Universidade de Trás-os-Montes e Alto Douro

Use-wear analysis of discoid-conception lithic industries.

- Versão Provisória –

International Doctorate in

Quaternary and Prehistory

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Declaração de autoria do texto

Declaro ser o autor deste trabalho, que é original e inédito.

Os autores e trabalhos consultados encontram-se devidamente referenciados no texto e constam da lista de referências bibliográficas incluída.

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ABSTRACT

The thesis presents data and interpretations relevant to the Lower and Middle Paleolithic with the aim to define if there were functional differences between the discoid and the Levallois products and, furthermore, to define the possible reasons that led prehistoric people to the employment of the discoid or of the Levallois knapping method. This work consists in the use-wear analysis of the lithic industries from eight sites located in Portugal, Italy and Spain: Pirro Nord (FG, Italy), Guado san Nicola (IS, Italy), Ciota Ciara (VC, Italy), Can Garriga (Gerona, Spain), Pedra Dreta (Gerona, Spain), Riparo Tagliente (VR, Italy), Lagoa du Bando (Maçao, Portugal), Fenx (Rodao, Portugal). The results of these work permit to obtain new data about the type of human occupation of the sites and highlight that, in general, there were not clear differences in the use or production of the blanks made through the two methods. We also come to the definition of the prehistoric sites as chaotic systems. Which means that we are facing a dynamic system highly dependent on the initial conditions and with a non-linear evolution where a little change in the initial conditions determines finite and important changes both in the final results and in the evolution of the system over time. Then, the only way to try to understand the technological choices that determined the choice of a particular knapping method rather than another is to reduce the influence of all the non-cultural variables.

Key words: Lower Paleolithic, Middle Paleolithic, use-wear analysis, Discoid, Levallois.

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Table 1.11: P.N.= Pirro Nord; G.S.N.= Guado San Nicola; C.C.= Ciota Ciara; C.G.= Can Garriga; P.D.= Petra Dreta; R.T.= Riparo Tagliente; L.B.= Lagoa du Bando; FENX = Foz do Enxarrique; W.T.= wear traces.
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INTRODUCTION

The present work represents the result of three years of Ph.D research held in three different university: University of Trás-os-Montes and Alto Douro (UTAD), Rovira i Virgili University and University of Ferrara. The main objective of all the researches carried out can be resumed in a single question: **is there a functional difference between the products obtained by discoid and those obtained by Levallois débitage?**

In order to give an answer to this question eight different sites, placed in three different countries, have been studied. These sites are characterized by different problems and for their study it was necessary to adopt different analytical techniques. For this reason, the present work is structured like a collection of different published or submitted articles (one for each site), to emphasize the peculiarity of each site and to better explain the different techniques used to conduct each analysis. The chapters dedicated to each considered site are preceded by two introductive chapters and the work ends with two chapters concerning the discussion of the results achieved and the conclusions where the answer to the main question of this work will be exposed. The last part of this work consists in two appendixes: one with the papers published during these three years and concerning other researches carried out and the other one where are described in detail all the different traces identifiable through the use-wear analysis methodology.

CHAPTER I

OBJECTIVES AND STATE OF THE ART

1. introduction:

The employ of objects in order to extract resources, to create a shelter or to in not only a human trait. A bird can use different materials to build a nest (Campbell and Lack 1985), the chimpanzees can use a twig to capture termites , the Sea otter can use stones as anvils to break the shell of the mollusks (Hall and Schalle 1964). Nonetheless, human beings are unique among living species for the extent they rely on technology: *Homo* is characterized as a *genus* of obligated tool users (Kuhn 1992) since tools are crucial for a wide array of pursuits and to fulfill its vast and changing array of technological requirements. The surviving evidences of Middle Paleolithic and earlier technologies refer almost exclusively to knapped stone artifacts. Flaked stone technology requires relatively little time and energy to produce tools, compared to that of bone, wood or ground stone (Kuhn 1994). Although flaked stone artifacts are rather easy to make, their production was fruit of deliberate and planned choices. The ancients knappers had to choose very carefully the *débitage* methods to be adopted for the production of the lithic instruments, since they were obligate tool users and their chance of survival depended on tools (Kuhn 1994).

These choices were the results of the combination of the skills of each single knapper, of his culture and of all the other environmental conditions (e.g. presence or absence of raw materials in the area, type of raw material used, type of work to do, etc..) (Bar-Yosef and Van Peer 2009). Wrong choices or sub-optimal choices due to the cultural component could have had an impact on the adaptive capacity (fitness) of the knapper’s culture. The study of the reasons of these choices is one of the aims of prehistoric archaeology. The main aim of this study is to clarify the reason of one of these choices and in particular it focuses on the choices that caused the adoption of two different *débitage* methods, *Levallois* (Boëda 1994) and discoid (Böeda 1993; Peresani 2003) in different European Middle Paleolithic sites. Frequently the discoid method is found within the same levels as all the typologies of the *Levallois*, for example in the middle Paleolithic deposits of Ciota Ciara cave (Arzarello et al. 2012; Daffara et al. 2014), Guado San Nicola (Peretto et al. 2015; Pereira et al. 2016) and Abric Romaní (Chacón et al. 2012; Vaquero et al. 2012) . Sometimes, as at Fumane cave, the discoid method is prevailing in some levels: along the stratigraphic sequence there are levels within which the discoid method prevails (A8 e A9) and levels characterized by a *Levallois* technology (Peresani 1998; Peresani, Cristiani, and Romandini 2016; Lemorini et al. 2003). In particular, we intend to verify if the use of such *débitage* methods, which allow a standardized production of flakes, is linked or not to precise functional purposes. That being stated, it will be interesting, concerning Middle Paleolithic, to wonder if the employment of the discoid flaking method rather than of the *Levallois* is due to **cultural** reasons: is that of different “cultures” which answer the same needs applying different technologies, or is that of the same “culture” which applies different technologies to answer different needs? In particular, in the archaeological contexts where both are present, is there a **functional** difference between the products obtained by discoid *débitage* and those obtained by *Levallois débitage*?

2. Descriptions and definitions:

2.1 *Levallois* methods:

The first description of artefacts realized through the *Levallois* method date at the end of the XIXth century (De Mortillet 1983). But it is only with the works of E. Boëda (Boëda 1994; Böeda 1993) that the definition of this method can be considered as complete. Boëda (Boëda 1994) identifies and describes six discriminating criteria to distinguish the *Levallois* method:

- The volume of the core is divided in two surfaces that meet at a plane of intersection.
- The two surfaces are hierarchically related, one being the striking platform and the other being the flaking surface.
- The flaking surface is organized so that the morphology of the products is predetermined. This predetermination is based on the management of lateral and distal convexities.
- The fracture plane of the predetermined flakes is subparallel to the plane of intersection between the two surfaces.
- The striking platform is organized to allow the removal of the predetermined flakes from the flaking surface. This requires that the intersection of the striking platform and the flaking surface must be parallel to the flaking axis of the predetermined flakes.
- The technique employed is always direct percussion by hard hammer.

Briefly, the *Levallois* technology is characterized by a hierarchical division of the two surfaces of the core and from the shaping of the flaking surface in order to predetermine the final morphology of the products. The *Levallois* method consist of different modalities discriminated by a preferential or a recurrent character (Boëda 1994). The preferential *Levallois* method is characterized by the production of a single flake for each shaping out of the flaking surface, practically is necessary the reconfiguration of the core convexities for each removal of a predetermined flake. The recurrent modalities, allow a production of a series of predetermined and predetermining flakes till the exhaustion of the convexities, avoiding the continuous reconfiguration of the flaking surface

(Fig.1). In the *Levallois* recurrent uni- and bi-directional methods one or two opposed striking platforms are used (Fig. 2 and 3) while in the recurrent centripetal *Levallois* method, the whole striking platform is employed (Fig. 1-b).

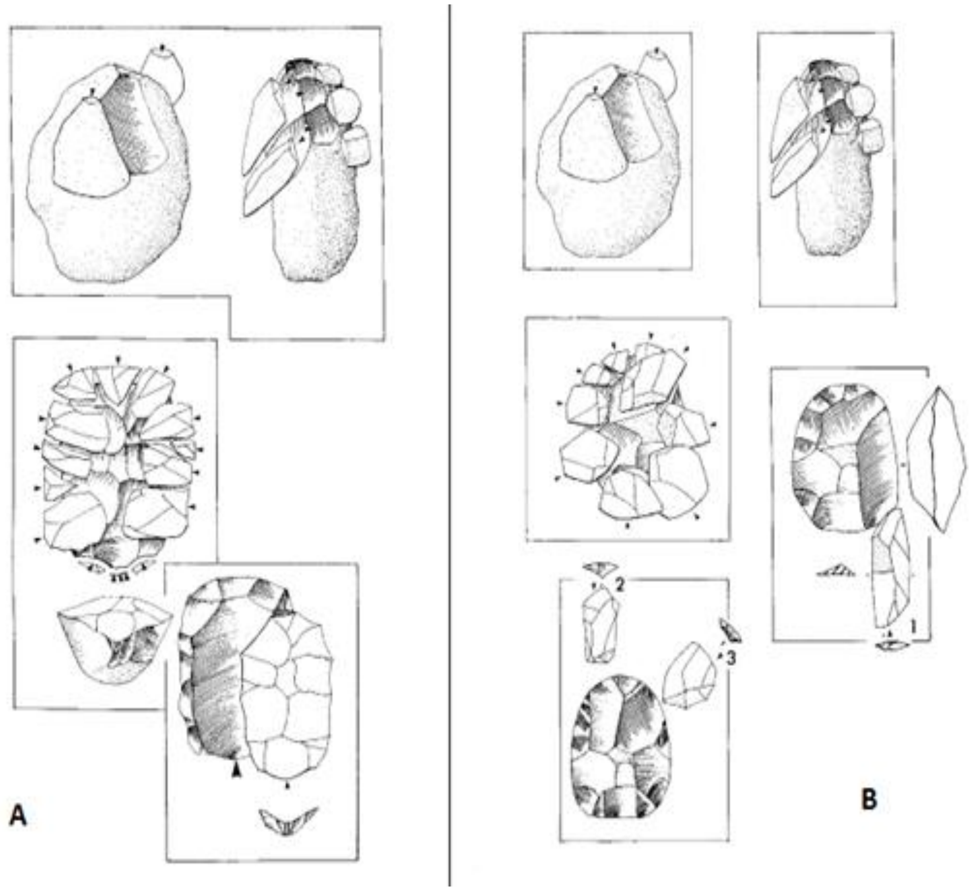

Figure 1:1 Levallois *débitage of a preferential flake; B – recurrent centripetal* Levallois *débitage* .(Inizan, Michèle, and Hélène 1999).

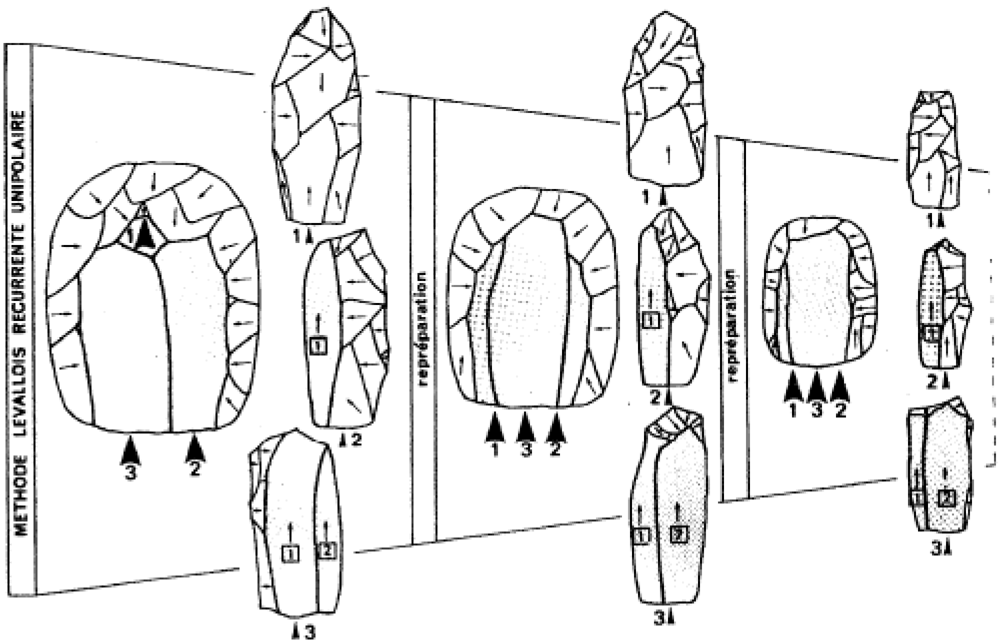

Figure 2:1 recurrent unipolar Levallois method (Boëda et al1990).

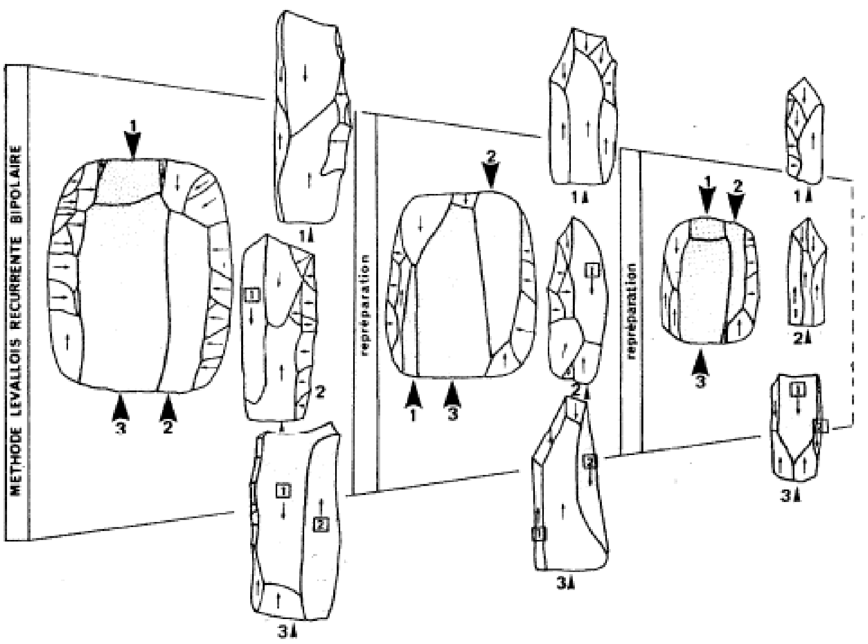

Figure 3:1 recurrent bipolar Levallois method (Boëda et al 1990).

If in the preferential modality, the shape of the *Levallois* flake is predetermined only by the lateral and distal convexity, in the recurrent methods, the predetermination of the flakes is due to the position of the previous removals (Boëda 1994). Then, controlling the number and the position of the ridges on the core surface and the platform thickness, it is possible to predetermine the dimension and the morphology of the products (Boëda 1994; Van Peer et al. 2010). Despite these differences, the *Levallois* methods are all characterized by a *discontinuous rate* of production of predetermined flakes since all of them have the necessity of reshaping the convexities (if the volume of the core permits the reshaping) of the cores in order to continue the extraction of predetermined flakes. Concerning the products, the *Levallois* flakes have a moderate thickness distributed across the cross-section and a greater general symmetry in comparison with flakes produced with other *débitage* methods (Eren and Lycett 2012).
Levallois method is considered the technological innovation that marked the beginning of the Middle Paleolithic in Eurasia (Adler et al. 2014).

2.2 Discoid method

The discoid method, once placed inside the great group of the "*non-Levallois*" lithic industries, has been recognized as a flaking method linked to a concept of volumetric predetermination, different from the *Levallois* method, just about twenty-four years ago by E. Boëda (Böeda 1993). Already in the fifties F. Bordes (Bordes 1950) distinguished the discoid cores from the *Levallois* ones from a tecno–typological point of view, without however being able to draw a clear distinction between the two knapping methods: in his *Typologie du Paléolithique ancien et moyen* (Tav, 105-106 in Bordes, 1961), on the Mousterian discoid plates, both discoid and recurrent centripetal *Levallois* cores are presented (Böeda 1993).

In his description E. Boëda uses the term "*discoid*" to define a flaking method ruled by six technical parameters which fix and delineate the core structure, four of them allowing to distinguish the discoid method from the recurrent centripetal *Levallois* (Fig.4) (Böeda 1993).

The six technical parameters described by E. Boëda are:

- The core volume conceived as two oblique asymmetric convex surfaces divided by one theoretical plane on intersection

- The non-existence of hierarchization between the two surfaces of the core. During one operational sequence the flaking surface and the striking platform can be reversed.

- The predetermination of the products is due to the control of the peripheral convexity, with the aim of controlling lateral and distal attachment of each predetermined flakes.

- The flaking axis of predetermined removals is perpendicular to the striking platform.

- The detachment plane of predeterminant and predetermined removals is oblique with respect to the plane of intersection of the two core surfaces.

-The unique technique employed is direct percussion by a hard stone hammer.

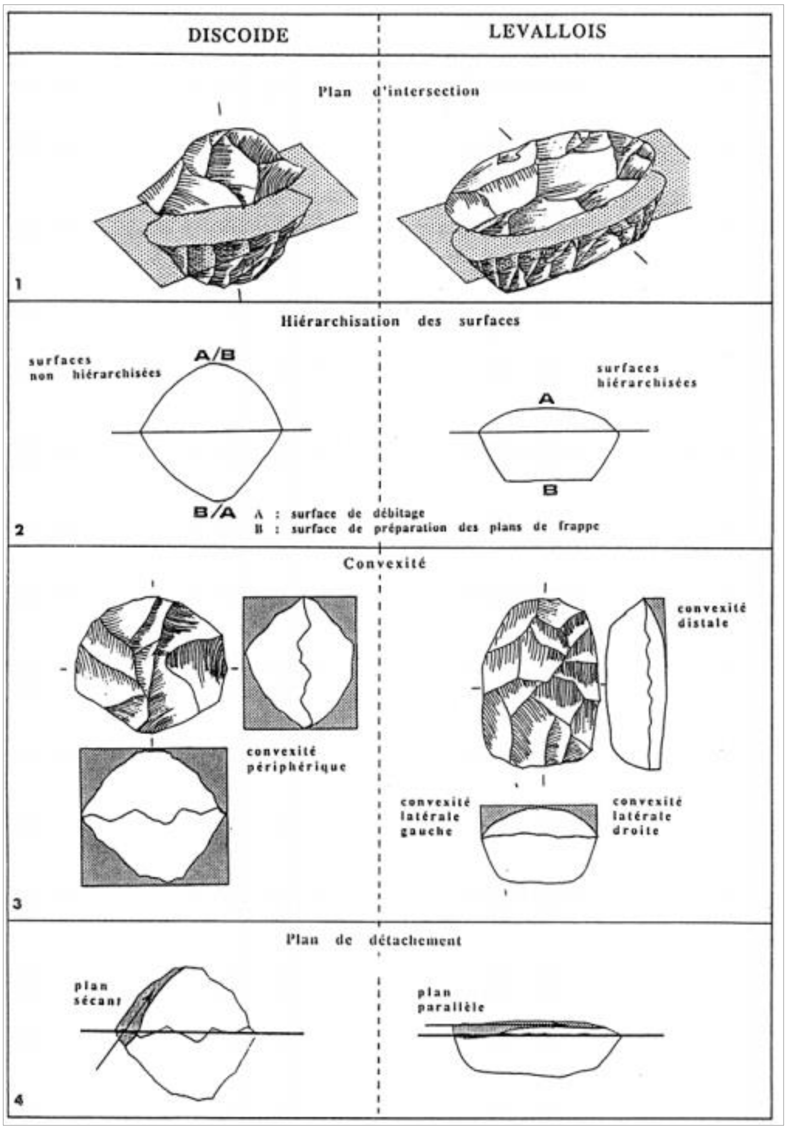

Figure 4:1 technical criteria established by Boëda (1993)

Other studies demonstrate that not all the six parameters actually have an univocal value for the right characterization of discoid cores; according to Vincent Mourre, the really diagnostic parameters are just three (Mourre 2003) while Tarradas affirms that the distinctive criterions are only two (Tarradas 2003).

Mourre's study highlights from one side that the discoid knapping concept is part of the great group of the centripetal *débitage* (Fig. 5), to the other, that it has within it some important variations that often overlap the *Levallois* knapping concept (Mourre 2003).

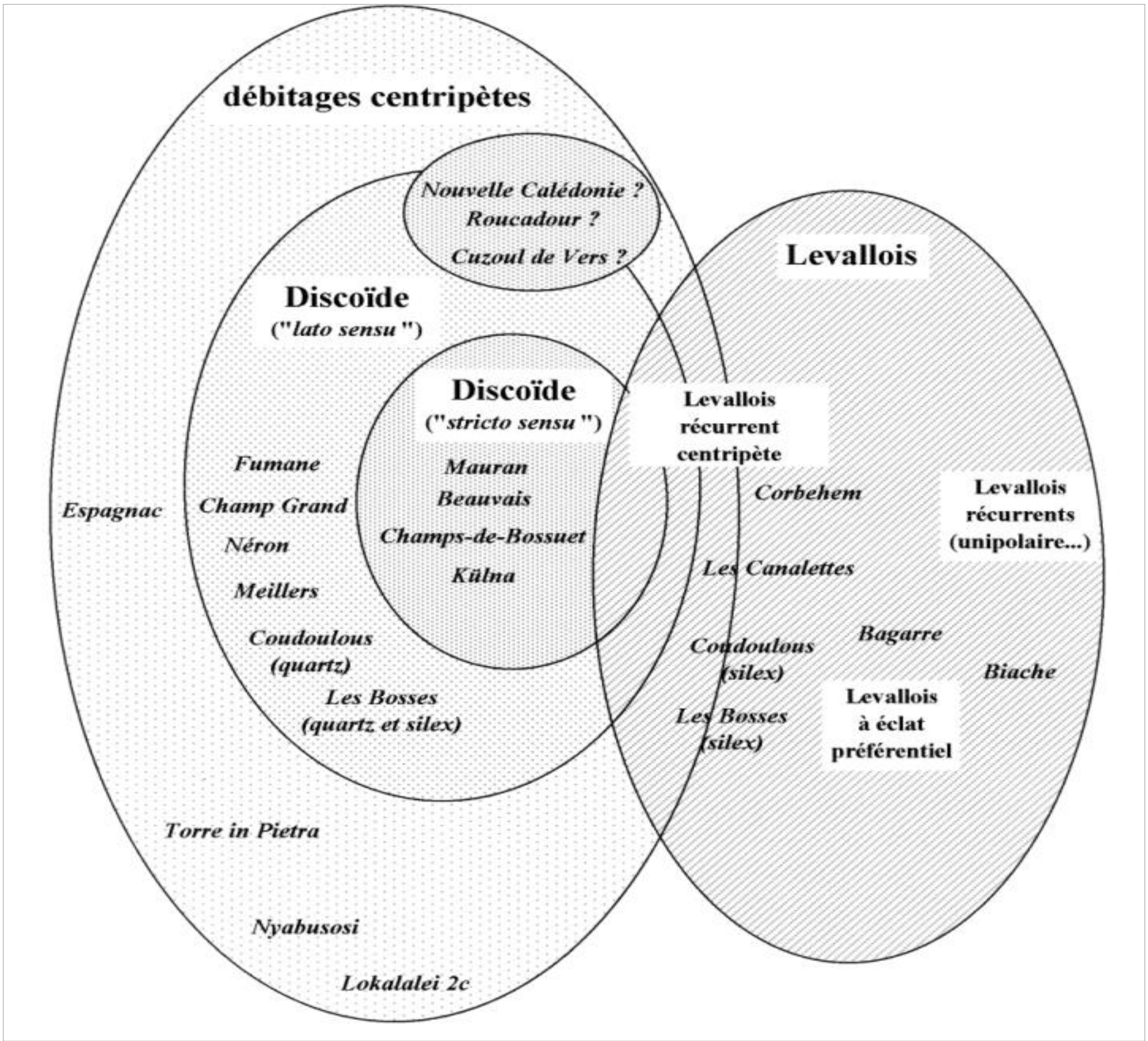

Figure 5:1 Interpretation of the relationship between the various methods of débitage *by Mourre (2003).*

In general, the discoid method is characterized by a great internal variability and some scholars distinguished in the discoid method two modalities: *sensu lato*, in which the objectives are varied, or *sensu stricto*, in which the sequence focuses on the production of pseudo-*Levallois* points and core-edge removal flakes (Picin and Vaquero 2016; Mourre 2003). The discoid method is strongly characterized by the possibility of obtaining, theoretically, a continuous and unique series of predetermined flakes until the core exhaustion, without reshaping phases (Fig.6).

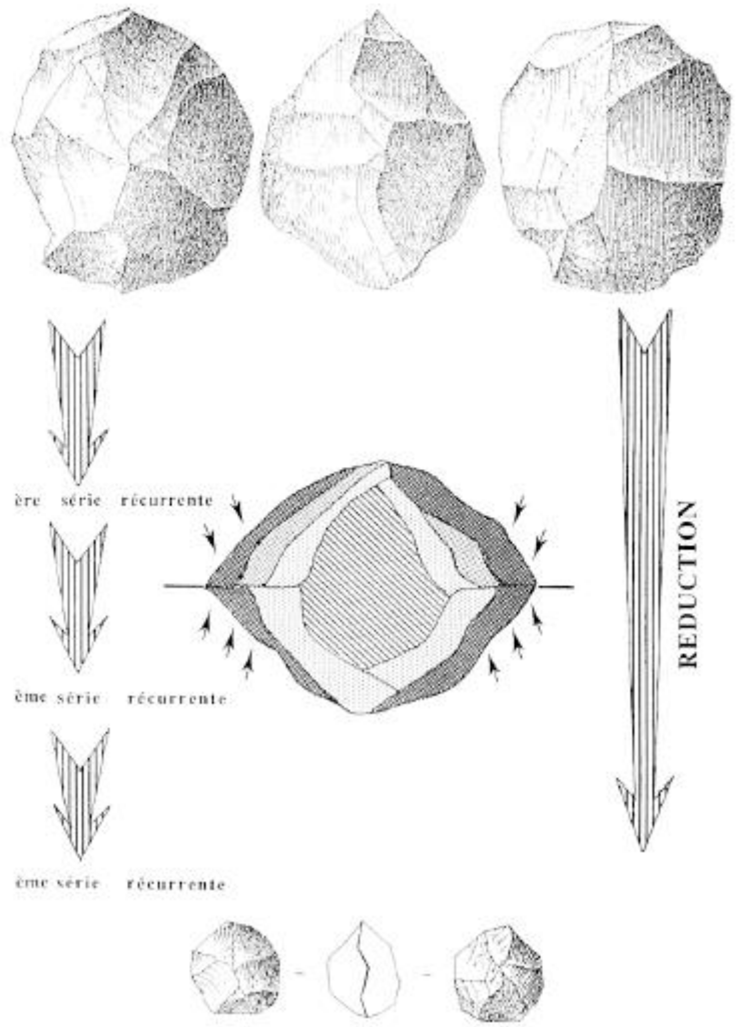

Figure 6:1 descriptive scheme of the reduction sequence of a discoid core (Arzarello et al. 2011).

Predetermined discoid products are basically classifiable in three typologies: pseudo – *Levallois* points and debordant flakes, obtained by cordal removals, and polygonal flakes (long and short ones), typical of a centripetal exploitation of the core (Fig.7); all the obtainable products are characterized by an high average thickness and by a good aptitude for being handle (Lemorini et al. 2003; Böeda 1993; Arzarello et al. 2011).

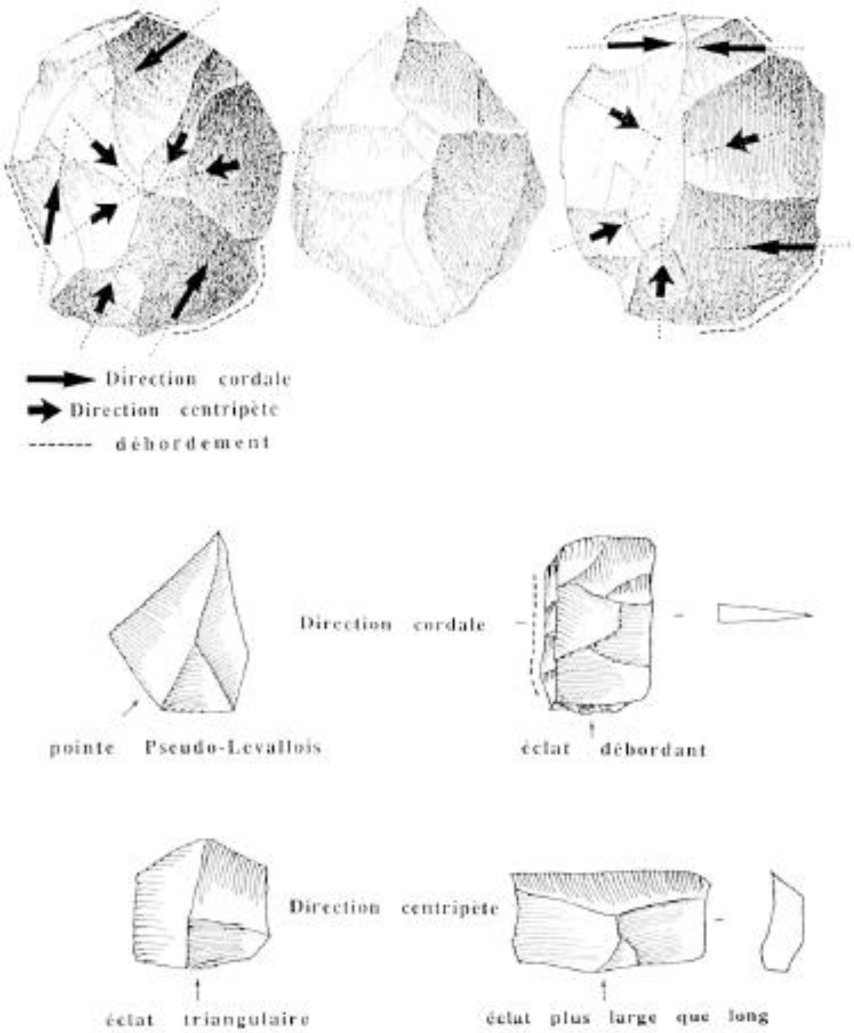

Figure 7:1 discoid products (Böeda 1993)

The discoid *débitage* is also a very diachronic flaking method, which goes from Lower (e.g. Atapuerca, Tinchera Galeria, Levels TN9, TN8, TG10A) to Middle and Upper Paleolithic (e.g. Fumane, Moli del Salt) up to reach the Middle Bronze Age (e.g. Grotta di Rucador) (Carbonell et al. 1999; Mourre 2003; Peresani 1998; Peresani 2003; Carbonell and Vaquero 2003).

<u>2.3 Recurrent centripetal *Levallois* and discoid methods:</u>

Both the methods are part of the family of the centripetal *débitage* methods (Fig.4), and there are some cases where, from the point of view of the cores, it is difficult to assign an element to one or to the other method (Peresani 2003). If from a techno – typological point of view the differences between discoid and *Levallois* recurrent centripetal knapping method is still subject of debate (Peresani 2003; Tarradas 2003; Slimak 2003), from an **economic** point of view the recurrent centripetal *Levallois* method seems to be strongly characterized by the feature of obtaining a *continuous series* of predetermined flakes (Tarradas 2003), characteristic that clearly distinguish it from the other Levallois methods which provide a more *discontinuous rate* of production (Slimak 2003). The discoid method is more flexible and more productive, in term of number of predetermined flakes, than the *Levallois* recurrent centripetal method. The bifacial exploitation of the discoid cores exploits the raw material more efficiently, while the configuration of the core convexities in the *Levallois* recurrent centripetal method produces a high number of management flakes (Picin and Vaquero 2016). From the point of view of the products the discoid method, as already mentioned, is characterized by the production of thicker blanks and the *Levallois* recurrent centripetal method is characterized, as all the Levallois methods, by the production of thinner blanks (Picin and Vaquero 2016).

3. Levallois and discoid methods

Afterwards the description of the two *débitage* methods, we can analyze their differences, because only the differences between the two methods could explain the reasons of the choice of one method rather than the other

3.1 Affinity and differences.

As described in the previous paragraphs the two methods show some affinities and great diversities. In our opinion the main affinity between the *Levallois* and the discoid methods is the possibility of production of predetermined flakes. They are the first methods developed by the humankind that give the possibility to produce lithic blanks giving the knapper the control of a great part of the final morphological characteristics of the products. The other affinity can be found in the capacity of production of a series of these predetermined flakes: that feature is not referable to the preferential *Levallois* method, but it is common to all the recurrent *Levallois* methods (uni- bipolar and centripetal) and to the discoid method. The *Levallois* recurrent centripetal method is more productive, in terms of predetermined flakes for single preparation of the core convexities of the other recurrent *Levallois* methods and the discoid method is more productive of all the others Arzarello et al. 2011; Picin and Vaquero 2016; Boëda 1993; Boëda 1994). The great difference between the Levallois and the discoid method relies on the morphology of the products, although "comparison of morphometric analysis of the products of centripetal recurrent *Levallois* and discoid bifacial technology points to a considerable degree of morphological correspondence, in terms of the flake outlines, between these two methods" (Picin et al. 2014). However, many scholars noted that discoid products are characterized by a thicker sections instead all the Levallois products are characterized by thinner sections (Arzarello et al. 2011; Picin and Vaquero 2016a; Boëda 1993; Boëda 1994; Eren and Lycett 2012; Kuhn 1994; Lemorini et al. 2003; Eren and Lycett 2016).

3.2 Reasons for a choice

In lithic studies concerning Middle Paleolithic technical behavior there are several works focused on Levallois technology (e.g. Eren and Lycett 2012; Eren and Lycett 2016; Baumler 1998; É. Boëda 1994) and only recently it is possible to find works dealing with a comparison between the *Levallois* and the discoid methods (e.g. Picin et al. 2014; Brenet et al. 2013; Brenet et al. 2009; Mourre 2003; Slimak 2003). The productive differences and the size of the artefacts produced could be linked to the mobility of prehistoric hunter-gatherers and the possible scenarios of artifact transport (Vaquero et al. 2012; Picin and Vaquero 2016; Vaquero et al. 2015). If the difference in productivity could have been one of the discriminants for the choice between the two *débitage* methods, the different morphology of the predetermined flakes could have been another. The classical techno-typological studies pointed the attention mostly on the cores differences and gave lower attention to the different morphology of the products (Boëda 1993; Boëda 1994; Peresani 2003; Arzarello et al. 2011). Many studies point the attention on the characteristics of the *Levallois* products and in particular on the products of the preferential *Levallois* method (Eren and Lycett 2012; Eren and Lycett 2016; Kuhn 1992; Kuhn 1994), while concerning the discoid products there are just a few studies (Vaquero et al. 2012; Picin and Vaquero 2016). In these works the Levallois products are usually defined as economically more convenient for hunter-gatherers than the shorter and thicker discoid flakes (Picin and Vaquero 2016; Kuhn 1992; Kuhn 1994; Eren and Lycett 2012). This definition is linked to the concept of re-sharpening by retouching the blanks and it was developed from Kuhn (Kuhn 1994) for the personal tool-kit and later revived by other scholars (e.g. Picin and Vaquero 2016). For the flakes of the personal tool-kit, the attitude for the re-sharpening can be a vantage, but the elements of the personal tool-kit are, for definition, limited then it is impossible to justify the widespread of the *Levallois* methods with this explanation. Furthermore, it is universally recognized that the retouched tools represent only a minimal part of all the lithic industries (Arzarello et al. 2011). Another possibility is that the adoption of a determinate type of *débitage* method was due to the type of work that was to be carried out with the flakes: this possibility was partially explored by a very few works like the article of C. Lemorini (2003) "Techno-morphological and use-wear functional analysis: An integrated approach to the study of a discoid industry"

We could be tempted to attribute the choice of one of the two method to the quality or to the typology of the raw materials available, but both were employed with many kind of raw materials, from good quality flint to quartzite and from vein quartz to radiolarite (e.g. Arzarello et al. 2012; Daffara et al. 2014; Cura and Grimaldi 2009; Rosina and Cura 2010; C. Lemorini et al. 2001).

4 . The questions: (whose answers aren't 42…I suppose)

In the previous paragraphs the *Levallois* and discoid methods have been described and defined and have been analyzed different motivations that could have led to the choice between these two *débitage* methods. With these data is it possible to give an answer to the two questions that we set ourselves? i.e. the employment of the discoid flaking method rather than of the *Levallois* is due to **cultural** reasons? Is there a **functional** difference between the products obtained through a discoid *débitage* and those obtained through a Levallois *débitage*?

At the moment we can't give a satisfying answer to these two questions. Some data are missing, especially regarding the use of the predetermined flakes obtained with the two methods. The analysis of the wear traces on a significant sample of predetermined products could give information about the reasons that led to the choice of one method rather than the other. The great difference in the morphology between the *Levallois* and the discoid products is mainly in their relative thickness: the discoid flakes have usually a high thickness and are characterized by a good aptitude for being handled (Cristina Lemorini et al. 2003), while the *Levallois* flakes have a relative symmetry and an evenly distributed thickness (Eren and Lycett 2012; Lycett and Eren 2013; Eren and Lycett 2016; Kuhn 1994; Kuhn 1992). These characteristics could have been intentionally researched to do different actions or to work different materials.

We take similar decisions when we make a choice between a saw and an axe to saw or break the wood, or when we make a choice between the various type of knives during a gala dinner (dinner knife, butter knife, dessert knife, table knife, fish knife, etc...). The use-wear analysis of a big sample of discoid and *Levallois* predetermined products coming from different sites, may lead to find a correlation between flakes produced with different methods and different works or processing of different materials. Through this kind of analysis, it could be possible to understand if the choices are the result of different cultures which answer the same needs applying different technologies, or if it is the same culture that applies different technologies to answer different needs.

5. Composition of the sample:

The chosen sample includes sites with different variables: chronology, settlements type (cave and open air sites), raw materials used (flint, vein quartz, quartzite, etc...), human species (*Homo neanderthalensis*, *Homo heidelbergensis* and *Homo erectus* s.l.); this choice was made to check if there were relations between the different variables (Tab.1). The eight sites analyzed are equally distributed in two different geographical regions: Italian Peninsula and Iberian Peninsula (Fig.8). From the chronological point of view they cover all the period of coexistence of the two methods. The oldest one is the site of Pirro Nord (Apricena, FG, Italy) where none of the methods is present, but where there is the first European attestation of a centripetal *débitage* that, as outlined by Mourre (Mourre 2003), is a method strictly related with the *Levallois* and the discoid methods (Fig.4). The subsequent site is Guado san Nicola (Monte Roduni, Is, Italy) that represents one of the firsts evidence of the presence of the Levallois method in Europe and where also the discoid method is well attested. The Ciota Ciara cave (Borgosesia, VC, Italy) is the second site where it is possible to analyze the coexistence of the two methods in pre-Neanderthal contexts. The sites of Riparo Tagliente (Grezzana, VR, Italy), Can Garriga and Pedra Dreta (St. Julià de Ramis, Gerona, Spain) are classical Mousterian sites while Foz do Enxarrique (Villa Velha de Rödäo, Portugal) and Lagoa du Bando (Mação, Portugal) represent probably two of the last traces of the Mousterian culture in Europe.

Table 1.1: summary table with the various characteristics of the analyzed sites. ● = chronology obtained through the biochronology; º = hypothesized chronology through comparison with the other sites of the area.

SITE NAME	GEOGRAPHICAL LOCATION	AGE	TYPE OF SETTLEMENT	RAW MATERIALS USED
Pirro Nord	Apricena, FG, Italy.	1.6 / 1.3 Ma●	Open air, dry with seasonal wetlands.	Flint
Guado S.Nicola	Monte Roduni, IS, Italy	400 ± 9 ka / 345 ± 9 ka	Open air, on a river terrace, open woodland.	Flint
Ciota Ciara	Borgosesia, VC, Italy	300 ka	Cave, open woodland.	Quartz, spongolite, flint
Can Garriga	St. Julià de Ramis, Gerona, Spain	107.6 ka / 87.7 ± 2.5ka	Open air, river banks.	Quartz, quartzite, porphyry, flint, syenite, etc…
Pedra Dreta	St. Julià de Ramis, Gerona, Spain	92.4 ± 4 ka / 82.4 ± 4ka	Rock shelter near a river	Quartz, quartzite, porphyry, flint, syenite, etc…
Riparo Tagliente	Grezzana, VR, Italy	60 / 40 ka	Rock shelter near a river	Flint
Fenx	Villa Velha de Rödäo, Portugal	33,6 ± 5 ka	Open air, river banks.	Quartzite
Lagoa du Bando	Mação, Portugal	± 30 kaº	Open air, lake banks.	Quartzite

Figure 8.1: sites position. 1- Pirro Nord (Apricena, FG, Italy); 2- Guado san Nicola (Monte Roduni, Is, Italy); 3- Riparo Tagliente (Grezzana, VR, Italy); 4- The Ciota Ciara cave (Borgosesia, VC, Italy); 5/6- sites of Can Garriga and Pedra Dreta (St. Julià de Ramis, Gerona, Spain); 7-Foz do Enxarrique (Villa Velha de Rödäo, Portugal); 8- Lagoa du Bando (Mação, Portugal).

CHAPTER II

THE USE-WEAR ANALYSIS:

"The use-wear analysis is the identification of the traces left on the edges of lithic tools by the processed materials, with the aim of reconstructing the activities done with them, the chaine opératoire and the economical scheme of which they were part"(Ibanez and Gonzales 1996).

1. History of the discipline

The will of giving a particular function to the lithic tools is not a peculiarity of the modern archaeology: the names used for the typological classification of lithic tools (i.e. scraper, burin, etc.) make explicit the type of action that was attributed to each kind of instrument. Among the first authors who tried to identify the actual functions of the lithic tools we should remember Evans (Evans 1872) and Spurrell (Spurrell 1892); the latter in particular took advantage of an experimental collection. Similarly, Curwen (Curwen 1930) used an experimental collection to study the polish identified on the edges of Neolithic sickle elements (Fig.1).

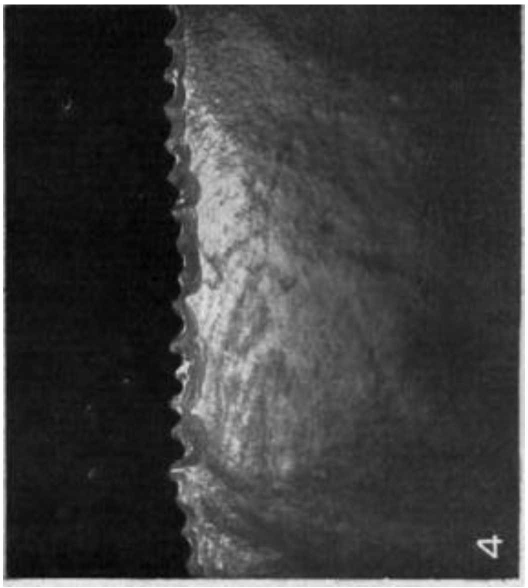

Figure 1:2 experimental flake with broad band of lustre due to cutting straw (x2) (Curwen 1930).

The modern use-wear analysis born in the Soviet Union thanks to the Russian researcher S.A. Semenov who, in the volume доисторическая технология (Pervobytnaya Tekhnika – Prehistoric technology) published in 1954, laid the foundations of the discipline. Semenov faces the study of prehistoric artefacts with a scientific approach, using a precise methodology that, through the application of a strict experimental protocol, allows to classify and code the use-wear traces, identifying the hardness of the processed material and the direction of the gesture (Odell 1981). The functional study of the prehistoric artefacts created by Semenov consists in the microscopic observation of the edges of the stone tools and in the comparison of the traces identified with those reproduced experimentally. In 1964, the work of Semenov was translated and published in English allowing its spread in the Western world (Semenov 1964). European and American archaeologists showed a keen interest in the new discipline, and once acquired the methodology, they gave way to a lively debate, developing other methods of research related to the use of different technical equipment. In 1980, L. Keeley elaborated a new technique using metallographic microscopes with incident light: this approach, named High-Power Approach (HPA), allows the identification of micro-traces on the edges of the tools (micro-polish). Keeley (Keeley 1980) also showed that these micro-traces have different morphologies depending on the processed material, allowing an univocal identification. The subsequent methodological developments of the discipline took place in France where F. Bordes, at the end of the seventies, assigned the first Ph.D. thesis about use-wear analysis. In the following years, the discipline was characterized by a bitter controversy between the supporters of observation through microscopes at low magnification (Low Power Approach – LPA: Odell 1981; Tringham et al. 1974) and those adopting the methodology at high magnification (HPA) proposed by Keeley. Today the contrast between these two different approaches seems finally overcome and many works (e.g. Lemorini et al. 2014; Wilkins et al. 2015; Moss 1983; Beyries 1987; Ziggioti 2011; Van Gijn 2014; Berruti and Daffara 2014; Cruz and Berruti 2015) show that the use of both the methodologies integrated is more effective and productive. There are indeed some advantages working with the two methods together: the stereoscopic microscope (LPA) has a long working distance, wide depth of field and produces 3D image (Keeley 1980); it is less expensive in terms of time-consuming and large samples can be observed to verify the possible presence of use-traces (Van Gijn 2014). However, due to lower magnification, slight traces can be missed, but this can happen also with HPA (Van Gijn 2014). In the combined approach the stereo microscope analysis (LPA) represent an excellent tool for the screening of the material, for the selection of the sample and for macroscopic observations (Lemorini et al. 2014). The different use-traces identified with the LPA need to be further studied through the high-power approach (Van Gijn 2014) (Fig.2).

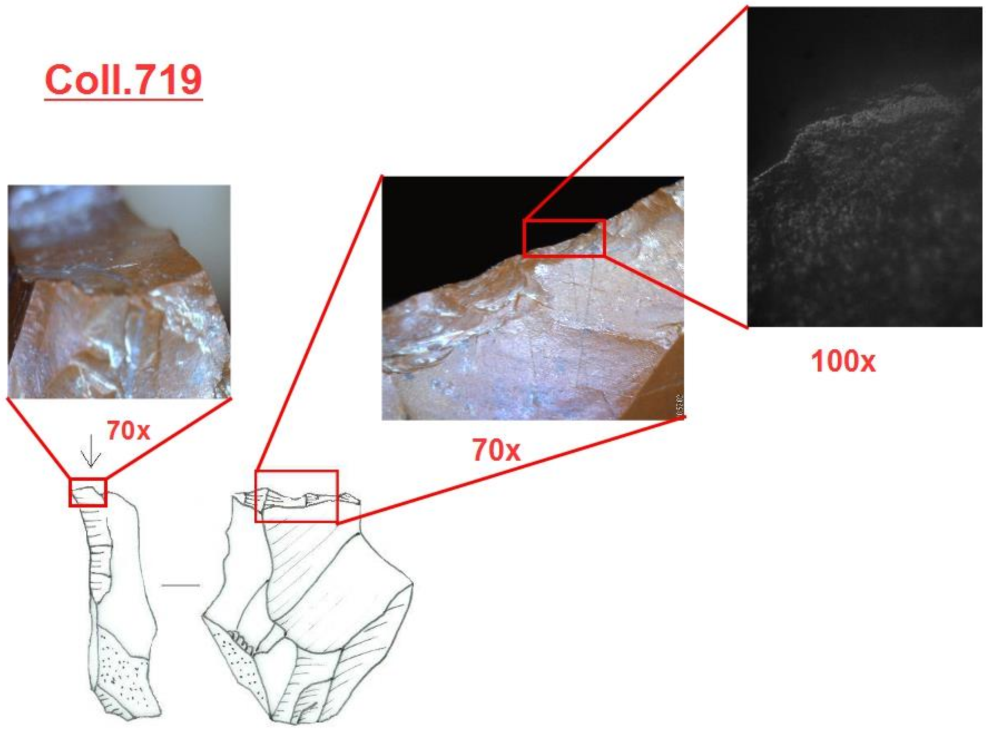

Figure 2:2 Evidence from the Mesolithic site of Collecchio (PR - Italy). Coll.719, although typologically similar to a burin (B6), doesn't have use wear traces on the dihedral, while a polish referable to the processing of wood was identified on the retouched edge. (Berruti and Daffara 2014).

Moreover, other methods using different equipment have been developed in recent years: the "Ultra High Power Approach" (e.g. Ollé and Vergès 2014) that uses scanning electron microscopes and atomic force microscopes (Kimball, Kimball, and Allen 1995), prophilometry (Beyries 1988), residue analysis (Kealhofer, Torrence, and Fullagar 1999; Fullagar 1994), laser prophilometry (e.g. Stemp et al 2013) and use of confocal laser scanner microscopy (Evans et al 2014; Ibáñez et al 2014) (Fig 3).

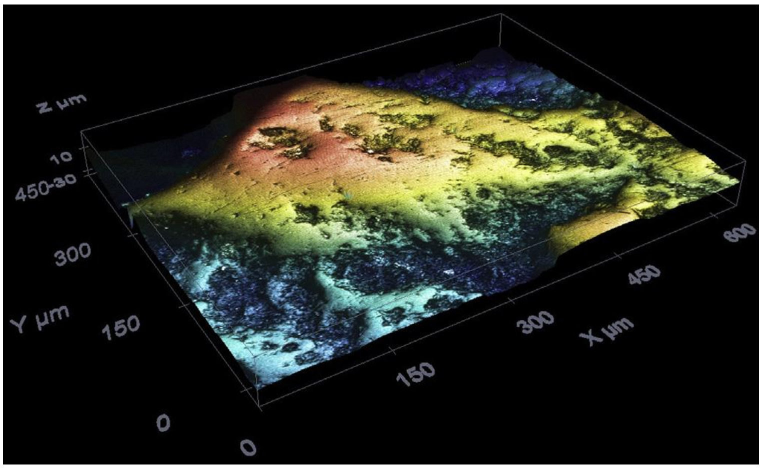

Figure 3:2 D image through laser confocal microscopy of use-wear micropolish from harvesting domestic cereals (Ibáñez et al 2014).

1.1. Potentialities and limits of the use-wear analysis

The functional analysis of stone tools has great potentialities in the field of prehistoric research since lithic artefacts are usually the best preserved remains within an archaeological site. It is also a discipline suitable and applicable to different chronological and cultural contexts. However, there are some limits to its application, mainly due to the sort of the considered context or to the state of preservation of the artefacts. Frequently, in fact, the archaeological context consists of deposits which reflect only a fraction of the activities carried out by the human groups and we should always keep in mind that the activities of the hunter-gatherers were widely varied in time and space (Binford 1978; Plisson et al 2008). Then, although the functional analysis allows to identify the spatiotemporal breakages occurred within a single context, it is necessary to widen our research including a wider archaeological record in order to understand the actual economic organization of the human groups (and not of the single context) (Ziggioti 2011; Ibanez and Gonzales 1996). Another inherent limitation of the functional analysis is related to the exceptional strength of the stone tools, that may lead to the risk of overestimating their importance within the technical systems of the human groups in spite of instruments made of less resistant materials. The ethnographic studies attest the use of a variety of instruments made on perishable materials such as wood or hard materials of animal origin: this equipment, in some cases, is numerically predominant and technically preferred in comparison to that obtained from lithic raw materials (Binford 1978). Concerning the problems related to the conservation of the artefacts, there are different types of post depositional alterations that could invalidate the analysis: trampling, water transportation, abrasion and strong thermal stresses may limit the effectiveness of the analysis depending on their intensity. The patinas, such as soil-sheen and white-patina, result of physical or chemical phenomena, tend to be more damaging for the use-wear analysis (e.g. Van Gijn 1990; Venditti et al 2015; Eren et al. 2012; Clemente-Conte 1997). Very often the presence of such post-depositional alterations makes the functional analysis completely ineffective (Asryan et al 2014; Levi Sala 1986; Plisson and Mauger 1988) but on the other hand it can provide information about the environmental processes that involved the lithic implements (Burroni et al. 2002).

2. Introduction to the study of use-wear traces

The microscopic analysis of a lithic artefact shows to an expert eye a multitude of "signs", more or less clear, visible on the edges of the examined tool. The surface of the lithic tool is like a record of all its vicissitude: these "signs" are

the language that allows us to reconstruct the history of the lithic tool. The use-wear analysis concerns the decoding of this language, in order to reconstruct the "life" of every examined lithic artefact and then understand which kind of needs and motivations led to its production, use and abandonment. Thanks to functional analysis, we can reconstruct part of the life of the people who made the stone tools we are analyzing. The traces left by our ancestors are not the only ones recorded on the surface of the lithic artefacts but there are also traces of events concerning both the period after the abandonment of the lithic tool and the period preceding the manufacturing of the tool. As said before, the "signs" visible on the surface of the lithic artefacts, if correctly interpreted, can clarify their use. These "signs", that the functional analysis defines “traces”, are various since they are the result of different phenomena. First of all, we want to classify the different kind of traces according to their origin, and then analyze each group of traces in order to clarify specific features.
We must distinguish two main groups:

- **anthropic traces**
- **natural traces (alterations)**

The first group includes all those traces produced by human actions and for this reason they are analyzed. The second group includes all the traces originating from events not directly related to man (Fig.4). Although they also provide important information, especially about taphonomy, they are not part of the use-wear analysis (Burroni et al. 2002). Both groups, looking at the origin of the traces, can be subdivided into two further subgroups: **mechanical traces** and **chemical traces.** Among the traces of chemical origin, polishes should be included, even if their origin is due to both mechanical and chemical actions (Ziggioti 2005).

In the table 1 were indicated the main types of traces divided by cause (man-made or natural) and origin (chemical or mechanical); for each trace is listed the main bibliography; a more exhaustive and complete description of all these traces is present in the appendix two.

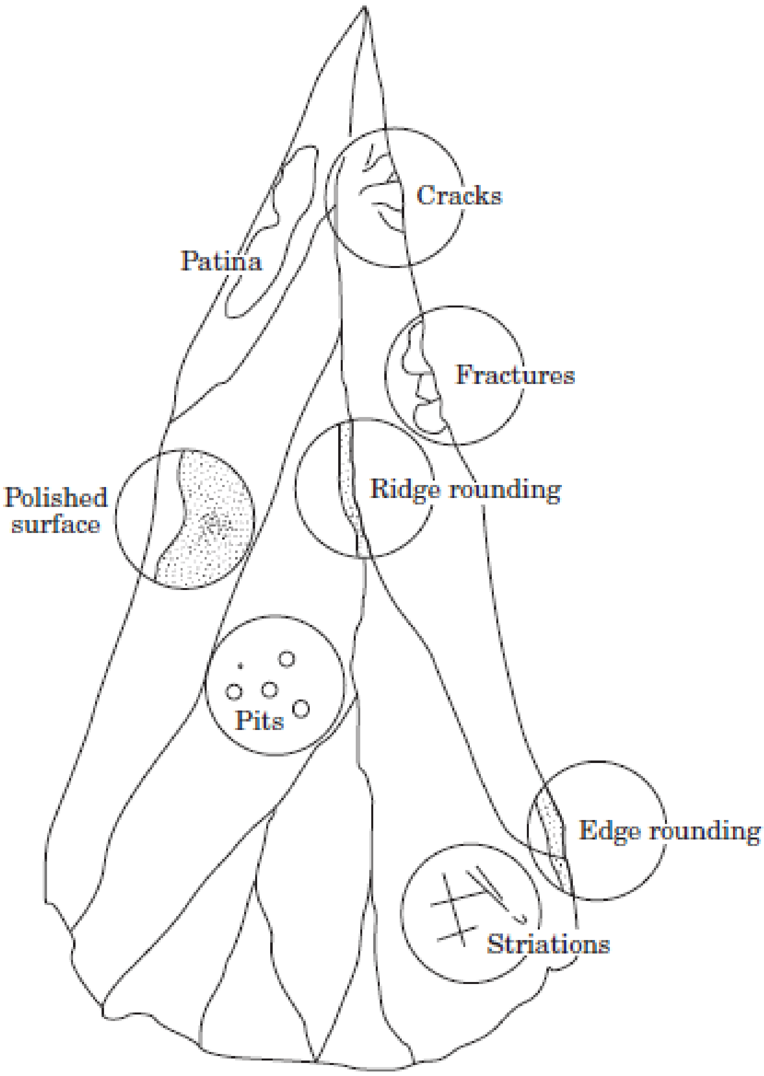

Figure 4:2 Some frequent natural modifications of a flint flake (from Burroni et al 2002).

Type of traces	Origin of the traces	
	Mechanical	**Chemical**
Anthropic	**Bright spots** (Rots 2008; Rots 2001; Rots 2002); **edge removals and rounding** (Semenov 1964; Odell 1981; Tringham et al. 1974)**; fractures; impact fractures** (Fischer et al. 1984); **striae (**Mansur-Franchomme 1983); **Polishes** (Keely 1980)	**Polishes** (Keely 1980)
Natural (alterations)	**Bright spots** (Moss 1983; Mazzucco et al. 2013; Levi Sala 1986); **Soil sheen** (Levi Sala 1986,; Mazzucco et al. 2013); **edge removals, cracks and strie** (due to trampling (McBrearty et al. 1998; Flenniken and Haggart 1979) or pressure of the sediment (McPherron et al. 2014; Bird, Minichillo, and Marean 2007); **micro-pitting** (Keeley 1980; Levi Sala 1986; Asryan 2015) **Fractures** (Hayden 1979, Fischer et al. 1984).	**Soil** sheen (Hurst and Kelly **1961); white** patina (Glauberman and Thorson 2012; Andersen and Whitlow 1983)**; oxides of** manganese (Marín-Arroyo et al. 2014; Hill 1982)**; color patinas, gloss patina, porcelain patina, dendritic** patina (Glauberman and Thorson 2012; Mazzucco et al. 2013; Asryan et al. 2014; Asryan 2015; Burroni et al. 2002; Van Gijn 1990)

3. Experimental Collections

Common practice in the use wear analysis is the creation of experimental collections. The importance of experiments has been recognized since the beginnings of the discipline (Semenov 1964). Use-oriented experiments are the most common ones, done to serve as a comparison for archaeological collection, and to understand the process of use wear formation. Experimental collections should be done for every particular study in order to adapt the creation of the collection and to give answers to particular questions, taking into account every peculiarity of the lithic industry under examination, e.g. differences in raw materials use, etc. However, because of the limits of each study and experimental program, integration with data from other studies should also be done. During the creations of the reference collection it is very important to record all the data linked to the activities done with a single tool on every worked material. Data as time of use, kind of material worked, direction of the action, type of raw material, presence of retouch, picture of the edges before and during all the phases of use, etc. must be collected for each tool used, in order to understand the formation process of any type of micro wear (Ziggioti 2005). This data are usually collected on worksheets and after inserted in a electronic database. (such as Microsoft Access Data Base or Excell). Concerning some of the sites studied in this work (Ciota Ciara, Fenx, Lagoa du Bando, Pedra Dreta and Can Garriga), it was realized a specific experimental collection linked to particular raw materials (vein quartz, quartzite, porphyry, etc.) (Fig.17); in the other sites, it was used an experimental collection already realized by the author. For the experimental collection in quartzite it was used the huge and complete collection of the Instituto Terra e Memoria of Mação (I.T.M.). For each site, studied in this work, the experimental data were sustained and integrated by the use of a iconography database from other studies.

Figure 5.2: on the left: skin work with a sidescraper made in vein quartz; on the right: butchering activity of a wild boar carcass with flakes made in flint and vein quartz.

CHAPTER III

TALKING STONES: TAPHONOMY AND USE-WEAR ANALYSIS OF THE LITHIC ASSEMBLAGE OF PIRRO NORD 13 (APRICENA, FG, SOUTHERN ITALY).

1. Introduction

The aim of this study is to answer to three different questions: does the lithic assemblage of PN13, despite the antiquity, preserve wear traces linked to the activities carried out by the first Europeans? Can the taphonomic analysis of the lithic assemblage increase the information about the site formation process? Are there any correspondences between the lithic taphonomy and the faunal remains taphonomy?

The fissure of Pirro 13 is a residual component of a wider karst system (Giusti and Arzarello 2016) and it is worthwhile to assess the degree of any potential post-positional reworking of the archaeological and paleontological remains and to evaluate the stratigraphic integrity of the site. Even if the lithic artefacts were found in a secondary deposition, the dimensional analysis shows the consistency of the assemblage where all phases of the reduction sequences are represented: from decortication passing through the production of small waste to core abandonment (Arzarello et al. 2015). Some scholars noted that different post-depositional alterations are identifiable using the same microscopes employed for the use-wear analysis (e.g. Levi Sala 1986; Levi Sala 1988; Andersen and Whitlow 1983). Usually these post-depositional alterations are considered as a problematic for the correct interpretation of the use-wear traces (e.g. Lemorini, Plummer, et al. 2014; Keeley 1980; Márquez et al. 2001). Other scholars suggest to use post-depositional alterations to understand the environmental processes that determined the site formation processes (Burroni et al. 2002; Eren et al. 2011; Mazzucco et al. 2013). In the case of PN 13 the data about the post-depositional alteration (PdA) collected during the use-wear analysis could identify the "taphonomic history" of the lithic assemblage to understand if all the assemblage was exposed at the same environmental processes or if there are some difference among the various lithic elements. As such, they can be used as an alternative line of evidence to assess the integrity of archaeological contexts and sites.

2. Pirro Nord 13

The fossiliferous area of Pirro Nord (also known as Cava Pirro or Cava Dell'Erba) is located at the northwestern margin of the Gargano promontory, close to the village of Apricena (FG, Apulia, Italy; 41º4800700N, 15º2300500E). The fossiliferous area is located inside an active limestone quarry and the findings are positioned in karst fissures. The fissures are situated at the top of the Mesozoic limestone formation which is the object of the exploitation of the quarries. During Pleistocene, the fissures were part of a very complex interconnected karst system, result of a dissolution that was effective along the fractured core zone of the Pliocene fault that bordered the "Apricena horst" to the south (Pavia et al. 2012). Each fissure containing Villafranchian paleontological remains has been named "P" followed by a progressive number. Paleontological studies have been conducted there since the 1970s (Freudenthal 1971), and systematic field investigation have been carried out by several research teams (De Giuli, Masini, and Torre 1987). In the P13 fissure, associated with paleontological remains of vertebrate fossils of the Pirro Nord Faunal Unit were found some lithic industries (Fig.1). It represents one of the earliest records of European peopling as it is dated, on a biochronological basis, between 1.6 and 1.3 Ma (Arzarello et al. 2015; Lopez-Garcìa et al. 2015). The site thus provides important contributions to the ongoing debate about the first hominin occurrence in Europe (Carbonell et al. 2008; Despriée et al. 2010; Despriée et al. 2009; Despriée et al. 2006; Parés et al. 2006; Toro-Moyano et al. 2009; Moyano et al. 2011).

Figure 1.3: left- position of Pirro Nord fossiliferous area; center – position of the fissure of P13 inside the quarry (aerial view); right - position of the fissure of P13 from the base of the quarry.

2.1 Geomorphological setting

The paleontological and archaeological remains are preserved inside a karst fissure that was exposed and partially destroyed by mining activities. It is located at the stratigraphic boundary between the Mesozoic limestone and the Pleistocene calcarenite formation and it has a vertical profile. The sedimentary filling of the fissure is due to a downfall derived from the top, by gravity, and it follows the position of the large limestone and calcarenite blocks that made up the skeleton of the fissure. The sediments were deposited in a chaotic way. The archeological sequence is more than 4m thick and Inside this sequence four Sedimentary Units (SUs) have been distinguished from the top to the bottom: SUs A, B, C, D (Fig.2), distinguished on lithological basis. The units from B to D are characterized by clayey-sandy sediments of increasing thickness. SU A is characterized by clayey sediment with few coarse gravels and a very low number of paleontological and archaeological remains. Unit B contains more gravels, while an abrupt increase in the number and dimensions of clasts and large blocks of Pleistocene calcarenite is evident within SUs C and D. These last units show a certain sorting of angular and sub-rounded gravels, probably correlated to a low degree of reworking that took place during a short time laps. It is also recorded a significant increase in the number of fossils and lithic artifacts (Giusti and Arzarello 2016).

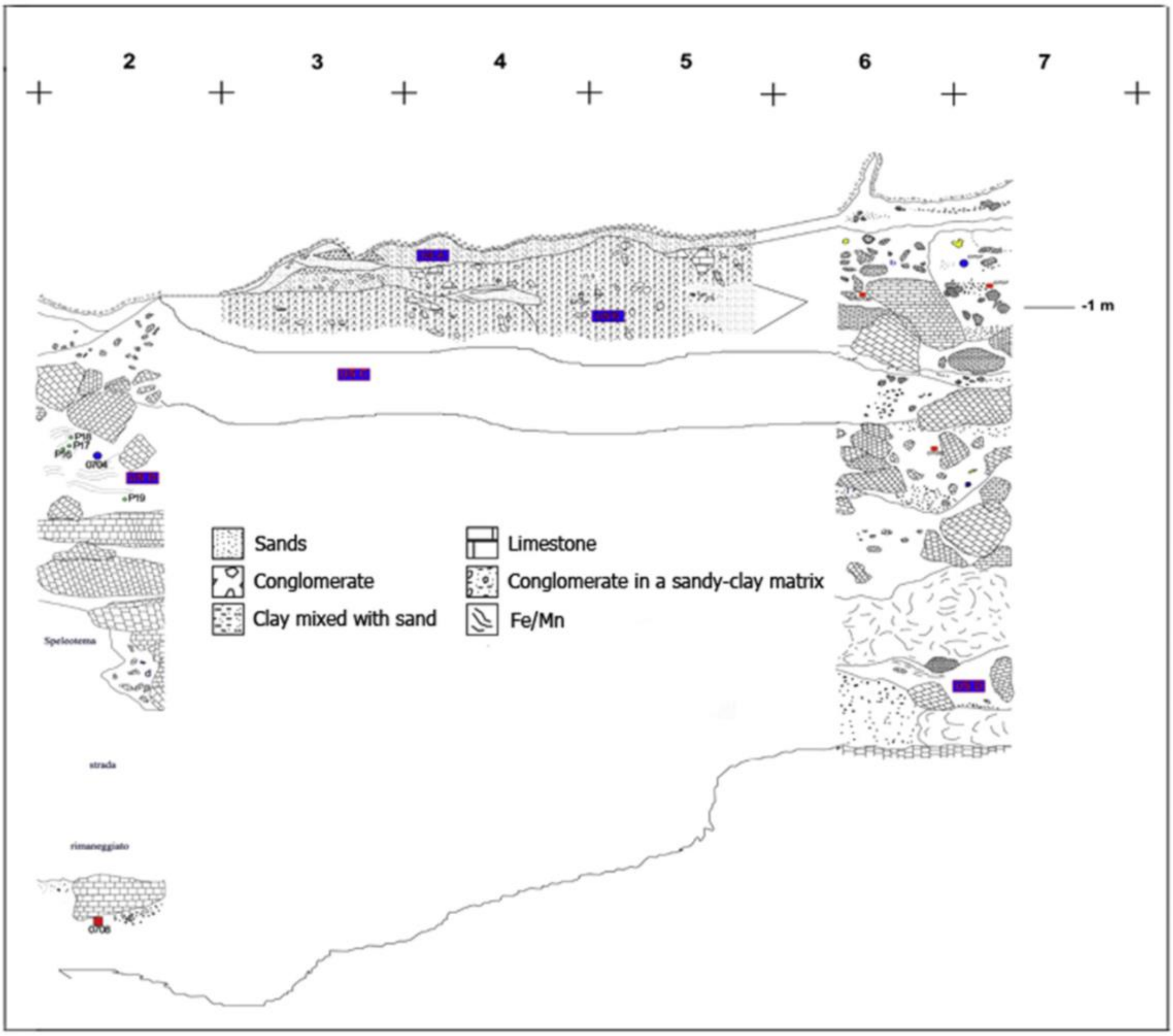

Figure 2.3 stratigrapy of PN13; (Arzarello et al. 2015)

SUs D, C and B are also characterized by the presence rare sand lens. The formation of the deposit is due to the collapse of the top of the fissure which put in communication the karst system with the surface. To this collapse can be attributed the presence of the big blocks of calcarenite and limestone. The deposition of the SUs D, C and B is the result of one or more subsequent events of some kind of mass-wasting process, such as a mud-flow or earth-flow, carrying rock rubble with fossils and artifacts. The formation of the different SUs (B, C and D) is the result of a gravitational selection of the chaotic materials carried into the fissure by these phenomena. The applied set of spatial analyses confirms, with an adequate level of statistical significance, this assumption (Giusti and Arzarello 2016). For this motivation the faunal remains and the lithic artefacts found in the fissure of PN13, in different SUs, were studied as a unique assemblage (Arzarello et al. 2015; Bagnus 2011; Giusti and Arzarello 2016; Lopez-Garcìa et al. 2015; Arzarello et al. 2012; Arzarello et al. 2009). The deposition of the SU A is due to the presence of a vertical percolation of water that led to the deposition of secondary clay at the top of the sequence; the same event led to the deposition of the same type of secondary clay in the empty interstices near the big blocks of calcarenite and limestone.

2.2 Faunal remains

Inside PN13 was found a typical association of vertebrate fossils of the Pirro Nord Faunal Unit. The faunal assemblage is characterized by the presence of 20 species of amphibians and reptiles (Delfino and Bailon 2000) 47 species of birds (Benedetti 2003) and over 40 species of mammals. The association of mammals' species is characterized by the earliest occurrence of *Bison degiulii*, *Capreolus* sp., *Equus altidens*, and *Meles meles* (Delfino and Bailon, 2000). Among the others species of mammals are present: *Stephanorhinus* sp., *Pachycrocuta brevirostris*, *Homotherium latidens*, *Axis* sp., *Praemegaceros obscurus* and

Mammuthus meridionalis. The only arvicolid species present in the PN13 is *Allophaiomys ruffoi*. “Taking into account the evolutionary trends of *A. ruffoi* and its presence in other western European Early Pleistocene sites, it is possible to obtain a relative age of Pirro 13 in a ranges between 1.3 and 1.6 Ma” (Lopez-Garcìa et al. 2015). Independently from the debate on the chronology of the Early Pleistocene human remains, the presence of *A. ruffoi* shows that Pirro 13 is older than the other Western European sites with ancient human remains, such as Sima del Elefante (ca 1.22 ± 0.16 Ma; Carbonell et al. 2008) and Barranco Leon (ca 1.4 ± 0.38 Ma; Toro-Moyano et al. 2013); where the evolved vole form *A. lavocati* is present (Lopez-Garcìa et al. 2015). The presence of birds such as *Otis tarda*, *Tetrax tetrax* and *Pterocles oreintalis*, together with other species of Anatidae and Charadriiformes, allow to obtain a paleoenvironmental reconstruction that indicates an open environment, tending to dry, but with a seasonal wetland. The significant presence of *Alaudidae* indicates that open areas were characterized by low-type vegetation (Bedetti 2003; Arzarello et al. 2009).

<u>2.3 Lithic assemblage</u>

From 2006 to 2015 in the PN13 fissure were found 340 artefacts related to anthropic activities (231 flakes, 37 core and 72 debris) (Tab.1). The raw material has been collected no more than 7 Km far from PN13, in secondary position (river beds or slope deposits). The exploited flint pebbles and cobbles have different morphologies and sizes and they come from the Gargano Cretaceous succession. Four different types of flint were exploited from this succession: brown oolitich flint, grey homogeneous flint, grey bedded flint and black flint. In the PN13 lithic assemblage two main reduction sequences were adopted: an “opportunistic” *débitage* based on the exploitation of multiple striking platforms (max 5) to produce flakes with different morphologies but always with at least one cutting edge and a “centripetal” *débitage* for the production of flakes with convergent cutting edges. The presence of the Kombewa *l.s. débitage* method is documented as well (Owen 1938). Five largest flakes, in most cases completely cortical, are produced by centripetal *débitage* on the ventral face of the cores on flakes or by unipolar *débitage* using the ventral face of the core on flake as a striking platform (Arzarello et al. 2015; Giusti and Arzarello 2016; Arzarello et al. 2009)

Table 1.3: Composition of the lithic assemblage of Pirro Nord. The material comes from the stratigraphic units A (9%), B (12%), C (19%) and D (60%); the different amounts of material found in the stratigraphic units are function of the different thickness of each. (Arzarello et al. 2015).

Type	**N.**
Cores	**37**
1 streaking platform	6
2 streaking platforms	8
3 to 5 streaking platforms	3
Centripetal exploitation	12
Indet./fragment	8
Flakes	**231**
Unipolar removals	81
Bipolar removals	10
Orthogonal removals	14
Crossed removals	49
Centripetal removals	39
Kombewa *l.s.*	9
Indet.	29
Debris	**72**
Tot.	**340**

There is not a clear relationship between the kind of flint and the method of *débitage* adopted for the reduction but, there is a relationship between the raw material morphology and size and the knapping method. The “opportunistic” reduction sequence has been employed for the reduction of the largest flint cobbles and of the polyhedral pebbles/cobbles. This exploitation can be compared to some S.S.D.A. cores described by Forestier (Forestier 1993) and it can be considered as an adaptation to the raw material morphology to obtain the greatest quantity of blanks with a sharp cutting edge and through the lowest number of gestures. The technique used is always direct percussion with hard hammer. The raw material is rarely fully exhausted and most of the cores were abandoned before their complete exaustion.

The reduction sequences on the largest cobbles are usually longer, but they always stop before the full exploitation of the core. “Centripetal *débitage*” was almost exclusively performed on small pebbles and cobbles with spherical/ovoid morphology (maximum length between 20 and 70 mm). All of those cores led to the production of flakes with medium-small dimension, mostly debordant and with two convergent cutting edges. This method was the best/easiest way to exploit small ovoid pebbles, but it is evident a recurrence and a “standardization” in the blanks production. That may also be evidence of a voluntary technical choice made by the knappers (Arzarello et al. 2015; Arzarello et al. 2009).

In the lithic assemblage of PN13 there are four retouched flakes all obtained from an opportunistic *débitage* with multiple flaking surfaces. All of them were broken and two show a bending fracture. There are one notch, one denticulate and two side scrapers, both with an inverse retouch, one on the distal edge of the flake and the other one on the lateral edge (Arzarello et al. 2015; Giusti and Arzarello 2016; Arzarello et al. 2009).

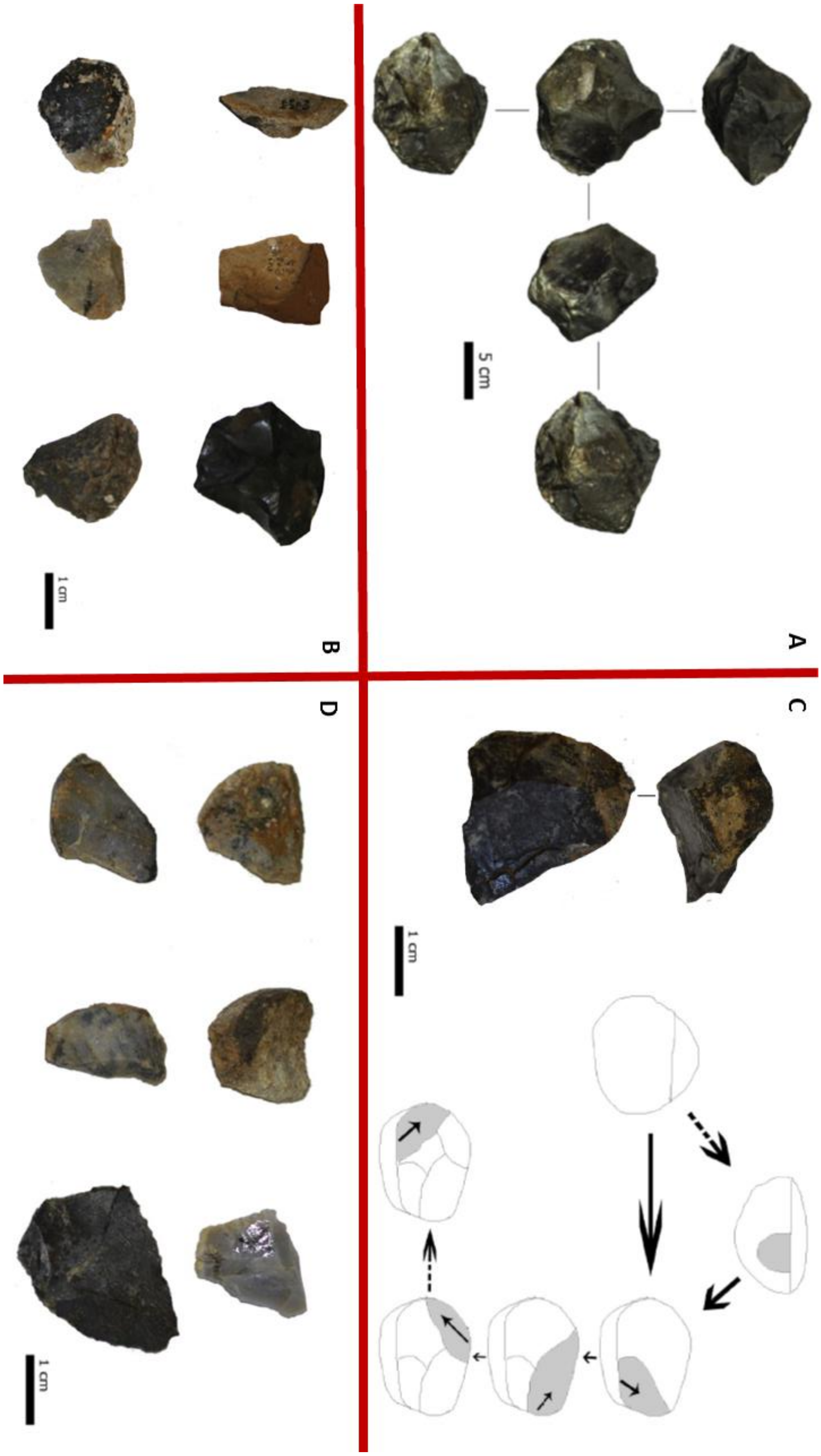

Figure 3.3: A-Core with 3 striking platforms managed by unipolar débitage. The core is not exhausted and has produced a minimum of 12 flakes of middle/big sizes; B-Flakes issued from an opportunistic débitage; C- left: centripetal débitage core / right: outline of centripetal production, the dashed arrows indicate not mandatory steps; D- Flakes issued from a centripetal débitage. (Modified from Arzarello et al. 2015).

The macroscopic analysis attest that the whole series of artefacts is characterized by a very good state of preservation. At this level of analysis, the artefacts have sharp edges and do not show macroscopic evidence of transportation: 35% carry traces of Fe-Mn oxide patinas on their surface, as observed on more than 70% of the faunal remains. The only post-depositional alteration identified at this level of magnification (naked eye) are fractures that have affected 20% of the lithic material and they are probably due to the falling into the fissure (Giusti and Arzarello 2016; Arzarello, et al. 2015).

3. Background:

The "taphonomy" was originally defined as "the study of geological processes of the transition of animal remains from the biosphere into the lithosphere" (Efremov 1940). The term derives from the greek word "*taphos*" (= tomb). The taphonomy of the faunal remains now encompasses different processes such as: the burial, the processes of death (e.g. hunting), the relationships between the death and the burial process (e.g. cuts mark) and the different instances occurred after the burial process (e.g. exposure and reburial). Essentially, the taphonomic study of archaeological faunal remains aims to understand any and every circumstance that may have affected the context and appearance of those remains between the animal's death and modern discovery (Lyman 2010; Domínguez-rodrigo, Fernandez-Lopez, and Alcalá 2011). The flaked stone taphonomy is defined as the discipline that has the aim of identifying and analyzing the processes affecting the appearance and context of lithic artifacts subsequent to their cultural use lives (Eren et al. 2011). In Paleolithic studies, the cultural modifications of the stone artefacts represent a crucial line for investigating many archaeological issues. Together with the cultural modifications there are natural modifications of the lithic industry, so-called post-depositional alterations (PdA) (Stapert 1976). The study of the PdA should not be limited to understand their origins in order to minimize their ability to mimic tools (Eren et al. 2011; McPherron et al. 2014) and confound the interpretation of use-wear traces (Moss 1983; Plisson 1983; Levi Sala 1986; Plisson and Mauger 1988). The PdAs record, on the surfaces of the lithic artefacts, the processes to which any lithic instrument was subjected from the deposition to the modern discovery. The most common PdAs of stone artefacts are: fractures (Asryan 2015; Burroni et al. 2002; Thiébaut 2007), edge crumbling (Eren et al. 2011; Asryan et. al. 2014; Keeley 1980; Lemorini, Plummer, et al. 2014; Vaughan 1985), soil sheen (Hurst and Kelly 1961; Levi Sala 1986; Mazzucco et al. 2013), striations (McBrearty et al. 1998; Flenniken and Haggart 1979), bright spots (Moss 1983; Mazzucco et al. 2013; Levi Sala 1986), roundness of edges and ridges (Burroni et al. 2002), pits (Keeley 1980; Levi Sala 1986; Asryan 2015) and patina (Glauberman and Thorson 2012; Mazzucco et al. 2013; Asryan, Ollé, and Moloney 2014; Asryan 2015; Burroni et al. 2002; Van Gijn 1990). Some of these PdA may be macroscopically visible, while others may require the use of a microscope. There are many studies (especially in the use-wear analysis sector) that analyzed the formation process of the PdA in order to distinguish wear produced by use from those resulting from natural processes (e.g. Asryan, Ollé, and Moloney 2014; Asryan 2015; Mazzucco et al. 2013). These studies allowed to understand the formation process of many PdAs, indicating if the single PdA is the result of specific chemical conditions occurred in the sediment (e.g. white-patina, Fe-Mn oxide patina) or it is the result of mechanical actions (e.g. trampling, pitting). These process are due the different environmental and geomorphological conditions that involved the site where the lithic industry was found (e.g. Burroni et al. 2002; Mazzucco et al. 2013; McPherron et al. 2014; Asryan, Ollé, and Moloney 2014; Donahue 1998). Consequently, the study of the PdAs can give several information about the environmental conditions and the site formation processes. Today, there are very few attempts to apply lithic thaponomy to reconstruct past environmental conditions and site formation processes, but they indicate that the approach has a great potential (Burroni et al. 2002; Donahue 1998; Glauberman and Thorson 2012).

3.1 Overlapping method for the taphonomy of the lithic artefacts: potentiality and limits.

The PdAs are the result of different processes that damaged the lithic industry between the end of their cultural life and the modern discovery. During this period on the surfaces of the lithic artefacts all these processes were recorded. In many cases on the surfaces of a single lithic artefact is recorded more than one of this processes, or from a "classic" point of view, may happen that on a single lithic artefact there is more than one PdA. In some cases, the processes recorded through the PdAs persisted for a limited span of time and were replaced from other processes that were recorded through other PdAs. In these cases, it is possible to determine the sequence of the different processes studying the overlapping of the different PdAs, using the same conceptual methodology developed to create histories regarding the study of rock art (Arcà et al. 2008). For example, a flake of flint abandoned on the soil of a shelter could be affected first by trampling activities and after its burial it could be affected by the formation of white patina due to the presence of water in an acid soil (Mazzucco et al. 2013; Burroni et al. 2002). In that case, the edge crumbling due to trampling will be covered, totally or partially, by white patina. That example is very simple and the study of the PdAs overlapping is more complex, with more than two different phases of PdAs formation. This method gives us the possibility to create a sequence of difference phases of PdAs and to obtain a relative chronology of the PdAs. Furthermore, different causes could affect the registration of the PdA or of the PdAs overlapping. For example: if for a period more than one process was operating at the same time, it is possible to detect only what process ended up by last, but not the contemporaneity of the two phenomena. Another problem of this method it may be caused by heavy post-depositional processes that delete the registration of other processes, for example a very developed patina can obscure the presence of striae, or a heavy process of rounding due by water transport (e.g. in a river bed) can obscure all the traces of other previous processes. Furthermore, different local conditions may inhibit or modify the registration of the different environmental and geomorphological conditions through the PdAs. A little difference in the positioning of the finds within the site could lead to different types of recording of the same process. For example, one flake abandoned in the atrial part of a cave has surely more trampling damage than other flakes abandoned in the same site but near the cave walls. Then, for a precise reconstruction of the past environmental conditions and of the formation processes of the site is important take in consideration the highest possible number of lithic artefacts. This is even more important when the overlapping sequences of PdAs are studied, since not all the phases will be recorded on all the evidences, but the phases will be recorded on all the finds in the same sequence. Therefore, it is necessary, during the study of the overlapping sequences, to recreate an ideal general sequence that describes the relations among all the detected phases, to obtain a relative chronology of all the processes that damaged the considered lithic asseblage between the end of its cultural life and the modern discovery. In conclusion, the lithic taphonomic analysis, conducted on an appropriate number of finds, can give information about the environmental and geomorphological processes registered on the lithic surfaces and through the overlapping method it is possible to gain a relative chronology of these different events and to obtain information about the site formation processes.

4. Materials and methods

This study began with the preliminary evaluation of the state of conservation of the entire artefacts sample coming from the fissure of PN13 to identify the different PdAs that affected the lithic industry. In this way, it was possible to calibrate the analysis to be carried out and to set up different databases for recording the data.

4.1 Taphonomy of the lithic artefacts

The taphonomic study was conducted on all flakes and debris of the considered lithic assemblage. Each artefact was gently washed with warm water and soap, then washed for 3 minutes in a mixture of demineralized water (75%) and alcohol (25%) in an ultrasonic tank and open air dried. Each artefact was observed and analyzed in three steps: macroscopically at the naked eye, with a stereomicroscope Seben Incognita III with magnification from 20x to 80x and with a microscope Optika B 600 Met. with 5 objectives PLAN IOS MET (5-10-20-50-100x). Most of the PdAs of mechanical origin (cracks, edge crumbling, fractures and rounding of edges and ridges) are visible at the naked eye and can be analysed in detail with the help of the stereomicroscope. The study of the bright spots and of the polished surfaces was carried out through the metallographic microscope. The chemical modifications include various degrees of patination, mostly visible at the naked eye, but also some stains on the lithic surfaces better discernible at greater magnification whit the stereomicroscope. The study of the overlapping of the different PdAs was conducted with the aid of the stereomicroscope and just in few cases, when polished surfaces were involved, it was necessary the use of the metallographic microscope. For each lithic artefact were recorded the types of PdAs identified on the surfaces, the degree of development of the different PdAs and the eventual sequence of overlapping of the PdAs. For the registration of the overlapping sequences of

PdAs, this method was used: each PdAs was considered like a different phase (identified with the initial of the PdA, e.g. E for edge crumbling), then they were linked one another with two type of relation, consequentiality (-) and contingency (=); consequentiality when it was possible to identify a clear overlapping between two PdAs (e.g. E-M) and contingency when it was impossible to identify a clear overlapping between different PdAs (e.g. E=R=P). In some case was identified a contingency between different phases having a clear relation of consequentiality with other PdAs phases: in these case the different phases linked to a contingency relation were identified like a single phase (e.g. E-R=P-M) (see fig. 5).

4.2 Use-wear analysis of the lithic artefacts

Four criteria were applied to select artefacts for the use-wear analysis: completeness, presence of at least one functional edge (artefacts without potential functional edges were excluded from the analysis), morphology suitable for prehension and surface preservation (absence of marked post depositional alterations). The PN13 evaluated sample is composed by 63 flint flakes, of which 15 are centripetal flakes and 48 are S.S.D.A. flakes. The use-wear analysis of the PN13 assemblage was conducted with an integrated approach that use the low power approach (Odell 1986) in combination with high power approach (Keeley 1980). Several works (e.g. Lemorini et al. 2014; Wilkins et al. 2015; Moss 1983; Beyries 1987; Ziggioti 2011; Van Gijn 2014; Berruti and Daffara 2014; Cruz and Berruti 2015;) show in fact that the use of both the methodologies integrated is more effective and productive. The analysis of the macro-traces or low power approach provide information about the potential activities carried out (e.g., cutting, scraping, piercing, etc.) and general interpretation of the hardness of the worked materials. The hardness categories used to describe the worked materials are: soft (e.g. animal soft tissue, herbaceous plants and some tubers), medium (e.g. fresh wood and hide) and hard (e.g. bone, horn, antler, dry wood and stone). There are some materials with intermediate hardness or resistance such as soft/medium materials (e.g. fresh hide, wet softwood) or medium/hard materials (e.g. softwood, wet antler) (e.g. Lemorini et al. 2006; Lemorini, Plummer, et al. 2014; Odell 1981; Tringham et al. 1974; Semenov 1964). The analysis of the micro-traces or high power approach is the study of micro-edge rounding, polishes, abrasions, and striations. This kind of study was conducted to provide a more detailed understanding of the activities carried out with the lithic artefacts, and to support the diagnosis of the processed materials (e.g. Lemorini, Plummer, et al. 2014; Lemorini et al. 2006; Rots 2010; Ziggioti 2005; Keeley 1980; Van Gijn 2014). The analysis of the lithic artefacts was conducted using three different types of microscope: a stereoscopic microscope Seben Incognita III with magnification from 20x to 80x, a metallographic microscope Optika B 600 Met supplied with 5 objectives PLAN IOS MET (5-10-20-50-100x) and a Microscope Camera Dinolight Am413T.

5. Results

5.2 Taphonomy results

296 of the 303 lithic artefacts studied presents PdAs: 259 edge crumbling, 208 Fe-Mn oxide patinas, 190 rounding of edges and ridges, 277 polished surfaces and 58 white patinas. The different PdAs present on the lithic artifacts have different intensity and overlapping relation and for each PdA detected was created a simple recording method that considers no more than two numerical variables. The description of edge crumbling (E) PdA takes in consideration two variables (Tab 2). The first variable can have a value between 0 and 7 and describes the intensity of the edge crumbling.

Table 2.3: summary table of the edge crumbling post-depositional alteration (0 - no edge crumbling; 1- edge removals isolated and shallow; 2 - edge removals isolated and deep; 3 - edge removals continuous and shallow; 4 - edge removals continuous and deep; 5 – edge removals continuous and mixed; 6 - edge removals isolated and mixed). The second variable is the position of the edge crumbling and can have a value between 1 and 6 (1-right edge; 2 – left edge; 3 - prossimal positon; 4 - distal positon; 5 - all the edges).

		Position					
Intensity	**N.**	**1**	**2**	**3**	**4**	**5**	**Tot.**
1	163	23	11	1	2	126	163
2	68	10	11	-	1	46	68
3	9	2	1	-	1	5	9
4	-	-	-	-	-	-	-
5	7	2	2	-	-	3	7
6	12	-	-	-	-	12	12
Tot.	259	37	25	1	4	191	259

The description of the oxides of Fe-Mn oxide patina (M) considers two variables (Tab 3). The first variable can have a value between 0 and 4 and describes the intensity of the patination, the second variable is the type of coating and can have a value between massive and soft. The description of the white patina (W) just one variable is considered, it (Tab 4) can have a value between 0 and 4 and describes the intensity of the patination.

Table 3.3: summary table of the Fe-Mn oxide patinas post-depositional alteration. (0 - no patination; 1- isolated patina, ≤ of 10% of the surface covered by a compacted patina; 2 - concentrated patina, ≤ of 50% of the surface covered by a compacted patina; 3 - generalized patina, ≥ of 50% of the surface covered by a compacted patina; 4 - dispersed patina, little isolated spots of patina). The second variable is the type of coating and can have a value between 1 and 2 (1- massive; 2 - soft).

		Type of coating		
Intensity	**N.**	**1**	**2**	**Tot.**
1	39	26	13	39
2	37	27	10	37
3	31	29	2	31
4	101	64	37	101
Tot.	208	146	62	208

The description of edge and ridge rounding (R) one variable is considered (Tab 5), it can have a value between 0 and 3 and it describes the intensity of the rounding.

Table 4.3: summary table of the white patina post-depositional alteration. (0 - no patination; 1- isolated patina, ≤ of 10% of the surface covered; 2 - concentrated patina, ≤ of 50% of the surfaces covered; 3 - generalized patina, ≥ of 50% of the surface covered; 4 - dispersed patina, little isolated spots of patina).

	Intensity					
	1	**2**	**3**	**4**	**5**	**Tot.**
N.	42	8	3	4	1	58

The description of the polish surfaces and ridges (P) is considered one variable (Tab 6), it can have a value between 0 and 4 and it describes the intensity of the polish.

Within the lithic assemblage, only one artefact is affected by thermal post depositional alteration and another one has traces of concretion. Analyzing the PdAs overlapping have been identified 43 overlapping series (Fig. 4).

Table 5.3: summary table of the rounding post-depositional alteration (0 - no rounding; 1- isolated rounding of the edges, ≤ of 10% of the surfaces affected; 2 - concentrated rounding of the edges and of the apical part of the ridges, ≤ of 50% of the surface affected; 3 - generalized rounding of edges and ridges, ≥ of 50% of the surface affected).

	Intensity			
	1	**2**	**3**	**Tot.**
N.	130	49	11	190

Table 6.3: summary table of the polishing post-depositional alteration (0 - no polishing; 1- isolated polishing, ≤ of 10% of the surface affected; 2 - concentrated polishing, ≤ of 50% of the surface affected; 3 - generalized polishing, ≥ of 50% of the surface affected; 4 – dispersed polishing).

	Intensity				
	1	**2**	**3**	**4**	**Tot.**
N.	210	41	15	1	267

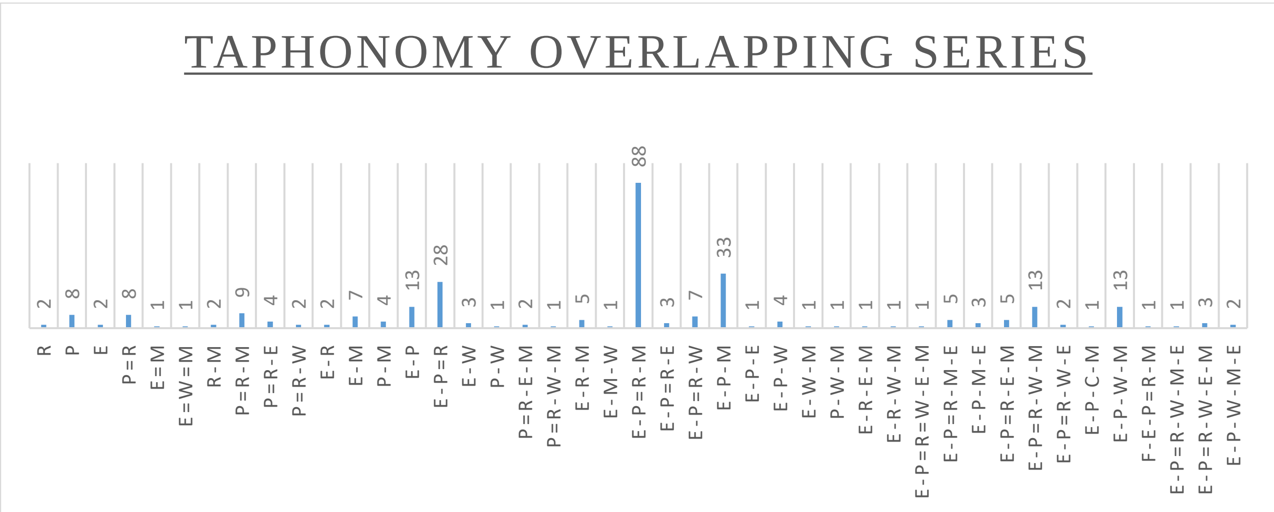

Figure 4.3: graph that show the PdA overlapping series identified. For each series the first letter indicatse the oldest one; the symbol "-" represents the consequentiality of the PdA; the symbol "=" indicates that it was not possible to individuate timing difference between the two PdA. E= edge crumbling; R= rounding; P = polishing; M= Fe-Mn oxide patinas; W= withe patina; F=fire; C=concretion.

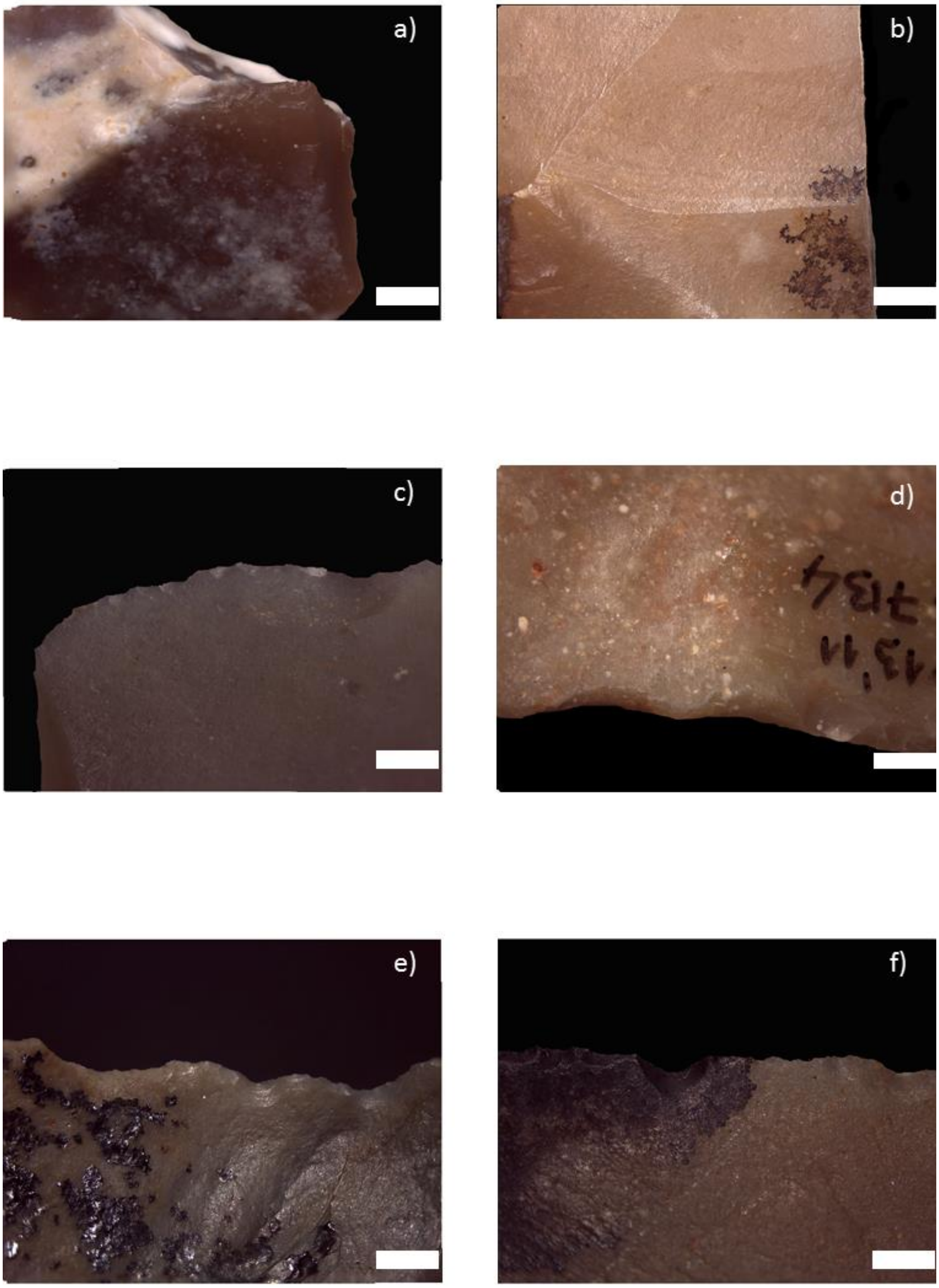

Figure 5.3: a) type 2 white patina on the flake 144 B2 D (scale bar 1 mm).; b) isolated spot (type 1) of soft (type 2) Fe-Mn patina on 154 B3 D flake (scale bar 1,5 mm); c) edge crumbling (type 3) covered by a generalized (type3) soft (type 2) Fe-Mn patina on the edge of the flake 82 B2 B5 (sequence E-M) (scale bar 1 mm) ; d) veil of light polishing (type 1) and edge rounding (type 1) on the edge (affected by edge crumbling of type 3) of the flake s128 B4 C7 (sequence E-P=R) (scale bar 0,5 mm) ;e) example of massive manganese spots on the edge of the flake 13 γ 2007 affected by light polishing (type 1) (scale bar 1 mm); f) edge removals (linked to ancient use) covered by a Fn-Mn patina on the flake S11 B3 (scale bars 0,5 mm).

5.2 Use-wear analysis results

Among the 68 artefacts selected for the use-wear analysis only five showed use-wear traces (Fig. 5). They are medium and small-sized flakes, measuring between 20 and 43 mm in length, 30 and 15 mm in width, and 6 -15 mm thick. Four of them show only one used edge while the other flake has two active edges. In total, have been found 5 different used flakes with 6 functional edges. Some of the functional edges identified present edge removals not due to intentional retouching but rather micro-flaking produced during use (Odell 1981; Semenov 1964). Considering the antiquity of the site and the formation process of this archaeological deposit only the edges that present edge removals in association with polishes were considered as used (Keeley 1980). The use wear traces on the artifacts are developed enough to determine the tool kinematics (motion) and the worked material with an acceptable degree of reliability. Cutting motions were recognized on the 4 functional edges belonging to the flakes with just one functional edge and all them are linked to butchering activities. The extension of the polishes affects the edges surface gradually, decreasing from the outside to the inner part. The recorded polishes, appear opaque and not so smooth to completely obliterate the original flint surface (contact with soft animal tissue). There are also areas showing polishes where the surface texture is smoother and more compact (contact with bone). On the last two functional edges was recognized a transversal action linked to the processing of soft animal tissue. The state of preservation and the degree of development of these butchery traces do not allow us to identify in which phase of carcass processing they originated.

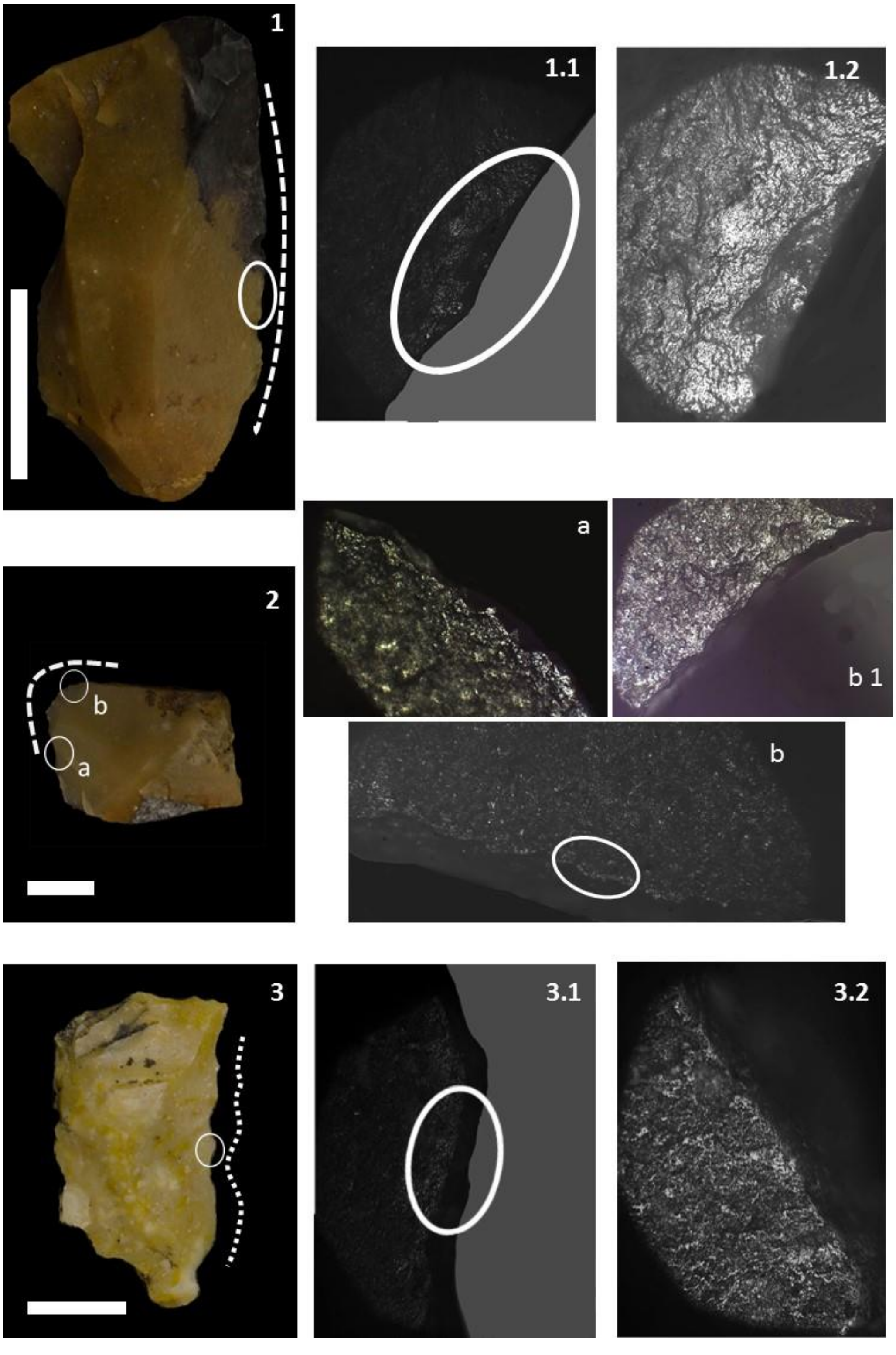

*Figure 6.3: use wear traces on PN12 artefacts. 1. Flake S11 B3 A (scale bar 2 cm); 1.1 micro- use-wear (dotted line) interpreted as the result of a mixed motion of butchering (50x); 1.2 details of the area in the circle (200x) with rough polish (**contact with fleshy tissues**) and small, smooth and flat spots of polish (**contact with bone**). 2. S107 C6 D21 (scale bar 1 cm); a - details of the area in the circle (100x) with rough polish (**contact with fleshy tissues**) and small, smooth and flat spots of polish (**contact with bone**); b - details of the area in the circle (50x) with polish on the edge; b-1 - details of the area (100x) b with rough polish (**contact with fleshy tissues**). 3. 140 B4 C7 (scale bar 1 cm); 3.1 micro- use-wear (dotted line) interpreted as the result of a mixed motion of butchering (50x); 3.2 details of the edge area (100x) b with rough polish (**contact with fleshy tissues**).*

6. Discussion

The analysis of the PdAs of a lithic assemblage gives an idea of the different post-depositional process that led to the formation of an archaeological deposit (Burroni et al. 2002). Observing the list of the PdAs sequences identified on the PN13 lithic industry it is possible to distinguish some taphonomic phases (Fig. 4,7 and 8). In the 83.4% of the analyzed artefacts with PdAs, edge crumbling (E) is the first phase of PdA recorded on the artefacts surfaces (Fig. 7). The 53% of the sequences recorded the edge crumbling phase is followed by another phase characterized by the presence of polishing and rounding (E-P=R) (Fig. 7). Furthermore, the phase characterized by a contingency relation of polishes and rounding is present on the 61,82% of the artefacts (Fig. 7). The presence of one of these two PdAs alone is recorded on the 23% of the artefacts for the polish (P) and on the 4,7% for the rounding (R).

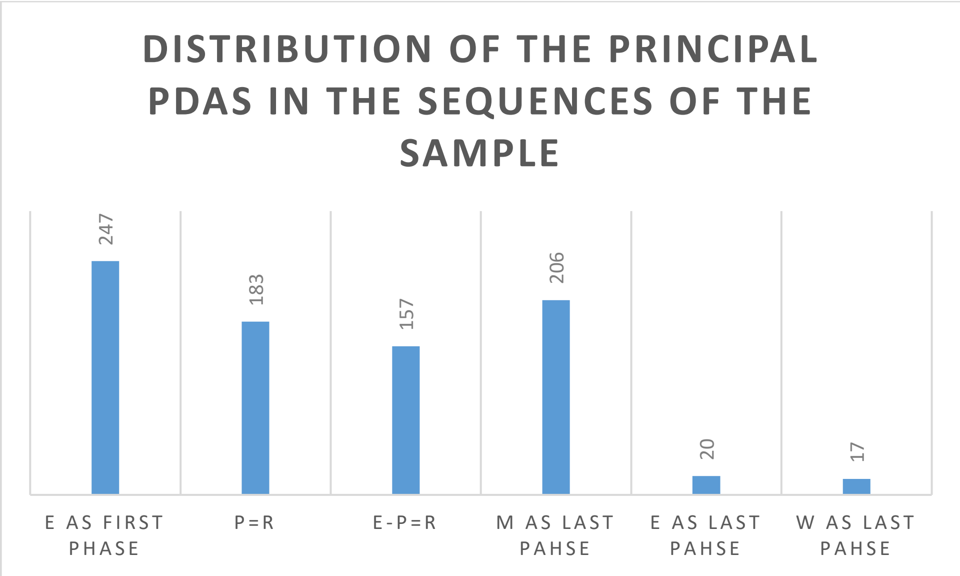

Figure 7.3: distribution of the principal phase in the PdAs sequence of the sample.

In the 24% of the cases studied, the sequence of PdAs ends with one of the phases above mentioned (P=R: 36, P: 21, R: 4, E: 16), in the 76% of the cases the lasts stages recorded are oxide of manganese iron patina (M) or white patina (W) and the two patinas overlap all the other post depositional alteration. When these two phases are both present, the deposition of the white patina precedes the deposition of the Fe-Mn oxide patina. Analyzing the data collected about the PdAs sequences identified on the lithic assemblage and focusing the attention on the relative chronology of the different phases, it is possible to observe that two different macro-phases can be identified. The first one is characterized by the presence of edge crumbling, polishing and rounding while the second is characterized by the presence of Fe-Mn oxide patina and/or white patina (Fig.9). The first sequence is characterized by mechanically alterations (Burroni et al. 2002; Mazzucco et al. 2013) and the second one by chemical alteration (Burroni et al. 2002; Mazzucco et al. 2013; Marín-Arroyo et al. 2014; P J Glauberman and Thorson 2012). The sequence of these two macro-phases is repeated in all the lithic assemblage except for 8 cases where was detected the presence of edge crumbling after one phase of chemical alteration (W and M) and for 4 cases where was detected a presence of edge crumbling between two phases of chemical alteration.

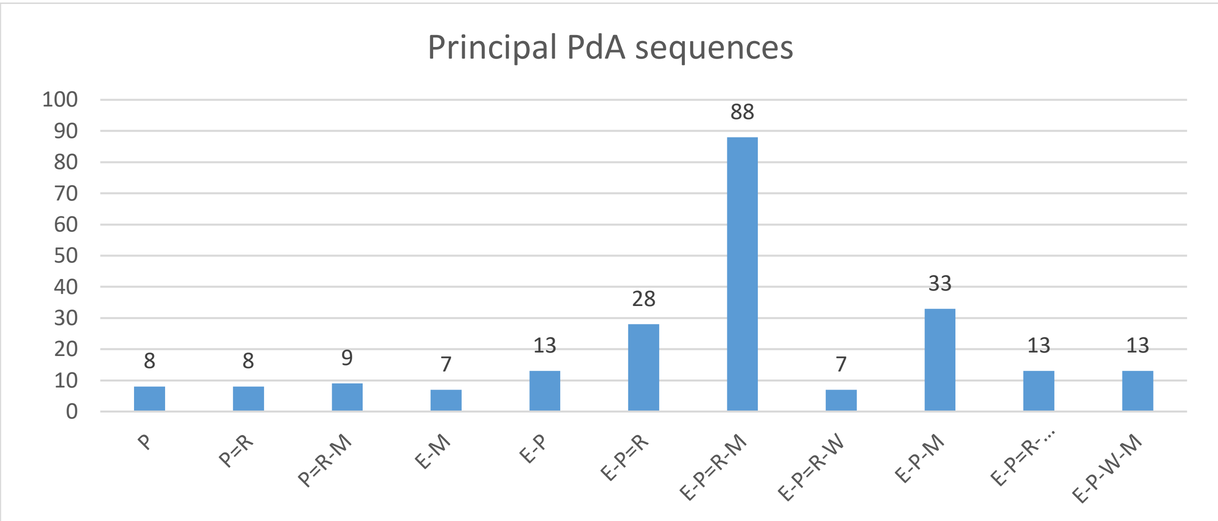

Figure 8.3: Principal PdAs sequences (these have more than 4 elements).

According to the results obtained, it is possible to recreate the general sequence that explains (and contains) all the singular sequences detected during the taphonomic analysis. The general sequence obtained is: edge crumbling, rounding and polishing, white patina and, at the end, Fe-Mn oxide patina with the addition of a few scattered phases of edge crumbling (or E-P=R-W-M).

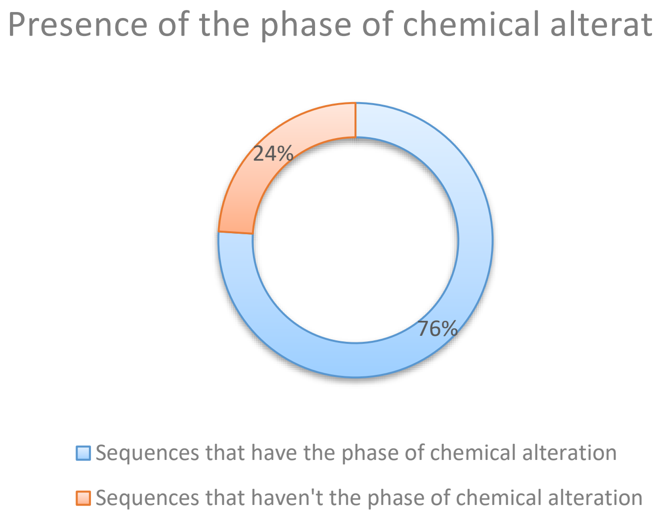

Figure 9.3: Graph showing the percentage of the two macro phases identified

Because of the different origin of the alterations (chemical and mechanical) the interpretation of the PDAs will be subdivided in the two macro-phases individuated. The first macro-phase was probably the result of two different taphonomic processes occurred in two different moments, hardly to be disentangle one from the other. The first taphonomic process is linked to the abandonment of the lithic industry in an open air site, during which it was affected by trampling (edge crumbling) (e.g. Asryan, Ollé, and Moloney 2014; McPherron et al. 2014). The second one is linked to the transport of the lithic assemblage from the open-air site to the karst fissure. This process is compatible with the formation of rounding, polishing and of a second generation of edge crumbling (e.g. Mazzucco et al. 2013; Burroni et al. 2002). The presence of these three PdAs on the surface of the lithic artefacts is due to a slow movement of the sediment containing the archeological materials through a slope system. (Burroni et al. 2002; Wood and Donald 1978). The difficulty relies on the attempt of disentangle the edge crumbling due to trampling and the edge crumbling due to transport because, as reported by McPherron, "....it seems likely that other post-depositional processes such a solifluction, cryoturbation, and fluvial transport may result in similar patterns"(McPherron et al. 2014). As described above, in the background section, one of the limit of this method is the problem of the individuation of the contemporaneity of different processes that affected the lithic surfaces, consequently edge crumbling can be due to trampling (so prior to transport) or to transport of the lithic industry inside de karst fissure. The lithic industry of PN13 is also affected by light rounding and polishing (see tab. 5 and 6), similar to those that can be obtain putting experimental lithic flakes for few hours in a tumbling machine (Mazzucco et al. 2013). The presence of these two PdAs and the presence of edge crumbling, mainly characterized by isolated and shallow edge removals spread over all the edges (see tab.2), can relate this macro-phase to events such as a mud-flow or earth-flow, carrying rubble with fossils and artifacts with probably a previous phase of trampling (Giusti and Arzarello 2016; Arzarello et al. 2012). The slight development of the all PdAs referable to this macro phase indicates that the transport was short and started from an area close to the karst fissure. Furthermore, it should have occurred a short time after the abandonment of the lithic industries. These interpretation agrees with the studies conducted on the taphonomy of the faunal remains (Bagnus 2011), on the spatial analysis of the finds and on the formation process of the site (Giusti and Arzarello 2016). The second macro-phase is the result of the processes occurred during the burial of the lithic industry. As mentioned above, these macro-phase is characterized by two kind of chemical alteration: white patina and Fe-Mn oxide patina. The formation of white patina, need of aqueous solutions for the process of kinetic dissolution of quartz and amorphous silica at ambient temperature (c. 0–25°C) (Glauberman and Thorson 2012; Dove and Nix 1997; Dove et al. 2008; Burroni et al. 2002). The artefacts with white patinas are commonly present within limestone terrains (as the PN13 sediment) because the increases in pH (alkalinity) and temperature raise the rate of quartz dissolution and the concentration of dissolved silica at chemical equilibrium (pH between 4-9 are typical of the groundwater) (Burroni et al. 2002; Glauberman and Thorson 2012). The presence of alkaline groundwater solutions in these terrains enhances the mobility of dissolved silica, which leads the formation of patinas (Dove et al. 2008; Dove and Nix 1997). Laboratory experiments on the white patina formation indicate that at a given temperature, the greatest leach rates occur during the early stages, then the rates tend to reduce. One reason for the decrease is that, as time increases, the surface solution becomes more saturated, which retards subsequent silica removal, but in many archeological contest this situation may not apply because the surface solution is constantly replaced (Burroni et al. 2002). In PN 13 the presence of with patina is generally very light (see Tab. 4), probably due to the absence of water circulation in the karst fissure. Presence of water circulation in the karst cave has been suggested by Bagnus (Bagnus 2011), but it is ascribed to the presence of moisture in the sediment (Giusti and Arzarello 2016). The presence of Fe-Mn oxides patinas is due to the precipitation, on the lithic surfaces, of oxides and hydroxides (Hill 1982) of manganese and iron dissolved in the water present in the soil. The source of the manganese can be organic: if the origin of the MnO_2 is imputable to the decomposition of organic materials due to bacteria (Marín-Arroyo et al. 2014) or may derive from the manganese and iron present in the surrounding limestone rock dissolved by groundwater (Hill 1982). This patina affects the 70% of the PN13 lithic finds and of them, the 62% present an elevated intensity of the patination (between the 50% and the 100% of the surfaces). The spatial distribution of the finds affected by the patination follows a random dispersion model (Giusti and Arzarello 2016). The presence of this patina can attest a presence of organic material in the deposit that were introduced as carcass of animals still partially articulated (Bagnus 2011) or entire (the fissure like natural trap?), then disarticulated by the subsequent material inputs (Giusti and Arzarello 2016). The difference of moisture of the sedimentary body, given the relationship between this type of coating and water, could also be accounted for the wide random spread and development of this type of patina, as supposed by Giusti (Giusti and Arzarello 2016). The randomized presence of edge crumbling removals, after the first macro-phase, can be explained as a possible effect of different phenomena: sediment consolidation (Eren et al. 2011), violent sediment movement correlated to the seismic activity of the region (Giusti and Arzarello 2016; Bertok et al. 2013), use of explosive due to the mining operation and not last the lithic finds could have been damaged during excavation activities. Analyzing the distribution of the different PdAs sequences among the different SUs (Fig. 10) it is possible to observe that the principal sequences identified (E-R=P-M; E-R=P) are present in all the SUs, and in all the cases the general sequence highlighted(E-R=P-W-M) is applicable in all the SUs; the only variable that seems to influence the number of sequences for the different SUs is the number of lithic finds found in the SUs. Which means, probably, that all the lithic artefacts, independently from the SUs of provenience, were affect by the same general sequence of process, thus suggesting that the differentiation of the SUs is the result of a gravitational selection of chaotic materials coming from a nearby narrowed area, carried into the fissure by the same type of phenomena (mud-flow or earth-flow), thus confirming the data obtained by other works (Giusti and Arzarello 2016; Arzarello, Peretto, and Moncel 2015; Arzarello et al. 2012). Despite the evaluation of the state of preservation of the lithic assemblage conducted at naked eye during the technological analysis attested that the whole series of artefacts was characterized by a very good state of preservation (Arzarello, Peretto, and Moncel 2015; Giusti and Arzarello 2016; Arzarello et al. 2012), the present study on the PdAs carried out through microscopical analysis attests that this lithic industry is affected by various alterations. At the end of the use-wear study only 5 flakes of the 68 selected from more than 300 finds show use-wear traces. The sample is very small but considering the formation processes of the archaeological deposit and its antiquity, the existence of these 5 artefacts with wear traces is a chance that gives the opportunity to assess, although partially, the subsistence activities carried out by the first habitants of Europe. The only activity carried out at PN13, inferable from the use-wear analysis, is the exploitation of animal resources to obtain meat (here referring to all soft tissue within the body, e.g., muscle, viscera, brains, and marrow). The exploitation of animal resources as food resources is the salient feature of the Oldowan diet. Large mammal bones with cut-marks are coeval with the oldest archaeological traces at 2.6 Ma (Domínguez-Rodrigo et al. 2005), suggesting that meat was a component of the Oldowan diet (Semaw et al. 2003; De Heinzelin et al. 1999).

Use-wear traces referable to butchery activities was found on ± 2.0 Ma Oldowan artifacts of Kanjera South, Kenya (Lemorini, Plummer, et al. 2014), on ± 1.78 Ma Oldowan artifacts from Aïn Hanech, Algeria (Sahnouni et al. 2013), and on artifacts from Koobi Fora at ± 1.5 Ma (Keeley and Toth 1981). The presence of use-wear traces linked to butchery activities on lithic tools is reported in many European and Asian sites like: Monte Poggiolo (C. Peretto et al. 1998; Longo 1994), level TD6 of Gran Dolina (E Carbonell et al. 1999) and Xiaochangliang (Shen and Chen 2000). Given the small number of identified traces of use, we cannot confirm or deny that the slaughtering activities were the only activities that took place in PN13.

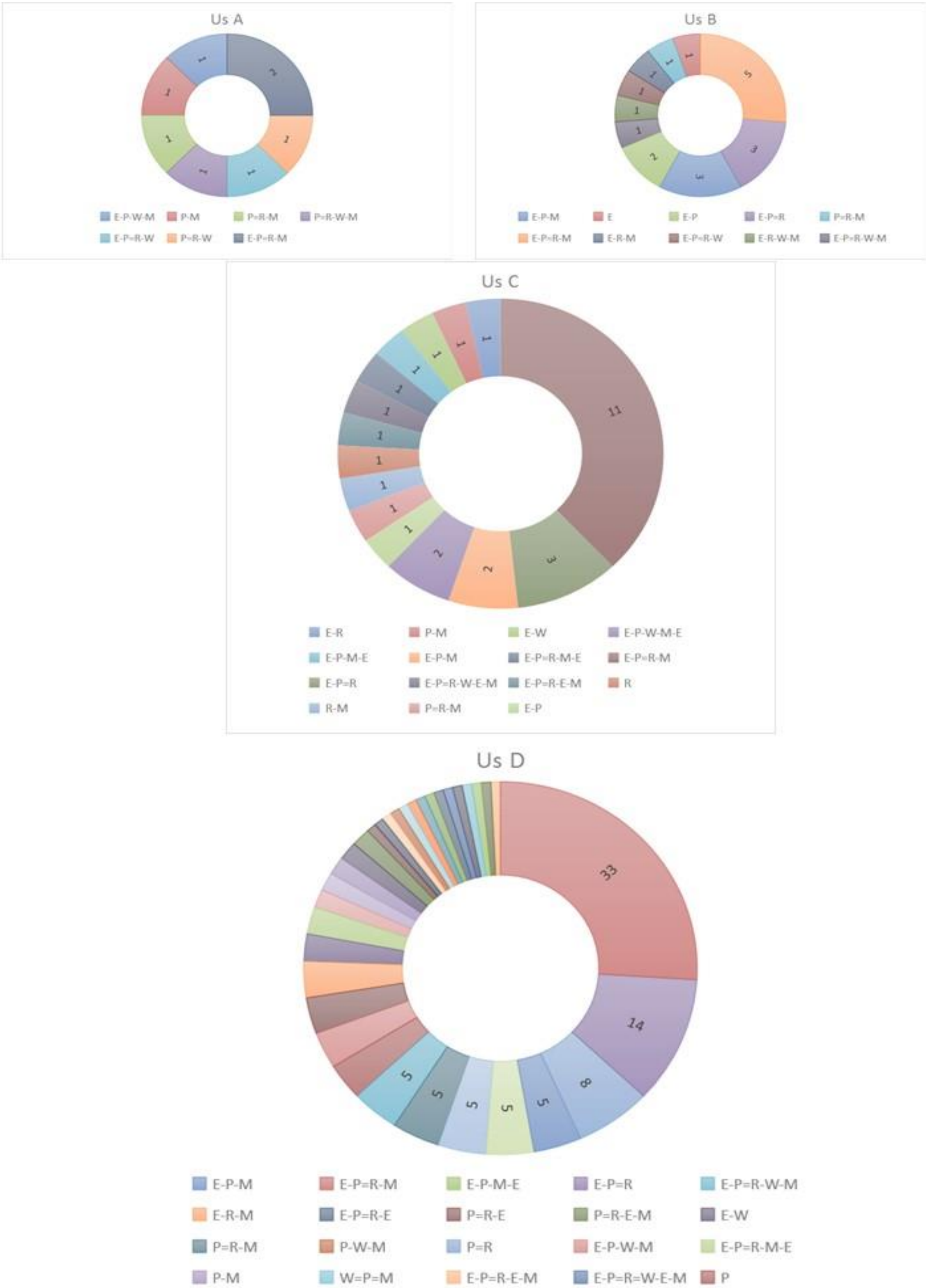

Figure 10.3: distribution of the PdAs series divided for S.U.

7. Conclusion

The results of the study of the taphonomy, of the PdAs sequences and the use-wear analysis of the lithic artefacts of PN13 provides a schematic reconstruction of the process of formation of the archaeological deposit of PN13 as exemplified by the graphic reconstruction (Fig.11). It is possible to identify a first phase characterized by the presence of a human group near the PN13 fissure where were carried out knapping and butchering activities, as testified by the completeness of the lithic assemblage (Arzarello et al. 2012; Arzarello, Peretto, and Moncel 2015) and by the use-wear traces. The second phase corresponds to the abandonment of the site as testified by the presence of trampling on the artefacts edges. After that phase, which should not be long-lasting, it was individuated a third phase characterized by mud-flow or earth-flow, carrying rubbles with fossils and artifacts and filling the fissure. The last phase is the presence of humidity in the sediment that led to the formation of chemical alterations. This study shows how useful and important is the study of taphonomy of stone tools for the reconstruction of the formation processes of an archaeological site. Although it would be important to continue studies about the formation processes of PDAs on the stone tools focusing the attention only on them and not only (or primarily) on the problem of distinguishing PDAs from use-wear traces. This approach transforms PDAs from problems to a powerful means of analysis of archaeological sites.

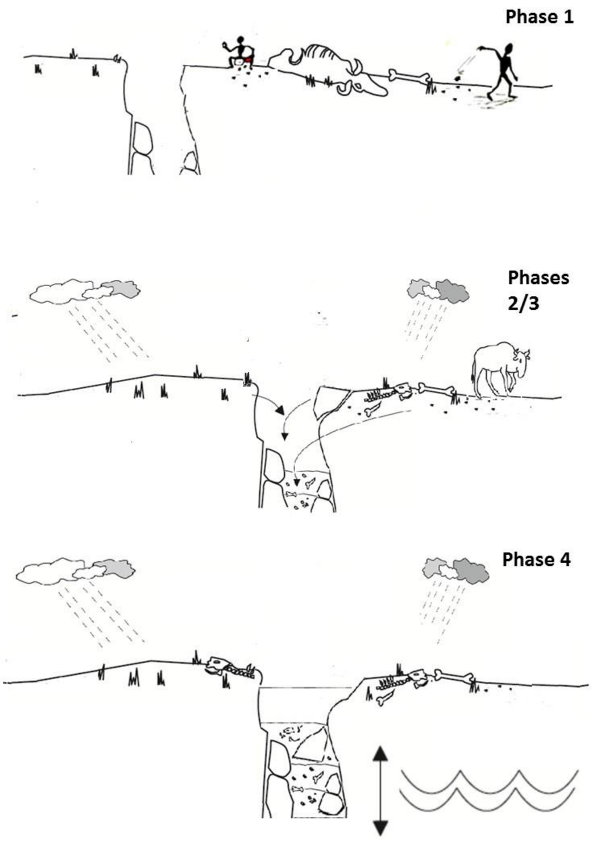

Figure 11.3: phase 1 – settlement; production and use of the lithic industry; phase 2/3 – creation of the mechanical alterations; 4 - creation of the chemical alterations.

CHAPTER IV

THE USE WEAR ANALYSIS OF THE LITHIC INDUSTRY OF THE LOWER PALEOLITHIC SITE OF GUADO SAN NICOLA (ISERNIA, ITALY).

1. Introduction

The Lower Paleolithic site of Guado San Nicola (GSN) is located near the village of Monteroduni (Molise, Central Italy). The stratigraphic units with traces of human occupation date to the transition between the interglacial and the glacial marine isotope stages MIS 11 (i.e. 400 ± 9 ka) and MIS 10 (i.e. 345 ± 9ka). The lithic industry is characterized by the presence of bifaces and of the *Levallois débitage*, of which GSN represents the most ancient evidence in Italy and one of the earliest evidence in Western Europe (Pereira et al. 2016; Peretto, Arzarello, et al. 2015; Muttillo, Lembo, and Peretto 2014). The considerable archaeological record found during the excavation campaigns, the clear chrono-stratigraphic context, and the early presence of the *Levallois* method, make Guado San Nicola one of the sites that can strongly contribute to a better understanding of the dynamics of human settlement in the Italian peninsula and in the Mediterranean basin during the Lower/Middle Paleolithic transition during Middle Pleistocene. The main objective of this work is thus the use-wear analysis of the lithic industry to understand the types of activities carried out in the site but it has also a particular objective, i.e. understand how the *Levallois* products were used, if there were particular uses of these artefacts or if there were different uses between the *Levallois* products and the products obtained with other methods. This work focuses on flakes and for these reason bifaces were excluded from this study but of course not the bifaces' manufacturing (and maintenance) flakes.

1.1 Background

The emergence of the Levallois method can be interpreted from two different points of view: as a consequence of the diffusion of new human species with innovative technology and consequently as a single emergence of a new method (Foley et al. 1997) or as technological multiregional evolution from a common technological substratum (evolution from the "shaping-façonnage" for the bifacial production) (Rolland 1995; Adler et al. 2014; White and Ashton 2003). The oldest (and well-dated) European sites where Levallois method is present are: Guado San Nicola - 379 Ka (Italy; Peretto et al. 2015), Botany Pit - 324 Ka (UK; Nick Ashton and Scott 2016) and Nor Geghi - 308 Ma (Armenia; Adler et al. 2014). Looking at the chronology and at the geographical position of these sites it seems that the emergence of Levallois is more likely a simultaneous process than a process of diffusion. Furthermore, around 300 Ka, in all the sites where *Levallois* reduction sequences are attested, there is a simultaneous production of bifaces (Arnaud et al. 2016). Thus, it is interesting to see if in GSN exist a relationship between the production of *Levallois* blanks and the bifaces manufacturing flakes (Adler et al. 2014).

2. Guado San Nicola

The site of Guado San Nicola was discovered in 2005 during the investigation of the Acheulean site of Colle delle Api (Marta Arzarello and Peretto 2006; Ricciardi 2006; Sala and Thun Hohenstein 2006). The site is located at 100 m from the Colle delle Api site and has been subject of systematic excavations since 2008. The excavation area is of 98 m^2 with a stratigraphic sequence of more than two meters and several archaeological levels were recognized. These levels, chronologically referable between the end of MIS 11 and the beginning of MIS 10 by biostratigraphic and geochronological (40Ar/39Ar and ESR methods) data, (Nomade and Pereira 2014), are rich in lithic and paleontological remains, including bifaces and Levallois flakes and cores

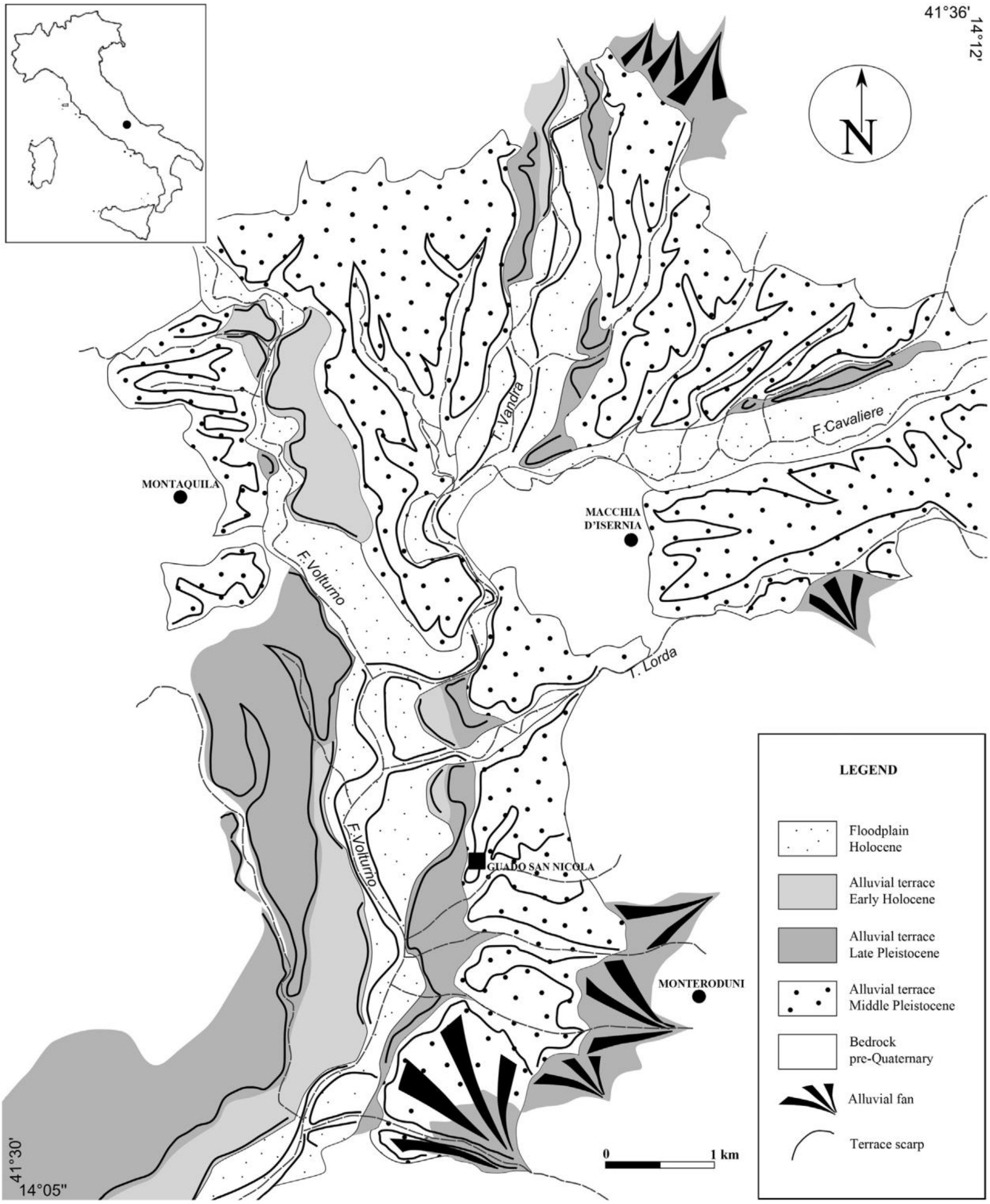

Figure 1.4: Guado San Nicola. Geomorphological sketch of the area and site location (Coltorti and Pieruccini 2014).

2.1 Geomorphological setting

The site of Guado San Nicola is located in the Volturno valley, on left bank of the Volturno river, approximately 2 km north-west from Monteroduni (Molise, Central Italy), at ~250m a.s.l and ~30m above the (current) floodplain of the Volturno river (Fig. 1). This sector of the Volturno valley separates the two major orographic systems of the Molise Apennines: the southern reliefs of the Matese and the western reliefs of the Mainarde. The site is placed near the upper area of the oldest fluvial terrace (Mauro Coltorti and Cremaschi 1981; Brancaccio et al. 1997), in an area delimited to the west by the Volturno river, to the north by the Lorda stream (a tributary of the Volturno river) and to the south by a small valley originating from a spring located in the distal part of an alluvial fan (Fig. 1) (Mauro Coltorti and Pieruccini 2014). This fluvial terrace belongs to the "main filling" of the Isernia basin (Mauro Coltorti and Cremaschi 1981): this morpho-lithostratigraphic unit, which represents the first cycle of Quaternary deposition in the Monteroduni area, mainly consists of polygenic gravelly, silty, and clayey deposits that contained interstratified tephra layers (Peretto, Arzarello, et al. 2015) The unit was attributed to the Middle Pleistocene thanks to different studies (morphostratigraphic considerations, radioisotopic dating of volcanic deposits found in the succession and palaeomagnetism) carried out during the study of the archaeological site of Isernia La Pineta, 10 km far from the Guado San Nicola site (Coltorti and Cremaschi 1981; Coltorti et al. 1982; Coltorti and Pieruccini 2006).

2.2 Stratigraphy

During the systematic excavations of Guado San Nicola a 2m thick and articulated stratigraphic sequence was identified. A 20m depth stratigraphic pit sample was realized next to the excavation and another series of stratigraphic sections were investigated in the area. The studies of these samples confirmed the sequence highlighted in the archaeological site. From bottom to top, the stratigraphic sequence identified is composed of the following stratigraphic units (S.U.) (Fig. 2):

- S. U. E: (≈ 1.0 m thick) deposit of gravels, composed of sub-angular and sub- rounded clasts of different sizes in a sandy matrix; sterile level;
- S. U. D: alternated layers and lenses of pyroclastic deposits rich in phenocrysts of sanidine and piroxene, subordinate micro pumice fragments and a cinerite matrix with abundant fine-grained ashes; no archaeological remains;
- S. U. C: formed by coarse to fine-grained ash layer with sub-rounded and sub-angular pumice and rock fragments, rich in pyroclastic sediments and reworked pumices. An abundance of lithic and faunal remains characterizes this unit (strongly affected by post depositional alterations);

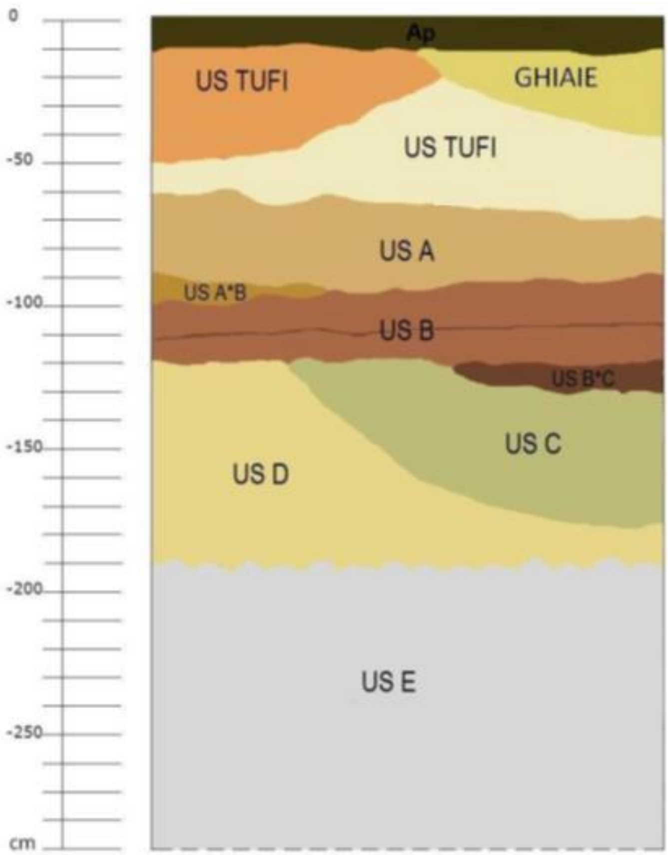

Figure 2.4: GSN: schematic reconstruction of the stratigraphic sequence (modified from Peretto et al. 2014).

- S. U. B*C: formed by gravels with a pyroclastic matrix, it is present only in a limited portion of the excavated area; this unit is interpreted as a debris flow and it contains a high concentration of lithic and faunal remains in a good state of preservation;
- S. U. B: formed by gravels with sub-rounded and sub-angular clasts in a cinerite rich in ash of pyroclastic products and altered glass matrix. This unit, locally constituted by two different debris flows, is rich in lithic and faunal remains with a pretty good state of preservation;
- S. U. A: formed by micro pumice with a low presence of cinerite and gravels, produced by an earth flow; this unit, lacking in archaeological material, displays a homogenous population of sanidine crystals;
- S. U. Tufi: pyroclastic deposit with an abundance of coarse pumice dispersed in a fine-grained matrix. This unit, without archaeological remains, is rich in pumices and other materials of pyroclastic origin, locally turned red due to alteration processes;
- S.U. Ghiaie: it overlays the stratigraphic sequence with a coarse gravel braided system.

The top of the alluvial terrace closes the stratigraphic sequence. It is composed by a rubified relict paleosoil (Argillisoil), characterised by a succession of decarbonated and argillic horizons, with clasts, strongly corroded, of flint and limestone (Peretto, Arzarello, et al. 2015; Coltorti and Pieruccini 2014).

2.3 Chronology

The chronological study was realized with two different methodologies: geochronological analysis by 40Ar/39Ar on single-crystal and ESR/U-series on teeth. Three samples for the 40Ar/39Ar datings were taken directly in the site from the S.Us. C, A and Tufi. Another sample for the 40Ar/39Ar was taken from volcanic sands found in a drill core made below the S.U. E, until the 8 m of depth. Six teeth (horses and rhinoceros) from the S.U. B (3 teeth), B*C (1 tooth) and C (2 teeth) were selected for the ESR/U-series analyses. Gamma-ray measurements and sediment sampling were done in situ, for the dose rate determination (Pereira et al. 2016). The S.U. C is dated 400 ± 9 ka by 40Ar/39Ar on the reworked sanidine grains (maximum age). For the S.U. The dating made with 40Ar/39Ar gave a proposed deposition age of 379 ± 8ka. For the S.U. Tufi the 40Ar/39Ar dating gave a homogeneous age of 345 ± 9ka (Pereira et al. 2016) (Fig. 3). The Electron Spin Resonance and Uranium series (ESR/U-series) method applied on the 6 teeth sampled from the different stratigraphic units (C, B*C and B) gave an average age of 364 ± 36 ka. Altogether, the radio-isotopic investigations show that the Guado San Nicola sequence was deposited during the transition between the interglacial and the glacial marine isotopic stages MIS 11 (i.e. 400 ± 9 ka) and MIS 10 (i.e. 345 ± 9ka) (Pereira et al. 2016).

2.4 Faunal remains

During the archaeological investigations, more the 1200 faunal remains were found and most of them have a bad preservation (Peretto, Arzarello, et al. 2015). The faunal assemblage coming from the S.Us. C, B*C, B and A*B, in order of abundance, is composed of: *Cervus elaphus acoronatus*, Cervidae, *Equus ferus* sp., *Palaeoloxodon* sp., *Bos primigenius, Stephanorhinus kirchbergensis*, *Ursus* sp., *Dama* sp. and very rare traces of Megacerini (Table 1). The scarcity of identifiable faunal remains in each stratigraphic unit did not allow the identification of variations within the faunal sequence, and the assemblage was therefore considered as a whole, thanks also to the relatively short time of the stratigraphic units deposition (Sala et al. 2014).The faunal composition suggests the occurrence of an environment characterized by areas with woodland and shrub, occupied by cervids, and with open grassland, populated by elephants, aurochs and horses. The presence of Merk's rhinoceros and of aurochs, together with the absence of cold indicators, can be linked to one more temperate or warm temperate phase. The presence of *Cervus elaphus acoronatus* and horses with a relatively large body size, allows the attribution of the faunal assemblage to the Fontana Ranuccio faunal unit (FU) (Gliozzi et al. 1997; Masini and Sala 2007), confirming the assignment of the site to the latest part of MIS 11.

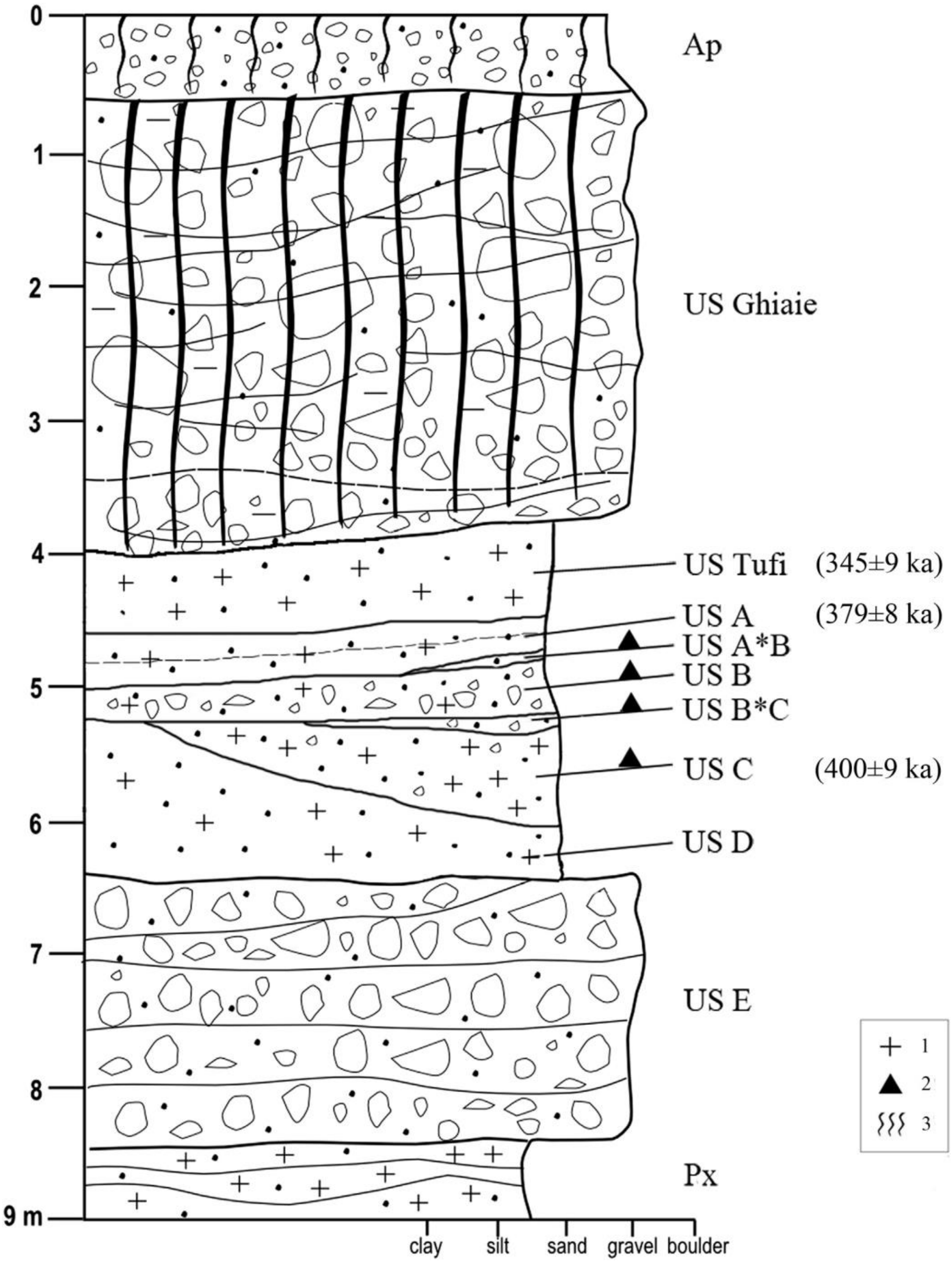

Figure 3.4: Guado San Nicola. Stratigraphic sequence with 40Ar/39Ar dating. 1. Pyroclastics; 2. Archaeological remains; 3. Soils; (modified from Coltorti and Pieruccini 2014)

Despite the bad conservation of the faunal remains, the zooarchaeological analysis led to the identification of some intentional fractures associated with anthropic activities aimed at marrow recovery, mainly on elephant, aurochs and rhinoceros diaphyses. Cut marks were also identified on several anatomically and taxonomically determined remains of horse and rhinoceros, allowing their attribution to different stages of butchery (Sala et al. 2014). Anyway, the scarcity of identified remains and the scarce anatomical representation of carcasses in addition to the bad bone preservation, prevented the reconstruction of the modalities of prey exploitation.

Table 1.4: Guado San Nicola. Faunal composition grouped by stratigraphic unit. In the S.U. C elephant is overestimated due to the presence of fragments of tusk and dental plates (data from Sala et al 2014).

NRdT	**A*B**	**B**	**B*C**	**C**
Ursus sp.			1	
Palaeoloxodon sp.		6	5	30
*Stephanorhinus kirchbergensi*s	2	7	3	4
Equus ferus ssp.		32	12	3
Cervus elaphus acoronatus		7	5	20
Dama sp.			1	1
Megacerini			1	2
Cervidae	1	6	2	9
Bos primigenius		8	3	6
Ungulata		10	6	4
Antler fragments		23	24	260
Unidentified	16	175	82	475
Total	19	274	145	814
Total identified remains	3	66	33	75

However, the zooarchaeological analysis of the faunal remains of GSN suggests that the assemblage was the result of anthropic accumulations, subsequently modified by different post depositional factors (Peretto, Arzarello, et al. 2015).

2.5 Lithic assemblage

The lithic assemblage of GSN was mostly obtained through the exploitation of flint and rarely through the exploitation of limestone (the limestone assemblage is composed of just a few elements and most of them are unworked, not allowing the understanding of the reduction sequences or of the techno economic system, therefore it was not considered in these study) (Muttillo, Lembo, and Peretto 2014; Pereira et al. 2016; Peretto et al. 2015). The flint lithic assemblage found during the excavations, amounts to 4168 elements, and it is divided as follows: 1417 from S.U. C, 626 from S.U. B*C, 2018 from S.U. B and 107 from S.U. A*B (Table 2). S.U. A*B is not significant for statistical purposes because of the paucity of the lithic pieces and the incompleteness and fragmentation of the reduction sequences, for these reasons it was not considered in this study. Two components characterize the lithic assemblage, one linked to bifacial shaping and one linked to *débitage*, with the use of different methods that lead to the exhaustive exploitation of the raw material. Several types of flint have been used in the lithic assemblage and according to their texture, granulometry and colors, four groups were distinguished: aphanitic flint, micro brecciated flint, macro brecciated flint and silicified limestone. These raw materials are locally available near the site and they were collected in a secondary position in the detrital deposits where flint is present in the form of slabs. Blocks of flint with a roughly parallelepiped shape, partially covered by cortex, poorly preserved and with dimensions between 5 and 15 cm were also exploited Most of the raw materials used has a good attitude to knapping and a high degree of silicification, though some types of flint are characterized by a series of parallel and crossed fracture planes and by the presence of inclusions. The presence of inclusions and of fracture planes does not seem to affect the technical choices of the knappers. In general, the characteristics of the raw materials influenced the *débitage* reduction sequences more in terms of length than of management of the core, and did not affect the component of bifacial shaping (biblio). The bifacials were produced exploiting slabs of flint and only very rarely from big flakes. The representation of bifaces is not very high with respect to the composition of the whole lithic assemblage (3% in S.U. C;4% in S.U. B). Retouched tools are rare and mostly obtained from the retouch of flakes almost exclusively result of an opportunistic *débitage*. The bifaces representation is more significant if compared with the other tools and constitutes between 35% and 40% of the formal tools. The composition of the lithic assemblage is more or less stable all along the stratigraphic sequence All the lithic assemblage is affected by a moderate sediment transport. This phenomenon is less pronounced for the remains from S.U. B and particularly the remains from S.U. B*C have a very good state of preservation even if was observed a weak dislocation and transport in the distribution of the artefacts. The lithic artefacts of the S.U. C are instead highly altered by mechanical, physical and chemical processes (Muttillo, Lembo, and Peretto 2014; Peretto et al. 2015; Peretto, Arzarello, et al. 2015).

2.5.1 Débitage.

The *debitage* methods used are the same all along the stratigraphic sequence, revealing a prevalence of the S.S.D.A. (*Système par Surface de Dèbitage Alternè*) method (Forestier 1993), followed by discoid *sensu sticto* (E. Boëda 1993) and discoid *sensu lato* débitage (Mourre 2003). The *Levallois* method (Boëda et al. 2008; Boëda 1993; Boëda 1991) is rare but present and it is significant especially in the S.Us. B*C and B, where the purpose of obtaining products with a predetermined shape becomes more evident (Peretto, Arzarello, et al. 2015; Peretto et al. 2014).

Table 2.4: Frequency of cores grouped by knapping method and strati- graphic unit (data from Muttillo et al 2014).

Stratigraphic unit	**S.S.D.A. cores**		**Discoid s.l. cores**		**Discoid s.s. cores**		**Levallois cores**		**Total**
	n.	%	n.	%	n.	%	n.	%	
A*B	5	71,4	2	28,6		0,0		0,0	7
B	103	61,7	38	22,8	12	7,2	14	8,4	167
B*C	26	53,1	15	30,6	3	6,1	5	10,2	49
C	40	59,7	17	25,4	7	10,4	3	4,5	67

An intense exploitation of the cores has been observed for all the methods and in all the S.Us., through a mixed technical system aimed at the maximum exploitation of the raw material, increasing the productivity of the *débitage* (Peretto, Arzarello, et al. 2015). The cores are usually exploited until the exhaustion of the raw material and when they were prematurely abandoned it is due to fractures (influencing the organization of the *débitage*), or knapping accident (usually hinged flakes) that would require a too expensive technical investment for the restoration of adequate convexities and angles. The dimensional data of knapping products cluster in small-medium values in all the anthropic levels (Peretto, Arzarello, et al. 2015). The S.S.D.A. method (Forestier 1993) involves the use of 2-7 striking platforms and each surface was used for the detachment of 2 or more flakes, the negatives of which serve as striking plat- forms for a further series of detachments. The S.S.D.A. flakes have an extremely varied morphology linked to the morphology of the core, to the organization of the *débitage* and to the length of the reduction sequence (Peretto, Arzarello, et al. 2015; Peretto et al. 2014).

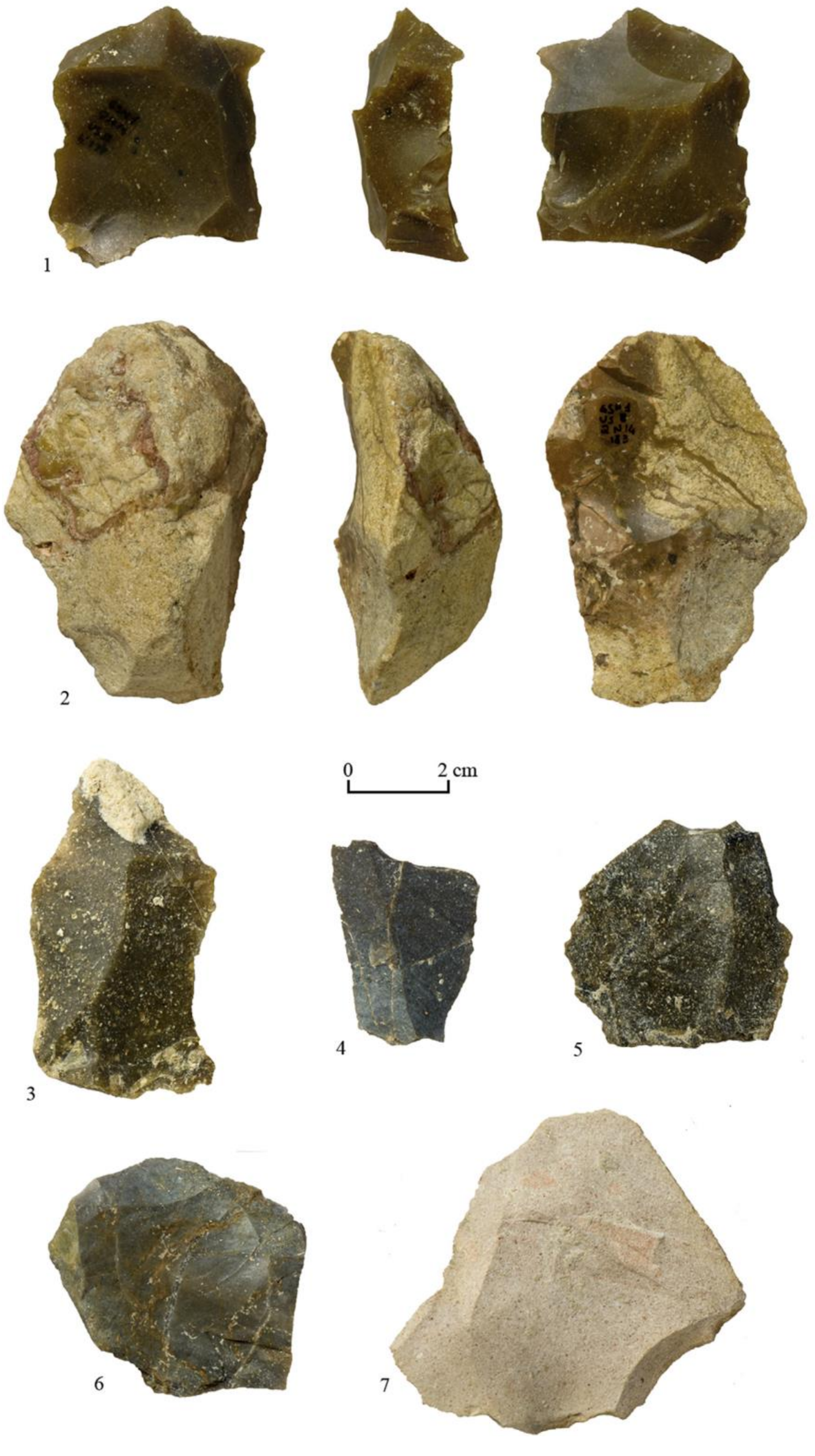

*Figure 4.4: Guado San Nicola. Levallois method. 1: preferential core (S.U. B); 2: recurrent core (S.U. B); 3, 4: recurrent unipolar flakes (3, S.U. B; 4, S.U. C); 5e7: preferential flakes (5, S.U. C; 6, 7: S.U. B*C).* (by Peretto, Arzarello, et al. 2015)

Generally, these flakes have a length/ width ratio greater than 1:1, a flat butt and the negatives are mostly orthogonal and, to a lesser extent, unipolar. The discoid *débitage* sensu lato, in which the inclination of the removals and the hierarchy of the surfaces could be different from the strict definition (Mourre 2003), in the Guado San Nicola lithic assemblage is characterized by the exploitation of a peripheral striking platform that separates two convex surfaces, generally asymmetric, through the detachment of short and slightly invasive flakes in a centripetal direction. Many of these cores are exploited on one surface and, only rarely and partly, also on the other surface. The abandonment of the cores usually coincides with the exhaustion of one of the convexities. The knapping products have mostly centripetal negatives on the dorsal face and, to a lesser extent, unipolar; butts are flats and only seldom dihedrals; often the flaking angle is greater than 90°(Peretto et al. 2014; Peretto, Arzarello, et al. 2015; Muttillo, Lembo, and Peretto 2014; Muttillo, Arzarello, and Peretto 2014). The discoid *débitage sensu stricto*, corresponding to the Boëda definition (Boëda 1993) is barely represented in the lithic assemblage but it was observed the application of an opportunistic knapping method in the final stage of the reduction sequence, as can be seen in some cores with intermediate characteristics between the discoid and the S.S.D.A. knapping methods (Peretto, et al. 2015; Peretto et al. 2014). The abandonment of the discoid cores is due largely to the depletion of the core itself and, in a few cases, to the flattening of one of the two convexities that would have required a shaping out of the core for the re-creation of a suitable convexity. The *Levallois* method (Boëda et al. 2008; Boëda 1993; Boëda 1991) is rare in the S.U. C but becomes more frequent in the upper units of the stratigraphic sequence where there is a greater representation of the different stages of the *Levallois* reduction process (Fig. 4). The Levallois assemblage (Table 3), revealing careful preparation/management/maintenance of flaking platforms and convexities, indicates the ability to prepare and re-prepare cores aimed to the production of predetermined flakes. The raw material chosen for the Levallois method is of good quality (no fractured slabs or cobbles are exploited) and is better than the one used for bifacial shaping.

Table 3.4: Variability of Levallois method, grouped by stratigraphic unit (data from Muttillo et al 2014).

S. U.	**Levallois lineal**		**Levallois rec. cent.**		**Levallois rec. uni.**		**Levallois rec. bip.**		**Levallois indet.**				
	Cores	Flakes	Cores	Flakes	Cores	Flakes	Cores	Flakes	Cores	Flakes	Total	Total F.	Total C.
B	4	8	7	6	1	13		1		29	**69**	**44**	**12**
B*C	2	5	2	4	1	7				6	**27**	**22**	**5**
C	2	4	1	1		5				7	**20**	**17**	**3**

The raw material consists of ovoid cobbles and quadrangular slabs and both morphologies are exploited by recurrent centripetal, unipolar and lineal *Levallois* (Boëda 1994). In some cases, large flakes are also used as cores applying a centripetal *débitage*. The exploitation of the *Levallois* cores is intensive and normally proceeds until the total exploitation of the raw material volume. *Levallois* flakes (n = 96) are mostly referred to the *plein débitage* phase although some can be referred to the preparation or ri-preparation of the convexities. Most of the *Levallois* flakes are obtained through a recurrent method, mainly unipolar and, to a lesser extent, through a centripetal or lineal *Levallois* method. The flakes are usually small-medium sized and usually the preferential products are bigger than the recurrent flakes. The unipolar method is usually attested for the final stages of production and it generates products that tend to be longer than wider. It should be noted that 2 conjoining *Levallois* flakes were discovered in the S.U. B*C i.e. two debordant flakes, linked to the preparation of the core convexities, belong to a recurrent centripetal *débitage* (Peretto et al. 2014; Peretto, Arzarello, et al. 2015; Muttillo, Lembo, and Peretto 2014; Muttillo, Arzarello, and Peretto 2014). Retouched tools are not frequent in the GSN lithic assemblage. They become more frequent in the upper units of the stratigraphic sequence, with a greater diversification, as well as systematization and standardization of the retouching characters. The most common retouched pieces are sidescrapers and denticulates, followed by notches, endscrapers and Tayac points, while flakes with abrupt retouch are very rare. Along the stratigraphic sequence, there is an upward increase of denticulates and notches together with a decrease of sidescrapers. Among the sidescrapers, simple convex scrapers, bifacial scrapers and convex convergent scrapers are common (Table 4) (Peretto et al. 2014; Peretto, Arzarello, et al. 2015; Muttillo, Lembo, and Peretto 2014; Muttillo, Arzarello, and Peretto 2014).

Table 4.4:Composition of the tool-kit, grouped by stratigraphic unit (data from Muttillo et al 2014).

Retouched tools	**S.U. A**	**S.U. B**	**S.U. B*C**	**S.U. C**
Sidescrapers	1	41	7	29
Denticulates	1	62	7	26
Notches	1	25	1	9
Endscrapers		6		2
Tayac point		1		1
Retouched Flake		3		1
Total	**3**	**138**	**15**	**68**

2.4.2. Bifacial shaping

Bifaces and the *shaping* flakes are present in all the stratigraphic sequence (Tab.5). Bifacial shaping is mainly made on slabs and more rarely on flakes. In most cases, for the bifacial shaping were used medium sized flattened slabs of flint, characterized by two parallel and opposite surfaces with thin cortex of. The aphanitic flint is the most exploited type of raw material for the shaping of bifaces; the exploitation of brecciated raw materials is also attested, despite their poor quality due to the presence of several fracture planes. A morphological and dimensional heterogeneity characterizes the set of bifaces all along the stratigraphic sequence, in the of cluster in the 60-90 mm size range in length and 40-60 mm size range in width and the pointed shapes prevail over the round ones (Muttillo, Arzarello, and Peretto 2014). Although there is a dimensional and morphological variability among the bifaces, the technical investment was focused on the shaping of the point and of the distal edges, which could represent the effective functional part. It does not seem to exist any relationship between bifaces morphology and type of raw material, in opposition to the “raw material model” reported by Ashton and McNabb (1994) and White (1998), that identifies in pointed forms the result of an adaptation to the limitations imposed by raw material (Peretto, Arzarello, et al. 2015)”. The *shaping* flakes, very thin and invasive, mostly belong to the latest stages of bifacial shaping (edges shaping) and were made through direct percussion by soft organic hammer. They are rarely used as blanks for tools (Muttillo, Arzarello, and Peretto 2014; Peretto, Arzarello, et al. 2015).

Table 5.4: bifaces and bifacial shaping flakes, grouped by stratigraphic unit (data from Muttillo et al 2014).

	S.U. B	**S.U. B*C**	**S.U. C**
Bifaces	86	13	43
Façonnage flakes	40	38	40

3. Materials and methods

This study began with the preliminary evaluation of the state of preservation of the lithic assemblage of GSN to identify the different PdAs that affected the lithic industry. In this way, it was possible to calibrate the analysis to be carried out and to set up different databases for recording the data. The considered sample is composed by all the *débitage* products (simple flakes and formal tool) of the S.Us. B, B*C, C while bifaces, cores and debris were excluded. In total, for this phase of the study were analysed 3061 different artefacts, equal to the 73% of the lithic assemblage.

3.1 Use-wear analysis of the lithic artefacts

Four criteria were applied to select artefacts for the use-wear analysis: completeness, presence of at least one functional edge (artefacts without potential functional edges were excluded from the analysis), morphology suitable for prehension and surface

Figure 5.4: Flint bifaces (1, 2: S.U. B; 3: S.U. C). (by Peretto, Arzarello, et al. 2015)

preservation (absence of marked post depositional alterations). The GSN considered sample is composed by 226 *débitage* products 113 come from the S.U. B, 75 come from the S.U. B*C and 38 come from the S.U. C (Tab. 6). The scarcity of products coming from the S.U. C, despite the abundance of the lithic industry of this S.U., is due to the strong presence of post depositional alterations (Peretto, Arzarello, et al. 2015; Muttillo, Arzarello, and Peretto 2014). The use-wear analysis of the GNS assemblage was carried out with an integrated approach that uses the low power approach (Odell 1986) in combination with the high power approach (Keeley 1980). Several works (e.g. Lemorini et al. 2014; Wilkins et al. 2015; Moss 1983; Beyries 1987; Ziggioti 2011; Van Gijn 2014; Berruti and Daffara 2014; Cruz and Berruti 2015;) show in fact that the use of both the methodologies integrated is more effective and productive.

Table 6.4: composition of the considered sample and composition of the sample with use-wear traces, grouped by stratigraphic unit.

Stratigraphic Unit	TOT.	Artifacts selected	%	Artifacts with traces	%
B	1636	113	6,9	45	2,8
B*C	484	75	15,5	22	4,5
C	941	38	4,0	15	1,6

The analysis of the macro-traces, or low power approach, provides information about the potential activities carried out (e.g., cutting, scraping, piercing, etc.) and general interpretation of the hardness of the worked materials. The hardness categories used to describe the worked materials are: soft (e.g. animal soft tissue, herbaceous plants and some tubers), medium (e.g. fresh wood and hide) and hard (e.g. bone, horn, antler, dry wood and stone). There are some materials with intermediate hardness or resistance such as soft/medium materials (e.g. fresh hide, wet softwood) or medium/hard materials (e.g. softwood, wet antler) (e.g. Lemorini et al. 2006; Lemorini, Plummer, et al. 2014; Odell 1981; Tringham et al. 1974; Semenov 1964). The analysis of the micro-traces or high power approach is the study of micro-edge rounding, polishes, abrasions, and striations. This kind of study was conducted to provide a more detailed understanding of the activities carried out with the lithic artefacts and to support the diagnosis of the processed materials (e.g. Lemorini, Plummer, et al. 2014; Lemorini et al. 2006; Rots 2010; Ziggioti 2005; Keeley 1980; Van Gijn 2014). The analysis of the lithic artefacts was conducted using three different types of microscope: a stereoscopic microscope Seben Incognita III with magnification from 20x to 80x, a metallographic microscope Optika B 600 Met supplied with oculars 10x and 5 objectives PLAN IOS MET (5-10-20-50-100x) and a Microscope Camera Dinolight Am413T. Together with the use-wear analysis was conducted a detailed study of the lithic taphonomy (Mazzucco et al. 2013; Burroni et al. 2002). (Tab.6). Each artefact was gently washed with warm water and soap, then washed for 3 minutes in a mixture of demineralized water (75%) and alcohol (25%) in an ultrasonic tank and open air dried. Each artefact was observed and analyzed in three steps: macroscopically at the naked eye, with a stereomicroscope Seben Incognita III with magnification from 20x to 80x and with a microscope Optika B 600 Met. with 5 objectives PLAN IOS MET (5-10-20-50-100x). Most of the post depositional alterations **(**PdAs**)** of mechanical origin (cracks, edge crumbling, fractures and rounding of edges and ridges) are visible at the naked eye and can be analyzed in detail with the help of the stereomicroscope (Lemorini, Plummer, et al. 2014; Burroni et al. 2002; Mazzucco et al. 2013; Eren et al. 2011; Asryan, Ollé, and Moloney 2014; Asryan 2015; Levi Sala 1986). The study of the bright spots (Moss 1983; Mazzucco et al. 2015; Levi Sala 1986) and of the polished surfaces (Moss 1983; Mazzucco et al. 2013; Burroni et al. 2002) was carried out through the metallographic microscope. The chemical modifications include various degrees of patination (Glauberman and Thorson 2012; Mazzucco et al. 2013; Asryan, Ollé, and Moloney 2014; Asryan 2015; Burroni et al. 2002; Van Gijn 1990), mostly visible at the naked eye, but also some stains on the lithic surfaces better discernible at greater magnification whit the stereomicroscope (Burroni et al. 2002).

4. Results

4.1 Taphonomic results

The taphonomic analysis of the sample has confirmed that between the different S.Us there are some differences concerning conservation (Peretto, Arzarello, et al. 2015). As already noted during the technological analysis of the lithic industry, the geomorphological analysis and the spatial analysis, S.U. C has suffered various heavy post depositional alterations process (Peretto, Arzarello, et al. 2015; Muttillo, Lembo, and Peretto 2014; Muttillo, Arzarello, and Peretto 2014). Thanks to the microscopic analysis it was possible to identify these alterations: polishing and rounding, edge crumbling, white patina and Fe-Mn patina (Tab.7). Polishing of the surfaces and rounding of the edges and of the ridges can be attributed to the transport of the lithic industry in the sediment (like a debris flow), edge crumbling can be due to the same phenomenon or to a trampling activity. White patina, although not very developed, testifies alkaline and wet conditions of deposition (Glauberman and Thorson 2012; Dove et al. 2008; Dove and Nix 1997; Burroni et al. 2002). The presence of rare spots of Fe-Mn patina is imputable to the decomposition of organic materials due to bacteria (Marín-Arroyo et al. 2014) or may derive from the manganese and iron present in the surrounding limestone rocks dissolved by groundwater (Hill 1982).

Table 7.4: post-depositional alterations, grouped by stratigraphic unit.

	S.U. B		**S.U. B*C**		**S.U. C**	
Pd.A.s	*%*	*N.*	*%*	*N.*	*%*	*N.*
Polishing and rounding	75,2	85	28	21	71,1	27
Edge crumbling	42,5	48	4	3	42,1	16
White patina	18,6	21	5,3	4	28,9	11
Fe-Mn patina	3,5	4	0	1	23,7	9

4.2 Use-wear analysis results

The use-wear analysis of the GNS lithic assemblage allowed to identify 82 artefacts with traces of use: 45 belong to S.U. B, 22 to S.U. B*C and 15 to S.U. C. (Tab.6). In percentage, the S.U. with the best relationship between the artifacts selected among the entire lithic industry and artifacts with wear traces is the S.U. B*C, probably due to the better preservation of the lithic industry. The use-wear analysis of the 38 artefacts belonging to S.U. C allowed to identify 15 flakes with wear traces (6 *Levallois*, 3 discoid and 6 opportunistic flakes. Among them, 4 artefacts (1 *Levallois*, 1 discoid and 2 opportunistic flakes) have two different zone of use (Z.U.) but in all the cases the two Z.U. are referable to the same type of traces. In S.U. C 19 different use-wear traces referable to 15 flakes were found. As shown in Tab 8 and in the graph (Fig.4) the only activity that was for sure carried out in the site is animal carcass processing, that includes the categories: butchering, hide, fresh bone and soft animal tissue listed in the table). The use-wear analysis of the 75 artefacts of S.U. B*C allowed to identify 22 artefacts with wear traces (7 *Levallois*, 3 discoid, 3 *shaping* and 6 opportunistic flakes). Four of them (1 discoid and 3 opportunistic flakes) have two different Z.U.: the discoid flake present the same type of traces on both the Z.U. while concerning all the opportunistic flakes, the two different Z.U. are referable to different type of traces. In S.U. B*C was found a total of 26 different use-wear traces referable to 22 artefacts. As shown in the table (Tab. 9) and in the graph (Fig.4) the two activities carried out are: animal carcass processing (that include the categories: butchering, hide, fresh bone and soft animal tissue listed in the table) that is the more representative activity and vegetal material processing. The use-wear analysis of the 113 artefacts from S.U. B allowed to identify 45 artefacts with wear traces (17 *Levallois*, 11 discoid, and 17 opportunistic flakes). Eight artefacts (5 *Levallois* and 3 opportunistic flakes) have two different Z.U.: all the *Levallois* and two of the opportunistic flakes present the same type of traces on both the Z.U. while concerning the third opportunistic flake the two Z.U. are referable to different type of traces.

Table 8.4: use-wear traces of the unit C, grouped by action, method of debitage and worked material. (Tran. Act. =transversal action; Long. Act. = longitudinal action; Mix = mixed action; Indet. = indeterminate action).

Worked Material	Discoid				Levallois				Opp.				Tot.	%
	Tran. Act.	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*		
Butchering		1			3	1			1	1			7	13,2
Fresh Hide						1							1	1,9
Soft animal tissue										1			1	1,9
Fresh Bone					1								1	1,9
Wood													0	-
Non woody plant													0	-
Indet Hard mat. (antler or bone)						1				2			3	5,7
Indet Pol.													0	-
Soft													0	-
Medium Soft										2			2	3,8
Medium Hard	1	2											3	5,7
Hard									1				1	1,9
Tot.	**1**	**3**	**0**	**0**	**4**	**3**	**0**	**0**	**2**	**6**	**0**	**0**	19	100,0
Tot. for method	**4**				**7**				**8**				19	100,0

*Table 9.4: use-wear traces of the unit B*C, grouped by action, method of debitage and worked material. (Tran. Act. =transversal action; Long. Act. = longitudinal action; Mix = mixed action; Indet. = indeterminate action).*

Material	Discoid				Levallois				Façonnage				Opp.				Tot.	%
	Tran. Act.	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*		
Butchering						1				1			3	5			10	38,5
Fresh Hide	1				1								1		1		4	15,4
Soft animal tissue		1				1											2	7,7
Fresh Bone																	0	-
Wood									1					1			2	7,7
Non woody plant																	0	-
Indet Hard mat. (antler or bone)																	0	-
Indet Pol.																	0	-
Soft																	0	-
Medium Soft						1								1			2	7,7
Medium Hard					2	1			1								4	15,4
Hard		2															2	7,7
Tot.	**1**	**3**	**0**	**0**	**3**	**4**	**0**	**0**	**2**	**1**	**0**	**0**	**4**	**7**	**1**	**0**	26	100,0
Tot. for method	**4**				**7**				**3**				**12**				26	100,0

Table 10.4: use-wear traces of the unit B, grouped by action, method of debitage and worked material. (Tran. Act. =transversal action; Long. Act. = longitudinal action; Mix = mixed action; Indet. = indeterminate action).

Material	**Discoid**				**Levallois**				**Opp.**				**Tot.**	**%**
	Tran. Act.	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*		
Butchering	1					8	2		1	2	1		15	28,3
Fresh Hide	2				1	3							6	11,3
Soft animal tissue		2							1	2			5	9,4
Fresh Bone	1								1		1		3	5,7
Wood									2	2			4	7,5
Non woody plant									1				1	1,9
Indet Hard mat. (antler or bon	1					1			1				3	5,7
Indet Pol.									1			1	2	3,8
Soft													0	-
Medium Soft					1	2							3	5,7
Medium Hard	1	1			2	1			2				7	13,2
Hard		2				1			1				4	7,5
Tot.	**6**	**5**	**0**	**0**	**4**	**16**	**2**	**0**	**11**	**6**	**2**	**1**	53	100,0
Tot. for method	**11**				**22**				**20**				53	100,0

Table 11.4: use-wear traces on tools, grouped by action, method of debitage and worked material. (Tran. Act. =transversal action; Long. Act. = longitudinal action; Mix = mixed action; Indet. = indeterminate action

Material	**Denticulates**				**Sidescrapers**				**Tayac point**				**Tot.**
	Tran. Act.	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*	
Butchering		2	1										3
Hide							1						1
Soft animal tissue													0
Fresh Bone					1								1
Wood	1												1
Non woody plant													0
Indet Hard mat. (Wood, antler or bo		2							1				3
Indet Pol.		1											1
Soft													0
Medium Soft													0
Medium Hard					1								1
Hard					1								1
Tot.	**1**	**5**	**1**	**0**	**3**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	12
Tot. for method	**7**				**4**				**1**				12

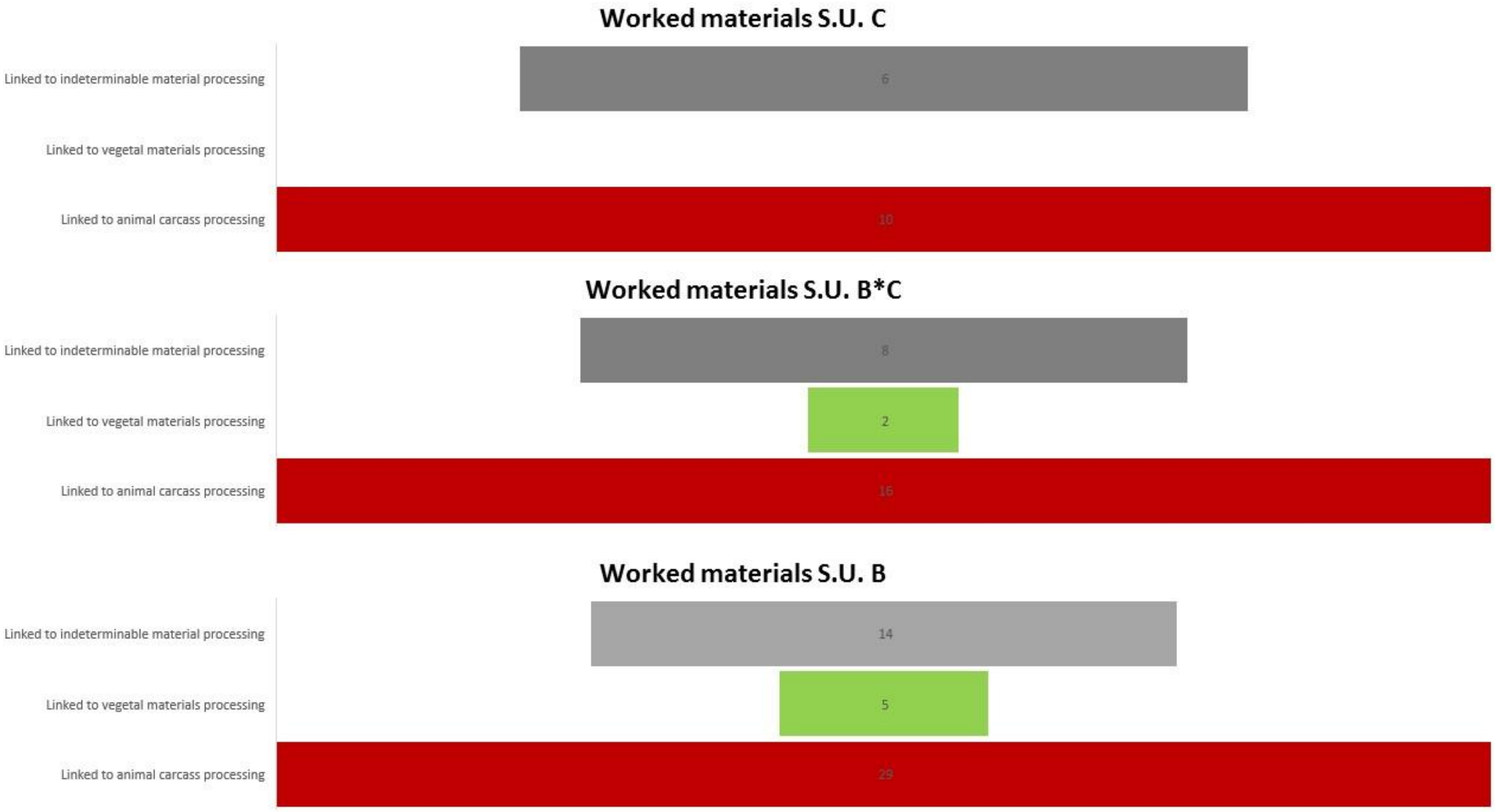

Figure 6.4: use- wear traces individuated grouped by stratigraphic unit and material processed.

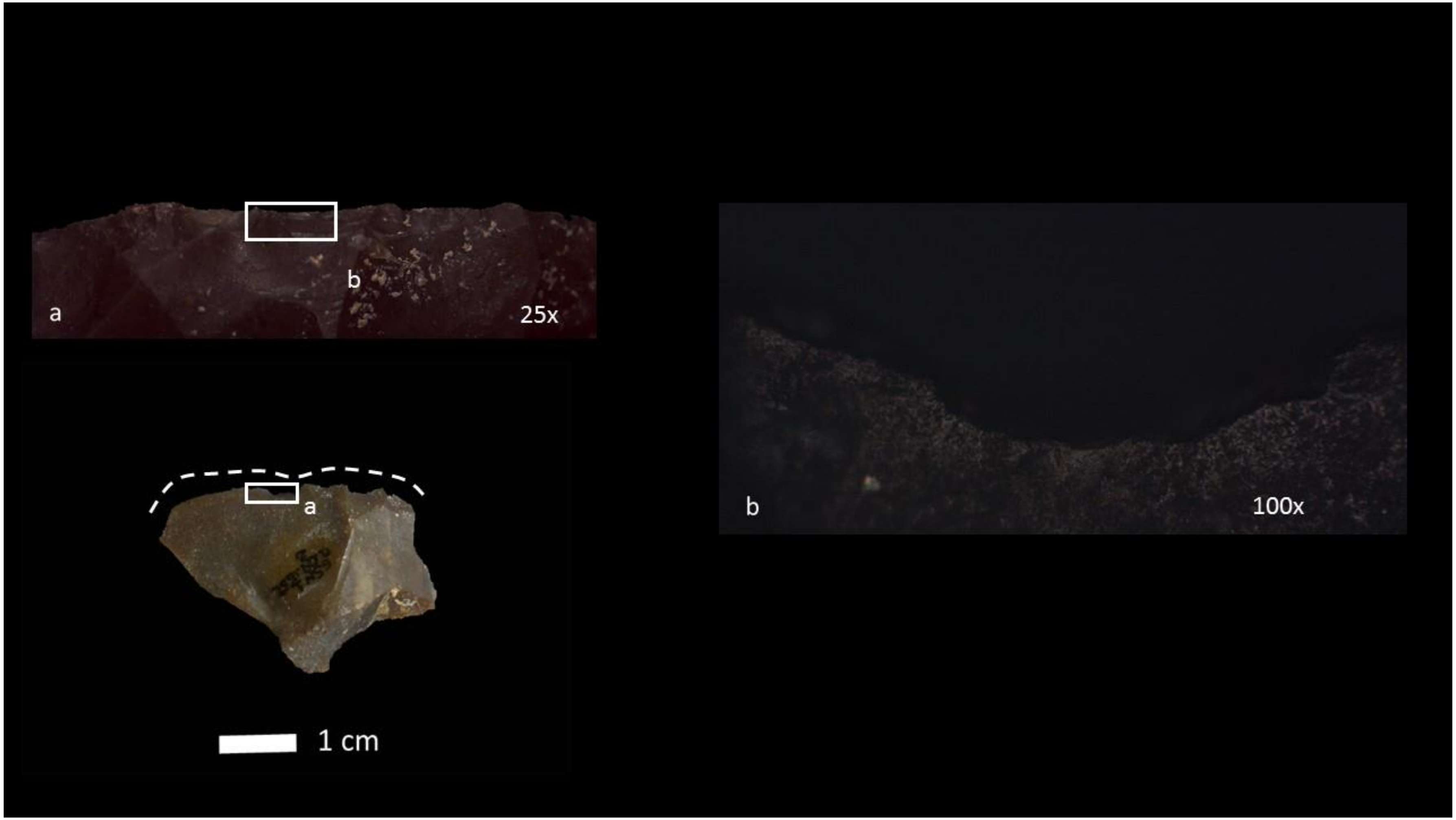

*Figure 7.4: flake B*C Q9 2 - b) band of rough polish (contact with fleshy tissues)*

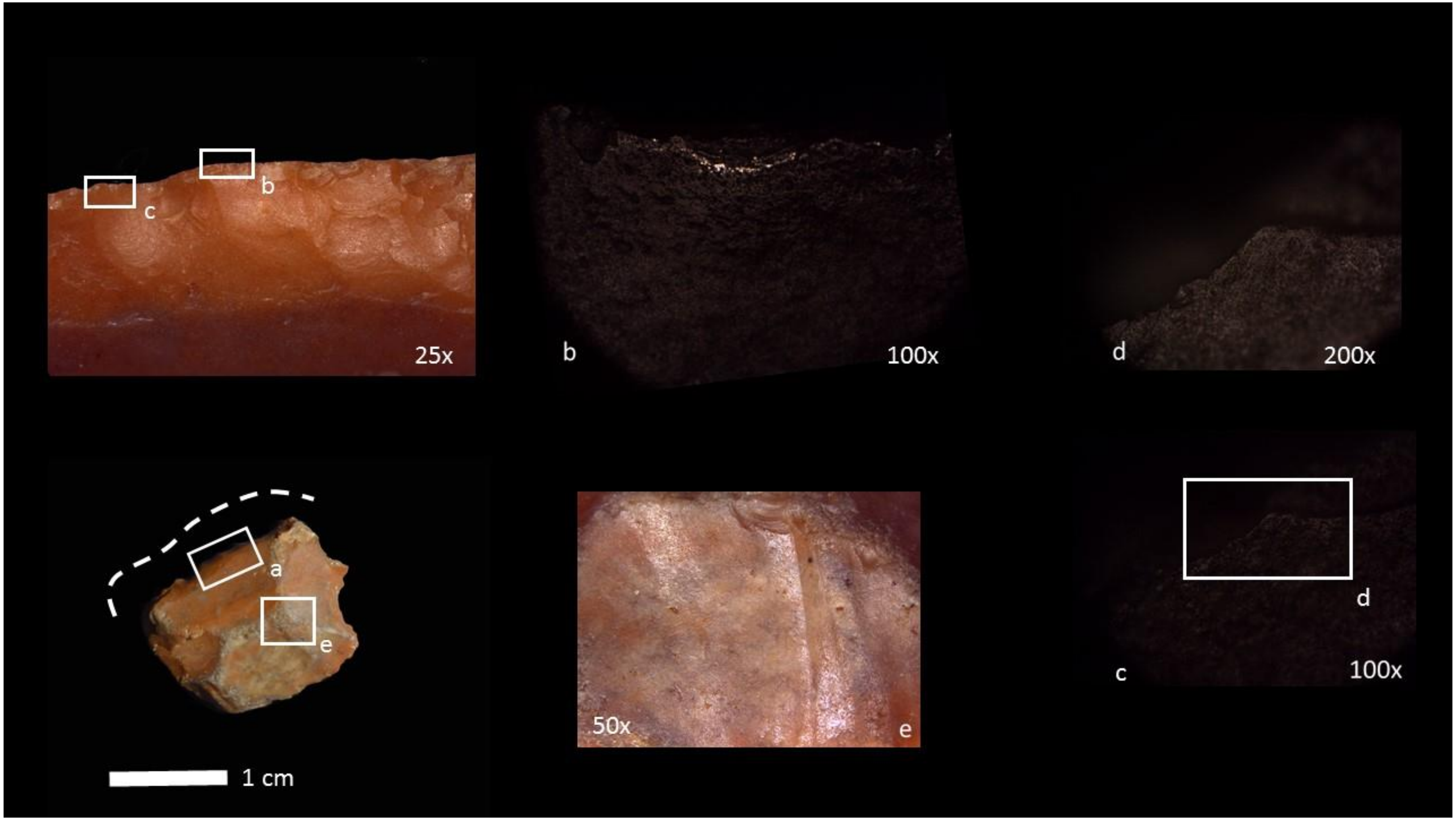

*Figure 8.4: side scraper B*C P9 12 – a) in this picture is possible see the altered surface interrupted by the retouch; b) small and localized areas of smooth and flat polish (contact with bone); c) band of rough polish (contact with fleshy tissues); d) edge rounding and polish characteristic of scraping hide; e) enlargement of the altered surface*

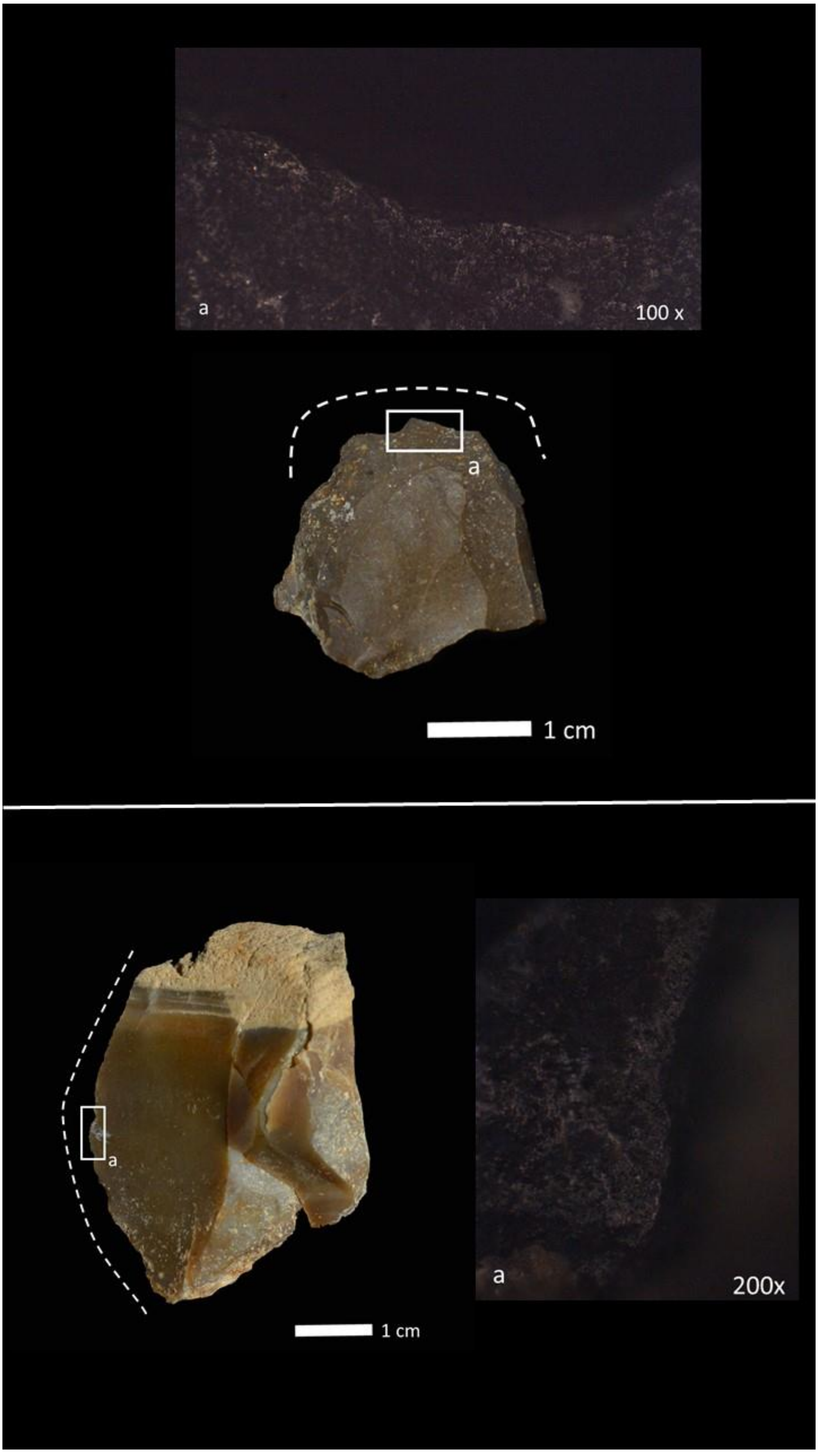

*Figure 9.4: above, flake B AZ14 36 - a) band of rough polish (contact with fleshy tissues) - down: flake B*C Q10 59 - a) polish with dommed topography typical of wood working.*

In the S.U. B, a total of 53 different use-wear traces referable to 45 artefacts were found. As shown in the table (Tab. 10) and in the graph (Fig.6) the two activities carried out, are: animal carcass processing (that include the categories: butchering, hide, fresh bone and soft animal tissue listed in the table) that is the more representative activity and vegetal material processing. If we look just at the formal tools, in all the assemblage, it is possible to observe that the activities carried out are the same of those carried out with the unretouched flakes (Tab. 11). Among the formal tools with use-wear traces, only 2 artefacts (both denticulates) have two different Z.U.: one of them present the same type of traces on both the Z.U. (work of indeterminable hard material with polish that may be linked to wood, antler or bone processing) while the other has one of its Z.U. liked to butchering activity and the other linked to the prehension of the tool.

5. Discussion

Only a few sites, in the word, with an age comparable with the site of GSN, provide comparative data in terms of use-wear analysis. Use-wear analysis have already been successful for older assemblages, such as the Oldowan sites of Koobi Fora (1.5 mya; Kenya; Keeley and Toth 1981) and Kanjera South (2.0 mya; Kenya; Lemorini, Plummer, et al. 2014). Other interesting data come from the Lower Paleolithic open-air site of Boxgrove (UK; about 500 ka), that provided identifiable use-wear traces on bifaces edges (Mitchell 1998), and from the site of Monte Poggiolo (Italy; about 900 ka; Peretto et al. 1998). Other sites comparable to GSN are the Acheuleo-Yabrudian laminar assemblage of Qesem Cave (Israel; 382-207ka; Lemorini et al. 2006), Isernia la Pineta (Italy, 583–561 ka; Longo 1994), Schöningen (Germany; 300 ka; Veerle Rots and Hardy 2015) and the site of Revadim (Israel; 500-300 ka; Solodenko et al. 2015). All these sites are located in quite different environments and although the lithic artefacts show different post-depositional surface alterations, wear traces are sufficiently preserved to allow interpretations. In the case of GSN the post depositional alterations affected the lithic industry differently along the stratigraphic sequence (Tab. 6) but also in this case they do not prevent the use-wear analysis.

The analysis of the post depositional alterations recorded on the lithic artefacts (Eren et al. 2011) can be an important indicator for the reconstruction of past environmental conditions and site formation processes (Burroni et al. 2002; Donahue 1998; P J Glauberman and Thorson 2012). The taphonomy of the lithic assemblage of GSN show that the same kind of post depositional alterations affected the three considered S.U. with different intensity: the most affected is S.U. C, followed by S.U. B and S.U. B*C. The different degree of development of the same alterations in the different S.U. testifies that they have suffered similar processes. The presence of polishes on the surfaces and of rounding on the edges and on the ridges is referable to a strong transport phenomenon, like a debris flow, as supposed also by the geological analysis and by the taphonomic study of the faunal remains (Carlo Peretto, Arzarello, et al. 2015) . Observing the lithic assemblage in its totality and according to the results of all these studies, it is possible to propose general conclusions on GSN. Observing the assemblage of the lithic artefacts with use-wear for each S.U. it is possible to observe that the type of behavior registered by the use-wear traces does not change along the three S.U. studied. This consideration is confirmed also by the zooarchaeological data that does not record any difference between the three S.U. (Peretto, Arzarello, et al. 2015; Muttillo, Lembo, and Peretto 2014). The *débitage* lithic artefacts of the different S.U. show the same type of traces. The collection is dominated by artefacts with traces linked to carcass processing (55 artefacts out of 86) with a marginal component linked to vegetal materials processing (primarily woodworking activities). All the activities linked with carcass processing are represented: traces linked directly with the butchering activity are present on 29 artefacts, to cutting soft animal tissue on 7 artefacts, to cutting and scraping fresh hide on 8 artefacts and to bone working on 4 artefacts. The bone working traces (especially those linked to the scraping motion) are probably linked to periosteum removal activities necessary during the process of marrow-extraction (Grayson

1984). The predominance of evidence linked to the processing of animal carcasses is recorded in many Lower Paleolithic sites, such as Monte Poggiolo (C. Peretto et al. 1998), Isernia la Pineta (Longo 1994), Boxgrove (Mitchell 1998), Qesem Cave (Lemorini et al. 2006), Revadim (Solodenko et al. 2015) and Schöningen (Rots and Hardy 2015). The presence of wood working activities is attested, as a secondary activity, in some sites linked to the processing of animal carcass, such as: Isernia la Pineta (Longo 1994), Revadim (Solodenko et al. 2015) and Schöningen (Rots and Hardy 2015). The woodworking evidences in GSN include, like at Schöningen, pieces used as a kind of 'shave' (transversal woodworking) which corresponds to the motion required for sharpening spears or manufacturing other wooden tools (Rots and Hardy 2015).

The presence of use-wear traces on the bifaces shaping flakes is documented in three French Middle Paleolithic sites: Jonzac, Fonseigner, and Saint-Amand-les-Eaux (Claud 2015). In these cases, the use of the shaping flakes has been mainly linked to butchering activities (Claud 2015), while in GSN there is also one flake with traces linked to woodworking. This aspect is more consistent with an opportunistic behavior rather than a specific and intentional production or of an intentional kind of circular economy as supposed in the work of Claud (Claud 2015). The presence of opportunistic behavior is testified also by the presence of instrument with evident traces re-use; the side-scraper B*C P9 12 has traces of a double patination; of which the alterated surface is interrupted by the retouch (Fig. 8). It was not possible to understand if the formal tools were used for particular activities because the sample of tools with use-wear traces is too small. Anyway, it is possible to observe that the materials worked with the formal tools are the same that were worked with the unretouched flakes. The scarcity of formal tools realized on blanks obtained with predetermined methods (discoid and *Levallois*) showing use-wear traces is in line with the scarce presence of formal tools in the lithic industry (Muttillo, Arzarello, and Peretto 2014). Looking at the artefacts with use-wear traces it is possible to note that there is a relation between the longitudinal action and the *Levallois* products (Tab. 12).

Table 12.4: actions carried out, grouped by stratigraphic unit and method of flakes production.

Method	**Action**	**S.U. B**	**S.U. B*C**	**S.U. C**	**Tot.**
Levallois	Transversal	16	4	3	23
	Longitudinal	4	3	4	11
Discoid	Transversal	5	1	3	9
	Longitudinal	6	3	1	10
Opp.	Transversal	6	7	6	19
	Longitudinal	11	4	2	17

This data can indicate that the *Levallois* products were usually made to carry out longitudinal actions, probably for their intrinsic characteristics. Indeed, the *Levallois* flakes are characterized by long and thin cutting edges that are efficient to perform cutting actions (Eren and Lycett 2012; Lycett and Eren 2013; Eren and Lycett 2016; Kuhn 1994; Kuhn 1992).

6. Conclusion

In conclusion, GSN can be defined as site characterized by an accumulation of lithic artifacts and bones linked to a butchering or killing site or sites. The use-wear traces found on the lithic industry of GSN are indubitably referable to animal carcasses processing and the presence of the few traces linked to woodworking activities can be related to the maintenance or manufacturing of wood objects, like spears. Their presence in the sample is in line with the results of other use-wear studies carried out for sites with similar chronology and similar functional attribution (Revadim and Schöningen; Rots and Hardy 2015; Solodenko et al. 2015).

Interestingly, the same assemblage of wear traces can be found in different sites with similar functional interpretation but with an older chronological attribution like the near site of Isernia La Pineta (Longo 1994). The presence, in all these sites, of woodworking activities can be interpreted as an indirect signal of the great (and nowadays underestimated) importance of wooden instruments during Lower Palaeolithic. Besides, the use of *shaping* flakes demonstrates that there was not a practical difference between flakes produced through *debitage* and those from shaping. These empirical evidence appear to sustain the thesis that Levallois technology is an inherent property of the Acheulian that evolves out of the existing, but previously separate technological systems of façonnage and débitage (White and Ashton 2003; Hopkinson, Nowell, and White 2013), and appear to show that Acheulian bifacial technology and Levallois technology are homologous, reflecting an ancestor-descendant relationship (Rolland 1995; White and Ashton 2003; Adler et al. 2014; Lycett 2007).

CHAPTER V

THE USE WEAR ANALYSIS OF THE LITHIC INDUSTRY OF THE S.U. 14 FROM THE PALEOLITHIC SITE OF CIOTA CIARA CAVE (VC, ITALY)

1. Introduction

The Ciota Ciara Cave is one of the most important Palaeolithic sites in northwestern Italy, and it is the only one placed close to the Alps. The stratigraphy of the site contains lithic and faunal remains referable to different human occupations. In 2012 the lithic industry of the S.U. (stratigraphic unit) 13 was matter of a technological and functional study (Berruti and Arzarello 2012; Arzarello, Daffara, Berruti, Berruto, Berté, Berto, Gambari, et al. 2012; Daffara et al. 2014). These studies allowed to identify the lithics found in the S.U. 13 as a result of residential occupation of short / medium term, characterized by long and complete reduction sequences mainly related to the transformation and not to the acquisition of resources (Arzarello, Daffara, Berruti, Berruto, Berté, Berto, Gambari, et al. 2012; Berruti and Arzarello 2012). In the last four years, the excavation activities permitted to complete the exploration of the underlying S.U. 14, leading to the recovery of hundreds of lithic artefacts and of thousands of faunal remains and to the discovery of one hearth (Angelucci et al. 2015; Arnaud et al. 2013; Aranud et al. in press). The preliminary works about the lithic industry (Daffara et al. 2014; Angelucci et al. 2015) and the paleontological (Berto et al. 2016) and archeozoological (Buccheri 2014; Buccheri et al. 2016) analysis of the faunal remains suggest that, if compared with S.U. 13, different types of human occupations could have interested the S.U. 14. The aim of this work is to verify this hypothesis with the help of the use-wear analysis.

2. The Ciota Ciara Cave

The Ciota Ciara cave is a karstic cave located on Monte Fenera, an isolated karst relief in the North West of Italy (Piedmont), at 670 m. a.s.l. (Fig. 1). It is a still active karstic cave developed on more than 80 m in its principal axe. The cave is in the west side of the mountain and together with other caves placed in the same area, it represents one of the most important and complete evidences of the Paleolithic settlements of Piedmont. The first investigations of the cave, with a naturalistic intent, were conducted in the second half of the nineteenth century but it is since the fifties that archeological researches were started in the Ciota Ciara cave. The first scientific investigations are dated to 1953 (Conti 1960) when C. Conti realized a survey pit inside the cave. Another survey pit was done in 1964 by G. Isetti who found several remains of *Ursus spelaeus* and a lithic industry ascribed to the Middle Paleolithic. The first systematic excavations took place in 1966 (Francesco Fedele 1966; Fedele, Chiarelli and Masali 1966), 35 m inside the cave, and lithic industry made in quartz together with paleontological materials, especially of *Ursus spelaeus*, has been found (Francesco Fedele 1968; Francesco Fedele 1988). At the end of the seventies the systematic researches in the Ciota Ciara cave (and in all the other caves of the area) were interrupted. In the same years, numerous clandestine excavations were carried out all over the cave: among the remains abandoned during these excavations a human right temporal squama has been found, later identified as a cranial bone of *Homo neanderthalensis* (Fig.2) (Villa and Giacobini 1993; Villa and Giacobini 1998). Systematic excavations restarted between 1992 and 1994, under the direction of *Sopritendenza Archeologica del Piemonte*, after the chance discovery of two teeth ascribed to *Homo neanderthalensis* within reworked sediments in the vestibular area of the cave (Fig.2) (Villa and Giacobini 1993; Villa and Giacobini 1998). In t 2009 the systematic excavation of the Ciota Ciara Paleolithic deposit was started again by the University of

Ferrara under the supervision of M. Arzarello, in collaboration with S*oprintendenza per i Beni Archeologici del Piemonte e del Museo di Antichità Egizie*.

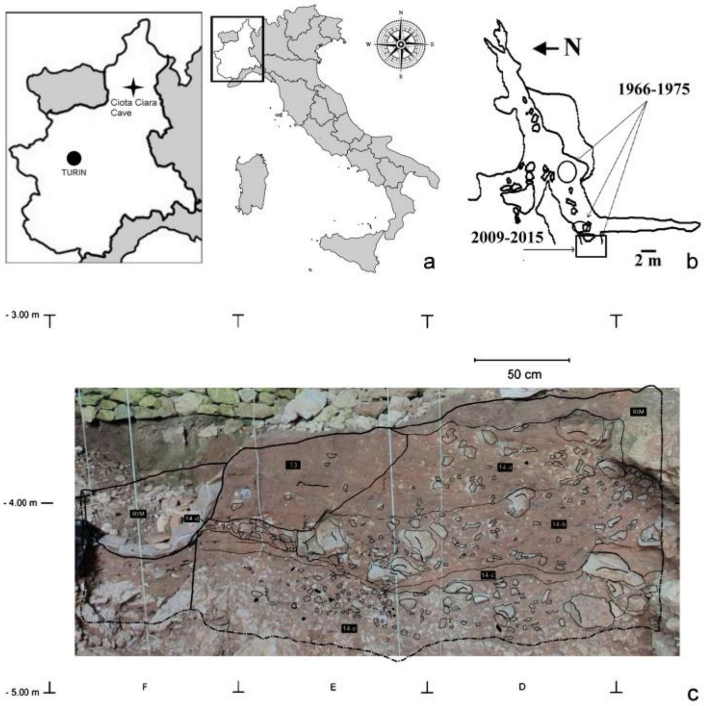

Figure 1.5: Ciota Ciara Cave. a: location of Monte Fenera (Piedmont, Italy) and of the Ciota Ciara Cave; b: map of the Ciota Ciara cave with location of the archaeological interventions; c: stratigraphy of the Nord section (modified from Angelucci et al. 2015).

After a preliminary phase of restoration of the previous excavations, the new researches are concentrated in the atrium of the cave where five stratigraphic units were investigated: 13, 103, 14, 15 and 16 (Fig. 1).

2.1 Geomorphological setting

In the southern Alps, the Fenera mount is the widest and stratigraphically most important portion of the Mesozoic sedimentary cover: sedimentary portions are preserved where the presence of faults led to their displacement and subsequent protection against erosion (Bertolani 1974; R. Fantoni et al. 2005). Looking at the Alpine geological background, the Fenera mount is close to the connection between the Po plain subsiding and the Alps rising (R. Fantoni et al. 2005). The considered area is crossed by two main tectonic lineaments: *Linea della Colma*

(LCo) and *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.

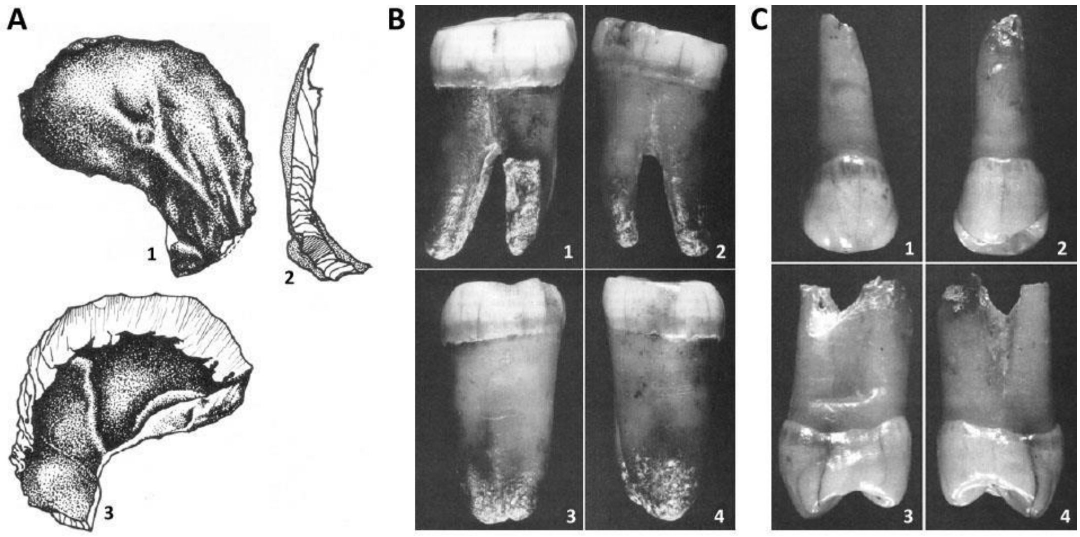

Figure 2.5: Human remains from the Ciota Ciara cave: A) Squamous portion of human right temporal bone (Mottura 1980, modified) 1) external view 2) inner view3) frontal view; B) right mandibular molar, M2 and C) right maxillary premolar P1 (Villa and Giacobini, 1996, modified by Vietti 2016) 1) buccal view, 2) lingual view, 3) mesial view, 4) distal view.

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 et al. 2005; Fantoni and Fantoni 1991). 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, parallel to LCo and LCr (Fantoni et al. 2005). Their presence led to an intense fracturing of the carbonate units of the mount, thus causing secondary porosity and increasing both water circulation inside the mount and of the dissolution phenomena responsible for karstification (Fantoni et al. 2005; Fantoni and Fantoni 1991). Seventy-two caves have been discovered and explored: many of them have a horizontal development and open on the west side of the Fenera mount, in the central part of that side and in its southern extremity (Fantoni et al. 2005; Fantoni and Fantoni 1991).

2.2 Stratigraphy

The stratigraphic succession excavated since 2009 in the atrial area of the cave corresponds to the lower portion of the original entrance deposit, as its upper part was removed in previous excavation campaigns. This succession has five principal stratigraphic units, furtherly sub-divided into sub-units (Fig. 1- C and 16).

- S.U. 13: silty unit, brown/dark-brown colored, 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 and 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 (Zambaldi 2015; Zambaldi, Angelucci, and Arzarello 2016; Angelucci et al. 2015).

All the stratigraphic units (except the S.U. 103) present a sub-horizontal disposition and are characterized by a reddish-brown clayey-sandy matrix with rare, and altered centimeter-sized pebbles, more frequent in the lower SS.UU. Most of the units are sandy-silt, with common to many stones, badly-sorted, massive and show chaotic arrangement and fabric. There are also thin layers of well-sorted fine sand. Concentrations of Fe-Mn oxides (often coating bones and lithics), phosphatic rinds and (clay?) coatings are detected in almost all the units. The laboratory analysis demonstrated that most of the units are composed of poorly sorted silty-sand sediment; two grain size distributions were detected and sand fraction prevails in all the samples and the silt one is common. The dolostone fragments detached from the cave structure and rare sandstone fragments (probably coming from geological formations outcropping at the top of Monte Fenera and embedded in the sediment by karstic waters) constitute the coarser fraction of the units. The calcimetry and the LOI (Loss on Ignition) analyses revealed that the content of carbonates and organic materials is scarce. “These data indicate that the deposit filling Ciota Ciara entrance was mostly laid down by dynamics related to concentrated flows emerging from the cave, with inputs of dolomite fragments from the cave bedrock and occasional events of deposition by surface water currents with tractive mechanisms” (Zambaldi, Angelucci, and Arzarello 2016). This implies that part of the collected assemblage is in its 'original' position (as testified by the presence of one fireplace in S.U.14 square F2), but that some objects may have suffered short-distance displacement from the inner cave to its entrance. There aren't significant discontinuities within the stratigraphic succession, which seems to have accumulated within the same climatic and environmental context (Zambaldi 2015; Zambaldi, Angelucci, and Arzarello 2016; Angelucci et al. 2015).

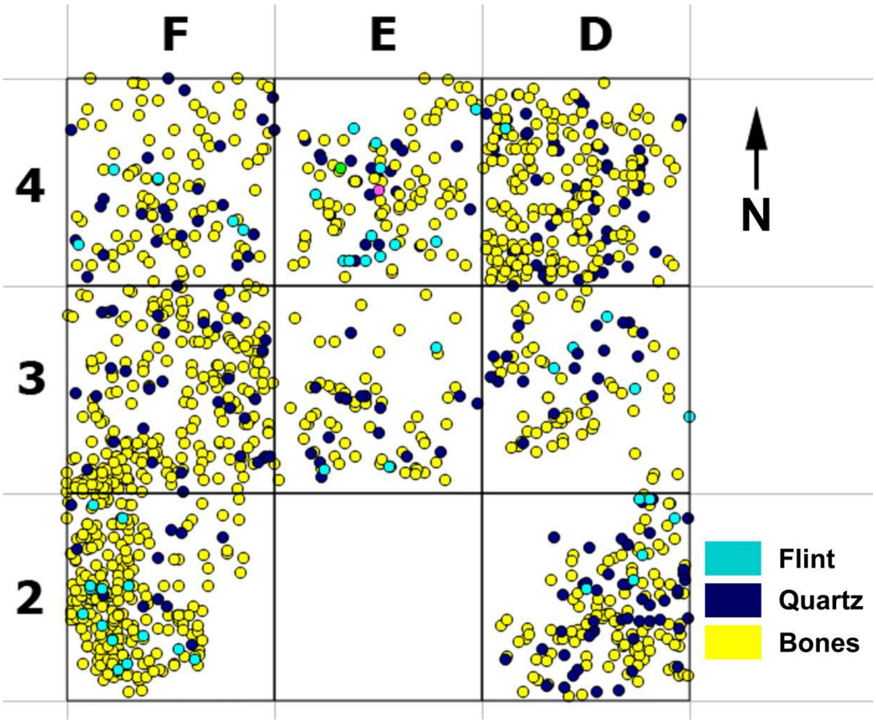

Figure 3.5: Ciota Ciara cave. Spatial distribution of the coordinated objects from S.U. 14 (excavation 2013). 1 meter grid (Daffara et al 2014).

The spatial distribution of litchis and faunal remains not allowed to recognize, at now, any particular spatial organization: this is also probably due to the restricted area of investigation (Daffara et al. 2014; Arzarello, Daffara, Berruti, Berruto, Berté, Berto, Gambari, et al. 2012) (Fig. 3).

2.3 Chronology

The chronological study was realized with ESR/U-series on teeth and Currently, only S.U. 14 was dated with radiometric methods. The samples used for the combined ESR/U-series dating analyses have been collected during the 2012 excavation campaign and belong to the S.U.14 (Fig.4): CC073, a lower third molar M3 of chamois (*Rupicapra rupicapra*); CC100, an upper second molar M2 of red deer (*Cervus elaphus*) and CC203, a lower molar of bovid (*Bos* vel. *Bison*). The ages 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 aren't coherent with the expected age of the deposit, since the previous age estimations, based on biochronology, placed the deposition of S.U. 14 during the MIS 5 (Berto et al. 2016; Arzarello, Daffara, Berruti, Berruto, Berté, Berto, and Peretto 2012). This extimation was based on different factors: the enamel differentiation quotient (SDQ) of *Arvicola amphibius*, the general composition of the faunal assemblage and the presence of *Pliomys coronensis* (Berto et al. 2016). However, the homogeneity of the ages obtained with the ESR/U-series is undeniable and suggest a correlation of the human occupation with the end of MIS 9 or the beginning of MIS 8 (Vietti 2016).

2.4 Faunal remains

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*, *Stephanorinus* sp. (Angelucci et al. 2015; Arzarello et al. 2014; Arnaud et al. 2013; Daffara et al. 2014; 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).

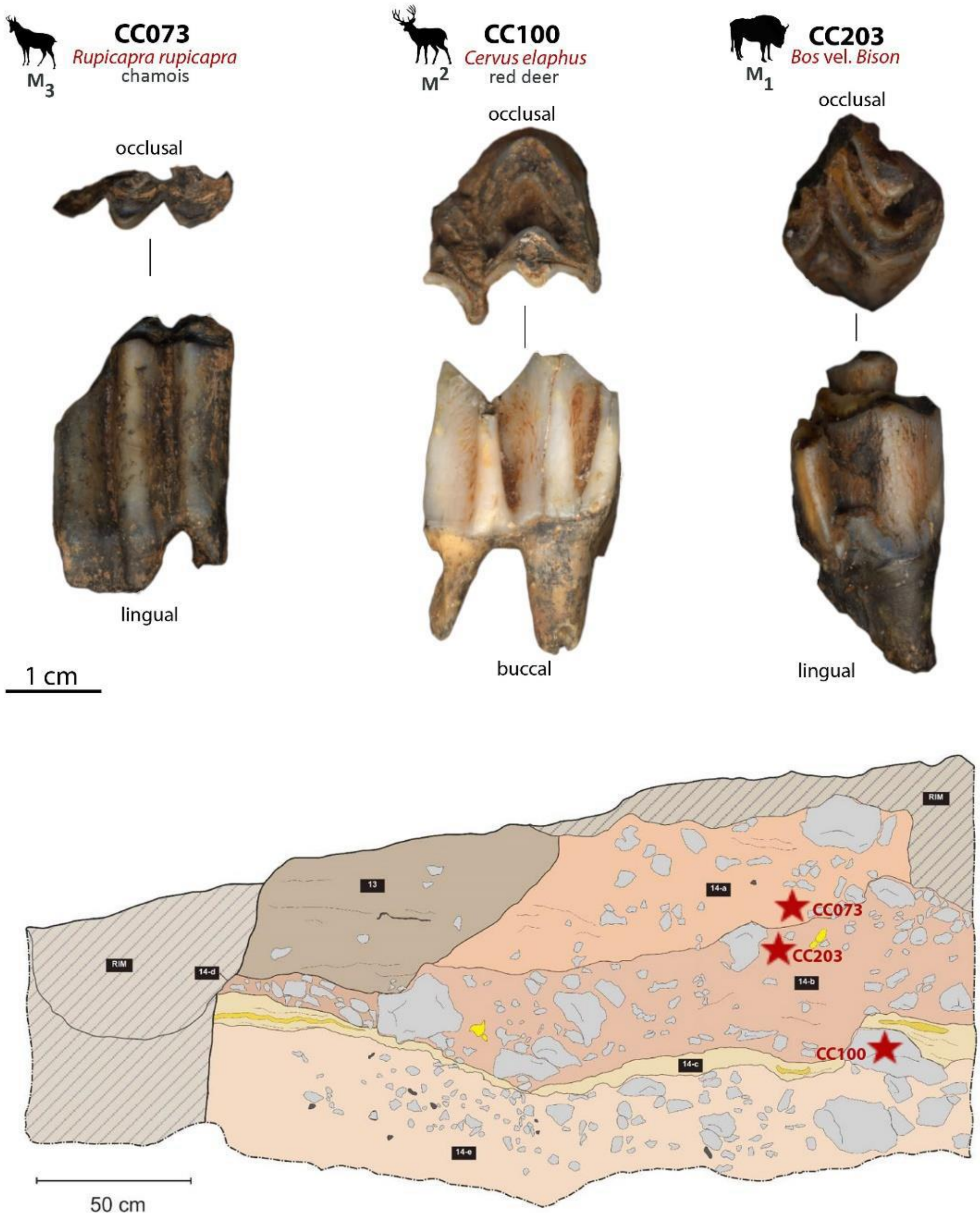

Figure 4.5: Samples for combined ESR/U-series dating and their position in S.U. 14 (Vietti, 2016).

All the other species are represented by just one or two individuals, indicating anyway a great biodiversity (Berto 2012; Berto et al. 2016) (Tab.1). The paleontological study of the faunal assemblage demonstrates a marked predominance of *U. spelaeus* in all the five stratigraphic units. The occurrence of several cubs of *U. spelaeus* suggests a recurring use of the cave as a den (Berto 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, Daffara, Berruti, et al. 2012; Berto 2012; Berto et al. 2016). The most represented species is *Clethrionomys glareoulus* 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).

Table 1.5: Faunal remains in the Ciota Ciara Cave subdivided for Stratigraphic Unit. NISP: number of individual specimens; MNI: minimum number of individuals. (From Buccheri et al 2016)

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

The archeozoological study of the faunal remains of the Ciota Ciara Cave, was conducted on 1144 bones from S.U. 14, corresponding to the total of the faunal remains recorded during the 2013 excavation campaign. The study of these faunal remains highlighted nine types of taphonomic alterations: roots activities, cracking, carnivore intervention, deposition of manganese oxide, concretions, trampling marks, water abrasion (rounding and smoothing) and cut-marks (Fig. 5).

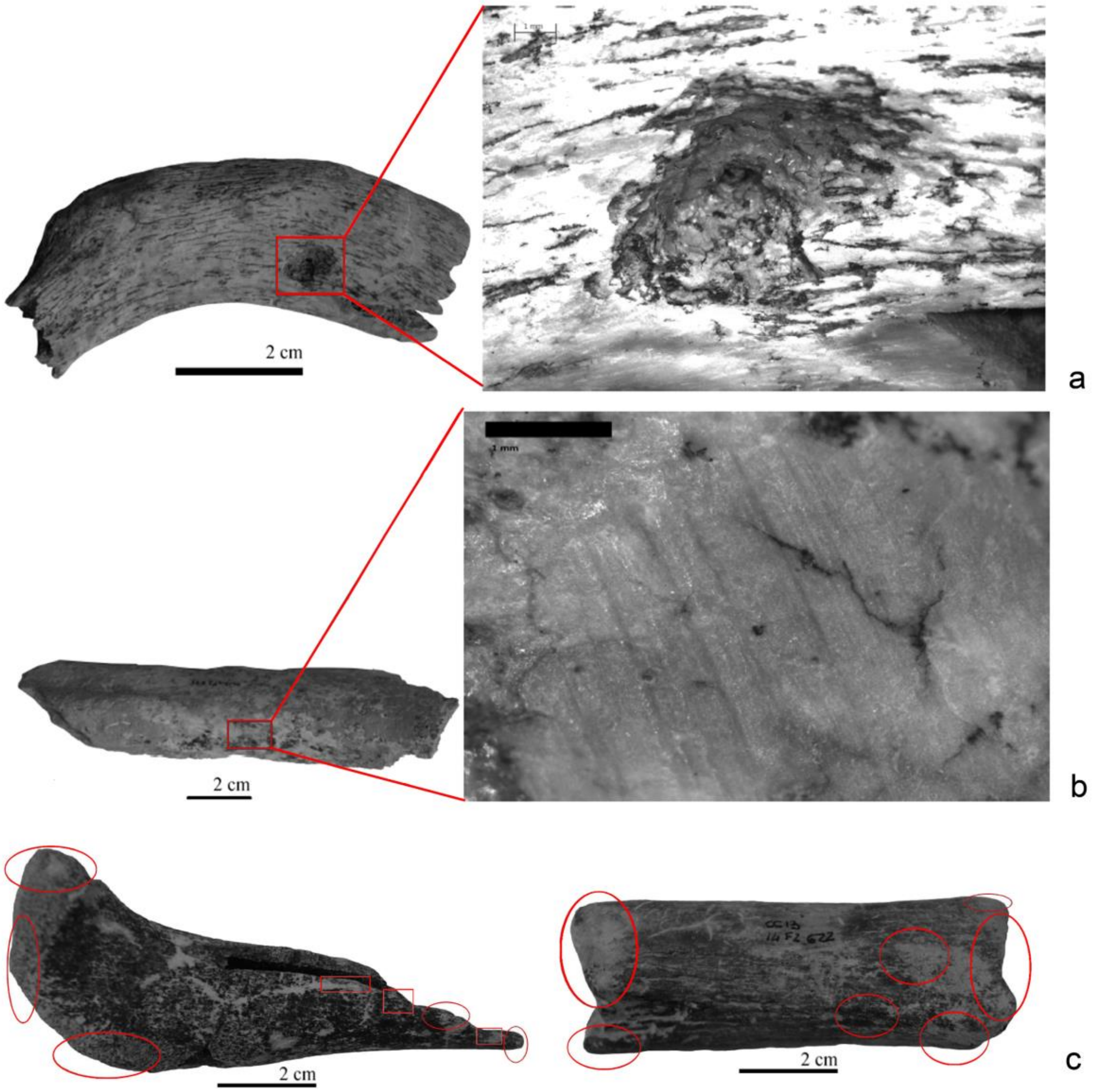

Figure 5.5: Taphonomic alterations; a: bite marks; b: trampling marks; c: hydric abrasion (Buccheri et al 2016).

35 bones, (the 2,97% of the sample analyzed), show on their surface evidence of cut marks: half of the remains are undeterminable while the others half are attributable to large or medium-sized animals. Twelve cut marks have been identified on determinable bones of two different species: one *Canis lupus* and eleven *U. spelaeus* remains (Fig. 6) (Buccheri et al. 2016; Buccheri 2014).

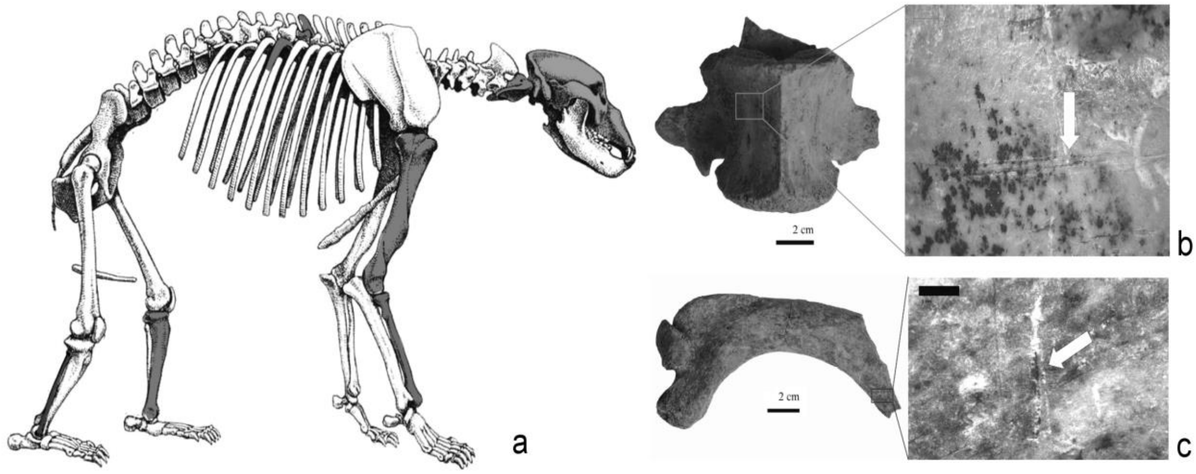

Figure 6.5: Cut-marks; a: location of cut-marks on Ursus spelaeus; b: fossil vertebra with cut marks; c: fossil rib with cut marks (From Buccheri et al 2016).

<u>2.5 Lithic assemblage</u>

2.5.1 Supply areas and lithic raw materials

The study of the supply areas has been performed on the remains coming from levels 13 and 103. The analysis of the archaeological record of these two levels (498 finds) shows that many lithologies are represented: quartz is the prevalent used material (83.18 %), followed by spongolite (15.89 %), sandstone (0.56 %), milonite (0.19 %) and opal (0.19 %). Concerning quartz, many typologies are present: macrocrystalline pegmatitic quartz, microcrystalline pegmatitic quartz and hyaline quartz. All these types of raw materials have been found, in secondary position (pebble of quartz and blocks of spongolite) in the proximity of the site, within a range of 5 km (Arnaud et al. 2013; Berruto 2011; Daffara et al. 2014). The preliminary studies of the S.S.U.U. 14 and 15 seem to testify that, in the S.U. 14 and with a lesser degree in the S.U. 15 are present tools and retouch flakes made in allochthonous red flint of unknown provenance (Angelucci et al. 2015).

2.5.2 Technological analysis

The technological studies are completed for the S.U. 13 and are incomplete, but ongoing, for the S.S.U.U. 14 and 15. The opportunistic knapping methods are dominant within the lithic assemblage and very high is the number of *débris*, fractures and knapping accidents almost all difinable as *Syret* accidents (Mourre 1996). Direct percussion by hard hammer is the only technique employed while the methods are various: opportunistic/S.S.D.A. (Forestier 1993), *Levallois* and discoid (Böeda 1993; Boëda 1994).

The S.S.D.A./opportunistic knapping method has been employed to produce irregular and non-standardized blanks, all characterized by the presence of at least one cutting edge (Arzarello, Daffara, Berruti, Berruto, Berté, Berto, and Peretto 2012) The *Levallois* method was employed to produce blanks with convergent edges or *Levallois* points. In the lithic assemblage of the Ciota Ciara cave only two modalities of this knapping method are represented: recurrent centripetal and lineal (Boëda 1994). The *Levallois* method was employed only on pebbles with suitable natural convexities in order to reduce the shaping out of the core to its lowest (Fig. 7). The discoid method (Boëda 1993) is represented both by the bifacial and the unifacial modality depending on the morphology more or less spherical of the cores (Daffara et al. 2014) The shaping out of the core never precedes the phase of *plein débitage*: the discoid exploitation starts from the natural surface of the pebbles and continues through the detachment of debordant flakes in order to preserve and manage the convexities of the core.

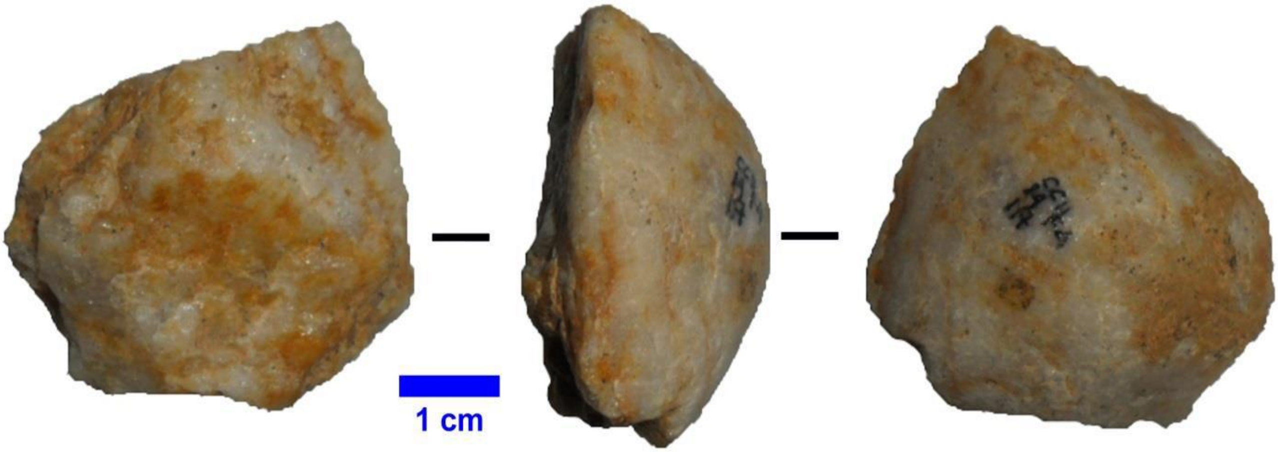

Figure 7.5: Levallois core with cortical striking platform from the Ciota Ciara cave. (From Daffara et al 2014).

The discoid products have quadrangular or triangular shapes and are characterized by a great thickness in the proximal part. The debordant flakes often have the typical morphology of a *pseudo-Levallois* point (Daffara et al. 2014) (Fig. 8).

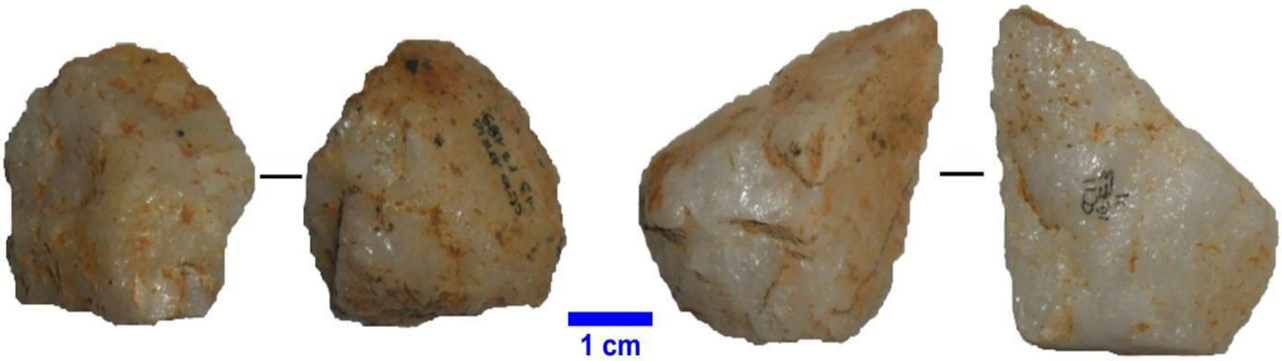

Figure 8.5: Discoid core (on the left) and side-scraper on pseudo-Levallois point (on the right) from the Ciota Ciara cave. (From Daffara et al 2014).

Sometimes big flakes were used as cores. This kind of exploitation, although referable to a Kombewa l.s. knapping method (Tixier and Turq 1999), has as its purposes the reduction of the technical investment and the maximum exploitation of the raw material. The reduction sequences, especially the S.S.D.A., are short and they rarely come to the complete exploitation of the cores; also, the *Levallois* and the discoid cores never show more than one phase of exploitation. This is probably due to the easy availability of the raw material, to the characteristics of quartz that brokes very easily during the *débitage* and to the preferential use of the natural surfaces of the quartz pebble to put in action these *débitage* methods. Although no refitting was found because of the characteristics of the raw material and the presence of a great number of fractures, the reduction sequences on quartz are complete: surely the exploitation of quartz has been carried out within the site. This is not true for the siliceous rocks because the reduction sequences related to them are fragmentary showing the management of one or more phases of the reduction sequence out from the excavated area or the importation of finished tools within the cave (Daffara et al. 2014). The small number of retouched tools present in the lithic assemblage reveals a further adaptation to the characteristics of the raw material: the retouch on quartz flakes is quite difficult and it does not permit to obtain stronger or more useful edges in comparison to the unretouched ones (Berruti and Arzarello 2012). Among the retouched tools, most of them are side-scrapers, lateral or convergent, followed by denticulates and notches (Daffara et al. 2014). In the S.U. 14 there are 27 tools made with allochthonous red flint of unknown provenance, these tools were made in another location and transported in the Ciota Ciara Cave (probably as parts of personal tools kits Kuhn 1994) where were only retouched (probably with the aim of reshaping the edges) (Angelucci et al. 2015). In the Ciota Ciara cave is also attested the use of fossil bones to produce tools: a denticulate and a sidescraper come from S.U. 13 and 14 respectively, while another denticulate was found during the 2009 excavation in reworked sediments (Daffara et al. 2014). This kind of “organic” raw material has been exploited in the same way of the lithic raw material and on the edge of the tools it is possible see the marks of direct percussion by hard hammer.

3. Materials and methods

As mentioned before, the use wear analysis of the lithic assemblage of the Ciota Ciara cave focuses on S.U. 14.

This study began with the preliminary evaluation (at naked eye or with a stereomicroscope) of all lithic assemblage of S.U.14 to identify the artefacts that have the right characteristics for the development of the use-wear analysis. During this preliminary phase, have been considered composed all the *débitage* products (simple flakes and formal tools) of the S.U. 14 collected during the excavation activities, while all the lithics coming from the sieving were excluded. In total, were analysed 489 different artefacts. Four criteria were applied to select artefacts for the use-wear analysis: completeness, presence of at least one functional edge, morphology suitable for prehension or for hafting and surface preservation (absence of marked post depositional alterations). After the preliminary evaluation, the considered sample is composed by 79 *débitage* products, 55 made in quartz and 21 made in flint. For the analysis, each selected artefact was gently washed with warm water and soap, then washed for 3 minutes in a mixture of demineralized water (75%) and alcohol (25%) in an ultrasonic tank and open air dried. The use-wear analysis of the flint lithic assemblage was carried out with an integrated approach that uses the low power approach (Odell 1986) in combination with the high power approach (Keeley 1980). Several works (e.g. Lemorini et al. 2014; Wilkins et al. 2015; Moss 1983; Beyries 1987; Ziggioti 2011; Van Gijn 2014; Berruti and Daffara 2014; Cruz and Berruti 2015;) show in fact that the use of both these methodologies integrated is more effective and productive, since it provides a more detailed understanding of the activities carried out with the lithic artefacts and is useful support the diagnosis of the processed materials (e.g. Lemorini, Plummer, et al. 2014; Lemorini et al. 2006; Rots 2010; Ziggioti 2005; Keeley 1980; Van Gijn 2014). The use-wear analysis of the quartz lithic assemblage was also carried out with an integrated approach (Clemente-Conte and Gibaja Bao 2009; Igreja 2009; Lemorini, Plummer, et al. 2014). For the study of quartz artefacts with the metallographic microscope usually two techniques of visualisation were used to reduce the glare of this highly reflective raw material (Igreja 2009; Lemorini et al. 2014): equip the microscope with a Differential Interference Contrast Capability DIC, also known as Nomarski contrast, or use high-resolution epoxy casts of the edges of the artefacts (Banks & Kay 2003; Plisson 1983). For this study we decided to test the use of a metallographic microscope equipped with two different polarizing filters. One of them is placed after the light source (polarizer filter) while the other one (the analyser) is placed to the light path between the objective and the eyepiece. The use of these filters, although not guarantees the high resolution and the three-dimensional view usually obtained with the DIC, allows a high reduction of the glare and a good image definition (Fig.9), sufficient to identify the different types of wear traces. A Photoshop CS6 Portable (© Adobe) software was used for the treatment of the images since it allows a single image to be built up from several photos taken at different depths of field. The wear traces on quartz edges are easily visible with magnifications between 200× and 500×. Processes like micro-fracturing, material fatigue, silica precipitation, dissolution, plastic deformation, polishing and phase transformation have been found to be important in wear formation. "The differences in the structure of flint and quartz (a slight topography of flint compared to flat fracture and cleavage planes in quartz) cause these two lithic raw materials to behave differently under mechanical stress" (Knutsson et al. 2015). Different combinations of the wear features can be systematically related to the characteristics of the different worked materials (Knutsson et al. 2015). For this study was performed a small reference collection (10 lithic artefacts) in order to compare the traces detected on it with the traces found on the archaeological remains and with the data present in the bibliography (Knutsson et al. 2015; Marquez et al. 2016; Clemente-conte, Boeda, and Farias-gluchy 2016; Venditti, Tirillò, and Garcea 2015). The experimental lithics were used to process bone, meat, hide, wood and in butchering activities for 5 and 15 min. each. The data obtained during the analysis of the reference collection are comparable with those present in literature and they are summarized in the table (Tab.2). For the analysis were used different microscopes: a stereomicroscope Seben Incognita III with magnification from 20x to 80x, a stereomicroscope Leica Ez4 HD with magnification from 8x to 35x and a metallographic microscope Optika B 600 Met. with oculars 10x, 5 objectives PLAN IOS MET (5-10-20-50-100x), polarizing filters and bright and dark field equipped with a digital camera Optika B5.

4. Results

The use wear analysis of the S.U. 14 of the Ciota Ciara cave lithic assemblage allowed to identify 30 artefacts with traces of use: 19 in quartz (Fig.11-12) and 11 in flint (Fig.10) (Tab.2). Concerning quartz, 5 of the artefacts with traces are Levallois flakes (3 lineal *Levallois* and 2 recurrent *Levallois*), 1 is a discoid flake, and 13 are opportunistic/SSDA flakes. Among them, 1 artefact (1 lineal *Levallois* flakes) has two different zones of use (Z.U.) referable to two different type of traces (transversal work on bone and longitudinal work on fresh hide). The use-wear analysis of the 19 artefacts made in flint (both local and alloctonus) allowed to identify 11 artefacts with wear traces: 4 *Levallois* flakes (1 lineal *Levallois* and 3 recurrent *Levallois*), 2 discoid flakes and 4 opportunistic/SSDA flakes. As shown in the tables (Tab. 4, 5, 6) and in the graphs (Fig.14, 15, 16) the use wear analysis led to the identification of different activities carried out in the site. They can be divided in two main groups: animal carcass processing (that include the categories: butchering, fresh hide working, dry hide working and bone working listed in the table) and vegetal material processing. If we look just at the formal tools, in all the assemblage, it is possible to observe that the activities carried out are the same of those carried out with the unretouched flakes (Tab. 7, 8).

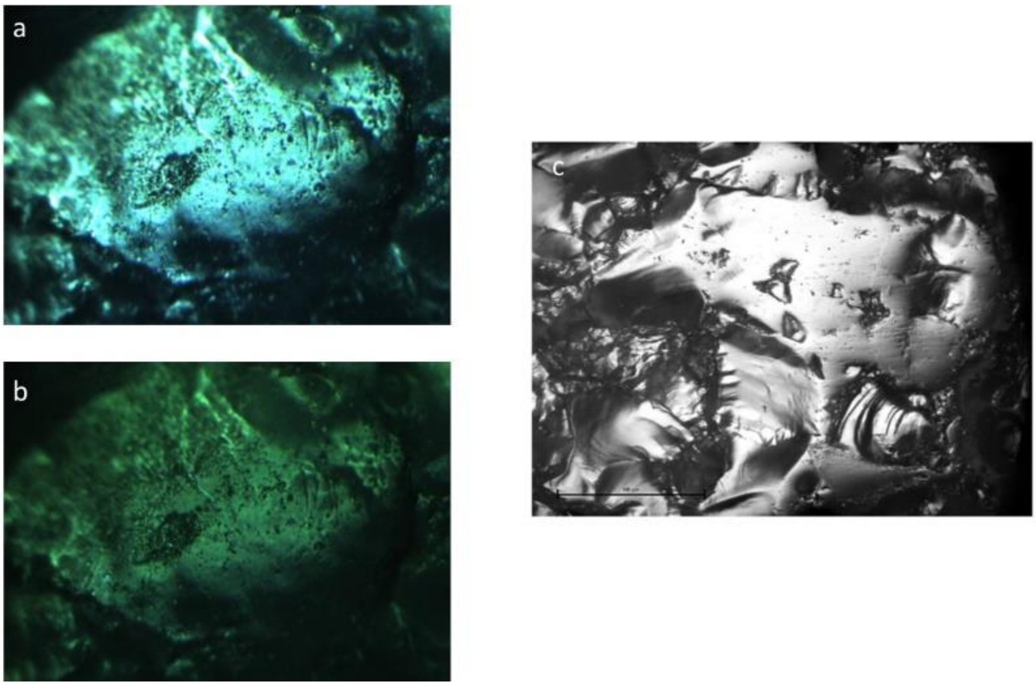

Figure 9.5: CC F3 133- wood working traces (the surface displays a well-developed polish, striations and micro hole); (a) surface under the metallographic microscope without the polarizing filters (500x); (b) surface under the metallographic microscope with the polarizing filters (500x) . (c) image of wood working experimental traces under a metallographic microscope equipped with DIC (From Knutsson et al. 2105)

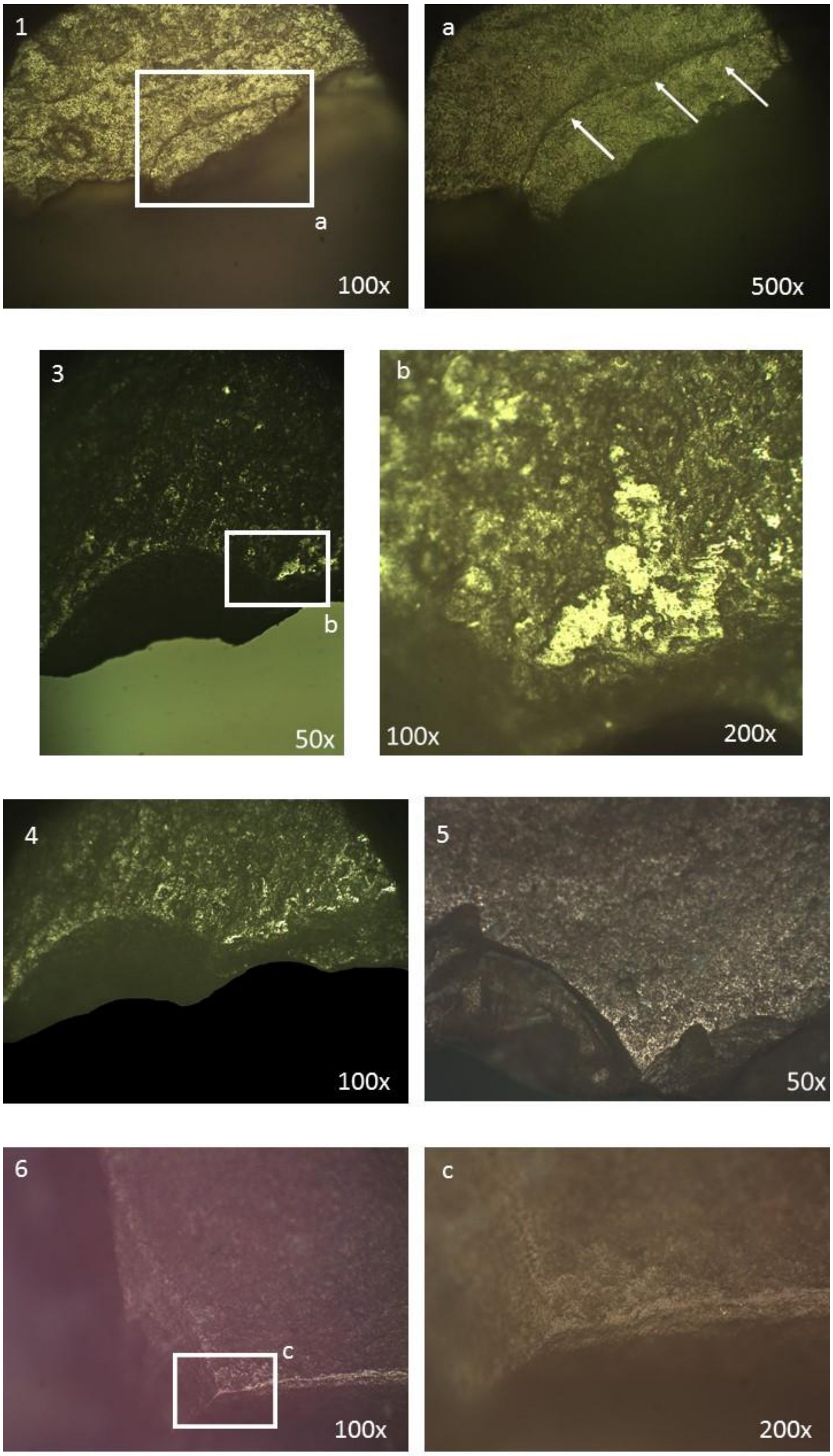

Figure 10.5: use wear traces on flint artefacts: 1- CC 14 F3 53 showing use-wear interpreted as cutting of not woody plants line/band of polish rough with a closed linkage of its topography; in detail, (a) and latent fracture; 2-4 CC 14 F4 1 showing use wear traces interpreted as the result of a mixed motion of butchering combined fleshy tissues traces - line of rough polish - (4) with traces of bone working (3); in detail (b) small, smooth and flat spots of polish (contact with bone).5-6 CC 14 F3 26 showing use wear traces interpreted as the result of a mixed motion of butchering combined fleshy tissues traces - line of rough polish - (4) with traces of fresh hide working (3); in detail (c) the rounded edge.

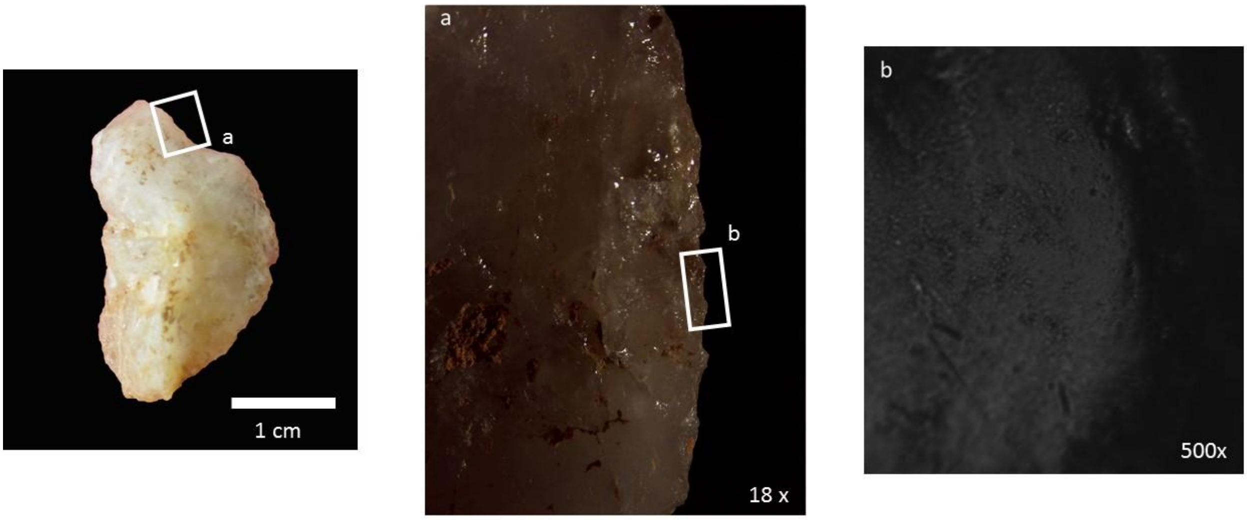

*Figure 11.5: CC 14 E4 83 notch with wear traces interpreted as dry hide working with probably fat and tanning agents***.** *The edge rims heavily worn and polished by the combination of a lubricant (fat) and the mineral component of the tanning agent.*

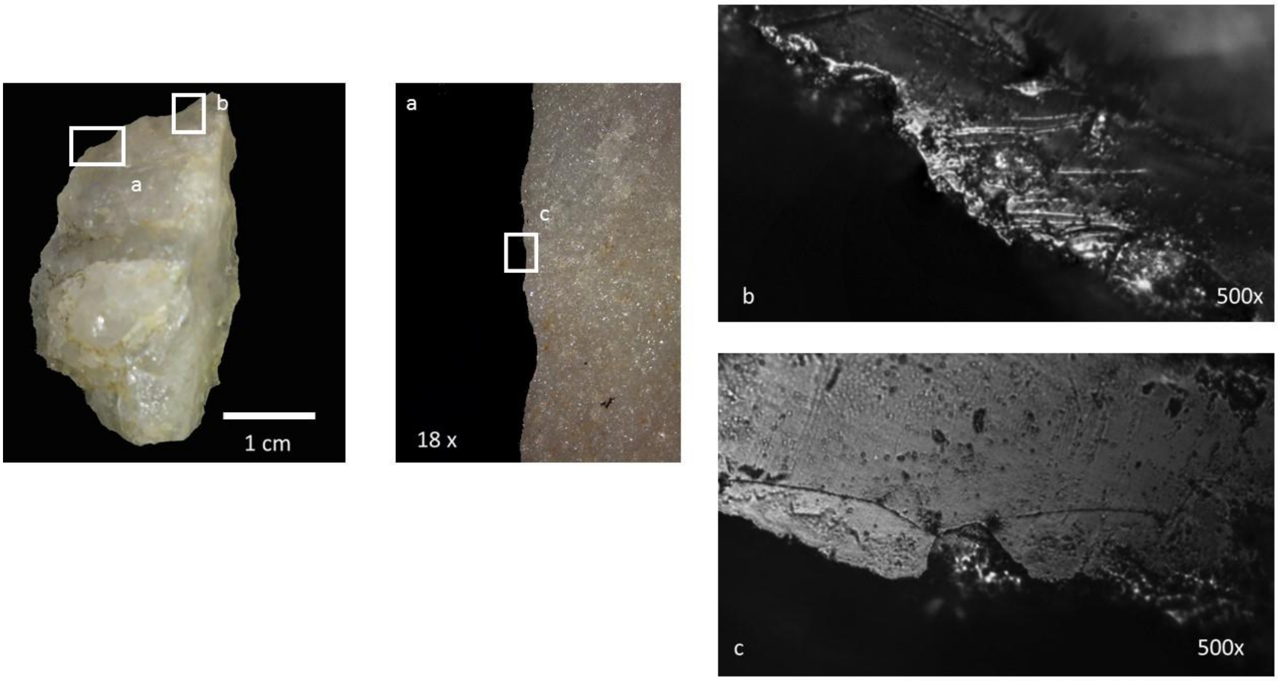

Figure 12.5: CC 14 D3 24 unretouched flake whit use wear traces interpreted as scraping on bone; in detail: (b) the edge rim is worn down and polished. U-formed troughs and sleeks are oriented perpendicularly to the edge rim; (c) cracks and latent fracture typical of hard material working are present as well as abundant small micro holes and sleeks.

Table 2.5: Microwear attributes used to diagnose the material being worked with quartz tools.

Microwear attributes used to diagnose the material being worked with quartz tools.	
Material being processed	**Wear on the crystals**
MEAT	Widespread lightly rounding, micro scars, striae.
BONE	Polish with domed topography (with the possibility of presence of flat area on the upper part), edge rim worn down, striae, surface cracks, micro holes, micro scars.
WOOD	Polish with domed topography, striae and edge rounding, micro holes, micro scars.
SKIN	Widespread rounding, fracture of the edge, polish with rough appearance, plastic deformations.
BUTCHERING	Polish with domed topography associated with polish with rough appearance widespread rounding, striae, edge rim worn down.

Table 3.5: selected sample of the lithic industry grouped by raw material and presence of use wear traces.

SU	TOT.	SELECTED	%	WITH TRACES	% TOT	% SEL
Flint	103	19	18,4	11	10,7	57,9
Quartz	427	54	12,6	19	4,4	35,2
	530	**73**	**13,8**	**30**	**5,7**	**41,1**

Table 4.5: use-wear traces on the lithic artefacts of the S.U. 14 grouped by action, method of debitage and worked material. (Tran. Act. =transversal action; Long. Act. = longitudinal action; Mix = mixed action; Indet. = indeterminate action).

Material	**Discoid**				**Levallois**				**Opp./SSDA/Indet.**				**Tot.**	**%**
	Tran. Act.	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*		
Butchering						1			1	5			7	22,6
Fresh Hide										1			1	3,2
Soft animal tissue		1								1			2	6,5
Bone					2	1			3				6	19,4
Wood		1			2		1		2	1			7	22,6
Non woody plant									1				1	3,2
Dry Hide					1				2			1	4	12,9
Indet									1				1	3,2
Soft													0	-
Medium Soft													0	-
Medium Hard	1												1	3,2
Hard					1								1	3,2
Tot.	**1**	**2**	**0**	**0**	**6**	**2**	**1**	**0**	**10**	**8**	**0**	**1**	31	100,0
Tot. for method	**3**				**9**				**19**				31	100,0

Table 5.5: use-wear traces on the flint lithic s artefacts of the S.U. 14 grouped by action, method of debitage and worked material. (Tran. Act. =transversal action; Long. Act. = longitudinal action; Mix = mixed action; Indet. = indeterminate action).

Material	Discoid				Levallois				Opp./SSDA/Indet.				Tot.	%
	Tran. Act.	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*		
Butchering										2			2	18,2
Fresh Hide													0	-
Soft animal tissue		1								1			2	18,2
Bone					1	1							2	18,2
Wood					1								1	9,1
Non woody plant									1				1	9,1
Dry Hide					1							1	2	18,2
Indet Pol.													0	-
Soft													0	-
Medium Soft													0	-
Medium Hard	1												1	9,1
Hard													0	-
Tot.	**1**	**1**	**0**	**0**	**3**	**1**	**0**	**0**	**1**	**3**	**0**	**1**	11	100,0
Tot. for method	**2**				**4**				**5**				11	100,0

Table 6.5: use-wear traces on the quartz lithic artefacts of the S.U. 14 grouped by action, method of debitage and worked material. (Tran. Act. =transversal action; Long. Act. = longitudinal action; Mix = mixed action; Indet. = indeterminate action).

Material	Discoid				Levallois				Opp./SSDA				Tot.	%
	Tran. Act.	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*		
Butchering						1			1	3			5	25,0
Fresh Hide										1			1	5,0
Soft animal tissue													0	-
Bone					1				3				4	20,0
Wood		1			1		1		2	1			6	30,0
Non woody plant													0	-
Dry Hide									2				2	10,0
Indet									1				1	5,0
Soft													0	-
Medium Soft													0	-
Medium Hard													0	-
Hard					1								1	5,0
Tot.	**0**	**1**	**0**	**0**	**3**	**1**	**1**	**0**	**9**	**5**	**0**	**0**	20	100,0
Tot. for method	**1**				**5**				**14**				20	100,0

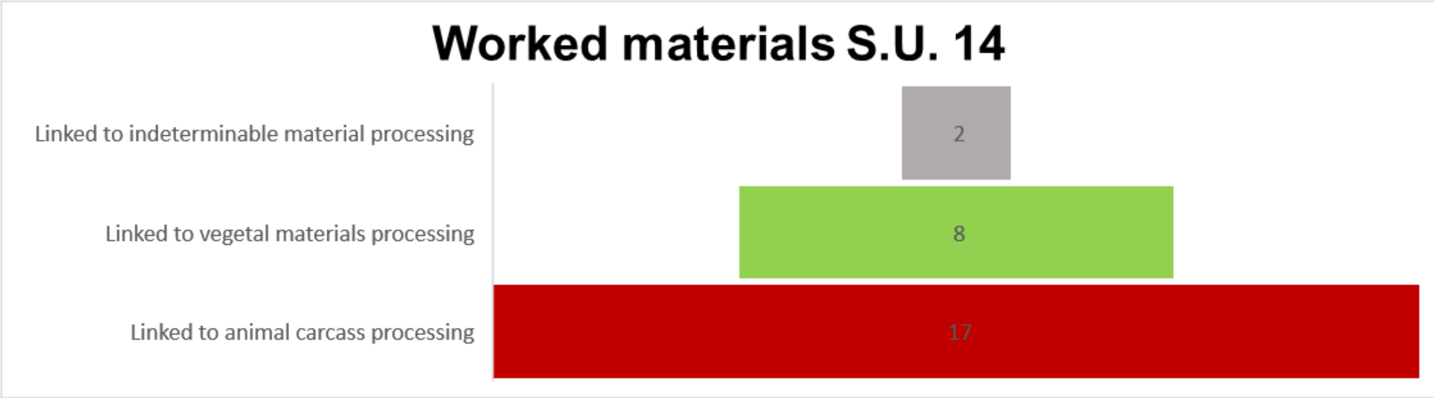

Figure 13.5: use- wear traces identified, grouped by material processed.

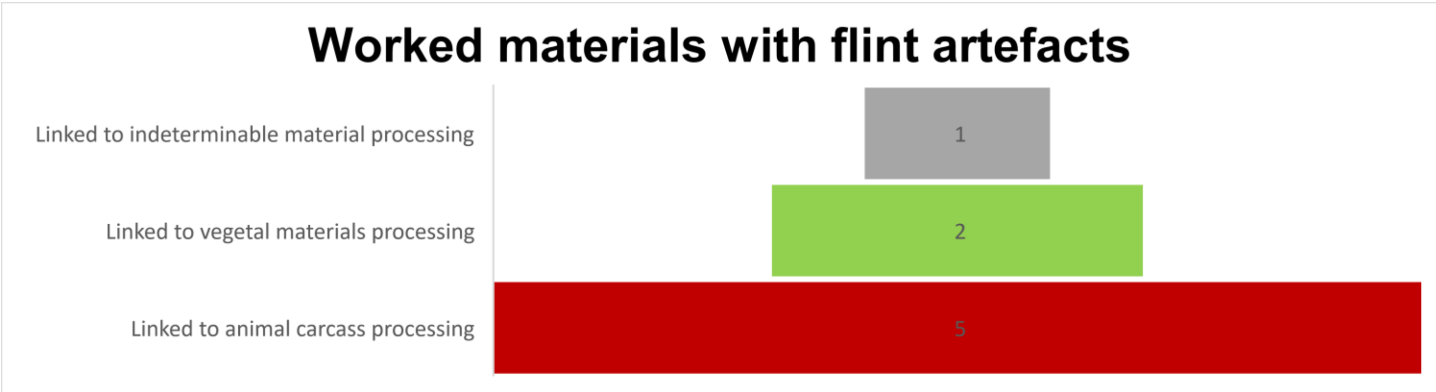

Figure 14.5: use- wear traces identified on flint artefacts grouped by material processed.

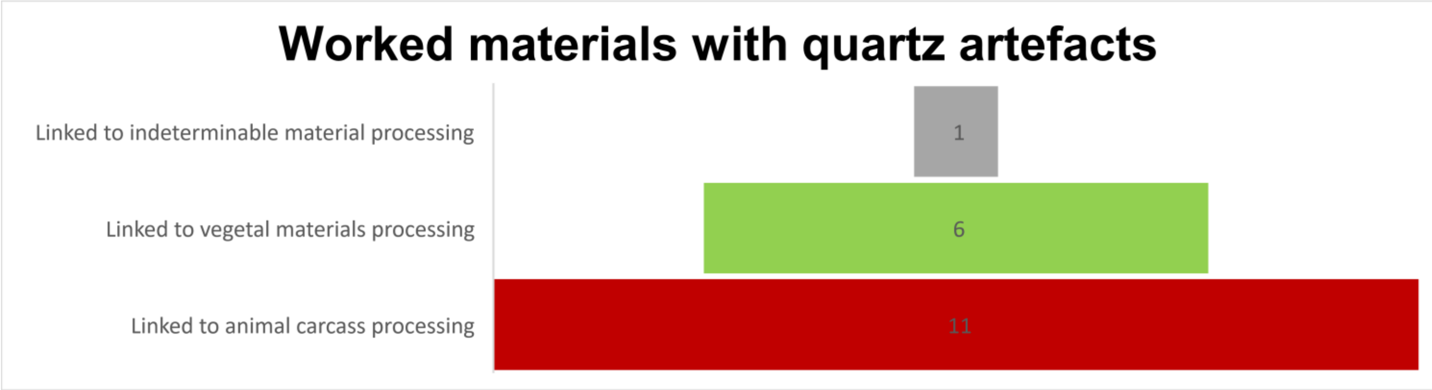

Figure 15.5: use- wear traces identified on quartz artefacts grouped by material processed.

Table 7.5: S.U. 14, formal tools with use-wear traces grouped by typology and raw materials.

Method	**Levallois**			**Discoid**			**Opp.**			**Indet**	
Raw materials	*Denticulates*	*Sidescrapers*	*Notch*	*Denticulates*	*Sidescrapers*	*Notch*	*Denticulates*	*Sidescrapers*	*Notch*	*Quinson point*	*Tot. X R.M.*
Quartz		1	1		1		1	1	2		7
Spongolite		1									1
Alloctonus flint				1				1		1	3
Tot x Raw materials	3			2			5				11

Table 8.5: S.U. 14, use-wear traces on the formal tools grouped by action, typology and worked material. (Tran. Act. =transversal action; Long. Act. = longitudinal action; Mix = mixed action; Indet. = indeterminate action).

Material	Denticulates				Sidescrapers				Notch				Quinson point				Tot.
	Tran. Act.	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*	
Butchering						1				1							2
Hide	1																1
Soft animal tissue																	0
Fresh Bone																	0
Wood					1	2											3
Non woody plant					1												1
Dry Hide									1							1	2
Indet.																	0
Soft																	0
Medium Soft																	0
Medium Hard	1								1								2
Hard																	0
Tot.	**2**	**0**	**0**	**0**	**2**	**3**	**0**	**0**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	11
Tot. for typology	**2**				**5**				**3**				1				11

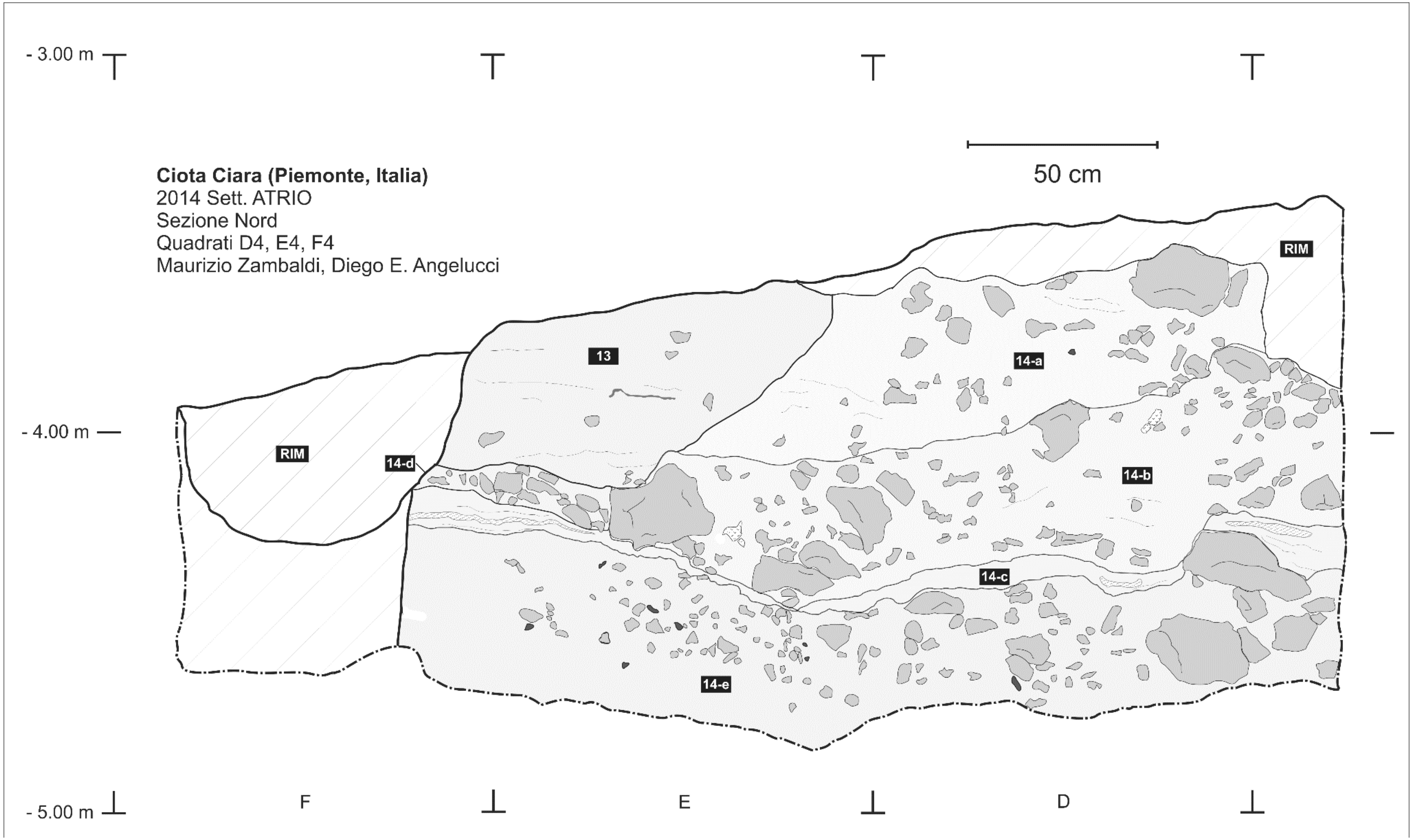

Figure 16.5: stratigraphy of the N. section squares:D4; E4; F4 (Zambaldi, Angelucci, and Arzarello 2016).

5. Discussion

Almost half (41%) of the SU 14 selected sample shows diagnostic traces of use (30 artefacts). Quartz and flint products were used to perform the same kind of activities with similar percentage (Fig. 14 and 15). Moreover, a fraction of the artefacts could have been so lightly used that no visible traces developed. Although probably under-represented, the total number of used artefacts in the SU 14 assemblage, permits a secure interpretation of the use-wear patterns. Note that un-retouched and retouched artefacts with recognizable wear-traces here are all defined as ‘‘tools’’. Fig. 13 and Tab. 3 summarize their functional interpretation. Animal carcasses processing activities were more often performed including different phases of the exploitation of the carcasses: 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 (22%; 7 tools) that are referable to activities such as skinning, evisceration, disarticulation and de-fleshing of carcasses (Lemorini et al. 2006). The tools with traces of fresh and dry hide work (5 tools in total) suggest the presence of some type of tanning activity performed in the site, these are long lasting processes (Anderson-Gerfaud 1990; Beyries 1987; Lemorini 2000; Palmqvist et al. 2005). Bone working (19%; 6 tools), linked mainly to a transversal action (5 tools) can be referred to the periosteum removal, necessary during the process of marrow extraction (Grayson 1984). The tools with traces of contact with fleshy tissues (2) are probably linked to filleting activities. Vegetal materials processing was performed less frequently and in these groups are included wood working and non-woody plant working. Woodworking traces can be interpreted as the results of the manufacture of spears or of other utilitarian wood objects (Rots and Hardy 2015). However, part of these traces and actions can also be associated with herbaceous plants/wood processing, thus suggesting that the Ciota Ciara cave inhabitants may have gathered such materials in addition to animal carcasses.

In the case of the studied sample of S.U. 14, a good quantity of the formal tools were used, even if the most of the edges with Z.U. are un-retouched (20 as opposed to 11) and all the activities carried out in the site were performed using indistinctly retouched-edges and un-retouched edges (Tab. 6 and 7). Also important is the observation that all the formal tools, made in quartz and in local flint, were discarded before exhaustion, suggesting only brief use, probably related to a single activity (Lemorini et al. 2006). On the contrary, the tools made in allochthonous flint have more than one phase of reshaping and were probably used for several activities. This behavior can be due to the low efficiency of the cutting-edges made in quartz and local flint (Daffara et al. 2014; Arnaud et al. 2013; Berruti and Arzarello 2012). These data is confirmed by the relatively high presence of traces on tools made in allochthonous flint despite their scarce numeric presence in the lithic assemblage (Daffara et al. 2014; Arnaud et al. 2013; Angelucci et al. 2015).

The archeozoological study of the cut-marks allowed the identification of three different activities: evisceration, filleting and fur removal. Fur removal is also confirmed by the traces of hide work found during the use-wear analysis (Buccheri 2014; Buccheri et al. 2016). The archaeozoological data also confirmed the presence in the site of activities of bone scraping thanks to the presence of several bone with clear traces of scraping (Buccheri 2014; Buccheri et al. 2016).

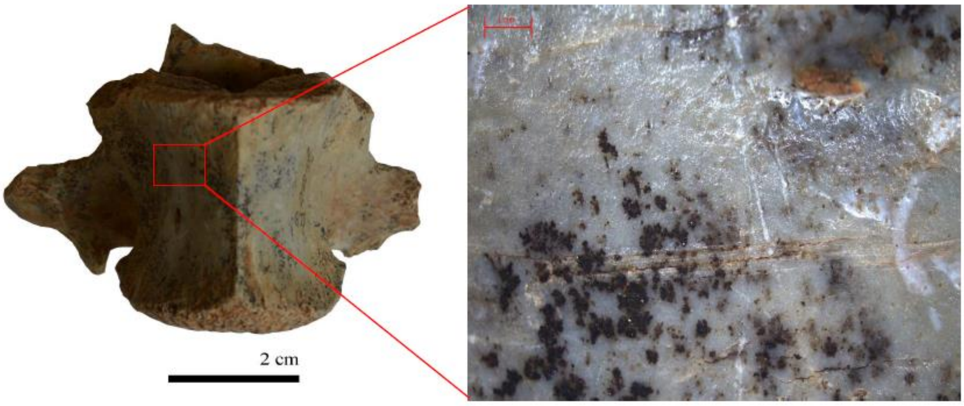

Figure 17.5: traces of scraping on Ursus spelaeus vertebra (from Buccheri 2014).

6. Conclusion

The use wear analysis results, together with the archeozoological and the technological study, contributes to the interpretation of the the SU 14 of the Ciota Ciara Cave as base camp with repeated medium-term occupations. In this S.U., the presence of various and good documented activities identified by the use wear-study together with the results of the archeozoological analysis (Buccheri et al. 2016; Arnaud et al. 2013; Buccheri 2014) confirm, a long (medium)-term occupation of the cave (Stiner 2013), as already supposed according to the following observations : increasing of the lithic implements (Arnaud et al. 2013; Angelucci et al. 2015, Arnaud et al. in press), increasing of the lithic artefacts made in good quality allochthonous flint (Arnaud et al. 2013; Angelucci et al. 2015, Arnaud et al. in press), presence of a fireplace (Arnaud et al. 2013), increasing of the presence of herbivorous faunal remains (Berto et al. 2016) and presence of faunal remains with cut-marks (Buccheri et al. 2016; Buccheri 2014). These occupations were characterized by a strong exploitation of animal resources, with long lasting processes, as hide treatments, combined with a marginal exploitation of vegetal resources.

CHAPTER VI

THE USE WEAR ANALYSIS OF THE LITHIC INDUSTRY FROM THE MIDDLE PALEOLITHIC SITE OF CAN GARRIGA (LAYER 1), ST. JULIÀ DE RAMIS (GIRONA).

1. Introduction

Can Garriga is one the Middle Paleolithic sites located in the surroundings of Girona (Fig. 1) (Mora et al., 1987; Rodriguez, 2004; Rodriguez et al., 1995). The site was known and excavated since 1986 and hundreds of lithic remains were found during two different excavation campaigns. In the site were discovered 3 different archaeological layers, characterized by the presence of lithic industries on different local raw materials (mainly quartz followed by quartzite, porphyry, hornfels, syenite, etc.) attributable to Mousterian. The site is well dated thanks to a succession of travertine layers (Rodríguez et al. 2004; Giralt et al. 1995; Carbonell, Rodríguez, and Sala 1992). Level 1 is the richest in archaeological finds and it was interpreted as a phase of occupation specialized in the processing of animal carcasses. This hypothesis is supported by the technological study of the lithic industries and by the spatial organization of the site (Rodríguez et al. 2004; Giralt et al. 1995; Carbonell, Rodríguez, and Sala 1992). The aim of this work is to verify this hypothesis through the use-wear analysis; furthermore, specifically for the quartz lithic industry, it is interesting to determine whether or not there is a relationship between the quartz morpho-structural groups (Hermida 2005; Rodríguez-Rellán 2016; Venditti, Tirill, and Garcea 2016; Hermida 2008)and the use of the lithic implements. This study focuses only on Level 1 while Level 2 and 3 are not considered, since just a little number of lithic artefacts are clearly referable to these archaeological levels, respectively 33 and 32.

2. Can Garriga

The archaeological site of Can Garriga was discovered in 1986 by Eudald Carbonell and Rafael Mora thanks to the finding of some lithic artefacts along the National route II (Mora, Carbonell, and Martínez 1987; Xosé Pedro Rodriguez 2004; Xosé Pedro Rodriguez et al. 1995). The site is situated in the municipality of St. Julià de Ramis (Gerona) at the slope of a small hill, in the distal side of the promontory of an ancient glacier, above the Ter second terrace (Fig.2), seventy meters above the sea level and twenty-two meters above the Ter river (Giralt et al. 1995; Xosé Pedro Rodriguez 2004).

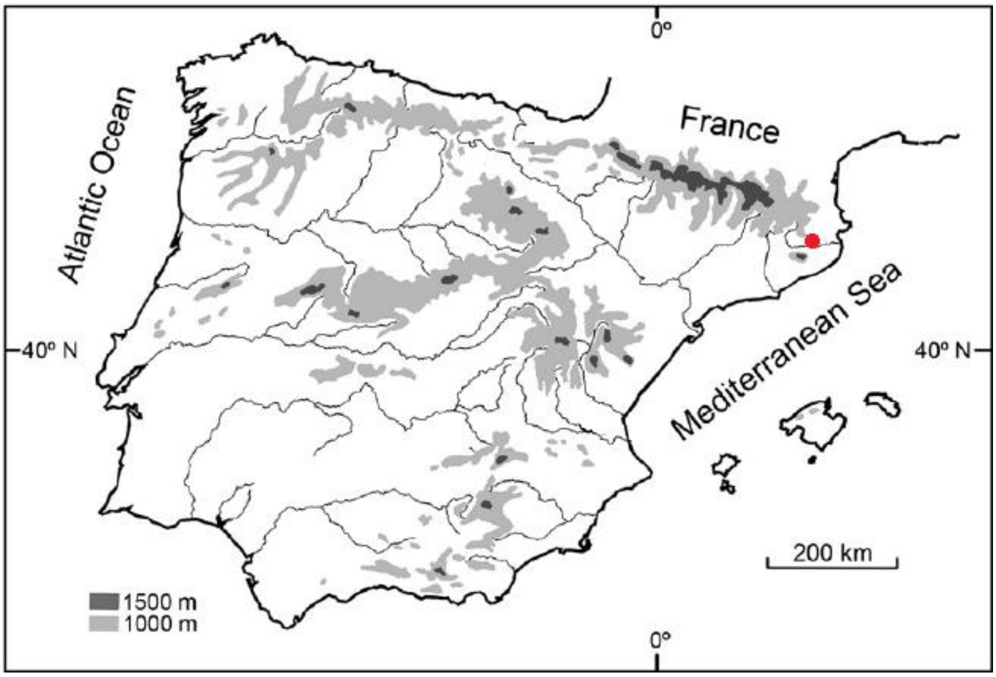

Figure 1.6: location of Can Garriga.

It is placed between the left side of the Ter river and of the National route II and the right side of La Garriga stream (Xosé Pedro Rodriguez and Lozano Ruiz 1999; Canal and Carbonell 1989; Sala et al. 1992; Carbonell, Rodriguez, and Sala 1992; Giralt et al. 1995; Mora, Carbonell, and Martínez 1987).

When the site was discovered, it was already partially destroyed by the roadworks for the realization of the highway. The same year of the discovery an excavation took place and in the spring of 1991 another excavation campaign was accomplished in order to save the data from the imminent destruction of the site, due to the remarking of the highway. During the excavations, were identified four archaeological levels that 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 for the entire region (Giralt et al. 1995).

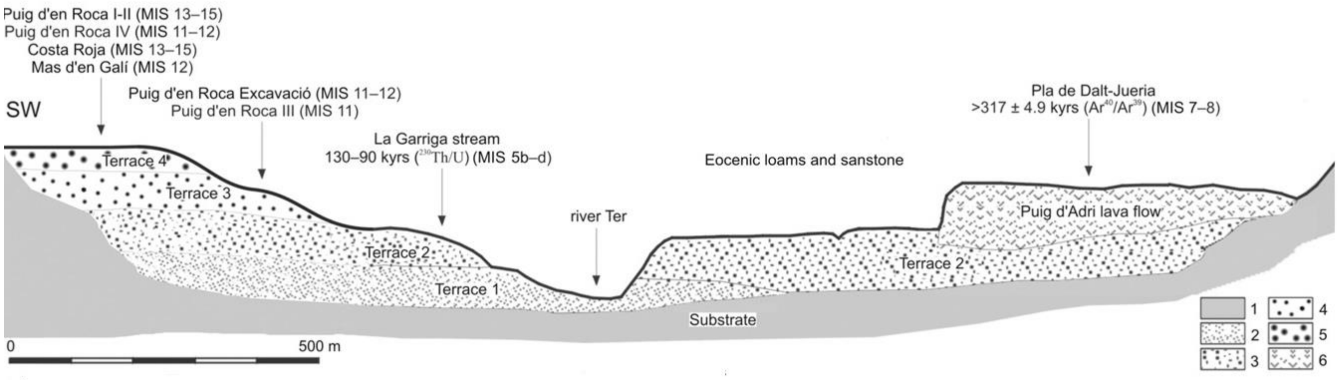

Figure 2.6: synthetic longitudinal profile of the middle basin of the Ter terraces. 1: Eocenic loams and sandstones substrate, 2: silts and clays from the recent river bed (T1), 3: dark brownish silt soils (T2), 4: carbonated brownish silt soils (T3), 5: reddish-brownish clays soils (T4), and 6: basalt from the Puig d'Adri volcano (modified from Garcia 2015).

2.1 Stratigraphy and chronology

In 1991, three stratigraphic sequences were exposed in Can Garriga, one with the aim to contextualise the archaeological levels and define the sedimentary dynamics (CG-1), two to identify possible lateral lithological changes (CG-2 and CG-3) (Giralt et al. 1995; Carbonell, Rodríguez, and Sala 1992). CG-1 consist in an alternation between carbonate sands and travertine levels. CG-2 and CG-3 show an alternation between sands and travertine levels: the travertine has a reduced lateral extension, showing an important lateral variability, as it is evident from the comparison of the three stratigraphic sequences. The analysis of these stratigraphic sequences led to the reconstruction of the sedimentation dynamics of the site, characterized by the alternation of glacis deposits, putting sands, and periods of stability, whereon little rafts appeared and generated travertines (Giralt et al. 1995; Xosé Pedro Rodriguez 2004). The sedimentary dynamic of Can Garriga began with the formation of a travertine level on the second terrace (T2) of Ter river (Fig. 2), 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, formed by the action of the superficial streams of La Garriga's hill. On the top, a travertine layer was localized, dated in 107.6 Ka. On this travertine layer was found the archaeological level 3, formed by pedogenic clays, with volcanic particles on its top. The analysis of these volcanic particles offered a magnetic inverse polarity, corresponding to the Blake episodes (118 Ka).

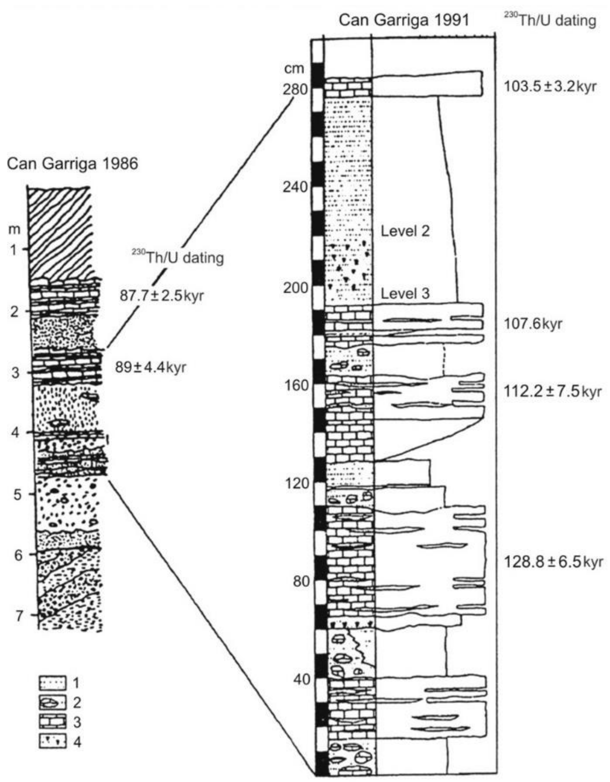

Figure 3.6: Stratigraphy of Can Garriga, and correlation of the stratigraphic sequence with the 230Th/U chronology. 1: sand, 2: sand with travertine nodules, 3: travertine 4: sand with volcanic particles (From Garcia 2015).

Above it, the archaeological level 2 was deposited, in a deposit of clays and sands. On its top there is a travertine layer that was dated in 103.5 ± 3.2 Ka

(Garcia 2015; Mora, Carbonell, and Martínez 1987). Above is located the archaeological layer 1 (also in a deposit of clays and sands) and finally, the last travertine level dated in 87.7 ± 2.5 Ka (Mora, Carbonell, and Martínez 1987; Xosé Pedro Rodriguez 2004; Giralt et al. 1995; Garcia 2015).

Figure 4.6: 1991 excavationin Can Garriga (From Garcia 2015)

2.2 The lithic industry

The lithic industry is characterized by the use of many different raw materials: mainly vein quartz followed by quartzite, porphyry, hornfels, syenite and other raw materials scarcely represented in the assemblage (sandstone, granite, limestone, diorite, lydite and basalt). The various raw materials were available locally in the surroundings of the site, in secondary deposition in the form of pebbles, probably in the rivers bed. The knapping methods are various with a clear preponderance of opportunistic reduction sequences on all the raw materials. Discoid (E. Boëda, Geneste, and Meignen 1990; Böeda 1993; Peresani 1998) and recurrent centripetal Levallois (Böeda 1993; É. Boëda 1994) knapping methods are also represented and employed on all the main raw materials (Fig.5). The reduction sequences are short for all the raw materials and for all the knapping methods and cores were often discarded before their complete exhaustion. Retouched tools are barely attested in the lithic industry, and they are represented by denticulates, scrapers and notches (Xosé Pedro Rodriguez and Lozano Ruiz 1999; Canal and Carbonell 1989; Sala et al. 1992; Carbonell, Rodriguez, and Sala 1992; Giralt et al. 1995; Mora, Carbonell, and Martínez 1987; Garcia 2015; Rodríguez 2004).

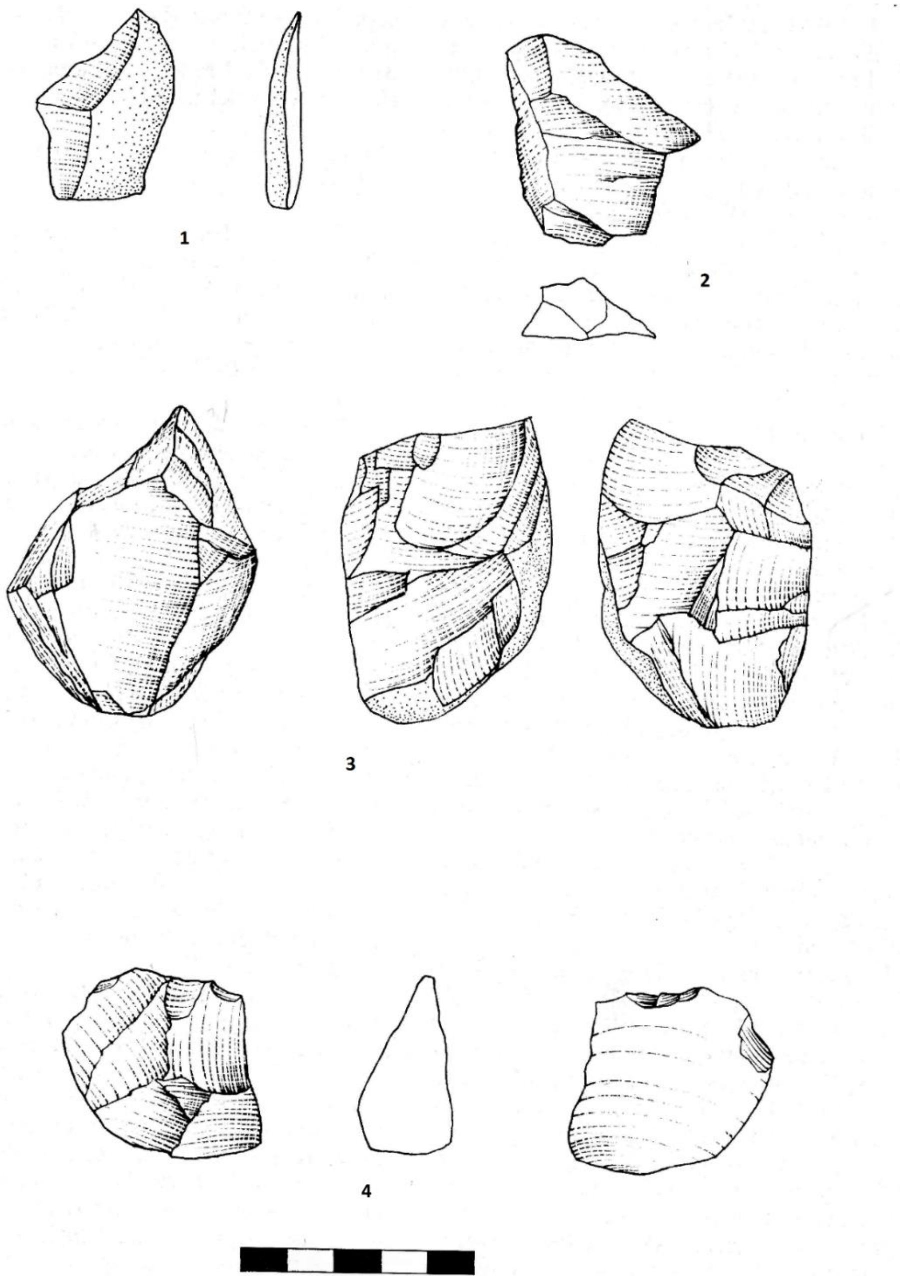

Figure 5.6: Can Garriga lithic industry : 1-2:quartz discoid flakes; 3: porphyry opportunistic core; 4: quartz notch (modified from Rodriguez et al., 1995).

2.3 Structures and faunal remains

In level 1 were found numerous limestone cobbles and travertine plaques that seem to be heaped intentionally. The main association consist of a heap (270 x 190 x 30 mm) of six travertine's fragments and seven limestone cobbles (Fig.6). In the same level was found also a group of syenite cobbles with percussion marks that were likely used as anvils for the breakage of bones, even if the absence of faunal remains does not allowed to confirm this hypothesis (Rodriguez et al., 1995). The unique paleontological remains found in the site are two indeterminable and burned fragments of diaphysis, and a small quantity of malacofauna remains (Xosé Pedro Rodriguez 2004).

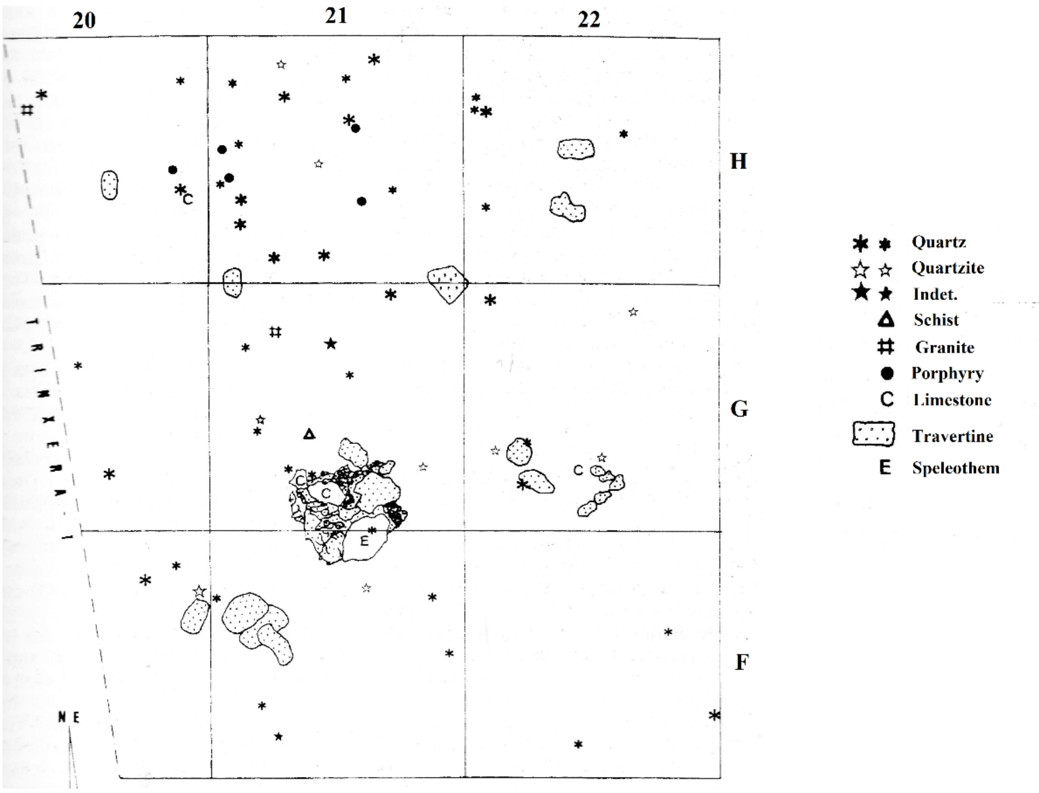

Figure 6.6: Can Garriga, a heap (270 x 190 x 30 mm) of six travertine's fragments and seven limestone cobbles (modified from Rodriguez et al., 1995).

2.4 Quartz morpho-structural groups

In archaeology, quartz is traditionally considered a homogeneous raw material, classified following its external aspect (colour and opacity) in two main types:

hyaline and milky quartz (or vein quartz). This classification does not take into account its different petrological characteristics and does not allow to distinguish among the different knapping qualities of each type of quartz. For that reason, some scholars prefer to use the petrological and geological classification based on its formation processes (A. D. L. Hermida 2005; Rodríguez-Rellán 2016; Venditti, Tirill, and Garcea 2016; L. Hermida 2008). In that way it is possible to define two main types of quartz: automorphic quartz, that displays its crystal structure (hyaline or translucent quartz) and xenomorphic quartz, formed through the aggregation of several microcrystals, that macroscopically present a solid structure (Luedtke 1992; Rogers 1935). These differences are caused by different formation conditions such as: temperature, cooling rate time and empty space (Luedtke 1992; Rogers 1935). Differences in cooling rates, temperature and core density can occur in the same primary vein formation, therefore, different kind of quartz textures can be observed in the same vein formation (Fig.6) Consequently, a number of different textures can be observed in quartz samples that come from the same vein, or even in the same cobble. Different textures correspond to different mechanical properties (Collina-Girard 1997). It is possible to distinguish four morpho-structural groups of quartz based on the presence/absence of the morpho-structural variables of grains (distinguishes grainy quartz from macro-crystalline quartz) and planes (applied to quartz with internal flaws or crystalline surfaces). Following this scheme, quartz artefacts can be placed into the following morpho-structural groups: NN (no grains, no planes), NS (no grains, planes), SN (grainy, no planes) and SS (grainy, planes) (A. D. L. Hermida 2005). The use of this morpho-structural classification could allow the identification, if there was, of the criteria for the selection of quartz blanks according to their formation and/or mechanical properties (A. D. L. Hermida 2005).

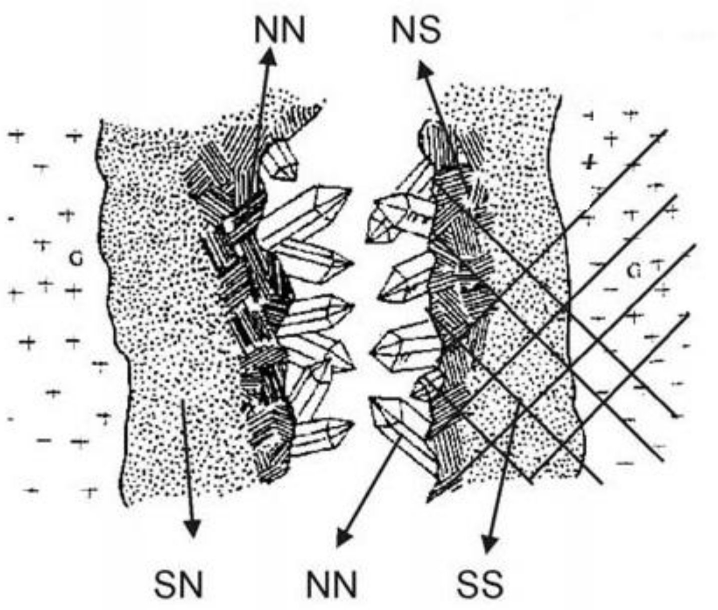

Figure 7.6: Vein quartz formation and morpho-structural groups (Collina-Girard, 1997).

3. Materials and methods

The lithic assemblage analysed corresponds to the lithic artefacts clearly referable to the 1991 excavation and it consists of 283 lithic artefacts coming from the archaeological Level 1. The same assemblage is now under study for a new technological analysis by Sara Daffara. Among the 283 lithic artefacts, for the use wear analysis a sample of 32 artefacts was selected, of which 8 finds are made in quartzite, 1 in hornfels, 3 in porphyry, 19 in quartz belonging to various morpho-structural groups (NN 1; 2 NS; 14 SN; 1 SS; 1indet.) and 1 in syenite. Five criteria were applied to select artefacts for the use-wear analysis: 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 which are probably related to an ancient use. 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.

3.1 Experimental collection

An experimental collection composed of about 50 artefacts obtained from the most particular raw materials represented in the sample (limestone, hornfels, porphyry and syenite) was realized. 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 time intervals (5-15-25 min.).

3.2 Use-wear method

The method employed for the use wear analysis of the experimental collection and of the selected sample was 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 of also the type of material worked. There are indeed some advantages working with the two methods together: the stereoscopic microscope (LPA) has a long working distance, wide depth of field and produces 3D image, 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 lower magnification, slight traces can be missed, but this can happen also with HPA. In the combined approach the stereo microscope analysis (LPA) represent an excellent tool for the screening of the material, for the selection of the sample and for macroscopic observations (e.g. Lemorini et al. 2014; Wilkins et al. 2015; Moss 1983; Beyries 1987; Ziggioti 2011; 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 high-power approach. The combinate 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., 2014a; Plisson et al., 2008). To reduce the intensity of the fastidious glare, typical of quartz-rich raw materials (quartz and quartzite) (Clemente-Conte and Gibaja Bao 2009; Lemorini, Plummer, et al. 2014; Igreja 2009) 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 was applied for all the lithic artefacts, even that in limestone, hornfesls, porphyry and syenite.

4. Results

4.1 Experimental collection results

The study of the experimental collection led to interesting observations concerning the most particular raw materials present in the considered lithic assemblage. Porphyry has, more or less, the same reaction to use as quartzite (Clemente & Gibaja 2009; Gibaja et al. 2002; Gibaja et al. 2009; Igreja 2009; Lemorni et al. 2014a). The experimentation carried out show that the edges of porphyry tools are 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, when they are present on the active edges of the tools. In these cases, it is possible the identification of the material worked following the same procedure used for the quartz crystals in quartzite lithic tools (Clemente & Gibaja 2009; Gibaja et al. 2002; Gibaja et al. 2009; Igreja 2009; Lemorni et al. 2014a). 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 (limestone, hornfesls, and syenite) show a different pattern. At a low magnification (LPA), the analysis of the edges shows marked and widespread macro use-wear traces (as edge removals and fractures) that lead to a rapid dulling of the blanks, thus attesting their lower efficiency compared to chert, quartz and quartzite. The non-vitreous surfaces of these blanks have not allowed any profitable analysis with a metallographic microscope. In particular, no diagnostic features for identification and description of micro-polishes could be detected. For the experimental tools made with these particular raw material is possible to detect the shape, the dimension and the orientation of the mechanical traces and then it is possible to identify the direction of the gesture and the hardness of the material processed (Odell 1981; Tringham et al. 1974; Semenov 1964).

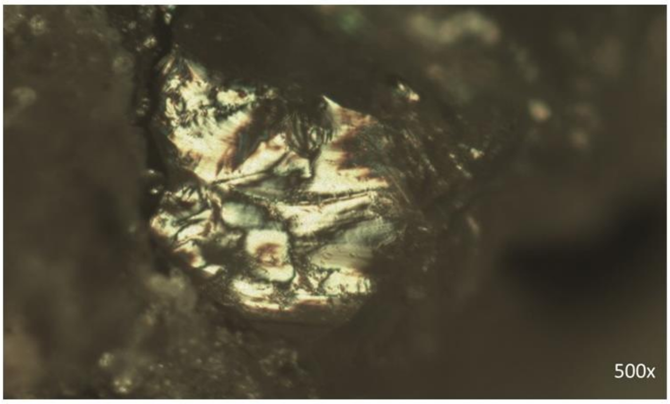

Figure 8.6: wear traces on the edge of a quartz flake (sper 11) use for woodworking (15 min), compare with the Fig 10.

4.2 Use wear analysis results.

At the macroscopic level the state of conservation of the lithic industry of level 1 is generally good and three type 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).

The study of the archaeological sample allowed to identify 9 artefacts with traces of use (Fig. 8, 9, 10, 11). Among them, 8 are made in quartz and 1 in porphyry (Table 1). 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 the worked material (1 wood and 1 dry bone) was identified, while in 2 cases were detected only indeterminable micro-polish on the artefacts edges, but it was possible to determine also the hardness of the worked material (medium 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 found on 1 quartz artefacts and they are linked to dry bone working.

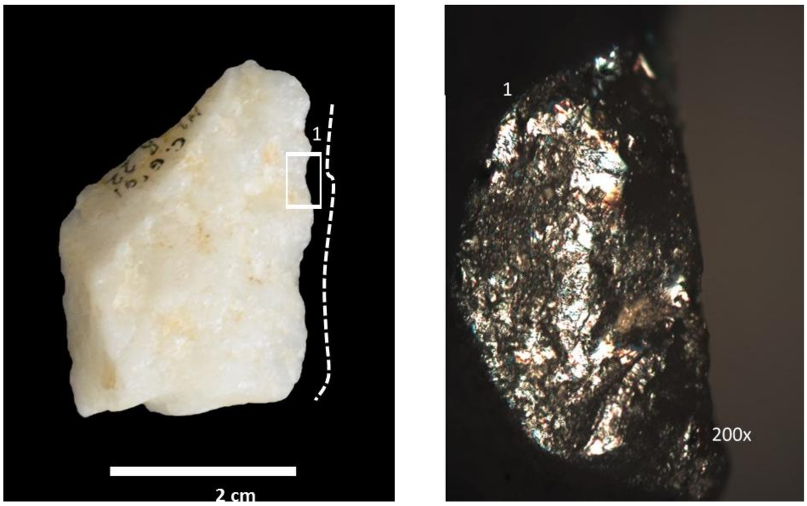

Figure 9.6: Can Garriga, quartz flake (R22). Behind the crushed and worn edge rim of the flake, thin plastic deformations (sleeks) have developed, oriented perpendicular to the edge. Typical of hide working.

Table 1.6: Can Garriga, use-wear traces on the litchis artefacts of layer 1 grouped by action, method of debitage and worked material. (T =transversal action; L = longitudinal action; Mix = mixed action; Indet. = indeterminate action; MH = medium hard material; H = hard material; MS = Medium soft material).

Square	Number	Raw Material	Method	Formal Tools	Morpho structural groups	Action	Hardness	Material
G21	22	Quartz	Discoid		SN	MIX	MH	Dry bone
K21	10	Quartz	SSDA	Notces	SN	T	H	Indet pol
G22	1	Porphyry	SSDA		/	L	MS	Wood fresh
K21	5	Quartz	SSDA	Side-scarper	SS	T	MH	?
G22	22	Quartz	Levallois R.C.	Denticulate	SN	T	MS	Wood fresh
G21	24	Quartz	Opp.	Denticulate	SN	T	MH	Indet pol
	R22	Quartz	SSDA		SN	L	MS	Hide
J21	16	Quartz	Discoid		SN	T	MS/MH	?
K20	13	Quartz	Levallois R.C.		SN	T	MS	Bone

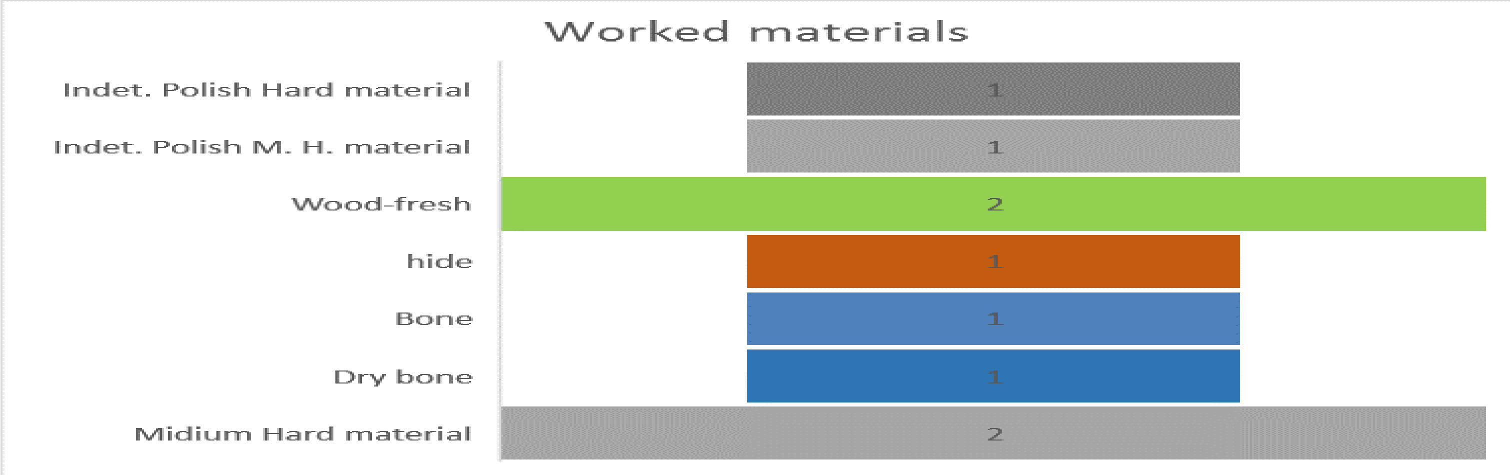

Figure 10.6: Can Garriga, worked materials.

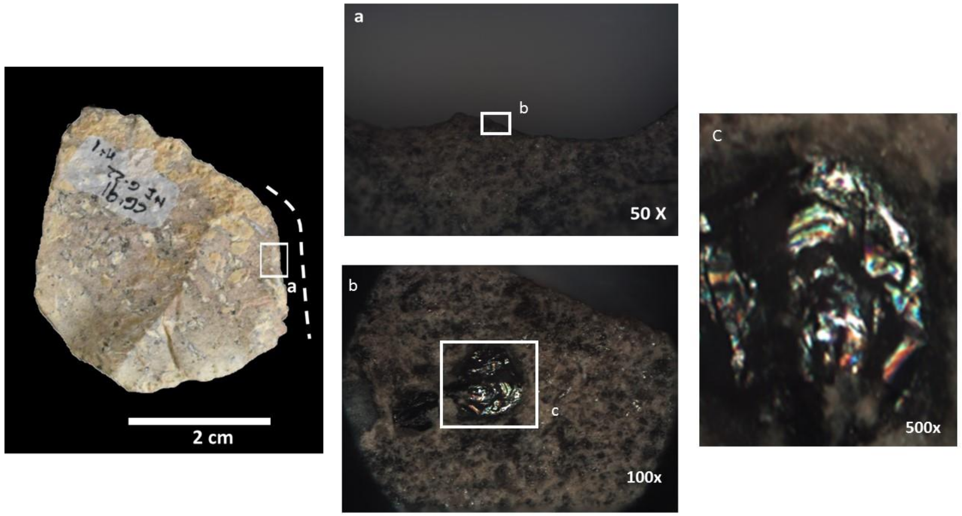

Figure 11.6: Can Garriga, porphyry flake (G22 1) a – edge removal typical of a longitudinal action, b- quartz crystal near the edge; c- well developed dommed polish on the crystal quartz surface near the edge typical of woodworking.

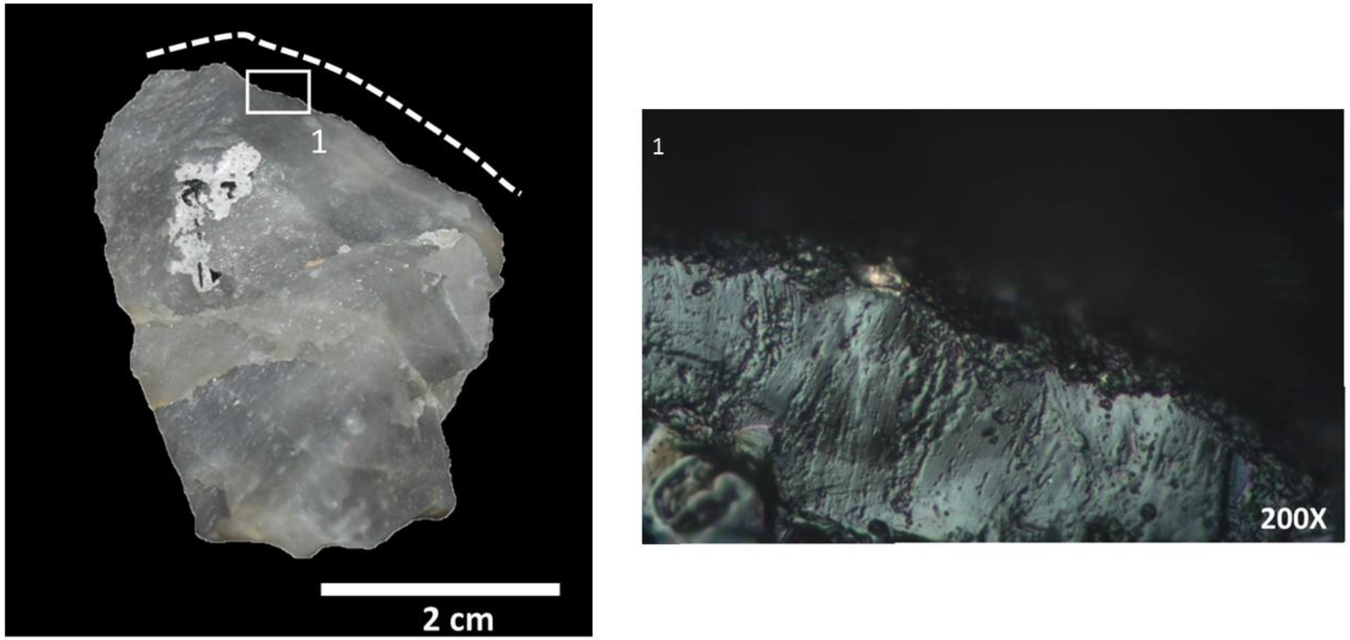

Figure 12.6: Can Garriga, quartz flake (G21 22).1- troughs and sleeks oriented perpendicularly to the edge. In line with the edge, deep surface cracks and micro holes typical of bone working

5. Discussion

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. The presence of these activities falls in the normal scenery of activities carried out in Middle Paleolithic 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 (Gibaja, Clemente, and Mir 2002; Clemente-Conte and Gibaja Bao 2009). 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, Tirill, and Garcea 2016). The same post depositional alteration have probably destroyed the most part of the faunal remains (Xosé Pedro 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 (Longo 1994; Grayson 1984; Hardy et al. 2004). 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 (Rodríguez, 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.

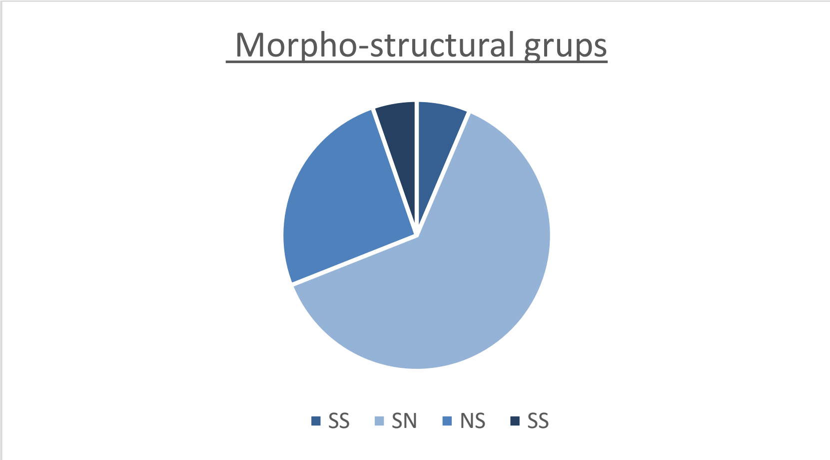

Figure 13.6: Division by morpho-structural groups of all the quartz lithic assemblage (S.Daffara personal communication).

The crossed analysis of the morpho-structural groups of quartz and of the use wear traces, shows how the group SN shows more traces (8 on 9), without differentiation based on type and hardness of the worked material or on the action carried out. These data are consistent with the percentage of presence of lithic finds made with this morpho-structural group in the quartz lithic assemblage (Fig. 11) (S. Daffara personal communication). This can be due to a conscious choice or by a greater presence of quartz pebbles of this morpho-structural group in the raw material supply area. On this point, more focused studies are needed.

6. Conclusion

Although scarce, the results of the use wear analysis can be used to hypothesize the function of the site. 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 came at the same conclusions observing the shortness of the *chaînes* *opératoires* (characterized by the production of unretouched flakes), the presence of an organization of the space and the presence of stone anvils used to break the bones (Rodríguez et al. 2004; Giralt et al. 1995; Carbonell, Rodríguez, and Sala 1992).

CHAPTER VII

THE USE WEAR ANALYSIS OF THE LITHIC INDUSTRY FROM THE MIDDLE PALEOLITHIC SITE OF PETRA DRETA, ST. JULIÀ DE RAMIS (GIRONA).

1. Introduction

Petra Dreta is one of the Middle Paleolithic sites located in the surroundings of Girona (Fig. 1) (Canal et al., 1978; Canal and Carbonell, 1989; Carbonell et al., 1992a; Rodriguez et al., 1995). The site was known and excavated since 1965 and hundreds of lithic remains were found during several different excavation campaigns. In the site was discovered one archaeological layer, characterized by the presence lithic industries on different raw materials (mainly quartz followed by quartzite, porphyry, hornfels, syenite and others) attributable to Mousterian. The site is well dated thanks to a succession of travertine layers (Garcia 2015; Sala et al. 1992; Giralt et al. 1995; Carbonell, Rodriguez, and Sala 1992). The aim of this work is ,with the help of the use-wear analysis, verify if it is possible define the type of occupation of the site; furthermore, specifically for the quartz lithic industry, it is seeking to determine whether there is a relationship between the quartz morpho-structural groups (Hermida 2005; Rodríguez-Rellán 2016; Venditti, Tirill, and Garcea 2016; Hermida 2008) and the use of the lithic implements.

2.Petra Dreta

Pedra Dreta 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. 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

(Rodriguez et al., 1995). On the other side, few hundred meters away from Pedra Dreta, the Garriga stream goes deeper, dividing the Pedra Dreta area from the higher plain where is located the open air site of Can Garriga (Rodriguez et al., 1995).

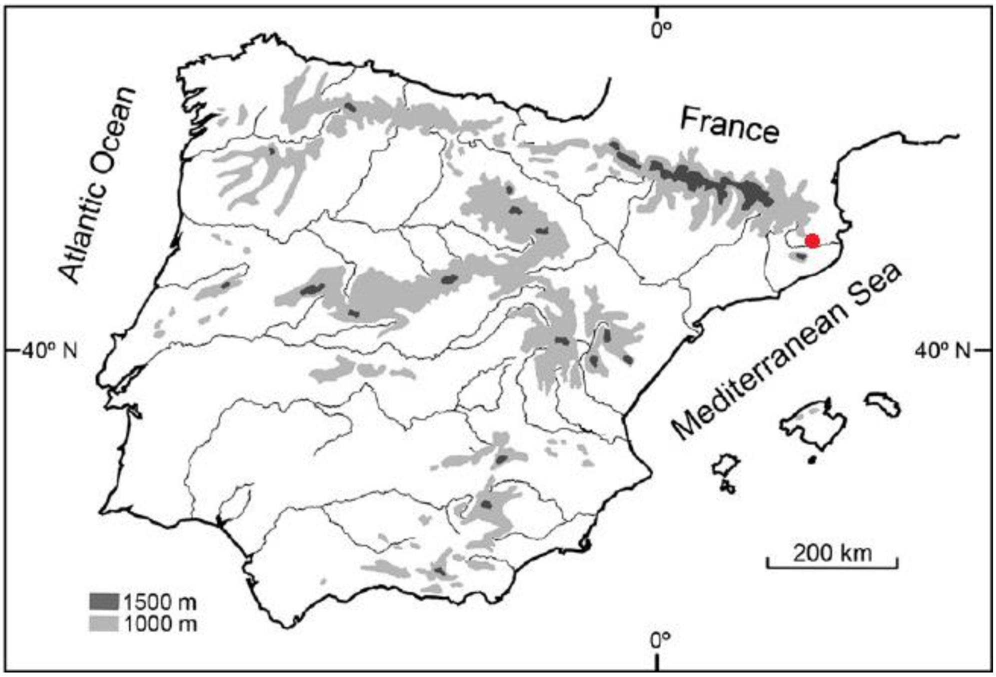

Figure 1.7: Location of the Petra Dreta site.

The site was discovered in 1965 by Francesco Riuró, that collected some lithic artefacts and fragmented fossilized bones during the works for the widening of the National route N-II. (Canal et al. 1978). The first archaeological excavation started in the 1976 was carried out by the “Associació Arqueològica de Girona”. This first excavation started in conjunction with maintenance works of the rural way that run close to the site (Rodriguez et al., 1995). During this first intervention were found 326 lithic artefacts and some fragment of faunal remains, all referable to a human frequentation datable at the Upper Pleistocene (Canal and Carbonell 1989; Canal et al. 1978). In 1991, during the works linked whit the remaking of the National route II and the construction of his connection with the highway A-7 was made a new archaeological intervention (Carbonell et al., 1992a; Rodriguez et al., 1995).

2.1 Geomorphological settings

Pedra Dreta was the name of a menhir, raised at the corner of the way from Cornellà to St. Julià de Ramis, still visible at the beginning of the XXth century (Rodriguez et al., 1995) (Fig. 2). When the excavations took place, it was a rock shelter collapsed and crossed by two routes that completely defaced the original structure of the deposit (Xosé Pedro Rodriguez and Lozano Ruiz 1999; Canal et al. 1978) (Fig. 3).

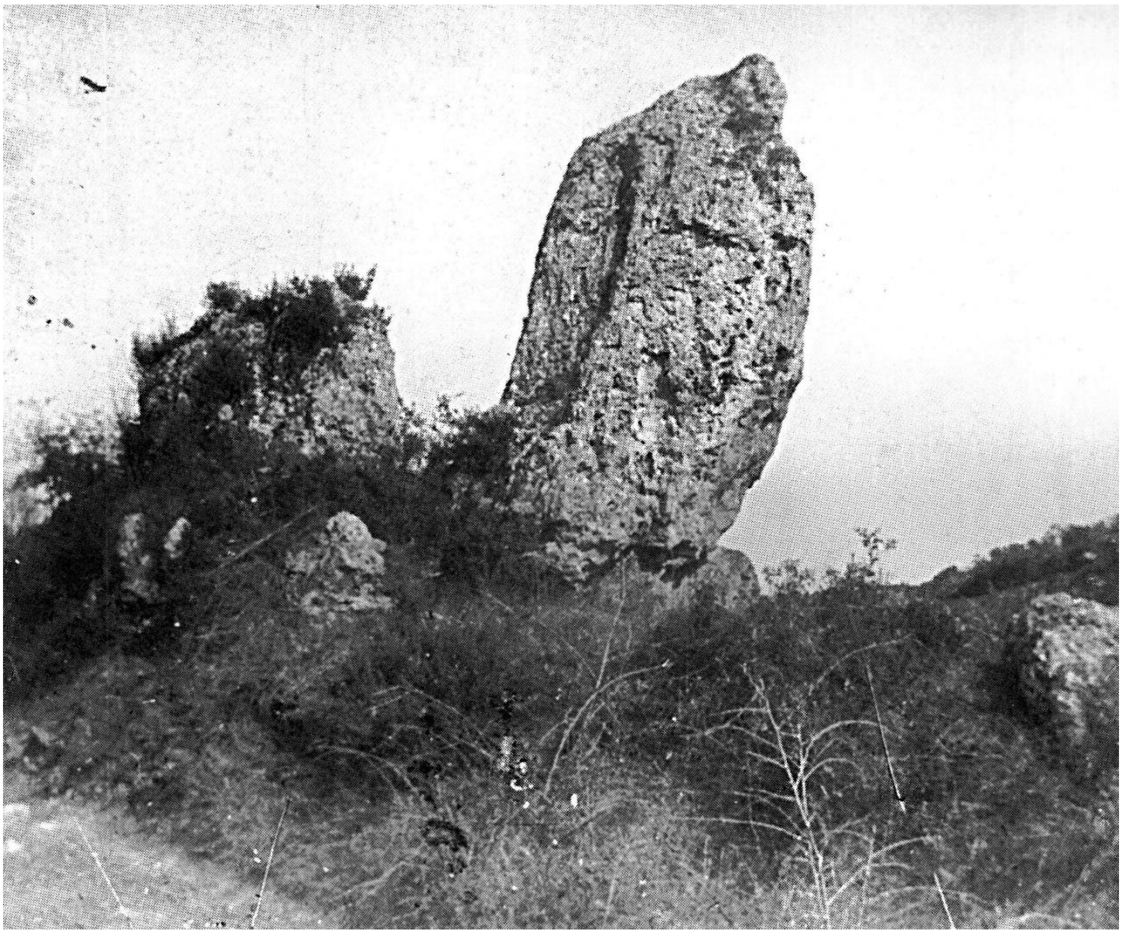

Figure 2.7: Pedra Dreta menhir, raised at the corner of the way from Cornellà to St. Julià de Ramis (from Rodriguez et al., 1995).

2.2 Archaeological excavations

In 1991, two areas of Pedra Dreta were investigated: the main area, located inside the area of the ancient rock shelter, was 42 m^2 wide and the second one was smaller (a survey pit) located just outside the rock-shelter, realized with the aim to identify its original width and to define the sedimentation dynamics (Rodriguez et al., 1995). The identification, in several areas of the excavated surface, of a stalagmitic basement and vault, led to the reconstruction of the ancient morphology of the Pedra Dreta rock shelter that should be 12 m wide and 6 m deep (Fig. 3).

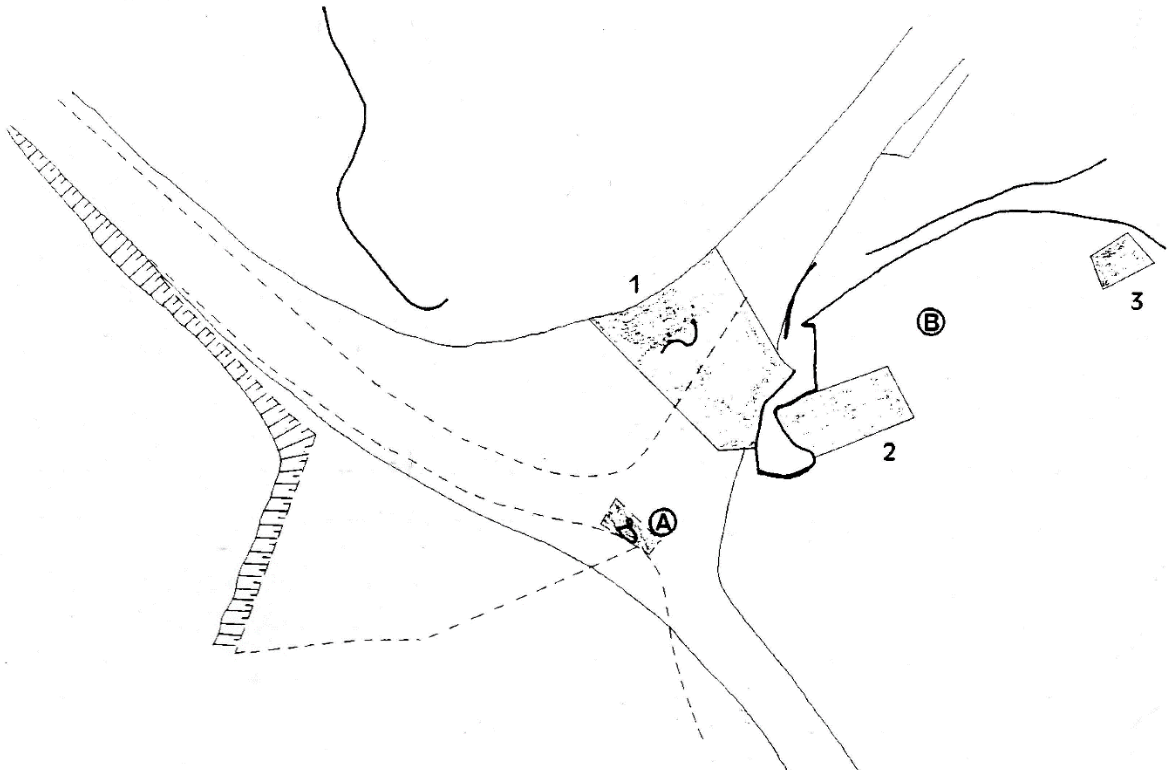

Figure 3.7: Maps of the archaeological excavations: A - area excavated in s 1976-1977; B - area excavated in 1991: B1 and B2 areas correspond to the internal part of the shelter, B3 is the external survey pit (from Rodriguez et al., 1995).

The shelter was oriented north-south, open to south-east, above the Garriga stream. During the excavation were identified two levels delimited by the presence of travertine blocks within the clay-sandy sequence. In the north and in the west part of the investigated area, was identified a structured 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; Rodriguez et al., 1995). In 1991 were collected 688 lithic artefacts and 184 faunal remains (Carbonell, Rodriguez, and Sala 1992) together with some charcoals revealing the presence of fireplaces within the site. That is also documented by the high percentage of burned bones (42%) i. The most part of the faunal remains are indeterminate and just two lower molar of *Equus sp.* and an upper right D3 of *Dicerorhinus sp.* have been clearly identified (Rodriguez et al., 1995; Rodriguez and Lozano Ruiz, 1999).

2.3 Stratigraphy

During the archaeological intervention of 1991, two stratigraphic sequences were exposed in Pedra Dreta, one inside the rock shelter and the other in the external survey pit (Giralt et al. 1995). The external sequence consists in 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. The lower part is clearly linked to a fluvial dynamic, while the upper part shows a slope dynamic with alluvial fans and the gradual collapse of the rock shelter proved by the travertine boulders (Giralt et al. 1995). The interior stratigraphic sequence show 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).

2.4 Chronology

The 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 by U/Th method. These data state that the sedimentation and collapse of the rock shelter have been quite rapid, covering a time range of the hominin settlement of some 4.000 years (Garcia 2015; Sala et al. 1992; Giralt et al. 1995; Carbonell, Rodriguez, and Sala 1992).

2.5The lithic industry

In this work it is considered only the lithic assemblage collected during the 1991 excavation, since the materials collected during previous interventions does not have any clear stratigraphic indication. The raw materials used are local and probably collected in the form of pebbles in the rivers beds in the surroundings of the site. Vein quartz is the main exploited raw material followed by syenite, quartzite and porphyry. There are also other raw materials, although scarcely represented: hornfels, limestone, basalt, gneiss and schist. The knapping methods are various with a clear preponderance of opportunistic reduction sequences on all the raw materials. The Discoid (E. Boëda, Geneste, and Meignen 1990; Böeda 1993; Peresani 1998) and recurrent centripetal Levallois (Böeda 1993; É. Boëda 1994) knapping methods are employed on all the most represented raw materials. For all the knapping methods, the reduction sequences are short and the cores are usually discarded before their complete exhaustion (Rodriguez et al., 1995; Rodriguez and Lozano Ruiz, 1999).

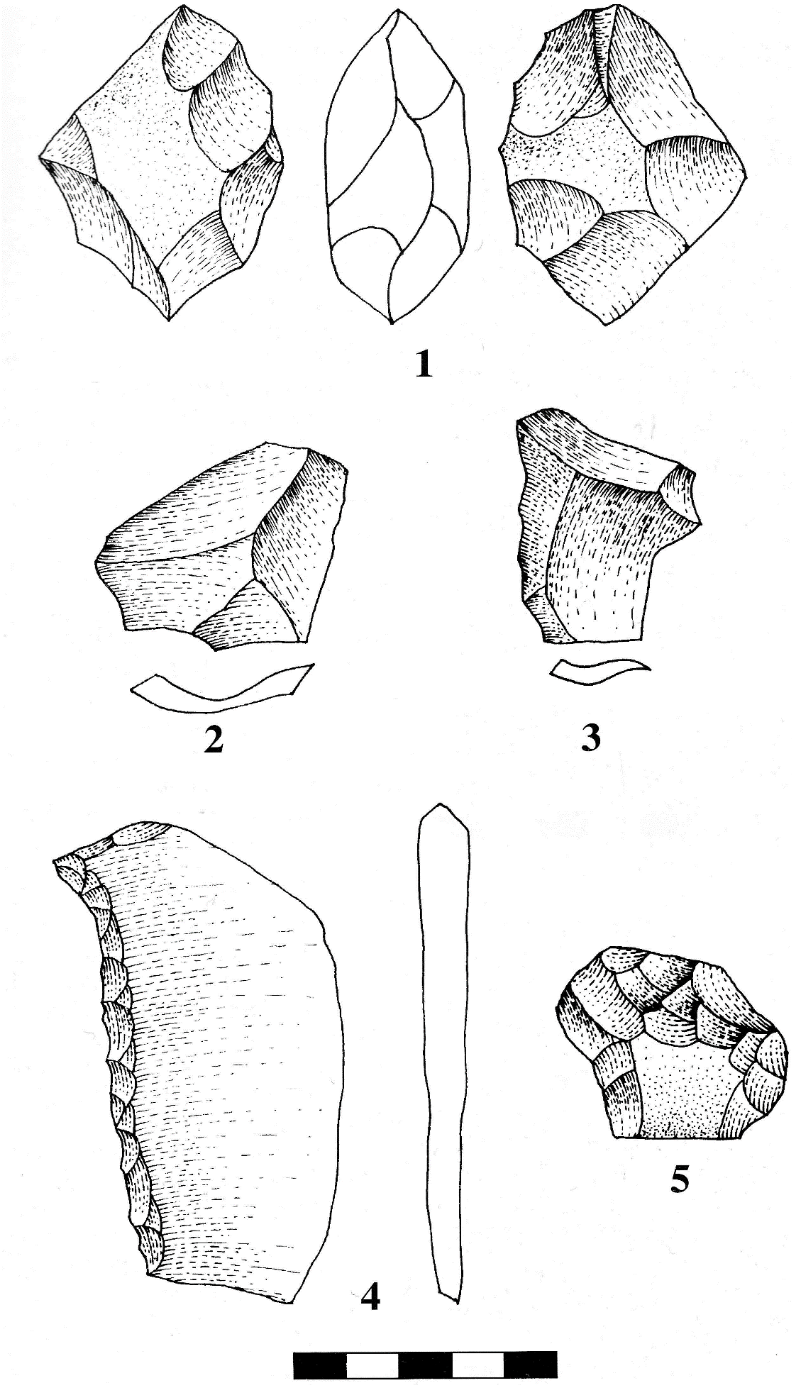

Figure 4.7: 1- discoid core in porphyry; 2-3 discoid flakes in porphyry; 4- 5 sidescraper in quartz. (from Rodriguez et al., 1995).

A low number of cores are present in the lithic assemblage, which suggests that probably part of the production of lithic tools was done out of the site. The formal tools are scarce and represented by few denticulates, scrapers and notches (Rodriguez et al., 1995; Rodriguez and Lozano Ruiz, 1999).

3. Materials and methods

In this study are applied the same methodology and the same experimental collection of Can Garriga, refer to paragraph 3 of the previous chapter.

3.1 Composition of the sample

The lithic assemblage analysed corresponds to the lithic artefacts clearly referable to the 1991 excavation, stored in the warehouses of the Girona Museum, and it consists of 550 lithic artefacts. The same assemblage is under study for a new technological analysis by Sara Daffara. Among the 550 lithics, a sample of 68 artefacts was selected for the use wear analysis. Five criteria were applied to select artefacts for the use-wear analysis: 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 which are probably related to an ancient use. 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.

The raw material composition of this selected sample is: 10 artefacts of quartzite, 1 of limestone, 1 of hornfesls, 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.

4. Results

The state of preservation of the assemblage is generally good. Three type of post depositional alterations were found on the lithic artefacts: white patina, concretion, and edge crumbling. In all the case 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. Traces referable to transversal actions have been recognized on 9 finds and for 8 of these cases 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 action 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 (5 butchering and 1 bone) and porphyry (1 bone). 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.

Table 1.7: Pedra Dreta , use-wear traces on the litchis artefacts of layer 1 grouped by action, method of debitage and worked material. (T =transversal action; L = longitudinal action; Mix = mixed action; Indet. = indeterminate action; MH = medium hard material; H = hard material; MS = Medium soft material).

Square	N.	Raw Material	Method	Tool	MS type	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	Levallois R.C.		SN	T	MS	wood
B3-C	71	Quartzite	Discoid		/	MIX	S	Butchering
E4	7	Quartz	OPPORTUNISTA		NS	T	MH	?
A4	19	Quartz	Discoid		SN	L	S	Butchering
A2	2	Quartz	Discoid		SN	T	MS	Hide
A2	2/	Quartz	SSDA		/	L	MS	Butchering
E5	31	Quartz	SSDA	side-scarper	SN	T	MH	Butchering
E5	41	Quartz	Centripetal		SN	T	MH	Wood
C5	73	Syenite	SSDA		/	L	S	?
B2	2	Quartz	SSDA		SN	L	MS	Butchering
A4	7	Quartz	SSDA		SN	L	MS	Butchering
A3-A	45	HORNFELS	SSDA		/	L	MH	?
B2	18	Quartz	SSDA		SN	L	MS	Butchering
C4-A	81	Porphyry	SSDA		/	T	MH	Wood
C4	78	Quartz	SSDA		SN	L	MS	?
D5	27	Quartz	Discoid		NS	L	MH	Bone
D4	43	Porphyry	Levallois R.C.		/	L	MS	?
D4	102	Quartz	SSDA	denticulate	/	T	MS	Hide
D4	72	Quartz	SSDA		SN	T	MS	Butchering
D4	44	Quartz	SSDA		/	MIX	MH	Wood
B5-D	4	Sienite	Discoid		/	L	MS	?

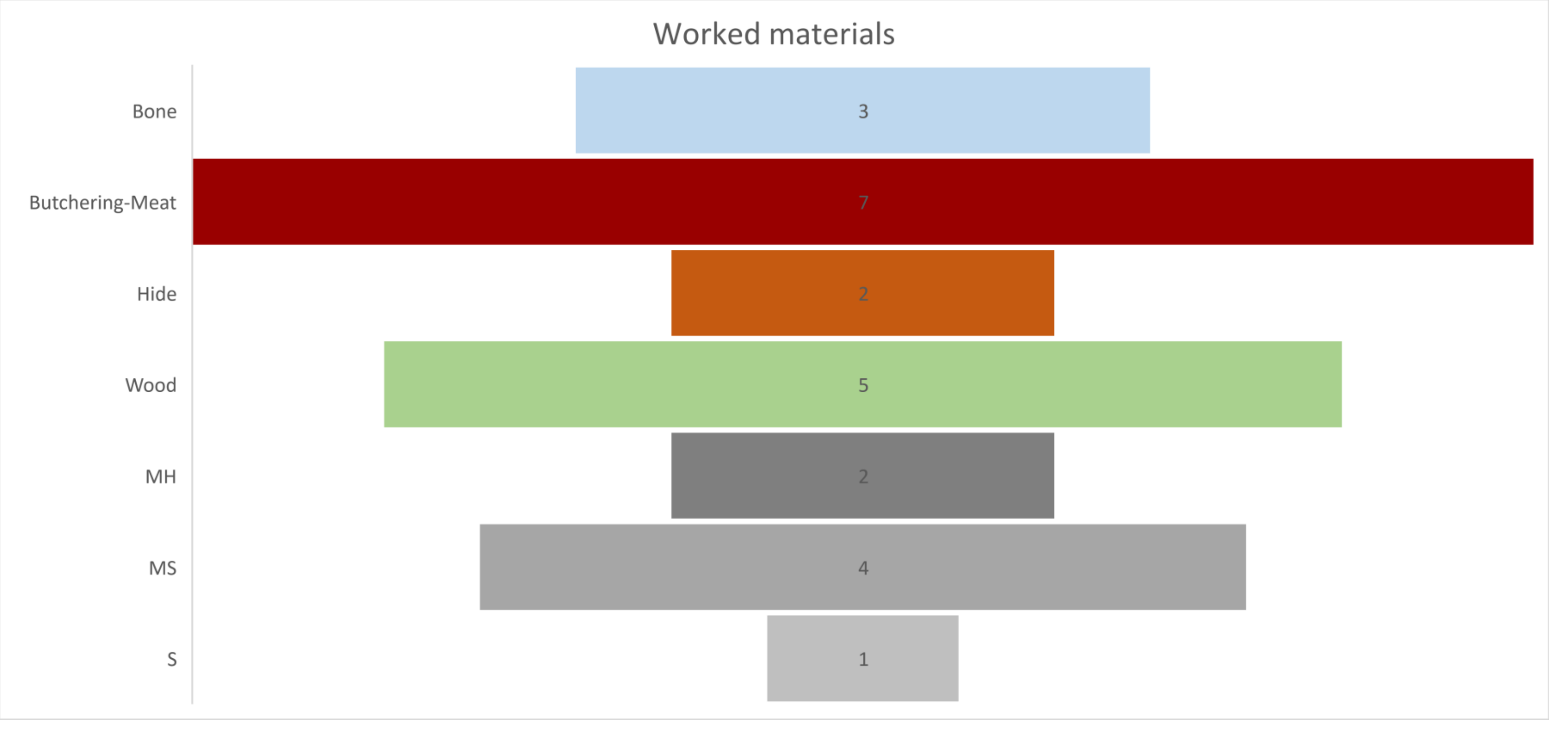

Figure 5.7: Pedra Dreta, worked materials.

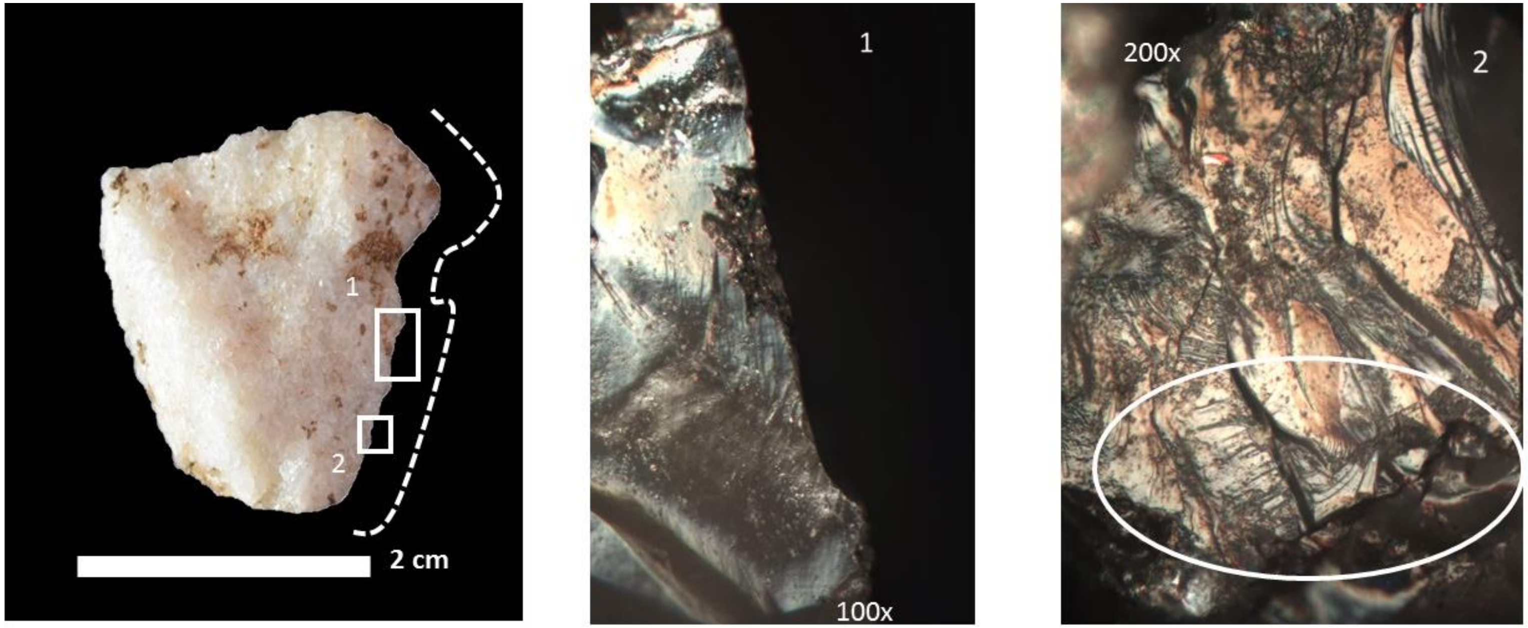

Figure 6.7: Petra Dreta quartz flake A4 19 with traces interpreted as butchering. 1 Striae, micro hole, micro scars. 2 Edge rounding (in the circle), polish with rough appearance;

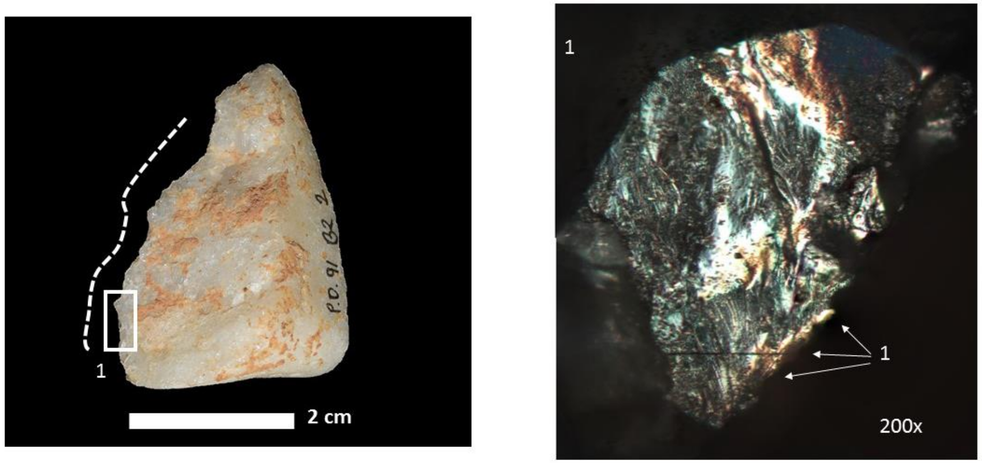

Figure 7.7: Petra Dreta quartz flake B2 2, with traces interpreted as butchering. Striae, micro hole, protuberance wear down, edge rim rounding (1), polish with rough appearance.

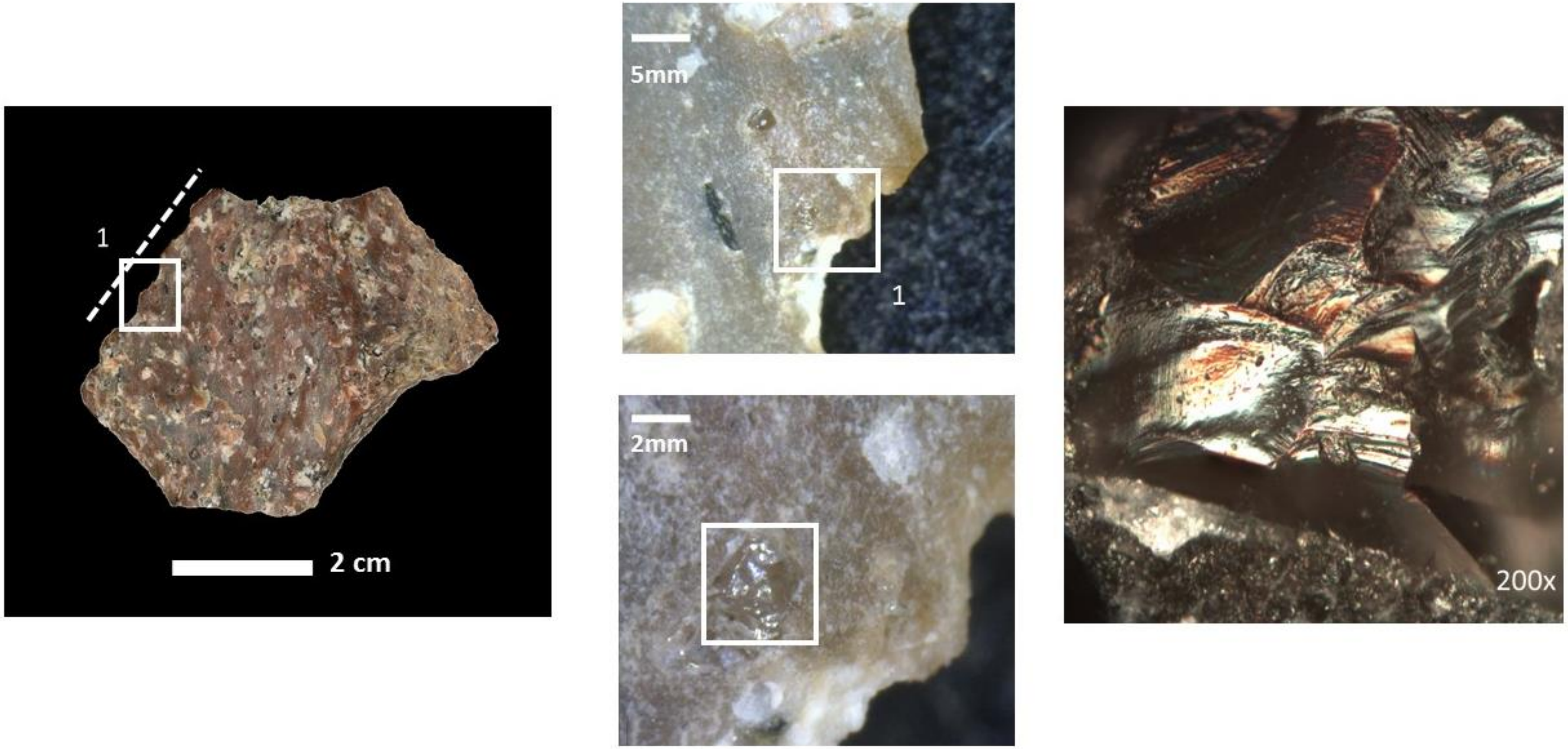

Figure 8.7: Petra Dreta, porphyry flake B3-B 46, a and b edge removals typical of a longitudinal action, dommed polish, micro holes and striae caused by bone working; note the striations oblique to the edge

5.Discussion

On the lithic tools from Pedra Dreta were found traces linked with two main activities: exploitation of animal carcasses and woodworking. The exploitation of animal carcasses is the most represented activity in the site 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). The presence of these activities, with this proportion, falls in the normal scenery of the Middle Paleolithic 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 (Rots and Hardy 2015). As results from the table 1 and from Fig.5, the animal carcasses processing includes different phases of the exploitation of the carcasses: 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 referable to activities such as skinning, evisceration, disarticulation and de-fleshing of carcasses (Lemorini et al. 2006). The traces referable to transversal work on bone can be related to periosteum removal in order to the extraction of marrow (Grayson, 1984; Longo, 1994).

The results of the use wear analysis can be used to hypothesize the site function. The presence of only two groups of activities can be due to a specialization of the site. 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).

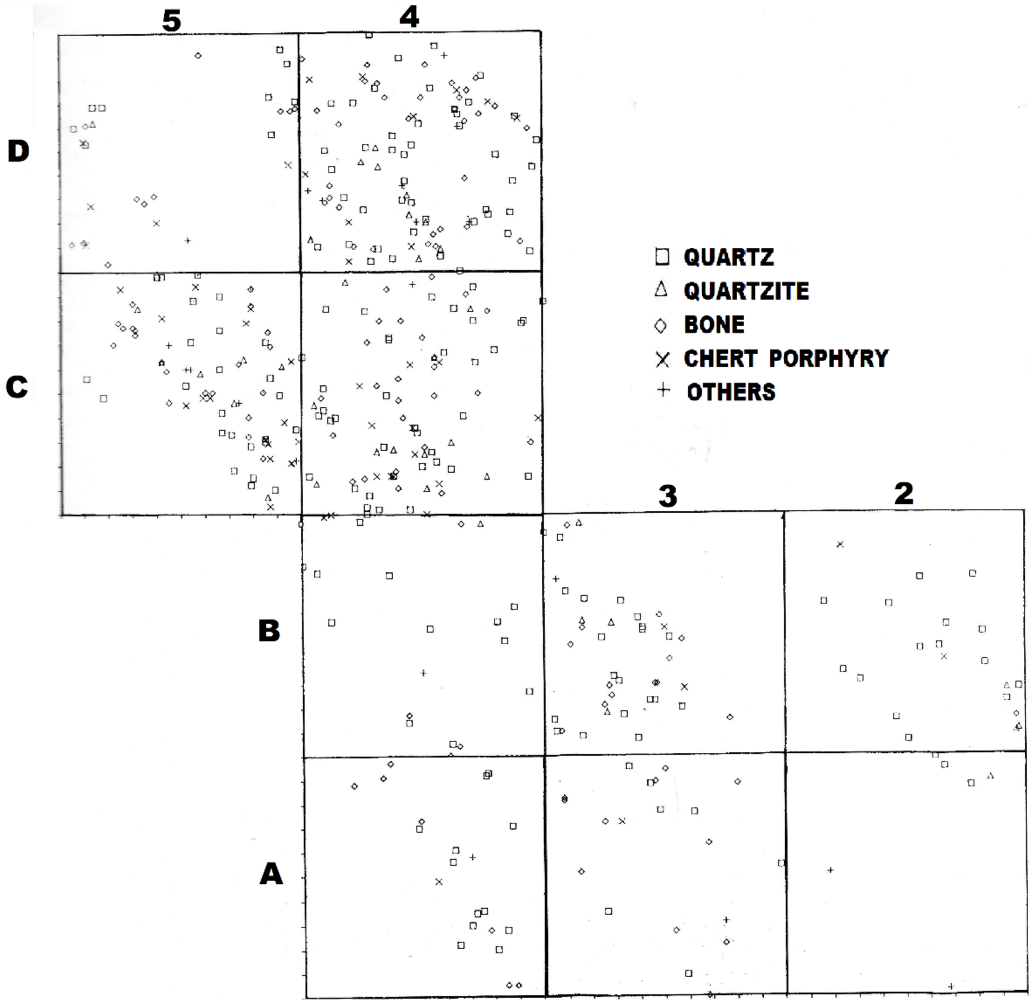

Figure 9.7: Pedra Dreta, spatial distribution of the findings found during the excavation campaign of 1991 (modified from Rodriguez et al., 1995).

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, that does not follow the general density of the lithic artefacts of Pedra Dreta (Fig.9). This can suggest the presence of a specialized butchering area not completely 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 (see the previous chapter), this data is consistent with the percentage of the lithic industry made with this morpho-structural group (S. Daffara personal communication). This can be due to a conscious choice or by a greater presence of quartz pebbles of this morpho-structural group in the raw material supply area. On this point, more focused studies are needed.

6. Conclusion

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 the site as a specialized settlement, linked to hunting activities, probably a hunting or killing camp where the prey were slaughtered in order to transport the meat to base camps (Stiner, 2013). Furthermore, the Petra Dreta site, is probably the result of one or of a series of ephemeral occupations. This hypothesis is consistent with previous studies (and with the one in progress by S. Daffara) which came at the same conclusions observing the shortness and the incompleteness of the *chaînes opératoires* (Canal and Carbonell 1989; Rodriguez et al. 1995,).

CHAPTER VIII

THE USE WEAR ANALYSIS OF THE LITHIC INDUSTRY FROM THE MIDDLE PALEOLITHIC LAYERS OF RIPARO TAGLIENTE (VR).

1. Introduction

The site of Riparo Tagliente is one of the most important Middle Paleolithic sites in northeastern Italy (Peresani 2010). The stratigraphy of the site contains lithic and faunal remains belonging to different human occupations referable to: Mousterian, Aurignacian and Epigravettian (Arzarello 2003; Thun Hohenstein and Peretto 2005; Bianchi 2011; Bartolomei et al. 1982; Bartolomei et al. 1984; Arnaud et al. 2016). The site was known and excavated since 1958 and thousands of lithic artefacts and faunal remains were found, together with some human remains (Arnaud et al. 2016; Bartolomei et al. 1982). The excavation of the Mousterian levels permitted to recovery of lithic artefacts and faunal remains referable to different occupations. In the upper layers of the sequence, the human occupations seem to be more intense (Bartolomei et al. 1982). This hypothesis is supported by studies about lithic technology (Arzarello and Peretto 2005; Arzarello 2003), archaeozoology and paleontology (Thun Hohenstein and Peretto 2005; Thun Hohenstein 2006). The aim of this work is to verify this hypothesis with the help of the use-wear analysis.

2. Riparo Tagliente

The Riparo Tagliente rock-shelter is located in the Venetian prealps (Stallavena di Grezzana, Verona, NE Italy) on the west site of Valpantena. The site was discovered in 1958 by Francesco Tagliente and was initially investigated from 1962 to 1964 by the *Museo Civico di Storia Naturale* of Verona (Bartolomei et al. 1982). Investigations were first conducted by the professors A. Pasa and F.

Zorzi with the collaboration of Mr. F. Mezzena and during these preliminar explorations a survey pit was realized inside the shelter (Arzarello 2003). In 1967 excavations were resumed by the University of Ferrara in collaboration with the *Museo Civico di Storia Naturale* of Verona and are still in progress (Arnaud et al. 2016; Bartolomei et al. 1982). Systematic excavations allowed to highlight an important stratigraphic sequence about 4.60 m thick.

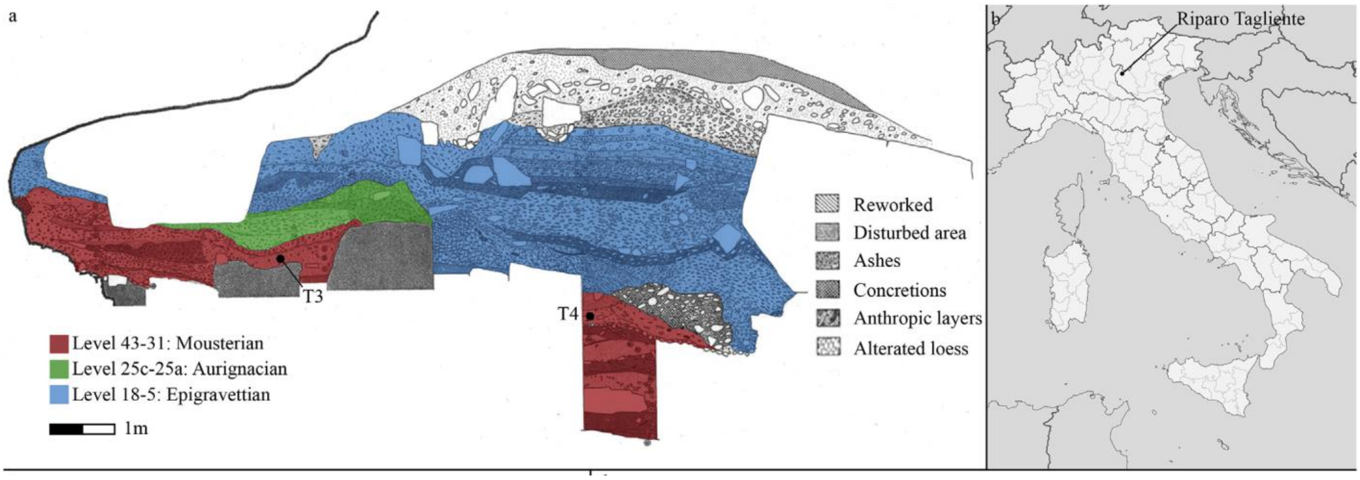

Figure 1.8: Riparo Tagliente, stratigraphical transversal section of the deposit (a); geographical position of the site (b). (From Arnaud et al. 2016).

It contains innumerable traces linked to human activities referable to different ages (Middle Paleolithic, Upper Paleolithic, and Medieval age). The lower part of the stratigraphic sequence is characterized by Mousterian lithic industries and it is surmounted by an Aurignacian level. This first part of the sequence was interrupted by an erosive episode, due to Progno of Valpantena, the river that now flows to the bottom of the valley. On this erosive surface set down sediments referable to isotopic stage 2, within which were found several archeological findings belonging to late Epigravettian (Bartolomei et al. 1982). The series was sealed by a deposit, dating to the Holocene. In medieval times the shelter underwent several re-excavations in order to realize refuges for herds.

These activities resulted in the destruction of the most recent part of the stratigraphic sequence and of a part of the lower series (Fig. 2).

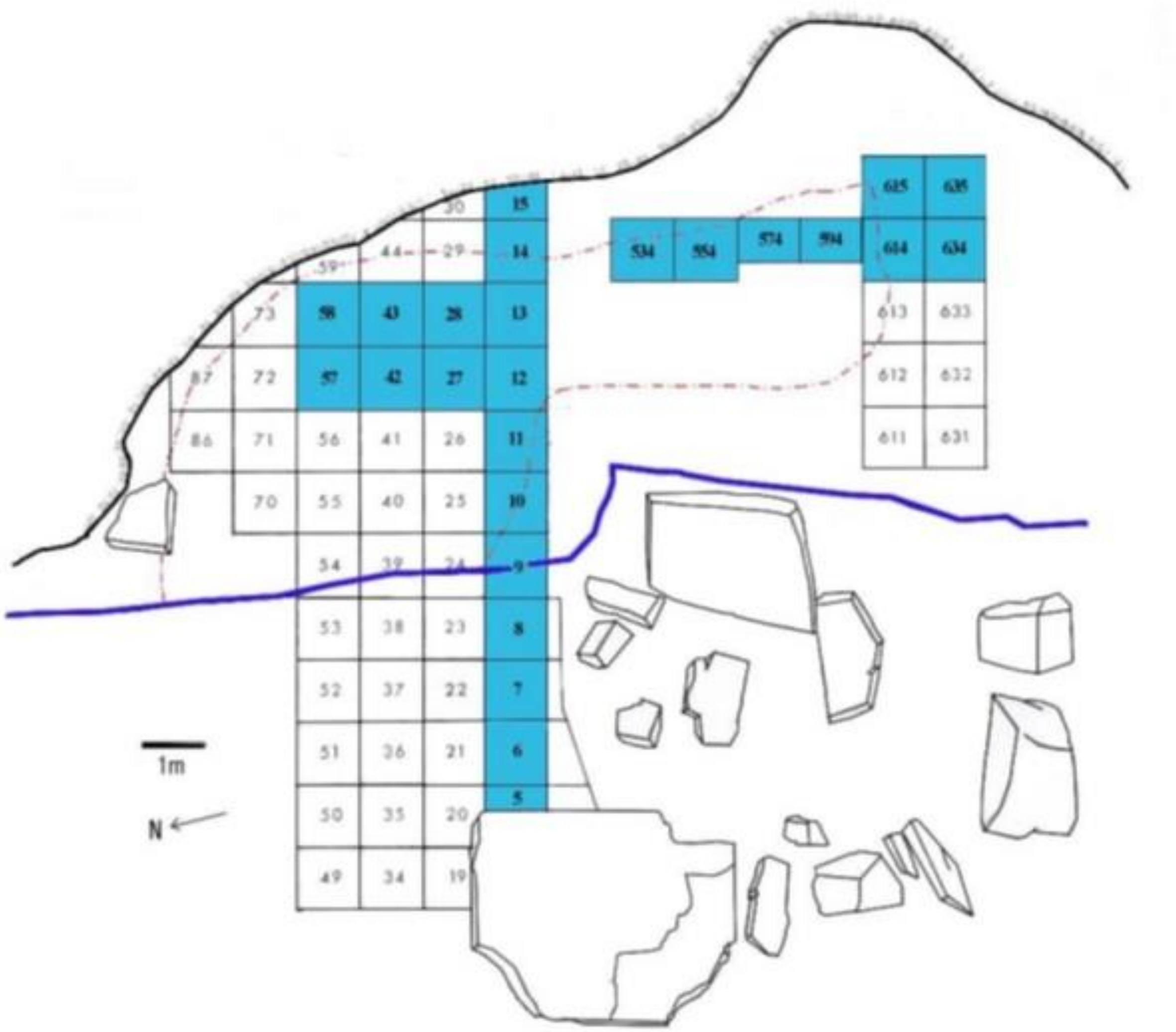

Figure 2.8: Riparo Tagliente. Map of the excavation area: in light blue the two trenches where the Mousterian levels were explored, the dotted line represents the extension of the Medieval excavations and the purple line represents the actual rain line of the shelter (modified from Bartolomei et al, 1982).

The complexity of the stratigraphic sequence, the site extension and the abundance of finds referable to the late Epigravettian did not allow an extensive excavation of the Mousterian series. At now, the Mousterian deposits were explored by means of a trench that cuts across the site (perpendicular to the rock wall), starting from the outside area, and an internal trench parallel to the rock wall.

2.1 Geomorphological setting

The site is placed in one of the main valley-bottoms of the pre-Alpine massif of Monti Lessini, at an altitude of 250 m a.s.l. (Fig. 1-b). The shelter opens few meters above the valley floor floods, at the base of the west slope of Tregnago mount (Fig. 3).

Figure 3.8: Riparo Tagliente in the 1999 (Arzarello 2003).

From the ecologic point of view, the rock-shelter occupies a strategic position at the intersection of different orographic formations: the plain, the valley-bottom, the rocky slopes and the top of the massif. This location permits the exploitation of several landscapes, rich in different faunal and vegetal resources, which have varied in distribution over the time. The limestone nature of the massif favors the presence of several karst cavities and abundant lithic and mineral resources, namely a variety of flints which were extensively exploited by the inhabitants of the Paleolithic sites of the area (Arzarello 2003; Bianchi 2011; Bartolomei et al. 1982; Bertola 2001).

2.2 Stratigraphy

The lower part of the stratigraphic sequence, that contains the Middle Paleolithic finds, has been localized both inside and outside the shelter, but it is not yet possible to achieve a correlation between the two areas for all the layers mainly because of geological phenomena and post depositional events (Arzarello 2003).

The significant thickness of the deposit, that for the Mousterian series reaches 2.80 meters and the homogeneity of the sediment, imposed an excavations through artificial layers (Arzarello 2003; Bartolomei et al. 1982). The lower part of the inside stratigraphic sequence begins with the "red earths" of colluvial origin, attributable to soil erosion outside the shelter and corresponding to the initial phase of the Würm (units 1a, layers 52 to 44). During this depositional event, the climate was characterized by cold, damp winters and arid summers (Bartolomei et al. 1982; Bartolomei et al. 1984). The other layers of the lower series (layers 43 to 25) constitute unit 1b: the layers 43 to 40 are characterized by a massive rockfall and by clasts derived from the degradation of the walls of the rock shelter. The top of the Mousterian layers (layers 39 to 31) is constituted by loess, intercalated with thin levels of crushed stone. The presence of loess attests an arid periglacial environment, while crushed stone is characteristic of a more humid glacial environment (Bartolomei et al. 1984). The layers 30 to 25 have the same characteristics described for the previous layers but at the top is visible an interruption of the loess sedimentation. Layer 25, that seems to be in stratigraphic continuity with the sequence below, is characterized by the presence of an important pedogenetic phenomenon associated to Aurignacian lithic industry with *Dufour* bladelets (Bartolomei et al. 1982; Arzarello 2003). At this point the stratigraphy has undergone a phase of fluvial erosion, with accumulation of pebbles (Bartolomei et al. 1982).

2.3 Faunal remains

The faunal remains are more abundant in the uppermost Mousterian layers (from 41 to 35). The majority of the large mammal remains of the Mousterian layers consists of teeth, mandible fragments, limb elements, vertebrae and sesamoids belonging to adults and sub-adults ungulates (Thun Hohenstein 2006). The most represented specie is *Capreolus capreolus* followed by *Cervus elaphus*, *Capra ibex* and *Rupicapra rupicapra*.

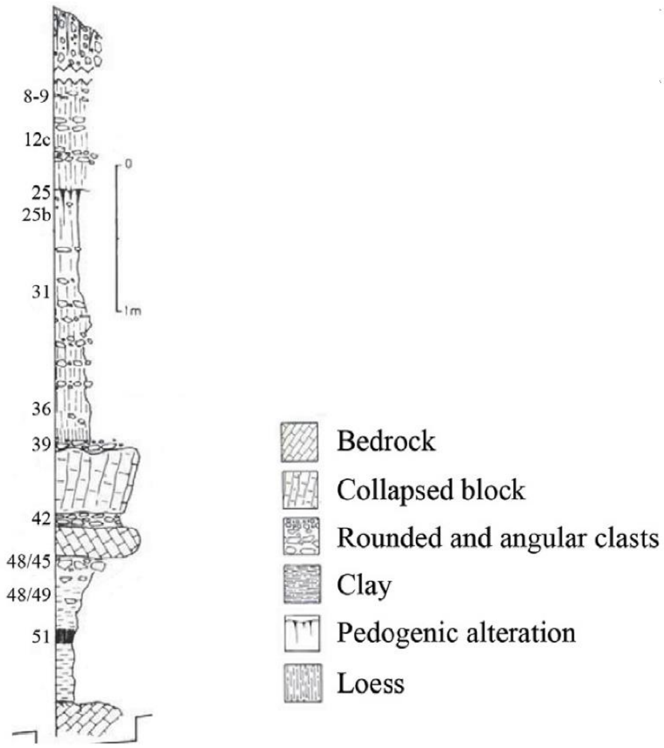

Figure 4.8: Simplify stratigraphy of the deposits in the internal area (From Arnaud et al. 2016).

The assemblage of carnivores is dominated by *Canis lupus* and *Ursus arctos* followed by *Vulpes vulpes*. *Marmota marmota* remains have been identified among rodents. In the lower layers (44-52), the composition of the faunal assemblage remains unchanged among artiodactyls, while carnivores remains increase in the number and variety of represented taxa (*Canis lupus*, *Vulpes vulpes*, *Ursus arctos*, *Panthera pardus*, *Meles meles* and *Martes martes*) (Thun Hohenstein 2006; Thun Hohenstein and Peretto 2005; Bartolomei et al. 1982). The abundant presence of remains attributable to neonatal or fetal cervids, indicates that Neanderthals occupied the rock shelter mainly during spring. The remains of *Capreolus capreolus*, *Alces alces* and *Marmota marmota* suggest a relatively cold-temperate and humid climate (Thun Hohenstein and Peretto

2005). Cut-marks and intentional bone fracturing are mostly on artiodactyls and on some *Marmota marmota* remains (Thun Hohenstein 2006). The human activities recorded on the faunal remains are well documented along the whole sequence but are more abundant in its upper part, from the layers 41 to 35. The small mammal remains assemblage is dominated by *Microtus arvalis* along all the lower sequence (except for layer 25) in association with *Microtus oeconomus*, *Microtus gregalis*, *Ochotona* sp. and *Sicista* sp., whichsuggest the presence of a cold climate. The replacement of these species with *Chionomys nivalis* and *Apodemus* sp. in the layers from 35 to 31 suggest a decrease of the temperatures (Arnaud et al. 2016; Bartolomei et al. 1982).

2.4 Paleoenvironment

The interdisciplinary analysis of the data coming from the studies of faunal, pollen and sedimentology allowed a preliminary reconstruction of the paleoenvironments corresponding to the deposition of the Mousterian levels. In the layers 52-44, the micro-mammal's fauna is dominated by species typical of a continental mountainous environment with grasslands (*Apodemus sylvaticus* and *Microtus arvalis*) (Bartolomei et al. 1982). Paleobotanical data document a typical association of continental glacial steppe, with a prevalence of *Pinus silvestris*, *Juneprus* and *Betula* while herbaceous are mainly represented by *Poaceae* and *Compositae Liguliflorae* (Cattani 1994). In these layers macro fauna is constituted by roe deer, deer and ibex and among carnivores, there are: fox, wolf, bear, badger and marten (Thun Hohenstein and Peretto 2005; Thun Hohenstein 2006). In layers 43-40, the association of micro-mammals and pollens changes radically: there is a reduction of trees and an increase of *Compositae liguliflora*, typical of a steppe environment; among micro-mammals are well represented *Microtus agrestis* and *Microtus arvalis*, associated with the typical species of the Asian steppes, *Microtus gregalis*, *Sicista* sp. and *Cricetus*

cricetus (Bartolomei et al. 1982). In 39 - 31 is visible a decrease of the percentage of the tree cover with a decrease of *Pinus* and the appearance of *Quercus robur*. Although the environment is still the continental steppe, is evident a change towards more temperate and humid climate (Bartolomei et al. 1982). During this stage, the macro-fauna assemblage is composed by roe deer, deer, chamois, ibex, and wild boar (Thun Hohenstein and Peretto 2005; Thun Hohenstein 2006). The abundance of deer and marmot suggests a cold-temperate climate, rather wet, according to palynological and sedimentological data (Arzarello 2003).

2.5 Chronology

None radiometric dating have yet been done on the Mousterian sequence of Riparo Tagliente . However, the Aurignacian industry with *Dufour* bladelets of layer 25 can be considered as a good chronological indicator (Bartolomei et al. 1982; Arzarello 2003). Then, crossing the data of faunal, sedimentological and archaeological studies, it is possible to hypothesize, for the deposition of the Mousterian levels, a chronology spanning between MIS 4 and MIS 3 (Bartolomei et al. 1982; Bartolomei et al. 1984; Arnaud et al. 2016)

2.6 Lithic assemblage

The Mousterian sequence is characterized by the use of different reduction methods, all on local raw materials (flint) collected in the surroundings of the site, usually from the bed of the Progno creek (Arzarello 2003; Arzarello and Peretto 2005). The opportunistic knapping method is the best represented (c.f. S.S.D.A, Forestier 1993) and the Levallois method (E. Boëda 1993; E. Boëda, Geneste, and Meignen 1990) is also present with the lineal and recurrent modalities. In the lower levels, centripetal recurrent Levallois is the most frequent, but in the upper part of the sequence unipolar recurrent Levallois becomes dominant (Arzarello 2003; Arzarello and Peretto 2005). The discoid method (E. Boëda 1993; Peresani 2003) is also attested especially in the final reduction phases of the Levallois cores but it never reaches relevant proportions in the lithic assemblage (Arzarello 2003; Arzarello and Peretto 2005). One of the main peculiarities of the lithic assemblage is the presence of a volumetric laminar *débitage* starting from level 37: in level 34 it becomes the most important pre-determined *débitage* method (Arzarello 2003; Bianchi 2011; Arzarello and Peretto 2005). The formal tools assemblage is mainly composed by side-scrapers and denticulates made on opportunistic and, more rarely, on Levallois flakes.

2.7 Human occupation of the site during the Mousterian sequence

The occupation phases corresponding to layers 52-50 and 44-42 correspond to not particularly intense frequentations of the site, characterized by a rather homogeneous technology both concerning the *débitage* methods and the type of instruments and the choice of the raw material (Arzarello 2003).In the upper layers, 37-34, the situation is different All the layers are here characterized by an intense occupation, with a big quantity of lithic material and faunal remains with cuts marks (Thun Hohenstein 2006; Thun Hohenstein and Peretto 2005; Arzarello 2003; Arzarello and Peretto 2005). On the basis of the technological characteristics, it seems that the different layers correspond to successive phases of occupation, for which it is possible to highlight a sort of evolution of the lithic production system (Arzarello 2003; Arzarello and Peretto 2005).

2.8 The layer 36 of the internal survey.

Square 635, 634, 614 and 615 of layer 36 of the internal survey of the Mousterian sequence of the Riparo Tagliente shelter were selected for this study due to their peculiarities and because they were subjects of a comprehensive technological study (Arzarello 2003; Arzarello and Peretto 2005). Furthermore, for this layer we can suppose a particular selection of flint pebbles of "scaglia rossa" and "scaglia variegata" to produce flakes through the *Levallois* method. The lithic assemblage is abundant, thus suggesting an intense occupation of the site, and well preserved (less than the 5% of the finds present patinas) (Arzarello 2003). The *débitage* methods present in these layers are the same previously described, although here, as in all the layers between the 37 and the 34 is also present a volumetric laminar *débitage* method (Fig. 5) (Arzarello 2003). From layer 36, but from other squares, come three human finds, one phalanx and two teeth (Tagliente 3 and Tagliente 4), recovered in levels 36bI-bII and 37baII, respectively, all identified as Neanderthal remains.(Arnaud et al. 2016).

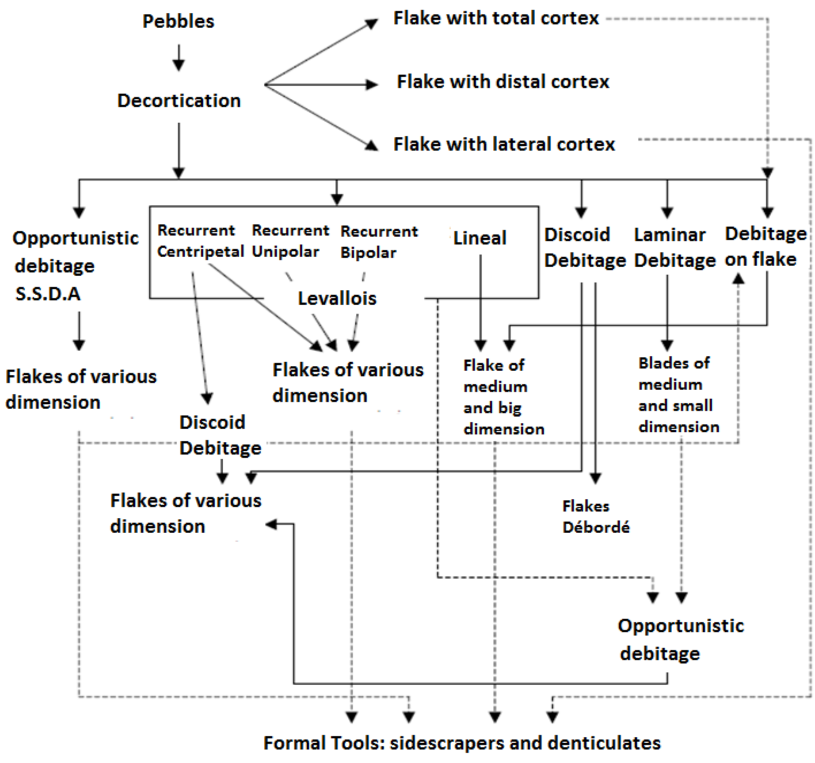

Figure 5.8: Diagram of the débitage methods and of the formal tools of the totality of internal survey (Q.Q. 634-635; 614-615) (modified from Arzarello 2003).

3. Materials and methods

The study began with the preliminary evaluation, at the naked eye and with a stereomicroscope, of all the lithic assemblage of layer 36, squares 635, 634,614 and 615, in order to identify the artefacts that have suitable characteristics for the use-wear analysis. In this preliminary phase, the considered sample was composed by all the *débitage* products (simple flakes and formal tools) collected during the excavation while all the lithics with a length less than 2 cm (they are stored all together in paper bags). In total, were analysed 609 different artefacts. Four criteria were applied to select artefacts for the use-wear analysis: completeness, presence of at least one functional edge, morphology suitable for prehension or for hafting and surface preservation (absence of marked post depositional alterations). After the preliminary evaluation, the considered sample is composed by 60 *débitage* products, corresponding to about 10% of the sample. For the analysis, each selected artefact was gently washed with warm water and soap, then washed for 3 minutes in a mixture of demineralized water (75%) and alcohol (25%) in an ultrasonic tank and open air dried. The use-wear analysis of the lithic assemblage was carried out with an integrated approach that uses the low power approach (Odell 1986) in combination with the high power approach (Keeley 1980). Several works (e.g. Lemorini et al. 2014; Wilkins et al. 2015; Moss 1983; Beyries 1987; Ziggioti 2011; Van Gijn 2014; Berruti and Daffara 2014; Cruz and Berruti 2015;) show in fact that the use of both the methodologies integrated is more effective and productive. This kind of study was conducted to provide a more detailed understanding of the activities carried out with the lithic artefacts and to support the diagnosis of the processed materials (e.g. Lemorini, Plummer, et al. 2014; Lemorini et al. 2006; Rots 2010; Ziggioti 2005; Keeley 1980; Van Gijn 2014). For the analysis were used different microscopes: a stereomicroscope Seben Incognita III with magnification from 20x to 80x, a stereomicroscope Leica Ez4 HD with magnification from 8x to 35x and a metallographic microscope Optika B 600 Met. with oculars 10x, 5 objectives PLAN IOS MET (5-10-20-50-100x), polarizing filters and bright and dark field equipped with a digital camera Optika B5.

4. Results

4.1 Sample taphonomy and conservation

The taphonomical analysis of the sample confirms that the lithic assemblage of layer 36 was in a good state of preservation even if it suffers of serious conservation problems. The majority of these lithic finds were discovered during old excavations (in the ‘80) and were conserved both in large groups in wooden boxes or individually in paper bags. The conservation in large groups has favored the formation of pseudo-retouches on the edges of the flakes, preventing the proper analysis of edges removals. On the other hand, the storage in paper bags favored the deposition, on the edges, of micro residues of the glue sealing the bottom of the bags (Fig. 6).

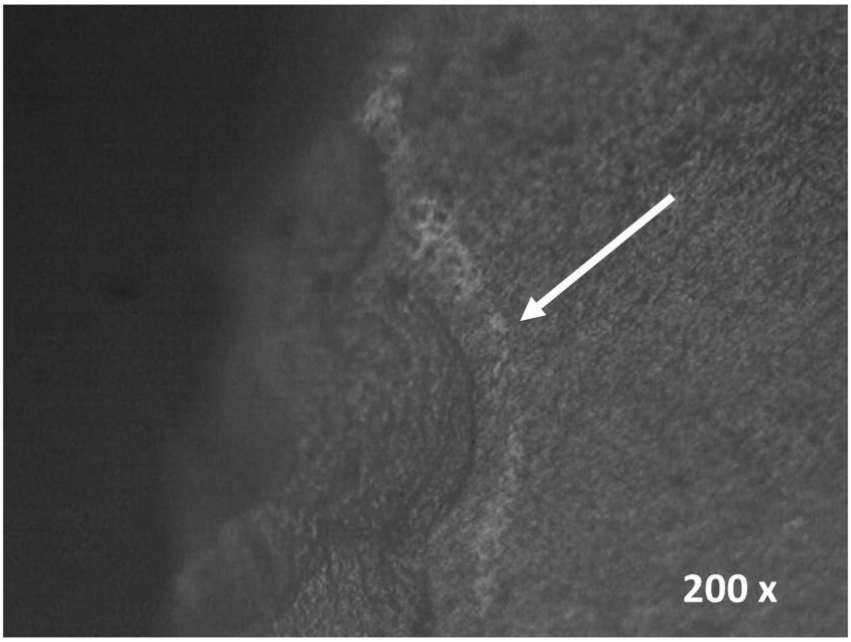

Figure 6.8: residues of glue on the edge of the Levallois flake RT 36 534.

Residues of glue are extremely durable and can prevent the use-wear study of polishes. Another problem affecting especially the formal tools found during of the oldest excavations is the presence of traces of graphite on the edges, due probably to the drawing of the tools (Fig. 7). These factors contributed to the reduction of the analyzed sample.

Figure 7.8: Levallois flake RT 36 534. with pseudo-retouches (dotted line) and graphite signs (circle).

<u>4.2 Use-wear analysis results</u>

The use wear analysis of the lithic assemblage from the squares 635, 634, 614 and 615 of the layer 36 allowed to identify 23 artefacts with traces of use (Tab. 2). Among them 6 are *Levallois* flakes (3 lineal *Levallois*, 1 recurrent bipolar *Levallois, 1* recurrent unipolar *Levallois* and 1 recurrent centripetal *Levallois*), 1 is a discoid flake and 16 are opportunistic/S.S.D.A. flakes, of which 2 are related to phases of shaping and management and not to production phases. Two of the flakes with use-wear analysis show different zones of use: 1 sidescraper on a lineal *Levallois* flakes with two different zones of use (Z.U.) referable to two different type of traces (transversal work on indeterminable medium hard material and longitudinal work on fresh hide) and 1 unretouched recurrent unipolar *Levallois* flake with 2 Z.U. referable to the same type of traces (longitudinal action on bone). As shown in the tables (Tab. 3 and 4) and in the graphs (Fig. 8, 9) the use wear analysis led to the identification of different activities carried out in the site. They can be divided in three main groups: animal carcass processing (that include the categories: butchering, fresh hide working, dry hide working and bone working listed in the table), vegetal material processing and working of indeterminable material. If we look just at the formal tools, use-wear traces were found only in side-scrapers (Tab. 4).

Table 1.8: selected sample of the lithic industry grouped by presence of use wear traces.

Layer 36	TOT.	SELECTED	%	WITH TRACES	% TOT	% SEL
Lithics	609	60	9,9	23	3,8	38,3

Table 2.8: zones of use found.

Action	Discoid	Levallois	Opp.	Tot.	%
Transversal	1	2	9	12	48
Longitudinal	0	6	6	12	48
Mix.	0	0	0	0	0
Indet.	0	0	1	1	4
Tot.	1	8	16	25	100

Table 3.8: use-wear traces on the formal tools of layer 36 grouped by action, method of debitage and worked material. (Tran. Act. =transversal action; Long. Act. = longitudinal action; Mix = mixed action; Indet. = indeterminate action).

Material	Sidescrapers				Tot.
	Tran. Act.	*Long. Act.*	*Mix.*	*Indet.*	
Butchering					0
Hide					0
Soft animal tissue		1			1
Bone/ Antler	2				2
Wood	2				2
Non-woody plant					0
Dry Hide	1				1
Indet.					0
Soft					0
Medium Soft					0
Medium Hard					0
Hard	1				1
Tot.	**6**	**1**	**0**	**0**	**7**

Table 4.8: use-wear traces on the lithic artefacts of layer 36 grouped by action, method of debitage and worked material. (Tran. Act. =transversal action; Long. Act. = longitudinal action; Mix = mixed action; Indet. = indeterminate action).

Material	Discoid				Levallois				Opp./SSDA/Indet.				Tot.	%
	Tran. Act.	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*	*Tran. Act.*	*Long. Act.*	*Mix.*	*Indet.*		
Butchering						1			1	2			4	16,7
Fresh Hide													0	-
Soft animal tissue						1				2		1	4	16,7
Bone	1					2			1	1			5	20,8
Wood					1				2				3	12,5
Non woody plant													0	-
Dry Hide									3				3	12,5
Indet hard material- stone?						1							1	4,2
Soft													0	-
Medium Soft						1		1					2	8,3
Medium Hard									1	1			2	8,3
Hard									1				1	4,2
Tot.	**1**	**0**	**0**	**0**	**1**	**6**	**0**	**1**	**9**	**6**	**0**	**1**	25	104,2
Tot. for method	**1**				**8**				**16**				25	104,2

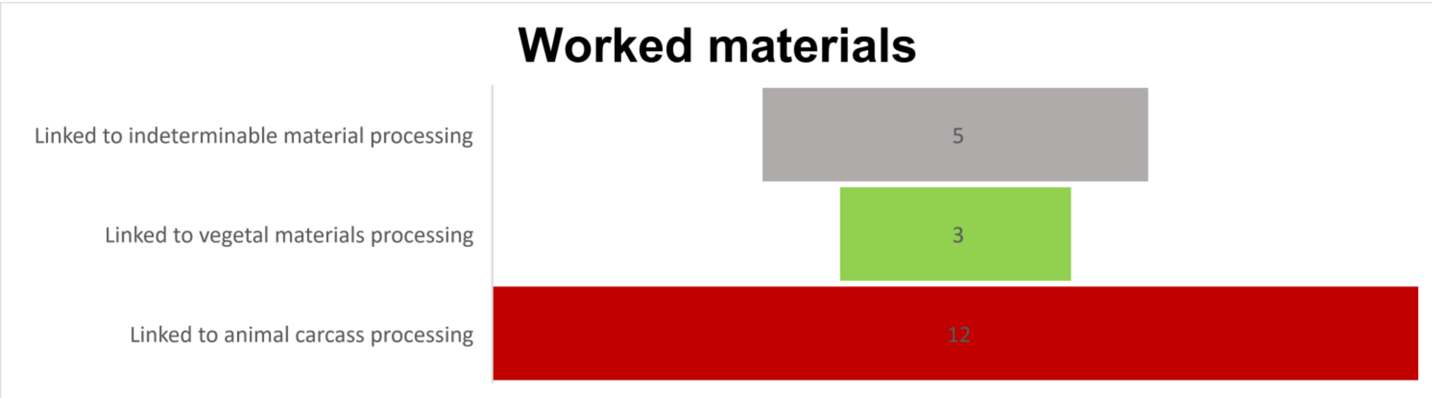

Figure 8.8: use-wear traces grouped by material processed.

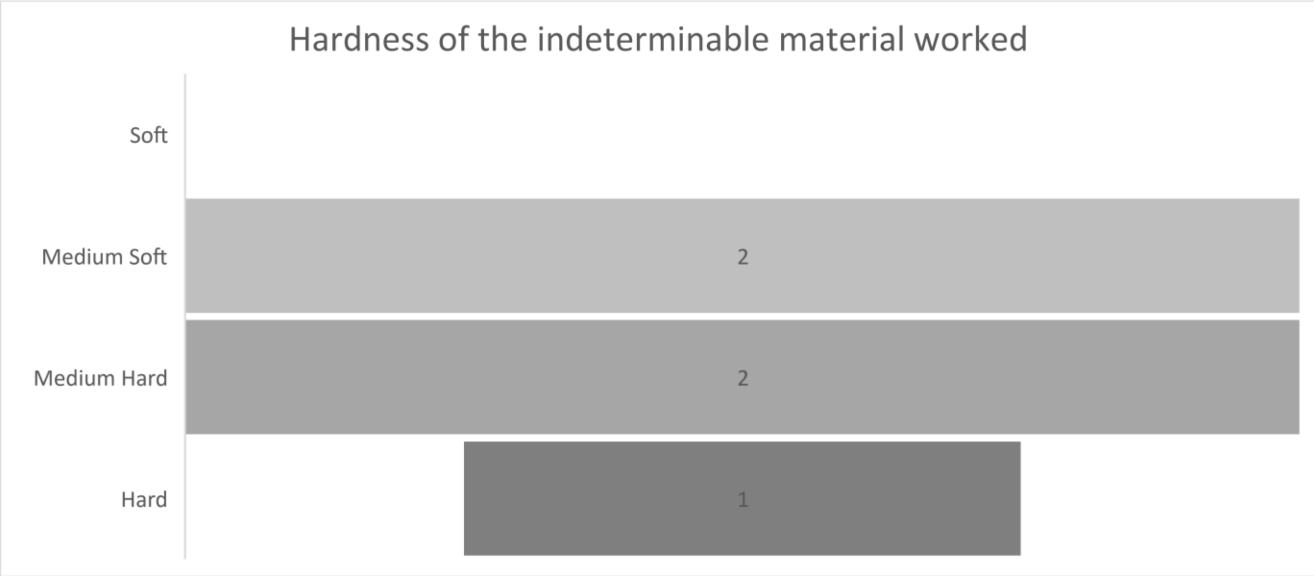

Figure 9.8: hardness of the indeterminable material worked.

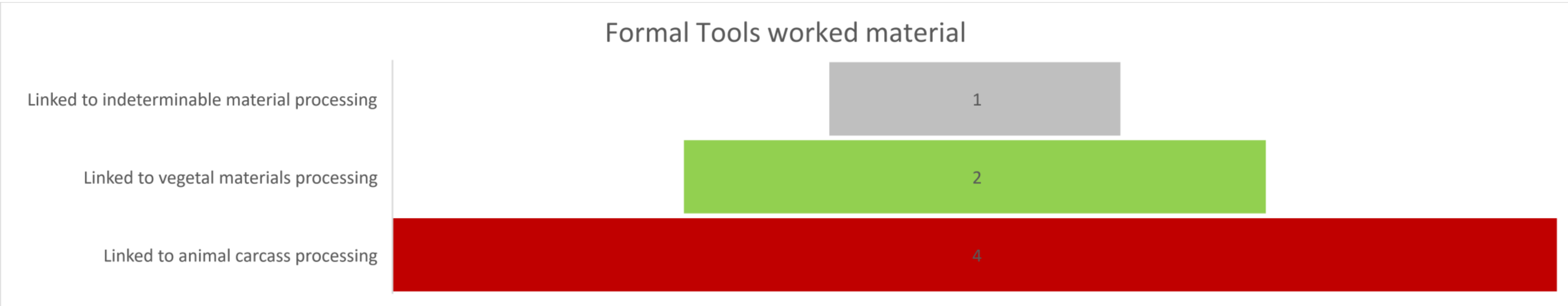

Figure 10.8: use-wear traces on the formal tools grouped by material processed

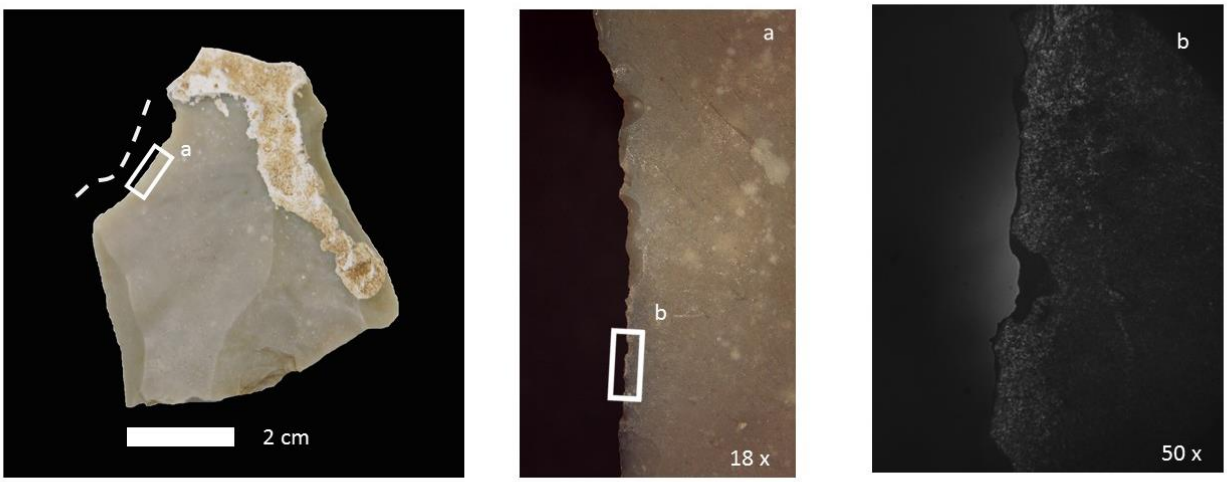

Figure 11.8: R.T. 614/5 t.36 76 use wear traces interpreted as longitudinal action on fleshy tissues (line of rough polish).

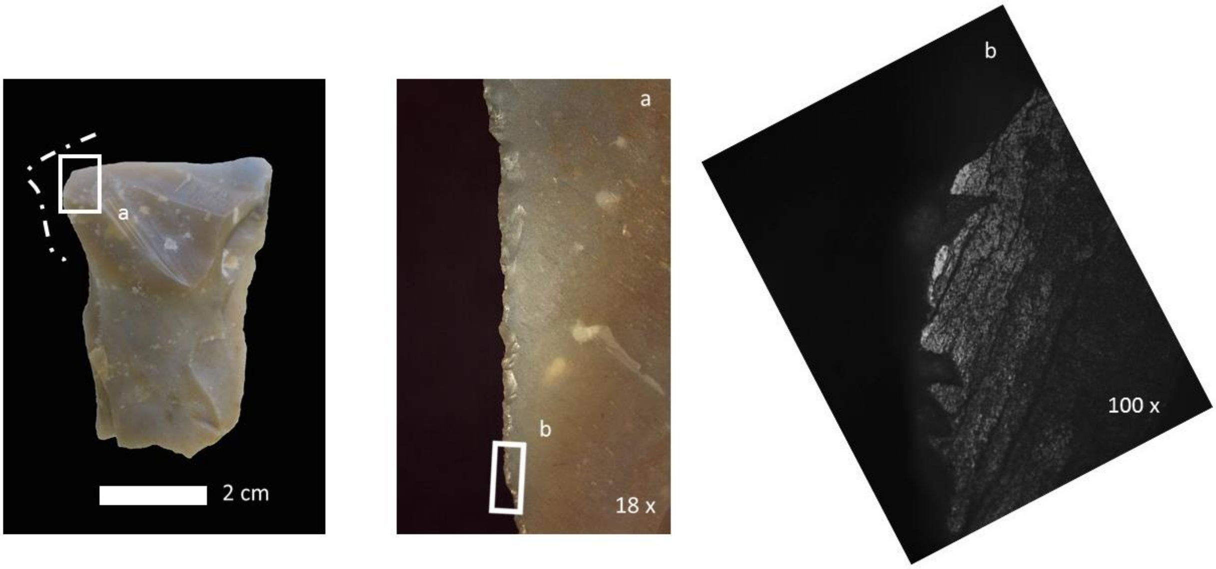

Figure 12.8: R.T. 614/5 t.36 88 use wear traces interpreted as transversal action on bone (small and localized areas of smooth and flat polish).

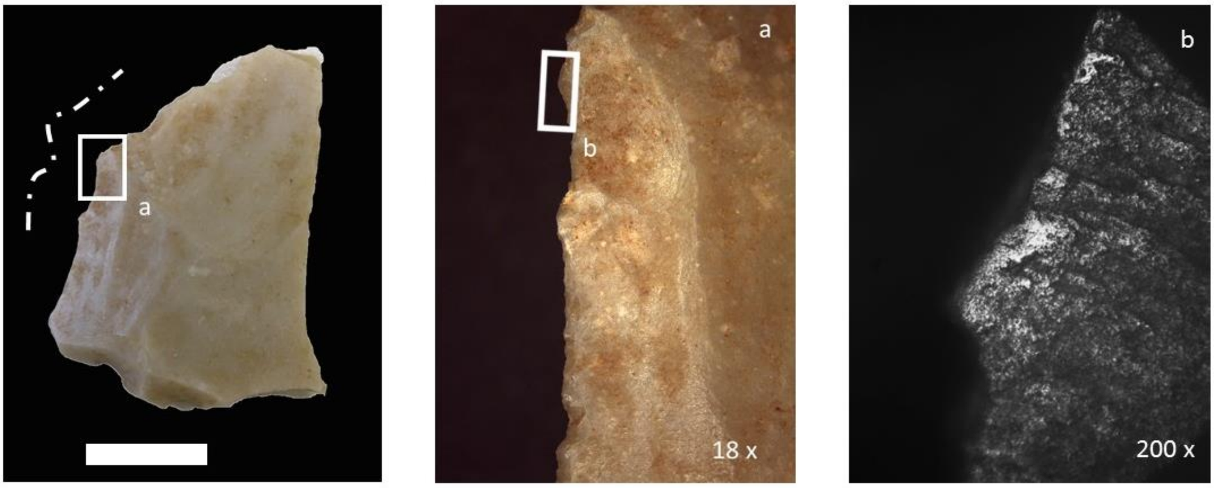

Figure 13.8: R.T. 614/5 t.36 591 use wear traces interpreted as dry hide working. The edge rims are heavily worn and polished.

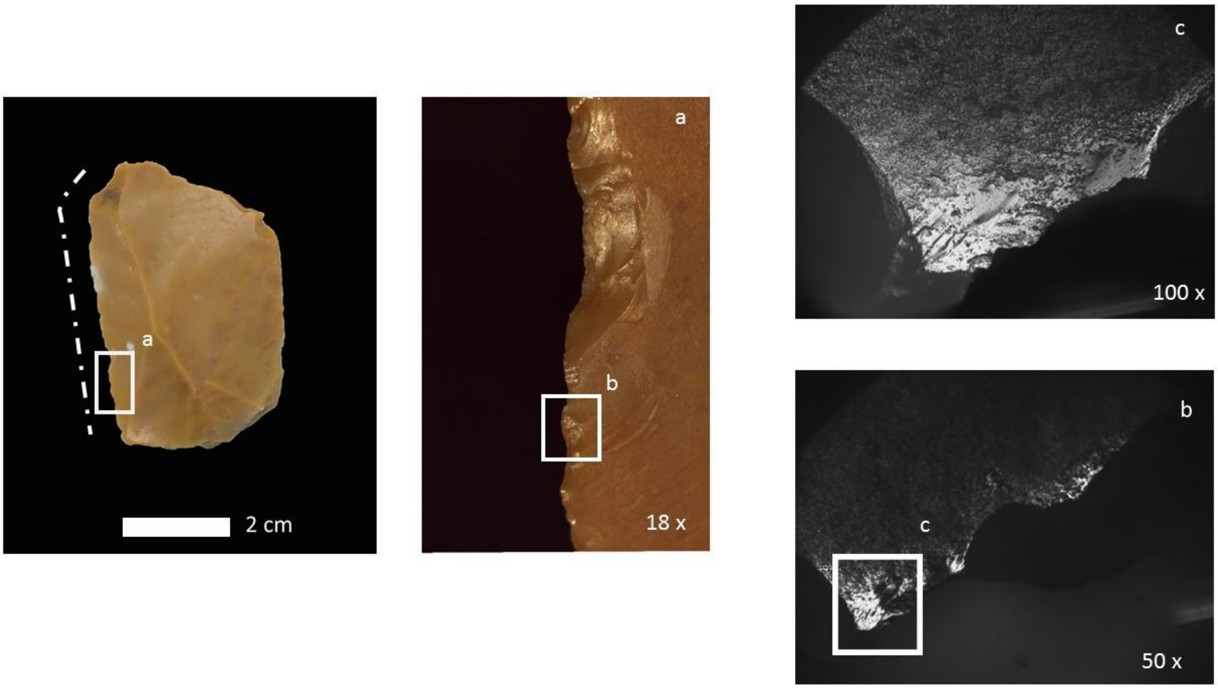

Figure 14.8: R.T. 615/1 t.36 603 use wear traces interpreted as transversal action on bone (localized areas of smooth and flat polish).

5. Discussion

More than a third (38%) of the selected sample shows diagnostic traces of use (23 artefacts). Moreover, a fraction of the artefacts could have been so lightly used that no visible traces developed and another fraction may have suffered so much damages during storage to obliterated any traces of use. Although probably under-represented, the total number of artefacts with use wear traces, permits to propose an interpretation of the use-wear patterns. Note that un-retouched and retouched artefacts with recognizable wear-traces here are all defined as ‘‘tools’’. Figures 9, 8 and table 5 summarize the functional interpretation of the different tools. Animal carcasses processing activities were often performed, including different phases of carcasses exploitation: 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 (16%; 4 tools) that are referable to activities such as skinning, evisceration, disarticulation and de-fleshing of carcasses (Lemorini et al. 2006). The tools with traces of dry hide work (3 tools in total) suggest the presence of some type of tanning activity performed in the site (Anderson-Gerfaud 1990; Beyries 1987; Lemorini 2000; Palmqvist et al. 2005; Lemorini, Bourguignon, and Zupancich 2016) (Fig.13). Bone working (20%; 5 tools) can be referred to the periosteum removal (for the transversal action 2 artifacts) (Grayson 1984), or to disarticulation activities (Fig.12 and 14). Both of these activities are also attested by the archeozoological study of the faunal remains of layer 36 (Thun Hohenstein 2006; Thun Hohenstein and Peretto 2005). The tools with traces of contact with fleshy tissues (4) are probably linked to filleting activities (Fig. 11). Usually in the archaeological record of the Mousterian sites the processing of vegetable materials is recorded less frequently and usually is absent or scarce (Tares-Dordogne (Geneste & Plisson 1996); LaCombette - Vaucluse (Lemorini 2000); Vault Romani - Catalonia (Martinez 2008); Grand Champ - Loire (Igreja 2009) and La Mouline - Dordogne (Pasquini 2008). The wood-working traces found can be interpreted as a result of the manufacture of spears or of other utilitarian wood objects (Rots and Hardy 2015). In the selected sample, there are some formal tools (17 on 60) and part of them has traces of use (7). The analysis of the use-wear study data of the side-scraper (Tab.4) seem to indicate that there was a preferential use, although not exclusive, of these tools for the work of materials with a medium/high hardness, such as bone and wood. Unfortunately, the data and the sample are too scarce to ensure this type of behavior. However, some use-wear analyses studies (Lemorini 2000; Texier et al. 1998; Zupancich et al. 2016; Hardy et al. 2004; Wilkins et al. 2015; Claud 2012) performed on side-scrapers from Lower and Middle Paleolithic contexts indicate that these tools were used on a variety of materials and for different activities. Among the lithics with wear traces, there are two cases of used flakes that technologically were attributed at phases of shaping and management of the cores (one is a flake of management of a *Levallois* core and the other one is a reshaping flake). These data, although isolated, suggests an opportunistic behavior of the Neanderthals and also that for them there were probably not practical differences between the "products" and the management flakes (E. Boëda et al. 1990; É. Boëda 1994). Therefore we should reconsider our conception of "waste" flakes for the *Levallois* and the other predetermined methods (Brantingham and Kuhn 2001; Lycett and Eren 2013; Picin and Vaquero 2016). These consideration is very similar to those obtained through the study of the re-use and modification of biface manufacturing flakes (Claud 2015).

6. Conclusion

The presence of various and well documented activities identified by the use wear-study of the lithic assemblage of layer 36 confirms, a complex occupation of the cave (as base camp) (Stiner 2013), as already supposed according to the following observations: increasing of the lithic implements and of the faunal remains with cuts marks (Arzarello 2003; Thun Hohenstein and Peretto 2005; Thun Hohenstein 2006; Arzarello and Peretto 2005), probably presence of almost one fireplace (suggested by the high percentage of burned bone) (Thun Hohenstein and Peretto 2005; Thun Hohenstein 2006) and presence in the site of all the phases of the lithic reduction sequences. The use wear analysis data suggest that layer 36 of Riparo Tagliente is characterized by a strong exploitation of animal resources, with long lasting processes, as hide treatments, combined with a marginal exploitation of vegetal resources. The presence of use traces on “waste” flakes, if confirmed in the future by other finds in Mousterian contexts, may force us to rethink the concept of lithic tools within the *débitage* knapping sequences

CHAPTER IX

THE USE WEAR ANALYSIS OF QUARTZITE LITHIC IMPLEMENTS FROM THE MIDDLE PALAEOLITHIC SITE OF LAGOA DO BANDO (CENTRAL PORTUGAL)

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Use wear analysis of quartzite lithic implements from the Middle Palaeolithic site of Lagoa do Bando (Central Portugal)

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Abstract:

The Middle Palaeolithic site of Lagoa do Bando is an open air site in a lacustrian context located at 570 m a.s.l. in the municipality of Mação in the center of Portugal. The site was discovered in 2011, during an emergency excavation, and resulted on the recovery of a Middle Palaeolithic lithic assemblage mainly composed of fine grained quartzite implements of expedient, discoid and Levallois technology. Use wear analysis was conducted on 41 artifacts formed through discoid and Levallois technology. Twenty one of these artifacts revealed use wear traces. Ten of them show traces of wood work, five have traces of butchering activities, three present traces of meat processing and two present undetermined traces. The site is located at an atypically high elevation for an open air site and there is evidence of a high rate of woodworking activity, rare in the Middle Palaeolithic occupations. The woodworking activities are possibly linked to the exploitation of woody local resources (maybe for the construction of hunting blinds) and not only with to the manufacture and maintenance of spears and shafts. These results converge with the interpretation of this site as a temporary hunting site integrated in a complex pattern of occupation of the area between the river valleys and the top of low mountains.

Keywords: Middle Palaeolithic; quartzite; use-wear analysis; Central Portugal; Neanderthal behaviour

1. Introduction

The work addresses the use wear analysis of a sample of quartzite implements from the lacustrian open air site of Lagoa do Bando. The site is located on the top of a small mountain (570 m a.s.l.) of the metamorphic complex in the middle Tagus region (Central Portugal) (see Figure 1). So far, there is no absolute dating for the site, nevertheless the techno-typological

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study allows the interpretation of the site as a result of a Middle Palaeolithic occupation. This interpretation is reinforced by the comparison of the Lagoa do Bando lithic assemblage with the main sites of this period identified in the Middle Tagus region. The detailed descriptions of these sites will be offered, below, to serve as a baseline for comparison with the Lagoa do Bando assemblage.

The Middle Palaeolithic occupation of this region is represented by open air sites located on the fluvial terraces of the valleys of small rivers and streams, tributary of the Tagus River, being part of its sedimentary basin. Respectively from east to west, Foz do Enxarrique (Cardoso 1993; Brugal & Raposo 1999; Raposo *et al.* 1985; Zilhão 2006), Vilas Ruivas (GEPP 1983; 1995; Toscano *et al.* 1999; Zilhão 1992; 2001), Ribeira da Ponte da Pedra (Graziano 2013), Santa Cita (Bicho & Ferring 2001; Lussu 2001; Pedergnana 2011) and Estrada do Prado (Chácon & Raposo 2001; Mateus 1984) (see Figure 2) are the excavated open air reference sites. The occupation of caves is recorded in the limestone border in Caldeirão cave (Davis 2002; Zilhão 1993; 1997; 2006), and Oliveira Cave (Angelucci & Zilhão 2009; Marks *et al.* 2001; Richter *et al.* 2014; Trinkaus *et al.* 2007; Willman *et al.* 2012; Zilhão *et al.* 2010) (see Figure 2).

The open air site of Foz do Enxarrique is located on the right bank of the Tagus River at the mouth of the Enxarrique stream. Excavations in the fluvial deposits revealed a single archaeological level with a very rich lithic assemblage associated with bones and teeth of large mammals. The lithic implements are characterized by numerous discoid and Levallois recurrent centripetal cores. There is a high incidence of Levallois products, mainly flakes, but also some points and blades. Entire reduction sequences are represented in the site, evidencing the exploitation of local raw materials represented by quartzite and quartz. Retouched tools are mainly notches and denticulates and side scrapers are rare. (Brugal & Raposo 1999). Preliminary use wear analyses indicate a considerable utilization of many types of flakes, including both Levallois and non Levallois flakes (Pereira 1993). The faunal assemblage includes red deer and horse, together with some remains of aurochs and elephant, rabbit, fox, hyena, rhinoceros, birds and fish and some mollusc shells (Brugal & Raposo 1999).

The particular importance of Vila Ruivas site results from the two preserved, curved structures which might represent the bases of wind-breaks protecting fire structures as suggested by the accumulation of thermoclast elements. Four circular structures have been interpreted as post holes. Following L. Binford's ethno-archaeological model, J. Zilhão considers the hypothesis of a hunters' camp, and he interprets the two curved structures as "hunting blinds" (Zilhão 2001). The lithic industry includes Levallois and discoid cores, knapping products and some retouched tools, such as scrapers and denticulates (Cardoso 2006).

Located on a slope on the left blank of the Atalaia stream, a tributary of the Tagus, the open air site of Ribeira da Ponte da Pedra contains Lower, Middle and Upper Palaeolithic lithic artifacts, and an Upper Palaeolithic hearth (Cura 2014). A total of 442 Middle Palaeolithic artifacts were found in the top of the sedimentary sequence of the T5 Tagus fluvial terrace, the majority in quartzite and very residually in quartz. The assemblage is mainly composed of simple flakes, together with predetermined Levallois and discoid flakes, worked pebbles, cores and retouched flakes (Graziano 2001).

The open air site of Santa Cita is associated with a low terrace on the right bank of the River Nabão, near the mouth of the tributary Bezelga. The archaeological works published in Lussu 2001 revealed the existence of two Mousterian levels. The raw materials include quartz, quartzite and flint. Levallois and centripetal methods are present. The presence of tools is not mentioned in this study.

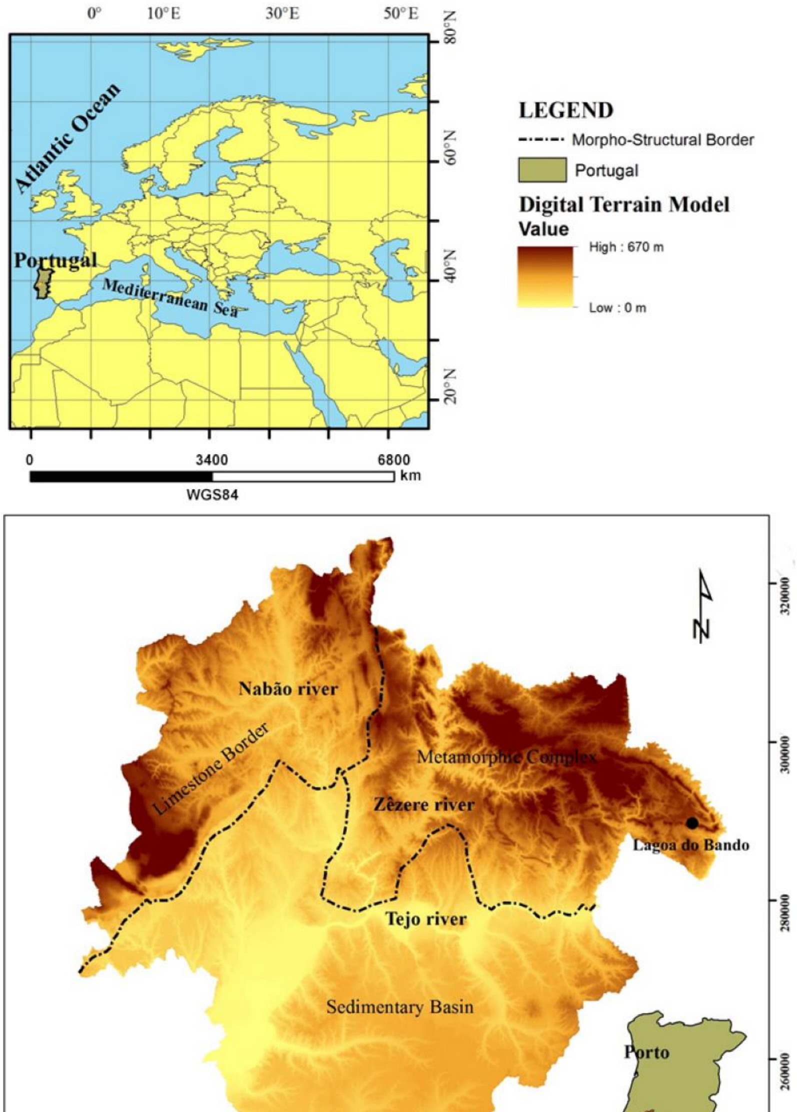

Figure 1. Geographic localization of the site in the Middle Tagus region (Referencing System HGM; Lisboa Hay for-Gauss Militar. (Created by Belo João, 2011.) (Cartographic basis: Carta Militar de Portugal (série M888), 1:25000, Instituto Geográfico do Exército, (digital format); Carta Geológica de Portugal, 1:500,000, 5a Edição, S.G.P., (digital format).) Referencing system (HGM) Lisboa Hayfor-Gauss Militar.

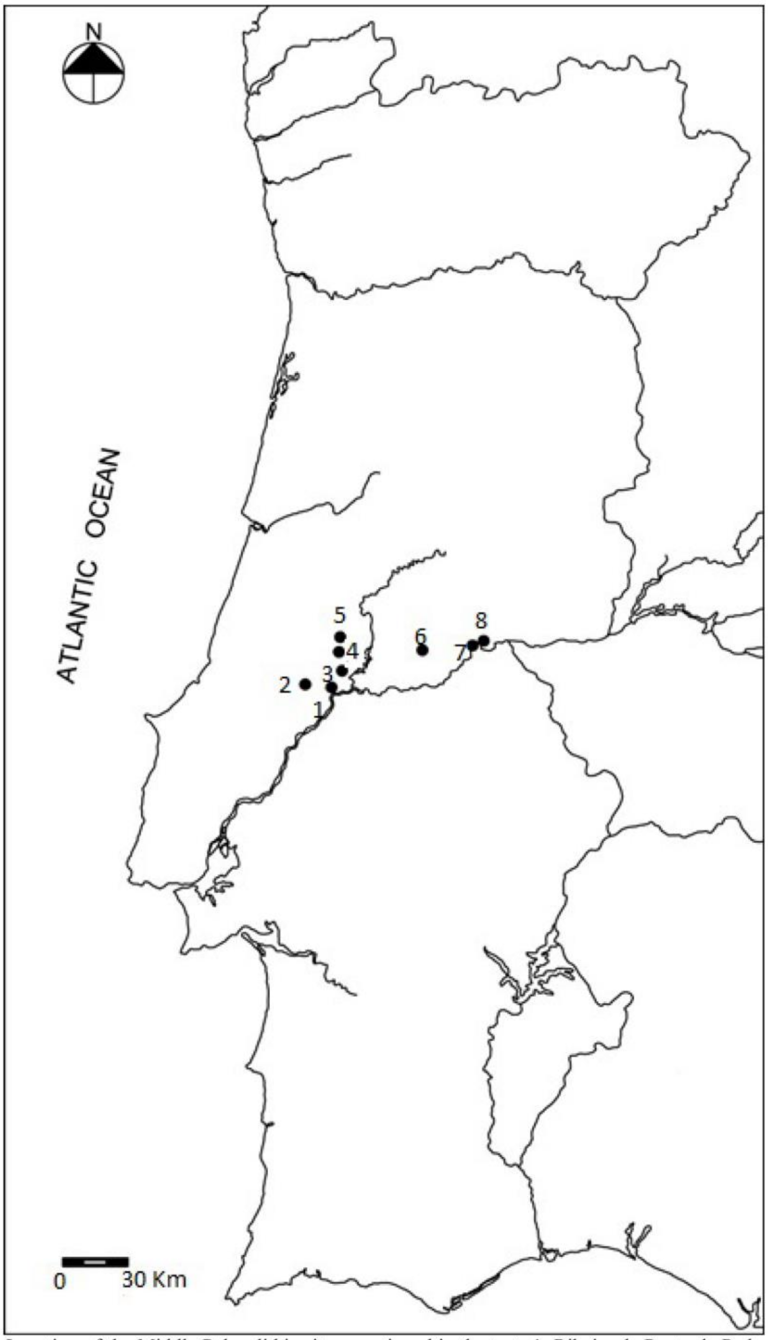

Figure 2. Location of the Middle Palaeolithic sites mentioned in the text. 1. Ribeira da Ponte da Pedra; 2. Gruta da Oliveira; 3. Santa Cita; 4. Gruta do Caldeirão; 5. Estrada do Prado; 6. Lagoa do Bando; 7. Vilas Ruivas; 8. Foz do Enxarrique (modified from Cardoso, 2006).

A more recent study on these materials points to the absence of Levallois, presence of discoid products and cores and abundant undifferentiated cores (Pedergnana 2011). The work led by Nuno Bicho (Bicho & Ferring 2001) also indicates the presence of two levels but points to different conclusions. According to this author the older level indicates a more intensive occupation associated with a possible structure consisting of 5 post holes describing a trapezoidal circuit. This work mentions the application of discoid method and more rarely Levallois, especially on flint, this being heavily exploited. Scrapers, denticulates and notches were identified amongst other items.

Located in a middle terrace of the Nabão River the open air site of Estrada do Prado resulted in the excavation of 2932 artifacts in quartzite, quartz, shale, sandstone and flint. Despite the importance of the site only a preliminary report has been published (Mateus 1984) and only the flint implements have been studied in detail. This study shows the application of Levallois and centripetal methods. Cores were highly exploited and blanks show a high incidence of transformation into tools such as scrapers (Chacon & Raposo 2001).

The Middle Palaeolithic sequence of the Caldeirão cave has been identified, approximately 1 m deep (Levels N to L). Few artifacts have been recovered from all the levels and these are mixed with numerous remains of carnivores. Level K revealed the presence of some Levallois implements in association with many bone remains, suggesting a natural accumulation, possibly due to hyena activity (Cardoso 2006).

The Gruta da Oliveira is a collapsed entrance of the multilevel karstic system associated with the spring of a tributary of the Tagus, the Almonda River. The site contains a Middle Palaeolithic sequence excavated to a depth of around 7 m. The preliminary study of lithics coming from layers 8-9 present an industry of mostly quartzite, followed by flint and quartz. Both layers held Levallois products and the number of tools is low, mainly notches, denticulates and irregularly retouched implements. Authors mention that in levels 10-14 there are backed microliths associated with some prismatic and pyramidal blade and bladelet cores, together with discoidal, Levallois and Kombewa flake production schemes (Marks *et al.* 2001). Faunal assemblages include red deer, ibex, horse, aurochs, rhino and tortoise: large carnivores are rare and the presence of hyenas is attested in some layers by coprolites (Angelucci & Zilhão 2009).

Middle Palaeolithic human remains from layers 9, 10, 17, 18, 19 and 22 consist of a proximal manual phalanx, an ulna, a partial postcanine tooth, a humeral diaphysis, a distal mandibular molar, and a mandibular premolar (Trinkaus & Zilhão 2007; Willman *et al.* 2012).

The lithic raw material procurement systems of these sites are overwhelmingly based on the exploitation of local resources mainly quartzite and quartz, even in areas where flint is available within a short distance (Zilhão 2001). The composition of the faunal assemblages also suggests the exploitation of the immediate environment (Zilhão 2001). Analyzing the Middle Palaeolithic settlement of Portugal, in 2001, Zilhão pointed out that while "small, temporary, highly specialized sites located in mountainous country are well known in the Upper Palaeolithic, such types of occupation are totally unknown in the Middle Palaeolithic" (Zilhão 2001: 606). Despite the fact that further research is required, Lagoa do Bando high location seems to reveal a different pattern of settlement than the one "of a residential mobility inside relatively small territories" (Zilhão 2001: 606).

The chronological data currently available for the Middle Palaeolhitic of this region indicates the occupation of the open air site of Ribeira da Ponte da Pedra as the earliest one. The ESR age 80 ±9 ka for sediments holding Middle Palaeolithic artifacts confirms its attribution to MIS 5 (Rosina *et al.* 2014). Also attributable to the MIS 5 is the Mousterian Cone considered to be the exposure of the basal levels of Oliveira cave which is U-Th dated between 80,400 BP and 46,800 BP (Richter 2014). Oliveira Cave presents the largest number of dates for the Middle Palaeolithic of the middle Tagus region: 14C-AMS dating of burnt bones of level 9 are between 45,955 BP and 43,555 BP and level 11 point between 48,934 BP and 44,335 BP, charcoals from level 13 have been dated by the same method from 44,391 BP to 42,891 BP, also with the same method charcoals from level 14 point 49,861 BP to 42,912 BP and level 15 from 42,774 BP to 41,667 BP, a burnt bone from level 18 still with the same method is dated between 42,503 BP to 41,387 BP and recent TL datings of heated flint are between 59.6 ±12.1 ka and 52.1 ±11.6 ka for layer 13 and from 79.2 ±20.5 ka to 75.1 ±14.8 ka for layer 14 (Richter *et al.* 2014). Also of this MIS 4 is the open air site of Vilas Ruivas with TL dates of ca. 68 ka ago and ca. 51 ka ago (Zilhão 2001). The late MIS 3 human occupation is testified by the open air site of Foz do Enxarrique U-Th dated between 32,938 ±1005 BP and 34,093 ±920 BP (Raposo & Cardoso 1998) and more recently by OSL to between 38.5 ±1.6 ka and 31.6 ±1.3 ka (Cunha *et al.* 2008). The Oliveira cave burnt bone of level 8 is dated by 14C-AMS to between 38,552 BP to 36,835 BP and by U-Th from 40,580 BP to 35,770 BP (Richter 2014). The Middle Palaeolithic sequence of Gruta do Caldeirão presents a radiocarbon date of 27,600 ±600 BP (Raposo & Cardoso 1998). However this date has been questioned and according to Zilhão the date cannot be considered much earlier than ca. 35 ka cal. BP (Cardoso 2006).

1.1. The Lagoa do Bando site and its regional setting

The Mação region, where the site is located, is geologically characterized by the contrast between the Tagus sedimentary basin in the extreme south and east and the ancient Hesperian massif on the north and west. This distinction is visible, not only in the lithologic characteristics of each complex, but also in the relief. To the north there are formations like Bando dos Santos reaching 640 m a.s.l. which are among the highest reliefs in Middle Tagus region. Lagoa do Bando is located on these reliefs and according to the geological map of Portugal (28-A, Mação) belongs to the quartzitic complex of the Bando dos Santos formation (Romão 2000) (see Figure 3).

From a geomorphologic point of view the site corresponds to a unique context of Palaeolithic human occupation of the middle Tagus, since it is located on a lacustrian environment on a significantly elevated hill while considering the relief of this region. Its context is in contrast with the known Middle Palaeolithic evidence found in fluvial terraces and caves indicating a diverse territorial exploitation that conjugates different geomorphologic settings and resources.

The stratigraphy observed in the several machine excavated trenches and in the open-area excavation corresponds to a typical lacustrian sequence mainly composed of clays and very fine sands. The archaeological works (mechanical trenches and excavation) revealed a stratigraphic uniformity in the number of layers and in their respective topography in all 6 mechanical trenches and open area excavation (see Figure 4).

1.2. The lithic assemblage

The lithic assemblage is composed of 368 artifacts, coming from two layers (B* and P: Layer B* is not represented in Figure 4 because it was identified in another trench, nevertheless it is very similar to Layer B, instead of orange is dark orange. Further sedimentological analysis will clear if it's the same layer), mainly in fine and very fine quartzite and residually in quartz and flint. While being minimal, the presence of flint, represented by 3 flakes and 1 debris, indicates an extensive territorial occupation since this raw material is only found in the limestone massif, several tens of kilometres to the west of the site (Figure 1). The very fine dark blue quartzite (the most used raw material) is found in primary context and angular fragments in the valleys of small streams around 10 km down the hill and in secondary context in Pleistocene conglomerate deposits, in the form of pebbles. The quartzites near the site are of poor quality for knapping activities and were not used. The surveys carried out to find the possible sources of the utilized quartzite showed that they are very difficult to find, thus proving a deep knowledge of the territory by the human communities that occupied this region during Middle Palaeolithic.

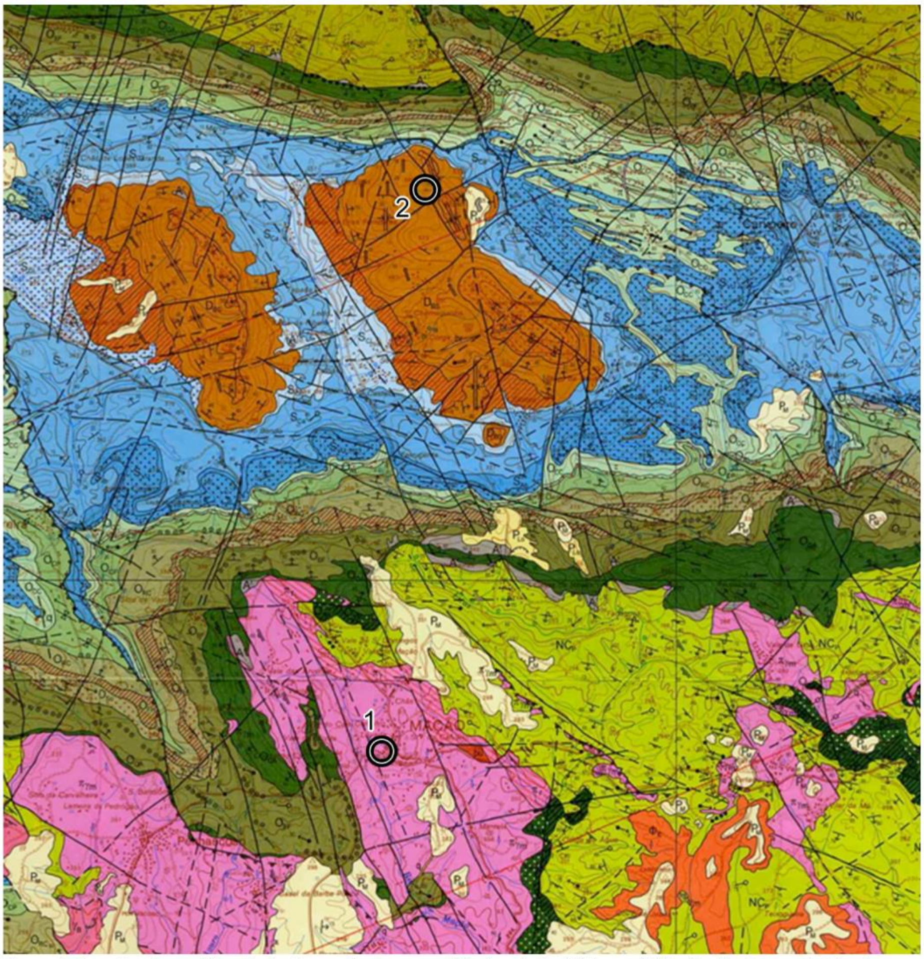

Figure 3. Localization of the site in the geologic map of Portugal. 1 - Village of Mação; 2 - Lagoa do Bando.

The assemblage, composed of cores and flakes, represents the techno-functional choice for 3 different methods of débitage: expedient, discoidal and Levallois (see Table 1 and Figures 5 and 6).

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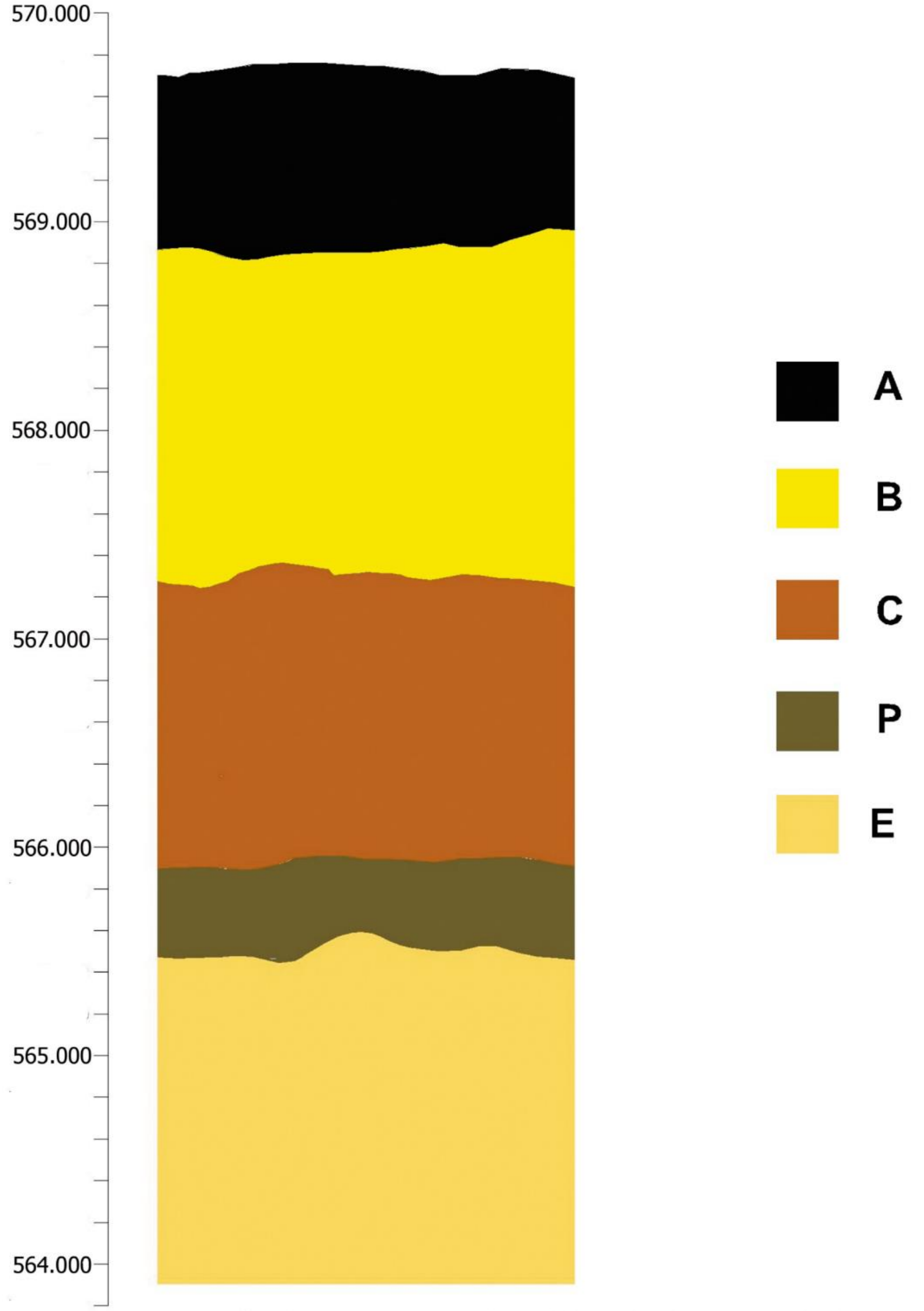

Figure 4. Stratigraphic profile of trench 6: A - Dark clay and fine sand with many organic elements in decomposition; B - Orange clay with brown silt inclusions; C - Orange clay; P - Dark brown clay; E - White and yellow clay.

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Table 1. Techno-typological lithic categories.

Techno-typological category	Layer B*	Layer P	Total
Multifacial core	5	12	17
Prismatic core		1	1
Preferential Levallois core	3	4	7
Recurrent Levallois core		1	1
Discoidal core	2	1	3
Core on flake	4	1	5
Worked pebble		2	2
Flake	37	51	88
Retouched flake	6	5	11
Discoidal flake	20	11	31
Levallois flake	5	15	20
Blade flake	1	7	8
Levallois point	1	1	2
Debris	33	42	75
Retouched debris	1		1
Core Fragment	2		2
Flake Fragment	11	27	38
Undetermined fragment	12	17	29
Total	**143**	**225**	**368**

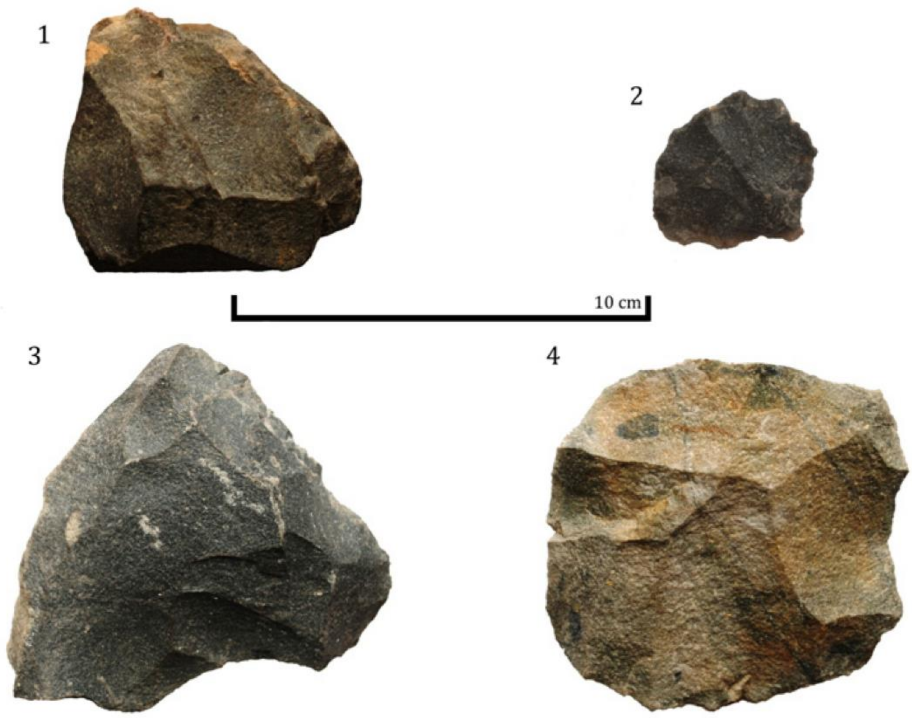

Figure 5. 1: Quartzite multifacial core; 2 & 3: Quartzite Levallois cores; 4: Quartzite discoid core.

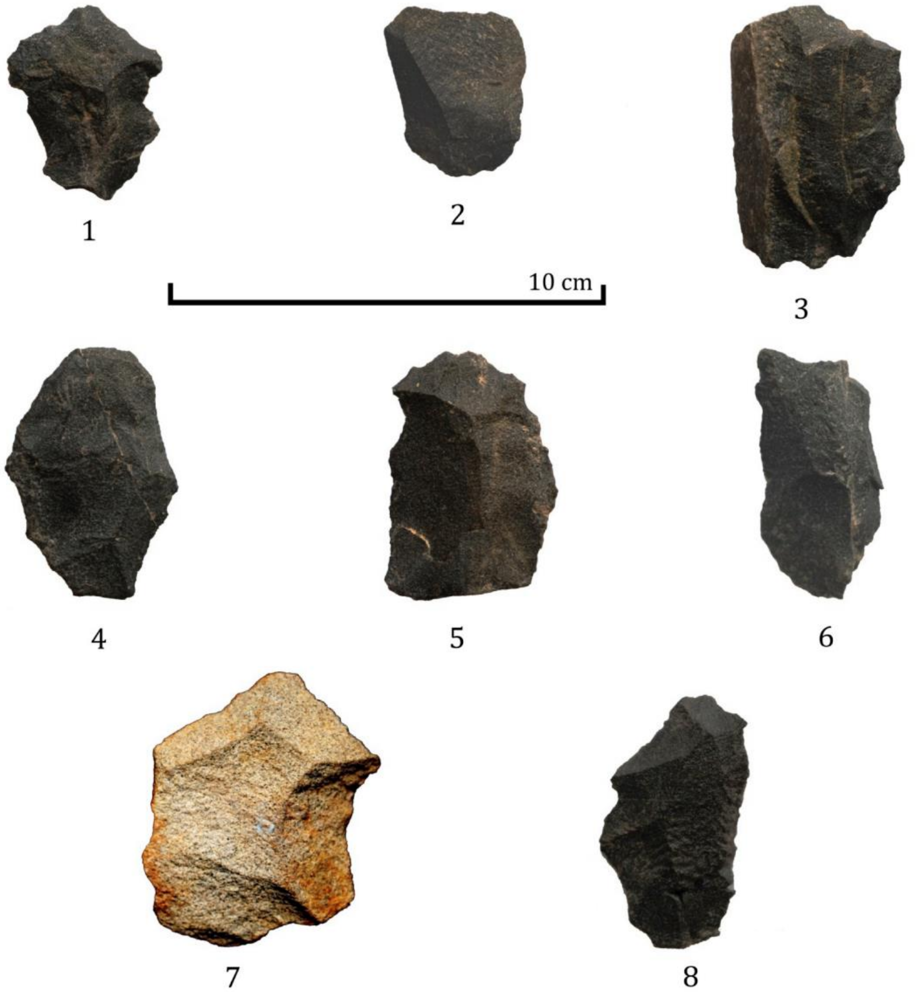

Figure 6. 1, 4-8: Quartzite Levallois flakes; 2: Quartzite discoid flake; 3: Quartzite side scraper.

The expedient method was the main option represented by multifacial cores and simple flakes, while among the predetermined methods the discoid is more represented in flakes, while the Levallois (preferential and recurrent) is more represented in cores. This might be related to the minor production of flakes from Levallois preferential cores and higher productivity of discoid cores, thus we consider that both methods are equal in their presence. Concerning the stages of the reduction sequences of the 3 methods, the initial phases are absent: all cores are in advanced stage of exploitation and the majority of flakes are non-cortical. This indicates that raw material acquisition and first stages of exploitation and configuration took place elsewhere revealing a pattern of transport and use where only the final products where brought to the site to be used. Such a pattern is certainly linked to the setting of the site on the top of the hill, far from raw material sources, and the specific activities undertaken here. Nevertheless the high quantity of debris indicates that knapping activities took place in the site. These probably correspond to the maintenance of blanks, namely of Levallois and discoid cores. The considerable quantity of fragments might be related to the discard of unusable implements. Formal tools consist only of 11 retouched flakes (sidescrapers) and 2 Levallois points, evincing a preference for the utilization of unretouched blanks.

2. Materials and methods

At the present day, a lot of use-wear studies are carried out using Scanning Electron Microscopy (SEM). SEM has the advantage of a wider depth of field and it is also useful for the analysis of highly reflective raw materials such as a quartz and quartzite (Knutsson & Lindé 1990; Ollé & Vergès 2014). However, scanning electron microscopes present three disadvantages: they are not as readily available as optical light microscopes, not transportable to the field, and very expensive in terms of time and resources. For this study, we used a metallographic microscope to carry out the analysis of the lithic artifacts (archaeological and experimental) (Clemente & Gibaja 2009; Gibaja *et al.* 2002; Gibaja & Carvalho 2005; Gibaja *et al.* 2009). With this kind of microscopy two techniques of visualisation are available to reduce the glare of highly reflective raw materials (such as the quartz-rich raw materials) (Igreja 2009; Lemorini *et al.* 2014): equip the microscope with a Differential Interference Contrast Capability (also known as Nomarski contrast) or use high-resolution epoxy casts of the edges of the artifacts (Banks & Kay 2003; Plisson 1983). We used also the second methodology with a little modification since the observations were made only on the moulds (negative replicas) rather than making casts (positive replicas) of each mould surface. This protocol, already used by C. Lemorini (Lemorini *et al.* 2014) has as advantages the lowering of the laboratory expenses by eliminating the need for casting material, the reduction of the loss of fine detail that can occur when using casts and a better placement of the edges under the microscope. The use of moulds, in addition to being cheap also allows the easy transport of the samples to be analysed (Plisson 1983), without move the archaeological artifacts (eliminating conservation, legal and insurance problems).

To perform this study a three step methodology has been followed. First, a macroscopic preliminary observation assessed the suitability for the use-wear study of the lithic remains from Lagoa do Bando and to select the best preserved edges for the investigation.

In second instance a reference collection with flakes made of the same raw materials used by the Neanderthals of Lagoa do Bando was produced. Several specific activities were then carried out on different materials with the experimental lithic tools, to link the use-wear features to tool motions and to the processed materials. A use-wear study was done on a selected group of lithic artifacts. The above mentioned steps are considered here.

2.1. Initial examination of the archaeological materials

This study began with the preliminary evaluation of part of the lithic assemblage with the aim of identifying suitable lithic artifacts for the use-wear study. The sample was composed of all the Levallois and the discoid products. Five criteria were applied to select artifacts for the use-wear analysis: completeness, presence of at least one functional edge (artifacts 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 artifacts which are probably related to an ancient use. This preliminary phase was divided in two parts. The first examination was carried out by naked eye observation, followed by a second inspection with one stereo-microscope in reflected light. In this way it is possible to minimize the likelihood of confusing the modifications due to artifact's use, rather than post-depositional processes.

The main features that differentiate traces of use from post-depositional alterations are the combinations of the trace attributes: the contact with the worked material produces specific combinations of attributes, which rarely are replicated by post-depositional agents (*e.g.,* Asryan *et al.* 2014; Keeley 1980; Lemorini *et al.* 2014; Mansur-Franchomme 1986; Vaughan 1985). As testified by the experimental reference collections, the traces of use are always distributed in a localized portion of the artifact, usually in close proximity to the edge. The post-depositional marks are randomly spread over the lithic surface (Shea & Klenck 1993). There are three types of post-depositional surface alterations detectable by the naked eye: post-depositional edge damage (Flenniken & Haggarty 1979; McBrearty *et al.* 1998), generalized rounding of the surface (Plisson & Mauger 1988) and widespread glossy and bright appearance of the quartzite cement matrix (Stapert 1976; Plisson & Mauger 1988). Although superficially all the Lagoa do Bando collection appears well preserved some edge removals are visible on some of the artifacts. Through a stereo-microscope in reflected light it is possible to detect on the surfaces of some artifacts a light widespread gloss. All the artifacts with marked post-depositional alterations or that did not satisfy at least one of the other five criteria were discarded from the sample. After this preliminary screening phase, the Lagoa do Bando sample dataset is reduced to 42 quartzite artifacts, of which 16 are discoid flakes, 26 are Levallois flakes (16 are preferential Levallois flakes and 6 are centripetal Levallois flakes) and 4 simple flake. After this selection, no formal tools are registered in the dataset. This is probably due to their under-representation in the lithic assemblage. Forty five percent of the selected artifacts present a small amount of post-depositional edge removals.

2.2. Reference collection

The reference collections of quartzite flakes used to process different materials during controlled experiments were necessary to interpret the use-wear on the Mousterian artifacts. These collections come from two different sources. The first reference collection is the experiments carried out with quartzite flakes in the CIAAR (Centro de Interpretação de Arqueologia do Alto Ribatejo, Vila Nova da Barquinha) laboratory. This reference collection has been made with the same quartzite found at Lagoa do Bando. A total of 25 quartzite flakes were used in the experiments to link specific types of edge modification to the processing of specific types of materials and to specific processing tasks (see Table 2). The second reference collection is the experimental reference collection of quartzite implements of the Instituto Terra e Memória of Mação (I.T.M.): this collection was realized for others use-wear studies on-the quartzite lithic industries conducted by the Institute. The collection has more than one hundred quartzite flakes used on different materials (*e.g.*, butchering activities, fresh hide, bone, fresh and dry wood). For each flake of the I.T.M. experimental collection the following data are registered on a label: material worked, time of working, direction of the action done and name of the operator. The flakes of the CIAAR reference collection were washed first with water and soap. After this procedure the artifacts were placed for 48 hours in a mixture of alcohol (50%) and distilled water (50%). At the end the artifacts were washed with distilled water (75%) and alcohol (25%) in an ultrasonic cleaner for 5 minutes. The flakes of the ITM reference collection were only washed with distilled water (75%) and alcohol (25%) in an ultrasonic cleaner for 5 minutes.

2.3. Microscopic analysis of Lagoa do Bando artifacts

The analysis of the lithic artifacts was carried out using three different types of microscope: a stereoscopic microscope Seben Incognita III with magnification from 10x to 80x, a metallographic microscope Optika B 600 MET supplied with 5 objectives PLAN IOS MET with 5-10-20-50-100 objectives and 10x oculars equipped with a Optika camera B5. and a Microscope Camera Dinolight Am413T). The macro-traces were observed with the stereo-microscope in reflected light and micro-traces with the metallographic microscope.

The analysis of the macro-traces provides information about the potential activities carried out (*e.g.*, cutting, scraping, piercing, *etc.*) together with a first hypothetical interpretation of the hardness of the worked materials. The hardness categories used to describe the worked materials are: soft (*e.g.,* animal soft tissue, herbaceous plants and some tubers), medium (*e.g.,* fresh wood and hide) and hard (*e.g.*, bone, horn, antler, dry wood and stone). Some materials display intermediate hardness or resistance such as soft-medium materials (*e.g.*, fresh hide, wet softwood) or medium-hard materials (*e.g.*, softwood, wet antler) (*e.g.*, Lemorini *et al.* 2006; Lemorini *et al.* 2014; Odell 1981; 2004; Rots 2010; Semenov 1964; Tringham *et al.* 1975). The analysis of the micro-traces is the study of micro-edge rounding, polishes, abrasions, and striations. This study was conducted to provide a more detailed understanding of the activities carried out with the lithic artifacts, and to define the diagnosis of the processed materials (*e.g.*, Beyries 1987; Christensen 1996; Moss 1983; Keeley 1980; Lemorini *et al.* 2014; Lemorini 2000; 2006; Plisson 1985; Rots 2010; Vaughan 1985; Ziggiotti 2011.).

Table 2. Reference collection. Materials worked with the experimental quartzite flakes.

	Work Time (minutes)		
Processed materials	**20**	**30**	**45**
Butchering (rabbit and wild boar)	2	2	2
Fresh bone (rabbit and wild boar)	2	2	2
Dry wood	1	1	-
Fresh wood	1	1	1
Dry antler (red deer)	1	1	-
Fresh skin (wild boar)	1	1	1
Dry bone (goat)	1	1	1
Total time: 25 minutes	**9**	**9**	**7**

3. Results

The analysis of the reference collections allowed to identify different type of micro wear traces on the quartz crystals and on the silica matrix surrounding them. The different extent of the use-wear traces, the texture and the topography of the polish, the presence of striations together with their depth and shape allow the definition of the hardness of the worked materials and, in some cases, they could be used to gain a specific diagnosis of the processed material (see Table 3).

Table 3. Microwear attributes used to diagnose the material being worked with quartzite tools

Material being processed	Wear on the crystals	Wear on the cement matrix
Meat	Widespread light rounding	Rough polish
Bone	Domed (convex) topography and possible striae on the upper parts.	Patches of flat polish
Wood	Lightly domed (convex) topography, possible striae and edge rounding.	Rough polish on domed and irregular micro holes.
Skin	Widespread rounding.	Possible striae
Butchering	Domed (convex) topography, widespread rounding and possible striae.	Rough polish and striae

The location and the orientation of the traces permits the diagnosis of the direction of the actions carried out with the tool (cutting or scraping) (Clemente & Gibaja 2009; Gibaja *et al.* 2002; Gibaja *et al.* 2009; Igreja 2009; Lemorniet *et al.* 2014; Pereira 1992a; 1992b; 1993; 1994; 1996). Twenty-one of the 42 archaeological quartzite artifacts (50%) selected for the analysis showed use-wear traces. Thirteen of them show no post-depositional alterations and five show minimal post-depositional edge damages. Three have post-depositional edge damages due to the mechanical excavation activities. The morphological features of the traces that allow interpretation of the kinetic actions and of the properties of the worked material are readily observable thanks to the excellent preservation of the surfaces of the artifacts.

During the study of the selected lithic assemblage, three instruments were identified with two different edges used. Cutting motions were recognized on 14 functional edges, linked to the processing of soft animal tissue (n = 5), butchering activities (n = 3), and wood working (n = 6). Scraping activities (nine of 24 functional edges) are related to wood working (n = 6) indeterminate medium-hard material (n = 1) and indeterminate hard material (n = 2) (see Figure 7 and Table 3). All of the three instruments with two edges used show use-wear traces of the same materials on the two edges, two of them present traces of wood working (one with longitudinal motion and the other one with transversal motion), the last one presents traces of longitudinal motion referable to a butchering activity. One artifact presents traces of indeterminate medium-hard material processing with a mixed action (see Table 4).

Table 4. Table with the use-wear traces found on the Lagoa do Bando artifacts Abbreviations: ZU - zone of use; SU. - stratigraphic unit; p - Layer P; b* - Layer B*; LP - Levallois preferential flake; LRC - Levallois recurrent centripetal flake ; Opp. – opportunistic flake; Qzt - quartzite; m. - medium; tran - transversal; long - longitudinal; unk. - unknown; SAT - soft animal tissue.

					ZU 1			ZU 2		
no.	**SU**	**technology**	**material**	**ZU**	**hardness**	**action**	**material**	**hardness**	**action**	**material**
17	p	LP	black Qzt	1	hard	tran	wood			
52	b*	Discoid	black Qzt	1	hard	tran	wood			
5	b*	Discoid	black Qzt	1	hard	long	wood			
118	b*	LRC	black Qzt	1	soft	long	SAT			
6	p	LP	black Qzt	1	soft	long	SAT			
7	p	Opp.	black Qzt	2	hard	long	wood	hard	long	wood
1	p	LP	black Qzt	1	m. soft	long	SAT			
1	b*	Discoid	grey Qzt	1	m. hard	long	wood			
64	b*	LRC	grey Qzt	1	m. soft	long	butchering			
18	p	LP	black Qzt	1	m. hard	tran	unknown			
60	b*	Discoid	black Qzt	1	m. hard	long	butchering			
17	b*	Discoid	grey Qzt	1	hard	tran	unknown			
15	p	Discoid	black Qzt	1	hard	long	wood			
75	b*	Discoid	black Qzt	2	hard	tran	wood	hard	tran	wood
61	b*	Discoid	grey Qzt	1	m. hard	unk.	unknown			
35	p	LP	black Qzt	1	hard	tran	unknown			
2	p	Discoid	black Qzt	2	m. hard	long	butchering	m hard	long	butchering
35	b*	LRC	black Qzt	1	m. hard	tran	wood			
12	b*	LP	black Qzt	1	hard	long	wood			
8	p	Discoid	black Qzt	1	hard	tran	wood			
47	b*	LRC	flint	1	m. hard	long	butchering			

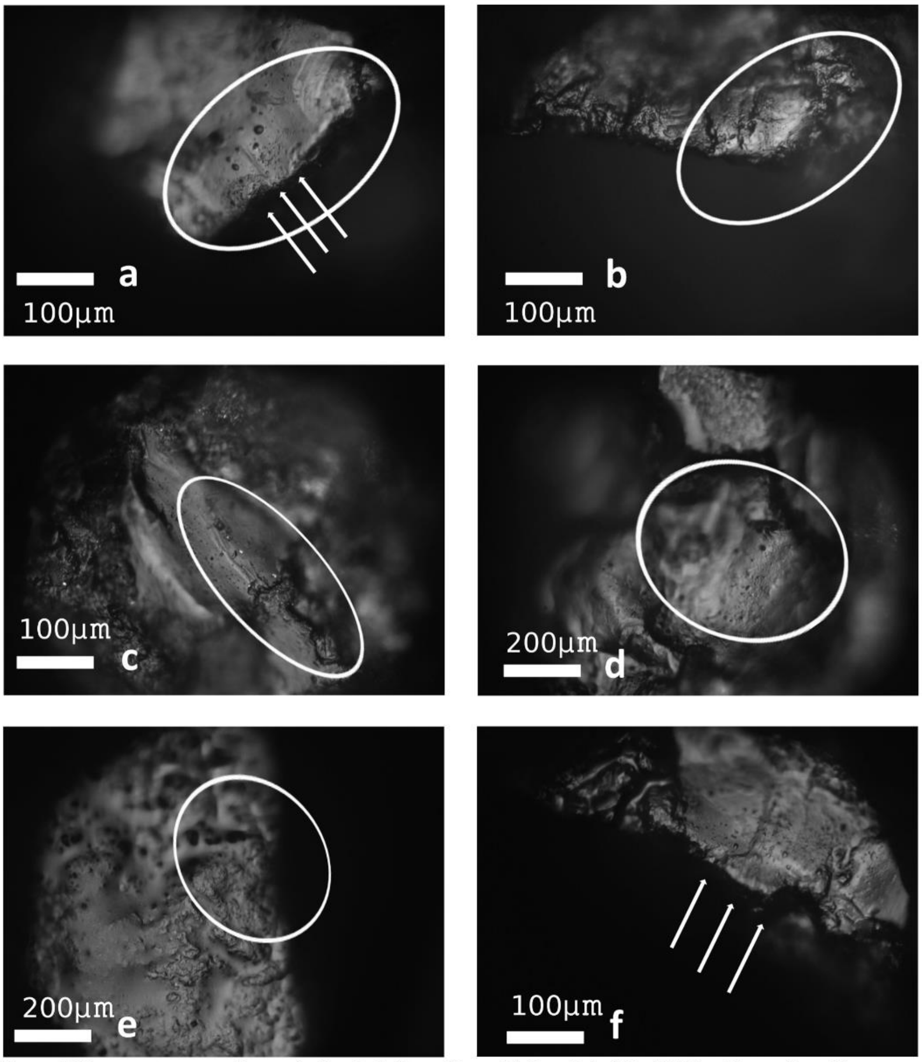

Figure 7. Use wear traces on Lagoa do Bando lithic artifacts: (a) Levallois flake B* 12 with wood-working traces on the edge; (b) Levallois flake P 1 with well-developed meat-working traces; (c) Discoid flake B* 75 with wood-working traces on the edge; (d) Edge of the Levallois Flake B* 35 wood-working traces; (e) Edge of the Levallois Flake P 6 with meat-working traces; (f) Discoid flake B* 60 with butchering traces on the edge.

4. Discussion and conclusions

Through the use-wear study of the lithic assemblage of Lagoa do Bando it is possible to describe part of the activities that were carried out on the site. The use-wear traces identified on the artifacts of the selected assemblage are linked to wood working activities and to the acquisition of meat resources. For four artifacts was impossible to define the type of the material worked. In these case just the hardness of that worked materials was identified: two artifacts were used to work hard materials and two were used to work medium-hard materials.

Dividing the artifacts into the two different stratigraphic units it is possible to see that the edges of the artifacts of the two different units show the same types of use wear traces, more or less in the same proportions (see Table 4).The low efficiency of quartzite cutting-edges for wood scraping was experimentally observed in the collective research project "Des Traces et de Hommes" (Thiébaut *et al.* 2009a; 2009b). Probably the choice of this raw material is due to the abundance of quartzite near the site and to the lack of better raw materials in the area: vein quartz presents the same problem (Berruti & Arzarello 2012) and flint is not present. The use of quartzite instruments for woodworking is also documented in all the other use-wear studies conducted on sites of the same area (Fonte da Moita, Ribeira Ponte da Pedra), but unfortunately these are Lower Palaeolithic sites (Cristiani *et al.* 2009; Lemorini *et al.* 2001). The high presence of tools with use-wear traces linked to wood working activities is very interesting because it is very rare to identify this type of trace in Middle Palaeolithic sites (Claud *et al.* 2013). Some other functional studies on Middle Palaeolithic industries show some diversity in the activities practiced in the sites and usually slaughter activities are dominant and wood-working is absent or scarce (Tares-Dordogne (Geneste & Plisson 1996); LaCombette - Vaucluse (Lemorini 2000); Vault Romani - Catalonia (Martinez 2008); Grand Champ - Loire (Igreja 2009) and La Mouline - Dordogne (Pasquini 2008); Ciota Ciara - Piemonte (Daffara *et al.* 2014). Although, a few functional studies conducted on others Middle Palaeolithic series, have highlighted a high proportion of artifacts used for a wood-working activities such as: Sesselfelsgrotte - Germany (Rots 2009) and San Quirce - Castile (Clemente *et al.* 2012). The abundance of wood-working activities in both of the stratigraphic unit of Lagoa do Bando, suggests the presence of a wide range of activities, not only shaft or spear manufacture.

This data may suggest a long term occupation. On the other hand, if the hearths were social spaces and the center of the activities (Foley & Gamble 2009; Rosell *et al.* 2012; Vallverdú *et al.* 2012; Vaquero & Pastó 2001), their absence in Lagoa do Bando together with the small quantity of lithic artifacts found, could suggest that the site is an ephemeral occupation site (such consideration remains to be confirmed through future excavations). Considering the available data in our opinion, the Lagoa do Bando remains might be related to two (or more) ephemeral and specialized occupations of the site (Stiner 2013).

These occupations were probably linked to the exploitation of woody local resources, maybe of lacustrine plants (*e.g.*, the Gravettian site of Bilancino (Aranguren and Revedin 2001), and to hunting activities. The presence of wood working traces on the edge of the Lagoa do Bando artifacts can be interpreted also as part of the "*chaîne opératoire*" for the realization of "hunting blinds" like the ones found in the Vila Ruivas site (Zilhão 1992; 2001). Lagoa do Bando could be interpreted as a butchery site (Manuel Domínguez-Rodrigo 2008) probably linked to the hunt of animals coming to drink. This interpretation, agrees with Zilhão (2000; 2000b; 2001) and Raposo's (2000) hypothesis that the Middle Palaeolithic people of the area were highly mobile and exploited predominately locally available raw materials especially quartzite.

The Lagoa do Bando site is one of a group of Mousterian open air sites of the middle Tagus area, like the nearest sites of Foz do Enxarrique, Vila Ruivas, Santa Cita, Estrada do Prado and Ribeira da Atalaia. But unlike these sites Lagoa do Bando is located in a relatively high mountainous environment, suggesting a more complex strategy of territorial exploitation for the Middle Palaeolithic of this region. Despite this different setting the lithic industry is similar to the mentioned open air sites where Levallois and Discoidal methods are present although not dominant and formal tools are not abundant, mainly represented by notches and denticulates. The predominance of unretouched flakes might be explained by the exploitation of the abundant local raw materials with technological exploitation resulting in adequate functional morphologies suitable for use without the need for retouch.

The Lagoa do Bando site contributes to understanding the behaviour of the Neanderthals who occupied open air sites in wetland environments. This behavior is documented across Europe from England (Hosfield 2005) to Greece (in the terra rossa, or "red beds") and Germany (*e.g.*, Wallertheim) (van Andel 1998; van Andel & Runnels 2005; Haws *et al.* 2010;).

In order to obtain a more accurate reconstruction of the activities that took place in Lagoa do Bando during the Middle Palaeolithic and to determine with more precision the type of occupation of the site (long or short term occupation) new excavation campaigns will be needed. This will increase the lithic assemblage and consequently the sample for the use-wear analysis (*e.g.*, in this study only flakes have provided functional diagnostics because the few formal tools were too weathered).

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CHAPTER X

THE USE-WEAR ANALYSIS OF THE QUARTZITE LITHIC ASSEMBLAGE FROM THE MIDDLE PALAEOLITHIC SITE OF FOZ DO ENXARRIQUE (RODAO, PORTUGAL).

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THE USE-WEAR ANALYSIS OF THE QUARTZITE LITHIC ASSEMBLAGE FROM THE MIDDLE PALAEOLITHIC SITE OF FOZ DO ENXARRIQUE (RODAO, PORTUGAL)

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ABSTRACT

The Middle Palaeolithic site of Foz do Enxarrique is located on the right bank of the Tagus River at the mouth of the Enxarrique stream. The excavations revealed a single archaeological level together with a large lithic assemblage associated with a relatively small amount of bones and teeth of large mammals. Uranium-series determinations on equid and bovid teeth provide an average date of 33.600 ±500 BP. The use-wear analysis was conducted on 110 lithic artefacts selected from the finds found in the central area of the excavation. During the use-wear study were analysed all the unretouched flakes with potential functional edges, good surface preservation and showing the presence of removals and/or roundings localized on the edges of the artefacts, thus indicating ancient use. Despite of the good condition of the lithic artefacts and the relatively good preservation of the faunal remains, it is clear that the material has been slightly reworked by to geological and biological factors. The use-wear study shows that the assemblage is dominated by tools with traces of activities linked to the acquisition and processing of animal carcasses but there are also tools with traces linked to the processing of other materials (such as skin and wood). According with the data obtained from the use-wear analysis and from the other studies carried out, we can conclude that the site of Foz do Enxarrique is probably a hunting camp or more likely a medium term occupations base camp, related to seasonal river floods.

KEYWORDS: Portugal, Mousterian, Quartzite, Use-wear analysis, Neanderthals behaviors, Tagus valley.

1. INTRODUCTION

The Middle Palaeolithic site of Foz do Enxarrique (henceforth indicated as Fenx) is located on the right bank of the Tagus river at the mouth of the Enxarrique stream, near the village of Villa Velha de Rödäo, about 10 km far from the Spanish border (Fig. 1).

The site was discovered by a local archaeologist, Francisco Henriques, subsequently studied by L. Raposo in 1982, and extended excavations have been conducted from the same year onwards by L. Raposo and A.C. Silva.

Excavation was made in the fluvial deposits of the Tagus river revealing a single archaeological level with a large lithic assemblage associated with a relatively small amount of bones and teeth of large mammals (Brugal and Raposo 1999; Raposo *et al.* 1985; Raposo and Silva 1987; Raposo 1995; 2000).

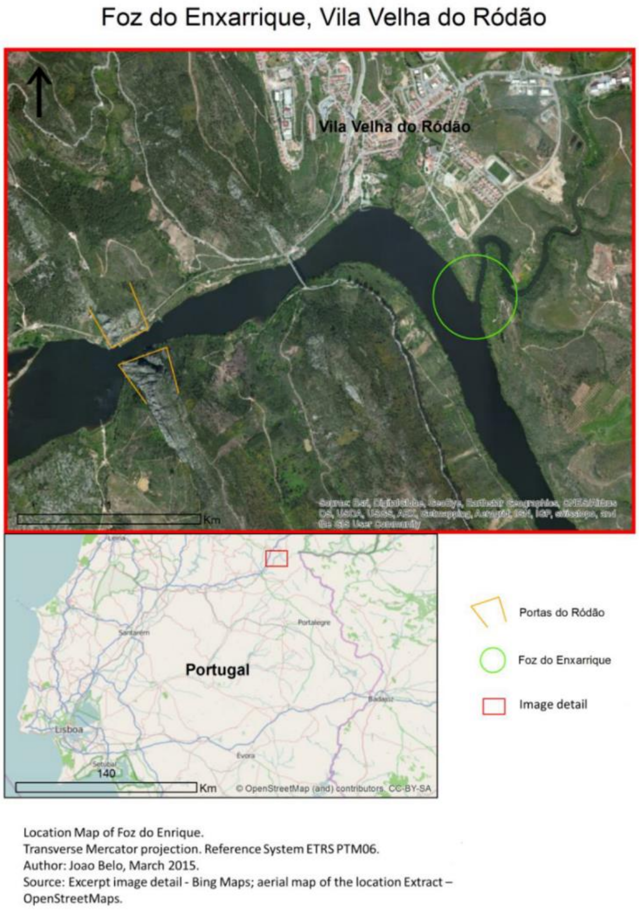


Figure 1. Fenx location (elaboration made by Belo & Rosina).

Three Uranium-series dates made on equid and bovid teeth (two horse and one uro tooth) provide a chronological frame for the human frequentation of the site. The obtained datation are: 32.938± 1055 (SMU-225, horse tooth); 34 088 ± 800 (SMU-226, horse tooth), and 34.093± 920 (SMU-224, uro tooth); the average weighted is 33,600 ± 500" (Raposo, 1995). In addition, these chronologies were confirmed by the study conducted on the fluvial terraces of the Tagus river.

This study suggests a chronology between 31 to 40 kya for the basal sequence (Cunha *et al.* 2008; 2012). As a consequence, it is possible to suggest a chronology for the Mousterian level of Fenx to a later phase of the Last Glaciation (initial pleniglacial transition, OIS 2/3).

The excavation of Fenx affected an area of approximately 150 m², and allowed the recovery of more than 10,000 lithic artifacts, 399 determinable bones, and 559 indeterminable bones. This paper outlines the preliminary results obtained by the use-wear analysis of 110 lithic artifacts coming from the central area of the excavation, the same area where the most of the faunal remains were found. The main objective of this study is to complete, through the use-wear analysis, the interpretation of the site made by Brugal with the palaeontological and zooarchaeological analysis (Brugal and Raposo 1999). When all the other studies, currently ongoing, will be completed (e.g. technological study of the lithic industries and spatial analysis), the results will give useful information for the reconstruction of the Neanderthals economies in the Tagus valley during the last glacial cycle by providing data for the comparison with other Middle Palaeolithic Portuguese and European sites.

1.1 Geomorphological setting

Fenx is located in the Pleistocene fluvial deposits of the lower river terrace (T6) of Tagus River, in the Ródão depression, adjacent to two quartzite ridges crests of Ancient Massif, and about 10 km after the complete entrance of the river in the Portuguese territory. The Fenx terrace forms a constructional bench at 82 m a.s.l. (16 m above river bank a.r.b.) on the Tagus right bank, between the mouths of the Açafal and the Enxarrique streams. The Fenx terrace is 6 m thick, with the base of the terrace being a clast-supported boulder discontinuous conglomerate (fulfilling mainly the concave irregularities of the bedrock) and containing sub-rounded clasts of quartzite, white quartz and meta grey wackes/slates. White brown massive extra-fine sandstones (rich in quartz and muscovite) and coarse siltites form the upper 5m of the terrace, with the addition of some thin levels of pedogenic calcareous concretions. The archaeological level (5 to 20 cm-thick) is located at the base of fine sandstones levels (Cunha *et al.* 2008; 2012; Raposo *et al.* 1985) (Fig.2).

The archaeological level is stratified in yellow-brown silt located in the lower part of the sequence, slightly slopping both in direction of the river Tagus as the Enxarrique stream, from the East to West, where it comes in contact with the basal gravels (Fig.3).

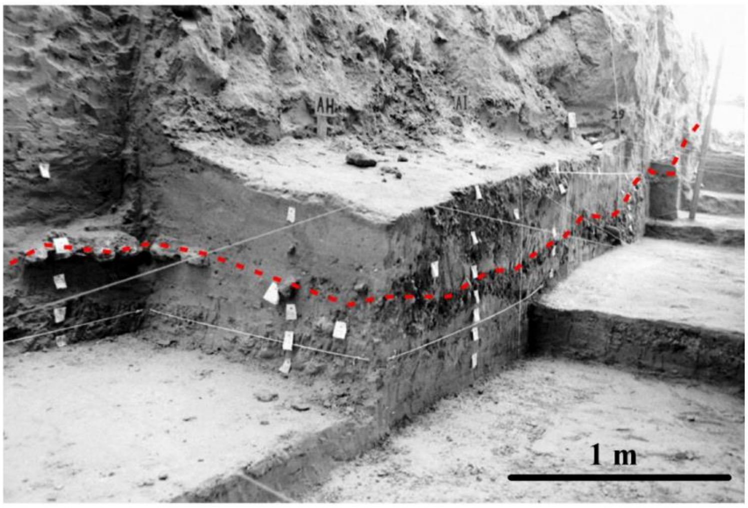


Figure 2. Photo of the section of Fenx, in red the archaeological level is indicated (Raposo).

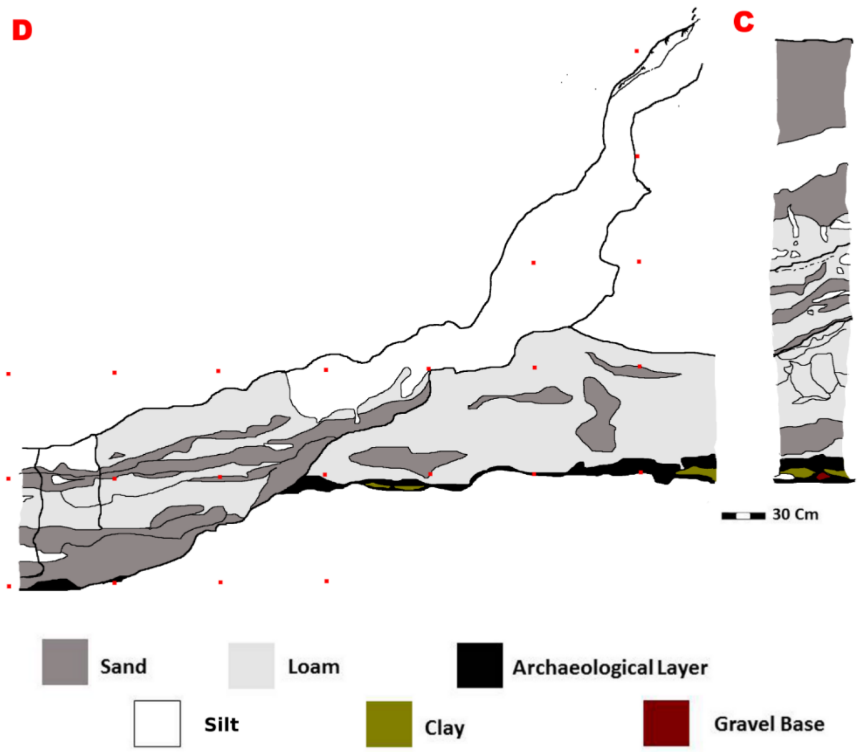
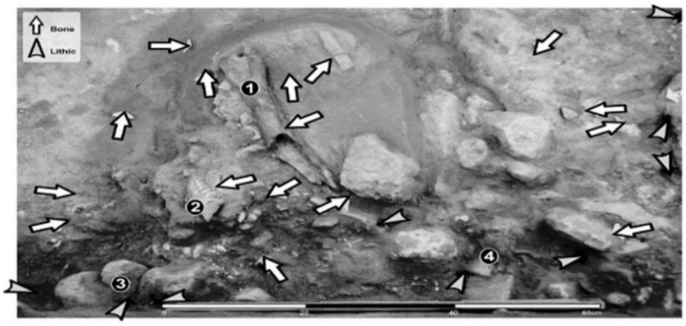


Figure 3. Stratigraphy of Fenx; C, D indicate the square (picture from Raposo 1991, elaboration Berruti).

The sediment is rich in secondary carbonates (concretions of $CaCO_3$) in particular at the base of the sequence (Brugal and Raposo, 1999; Raposo, 1995). The uncommon high carbonate content of Tagus river' waters is responsible for the good preservation of the faunal elements. For this reason, Fenx is the only Pleistocene open air-site in the region with faunal remains. Normally the substrate and relative soils acidity, who characterized this area, destroys the faunal remains.

The archaeological remains were preserved by the aggradation of the sediment (alluvial processes) in a low energetic context, where waterlogging of the sediments was presumably frequent. The majority of the finds concentrate close to the bedrock, and sometimes seem to be concentrated in irregular pockets of clay with a few gravel lenticules (Fig.4). The post-depositional horizontal and vertical movement of the remains is well documented in such stratified alluvial contexts. The cumulative effects of climatic and biological (including trampling) processes in this fluvial deposit lead to horizontal and vertical spatial dispersal of the archaeological remains. All these taphonomic processes typically occur in fluvial sedimentation. On the other hand, as it has been demonstrated in other cases where "living floors", or more appropriately, "archaeological horizons" have been described in equivalent sites, their presence is not sufficient to negate the occurrence of an association between lithic and faunal remains, as well as the local human activity on both of them. This is confirmed cumulatively by stratigraphy and micromorphology (lithics and fauna integrate the same thin silty level of about 5 to 10 cm tick, even if locally subdivided into 2 or 3 lenticules attaining 20 cm, but with limited surface development), spatial distribution analysis (lithics and fauna show the same pattern, centred in an area of about 20 to 30 m^2 of high concentration of both), lithic analysis (presence of all metric categories and refitting between flakes and cores), and human action on bones, even if discrete (Fig.4).



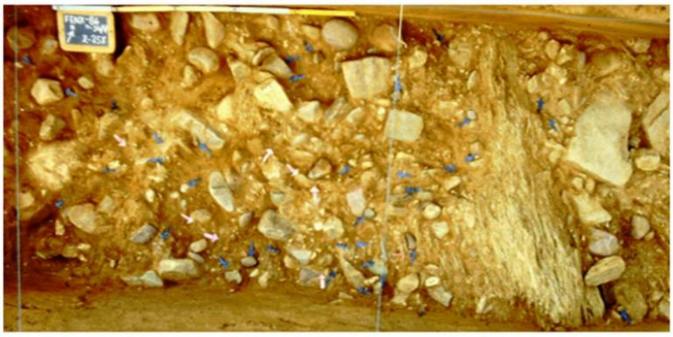


Figure 4. Upper image. Photo of O34 square area (photographic base black/white and overlap with the indication of bone and lithic artifacts): 1: Tibia of aurochs; 2: hemimandible of deer; 3: Levallois core, 4: flake Levallois (Raposo). Lower image. Photo of the squares O37 and O37; the blue arrows in indicate lithic artifacts, the pink arrows indicate bones (Raposo)).

All these factors indicate a single depositional phase, even though the exact number of episodes of human occupation cannot be determined exactly (Brugal and Raposo, 1999). In fact, one must always keep in mind that the ethnographic concept of "present" is usually applicable for the Palaeolithic sites and almost all, if not all of the so-called "living floors" are the result of the accumulation of different episodes (cf. for instance Bordes, 1975), documenting an unknown number of human presences, giving rise to the definition of "archaeological horizons", as in the current situation.

1.2 The faunal remains assemblage

The analysis of the bones assemblage highlights the preponderant presence of two genus of cervid (*Cervus elaphus*) (58,7% of the assemblage) and equid (*Equus caballus* ssp. indet.), (39% of the assemblage) with the interesting presence of aurochs (*Bos primigenius*) remains (2,5% of the assemblage) representing a minimum number of three individuals. In this assemblage the axial skeletal parts are underrepresented and there are numerous isolated teeth, together with many teeth fragments and few larger cranial parts. Human or carnivore modifications (e.g,. cut marks) of bone, although rare, are present in the assemblage. Those elements of upper limb bones rich in resources (meat, marrow) are relatively abundant and their presence, in terms of human procurement, suggests either early access to carcass (scavenging) or hunting by humans. Hominids are responsible for some modifications observed on the remains: several diaphysis fragments, mainly from unidentifiable bone fragments, show impact fractures probably results of deliberate bone breakage by hominids in order to obtain marrow; also cut-marks are visible on several bones. Within the faunal remains assemblage there are visible traces of an hydraulic transport. Traces of different taphonomic processes, like weathering, have been observed on cervid and equid remains at Fenx. One part has been buried relatively rapidly (cervid bones), others over a longer period of time (equid remains), and some are indeterminable as to the duration of the deposition (the background fauna). In conclusion, Fenx bone assemblage is characterized by the presence of few remains of large herbivores (elephant, bovid) and carnivores (fox, hyenid), which probably died naturally and whose remains were scattered along the river, associated with two main species (equid, cervid) represented by abundant bone remains (91.5% of the faunal assemblage) probably victims of the human hunting (Brugal and Raposo 1999).

1.3 Lithic assemblage

The site delivered a rich lithic assemblage composed by more or less 10,000 artifacts (a complete techno-typological study is still on-going). The lithic industry is characterized by the use of discoid (Boeda,1993), S.S.D.A. (*Système par Surface de Débitage Alterné*) (Forestier 1993) and Levallois (Boeda 1993; 1994) knapping methods. There is a high incidence of Levallois by-products, consisting mainly of flakes but also some points and a few blades or blade-like flakes (Raposo 1991; 1993; 1995; Raposo *et al.* 1985; Raposo and Silva 1987) (Fig.5).

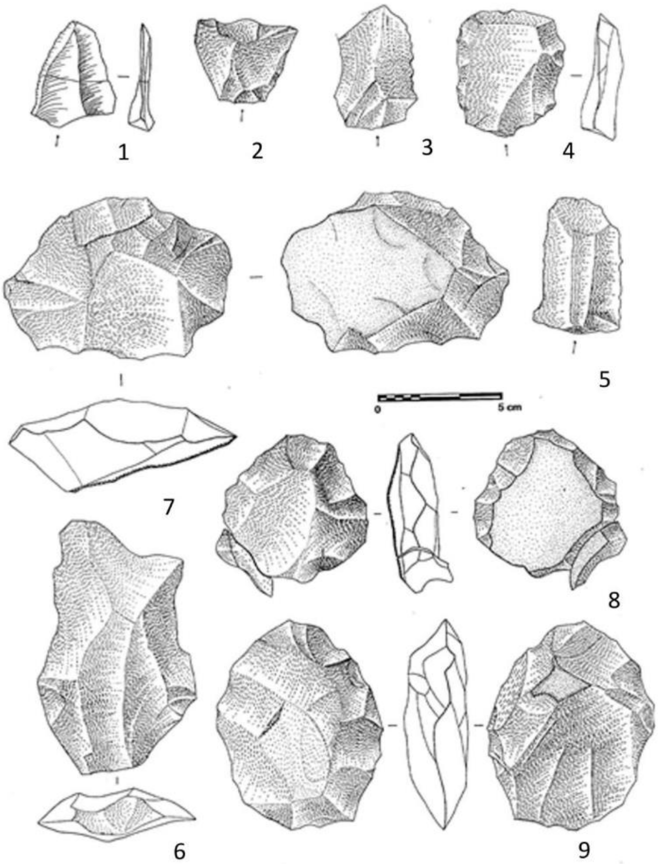


***Figure 5. Sample of Fenx lithic artifacts: Levallois point; 2 to 6: Levallois flakes; 7: Levallois core for preferential flake; 8: Levallois core for preferential point (note the refitting of a flake in the platform of the point); 9: Levallois recurrent unipolar core (picture from Raposo 1991, elaboration Berruti*).**

Complete reduction sequences are documented, probably due to the availability of the raw materials in the vicinity of the site. Raw materials are available in the river bed or in the escarpments near the site. Two thirds of the lithics were made of quartzite. This raw material together with vein quartz represents more than the 90% of the raw materials of the whole assemblage. Some small flint pebbles, were also used: they have probably been eroded by the Tagus in the upper part of his course, from deposits located in the Spanish territory. This type of raw material does not seem to have been intentionally looked for in the locally available gravels of the Tagus. More evident is the differential procurement of vein quartz and quartzite. Whereas vein quartz comes from local fluvial gravels, quartzite was collected in the vicinity of the site within colluvial deposits derived from a major quartzite ridge which crosses the Tagus and dominates the valley.

In comparison, retouched tools represent a smaller portion of the whole lithic assemblage, but in this small group dominate notches and denticulates, while sidescrapers are rare. From the technological point of view, it is clear the "Middle Palaeolithic / mode 3" belonging of this lithic industry, as for the majority of the Portugese lithic assemblages dated to the same period (Brugal and Raposo 1999; Raposo 1991; 1993; 1995; Raposo *et al.* 1985; Raposo and Silva 1987). From the typological point of view the lithic industry of Fenx is "indisputably »Middle Palaeolithic«…, this industry,..., cannot be referred to a specific Mousterian facies due to the underrepresentation of retouched tools" (Brugal and Raposo 1999). Similar lithic industries are present in other Mousterian site of the Middle Tagus area: Vila Ruivas (Raposo and Silva 1987; Raposo 2007), Santa Cita (Cura and Grimaldi 2009; Grimaldi et al. 1998; 1999a; 1999b; Martins et al. 2010), Estrada du Prado (Raposo *et al.* 2007) and Ribeira da Atalaia (Grimaldi and Rosina 2001, Oosterbeek et al. 2004).

2. MATERIALS AND METHODS

The use wear study of the Fenix lithic assemblage was conducted using the integration of two different methods: Low Power Approach (Odell, 1981) and High Power Approach (Keeley, 1980); this integrate approach is usually used in all the modern use-wear studies (e.g. Asryan *et al.* 2014; Lemorini *et al.* 2014a, b). For the use-wear study of lithic industries made in quartzite it is necessary the use of some precautions reported in the paragraph 2.3.

To perform this study a three step methodology has been followed. First, a microscopicpreliminary observation allowed to assess the suitability for the use-wear study of the lithic remains from Fenx and to select the best preserved edges for the investigation.

In second instance a reference collection with flakes made of the same raw materials used by the Neanderthals of Fenx was realized. Several specific activities were then carried out on different materials with the experimental lithic tools to link the use-wear features to tool motions and to the processed materials. A useear study was done on a selected group of lithic artifacts.

The abovementioned steps are here therefore considered.

2.1 Initial examination of the archaeological materials

This study began with the preliminary evaluation of the entire lithic assemblage belonging to the central excavation area (see the Fig.6), with the primary aim of identifying the suitable artifacts for the use-wear study (736 artifacts, in this group there aren't cores, debris and flakes smaller than 2 cm).

This preliminary phase was conducted in the Archaeological Museum of Lisbon, where the Fenx remains are stored. Five criteria were applied to select the artifacts for the use-wear analysis: completeness, presence of at least one functional edge (artifacts without potential functional edges were excluded from the analysis), morphology suitable for prehension, surface preservation (absence of marked post depositional alterations), and presence of removals and/or roundings localized on the edges of the artifacts which are probably referable to an ancient use. This preliminary phase was divided in two parts. The first examination was carried out by naked eye observation, followed by a second inspection with a stereomicroscope in reflected light equipped with a Microscope Camera. In this way it is possible to identify modifications due to artefact's use, rather than post-depositional processes. The main features that differentiate traces of use from post-depositional alterations are the combinations of the trace attributes: the contact with the worked material produces specific combinations of attributes, which rarely are replicated by post depositional agents (e.g.: Asryan *et al.* 2014; Keeley 1980; Lemorini *et al.* 2014; Vaughan 1985). As testify by the experimental reference collections, the traces of use are always distributed in a localized portion of the artefact, usually in close proximity to the edge. The post-depositional marks are randomly spread over the lithic surface (Shea and Klenck 1993). There are three types of post-depositional surface alterations detectable by naked eye: edge crumbling, generalized rounding of the surface and widespread glossy/bright appearance of the quartzite cement matrix. The edge crumbling is caused by pressure on the flake edges: the causes of this pressure are trampling or sedimentary load. The results of this post-depositional alteration are the micro-fracturing of the most fragile portions of the artifacts edges (Flenniken and Haggarty 1979; McBrearty *et al.* 1998). The generalized rounding appearances are caused by sedimentary abrasion, which could have been the result of hydraulic transport prior to deposition, or sediment settling and pedogenic processes following deposition (Levi Sala 1988; Plisson and Mauger 1988). The widespread glossy can have the same causes of the generalized rounding or can be due to a post-depositional chemical alteration (Stapert 1976; Plisson and Mauger 1988). Although at the naked eye all the Fenx collection appears well preserved, some edge removals are visible on some of the artifacts. Through a stereomicroscope in reflected light and a Microscope Camera is possible to detect on the surfaces of some artifacts a light widespread glossy. All the artifacts with marked post depositional alterations or that did not satisfy at least one of the other four criteria were discarded from the sample. After this preliminary screening phase, the Fenx sample dataset is reduced to 110 quartzite artifacts, of which 34 are discoid flakes, 61 are Levallois flakes and 27 were S.S.D.A (the 15% of the initial sample). After this selection, no formal tools fulfilled these criteria. This is probably due to their underrepresentation in the lithic assemblage. The 30% of the selected artifacts present a small amount of post-depositional edge removals (Fig.7).

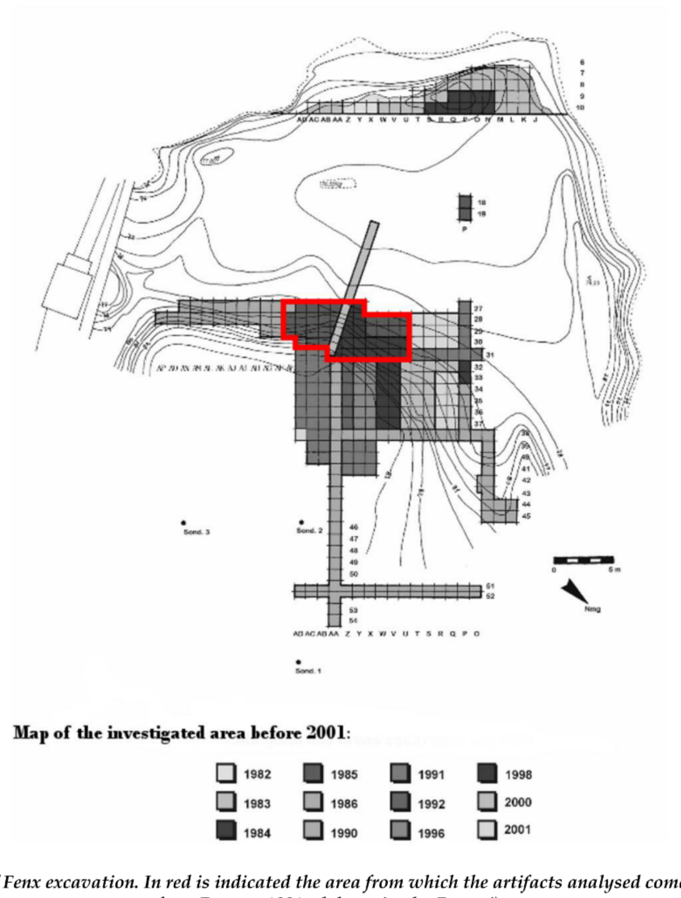
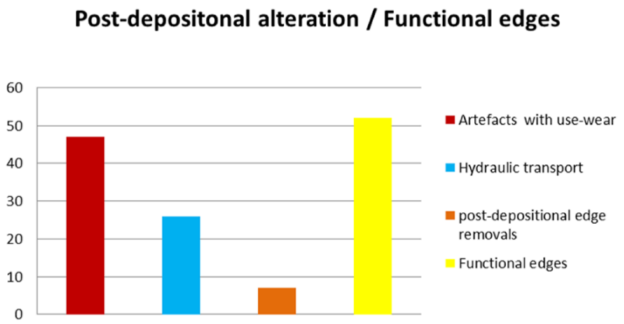


Figure 6. Plant of Fenx excavation. In red is indicated the area from which the artifacts analysed come from (picture from Raposo 1991, elaboration by Berruti)



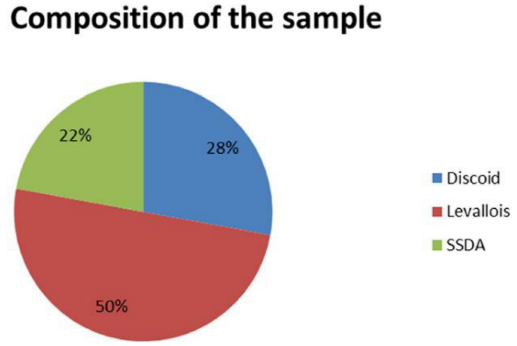


Figure 7. Graphics: type and percentages of the post-depositional alterations identified on the sample; technological composition of the sample (Berruti).

2.2 Reference quartzite flakes collection and blind test

The reference collections of quartzite flakes used to process different materials during controlled experiments were necessary to interpret the use-wear on the Mousterian artifacts. These collections come from two different sources. The first reference collection is the experiments carried out with quartzite flakes in the C.I.A.A.R. (Centro de Interpretação de Arqueologia do Alto Ribatejo, Vila Nova da Barquinha) laboratory. This reference collection has been made with the same quarzite found at Fenx. A total of 41 quartzite flakes was used in the experiments (the experiments were generally conducted for a minimum of 20 min) to link specific types of edge modification to the processing of specific types of materials and to specific processing tasks (Table 1). The second reference collection is the experimental reference collection of quartzite implements of the Instituto Terra e Memoria of Mação (I.T.M.): this collection was realized for others use-wear studies on the quartzite lithic industries conducted by the Institute. The collection has more than one hundred quartzite flakes used on different materials (e.g: butchering activities, fresh hide, bone, fresh and dry wood). For each flake of the I.T.M. experimental collection the following data are registered on a label: material worked, time of working, direction of the action done and name of the operator. The use of this collection gave us the possibility to conduct a blind test to verify our capability of use-wear analysis for the interpretation of the function of quartzite artifacts, since it was possible to analyse the artifacts avoiding the reading of the description of the processing made. The flakes of the CIAAR reference collection were washed first with water and soap. After this procedure the artifacts were placed for 48 hours in a mixture of alcohol (50%) and distilled water (50%). At the end the artifacts were washed with distilled water (75%) and alcohol (25%) in an ultrasonic cleaner for 5 minutes. The flakes of the ITM reference collection were only washed with distilled water (75%) and alcohol (25%) in an ultrasonic cleaner for 5 minutes.

Table 1: Material worked with the experimental quartzite tools.

Materials worked with the experimental quartzite tools		
Material being processed	**CUTTING**	**SCRAPING**
BUTCHERING OF A WILD BOAR CARCASS	3	/
BUTCHERING OF RABBIT CARCASS	3	/
FRESH BONE OF RABBIT	3	3
FRESH BONE OF WIL BOAR	3	3
DRY ANTLER	1	1
DRY BONE OF GOAT	3	3
DRY WOOD	3	/
FRESH WOOD	3	/
FRESH SKIN OF WILD BOAR	1	3
DRY SKIN OF WILD BOAR	1	3
TOTAL	**25**	**16**

2.3 Microscopic analysis of Fenx artifacts

The selected artifacts were transported to the laboratory where they have been gently washed with warm water and soap, and then washed for 3 minutes in a mixture of demineralized water (75%) and alcohol (25%) in an ultrasonic tank and open air dried.

The microscopic analysis of the Fenx artefact was carried out with the combined use of stereomicroscope in reflected light and metallographic microscope. With the stereomicroscope in reflected light were observed the macro-traces and with the metallographic microscope the micro-traces. At the present day, the most of the use-wear studies are carried out with scanning electron microscopy (S.E.M.). S.E.M. has the advantage of a wider depth of field and is also useful for the analysis of highly reflective raw materials such as a quartz and quartzite (e.g.: Knutsson 1988; Knutsson and Lindé 1990; Ollé and Vergès 2014). However, scanning electron microscopes present three disadvantages: they are not as readily available as optical light microscopes, not transportable to the field, and very expensive in terms of time and resources. For this study, we used a metallographic microscope to carry out the analysis of the lithic (archaeological and experimental) artifacts (Clemente and Gibaja 2009; Gibaja and Carvalho 2005; Gibaja *et al.* 2002; Gibaja *et al* 2009). To reduce the intensity of the fastidious glare, typical of the quartz-rich raw materials, two methods are available (Igreja 2009): equip the microscope with a Differential Interference Contrast Microscopy (also known as Nomarski contrast) or use high-resolution epoxy casts of the edges of the artifacts (Plisson 1983; Banks and Kay 2003). We use the second methodology with a little modification since the observations were made only on the moulds (negative replicas) rather than making casts (positive replicas) of each mould surface. This protocol, already used by C. Lemorini (Lemorini *et al*. 2014a) has as advantages the lowering of the laboratory expenses by eliminating the need for casting material, the reduction of the loss of fine details that can occur when using casts and a better placement of the edges under the microscope The use of mould, in addition of being cheap allows also the easy transport of the samples to be analyse (Plisson 1983).

The analysis of the macro-traces, provide information about the potential activities carried out (e.g., cutting, scraping, piercing, etc.) together with a first hypothetical interpretation of the hardness of the worked materials. The hardness categories used to describe the worked materials are: soft (e.g. animal soft tissue, herbaceous plants and some tubers), medium (e.g. fresh wood and hide) and hard (e.g. bone, horn, antler, dry wood and stone). Some materials display intermediate hardness or resistance such as soft/medium materials (e.g. fresh hide, wet softwood) or medium/hard materials (e.g. softwood, wet antler) (e.g. Lemorini 2006; Lemorini *et al*. 2014a; Odell 1981; Rots 2010; Semenov 1964; Tringham *et al.* 1974). The analysis of the micro-traces is the study of micro-edge rounding, polishes, abrasions, and striations. This study was conducted to provide a more detailed understanding of the activities carried out with the lithic artifacts, and to define the diagnosis of the processed materials (e.g. Beyries 1987; Christensen 1996; Moss 1983; Keeley 1980; Lemorini *et al.* 2014a, b; Lemorini 2006; 2000; Plisson 1985; Rots 2010; Vaughan 1985; Ziggiotti 2011.).

2.4 Microscopes used for the analysis

The analysis of the lithic artifacts was carried out using three different types of microscope: a stereoscopic microscope Seben Incognita III with magnification from 10x to 80x, a metallographic microscope Optika B 600 MET supplied with 5 objectives PLAN IOS MET with 5-10-20-50-100 objectives and 10x oculars equipped with a Optika camera B5. and a Microscope Camera Dinolight Am413T.) .

3. RESULTS

Results obtained from the analysis of the reference tools were similar to the ones obtained in previous studies. In the quartzite tools use traces are very localised, appearing on the face of a single quartz crystal, on small clusters of crystals, and on small patches of silica matrix. This response of the quartzite tools seems to be in contrast with the response of the tools in microcrystalline and glassy raw materials such as flint, jasper and obsidian. The functional edges of this kind of tools have use-wear distributed extensively and more uniformly (Lemorini *et al.* 2014a; Gibaja *et al.* 2002). The analysis of the experimental reference collections allowed to compare the results obtained by similar studies that have developed a set of micro-wear attributes for interpreting the use-wear traces on quartzite tools (Clemente and Gibaja 2009; Gibaja *et al.* 2002; Gibaja *et al* 2009; Igreja 2009; Lemorni *et al.* 2014a, Pereira 1993). Regarding the macro traces, the experimentation conducted show that the edges of the quartzite tools are rounded and broken very quickly, especially when used on very hard materials. This is due to the quartzite structure (quartz grains in a cement matrix) which leads, during the activities, to a rapid detachment of the quartz grains from the matrix. This phenomenon depends also on the quartzite type: with quartzite compacted with fine quartz grains it is less present than in the quartzite less compacted and with coarse quartz grains. Moreover, the scars present on the quartz crystals usually have a hinged or abrupt end morphology (due to the degree on hardness of the material worked). They are normally arranged in accordance with the direction of use: if they occupy the proximal areas and are arranged perpendicularly or obliquely to the edge, it allows to identify a transversal action, while if they are located on the sides of the crystal and parallel to the edge, it allows to identify a longitudinal action (Clemente and Gibaja 2009). The micro-traces were identified on the quartz crystals and on the silica matrix surrounding them. The formation of microwear polishes in the matrix of quartzite is comparable to those of flint tools (Clemente and Gibaja 2009). The different extent of use-wear traces on the quartz crystals, the texture and the topography of the polish, the presence of striae together with their depth and shape allow the diagnosing of the hardness of the worked materials and, in some cases, they could be used to gain a more specific diagnosis of the processed material. For example, the work of materials such as wood or bone, results in a domed polishing on the crystals and in the loss of all technological indicators; tools used on abrasive materials, such as dry hide, show a "corrosion" of the crystals (widespread rounding) (Clemente and Gibaja 2009; Gibaja et al. 2002; Gibaja et al 2009; Igreja 2009; Lemorni et al. 2014a). The use-wears related with soft animal tissues are barely recognizable, as it is also noticed by other analysts concerning this kind of activity (Igreja 2009;; Gibaja, 2005), and it is characterized by a presence of a widespread lightly rounding on the quartz crystals and a rough polish on the matrix (Igreja 2009, Lemorini et al. 2014). The tools used for butchering activities are characterized by a presence of traces characteristics of both bone and soft animal tissue (Tab. 2) (Clemente and Gibaja 2009; Gibaja et al. 2002; Gibaja et al 2009; Igreja 2009; Lemorni et al. 2014a).

Table 2: Microwear attributes used to diagnose the material being worked with quartzite tools.

Microwear attributes used to diagnose the material being worked with quartzite tools		
Material being processed	**Wear on the crystals**	**Cement matrix**
SOFT ANIMAL TISSUE	Widespread lightly rounding.	Rough polish
BONE	Domed topography and possible striae on the upper parts.	Patches of flat polish
WOOD	Lightly domed topography, possible striae and edge rounding.	Rough polish on domed and irregular micro hole.
SKIN	Widespread rounding.	Possible striae
BUTCHERING	Domed topography, widespread rounding and possible striae.	Rough polish, striae and patches of flat polish

3.1 Blind test results

The results of the blind test confirmed the utility of the use-wear analysis for the interpretation of the function of quartzite artifacts. The blind test was carried-out with the integrated methodology illustrated above. The test was conducted on 20 quartzite tools, taken randomly from the I.T.M. experimental collection (without reading the labels). Eleven of these artifacts were used for wood working, three were used for butchering activities, and the last six were used for bone working. The correct attribution of use-wear has been achieved for sixteen flakes (success rate of the 70%). The hardness of the worked material was correctly recognized in the 90% of the cases. The motion (e.g., cutting, scraping) was also correctly inferred on the 84% of cases. In the majority of cases, tools showed signs of use: only in one case, a butchering tool was free of mark/trace on its surfaces. The actual material that was worked was correctly identified in fourteen cases (success rate of 70%). The discrimination between wood working and bone working is difficult, with a specific success rate of 64%. These results are very similar with the ones obtained in the blind test conducted by Cristina Lemorini for the study of the Oldowan quartzite assemblage from Kanjera South (Lemorini *et al.* 2014a).

3.2 Quartzite artefacts use-wear

Forty-seven of the 110 quartzite artifacts (42%) selected for the analysis showed use-wear traces (Figs. 8, 9). During the study of the selected lithic assemblage, six instruments with two different edges used were identified. In total, have been found 46 different used flakes with 52 functional edges. Thirteen of them show no post depositional alterations and thirty-four show minimal alterations. Twenty-seven have a diffuse matrix sheen that did not obscure the use-wear and a little quantity of post-depositional edge removals. These alterations are probably due to a soft hydraulic transport prior to deposition (Flenniken and Haggarty 1979; McBrearty *et al.* 1998; Plisson and Mauger, 1988; Stapert 1976). Seven other artifacts present only a little quantity of post-depositional edge removals. The morphological features of the traces that allow the interpretation of the kinetic actions and of the properties of the worked material are readily observable thanks to the excellent preservation of the surfaces of the artifacts.

Cutting motion was recognized on 33 functional edges, linked to the processing of soft animal tissue (n = 4), wood (n = 7), bone (n = 1), indeterminate soft material (n =1), indeterminate medium/hard material (n = 2), butchering (n = 16) and indeterminate hard material (n = 3). Scraping activities (eighteen of 52 edges) are related to wood-working (n = 5), bone (n = 4), hide (n=3), indeterminate medium/hard material (n = 4) and indeterminate hard material (n = 2). All of the six instruments with two edges used show use-wear traces of the same materials on the two edges. Five of them present cutting motion linked to the working of soft animal tissue while one shows scraping activities related to the working of an indeterminate medium/hard material (Table 3).

Table 3: Table with the use-wear traces found on the Fenx artifacts.

Code	Typology	Technology	Raw Material	Material Hardness Zu1	Action Zu1	Material Type Zu1	Mateal Hardness Zu2	Action Zu2	Material Type Zu2
AD 33-11	flake	Levall.	Quartzite	Hard	Transversal	Bone			
AA 34-92	flake	Levall.	Quartzite	Hard	Longitudinal	?			
AD 31-17	flake	Discoid	Quartzite	Hard	Longitudinal	Wood			
AD 33-18	flake	Levall.	Quartzite	Hard	Longitudinal	Bone			
AD 33-22	flake	S.S.D.A.	Quartzite	M. Soft	Transversal	Hide			
O 31-25	flake	Levall.	Quartzite	Hard	Longitudinal	Wood			
AD 33-48	flake	S.S.D.A.	Quartzite	Soft	Longitudinal	Soft. animal tissue			
AD 33 -5	flake	Discoid	Quartzite	Hard	Transversal	Bone			
AD 33-70	flake	Levall.	Quartzite	M. Soft	Longitudinal	Butch.	M. Soft	Longitudinal	Butch.
AA 41 -30	flake	Discoid	Quartzite	Hard	Transversal	Bone			
O 51	flake	S.S.D.A.	Quartzite	M. Soft	Longitudinal	Butch.	M. Soft	Longitudinal	Butch.
85 – 739	flake	Levall.	Quartzite	M. Soft	Longitudinal	Butch.			
S 33-121	flake	Levall.	Quartzite	M. Soft	Longitudinal	Butch.	M. Soft	Longitudinal	Butch.

Z 31-21	flake	Levall.	Quartzite	M. Soft	Longitudinal	Butch.			
Z 31-30	flake	Discoid	Quartzite	M. Hard	Transversal	Bone			
Z 31-11	flake	Levall.	Quartzite	M. Hard	Longitudinal	?			
Z 31-10	flake	S.S.D.A.	Quartzite	Soft	Longitudinal	?			
Z 31-25	flake	Discoid	Quartzite	M. Hard	Longitudinal	Butch.	M. Soft	Longitudinal	Butch.
AB 30-42	flake	Discoid	Quartzite	M. Hard	Longitudinal	Wood			
AD 28-29	flake	Levall.	Quartzite	M. Soft	Transversal	Hide			
AA 31-17	flake	Discoid	Quartzite	M. Hard	Transversal	?			
AB 29-2	flake	S.S.D.A.	Quartzite	M. Soft	Longitudinal	Butch.	M. Soft	Longitudinal	Butch.
AB 29-4	flake	Levall.	Quartzite	M. Soft	Longitudinal	Butch.			
AA 31-31	flake	Discoid	Quartzite	M. Hard	Transversal	Wood			
AA 29-02	flake	Discoid	Quartzite	M. Hard	Transversal	?	M. Hard	Transversal	?
AC 28-13	flake	S.S.D.A.	Quartzite	M. Hard	Transversal	Wood			
AC 30-29	flake	Levall.	Quartzite	M. Soft	Longitudinal	Butch.			
AA 31-39	flake	Levall.	Quartzite	M. Soft	Longitudinal	Butch.			
AA 30-48	flake	Levall.	Quartzite	Hard	Longitudinal	Wood			
AA 28-46	flake	S.S.D.A.	Quartzite	M. Hard	Longitudinal	Wood			
V 29-10	flake	Discoid	Quartzite	Hard	Transversal	Wood			
AE 29-36	flake	Levall.	Quartzite	Hard	Longitudinal	Wood			
V 29-31	flake	Levall.	Quartzite	M. Hard	Transversal	Wood			
AA 28-44	flake	Levall.	Quartzite	M. Hard	Transversal	?			
AC 27-3	flake	S.S.D.A.	Quartzite	M. Hard	Longitudinal	?			
AB 30-28	flake	S.S.D.A.	Quartzite	Soft	Longitudinal	Soft animal tissue			
AB 30-58	flake	Levall.	Quartzite	Hard	Transversal	?			
AA 31-62	flake	Discoid	Quartzite	Soft	Longitudinal	Soft animal tissue			
AB 30-33	flake	Discoid	Quartzite	M. Hard	Transversal	Wood			
V 29-95	flake	Discoid	Quartzite	Soft	Longitudinal	Soft animal tissue			
AF 27 -1	flake	Levall.	Quartzite	M. Soft	Longitudinal	Butch.			
AA 31-54	flake	Discoid	Quartzite	Hard	Longitudinal	Wood			
AE 29-68	flake	Levall.	Quartzite	Soft	Transversal	Hide			
AB 31-09	flake	S.S.D.A.	Quartzite	Hard	Transversal	?			
AA 28-29	flake	S.S.D.A.	Quartzite	Hard	Longitudinal	?			
AD 23-03	flake	S.S.D.A.	Quartzite	Hard	Longitudinal	?			

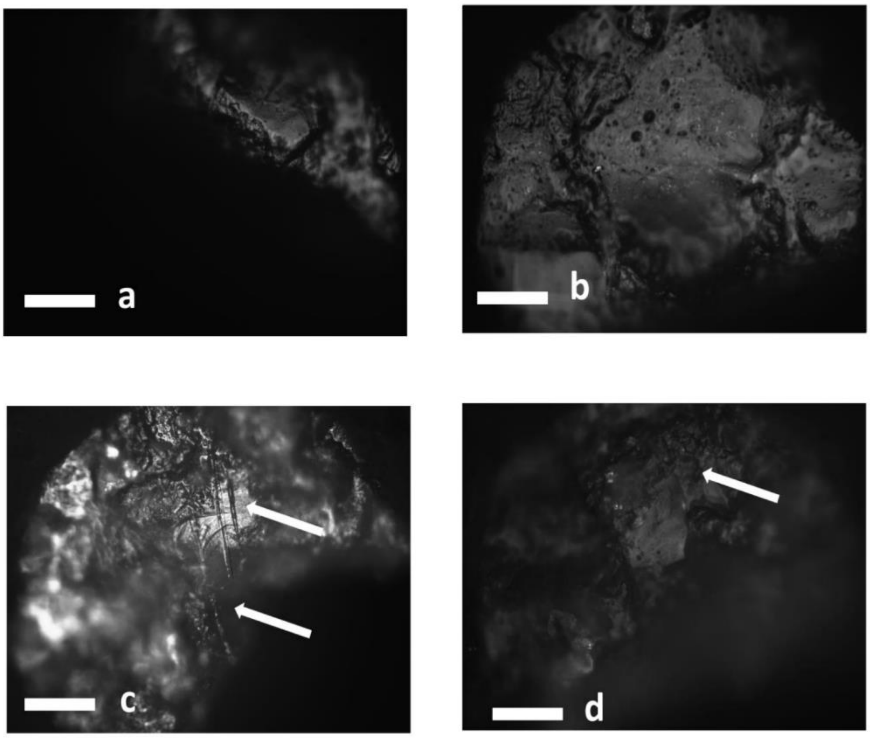


Figure 8. Micro use wear traces on Fenx lithic artifacts. a) Use-wear from meat-working on the flake FENX AB 29-4, showing rough polish on the matrix and lightly roundings on the crystals surfaces ; b) Use-wear from wood-working on FENX AA 29-46 flake, showing a domed topography of the crystal surface, irregular micro hole and edge rounding; c) Use-wear from butchering on FENX Z 31-31 flake, showing domed topography and striae on the crystal surface and rough polish on the matrix ; d)Use-wear from bone-working on FENX Z 31-30 flake, showing domed topography and flat polish; (Scale bars equal to 0,01 mm) (by Berruti).

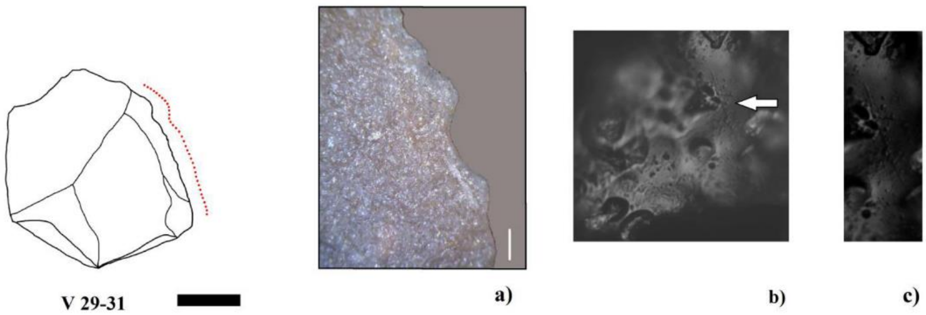


Figure 9. Use war analisys of the Fenx flake V29-31. Drawing of V29-31 (Scale bar 2cm); a) presence of removals and roundings localized on the edges of the artefact referable to a transversal action on hard material (scale bar 1 mm); b) Micro use-wear traces from wood-working, on the crystal surface showing domed topography, edge rounding and striae (magnification 200x); c) striae detail (magnification 500x) (by Berruti).

4. DISCUSSION

Through the use-wear study of the lithic assemblage of Fenx is possible to describe part of the activities that were carried out in the site. The assemblage is dominated by instruments that have traces of activities linked to butchery. Fifteen instruments out of 46 with use-wears that present traces of butchery activities or cutting on soft animal tissue; four instruments that present scraping traces on bone. The scraping of bone is probably linked to the periosteum removal, necessary during the process of marrow-extraction (Grayson 1984). This activity is documented in the bones assemblage of Fenx (Brugal and Raposo 1999).

Despite the low efficiency of quartzite cutting-edges for wood scraping, it was experimentally observed in the collective research project "Des Traces et de Hommes" (Thiébaut *et al.* 2009a; 2009b); in the Fenx lithic assemblage there are five instruments that present this kind of traces. There are also seven tools with traces of cutting on wood. This choice is due to the abundance of quartzite near the site and to the shortage of better raw material in the area: vein quartz presents the same problem (Berruti and Arzarello 2012) and flint is not abundant. This data agrees with the other Middle Palaeolithic site of the area, that usually are characterized by the use of flint, quartzite, and quartz in varying frequencies depending on distance from the raw material sources. For this reason, Zilhão (2000a; 2000b; 2001) and Raposo (2000) hypothesized that Middle Palaeolithic people were highly mobile and utilized predominately locally available raw material (although of bad quality), especially quartzite. The use of quartzite instruments for woodworking is also documented in all the other use-wear studies conducted on sites of the same area (Fonte da Moita, Ribeira Ponte da Pedra), but unfortunately these are Lower Paleolithic sites (Cristiani *et al.* 2006; Lemorini *et al.* 2001). Three artifacts have hide scraping traces. The other twelve artifacts display indeterminate material traces. Different types of post-depositional alterations are present on the surfaces of the lithic instruments (; McPherron *et al.* 2014; Shea and Klenk 1992). This data confirms the interpretation about the formation of the site made by Brugal and Raposo. The Fenx site is part of the Mousterian open air sites of the middle Tagus terrace, like the nearest site of Vila Ruivas (Raposo and Silva 1987; Raposo 1995; 2007), Santa Cita (Cura and Grimaldi 2009; Grimaldi *et al.* 1998; 1999a; 1999b; Martins *et al.* 2010), Estrada du Prado (Raposo *et al.* 2007) and Ribeira da Atalaia (Grimaldi and Rosina 2001, Oosterbeek *et al.* 2004) (Fig.10).

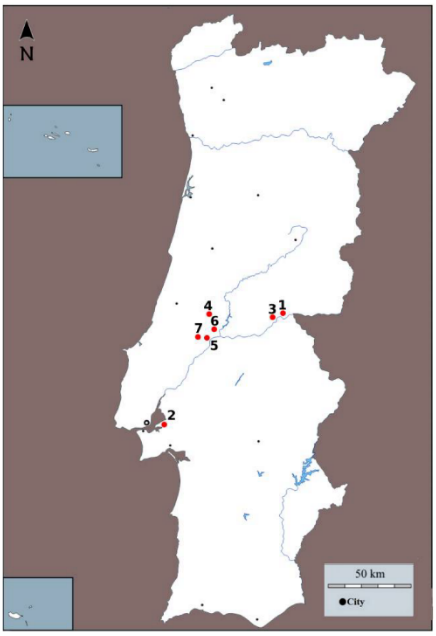


Figure 11. The position of the Middle paleolithic sites indicated in the text. 1- Foz do Enxarrique; 2-Conceição, 3--Vila Ruivas; 4- Estrada du Prado; 5-Ribeira da Atalaia; 6-Santa Cita; 7- Gruta da Oliveira

All these Mousterian sites associated to the Tagus fluvial terraces are older than Fenx, which represents the last evidence of the Neanderthal occupation of this area. We do not consider the site of Conceição, because its dating of 27 ky represents only a terminus post quem for the human occupation, without dating it precisely and because it belongs to a different geographic region, directly associated with the Tagus river estuary (Raposo and Cardoso, 1998). On the other hand, both these sites (Conceição and Foz do Enxiarrique), seem to show that there was a similar occupation of the fluvial settings where large areas with dense artifacts suggest long stays by large groups (Haws *et al.* 2010).

Due to its large lithic assemblage and to the presence of faunal remains and of precise dating, Fenx is the most important open air site of the Final Middle Palaeolithic, not only of the middle Tagus area but probably of the whole Iberian Peninsula fluvial environments (Raposo, 2007). It documents as a matter of fact the persistence of the behaviour of the last Iberian Neanderthal that still maintain the same preferential open air settlements on the wetland, as it occur widely with Neanderthals which occupied also fluvial deposits such as stream terraces or channels (e.g., Swanscombe, Maasrticht-Belvédère, Biache-St.-Vaast) or colluvium (e.g., Molodova). This behaviour is documented among the whole Europe from England (Hosfield 2005) to Greece (in the terra rosa, or "red beds") and Germany (es: Wallertheim) (van Andel and Runnels 2005; Haws *et al.* 2010; van Andel 1998). For C. Stiner (Stiner 2013) two models have been noted in Middle Palaeolithic site formation or functionality: ephemeral occupations with high mobility and relatively intensive occupations with high material inputs.

The results of the use-wear analysis of the considered sample of the lithic assemblage of Fenx allowed to identify part of the activities performed in the site. This data, according with the results obtained by other studies, permit to hypothesize the function of this site. The lithic sample is dominated by instruments with traces linked to butchering activities and the presence of woodwork activities and of hide working are attested. With similar results, the Mousterian site of Mauran was considered to be a hunting camp (ephemeral occupations). In this site the woodwork was interpreted like shaft or spear manufacture and the dry hide processing was interpreted like a random work carried out to answer to a particular need (ligature scraping?) (Thiébaut *et al.* 2012). In our opinion the set of activities identified in Fenx is associated with acquisition and processing of animal carcasses but they are very differentiated in worked material and actions. The occurrence of transversal hide working, suggests the presence of tanning activity (Anderson-Gerfaud 1990; Beyries 1987; Lemorini 2000; Martìnez-Molina 2005) instead of a ligature scraping; the abundance of woodworking activities suggest the presence of a wide range of activities, not only shaft or spear manufacture. This data suggests a long term occupation. On the other hand, if the hearths were social spaces and the centre of the activities (Foley and Gamble 2009; Gaudzinski and Turner 1996; Rosell *et al.* 2012; Vallverdú *et al.* 2012; Vaquero and Pastó 2001), their absence in Fenx and the scarce presence of burned bones suggests that Fenx is an ephemeral occupations site. For this reason, in our interpretation Fenx site is a series of medium term occupations made by large groups. It is possible to define this occupation as a temporary base camp. The paleoenvironmental reconstruction, according to the composition of the faunal assemblage, describes a period of relatively wet and temperate conditions, typical of the Portuguese Late Pleistocene which was characterized by a stable climate (Brugal and Raposo 1999; Cardoso 1993; Roche 1971; 1972). The paleoenvironment was relatively open with grassland, well developed marshes along the river and some forested areas on the hills or in the surrounding valleys. In this period the Tagus was subject to seasonal flooding (Cunha *et al* 2008; 2012; Martins *et al*. 2010).

5. CONCLUSION

The use wear analysis results, the paleoenvironment studies and the position of the site contribute to its interpretation as a temporary settlement on the seasonal flooding levels of the river. This interpretation explains the different taphonomic processes recognized on both assemblages (bones and lithics). At Fenx, the presence of various and good documented activities identified by the use wear-study together with the results of the faunal assemblage analysis (Brugal and Raposo 1999), and with the paleoenvironmental reconstruction and the site topograhpic position suggest the idea that we are in face of a base camp.

According to the data obtained from the use-wear analysis and from the other studies carried out, we can conclude that the site of Foz do Enxarrique is probably a hunting camp or more likely a medium term occupations base camp, related to seasonal river floods.

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CHAPTER XI

DISCUSSION

1. Introduction

At the beginning of this trip through eight prehistoric sites we posed ourselves two questions: is the employment of the discoid rather than of the Levallois method due to cultural reasons? Is there a functional difference between the products obtained from a discoid *débitage* and those obtained from a Levallois *débitage*?

Now, after the functional analysis of more than 677 different lithic tools among which 140 are Levallois or discoid products with wear traces (Tab.1), we can try to answer these questions, starting from the last one and then coming to the first and more complex issue.

Table 1.11:P.N.= Pirro Nord; G.S.N.= Guado San Nicola; C.C.= Ciota Ciara; C.G.= Can Garriga; P.D.= Petra Dreta; R.T.= Riparo Tagliente; L.B.= Lagoa du Bando; FENX = Foz do Enxarrique; W.T.= wear traces.

Site	**Sample analyzed**	**Tot. D+*L* with W.T.**	**Discoid with W.T.**	***Levallois* with W.T.**
P.N.	63	-	-	-
G.S.N.	226	55	19	36
C.C.	76	12	3	9
C.G.	32	4	2	2
P.D.	68	7	5	2
R.T.	60	9	1	8
L.B.	42	20	10	10
F.ENX	110	33	14	19
Tot.	**677**	**140**	**54**	**86**

The considered sample, although large for the use-wear analysis, it is limited on an absolute scale; then, the results of the study may induce to a misrepresentation of the general real situation. Other problems are linked to the eventual under-representation of some kind of traces (e.g. those linked to the work of soft materials, that can be easily overlapped by other successive uses on harder materials or by post-depositional alterations) or to the misinterpretation of the traces (it is relatively easy to confuse wear traces linked to the work of materials whit similar hardness). These are the limits of the discipline and it is always necessary to take them into account (Ziggioti 2005; Berruti and Daffara 2014; Ibanez and Gonzales 1996; Marquez et al. 2016). The site of Pirro Nord, that was added to the group of the sites to be studied in order to investigate the use of centripetal *débitage* products and their possible relationships with the use of discoid products, is excluded from this general discussion inasmuch during the analysis of the lithic industry only five tools with wear traces have been found.

1.1 Background

To answer the two questions that have been posed in the first chapter of this work it is necessary to review the concepts and the chronology of the two *débitage* methods: discoid and *Levallois*. Both the methods lead to the production of flakes with predetermined and specific characteristics, that allow, during technological studies to assign them at the appropriate reduction sequence (Boëda 1993; Boëda et al. 1998; Boëda 1994; Peresani 2003). Discoid technology is considered to be a more simple method, common since the Lower Paleolithic (Carbonell and Vaquero 2003; Peresani 2003; Picin and Vaquero 2016) and reduction sequences that can be assimilated to the discoid one are present in the lithic industry of Kada Gona (2.6 My) (Semaw 2000; Stout et al. 2010). The discoid *débitage* shares with the Levallois four of the six fundamental criteria described by Boëda (1993): the main differences include the un-hierarchal relation of the two convex surfaces of the core and the direction of the *débitage* (that is secant to the plane of intersection of the two surfaces). These characteristics allow a less rigid configuration of the core volume and a more flexibility in the flaking reduction (e.g. Carbonell and Vaquero 2003; Slimak 2003; Mourre 2003). The adoption of the Levallois method is considered the mark that indicates the beginning of Middle Paleolithic in Eurasia (Adler et al. 2014; Fontana et al. 2013; Picin et al. 2013). The earliest reports of Levallois artifacts are dated to the end of the XIX century (De Mortillet 1883) but an exhaustive description of its technological features was accomplished only a century later with the identification of six discriminating criteria (Böeda 1993; Boëda 1994). The oldest (and well-dated) European sites where Levallois method is present are: Guado San Nicola - 379 Ka (Italy; Peretto et al. 2015), Botany Pit - 324 Ka (UK; Ashton and Scott 2016) and Nor Geghi - 308 Ma (Armenia; Adler et al. 2014). The Levallois reduction sequence is characterized by the hierarchical division of the core volume and by the preparation of the flaking surface, which makes possible to predetermine the shape of the final products. The Levallois method comprehends different modalities of reduction sequence discriminated through the preferential or the recurrent production of flakes (Böeda 1993; Boëda 1994).

The emergence of the Levallois method can be interpreted from two different points of view: as a consequence of the diffusion of new human species with innovative technology and consequently as a single emergence of a new method (Foley et al. 1997) or as a technological multiregional evolution from a common technological substratum (i.e. evolution from the "shaping-façonnage" for the production of bifaces) (Rolland 1995; M. White and Ashton 2003; Adler et al. 2014). The adoption of the Levallois method is linked to the evidence of modifications in behavioral strategies, recorded around 400,000 years ago in organized hunting strategies (for instance at Schöningen, Thieme 1997), but from the point of view of the use wear analysis the adoption of the Levallois method does not bring any change in the categories of processed materials, that remain substantially the same (Lemorini, Bourguignon, and Zupancich 2016;

Lemorini et al. 2006; Rots and Hardy 2015; Toro-Moyano et al. 2013; Lemorini et al. 2014; Sahnouni et al. 2013). Observing fig. 1, it appears evident that the Levallois and the discoid methods coexist for a long time (more or less 400 ky) despite climate changes and geographic location and that these two methods were adopted by different species of the genus Homo. In Europe and in the Near East, for example, were individuated at least 3 different species of the genus Homo that used both these methods (*Homo heidelbergensis*, *Homo neanderthalensis* and *Homo sapiens*) (e.g. Manzi 2016; Hublin and Pääbo 2006; Ferreira Bicho 2005; Papagianni and Morse 2015; Benazzi et al. 2015; White, Gowlett, and Grove 2014).

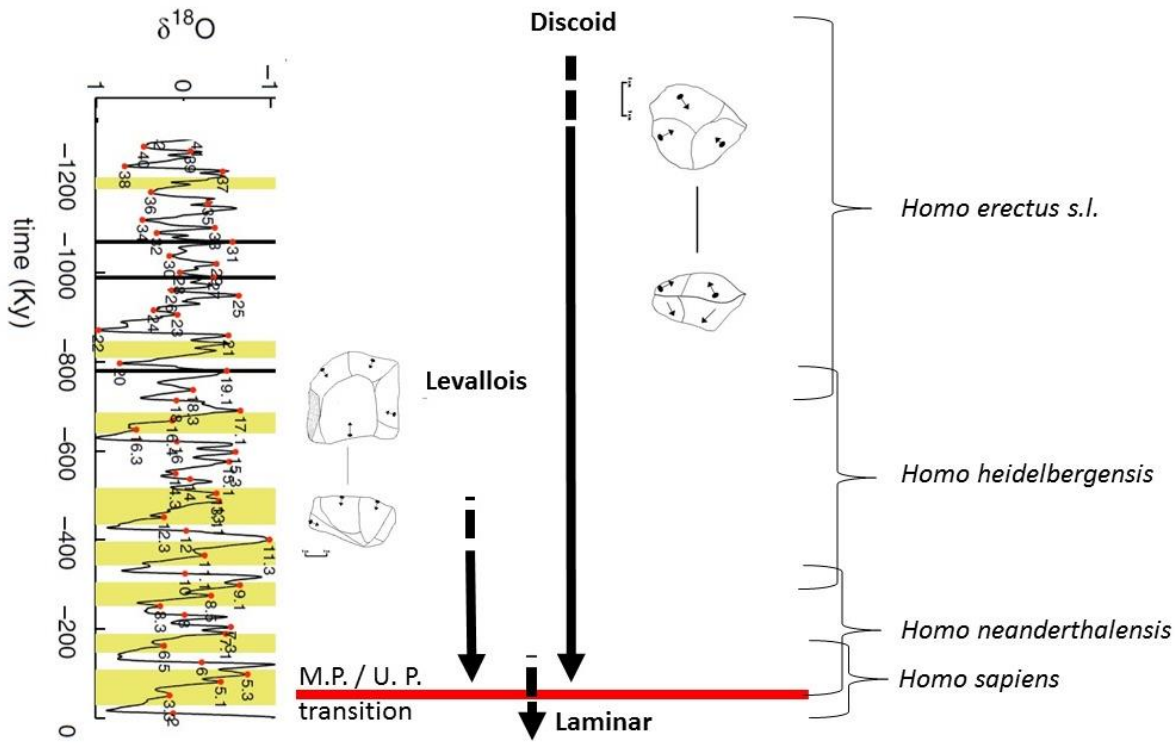

Figure 1.11: General diagram showing the appearance of the discoid and Levallois methods in relation with the MIS sequence and of the different species of the genus Homo *(O^{18} sequence modified from* Huybers 2007).

2. Is there a functional difference between the products obtained from a discoid *débitage* and those obtained from a Levallois *débitage*?

In the light of the data collected during this study seems to be easy to answer this question: **no, there aren't functional differences between Levallois and discoid products**. In all the sites analyzed, it is evident that there is not functional difference, not only between the discoid and the *Levallois* products but also between these predetermined products and the products obtained from opportunistic knapping sequences (See: Tab. 8, 9, 10 Chap. 4; Tab. 4 Chap. 5; Tab. 1 Chap. 6; Tab. 1 Chap. 7; Tab. 5 Chap. 8; Tab. 3 Chap. 9 and Tab. 3 Chap. 10). The only site that shows a slight functional differentiation among the products obtained from different knapping methods is Guado San Nicola, S.U. B, where, apparently, there is a difference in the type of actions carried out with the Levallois products in comparison with the products of the other *débitage* methods (See Tab.2). Even in this case the alleged differentiation is probably accidental and it is linked to the composition of the sample. This observation is also supported by the absence of an analogous differentiation in the other stratigraphic units of the same site (C and B*C).

Table 2.11: Guado San Nicola: actions carried out, grouped by stratigraphic unit and method of flakes production.

Method	**Action**	**S.U. B**	**S.U. B*C**	**S.U. C**	**Tot.**
Levallois	Longitudinal	16	4	3	23
	Transversal	4	3	4	11
Discoid	Transversal	5	1	3	9
	Longitudinal	6	3	1	10
Opp.	Transversal	6	7	6	19
	Longitudinal	11	4	2	17

A general opportunistic behavior in the use of flakes is also attested by the identification of wear traces even on flakes that usually, in the reconstruction of the *chaîne opératoires*, are considered as waste products (see Chap. 4 and 8). It refers at the use of the bifaces "shaping" flakes in the lithic industry of Guado San Nicola and at the use, in layer 36 of Riparo Tagliente, of flakes that technologically are attributed to phases of shaping and management of the cores (one is a flake of management of a Levallois core and the other is a reshaping flake). This data, despite it may seem surprising, correspond to what has been noted in several functional studies on Middle Paleolithic lithic assemblages (e.g. Texier et al. 1998; Hardy et al. 2004; Lemorini 2000; Claud 2012; Zupancich et al. 2016; Lemorini et al. 2016; Lazuén and González-Urquijo 2014; Lemorini et al. 2003).

Furthermore, tools or flakes classified as part of the same "tools group" or as products of the same *débitage* method were, normally, used to perform different tasks. Concerning scrapers, for example, despite their definition that suggests their functional homogeneity, different functional studies show that these tools were used for several different tasks (Texier et al. 1998; Hardy et al. 2004; Lemorini 2000; Claud 2012); a recent study on the Quina and demi-Quina scrapers from the Yabrudian levels at Qesem Cave (Israel) (MIS 11), highlights that these tools were used in a great variety of activities, from woodworking to butchering activities and for different actions (Zupancich et al. 2016; Lemorini et al. 2016). In the same way, it is interesting the study about the use of re-sharpening flakes in three different lithic assemblages coming from two Spanish Middle Paleolithic sites (late MIS 5 and early MIS 4) (Axlor R and Morín Cave, levels 16 and 18): the use wear analysis shows that this tiny flakes were used on hide (mainly fresh), non woody and woody plants and in carcasses butchering (Lazuén and González-Urquijo 2014). This study, like our study, can be linked with the work conducted on the biface manufacture flakes of two French sites with a Mousterian of Acheulean Tradition lithic industry (Jonzac and Saint-Amand both referable at the MIS 3), which highlighted that these flakes were used primarily, but not only, for butchery; this is probably due to the sites function, since both are interpreted as animal carcass exploitation and treatment sites (Claud 2015). Even more interesting, as comparison for this work, are two studies conducted one on the discoid lithic products of Fumane cave, level A8 and A9. (Italy, MIS 3) (Lemorini et al. 2003) and the other on the particular lithic industry of the second occupation phase of Le Pucheuil (France, MIS 6) (Lazuén and Delagnes 2014). In the case of Le Pucheuil the flakes produced through a reduction sequence called Le Pucheuil-type were analyzed, i.e. a unidirectional opportunistic exploitation of Levallois cores (Fig. 2). Also in these case the functional analysis confirms that products coming from the same kind of reduction sequence and with similar morphometric features, were used to work a wide range of materials, like hide, wood and non-woody materials and for butchering activities (Lazuén and Delagnes 2014).

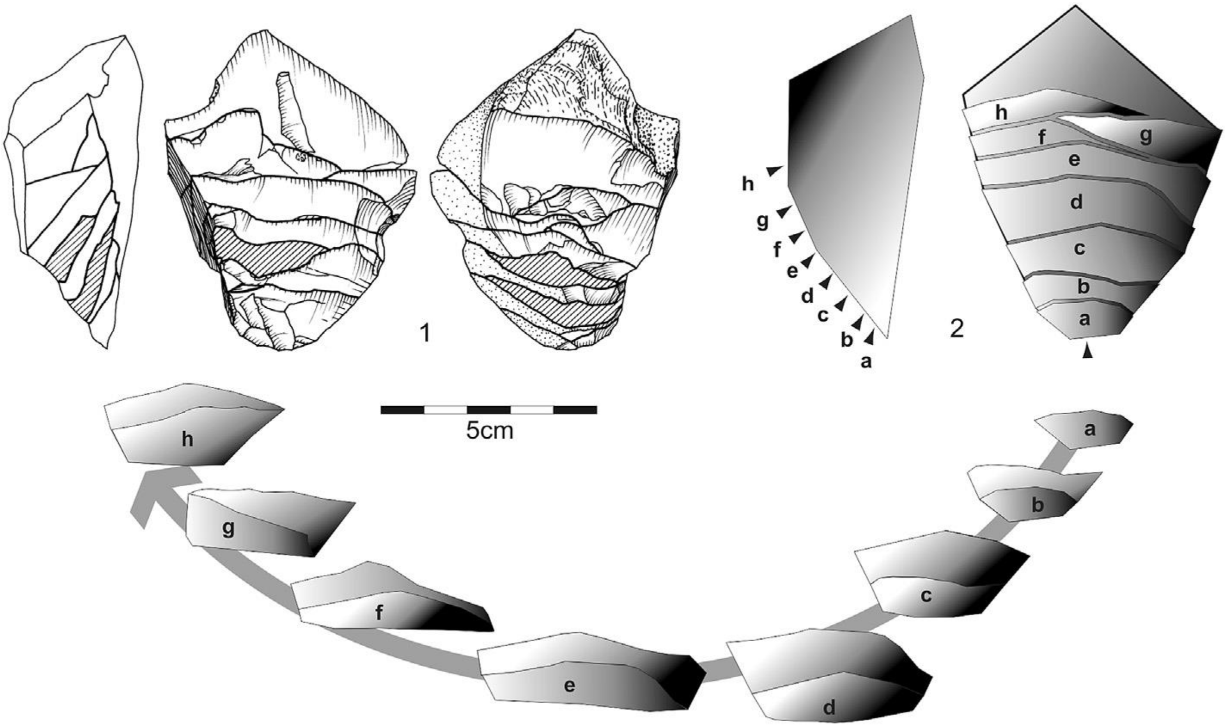

Figure 2.11: Technological principle of the Pucheuil type débitage; 1. Refit of a series of 8 Pucheuil type flakes and resulting core, belonging to a larger refitted set (refit 6: 75 refitted products) that evidences the exploitation of 9 by-products into Le Pucheuil type cores, from a cobble initially used for the Levallois unidirectional convergent débitage; 2. Schematic reconstitution of a Pucheuil type reduction sequence (Lazuén and Delagnes 2014).

At Fumane cave, the integrated study, techno-morphological and functional, conducted on the discoid lithic industry showed that these products were used for several tasks and demonstrated they were not specialized implements but, on the contrary, polyvalent blanks employable «ad hoc» for occasional activities (Lemorini et al. 2003). The data exposed above highlight how, in general, in the considered time span from MIS 11 of Guado San Nicola and Qesem Cave, to the MIS 3/2 of Jonzac, Fumane and FENX, it is difficult to see any clear relationship between tool typology or blanks production system, and the tasks they are involved in.

3. Is the employment of the discoid flaking method rather than of the Levallois due to cultural reasons?

To define if the employment of the discoid flaking method rather than of the Levallois is due to cultural reasons, first it is necessary to define e what the word "culture" means for us. Here, will be used the anthropological classical definition of culture developed by Edward B. Tylor in his work "Primitive Culture" (1871): "Culture, or civilization, taken in its broad, ethnographic sense, is that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society". From this point of view, it is possible to define the technological choices as cultural choices, because the technological knowledges of an individual are part of his culture. This definition is more inclusive than the classical definition usually employed for the Paleolithic cultures, that is based on the presence or absence of certain tools or reduction sequences (Broglio 2007; Arzarello et al. 2011). The definition of culture adopted in this work, allows to understand how people with the same material culture, that use the same "objects", according to their common technological background, can be part of two different cultures and how people, with apparent different material cultures, that use different “objects” according to different and contingent technical choices, can be part of the same culture. Moreover, as it is evident from the scheme in fig.1, this definition of culture allows to understand how two populations, one of *Homo heidelbergensis* and one of *Homo neanderthalensis*, can have the same technological background (the knowledge of the Levallois and discoid methods) but belong to two different cultures (hypothetically they could be separate by 200 ky and thousands of kilometers). After the definition of the term culture, we analyze which technological/cultural choices may have affected the adoption of one of the two methods.

The first hypothesis which will be analyzed, is the one proposed in the first question, namely, if the choice between the two methods was linked or not to the worked material. Through the discoid and the *Levallois* methods it is possible to produce blanks with particular morpho-technical features that allow, during technological studies to assign them at the appropriate reduction sequence (Boëda 1993; Boëda et al. 1998; Boëda 1994; Peresani 2003). Concerning the discoid method, all the obtainable products are characterized by an high average thickness and by a good aptitude for being handled, which would make them suitable for the processing of resistant materials (Lemorini et al. 2003; Böeda 1993; Arzarello et al. 2011), while the *Levallois* products are characterized by long and thin cutting edges, which make them suitable to perform cutting actions (Eren and Lycett 2012; Lycett and Eren 2013; Eren and Lycett 2016; Kuhn 1994; Kuhn 1992). Despite these clear technological features, that would suggest a kind of specialization of the different blanks (Lemorini et al. 2003), the data obtained during the study of the sites taken in consideration do not highlighted any kind of relation between the type of blanks and their use. For example, in the Ciota Ciara cave (Chap. 5) the discoid and the Levallois products were used on a huge variety of materials without any distinction and the same variety is observable for SSDA products (Chap 5, table: 4, 5, 6, 7).

This data does not change if the focus of the analysis is placed on the different raw materials employed (the sample of the retouched objects seems to follow the same trend, but it is too small to give reliable indications). Furthermore, these data correspond to what was observed on the discoid products of the Fumane cave, by C. Lemorini (Lemorini et al. 2003), and in all the sites that are analyzed in this work. This empirical observation, also admitting that it could be vitiated by some errors due to traces conservation or to a misinterpretation of a certain amount of traces, seems to be too generalized to be completely far from reality.
If the employment of the discoid flaking method rather than of the Levallois is not due to functional reasons, it can be linked to other cultural choices. Many scholars, concerning the changeover between the Levallois method and the bifacial discoid method for the Mousterian cultures, proposed that the quality of the raw material might influenced the Neanderthals' adoption of a particular technology (Picin and Vaquero 2016). Practically, according to this interpretation, the nodules with good flaking properties were used to produce Levallois flakes and scrapers whereas the mediocre ones were mainly utilized for more flexible reductions sequences (e.g., discoid) and to produce denticulates (e.g. Geneste 1988; Wengler 1990; Delagnes and Rendu 2011). Although these studies can be valid for some contexts, in some sites of our sample (e.g. Ciota Ciara, Pedra Dreta and Can Garriga) both the method were used on different raw materials, from flint to porphyry in the case of Pedra Dreta and Can Garriga (Mora, Carbonell, and Martínez 1987; Canal and Carbonell 1989; Canal et al. 1978; Garcia 2015; Arzarello et al. 2012; Daffara et al. 2014). This datum is also supported by many other studies conducted on different sites where the Levallois and the discoid methods were employed indifferently on different raw materials (e.g. Moncel et al. 2008; Byrne 2004; Aubry et al. 2015; Brenet et al. 2013; de Lombera-Hermida et al. 2011). The same situation is detectable if the focus of the analysis is direct on the retouched tools. As is clear

in the cases of the Ciota Ciara cave, of Petra Dreta and of Can Garriga, the different type of retouched tools (notches, scrapers and denticulates) were made with all the raw material available (Mora, Carbonell, and Martínez 1987; Canal and Carbonell 1989; Canal et al. 1978; Garcia 2015; Arzarello et al. 2012; Daffara et al. 2014), and similar results were observed in many other contexts (e.g. Moncel et al. 2008; Byrne 2004; Aubry et al. 2015). Other studies highlight the differences of productivity between the two methods (e.g. Lycett and Eren 2013; Baumler 1998; Eren, Greenspan, and Sampson 2008; Shimelmitz et al. 2014) but some other affirm that the productivity of the Levallois recurrent centripetal method and the bifacial discoid method is strongly influenced by the knapper's goals and experience (Picin and Vaquero 2016). Furthermore, the documented use of the "waste products" of different *chaîne opératoires* (Claud 2012; Claud 2015), detected also in Guado San Nicola (Chap. 4) (use of bifaces shaping flakes) and Riparo Tagliente (Chap. 8) (use of flakes that technologically are attributed to phases of shaping and management of the cores), makes difficult to define what is "waste" and what is "product" and consequently the productivity of the different methods.

If the choice between these two *débitage* methods or the choice of which raw material use to perform a particular reduction sequence or also of which types of tools use to perform a particular action, were made due to a cultural/technological motivation we should have found traces of this common operating principles at least within a single site. But it is not like this. For example, as it is explained in the previous section, there is not a clear relationship between the types of tools and the function both in the sites studied in this work and in many sites studied by other scholars (e.g. Texier et al. 1998; Hardy et al. 2004; Lemorini 2000; Claud 2012; Zupancich et al. 2016; Lemorini et al. 2016; Lazuén and González-Urquijo 2014; Lemorini et al. 2003).

Of consequence, assuming that the choices were made by rational operators, we must assume that there is a lack of some necessary elements in order to reconstruct the reasoning which led to those choices. To understand the choices of the prehistoric people, it is necessary to broaden the limits of the concept of *chaîne opératoires* beyond those imposed by the classical lithic technology. The definition of *chaîne opératoires* by Geneste (Geneste 1989) is: “therefore the means to chronologically organize the process of the transformation of raw material obtained from the natural environment and introduced into the technological cycle of production activities”. To understand the choices that brought to the diversified use of the blanks it is necessary to include inside the concept of *chaîne opératoires* (Bar-Yosef and Van Peer 2009) other variables, and not only the raw materials availability and the "technical knowledge of the different *débitage* methods". It is necessary to take in consideration also the personal ability of the operator, the environment (interpreted as the whole of the environmental components) and, more important, the aim of the blank production. The aim of the blank production has to be intended not as the shape of the blanks produced but as the purpose of their production, or rather the particular necessity because they were produced, practically the contingent elements that led to the production of a single flake. In the light of this reasoning, it is easy to understand that a small change in one of these variables (e.g. raw materials availability, environmental change, different personal capacities, different aim of the production, different technological background, different culture or different contingency) can lead to an enormous change in the archeological record. This fact can give us, modern scholars, the sensation to be facing a mosaic of random choices. Actually, these mosaics do not have the characteristics of a random system but rather they can be assimilated to a chaotic system (Lorenz 1969; Lorenz 1963). Many examples of chaotic behaviours are present in climatology, fluid mechanics (turbulence), laser theory and ecology (especially in the study of the population dynamics) (e.g. Leakey and Lewin 1995). Which means that we are facing a dynamic system highly dependent on the initial conditions and with a non-linear evolution where a little change in the initial conditions determines finite and important changes both in the final results and in the evolution of the system over time. Systems like this are governed by deterministic laws and are describable through mathematical formulas (e.g. Lorenz 1969; Lorenz 1963). In our context, it means that the motivations that bring to the production and to the use of a single flake are linked to many different variables (e.g. raw materials availability, environmental contest, personal capacities, different needs and culture) and that a minimal change of one these variables (also considering other variables as constant) determines important changes in all the system evolution. If it is accepted that the considered sites can be assimilated to a chaotic systems, one can draw the following conclusions: it is reductive or even deceptive to compare different Middle Paleolithic sites on the base of single studies, (technological, functional, archeozoological or others) without trying to define all the variables that led to the formation of the archaeological record; it is clear that it is impossible, at the present state of the research, to understand all the variables that contributed to the adoption of a determinate choice adopted by the Middle Paleolithic population. Moreover, since it was a choice took according to many variables, it is now impossible to understand the role of the sole variable "culture" in this choice. The only feasible way to understand the influence of the culture in the choices that determined the origin of the single flake is to try to reduce the influence of all the other variables. This can be achieved by analyzing sites with a secure stratigraphy where is possible to identify the presence of "living floors" corresponding to a single occupation episode. On the other hand, as it has been demonstrated in many cases where “living floors”, or more appropriately, “archaeological horizons” have been described, their presence is not sufficient to negate the presence of different moments of occupation of the same "living floors". In fact, one must always keep in mind that the so-called "living floors" are the result of the accumulation of different episodes (cf. for instance Bordes 1975), documenting an unknown number of human presences, thus giving rise to the definition of "archaeological horizons". This phenomenon is well documented in the site of Fenx, where the lithic and faunal remains are concentrated in a thin layer more or less 5 cm thick, which has been defined as a single "archaeological horizon" (Brugal and Raposo 1999; Raposo, Silva, and Salvador 1985; Raposo and Silva 1987), but that corresponds to a series of medium term occupations by large human groups (see Chap 10) (Berruti, Rosina, and Raposo 2016). In some sites with a more detailed occupation sequence, it is possible to identify the single occupation and in rare cases it is possible to define a single moment, and therefore to reduce at the minimum also the influence of the different contingencies. It is explanatory the case of Abric Romaní, where, through the analysis of the exploitation of the single "raw material units" (RMUs) (e.g. Frahm et al. 2016) and of the refitting of the different elements of the same *chaîne opératoires* (Martínez et al. 2005; Martínez and Rando 2001; Vaquero et al. 2015), it was possible to define different single moments of flakes production. Interestingly, one of the few work of functional analysis applied on lithic industries referable to the Middle Paleolithic that has identified a certain degree of link between a particular kind of tools and the worked material (denticulates and wood working activity) is the study conducted by Martínez and Rando on 6 different refitting sequences made with 31 different products (of them 11 retouched elements) of level Ja of Abric Romaní (Martínez and Rando 2001). Anyhow, sites with the same characteristics of Abric Romaní are rare and few of them are investigated with comparable methodologies. This datum results more meaningful if compared with the results of the work made on the same site by the same researcher

(Martínez et al. 2005), that concerns 422 findings (retouched and unretouched) from different layers and that excludes the finds that refits together. In this work, although it was found a little link between denticulates and t hide working (but also with butchering activities), the conclusion of the use wear analysis is: "all objects, retouched or not, were used in the same way for the same actions" (Martínez et al. 2005). These two studies demonstrate how the creation of a lithic assemblage is strongly linked to different variables and that one of the most important is related to the particular circumstances for which the lithic tools were produced, and that in particular cases, when all the other variables are more or less constant, it is possible to really observe the results of the cultural choices.

CHAPTER XI

CONCLUSIONS

The present work brought to the achievement of three different groups of results. The first group consists in different methodological results. Indeed, during the analysis of the considered lithic assemblages it was sometimes necessary to use, or develop, a specific methodology. In particular, three different methodologies were employed to analyze highly reflective raw materials (such as quartz-rich raw materials): high-resolution epoxy moulds of the artefacts' edges in the cases of Lagoa du Bando and Fenx, a metallographic microscope equipped with a Differential Interference Contrast Capability (also known as Nomarski filter) in the cases of Petra Dreta and Can Garriga and, finally, a metallographic microscope equipped with polarizing filters in the case of the Ciota Ciara cave (Igreja 2009; Stemp, Lerner, and Kristant 2013; Lemorini et al. 2014; Clemente-conte, Boeda, and Farias-gluchy 2016; Plisson 1983; Knutsson and Lindé 1990; Knutsson et al. 2015). A comparison among these three methodologies, each of which gave good results, is difficult: the Nomarski filter is the system that provides the clearest pictures; the microscope equipped with polarizing filters is more economic in terms of equipment acquisition while the use of moulds, although difficult and expensive, permitted an easy transport of the samples without bureaucratic problems. It can be concluded that each of these methods is suitable for the study of wear traces on highly reflective raw materials, but each one presents advantages and disadvantages (velocity, cost, transportability of the sample and availability) that should be evaluated case by case. Furthermore, for the study of the lithic artefacts of Petra Dreta and Can Garriga was developed a methodology that permits the identification of micro polishes on the stone tools made in porphyry (Chaps: 6 and 7). Finally, the study of the Pirro Nord lithic assemblage and in particular the development of the overlapping method for the taphonomic study of the lithic artefacts (Chap: 3), shows how useful and important is taphonomy for the reconstruction of the formation processes of an archaeological deposit.

The second group of results is linked to the peculiarities of each site. In general, for each context, it was possible to identify some of the activities carried out during the phases of human occupation. These data, together with the data obtained by other studies, allowed to reconstruct the different human behaviors performed in each site, thus recreating the general framework of the ancient occupations.

The results of the study of the lithic assemblage of Pirro Nord 13 (see Chap. 3), especially thanks to the overlapping method for the taphonomic study of the lithic artefacts, provides a schematic reconstruction of the process of formation of the archaeological deposit of PN13. It was indeed possible to identified four different phases of formation of post-depositional alterations and their study allowed the reconstruction of the different phenomena that affected the archaeological deposit. This analysis shows how useful and important is the study of taphonomy of stone tools for the reconstruction of the formation processes of an archaeological site. It would be important to continue studies about the formation processes of PDAs on the stone tools focusing the attention only on them and not only (or primarily) on the problem of distinguishing PDAs from use-wear traces.

The analysis of the Guado San Nicola lithic industry shows that it can be defined as a site characterized by an accumulation of lithic artifacts and bones due to butchering or killing activities. The use-wear traces found on the lithic industry of GSN (see Chap. 4) are indubitably referable to animal carcasses processing and the presence of a few traces linked to woodworking activities can be related to the maintenance or manufacturing of wood objects, like spears. Their presence in the sample is in line with the results of other use-wear studies carried out for sites with similar chronology and similar functional attribution (Revadim and Schöningen; Rots and Hardy 2015; Solodenko et al. 2015). Besides, through the analysis of the whole assemblage, has been ascertained the use of bifaces shaping flakes. These empirical evidences of an undifferentiated use of the shaping flakes, in a so ancient context, shows that there was not any conceptual difference between the *débitage* products and the shaping "wastes". This data seems to support the hypothesis that Levallois technology is an inherent property of the Acheulian, that evolves out of the existing, but previously separate, technological systems of *façonnage* and *débitage* (White and Ashton 2003; Hopkinson, Nowell, and White 2013) and appears to show that Acheulian bifacial technology and Levallois technology are homologous, reflecting an ancestor-descendant relationship (Rolland 1995; White and Ashton 2003; Adler et al. 2014; Lycett 2007).

The Ciota Ciara cave use wear analysis results (see Chap. 5), together with the archeozoological, paleontological and the technological study (Buccheri et al. 2016; Daffara et al. 2014; Berto et al. 2016), contributes to the interpretation of the S.U. 14 of the Ciota Ciara Cave as a base camp with repeated medium-term occupations. In this S.U., the presence of various and good documented activities identified through the use wear-study (there is a presence long lasting activities such as hide working with tanning agents), together with the results of the archeozoological analysis (Buccheri et al. 2016; Arnaud et al. 2013; Buccheri 2014) confirm a long (medium)-term occupation of the cave (Stiner 2013). These occupations were characterized by a strong exploitation of animal resources, with long lasting processes, as hide treatment, combined with a marginal exploitation of vegetal resources.

Although scarce, the results of the use wear analysis of Can Garriga lithic assemblage can be used to hypothesize the function of the site (see Chap. 6).

The presence of different type of activities on different materials, especially bone and hide, and despite the absence of traces of meat processing, that can be also explained through the difficult "registration" of these traces on quartz and quartzite tools (Clemente-Conte and Gibaja Bao, 2009; Gibaja et al., 2002), 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.. This hypothesis is consistent with previous studies which came at the same conclusions observing the shortness of the *chaînes opératoires* (characterized by the production of unretouched flakes), the presence of an organization of the space and the presence of stone anvils used to break the bone to extract the marrow (Carbonell et al., 1992b; Giralt et al., 1995; Rodríguez et al., 2004). The predominance of activities linked to animal carcass processing, suggests, for the site of Pedra Dreta (see Chap. 7), the interpretation of the site as a specialized settlement, linked to hunting activities, probably a hunting or killing camp where the preys were slaughtered in order to transport the meat to base camps (Stiner 2013). The site is the result of one or, more probably, of a series of ephemeral occupations; this hypothesis is consistent with previous technological studies which came at the same conclusions observing the shortness and the incompleteness of the *chaînes opératoires* (Canal and Carbonell 1989; Rodriguez et al. 1995).

During the analysis of these two sites, (Chap 6 and 7) we also tried to define if there is a relation between the quartz morpho-structural groups and the manufacture or the use of the different quartz blanks (Hermida, 2005, 2008; Rodríguez-Rellán, 2016; Venditti et al., 2016). In both the sites, the crossed analysis of the morpho-structural groups of quartz and of the use wear traces, shows how the group SN is dominant, without differentiation based on type and hardness of the worked material or on the action carried out. But these data are consistent with the percentage of presence of instruments made with this morpho-structural group in the whole quartz lithic assemblages (S. Daffara personal communication). This can be due to a conscious choice or by a greater presence of quartz pebbles of this morpho-structural group in the raw material supply area. Considering the composition of the analyze sample it seems that it cannot be hypothesized a better preservation of the wear traces on the blanks of this group. On this point, more focused studies are needed.

Concerning layer 36 of the internal survey pit of the Tagliente rock-shelter (square 635, 634, 614 and 615) (Chap. 8), it was documented the presence of various and well documented activities (strong exploitation of animal resources, with long lasting processes, as hide treatments, combined with a marginal exploitation of vegetal resources), identified by the use wear-study of the lithic assemblage. These data confirms the complex occupation of the shelter (as base camp) (Stiner 2013), as already supposed by technological studies and concerning archaeozoology and paleontology of the faunal remains (Arzarello 2003; Thun Hohenstein and Peretto 2005; Thun Hohenstein 2006; Arzarello and Peretto 2005). Among the lithics with wear traces, there are two cases of used flakes that technologically were attributed at phases of shaping and management of the cores (one is a flake of management of a *Levallois* core and the other one is a reshaping flake). These findings, although isolated, suggests that for the Neanderthals there were probably not practical (and conceptual) differences between the "products" and the management flakes (Boëda et al. 1990; Boëda 1994). The presence of use traces on "waste" flakes (Brantingham and Kuhn 2001; Lycett and Eren 2013; Picin and Vaquero 2016; Claud 2012; Claud 2015), if confirmed in the future by other finds in Mousterian contexts, may force us to rethink the concept of lithic tools within the *débitage* knapping sequences.

Through the use-wear study of the lithic assemblage of Lagoa do Bando (composed of fine grained quartzite implements belonging to opportunistic, discoid and Levallois technology) it is possible to describe part of the activities that were carried out on the site. The use-wear traces identified on the artifacts of the selected assemblage are linked to wood working activities and to the acquisition of meat resources (Chap. 9). The occupations of the site were probably linked to the exploitation of woody local resources, maybe of lacustrine plants (e.g., the Gravettian site of Bilancino (Aranguren and Revedin 2001), and to hunting activities. The presence of wood working traces on the edge of the Lagoa do Bando artifacts can be interpreted also as part of the *"chaîne opératoire*" for the realization of "hunting blinds" like the ones found in the Vila Ruivas site (Zilhão 1992; 2001). The Lagoa do Bando site is part of a group of Mousterian open air sites of the middle Tagus area, like the nearest sites of Foz do Enxarrique (Brugal and Raposo 1999; Berruti, Rosina, and Raposo 2016; Raposo, Silva, and Salvador 1985; Raposo and Silva 1987), Vila Ruivas (Zilhão 1992; 2001), Santa Cita (Pedergnana 2011), Estrada do Prado and Ribeira da Atalaia (Cristiani et al. 2009; Rosina and Cura 2010). But unlike these sites Lagoa do Bando is located in a relatively high mountainous environment, suggesting a more complex strategy of territorial exploitation for the Middle Palaeolithic of this region.

The last site analyzed is precisely one of the Mousterian open air sites of the middle Tagus area, Foz do Enxarrique, that account according to its dating (33,600 ± 500) is one of the last Neanderthal sites (Raposo 1995; Cunha et al. 2012; Cunha et al. 2008). The results of the use-wear analysis of the considered sample of the lithic assemblage of Fenx allowed to identify part of the activities performed in the site. This data, according with the results obtained by other studies, permits to hypothesize the function of this site. The lithic sample is dominated by finds with traces linked to butchering activities and the presence of woodwork activities and of hide working are also attested. The set of activities identified in Fenx is associated with acquisition and processing of animal carcasses but they are very differentiated in worked material and actions.

According to the data obtained from the use-wear analysis and from the other studies carried out (Brugal and Raposo 1999; Raposo, Silva, and Salvador 1985; Raposo and Silva 1987), we can conclude that the site of Fenx is probably a hunting camp or more likely a medium term occupation base camp, related to seasonal river floods.

The third and last group of results achieved during this work is linked to the attempt to find the answers at the two questions that we posed at the beginning this work is the employment of the discoid rather than of the Levallois method due to cultural reasons? Is there a functional difference between the products obtained from a discoid *débitage* and those obtained from a Levallois *débitage*? After the functional analysis of more than 677 different lithic finds from 8 different sites, we can try to answer these questions, starting from the last one and then coming to the first and more complex issue. The data collected during this study reveal that there are not functional differences between Levallois and discoid products. Indeed, in all the sites analyzed, it is evident that there is not any functional difference not only between the discoid and the Levallois products but also between these predetermined products and the products obtained from opportunistic knapping sequences. These data correspond to what was observed on the discoid products of the Fumane cave, by C. Lemorini (Lemorini et al. 2003and agree with several functional studies conducted on many different sites, that testify that it is difficult to see any clear relationship between tool typology or blanks production system, and the tasks they are involved in (e.g. Texier et al. 1998; Hardy et al. 2004; Lemorini 2000; Claud 2012; Zupancich et al. 2016; Lemorini et al. 2016; Lazuén and González-Urquijo 2014; Lemorini et al. 2003).

The answer at the first question that was posed at the beginning of this works, it is linked to an epistemological development of the prehistoric studies, and consists in the use of the chaos system theory for the description of the prehistoric lithic assemblages.

This intuition comes from the observation that, apparently, does not exist any common operating principle that directs not only the choice between the two *débitage* methods or the choice of which raw materials use to perform a particular reduction sequence but also of which types of tools use to perform a particular action. This fact can give us, modern scholars, the sensation to be facing a mosaic of random choices. Of consequence, assuming that the choices were made by rational operators, we must assume that there is a lack of some necessary elements in order to reconstruct the reasoning which led to those choices. Actually, these mosaics do not have the characteristics of a random system but rather they can be assimilated to a chaotic system (Lorenz 1969; Lorenz 1963). Which means that we are facing a dynamic system highly dependent on the initial conditions and with a non-linear evolution where a little change in the initial conditions determines finite and important changes both in the final results and in the evolution of the system over time. Then, the only way to try to understand the influence of the culture in the cultural/technological choices that have determined the origin of the single flake is try to reduce the influence of all the other variables. This is possible only in sites with a detailed stratigraphy, and only in few cases, it is possible to identify the single occupation "living floors" and in rare cases it is possible to define a single moment, and then reduce to the minimum also the influence of the different contingencies. It is explanatory the case of the work conducted by Martínez and Rando on the lithics implements referable to 6 different refitting of level Ja of Abric Romaní (Martínez and Rando 2001), that identified a link between a particular kind of tools and the worked material (denticulates and wood working activity). In that case the analysis of materials coming from "single" and determinate episodes has allowed to reduce many variables of the system and has allowed to identified a clear technical/cultural choice.

The results achieved during this study lead to different and interesting perspectives of research. Concerning methodology, the major perspective of research is linked to the development of the overlapping method of the post-depositional alterations: this methodology, developed specifically for the site of Pirro 13 (Chap. 3), was extremely effective in this contest. The application of this methodology, which will be further refined for other sites with similar problematics (related to the deposit formation), beside proving its effectiveness in other contexts, can help scholars to obtain a better definition of the formation processes of the archaeological sites. Furthermore, the development of a methodology that permits the identification of micro polish on the stone tools made in porphyry (Chap: 6 and 7) is useful for the future studies on lithic instruments made of this particular raw material.

Other interesting research perspectives are linked to the last results achieved during this work: the use of the chaos system theory for the description of the prehistoric lithic assemblages. This intuition, if confirmed, on one side will request us to pay more attention in the comparison of different sites and more caution in the use of definitions as culture or tradition; on the other side opens the door to the mathematical modeling of the behavior of the prehistoric societies and to the elaboration of predictive models.

Furthermore, the idea of reducing the number of variables contingents by subjecting to the functional analysis only lithic samples representing short and defined moments, could lead to a better definition of the various cultural choices that were adopted in the production and in the use of the lithics artefacts.

The last suggestion for future researches, can be found in the works concerning the site of Guado San Nicola and especially in that concerning Tagliente rock-shelter, where use traces were identified on "waste" products belonging to different *chaîne opératoires*. This results highlighted that it is necessary a revisiting of the definition of the concept of product and of waste in lithic technology. Probably, by applying the concept of reduction of the variables for the reconstruction of technological/cultural choices it will be possible, not only to better understand the reasons for the choices made by the ancient knappers, but also to have a clearer idea of which flakes were actually considered waste and which were considered products.

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