



UNDERSTANDING HUNTER-GATHERERS BEHAVIOUR THROUGH THE MACRO-FRACTURES ANALYSIS OF LITHIC BACKED POINTS

Giancarlo Ruta

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UNIVERSITAT ROVIRA I VIRGILI

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OF LITHIC BACKED POINTS

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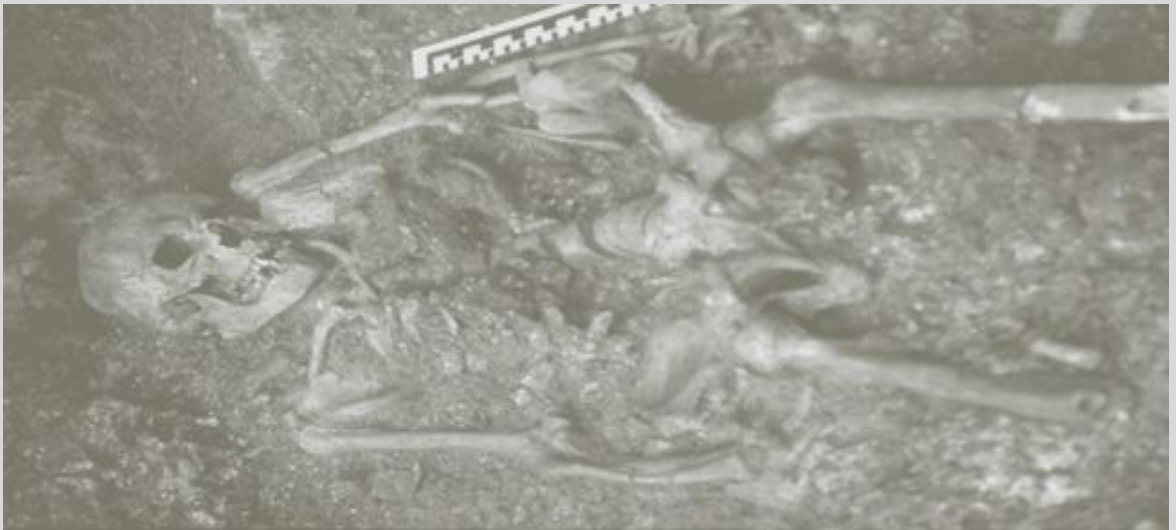
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degli Studi
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Understanding hunter-gatherers behaviour through the macro-fractures analysis of lithic backed points

Giancarlo Ruta



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UNDERSTANDING HUNTER-GATHERERS BEHAVIOUR THROUGH THE MACRO-FRACTURES ANALYSIS
OF LITHIC BACKED POINTS
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Doctoral Thesis

Department d'Història I Història de l'Art of Universitat Rovira I Virgili and
Department of Humanistic Studies of University of Ferrara

GIANCARLO RUTA

Supervised by:

Prof. Marta Arzarello

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abstract

Introduction. The chapter 1, INTRODUCTION, focusses the attention on the state of art of the functional analysis of lithic tools, raising the methodological problems on the identification of use-wear. The examined archaeological sites are here presented and there are underlined the main goals of this research.

Materials and Methods. On the second section, MATERIALS AND METHODS, the characteristics of the lithic sample selected are explained. The core of this chapter is the creation of a reliable analytical protocol in order to describe and interpret macro-fractures on lithic materials. This is split into different phases: terminology's definition; equipment used; evaluation of the previous methodology adopted, mainly based on a Master study; problems raised; analytical protocol for the identification of macro-fractures due to the use of lithic tools as projectile points. Lastly, other possible uses of lithic tools are investigated, by using a detailed experimental approach in order to create a reference collection.

Results. In the chapter 3, RESULTS, the analytical protocol on the lithic materials coming from the archaeological sites is applied. The aim is to individuate the function of backed points used by hunter-gatherers that frequented the caves after the Last Glacial Maximum and during the Lateglacial. The reference collection and the archaeological materials are analysed and compared as to understand the possible function of the tools.

Discussion and conclusion. Chapters 4 and 5, DISCUSSION and CONCLUSION, highlighted the data on a large point of view, especially on the environmental and chronological terms. The behaviour and strategies of hunter-gatherers are here illustrated in order to understand the function of the archaeological sites. Moreover, guidelines and future perspectives are proposed.

On the basis of edited data and those from the present work, backed points have been used by hunter-gatherers in different ways. The identified projectile points give information about the methods and hunting technique adopted. Other possible uses provide an ambitious scenario where the experimental archaeology and the functional analysis are the subject of future scientific research. Lastly, the raw materials exploitation, the zooarchaeology analysis and the hunting strategies allow to assume a strong human mobility and possible connection between different groups depending upon the opportunities and climate and environmental changes.

riassunto

Introduzione. Il capitolo 1, INTRODUCTION, si concentra inizialmente sullo stato dell'arte per quanto riguarda l'analisi funzionale di manufatti litici, sollevando il problema dell'ambiguità dal punto di vista metodologico nell'individuazione di macro-fratture dovute ad usura. Vengono presentati i casi studio, GROTTA DI POZZO E RIPARO VILLABRUNA, e sottolineati gli obiettivi di questa ricerca.

Materiali e Metodi. Nel capitolo 2, MATERIALS AND METHODS, viene presentato in dettaglio il numero e la tipologia di materiale litico selezionato per questa ricerca. Corpo centrale di questo capitolo è la creazione di un protocollo analitico affidabile per la descrizione ed interpretazione di macro-fratture su manufatti litici. Questa sezione è divisa in diverse fasi: definizione di una chiara terminologia; strumentazione microscopica utilizzata; revisione critica della metodologia adottata durante studi precedenti, riferibili alla tesi Magistrale dell'autore; problemi riscontrati; protocollo analitico ideato per l'identificazione di macro-fratture dovute all'uso di strumenti litici come punte di proiettile. Infine, l'ultima parte è dedicata alla valutazione di altri possibili usi di strumenti litici con l'adozione di una dettagliata attività di archeologia sperimentale, mirata alla produzione di una collezione di confronto.

Risultati. Il capitolo 3, RESULTS, è dedicato all'applicazione dell'ideato protocollo analitico sui materiali archeologici dei casi studio, così da individuare le tracce d'uso, e quindi la funzione, delle punte a dorso litiche utilizzate dai cacciatori-raccoglitori che frequentavano le grotte dopo l'Ultimo Massimo Glaciale e durante il Tardiglaciale. Le collezioni di confronto vengono dettagliatamente analizzate insieme ai materiali archeologici ed infine confrontati per interpretare i possibili usi di questi strumenti.

Discussione e conclusione. Nei capitoli 4 e 5, DISCUSSION e CONCLUSION, le informazioni ricavate vengono interpretate in un quadro più ampio dal punto di vista areale e cronologico, così da individuare i comportamenti e le strategie adottate dai cacciatori-raccoglitori e capire le funzionalità dei siti archeologici di riferimento. Infine, vengono sottolineate le linee-guida e le prospettive future di analisi in conseguenza ai risultati e alle deduzioni ottenute.

Basandosi sui dati evinti, frutto del presente lavoro e dalle informazioni ricavate da studi pluridecennali dei siti archeologici di GROTTA DI POZZO e RIPARO VILLABRUNA, si delinea uno uso plurimo delle punte a dorso da parte dei cacciatori-raccoglitori. Le punte di proiettile individuate offrono una panoramica sui possibili metodi e strategie di caccia utilizzate e i possibili altri usi forniscono un ambizioso scenario in cui l'archeologia sperimentale e l'analisi funzionale saranno al centro di future ricerche scientifiche. Infine, la stagionalità dei siti, dedotte da fonti archeozoologiche, il procacciamento delle materie prime e i dati sulle strategie di caccia permettono di supporre una intensa mobilità e possibili contatti da parte dei gruppi umani che sfruttavano al meglio il territorio in base ai cambiamenti climatici ed ambientali e alle opportunità che esso offriva.

List of publications

There are hereby listed the publications, and conferences attended, in preparation, submitted or published regarding the main topic of this research and other articles elaborated during the PhD.

Publications out of this research:

- Mussi, M., Brunelli, S., Cancellieri, E., Catelli, E., D'Angelo, E., De Angelis, G., Di Bianco, L., Fiore, I., Gala, M., Gargani, E., Melis, R., Piarulli, F., **Ruta, G.**, “La sequenza del Tardoglaciale e dell'Olocene antico di Grotta di Pozzo (L'Aquila), nelle montagne dell'Italia Centrale”, Primo Incontro Annuale di Preistoria e Protostoria – IIPP DAFIST, Via Balbi, 2-4 – Genova – 4-5 Febbraio 2016;
- Catelli, E., De Angelis, G., Fiore, I., **Ruta, G.**, Mussi, M., 2016, “La caccia a Grotta di Pozzo: armi e prede”, Atti del IV Convegno di Archeologia “Il Fucino e le aree limitrofe nell'antichità. La rinascita culturale dopo il sisma del 1915”, Avezzano, pp. 65-78;
- Mussi, M., Brunelli, E., Cancellieri, E., Catelli, E., D'Angelo, E., De Angelis, G., Di Bianco, L., Fiore, M., Gala, M., Gargani, E., Melis, R., Piarulli, F., **Ruta, G.**, 2017, “Ricerche archeologiche a Grotta di Pozzo (AQ)”, TourismA (Salone Internazionale dell'Archeologia) 2017;
- **Ruta, G.**, Rots, V., Peresani, M., 2018, “Looking for a standard method: impact fractures analysis of the lithic materials from Riparo Villabruna (Belluno – Italy)”, Incontri annuali di Preistoria e Protostoria 4, pp. 103-104, ISBN: 978 – 88 – 6045 – 066 – 1;
- **Ruta, G.**, Rots, V., Romandini, M., Duches, R., Peresani, M., 2018, Projectile points vs tool for dental treatment? From the impact fractures analysis to a new perspective of research: the case of Riparo Villabruna (Belluno – Italy), AWRANA (Association of Archaeological Wear and Residue Analysts) Conference 29 May – 01 June 2018, Beyond use-wear and traces: tools and people, Université de Nice, in Bulletin du Musée d'Anthropologie Préhistorique de Monaco, Numéro 58, p. 65, 2018, ISSN 0544-7631;
- **Ruta, G.**, Rots, V., Mussi, M., 2018, Finding a standard procedure in impact-fractures analysis: the case of Grotta di Pozzo (L'Aquila – Italy), UISPP (International Union of the Prehistoric and Protohistoric Sciences) Conference 4-9 June 2018, Paris – France;
- **Ruta, G.**, Rots, V., Mussi, M., Learning to recognize macrofractures and projectiles. The case study of Grotta di Pozzo (Central Italy), *submitted at the Journal of Archaeological Science: Reports*;

- **Ruta, G.**, Rots, V., Peresani, M., Projectiles or perforators? The materials of Riparo Villabruna (Belluno – Italy) on focus, *in progress*;

Other publications:

- Mendez-Quintas, E., Panera, J., Altamura, F., Di Bianco, L., Melis, R., Piarulli, F., **Ruta, G.**, Mussi, M., 2019, Gombore II (Melka Kunture, Ethiopia): a new approach to the formation processes and spatial patterns of an Early Pleistocene Acheulean site, *Journal of Archaeological Science* 108 (2019) 104975, <https://doi.org/10.1016/j.jas.2019.104975>;
- Mussi, M., Di Bianco, L., Gallotti, R., Gaudzinski-Windheuser, S., Geraads, D., Melis, R., Panera, J., Piarulli, F., Pioli, L., **Ruta, G.**, Sánchez Dehesa-Galán, S., Méndez-Quintas, E., 2020, After the emergence of the Acheulean at Melka Kunture (Upper Awash, Ethiopia): Gombore IB (1.6 Ma), Gombore Iγ and Gombore Iδ (1.4 Ma), *submitted to the Quaternary International*;
- Mutri, G., **Ruta, G.**, Mussi, M., 2020, Living on the Awash. Everyday life and activities of a Late Stone Age community, in: *Looking beyond the Microscope: Interdisciplinary Approaches to Use-Wear and Residue Analysis*, EAA (European Association of Archaeologists) Annual Meeting 2020.

“Ogni impedimento è giovamento”

cit. Savina Spataro

*Ai miei genitori Pietro e Savina,
i miei fratelli Alessandro e Barbara,
i miei nipoti Pietro e Tecla
e alla mia nonna Carmela.*

presentation

The application of a robust methodology is a fundamental precondition to get reliable information in every scientific investigation, in particular in prehistoric archaeology where it is easy to make mistakes on the interpretation level.

The main goal of this work is to understand the role of the hunter-gatherers after the Last Glacial Maximum and during the Late Glacial in a given area, through the functional analysis of the archaeological lithic materials, in order to give a glimpse of the function of the sites in a period of rapid climate and environmental changes. The Epigravettian sites of Grotta di Pozzo in the Central Italy and Riparo Villabruna in the North Italy have been investigated on the lithic point of view, as to individuate possible projectile points used during hunting activity. This contribution offers detailed information about hafting technologies and hunting techniques, giving a wide framework of knowledge and practical skills of the inhabitants.

The research project introduces unique aspects that have never been investigated before for the considered sites. The systematic adoption of the experimental archaeology is innovative, and there have been tested specific and mostly unknown aspects about the use of lithic tools.

The data coming from the large literature and the unexpected results are crossed together as to understand the hunting strategies, the behaviour, the movements, the seasonal settlements and the possible connection between human groups in this large area of North-Central Italy at the end of Pleistocene.

1. INTRODUCTION

After the Last Glacial Maximum (LGM) and at the beginning of the Late Glacial, the cultural complex named Epigravettian developed in the Mediterranean area. The upper limit of the Late Glacial is characterized by a global increase in temperature (11.700 cal. BP, Magri, 2008) while the lower limit is placed at the end of LGM at 18-19.000 cal. BP (Orombelli *et al.*, 2005). “Epigravettian” refers to the cultural complexes that succeed the Gravettian in a large area including the Balkans, the Provence and the Italian peninsula (Martini, 2019).

In Italy, the Early Epigravettian is marked by the abundance of backed tools as *gravettes* and *microgravettes*, long blades, burins, endscrapers on blades and points, including shouldered points. Through time, the dimensions of the tools decrease. The Final Epigravettian is marked by scrapers, backed and geometric armatures and blades, there is a strong morphological variability depending upon the different regions (Mussi, 2001).

In the Western Alpine foothills, the anthropic Lateglacial settlement by human groups starts during the better climatic condition due to the *Würmian* deglaciation. Riparo Tagliente, located in *Monti Lessini*, is the first attested archaeological site frequented over and over by the hunter-gatherers, where ibexes and bovids were the most predated preys (Fontana *et al.*, 2002). The expansion of forest vegetation fostered the anthropic penetration on the Prealps and Southern Dolomites on the valley floor and around 500 m a.s.l. In this scenario, archaeological sites as Riparo Villabruna (Aimar *et al.*, 1992) and Grotta del Clusantin (Gurioli *et al.*, 2006) testify, from 15.000 ca. cal. BP, the exploitation of suitable areas for specialized hunter-gatherers. During the Younger Dryas, the settlement became continuous, also at 1000 a.s.l., as documented by the sites of Bus de La Lum, Riparo La Cogola, Riparo Villabruna and Riparo Soman (Fiore & Tagliacozzo, 2004). Excluding

Riparo Tagliente, the Epigravettian archaeological complex of these sites has never truly been investigated before in terms of functional aspect.

From the Last Glacial Maximum to the beginning of Holocene, the Central Apennine is characterized by climatic fluctuations, with cold periods and temperate phases, with the presence/absence of hunter-gatherers (Giraudi & Mussi, 1999). This context is ideal to test models of human behaviour connected to environmental changes. In the last sixty years, the Fucino Plain (Central Italy – *Abruzzo* region) has been thoroughly investigated by the Italian *Soprintendenze* and researchers. Many caves, shelters and open-air sites have been found and studied, permitting reconstructions with regard to the human activities that took place. The archaeological evidence has proven that human groups occupied the Central Apennines and the Fucino Plain from the final Pleistocene onwards. The frequentation of this area started during the Upper Palaeolithic, with the Epigravettian lithic industry. Many archaeological sites are attributed to the Late Glacial (Grotta Maritza (Bietti, 2003) Grotta di Ortucchio (Grifoni, 1968), Grotta Clemente Tronci (Agostini *et al.*, 2008), Riparo Maurizio (Agostini *et al.*, 2008), Grotta di Ciccio Felice (Agostini *et al.*, 2008), Grotta la Punta (Grifoni, 1968), Grotta Continenza (Boschian *et al.*, 2017), Riparo Venere (Radi, 1982) and Grotta di Pozzo (Mussi *et al.*, 2011)). Excluding Grotta di Pozzo and Grotta Continenza, the most recent lithic studies on these archaeological sites date to the end of 1990s (Radmilli, 1997).

Functional analyses of Epigravettian sites involved a wide geographic area from Southwestern Europe to the Caucasus region (Montoya *et al.*, 2013). A functional analysis allows understanding the use of artifacts on the basis of macro- and microscopic traces that form as a result of contact with worked materials (Keeley, 1980; Odell, 1980; Vaughan, 1985) or the hafting system (Rots, 2002, 2003, 2010). It helps reconstructing the activities that were performed and thus the function of an archaeological site and its economic organization (Ibáñez & Gonzáles, 1996, Lemorini & Rossetti, 2004; Nelson, 1997; Knecht, 1997; Pitts & Keeley, 1981; Odell, 1980).

Over several decades, scholars have spent much effort in improving the identification of projectile points in the context of an improved insight in cultural variations of hunter-gatherers. Indeed, within the framework of lithic analysis, projectile points have received great attention by archaeologists due to their fast morphological variation over time and space (Nelson, 1997). From the 1970's onwards, lithic analyses supported by experimental programs (Frison, 1974; Bergam & Newcomer, 1983; Fischer, 1984; Odell & Cowan, 1986; Geneste & Plisson, 1993; O'Farrell, 1996; Caspar & De Bie, 1996; Dockall, 1997) permitted adequate descriptions of fracture evidence and criteria to recognize projectile points in the archaeological record. These earlier works have been fundamental for current-day approaches and terminologies used in projectile analysis as recently discussed by Coppe and Rots (2017). Frison already integrated an examination of fractures in combination with experiments and some initial propositions for the differentiation between fracture types in his analysis of the Casper site (Frison, 1974, p. 198, fig. 1.53). Later on, an ad hoc commission created at the use-wear conference in Vancouver (Ho Ho Committee 1979) proposed a terminology for different fracture characteristics (Hayden, 1979; Tsirk, 1979, Cotterell & Kamminga, 1979), including a fracture's initiation (cone, bending) and termination (feather, hinge, step, snap). Special fracture categories, such as burin-like and flute-like fractures were added later on (Bergman & Newcomer 1983). Also the work of Fischer (1984) was largely inspired by the propositions of the Ho Ho Committee (1979) and he added the term spin-off and the notion of what fracture could be considered "diagnostic" of impact. The latter indirectly resulted in the development of an approach relying on specific so-called "diagnostic impact fracture" categories (DIF) (cf. Coppe and Rots 2017). This "DIF approach" is one of the main approaches used in present-day analyses aimed at identifying projectile points in archaeological assemblages.

A recent review (Coppe & Rots, 2017) has called into question the validity of the DIF categories given the confusion that proves to exist concerning their definition and their recognition on archaeological points. This problem is amplified when

few pictures are added to publications and/or when different attributes that characterize a fracture are insufficiently visible, recognizable, or described. While expert users with direct access to large reference collections may not necessarily be much affected by such issues, a problem exists for aspiring analysts who attempt to identify projectiles based on published data only. Misunderstandings are not easy to avoid when one can only base oneself on pictures, drawings or descriptions. The importance of an access to large and representative reference collections when analysing archaeological projectiles has been emphasized before (Rots & Plisson 2014), but it has never been demonstrated in a specific study. The same goes for the importance of training.

Even though the identification of lithic armatures is at the centre of scientific debate in Europe, Epigravettian projectiles on Italian archaeological sites have played a minor role as they have only been infrequently analysed (i.e. Riparo Cogola (Ziggiotti, 2008), Riparo Dalmeri (Duches et al., 2016)), in spite of their relevance for understanding hunting strategies and behaviour of Late Pleistocene human groups.

Grotta di Pozzo has great potential for a detailed study of the possible presence of projectiles as the site was occupied after the LGM and during the Late Glacial, in a strategic and favourable area, the Fucino Plain, that was attractive for human groups thanks to its rich resources in a period of rapid climatic change. The Lake Fucino, the second largest lake in Italy (artificially drained at the end of 1800), existed at the time of the human settlement. The combination of high and low altitude environments (from mountains to lake) and the presence of a lake likely created unique opportunities for Late Pleistocene hunter-gatherers, allowing an earlier post-LGM re-colonization than elsewhere in Europe. Many Epigravettian archaeological sites have been found in this plain and, based on zooarchaeological data, Grotta di Pozzo appears to witness seasonal hunting movements (Mussi et al., 2011); an interpretation that remains to be verified through lithic analysis. Technological aspects of the lithic assemblage have been discussed in general

terms (Mussi et al., 2011), but no use-wear analysis of the material was yet performed.

Riparo Villabruna, located in the Alpine foothills, was settled on several occasion by hunter-gatherers, due to the favourable environment, in a period that is coeval with Grotta di Pozzo. The raw material used to produce lithic tools is quite similar to those found in the Abruzzo region and, by analysing the lithic implements on the use-wear point of view, they could offer detailed information about hafting technologies and hunting techniques, giving a wide framework of knowledge and practical skills of the inhabitants.

The difficulty of engaging oneself in fracture analysis without formal training and without access to a reference collection has never been truly tested before. These problems may lie at the basis of terminological confusion that exists in present-day projectile studies (see Coppe and Rots 2017 for a discussion). As such, the analysis of the material from the sites of Grotta di Pozzo (L'Aquila – Abruzzo – Italy) and Riparo Villabruna (Belluno – Veneto – Italy) presented ideal test cases to investigate possible methodological problems in more detail in addition of the identification of specific tools within the lithic assemblage. The goal of the presented study is thus divided on four sections: 1. To evaluate the difficulties in identifying projectiles when basing oneself on published resources only, without formal training and access to a reference collection, 2. To apply experimental archaeology when the available reference collection is not enough for the interpretation of the use of tools, 3. To identify projectile points at the Epigravettian sites of Grotta di Pozzo and Riparo Villabruna, gaining insight in hunting strategies and technology, 4. To identify other possible uses of the tools of both archaeological sites.

1.1. GROTTA DI POZZO



Fig. 1: Localization of the archaeological site of Grotta di Pozzo with a reconstruction of the Lake Fucino.

Grotta di Pozzo (Ortucchio - L'Aquila - Abruzzo) is a small cave (12x5 m) located at 42° N on the southern edge of the Avezzano basin, at 720m a.s.l. in the Apennine range of Central Italy. The cave had been occupied by the Pleistocene and Holocene during the fluctuation of Lake Fucino; now artificially drained. The water level was high during the Last Glacial Maximum (LGM), when fluvio-lacustrine sediments were deposited inside the cave (Fig. 1).

The formation of the cave is due to water gelifraction, collapse and erosion processes. The bedrock is characterized by stratified microgranular limestones and Dolomitic intercalations. Moreover, several differential erosive processes have damaged the weakest rocky side, leaving the hardest side. As testified from considerable numbers of rockfall nearby the entrance of the area, the configuration

of the site was larger in the past. Furthermore, the inner part may be more extended because it is still full of archaeological sediment.

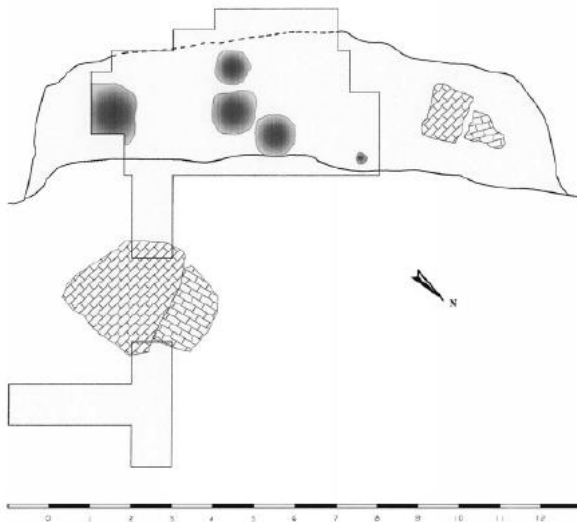


Fig. 2: Overview and planimetry of the excavation made in Grotta di Pozzo on the 2013.

The archaeological site was discovered on the 1992 during landscape surveys by the *Dipartimento di Scienze dell'Antichità* of the *Università di Roma "La Sapienza"* and excavated systematically from 1993 to 2015, under the supervision of Prof. Margherita Mussi. The annual surveys were focussed inside the cave and there have been excavated 24 m² of surface and more than 30 m³ of sediments

(Mussi *et al.*, 2011) while the external *talus* has been investigated on 7 m² in extension and 15 m³ of deposits (Fig. 2). The archaeological layers start from the Last Glacial Maximum and spans over the Lateglacial period, with Epigravettian lithic industry, until the Holocene, with Sauveterrian and Neolithic materials.

The cave has a NE orientation and, during the first part of the day and in particular during the autumn, the sun creates a pleasant microclimate. Thus, the Palaeolithic hunter-gatherers frequented many times this favourable environment. Furthermore, the cave is located alongside a tiny short valley that was strategically useful to check the movement of the preys: on the entrance there is an excellent point of view on the SW side of the basin; upstream there is a short rocky path, a natural trap for example horses and deer. Moreover, the watercourse was closer that today.



Fig. 3: Panoramic overview of the area that surrounds Grotta di Pozzo.

The Epigravettian site of Grotta di Pozzo has great potential for gaining insight in hunting strategies and technology. Indeed, the site was occupied at least two times after the Last Glacial Maximum and during the Lateglacial, in an area, the Great Adriatic Plain, where human groups frequented this favourable strategic environment throughout different modalities due to the exceptional resources that

it offered in a period of rapid climatic changes. The combination of high and low altitude and the presence of a lake apparently created a unique set of opportunities for the Late Pleistocene hunter-gatherers, allowing the post-LGM re-colonization to start there earlier than elsewhere in Europe. Many archaeological sites with Epigravettian lithic industry have been found in this Plain and on the basis of zooarchaeological data, Grotta di Pozzo seems to have been chosen by the hunter-gatherers as a base camp during the seasonal hunting movements (Mussi *et al.*, 2011) (Fig. 3).

Different issue is the raw materials exploitation for the human groups: both knappable silex and others lithotypes are absent on the Fucino Plain. Nevertheless, the closest outcrops of silex are located Eastern *Marsica*, around 30 km far away from the site (D'Angelo, 2004). However, a raw material characterization has been done on an archaeological sample of 2887 lithic elements (Mussi *et al.*, 2008) and the 65% is comparable with the Eastern *Marsica*. There have been identified three different typologies of silex:

- Type 1: from grey to beige colour, medium texture, two qualities (one acceptable called 1A and one good called 1B), coming from the Majolica limestone formation (Upper Jurassic, Lower Cretaceous). This is the most common;
- Type 2: from brown to beige to pink colour, from translucent to semi-translucent, good quality, from *Scaglia* limestone formation (Upper Cretaceous);
- Type 3: blackish colour, thin texture, sometimes not knappable, from *Marne a Fucoidi* (Lower Cretaceous).

Lastly, the 7% is a red chert coming probably from the *Umbro-Marchigiana* formation, really far away from the Fucino area. It is reasonable to think that the Eastern *Marsica* was the place where happened the raw material exploitation (Fig. 4), during the summer hunting. The “mountains” lithic material was abandoned at Grotta di Pozzo during the autumn, after the summer hunts (Mussi *et al.*, 2008).

Fig. 4: Human groups' probable path for raw material exploitation.



1.1.1. Stratigraphy

The stratigraphy currently known is divided, from the bottom to the top, on seven lithostratigraphic units (Fig. 5, Tab. 1):

- *Unità 1*: fluvio-lacustrine deposit, found at the end of the NE area of the cave at -150 cm of depth, marked by sub-horizontal pebbly layers interbedded between two sandy layers. This unity stands on rounded blocks of limestone and it is comparable with a high level of the Lake Fucino during LGM at 23.000 cal. BP (Mussi, *in progress*), confirmed by absolute dating of upper layers (*Unità III*, PSβ 19.015±230 cal. BP, Mussi *et al.*, 2008) and *talus* (19.810±310 cal. BP, Mussi *et al.*, 2011);

- *Unità II*: NE side of the cave, collapse of the vault deposit with large sharp edges limestone blocks above a heterometric unclassified deposit with limestone blocks from 2 to 20 cm. This is referable with the beginning of

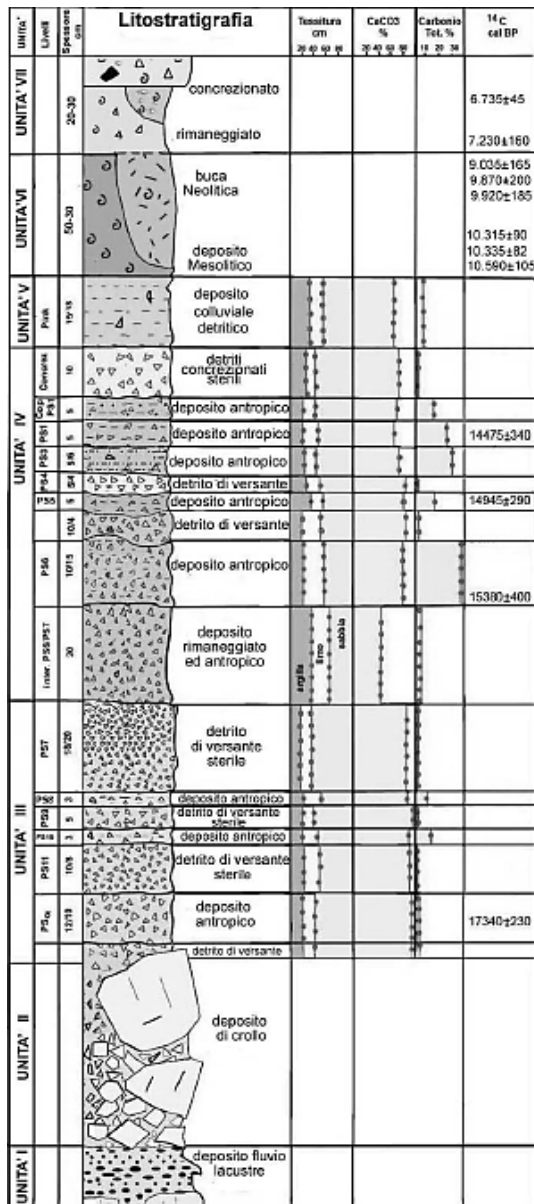


Fig. 5: Stratigraphic sequence of Grotta di Pozzo (Mussi *et al.*, 2011).

Lateglacial;

Unità	Livello	Laboratorio	Campione	Data BP	Data calibrata EP
Unità VII	Distrutto sup.	GX-27905	Ossio	5.910 ± 40	6.735 ± 45
Unità VII	Bucca 1-4	TO-6083	Sedimento	6.340 ± 140	7.230 ± 160
Unità VI	Riemp. Bucca 1	TO-3420	Carbone	8.110 ± 90	9.035 ± 165
Unità VI	Riemp. Bucca 1	TO-6084	Carbone	8.790 ± 110	9.870 ± 200
Unità VI	Riemp. Bucca 1	TO-6082	Carbone	8.840 ± 100	9.920 ± 185
Unità VI	Chiocciolino A	TO-6081	Carbone	9.110 ± 80	10.315 ± 90
Unità VI	Chiocciolino C	TO-3421	Carbone	9.140 ± 70	10.335 ± 80
Unità VI	Chiocciolino C	TO-3422	Carbone	9.370 ± 80	10.590 ± 105
Unità IV	PS1	GX-27906	<i>Salmo trutta</i>	12.320 ± 50	14.475 ± 340
Unità IV	PS5	GX-27907	Ossio	12.590 ± 40	14.945 ± 290
Unità IV	PS6a	AA-78136	Ossio	12.820 ± 130	15.380 ± 400
Unità III	PSa	GX-30436	Ossio	14.100 ± 70	17.340 ± 230
Unità III	PSp	LTL-1163A	Ossio e carbone	15.790 ± 90	19.015 ± 230
Esterno	Det. fine 4	AA-78134	Carbone	16.495 ± 90	19.810 ± 310
Esterno	Det. fine 5	AA-78135	Carbone	14.585 ± 80	17.860 ± 340

Tab. 1: Radio-metrical dates (C14 – AMS) from Grotta di Pozzo (Mussi *et al.*, 2011).

- *Unità III*: 50 cm of stratified sediments, alternated by darky anthropic layers with archaeological and organic materials, 3 cm thick. Their thickness let think a short occupation by human groups. An erosion surface divides the *Unità III* from *Unità IV*. The paleoclimatic data indicates a cold phase (Mussi *et al.*, 2008), less than *Unità II*, traceable to the first part of Lateglacial. The radio-metric date of PSα (17.000 cal. BP) confirm it.

- *Unità IV*: detrital deposit alternated by anthropic sub-parallel layers with SW inclination in close to the entrance. The anthropic layers are rich of bone remains, small charcoals and a brownie-reddish organic material. The abundance of them compared to the previous unit suggests a longer occupation, in particular below the shelter. This unit has a temperate climatic condition referable to the

beginning of the *Bølling–Allerød* interstadial, confirmed by the PS6 dating of 15.000 cal. BP;

- *Unità V*: thin colluvial sediments with a gross fraction of thin pebbles and sub-angular limestones. This is the last Pleistocene unit, referable with the *Younger Dryas* (Mussi *et al.*, 2011), with very few artefacts;
- *Unità VI*: between 10.500 and 9.000 cal. BP, it belongs to the beginning of Holocene;
- *Unità VII*: latest Holocene, around 7.000 cal. BP;

1.1.2. The archaeological sequence

In the 2007 a survey of 1 m² called *talus* has been opened at 4 m far from the entrance of the cave, a level dated between 20.000 and 17.500 cal. BP (Tab. 1). According to the lithic industry with shouldered points, this level refers to Early Epigravettian (Mussi *et al.*, 2008).

Inside the cave, the sequence starts with the PS β dated 23.000 (Mussi, *in progress*) and 19.000 cal. BP, rich of *débitage* and small flakes and bladelets, lithic industry referable to the Early Epigravettian. The *Unità III* belongs to the Epigravettian industry from PS13 to PS7, alternated between sterile sediments (PS12, PS11, PS9, PS7) and anthropic deposits (PS α , PS10, PS8), poor of retouched elements and faunal remains (important to mention small gastropods probably used as ornaments). As reported above, PS α is date to 17.300 cal. BP. At the top of the *Unità III*, referable to the *Unità IV*, there are three flattered pits with a diameter between 25-50 cm.

Moving upwards, there are the upper layers of 45 cm thick of *Unità IV*, from inter PS6/PS7 to *Concrezionato*. They are characterized by the alternance and not of carbonaceous materials. The lithic industry and dates refer this unit to the Final Epigravettian, documented by *débitage* products and retouched tools. Moreover,

faunal remains are well preserved, rich of residues of fish and there are ornaments as perforated shells and one perforated atrophic canine of red deer (*Cervus elaphus*). Furthermore, it has been found a fireplace (PS1) with the dust that cover the nearby area.

Then, there is a weak eroded archaeological layer (PS0), covered by fallen rocky limestones, referable to the *Younger Drias* (Mussi *et al.*, 2008).

Lastly, the *Unità VI* (10.700-9.000 cal. BP) is connected to the Mesolithic period, with Sauveterrian industry and a conglomerate of *Helix delpretiana*, and *Unità VII* (7.200-6.700 cal. BP) to the Neolithic period.



Fig. 6: Excavation campaign at Grotta di Pozzo in 2013.

1.1.3. The faunal remains

The lower archaeological layers belonging to the *Unità III* and the *talus* have yielded poor and not-well preserved faunal remains, including ibex (*Capra ibex*) and chamois (*Rupicapra rupicapra*).

Taxa	NR	%
<i>Erinaceus europaeus</i>	1	0,7
<i>Lepus</i> sp.	6	4,0
<i>Marmota marmota</i>	8	5,3
<i>Vulpes vulpes</i>	2	1,3
Carnivora	4	2,6
cfr. <i>Equus hydruntinus</i>	1	0,7
<i>Sus scrofa</i>	4	2,6
<i>Cervus elaphus</i>	29	19,2
Cervidae	2	1,3
<i>Capra ibex</i>	5	3,3
<i>Rupicapra</i> sp.	62	41,1
Caprinae	25	16,6
cfr. <i>Bos primigenius</i>	1	0,7
Microfauna indet.	1	0,7
Totale Mammiferi	151	93,2
Aves indet.	11	6,8
Totale determinati	162	(20,7)
Mammifero piccola taglia	30	4,84
Mammifero media taglia	119	19,19
Mammifero grossa	33	5,32
Indeterminato	438	70,65
Totale indeterminati	620	(79,3)
Totale complessivo	782	100

Tab. 2: Faunal remains of upper layers (Mussi *et al.*, 2008).

(Mussi *et al.*, 2008). Regarding carnivores, only foxes (*Vulpes Vulpes*) have been identified while hunted preys also are rabbits (*Lepus* sp.) and marmots (*Marmota marmota*). However, the medium size of animals is predominated.

Butchering activities (cut-marks and impact traces) have been found on ungulates bones, testifying the preys exploitation by the human groups: the integral animal bodies were carries inside the cave and butchered *in situ*. Moreover, it is important

By contrast, the upper layers of the *Unità IV* are characterized by a good quantity of bone remains (Tab. 2): the identified species are in order chamois (*Rupicapra rupicapra*), red deer (*Cervus elaphus*), ibex (*Capra ibex*) and wild boar (*Sus scrofa*) while only two fragmented pieces belong to *Equus hydruntinus* and aurochs (*Bos primigenius*). The NMI of chamois is 10 with predominance of young individuals while for the red deer is 4, all adults

to underline a distal humerus of marmot with cut-marks due to disarticulation of the carcass.

Based on the animals' age of death (prevailing young-adults I individual in spite of the absence of adults II-senile), Grotta di Pozzo was seasonally occupied by hunter-gatherers, during the summer-autumn (Mussi *et al.*, 2004).

Another important food resource was the avifauna, demonstrated by the disarticulation cut-marks found on a distal humerus of mountain pheasant (*Tetrao tetrrix*, Fig. 7).

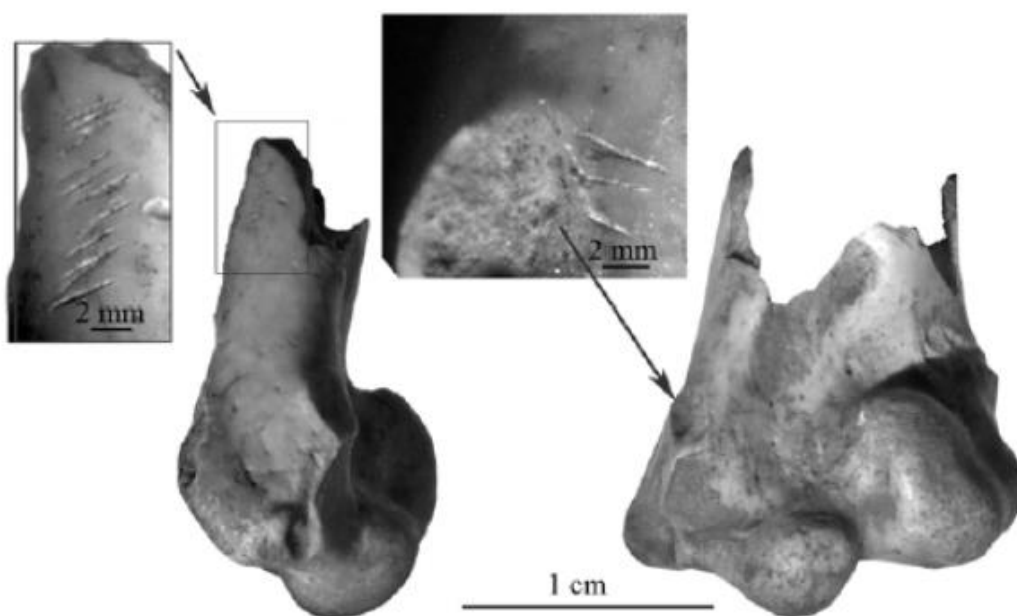


Fig. 7: *Tetrao tetrrix* distal humerus with cut-marks from Grotta di Pozzo (Mussi *et al.*, 2008).

There have also been found *Salmo trutta* remains between PS6 and PS1 layers (Russ & Jones, 2009), revealing fishing activities during their reproduction on the lake. The high percentage of cranial elements indicates the trout preparation and transport inside the cave.

Regarding the Mesolithic levels, there are fragmented and burned bones of red deer, wild boar, ibex and chamois. Based upon the quantity of *Helix delpretiana*

elements, it has been assumed that a restricted human group eating them during the autumn (Mussi *et al.*, 2011).

Currently, there have been applied faunal techniques for the identification of the so-called Projectile Impact Marks (PIMs). They are defined as the resulting trauma of the bone after the contact with a projectile (O’Driscoll & Thompson, 2014). A preliminary analysis on bone remains of medium and large size mammals has been conducted as to find Projectile Impact Marks (Catelli *et al.*, 2016). Although the fragmentation of the animal bones due to post-depositional processes, 3 ungulates ribs have shown similar traces to the PIMs of O’Driscoll and Thompson’s (2014) experimentation. In particular, a rib (Fig. 8) shows an impact and an exfoliation comparable with a Puncture/Fracture or rather a direct shot that has removed the surface of the bone.

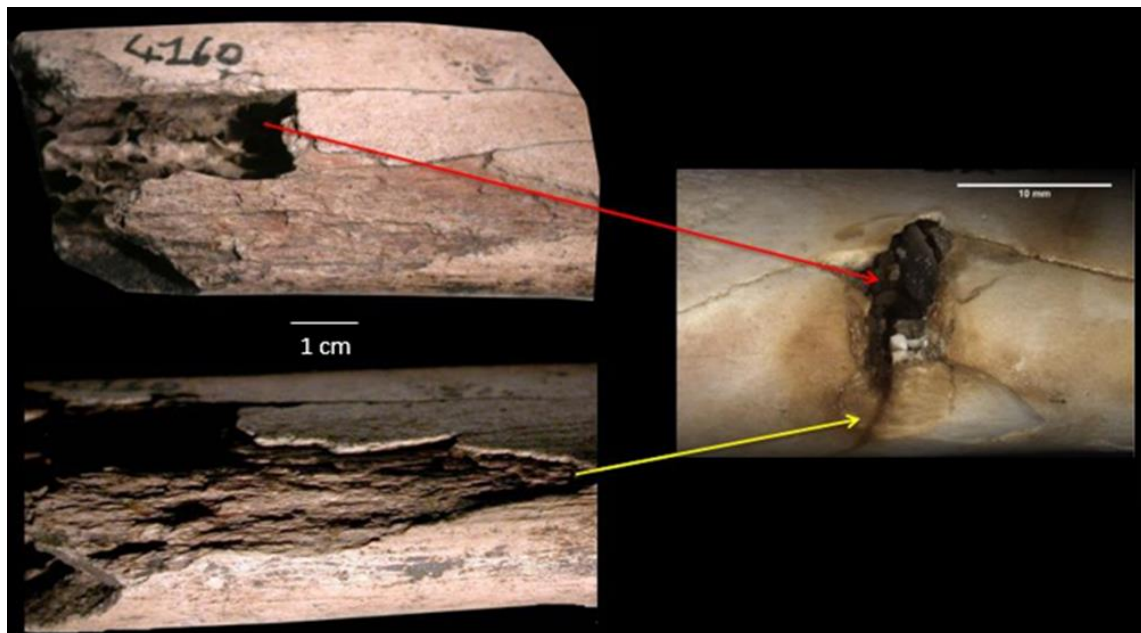


Fig. 8: Puncture marks from an Ungulate bone, impact and exfoliation. Comparison between the rib of Grotta di Pozzo (Pz 4160) (on the left, Catelli *et al.*, 2016) and an experimental tibia (on the right) from O’Driscoll and Thompson, 2014, pag. 407, Fig. 5C.

1.1.4. Bone industry and decorative objects

Talking about the lower layers (*Unità III* and *talus*), there have been found a bone point, three smalls not perforated marine gastropods, one *Dentalium* sp. and some lithic artefacts with residues of ochre as well as fragmented pieces of ochre (Mussi *et al.*, 2011).

The upper layers (*Unità IV*) have yielded 12 perforated shells (*Cyclope neritea*), one perforated atrophic canine of red deer (*Cervus elaphus*) and fragmented ochre. There have also been found a levigated bone point with a distal fracture and two fragments of bone points with scars probably due to use. Moreover, there have been found linear marks of engraving on the cortex of a knapped lithic artefact (Fig. 9).

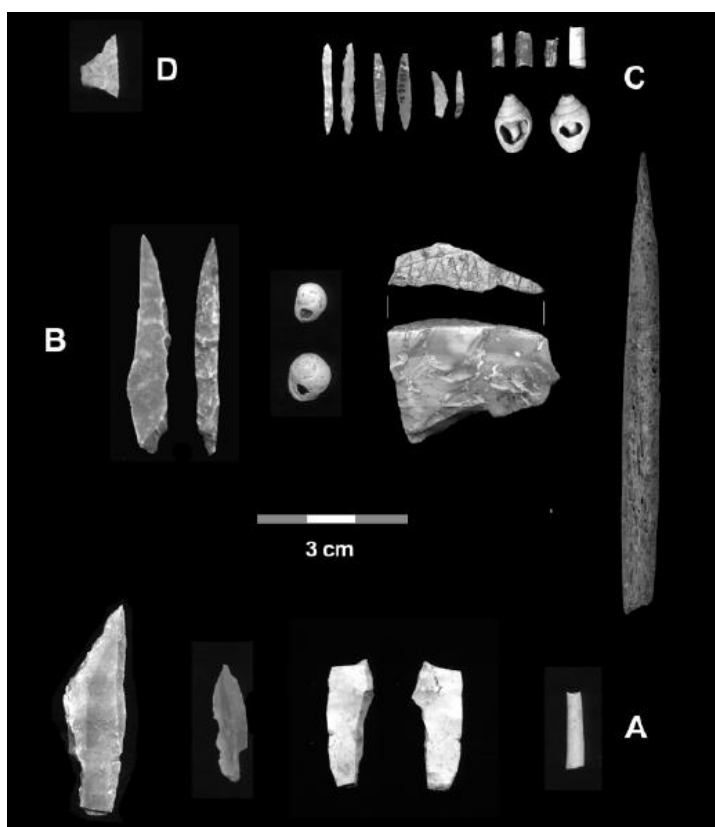


Fig. 9: Grotta di Pozzo. A: shouldered point and a *Dentalium* coming from the *Unità III* and *talus*; B: *La Gravette* point, *Cyclope neritea*, engraved cortex of flake and bone point from *Unità III*; C: Sauveterrian points, geometric, *Dentalium dentalis* and *Columbella rustica* from *Unità VI*; D: asymmetric trapeze from Neolithic levels (Mussi *et al.*, 2011).

1.1.5. The lithic industry

The lithic industry of the *Unità III* and *talus* (Tab. 3) is attributed to the Early Epigravettian, testified by shouldered points and chronology (23.000 – 19.000 cal. BP). In details, the low presence of cortical flakes and crest blades and bladelets suggests knapping activity on preformed blocks with direct percussion with hard hammer for the preparation of the core and soft hammer for the *plein débitage* phase.

	n.	%	Tipologia	n.	%
Nuclei	3	0,7	Grattatoi	3	3,4
Prodotti laminari di inizializzazione	4	0,9	Compositi grattatoio/punta	1	1,2
Schegge di messa in forma	48	10,9	Bulini	4	4,6
Prodotti laminari di piena produzione	113	25,6	Troncature	8	9,1
Prodotti laminari di gestione	12	2,7	Becchi	2	2,2
Schegge di gestione	9	2	Intaccature	17	19,3
Strumenti	88	19,9	Lamelle appuntite	3	3,4
Residui di trasformazione	7	1,6	Lame/Lamelle ritoccate	18	20,4
Frammenti indeterminabili > 15mm	12	2,7	Raschiatoi	6	6,8
Debris < 15 mm	146	33	Scagliati (<i>Pièces mûchurées</i>)	4	4,6
			Armature à cran	4	4,6
			Dorsi	12	13,6
			Dorsi-Troncatura	6	6,8
TOTALE	442	100	TOTALE	88	100

Tab. 3: Early Epigravettian lithic industry from *talus* (Mussi *et al.*, 2011).

Moreover, production of blades and large bladelets (5-14 mm of width) is indicated, together with the cores, from the good quantity of not cortical and regular laminar product of full production. Retouched tools as common ones and armatures are frequent. Lastly, shouldered points are small, stubby and unsophisticated.

The lithic industry of the *Unità IV* (Tab. 4) is referred to the Final Epigravettian, in terms of typology and chronology (Mussi *et al.*, 2011). This industry is characterized by microliths: the 98% of artefacts have a length less than 40 mm. The largest blanks are those of the scrapers, burins, truncations, blades and retouched flakes (up to 60 mm) while the maximal length of backed tools is 47 mm. From the archaeological record, 74% is *débitage*, 24% is *débris* and only 12%

concern retouched elements. Regarding the *débitage*, there are more flakes than blades and bladelets while, regarding the retouched tools, prevails the laminar (20%) and lamellar (44%) blanks despite of on flake (36%). The retouched elements are 62% common tools, scrapers, burins, truncations, denticulates, retouched blades and bladelets, and 38% armatures, backed, backed-truncated, *microgravettes* and *La Gravette* points. The last ones have abrupt retouch on one edge along the length of the tool.

	n.	%	Tipologia	n.	%
Nuclei	7	0,3	Grattatoi	22	8,4
Elementi con cortice ≤ 50%	276	11,4	Bulini	11	4,2
Elementi con cortice > 50%	66	2,7	Troncature	8	3,1
Lame a cresta	2	0,1	Becchi/Punteruoli	5	1,8
Schegge > 20mm	76	3,1	Intaccature/Denticolati	9	3,4
Schegge 5-20mm	1006	41,6	Punte	1	0,4
Schegge ≤ 5mm	229	9,5	Schegge ritoccate	70	26,7
Lame	57	2,3	Lame/Lamelle ritoccate	41	15,7
Lamelle	382	15,8	Raschiatoi	2	0,8
Ravvivamenti nucleo	45	1,9	Scagliati	1	0,4
Strumenti	262	10,8	Gravette./microgravette	22	8,4
Stacchi di bulino	9	0,4	Dorsi	70	26,7
Microbulini	1	0,1			
TOTALE	2418	100	TOTALE	262	100

Tab. 4: Final Epigravettian lithic industry from the *Unità IV* (Mussi *et al.*, 2011).

If we compare the lower (PSβ-PS7) and upper (PS6-PS1) layers, the retouched tools and their typological structure are increased. From an analysed sample of 353 elements coming from the upper layers consisting on lamellar production, it is possible to understand their morphology. The lamellar production is represented by straight and standard blanks: thickness 1-7 mm, with 3-28 mm, length has not been counted for the high percentage of fragmented pieces. It is possible to deduct that there is the will to obtain thicker lamellar blanks in order to product different armatures: backed points, *microgravettes*, *La Gravette* points (Mussi *et al.*, 2008).

Throughout experimentation, it has been tried to reconstruct the retouching technique used for the creation of the backed points (direct percussion, pressure, abrasion). By comparing the experimental materials with the archaeological ones, it has been possible to determinate that the possible technique used to making the

retouch was pressure and, in few cases, direct percussion (Mussi *et al.*, 2008; Fig. 10).

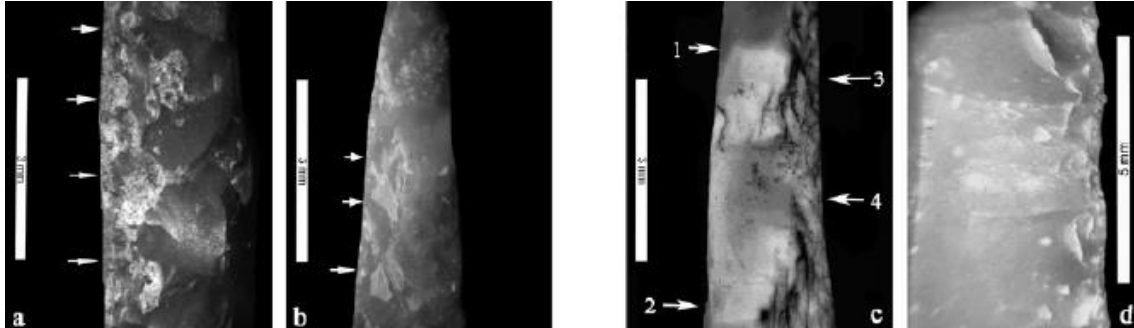


Fig. 10: Archaeological and experimental materials in comparison: a) backed-truncated bladelet N. 1456; b) experimental backed point obtained by direct percussion; c) *La Gravette* point N. 1325 (1-2 gibbosity; 3 abrasion; 4 negative of pressure spall); d) experimental backed point obtained by pressure technique (Mussi *et al.*, 2008).

Lastly, it is necessary to mention the information about the Sauveterrian lithic industry for the Mesolithic layers: the 72% are retouched artefacts like scrapers, burins, truncations, awls, denticulates, retouched blades, bladelets (i.e. backed armatures, backed points and Sauveterrian points) and flakes (Mussi *et al.*, 2011). *Débitage* products are the 23% and the 5% are *débris*. There also are geometrical microliths of 5-40 mm of length.

1.2. RIPARO VILLABRUNA



Fig. 11: Localization of the archaeological site of Riparo Villabruna and a panoramic overview of the excavation at the end of Eighties.

Riparo Villabruna (Sovramonte – Belluno – Italy) is a small shelter at 500 m a.s.l., located in the *Val Cismon* (Dolomites of Veneto region) (Fig. 11). The area is characterized by several streams that run through the valley and the *Monte Avena* on the western side of the site. Facing at NE, Riparo Villabruna is 50m above the valley floor where the *Rosna* and *Cismon*'s streams converge, in an area called *Val Schener*. The *Rosna* valley, where the shelter is exactly located, is delimited by different rocks, coming from the Upper Triassic to the Medium Eocene. Moreover, the area is involved on several glacier and water erosions and freezing and thawing actions. Climatic change made more stable the deposit due to vegetation action. Furthermore, the glacier retreatment after the *Würmian* period (15.000 years ago) permitted the formation of a large detrital cone where Upper Palaeolithic hunter-gatherers settled on several occasions (Aimar *et al.*, 1992).

The site was discovered at the beginning of the Eighties during roadworks that partially cut the detrital cone, unearthing several rock shelters showing anthropic activities. Nowadays, it is possible to appreciate the original rocky wall that have been saved (Fig. 11). During the 1988-89 the site has been systematically

excavated by the Prof. Alberto Broglio's team of the *Università di Ferrara*, highlighting three shelters called A, B and C (Fig. 12).



Fig. 12: Panoramic overview of the excavation made at Riparo Villabruna at the end of Eighties.

Direct radiocarbon dating of the basal layer indicates an irregular human occupation of Riparo Villabruna from 14.000 cal. B.P. to the Neolithic. In particular, the archaeological site was divided in three sectors: *Riparo A* refers to the Lateglacial with Final Epigravettian and Sauveterrian lithic industries, *Riparo B* with Castelnovian and Neolithic archaeological materials and *Riparo C* with Final Epigravettian lithic industry (Aimar *et al.*, 1992) (Fig. 13).

Moreover, the surrounding environment consisted of alpine prairies, with scarce arboreal vegetation including *Pinus sylvestris/montana*, as revealed by the anthracological analysis (Aimar *et al.*, 1992).

The following information only considers the better-preserved area, *Riparo A*. This has been extensively excavated for a total of 12 m².

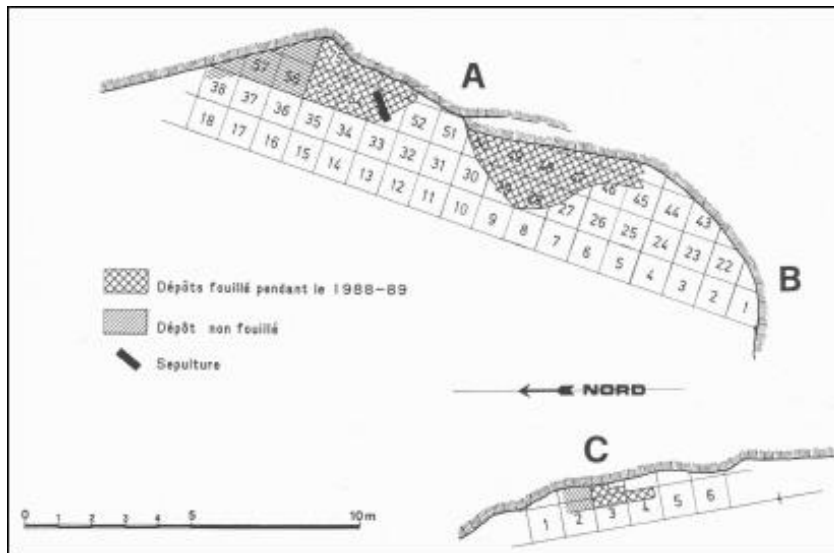


Fig. 13: Planimetry of the three sectors of Riparo Villabruna (Aimar *et al.*, 1992)

1.2.1. Stratigraphy

The stratigraphy of *Riparo A* is divided on 18 layers for a total of 2 m of depth (Fig. 14). The Palaeolithic sequence starts with the level 17 where a burial was found and exposed during roadworks that cut the lower limbs at the level of distal femoral shafts (Aimar *et al.*, 1992). The levels from 16 to 4 are characterized by Epigravettian lithic industry while the layer 3 by Sauveterrian lithic industry.

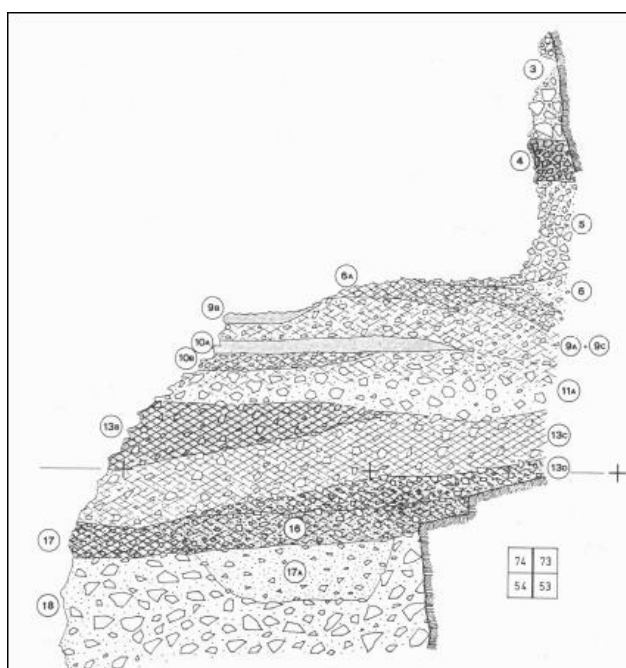


Fig. 14: Stratigraphy of Riparo Villabruna A (Aimar *et al.*, 1992).

From the bottom to the top, hereby are reported the most important information about the layers (Broglia, 1999). First, the layers are called by numbers, from 18 to 1. The strata 1, 2 and 18 are completely sterile. Important to mention are layers 16-17: between those levels, there is the coverage (20-30 cm called 17A) where it was found the burial of a hunter-gatherer while on level 16 an ochre painted rock. From 17 to 3 there was found lithic materials referred to the Final Epigravettian, faunal remains and charcoals.

Radio-metrical dates have been done nearby the burial and on the lower layers. The burial and the lower layers were dated approx. 14.000 cal. BP while the upper layers approx. 11.000-9.000 cal. BP (Broglia, 1999). Based on this information, it is possible to consider that the hunter-gatherers frequented the shelter at least for 5.000 years, during the temperate climatic condition of the interstadial *Bølling-Allerød* interspersed with short cold climatic phases of *Dryas*.

1.2.2. The burial

The archaeological site is famous for the discovering of a burial (Fig. 15) found and exposed during roadworks that cut the lower limbs at the level of distal femoral shafts (Aimar *et al.*, 1992). The buried individual was an adult male of 25 years old and 170cm tall, buried at 30-40 cm deep within a grave, facing the skull towards the individuals left hand side and located nearby the shelter wall (Vercellotti *et al.*, 2008). Direct radiocarbon dates, in addition to dated charcoals found in the burial pit, place it between 14,400 – 13,800 cal. BP (Aimar *et al.*, 1992).

The individual is characterized by a relatively tall stature for the time period, short trunk and more linear body proportions than its contemporaries, similar to those of recent North-African populations. Multivariate statistical analysis of craniofacial characteristics place Villabruna 1 close to Le Bichon 1, a geographically and

chronologically nearby specimen, suggesting genetic affinity among the last hunter and gatherers from the alpine region. Observations on dental wear and microwear indicates that the anterior dentition was involved in non-alimentary activities such as the mastication of fibrous materials including large abrasive contaminants. Whereas the information on dietary habits drawn from dental wear is not conclusive, stable isotopes analysis points to a terrestrial based diet rich in animal proteins. Biomechanical study of major long bones indicates an overall robusticity and a marked humeral asymmetry. These results suggest intense unimanual



activity, possibly linked to repeated throw-hunting movements, and the combined effect of mobile lifestyle and mountainous terrain, as far as the femur is concerned (Vercellotti *et al.*, 2008).

The dentition of this individual also documents the earliest evidence of

Fig. 15: Burial of hunter-gatherer and funerary goods.



dental caries intervention on a Late Upper Palaeolithic modern human specimen. Using SEM, striations were observed that were interpreted as deriving from the manipulation of a large occlusal carious cavity of the lower right third molar, which also was confirmed experimentally. Those striations appear to have been produced *ante-mortem* with pointed flint tools during scratching and levering activities (Oxilia *et al.*, 2015) (Fig. 16).

The individual was recognized as a hunter-gatherer for the presence of funerary goods: two refitted fragments of a bone point engraved with two series of notches, a backed knife, a flint blade and a core, a siltstone pebble identified as a retoucher and a lump of ochre and propolis with attached carbonate concretions (Fig. 15).

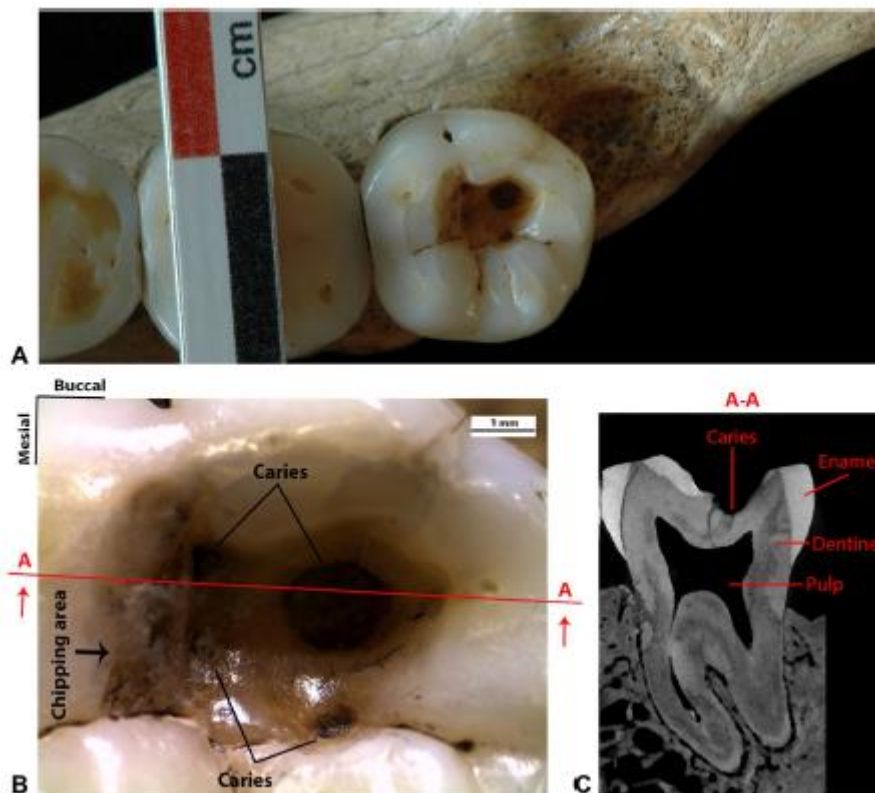


Fig. 16: Lower third molar of the Late Upper Paleolithic specimen called Villabruna (Oxilia *et al.*, 2015).

The bone point was broken and decorated by symmetrical transversal lines. The lump of ochre and propolis corroded destroying the leg of the skeleton and have altered the artefacts nearby.

Furthermore, the bottom of the pit is covered by ochre under the skeleton, near the cranium and pelvic bones. The wall of the shelter close to the burial is decorated of red ochre with six vertical lines.



Fig. 17: Stones on the top of the burial and particular of iperantrophic and symbolic red ochre painted stones.

Moreover, on the top of the burial were found twenty calcareous stones, collected on the riverbed of *Cismon* and *Rosna*, at 10 m from the shelter. Some of these stones show slightly drawings with red ochre, showing anthropomorphic and geometrical motives (Fig. 17). A fifth painted stone was found outside the burial, with a geometrical pattern. Furthermore, red vertical stripes have been found nearby the burial on the wall of the shelter. It has been advanced the hypothesis that the position of these stones means the intention to mark the burial location (Broglia, 1999).

1.2.3. *The faunal remains*

The followed archaeozoological data coming from a sample of 2202 from *Riparo A* and has a good state of preservation. The lower layers (17-10) show the frequentation of ibex (*Capra ibex*) (57%) followed by chamois (*Rupicapra rupicapra*) (21%), red deer (*Cervus elaphus*) (18%) and wild boar (*Sus scrofa*) (4%). Regarding the upper layers (9-4), there is the dominance of red deer (70%) followed by ibex (14%), chamois (10%), mustelids (*Martes* sp.) (4%) and deer

(*Capreolus capreolus*) (2,5%). These differences are connected to climate changes that affected the hunting strategies of the hunter-gatherers due to the animals' migration.

Moreover, the analysis of faunal remains confirms the exploitation of ungulates. Indeed, striations and fractures have been found on the surface of bones indicating butchering activities. On long bones of ungulates, there are transversal and oblique striations along its axis. On metapodium there are longitudinal *strie*. Intentional fractures on bones are testified by many points of impact. Burned bones are uncommon, while there is a large number of fragments with ochre (Aimar *et al.*, 1992) (Fig. 18).

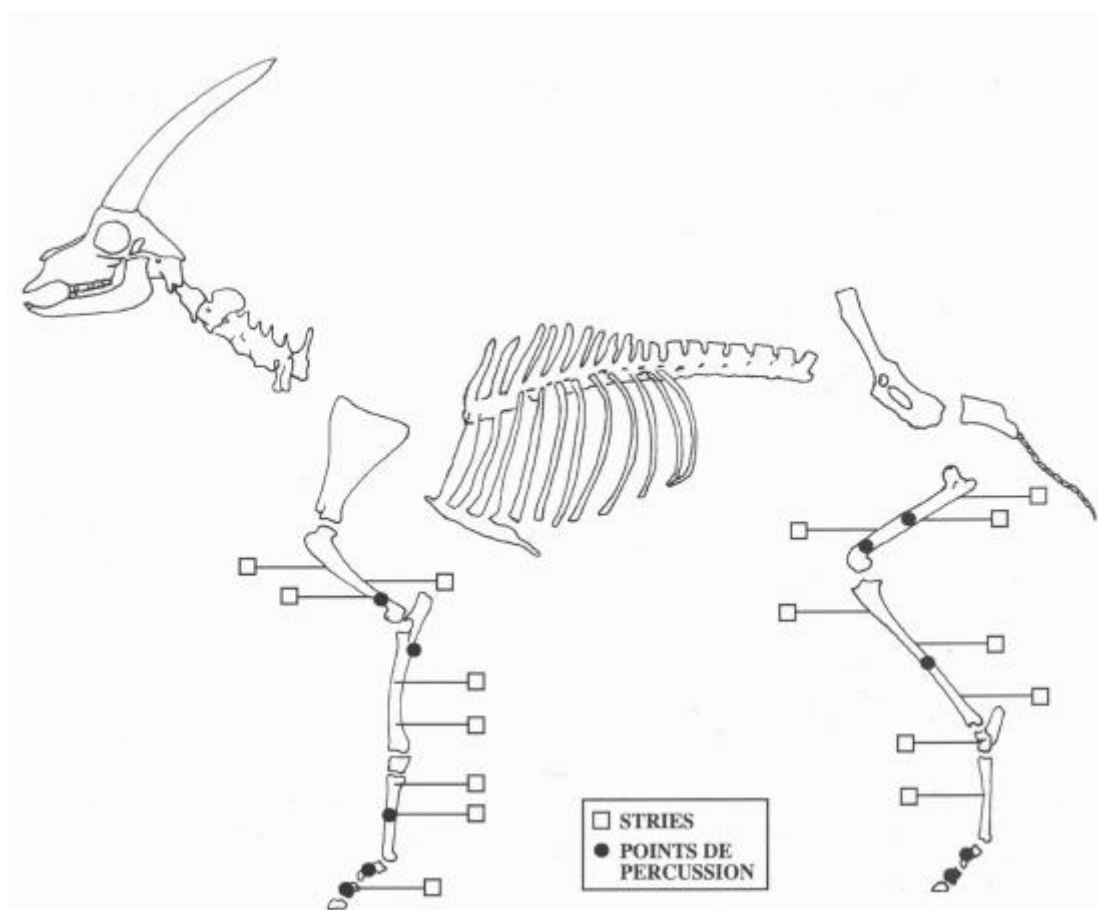


Fig. 18: Riparo Villabruna A: striation and impact of percussion location on bones of ibex coming from the Epigravettian layers (Aimar *et al.*, 1992).

The archaeozoological data suggests a protracted period of the anthropic frequentation of the site. The hunting activity was focussed on adult individuals. Data of eruption of the teeth on ibex permits to consider the seasonality of the site

during spring (Aimar *et al.*, 1992). Butchering activities took place inside the shelter, as suggested by the bones' portions and traces. Furthermore, the layers 5 and 4 are connected to the cessation of the frequentation of the site, as indicated the long exposition of bones and scratching traces of rodents on their surface.

1.2.4. The lithic and other materials industries

The lithic materials coming from the *Riparo A* and *Riparo C* are referred to the Final Epigravettian, according to the chronology and their typological characterization. By contrast, *Riparo B* is attributed to the Mesolithic and Neolithic period. Regarding the Epigravettian layers, there is a good quantity of tools and armatures in the archaeological record: backed points, backed bladelets, *microgravettes*, geometric elements, truncations, scrapers. Prismatic cores are predominant, used for the realization of bladelets (Aimar *et al.*, 1992).

The lithic industry of *Riparo A* has never been systematically studied in terms of technology. We considered here the preliminary study of a PhD student from *University of Ferrara* (DD). The sample is of 2971 elements with length more than 15 mm, divided on 13 layers (Tab. 5). The retouched elements (tools and armatures) are 252 (8,5%) while unretouched blades and bladelets are 440 (14,8%).

It is possible to consider that the layers richest of materials are 5 and 6. By contrast are almost sterile the layers 3 and 11. The retouched elements are poor on upper layers (5 and 6) while increase on the lower layers (12, 13, 16, 17). Moreover, the lithic industry is characterized by fractured elements: the 85% of unretouched tools are fractured. Furthermore, the tools fractured are less in number, except for backed tools that are fractured on the 3/4 of the total.

The 52 cores have good state of preservation and high level of use: they have polyhedral or prismatic form and have been used for laminar blanks.

Layer	Retouched		Unretouched		Cores		Total	
	N°	%	N°	%	N°	%	N°	%
3	3	1,2%	3	0,7%	1	1,9%	11	0,4%
4	7	2,8%	12	2,9%	6	11,5%	68	2,3%
5	34	13,4%	77	18,5%	8	15,4%	514	17,3%
6	61	24%	132	31,6%	9	17,3%	992	33,4%
9	31	12,2%	71	17%	2	3,8%	326	11%
10	13	5,1%	16	3,8%	5	9,6%	96	3,2%
11	2	0,8%	2	0,5%	/	/	18	0,6%
12	24	9,4%	14	3,4%	3	5,8%	185	6,2%
13	13	5,1%	16	3,8%	5	9,6%	103	3,5%
14	/	/	3	0,7%	/	/	61	2,1%
5/15	18	7,1%	38	9,1%	3	5,8%	346	11,6%
16	27	10,7%	30	7,2%	10	19,2%	196	6,6%
17	19	7,5%	3	0,7%	/	/	55	1,8%
TOT	252	100%	440	100%	52	100%	2971	100%

Tab. 5: The lithic materials coming from Riparo A divided by layers.

The silex has a good preservation state, as demonstrated by the low presence of *patina* (3% burned). Regarding the raw material used, there are grey silex “*Biancone*” (91,9%), red silex “*Scaglia rossa*” (6,6%) and heterogenous silex “*Scaglia Variiegata*” (1,5%, yellow, brown, beige and green) (Tab. 6).

	Biancone	Scaglia rossa	Others	Tot
> 15 mm	2730 (91,9%)	196 (6,6%)	45 (1,5%)	2971
blades/blatelets	375 (85,2%)	51 (11,6%)	14 (3,2%)	440
Tools	80 (83,3%)	13 (13,5%)	3 (3,1%)	96
Armatures	123 (78,8%)	31 (19,9%)	2 (1,3%)	156
Cores	45 (86,5%)	7 (13,5%)	-	52

Tab. 6: Raw materials differentiation.

A petro-archeometrical study on 15 artefacts (7 grey, 7 red, 1 heterogenous) indicates that the grey silex coming from 10 km N-NW on the area of *Malga Dotessa* while the red silex has not been identified (Benedetti *et al.*, 1992). The local silex has bad quality and has been ignored. Moreover, regarding the production of the lithic tools with *Biancone*, there has been found the full *chaîne opératoire* and the discarded cores due to knapping accidents inside the site. We

can consider that this kind of raw material has been carried by hunter-gatherers through nodules and knapped *in situ*. Concerning the *Scaglia rossa*, are prevailing the ended products (armatures, few scrapers and some cores) in spite of knapping products. This probably because this raw material has been worked on the exploitation zone and directly carried at the site as ended or semi-finished products.

In addition to the lithic materials, there were found bone artefacts, including an awl and an integral and a fragmented spatula. Moreover, ornaments are present in Riparo Villabruna, so as a *Dentalium* and a *Columbella* (Aimar *et al.*, 1992). Nevertheless, four perforated atrophic canines of red deer (*Cervus elaphus*) have been found on 9C, 6A and reworked layers (Aimar *et al.*, 1992). These objects look as “shiny pearl” and tears profile, with an undoubtable beauty. They have concave-convex profile and have been classified as trophies rich of symbolism, with sexual implications (Taborin, 1990). (Fig. 19).



Fig. 19: Decorative objects from Riparo Villabruna. On the top, perforated atrophic canines of red deer (*Cervus elaphus*); on the bottom, perforated marine shells and a *Dentalium*.

2. MATERIALS AND METHODS

The artifacts selected for the case study of Grotta di Pozzo were excavated from 1993 to 2013 and related to the Early and Final Epigravettian layers (PS19 – PS1 23.000-14.000 cal. BP). In total, 5.012 pieces were screened for this research from which 1.315 artifacts were selected for analysis (i.e., 167 attributed to Early Epigravettian, 1.148 attributed to the Final Epigravettian) on the basis of technomorphological parameters, with the specific goal to recognizing possible projectile points. Starting from the assumption that retouched and unretouched elements could both have been used as projectile points (cf. Odell & Cowan, 1986), both were considered. As a result, retouched blades and bladelets, backed and backed-truncated points, *microgravettes*, *La Gravette* points, shouldered points were included in addition to unretouched items (blades and bladelets) of similar dimension as the retouched ones. A further selection has been done and it is indicated in the next section (Tab. 9).

Concerning Riparo Villabruna, the sample studied in this research come from the archaeological excavation made in shelters A, B and C in 1988-89, related to Final Epigravettian layers (14,400 – 13,800 cal. BP). The screened assemblage consists in 3.051 lithic materials, situated in the storehouse of the *Università di Ferrara* and exposed in the *Museo Civico di Belluno* (Italy). There have been selected 250 elements, mostly fragmented, considered suitable as their use as projectile points, in morphological terms (backed blades and bladelets, truncations, *microgravettes*, geometrics) (Tab. 7).

Typology	n°	%
Backed blades	11	4,4
Backed bladelets	128	51,2
Backed points	2	0,8
Backed-truncated blades	2	0,8
Backed-truncated bladelets	33	13,2
<i>Microgravettes</i>	23	9,2
Geometrics	3	1,2
Trapezes	3	1,2
Retouched blades	4	1,6
Retouched bladelets	9	3,6
Truncated blades	2	0,8
Truncated bladelets	4	1,6
Blades	4	1,6
Bladelets	16	6,4
burin spalls	1	0,4
Others retouched	5	2
TOTAL	250	100

Tab. 7: Typological overview of the sample used for the use-wear analysis from Riparo Villabruna.

2.1. ANALYTICAL PROTOCOL

This study is divided on two phases. A first phase is more methodological in nature and provides clarifications in terms of terminology used next to an evaluation of the initial study performed during the Ruta's Master thesis (2014) about the archaeological site of Grotta di Pozzo. The second phase presents the results of a revised and extended functional analysis of the selected materials from Grotta di Pozzo and Riparo Villabruna.

2.1.1. Terminology

The terms “*projectile*” or “*armature*” are used here as generic names that include both tips (the “head” of the weapon system) and barbs (pieces positioned laterally) of all weapon types, independent of their projection mode (cf. Rots & Plisson, 2014). In the literature, the term “*impact fracture*” generally refers to a supposedly (cf. Coppe & Rots 2017) specific form of breakage and scarring that may occur on the tip of a lithic implement, or for some authors also on its edges or base, as a result of their use as hunting weapon. Given the fragility of the link between a certain fracture type and a specific cause, it has been avoided the use of the term impact fracture here and preferred the use of macro-damage and/or macro-fractures.

The terminology used for the first phase of the presented study is based on descriptions in the literature available up to 2014 (i.e., Fischer *et al.*, 1984; Plisson & Geneste, 1989; Caspar & De Bie, 1996; O’Farrell, 1996, 2004; Soriano, 1998; Christensen & Valentin, 2004; Chesnaux, 2008; Ziggotti, 2008; Borgia, 2008; Sano, 2009; Villa, 2009; Pétilion *et al.*, 2011; Taller, 2012; Sahle, 2013). The terminology and attribute system used in the second phase of this study heavily relies on the work of Coppe & Rots (2017). Their system is based on the principle that a fracturing phenomenon can be divided into three sequential mechanical phases: initiation, propagation and termination (see also Cotterell and Kamminga, 1979; Tsirk, 2014; Coppe & Rots 2017, fig. 2, p. 113). For the initiation, three categories are considered, *cone*, *bending* and an intermediate state (cf. Coppe and Rots 2017). For the propagation, the general direction is considered (i.e., *apex to base*, *base to apex*, *diagonal towards the apex/base*, *perpendicular to the long axis*, cf. Coppe and Rots, 2017) and its length as absolute value. For the termination, *feather*, *hinge*, *step*, *snap* (Cotterell and Kamminga, 1979; Ho Ho Committee, 1979; Tsirk, 2014; Coppe & Rots, 2017) are used as *simple* categories, next to *complex* or multiple terminations (cf. Coppe and Rots 2017). Groups of

terminations, referable to the same event are identified using the terms *juxtaposed* and *superposed*, while initiations or terminations that are removed by consecutive fractures are inventoried as *indeterminable* and *absent* (cf. Coppe & Rots, 2017) (Tab. 8). Moreover, also secondary removals such as *spin-offs* (i.e., initiate in cone from the termination of a bending fracture due to a compression phenomenon, cf. Coppe and Rots 2017) are considered. In contrast to Coppe and Rots (2017), a *burination* (i.e., a bending-initiated, elongated removal, propagated along one lateral edge of the specimen analogue to an intentional burin blow) is specifically separated out (Tsirk, 2014). Terms such as flute-like fractures and crushing are avoided, given their ambiguity (cf. Coppe & Rots 2017).

In addition, the following elements are registered: the location of the trace (*tip (distal), mesial* or *base (proximal)*); the location of the initiation and termination (*ventral, dorsal, lateral*, or, in the case of an initiation, an *earlier fracture surface*); the profile of the initiation (*straight, convex* or *concave*) (cf. Coppe and Rots 2017).

Attribute	Attribute state
Fractures composition	<i>single, multiple</i>
Initiation	<i>bending, cone, intermediate, absent, indeterminable</i>
Locus	<i>distal, mesial, proximal</i>
Location initiation	<i>dorsal, ventral, left lateral edge, right lateral edge, earlier fracture surface</i>
Profile initiation	<i>convex, concave, straight</i>
General direction	<i>apex to base, base to apex, diagonal towards the apex, diagonal towards the base, perpendicular to the long axis</i>
Propagation phase length	<i>absolute value</i>
Termination	<i>feather, hinge, step, snap, complex (x to y, x and y), absent, indeterminable</i>
Location termination	<i>dorsal, ventral, left lateral edge, right lateral edge</i>
Thickness termination	<i>absolute value</i>
Length fissure	<i>absolute value</i>
Fracture group	<i>fracture, removal</i>
Fracture part	<i>positive, negative</i>

Tab. 8: List of parameters used on the basis of the Attribute System presented in Coppe and Rots (2017: 112, Table 2).

2.1.2. Equipment

All samples selected for the first phase of this study (no access to reference collection; no formal training) have been analysed with a binocular microscope, more precisely a 200M stereomicroscope NIKON SMZ 1000/800, objective x1 and x2 and magnification x10 and x20, available at the *Università di Roma “La Sapienza”*, *Dipartimento Scienze dell’Antichità*.

During the second phase, the equipment from TraceoLab, *University of Liège*, has been used: all the selected materials have been analysed with an Olympus SZX7 (magnifications up to 56x) and a Zeiss Axio Zoom V16 motorized microscope

(magnification up to x180). When needed, the lithic materials have been cleaned using ethanol to remove grease from manipulation or other dirt.

During the analysis, the reference collection of TraceoLab has been used for training purposes and for comparing the fracture patterns on the archaeological pieces with a range of experimental materials. The collection consists of lithic materials used experimentally for different activities such as woodworking, hide working, drilling and perforating activities, etc. (e.g., Rots 2002, 2010), next to a range of projectiles, including tips and barbs (e.g., Rots, 2016; Coppe & Rots, 2017).

Possible alterations on archaeological artefacts were examined with an Olympus SZX7 (magnifications up to 56x). Artifacts have been drawn, divided into three parts (distal, mesial, proximal) and two faces (dorsal, ventral) and fractures/scars have been recorded. All fractures/scars have been analysed and described following the TraceoLab protocol and according to the parameters indicated in Table 8, using a database (cf. Coppe & Rots, 2017).

2.2. EVALUATION OF PHASE 1: TOWARD A RELIABLE ANALYTICAL PROTOCOL

2.2.1. Preliminary analysis on the basis of literature alone and without formal training

In the framework of a Master's thesis (Ruta, 2014), the material from Grotta di Pozzo was analysed with the purpose of identifying projectiles without formal training and mainly based on the comparison with published pictures in scientific

articles discussing impact fractures and projectile identifications (i.e. Frison, 1974; Bergman & Newcomer, 1983; Fischer *et al.*, 1984; Odell & Cowan, 1986; Shea, 1988; Geneste & Plisson, 1993; Caspar & De Bie, 1996; Dockall, 1997; Christensen & Valentin, 2004; Ziggiotti, 2008; Chesnaux, 2008; Sano, 2009, Taller *et al.*, 2012, Sahle, 2013). The work of Christensen (2004), Ziggiotti (2008) and Sano (2009) was used to help distinguishing impact scars from traces due to trampling, post-depositional process and knapping activities. These studies were judged appropriate given that the archaeological material they deal with is coherent with the material from Grotta di Pozzo in terms of chronology and morphology. Based on this literature, the following fracture types were considered diagnostic of impact (Fig. 20): bending initiated fractures with feather or hinge termination and width greater than or equal to 2 mm (cf. Chesnaux, 2008, pag. 6, 8, 12, fig. 2, 5, 10, 11a; Taller *et al.*, 2012, pag. 44, fig. 5; Christensen & Valentin, 2004), bending initiated fractures with a step termination (cf. Ziggiotti, 2008, pag. 18-20, fig. 5, 7, 8, 11; Taller *et al.*, 2012, pag. 44, fig. 5), flute-like and burin-like fractures (cf. Sano, 2009, pag. 79, fig. 18; Ziggiotti, 2008, pag. 18-20, fig. 5, 7, 8, 11; Taller *et al.*, 2012, pag. 44, fig. 5), spin-offs of any width (cf. Chesnaux, 2008, pag. 6, 8, 12, fig. 2, 5, 10, 11a; Taller *et al.*, 2012, pag. 44, fig. 5). Also crushing was considered as diagnostic.

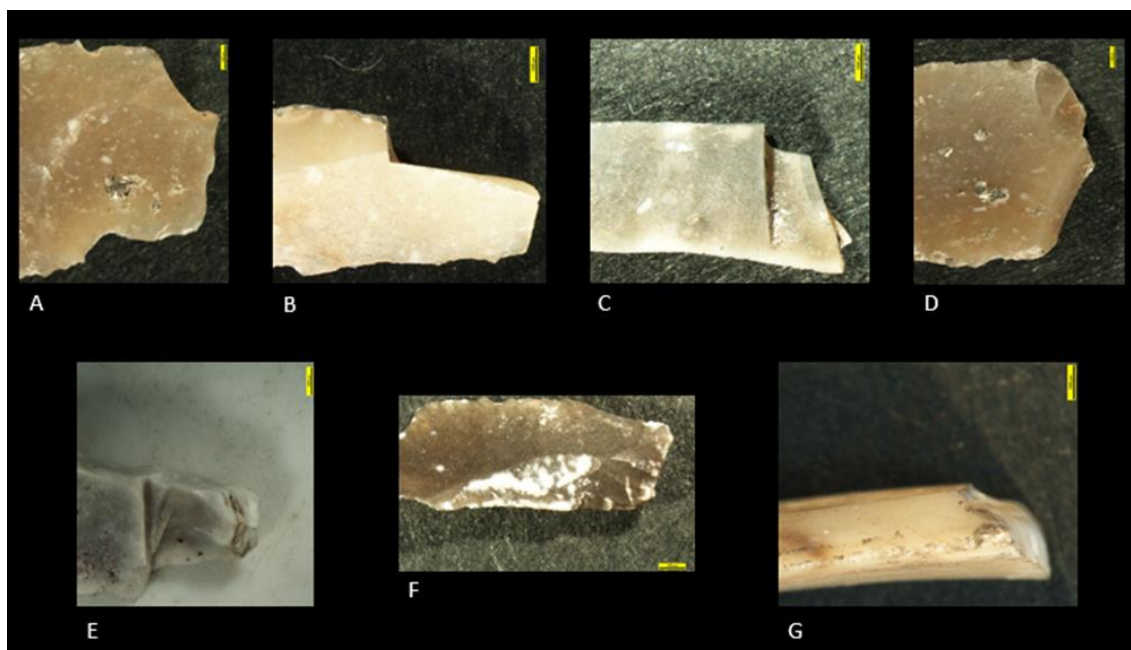


Fig. 20: Projectile points from Grotta di Pozzo identified during Ruta's Master thesis (2014) (scale bar = 1 mm). A: N° 7511 distal fragment of retouched bladelet with flute-like, ventral distal view (1° analysis). Wrong description because it is a bending initiated feather terminating removal (2° analysis); B: 7457 bladelet with burin-like, dorsal proximal view (1° analysis). Wrong description because the second analysis revealed that it is a lateral removal, bending initiated and feather terminated; C: N°7264 proximal fragment of bladelet with bending step fracture, ventral distal view (1° analysis). Right description but wrong terminology: it is a bending initiated step terminating fracture (2° analysis); D: N°7511 distal fragment of retouched bladelet with spin off, ventral proximal view (1° analysis). Wrong description, there are two different scars, both bending initiated feather terminating (2° analysis); E: N°1004 backed bladelet with crushing and step terminated fracture, dorsal proximal view (1° analysis). Wrong description because it is a cone initiated step to step terminating fracture (2° analysis); F: N°7469 fragment of bladelet with bending feather fracture, ventral view (1° analysis). Wrong description because it is a cone initiated feather terminating fracture (2° analysis); G: N°7443 fragment of microgravette with bending hinge fracture, left side view (1° analysis). Although the trace is correct, the description is bending initiated hinge terminating fracture (2° analysis).

On the basis of these criteria, fractures and scars were identified, localized and described on 227 artefacts (17%) and were at the time interpreted as being due to a use as projectiles. Surprisingly, a majority of these “identified” pieces concerned unretouched elements, being 148 pieces (65%), while only 79 (35%) retouched tools were interpreted as projectile. Only 24 identified specimens belong to the Early Epigravettian layers (15% from the total selection of this level) while 203 pieces derive from the Final Epigravettian layers (18% from the total selection of this level). The details are shown in Tab. 9. A total of 76% of the used pieces were manufactured on bladelets. A total of 341 “impact fractures” was registered,

predominantly showing what was assumed to represent a bending initiation and a step termination (36%).

	<i>1° Sample</i>		<i>2° Sample</i>	
Typology	n°	%	n°	%
shouldered bladelets	1	0,44	1	0,36
backed point	1	0,44	1	
backed blades	6	2,64	10	3,58
backed bladelets	46	20,26	79	28,32
backed-truncated bladelets	2	0,88	4	1,43
<i>Microgravettes</i>	7	3,08	15	5,38
retouched crested blade	1	0,44	1	
bladelet with notch	1	0,44	1	
<i>Gravette</i> points	1	0,44	1	0,36
retouched blades	2	0,88	5	1,79
retouched bladelets	11	4,85	13	4,66
Blades	23	10,13	23	8,24
Bladelets	99	43,61	99	35,48
Flakes	18	7,93	18	6,45
burin spalls	4	1,76	4	1,43
Indeterminable	4	1,76	4	1,43
TOTAL	227	100	279	100

Tab. 9: Typological composition of the samples analysed for macro-fractures. The 2nd sample was analysed with access to a reference collection.

Subsequent discussions with specialists have cast doubt on these interpretations and their reliability. Both the descriptions and photographic documentation were highly suggestive of the fact that fracture mechanics and terminology were poorly understood. All functional interpretations thus had to be revisited.

2.2.2. Problems raised

After discussions with experts, we noted two problems with regard to the results of the initial analysis. Firstly, due to a lack of experience, published descriptions were misunderstood and fractures identified as being due to impact were actually due to other causes (including knapping accidents) and thus not diagnostic for projectiles (Tab. 10). Secondly, fracture types considered as diagnostic of impact were understood too broadly and no attention had been devoted to a combination of features even though it has been argued previously that trace patterning is essential for reliable functional interpretations (cf. Rots & Plisson, 2014).

1° approach	2° approach							
	Production		Possible impact		Indeterminate		No fracture	
	N	%	N	%	N	%	N	%
Bending initiation (N=156)								
<i>Feather termination (N=13)</i>	12	92%	1	8%				
<i>Hinge termination (N=19)</i>	17	89%	1	5%			1	5%
<i>Step termination (N=124)</i>	97	78%	7	6%	19	15%	1	1%
Burin-like (N=69)	55	80%	6	8%	8	12%		
Flute-like (N=66)	63	95%	2	3%	1	2%		
Spin-off (N=47)	38	81%	5	11%	4	8%		
Crushing (N=3)	3	100%						
TOTAL (N=341)	285	84%	22	6%	32	9%	2	1%

Tab. 10: Fractures identified as due to projectile use after Ruta (2014) and after re-analysis.

A key problem proved to be the lack of knowledge with regard to what fractures may result from production. Indeed, the 84% of the fractures and removals considered as being caused by impact in the initial analysis are probably due to production, such as for example the so-called flute-like fractures located in the

ventral proximal area of the artifact. The latter fracture is a common knapping accident, also termed *errailure* flake or bulb scar, where a chip is removed through contact of a dominant force wave that creates the conchoidal flake and inferior waves due to an excessive force being applied in the removal of the flake (Hiscock, 1997; Collins, 1999; Clarkson and O’Connor, 2013, pag. 157, fig. 6.3). Also some other fractures, including some of the fractures described as “bending step fracture” (note: correct qualification would be “bending initiated fracture with step termination”), and “burin-like” fracture (here called “burination”) proved to be in fact knapping mistakes. Also spin-offs were not correctly understood at the time. By definition, spin-offs are secondary removals with cone initiation that initiate from the termination of a bending fracture due to a compression phenomenon (cf. Coppe & Rots, 2017), but in Ruta’s Master thesis, the term spin-off was incorrectly used for scars without a true relation to the fracture phenomenon (Tab. 11). After re-evaluation, it became clear that the described scars may have been caused by various phenomena, including production, trampling or post-depositional processes. Also descriptions of the fractures proved to be fragmentary, confusing, incomplete and non-systematic.

Ruta (2014) terminology	New terminology
bending feather fracture	bending initiation feather termination fracture
bending hinge fracture	bending initiation hinge termination fracture
bending step fracture	bending initiation step termination fracture
bending snap fracture	bending initiation snap termination fracture
burin-like fracture	Burination
spin-off (wrong detected)	spin-off according to the definition presented in Coppe and Rots (2017)
Crushing	not considered
flute-like fracture	not considered

Tab. 11: Terminology in Ruta (2014) and later on in re-analysis.

Another important issue was the fact that in many cases the identification of projectile use relied on one trace only, which has been argued to be unreliable (cf. Rots & Plisson, 2014). Even if the interpretation of 6% of the pieces was partially

correct (though incomplete), other traces should not have been ignored (e.g., Fig. 20G).

With hindsight, it proved difficult to base an analysis of lithic materials on images and literature only. Projectile identification proved to require a good understanding of fracture formation, of the different causes that may result in fractures, and of the variation in fractures types depending on the cause. Without any formal training, access to a reference collection and experimentation, an adequate understanding of fractures proved impossible. The advantages of experimentation are multiple, other than allowing to understand the impact of particular variables, the understanding of fracture mechanics and the creation of a reference collection, it also allows the analysis of tools before and after use providing thorough insight into fractures caused in production or in use. A formal training by an expert may also facilitate the learning process, in particular with regard to appropriate analytical protocols, the adequate use of terminologies, accurateness in descriptions, etc. An experimental reference collection that is continuously available during the analysis of archaeological material permits a systematic comparison of traces observed on archaeological materials with experimental examples. The analytical protocol used in Ruta's Master thesis (2014) did not respect any these important elements, which largely explains the difficulties encountered during the study and the questionable reliability of the results.

These problems were only highlighted during subsequent discussions with specialists and it became clear that the number of projectiles was likely significantly over-estimated. A complete re-evaluation was thus necessary and this was performed in association with a training program at TraceoLab, *University of Liège*. This second phase called into question the results presented in the Master study of Ruta (2014) and it is now clear that these have to be considered as incorrect.

Also the macro-fractures analysis of the materials coming from Riparo Villabruna needs a reliable method, that, seeing the previous difficulties, cannot be an incorrect one because it is dangerous in terms of interpretation of the results. So,

for the study of the macro-damages of the lithic materials coming from the archaeological sites of Riparo Villabruna and Grotta di Pozzo it has been applied the strong method, connected to a reference collection, indicated on the Phase 2.

2.2.3. Training

Taking into consideration the shortcomings on the first phase of the research, training focused on the distinction between fractures from projectile use and those resulting from knapping or retouch accidents, trampling, post-depositional phenomena, or other tool uses.

Therefore, large parts of the Traceolab experimental reference collection were examined as part of the learning process, including tips and barbs (e.g. Rots, 2016). The collection consists in lithic materials experimentally used in different kind of activities: drilling, intentional fractures, trampling, knapping, woodworking, hide working, free use, transport tranches/earth working, storage, controlled – constant parameters/hafting (Rots, 2010, 2016; Coppe & Rots, 2017).

Training also extended towards understanding fracture mechanics, the use of adequate descriptive terms for fractures and the difference between fracture description and interpretation. Also knapping experiments were performed and the resulting blanks were analysed.

2.3. THE ANALYTICAL PROTOCOL OF PHASE 2: DESCRIPTION AND INTERPRETATION

The use-wear analysis of the archaeological materials during Phase 2 has followed two main steps: description and interpretation. All 227 pieces interpreted as

projectile points during the Ruta's Master thesis were re-analysed and re-evaluated. In addition, the lithic assemblage was re-screened and an additional 52 lithic tools were selected on the basis of features unknown or unrecognized before training. In sum, the total number of pieces considered in this study for Grotta di Pozzo is 279 artefacts (29 Early Epigravettian, 250 Final Epigravettian) (Tab. 9).

The same method was applied for the archaeological materials coming from Riparo Villabruna, related to Final Epigravettian layers (14,400 – 13,800 cal. BP). In sum, the total number of pieces analysed is 250 artefacts (Tab. 7).

The selected lithic materials were evaluated according to the attribute system discussed earlier and initially proposed by Coppe & Rots (2017) (see also Tab. 8). In contrast to Phase 1, also lateral removals were considered.

Depending on the number and the kind of fractures, a piece was attributed to one of four probability categories in terms of its use as a projectile point:

- **1° group:** projectile identifications with the highest level of confidence. Ideally, pieces show fractures with complex terminations on the tip, associated with secondary removals; oriented removals on the lateral edge; and fractures on the base. On an experimental level, this combination of fracture features has been observed to be reliable for projectile identification in comparison to other possible causes (e.g. production, trampling, post-depositional, other uses) (Fig. 21, 22);
- **2° group:** the same fracture features as for the 1st group are observed, but not all three categories of traces occur in combination resulting in a somewhat less convincing overall pattern even though bending initiated fractures with complex termination occur. Tools placed in this category are identified as projectiles with moderate level of confidence (Fig. 23A);
- **3° group:** only one of the three categories of fractures listed for the 1st group is visible and the identification of the piece as projectile is uncertain (Fig. 23B). Fractures are generally on one of the three part of the tool and fractures predominantly have simple termination;

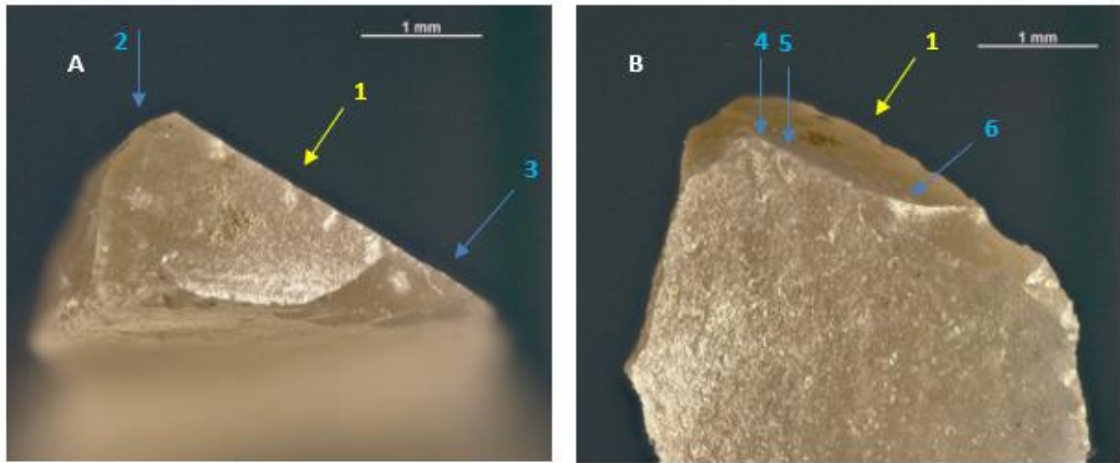


Fig. 21: N° 1407: Backed bladelet used as armature from Grotta di Pozzo (magnification 47.5x), ventral tip view. A: Bending initiated snap terminating tip fracture (1) with secondary removals (2, 3) that cut the retouched edge. B: The fracture (1) is associated with spin offs (4, 5, 6,) due to counter pressure phenomenon. 1° group recognized as barb on the basis of the fracture patterns, including compression phenomena (cf. Rots 2016, fig. 12.13, p. 180).

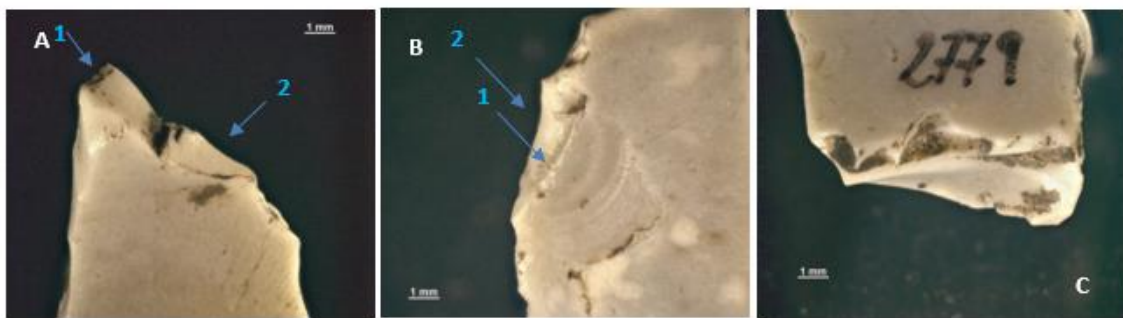


Fig. 22: N° 2779: Backed bladelet used as armature from Grotta di Pozzo (A: magnification 7.8x; dorsal tip; B: 17.2x, ventral face; C: 18.0x ventral base). A: Oblique fracture (1) that cut the retouch part with bending initiation from the left lateral edge with hinge to step fissured termination superposing an earlier fracture surface (bending initiated step terminated) (2); B: lateral removal (1) step terminated of which the initiation is removed by another lateral removal (2) bending initiated step and feather terminated; C: proximal fracture bending initiated step terminated associated to multiple removals. 1° group recognized as barb for the particular tip fracture associated and combined with fractures/removal along the tool.

- **4° group:** insufficient traces are visible due to which the piece cannot be considered as a possible projectile. Fractures may occur but these are isolated and not associated with other evidence. Traces may have been caused by another phenomenon than projectile use.

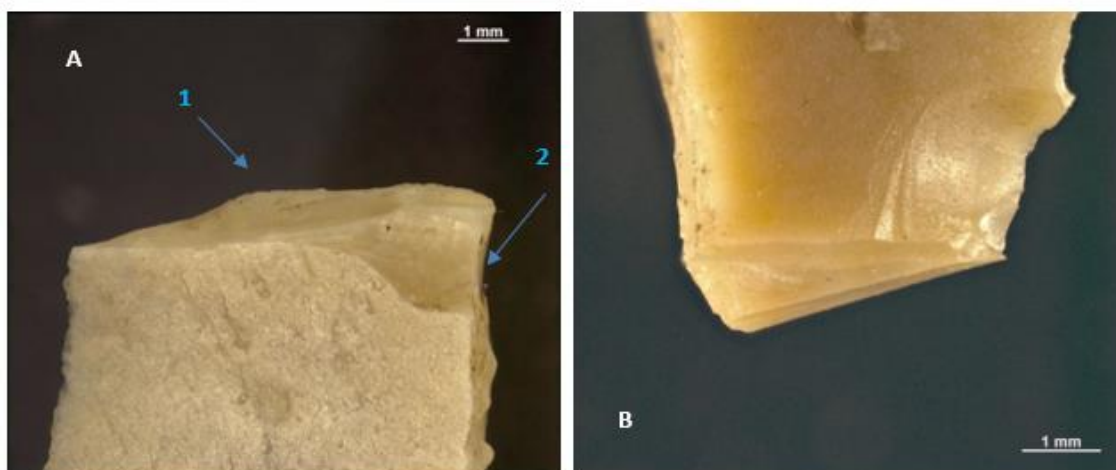


Fig. 23: Backed bladelets used as armature from Grotta di Pozzo. A N° 1390 tip fracture (1) on ventral face bending initiated snap and hinge terminated on the retouched part due a counter pressure event. The main fracture occurs at the same moment as the lateral one (2) bending initiated hinge terminated (magnification 20.5x). 2° group, indiscernible between tip and barb. B: N° 7459 ventral base view, base fracture bending initiated step terminated that cuts the lateral removal bending initiated step terminated and the retouch part. 3° group considered as a possible barb for the lateral fractures and the proximal fracture on one corner (magnification 30.0x).

In addition to the identification of projectiles, this second phase of analysis also focused on evaluating whether the position and orientation of the armatures could be identified and whether evidence existed for tips and/or barbs. It has been proposed that a combination of different fracture characteristics and their distribution over the lithic element may permit such a distinction (cf. Rots, 2016; Tomasso *et al.*, 2018). Experimental arrowheads and barbs available in the reference collection of TraceoLab were examined in order to understand the traits that may be considered useful for a distinction, in line with the propositions of Rots (2016). Although tool morphologies of the experimental pieces examined in this study are not identical to the archaeological ones, which is not ideal, the general characteristics of the traces and their distribution were nevertheless taken into consideration and their usefulness was evaluated for the material of Grotta di Pozzo and Riparo Villabruna. On the basis of the experimental evidence of Rots (2016) and the kind of traces including their patterning, the position of the archaeological armatures has been evaluated. For instance, tips were expected to show damage concentrated around the apex (e.g. bending-initiated step-terminating fracture) and the adjacent edges while a barb was expected to (also) show sliced scarring along one lateral edge and/or proximal damage on the

proximal extremity (cf. Rots, 2010, 2016) (Fig. 23B). It needs to be emphasized that similar fractures may occur on both tips and barbs, for example spin-offs, burinations, lateral scarring (cf. Rots, 2016, fig. 12.9, 12.10, 12.13), and that the key lies in their combined occurrence and patterning. When little damage is visible or no patterning can be identified, a distinction between barbs and tips is not possible.

2.4. OTHER POSSIBLE USES

2.4.1. *Dental treatment*

As reported in chapter 1.2, Riparo Villabruna is famous for the discovering of a burial of an adult male of 25 years old, identified as a hunter-gatherer for the presence of funerary goods. Recently, the dentition of this individual has been analysed in order to eventually find human manipulation on those teeth (Oxilia *et al.*, 2015). The results documented the earliest evidence of dental caries intervention on a Late Upper Palaeolithic modern human specimen. Using SEM, striations were observed that were interpreted as deriving from the manipulation of a large occlusal carious cavity of the lower right third molar, which also was confirmed experimentally. Those striations appear to have been produced *ante-mortem* with pointed flint tools during scratching and levering activities (Oxilia *et al.*, 2015).

During the use-wear analysis of the lithic materials focused on an evaluation of the presence of macro-fractures and the potential presence of projectile points, some fragmented backed points showed ambiguous wear patterns. In particular, the elements N° 1187 and N° 1241 exhibited fractures and scars not comparable with the experimental materials due to the use of projectile point and other uses. Basing

on pictures (Fig. 24), those fractures apparently were analogues with the pictures published in Oxilia *et al.* (2015) related of experimental backed points used for dental caries intervention use (Oxilia *et al.*, 2015, Supplementary Information, Fig. S8, p. 12). Therefore, it was questioned whether these traces could correspond to dental caries intervention. In order to test this hypothesis, experiments are performed in combination with use-wear analysis to evaluate whether the observed damage patterns could indeed be caused by scratching enamel and dentine in view of dental treatment.

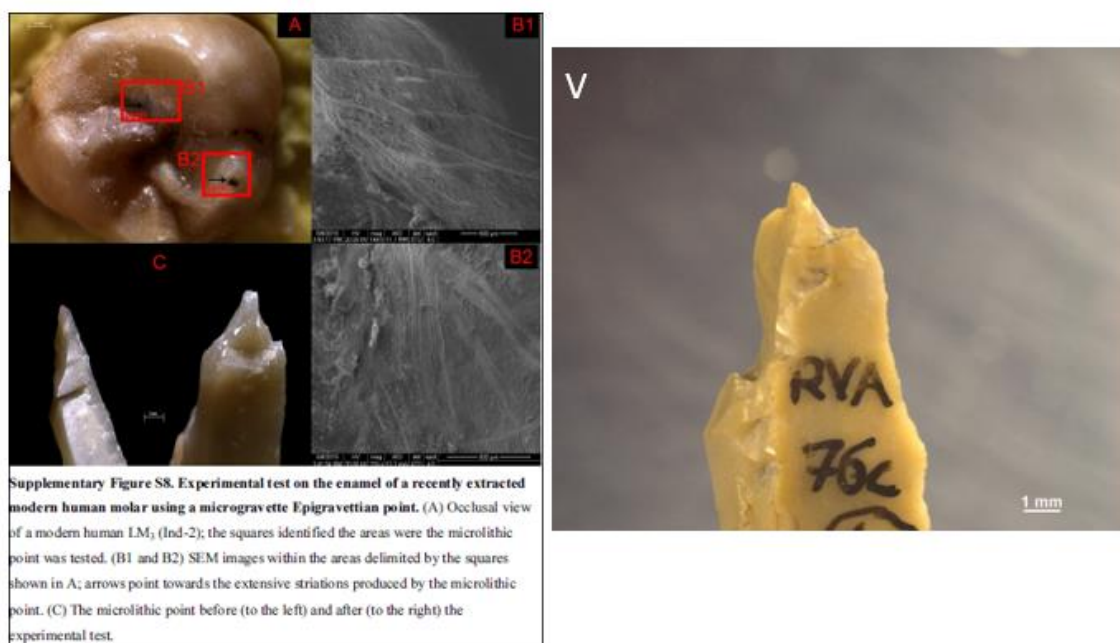


Fig. 24: Comparison between the experimental point used for dental treatment (Oxilia *et al.*, 2015) and a fragment of backed bladelet N° 1241 coming from Riparo Villabruna.

2.4.1.1. Experimental set

The experimentation set consists of 8 backed points comparable to those found in the archaeological site of Riparo Villabruna and third fresh molars teeth of modern humans with caries. The backed points are coherent with the blade-bladelet production of Final Epigravettian lithic industries (Tab. 12).

It has been used two types of raw material: 2 pieces realized with a grey to beige Majolica chert and other 6 pieces with Red chert coming from the Italian Dolomites. Moreover, the knapping technique adopted is direct percussion with soft hammer and, for the retouch, indirect percussion with soft hammer and pressure with antler of deer (Fig. 25). All these pieces have been analysed before the experimentation by stereomicroscope, making pictures, in order to avoid scars due to knapping events.

ID	#	L	w	Th	Typology	Cortex	Raw material	Alteration
1	RV- EXP1	39	7	5	Backed point	5%	scaglia rossa	Tip scar (prod.)
2	RV- EXP2	37	7	3	Backed point	5%	scaglia rossa	Tip scar (prod.)
3	RV- EXP3	34	7	3	Backed point	0	scaglia rossa	
4	RV- EXP4	38	6	3	Backed point	0	scaglia rossa	Tip scar (prod.)
5	RV- EXP5	44	9	4	Backed point	5%	scaglia rossa	
6	RV- EXP6	41	7	4	Backed point	0	biancone	Base scar (prod.)
7	RV- EXP7	30	6	5	Backed point	0	biancone	
8	RV- EXP7	36	7	2	Backed point	0	biancone	Base scar (prod.)

Tab. 12: Experimental backed points before the experiment for dental treatment.

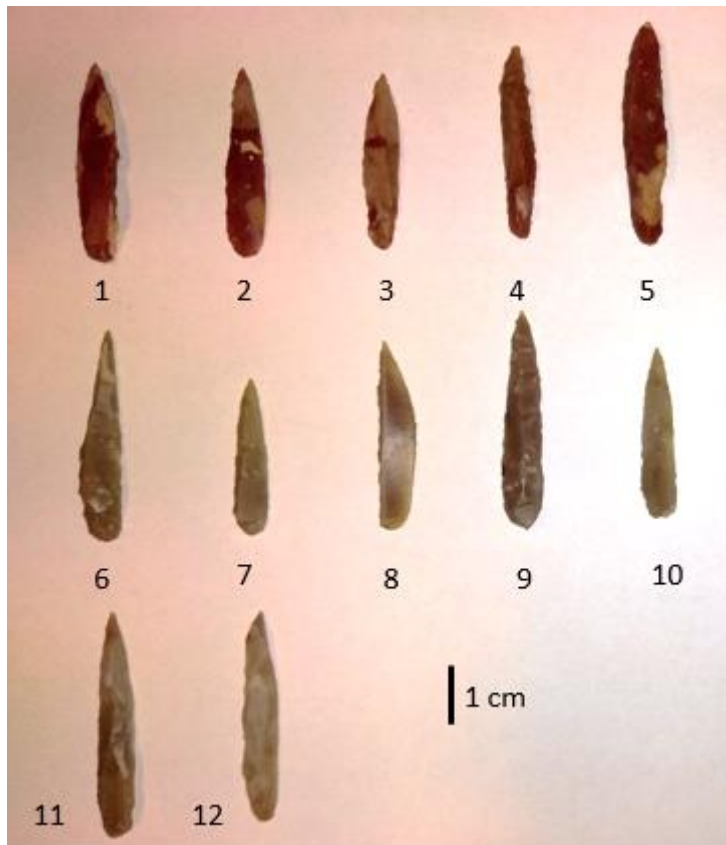


Fig. 25: Experimental backed points: 1-8 for EXP. 1-7, 9-12 for EXP. 8-11.

There have been selected 5 fresh third molars teeth of modern humans with caries, thanks to different dentists that were gently available to donate them from previous patients. The teeth were put in a specific liquid used by the dentist for the sterilization. The tooth A is a third right molar of a male of 37 years old, the tooth B is a third left molar of a female of 27 years old, the tooth C is a third right molar of a male of 30 years old and the teeth D and E third right and left molars of a female of 50 years old (Fig. 26).

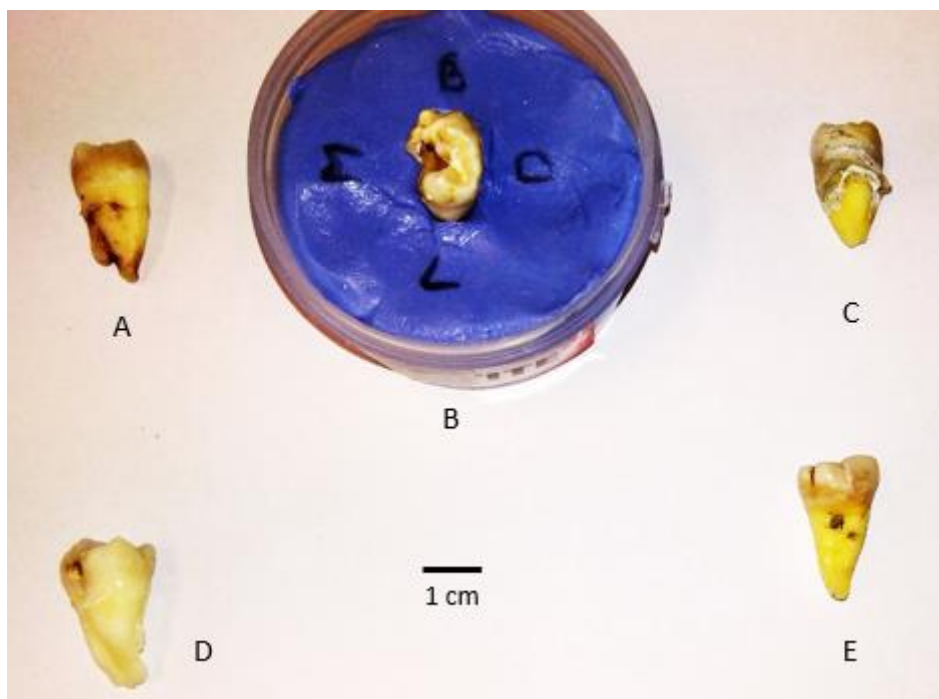


Fig. 26: Experimental fresh third molars teeth of modern humans with caries.

Furthermore, the creation of the right experimental gesture is essential to make the experimentation as much reliable as possible. For this reason, it has been decided to develop a replica of a mandible to recreate the right movement during the activity of caries removal (Fig. 27). It has been used a dentist plastic box for the shape of the mandible. It has inserted inside cold water (Fig 27.1). To setting up the gingiva, it has been prepared a glue with the 30% of resin and 70% of beeswax, warmed with fire and insert inside the plastic box (Fig. 27.2). The cold water outside the box permits to avoid the fusion of the plastic box. In the meantime of the glue cooling, there are positioned in sequence the fresh teeth A, C, D, E, as to recreate molar part of the mandible (Fig. 27.3, 27.4). Moreover, the experimental mandible has been blocked with a complex system of lever with wood as to avoid movement during the experimentation (Fig. 27.5). Lastly, cheeks have been created on the lateral side of the mandible with polyester (Fig. 27.6).



Fig. 27: Creation of experimental mandible. 1: dentist plastic box inside cold water; 2: gum reconstruction with glue (30% resin/70% beeswax); 3: placement of teeth; 4: mandible with four third molars with caries in sequence; 5: blocking of mandible open; 6: cheek of mandible.

2.4.1.2. *The archaeological sample*

The selected 250 archaeological materials from Riparo Villabruna used for the impact-related analysis (Tab. 7) were screened again in order to recognize use-wears comparable with perforation or drilling damage, selecting 26 backed points and fragmented backed bladelets (Fig. 28). A further selection has been done from this number and, at the end, 10 backed points and fragmented backed bladelets were considered the candidates for this analysis and for the comparison with the experimental materials (Tab. 13). There have been reported all the techno-

morphometrical parameters on a database and analysed following the Attribute Based System (Cf. Coppe & Rots, 2017).



Fig. 28: The selected archaeological materials from Riparo Villabruna.

ID	Raw material	L	w	Th	Typology	Alteration
1250	Biancone	27	7	3	Backed bladelet	Dist. Fracture
1251	Biancone	25	4	3	Backed bladelet	Dist.+prox. Fractures
1252	Biancone	23	5	3	Backed point	Prox. Fracture
1253	Biancone	21	5	3	Backed point	Dist. Fracture
1254	Biancone	17	3	3	microgravette	fratt prox?
1031	Biancone	19	4	2	microgravette	Prox. Fracture
1241	Biancone	19	5	4	Backed bladelet	Dist.+prox. Fractures
1139	Biancone	24	6	3	Backed bladelet	Prox. Fracture
1189	Biancone	19	6	3	Backed bladelet	Prox. Fracture
1187	Biancone	45	7	4	Backed point	

Tab. 13: Archaeological materials from Riparo Villabruna used as comparison for the two experiments.

2.4.1.3. The experimental activity

ID TOOL	ID TOOTH	ACTION	DIRECTION	INCLINATION	TIME	LOCATION OF ACTION
1	A	Clockwise rotation, levering, twisting	distal->mesial	60° - 80°	7' 56''	lateral external and on the top drilling, molar hold by hand
2	E	shaving, clockwise rotation, levering	buccal->lingual	60°-70°	2' 47''	lateral external
3	E	shaving, cutting by right edge, levering	distal->mesial	75°	5' 38''	on the top
4	E-D	levering, clockwise rotation, scraping, twisting, shaving		60°-70°	2' 42''	in between
5	E	scraping, shaving, levering	distal->mesial	70°-75°	6' 2''	lateral internal
6	E	Shaving scraping, levering	distal->mesial, lingual->buccal	60°-75°	4' 53''	lateral internal, lateral external, in front, with cheeks
7	A-C	lateral scraping , shaving	buccal->lingual, lingual->buccal	50°	50''	toothpick. Lateral external, internal. 1° use
8	C-D	lateral scraping , shaving	buccal->lingual	50°	47''	toothpick, lateral external, 1° use
7	A-C	lateral scraping , shaving	buccal->lingual, lingual->buccal	50°	1' 9''	toothpick. Lateral external, internal. 2° use
8	C-D	lateral scraping , shaving	buccal->lingual, lingual->buccal	50°-60°	1' 9''	toothpick. Lateral external, internal. 2° use

Tab. 14: Details about the experiment of dental treatment with backed points.

There were performed a total of seven types of experiments, trying to apply different possible gestures during the removal of caries through flint tools on fresh third molar teeth (Tab. 14).

The first experimentation (EXP 1) was performed using the experimental backed point N° 1 and the tooth A. The tooth was held by hand, trying to remove the caries through the backed point with levering and scraping actions at 60°-80° of inclination (Fig. 29). Since the beginning, the point was damaged but it was possible to remove a small portion of caries. The problem was the hardness of the enamel that scratch the point due to rotation movement and the contact with the lateral side of the tooth. This experimentation ended at 7' 56'' because the point was too much damaged to remove caries. In the Fig. 29, it is showed the experimental backed point N° 1 before and after the experiment. The first experimentation was a good test but we realized that it was not the best gesture in a real situation of caries removal on human being. So, it was decided to recreate a replica of human mandible in order to start the followed six experimentations.

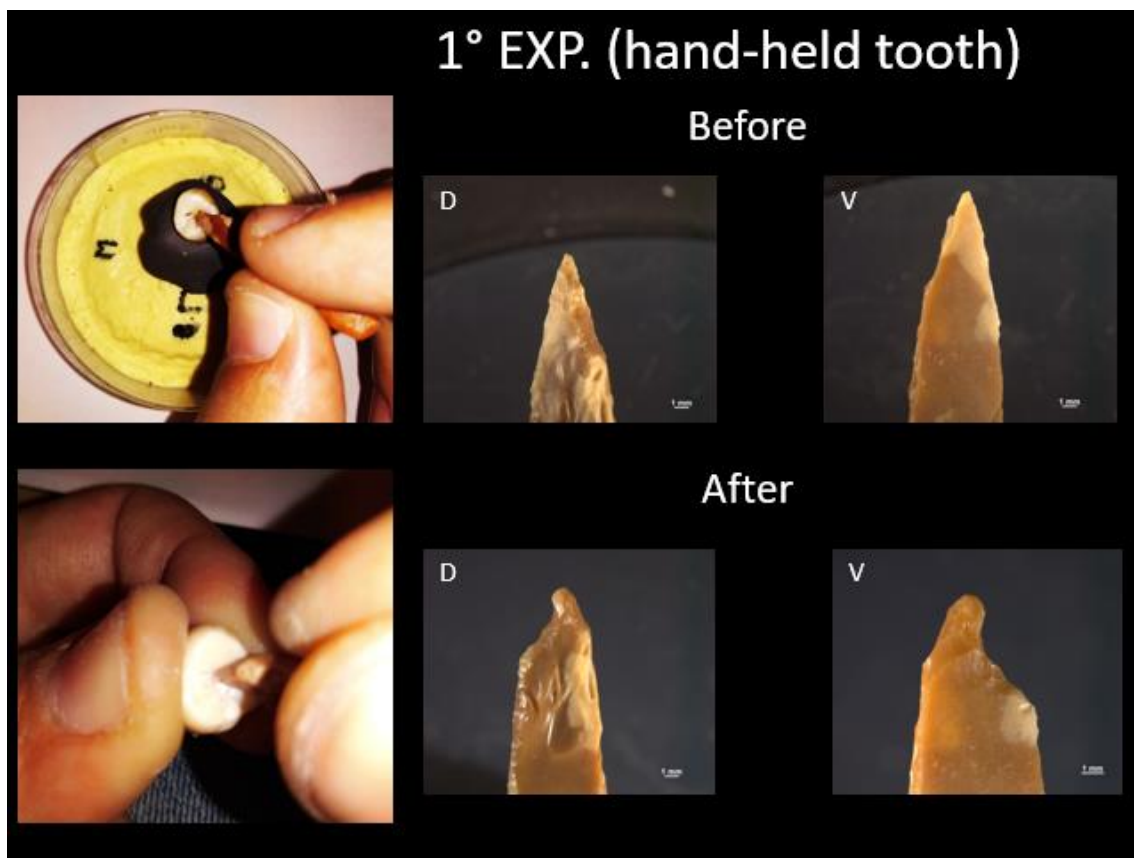


Fig. 29: EXP. 1, backed point N° 1 and tooth A. On the left, the gesture adopted, on the right the differences before and after the experiment on the lithic point.

The second experimentation (EXP 2) was performed using the experimental backed point N° 2 and the tooth E. The backed tool was held by hand with lateral

external direction of removal, with inclination of 60°-70° and making scraping, rotation and levering actions (Fig. 30). This experiment ended after 2' 47'' because the point was broken and unusable. Anyway, it was removed a little portion of caries and the gesture seems that was better than before. In the Fig. 30, there is showed the experimental backed point N° 2 before and after the experiment.

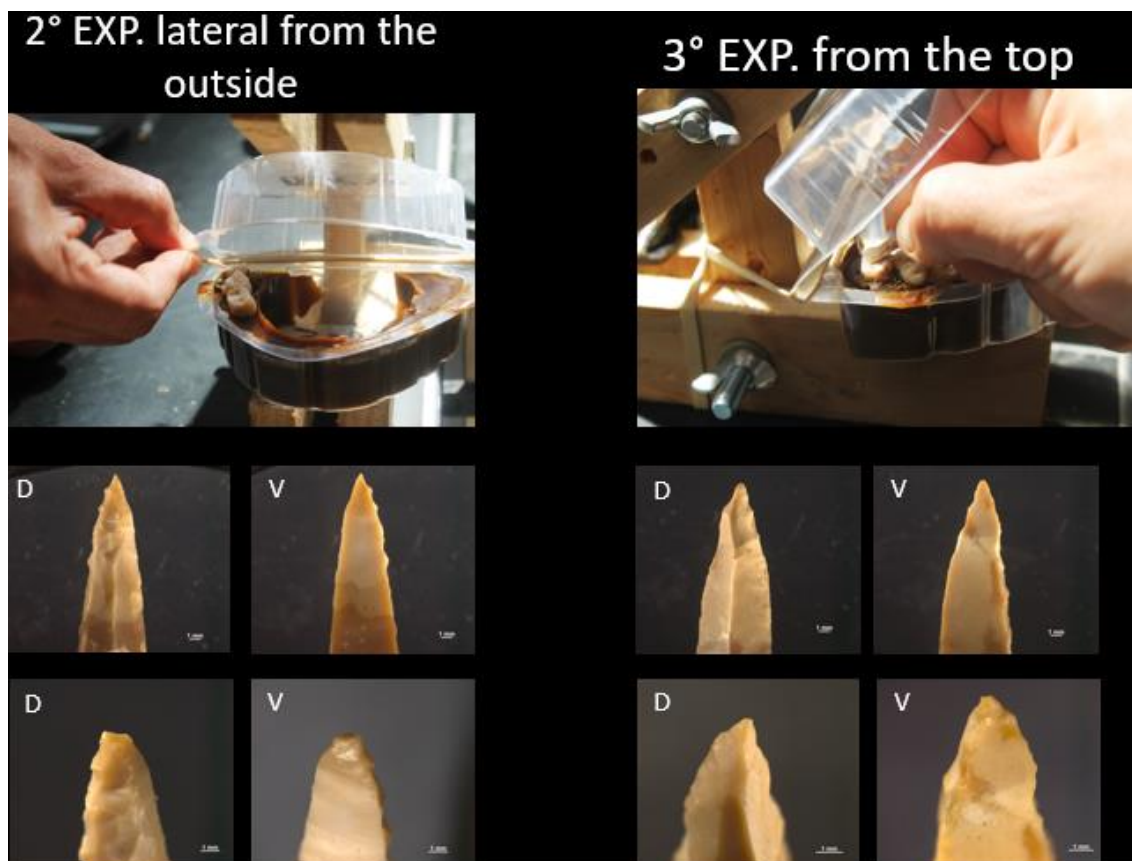


Fig. 30: EXP. 2 on the left, using the backed point N° 2 and tooth E; EXP. 3 on the right, using the backed point N° 3 and tooth E.

The third experimentation (EXP 3) was performed using the experimental backed point N° 3 and continuing with the tooth E because there still was presence of caries. The backed tool was held by hand with direction of removal from the top of the tooth, with inclination of 75° and making scraping, levering and cutting actions (Fig. 30). The duration of the experiment was 5' 38'' because the point was unusable. It was noted that the use of the point is more difficult than the EXP 2 but useful for the caries removal. It was impossible to use the tip of the point for the inclination of the gesture and the morphology of the mandible. So, it was used the

right edge of the point by cutting and scraping actions. In the Fig. 30 there is showed the experimental backed point N° 3 before and after the experiment.

During fourth experiment (EXP 4) it was used the backed point N° 4 and the teeth E and D. The backed tool was held by hand and the gesture adopted was in between two teeth, with inclination between 60°-70° and making levering, rotation, scraping, twisting and shaving movements (Fig. 31). The duration of the experiment was 2' 42''. This was hardest movement: the tooth has made a lot of resistance in the lateral side due to the presence of enamel and it was removed just a small part of caries. Furthermore, there was more damage in the point. It was decided to stop the experiment because it was considered not useful for the caries removal. In the Fig. 31 there is showed the experimental backed point N° 4 before and after the experiment.

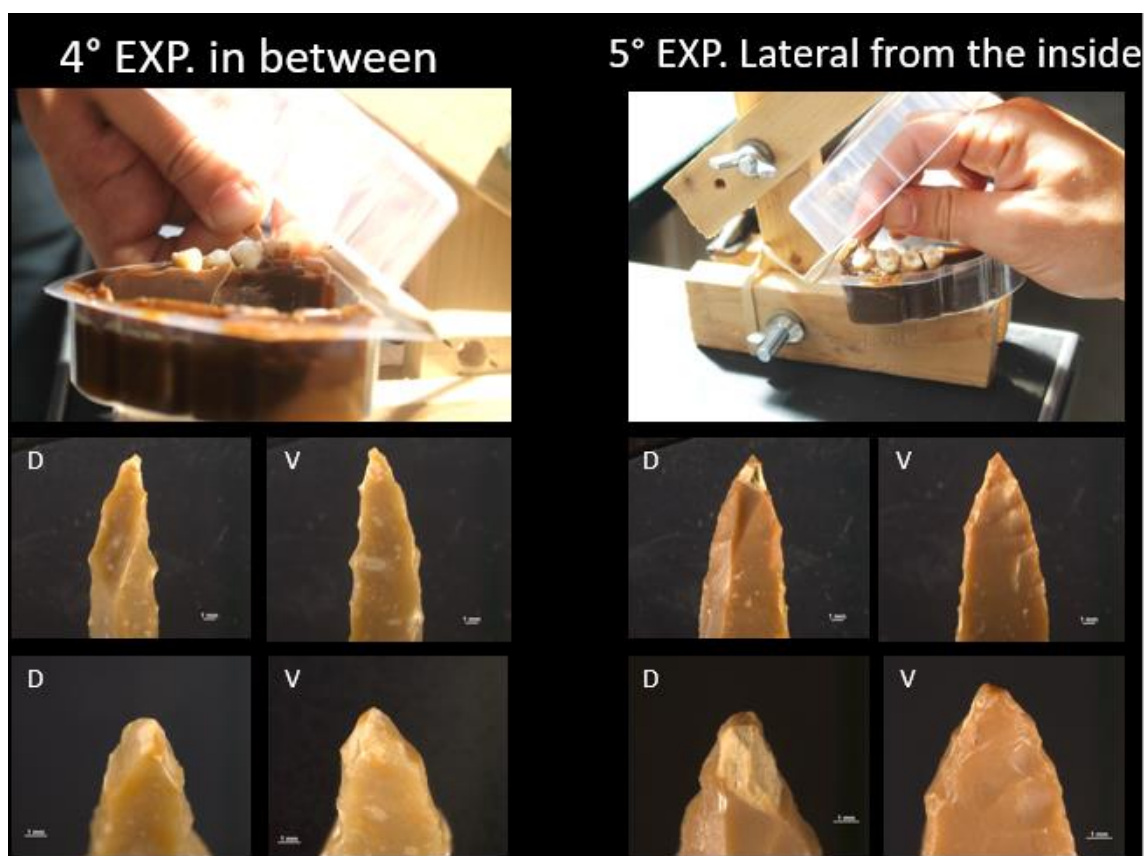


Fig. 31: EXP. 4, using the backed point N° 4 and teeth E and D; EXP. 5, using the backed point N° 5 and tooth E.

The fifth experiment (EXP. 5) was performed using the experimental backed point N° 5 and the tooth E. The backed point was held by hand with lateral internal

direction of removal, with inclination between 70° - 75° and making scraping, shaving and levering actions (Fig. 31). The experiment ended at 6' 2''. The movement was difficult but it seems that was working better than before and it has been removed a big portion of the caries. It was impossible to make the rotation gesture so the movements were shaving and scraping. In the Fig. 31 there is showed the experimental backed point N° 5 before and after the experiment.

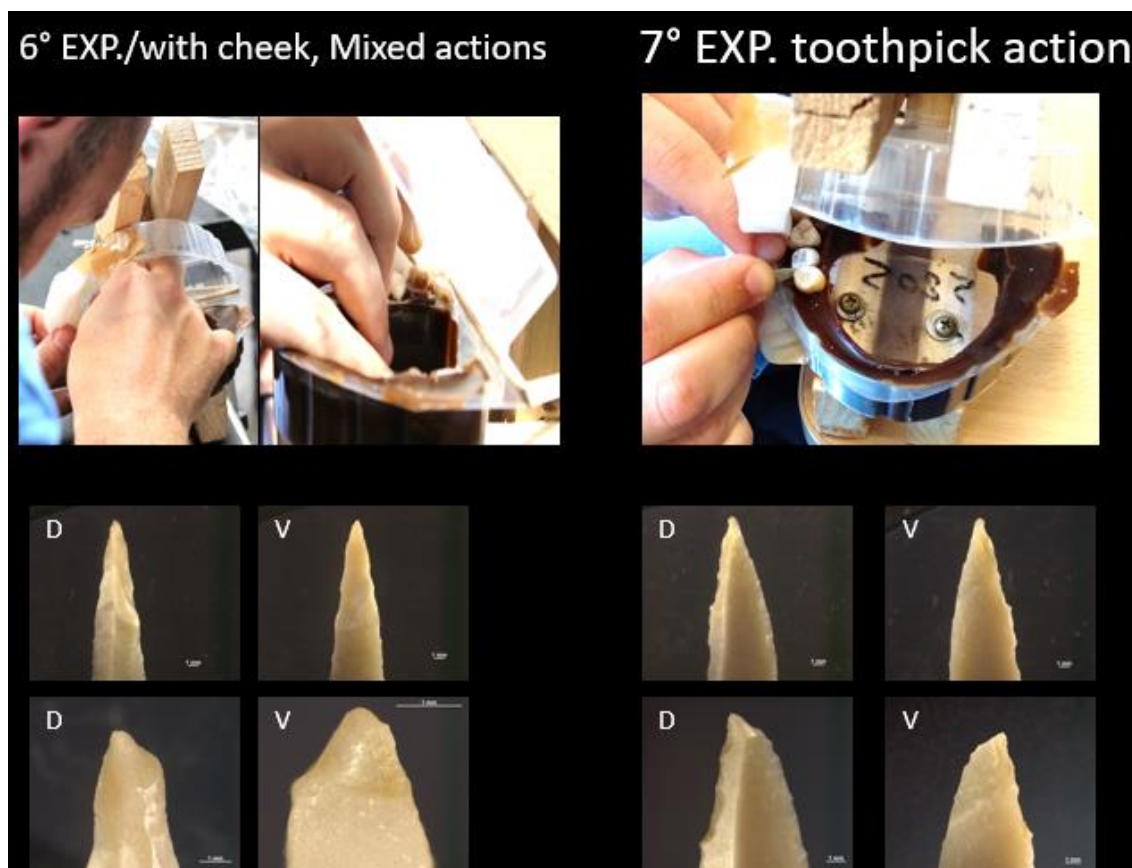


Fig. 32: EXP. 6, using the backed point N° 6 and tooth E; EXP. 7, using the backed point N° 7 and teeth A-C.

Furthermore, during the sixth experiment (EXP. 6) it was inserted polyester on the sides of mandible to recreate the cheeks. There were used the experimental backed point N° 6 and the tooth E. The backed point was held by hand with multiple direction of removal, such as lateral internal, lateral external and from the top, with inclination between 60° - 75° and making shaving, scraping and levering actions (Fig. 32). At 4' 30'' the point was broken and the experiment finished at 4' 53''. It was noted that was difficult reach the tooth. The action was combined and focused on the removal of the caries and the position of the tooth was not helpful.

There were used both part (ventral and dorsal) of the point. In the Fig. 32 there is showed the experimental backed point N° 6 before and after the experiment.

The last experimentation consisted of the use of backed points as toothpicks (EXP. 7). There were used the experimental backed points N° 7 and N° 8 on the teeth A-C and C-D, respectively. The point was held by hand, with inclination between 50°-60°, making lateral scraping and shaving actions. (Fig. 32) For the point N° 7 the experiment finished at 1' 59'', for the N° 8 at 1' 56'', because in a certain point the tip has been broken. This experimentation has been done in order to try to clean the teeth in between from hypothetical food and tartar. In the Fig. 32 there is showed the experimental backed point N° 7 before and after the experiment.

2.4.1.4. Analysis of the experimental data

ID.	#	L	W	Th	Raw material	use	Alteration
1	RV-EXP1	35	7	4	scaglia rossa	A, hold by hand	Distal fracture
2	RV-EXP2	36	7	3	scaglia rossa	E, lateral from the outside	Distal fracture
3	RV-EXP3	34	7	3	scaglia rossa-variegata	E, from the top	Distal fracture
4	RV-EXP4	37	6	3	scaglia rossa	E-D, in between	Distal fracture
5	RV-EXP5	43	9	4	scaglia rossa	E, lateral from the inside	Distal fracture
6.1	RV-EXP6	7	3	2	Biancone	E with cheek, mixed action	Distal and proximal fracture
6.2	RV-EXP6	33	7	4	Biancone	E with cheek, mixed action	Distal fracture
7	RV-EXP7	28	6	5	Biancone	A-C, toothpick, 1° and 2° try	Distal and proximal fracture
8	RV-EXP7	34	7	2	Biancone	C-D, toothpick, 1° and 2° try	Distal fracture

Tab. 15: Experimental backed points after the experiment for dental treatment.

The experimental materials were analysed by stereomicroscope in order to identify and describe macro-wears (Tab. 15).

Firstly, there is a reduction in the length of the points, a variation between 4-8 mm, due to the perforating action during the experiment. Using the Attribute Based System (cf. Coppe & Rots, 2017), traces have specifically been described. Fractures and removals are connected to perforating damage that, unfortunately for us, may happen on several uses of the tool. Anyway, the traces' identification permits to isolate recurring damages on experimental points: tips are mostly removed on both edges, tip removals mostly terminate on both faces and edges, many lateral removals are present on ventral faces (Fig. 33).

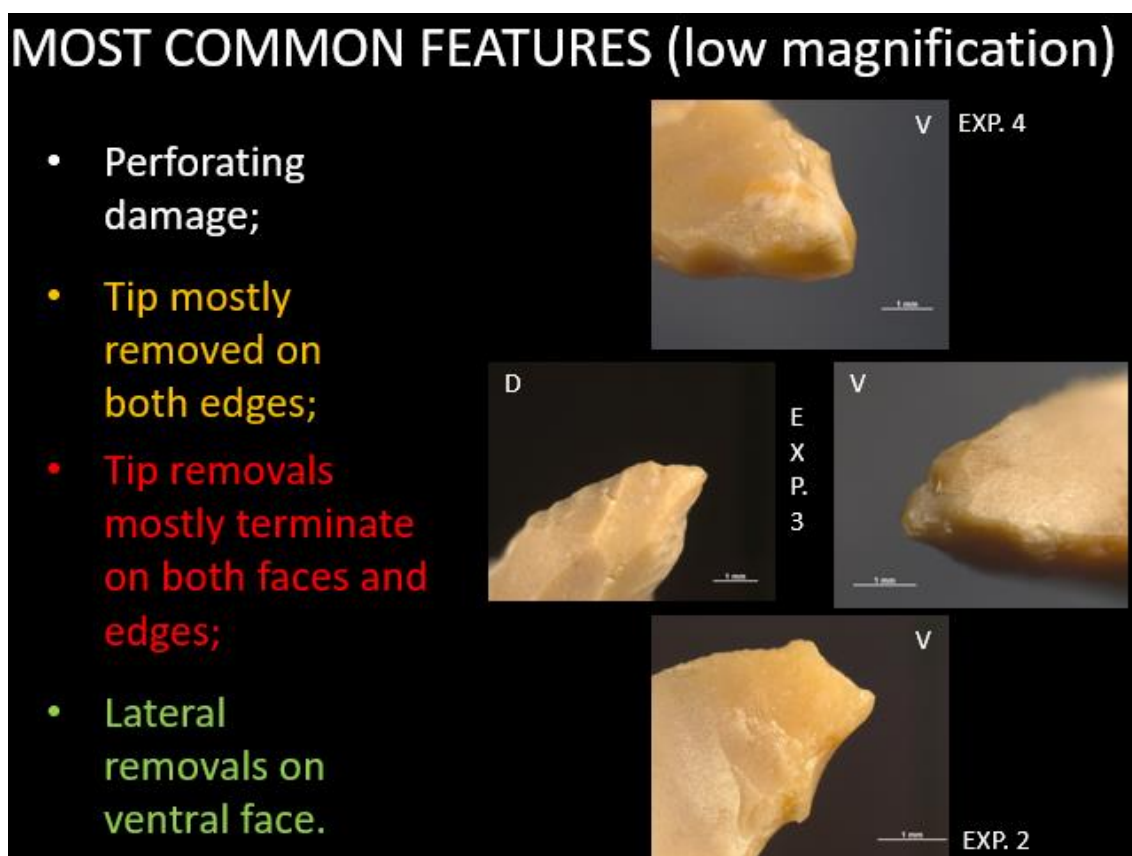


Fig. 33: Recurrent traces on experimental backed points used for caries removal. Fractures and scars are connected to perforating damages.

Moreover, it has also been carried out a high magnification approach analysis as to find microwears on the experimental materials. As suspected, there were found many polishes and striations while when the point was broken just residual presence of polish (Fig. 34).

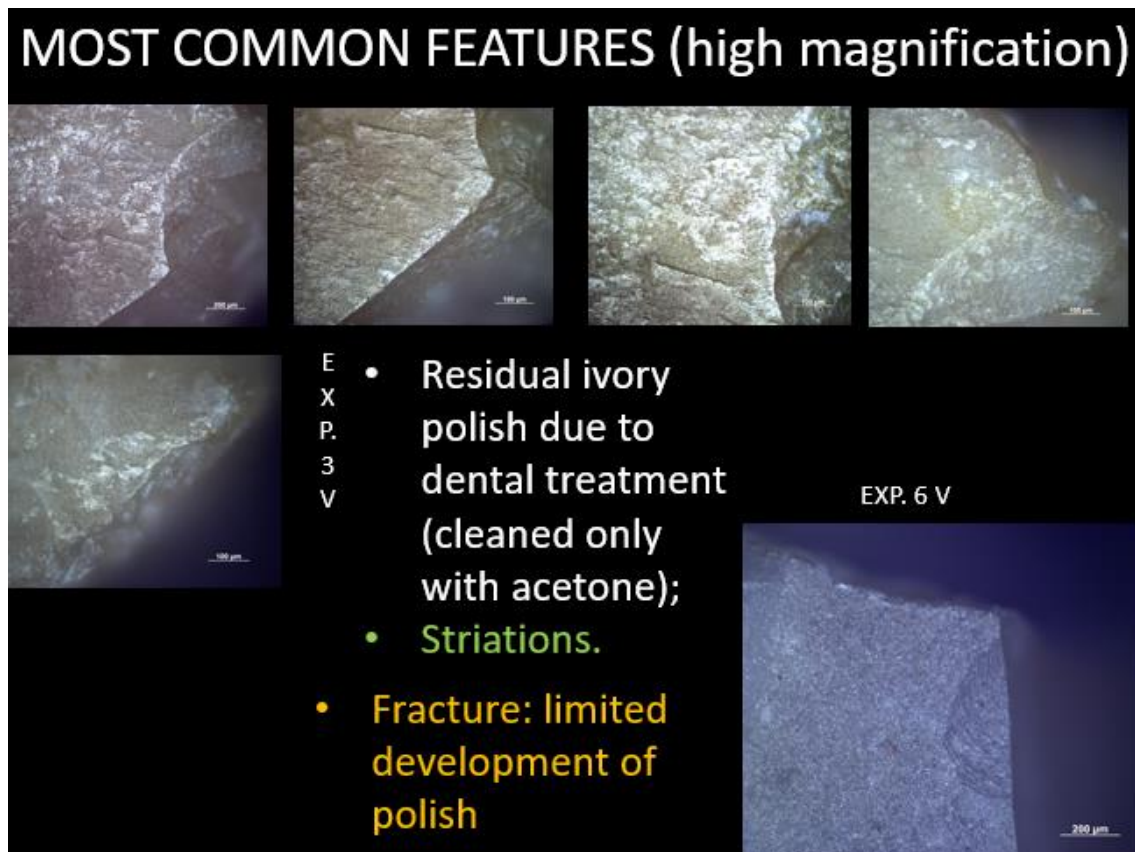


Fig. 34: High magnification pictures to delight polishes and striations on experimental backed points used for caries removal.

2.4.2. Perforators to create ornaments

One of the most famous prehistoric artefacts created by human groups during the Palaeolithic are decorative objects. Often in Europe, perforated red deer (*Cervus elaphus*) canines were used as personal decoration by prehistoric human groups (Bordreuil, 1966; Newell *et al.*, 1990; Camps-Faber *et al.*, 1991; Ladier & Welté, 1994; D’Errico & Vanhaeren, 2002). On the ethnographical point of view, they may give important information about the holder, for example the gender, age, social status and ethnic and linguistic affiliation (Hodder, 1979; McCabe, 1982; Wiessner, 1984). They have a strong symbolic value and are often decorated with sets of notches and covered with ochre (D’Errico & Vanhaeren, 2002).

The style of manufacturing is extraordinary and the best way to understand them is to reconstruct the way of how they have been developed by the hunter-gatherers. For example, D'Errico & Rigaud (2011) have studied the way to make perforated red deer canines. In detail, the buccal and lingual aspect of the crown are crossed by striations, parallel by the main axis of the tooth. Those are due to scraping activity made by abrasion in order to create a regular shape and delete the enamel. Regarding the perforation, the buccal and lingual faces showed scraping activities made by a lithic tool, with parallel or oblique movement by the main axis of the tooth. This scraping action was useful to refine both faces in order to proceed with the perforation. The perforation of the root consists of rotation action as to create a hole, switch between both faces. Lastly, red pigments are present around the perforation, on the surface of striations and scars.

Ornaments are present in the Riparo Villabruna and Grotta di Pozzo archaeological sites. In particular, at Riparo Villabruna 4 perforated red deer canines have been found on 9C, 6A and reworked layers (Aimar *et al.*, 1992; Fig. 19). Moreover, at Grotta di Pozzo 1 perforated red deer canine have been found on upper layers (Mussi *et al.*, 2011). These objects look as “shiny pearl” and tears profile, with an undoubtable beauty. They have concave-convex profile and have been classified as trophies rich of symbolism, with sexual implications (Taborin, 1990).

It was decided to test another hypothesis: a new experiment that consisted on the use of the backed points as perforators on athropic red deer canines to create ornaments. The goal is always to try to define the use of the Epigravettian backed points in the selected archaeological sites.

2.4.2.1. *Experimental set*

The experimentation set consists of 4 backed points comparable to those found in the archaeological site of Riparo Villabruna and 5 fresh athropic red deer canines.

The backed points are coherent with the blade-bladelet production of Final Epigravettian lithic industries (Tab. 16).

ID	#	L	w	th	Typology	Cortex	Raw material	Alteration
9	RV-EXP8	42	9	5	Backed point	0	Biancone	
10	RV-EXP9	33	7	3	Backed point	0	Biancone	Tip and base scar (prod.)
11	RV-EXP10	43	7	3	Backed point	0	Biancone	Tip and base scar (prod.)
12	RV-EXP11	40	7	2	Backed point	0	Biancone	

Tab. 16: Experimental backed points before the experiment as perforators.

They have been realized with a grey to beige Majolica chert from the Italian Dolomites (“*biancone*”). Moreover, the knapping technique adopted was direct percussion with soft hammer and, for the retouch, indirect percussion with soft hammer and pressure with antler of deer (Fig. 25). All these pieces have been analysed before the experimentation by stereomicroscope, making pictures, in order to avoid scars due to knapping events. They are named with numbers from 9 to 12.

There were selected 4 fresh atrophic canines of adult red deer, thanks to a hunter that was gently available to donate them. The teeth have been called W, X, Y, Z (Fig. 35).

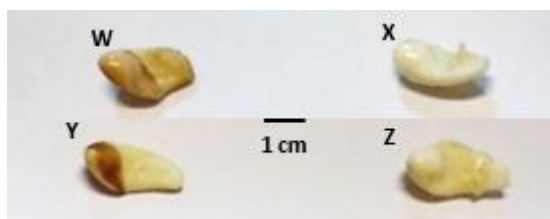


Fig. 35: Experimental fresh atrophic canines of adult red deer.

Furthermore, the creation of the right experimental gesture is essential to make the experimentation as much reliable as possible (Fig. 36). For this reason, there have been used the guidelines proposed by D’Errico & Rigaud (2011).

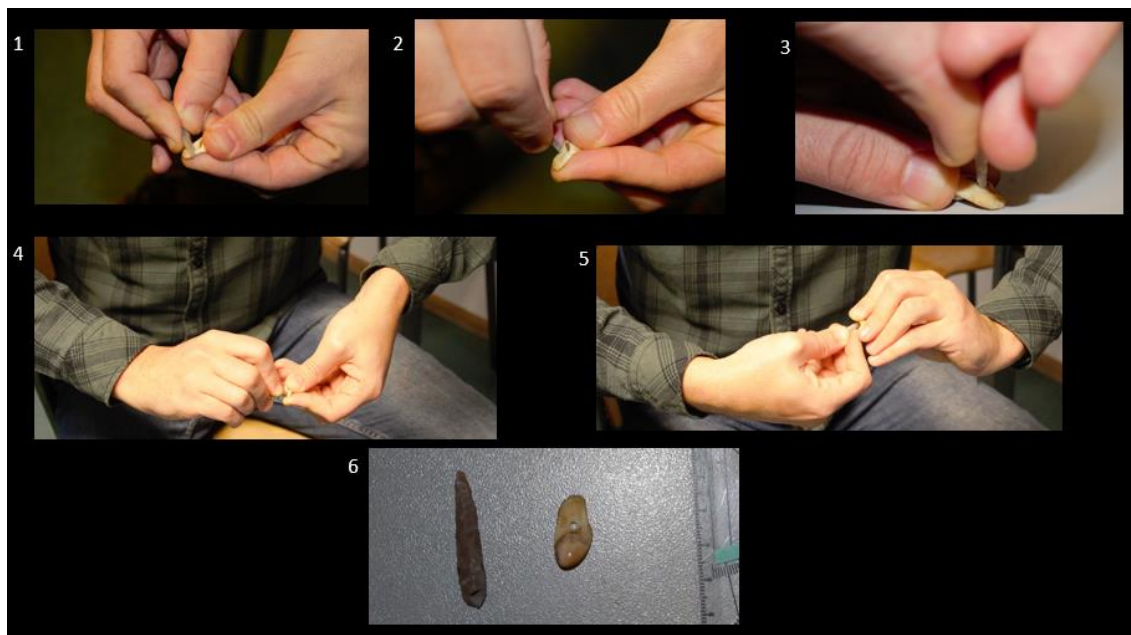


Fig. 36: Experimental backed point used as perforator to create decorative objects with experimental fresh athropic canines of adult red deer. 1: scratching action. Abrasion of the surface of the tooth with the edge of the experimental backed point to delete the enamel. 2-3: perforation starter. The tip of the backed point used on the center of the tooth. 4-5: perforation with clockwise and counterclockwise rotation. 6: result of experimentation.

2.4.2.2. *The archaeological sample*

The archaeological sample considered candidate for this analysis and for the comparison with the experimental materials are the same of the previous chapter (see chapter 2.4.1.2. and Fig. 28, Tab. 13), so as 10 backed points and fragmented backed bladelets.

2.4.2.3. *The experimental activity*

There were performed a total of four types of experiments, trying to replicate the same gesture indicated by D'Errico & Rigaud (2011) and alternate the use or not of ochre. Ochre is well known as its decorative purpose and has been used as element to create glue to haft artefacts but it is also known for its abrasion action.

For this reason, it has also been investigated the possible difference of the use or not of ochre in the perforation action.

The first experimentation (EXP. 8) involved the experimental point N° 9 and the atrophic canine of red deer W. The ochre was not used. It started with abrasion action on both sides of the tooth, using the left side of the tool, in order to eliminate the enamel, with scratching action. After, the perforation started on the centre of the tooth using the lithic point with clockwise and counter-clockwise rotation. After 25 minutes the hole started to be created and, in 1 hour 5' and 32'', the hole was almost completed. In a total of 1 hour 12' and 23'' the experimentation was finished, because it needed time to enlarge and finish the hole. We can consider that the backed point is very efficient due to its width and thickness, perfect for the creation of the hole (Fig, 37; Tab. 17).

ID TOOL	ID TOOTH	ACTION	DIRECTION	INCLINATION	TIME	LOCATION OF ACTION
9	W	abrasion & perforating clockwise rotation abrasion shaving	buccal and lingual root	90°	1h 5' 32'' hole, 1h 12' 23'' finished	central root, both sides Hold by hand Without ochre
10	X	abrasion & perforating clockwise rotation abrasion shaving	buccal and lingual root	90°	51' 29'' hole, 55' 19'' finished	central root, both sides Hold by hand Without ochre
11	Y	abrasion & perforating clockwise rotation abrasion shaving	buccal and lingual root	90°	31' 59'' hole, 38' 19'' finished	central root, both sides Hold by hand With ochre
12	Z	abrasion & perforating clockwise rotation abrasion shaving	buccal and lingual root	90°	24' 9'' hole, 26' 14'' finished	central root, both sides Hold by hand With ochre

Tab. 17: Details about the experiment with atrophic canines of red deer.

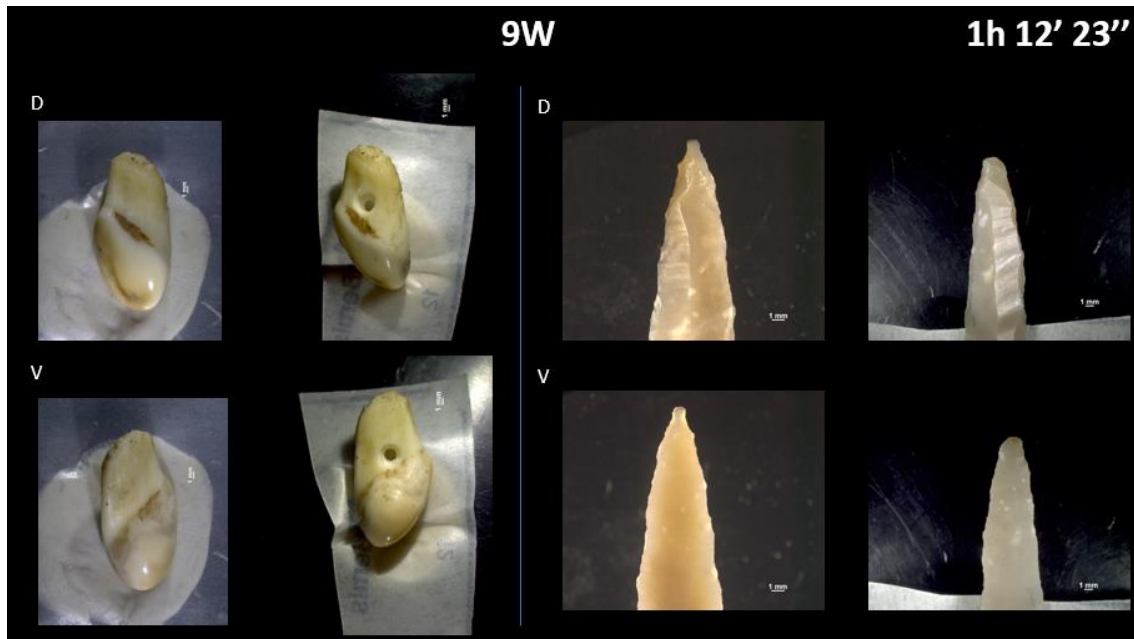


Fig. 37: EXP. 8, backed point N° 9 and tooth W. On the left the differences before and after the experiment on the tooth, while on the right regarding on the lithic point.

The second experiment (EXP. 9) was performed with the experimental point N° 10 and the atrophic canine of red deer X, without ochre. The gesture was the same of the first experiment but it took less time, 51' 29'' for the creation of the hole, 55' 19' experiment completed (Fig. 38). Perhaps, this was due to the higher confidence of the experimenter.

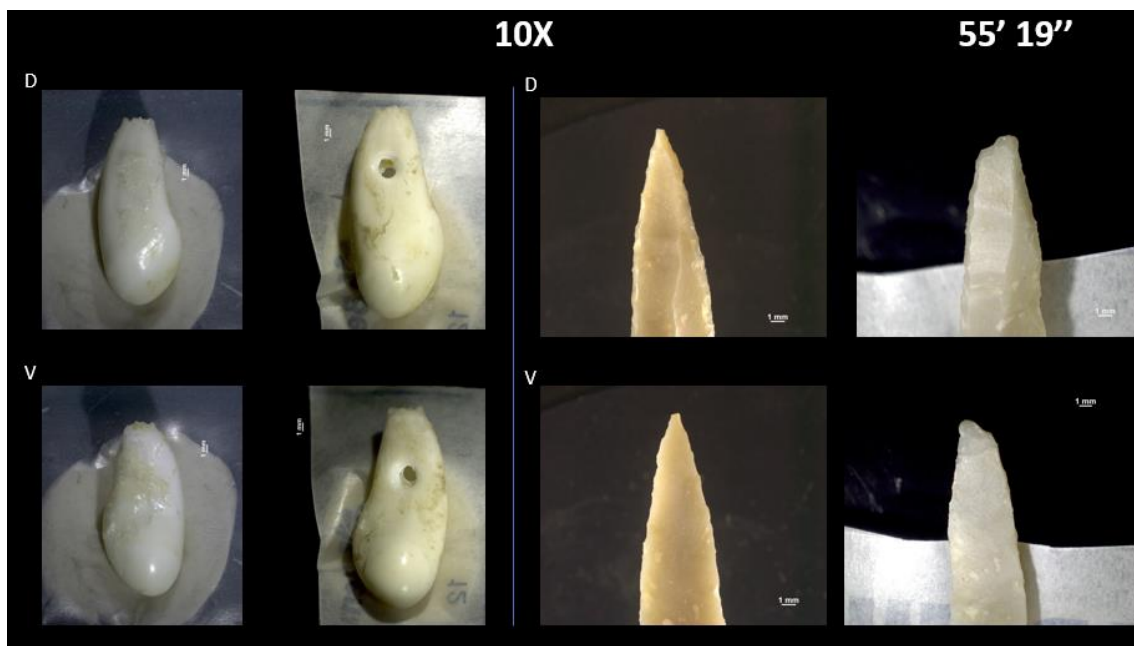


Fig. 38: EXP. 9, backed point N° 10 and tooth X. On the left the differences before and after the experiment on the tooth, while on the right regarding on the lithic point.

The third experiment (EXP. 10) included point N° 11 and the tooth Y, using red ochre. It started placing the ochre with the finger on both faces of the tooth and using the backed point. Then, it started the scratching action to delete the enamel. It was evident the great abrasion effect of the ochre. Hence, it started the perforation, in the same way of the previous experiments. The ochre was constantly used inside the hole of the tooth. We can notice that it was easier the creation of the hole and it has spent less time than before: 31' 59'' for the creation of the hole and 38' 19'' to complete the experiment (Fig. 39).

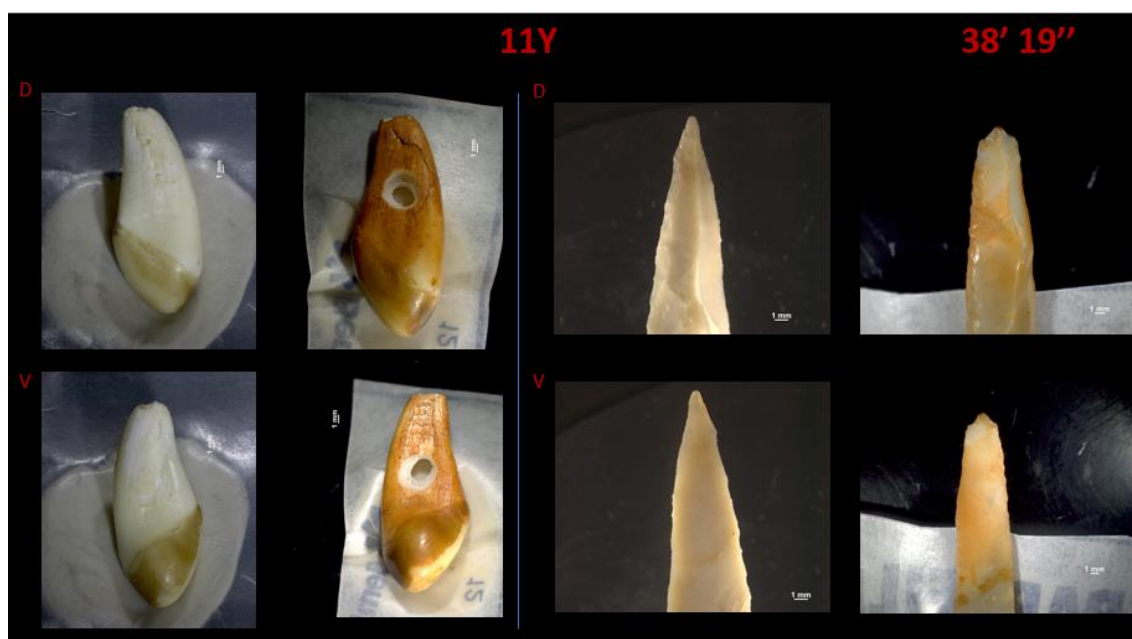


Fig. 39: EXP. 10, backed point N° 11 and tooth Y. On the left the differences before and after the experiment on the tooth, while on the right regarding on the lithic point.

The last experiment (EXP. 11) was operated with point N° 12 and tooth Z, using red ochre. This was practically the same of EXP. 10 but it took less time, 24' 09'' for the creation of the hole and 26' 14'' to terminate the experiment (Fig. 40).

At first sight, it seemed that the abrasion action of ochre was incredibly functional. In fact, if we compare the four experiments, the points connected with the use of ochre took at least one half of time to create the ornament. Despite that, there should be underlined that the confidence of the gesture of the experimenter increased experiment by experiment. So, the above sentence is not reliable.

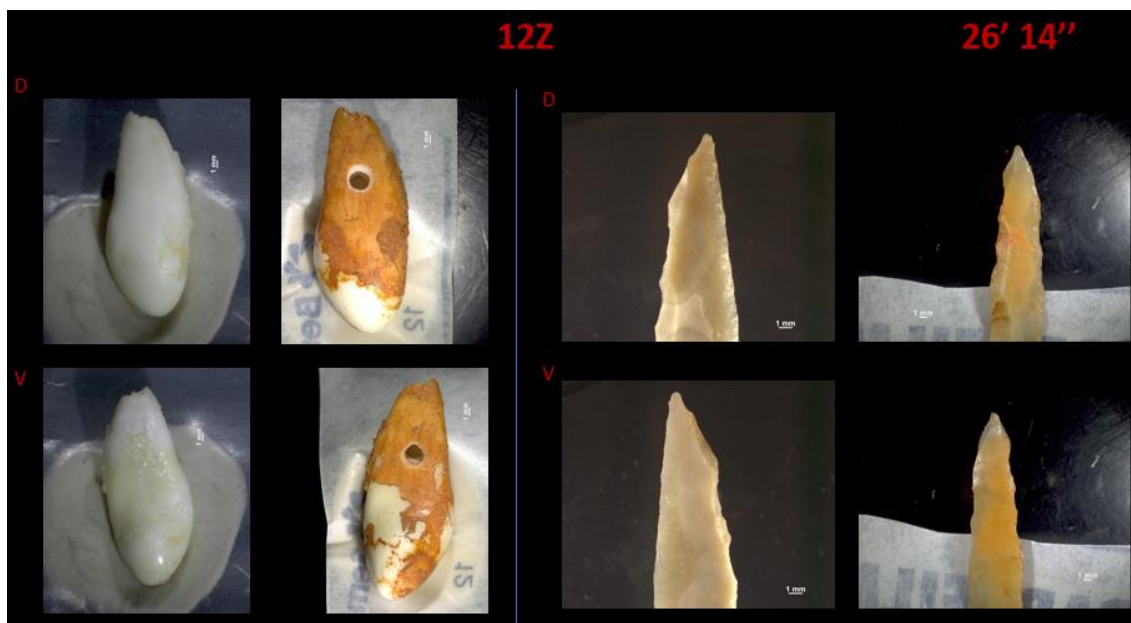


Fig. 40: EXP. 11, backed point N° 12 and tooth Z. On the left the differences before and after the experiment on the tooth, while on the right regarding on the lithic point.

For this reason, it was decided to do other six experiments, alternating the use of ochre. There were create 6 backed points with another kind of raw material, the Harmignies chert coming from Belgium. The points were perfectly comparable with the Final Epigravettian lithic industry. This experiment was called EXP 76 and the lithic materials N° 2212, 2213, 2214, 2215, 2216, 2217.

Therefore, six atrophic canines of red deer were used, called F, G, H, I, J, K. In synthesis, it was adopted the same gesture of the previous experiments, alternating the use of ochre and not.

The backed point N° 2212 was used as perforator on the tooth F, without ochre, starting with abrasion action on both sides of the tooth and the left edge of the point; then, starting perforation action alternating both faces of the tooth and the tool. The experimentation ended at 33' 36''.

The backed point N° 2213 was used as perforator on the tooth G, with ochre, starting with abrasion action on both sides of the tooth and the right edge of the point; then, starting perforation action alternating both faces of the tooth and the tool. Used ochre with finger during abrasion and during perforation, put constantly inside the hole. The experimentation finished at 20' 29''.

The backed point N° 2214 was used as perforator on the tooth H, without ochre, starting with abrasion action on both sides of the tooth and the right edge of the point; then, starting perforation action alternating both faces of the tooth and the tool. The experiment ended at 35' 52''.

The backed point N° 2215 was used as perforator on the tooth I, with ochre, starting with abrasion action on both sides of the tooth and the left edge of the point; then, starting perforation action alternating both faces of the tooth and the tool. It was used ochre with finger during abrasion and during perforation, put constantly inside the hole. The experiment finished at 26' 55''.

The backed point N° 2216 was used as perforator on the tooth J, without ochre, starting with abrasion action on both sides of the tooth and the right edge of the point; then, starting perforation action alternating both faces of the tooth and the tool. The experimentation ended at 43' 14''.

The backed point N° 2217 was used as perforator on the tooth K, with ochre, starting with abrasion action on both sides of the tooth and the right edge of the point; then, starting perforation action alternating both faces of the tooth and the tool. It was used ochre with finger during abrasion and during perforation, put constantly inside the hole. The experimentation finished at 30' 17''.

As showed in Tab. 18 and Fig. 41, we have considered that it is true that the experimenter gained more experience in the gesture, confirmed by the amount of time spent for the realization of the ornaments. However, this is in any case clear that using the abrasion action of the ochre is functional and it took less time.

ID TOOL	ID TOOTH	ACTION	DIRECTION	INCLINATION	TIME	LOCATION OF ACTION
2212	F	abrasion & perforating, clockwise rotation, abrasion, shaving	buccal and lingual root	90°	33' 36"	central root, both sides. Hold by hand alternate with a support. Without ochre and no hafting.
2213	G	abrasion & perforating, clockwise rotation, abrasion, shaving	buccal and lingual root	90°	20' 29"	central root, both sides. Hold by hand. With ochre inside constantly.
2214	H	abrasion & perforating, clockwise rotation, abrasion, shaving	buccal and lingual root	90°	35' 52"	central root, both sides. Hold by hand alternate with a support. Without ochre and no hafting.
2215	I	abrasion & perforating, clockwise rotation, abrasion, shaving	buccal and lingual root	90°	26' 55"	central root, both sides. Hold by hand. With ochre inside constantly.
2216	J	abrasion & perforating, clockwise rotation, abrasion, shaving	buccal and lingual root	90°	43' 14"	central root, both sides. Hold by hand alternate with a support. Without ochre and no hafting.
2217	K	abrasion & perforating, clockwise rotation, abrasion, shaving	buccal and lingual root	90°	30' 17"	central root, both sides. Hold by hand. With ochre inside constantly.

Tab. 18: Details about the EXP 76 with atrophic canines of red deer

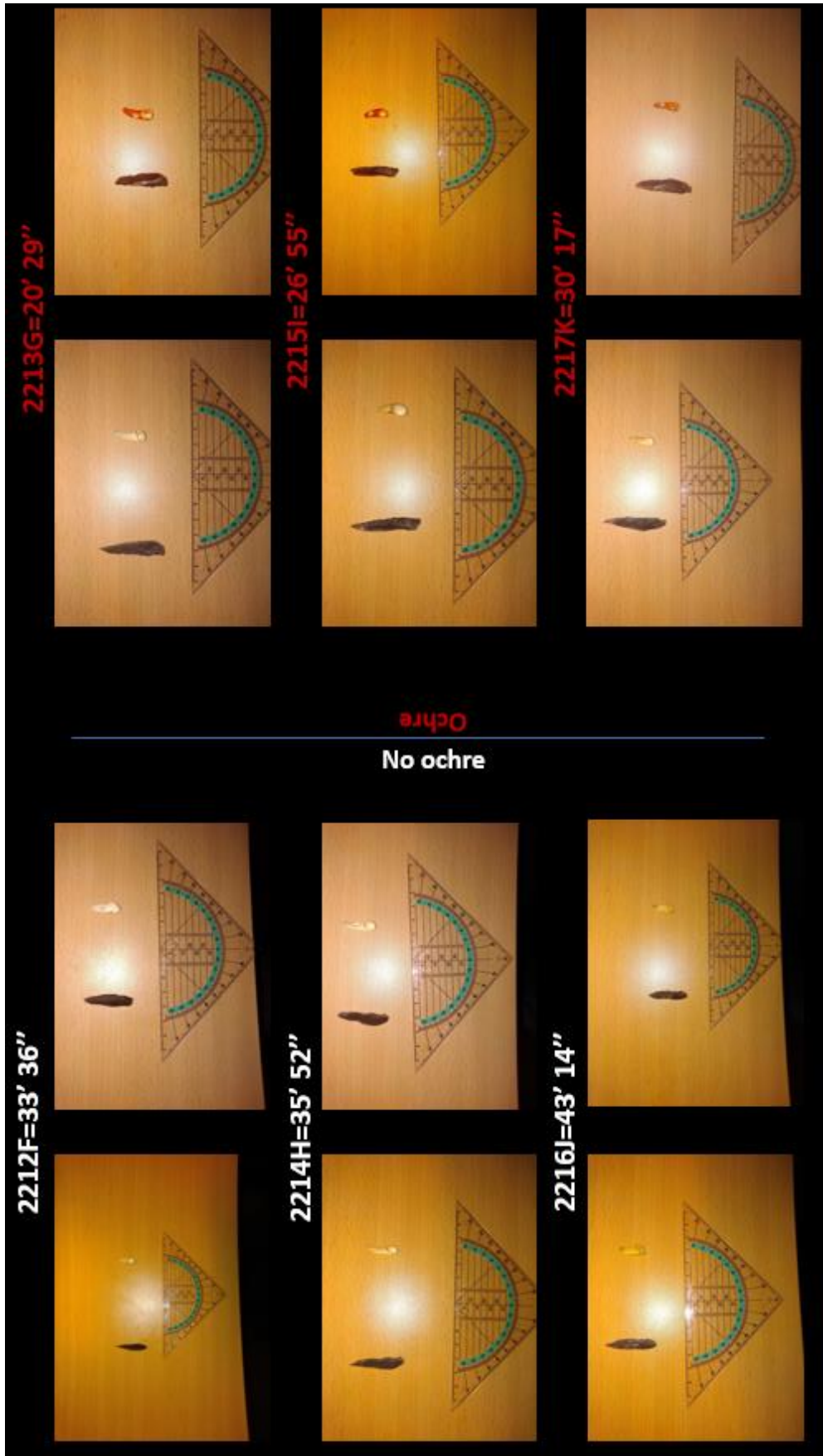


Fig. 41: Overview of the experimentation 76

2.4.2.4. Analysis of the experimental data

The experimental materials were analysed by stereomicroscope in order to identify and describe macro-wears (Tab. 19).

ID	#	L	w	th	Raw material	Use	Alteration
9	RV-EXP8	40	8	5	Biancone	abrasion/perforation on W	Distal fracture and lateral removals on both edges
10	RV-EXP9	30	7	3	Biancone	abrasion/perforation on X	Distal fracture, lateral removals on the right edge
11	RV-EXP10	37	7	3	Biancone	abrasion/perforation on Y with ochre	Distal fracture and lateral removals on both edges, ochre residues
12	RV-EXP11	37	7	2	Biancone	abrasion/perforation on Z with ochre	Distal fracture, burination, lateral removals on both edges, ochre residues

Tab. 19: Experimental backed points after the experiment as perforators.

The point N° 9 shows abrasion damage on the dorsal left edge. On the tip there is a fracture, followed by lateral scars both on dorsal and ventral faces, with cone initiation and feather termination and cone initiation and step termination (Fig. 42).

The point N° 10 shows abrasion traces on both edges and a tip fracture, followed by lateral scars along the width of the point (Fig. 43).

The point N° 11 shows clear abrasion wears on the dorsal left side, nearby the retouched area. Two fractures on the tip go to opposite direction and, on the ventral face, there is another one with bending initiation. There is evident the red colour due to the use of ochre (Fig. 44).

Lastly, the point N° 12 shows abrasion damage on the mesial right side and two scars on the dorsal tip. On the ventral area, there is a burination comparable with the use as projectile point and two scars. It is clear the red colour due to the use of ochre (Fig. 45, 46).

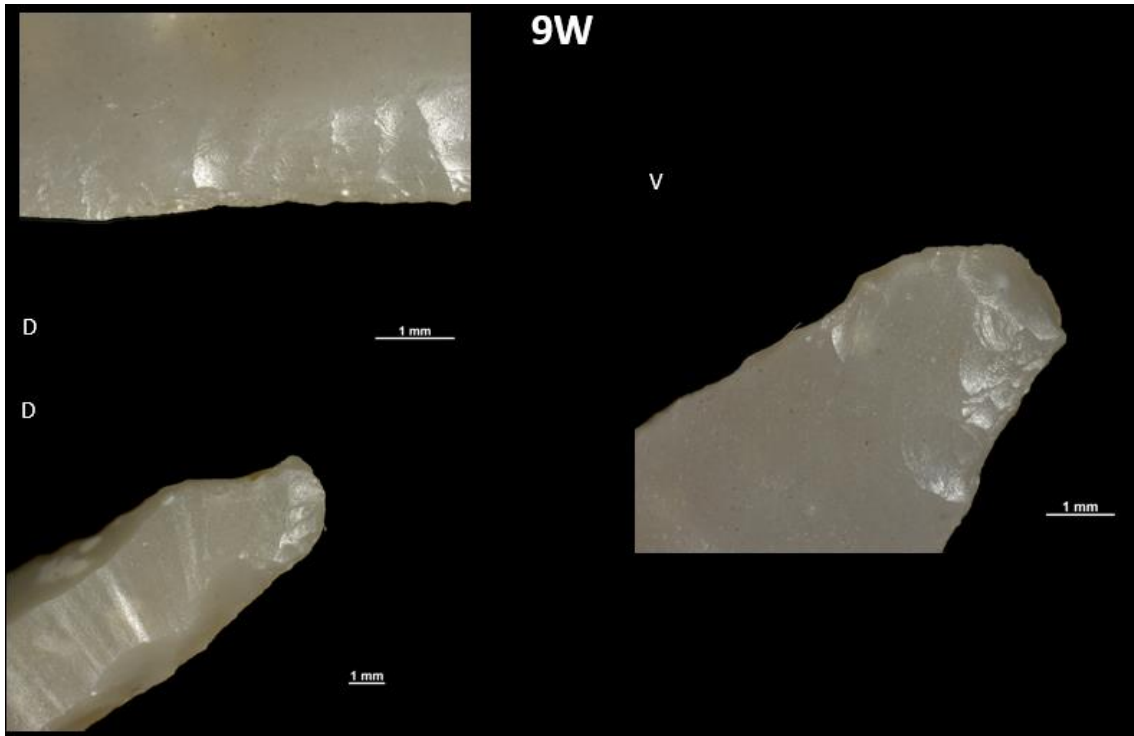


Fig. 42: Experimental point N° 9. Details of removals: on the top left, series of lateral removals; on the bottom left, the distal fracture with scars that end on the dorsal area; on the right, the distal fracture on the ventral area and series of lateral scars on both edges.

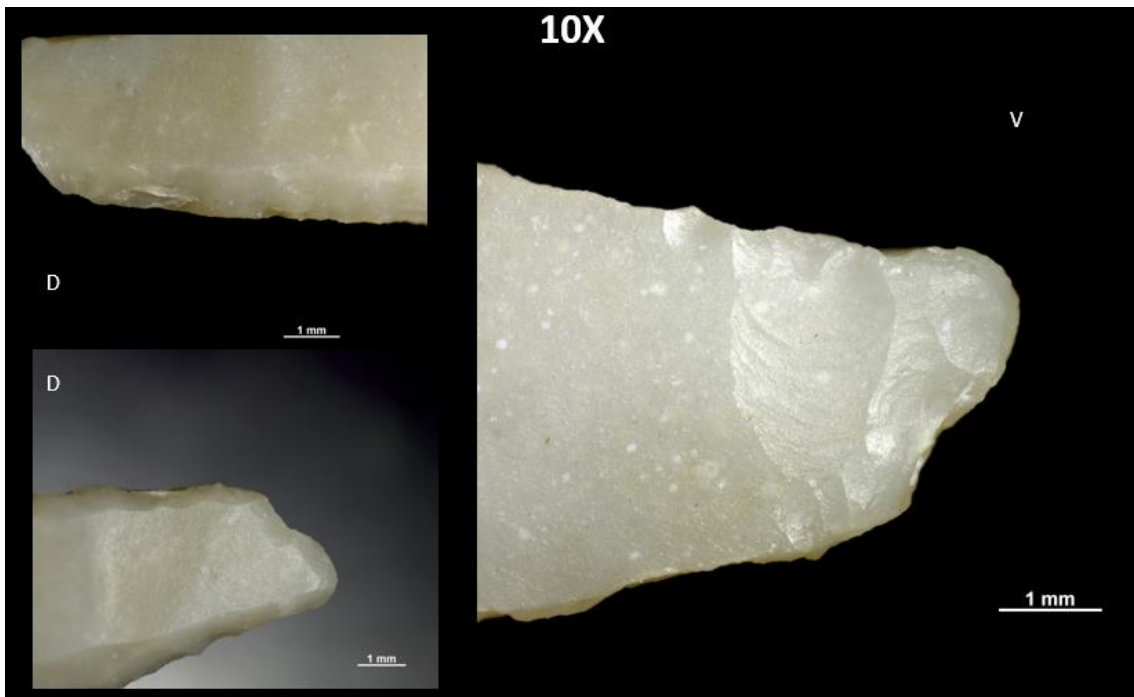


Fig. 43: Experimental point N° 10. Details of the removals: top left, lateral scars; bottom left, distal fracture; on the right, series lateral removals that cross all the ventral surface.



Fig. 44: Experimental point N° 11. Details of the removals: top left, lateral scars; bottom left, distal fracture; on the right, series lateral removals and distal fracture that cross all the ventral surface. There are evident ochre residues.

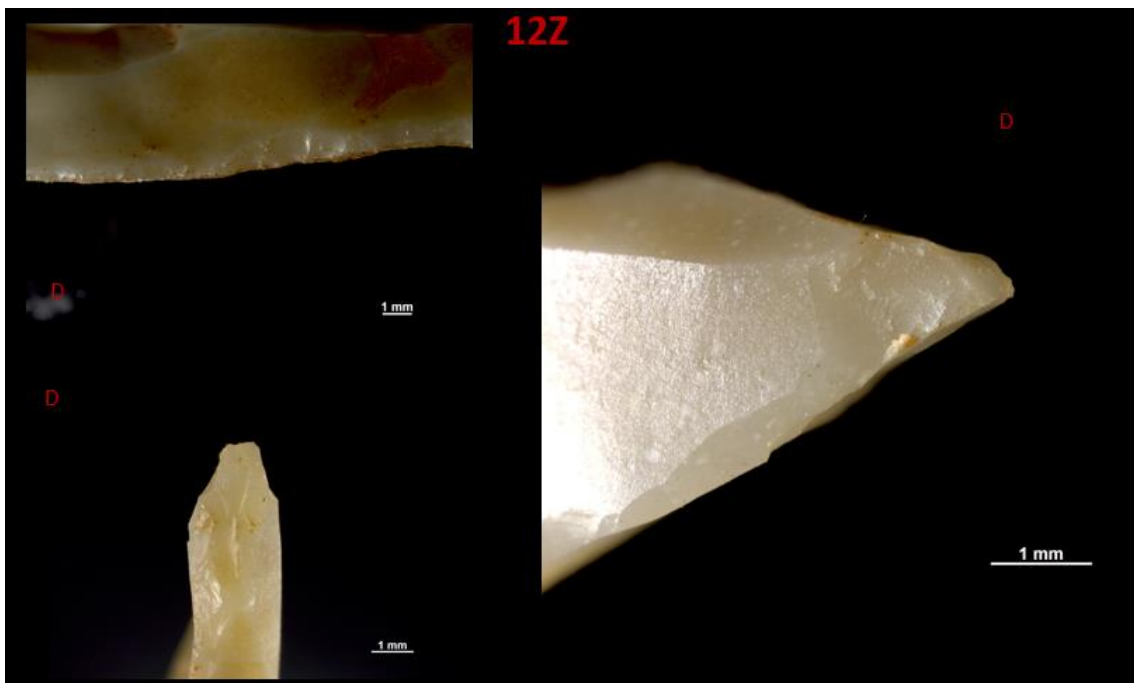


Fig. 45: Experimental point N° 12. Details of the removals: top left, lateral scars; bottom left, distal fracture, left edge point of view; on the right, series distal removals, right edge point of view. There are evident ochre residues.

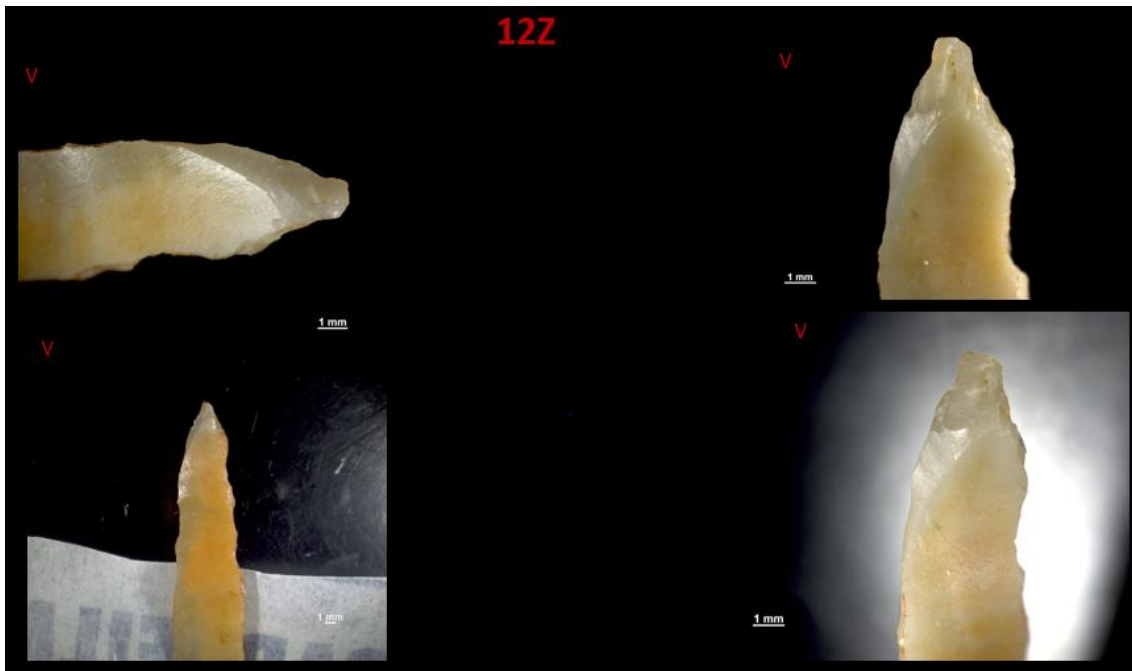


Fig. 46: Experimental point N° 12, ventral face. Details of the burination.

Furthermore, the teeth W and X show striations on both faces due to abrasion action. They are parallel to the main axis and terminated on the crown. There are perforation traces due to rotation movement and polishes on the crown area (Fig. 37, 38). The teeth Y and Z show a red shiny surface, due to the use of ochre. The presence of it is less evident on the hole. The use-wear are practically the same of W and X and there are polishes (Fig. 39, 40).

3. RESULTS

3.1. MACRO-FRACTURES ANALYSIS - GROTTA DI POZZO

3.1.1. General

A total of 26 possible projectile points was recognized in the new sample of 279 artefacts (Tab. 9), corresponding to a percentage of 9% of the selected sample. From the 227 elements identified as projectiles during the first phase of analysis, only 15 pieces could be confirmed to be projectile during the second phase of the study. From the additional sample of 52 pieces, 11 pieces show wear traces that may possibly be due to impact (Fig. 47).

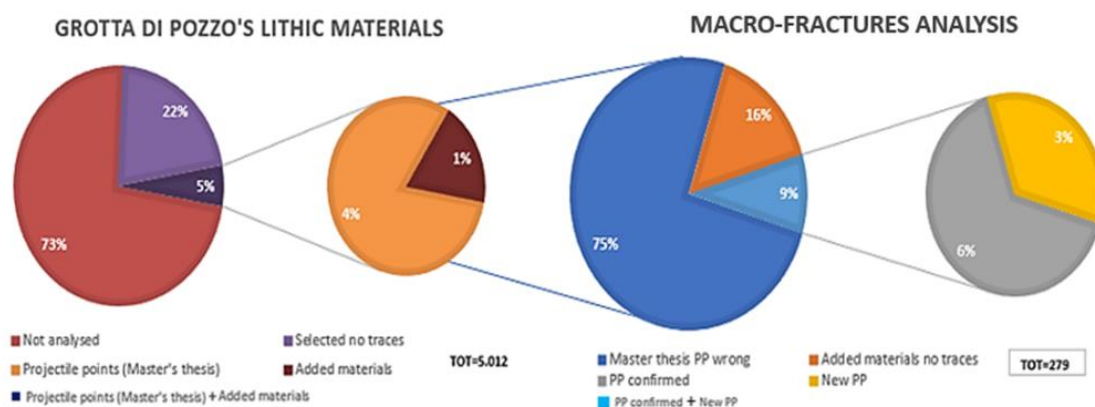


Fig. 47: Summary of the materials analysed from Grotta di Pozzo. The first diagram includes all the lithic materials (5.012), the selected materials (1.315), 279 pieces further selected for the macro-fracture analysis (227 pieces identified as possible projectile points in Ruta's Master thesis (2014) plus 52 additional ones). The second diagram concerns the materials analyzed by Attribute Based System (279), 9% of which (26) proved to have been used as armatures (15 of these are part of the first analysis conducted during the Master thesis research, while 11 pieces are part of the additional materials analysed in the framework of this study).

On the totality of 279 lithic tools, 572 individual fractures and/or removals (of various origin) have been registered and described. On the 26 pieces that were identified as projectile points with reasonable or high certainty, a total of 199 removals/fractures were identified and described (Fig. 48).

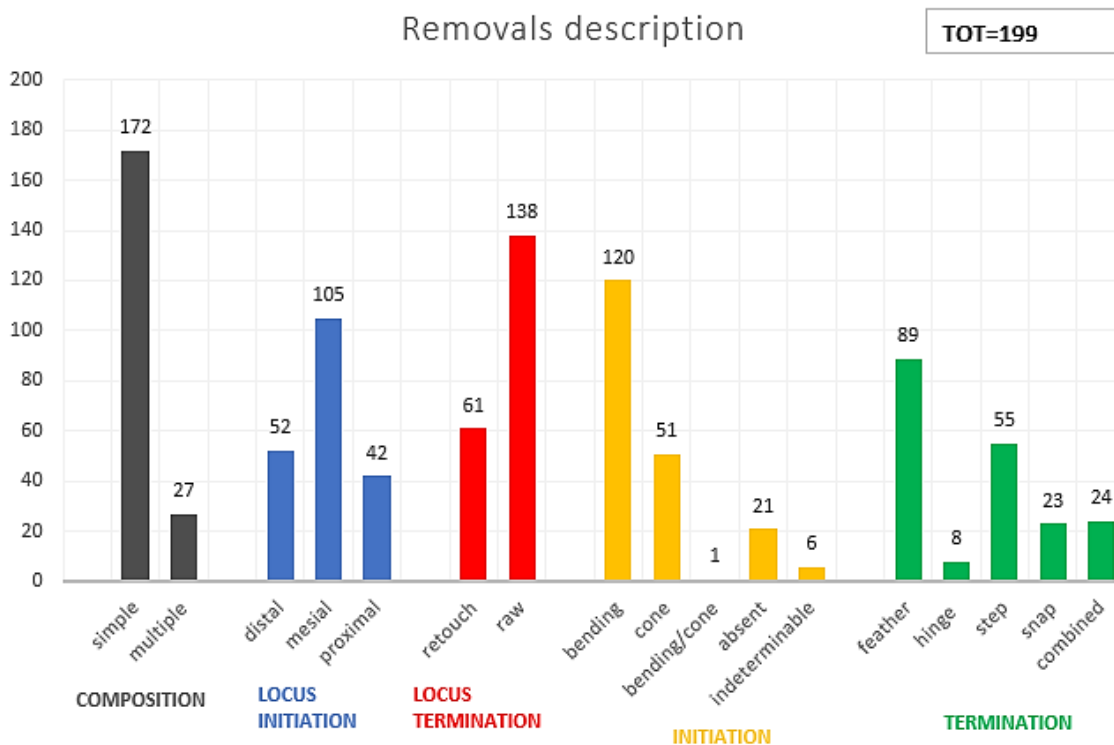


Fig. 48: Macro-fractures description of the lithic materials from Grotta di Pozzo: there are indicated the characteristics of fractures/removals.

Each of the 26 identified armatures has been classified in one of the four groups based on the quantity and quality of fractures features and their association and distribution: 8 armatures were classified in the first group (31%), 6 in the second group (23%) and 12 in the third group (46%). The armatures of the 3rd group have been considered as possible projectiles even if this is uncertain. Of the 26 identified armatures, only 1 armature belongs to the Early Epigravettian (3,4% from the sample belonging to the lower layers), the remaining 25 are attributed to the Final Epigravettian (10% of the sample belonging to the upper layers). The majority of the identified armatures shows traces that correspond to a use as barb, more in particular 15 pieces (58%), while none could be identified with certainty as a tip.

For 11 pieces, no hafting position could be proposed (42%) (Tab. 20; Supplementary Information, Tab. 1).

ID	Group	L	w	Th	gr	Typology	Alteration	Barb or tip
1006	3°	24	18	5	2,25	backed blade	proximal fracture	?
1390	2°	23	8	3	0,81	backed bladelet	distal fracture	?
1407	1°	16	4	2	0,18	backed bladelet	distal fracture	Barb
1408	3°	20	3	1,5	0,17	backed bladelet		Barb
1466	3°	22	7	2	0,43	backed bladelet		Barb
1467	2°	20	7	4	0,66	backed bladelet	distal fracture	Barb
1527	2°	27	6	2	0,36	backed bladelet	distal fracture	Barb
1535	1°	23	7	4	0,61	backed bladelet	distal fracture	Barb
1609	2°	14	5	2,5	0,19	backed bladelet	distal+proximal fractures	Barb
1787	3°	8	5	2	0,11	backed bladelet	distal fracture	?
2779	1°	23	10	4	1,02	backed bladelet	distal+proximal fractures	Barb
3212	3°	13	5	2	0,19	backed bladelet	distal fracture	?
3236	1°	30	9	5	1,67	backed blade	distal fracture	Barb
5192	3°	18	7	1	0,21	backed bladelet	distal+proximal fractures	?
5213	1°	11	10	4	0,39	backed bladelet	distal fracture	Barb
5261	3°	20	7	2	0,45	backed bladelet	distal fracture	?
5568	1°	13	8	4	0,38	backed bladelet	distal fracture	?
5653	3°	14	10	3	0,48	cran bladelet	distal fracture	?
7059	2°	21	4	3	0,33	backed bladelet	distal fracture	Barb
7145	3°	18	7	4	0,66	backed bladelet	distal+proximal fractures	?
7147	2°	25	7	2	0,78	backed bladelet	distal+proximal fractures	Barb
7303	1°	17	7	4	0,67	backed bladelet	proximal fracture	Barb
7420	1°	22	6	2	0,44	backed bladelet	distal fracture	Barb
7450	3°	14	4	3	0,23	backed bladelet	distal fracture	?
7457	3°	26	10	5	1,56	crest bladelet		?
7459	3°	28	7	4	1,03	backed bladelet	fratt prox	Barb

Tab. 20: Overview of the armatures recognized from Grotta di Pozzo based on the Attribute System in the second phase of the analysis. All tools from Final Epigravettian layers, except for N° 7450 from an Early Epigravettian layer.

3.1.2. Detailed observations per probability group

Some of the armatures are described in detail to illustrate the wear patterns that were observed for each probability category (Fig. 21, 22, 23). The description

proposed in the second phase is compared to the initial description of phase one (Ruta, 2014) when considered relevant. Those pictures are reported again in order to have a clear overview of the description of the fractures. Subsequently, there are added the description of others noteworthy armatures.

3.1.2.1. Group 1: projectile identification with high level of confidence

A total of 8 armatures were classified in this category consisting of 7 backed bladelets (from 11 to 23 mm length, 4 to 10 mm width, 2 to 4 mm thick; all fractured on the distal area except one on the proximal area; abrupt retouch on one lateral edge) and 1 backed blade (30x9x5 mm; distal fracture; abrupt retouch on the lateral edge). All pieces but one had already been identified as projectile during the first phase of this research given explicit evidence that proved recognizable by a novice.

The observed wear pattern is nicely illustrated by the backed bladelet N° 1407 (16x4x2 mm), showing abrupt retouch on the right edge, cut by a tip fracture. The use-wear analysis of this artefact shows a bending-initiated snap-terminating tip fracture associated with a cone-initiated snap terminated spin-off and three spin-offs that started from the earlier fracture surface with cone initiations and with feather termination in one case, step termination the other two cases (Fig. 49). Moreover, several lateral removals (7) are located on the right edge of the tool, all oriented in the same direction, perpendicular to the long axis. Lastly, there is a bending initiated feather-terminating fracture on the base associated with a secondary removal. The abundant presence of fractures and removals, associated with secondary removals, oriented in the same direction, permits to identify this artefact as projectile point. On the basis of the compression fracture on the tip and the oriented lateral removals (some of them sliced scarring resulted as “typical of the cutting motion upon impact (cf. Rots, 2016, p. 175)) it was more specifically identified as barb.

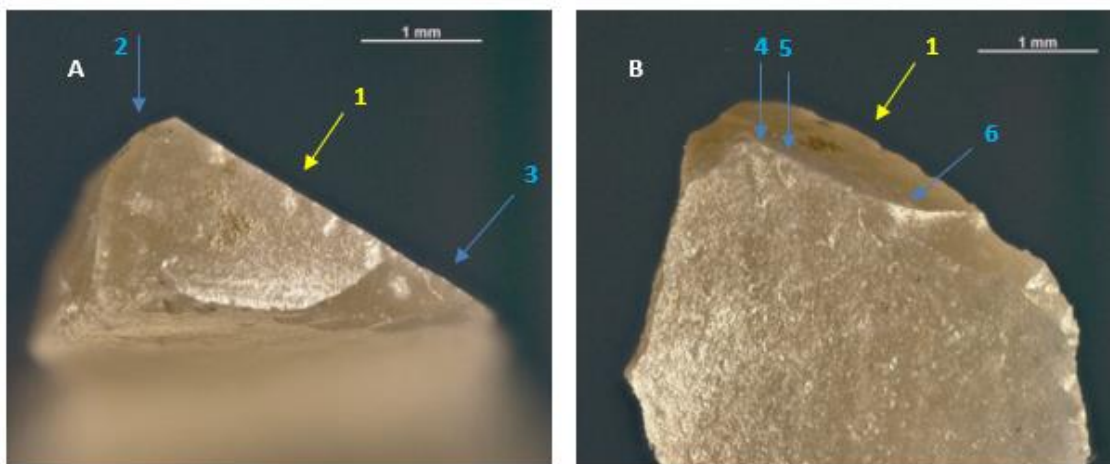


Fig. 49: N° 1407: Backed bladelet used as armature from Grotta di Pozzo (magnification 47.5x), ventral tip view. A: Bending initiated snap terminating tip fracture (1) with secondary removals (2, 3) that cut the retouched edge. B: The fracture (1) is associated with spin offs (4, 5, 6,) due to counter pressure phenomenon. 1° group recognized as barb on the basis of the fracture patterns, including compression phenomena (cf. Rots 2016, fig. 12.13, p. 180).

This piece had already been recognized as projectile during the first phase. The spin-offs on this piece were identified, but no details about the connection with the main fracture and how they initiated and terminated were provided. Several other removals were not registered as they were not considered relevant at the time.

Backed bladelet N° 2779 (24x10x4 mm) has abrupt retouch on the left edge. The macro-fracture analysis shows an oblique fracture initiated in bending from the left lateral edge that cuts through the retouch. It terminates in a combined and fissured hinge to step on an earlier lateral removal (Fig. 50A). The mesial area is characterized by several juxtaposed lateral removals with the same oblique orientation toward the base (Fig. 50B). Lastly, the fracture on the base is initiated in bending and terminates in step, cutting through the retouched edge. The termination partially exploded resulting in removals on the termination (Fig. 50C). The combination and association of fractures and removals allow a confident identification as projectile. It has further been recognized as barb on the basis of the particular oblique fracture on the tip and the combination and association of removals along the tool.

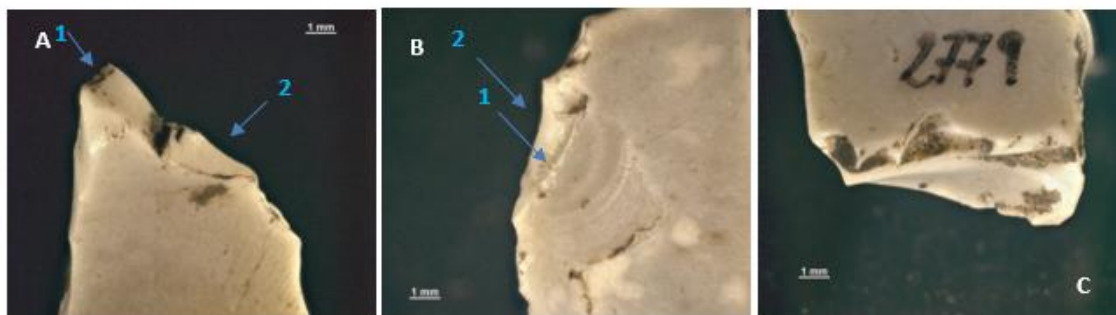


Fig. 50: N° 2779: Backed bladelet used as armature from Grotta di Pozzo (A: magnification 7.8x; dorsal tip; B: 17.2x, ventral face; C: 18.0x ventral base). A: Oblique fracture (1) that cut the retouch part with bending initiation from the left lateral edge with hinge to step fissured termination superposing an earlier fracture surface (bending initiated step terminated) (2); B: lateral removal (1) step terminated of which the initiation is removed by another lateral removal (2) bending initiated step and feather terminated; C: proximal fracture bending initiated step terminated associated to multiple removals. 1° group recognized as barb for the particular tip fracture associated and combined with fractures/removal along the tool.

In the first phase of the analysis, this piece was recognized as projectile, but the distal laterally-initiated fracture was identified as a burination while the lateral scars were incorrectly identified as spin-offs.

The main mistakes made during the first phase, with regard to these pieces are thus an underestimation of the wear evidence that is relevant for identifying projectiles and the use of inappropriate terms and definitions.

3.1.2.2. Group 2: projectile identification with moderate level of confidence

Six armatures were classified in this group consisting of backed bladelets (14 to 27 mm length, 4 to 7 mm width, 2 to 4 mm thick; all distally fractured and in two cases also proximally fractured; abrupt retouch on one lateral edge and in 2 cases also direct retouch on the opposite edge). Two third of these armatures has been recognized as projectiles during the first phase of this research.

Backed bladelet N° 1390 (23x8x3 mm) has abrupt retouch on the left edge, cut by a fracture on the tip. This fracture has a bending initiation and a combined snap

and hinge termination, associated with a secondary removal that starts from the previous fracture with a diffuse initiation and hinge termination (Fig. 51A). This is a compression phenomenon and both removals co-occurred. Moreover, there are lateral removals on both faces, but these are not oriented in the same direction. The fractures are considered as sufficient evidence to identify the piece as a projectile with moderate certainty, but no distinction between a tip and barb proved possible. During the first phase a spin-off was mentioned, but this proved to be a confusion with a lateral scar. By contrast, the tip fracture was not identified. While this piece was identified as projectile in the first phase, it was clearly based on the wrong criteria.

Similar to group 1, mistakes during the phase 1 were due to an underestimation of the traces and an inappropriate use of terms and definitions.

3.1.2.3. Group 3: uncertain

Twelve armatures were included in this group, all backed bladelets (8 to 28 mm length, 4 to 10 mm width, 1 to 5 mm thick). All pieces show a distal fracture except for one piece that shows a proximal fracture only. Two of them have a distal and proximal fracture and one of them a lateral fracture. Four of them have abrupt retouch on one lateral edge and 7 of them have abrupt retouch on one lateral edge and direct retouch on the opposite edge. Lastly, 1 is a possible fragment of shouldered bladelet (14x10x3 mm; distal fractured; abrupt retouch on the base).

Backed bladelet N° 7459 (28x7x4 mm) has abrupt retouch on the right edge and direct marginal retouch on the opposite edge. It shows lateral removals cut by a base fracture on the right ventral edge (Fig. 51B). This fracture, positioned on one proximal corner, seems typical of the use as barb but the poor presence of associated removals does not permit a confident identification. In the initial phase, the possible use of this piece as armature was not recognized and the piece was not described

Again, mistakes made during phase 1 were a consequence of the same problems as for group 1 and 2. Interestingly, 7 on 12 included pieces had been excluded as possible armatures during the first phase.

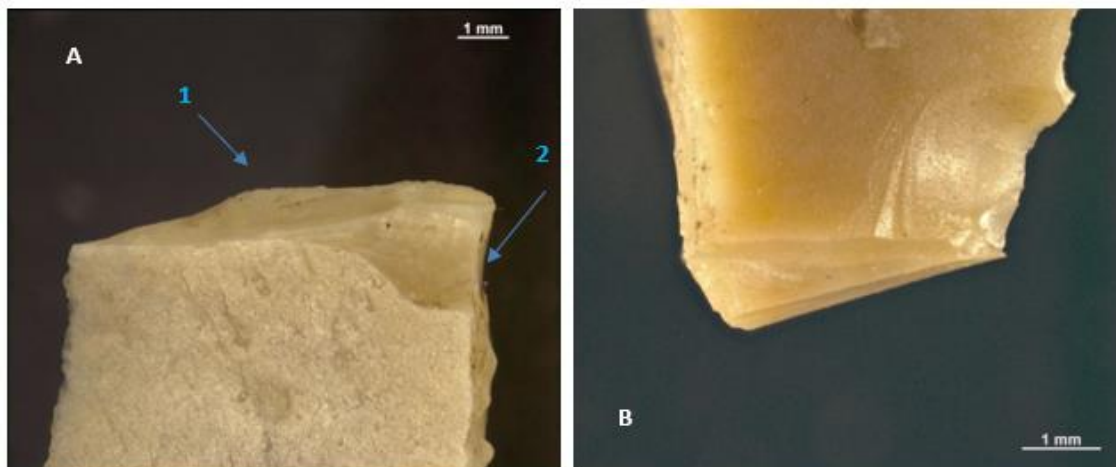


Fig. 51: Backed bladelets used as armature from Grotta di Pozzo. A N° 1390 tip fracture (1) on ventral face bending initiated snap and hinge terminated on the retouched part due a counter pressure event. The main fracture occurs at the same moment as the lateral one (2) bending initiated hinge terminated (magnification 20.5x). 2° group, indiscernible between tip and barb. B: N° 7459 ventral base view, base fracture bending initiated step terminated that cuts the lateral removal bending initiated step terminated and the retouch part. 3° group considered as a possible barb for the lateral fractures and the proximal fracture on one corner (magnification 30.0x).

3.1.2.4. Additional noteworthy identified armatures

Backed bladelet N° 1408 (20x3x1,5 mm) has abrupt retouch on the left edge and direct retouch on the proximal area of the opposite edge. There are highlighted several lateral removals on the right edge that terminates both on dorsal and ventral area, all of them bending initiated and feather terminating, with the same orientation (probably due to abrasion). Moreover, it has a bending initiated snap terminating fracture on the tip that cuts the retouched area. Although the lateral scars might suggest the use as barb, it has been placed on the 3rd group for the uncertainty of the fractures (Fig. 52).

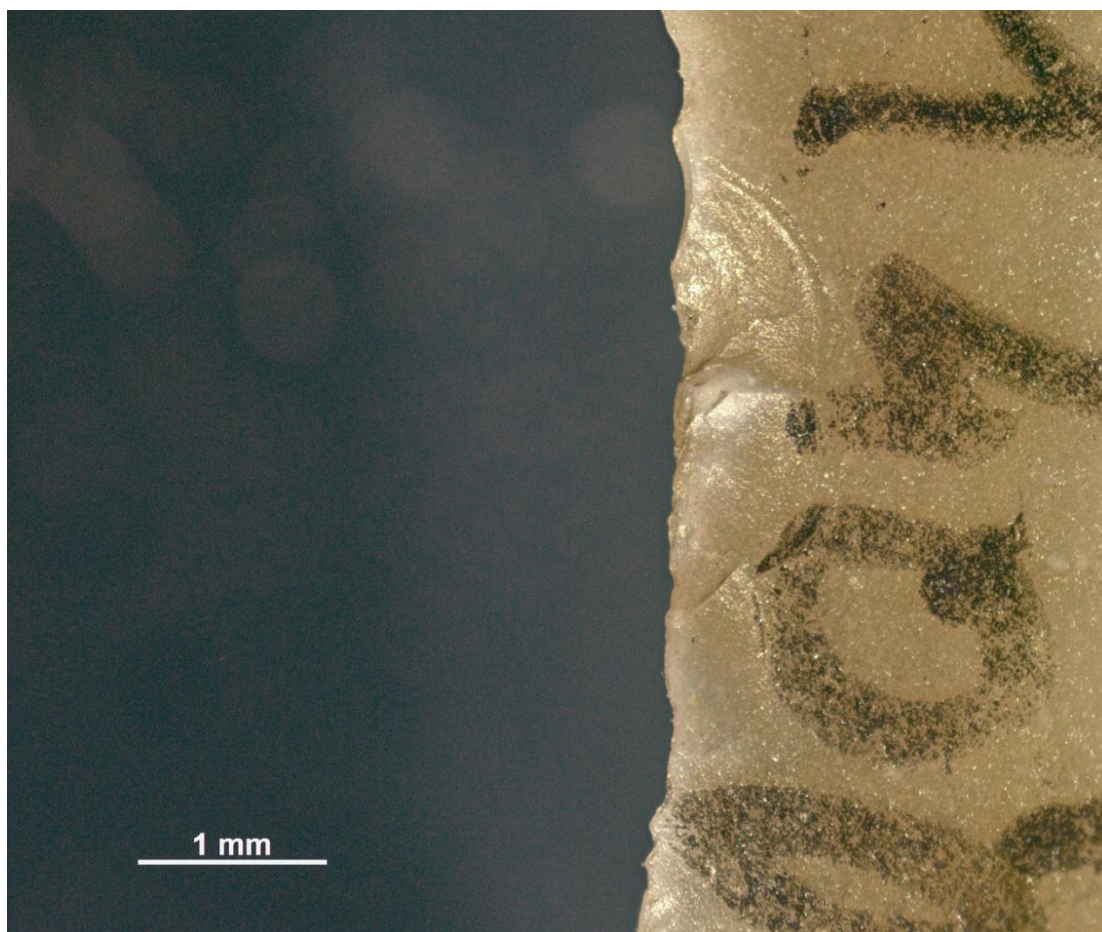


Fig. 52: Backed bladelet N° 1408 from Grotta di Pozzo. Overview of groups of lateral removals on the right side, ventral face. They have bending initiation and feather termination and the same propagation phase.

Backed bladelet N° 1467 (20x7x4 mm) has abrupt retouch on the right edge and marginal retouch on the opposite edge. It shows multiple distal fractures, well associated with an oblique fracture which, most of them, do not show initiations and terminations because they have been removed by earlier fractures. This event is connected to an explosion due to an impact event that affect the three dimensions of the tip. For these reasons, the tool has been placed as barb in the 2nd group (Fig. 53).



Fig. 53: Backed bladelet N° 1467 from Grotta di Pozzo. Overview of the explosion due to impact with multiple fractures on the tip.

Backed bladelet N° 1527 (27x6x2 mm) has abrupt retouch on the right edge. It shows a bending initiated snap terminating fracture on the tip and an abundance (20) of lateral bifacial removals on the left edge, not oriented and complex, juxtaposed and superposed. This tool has been identified as barb for the lateral removals and placed on the 2nd group (Fig. 54).

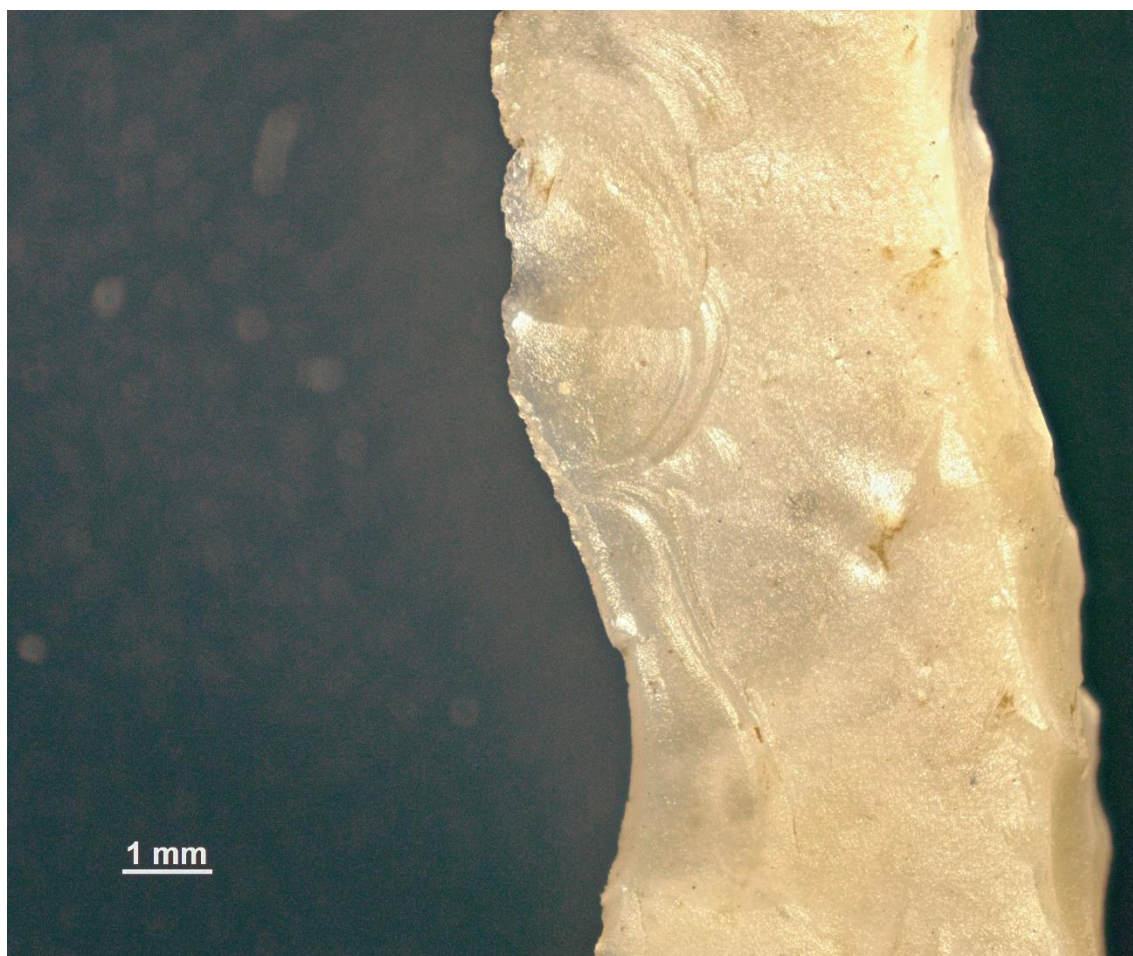


Fig. 54: Backed bladelet N° 1527 from Grotta di Pozzo. Overview of groups of lateral removals on the right side of dorsal face.

Backed bladelet N° 1535 (23x7x4 mm) is a clear example of projectile point belonging in the 1st group. It has abrupt retouch on right lateral edge. It shows several fractures and removals along its whole length: on the tip, there is a main bending initiated hinge terminating fracture associated with a spin-off (Fig. 55B) and secondary removals on the dorsal face (Fig. 55A) and a group of secondary removals and two burinations (Fig. 55D) on the ventral area. In the mesial area there are lateral removals. On the base, there is a bending initiated feather terminating fracture and a secondary removal (Fig. 55C). All the fractures are well associated to each other. This tool has been inserted as barb for the particular use-wears on the lateral edges, like burinations, and included in the first group (Fig. 55).

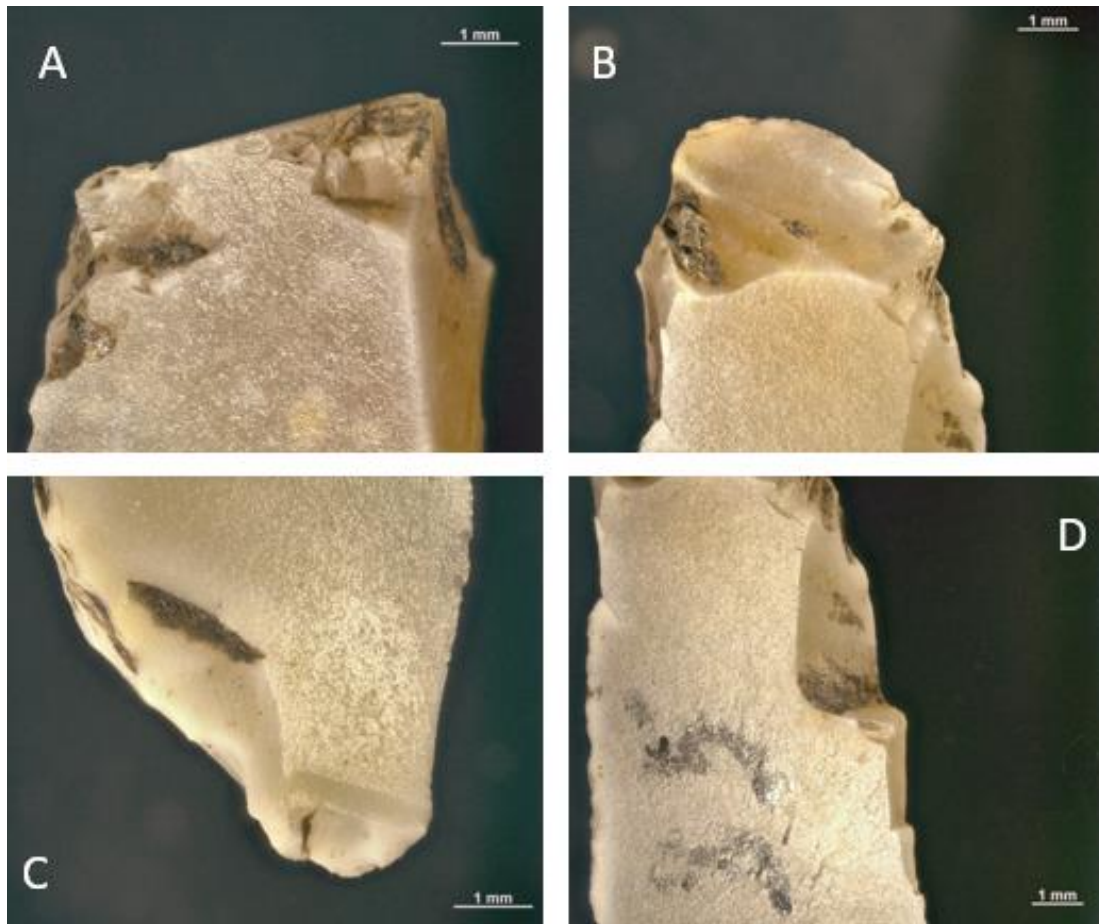


Fig. 55: Backed bladelet N° 1535 from Grotta di Pozzo. A: dorsal face with several fractures due to an explosion event; B: the main tip fracture connected with spin-off, secondary removals and two burinations (D); C: details of the removals on the base.

Fragment of backed bladelet N° 1609 (14x5x2,5 mm) has abrupt retouch on the left edge. There are fractures and scars on the three dimensions of piece, so as two tip fractures bending initiated and feather terminated connected with a spin-off due to compression event with twisted profile, continue and oriented lateral removals and a fracture on the base bending initiated snap terminated. This piece has been placed on the 2nd group and recognized as barb (Fig. 56).

Fragment of backed bladelet N° 3212 (13x5x2 mm) has abrupt retouch on the right edge. This artefact shows a tip fracture associate with a secondary removal and lateral removals, due to compression event. This piece has been placed on the 3rd group (Fig. 57).

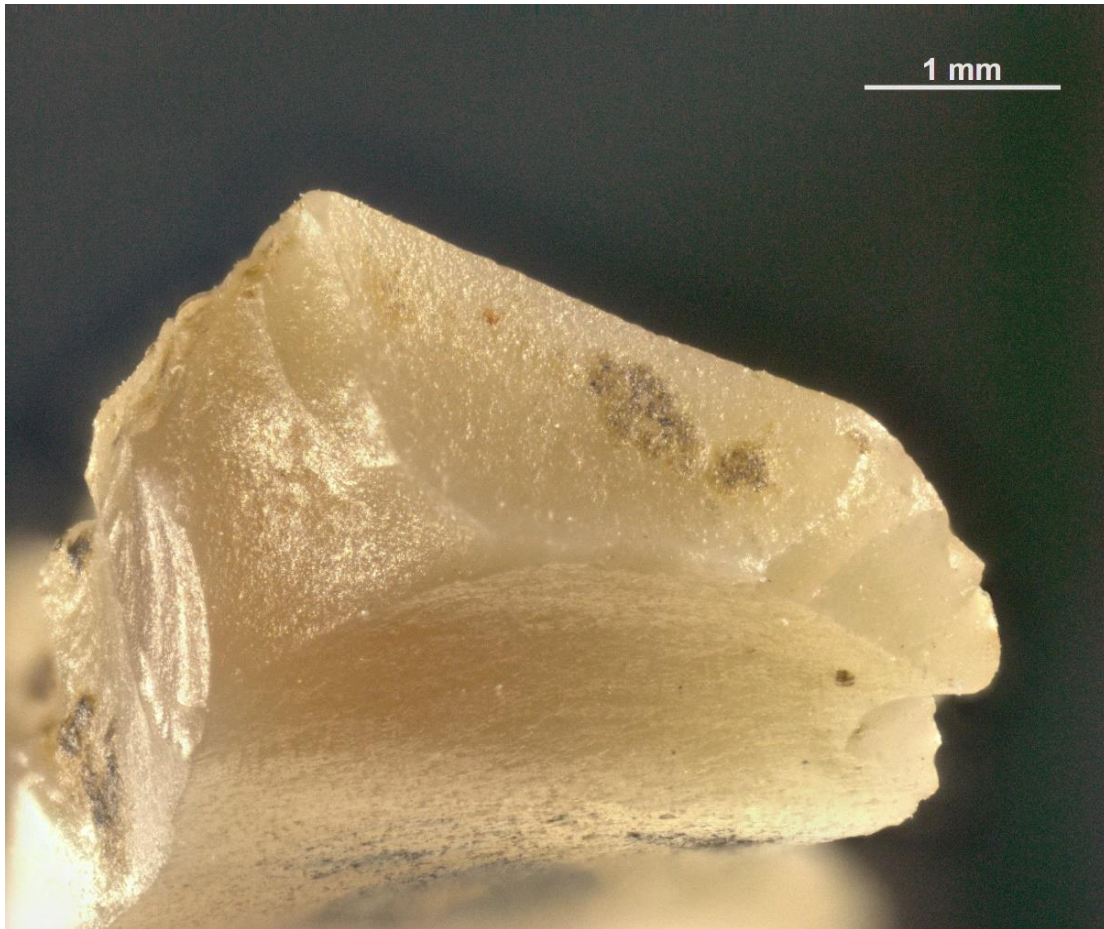


Fig. 56: Fragment of backed bladelet N° 1609 from Grotta di Pozzo, ventral tip overview. There is showed the main fracture on the tip and the other fracture that is clear on the left side of the picture, with a spin-off and secondary removals.

Backed bladelet N° 3236 (30x9x5 mm) has abrupt retouch on the left edge. This artefact has been placed on the 1st group as barb for the typical tip bending initiated hinge terminating fracture associated with a cone initiated feather terminating lateral removal and a spin-off, located on the retouched part that has been cut. Moreover, there are clear striations pattern and the fracture has twisted profile (Fig. 58).



Fig. 57: Fragment of backed bladelet N° 3212 from Grotta di Pozzo, ventral tip overview with a fracture connected with secondary removals and lateral removals.



Fig. 58: Backed bladelet N° 3236 from Grotta di Pozzo, lateral ventral tip overview with a fracture connected with secondary removals and spin-off typical of barb.

Proximal fragment of a backed bladelet N° 5213 (11x10x4 mm) has abrupt retouch on the left edge. This element shows multiple proximal bending initiated step to step terminated fractures, several oriented lateral removals only on the right edge and a bending initiated snap terminated fracture associated with secondary removals that has broken the piece. This has been placed on the 1st group and as a barb for the particular lateral removals only on one side of the piece (Fig. 59).



Fig. 59: Basal fragment of backed bladelet N° 5213 from Grotta di Pozzo, ventral tip overview with a fractures and scars that indicates the use as a barb.

Backed bladelet N° 7303 (17x7x4 mm) has abrupt retouch on the right edge. It shows a small fracture on the tip and a large one on the base connected with secondary removals as burination and spin-off. This is possibly due to an explosion event. Moreover, the morphology of the piece and the probable presence of residues of hafting have placed it on the 1st group as a barb (Fig. 60).

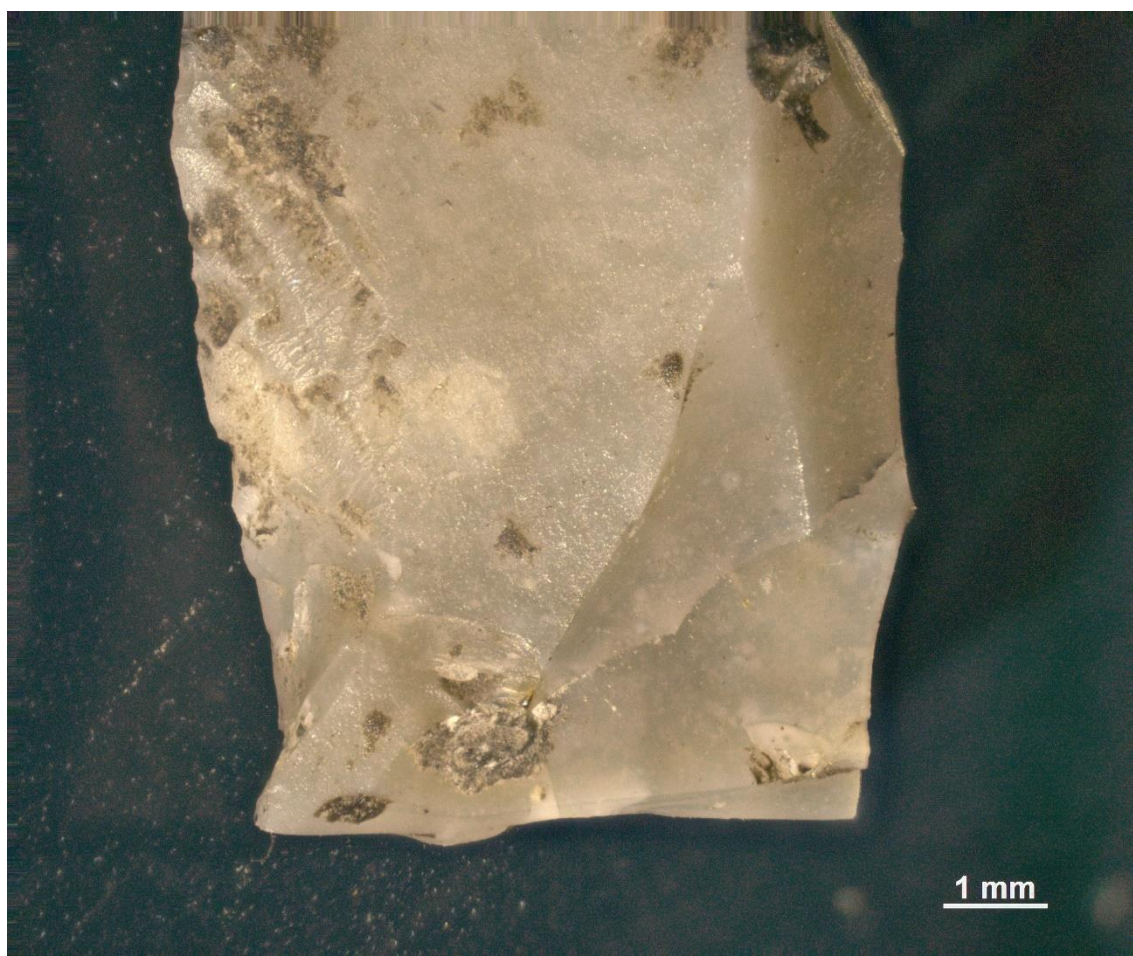


Fig. 60: Backed bladelet N° 7303 from Grotta di Pozzo, dorsal base overview with a fractures and scars combined and associated that indicates the use as a barb.

Lastly, the backed bladelet N° 7420 (22x6x2 mm) has abrupt retouch on the right edge. This artefact shows morphological characteristic as an armature and potential residues due to hafting. Thus, combined with the presence of primary fractures, secondary removals, well oriented, is interpreted as projectile point. The main fracture on the tip (Fig. 61) has a bidirectional twisted fracture due to lateral pressure. For these reasons, this artefact has been placed on the 1st group and included as a barb.

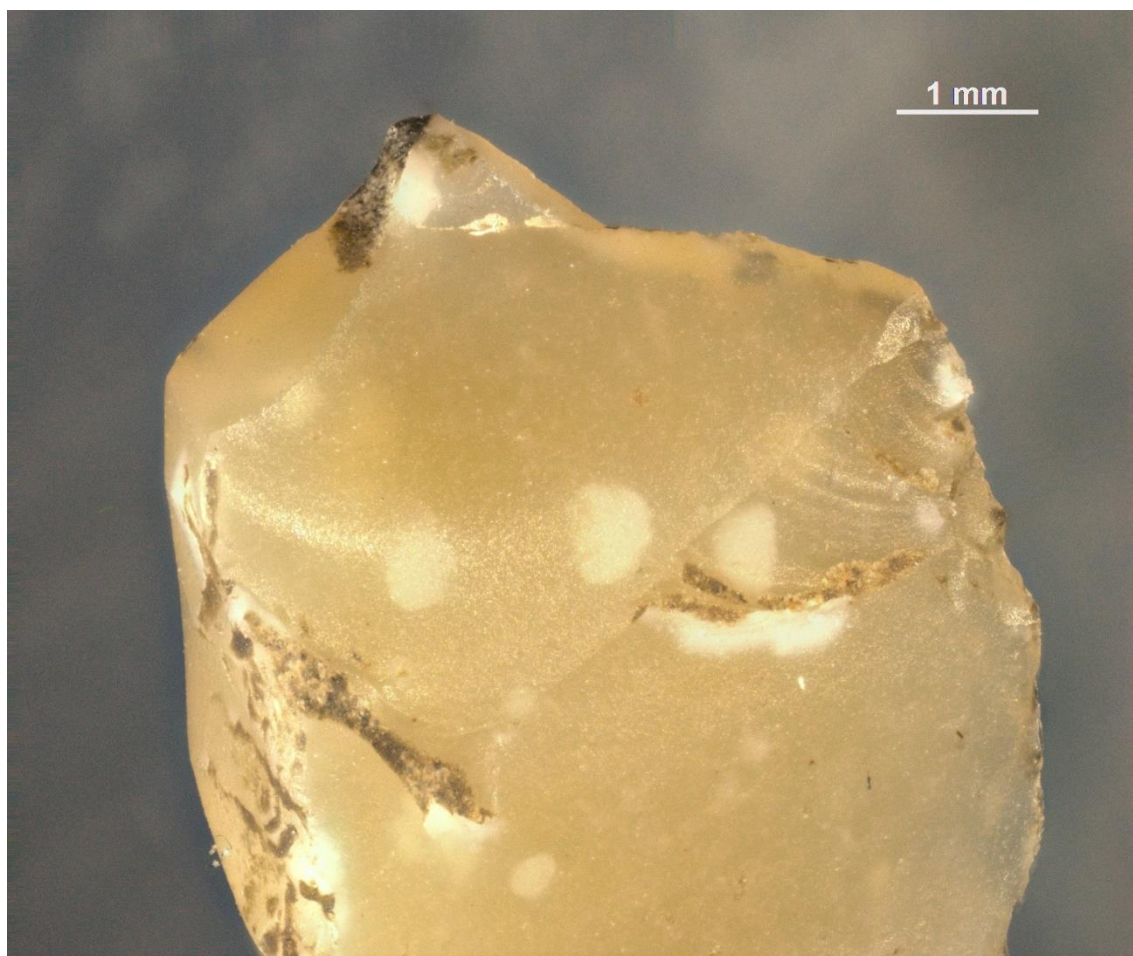


Fig. 61: Backed bladelet N° 7420 from Grotta di Pozzo, ventral tip overview with twisted fractures that goes on two directions due to a lateral impact.

3.1.2.5. Evaluation

An evaluation of the results of the first phase permits to state that the number of projectiles was seriously overestimated (Fig.20 illustrates the first phase, Fig.21, 22, 23 illustrates the second phase). Moreover, during phase two, projectiles mostly consist of backed bladelets while no *microgravette* has been identified as a projectile. On the contrary, during the first phase, the typological composition of the supposed projectiles was more variable (1 shouldered point, 6 backed blades, 49 backed bladelets, 1 *La Gravette* point, 7 *microgravette*, 3 retouched blades, 12 retouched bladelets, 148 were unretouched bladelets).

Interpretative problems were due to a lack of experience with a poor understanding of terminology and identification criteria. The analysis was generally based on the occurrence of a single fracture which has demonstrated to be unreliable for reliably recognizing projectiles (e.g. Rots and Plisson, 2014).

3.1.3. Hafting position

Criteria permitting a distinction between tips and barbs and proposed previously (cf. Rots, 2016) were used in this study. For 11 probable projectiles, no hafting position could be proposed, but 15 (58%) artifacts could be identified as barbs, while no tips could be identified with certainty. The results of the macro-fracture analysis thus suggest that the armatures identified for Grotta di Pozzo have been used mainly as lateral insets on shafts. This is an interesting conclusion given that 3 bone points were found at Grotta di Pozzo (Mussi *et al.*, 2011) with fractures on the tip even though these were not yet studied in detail. It recalls evidence for the existence of composite weapon systems presented earlier for the site of Les Prés de Laure in France (cf. Tomasso *et al.*, 2018), more in particular the lateral attachment of lithic insets on a bone point. It is an issue that requires further more detailed study, but it could explain why no tips could be identified. The incorporation of systematic experimentation and of a detailed analysis of the bone points would permit to further examine such a hypothesis.

3.1.4. Raw material

The raw material used for producing the majority of the projectiles identified during the second phase comes from the *Marsica orientale*, at 30 km from the site (for more information about the raw materials characterization of Grotta di Pozzo

see D'Angelo, 2004). Indeed, 22 identified as projectiles (85%) can be attributed to the "Type 1" from the Majolica limestones formation (Upper Jurassic, Lower Cretaceous) on the basis of macroscopic criteria such as a grey to beige color, a medium texture, a medium to good quality (D'Angelo, 2004). Three of the remaining 4 projectiles (15%) can be attributed to the *Umbro-Marchigiana* formation and have brown-red color. A single piece is too patinated to permit an identification of the raw material (Fig. 62) (Lubell *et al.*, 1999; Mussi *et al.*, 2000; D'Angelo, 2004).

Considering all the lithic points found in the assemblage (N=377) and the projectiles (N=26), the Type 1 chert is the most common raw material used by human groups, possibly due to the large availability in the surrounded area. The *Umbro-Marchigiana* chert that is generally judged to be of better quality is only present in limited quantities. On the basis of the other evidence (Mussi *et al.*, 2011; Cancellieri, 2011), it seems that the *Umbro-Marchigiana* chert was imported to the site as finished or semi-finished products.

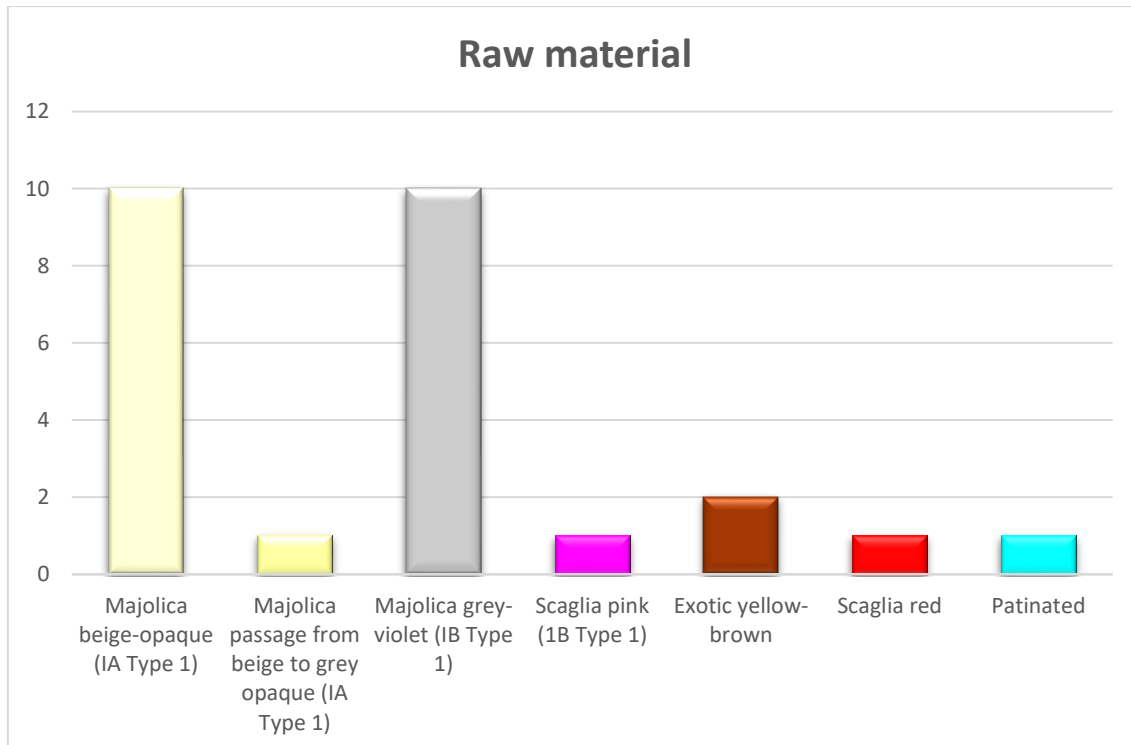


Fig. 62: Raw material used for producing the backed pieces that were definitely used as armatures.

3.2. MACRO-FRACTURES ANALYSIS – RIPARO VILLABRUNA

3.2.1. General

A total of 12 possible projectile points was recognized in the sample of 250 artefacts (Tab. 7), using the Attributed System (cf. Coppe & Rots, 2017), corresponding to a percentage of 5% of the selected sample. On the 12 pieces that were identified as projectile points with reasonable or high certainty, a total of 110 fractures/removals were identified and described (Fig. 63).

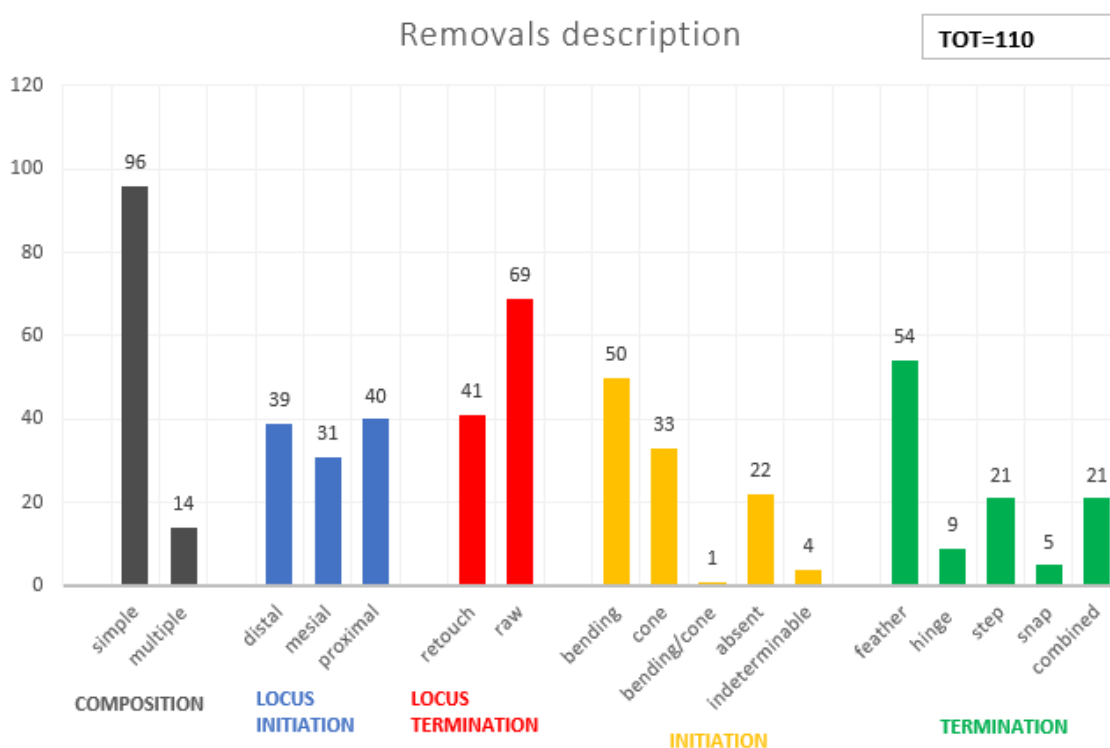


Fig. 63: Macro-fractures description of the lithic materials from Riparo Villabruna: there are indicated the characteristics of fractures/removals.

Each of the 12 identified armatures has been classified in one of the four groups based on the quantity and quality of the fracture features and their association and

distribution: 2 armatures were classified in the 1st group (17%), 3 in the 2nd group (25%) and 7 in the 3rd (58%). The armatures of the 3rd group have been considered projectiles even if this is uncertain.

Moreover, the projectile points are coming from the Riparo A sector and are referred to the Final Epigravettian. On stratigraphic point of view, 4 (33%) come from the layer 6, 2 (17%) from layer 9, 1 (8%) from layer 16, 2 (17%) from the layer 17A where it was found the burial of a hunter-gatherer and 3 (25%) from reworked layers.

The majority of the identified armatures shows traces that correspond to a use as barb, more in particular 6 pieces (50%), while 1 (8%) as tip. For 5 pieces (42%), no hafting position could be proposed (Tab. 21; Supplementary Information, Tab. 2).

ID	Group	Layer	L	w	th	gr	Typology	Alteration	Barb or tip
1014	3°	16	21	8	3	0,5	Backed bldl.	Prox.+lateral fr.	barb
1024	3°	9	17	5	3	0,4	Backed bldl.	Dist. fr.	?
1039	3°	17A	16	5	3	0,4	Backed bldl.	Dist.+lateral fr.	?
1060	3°	9A	27	9	3	0,7	Backed bldl.	Dist.+lateral fr.	barb
1139	1°	reworked	24	6	3	0,6	Backed bldl.	Prox. fr.	barb
1152	2°	reworked	23	10	3	0,9	Backed bldl.	Prox. fr.	tip
1154	3°	reworked	13	6	2	0,3	Backed bldl.	Dist. fr.	barb
1187	3°	6	45	7	4	1,4	Backed point		?
1189	3°	6	19	6	3	0,3	Backed bldl.	Prox. fr.	?
1192	2°	6a	19	4	3	0,3	Backed bldl.	Dist. fr.	barb
1215	2°	17A	24	8	3	0,8	Backed bldl.	Dist+prox fr.	barb
1241	1°	6A	19	5	4	0,5	Backed bldl.	Dist+prox fr.	?

Tab. 21: Overview of the armatures from Riparo Villabruna recognized with the Attribute System.

3.2.2. Detailed observations per probability group

Below, there are presented examples of noteworthy projectile points belonging to the three categories.

3.2.2.1. Group 1: projectile identification with high level of confidence

Two armatures were included in this category: the first backed bladelet (24x6x3 mm) has abrupt retouch on the right edge and a proximal fracture; the second backed bladelet (19x5x4 mm) has bidirectional retouch on the right edge, direct retouch on the opposite edge on the distal area and has fractures on distal and proximal areas.

Backed bladelet N° 1139 (24x6x3 mm) has abrupt retouch on the right edge. It shows a series of lateral removals on the tip; a basal bending initiated feather terminated fracture due to compression phenomenon connected with three spin-offs and a secondary removal; a group of lateral removals. All these fractures are associated to each others and with secondary removals (Fig. 64). For the complexity and the position of the fractures, this tool has been considered as a barb.

Backed bladelet N° 1241 (19x5x4 mm) has bidirectional retouch on the right edge and direct retouch on the distal opposite edge. This element shows a multiple fissured bending initiated hinge to step terminated tip fracture, connected with secondary removals as spin-off and burination due to a possible explosion event. There also are oriented lateral removals. Moreover, there is a bending initiated feather terminated basal fracture that cuts the retouch and generated a spin-off and secondary removals due to compression event. In a certain point it was questioned the use of this tool for dental treatment but, after the experimentation and an

accurate fracture analysis (see the next chapter), it has been considered a projectile point for the well associated fractures. Unfortunately, it is not possible to discern between tips and barbs for the complexity of the removals (Fig. 65).

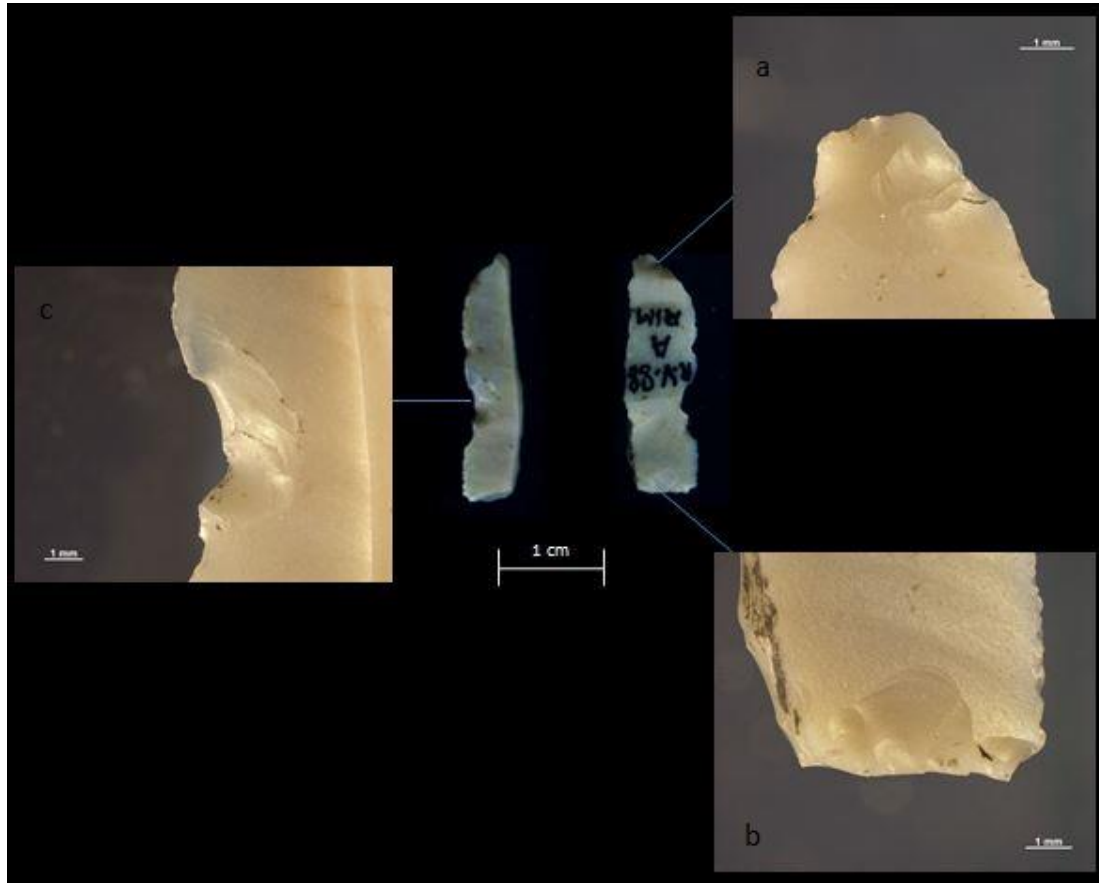


Fig. 64: Backed bladelet N° 1139 from Riparo Villabruna, ventral tip (a) and base (b), left dorsal edge (c): Series of lateral removals on the ventral tip: the biggest one was cut by the other two (a); Series of spin-offs and a lateral removal (b); Series of lateral removals (c).

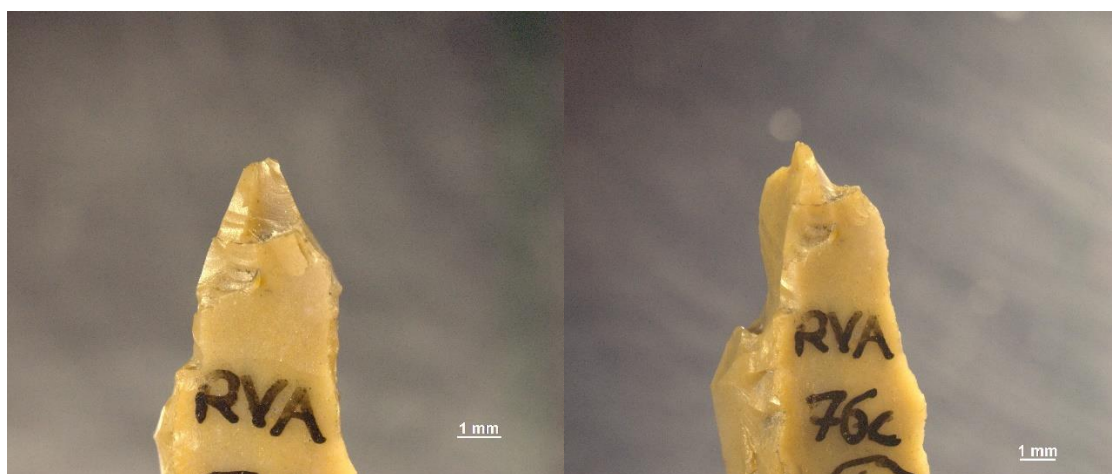


Fig. 65: Backed bladelet N° 1241 from Riparo Villabruna, ventral tip overview with multiple fractures on the tip.

3.2.2.2. Group 2: projectile identification with moderate level of confidence

Three armatures were classified in this category: the first backed bladelet (23x10x3 mm) has abrupt retouch on the right edge and the opposite edge on the distal area and a proximal fracture; the second backed bladelet (19x4x3 mm) has abrupt retouch on both edges and a distal fracture; the third backed bladelet (24x8x3 mm) has abrupt retouch on the left edge.

Backed bladelet N° 1152 (23x10x3 mm) has abrupt retouch on the right edge and on the opposite edge only on the distal area. The artefact shows multiple fractures but the initiation is uncertain due to a possible explosion event on the tip, series of bifacial oriented lateral removals on the mesial area of the piece and a fissured bending initiated step terminated basal fracture connected to a spin-off and secondary removals. These fractures indicate the use of the projectile as a tip (the only one in all this analysis) (Fig. 66).



Fig. 66: Backed bladelet N° 1152 from Riparo Villabruna, ventral tip overview. Explosion that generates a fracture step terminating with secondary removals. There is another elongated removal but it was happened after the retouch.

3.2.2.3. Group 3: uncertain

A total of seven armatures were included in this category consisting of 6 backed bladelet (27 to 13 mm of length, 9 to 5 mm of width, 3 to 2 mm of thickness; 2 of them with only a distal fracture, 1 with only a proximal fracture, 1 with distal and proximal fractures and 2 with proximal and lateral fractures; all with abrupt retouch on one edge or both edges) and 1 backed point (45x7x4 mm; abrupt retouch on the left edge; no fractures).

Backed bladelet N° 1014 (21x8x3 mm) has abrupt retouch limited on the mesial-proximal area of the left edge. This artefact shows a multiple bending initiated hinge to step terminated fracture due to a possible explosion on the tip, lateral sliced fracture, a mesial lateral notch and a bending initiated snap terminated fracture at the base, connected with secondary removals like spin-offs and scars. It has been placed on this group because many fractures might be due to knapping activity and enters on the group of barbs for the particular sliced lateral scar (Fig. 67).

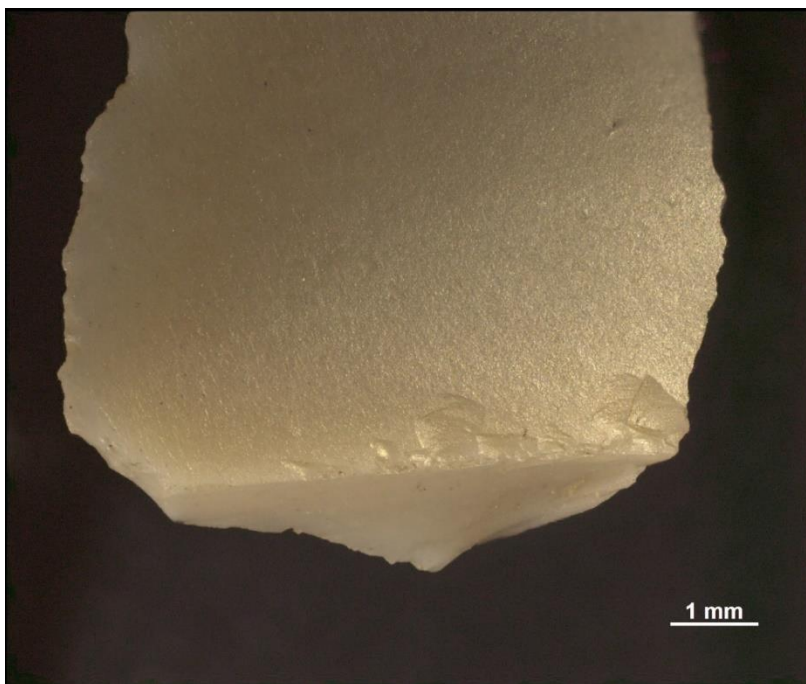


Fig. 67: Backed bladelet N° 1014 from Riparo Villabruna. Ventral face overview of the basal fracture with series of spin-offs.

Backed bladelet N° 1024 (17x5x3 mm) has abrupt retouch on the right edge and direct retouch on the opposite edge. It has been placed in this group because it only has a bending initiated feather terminated tip fracture connected with two spin-offs, with cone initiation feather termination and cone initiation and step termination. Moreover, there are not enough indication to distinguish this artefact between tip and barb (Fig. 68).

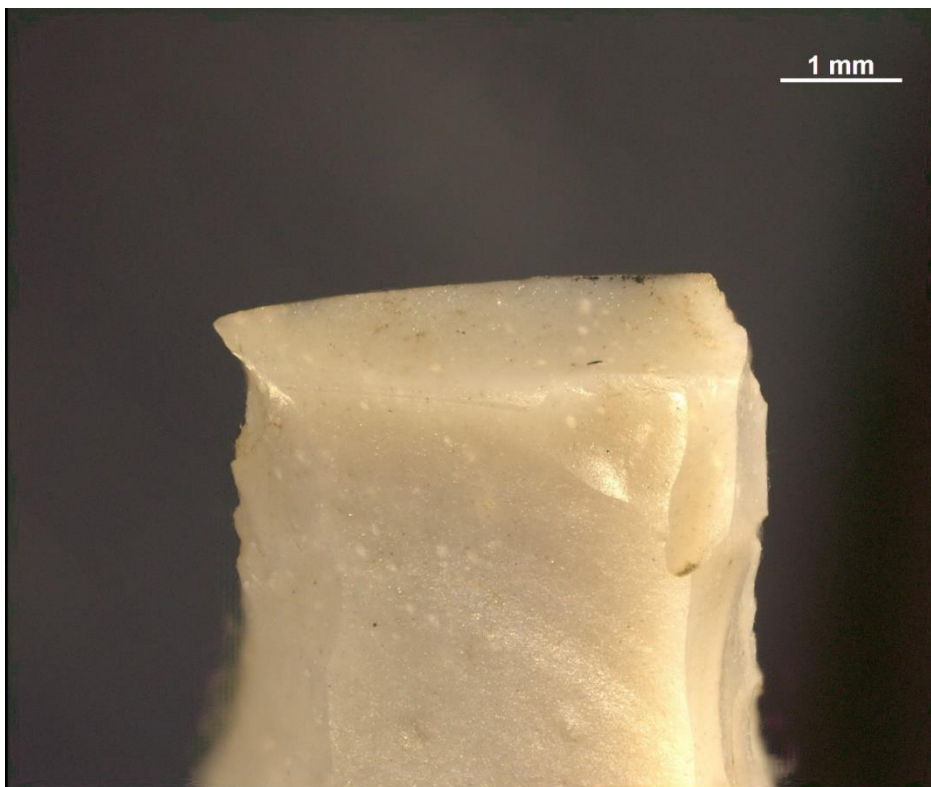


Fig. 68: Backed bladelet N° 1024 from Riparo Villabruna. Dorsal face overview of the tip fracture that cut the retouch area with series of spin-offs.

Backed bladelet N° 1060 (27x9x3 mm) has abrupt retouch on the left edge. This artefact shows a bending initiated feather terminating tip fracture associated with a spin-off and secondary removals that cuts the retouch area. Moreover, along the lateral edges of the piece, there are oriented lateral removals. Lastly, on the proximal area there are small removals. Although there are many doubts about this element, it has been placed in this group as a barb (Fig. 69).

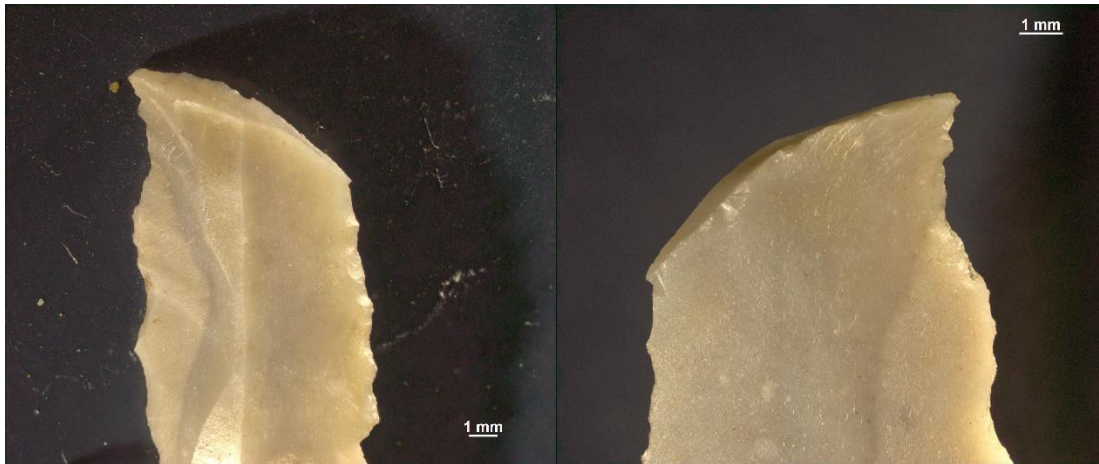


Fig. 69: Backed bladelet N° 1060 from Riparo Villabruna. On the left, dorsal face tip overview with the tip fracture and lateral removals; on the right, ventral face tip overview with the tip fracture connected with spin-off and secondary removals.

Backed bladelet N° 1154 (13x6x2 mm) has abrupt retouch on the left edge. This element shows a bending initiated snap terminated fracture on the tip that cuts the retouch area and a series of lateral removals. This has been considered as barb for the lateral removals (Fig. 70).

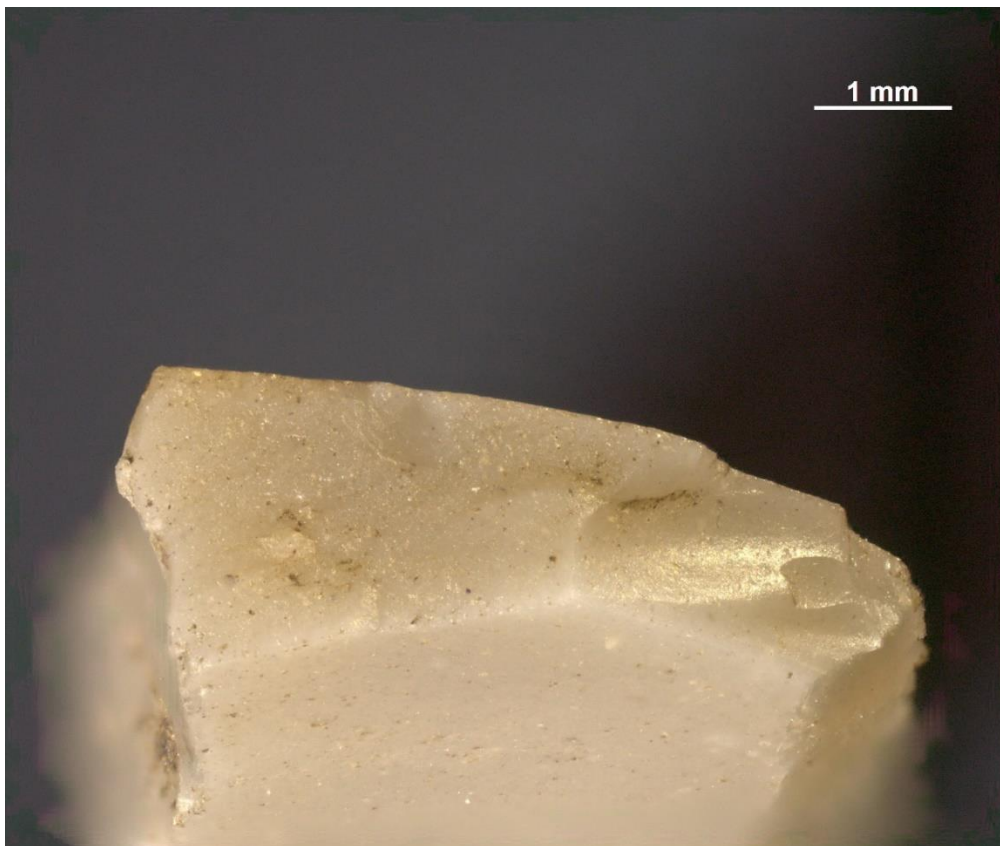


Fig. 70: Backed bladelet N° 1154 from Riparo Villabruna, dorsal tip overview with the bending initiated snap terminated fracture. This is a plan divided fracture: it follows two ways.

Backed point N° 1187 (45x7x4 mm) has abrupt retouch on the left edge. It shows small not oriented damages on the three dimensions. It was questioned the use of this point as tool for dental treatment (it will be discussed on the followed paragraph) but it is most probable that it might be used as projectile (Fig. 71).

Backed bladelet N° 1189 (19x6x3 mm) has bidirectional abrupt retouch on the right edge. This artefact shows a slight bending initiated hinge terminated fracture on the apex that cuts the retouch, a series of lateral removals on both faces oriented diagonally towards the base, mostly bending initiated feather terminated and a fissured fracture on the base bending initiated feather terminated that cuts the retouch. This piece has been placed in this group for the absence secondary removals and not-so-well represented combination. (Fig. 72).

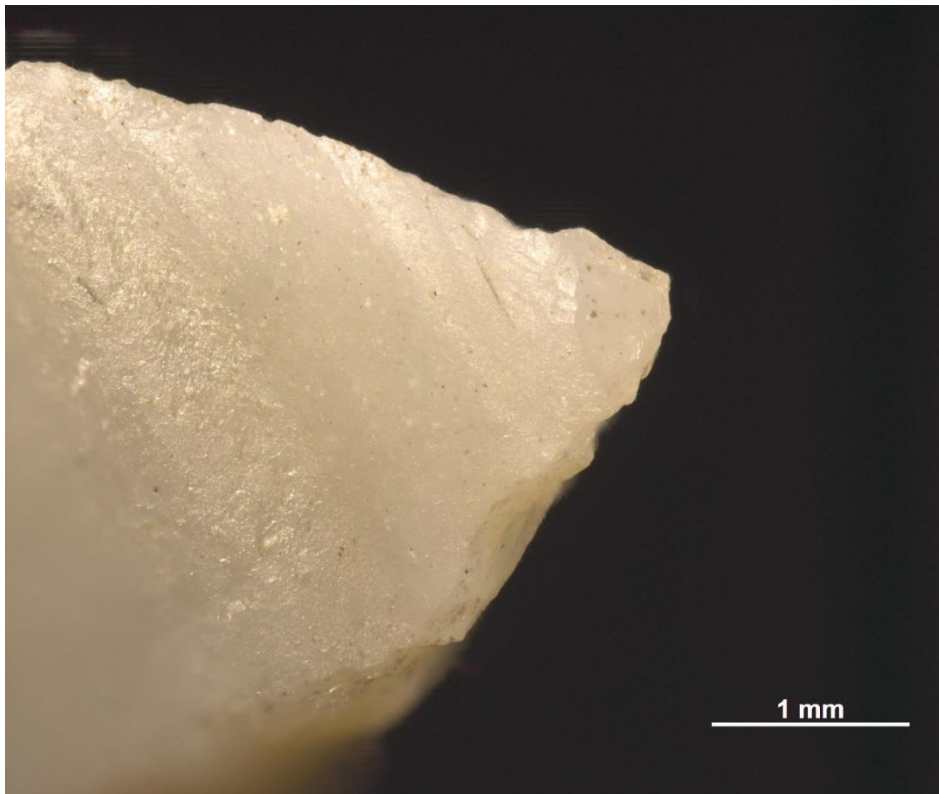


Fig. 71: Backed bladelet N° 1187 from Riparo Villabruna, ventral tip overview with a bending initiated feather terminated small fracture.

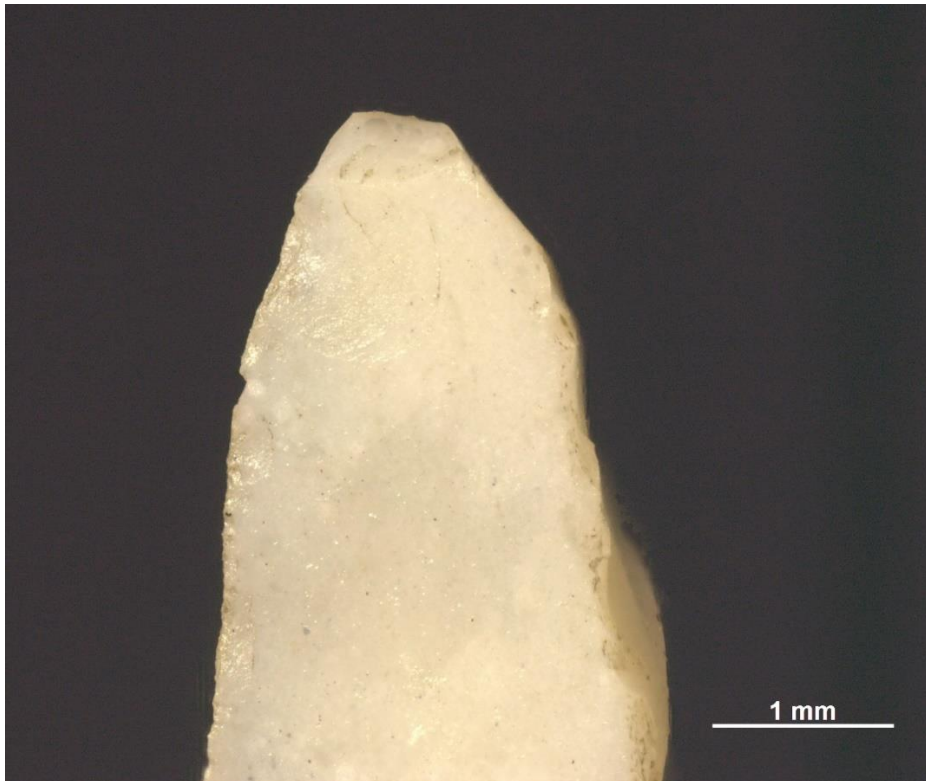


Fig. 72: Backed bladelet N° 1189 from Riparo Villabruna, ventral tip overview with a bending initiated hinge terminated fracture and lateral removals.

3.2.3. Hafting position

Also for the archaeological materials from Riparo Villabruna, by isolating the combination of different fractures characteristic and their distribution (cf. Rots, 2016), it has been tried to assume how these armatures could be hafted.

Even if for 5 possible projectile points no hafting position could be proposed, 6 (50%) pieces have been identified as barbs and 1 (8%) as tip. The results of macrofractures analysis, especially the damages along the lateral edges of the tools, have proved that lithic projectile points in Riparo Villabruna have been hafted frontally and laterally.

3.2.4. Raw material

The raw material used to produce the projectile points in Riparo Villabruna are on 11 cases of 12 (92%) *Biancone*. This is grey silex is coming from 10 km N-NW on the area of *Malga Dotessa*. Furthermore, 1 of 12 (8%) has red colour and it is referable to *Scaglia rossa*, coming from the *Umbro-Marchigiana* formation. The closest area of exploitation of this red chert is in *Veneto* region, in an area called *Colli Euganei* at 100 km ca. of distance.

3.3. TOOLS USED FOR DENTAL TREATMENT AND TO CREATE DECORATIVE OBJECTS

On this section, there are presented the comparison between the experimental points obtained during the experimental activity concerning the use as tools to remove caries on fresh third molars of modern humans, the use of tools to perforate fresh atrophic canines of red deer (*Cervus elaphus*) indicated in chapter 2.4 and, at the end, the selected archaeological materials from Riparo Villabruna.

Although at Grotta di Pozzo there have been found one perforated atrophic canine of red deer, the archaeological materials have not been analysed regarding this aspect but, in the future, they have to be considered. So, in this chapter there are considered *only* the archaeological materials coming from Riparo Villabruna.

In order to compare the experimental and the archaeological materials and have a clear overview of the possible similarities between the use-wear, there are reported again the detailed and noteworthy analysis of the experimental materials.

3.3.1. Dental treatment

The experimental materials regarding the use of tools for dental treatment have been analysed by stereomicroscope in order to identify and describe macro-wears (Tab. 22).

Firstly, there is a reduction in the length of the points, a variation between 4-8 mm, due to the perforating action during the experiment. The traces on the tools have been specifically described (Supplementary Information, Tab. 3).

ID.	#	L	W	th	Raw material	use	Alteration
1	RV-EXP1	35	7	4	scaglia rossa	A, hold by hand	Distal fracture
2	RV-EXP2	36	7	3	scaglia rossa	E, lateral from the outside	Distal fracture
3	RV-EXP3	34	7	3	scaglia rossa-variegata	E, from the top	Distal fracture
4	RV-EXP4	37	6	3	scaglia rossa	E-D, in between	Distal fracture
5	RV-EXP5	43	9	4	scaglia rossa	E, lateral from the inside	Distal fracture
6.1	RV-EXP6	7	3	2	Biancone	E with cheek, mixed actions	Distal and proximal fracture
6.2	RV-EXP6	33	7	4	Biancone	E with cheek, mixed actions	Distal fracture
7	RV-EXP7	28	6	5	Biancone	A-C, toothpick, 1° and 2° try	Distal and proximal fracture
8	RV-EXP7	34	7	2	Biancone	C-D, toothpick, 1° and 2° try	Distal fracture

Tab. 22: Experimental backed points after the experiment for dental treatment.

The experimental backed point N°1 referred the EXP 1 and used on the tooth A shows multiple removals on both faces of the tool, that cut to each other with variable bending to cone to indeterminate to absent initiations as well as for the terminations. (Fig. 73).



Fig. 73: Experimental backed point N° 1 used on tooth A, on the left, dorsal overview, on the right, ventral overview. It is clear the presence of multiple and confused removals that crosses the whole thickness of the piece.

The experimental backed point N° 2 concerns the EXP 2 and used on the tooth E shows a bending initiated feather termination tip fracture that ends on the dorsal face and cuts the retouch. Moreover, many lateral removals cone initiated feather terminated and step terminated are present on the distal part (Fig. 74).



Fig. 74: Experimental backed point N° 2 used on tooth E, tip ventral overview. There are evident lateral removals that cross the surface of the tool.

The experimental backed point N° 3 referred to EXP 3 and used in tooth E shows fractures on the tip: on the dorsal face are cone initiated and feather to step to hinge terminated while on the ventral face are fissured bending initiated and step or feather or step to feather terminated (Fig. 75).

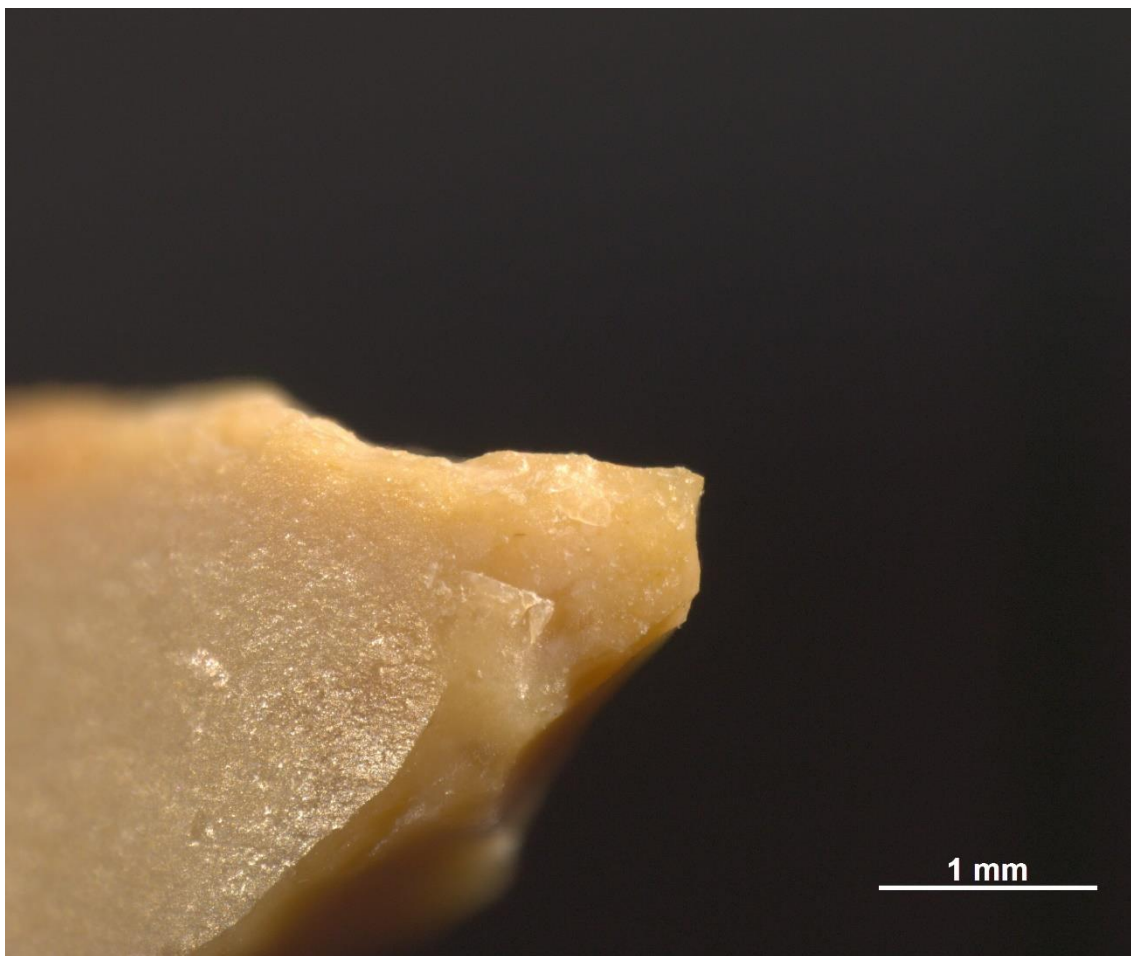


Fig. 75: Experimental backed point N° 3 used on tooth E, tip ventral overview. The picture emphasizes fissured bending initiated fractures.

The experimental backed point N° 4, EXP 4, used between the teeth E-D shows multiple burinations on the lateral edges of the tool and multiple removals on the tip bending initiated and cone initiated and step and feather, step, snap terminated. This is the only example of burination on those experimental pieces and it is interesting in view of the discussion chapter as a comparison with similar traces found on projectile points (Fig. 76).

The experimental backed point N° 5, EXP 5, used on the tooth E shows a small tip removal and interesting lateral removals, bending initiated feather terminated and cone initiated and step terminated, that cross the surface on the tool and partially cut the retouch area (Fig. 77).



Fig. 76: Experimental backed point N° 4 used between teeth E-D, tip ventral overview.



Fig. 77: Experimental backed point N° 5 used on tooth E, ventral overview, with the lateral removals.

The experimental backed point N° 6 referred to EXP 6 and used on the tooth E has been broken on the distal area, so it is possible to appreciate a bending initiated snap terminated connected to a lateral removal on the distal part. Moreover, on the tip there are lateral removals and fractures bending initiated and cone initiated and various terminations (Fig. 78).

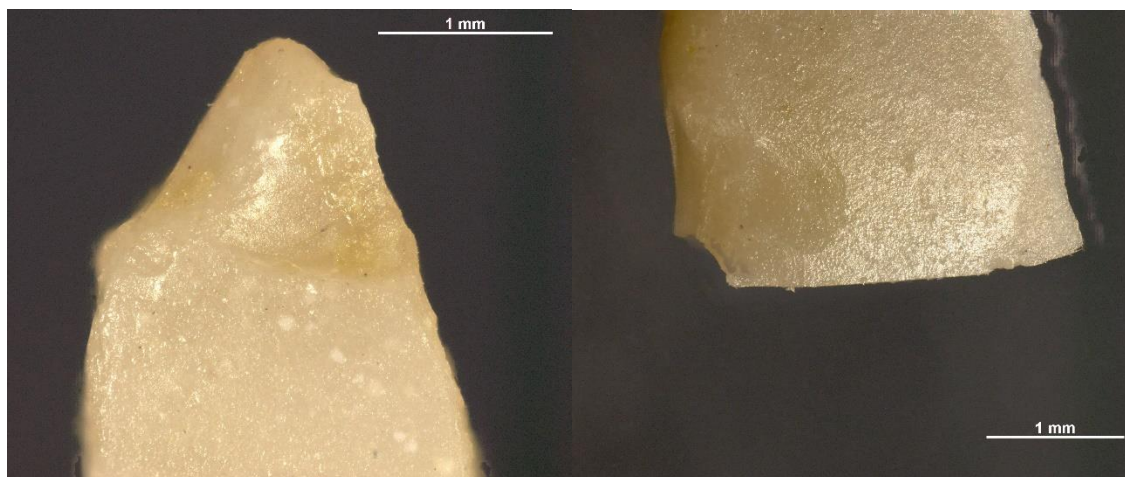


Fig. 78: Experimental backed point N° 6 used on the tooth E, ventral distal overview. On the left there are the tip fracture and lateral removals while, on the right, the distal bending initiated snap terminated connected to a lateral removal.

The experimental backed point N° 7, EXP 7 used as toothpick on the teeth A-C has been used two times, in order to appreciate the traces meanwhile. During the first try there have been produced bending and cone initiated and feather, step and step to feather terminated fracture on the retouch area that looks like a retouch but there are removals. During the second try, the tip has broken creating a bending initiated feather terminated fracture and multiple lateral removals with cone initiation and step termination (Fig. 79).

The experimental backed point N° 8, EXP 7 used as toothpick between teeth C-D has been used as the N° 7. During the first try, it shows a bending initiated feather terminated fracture while, during the 2nd test, the tip has broken creating a bending initiated feather terminated lateral fracture and multiple cone initiated feather terminated lateral removals (Fig. 80).

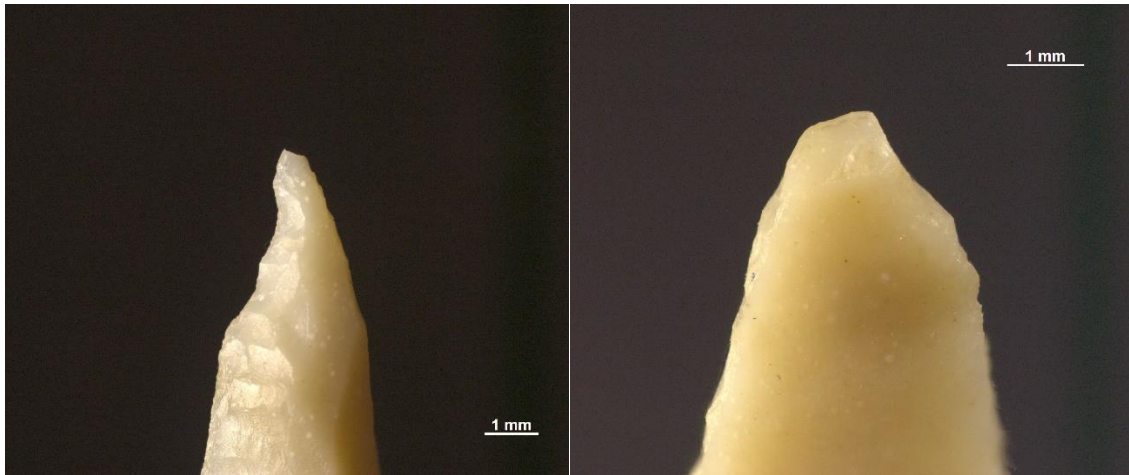


Fig. 79: Experimental backed point N° 7 used in between teeth A-C. On the left, dorsal overview of the first test; on the right, ventral overview of the second test with the tip fracture.

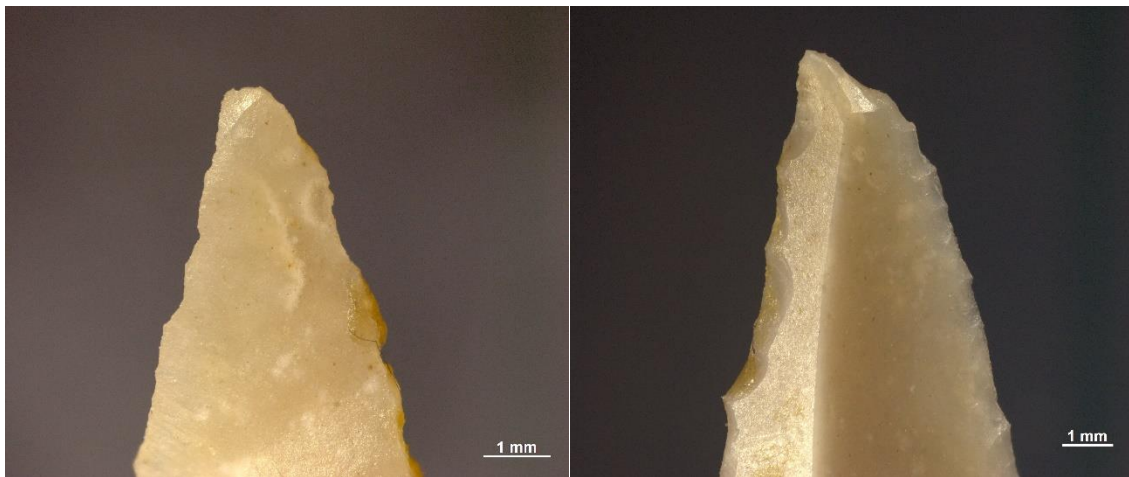


Fig. 80: Experimental backed point N° 8 used in between teeth C-D. On the left, ventral overview of the first test; on the right, ventral overview of the second test.

Resuming the damages obtained during the experimental activity, fractures and removals are connected to perforating damage that, unfortunately for us, could happen to several uses of the tool. Anyway, the traces' identification permits to isolate recurring damages on experimental points: tips are mostly removed on both lateral edges, tip removals mostly terminate on both faces and lateral edges, many lateral removals are present on ventral faces (Fig. 81). Moreover, it has also been carried out high magnification approach to find microwears on the experimental materials. As suspected, there have been found many polishes and striations while when the point is broken just residual presence of polish (Fig. 82).

MOST COMMON FEATURES (low magnification)

- Perforating damage;
- Tip mostly removed on both edges;
- Tip removals mostly terminate on both faces and edges;
- Lateral removals on ventral face.

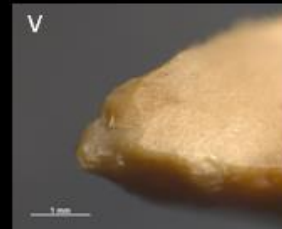
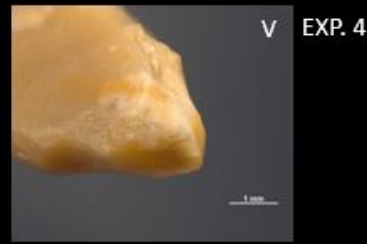
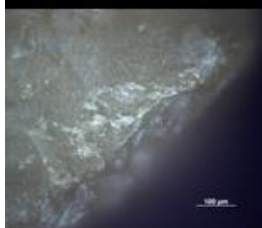
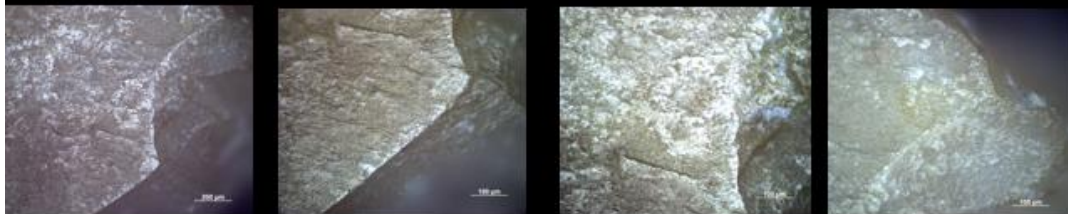


Fig. 81: Recurrent traces on experimental backed points used for caries removal. Fractures and scars are connected to perforating damages.

MOST COMMON FEATURES (high magnification)



- Residual ivory polish due to dental treatment (cleaned only with acetone);
- Striations.
- Fracture: limited development of polish

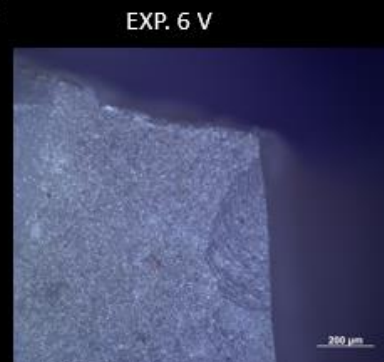


Fig. 82: High magnification to delight polishes and striations on experimental backed points used for caries removal.

3.3.2. Perforators to create decorative objects

The experimental materials have been analysed by stereomicroscope in order to identify and describe macro-fractures (Tab. 23) (Supplementary Information, Tab. 4).

ID	#	L	w	th	Raw material	Use	Alteration
9	RV-EXP8	40	8	5	Biancone	abrasion/perforation on W	Distal fracture and lateral removals on both edges
10	RV-EXP9	30	7	3	Biancone	abrasion/perforation on X	Distal fracture, lateral removals on the right edge
11	RV-EXP10	37	7	3	Biancone	abrasion/perforation on Y with ochre	Distal fracture and lateral removals on both edges, ochre residues
12	RV-EXP11	37	7	2	Biancone	abrasion/perforation on Z with ochre	Distal fracture, burination, lateral removals on both edges, ochre residues

Tab. 23: Experimental backed points after the experiment as perforators.

The point N° 9 shows series of lateral removals with multiple nature due to abrasion on the dorsal left lateral edge. On the tip there is a cone initiated feather terminated fracture, followed by lateral scars both on dorsal and ventral faces due to abrasion action, with cone initiation and feather termination and cone initiation step termination (Fig. 83).

The point N° 10 shows multiple removals juxtaposed to each other due to abrasion on both lateral edges and a tip fracture cone initiated feather terminated, followed by lateral scars cone initiated and feather or step terminated along the width of the point (Fig. 84).

The point N° 11 shows clear multiple removals due to abrasion on the dorsal left lateral side, nearby the retouched area, which is impossible to determinate the initiation step and feather termination. Moreover, two fractures on the tip go to opposite direction and on the ventral face there is another one with bending initiation feather termination. There is evident the red colour due to the use of ochre (Fig. 85).

Lastly, the point N° 12 shows multiple scars due to abrasion on the mesial right lateral side and two scars on the dorsal tip, the first bending initiated feather terminated, the second cone initiated step to step terminated. On the ventral area, there is a burination comparable with the use as projectile point and two scars. This secondary removal has no initiation because has been removed by the previous fracture, feather termination, a length of 6,4 mm placed nearby the retouch area. There is clear the red colour due to the use of ochre (Fig. 86, 87).

Furthermore, the tooth W and X show striation on both faces due to abrasion action. They are parallel to the main axis and terminated on the crown. There are perforation traces due to rotation movement and polishes on the crown area (Fig. 37, 38). The tooth Y and Z show a red shiny surface, due to the use of ochre. The presence of it is less evident on the hole. The use-wear are practically the same of W and X and there are polishes (Fig. 39, 40).

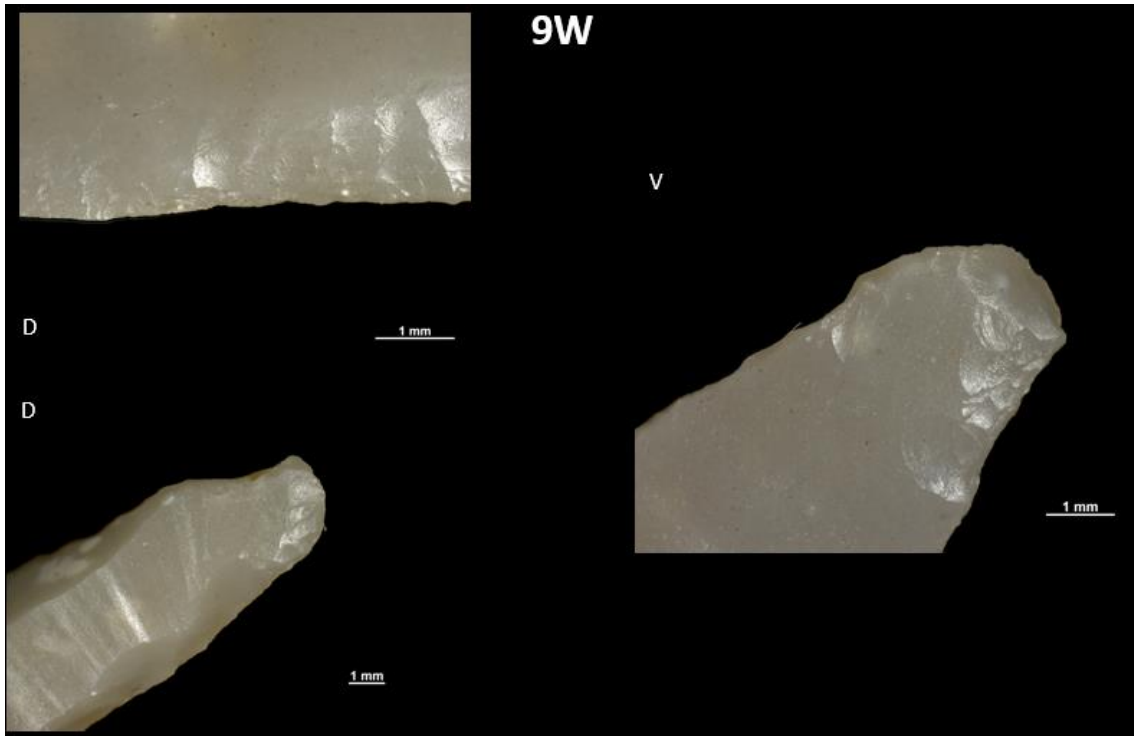


Fig. 83: Experimental point N° 9. Details of removals: on the top left, series of lateral removals; on the bottom left, the distal fracture with scars that end on the dorsal area; on the right, the distal fracture on the ventral area and series of lateral scars on both edges.

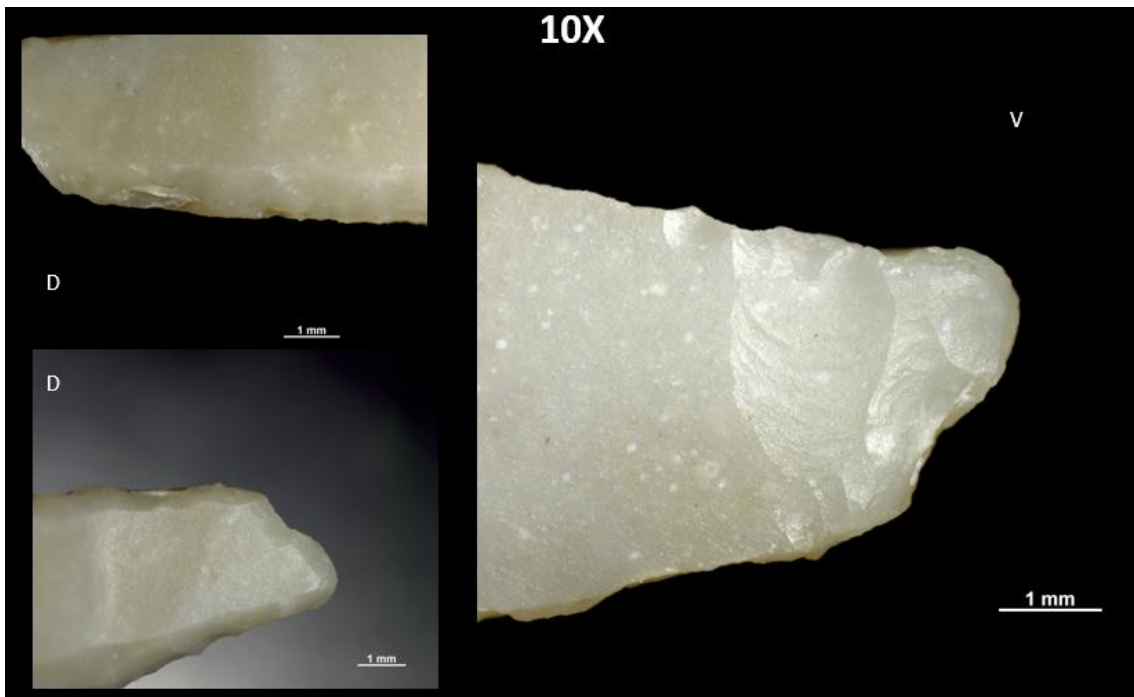


Fig. 84: Experimental point N° 10. Details of the removals: top left, lateral scars; bottom left, distal fracture; on the right, series lateral removals that cross all the ventral surface.



Fig. 85: Experimental point N° 11. Details of the removals: top left, lateral scars; bottom left, distal fracture; on the right, series lateral removals and distal fracture that cross all the ventral surface. There are evident ochre residues.

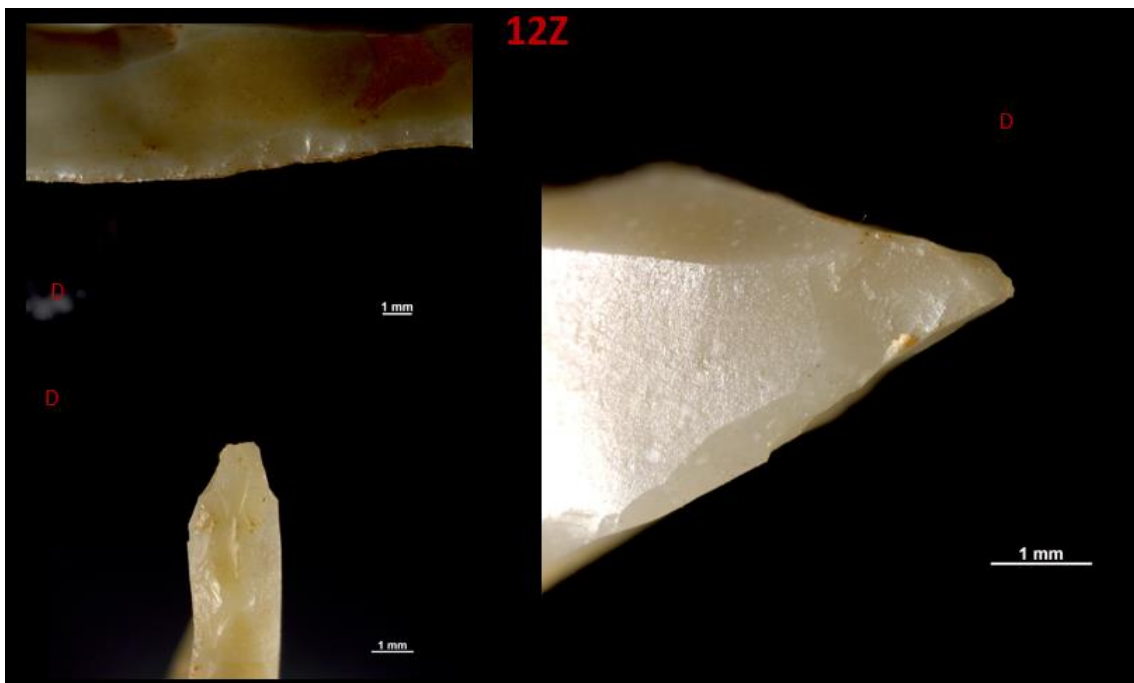


Fig. 86: Experimental point N° 12. Details of the removals: top left, lateral scars; bottom left, distal fracture, left edge point of view; on the right, series distal removals, right edge point of view. There are evident ochre residues.



Fig. 87: Experimental point N° 12, ventral face. Details of the burination.

The experimental data reveals that also in this case there is a reduction of the length of the tip between 2-6 mm due to abrasion action during the experiment. By comparing the experimental materials with the reference collection located in the Traceolab, *University of Liège*, it is possible to connect them to perforating damage. Recurrent traces are due abrasion on both lateral edges that creates multiple removals along the tool, small fractures on the tip due to the hardness of the enamel of the teeth.

3.3.3. Comparison with the archaeological materials

The sample selected coming from the archaeological site of Riparo Villabruna have been compared with the experimental materials in order to understand if wear patterns are similar.

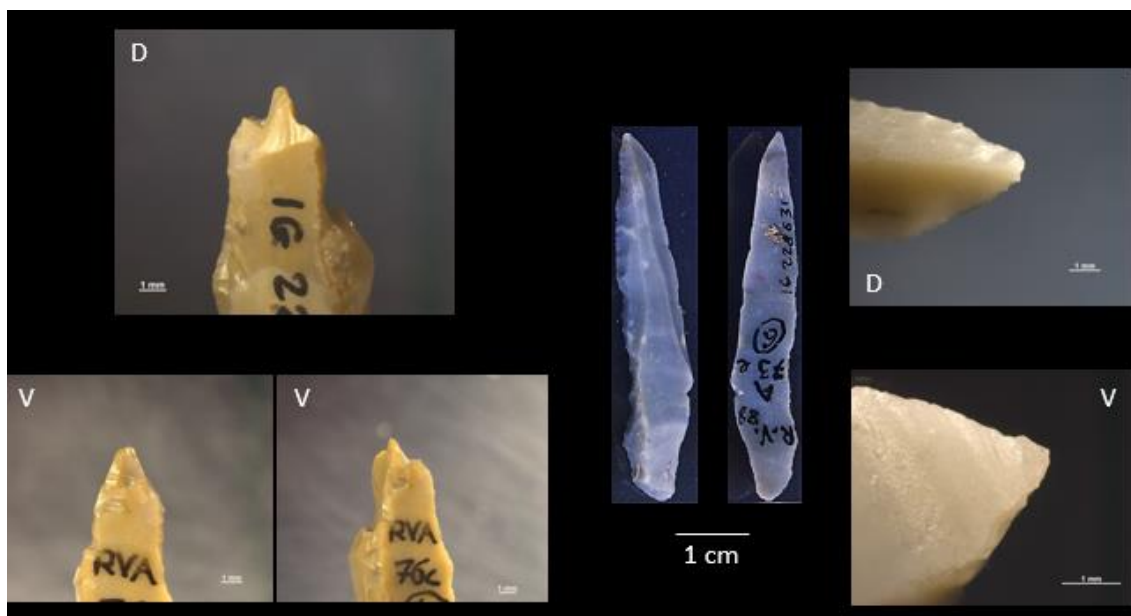


Fig. 88: Archaeological materials from Riparo Villabruna. N° 1241, fragment of backed bladelet, and 1187, backed point, suspected in the beginning: fractures and removals not comparable with the experimental data for dental treatment.

In sum, 10 archaeological backed points have been selected for the use-wear analysis and for the comparison with the experimental materials (Tab. 13). The first evidence is that the two suspected backed points (N° 1241 and N° 1187) for caries removals actually have different and not comparable fractures and removals with the experimental ones (Fig. 88), more suitable for the use of projectile point (see chapter 3.2).

By contrast, 4 other backed points with no impact traces have shown removals comparable with the experimental materials, both regarding dental treatment and used as perforators on atrophic canines of red deer (Supplementary Information, Tab. 5).

Backed bladelet N° 1250 (27x7x3 mm) has abrupt retouch on the left edge. It shows series of lateral removals and tip removals bending initiated feather terminated, multiple bending initiated snap terminated sliced lateral removals and secondary removals cone initiated step terminated (Fig. 89).

Backed bladelet N° 1251 (25x4x3 mm) has abrupt retouch on the left edge. Markable are the multiple tip bending initiated feather terminated fractures connected with secondary removals, series of oriented multiple lateral removals

bending initiated step to feather terminated and a proximal bending initiated hinge terminated fracture (Fig. 90).

Backed point N° 1253 (21x5x3 mm) has abrupt retouch on the left edge, direct retouch on the opposite edge and reverse retouch on the right proximal area. It shows several tip fractures on both faces, bending initiated feather, hinge, step and feather terminated (Fig. 91).

Microgravette N° 1031 (19x4x2 mm) has abrupt retouch on the right edge and direct retouch on the distal opposite edge. It shows a bidirectional tip fracture, bending initiated step or feather terminated and multiple lateral removals bending initiated feather terminated (Fig. 92).



Fig. 89: Backed bladelet N° 1250 from Riparo Villabruna, ventral tip overview with tip fractures and lateral removals.

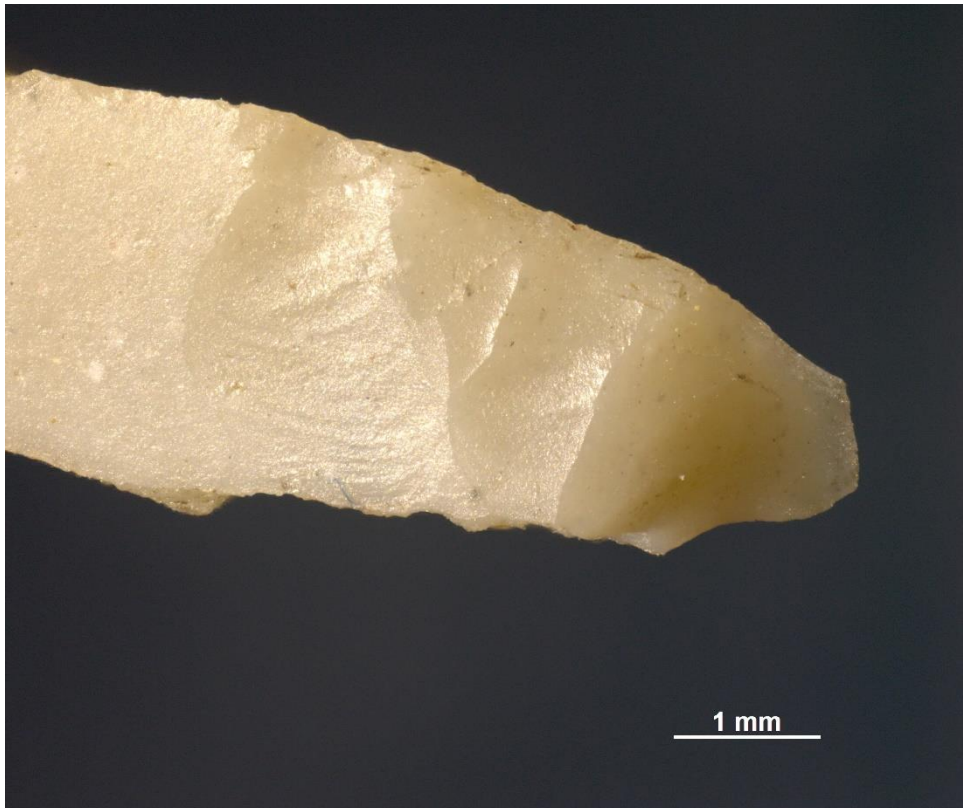


Fig. 90: Backed bladelet N° 1251 from Riparo Villabruna, ventral tip overview with tip fractures and lateral removals.



Fig. 91: Backed point N° 1253 from Riparo Villabruna, ventral tip overview with tip fractures and lateral removals.



Fig. 92: *Microgravette* N° 1031 from Riparo Villabruna, ventral tip overview with tip fractures and lateral removals.

In synthesis, the macro-fractures that seem to be repeated on the archaeological materials are the tip removals in each case bending initiated and many lateral removals, showing perforating damage (Fig. 93).



Fig. 93: Other archaeological fragmented tools from Riparo Villabruna that seem to have removals comparable with the experimental elements.

Although the damage is too intense, the dental treatment cannot be excluded as a cause while polishes are insufficient to confirm the hypothesis. Residue analysis is required to demonstrate such a use. Unluckily, the archaeological materials from Riparo Villabruna have been discovered at the end of the Eighties and have been manipulated several times and a residue analysis, essential at this point, would not be reliable. In terms of probability, there are many chances that the archaeological points have been used as perforators to create decorative objects.

Lastly, on the experimental points N° 4 and 12 there have been accidentally created a burination (Fig. 76, 87). This is very typical during the macro-damage analysis on projectile points and many scholars may call it “diagnostic of impact”. During a blind test, for example, a traceologist might confuse that fracture and make a wrong interpretation about the use of that tool.

4. DISCUSSION

The macro-fracture analysis of the lithic assemblages from the Epigravettian archaeological sites of Grotta di Pozzo and Riparo Villabruna allowed to identify the use of backed points as armatures. The results permit to emphasize once more that the availability of an experimental reference collection and training are essential to guarantee a reliable analysis.

For Grotta di Pozzo, an initial analysis of the microliths performed during a Master thesis proved to be problematic as it relied on no formal training, no hands-on access to experimental reference material and no prior knowledge other than what could be acquired through published resources. An in-depth revision permitted to correct earlier identifications and to demonstrate that traces were over-interpreted during the first phase.

While 227 projectiles were identified – supposedly with certainty – in the first phase, this reduced to 26 pieces in the second phase, in spite of 52 pieces being added to the study. From the 148 unretouched elements considered as projectile points during the initial analysis (Ruta, 2014) only 1 proved to be correct following the standards used in the follow-up study. The main problem in the initial study proved to be the difficulty in correctly distinguishing fractures resulting from knapping, trampling, or other uses from those caused by projectile use. This demonstrates that formal training and an access to an experimental reference collection are important if not essential to understand fracture formation and to get acquainted with appropriate terminologies and interpretative criteria. A crucial element proved to be the fact that *only one fracture will never define an artifact as a projectile point* (cf. Plisson & Beyries, 1998; Rots and Plisson, 2014; Rots, 2013; Rots, 2016). Only particular trace characteristics and trace associations, in specific distributions over the tool, permit reliable tool use identifications.

Other examples exist for the use of backed points, *Gravette* and *microgravette* points as armatures on different archaeological sites in the broader region (O'Farrel, 2004; Taller *et al.*, 2012; Sano, 2009; Ziggotti, 2008), even if the amount of detail on the exact fracture evidence varies between authors as well as the distinctive criteria considered as being “diagnostic”. For Grotta di Pozzo, pieces identified as projectiles concern backed bladelets with abrupt retouch on one lateral edge. Although most of them are fractured, there seems to be some standardization in blank size leading to similar metrics (average length of 19 mm, width of 6 mm, thickness of 3 mm).

Whether the site was part of logistical movements as proposed by Cancellieri (2011) cannot be confirmed, but it appears that the weapons may have been carried as personal gear to the site and that some retooling likely took place. Indeed, projectiles were manufactured from non-local raw materials, the majority from sources located at about 30 km from the site and a minority from a source further away (the *Umbro-Marchigiana* formation, at a distance of 200 km) (D'Angelo, 2004). Lithic raw material acquisition is a problematic matter in the Fucino basin area given the lack of flint outcrops. As a consequence, the exploitation of raw materials for the production of projectile points was likely associated with seasonal hunting activities in the mountains. On the other hand, Cancellieri (2011) asserted that flint blocks might have been collected along the paths during movements to or from the cave, given that evidence for the processing of flint cores is attested below the cave. Raw material in secondary position may thus have been collected. The small percentage of raw material coming from the Marche region suggests a territorial range or an exchange network with other groups of hunter-gatherers that frequented the macro-area of Central Italy. The lithic material of the “mountains” was abandoned at Grotta di Pozzo during autumn, after summer hunting. The archaeological site of Grotta Continenza (Boschian *et al.*, 2017), located on the southern side of Fucino basin and with the same chronology of the upper layers of Grotta di Pozzo, shows similar raw material exploitation patterns. Although no comparison of the flint used at both sites has been performed, Danese (2003)

asserted that at Grotta Continenza the grey raw material comes from Mount Genzana, about 30 km south-east from the site while the brown-red chert would come from 80 km to the north-east in the Montagna dei Fiori Area (Colombo *et al.*, 2011). So, the hunter-gatherers from Grotta di Pozzo might have exploited the red chert in these mountains, located closer to the site. In any case, we can only base our analysis on the raw material characterization made by D'Angelo (2004) because the chert found in Grotta Continenza and Grotta di Pozzo might be different and no comparison has been made, yet.

The strong method acquired during that investigation has been applied for the macro-fracture analysis of the archaeological materials of Riparo Villabruna, concerning a sample of 250 lithic elements. By comparing the materials between the two sites, it has been considered that the sample used for Riparo Villabruna has a better state of preservation. The macro-damage analysis carried out on lithic points permits to identify 12 projectile points: it was a good example to apply a new methodology concerning the identification of impact-scars. A solid method, definition, experiment, data should be replicable and a shared procedure is the only way to get an objective result. The main problems of the DIFs system are connected to categories not-so well defined, features classified under the same term and low level of precision in the classification of a trace. The proposed Attribute Based system seems a good starting point in our discipline. For sure, this number is an underestimation of the real number of armatures but there should be evaluated as a minimum number. Moreover, many elements have been avoided for the low quantity and quality of stigmata. But, in our discipline, it is absolutely better underestimating the results than an overestimation that could completely change the interpretation of the function of archaeological sites.

Regarding the manufacturing of these projectiles, even if on the typological point of view there was a distinction between backed bladelets and backed points due to the fractures state, after the macro-fracture analysis we can consider all of them backed points. They have an average length of 22 mm, width 7 mm, thickness 3 mm and have abrupt retouch on one lateral edge and in few cases direct retouch on

the opposite lateral edge. If we compare this data with Grotta di Pozzo, it seems that there is a standardization of the measures of projectile points. Moreover, it is important to underline that 3 projectile points coming from the archaeological layers nearby the burial of the hunter-gatherer (levels 16 and 17A). This confirms that during the frequentation of the individual, hunting activities took place around the site and, probably, there was a small group that frequented the shelter around 15.000 cal. BP. Furthermore, other projectiles coming from the upper layers (level 9 and 6). This data indicates that the site was also frequented by human groups after the burial placement and hunting activities took place over and over.

Concerning the raw materials acquisition to produce projectile points, in Riparo Villabruna, as well as for Grotta di Pozzo, there have been used two types of chert: mostly *Biancone* but a small percentage of *Scaglia Rossa*. The most part of production were conducted with chert that can be found nearby the frequented site. For Grotta di Pozzo it is at 30 km of the site, for Riparo Villabruna at 10 km. So, the frequentation by human groups it is also connected to the availability of raw materials that were exploited where there was the chert formation and carried at the shelters to be used as weapons during hunting activities. There have to be underlined that during butchering activities, integral or fractured projectiles might be inside the carcass and the presence of these lithic elements in the site may be the result of the discard during the animal's cleaning. However, a small percentage of raw material used to produce armatures is a red chert that is coming for *Umbro-Marchigiana* formation. It means that this kind of chert, of better quality than the grey one, was popular and the exploitation often happened. There should be evaluated and compared the raw materials acquisition, in particular for projectiles, where it was possible to extract the red chert, to evaluate the similarities between the final product and the possible sharing of knowledge between different human groups.

Moreover, butchering activities on animal bones are attested at Grotta di Pozzo. Based on traces of remains and on traces of anthropic activity on bones (cutmarks, fractures and combustion) (Mussi *et al.*, 2008; De Angelis *et al.*, 2015; Mussi *et*

al., 2015; Catelli *et al.*, 2016), the chamois was hunted most frequently, followed by red deer, marmot and ibex. Many caves in the Fucino basin have been occupied by the hunter-gatherers during the Late Glacial due to the rich resources it offered during the passage between cold and temperate phases. Archeozoological evidence (Radmilli, 1956a, 1956b; Grifoni, 1968; Radi, 1982; Alhaique & Recchi, 2003; Bietti, 2003; Agostini *et al.*, 2008) attests that human groups took advantage of this strategic environment and chose the best cave depending upon the season (i.e. Grotta Clemente Tronci during winter and summer, Riparo Maurizio on winter and spring, Grotta La Punta on autumn and spring, Grotta Maritza during spring/summer). At Grotta di Pozzo, archeozoological data permitted to hypothesize that hunting took place during autumn, when chamois were leaving summer grazing grounds at higher altitudes (De Angelis *et al.*, 2015). Recently, techniques have also been used to identify trauma from the impact of stone projectiles on animal bones, being the so-called Projectile Impact Marks (PIMs) (O'Driscoll & Thompson, 2014). A preliminary analysis on bone remains of medium and large size mammals has been conducted as to find Projectile Impact Marks (Catelli *et al.*, 2016). In spite of the fragmentation of the animal bones due to post-depositional processes, 3 ungulates ribs show similar to the PIMs described for the experimentation of O'Driscoll and Thompson's (2014). In particular, a rib (Fig. 8) shows an impact and an exfoliation comparable with a Puncture/Fracture or rather a direct shot that has removed the surface of the bone. This should of course be further examined by detailed study and experimentation.

In Riparo Villabruna there also are attested butchering activities on animal bones (cut marks, points of impact). The most hunted prey on the lower layers were ibex, followed by chamois and red deer while, for the upper layers, prevails red deer. The site was preferably occupied during spring, proved by the data of eruption of the teeth of ibex and the hunter-gatherers preferred to hunt adult individuals. Furthermore, the disarticulation of the preys took place inside the shelter, as suggested by the bones' portions and traces (Aimar *et al.*, 1992). Lastly, the layers 5 and 4 are connected to the end of the frequentation of the site, as indicated the

long exposition of bones and scratching traces of rodents on their surface. A stricter analysis of PIMs and experimentation on this point of view are needed, in order to understand the effect of projectile points on bones and obtain additional information about the hunting strategy.

The macro-fractures analysis also permits to recognize the armatures as tips and barbs on the basis of criteria proposed elsewhere (Rots, 2016). For the material of Grotta di Pozzo, no explicit evidence for projectile tips could be found, but for several pieces, no specific hafting position could be proposed. Given the predominance of barbs, a link could exist between the identified armatures and the bone points identified at Grotta di Pozzo even though the latter remain to be analysed. specific traces attributed to a use as barbs could be observed, while no explicit wear patterns due to a use as tips could be found. By contrast, in Riparo Villabruna specific traces allow the observation of the use of barbs and tips. Indeed, there have been found 6 elements with characteristic fractures due to the use as barb, 1 as a tip and 5 indeterminable. Unfortunately, many projectiles do not indicate discernible traces about their hafting position.

A recent study of the Gravettian site of Les Prés de Laure (23.500 cal. BP, Tomasso *et al.*, 2018) has shown the combined use of lateral lithic insets and a bone point in what is currently the oldest composite barbed weapon (Tomasso *et al.*, 2018). It provides an interesting comparison with Grotta di Pozzo in terms of chronology and possible hafting positions. Systematic experimentation is however needed to evaluate this hypothesis now that the required functional and technological data are available (i.e. morphology and techno-typology of the projectiles, use, possible hafting position, hunted prey). Based on the archaeological data, this argument cannot be applied for Riparo Villabruna. In fact, there have not been found bone points and, the presence of 1 lithic tip, might testify another kind of possible hafting method. Barbs have been placed laterally and tips at the head of the weapon. Naturally, we need to be cautious about this interpretation because many backed points have not been considered projectiles for the lack of markable traces. If we compare the weaponry system known and

coeval with Riparo Villabruna, famous are (and questionable) the oldest documented information about the use of bow in Mannheim-Vogelstang (18.000 cal. BP, Rosendhal *et al.*, 2006) and Stellmoor (13.000 cal. BP, Cattelain, 1994).

A systematic experimentation is however essential to evaluate these hypotheses now that all necessary data are available (i.e. morphology and techno-typology of the projectiles, the possible hafting position, hunted preys). The information gained are important during the creation of an experimental protocol. In this moment there are not clear and true evidence about a complex weaponry system in Grotta di Pozzo and Riparo Villabruna. There are only hypotheses that can be deeply investigated and solved only by experimentation.

In searching of macro-fracture as to isolate specific pattern to individuate projectile points, the contribute of experimental archaeology opened a new scenario about the ambiguity of the so-called “diagnostic of impact fractures” that have to be revised on some aspects. Starting from the assumption that similar wear pattern might confuse the interpretation of the use of the backed points, these other two variables of uses have been investigated and experimented: tools for dental treatment and perforators. Thus, it has been tested the use of backed tools as possible instruments to remove teeth caries on human beings. In fact, the opportunity to directly have the evidence of the Epigravettian burial of a hunter-gatherer permitted to evaluate uses that have never truly tested before in the literature. Moreover, considered the presence of perforated decorative objects on the archaeological record, it has been integrated with another possible use, so as perforators on atrophic canines of red deer.

By comparing the experimental data of Oxilia *et al.*, 2015, it has been carried out an innovative experimentation regarding the use of backed tools for dental treatment. This activity permitted to understand the gesture to remove dental caries on human teeth and the wear traces on lithic tools allowed to have a reference collection about this particular aspect. The experimental materials have been compared with a sample of 10 archaeological materials only from Riparo Villabruna. It is important to underline that no archaeological materials from

Grotta di Pozzo has been considered for this analysis. Nevertheless, the experimental protocol can be applied for any archaeological context where there are doubts about this particular activity that, in the literature, has never been tested before.

The results indicate that 4 backed points from Riparo Villabruna have similar wear patterns to the experimental ones. This is a first preliminary test to understand how to approach this interesting kind of analysis that has never been considered. Caries are suitable to be removed by backed points and dental treatment is a possible use to that is relevant to take into account when analysing microliths. However, a combined analysis would be essential for identifying this particular use with certainty.

The traces on the suspected backed tools are more likely linked with a use as projectile element but other archaeological pieces show perforating damage that compares better to what is produced during dental treatment. The damage is too intense on part of these pieces, but some shows more limited damage for which a cause in dental treatment cannot be excluded. While polishes are present under high magnification, this is insufficient to confirm the hypothesis. Lastly, residue analysis is required to demonstrate such a use, but the material has been washed and manipulated and is thus not suitable for such analysis.

At the end, this is a brief exploration of interesting hypothesis that might be considered during use-wear analysis on lithic tools. More experiments must be performed about caries removals, integrated in a broader experimental program that also includes other activities. And, after the understanding view of this experimentation, the archaeological materials from Riparo Villabruna should be screened again to verify if other tools have wear pattern comparable with those ones.

Lastly, it has been experimented the use of backed points as perforators to create decorative objects on atrophic canines of red deer. The decision to test this use has been settled after the experimentation of human teeth because they have similar

composition (enamel, dentine, root) and the perforation traces might be confused. For this reason, it has been replied the gesture to make these objects. Moreover, the experimental protocol can be applied for any archaeological situation. Also here, the archaeological materials from Grotta di Pozzo have not been considered. The experimental materials have been compared with the sample of 10 backed points from Riparo Villabruna. In addition, it has been tested the abrasion value of ochre. The results indicate that the traces on the experimental materials are due to perforation action, that are quite similar both on the experimental materials for dental treatment and on the archaeological sample. In terms of functionality, the ochre has a great value to perforate object. In fact, it has been proved that the time spent on this operation is a half compared to the use without ochre.

The experimentation of backed points on atrophic canines of red deer has given us many points of reflection. Firstly, this activity is essential to get as much information as possible about the manufacturing of these decorative objects. Understanding the gesture makes possible the comparison between the experimental objects and archaeological ones. Striations, abrasions and perforation damages on teeth are the direct consequence of their preparation to become ornaments. Moreover, it has been proved the great abrasive action of ochre, practically testified by the experimenter and through the time spent for the realization of perforated teeth. And in addition to the functional aspect, there should not be underestimated the unexpected decorative action of ochre. In fact, during the activity, the ochre remained attached on the teeth, creating a beautiful shiny red colour on their surface.

Furthermore, it has been demonstrated the usefulness of backed points in this activity. The lateral cutting edge is perfect for the abrasion action, the point is useful as a “pointer”, its width and thickness are suitable and makes easier the perforation for the creation of the hole. Moreover, it has been proved that many fractures/removals created during this experimental activity might be confused with “typical” traces related to impact. The burination of the experimental point N° 12 is an example and this adds doubts about the variety of cases to diagnosticate

projectile points. For sure, systematic experimental program with a larger number of cases have to be done, in order to understand if it is recurred or it was just a case.

The archaeological perforated atrophic canines of red deer found in Riparo Villabruna are coming from the 9, 6 and reworked layers. During the frequentation of the shelter in this period, the red deer became the most hunted prey and hunting activities are testified by the attested projectile points and by the zooarchaeological data. Thus, the red deer seems that was hunted also to recover these aspired objects. The 4 candidates backed points with similar use-wear with the experimental materials are coming from reworked layers (N° 1250 – 1251), level 9 (N° 1253) and level 16 (1031). Although for reworked layers it is not possible to make any conclusion, the backed point N° 1253 is coming from the same layer where it was found a perforated canine, so there is more than a suspicion that it has been used to perforate this decorative object. Moreover, the backed point N° 1031 is coming from the layer 16, nearby the burial of hunter-gatherer. So, it is possible to think about dental treatment, as suggests the stratigraphic finding position.

In conclusion, these two experimentations have revealed that some archaeological materials from Riparo Villabruna shows perforating damage comparable with the experimental materials. Both uses cannot be excluded but, in terms of probability, there are many chances that the archaeological points have been used as perforators to create decorative objects. Decisive will be the residue analysis, trying to eventually find ochre remains. Moreover, a further systematic broader experimental program is required.

5. CONCLUSION

Projectiles are generally identified in the archaeological record on the basis of wear features with a predominant attention to damage and macro-fractures. Generally, expertise in this method requires formal training, but it was never evaluated to what extent a reliable analysis could be performed by novices on the basis of published sources only.

The macro-fractures study of the Epigravettian lithic industries coming from the archaeological sites of Grotta di Pozzo and Riparo Villabruna gives an important contribute to understand the hunter-gatherer behaviour in the North-Central Italy connected to environmental and climate changes. In this sense, the role of functional analysis was crucial to individuate hidden evidence and permitted to reconstruct the type of activities made by human groups particularly related to hunting.

An initial analysis of the assemblage of Grotta di Pozzo in search for projectiles performed during a Master thesis research (Ruta, 2014) permitted to test the reliability and potential problems of such a strategy. It could be demonstrated that fractures were frequently described incorrectly and that they misinterpreted due to a lack of understanding of fracture mechanics and causality. Adequate training and an access to an elaborate experimental reference collection proved necessary for reliable interpretations and it permitted to adequately revise results during a second phase of this research with an important reduction in the number of identified projectiles.

Convincing evidence for projectile use could nevertheless be identified for the lithic assemblages of Grotta di Pozzo and Riparo Villabruna. In cases where sufficient evidences were visible to also identify the hafting positions, it proved to systematically concern barbs for Grotta di Pozzo, tips and barbs for Riparo Villabruna.

Previous results from lithic technological analysis and zooarchaeological analysis have revealed seasonal anthropic presence in Grotta di Pozzo during the autumn and in Riparo Villabruna during the spring and relationships with other areas. The armatures that could be identified in this study on the basis of robust methodology confirm the frequentation of the caves during possible logistic movements in view of hunting, starting 23.000 years ago for Grotta di Pozzo and 15.000 years ago for Riparo Villabruna.

While the use-wear analysis has opened a new potential, several questions remain and require systematic experimentation to be solved, such as for example with regard to the possible weapon used, the hafting method and the effects on animal bones. Broader investigation of the North-Central Apennines areas could also shed new light on the mobility strategies of the human groups in this macro area.

The breakthrough of this research is the hypothesis that some backed points might be used as tools to remove dental caries and as perforators to create decorative objects. The experimental archaeology has played a major role at this point, due to the innovative idea of study that has poorly been investigated before and no reference collections were available and/or created. The comparison between the experimental and archaeological materials reveals that dental treatment cannot be excluded as an activity that took place in Riparo Villabruna. It is a preliminary analysis because many variables should be included. However, these high-value results have been crossed with the results about the use of backed points as perforators on anthropic canines of red deer. It has been recreated in both cases the gesture and these experiments can be replicable. Unfortunately, the traces created on the experimental materials in both cases are typical of perforating damage and, at this moment, it is too ambitious to discern them on the archaeological materials. In any case, there are many probabilities that backed points have been used as projectiles, as tools for dental treatment and as perforators to create decorative objects.

The results open an ambitious scenario where further investigations are needed. Firstly, a systematic experimentation program for the evaluation of other uses of

backed points (on other supports, such as wood, bones, marine shells, etc.) must be done in order to understand if there are any similarities with the archaeological materials and to avoid misinterpretation. Secondly, the archaeological materials of Riparo Villabruna must be screened again and a good starting point is a selection of backed points coming from the layers (and the proximal ones) where there have been found the perforated canines of red deer (layers 8, 9, 10) and the burial of the hunter gatherer (layers 16, 17, 18). Moreover, it is required a comparison with coeval archaeological materials hopefully better preserved than the materials from Riparo Villabruna. Indeed, the residue analysis is crucial to get important information and, as mentioned before, in Riparo Villabruna it has not been possible because the tools have been washed and cleaned over and over. Surely, Grotta di Pozzo is the first candidate for this analysis. In fact, the presence of a perforated canine of red deer can indicates the use of backed points as perforators and they might show drilling damages.

Lastly, the final question mark is the use of a particular element found in Riparo Villabruna. The funerary goods of the buried hunter-gatherer included an organic lump that was interpreted as propolis. It might be used as a glue during hafting operation during the preparation of a weapon. Considering that the individual has an infection on the tooth, a personal communication by a dentist has revealed to the author of this research that it might be suitable to be used to fill a cavity, such as a caries. There must be analysed the chemical composition of the propolis and adopted in the aspired experimental program.

6. SUPPLEMENTARY INFORMATION

Additional data are here reported in order to have a clear overview of the descriptive method used for the analysis of archaeological and experimental tools.

The following tables can be read moving this elaborate on the vertical view, from the right to the left side.

Tool	Fracture	F. comp.	Initiation	Locus	Location I.	Profile I.	General direction	Propagation	Termination	Location T.	Thickness T.	Length fissure	Fracture group	Location of T.	Traditional terminology	Fracture part	Group	Barb-Tip
7457	1	single	bending	distal	ventral	convex	apex to base	2,2	fissure, step	dorsal	0,1	0,1	removal	raw	bending step termination fracture	negative	3°	?
	2	single	cone	distal	dorsal	concave	perpendicular to the long axis	0,1	step	right lateral edge	0,1		removal	raw	lateral removal	negative		
	3	single	bending	mesial	dorsal	convex	diagonal towards the apex	0,2	step	ventral	0,1		removal	raw	lateral removal	negative		
	4	multiple	bending	mesial	dorsal	convex	diagonal towards the apex	1,1	feather	ventral	0,2		removal	raw	lateral removal	negative		
	5	multiple	bending	mesial	dorsal	convex	diagonal towards the apex	0,5	feather	ventral	0,1		removal	raw	lateral removal	negative		
7420	1	multiple	bending	mesial	dorsal	convex	apex to base	5	feather	ventral	0,7		fracture	retouch	bending feather termination fracture	negative	1°	barb

7303			7459					
3	multiple	1	5	single	1	5	single	2
single	single	single	single	single	single	single	single	single
cone	bending/cone	indeterminable	bending	bending	bending	bending	bending	bending
mesial	mesial	distal	proximal	proximal	mesial	proximal	mesial	mesial
earlier fracture surface	ventral	ventral	ventral	dorsal	dorsal	dorsal	dorsal	earlier fracture surface
concave	convex	convex	concave	concave	convex	convex	concave	convex
base to apex	base to apex	apex to base	base to apex	diagonal towards the apex	diagonal towards the base	perpendicular to the long axis	perpendicular to the long axis	apex to base
7,9	2,1	0,3	0,1	2	1,6	1,4	0,3	1,1
feather	fissure, hinge	step	step	step	fissure, step to step	feather	feather	step
dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	ventral	ventral	ventral
0,8	0,5	0,1	0,1	0,3	0,2	0,7	0,1	0,1
	0,2				0,2			0,2
removal	fracture	fracture	fracture	removal	removal	removal	removal	removal
raw	retouch	retouch	retouch	retouch	retouch	raw	raw	retouch
burnination	bending hinge termination fracture	bending step termination fracture	bending snap termination fracture	lateral removal	lateral removal	lateral removal	lateral removal	secondary fracture
negative	negative	negative	negative	negative	negative	negative	negative	negative
	1°	3°						
	barb	barb						

7147		7059					1006					4
1		5	4	3	2	1	5	4	3	2	1	1
single		multiple	single	single	single	multiple	single	single	multiple	single	single	multiple
bending		bending	bending	cone	cone	bending	cone	cone	absent	bending	bending	cone
distal		mesial	distal	distal	distal	distal	mesial	mesial	mesial	mesial	distal	mesial
ventral		dorsal	ventral	ventral	earlier fracture surface	ventral	earlier fracture surface	earlier fracture surface	N/A	ventral	ventral	earlier fracture surface
convex		convex	convex	convex	convex	convex	convex	convex	N/A	convex	convex	convex
apex to base		diagonal towards the base	diagonal towards the base	apex to base	apex to base	apex to base	base to apex	base to apex	perpendicular to the long axis	base to apex	apex to base	base to apex
	2,1	4,5	0,4	0,1	0,2	0,4	1,2	1,2	4,6	0,6	0,3	0,7
feather		feather, step	feather	feather	step	hinge to step	fissure, step to step, to feather	step	step to feather	snap	feather	fissure, step
dorsal	0,6	ventral	ventral	dorsal	dorsal	dorsal	dorsal	dorsal	ventral	dorsal	dorsal	dorsal
fracture		removal	removal	removal	removal	fracture	removal	removal	removal	fracture	fracture	removal
retouch		raw	raw	retouch	raw	retouch	raw	raw	retouch	retouch	retouch	raw
bending feather termination fracture		lateral removal	lateral removal	secondary fracture	spin-off	bending hinge termination fracture	spin-off	spin-off	lateral removal	bending snap termination fracture	bending feather termination fracture	spin-off
negative		negative	negative	negative	negative	positive	negative	negative	negative	negative	negative	negative
2°						2°					3°	
barb						barb					?	

1609		3212						1390				14	
single	1	single	1	single	1	single	1	single	1	single	1	single	14
bending		bending	2	bending	2	bending	2	bending	2	bending	2	cone	cone
mesial		mesial	3	mesial	3	mesial	3	mesial	3	mesial	3	proximal	proximal
ventral		ventral	4	ventral	4	ventral	4	ventral	4	ventral	4	earlier fracture surface	earlier fracture surface
convex		convex	5	convex	5	convex	5	convex	5	convex	5	concave	concave
apex to base		apex to base	6	apex to base	6	apex to base	6	apex to base	6	apex to base	6	base to apex	base to apex
0,1		0,3	0,3	0,1	0,3	0,2	0,2	0,1	0,2	0,2	0,2	1,4	0,3
feather		feather	feather	feather	feather	feather	feather	feather	feather	feather	feather	hinge	step
dorsal		ventral	ventral	ventral	ventral	ventral	ventral	ventral	ventral	ventral	ventral	ventral	dorsal
fracture		removal	removal	removal	removal	removal	removal	removal	removal	removal	removal	fracture	removal
retouch		retouch	retouch	retouch	retouch	retouch	retouch	retouch	retouch	retouch	retouch	retouch	raw
bending feather termination fracture		lateral removal	secondary removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	bending step termination fracture	spin-off
negative		negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
2°		3°	3°	3°	3°	3°	3°	3°	3°	3°	3°	2°	2°
barb		barb	barb	barb	barb	barb	barb	barb	barb	barb	barb	?	?

						1408			3236			
	6	5	4	3	2	1	3	2	1	6	5	4
single	single	single	single	single	multiple	single	single	multiple	single	single	single	single
bending	bending	bending	bending	bending	bending	bending	cone	cone	bending	bending	bending	bending
proximal	mesial	distal	proximal	mesial	mesial	distal	distal	mesial	distal	distal	mesial	mesial
ventral	ventral	ventral	dorsal	dorsal	dorsal	dorsal	earlier fracture surface	ventral	dorsal	dorsal	ventral	ventral
convex	convex	convex	convex	convex	convex	convex	concave	concave	convex	convex	straight	straight
perpendicular to the long axis	perpendicular to the long axis	perpendicular to the long axis	diagonal towards the base	perpendicular to the long axis	perpendicular to the long axis	diagonal towards the base	apex to base	perpendicular to the long axis	apex to base	perpendicular to the long axis	perpendicular to the long axis	perpendicular to the long axis
0,3	0,5	0,9	1,9	0,5	0,5	0,3	0,2	1,4	5,6	0,1	0,7	1
feather	feather	feather	feather	feather	feather	fissure, step	feather	feather	hinge	snap	snap	snap
dorsal	dorsal	ventral	ventral	ventral	ventral	ventral	ventral	dorsal	ventral	ventral	dorsal	dorsal
0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,3	0,1		
removal	removal	removal	removal	removal	removal	removal	removal	removal	fracture	fracture	removal	removal
raw	raw	raw	raw	raw	raw	raw	retouch	raw	retouch	retouch	raw	raw
lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	spin-off	lateral removal	lateral removal (twisted)	bending hinge termination fracture	lateral removal	lateral removal
negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
						3°			1°			
						barb			barb			

		1407												
		1	2	3	4	5	6	7	8	9	10	11	7	
	single	single	single	single	single	single	single	single	single	single	single	single	single	single
	bending	bending	cone	cone	cone	bending	bending	bending	cone	bending	cone	bending	bending	bending
	distal	distal	distal	distal	mesial	proximal	proximal	proximal	mesial	mesial	mesial	mesial	distal	distal
	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	ventral	ventral	ventral	ventral	dorsal	dorsal
	convex	convex	concave	concave	convex	convex	convex	concave	concave	convex	convex	convex	convex	convex
	diagonal towards the apex	perpendicular to the long axis	perpendicular to the long axis	perpendicular to the long axis	perpendicular to the long axis	perpendicular to the long axis	perpendicular to the long axis	perpendicular to the long axis	perpendicular to the long axis	perpendicular to the long axis	perpendicular to the long axis	perpendicular to the long axis	apex to base	apex to base
	0,1	0,3	0,1	0,3	0,3	0,3	0,3	0,3	0,1	0,1	0,3	0,3	0,2	0,2
step	feather	feather	feather	feather	snap	step	feather	feather	feather	feather	feather	feather	snap	snap
dorsal	dorsal	dorsal	dorsal	ventral	ventral	ventral	ventral	ventral	ventral	ventral	ventral	ventral	ventral	ventral
	0,1	0,1	0,2	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
removal	removal	removal	removal	removal	removal	removal	removal	removal	removal	removal	removal	removal	fracture	fracture
raw	raw	raw	raw	raw	raw	raw	raw	raw	raw	raw	raw	raw	retouch	retouch
lateral removal	pseudo-burination	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	bending snap termination fracture	bending snap termination fracture
negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
													1°	barb

		1466								1467							
		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
	single	single	single	single	single	multiple	single	multiple	single	single	multiple	single	single	single	single	multiple	single
	bending	absent	absent	bending	bending	indeterminable	bending	bending	cone	cone	bending	cone	bending	bending	bending	bending	single
	distal	distal	distal	distal	distal	distal	distal	mesial	mesial	mesial	mesial	mesial	mesial	mesial	mesial	mesial	mesial
	dorsal	ventral	earlier fracture surface	earlier fracture surface	earlier fracture surface	earlier fracture surface	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal
	convex	N/A	N/A	concave	concave	convex	concave	convex	concave	convex	convex	concave	convex	convex	convex	convex	convex
	diagonal towards the base	apex to base	apex to base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base
	2	1,1	0,7	1,1	1,2	0,1-0,3	0,2	0,4	0,8	0,3	0,4	0,2	0,4	0,2	0,1	0,1	0,2
	feather	step, snap	hinge	step, snap	step, feather	feather	step	step to step	step	step	step to step	step	step	step	step	step to step	step
	ventral	right lateral edge	ventral	right lateral edge	dorsal	ventral	ventral	ventral	ventral	ventral	ventral	ventral	ventral	ventral	ventral	ventral	ventral
	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
	removal	removal	removal	removal	fracture	removal	removal	removal	removal	removal	removal	removal	removal	removal	removal	removal	removal
	raw	retouch	retouch	retouch	retouch	raw	raw	raw	raw	raw	raw	raw	raw	raw	raw	raw	raw
	lateral removal	secondary fracture	secondary fracture	secondary fracture	bending step termination fracture	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal
	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
		2°			3°												
		barb			barb?												

		5213											
		1	2	3	4	5	6	7	8	9	21	20	19
single	multiple	multiple	multiple	single	single	single	single	single	single	single	single	single	single
bending	bending	bending	bending	absent	bending	bending	bending	bending	bending	bending	bending	cone	cone
mesial	proximal	proximal	proximal	proximal	proximal	proximal	proximal	proximal	mesial	mesial	mesial	distal	distal
dorsal	ventral	dorsal	dorsal	N/A	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	earlier fracture surface	ventral
convex	convex	convex	convex	N/A	convex	convex	convex	convex	convex	convex	convex	concave	concave
apex to base	base to apex	base to apex	base to apex	base to apex	diagonal towards the apex	diagonal towards the apex	diagonal towards the apex	diagonal towards the apex	diagonal towards the apex	diagonal towards the apex	perpendicular to the long axis	apex to base	apex to base
0,2	0,4	0,1	0,3	0,7	0,5	0,3	0,1	3,5	0,4	0,2	0,2	0,1	0,1
snap	feather	feather	feather	snap	step	step	step	feather	feather	feather	step	step	snap
ventral	earlier fracture surface	ventral	ventral	right lateral edge	ventral	ventral	ventral	ventral	ventral	ventral	dorsal	ventral	dorsal
0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
fracture	removal	removal	removal	fracture	removal	removal	removal	removal	removal	removal	removal	removal	fracture
retouch	raw	retouch	retouch	raw	retouch	retouch	retouch	retouch	retouch	retouch	raw	raw	retouch
beding snap termination fracture	lateral removal	lateral removal	lateral removal	bending snap termination fracture	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	secondary fracture	bending snap termination fracture
negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
	1*	barb											

		2779								1787			
		4	3	2	1	8	7	6	5	4	3	2	1
single	single	single	single	single	single	single	single	single	single	single	single	single	single
bending	bending	bending	bending	bending	bending	bending	bending	bending	bending	bending	bending	bending	bending
mesial	distal	distal	distal	distal	distal	proximal	mesial	mesial	mesial	mesial	mesial	mesial	mesial
ventral	ventral	ventral	dorsal	dorsal	right lateral edge	dorsal	earlier fracture surface	earlier fracture surface	earlier fracture surface	earlier fracture surface	ventral	ventral	dorsal
convex	convex	convex	convex	convex	convex	convex	concave	concave	concave	convex	convex	convex	convex
diagonal towards the base		apex to base	apex to base	apex to base	apex to base	perpendicular to the long axis	apex to base	apex to base	apex to base	diagonal towards the base	diagonal towards the base	perpendicular to the long axis	apex to base
0,8	0,4	0,4	0,9	1,9	0,5	0,1	0,1	0,1	0,1	0,1	0,3	0,5	0,1
step	step	step	step	fissure, hinge to step	feather	feather	feather	feather	feather	feather	step	step to step	feather
dorsal	dorsal	dorsal	ventral	earlier fracture surface	ventral	ventral	ventral	ventral	ventral	ventral	dorsal	dorsal	ventral
0,1	0,2	0,2	0,1	0,8	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
				0,5									
removal	removal	removal	removal	fracture	removal	removal	removal	removal	removal	removal	removal	removal	fracture
raw	raw	raw	raw	retouch	raw	raw	raw	raw	raw	raw	raw	raw	retouch
lateral removal	lateral removal	lateral removal	lateral removal	bending hinge termination fracture	lateral removal	lateral removal	spin-off	spin-off	lateral removal	lateral removal	lateral removal	lateral removal	bending feather termination fracture
negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
				1°									3°
				barb									?

5568		1	2	3	4	5	6	7	8	9	10	11	12
multiple	single	single	single	multiple	single	single	multiple	single	single	single	single	single	single
bending	bending	bending	bending	bending	absent	absent	absent	absent	cone	cone	absent	absent	cone
mesial	distal	distal	distal	proximal	mesial	mesial	distal	mesial	mesial	mesial	mesial	mesial	mesial
dorsal	dorsal	dorsal	dorsal	dorsal	N/A	N/A	N/A	N/A	earlier fracture surface	earlier fracture surface	N/A	N/A	earlier fracture surface
convex	convex	convex	convex	convex	N/A	N/A	N/A	N/A	concave	concave	N/A	N/A	concave
diagonal towards the apex	diagonal towards the apex	base to apex	base to apex	apex to base	base to apex	apex to base	apex to base	apex to base	apex to base	apex to base	apex to base	apex to base	apex to base
0,7	0,4	0,7	0,4	2,2	1,1	0,6	3,1	0,3	1,1	1,3	0,1	0,3	1,1
step, feather	feather	feather	feather	feather	step to step	step to step	step	feather	fissure, step	feather	feather	feather	feather
ventral	ventral	ventral	ventral	ventral	ventral	ventral	dorsal	left lateral edge	ventral	ventral	ventral	ventral	ventral
0,3	0,1	0,1	0,1	0,1	0,1	0,1	0,2	0,1	1,3	0,2	0,1	0,2	0,2
removal	removal	fracture	fracture	removal	removal	removal	removal	removal	removal	removal	removal	removal	removal
retouch	retouch	retouch	retouch	raw	raw	raw	retouch	raw	raw	raw	raw	raw	raw
burination	lateral removal	lateral removal	lateral removal	bending feather termination fracture	burination	burination	secondary fracture	lateral removal	spin-off	burination	burination	lateral removal	secondary fracture
negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
		1°	?										

single	4
bending	
mesial	
dorsal	
convex	
apex to base	8,5
hinge	
ventral	0,2
fracture	
retouch	
bending hinge termination fracture	
negative	

Tab. 1: Description of the fractures on the armatures from Grotta di Pozzo by using with the Attribute Based System.

1152		1154										Tool	
2	1	multiple	single	9	8	7	6	5	4	3	2	1	Fracture
single	2	indeterminable	bending	single	single	single	single	single	single	single	single	single	F. comp.
absent		distal	proximal	bending	bending	bending	absent	absent	bending	cone	bending	bending	Initiation
distal			proximal	proximal	proximal	mesial	mesial	mesial	mesial	mesial	mesial	mesial	Locus
N/A		N/A	dorsal	dorsal	dorsal	dorsal	N/A	ventral	ventral	ventral	dorsal	dorsal	Location I.
N/A		N/A	convex	convex	convex	convex	N/A	convex	convex	concave	convex	convex	Profile I.
apex to base		apex to base	perpendicular to the long axis	perpendicular to the long axis	perpendicular to the long axis	perpendicular to the long axis	diagonal towards the apex	perpendicular to the long axis	perpendicular to the long axis	perpendicular to the long axis	diagonal towards the apex	apex to base	General direction
2,1		0,4	0,1	0,2	1,8	1,1	1,2	0,1	0,1	0,1	2,1	0,1	Propagation
step		feather, step	feather	step fissure	fissure, step	feather	feather	feather	feather	snap	feather	snap	Termination
ventral		ventral, right and left	ventral	ventral	ventral	ventral	ventral	dorsal	dorsal	dorsal	ventral	ventral	Location T.
fracture		fracture	removal	removal	removal	removal	removal	removal	removal	removal	removal	fracture	Thickness T.
retouch		retouch	raw	raw	raw	raw	raw	raw	raw	raw	raw	retouch	Length fissure
bending step termination fracture		explosion	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	bending snap termination fracture	Fracture group
negative		negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	Location T.
		2°											Traditional terminology
		tip											Fracture part
													Group
													Barb-tip

1060		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
single	single	single	single	single	single	single	single	single	single	single	single	single	single	single	single	single	single
cone	bending	cone	bending	cone	cone	cone	cone	cone	cone	cone	cone	cone	cone	absent	cone	cone	cone
distal	distal	proximal	distal	proximal	proximal	proximal	proximal	proximal	proximal	proximal	proximal	proximal	distal	mesial	mesial	proximal	proximal
earlier fracture surface	earlier fracture surface	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	earlier fracture surface	earlier fracture surface	earlier fracture surface	earlier fracture surface	earlier fracture surface	ventral	N/A	ventral	dorsal	earlier fracture surface
concave	convex	convex	convex	convex	convex	convex	convex	concave	concave	concave	concave	concave	concave	N/A	concave	concave	concave
apex to base	apex to base	base to apex	apex to base	base to apex	base to apex	base to apex	base to apex	base to apex	base to apex	base to apex	base to apex	base to apex	diagonal towards the base	diagonal towards the apex	perpendicular to the long axis	diagonal towards the apex	diagonal towards the apex
0,2	0,2	0,7	0,3	0,3	0,3	0,7	0,2	0,4	0,4	1,1	0,4	0,2-0,6	2,4	1,8	0,3	0,7	0,2
feather	feather	feather	feather, step	feather	feather	feather	step	feather	feather	feather	feather	feather	feather	step, feather	feather	feather	feather
ventral	ventral	ventral	dorsal	dorsal	dorsal	dorsal	ventral	ventral	ventral	ventral	ventral	ventral	dorsal	dorsal	dorsal	dorsal	ventral
0,1	0,1	0,3	0,1	0,1	0,1	0,3	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,3	0,1
removal	fracture	fracture	removal	removal	removal	removal	removal	removal	removal	removal	removal	removal	removal	removal	removal	removal	removal
raw	retouch	retouch	raw	raw	raw	raw	raw	raw	raw	raw	raw	raw	raw	raw	raw	raw	raw
spin-off	bending feather termination fracture	bending feather termination fracture	bending feather termination fracture	bending feather termination fracture	bending feather termination fracture	bending feather termination fracture	secondary removal	spin-off	spin-off	spin-off	spin-off	spin-off	spin-off	spin-off	spin-off	spin-off	spin-off
negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
	3°																
	barb																

1039		1	2	3	4	5	6	7	8	7	5	4	3
single	single	single	single	single	single	single	single	single	single	single	single	multiple	multiple
absent	absent	absent	absent	absent	absent	absent	absent	absent	absent	absent	absent	bending	bending-cone
mesial	mesial	distal	mesial	mesial	mesial	distal	distal	proximal	proximal	proximal	proximal	distal	mesial
N/A	N/A	N/A	N/A	N/A	N/A	right lateral edge	N/A	N/A	N/A	N/A	earlier fracture surface	dorsal	dorsal-ventral
N/A	N/A	N/A	N/A	N/A	N/A	concave	N/A	N/A	N/A	N/A	concave	convex	convex-concave
diagonal towards the apex	diagonal towards the apex	perpendicular to the long axis	diagonal towards the apex	diagonal towards the apex	diagonal towards the apex	perpendicular to the long axis	apex to base	apex to base	base to apex	base to apex	base to apex	diagonal towards the base	diagonal towards the base
0,3	4,1	0,3	2,3	1,7	8	0,3	0,4	3,1	1,1	3,1	1,8	diagonal towards the base	diagonal towards the base
feather	feather	feather	feather	feather	feather	feather	indeterminable	indeterminable	hinge	hinge	indeterminable	feather	feather, step
ventral	ventral	right lateral edge	dorsal	dorsal	dorsal	dorsal	left lateral edge	dorsal	dorsal	dorsal	left lateral edge	ventral	ventral
0,1	0,3	0,2	0,6	0,2	0,2	0,1	0,1	0,5	0,1	0,5	0,2	ventral	ventral-dorsal
removal	removal	removal	removal	removal	removal	removal	removal	removal	removal	removal	removal	removal	removal
raw	raw	retouch	raw	raw	raw	retouch	retouch	retouch	raw	retouch	retouch	retouch	raw
lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	secondary removal	lateral removal	lateral removal	lateral removal	lateral removal
negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
		3°											
		?											

		1187							
		1	2	3	4	5	6	7	8
single		single	single	single	multiple	multiple	single	single	single
indeterminable		bending	bending	bending	bending	bending	bending	bending	bending
mesial		distal	distal	mesial	mesial	proximal	mesial	proximal	proximal
N/A		dorsal	ventral	ventral	ventral	ventral	ventral	ventral	ventral
N/A		convex	convex	convex	convex	convex	convex	convex	convex
perpendicular to the long axis		diagonal towards the base	diagonal towards the base	diagonal towards the apex	diagonal towards the apex	perpendicular to the long axis	diagonal towards the base	diagonal towards the apex	diagonal towards the apex
	0,2	0,4	0,8	1,2	0,8	4,1	0,4	0,3	0,4
fissure, step		step	fissure, hinge to step	fissure, step, hinge	fissure, step, hinge	hinge	step	feather	feather
ventral		ventral	dorsal	dorsal	dorsal	dorsal	ventral	ventral	dorsal
	0,1	0,1	0,2	0,1	0,2	0,3	0,1	0,1	0,1
	0,1		0,3		0,3				
removal		removal	removal	removal	removal	removal	removal	removal	removal
raw		raw	raw	raw	raw	raw	raw	raw	raw
lateral removal		lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal	lateral removal
negative		negative	negative	negative	negative	negative	negative	negative	negative
		3°							
		?							

		1215								
		1	2	3	4	5	6	7	8	9
single	single	single	multiple	single	single	single	single	single	single	single
absent	bending	absent	cone	absent	absent	absent	absent	absent	bending	absent
proximal	proximal	distal	distal	distal	distal	distal	mesial	proximal	proximal	distal
N/A	ventral	earlier fracture surface	earlier fracture surface	N/A	N/A	N/A	ventral	N/A	ventral	N/A
N/A	convex	concave	concave	N/A	N/A	N/A	convex	N/A	convex	convex
diagonal towards the apex	diagonal towards the apex	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the apex	perpendicular to the long axis	diagonal towards the apex	diagonal towards the base
0,2	0,4	0,2	0,2	0,6	1,2	0,1	0,2	0,9	0,4	1,2
feather	step	feather, snap	step	feather	feather	feather	feather, snap	step	step	hinge
dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	ventral
0,1	0,1	0,1	0,2	0,1	0,1	0,1	0,1	0,2	0,1	0,2
removal	removal	removal	removal	removal	removal	removal	removal	removal	removal	removal
raw	raw	raw	retouch	retouch	raw	raw	raw	raw	raw	retouch
lateral removal	lateral removal	lateral removal	secondary removal	burination?	secondary removal	secondary removal	lateral removal	lateral removal	lateral removal	secondary removal
negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
									2°	
									barb	

		1241											
		1	2	3	4	5	6	7	8	13	12	11	10
single	single	single	single	multiple	single	single	single	single	single	single	single	single	single
bending	bending	absent	cone	bending	absent	bending	bending	bending	absent	bending	bending	cone	bending
mesial	mesial	distal	distal	distal	distal	distal	distal	distal	distal	proximal	mesial	mesial	proximal
right lateral edge	earlier fracture surface	earlier fracture surface	earlier fracture surface	earlier fracture surface	N/A	earlier fracture surface	earlier fracture surface	earlier fracture surface	N/A	dorsal	dorsal	dorsal	ventral
convex	concave	convex	convex	convex	N/A	convex	convex	convex	N/A	convex	convex	concave	convex
diagonal towards the base	apex to base	apex to base	apex to base	apex to base	apex to base	apex to base	apex to base	apex to base	perpendicular to the long axis	diagonal towards the base	diagonal towards the base	diagonal towards the base	base to apex
2,1	0,4	0,7	2,5	0,6	2,1	0,3	0,2	0,5	4,7	0,3	0,4	1,1	0,3
feather, step	step	hinge	fissure, hinge to step	hinge	step	hinge	hinge	hinge	feather	feather	feather	feather, step	feather
ventral	right lateral edge	ventral	ventral	earlier fracture surface	right lateral edge	right lateral edge	right lateral edge	right lateral edge	right lateral edge	ventral	ventral	ventral	dorsal
0,2	0,2	0,2	0,3	0,4	0,2	0,5	0,2	0,3	0,2	0,2	0,2	0,2	0,2
removal	removal	removal	removal	fracture	removal	removal	removal	removal	removal	removal	removal	removal	fracture
retouch	retouch	retouch	retouch	retouch	retouch	retouch	retouch	retouch	retouch	raw	raw	raw	retouch
lateral removal	spin-off	secondary removal	secondary removal	secondary removal	secondary removal	secondary removal	secondary removal	secondary removal	lateral removal	lateral removal	lateral removal	lateral removal	bending feather termination fracture
negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
									1°				
									?				

	11	10	9
	single	single	single
	cone	cone	bending
	proximal	proximal	proximal
	right lateral edge	earlier fracture surface	ventral
	concave	concave	convex
	perpendicular to the long axis	base to apex	base to apex
	0,4	0,3	0,6
	hinge	feather	feather
	ventral	dorsal	dorsal
	0,3	0,1	0,2
	removal	removal	fracture
	retouch	raw	retouch
	lateral removal	spin-off	bending feather termination fracture
	negative	negative	negative

Tab. 2: Description of the fractures on the armatures from Riparo Villabruna by using with the Attribute Based System.

1	2	1	2	3	4	5	6	7	8	9	10	1	2
	single	single	multiple	multiple	multiple	multiple	multiple	multiple	single	single	multiple	multiple	multiple
bending	bending	cone	cone	cone	cone	indeterminable	indeterminable	indeterminable	absent	absent	cone	cone	cone
distal	distal	distal	distal	distal	distal	distal	distal	distal	distal	distal	distal	distal	distal
ventral	ventral	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	earlier fracture surface	earlier fracture surface	earlier fracture surface	earlier fracture surface	earlier fracture surface
convex	convex	convex	concave	concave	concave	concave	concave	concave	convex	convex	convex	convex	convex
apex to base	apex to base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	perpendicular to the axes	perpendicular to the axes	perpendicular to the axes	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base
		0,4	1	0,4	1,2	1,5	2,4	1,5	1,6	1,6	1	0,4	0,7
feather	feather	feather	hinge to feather	feather	step to step	feather	step to feather	feather to step, step to feather	feather	feather	feather	feather	feather
dorsal	dorsal	ventral	ventral	ventral	earlier fracture surface	ventral	right lateral side	dorsal	right lateral side	dorsal	dorsal	dorsal	dorsal
retouch	retouch	raw	raw	raw	raw	raw	retouch	raw	retouch	raw	retouch	retouch	
negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative

		3							
		1	2	3	4	5	6	7	8
single		single	single	single	single	single	single	single	single
absent		cone	absent	cone	bending	bending	cone	cone	absent
distal		distal	distal	distal	distal	distal	distal	distal	distal
				earlier fracture surface					earlier fracture surface
		ventral		concave	dorsal	dorsal	dorsal	dorsal	dorsal
		concave		convex	convex	convex	concave	concave	concave
diagonal towards the base			diagonal towards the base	perpendicular to the axes	diagonal towards the base	perpendicular to the axes	perpendicular to the axes	perpendicular to the axes	diagonal towards the base
		0,4	0,2	0,2	0,4	0,1	0,1	0,2	0,4
step			feather	step	fissure, step to feather	fissure, step to feather	feather	feather	feather
		ventral	dorsal	dorsal	ventral	ventral	ventral	ventral	ventral
		0,2	0,1	0,2	0,2	0,2	0,1	0,1	0,1
			retouch	retouch	raw	raw	raw	raw	raw
retouch			retouch	retouch	raw	raw	raw	raw	raw
		0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
negative		negative	negative	negative	negative	negative	negative	negative	negative

6.1		5					4			
1	1	1	2	3	4	5	6	7	8	7
single	multiple	multiple	multiple	multiple	single	multiple	single	single	single	single
bending	bending	bending	bending	cone	bending	absent	bending	bending	bending	cone
distal	distal	distal	distal	distal	distal	distal	distal	distal	distal	distal
ventral	ventral	dorsal	dorsal	dorsal	dorsal	dorsal	left lateral edge	earlier fracture surface	dorsal	earlier fracture surface
convex	convex	convex	convex	convex	convex	convex	convex	concave	convex	concave
diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	perpendicular to the axes	apex to base	apex to base	perpendicular to the axes	perpendicular to the axes
0,2	0,8	1,3	1,3	0,7	0,7	1	1,3	1,4	0,2	0,2
feather	feather	feather	feather	step	feather	feather	feather	feather, snap	feather	hinge
right lateral side	ventral	dorsal	ventral	ventral	right lateral side	left lateral edge	left lateral edge	right lateral side	ventral	dorsal
0,1	0,2	0,1	0,2	0,1	0,1	0,1	0,1	0,1	0,1	0,2
retouch	retouch	retouch	retouch	raw	retouch	retouch	retouch	retouch	raw	retouch
negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative

		7				6.2			
		1	2	3	4	1	2	3	4
single	single	single	single	single	single	multiple	single	single	single
cone	cone	bending	cone	cone	cone	cone	cone	bending	bending
distal	distal	distal	distal	distal	distal	proximal	distal	distal	proximal
ventral	ventral	ventral	ventral	ventral	earlier fracture surface	dorsal	dorsal	dorsal	dorsal
convex	convex	convex	convex	convex	concave	concave	concave	convex	convex
diagonal towards the base	diagonal towards the base	perpendicular to the axes	diagonal towards the base	diagonal towards the base	perpendicular to the axes	perpendicular to the axes	perpendicular to the axes	apex to base	apex to base
0,4	0,4	0,2	0,4	0,4	0,2	2	0,2	0,1	0,3
step to feather	step to feather	feather	feather	feather	step	feather	feather	hinge	snap
dorsal	dorsal	dorsal	dorsal	dorsal	ventral	ventral	ventral	ventral	ventral
retouch	retouch	retouch	retouch	retouch	raw	raw	raw	raw	retouch
negative	negative	positive	negative	positive	negative	negative	negative	negative	negative
		0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,3

8		7		8	
2	1	2	1	1	1
multiple	single	multiple	single	single	single
cone	bending	cone	bending	bending	bending
distal	distal	distal	distal	distal	distal
ventral	left lateral edge	ventral	dorsal	dorsal	dorsal
concave	convex	concave	convex	convex	convex
diagonal towards the base	perpendicular to the axes	perpendicular to the axes	apex to base	apex to base	apex to base
0,2	0,8	0,2	0,4	0,2	0,2
feather	feather	step	feather	feather	feather
dorsal	right lateral side	dorsal	right lateral side	ventral	ventral
0,1	0,1	0,1	0,1	0,1	0,1
retouch	retouch	retouch	retouch	retouch	retouch
negative	negative	negative	negative	raw	positive

Tab. 3: Description of the fractures on the experimental materials as use for dental treatment by using with the Attribute Based System.

Tool		9											
Fracture	F. composition	Initiation	Locus	Location I.	Profile I.	General direction	Propagation	Termination	Location T.	Thickness T.	Lenght fissure	State of location of T.	Fracture part
1	multiple	indeterminable	mesial	ventral		perpendicular to the axes	7	step					
2	single	cone	distal	dorsal	concave	diagonal towards the base	0,3	feather	ventral	0,2	retouch	negative	
3	multiple	absent	distal			apex to base	0,4	feather	ventral	0,2	raw	negative	
4	multiple	cone	distal	dorsal	concave	perpendicular to the axes	0,7	step, feather	earlier fracture surface	0,2	raw	negative	
5	multiple	absent	distal		earlier fracture surface	perpendicular to the axes	0,8	feather	ventral	0,2	raw	negative	
6	single	absent	distal			diagonal towards the base	0,3	feather	dorsal	0,2	raw	negative	
7	single	cone	distal	earlier fracture surface	concave	diagonal towards the base	0,5	feather	dorsal	0,1	raw	negative	
8	single	cone	distal	earlier fracture surface	concave	diagonal towards the base	0,5	feather	dorsal	0,1	raw	negative	
9	single	cone	distal	earlier fracture surface	concave	diagonal towards the base	0,3	feather	dorsal	0,1	raw	negative	
10	single	absent	distal			apex to base	0,2	step	dorsal	0,3	retouch	negative	
11	single	indeterminable	distal			apex to base	1,2	step	dorsal	0,2	retouch	negative	

12		11											
multiple	1	multiple	single	multiple	multiple	multiple	single	multiple	1	single	single	single	8
indeterminable		bending	bending	indeterminable	indeterminable	indeterminable	bending	indeterminable		cone	absent	cone	
mesial		distal	distal	distal	distal	distal	distal	mesial		distal	distal	distal	
ventral		dorsal	dorsal	dorsal	dorsal	earlier fracture surface	earlier fracture surface	ventral		dorsal		dorsal	
		convex	convex	convex	convex	convex	convex	earlier fracture surface		concave		concave	
perpendicular to the axes		perpendicular to the axes	perpendicular to the axes	apex to base	apex to base	apex to base	perpendicular to the axes	perpendicular to the axes		apex to base	apex to base	perpendicular to the axes	
14		1,7	0,7	0,6	0,7	1,2	1,2	1,2	1,2	0,5	0,3	0,9	0,4
step, feather		feather	feather	feather	feather	feather	feather	step, feather	step, feather	feather	feather	feather, fissure	step
dorsal		ventral	earlier fracture surface	earlier fracture surface	ventral	dorsal	dorsal	dorsal	dorsal	ventral	ventral	ventral	earlier fracture surface
retouch		raw	raw	raw	raw	raw	raw	retouch	retouch	retouch	retouch	retouch	raw
negative		negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative

	7	6	5	4	3	2
multiple	single	multiple	single	multiple	single	2
cone	bending	absent	absent	bending	bending	
distal	distal	distal	distal	distal	distal	
dorsal	dorsal			ventral	earlier fracture surface	
convex	convex			convex	convex	
perpendicular to the axes	perpendicular to the axes	perpendicular to the axes	apex to base	apex to base	perpendicular to the axes	1
	0,3	2	1,3	6,4	2	
step to step	feather	hinge, step, feather	feather	feather, step	feather, snap	
earlier fracture surface	earlier fracture surface	earlier fracture surface	ventral	ventral	dorsal	
	0,3	0,3	0,3	0,3	0,4	0,3
raw	raw	raw	retouch	retouch	retouch	
negative	negative	negative	negative	negative	negative	negative

Tab. 4: Description of the fractures on the experimental materials as perforators by using with the Attribute Based System.

1252		1251						1250		Tool		
1		4	3	2	1	6	5	4	3	2	1	Fracture
single		single	multiple	multiple	multiple	multiple	simple	single	multiple	single	multiple	F. composition
cone		bending	bending	bending	bending	bending	cone	cone	bending	bending	bending	Initiation
distal		proximal	mesial-proximal	distal	distal	mesial	distal	distal	distal	distal	distal	Locus
dorsal		ventral	dorsal-ventral	dorsal	dorsal	ventral	earlier fracture surface	earlier fracture surface	dorsal	dorsal	dorsal	Location I.
convex		convex	convex	convex	convex	convex	concave	concave	convex	convex	convex	Profile I.
diagonal towards the base		base to apex	diagonal towards the base	perpendicular to the long axis	apex to base	perpendicular to the long axis	diagonal towards the base	apex to base	diagonal towards the base	apex to base	apex to base	General direction
0,2		0,4	0,9	2	2	3	0,2	0,2	0,9	1,2	2,4	Propagation
feather		hinge	feather	step to feather	feather	snap	step	step	feather and hinge	feather	feather	Termination
ventral		dorsal	ventral-dorsal	ventral	ventral	dorsal	dorsal	dorsal	ventral	ventral	left lateral edge	Location T.
0,1		0,5	0,1	0,1	0,3	0,1	0,1	0,1	0,2	0,1	0,1	Thickness T.
		retouch	raw	retouch	retouch	raw	raw	raw	raw	raw	retouch	Lenght fissure
negative		negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	State of location of T.
		negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	Fracture part

1139		1031					1254		1253		2
1		5	4	3	2	1	2	1	2	1	
single		multiple	single	single	single	single	multiple	single	single	multiple	
absent		bending	cone	bending	absent	bending	bending	cone	bending	absent	
distal		distal	distal	distal	distal	distal	distal	distal	distal	distal	
N/A		dorsal	dorsal	dorsal	earlier fracture surface	right lateral edge	right lateral edge	left lateral edge	earlier fracture surface	dorsal	
N/A		convex	concave	convex	convex	convex	convex	concave	convex	convex	
apex to base		diagonal towards the base	apex to base	apex to base	apex to base	perpendicular to the long axis	perpendicular to the long axis	perpendicular to the long axis	apex to base	perpendicular to the long axis	
2,6		2	0,5	0,3	0,2	0,3	0,3	0,6	0,8	0,5	
feather		feather	feather	feather	feather	snap, feather	snap	step, feather	hinge	feather	
ventral		ventral	ventral	ventral	ventral	left lateral edge	right lateral edge	ventral	ventral	dorsal	
0,1		0,1	0,1	0,1	0,1	0,4	0,2	0,2	0,2	0,1	
retouch		retouch	retouch	retouch	retouch	retouch	retouch	raw	raw	retouch	
negative		negative	negative	negative	negative	negative	negative	negative	negative	positive	
		negative	negative	negative	negative	negative	negative	negative	negative	negative	

	13	12	11	10	9	8	7	6	5	4	3	2
single	single	single	single	single	single	single	single	single	single	multiple	single	
cone	absent	cone	cone	cone	cone	cone	cone	bending	bending	cone	cone	
mesial	mesial	distal	proximal	proximal	proximal	proximal	proximal	proximal	distal	distal	distal	
ventral	N/A	ventral	dorsal	dorsal	earlier fracture surface	earlier fracture surface	earlier fracture surface	dorsal	dorsal	dorsal	dorsal	dorsal
concave	N/A	concave	concave	concave	concave	concave	concave	concave	convex	concave	concave	concave
perpendicular to the long axis	diagonal towards the apex	diagonal towards the base	diagonal towards the apex	diagonal towards the apex	diagonal towards the base to apex	diagonal towards the base to apex	diagonal towards the base to apex	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base
	1,8	2,4	0,2-0,6	0,4	1,1	1,9	1,1	0,2	1,2	0,3	1,2	1,2
feather	step, feather	feather	feather	feather	feather	feather	feather	feather	feather	step to feather, fissure	feather	feather
dorsal	dorsal	dorsal	ventral	ventral	ventral	ventral	ventral	earlier fracture surface	ventral	earlier fracture surface	earlier fracture surface	earlier fracture surface
	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
											0,1	
raw	raw	raw	raw	raw	raw	raw	raw	raw	raw	raw	raw	raw
negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative

		1241									
		1	2	3	4	5	6	7	8	9	14
single	single	single	single	multiple	single	single	single	single	single	single	single
bending	bending	absent	cone	bending	bending	absent	cone	bending	absent	absent	cone
proximal	mesial	distal	distal	distal	distal	distal	mesial	distal	distal	distal	proximal
ventral	right lateral edge	mesial-proximal	earlier fracture surface	earlier fracture surface	earlier fracture surface	N/A	earlier fracture surface	dorsal	dorsal	N/A	dorsal
convex	convex	convex	convex	convex	convex	N/A	concave	convex	convex	N/A	convex
base to apex	diagonal towards the base	diagonal towards the base	apex to base	apex to base	apex to base	apex to base	apex to base	apex to base	apex to base	apex to base	base to apex
	0,6	2,1	0,4	0,7	2,5	4,7	0,7	0,7	2,1	0,6	0,2
feather	feather, step	feather	step	hinge	hinge	hinge	step	hinge	hinge	hinge	feather
dorsal	ventral	ventral	right lateral edge	ventral	ventral	right lateral edge	ventral	right lateral edge	right lateral edge	right lateral edge	ventral
	0,2	0,2	0,2	0,2	0,3	0,5	0,2	0,2	0,2	0,4	0,1
retouch	retouch	raw	retouch	retouch	retouch	retouch	retouch	retouch	retouch	retouch	retouch
negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	positive
											negative
											raw
											retouch
											feather, step
											diagonal towards the apex
											concave
											convex
											dorsal
											earlier fracture surface
											proximal
											single
											single
											single

		1189									
		1									
		1	2	3	4	5	6	7	8	11	10
single	single	single	single	single	single	single	single	single	single	single	single
bending	bending	bending	bending	bending	bending	bending	bending	bending	bending	bending	cone
distal	distal	mesial	distal	mesial	mesial	distal	distal	distal	distal	proximal	proximal
ventral	dorsal	ventral	N/A	ventral	ventral	ventral	ventral	ventral	dorsal	right lateral edge	earlier fracture surface
convex	convex	convex	N/A	convex	convex	convex	convex	convex	convex	concave	concave
diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	diagonal towards the base	perpendicular to the long axis	perpendicular to the long axis
0,6	0,2	0,2	0,4	0,2	2,1	0,2	0,4	0,4	0,3	0,4	0,3
feather	feather	fissure feather	feather	feather	feather	feather	feather	feather	feather	feather	feather
dorsal	ventral	ventral	ventral	dorsal	dorsal	dorsal	dorsal	dorsal	dorsal	ventral	dorsal
0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,3	0,1
		0,4									
raw	retouch	retouch	raw	raw	raw	raw	raw	raw	raw	retouch	raw
negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative

	10	9	8	7	6	5	4	3
multiple	single	single	single	single	single	multiple	multiple	single
bending	cone	indeterminable	bending	bending	bending	bending	bending	bending
proximal	mesial	mesial	mesial	distal	proximal	mesial	mesial	mesial
ventral	dorsal	N/A	dorsal	dorsal	ventral	ventral	ventral	ventral
convex	concave	N/A	convex	convex	convex	convex	convex	convex
base to apex	diagonal towards the base	perpendicular to the long axis	perpendicular to the long axis	diagonal towards the base	perpendicular to the long axis	perpendicular to the long axis	diagonal towards the apex	diagonal towards the apex
	1,3	1,2	0,2	0,3	0,4	4,1	0,8	1,2
step, feather	feather	fissure, step	feather	step	fissure, step, hinge	feather	fissure, hinge to step	feather
dorsal	ventral	ventral	ventral	ventral	dorsal	dorsal	dorsal	dorsal
	0,1	0,1	0,1	0,1	0,1	0,3	0,2	0,1
retouch	raw	raw	raw	raw	raw	raw	raw	raw
negative	negative	negative	negative	negative	negative	negative	negative	negative
			0,1			0,3	0,3	

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Galatoma



I STATE that the present study, entitled “**Understanding hunter-gatherers behaviour through the macro-fractures analysis of lithic backed points**”, presented by
.....**Giancarlo Ruta**for the award of the degree of Doctor, has been carried
out under my supervision at the Department **of History and Art History**of this university.

Ferrara, 12/02/2021

Doctoral Thesis Supervisor

Marta Arzarello

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