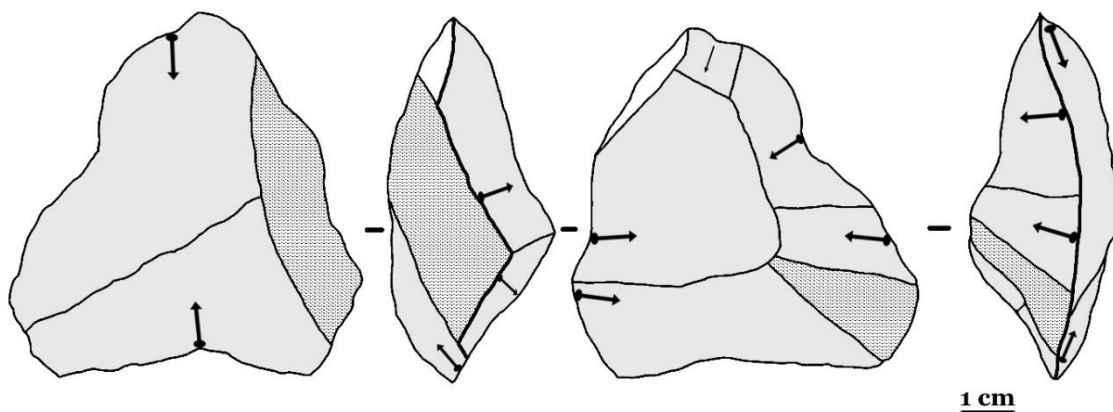
Payre D P6 101. Discoïd quartz (NS group) core on pebble: unifacial core; the core is discarded before its complete exhaustion; the surfaces are hierarchized and the striking platform surface, partially natural, is roughly prepared through two centripetal detachment; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces; 5 centripetal negatives on the knapping surface show that the wanted products are short and large flakes while the last detachment, in a chordal direction, correspond to an elongated flake.



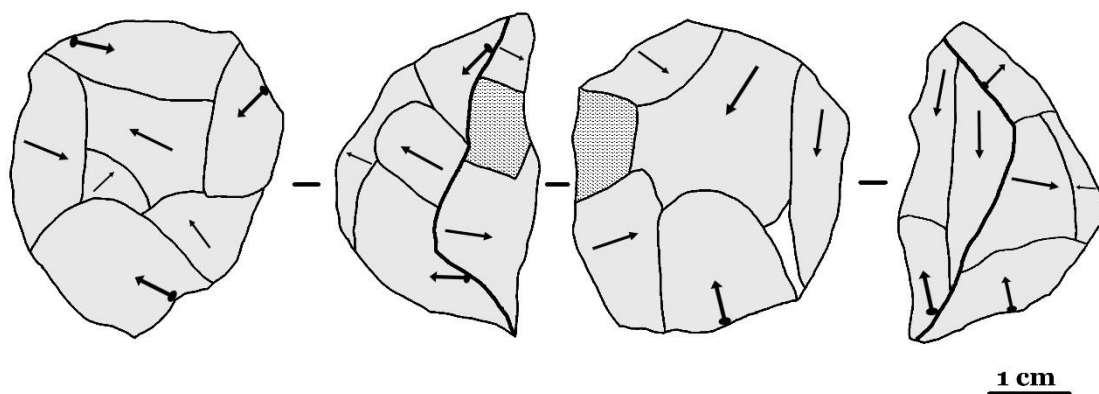
Payre D N8 100. Discoid quartz (SN group) core on pebble: unifacial core; the core is exhausted; one phase of exploitation; the striking platform is natural; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces; according to the 5 visible detachments, the wanted products are both short and large flakes (centripetal direction) and elongated flakes (chordal direction).



Payre D1 N8 12. Discoid quartz (NS group) core on pebble: one phase of exploitation; the core is discarded before its complete exhaustion; a partial shaping of the core would have been necessary to proceed with the exploitation; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces; according to the 4 visible detachments, the wanted products are short and large flakes.

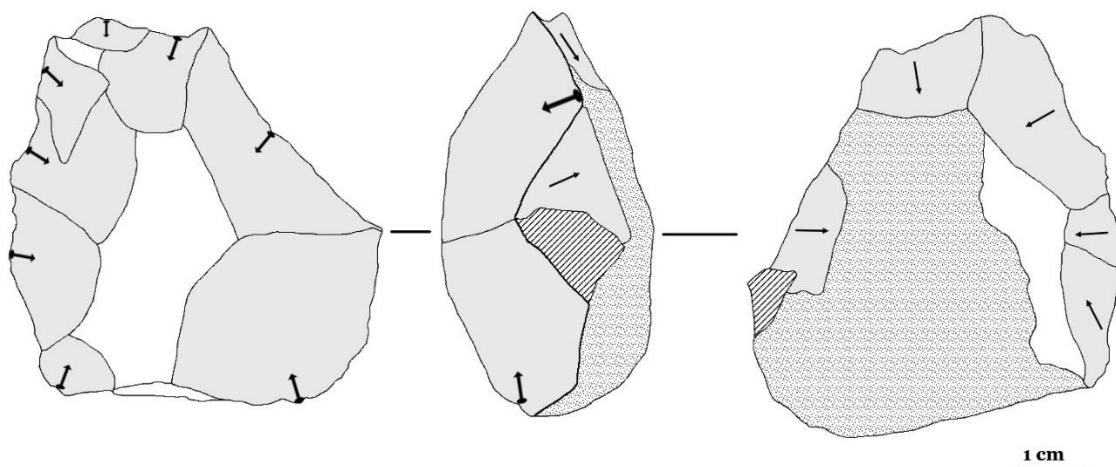


Payre D 13. Discoïd quartz (NS group) core on pebble: one phase of exploitation; the core is discarded before its exhaustion; a partial shaping of the core would have been necessary to proceed with the exploitation; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces; one of the surfaces is still partially natural; according to the 7 visible detachments, the wanted products are large centripetal flakes, sometimes debordant.

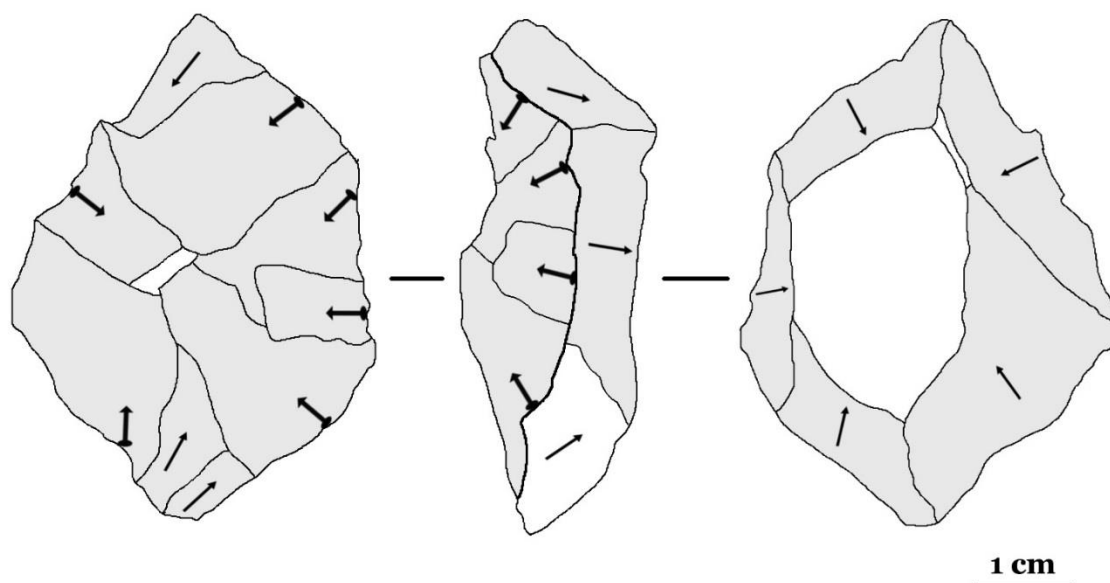


Payre D M8 2287. Discoïd quartz (NS group) core on pebble: two phases of exploitation; the core is exhausted; one of the surfaces is still partially natural; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces; the detachments have both a chordal and a centripetal direction; according to the 12 visible detachments, the wanted products are short and large flakes, sometimes debordant.

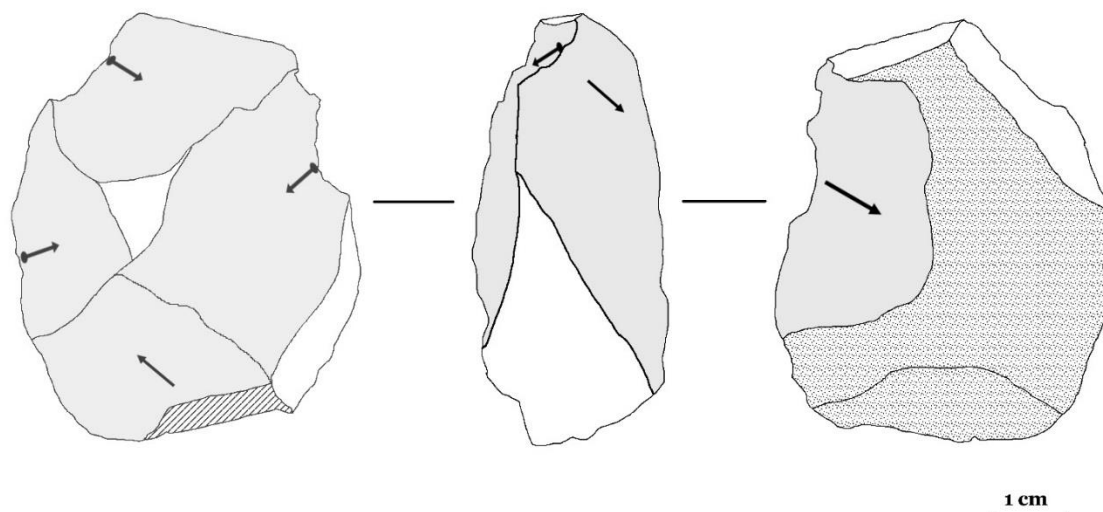
2. Flint discoid cores



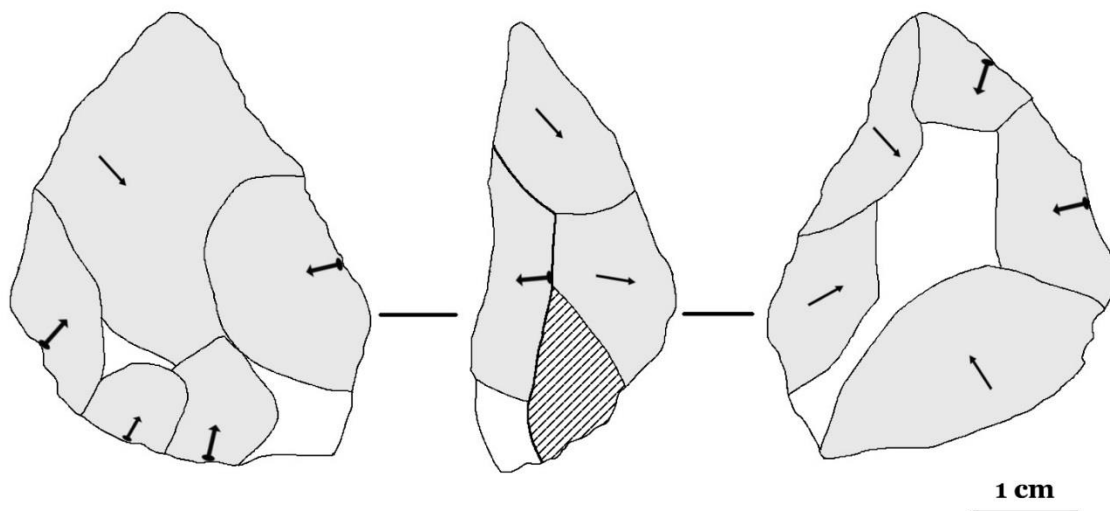
Payre D N6 10. Discoid flint core on pebble: unifacial discoid core; the surfaces are hierarchized; the striking platform surface is roughly prepared through 5 centripetal and short detachments; part of the striking platform is natural; one phase of exploitation; the core has been discarded before its complete exhaustion; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces; according to the 8 detachments visible on the knapping surface the wanted products are short and large centripetal flakes.



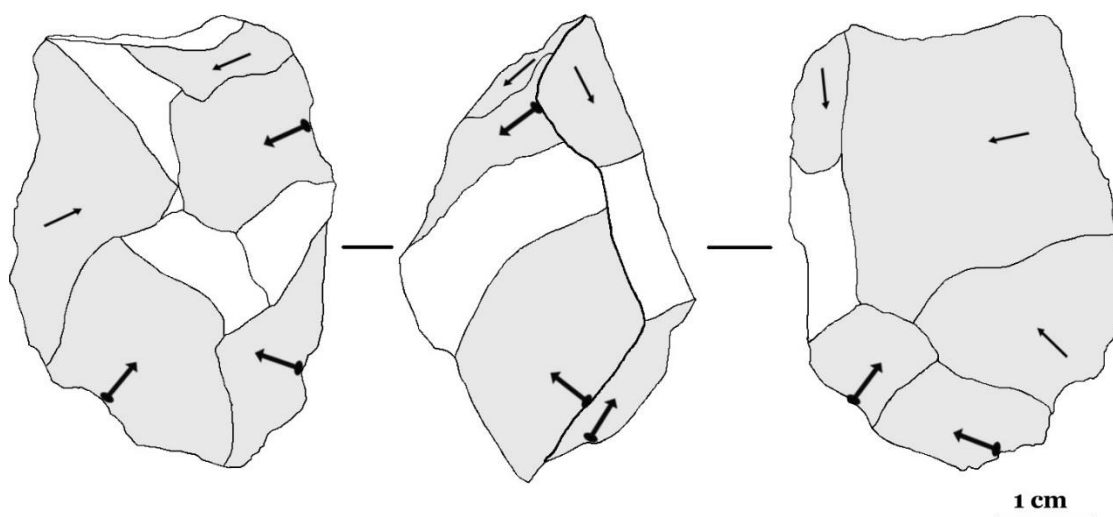
Payre D K7 40. Discoid flint core: bifacial core; exhausted; two phases of exploitation are visible; according to the 14 visible detachments the wanted products are large flakes obtained through centripetal or chordal detachments; some of the flakes are debordant; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



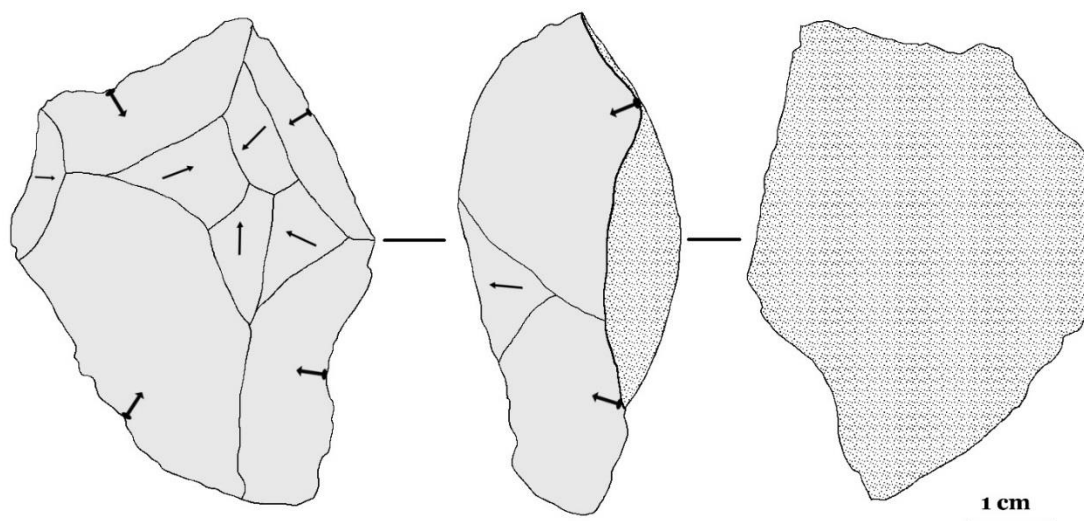
Payre D M7 91. Discoid flint core on pebble: unifacial core; the surfaces are hierarchized; the striking platform surface is almost totally natural, just one centripetal detachment is referable to a rough preparation of the surface; one phase of exploitation; the core is exhausted; according to the 4 visible detachments the wanted products are medium-sized large and short debordant flakes; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



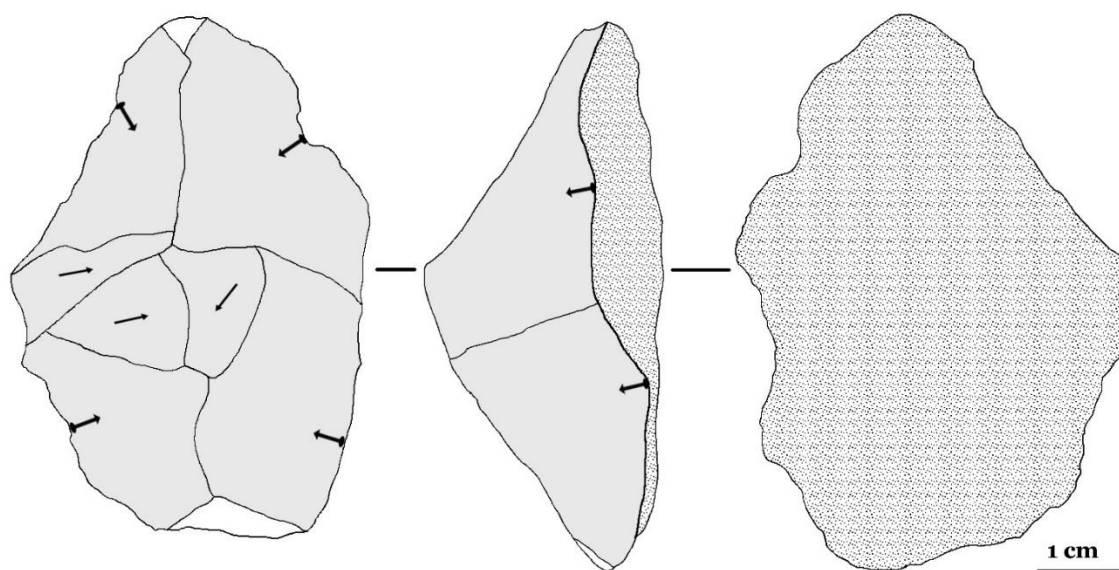
Payre D P5 rem. Discoid flint core: bifacial core; two phases of exploitation; the core is exhausted; according to the 10 visible detachments the wanted products are short and large flakes; some of the detachments are debordant; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



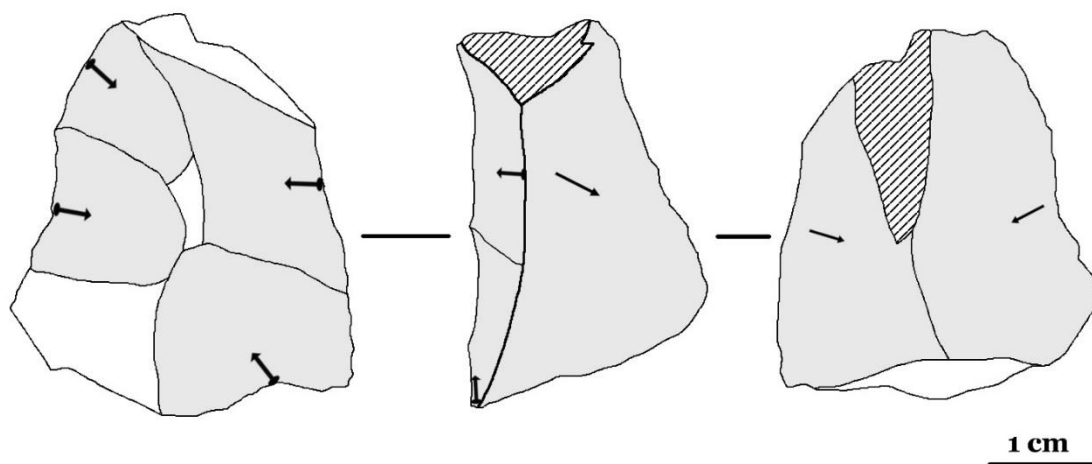
Payre D L8 140. Discoïd flint core: bifacial core; two phases of exploitation are visible; the core is exhausted; according to the 10 visible detachments, the wanted products are short and large flakes obtained through centripetal and chordal detachments; some of the detachments are debordant; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



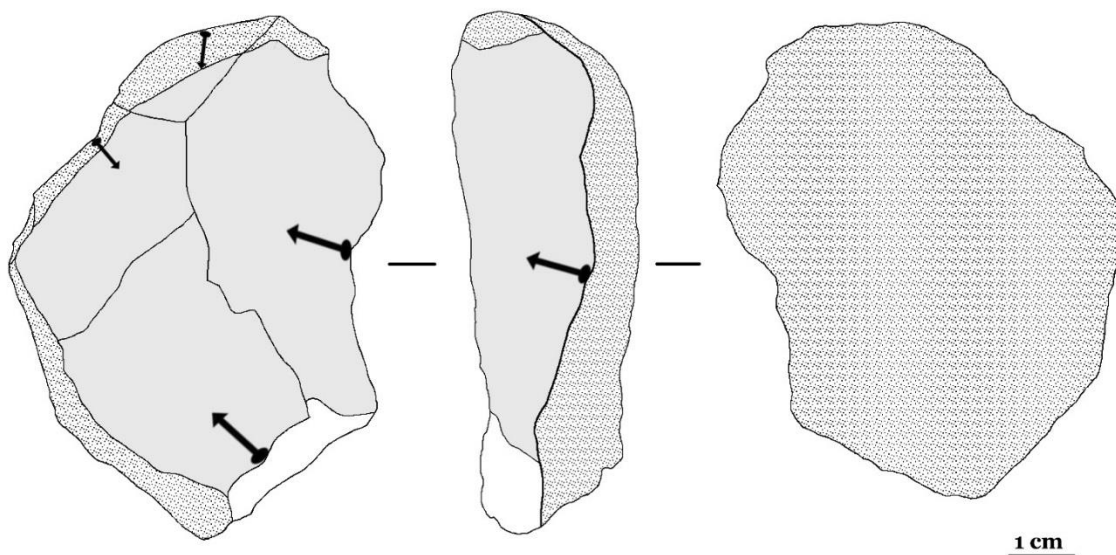
Payre D Q6 96. Discoïd flint core on pebble: unifacial core; two phases of exploitation are visible; the core is exhausted; the surfaces are hierarchized; the striking platform surface is natural; according to the 9 visible detachments, the wanted products are short and large flakes obtained through centripetal detachments; some of the detachments are debordant; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



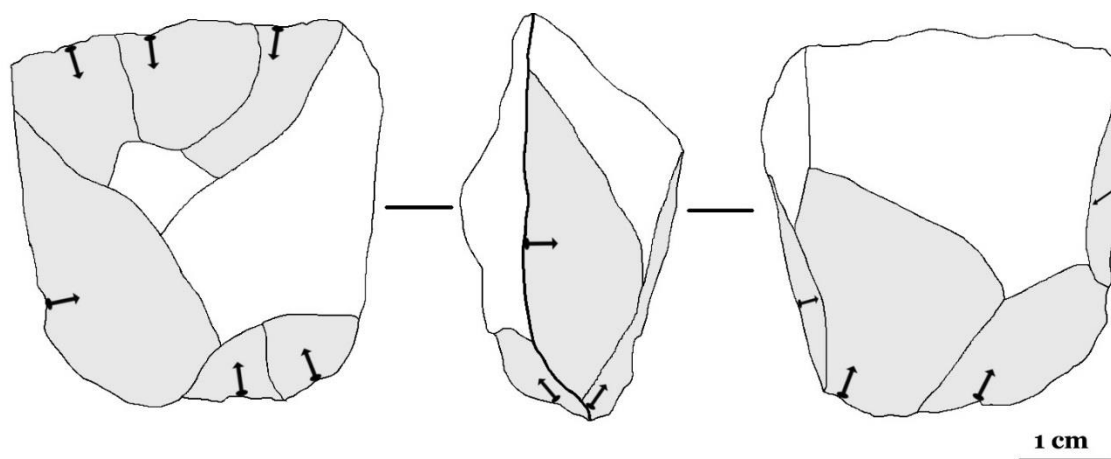
Payre D O8 34. Discoid flint core: unifacial core; the core is exhausted; two phases of exploitation are visible; the surfaces are hierarchized; the striking platform surface is natural; according to the 7 visible detachments, the wanted products are short and large debordant flakes obtained through centripetal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



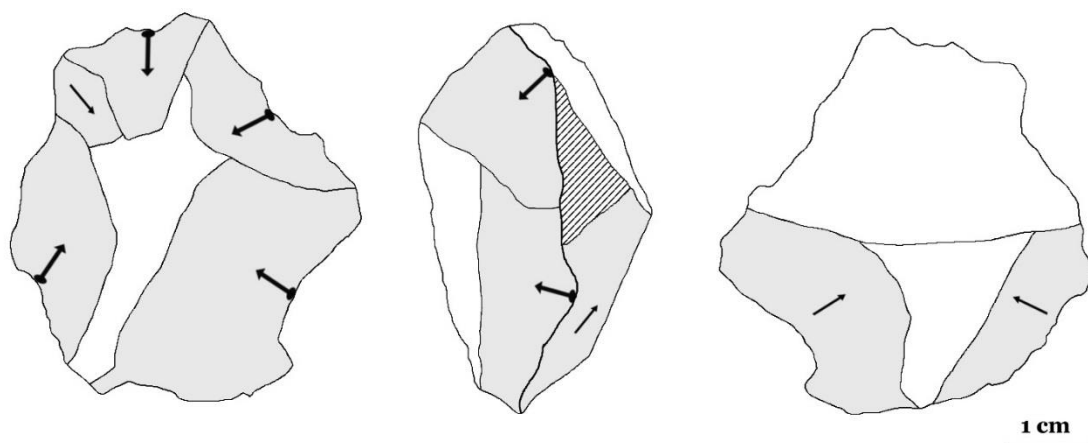
Payre D3 N7 84. Discoid flint core: bifacial core; the core is exhausted; one phase of exploitation; according to the 6 visible detachments, the wanted products are short and large flakes obtained through centripetal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



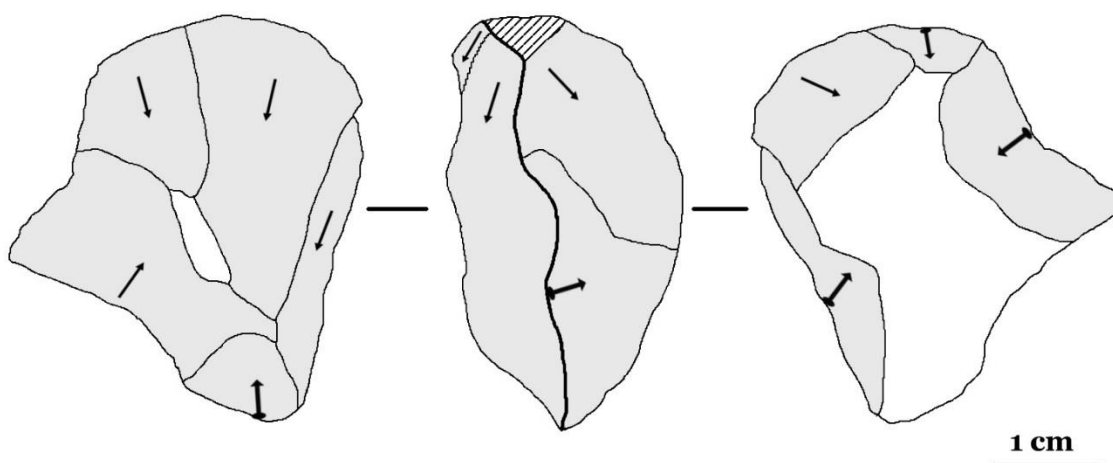
Payre D O8 135. Discoid flint core; unifacial core; the surfaces are hierarchized; the striking platform surface is natural; the core has been discarded before its complete exhaustion; according to the 4 visible negatives, the wanted products are short and large flakes obtained through centripetal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



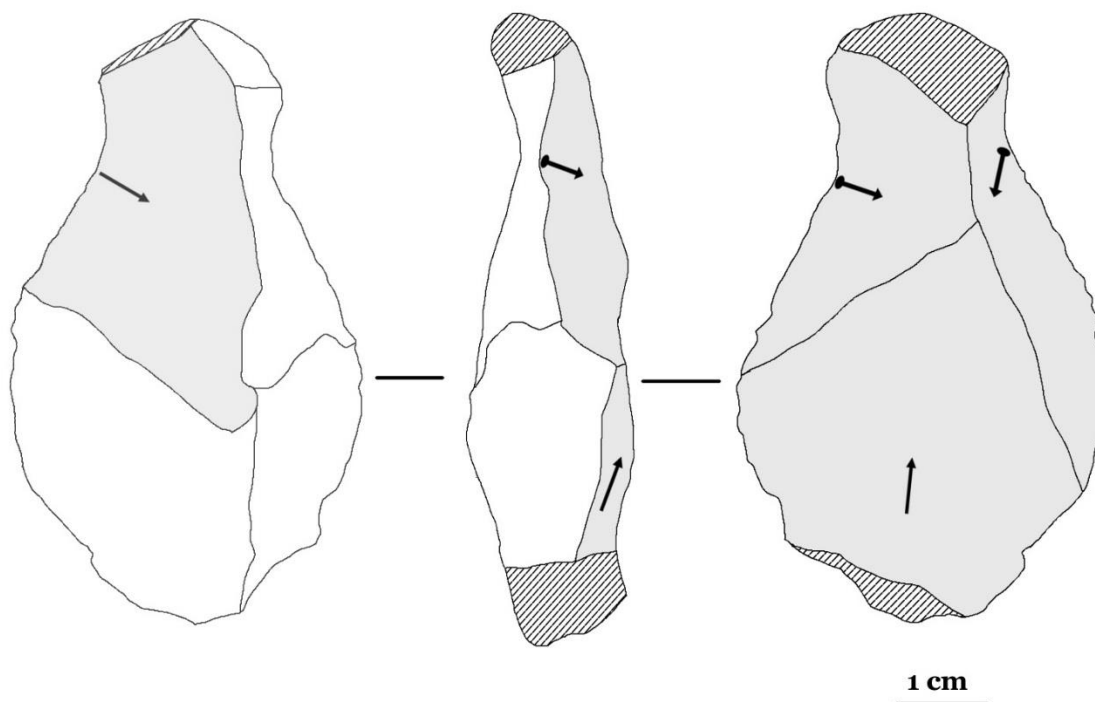
Payre D M7 55. Discoid flint core: bifacial core; one phase of exploitation; the core has been discarded before its complete exhaustion; according to the 10 visible detachments, the wanted products are short and large flakes obtained through centripetal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



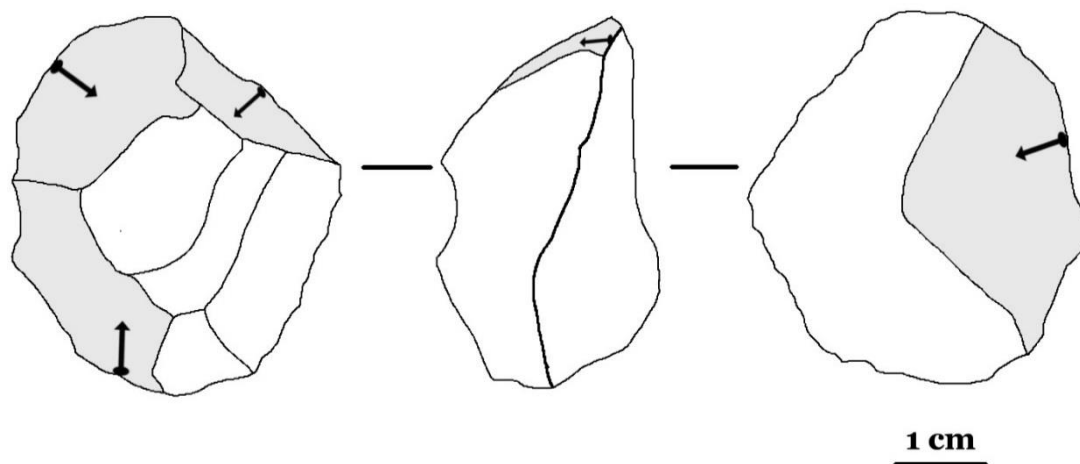
Payre D L7 221. Discoïd flint core; bifacial core; the core is exhausted; according to the 7 visible detachments, the wanted products are short flakes obtained through centripetal detachments; some of the detachments are debordant; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



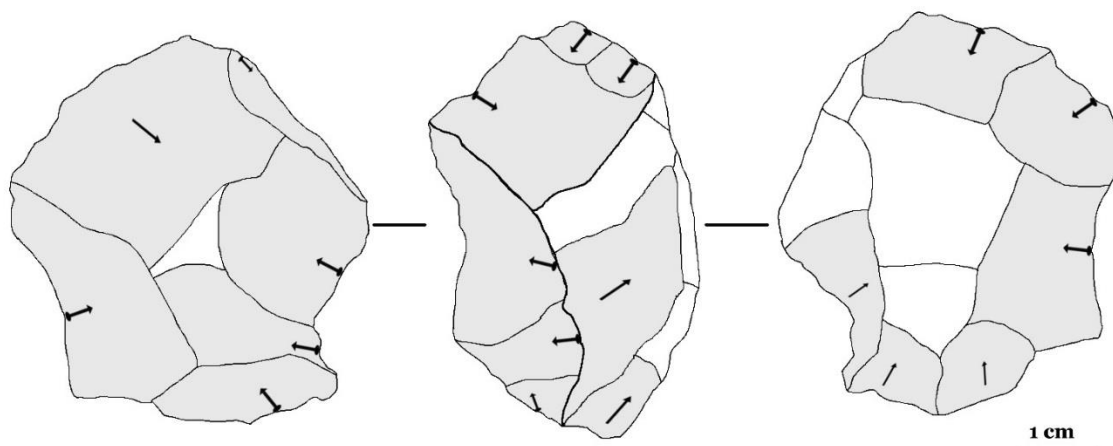
Payre D3 J11 50. Discoïd flint core; bifacial core; the core is exhausted; according to the 9 visible detachments, the wanted products are small flakes obtained through centripetal or chordal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



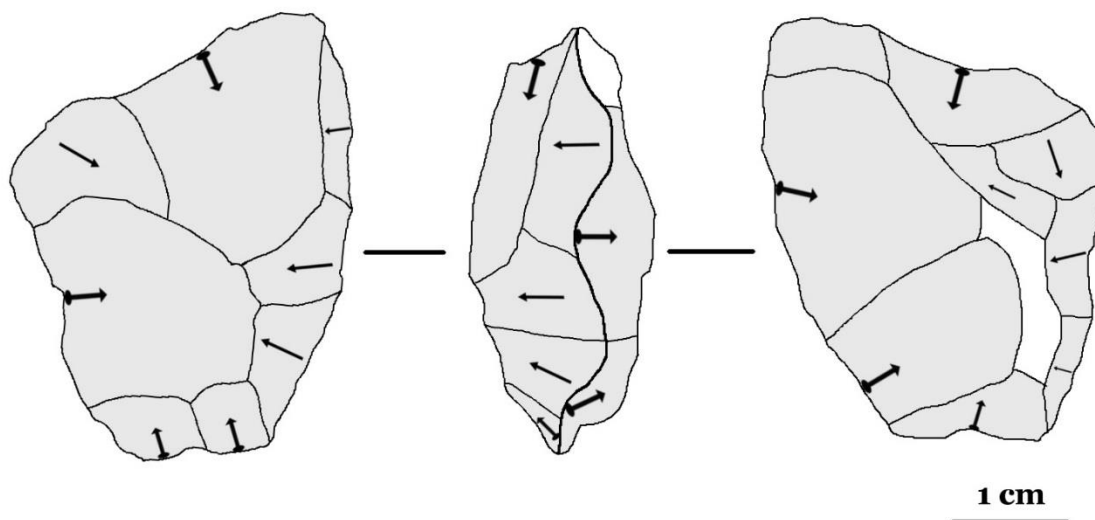
Payre D L7 102. Discoid flint core on flake: bifacial core; the core is exhausted; according to the 4 visible detachments, the wanted products are medium-sized debordant flakes obtained through centripetal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



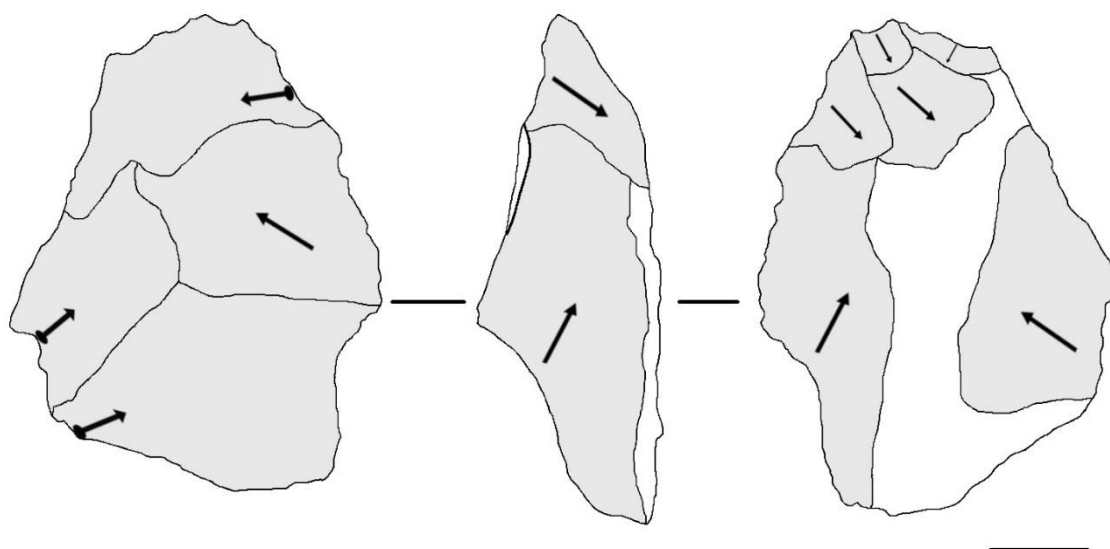
Payre D M8 107. Discoid flint core: bifacial core; the core is exhausted; according to the 4 visible detachments, the wanted products are short and debordant flakes obtained through centripetal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



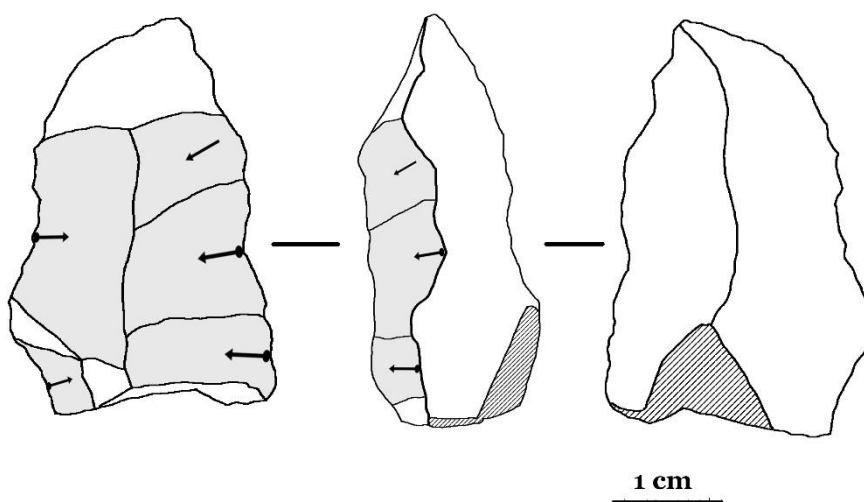
Payre D Q6 106. Discoïd flint core: bifacial core; two phases of exploitation; the core is exhausted; according to the 15 visible detachments, the wanted products are medium-sized short flakes obtained through centripetal detachments; a third surface has been exploited to produce three flakes; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



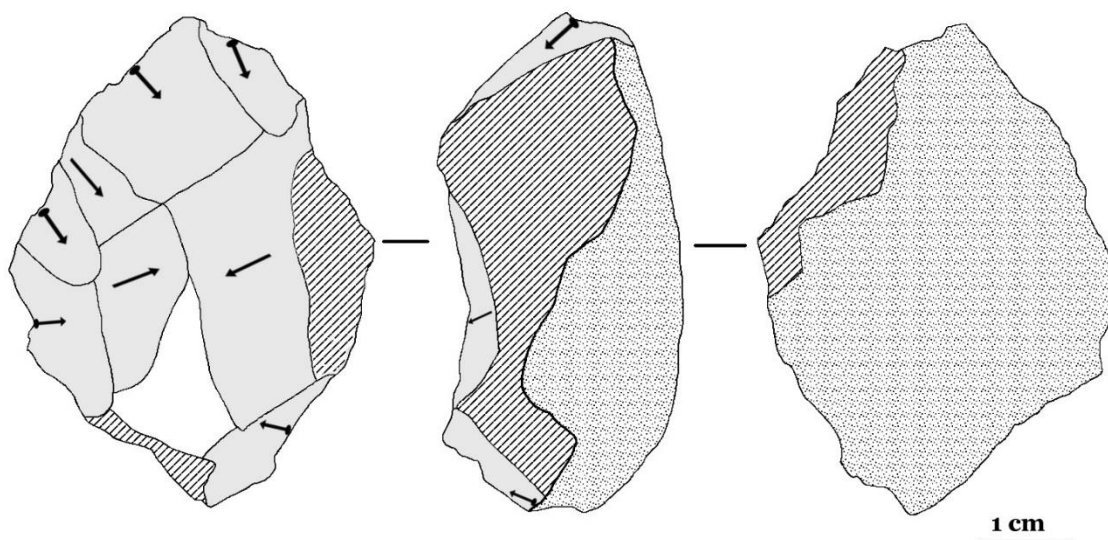
Payre D P7 103. Discoïd flint core: bifacial core; two phases of exploitation; the core is exhausted; according to the 16 visible detachments the wanted products are short and large flakes obtained through centripetal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



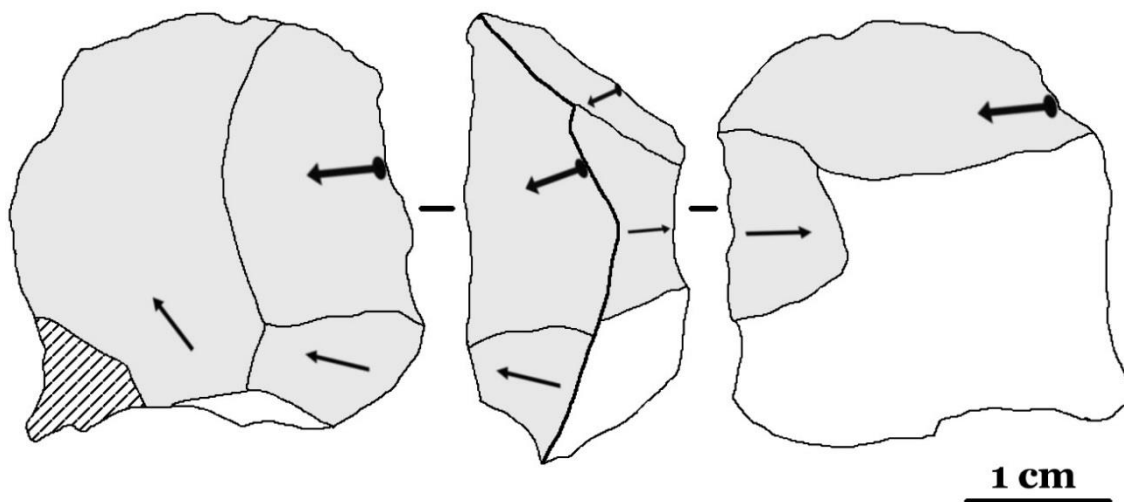
Payre D K7 184. Discoid flint core: unifacial core; one phase of exploitation; the surfaces are hierarchized; the striking platform surface is prepared through 6 centripetal detachments; according to the 4 visible detachments, the wanted products are short and large debordant flakes obtained through centripetal and chordal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



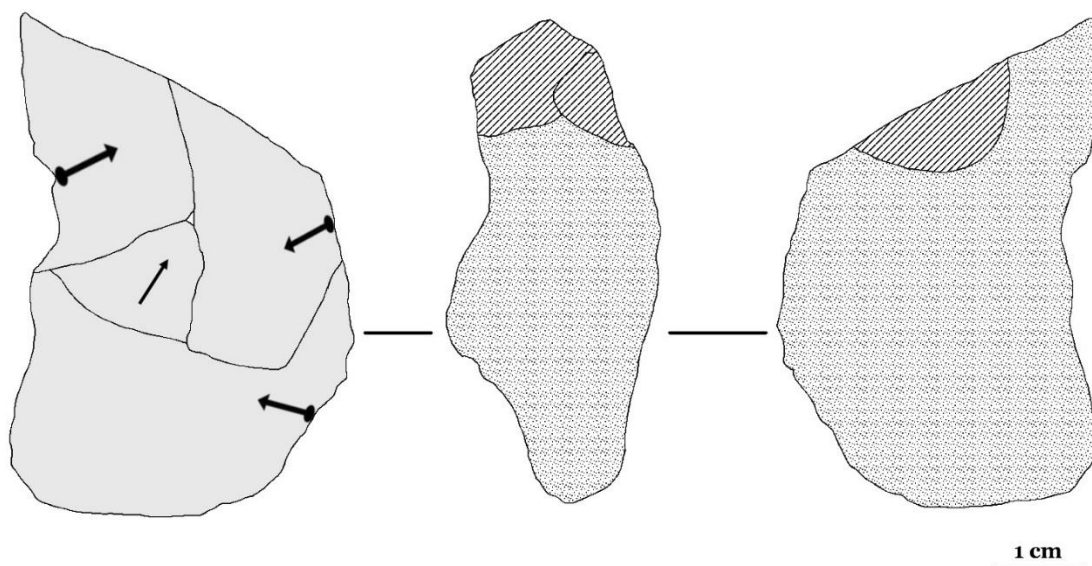
Payre D 122. Discoid flint core on flake: unifacial core; the core is exhausted; one phase of exploitation; the surfaces are hierarchized; according to the 5 visible detachments, the wanted products are small, short and large flakes obtained through centripetal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



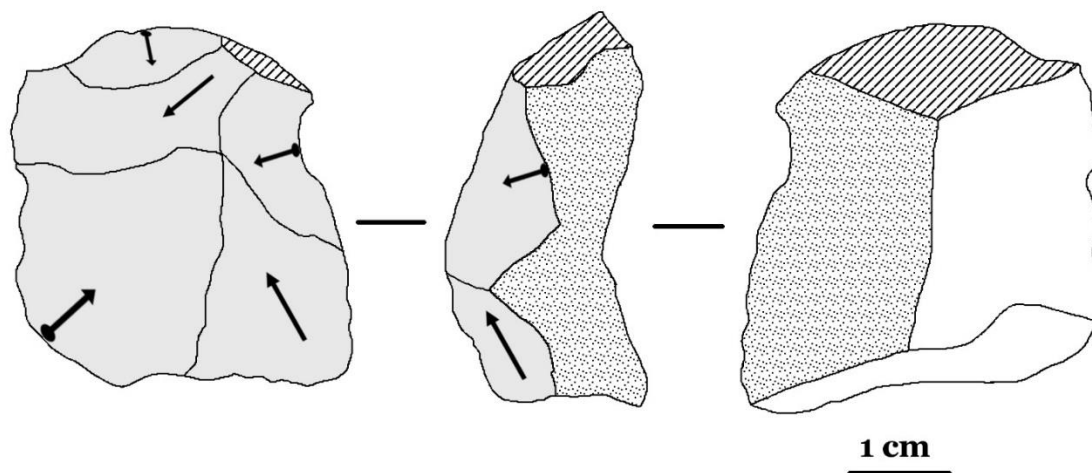
Payre D M4-5 123. Discoid flint core on pebble: unifacial core; the core is exhausted; two phases of exploitation; the surfaces are hierarchized, and the striking platform surface is natural; according to the 8 visible detachments, the wanted products are short and large flakes obtained through centripetal and chordal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



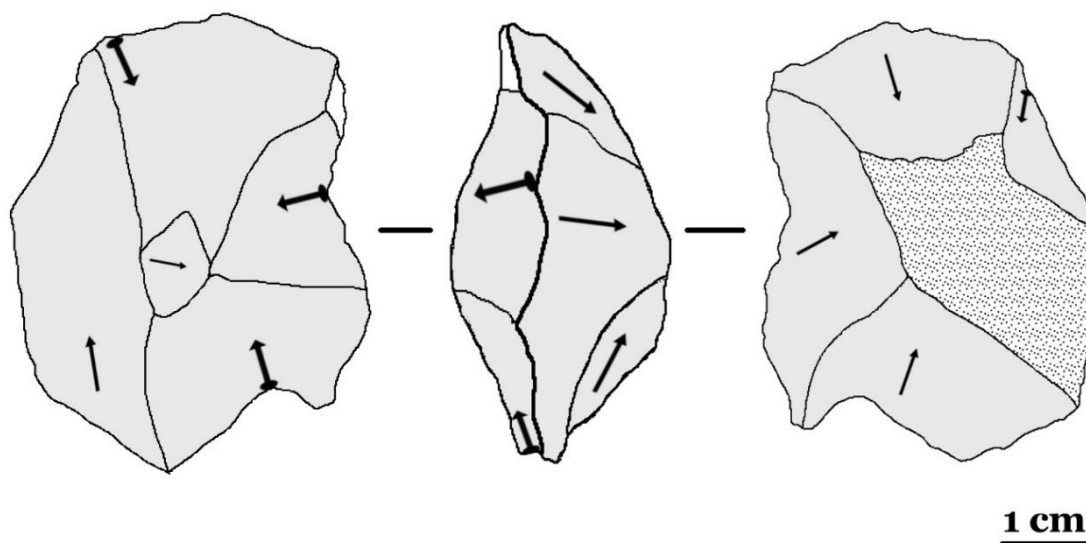
Payre D L9 165. Discoid flint core: bifacial core; the core is exhausted; one phase of exploitation; according to the 5 visible detachments, the wanted products are medium-sized short and large flakes obtained through centripetal and chordal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



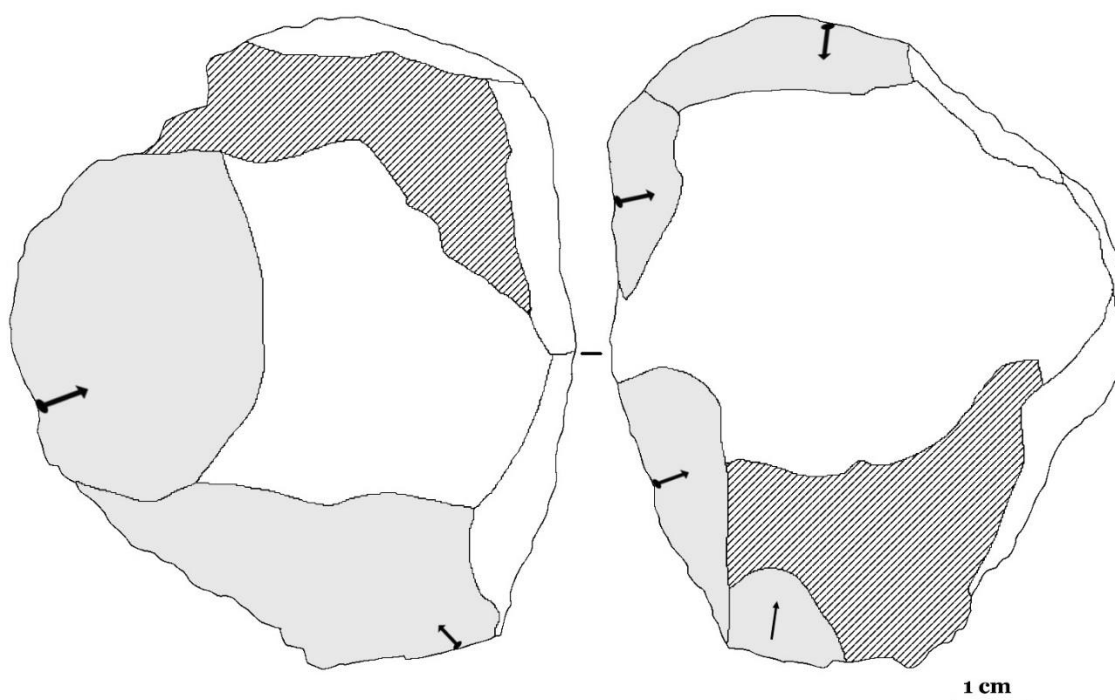
Payre D P5 143. Discoïd flint core: unifacial core; the core is exhausted; the surfaces are hierarchized and the striking platform surface is natural; two phases of exploitation; according to the 4 visible negatives, the wanted products are short and large debordant flakes obtained through centripetal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



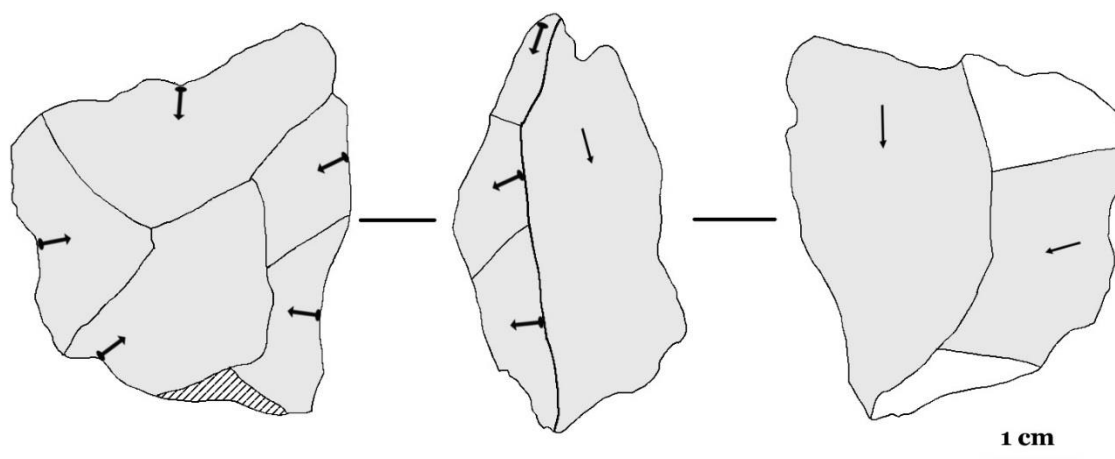
Payre D3 L8 143. Discoïd flint core: unifacial core; the core is exhausted; one phase of exploitation; the surfaces are hierarchized and the striking platform surface is partially natural; according to the 5 visible detachments, the wanted products are short and large flakes obtained through centripetal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



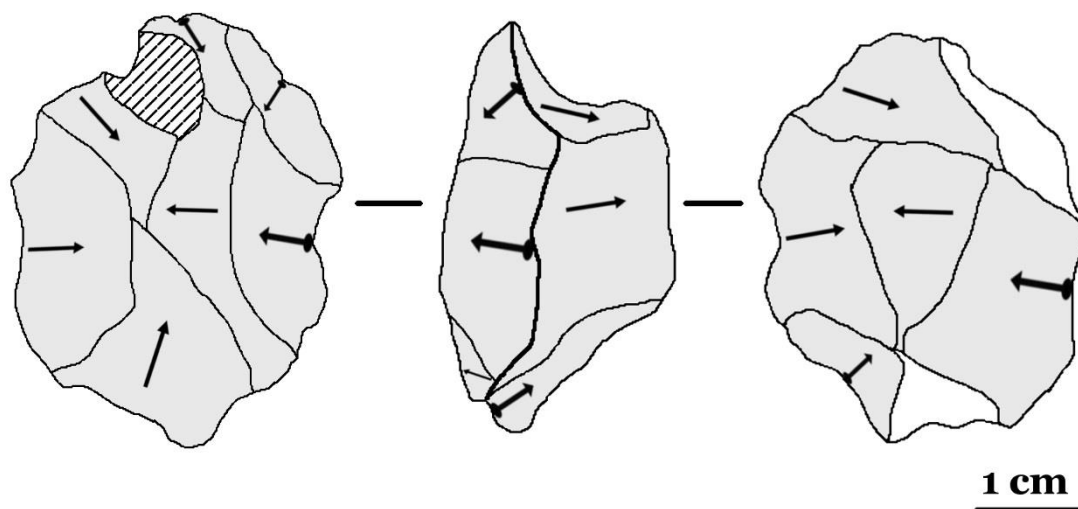
Payre D J6 296. Discoïd flint core on pebble: bifacial core; two phases of exploitation; the core is exhausted; one of the surfaces is partially natural; according to the 9 visible detachments, the wanted products are short and large flakes obtained through centripetal detachments; some of the detachments are debordant; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



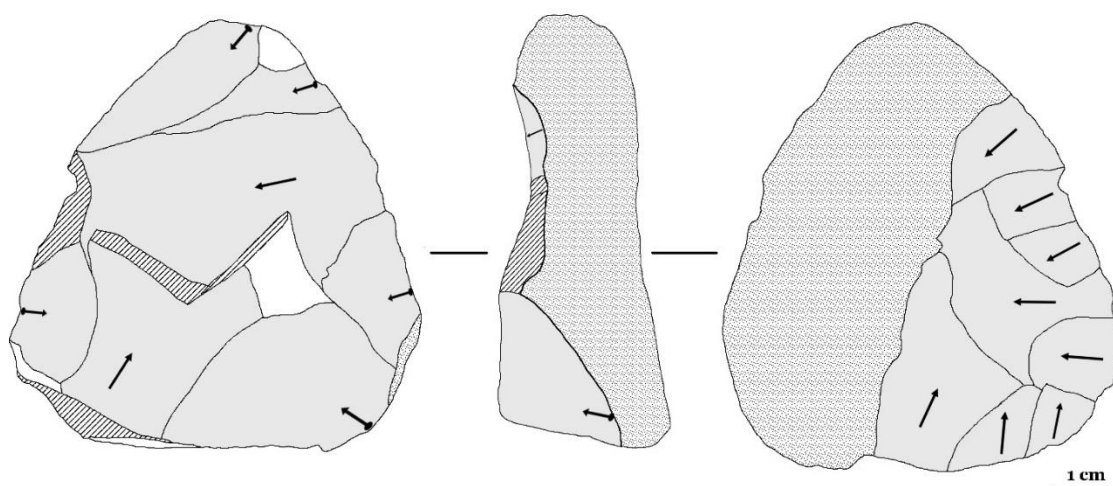
Payre D M5 125. Discoïd flint core: bifacial core; the core has been abandoned before its complete exhaustion; one phase of exploitation; the core is strongly affected by post-depositional alterations; according to the 4 visible detachments, the wanted products are big and large debordant flakes obtained through centripetal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



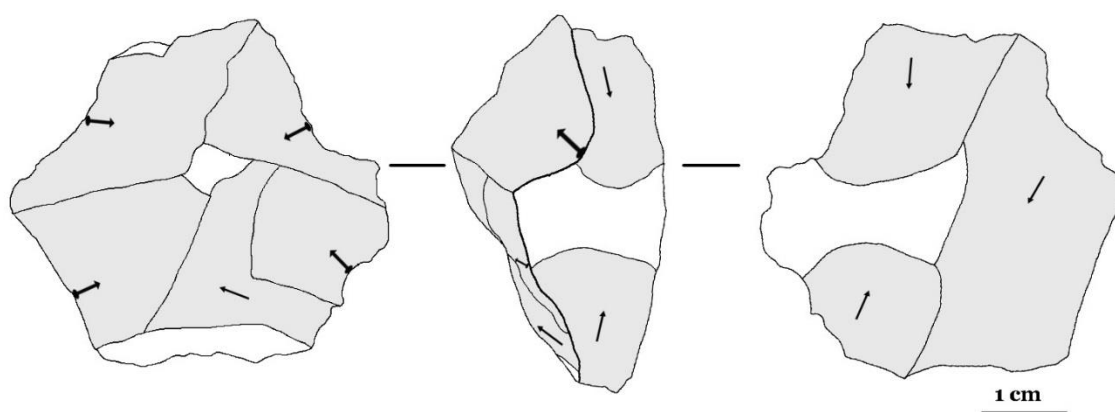
Payre D P6 625. Discoïd flint core: bifacial core; the core is exhausted; one phase of exploitation; according to the 7 visible detachments, the wanted products are short and large flakes obtained through centripetal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



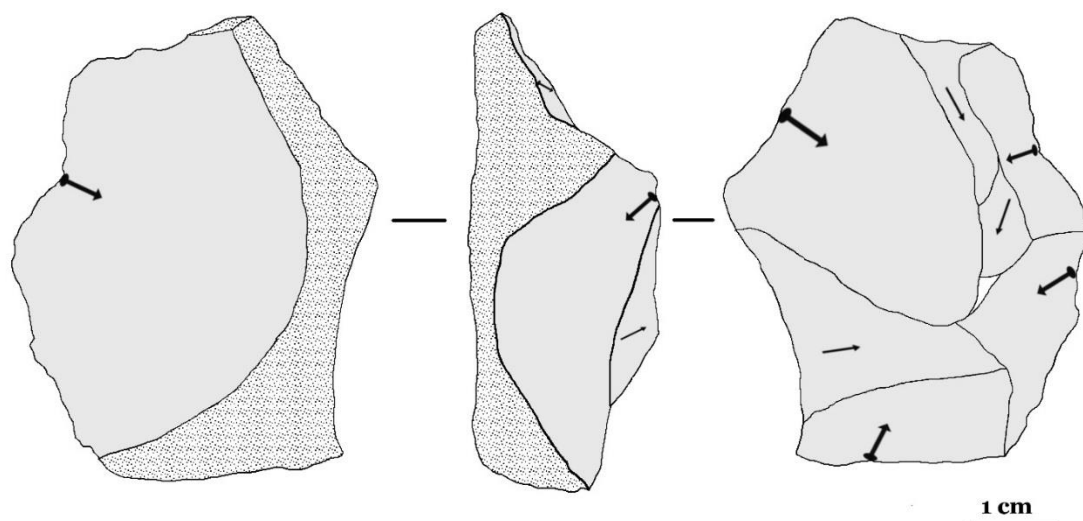
Payre D 118. Discoïd flint core: bifacial core; two phases of exploitation; the core is exhausted; according to the 12 visible detachments, the wanted products are short and large flakes obtained through centripetal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



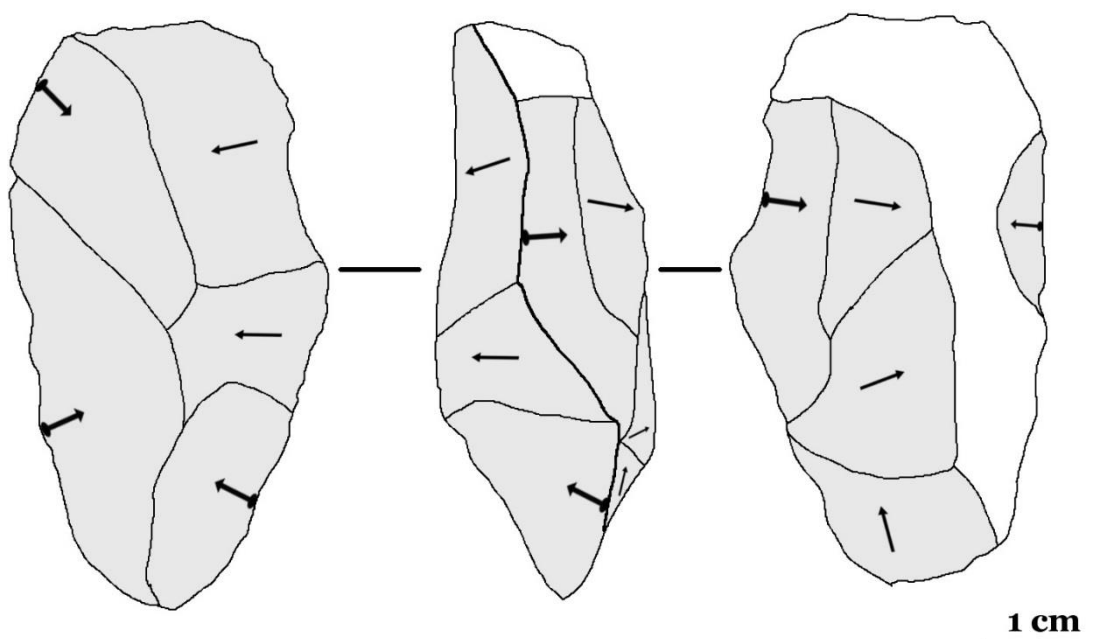
Payre D M4 29. Discoïd flint core: unifacial core; the surfaces are hierarchized; the core is exhausted; the striking platform surface has been prepared through 8 centripetal detachments; according to the 7 detachments visible on the knapping surface, the wanted products are medium-sized, short flakes obtained through centripetal and chordal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



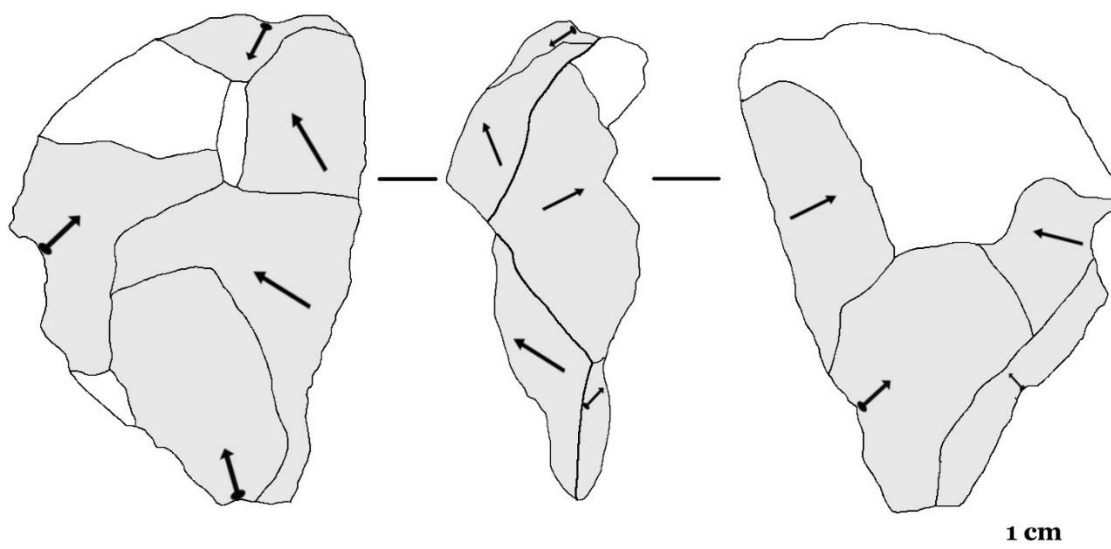
Payre D O9 2. Discoïd flint core: bifacial core; two phases of exploitation; the core is exhausted; according to the 8 visible detachments, the wanted products are short and large flakes obtained through centripetal and chordal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



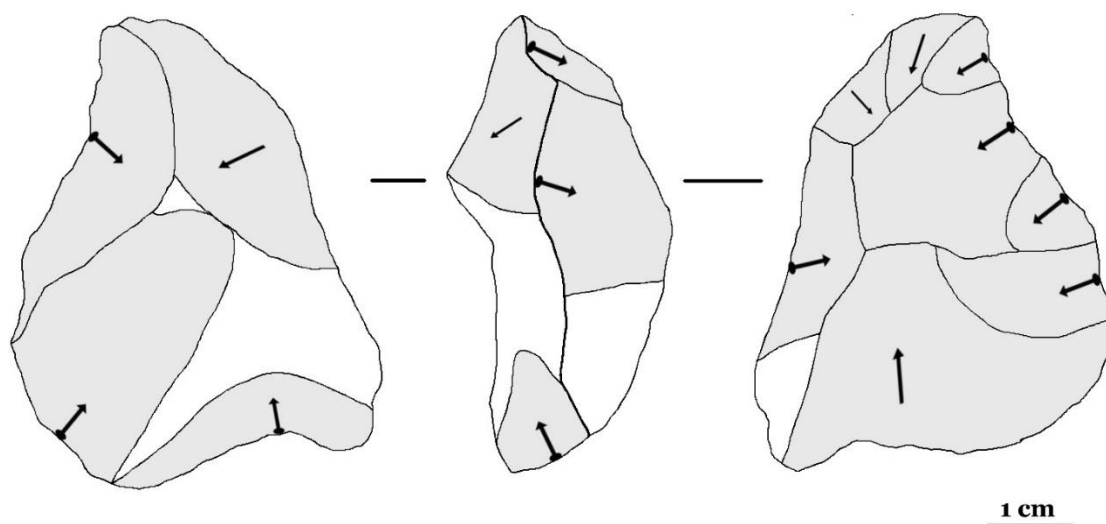
Payre D L-N6 119. Discoïd flint core: unifacial core; two phases of exploitation; the core is exhausted; the surfaces are hierarchized; the striking platform surface has been roughly prepared through the detachment of a big centripetal flake; in the last phase of exploitation a third surface has been exploited to produce a medium-sized debordant flake; according to the 7 negatives visible on the knapping surface, the wanted products are short and large flakes, sometimes debordant and obtained through centripetal and chordal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



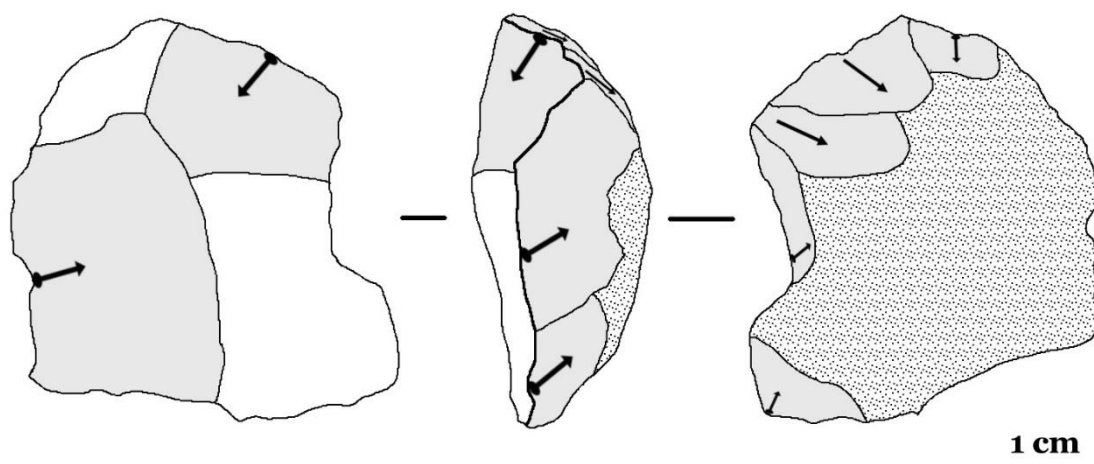
Payre D M5 8. Discoïd flint core: bifacial core; the core is exhausted; two phases of exploitation; according to the 10 visible detachments, the wanted products are short and large flakes, obtained through centripetal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



Payre D L6 121. Discoïd flint core on flake: bifacial core; the core is exhausted; two phases of exploitation; according to the 9 visible detachments, the wanted products are small and large debordant flakes; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



Payre D L-N6 116. Discoïd flint core: bifacial core; the core is exhausted; two phases of exploitation; according to the 12 visible detachments, the wanted products are medium-sized flakes obtained through centripetal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.



Payre D2 N5. Discoïd flint core: unifacial core; the surfaces are hierarchized; the core is exhausted; the striking platform surface is prepared through 5 centripetal detachments, not too invasive; according to the 2 detachments visible on the knapping surface, the wanted products are medium-sized short flakes obtained through centripetal detachments; the *débitage* direction is secant with respect to the plan of intersection of the two surfaces.

APPENDIX D

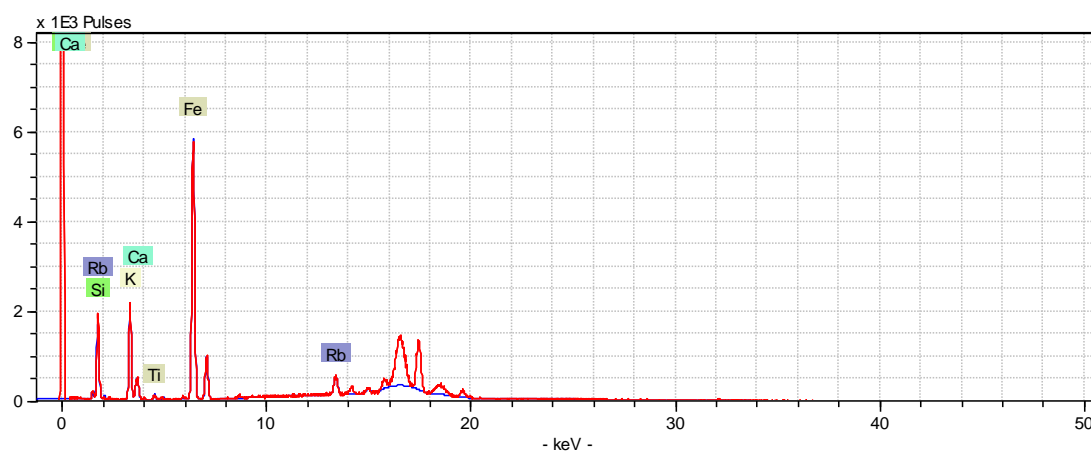
μ-XRF analysis

Appendix D

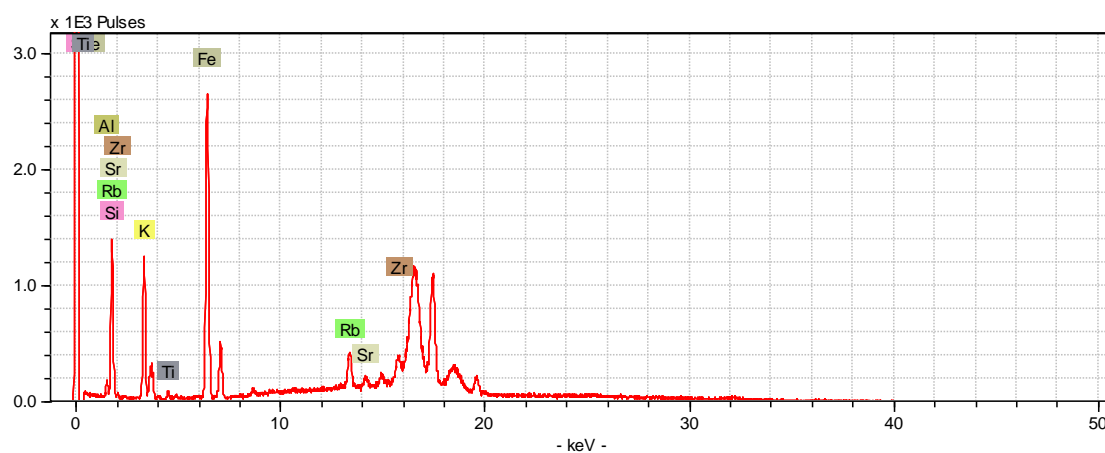
μ -XRF analysis

1. Rhyolite

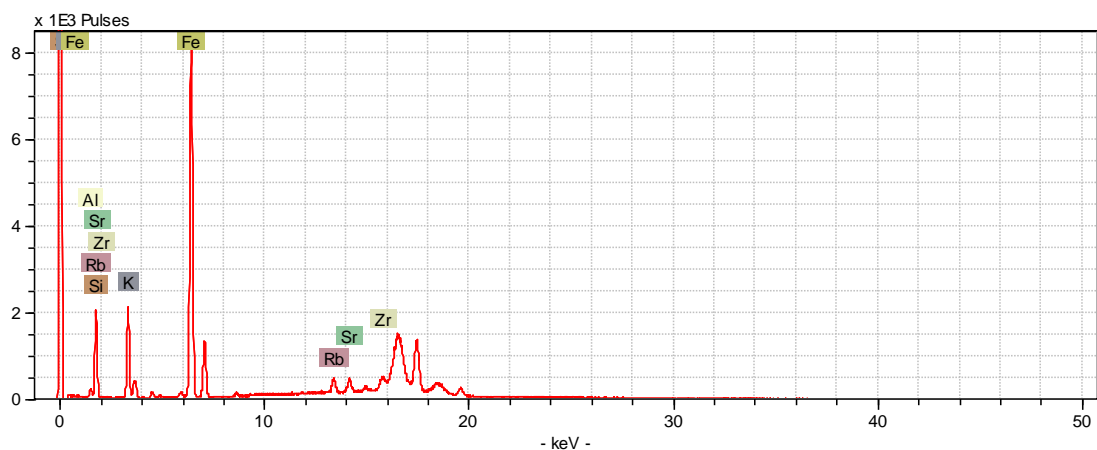
CC 14 D4 121



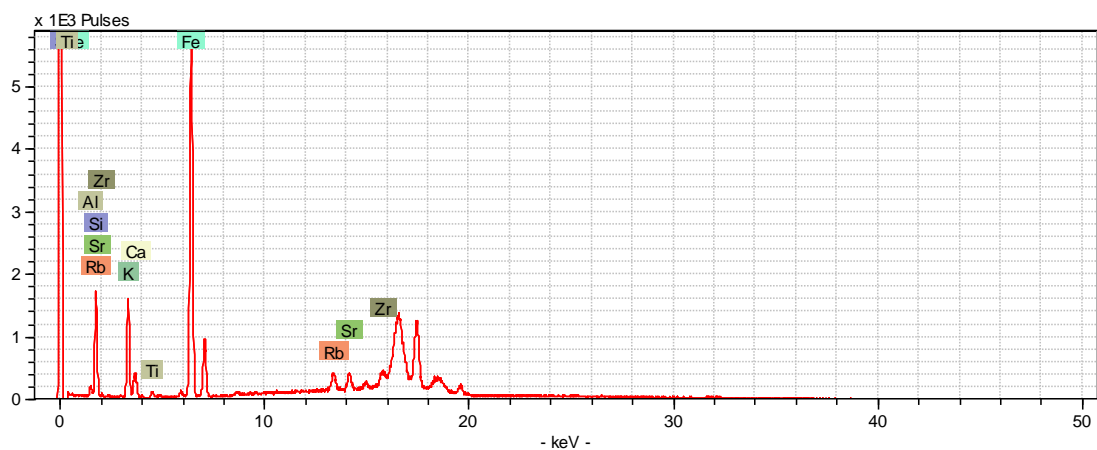
CC 14 D4 121 (b)



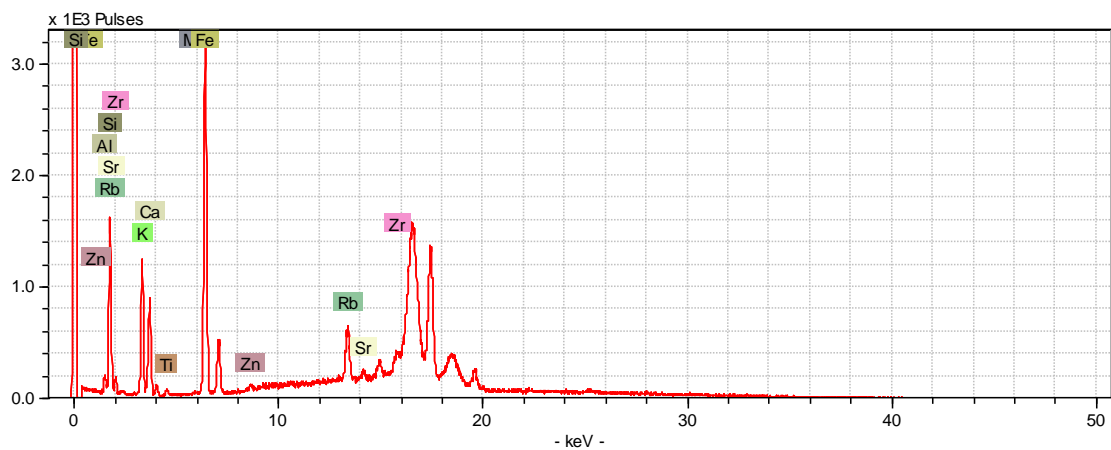
CC 14 E3 260



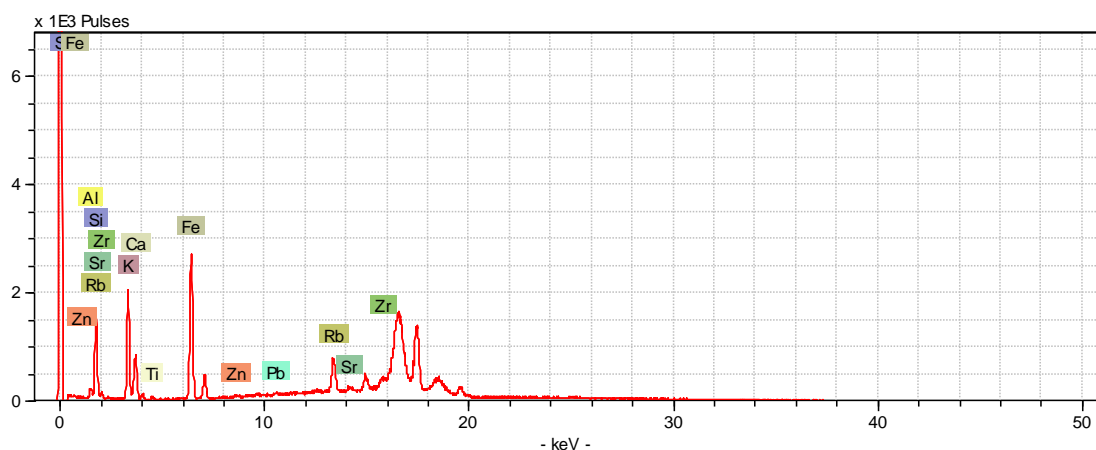
CC 14 E3 260 (b)



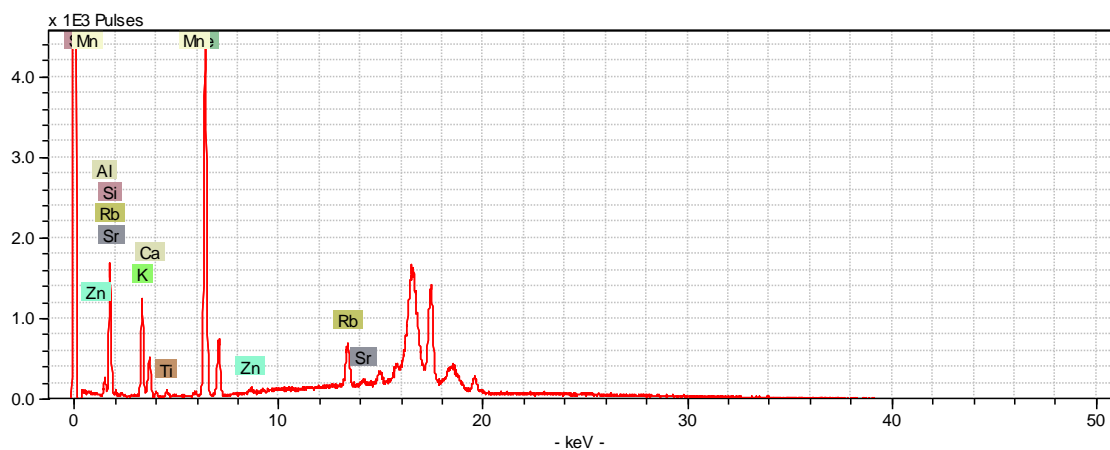
CC 15-13 F3 1527



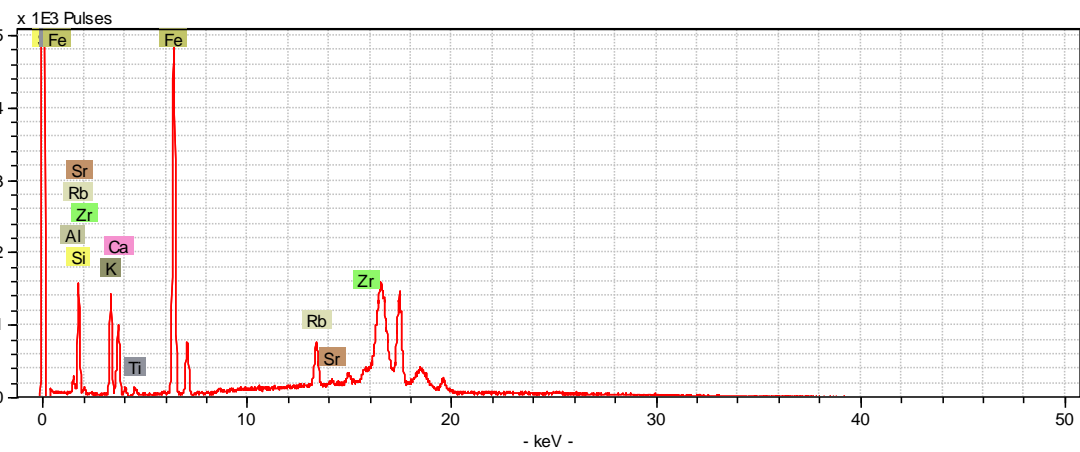
CC 15-13 F3 1527 (b)



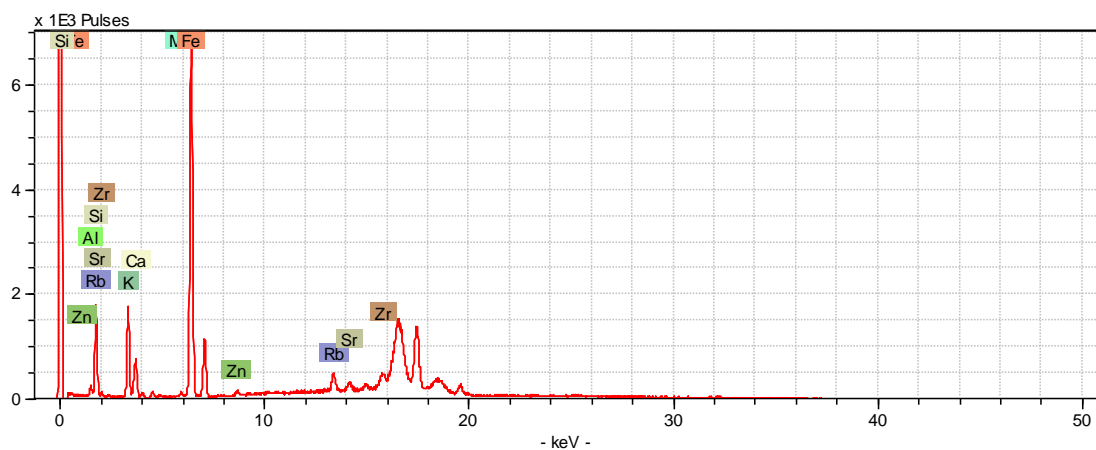
CC 15-13 F3 1527 (c)



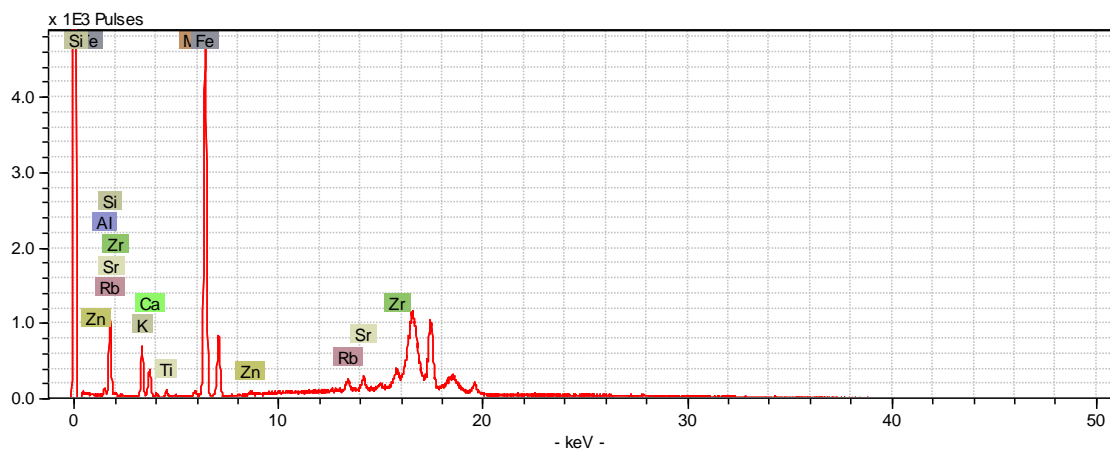
CC 15-13 F3 1527 (d)



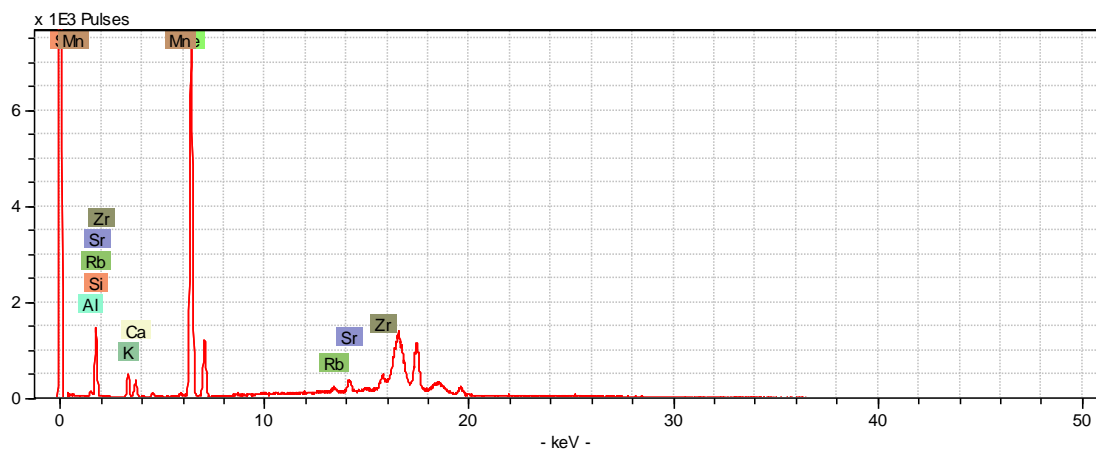
CC 14-5 F2 825



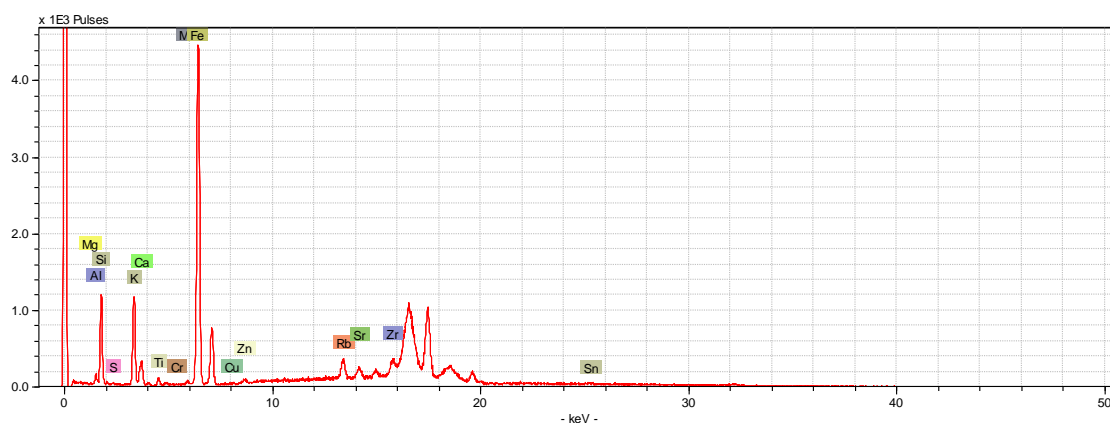
CC 14-5 F2 825 (b)



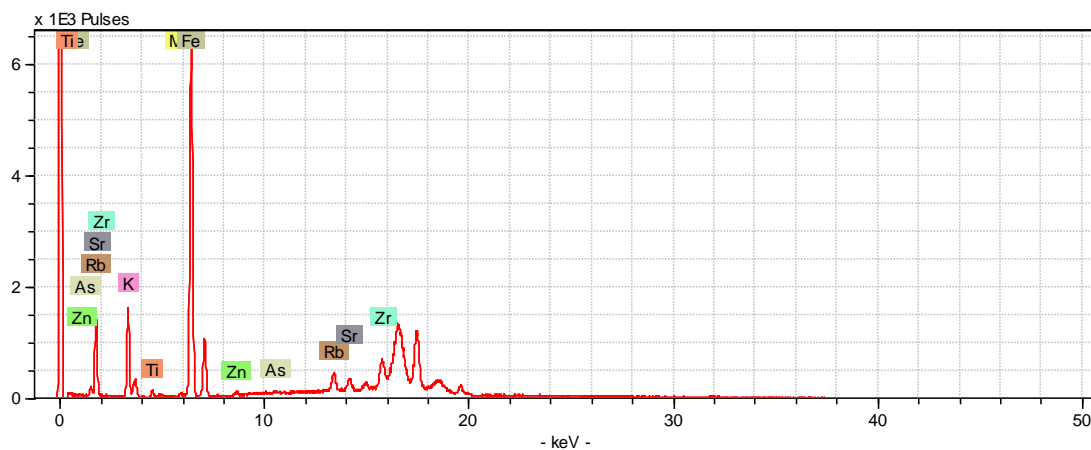
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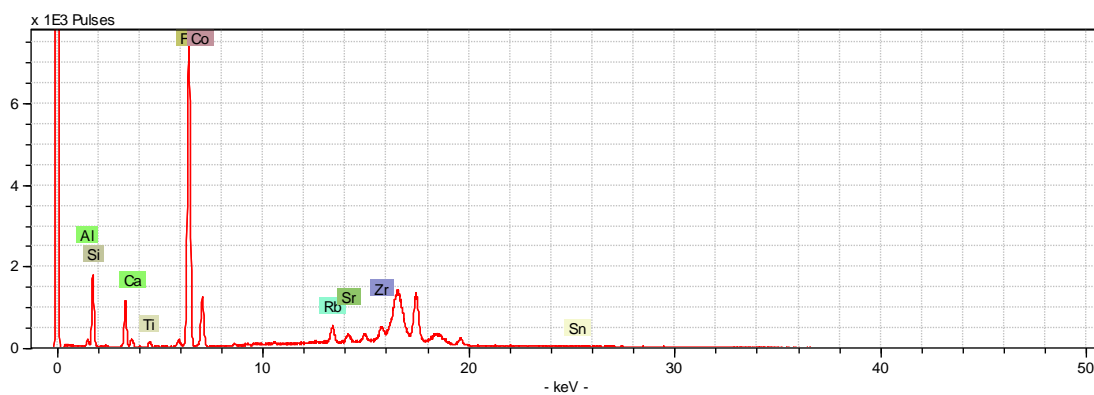
CC 14 E3 1276



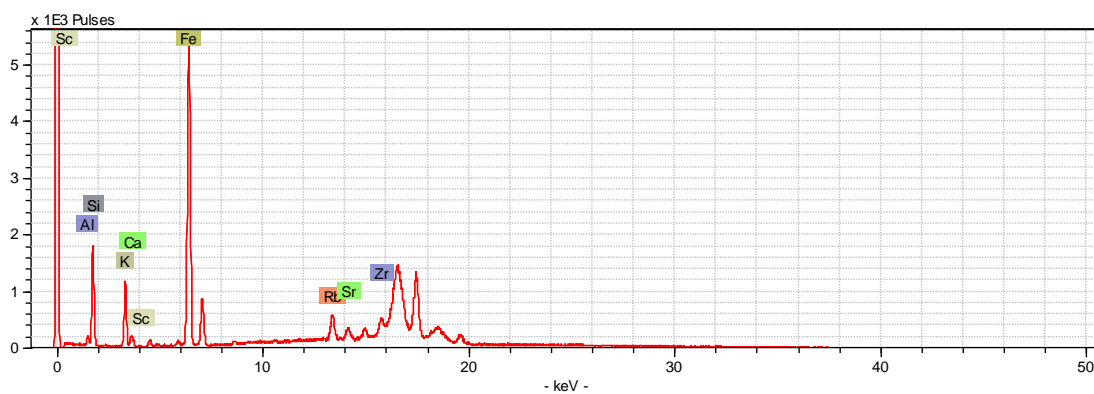
CC 14 E3 1276 (b)



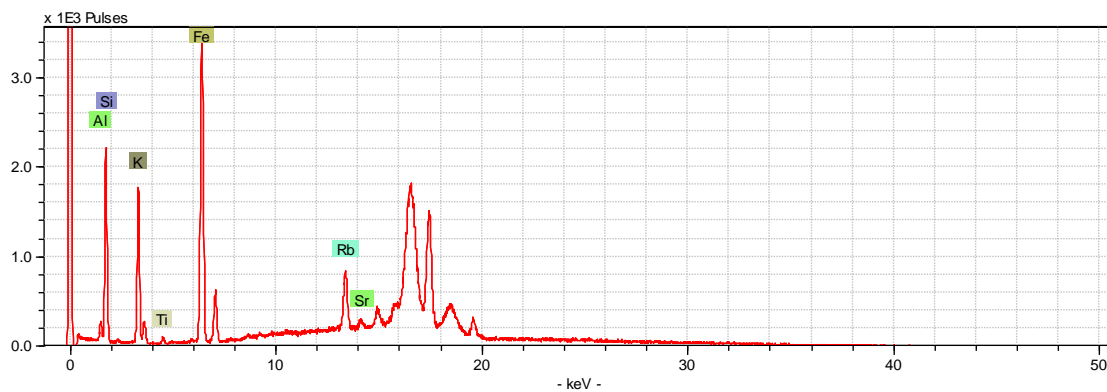
Sessera Geological sample n°1



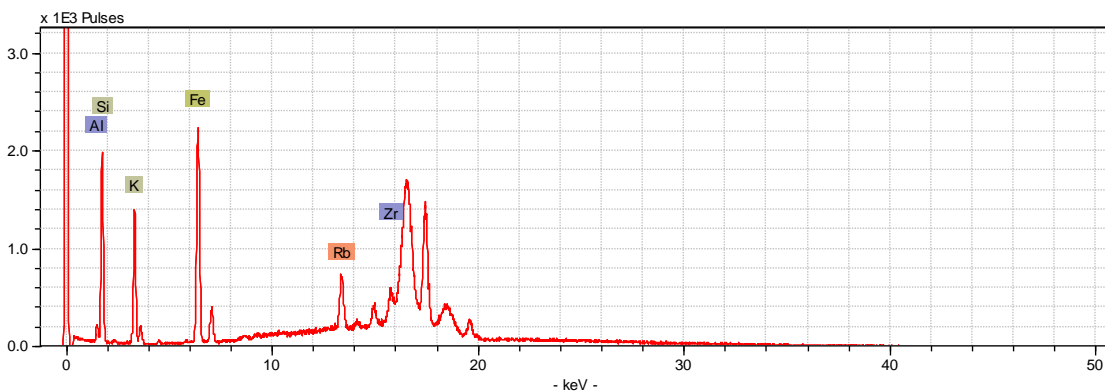
Sessera geological sample n°1 (b)



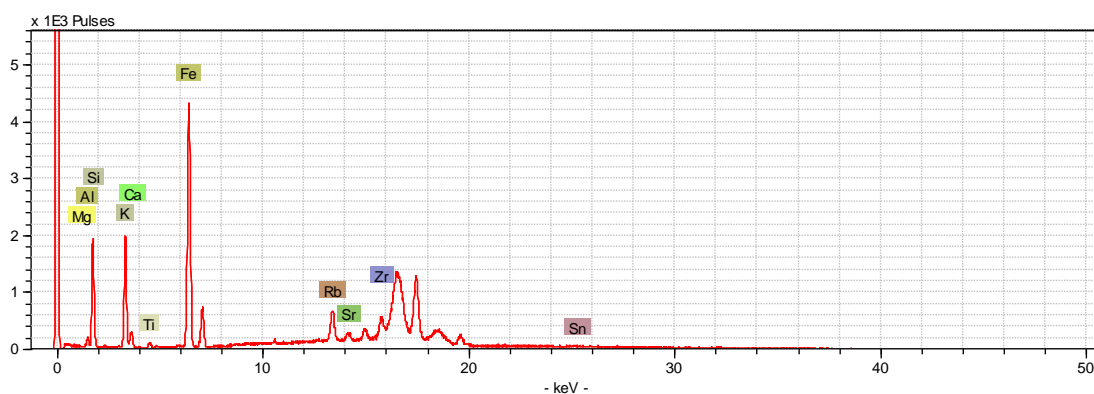
Sessera geological sample n°2



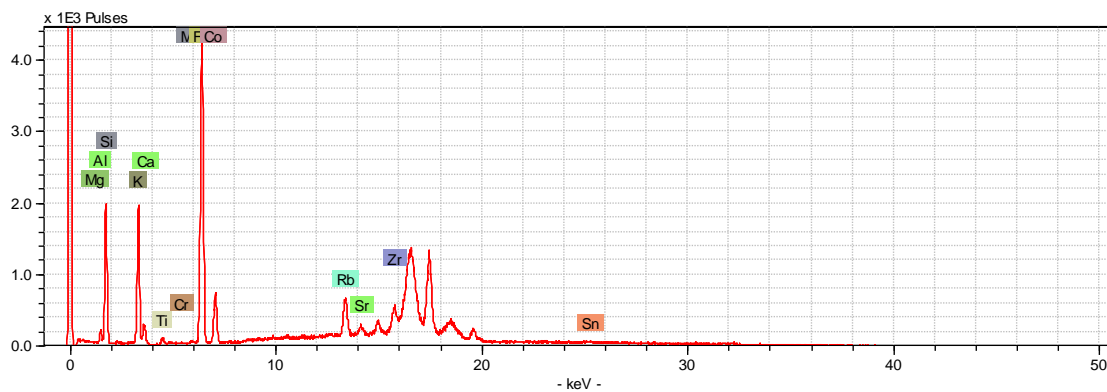
Sessera geological sample n°2 (b)



Sessera geological sample n° 3

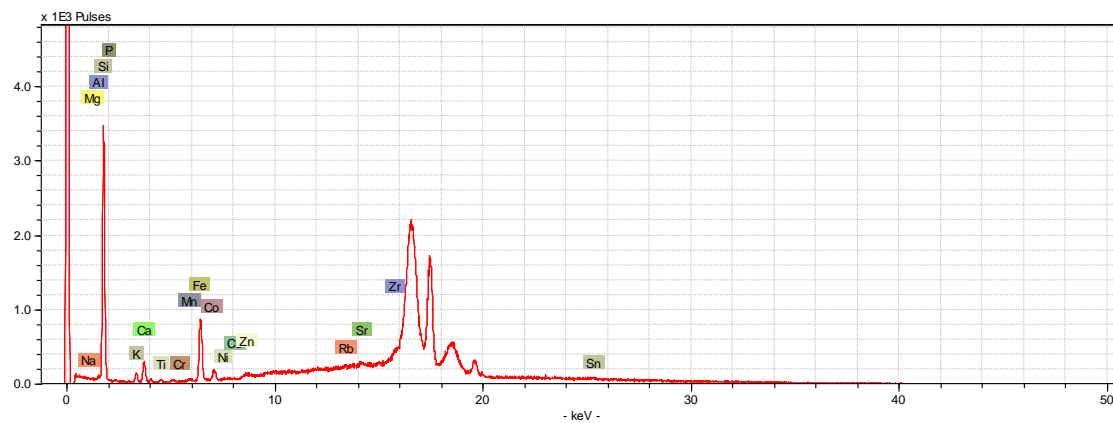


Sessera geological sample n°3 (b)

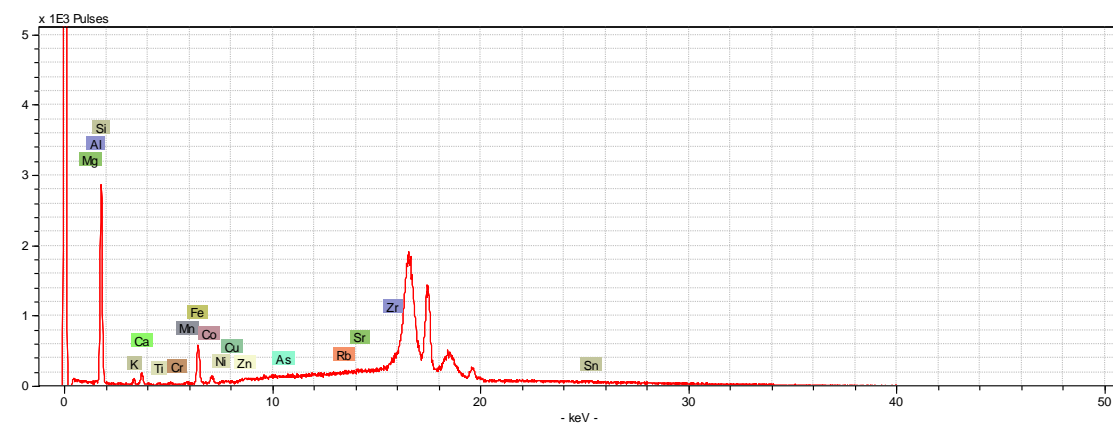


2. Radiolarite

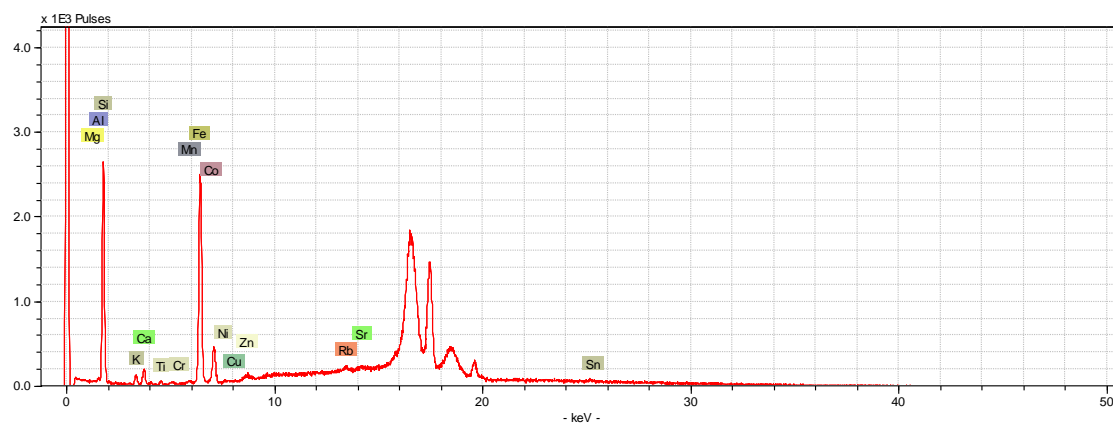
CC 14 F3 17



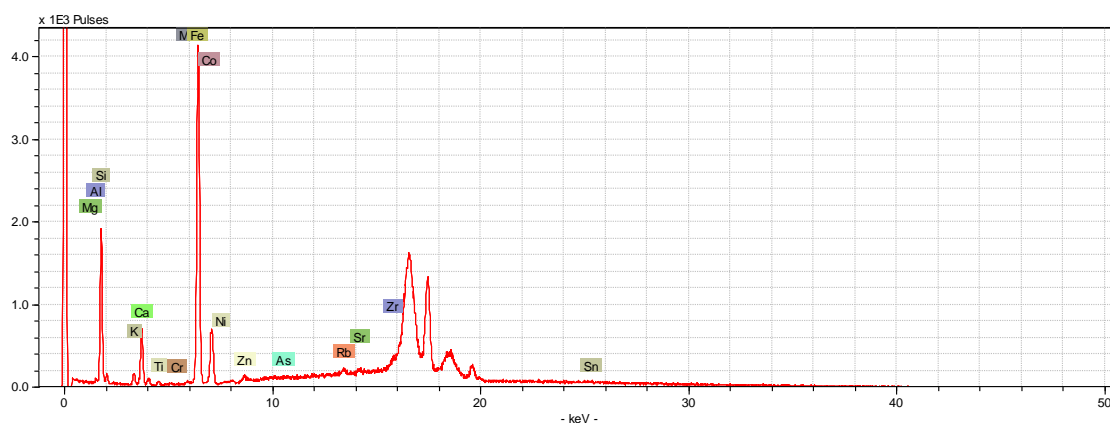
CC 14 F3 17 (b)



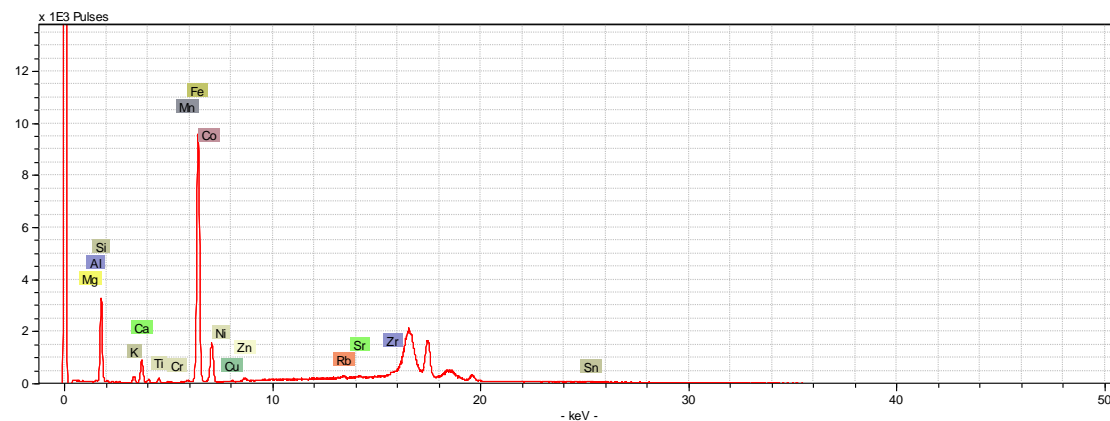
CC 14 F3 53



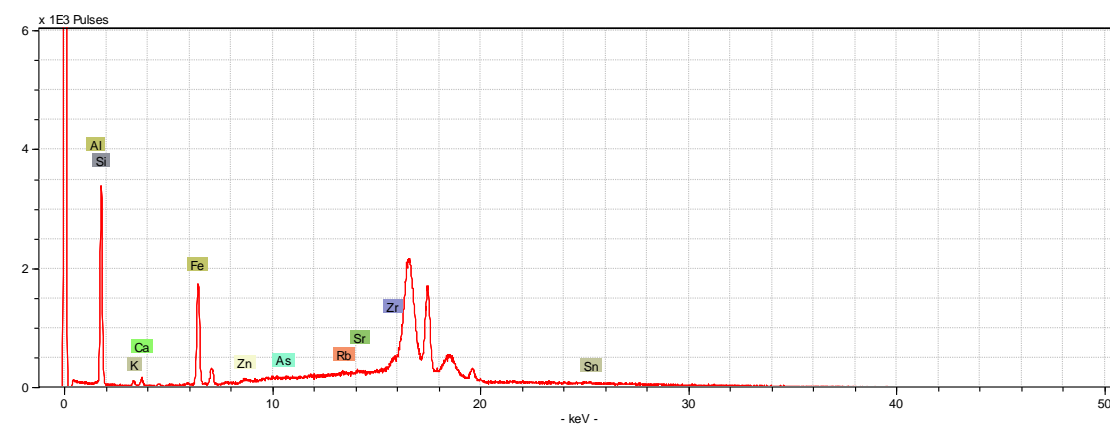
CC 14 F3 53 (b)



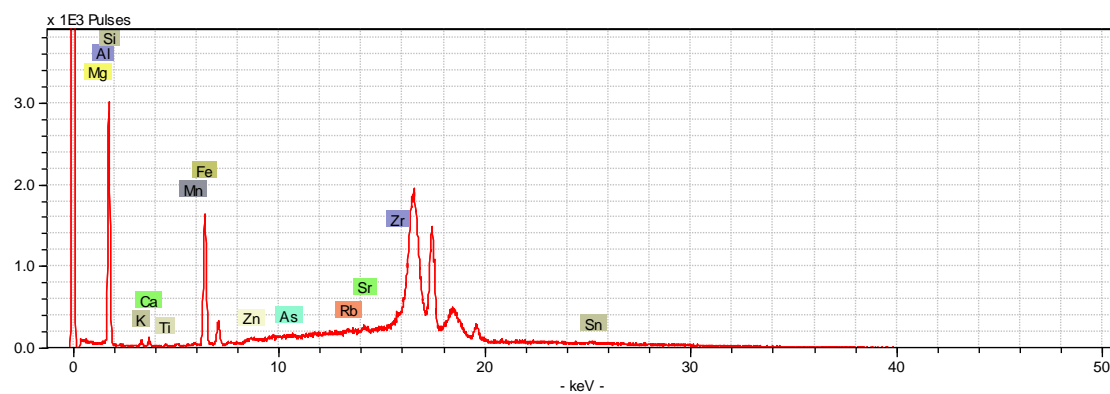
CC 14 F3 53 (c)



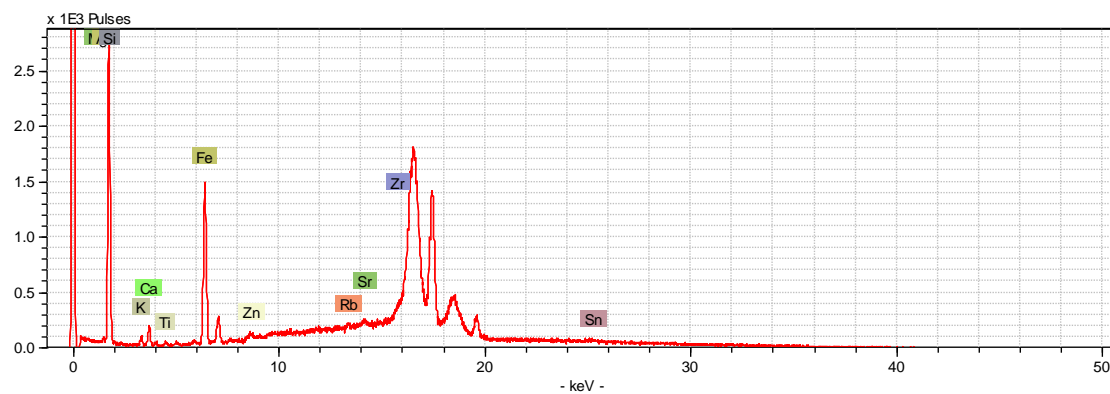
CC 15-11 F3 26



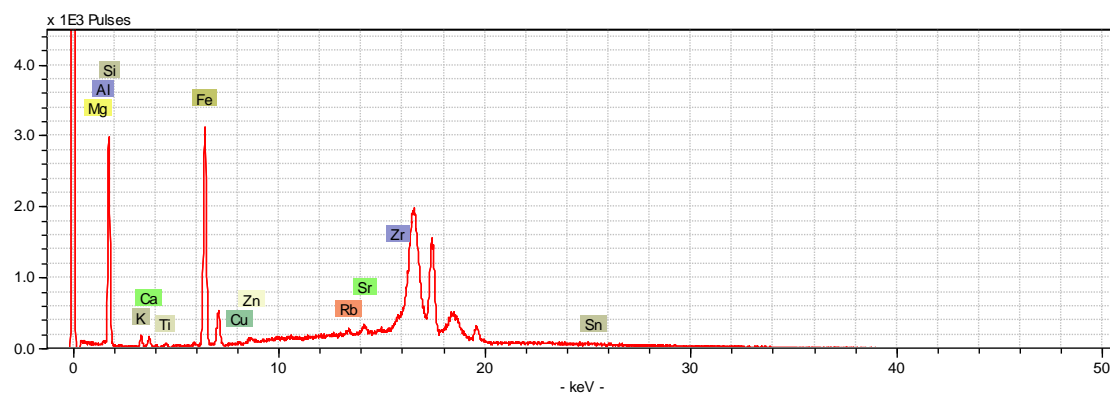
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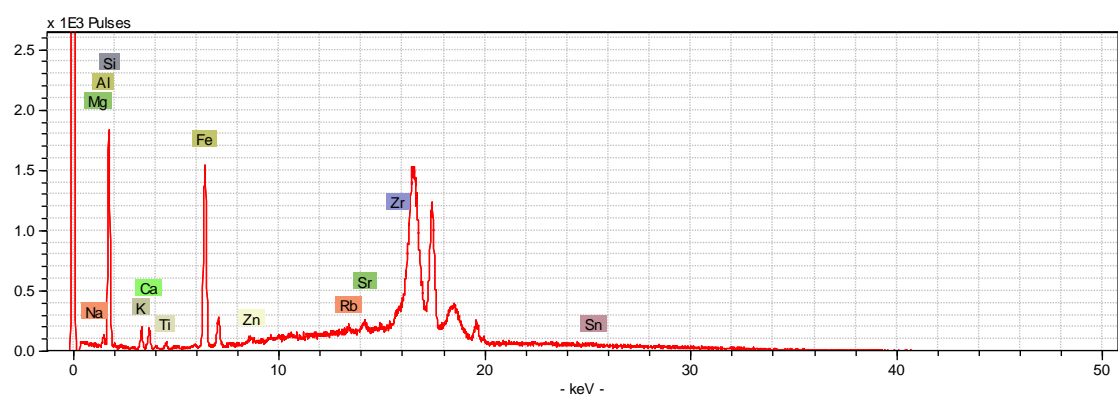
CC 15-11 F3 26 (c)



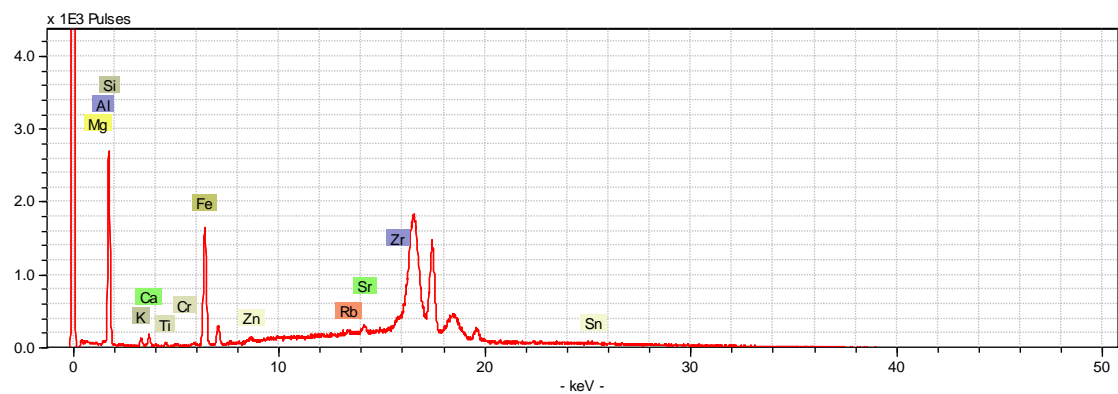
CC 15-15 D3 68



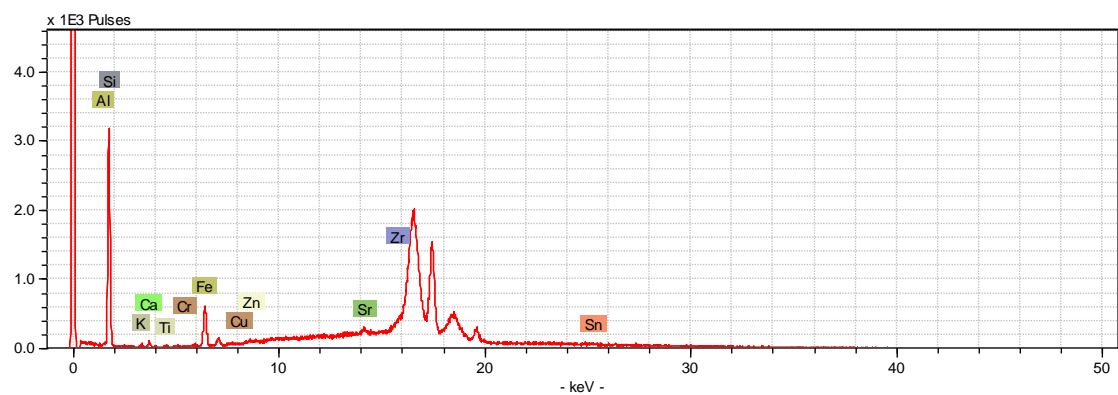
CC 15-15 D3 68 (b)



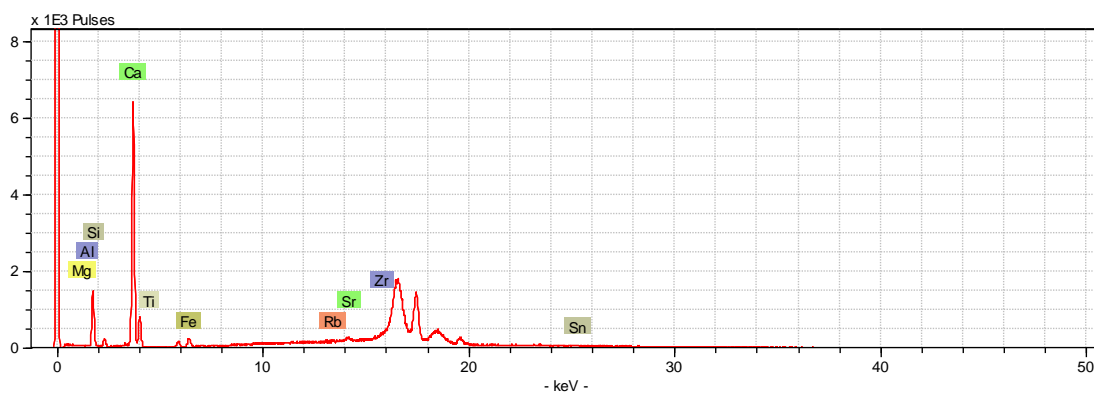
CC 15-15 D3 68 (c)



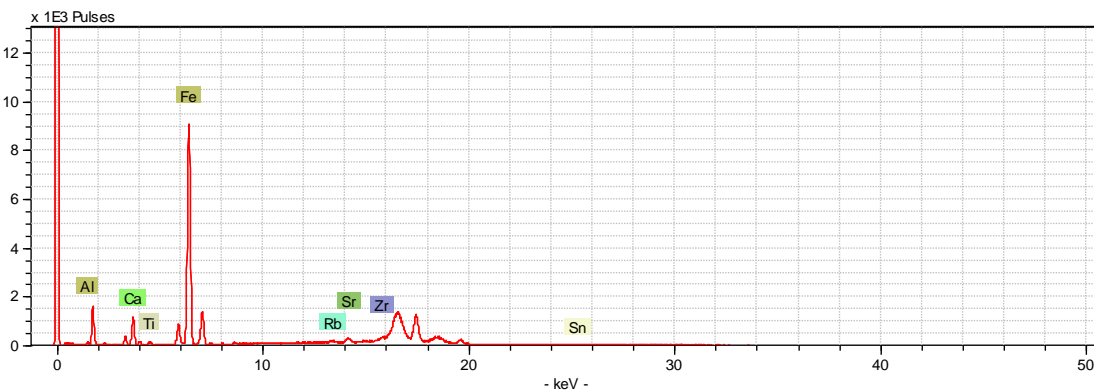
Sangiano (VA) geological sample n° 2



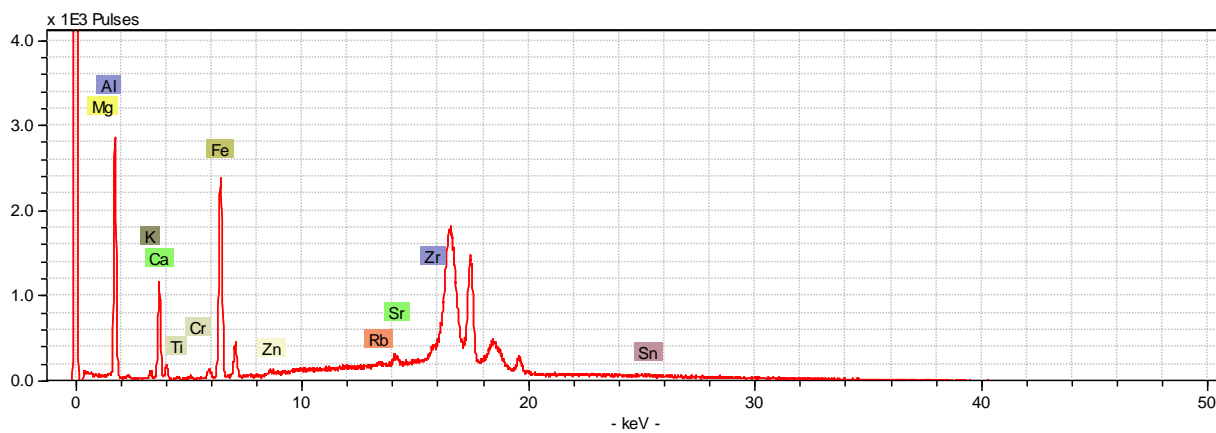
Sangiano (VA) geological sample n° 2 (b)



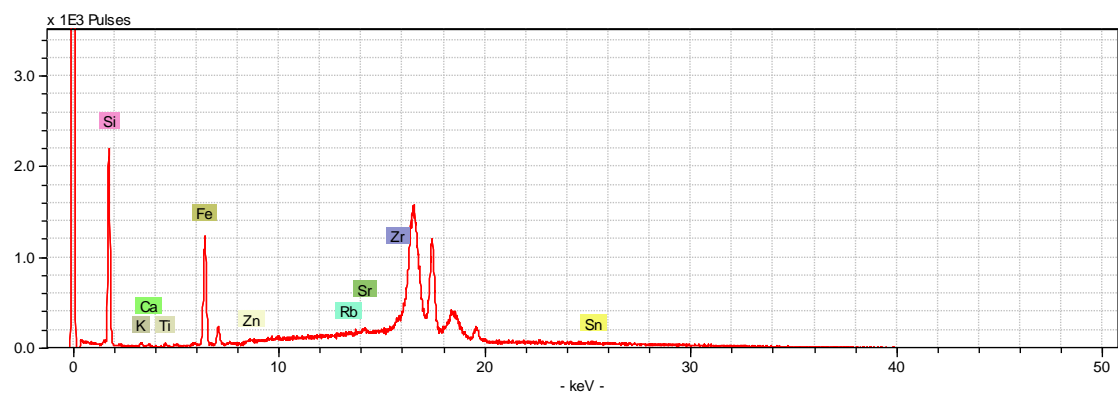
Sangiano (VA) geological sample n° 3



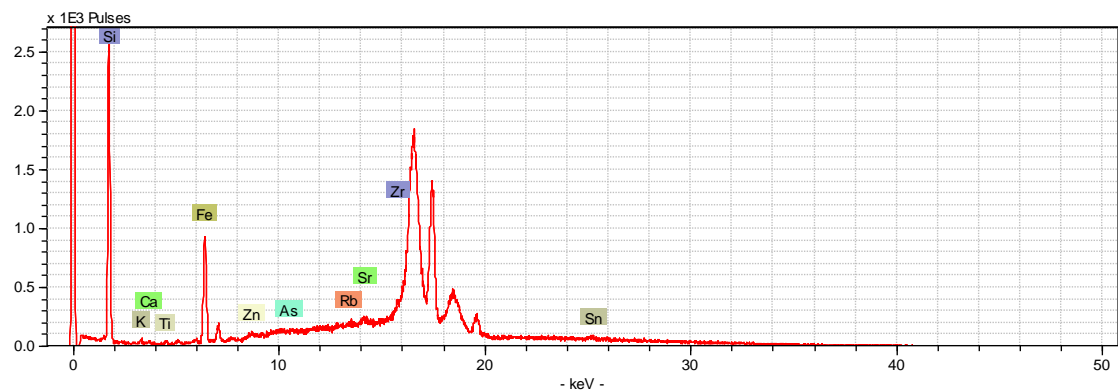
Sangiano (VA) geological sample n° 3 (b)



Sangiano (VA) geological sample n° 4



Sangiano (VA) geological sample n° 4 (b)



APPENDIX E

Side Works

APPENDIX E

Side works

During the three years of the International Doctorate in Quaternary and prehistory I had the chance to work not only on my research project, but also to get in touch and collaborate with other researchers. In this appendix are presented the papers, already published, or recently submitted, concerning the results achieved thanks to these collaborations.

- Berruti G.L.F., Bertè D., Caracausi S., Daffara S., Ferreira C., Garanzini F., Rubat Borel F., Scoz L., 2016. *New evidence of human frequentations in the western Alps: the project "Survey Alta Valsessera (Piedmont - Italy)"*. Quaternary International, 402, pp. 15-25.
- Berruti G.L.F., Arnaud J., Arzarello M., Belo J., Berruto G., Caracausi S., Daffara S., Ferreira C., Reis C.H., Rosina P., Rubat Borel F., 2016. *Geoarchaeological survey in the Baragge Biellesi area. New data on the Middle Palaeolithic in Piedmont*. Incontri annuali di preistoria e protostoria (2016), Vol. 1, pp. 92-93.
- Bertè D., Caracausi S., Berruti G.L.F., Daffara S., Zambaldi M., Montanari Canini G., Arzarello M., Albinì W., Miola V., Riboldazzi A., Siega G., Sellaro G., Panero E., submitted paper, *First report on the Upper Pleistocene paleontological deposits from the Morgana Cave (Mt. Fenera, Borgosesia, Piedmont, Italy)*. Bollettino della Società Paleontologica Italiana.
- Caracausi S., Berruti G.L.F., Daffara S., Bertè D., Rubat Borel F., submitted paper, *Use of a GIS predictive model for the identification of high altitude prehistoric human frequentations. Results of the Sessera valley project (Piedmont, Italy)*. Quaternary International.
- Angelucci D., Zambaldi M., Tessari U., Vaccaro C., Arnaud J., Berruti G.L.F., Daffara S., Arzarello M., submitted paper, *New insights on the Monte Fenera Palaeolithic (Italy): Geoarchaeology of the Ciota Ciara cave*. Geoarchaeology.
- Chelli Cheheb R., Arzarello M., Arnaud J., Berto C., Cáceres I., Caracausi S., Colopi F., Daffara S., Montanari Canini G., Huguet R., Karambatsou T., Sala B., Zambaldi M., Berruti G.L.F., submitted paper, *Human behavior and Homo-mammals interaction at the first European peopling: new evidences from the Pirro Nord site (Apricena, southern Italy)*. PloS One.



New evidence of human frequentations in the western Alps: The project “Survey Alta Valsessera (Piedmont–Italy)”



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^f Quaternary and Prehistory Group – Geosciences Centre, University of Coimbra, Rua Silvio Lima, 3030-789 Coimbra, Portugal

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ABSTRACT

The Sessera valley is an under-populated Italian alpine valley located in the north-eastern Piedmont (northwest Italy) between the provinces of Biella and Vercelli. We discuss the data obtained during the first and the second year of the project “Survey Alta Val Sessera” held in 2013 and in 2014 under the scientific direction of Soprintendenza Archeologia del Piemonte in collaboration with Associazione Culturale 3P – Progetto Preistoria Piemonte and DocBi – Centro Studi Biellesi that had as its main purpose the identification of new prehistoric human frequentations in the valley. The theoretical scheme employed starts from the one developed for Trentino and the South Tyrolean region (north-eastern Italy) by Broglio and Imbrota. During the campaigns, surveys in the Sessera and in the neighbouring Dolca valley have been carried out using the patterns of settlement and mobility in the alpine environment developed by Kompatscher and Kompatscher, in order to identify the most interesting areas to investigate. The most important results obtained during the first two survey campaigns indicate that the Sessera valley was occupied by human groups using knapped lithic industries made of local vein quartz. Another important result is the identification of a Late Ancient site located at high altitude (1642 m a.s.l.) along one of the ridge paths investigated. Even if the lithic findings have no diagnostic elements for a precise chronological positioning, the importance of the data obtained consists mainly in having successfully tested a method of research aimed at identifying human frequentations at high altitude in this part of Piedmont, where no comparable research has been carried out until now.

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1. Introduction

Since the beginning of the 1960s, not considering the sporadic and unreliable nineteenth-century information, there was not any evidence supporting a human presence in Piedmont (north-

western Italy) during the Palaeolithic and the Mesolithic. At that time, this lack of evidence was attributed to the persistence of hostile environmental conditions during the whole Pleistocene (Fedele, 1985). As it would be unlikely that a region like Piedmont, habitable and rich in natural resources, was not occupied by Palaeolithic and Mesolithic hunter-gatherers (Guerreschi and Giacobini, 1998), nowadays it is possible to state that the scarcity of data is certainly due to the lack of systematic research concerning these periods. Particularly concerning the Mesolithic, the data available are scarce, with the exception of the Alpe Veglia site

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(north-eastern Piedmont), where the studies carried out by A. Guerreschi during the 1980s and the 1990s led to the discovery of a lithic industry dated to the ancient Mesolithic and mainly made of local hyaline quartz (Gambari et al., 1989). Some other sporadic findings are those from the Piedmontese localities of Pratomorone (Mottura, 1993), Agrate Conturbia (Biagi, 1988) and Boira Fusca (Fedele, 1990). In such an incomplete framework, it is clear how difficult is to understand the modalities and the peculiarities of the Mesolithic peopling of the Piedmont.

The project "Survey Alta Valsessera" was born in 2013 with the aim to partly fill the existing gap in the scientific research concerning the prehistoric peopling of Piedmont. The research is part of the multi-year "Project Alta Val Sessera" promoted by DocBi – Centro Studi Biellesi since 1992, concerning different issues about this territory such as geology, flora and fauna, archaeology, history, toponymy and transhumance, thus allowing the survey campaigns to start shortly and with a good knowledge of the area.

According to the methodology employed (Broglia and Impròta, 1995; Kompatscher and Kompatscher, 2007), the choice of the high Sessera valley as the starting point for this kind of research was based on an accurate analysis of the available regional cartography in order to identify all the areas that, from a geomorphological point of view, could have been interesting for the research. The first two campaigns were realized in 2013 and in 2014 under the scientific direction of *Soprintendenza Archeologia del Piemonte* in collaboration with *Associazione Culturale 3P- Progetto Preistoria Piemonte* and DocBi – Centro Studi Biellesi and led to the identification of twelve sites characterized by the presence of lithic industries made of local vein quartz and of a Late Ancient site with abundant pottery remains and two fragmented iron artefacts (Rubat Borel et al., 2014, 2015).

2. Geological background

The Sessera valley is located in the marginal land between the north-eastern part of Piedmont and the Aosta valley (Fig. 1) and it is characterized by the presence of the tectonic Canavese Line and two large lithological complexes: the Ivrea-Verbano Zone and the Sesia-Lanzo zone (Fig. 2).

The Canavese Line, oriented NE–SW, consists of a series of fractures stretching through the two main depressions that link the Sessera valley with the Biella territory and the Sesia valley, located near Bocchetto Sessera (1373 m a.s.l.) and Bocchetta della Boscarola (1423 m a.s.l.). This tectonic lineament represents a western portion of the wider tectonic system, the Insubric Line (Compagnoni et al., 1977; Dal Piaz, 2001; Zucali and Spalla, 2011; Roda et al., 2012). The Canavese Line connects two very different rocky complexes. The outcrops on the left of Bocchetto Sessera are the igneous rocks of

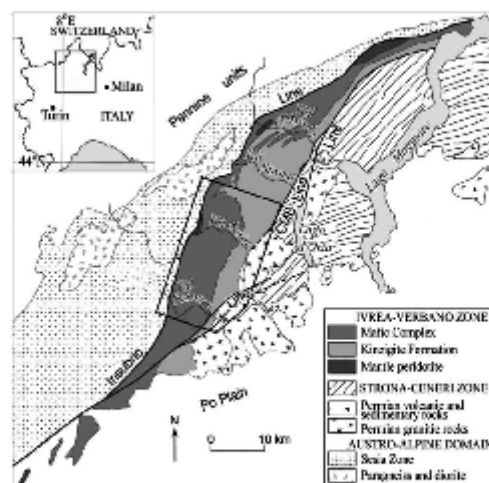


Fig. 2. Geological and structural map of the Alpine region. In the box, detail of the Sessera valley (modified from Peressini et al., 2007).

the Sesia-Lanzo series and represent the European continental margin known as Austroalpine nappes. Downstream, on the right of Bocchetto Sessera, there is the wide rocky series of the Ivrea-Verbano zone that represents the equivalent continental margin of the African lithospheric plate (Southalpine nappes). In the Sessera Valley, there are only rocks of the basic-ultrabasic complex (Sesia-Lanzo zone), and the prevailing lithotype is a gabbro-diorite medium-large grained, made up of basic plagioclases and pyroxenes that belong to the Penninic nappes and are present in the eastern part of the Sessera valley.

The Sesia-Lanzo Zone belongs to the Austroalpine nappes and it can be related to the Sesia-Lanzo series, made up of polymetamorphic rocks present in the north-eastern part of the Pennine Alps, including the heads of the main valleys and the highest peaks. It is divided in different lithological complexes (Dal Piaz et al., 1972; Compagnoni et al., 1977) and locally, in the neighbourhood of Alpe Isola (1560 m a.s.l.) and Alpe Piviale (1507 m a.s.l.) up to Cima del Bonòm (1877 m a.s.l.) (Fig. 4), there is a wide area with syenite outcrops. Eastwards, from Bocchetto Sessera along the Canavese Line (Fig. 4), there is a small belt of diabases, amphibolite porphyrites, calcareous outcrops. The Biella pluton, visible on the

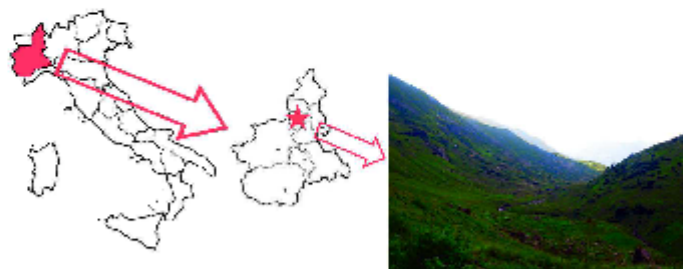


Fig. 1. Localization of the Sessera valley.

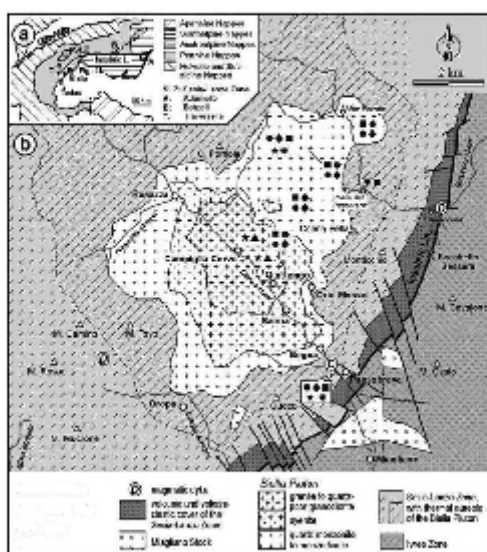


Fig. 3. Geological sketch map of the Grovo and Sessera valleys and lithological subdivisions of the Biella pluton (Rossetti et al., 2007).

right orographic side of the valley (Fig. 3) (Bigoggero et al., 1994; Romer et al., 1996; Rossetti et al., 2007), is a magmatic unit linked to the post-collisional formation of the western Alps.

Another geological process that contributed to the formation of the Sessera valley is represented by the glacial events occurred in the Pleistocene/Quaternary era (Fig. 4). The Last Glacial–Interglacial cycle ends with the beginning of the Holocene and inside the cycle are recorded three major glacial episodes: about 100 ka (MIS 5d), 75 to 60 ka (MIS 4) and 30 to 11.5 ka BP (MIS 2). The last episode, includes a step of acme called Last Glacial Maximum (LGM – 29–19 ka cal BP) and a subsequent reduction of the ice sheet called Late glacial and Late Würm (19–11.5 ka cal BP) (Oronelli et al., 2005). Many studies (Dansgaard et al., 1989; Johnsen et al., 1997; Friedrich et al., 1999; Merkt and Müller, 1999; Litt et al., 2003) show the correlation between palynological, isotopic and dendrochronological data for the upper limit of the Late glacial that is unambiguously placed in correspondence of an abrupt event, (Peyron et al., 1998) which coincides with the beginning of the Holocene at $11,550 \pm 50$ cal. BP (Gibbard, 2004).

Concerning the investigated area, studies about the variations in the upper limit of glacial erosion (trimline) recognize the Würm glaciation as the predominant glacial phase (Finsinger and Ribolini, 2001; Ivy-Ochs et al., 2008). The Würmian glacial maximum in the Alps occurred between 28,000 and $20,000 \pm 1800$ BP in the northern Alpine foreland (Florineth and Schlichter, 2000) while the beginning of the retreat of the Würmian glaciers can be dated $14,190 \pm 130$ BP (Ponel et al., 2001; Hughes et al., 2006). The reconstruction of the glacial margin fluctuations of the moraine amphitheatre of Ivrea (Pedmont) support the hypothesis that the Late Würm had phases of glacial recession (Gianotti et al., 2008). In the Alps, during the Late Würm, large valley glaciers formed as glaciers flowed out of the main accumulation areas and ice domes (Florineth and Schlichter, 2000, 1998). The glacial/inter-glacial cycle produces typical

landforms and morphologies such as U-shaped valleys, cirque glaciers and staircase cirques (Benn and Evans, 1998; Pidwiny, 2006). In the high Sessera valley, two accumulation zones of the Würmian glaciers are visible: the first one is located between the Cravile (2384 m asl) and the Del Mauro (2506 m asl) peaks, while the second one is located between the Cravile and the Guardia (2007 m asl) peaks (Fig. 4). In the first accumulation areas, looking at the trend of the contour lines, the presence of staircase cirques is clear, where two or more cirques occur one above the other (Gordon, 1977), thus corresponding to different phases of retreat of the glacier during the last inter-glacial period. Moreover, the presence of some small lakes in the highest cirque glacier (1900 m asl), in flat and slightly sunken areas, indicates the final stage of the glacier before its retreat in the northernmost areas during the Holocene (Hornes et al., 2001).

2.1. Geomorphological framework

The geomorphology of the high Sessera valley is closely related to the shaping action of the glaciers and particularly to the action of the glaciers during the Late glacial, when they covered some areas of the Sessera valley and the neighbouring Dolca valley (Fig. 4). During the following interglacial phase, the presence of several streams led to the erosion of the existing deposits, thus producing the present configuration of the valley. The rock-bed emerges diffusely over 1600 m a.s.l. and along the main streams, where the glacier action and the water erosion removed the moraines and the alluvial cover. The setting of the slopes through gravitational processes led to the generation of landslides with the subsequent formation of accumulation zones and of accumulations of slope mixed detritus. These deposits can be easily identified all along the valley's slopes, but the typical shapes are located within the plain of Tegge dell'Artignaga (1400 m a.s.l.) and around the three glacial lakes below Cima d'Ala (1900 m a.s.l.). In some areas, the lower steepness of the slopes allowed the formation of wide grazing areas, identifiable with the Balma zones (Fig. 4).

The investigated area is characterized by the presence of wide screes, fed by the mechanical break-up of the rocky slopes located in the cirque glacier area and at the feet of the highest peaks (Punta del Cravile, 2384 m a.s.l.; Punta del Mauro, 2506 m a.s.l.; Cima del Bonòm, 1877 m a.s.l.). The Sessera creek flows toward north-east within the diorites, crosswise to the lay of the lithological units and to the run of the main tectonic faults, setting itself within the beds of the Pleistocene glaciers. The Sessera valley is bordered, on one side, by the watershed with the Sesia valley and, on the other side, by the watershed represented by the Bo peak (2556 m), the Marca mount (1625 m) and the Rubello mount (1412 m), facing directly the Biella plain located more than 1000 m below. The observation of the Sessera valley from the homonymous Bocchetta highlights the presence of several and widespread gravitational phenomena all along the slopes, linked to the presence of the tectonic discontinuity. Looking south-east, the lengthened exposure at low altitude and the decay of the kinzigites and of the granites created a hill landscape with thick vegetation. The slopes' dynamics is mainly linked to the stream activity and to the mass gravitational phenomena. The slopes' high energy and the presence of several streams create the condition for intense erosion of the Quaternary deposits, represented by screes and ancient glacial deposits. At lower altitudes, wide gravitational accumulations are present, partly quiescent.

3. Materials and methods

The geological and geomorphological features of the high Sessera valley made necessary the employment of specific methods for

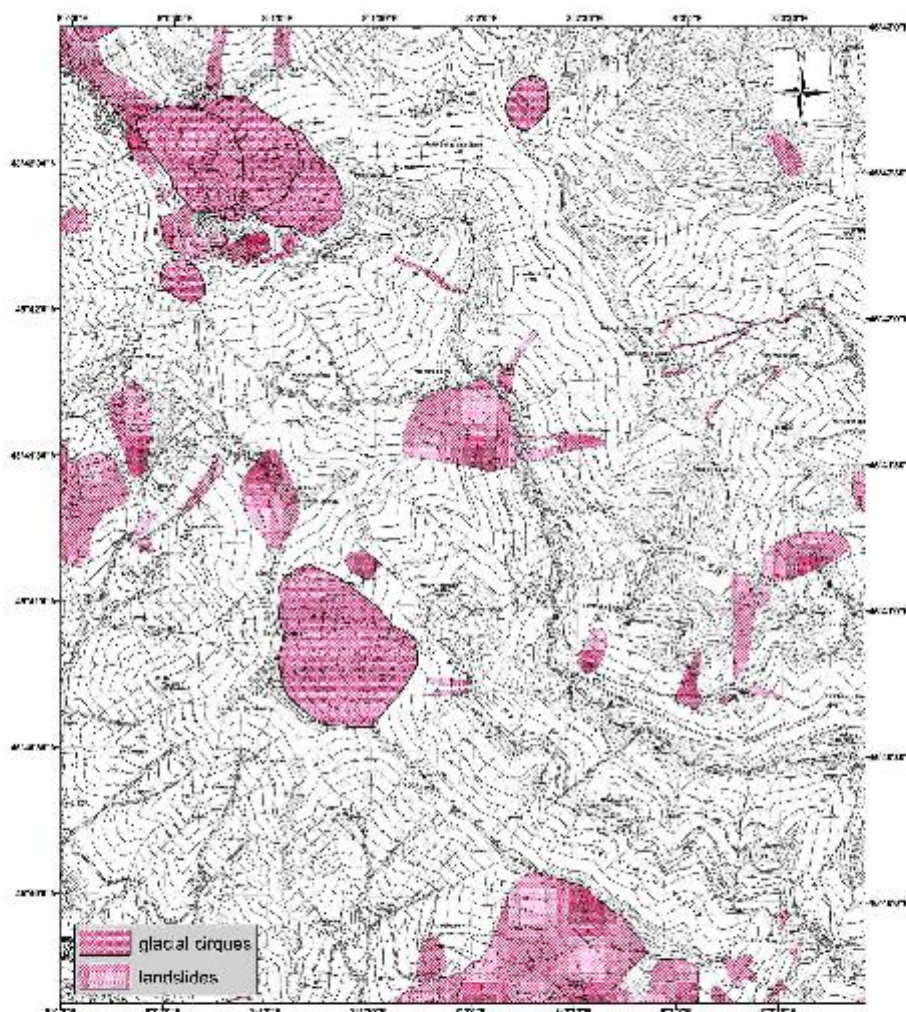


Fig. 4. Map of the high Sesera valley. In red are highlighted the glacial landforms and deposits visible in the area.

the development of the research project. The interpretative model used in this work is based on the one developed for the research of Mesolithic sites in the eastern Alpine region by Broglio and Imbrota (1995). In recent years, this model was successfully employed in the western Alps: i.e. the research carried out by Ufficio Beni Archeologici della Valle d'Aosta and the University of Ferrara at Monte Falère (Aosta valley) (Raiteri, 2009). It distinguishes between high altitude sites, located between 1900 and 2300 m a.s.l., and valley bottom sites, multi-stratified and usually located in small rock-shelters and at lower altitudes (210–250 m a.s.l.). The high altitude sites show recurring locations in the geographical context, thus allowing the identification of reference settlement models: rock-shelters, next to big erratic boulders; open air sites not far

from alpine lakes; along the ridge paths, in correspondence of mountain passes or in a dominant position over the surrounding territory (Broglio and Imbrota, 1995). Because of its orography, in the high Sesera valley the only identifiable sites are the high-altitude sites. The identification of the areas with a potential archaeological interest was based on the work of Kompatscher and Kompatscher (2007). Assuming that no great tectonic changes occurred in the alpine region from the last glaciation, and that the communication routes, like ridge paths and mountain passes, are basically the same used today (Mannoni, 1994a, 1994b), they identify some parameters useful for the identification of prehistoric human frequentations at high altitude: water supply, wide view of the surrounding territory, suitability of the area for the setting of a

camp, position of the area with regard to the main paths, availability of wide hunting and gathering areas, orientation of the slopes, and natural protection against the main wind direction (Kompatscher and Kompatscher, 2007).

The areas to investigate were chosen after the analysis of the available cartography and considering the geomorphological constraints. Afterwards, the suitability of each area was verified *in loco* and soundings were done in all the areas filling at least two of the criteria listed above.

Due to the aims of the research project and the geomorphological context, a non-systematic territorial sampling was chosen (Terranato, 1992; Cambi, 2000). Starting points for the identification of the most interesting areas to investigate have been the analysis of the available cartography and the geological study of the territory (Casoli and Bisetti, 1997; Bisetti, 2002, 2007). The availability of lithic raw materials, the presence of water sources and the orographic conditions were primarily considered. In this way, the following areas were investigated during the survey campaigns in 2013 and 2014 (Figs. 5–7): the valley going from Alpe Piviale (1507 m a.s.l.) to the Bo lakes (1900 m a.s.l.), the side valley going from Alpe Piviale to Alpe Isola (1560 m a.s.l.), the plateaus Tegge dell'Artignaga (1400 m a.s.l.) and Campo di Quara (1475 m a.s.l.) and the ridge path connecting Bocchetto Sessera (1373 m a.s.l.) to Colma Bella (1650 m a.s.l.). In these areas, the turf was lifted on a surface of 50 × 50 cm² with subsequent restoration of the previous conditions, while in the areas where the turf was already lifted by the passage of cattle an intense survey activity was carried out. For each sounding, the superficial turf was removed, while the subjacent ground was not excavated; in this way, each sampling is between fifteen and 30 cm deep. According to Terranato (1992), we use the term "site" to indicate every surveyed area where at least

one artefact was found. During the survey campaign, the waypoints were collected with a GPS in the UTM WGS84 coordinate system. The software QGIS was used for the spatial distributions of the evidence (i.e. the soundings, the surveyed areas and the raw material outcrops).

The techno-typological study of the lithic industries is based on the works of Inizan et al. (1995) and Pelegrin (2000) for the identification of the knapping techniques, on the works of Forestier (1993) and Tixier et al. (1984) for the identification of the knapping methods and on the works of Laplace (1968) and Broglio and Kozłowski (1984). As the lithic industries found are made of vein quartz, it was necessary to refer specific works (Mourre, 1996; De Lombera-Hernida, 2009). As the investigated area is rich in vein quartz outcrops and therefore in vein quartz ecofacts, only the lithic artefact showing clear knapping scars (presence of butt and bulb and/or visible negatives on the upper face of the flakes) have been collected during the survey activities.

The charcoal fragments found in some of the samplings were analysed with a stereomicroscope Optika Bmet 500, using different magnifications (×50, ×100, ×200, ×500), through the observation of the three main sections of wood: transversal section, longitudinal tangential section and longitudinal radial section. The identification of the species was made using the Wood Anatomy Atlas (Jacquot et al., 1973; Schweingruber, 1990).

4. Results

4.1. Survey 2013

The preliminary survey campaign carried out in 2013 and lasting four days, led the identification of nine sites characterized by the

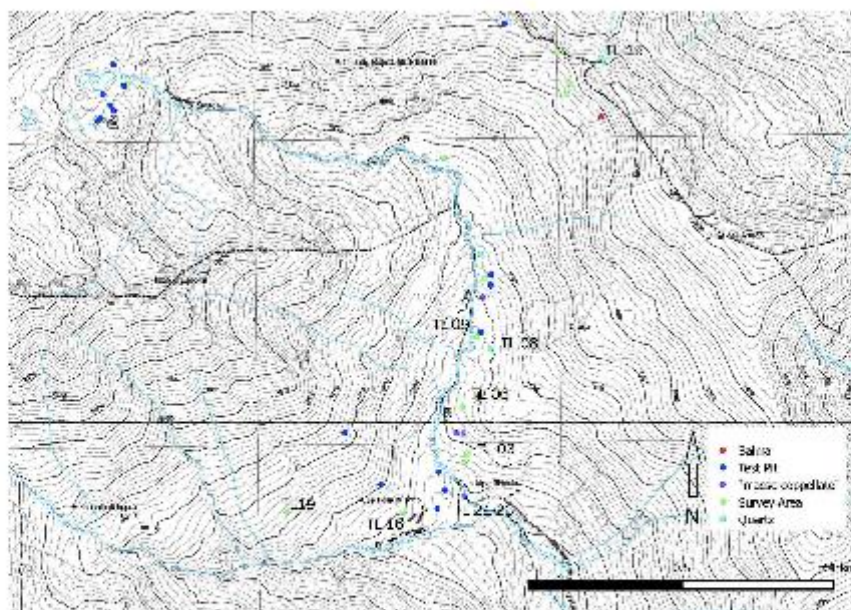


Fig. 5. Map showing all the waypoints collected during the 2013 survey campaigns in the high Sessera valley with indication of all the samplings and the survey areas. The abbreviation TL indicates the samplings or the survey areas located in the valley from Alpe Piviale (1507 m a.s.l.) to the Bo lakes (1900 m a.s.l.) where lithic industries were found.

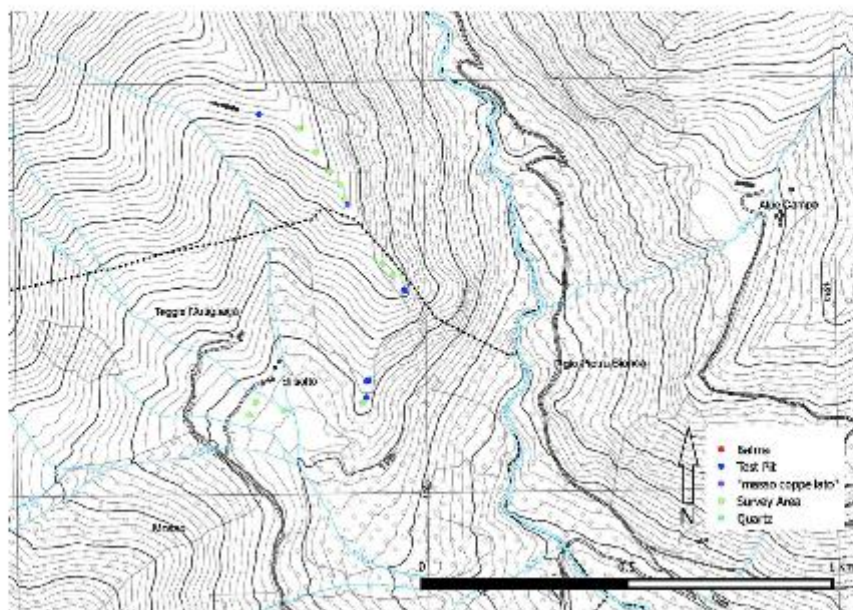


Fig. 6. Map showing the waypoints collected during the 2014 survey campaigns at Tegge dell'Artiguglia. In this area no archaeological evidences were found.

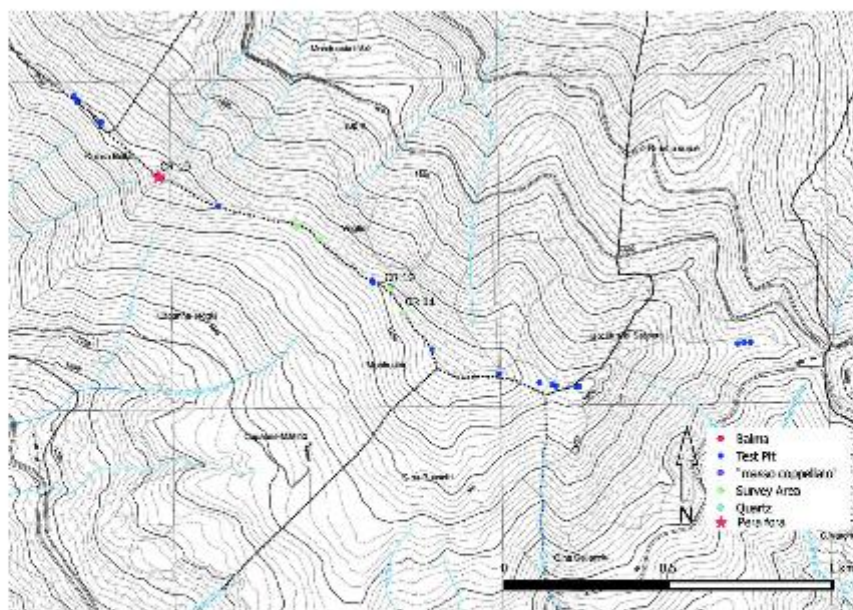


Fig. 7. Map showing all the waypoints collected during the 2014 survey campaign along the ridge path connecting Roccheto Sessano (1373 m a.s.l.) to Colma Bella (1650 m a.s.l.). The abbreviation CR indicates the survey areas where 3Hh1 Industries were found. CR 19 is the Late Ancient site of Piro Piro.

presence of lithic industries made of local vein quartz (Rubat Borel et al., 2014). The cartographic study identified three areas potentially interesting for the research, but just two of them showed signs of prehistoric human frequentations.

All the sites are located in the deep valley from Alpe Piovale (1507 m a.s.l.) to the Bo lakes (1900 m a.s.l.) and in the side valley from Alpe Piovale to Alpe Isola di sopra (1670 m a.s.l.), not far from the head of the Sessera valley (Fig. 5). Nine samplings have been done during the research in these valleys: three of them gave lithic industries made of local vein quartz, while six lithic artefacts come from the survey activities carried out all along the paths and where the turf was lifted by the passage of cattle (Fig. 8). This preliminary research concerned the orographic left side of this two valleys, while it was not possible to reach the area of the Bo lakes due to bad weather conditions. The lithic industries do not present any diagnostic element for a precise chronological collocation of this human frequentation of the Sessera valley, but a hypothesis concerning the *chaine operatoires* carried out can be formulated. The presence of not-prepared butts and the low number of negatives visible on the upper face of the flakes suggests short *chaine operatoires* with a mainly opportunistic exploitation of the cores for the production of

small flakes with at least one cutting edge. The core found in the sounding TL 19 and the dimension of the product, show that a choice was made for decimetric pebbles collected in secondary positions in the riverbeds of the streams crossing the valley. The exploitation started from the flat surface of a natural breakage without any phase of shaping of the core (Fig. 8). Only the improvement and the prosecution of systematic researches in this area will enable understanding of the chronology and the importance of this prehistoric frequentation of the Sessera valley.

The research conducted in the Alpe Carnera area (1625 m a.s.l.) did not produce any archaeological evidence. Two samplings have been done in this area, close to two small rock-shelters, while survey activities were carried out in the areas where the turf was lifted by the passage of cattle. Even if the area is rich in primary outcrops and in secondary deposition vein quartz, no lithic artefacts have been found.

This preliminary campaign also allowed the identification and the GPS positioning of three primary outcrops of vein quartz (Fig. 9) located in the investigated areas. Vein quartz is also present as prismatic decimetric and centimetric blocks in the riverbeds of the Sessera stream and of all the other creeks crossing the valley.

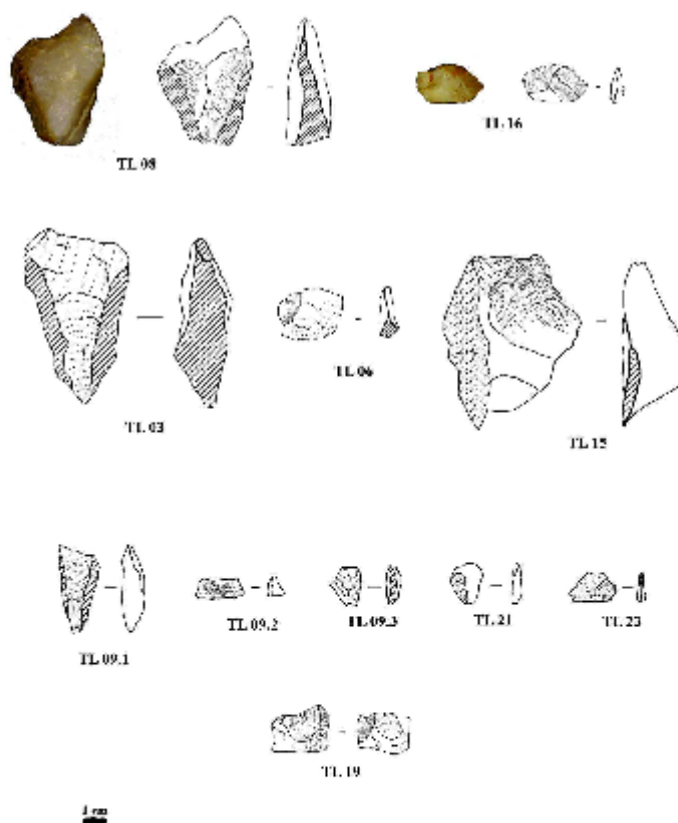


Fig. 8. Vein quartz lithic industries found during the 2013 survey in the high Sessera valley. TL 08, TL 16 and TL 21: complete flakes; TL 03, TL 09.1, TL 23: distal fragments; TL 06, TL 09.2, TL 09.3, TL 15: incomplete flakes; TL 19: core.

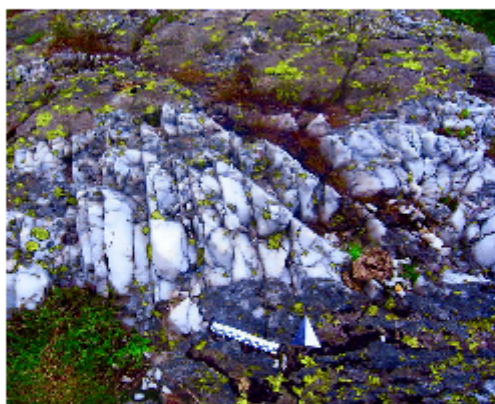


Fig. 9. Primary outcrop of vein quartz identified during the survey in the high Sessera valley, between Alpe Piovale (1507 m a.s.l.) and the Bo lakes (1900 m a.s.l.).

4.2. Survey 2014

The good results obtained during the preliminary campaign were the starting point for a further investigation in the high Sessera valley. The aims of this campaign, lasting one week, were the extension of the surveyed territory and a more intensive investigation of the areas where, during the preliminary campaign, lithic artefacts have been found, i.e. the valley from Alpe Piovale (1507 a.s.l.) to the Bo lakes (1900 m a.s.l.) and the side valley from Alpe Piovale to Alpe Isola di sopra (1670 m a.s.l.) (Fig. 5), involving both the sides of the valleys (Rübat Borel et al., 2015).

The orographic left side of the first valley, with most of the lithic artefacts found during the preliminary campaign, has been subjected to intense survey activities. Samplings have been carried out in correspondence to erratic boulders, on the top of hills with a wide view over the surrounding territory, next to the main paths with boulders giving a natural protection against the main wind direction. Fourteen samplings have been done, among which, one (TL 134), produced a quartz flake. TL 134 is located a few meters from TL09 where three quartz flakes were found in 2013.

The right orographic side of the valley going from Alpe Piovale to the Bo lakes is characterized by steep slopes, landslides and wide wet areas, thus appearing as an unsuitable area for research. For this reason, in this area just eleven samplings were carried out, in correspondence to hillocks and rock-shelters, but, as expected, no evidence of prehistoric human frequentations was identified.

Even the area of the Bo lakes was investigated during this campaign. Samplings involved the area close to the lakes, a small rock-shelter and the surrounding hillocks. The survey activity identified a large primary quartz outcrop (TL 207), but no evidence of prehistoric frequentation was found.

Starting from the study of the geological cartography available, two new areas have been identified as potentially interesting for research: Tegge dell'Artignaga (1406 m a.s.l.) (Fig. 6), and Campo di Quara (1476 m a.s.l.). These two plateaus are wide flat grasslands, characterized by a good view of the surrounding territory and by the presence of water sources. Samplings have been carried out at Tegge dell'Artignaga next to erratic boulders and all along the ridge path from Tegge dell'Artignaga di sotto (1374 m a.s.l.) to Tegge dell'Artignaga di sopra (1614 m a.s.l.), but no lithic industries have been found. Campo di Quara gave no sign of prehistoric human

frequentation, as the locality is characterized by the presence of a wide wet area. For this reason, only four samplings were done in this place, three in raised areas and one next to an erratic boulder.

The best results of this second survey campaign come from the exploration and the sampling of the ridge path from Bocchetto Sessera (1373 m a.s.l.) to Colma Bella (1678 m a.s.l.) (Fig. 7). Two quartz flakes were found during the survey activities where the turf was lifted by the passage of wild boars. The flakes are complete and one showed two negatives of previous removals on the upper face (Fig. 10) but there are no diagnostic elements allowing a precise chronological attribution of these artefacts. As for the lithic industries found during the previous campaign, the technological analysis suggest short *chaîne opératoires* with a mainly opportunistic exploitation of the cores for the production of small flakes with at least one cutting edge.

Sampling CR 19 was carried out along the ridge path, near the so called "Pera Forò" (1642 m a.s.l.), a rocky ridge composed by blocks of syenite that through erosive action developed its characteristic arch shape (Fig. 11). In the 50 × 50 cm² sample were found three fragments of Late Ancient pottery. The sample was then extended to 150 × 50 cm² for a depth of 20 cm, leading to the discovery of several other fragmented potteries and of two incomplete iron artefacts (a nail and a barb), thus allowing to identify a historical human frequentation. The sixty potsherds found, some of tiny size, are attributable to the production of common pottery, raw and uncoated, baked in a mainly reducing, or not uniform, atmosphere. Three fragmented rims are the only diagnostic elements. The first one, not graphically reconstructable, is a fragment of a triangular-section rim with a pronounced groove for the housing of a top. The second one is attributable to an olla with a sub-triangular-section banded rim, the beige ceramic body is porous and rich in impurities (mainly quartz and golden mica) and *chamotte*. The third diagnostic fragment is attributable to an olla characterized by a triangular-section rim, long neck and shoulder marked by a soft groove (Fig. 12). In spite of the limited data available, it is possible to confirm a Late Ancient (IV – VI century A.D.) human frequentation of the site, even if the modalities of this frequentation are still unknown. The analysis of the four charcoals found in CR 19 led to the identification of the two taxa *Acer* and *Ulmus*.

5. Discussion

The Piedmontese region and, in wider terms, the area of the western Alps, have always been poorly investigated concerning their prehistoric, and especially Palaeolithic and Mesolithic, peopling. Particularly concerning the frequentation of high and medium altitude territories, the only data available for a careful consideration of the data collected come from a very few sites (Gambari et al., 1989; Forno et al., 2013). Another peculiarity of this area is the widespread and intense use, from the Middle Palaeolithic (Arzarello et al., 2012; Daffara et al., 2014), of local raw materials like vein or hyaline quartz as the main raw materials for the production of lithic tools. Concerning the high-altitude human frequentation, the best examples are the Mesolithic sites of Alpe Veglia (northern Piedmont – 1750 m a.s.l.) (Gambari et al., 1989) and Monte Fallère (Aosta valley – 2300 m a.s.l.) (Forno et al., 2013) which are the only high-altitude sites systematically investigated in recent years. In the Alpe Veglia site, the archaeological excavation carried out in 1988 led to the recovery of an ancient Mesolithic lithic industry mainly made of local hyaline quartz. Similarly, the systematic excavations recently carried out at Monte Fallère led to the identification of a Mesolithic site characterized by the presence of a lithic industry made of local hyaline quartz. Also, some chance discoveries in the Piedmontese territory confirm the large employment of local vein quartz for the production of lithic tools

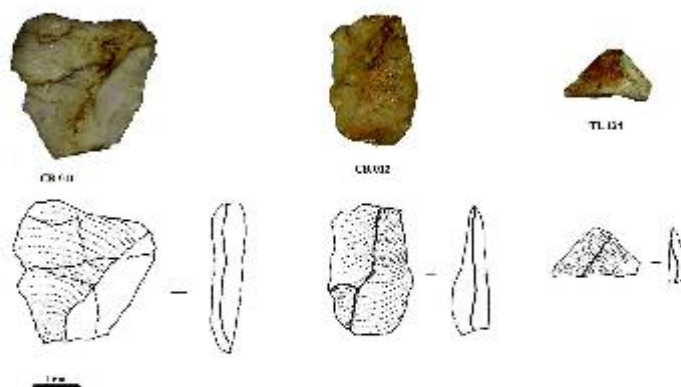


Fig. 10. Vein quartz lithic industries found during the 2014 survey in the high Sessera valley. CR 011 and CR 012: complete flakes from the ridge path connecting Bochetto Sessera (1373 m a.s.l.) to Colna Brilla (1678 m a.s.l.); TL 134: distal fragment found in the valley going from Alpe Isola to the Is lakes.



Fig. 11. Rocky ridge composed by blocks of syenite and known as Pera Forà (1642 m a.s.l.). From the sampling CR 019, located nearby the rock ridge, come sixty possible and two flint-gneissed iron artefacts attesting a Late Ancient human frequentation of the site (IV – VI century A.D.).

(Bernuti and Daffara, in press). Unlike other Italian regions, vein quartz is the most employed raw material during the whole prehistory of Piedmont despite its limited aptitude for knapping, as it tends to fracture following the surfaces of the macro or micro-crystals that form its inner structure (Moure, 1996; De Lombera-Hermida, 2009; De Lombera-Hermida et al., 2011) thus leading to lithic tools characterized by rough surfaces and by the rapid loss of their technological characteristics (Arzarello et al., 2011). The large use of such mediocre raw material can be easily explained with the almost complete absence of good quality raw materials outcrops in all the Piedmontese territory. Vein quartz, in contrast, is widespread and easily accessible at high-altitude. The lack of systematic research on the territory together with the not easy recognition of the vein quartz lithic industries due to the inner structure and to the mechanical characteristics of vein quartz (De Lombera-Hermida, 2009; De Lombera-Hermida et al., 2011), are, in our opinion, the main causes for the poor knowledge of the Prehistoric human peopling of the region.

In such a patchy framework, it is easy to understand the importance of the results obtained during the two survey campaigns in the high Sessera valley. The identification of knapped lithic industries made of local vein quartz represents a further step in the reconstruction of the high-altitude prehistoric human frequentation in Piedmont and, nowadays, they are the only evidence of a high-altitude prehistoric human presence in north-eastern Piedmont.

Concerning the Late Ancient site of Pera Forà, the typological analysis of the potsherds place them within the local productions typical of the period. The triangular-section rim is attributable to ollas, very common in the neighbouring area of Vercelli during the V–VI century A.D. (Botalla, 2013). The second rim is referable to potteries well attested in north-eastern Piedmont and in western Lombardy, produced from the IV century A.D., but their greater diffusion is dated between the V and VI century A.D. both in urban and in rural contexts (Parità, 2002). Similar potteries come from the VI century A.D. frequentation of the Ciota Ciara cave, located on the west side of Fenera mount, in correspondence to the junction between the Sessera and the Sesia valley (Brecciaroli Taborelli, 1995). The third rim belongs to a kind of pottery whose production started in the late III century A.D., as attested by the ones found in some necropolis of the region, such as Biella (Preacco Ancona, 2000) and Borgosesia (Brecciaroli Taborelli, 1995). Comparable potteries come

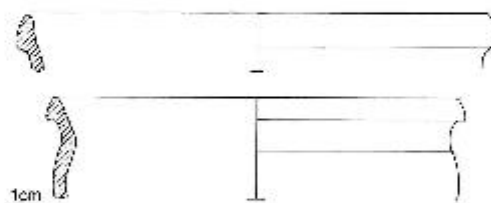


Fig. 12. Drawings of the two diagnostic rims found in the sampling CR 019. On the top: olla with a sub-triangular-section band rim referable to potteries well attested in north-eastern Piedmont and in western Lombardy from the IV century A.D. and with a greater diffusion between V and VI century A.D. both in urban and in rural contexts. On the bottom: olla characterized by a triangular-section rim, long neck and shoulder marked by a soft groove belonging to a kind of pottery whose production started in Piedmont in the late III century A.D.

also from several Piedmontese urban contexts dated between III and VI century A.D., e.g. Alba (Quercia, 1997), Vercelli (Vaschetti, 1996), Lu Monferrato (Martignetti and Vaschetti, 2004), Trino Vercellese (Pistan, 1999) and Lenta (Pantò, 2002). As this typology is widely attested in the area from the late III to the VII century A.D. (Vaschetti, 1996), without a stratigraphic context it is very difficult to propose a more precise chronological position for the potteries found during the survey.

6. Conclusions and research perspectives

The results obtained during the first two survey campaigns in the high Sessera valley show that the area was occupied by human groups, linked to the exploitation of lithic raw materials for the production of tools. Chronologically, these frequentations should be placed after the retreat of the glacier, which occurred in this area about 11000 BP (Biasetti, 2007). Unfortunately, the lithic industries found have no diagnostic elements useful to propose a more precise chronological assessment. Besides the small number of lithic artefacts found, the problem of the chronology of these human frequentations is also due to the scarce data available about the prehistoric human presence at high altitude in the Piedmont. On one side, this is due to the lack of systematic research, and, on the other side, to the actual complexity in recognizing vein quartz lithic industries. Especially in territories like the high Sessera valley where vein quartz is abundantly present in primary and secondary outcrops, the identification of the lithic industries among the great number of geofacts is very hard. As already highlighted by Broglio and Lunz (1984), another problem is that the raw material employed strongly affects the characteristics of a lithic industry: quartz lithic industries show great differences compared to flint lithic industries concerning shape, dimensions and frequency of retouched tools within the lithic assemblage. As the lithic industry found in the high Sessera valley is the first high-altitude vein quartz lithic assemblage found in Piedmont, only the progression of the research could give an answer to the problem of the chronological collocation of the prehistoric human presence in this territory. At the moment, the techno-typological study of the lithic industries does not allow to confirm or to exclude their Mesolithic attribution. New campaigns will complete the survey of the valley, paying particular attention to the ridge paths, still poorly investigated but showing great potential for the aims of the research.

Concerning the Late Ancient site of Pera Forù, the altitude (1642 m a.s.l.) probably indicates a seasonal frequentation of the site, maybe during transhumance, while the presence of a rock shelter and charcoals of *Acer* and *Ulmus* support the hypothesis of a temporary camp with storage of foodstuffs. The high number of potsherds found in the limited area of the sampling is evidence of a repeated human frequentation in the area of the Pera Forù. A systematic excavation of the area will be carried out in the next years, thus better defining modalities and characteristics of this frequentation.

In conclusion, it is possible to state that the high Sessera valley shows a great potentiality for the research of prehistoric human frequentation at high altitude. The method employed during the survey campaigns (Broglio and Improta, 1995; Kompatscher and Kompatscher, 2007), developed and extensively employed in the eastern Alps with excellent results, can be profitably employed in other geographical contexts. The last interesting consideration that can be done looking at the results obtained, is that this method is useful for the research of any kind of human frequentation at high altitude, since in these areas the ridge paths and, generically, the communication routes did not undergo substantial changes during the last thousands of years.

The final aim of the project, to be pursued through further and wider research, is to define the modalities and the dynamics of the prehistoric human presence in the Sessera valley, similarly to what has been done in the eastern Alps during the last thirty years (Broglio, 1994; Broglio and Lanzinger, 1996; Dalmeri and Lanzinger, 1998; Dalmeri et al., 2004; Angelucci and Bassetti, 2009). Concerning the historic frequentation, the data obtained will complete the work done by DocBi (VV.AA., 1997, 2002), thus coming to the reconstruction of the whole history of the human presence in the high Sessera valley.

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Geo-archaeological survey in the Baragge Biellesi area. New data on the Middle Palaeolithic in Piedmont

The "Baragge biellesi" project started in 2015 in order to develop a multidisciplinary research method, aimed at the identification of areas of interest for the prehistoric research in the Baragge territory, Piedmont, Biella district, between La Serra moraine wall and the Sesia river. The collaboration among the involved bodies, Soprintendenza Archeologia del Piemonte, Associazione culturale 3P - Progetto Preistoria Piemonte, Università degli Studi di Ferrara, Instituto Politécnico de Tomar (Portugal) and Universidade Federal Fluminense (Brazil), allowed to employ in a profitable way the most up-to-date technologies for the archaeological research, i.e. processing of satellite pictures and land survey with drones. The surveyed area corresponds to the plateaus known as Baragge, located between 40 and 80 m over the Cervo stream. They are relicts of the wide plains formed by fluvio-glacial and fluvial deposits during the Quaternary period and represent a unique record for the investigation of the Palaeolithic human frequentation at low altitude. In this territory, the most interesting areas to investigate for the present research are Baraggione di Candelo e Cossato and Baraggia del Piano Rosa, since they are the most ancient parts of the formation. During the five days of the survey, several stratigraphic verifications were carried out and two sites with evidence of a Middle Palaeolithic frequentation were identified within the military firing ground in Massazza municipality (BI).

Despite the low number of artefacts (12), the technological features of the lithic industry, suggest its attribution to the Middle Palaeolithic (fig. 1): a recurrent centripetal Levallois core, two discoid cores and a discoid flake have been found (Boëda 1993), together with cores and products resulting from an opportunistic/S.S.D.A. exploitation of the raw material (Forestier 1993). After a preliminary examination, the raw materials employed seem to be local, with a large use of vein quartz and a marginal, but interesting, use of igneous rocks or "greenstones". Concerning both raw materials and technological features of the lithic industries found in the Baragge territory, they fit well into the

regional context: direct comparisons are the Mousterian lithic industries of the Ciota Ciara cave (Arzarello *et alii* 2012; Daffara *et alii* 2014) and of the Vaude (TO) area (Rubat Borel *et alii* 2013). The analysis of the stratigraphic sequences exposed allow locating the lithic industry within a layer formed by cold-climate aeolian deposits that may be dated between 200.000 and 75.000 B.P.. The finding of lithic industries in the Baragge territory is an important contribution for the understanding and reconstruction of the Palaeolithic peopling of north-western Italy: together with the Ciota Ciara cave and the Vaude area, they highlight that the Palaeolithic frequentation of Piedmont has been more intense than it was thought and characterized by a certain technological variability. Further research will be aimed to the clarification of the intensity of the Palaeolithic frequentation of the area and to a better definition of its chronology.

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Fig. 1 - Baragge biellesi. Lithic industry: recurrent centripetal Levallois core (1), discoid cores (2, 3), discoid flake (4), S.S.D.A core and flakes (5-9).

Bollettino della Società Paleontologica Italiana (submitted paper)

**First report on the Upper Pleistocene paleontological deposits from
the Morgana Cave (Mt. Fenera, Borgosesia, Piedmont, Italy).**

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Abstract

The cultural association 3P-Progetto Preistoria Piemonte in collaboration with the University of Ferrara and the Valsesian Speleological and Mineralogical group, in agreement with the “Ente di gestione delle aree protette della Valle Sesia” and “Soprintendenza Archeologia del Piemonte”, arranged in 2016 a campaign of documentation and recovery of the paleontological remains from the Morgana Cave (Fenera Mount, Piedmont, Italy). The Fenera Mount is affected by a well-developed karst system; the Morgana Cave is located near the Ciota Ciara and the Ciotarun caves that have already documented *Homo neanderthalensis* in Piedmont.

*Quaternary International (submitted paper - Manuscript number
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**Use of a GIS predictive model for the identification of high altitude
prehistoric human frequentations. Results of the Sessera valley
project (Piedmont, Italy).**

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Abstract

Starting from statistical samplings or anthropological dynamics hypothesis, GIS predictive models are particularly helpful in archeological site detection. About 11,000 B.P., during the transition from the last glacial period and Holocene, there was a gradual decrease of glacier in Europe and groups of hunter-gatherers began to populate lot of lands in central-northern Europe and in the Alpine region. Currently, the better documented and known prehistoric human frequentations are in the eastern Italian Alps, where data collected during more than thirty years allowed to formulate realistic hypothesis concerning the human population dynamics of the region. In the western Alps, data about this issue are scarce: the “Survey *Alta Valsessera* (Piedmont, Italy)” project started in 2013 to fill this gap and combining field research, methodologies elaborated in the eastern Alps and GIS predictive modeling, traces of prehistoric and late roman human frequentations have been found for the first time in the region.

Geoarchaeology (submitted paper)

**New insights on the Monte Fenera Palaeolithic (Italy):
Geoarchaeology of the Ciota Ciara cave.**

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Abstract

Monte Fenera is a mostly carbonate-built hill at the southern border of Western Alps. It hosts several archaeological sites, among them karstic caves bearing evidence of Palaeolithic occupations. These sites have a long history within Alpine archaeology – having been explored since the 19th century – but information on their stratigraphy, chronology and formation remains incomplete. They are among the few cave-sites prior to the ALGM in the area, and their study is crucial for understanding human occupation and regional environmental evolution during the Pleistocene. Here we focus on Ciota Ciara, a cave formed in Triassic dolostone, and in particular on the geoarchaeological study of the succession unearthed at the cave entrances since 2009. The deposit dates from the Middle-Upper Pleistocene transition. Sediment accumulation was due to consecutive events of concentrated flow and runoff from the karstic system, alternating with episodes of wall disintegration and short phases of surface stabilization. Post-depositional processes include frost action, hydromorphism, and diagenesis that

Plos One (submitted paper)

**Human behavior and Homo-mammals interaction at the first
European peopling: new evidences from the Pirro Nord site
(Apricena, southern italy)**

Razika Chelli Cheheb, Marta Arzarello, Julie Arnaud, Claudio Berto, Isabel Cáceres, Sandro Caracausi, Francesco Colopi, Sara Daffara, Guido Montanari Canini, Rosa Huguet, Theodora Karambatsou, Benedetto Sala, Maurizio Zambaldi, Gabriele L.F. Berruti.

Abstract:

The recent functional and zooarchaeological studies conducted on the archaeological finds of Pirro Nord (PN13) produced new reliable data on early European hominid subsistence activities. The age of the site is estimated ~ 1.3 – 1.6 Ma, based on biochronological data and the archaeological excavation of the Pirro Nord 13 fissure led to the discovery of more than 300 lithic artefacts associated with thousands of vertebrate fossils remains of the final Villafranchian (Pirro Nord Faunal Unit). The analysis of the fossil faunal remains allowed to identify anthropogenic traces linked to the exploitation of different animal carcass (cut marks and intentional bone breakages). Use-wear traces were also observed on a few of the flint artefacts and have been interpreted as the result of the exploitation of animal resources by the early hominids and carnivores. It has not been possible to identify the type of access that hominins developed on the carcasses, although it has been established that the hominins competed with the carnivores for animal resources. The stone tools and the faunal remains with anthropogenic traces recovered in the PN13 fissure represent one of the first evidence of hominin faunal exploitation in Europe.



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