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Less is more! Uluzzian technical behaviour at the cave site of Castelcivita (southern Italy)

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Highlights:

- Technological analysis of the Uluzzian lithic assemblage of Castelcivita
- Focus on the cores' mode of exploitation employed by early *Homo sapiens* in Italy
- The production is characterised by the research of small flakes and blades/bladelets
- Bipolar technique on anvil is a distinctive feature of the Uluzzian technocomplex
- Uluzzian production model is characterised by the idea of "less is more"

Abstract:

The Uluzzian techno-complex is one of the first evidence for *Homo sapiens* successful dispersal in Europe. It develops from about 45 to 40 ka cal. BP, i.e., during the so-called "transition" from Middle to Upper Palaeolithic, the period in which Neandertals went extinct. The cave site of Castelcivita (southern Italy) contains a well-preserved stratigraphic sequence concentrated in this specific phase as it comprises Late-Final Mousterian, Uluzzian and Protoaurignacian layers. Here we present the technological study of the Uluzzian lithic assemblage found in layer rpi of this site.

The study specifically focuses on the methods used to exploit cores, characterised by a low degree of technical investment in which management of the convexities and angles of debitage are almost absent. The most used percussion technique is bipolar striking on anvil. Despite they are not standardized, the obtained products show features which make them apt to be used in composite devices. The use of local raw materials, the production of small items and the marginal role of retouched pieces, among which some lunates are present, are also typical of the rpi assemblage. Based on these results we argue that the strengths of the Castelcivita rpi technological approach are its versatility, and the reduction of unnecessary costs related to raw material procurement, the configuration of the core and the management of the convexities. All these elements tend to the use of the available resources in the most productive way, without the final product losing efficiency, according to the concept "less is more". A hypothesis possibly explaining this technical behaviour is provided in the conclusions.

Keywords: Uluzzian; Middle/Upper Palaeolithic transition; Bipolar technique; Lithic technology; Optimisation; southern Italy; modern humans

1. Introduction

The Uluzzian is a technocomplex belonging to the earliest phase of the Upper Palaeolithic, geographically distributed, in Italy and the Peloponnese (Greece) (Fig. 1). Most of the settlements are located in peninsular Italy, where there are both open-air sites (mainly surface sites; Fig. 1, yellow dots), in which the Uluzzian finds are often mixed with materials from different periods, and cave sites with well-dated archaeological deposits (Fig. 1, red dots) (Marciani et al., 2020; Moroni et al., 2013).

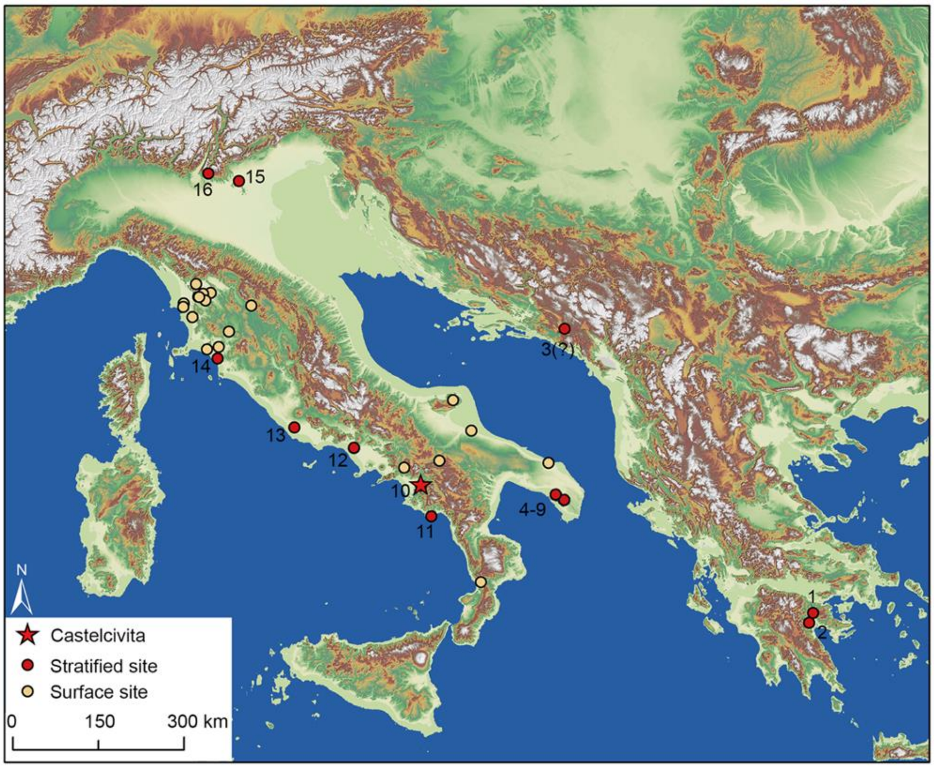


Fig. 1 - Locations of the Uluzzian findings in Italy and in the Balkan Peninsula. 1, Klissoura Cave; 2, Kephalari Cave; 3, Crvena Stijena; 4, Grotta del Cavallo; 5, Grotta di Serra Cicora A; 6, Grotta Mario Bernardini; 7, Grotta di Uluzzo; 8, Grotta di Uluzzo C/Cosma; 9, Grotta delle Veneri; 10, Grotta di Castelcivita; 11, Grotta della Cala; 12, Roccia San Sebastiano; 13, Colle Rotondo; 14, Grotta La Fabbrica; 15, Riparo del Broion; 16, Grotta di Fumane. Sea level is about 74m below the present-day level (data from ref. 60). The digital elevation model is the European digital elevation model from the GMES RDA project (https://www.eea.europa.eu/data-and-maps/data/eu-dem#tab-originaldata/eudem_hlsd_3035_europe). The bathymetric model is from the European Marine Observation and Data Network. The map was generated using ArcGIS version 10.5 (modified from Sano et al., 2019).

In all known stratigraphic sequences, the Uluzzian consistently overlies the Late Mousterian and is followed by the Protoaurignacian or by other Upper Palaeolithic complexes. In keeping with the most recent chronological data, the Uluzzian developed in the middle of the MIS3, as it started, according to the chronological data known so far, at 45-44 ka cal. BP, and ended about 40 ka cal. BP, immediately before the Campanian Ignimbrite (CI) eruption (39.85 ± 0.14 ka BP Giaccio et al., 2017) and the onset of the Heinrich 4 (H4) event (Hemming, 2004; Long and Stoy, 2013). This phase coincides, in Europe, with the so-called Middle to Upper Palaeolithic transition, i.e., the arrival of *Homo sapiens* and the demise of the Neandertals (Fewlass et al., 2020; Higham et al., 2014; Hublin et al., 2020). Biologically the Uluzzian has been attributed to *Homo sapiens*, based on two deciduous teeth found in 1964 at Grotta del Cavallo in layer EIII (Benazzi et al., 2011). Although the association between the teeth and the Uluzzian technocomplex has been questioned (Zilhao et al. 2015), the integrity of the deposit excavated in 1963-64 at Grotta del Cavallo has been widely demonstrated by a recent contribution by Moroni et al. (2018), which re-examined original fieldwork documentation in detail. In recent years, several studies have provided further evidence to confirm this attribution, revealing that the Uluzzian technological skills and subsistence practices appear to be much more similar to those displayed by Upper Palaeolithic *Homo sapiens* than to those typical of late Neandertals (e.g., Arrighi et al., 2020a, 2020b, 2020c; Boscato and Crezzini, 2012; Collina et al., 2020; Marciani et al., 2020; Moroni et al., 2013, 2018; Peresani et al., 2019; Riel-Salvatore, 2007, 2009, 2010; Romandini et al., 2020; Silvestrini et al. 2021; Sano et al., 2019). Typologically, the Uluzzian lithic industry contains innovative tools, the so-called lunates, i.e., crescent-shaped backed pieces which, at Grotta del Cavallo, have been shown to be mainly used to tip mechanically delivered weapons (Sano et al., 2019). Lunates are considered as the hallmark of the Uluzzian (independently from their quantity) as this particular tool occurs in all the Uluzzian sites and is absent both in the late Mousterian and in the Protoaurignacian, namely the two technocomplexes partly coeval to the Uluzzian.

The systematic production of bone tools and the recovery of colouring substances and ornaments are commonly considered distinctive of modern behaviour, independently from their authorship, therefore their presence in the Uluzzian (Arrighi et al., 2020a; 2020c; Moroni et al., 2013) adds further evidence to the “modern” character of this technocomplex. For these reasons and because of the absence of elements of Mousterian tradition (Moroni et al., 2018) the Uluzzian cannot be listed any longer among the so-called transitional industries (sensu Hublin, 2015). Despite this, there are aspects of the Uluzzian cultural suite, including the production of crescent-shaped armatures and the overwhelming use of task shells in the ornamental kit, that stand out as original with respect to the rest of the Upper Palaeolithic technocomplexes (e.g., the Protoaurignacian). Technologically, the lithic assemblage is characterised by a debitage with a low degree of technical investment. That is to say: the striking platforms are natural, cortical, or prepared by simply removing one or a few detachments and the debitage surface is poorly managed. A significant use of bipolar technique on anvil has been documented by identifying the stigmata of this procedure on cores, products (Collina et al., 2020; De Stefani et al., 2012; Gambassini, 1997; Marciani et al., 2020; Moroni et al., 2013, 2018; Palma di Cesnola, 1993; Peresani et al., 2019; Riel-Salvatore, 2009; 2010; Ronchitelli et al., 2018; Silvestrini et al., 2021; Villa et al., 2018) and anvils (Arrighi et al., 2020b). All these features taken together, besides expressing a well-defined cultural identity, appear to be unique when compared to the rest of the European Upper Palaeolithic assemblages and especially to the partially coeval Protoaurignacian/Aurignacian complexes. In this scenario, it would be interesting to better understand the reasons that led Uluzzian people to make such specific and exclusive choices in the manufacturing of their lithic equipment as well as to address the origins and behavioural implications of these characteristics.

The site of Castelcivita contains a well-preserved and detailed stratigraphic sequence where Late/Final Mousterian, Uluzzian and Protoaurignacian follow one to the other with a sedimentological hiatus in between the first two (Fumanal, 1997). The aim of this paper is to present a technological overview of the Uluzzian lithic assemblage found in layer rpi (rosso con pietre = red with stones) in order to provide some possible answers to the above questions. The study takes into account the whole reduction sequence, from raw material procurement to the various phases of the production process (Boëda, 1991, 2013; Geneste, 1991; Inizan et al., 1999; Sellet, 1993), with a focus on the exploitation modes of cores and on the specific traits of the bipolar technique on anvil (Breuil and Lantier, 1951). Based on this approach, we suggest that the strengths of the Uluzzian technical conceptualisation are its versatility and the reduction of unnecessary costs, without, however, the final product loosing efficiency. The low degree of standardisation in product morphologies plays a key role, as it allows one to get out of schematism and select only the best-performing products for the wished objective.

2. The site

The cave of Castelcivita (Castelcivita, Salerno, Campania, Southern Italy) opens at the foot of the Alburni massif, close to the right bank of the Calore River, at 94 m a.s.l. (Lat 40°29'44.28959049''N; Long 015°12'33.19838469''E.). Systematic excavations have been carried out since 1975 by the Research Unit of Prehistory and Anthropology of the University of Siena. Investigations concentrated at the cave's entrance, where, from 1975 to 1988, a ~ 2.60 m thick archaeological deposit was brought to light (Gambassini, 1997) over an area of ca.14 m^2, of which almost 6 m^2 had, unfortunately, been intensely damaged by looters earlier than 1975 (Fig. 2). The materials from this last area were rigorously kept separated from the rest of the industry and are not part of this study.

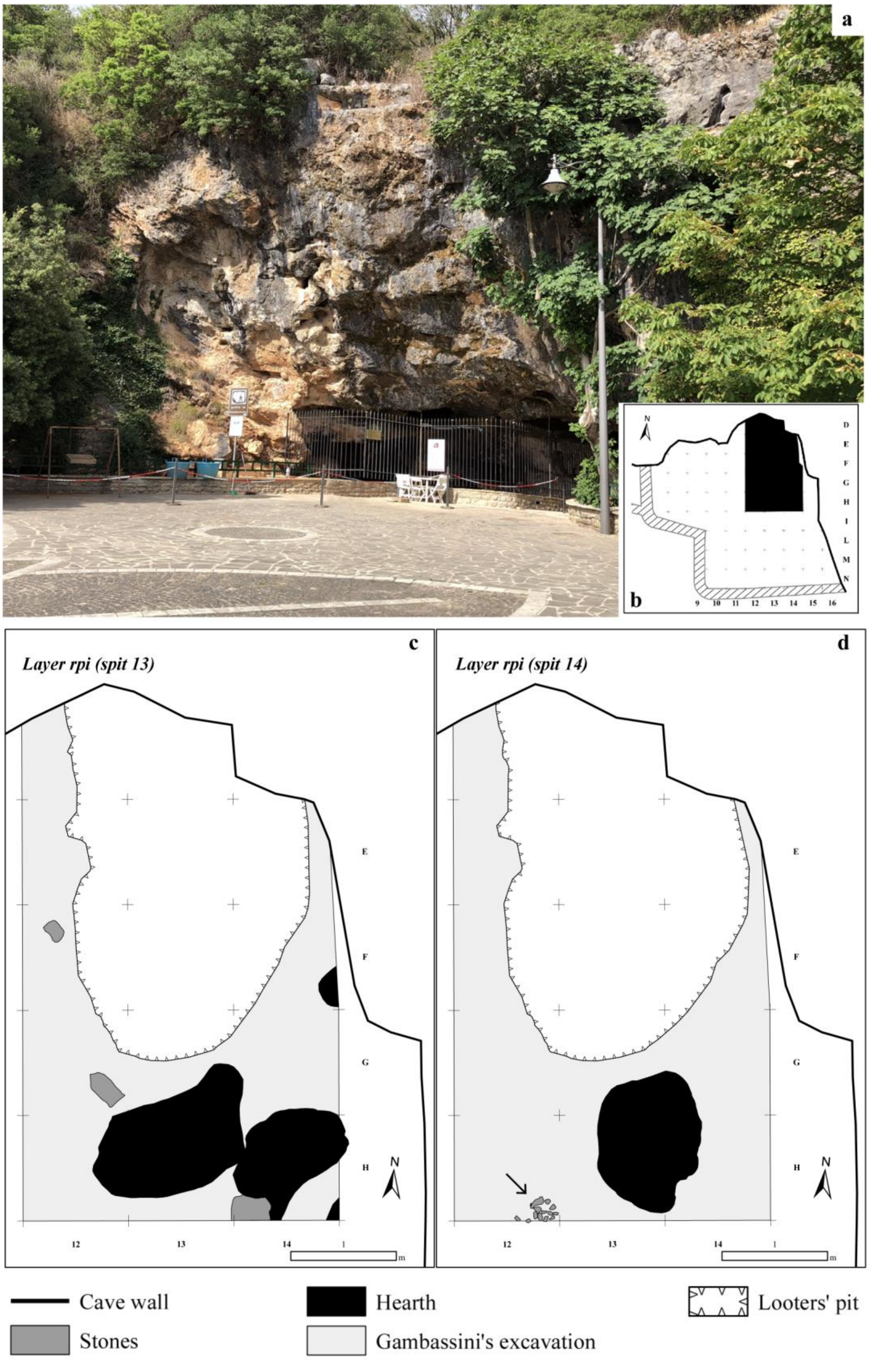


Fig. 2 - a: view of Grotta di Castelcivita; b: planimetry of the excavation surface; c and d: planimetries of the area excavated by Gambassini (1975– 1988) with the detail of living floors found in spits 13 and 14 of layer rpi; the black arrow indicates the small circular feature found in living floor of spit 14 (relief and graphics: P. Gambassini, A. Moroni and V. Spagnolo).

The sedimentary succession of Castelcivita (Fig. 3) preserves evidence of an important cultural sequence, encompassing the Late/Final Mousterian (layers cgr, gar and lower-rsi; layer cgr: 45,194 – 41,510 cal. BP 95% and 47,401 – 44,085 cal. BP 95%), the Uluzzian (layers upper-rsi, pie, rpi, and rsa”, this latter dated to 41,846 – 40,952 cal. BP 95% - Wood et al., 2012) and the Protoaurignacian (layers rsa’, gic and ars). The whole series is topped by a multi-layered flowstone with embedded thin layers of volcanic ashes, which have been attributed to the Campanian Ignimbrite (39.85 ± 0.14 ka BP Giaccio et al., 2017) (more information on the site and its sedimentary succession is available in SM1).

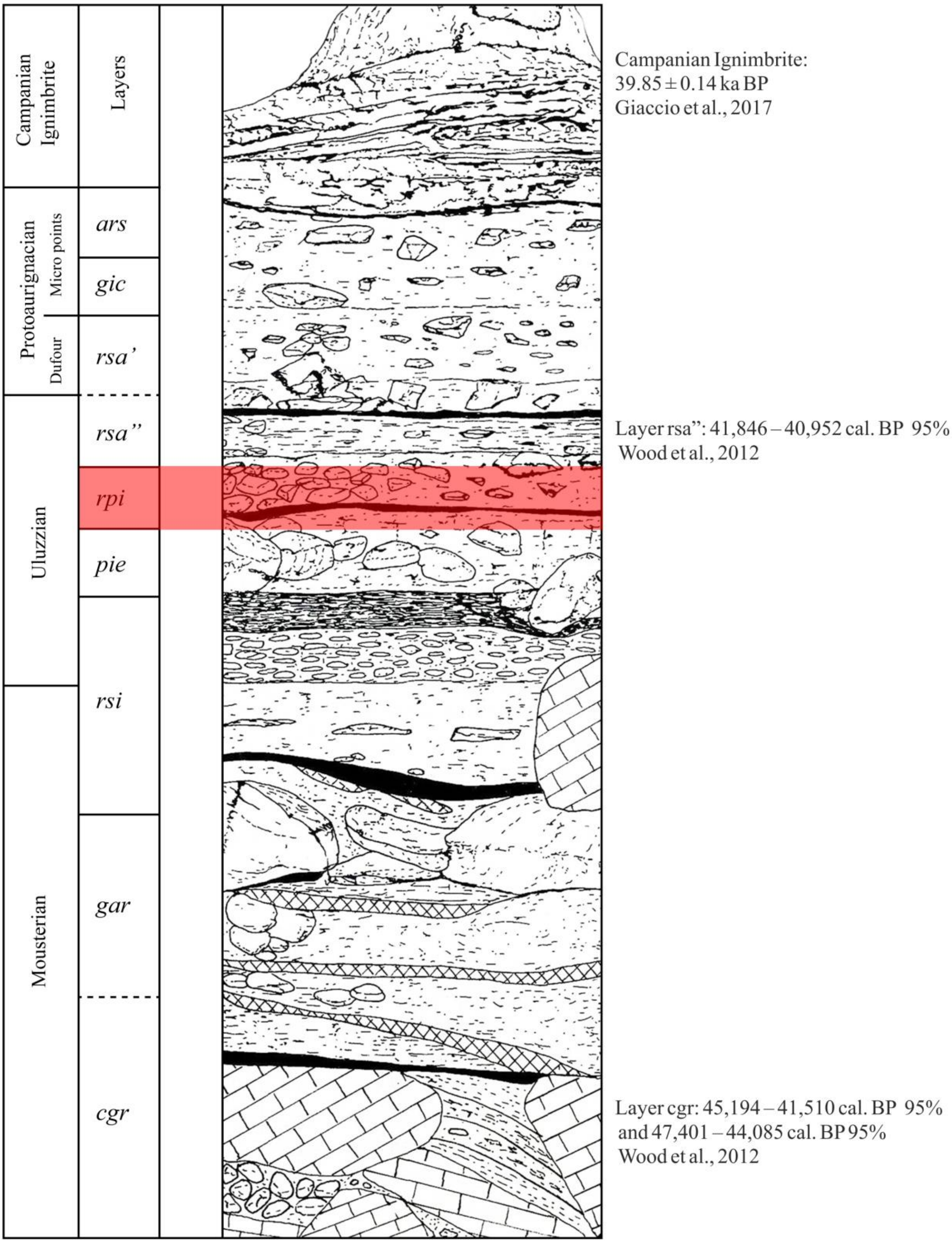


Fig. 3 - Stratigraphic sequence of Castelcivita; layer rpi is highlighted in red (modified from Gambassini, 1997).

3. Materials and Methods

The analysed material includes all the lithic artefacts (except for the abundant limestone component) uncovered in layer rpi (7510 pieces) in squares E12, E14, F12, F14, G12, G13, G14, H12, H13, and H14 (for information on fieldwork recovering procedures see SM2). The lithic assemblage was analysed using the technological approach (Boëda, 2013; Geneste, 1991; Inizan et al., 1999; Pelegrin et al., 1988; Perlès, 1991; Sellet, 1993).
An attribute analysis was performed, and each artefact was analysed by recording its characteristics in a database (Rossini 2020).

3.1 Lithic technology: description of the collected traits

The categories chosen to perform this study were: lithotypes (chert, quartz-arenite, quartz, sandstone); granulometry (fine, coarse); raw material (pebbles, blocks); presence of patina (yes/no); presence of combustion traces (yes/no). As for the morphometric data, these were taken for all the items whose area was larger than 100 mm^2: length, breadth and thickness were measured, when possible, following the piece technological axis, otherwise the longest measure was conventionally taken as the length. Furthermore, all items were divided into five dimensional classes (DC) based on their size: (first: 1–50 mm^2; second: >50 to 100 mm^2; third: > 100 to 150 mm^2; fourth: >150 to 200 mm^2; fifth: > 200 mm^2) (Marciani et al., 2020a; Spagnolo et al., 2020). The cores were technologically oriented in the following manner: the most used striking platform was positioned distally, and the most exploited face (usually the one with the last removals) was considered as the main face. If possible, measures were taken according to this orientation, otherwise the longest measure was conventionally taken as the length.
Identified technological classes are cores, debitage products, micro-flakes/debris (pieces that are smaller than the 3rd DC, micro-flakes are whole pieces; debris are broken pieces) and chunks (fragmented pieces, altered pieces, un-orientable pieces larger than the 2nd DC). Debitage products were assigned to integrity classes according to their degree of conservation. Broken items were indicated as distal, lateral, mesial, proximal, and composite. Among the debitage products, we considered the following technological categories: cortical flakes (100% cortical), semi-cortical flakes (between 99 % and 50% of cortex covering), and – within products presenting less than 51% of cortex covering – flakes (ratio length/breadth between 0-1.5), elongated flakes (ratio length/breadth >1.5 to 2), blades (ratio length/breadth > 2) (Bagolini, 1968), bladelets (if the item is a blade < 2.5 cm in length – Silvestrini et al., 2021) and debordant flakes (laterally overtaken flakes that remove the striking platform or a cortical surface). For each debitage product, the following traits were recorded: orientation; number of dorsal scars; extent of cortex (no cortex; up to 50 %

cortex; more than 50% cortex; total cortex); cross-section shape (trapezoidal; rectangular; triangular; semi-circular; linear; irregular); longitudinal profile of the ventral face (straight; concave; convex, wavy); distal end (feather; hinged; plunging; broken; crushed); type of butt (cortical; flat; dihedral; prepared; facetted; linear; punctiform; crushed; absent) and bulb (sheared; prominent; double; dihedral; Buonsanto and Peretto, 2012); position of the impact point (lateral; central; diffuse; indeterminate or absent); presence of parasite scars (yes/no).

The percussion technique was evaluated based on the stigmata present on the proximal portion of the flake. To distinguish debitage products and cores made by bipolar percussion on anvil we have taken into account the traits indicated in the following table (Table 1) based on published experimental and archaeological references (Soriano et al., 2010; de la Pena 2011; Roda Gilabert et al. 2015; Pargeter & Duke 2015; Morgan et al. 2015; Pargeter and de la Pena 2017; Moroni et al., 2018; Collina et al. 2020). In addition, we have also created our own experimental reference collection (partially published in Arrighi et al. 2020, it will be presented in detail in a paper in preparation).

Bipolar percussion technique	
Cores	**Debitage products**
Striking platform and lower portion of the core in contact with the anvil presenting blunt scars	Rectilinear longitudinal profile
Step and hinged terminations of scars produced by percussion	Similar ventral and dorsal faces
Blunting and splintering of the striking platform from recurrent knapping	Pronounced ripple marks
Overlap of removals and possible opposition of extractions	Crushed butts
Presence of overhang extractions	Punctiform butts
Edge battering on recurrent knapping	Linear butts
	Butt fissuration
	Diffused impact points
	Sheared bulbs of percussion
	Flat/absent bulb of percussion
	Hinge bulb of percussion
	Presence of a parasitical scar
	Possible splintering of distal and proximal areas
	Incidence of siret and tranversal fractures

Table 1: Traits of the bipolar technique on anvil on the debitage products and cores.

With reference to Boëda 's classification (2013), the cores have been attributed to a volumetric concept (additional or integrated). Additional cores are characterised by approaching the volume of the raw block without conceiving the entire block according to a sole idea of reduction, that is to say: one or more independent series of debitage can occur on the same raw block. Therefore, it is also possible that only a part of the volume (core stricto sensu) is flaked. The additional core is, in this case, divided into two volumes, the active one, which corresponds to the portion exploited by the knapper, and the passive one which is left unexploited. Therefore, in the additional cores, there may be more than one active volume (the core stricto sensu). In the integrated core, from the beginning of the exploitation, the entire volume of the block is conceived as part of a single idea of reduction which implies a considerable investment in the initialisation and configuration of the core from the very beginning of the reduction in order to obtain a specific, predetermined product. The core, in its entirety, is an integral part of a comprehensive productive synergy (Boëda, 2013; Marciani et al., 2020a).

For each core, an analytical and diacritical study was carried out, accompanied by a graphic representation (Inizan et al., 1999). We recorded the nature of the blank: block, flake, pebble or chunk (i.e., a blank that does not preserve characteristics that allow a clear attribution to one of the typologies previously quoted). We also considered the volumetry of the raw block (flat parallelepiped; parallelepiped; triangular prism; truncated pyramid), the hierarchy of surfaces (yes/no), that is to say, we indicated if the surfaces of the core were hierarchized (one surface is exploited as debitage surface and the other as striking platform); or not hierarchized (the surfaces of the core were used both as debitage surface and as striking platform) (Boeda 1995), the number, type, location, and mode of preparation of the striking platform as well as the number and orientation of the scars on the debitage surface. More specifically, regarding the debitage surface, we recorded the number of exploited faces and their position/relationships: adjacent debitage surfaces when they have a common edge (Fig. 4, n.1); opposite debitage surfaces when they do not have any common edge and faces are parallel (Fig. 4, n. 2). Directions of the scars on the debitage surfaces were also recorded. They can be parallel or orthogonal. When removals are parallel (Fig 4, n. 3), each face is exploited to extract products that geometrically represent lines that do not intersect at any point; when the detachments are orthogonal (Fig 4, n 4), two or more adjacent faces are exploited, and the direction of the detachments between the faces is orthogonal. Finally, the degree of exploitation was recorded (initial, medium, or exploited volume).

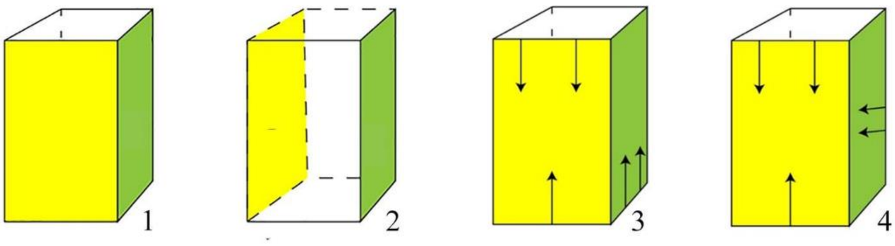


Fig. 4 - Position and relationships of debitage surface and direction of the scars (faces in yellow and green are the exploited debitage surfaces. The arrows indicate the direction of the removals). 1: cores with adjacent faces; 2: cores with opposite faces; 3: cores with adjacent faces and parallel detachments; 4: cores with adjacent faces and orthogonal detachments.

Retouched tools are categorised according to Laplace's typology (1964). The retouch of the lunates is described also recording its direction in relation to the two faces of the flake: direct (removals starting from the ventral face), inverse (removals starting from the dorsal face), alternate (adjacent removals form both ventral and dorsal faces) or bipolar (overlapping removals form both ventral and dorsal faces) (Laplace 1964).

4. Results

4.1 The lithic assemblage

Most of the pieces (99.9%) have fresh edges and the presence of patina is sporadic (1.0%). The occurrence of thermal alterations on some artefacts (5.9%) can be related to the presence of combustion features (see SM1). More than half of the assemblage, excluding the class of micro-flakes/debris, is fragmented (57.2%). The predominant technological classes (Table 2) are: micro-flakes/debris, containing 5813 pieces (77.4%) and debitage products, containing 1140 pieces (15.2 %). The class of chunks follows with 449 pieces (6%). Cores comprise 108 pieces (1.4%). The high percentages of lithics (most of which are debris, i.e., the waste from debitage) belonging to the first (58.9%) and second (18.5%) dimensional classes (Table 2) indicate that most of the flaking activity was performed in situ.

Technological classes	**Dimensional classes (mm^2)**											
	1–50		>50 to 100		>100 to150		>150 to 200		> 200		**Tot**	**%**
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**		

Cores	0	0	0	0	3	0.55	2	0.63	103	12.29	108	1.44
Debitage products	0	0	0	0	365	66.73	218	69.21	557	66.47	1140	15.18
Chunks	0	0	0	0	179	32.72	95	30.16	175	20.88	449	5.98
Micro-flakes_debris	4,422	100	1,391	100	0	0	0	0	0	0	5,813	77.40
Total	**4,422**	**58.88**	**1,391**	**18.52**	**547**	**7.28**	**315**	**4.19**	**835**	**11.12**	**7,510**	**100**

Table. 2 - Technological classes are divided according to dimensional classes, based on the area covered by each ~~individual~~ element (see paragraph 3.1). Debitage products include the technological categories of: blade, bladelet, flake, elongated flake, debordant flake, cortical flake, Semi cortical flake (see paragraph 3.1)**.**

4.2 Raw material

Fine-grained chert is the most frequent raw material (93.59%) (Table 3). This is followed by a very low percentages of quartz (3.42 %) and quartz-arenite (1.65%), and by a sporadic presence of radiolarite (0.67%).

The initial raw material is represented most of the times by blocks from primary or sub-primary sources, and by pebbles from secondary deposits, which were locally available, probably in the riverbed of the Calore stream (Gambassini, 1997; Aureli et al., in preparation).

Chert was used to produce the widest variety of technological categories, whilst quartz, radiolarite and quartz-arenite were mainly devoted to the production of flakes. The retouched tools are almost exclusively made of chert.

Lithotype	**Fine**		**Coarse**		**N.**	**%**
	N.	**%**	**N.**	**%**		
Quartz-arenite	0	0	124	28.77	**124**	1.65
Quartz	0	0	257	59.63	**257**	3.42
Radiolarite	50	0.71	0	0	**50**	0.67
Chert	7,029	99.29	50	11.60	**7,079**	94.26
Total	**7,079**		**431**		**7,510**	
%	94.26		5.74			

Table. 3 - Raw material lithotypes and granulometry

4.3 Cores

The methods and modality of debitage were determined based on the mode of exploitation of the core's faces, i.e., number of faces used as debitage surfaces and their position/relationships as well as direction and orientation of the scars (Rossini, 2020). The first method of debitage identified is the one defined "parallel planes" (PP, Fig. 5 Top, Table 4) which includes the cores in which one or more faces of the available volume were exploited in a parallel way (removals mostly have parallel directions). The PP modality includes 4 groups based on the number of faces used (one, two or three) and on the position of the faces (adjacent or opposite): i) single face cores with parallel detachments (PP-1F - n.37- Fig. 5A); ii) cores with 2 adjacent faces with parallel detachments (PP-2ADFs - n.8- Fig. 5B); iii) cores with 2 opposing faces with parallel detachments (PP-2OFs -n.22- Fig. 5C); iv) cores with 3 adjacent faces with parallel detachments (PP-3Fs -n.15- Fig. 5D). PP cores can show removals coming from one striking platform (Fig. 5 A, B, C, D) or removals coming from two opposed striking platforms. In the latter case, the bidirectional removals can be obtained by two different behaviours: i) by directly rotating the core or ii) by the addition of two activities performed on the two ends of the core-blank; the series of detachments result from the exploitation of 2 opposite striking platforms (Fig. 5 E) or are indirectly obtained from the counterblows due to bipolar technique on anvil (Fig.5 F). The second identified method of debitage is the one called "orthogonal planes" (OP - Fig. 5 G) which includes cores where two or more faces were exploited in an orthogonal way (the single debitage surface has detachments with parallel direction). The third method of debitage is the "semi-tournant" (STR - Fig. 5 H), consisting of cores where the detachments exploit adjacent faces with a continuous trend.

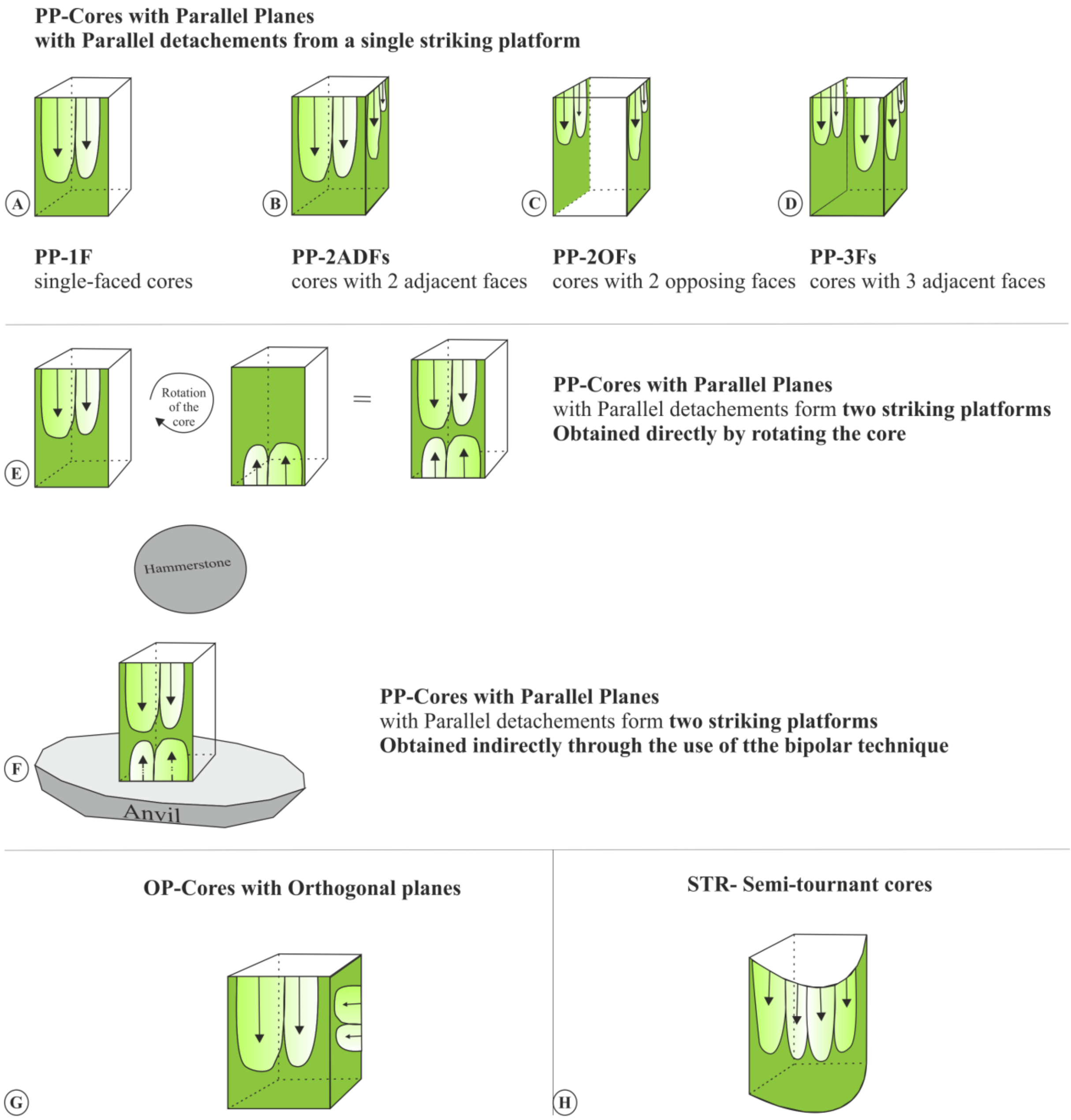


Fig. 5 - Schematic view of cores' exploitation. Above cores with parallel planes (PP). a, b: and unidirectional parallel detachments from one single striking platform. Specifically, A: single-faced cores (PP-1F); B cores with 2 adjacent faces (PP-2ADFs); C: cores with 2 opposing faces (PP-2OFs); D: cores with 3 adjacent faces (PP-3Fs).

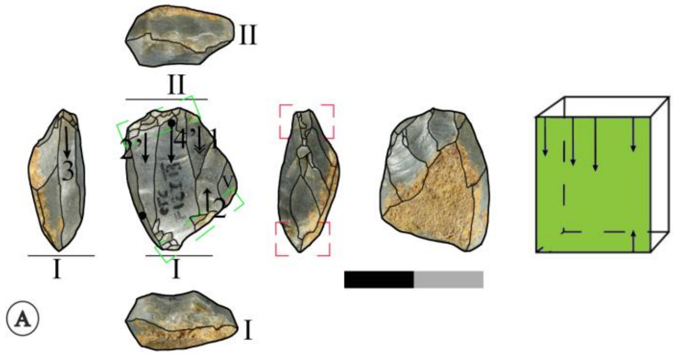
PP cores can show removals coming from the exploitation of 2 opposite striking platform, E: either by the addition of two activities directly (by rotating the core); or F: indirectly by counterblows due to bipolar technique on anvil. G: Orthogonal planes (OP) comprising cores where two or more faces were exploited in an orthogonal way. H: semi-tournant cores (STR) where the detachments exploit adjacent faces of the cores with a continuous trend.

Most of the cores found unbroken (n.103) were exploited with the PP method (n. 82) (Fig. 6) and are divided into PP-1F (single-faced cores with parallel detachments) (Fig. 6A), PP-2OFs (cores with 2 opposing faces with parallel detachments), PP-2ADFs (cores with 2 adjacent faces with parallel detachments) (Fig.6B), and PP-3Fs (cores with 3 adjacent faces with parallel detachments) (Fig. 6C) (Table 4). Secondly, we the use of the OP method (n.17) (Fig. 7A, B) can be observed, whilst the STR method is recorded more sporadically (n.4) (Fig. 7C). Morphological and technological attributes of cores are listed in Table 4. The analysis of cores shows that the most used core-blanks are rather thick flakes of various dimensional modules (Table 4), especially in the PP method. Blocks and pebbles represent the second and third type of blanks chosen in all the debitage methods. Blocks, pebbles, flakes and chunks were selected as rough blocks to be flaked. We believe that one possible explanation for this choice lies in the fact that the knappers were looking for certain specific technical characteristics regardless of the kind of raw block. That is to say, knapper selected pieces that naturally possessed guide ribs, angles and convexities suitable for producing debitage products. More than half of the core volumes can be considered as triangular prisms or parallelepipeds. In most cases, the striking platform and debitage surface are hierarchised, with the only exception of 7 cores exploited with the OP method.

The majority of the examined cores do not present a careful configuration of the volume or specific management of the convexities. When visible, the initialisation of the core appears to be limited to the opening and preparation of the striking platform. A simple management of lateral convexities (attested by lateral removals to create a guide rib) is documented in a few pieces, exploited with the PP method. In the STR cores, a series of products are extracted by exploiting the negatives of previous removals in a same and continuous reduction sequence. Most of the striking platforms used are not prepared or are prepared by a single stroke; to a lesser extent, there are also striking platforms opened by 2 or 3 strokes. Worth of note is the occurrence of a dihedron morphology opposite the striking platform especially in cores exploited by bipolar technique.

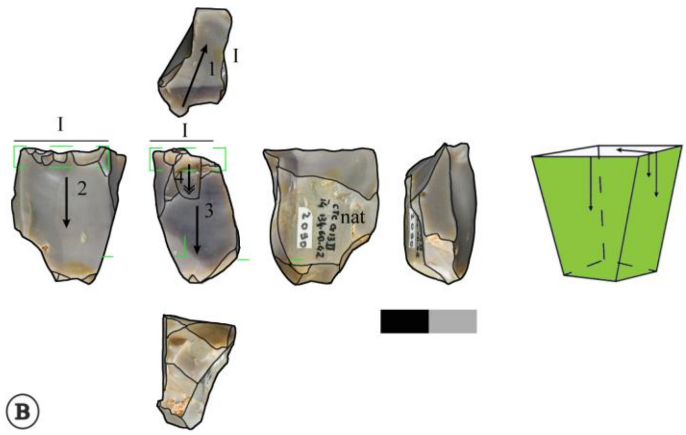
The production is diversified, and, usually, several technological categories are extracted from the same type of core. However, some trends can be identified: PP and STR cores are mostly used to extract products (usually flakes, elongated flakes, blades and bladelets) with unidirectional orientation; only exceptionally orientation is bidirectional. In OP cores, the adjacent faces used are often two or three, and in three cases only, the number of faces exploited is higher. The faces are mainly used to extract products with unidirectional orientation. OP cores usually produce flakes.

PP-1F: Parallel planes - 1 face



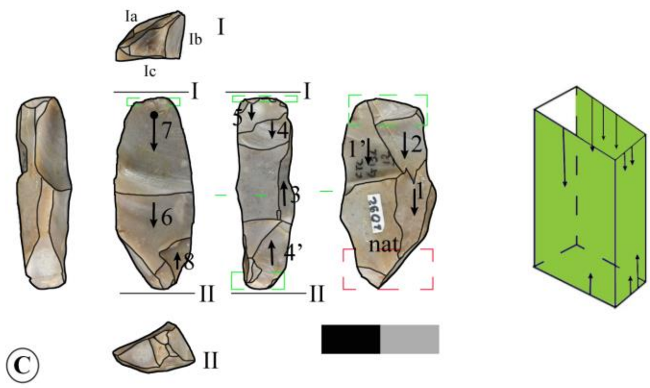
Selection	Semicortical flake
Striking platform	I; obliterated II; obliterated
Production	1 = hinged accident 2,2'= bladelet 3 = bladelet 4 = bladelet Crushing on the striking platform
Technique of percussion	Bipolar on anvil
Exploitation	Exploited

PP-2ADFs: Parallel planes - 2 face adjacent



Selection	Block
Striking platform	I; open whit a scar (1)
Production	2,3 = long flake 4 = hinged accident Crushing on the striking platform
Technique of percussion	Bipolar on anvil
Exploitation	Exploited

PP-3Fs: Parallel planes - 3 face adjacent



Selection	Fragment
Striking platform	I; a) obliterated b) linear c) linear II; linear
Production	1 = bladelet 1'= hinged accident 2 = flake 3 = bladelet 4'= flake 4, 5 = flakes 6 = long flake 7 = hinged accident 8 = counterblow Crushing on the striking platform
Technique of percussion	Bipolar on anvil
Exploitation	Exploited

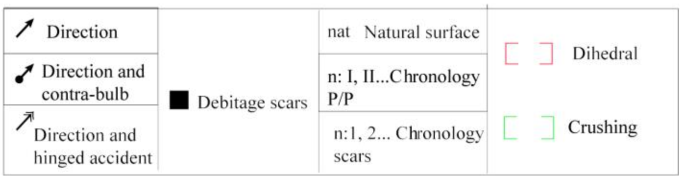
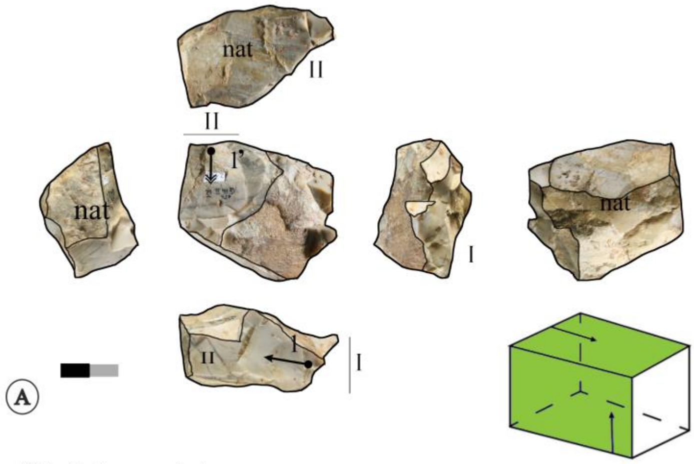


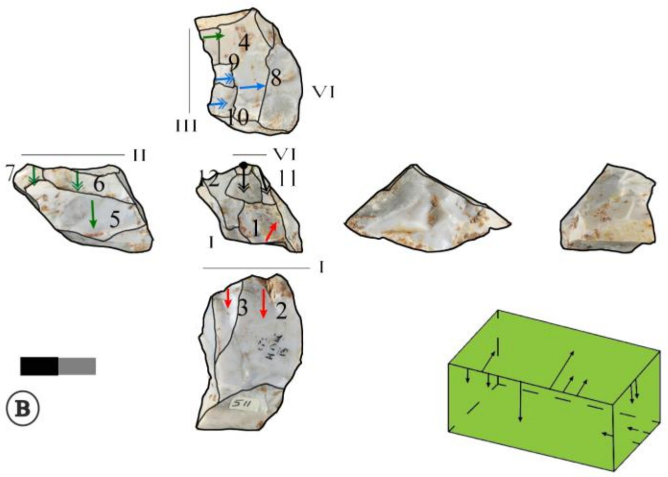
Fig. 6 - From top to bottom; A: single-faced cores with parallel detachments (PP-1F); B: cores with 2 adjacent faces with parallel detachments (PP-2ADFs); C: cores with 3 adjacent faces with parallel detachments (PP-3Fs).

OP- Orthogonal planes



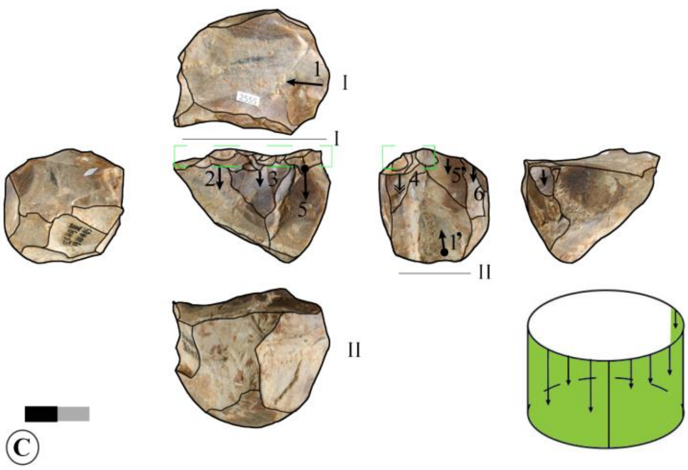
Selection	Block
Striking platform	I; ex. S/D II; natural surface
Production	1 = long flake 1'=hhinged accident
Technique of percussion	Direct freehand percussion
Exploitation	Low

OP- Orthogonal planes



Selection	Block
Striking platform	I, II; open whit one stroke (1, 2) III; ex S/D IV; ex S/D
Production	1 = flake 2 = flake 3,4 = flakes 5 = flake 6,7 = hinged accident 8 = flake 9,10= flakes (hinged accident) 11,12=flakes (hinged accident)
Technique of percussion	Direct freehand percussion
Exploitation	Medium

STR- Semi-tourning



Selection	Block
Striking platform	I; open whit one stroke (1) II; natural surface
Production	1 = flake (open P/P I) 1'= flake 2, 3 = flakes 4 = flake (hinged accident) 5 = elongated flake Crushing 6 = flake 7 = flake
Technique of percussion	Direct freehand percussion
Exploitation	Medium

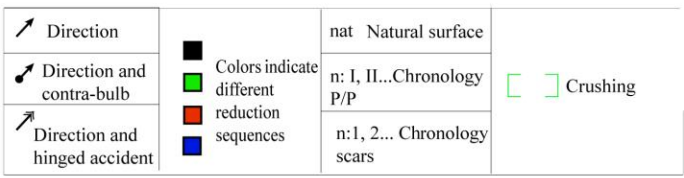


Fig. 7 - From top to bottom: cores with orthogonal planes (OP); semi-tournant cores (OP, STR).

Trait	Parallel planes (PP)								Orthogonal planes (OP)		Semi-tournant (STR)	
	PP-1F		PP-2ADFs		PP-2OFs		PP-3Fs					
	N	%	N	%	N	%	N	%	N	%	N	%
Total Cores:103	37	35.9	8	7.8	22	21.4	15	14.6	17	16.5	4	3.9
Core blank												
Block	2	5.4	3	37.5	1	4.5	3	20	5	29.4	3	75
Pebble	3	8.1	0	0	0	0	1	6.7	2	11.8	0	0
Flake	22	59.5	1	12.5	10	45.5	0	0	1	5.9	0	0
Block fragment	10	27.0	4	50	11	50.0	11	73.3	9	52.9	1	25
Volume												
Flat parallelepiped	12	32.4	0	0	13	59.1	2	13.3	0	0	0	0
Parallelepiped	9	24.3	7	87.5	1	4.5	5	33.3	12	70.6	0	0
Triangular prism	15	40.5	1	12.5	8	36.4	8	53.3	5	29.4	0	0
Truncated pyramid	1	2.7	0	0	0	0	0	0	0	0	4	100
Striking platform												
Not prepared	31	83.8	4	50	20	90.9	13	86.7	8	47.1	1	25
Prepared	6	16.2	4	50	2	9.1	2	13.3	9	52.9	3	75
Percussion technique												
Bipolar on anvil	28	75.7	5	62.5	22	100.0	14	93.3	7	41.2	0	0
Direct	9	24.3	2	25	0	0	1	6.7	10	58.8	4	100
Indetermined	0	0	1	12.5	0	0	0	0	0	0	0	0
Exploitation degree												
Initial	6	16.2	1	12.5	0	0	0	0	3	17.6	0	0
Medium	9	24.3	3	37.5	1	4.5	1	6.7	10	58.8	4	100
Exploited	22	59.5	4	50	21	95.5	14	93.3	4	23.5	0	0
Raw material												
Chert	35	94.6	8	100	21	95.5	14	93.3	15	88.2	4	100
Radiolarite	2	5.4	0	0	1	4.5	1	6.7	0	0	0	0
Quartzarenite	0	0	0	0	0	0	0	0	1	5.9	0	0
Quartz	0	0	0	0	0	0	0	0	1	5.9	0	0
Target product												
Flake	x		x		x		x		x		x	
Blade	x		x		x		x		x			

Table. 4 – Unbroken cores and their technological characteristics

The majority of the cores bear traces of the bipolar technique on anvil (Table 5). In detail, we note that bipolar percussion on anvil prevails in cores exploited with the PP method, whilst direct percussion plays a marginal role. Interestingly, three limestone anvils used for bipolar knapping were retrieved in layer rpi (Arrighi et al., 2020b). Greater heterogeneity is observed in the cores exploited with the OP method, where both techniques were equally used. This is in contrast to what happens for STR cores where direct percussion technique is exclusively used. Most of the cores are found in a medium or final stage of exploitation (Table 6). The bipolar technique on anvil is often applied in the final stages of reduction.

Technological classes	**Bipolar**		**Direct**		**Indet**		**Tot**
	N	**%**	**N**	**%**	**N**	**%**	
Core	76	73,8	26	25,2	1	1,0	103
Debitage products	428	37,5	127	11,1	585	51,3	1140
Tot	504	40,5	153	12,3	586	47,1	1243

Table 5: Quantity of cores and debitage products made by bipolar and direct percussion.

Exploitation degree	**Bipolar**		**Direct**		**Indet**		**Tot**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Initial	4	40	6	60	0	0	10	9,7
Medium	13	46,4	15	53,6	0	0	28	27,2
Final	59	90,8	5	7,7	1	1,5	65	63,1
Tot	76	73,8	26	25,2	1	1,0	103	100.0

Table 6: Exploitation degree of cores made by direct and bipolar technique.

Considering the dimensional distribution of the cores' length and width values, it can be noticed that PP-3Fs and STR cores are well clustered compared to the rest of the rpi cores, which are characterised by more variable dimensional modules (Fig. 8). STR cores are larger and were abandoned at a medium stage of reduction after one or two series of removals had been produced. In comparison, smaller cores characterise the PP-3Fs group, very clustered and significantly exploited, especially by bipolar technique. In addition to this capacity of exploiting the volume of the core until the very end of it, another feature of the bipolar technique is that products can be also created by the counterblows exerted by the anvil (Duke and Pargeter, 2015; Moroni et al., 2018;

Soriano et al., 2010; Vergès and Ollé, 2011). Given the large use of bipolar technique, more than half of the cores show flaking errors, mainly hinged scars.

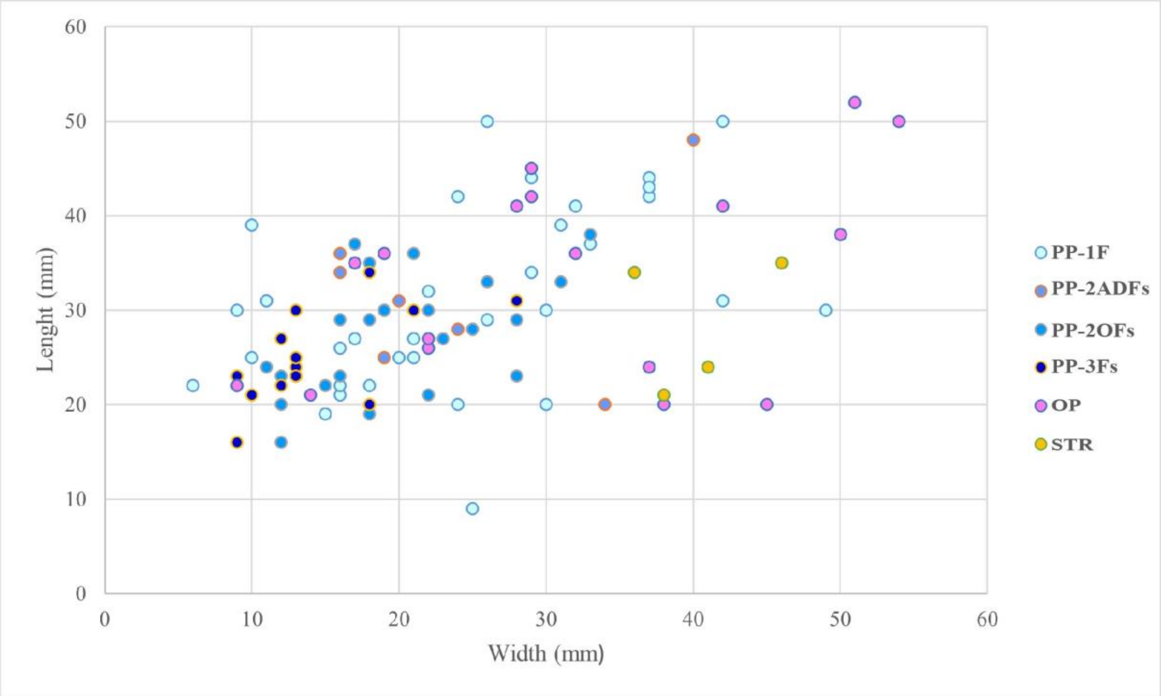


Fig. 8 - Scatterplot of length and width values of cores, coloured according to their modality of debitage: parallel planes-PP (PP-1F = single-faced cores with parallel detachments; PP- 2ADFs = cores with 2 adjacent faces with parallel detachments; PP-2OFs = cores with 2 opposing faces with parallel detachments; PP-3Fs = cores with 3 adjacent faces with parallel detachments); OP = cores with orthogonal planes and STR = semi-tournant cores.

4.4 Debitage products

The reduction sequences employed in layer rpi, led to the production of several debitage products (blades, bladelets, flakes, elongated flakes, debordant flakes, cortical flakes, semicortical flakes) (Fig. 9) from the same type of reduction system. In most cases flakes, blades and bladelets were produced from the same core. Only two cores were devoted to the exclusive production of bladelets. Both cases are characterized by a poorly managed reduction system which takes advantage of the guide ribs of the previous removals and of the natural convexities of the raw block (i.e., in blade/bladelet production crest preparation is never attested).

Fig. 9 - A: semicortical flake; B: debordant flake; C-F: flakes; G-H: elongated flakes; I-J: bladelets; K-L: blades.

Due to the large use of cores on flake/block fragments, cortical and semicortical flakes, usually attesting to the initial phase of the reduction, are poorly documented (18 flakes: 7 cortical and 11 semicortical - Table 7). The phases of full debitage are mainly attested by a production of flakes (n.

904) and, secondly, of elongated flakes (n. 107), bladelets (n. 45) blades (n. 37) and debordant flakes (n. 29) (Table 7; Fig. 9). Many pieces are broken (44.8%): items with composite fractures are the most represented category, followed by proximal and distal fragments (Table 8). This high rate of fragmentation is due to two main reasons: firstly, the wide use of bipolar technique on anvil, and, secondly, the quality of the raw material that is characterized by fissure planes.

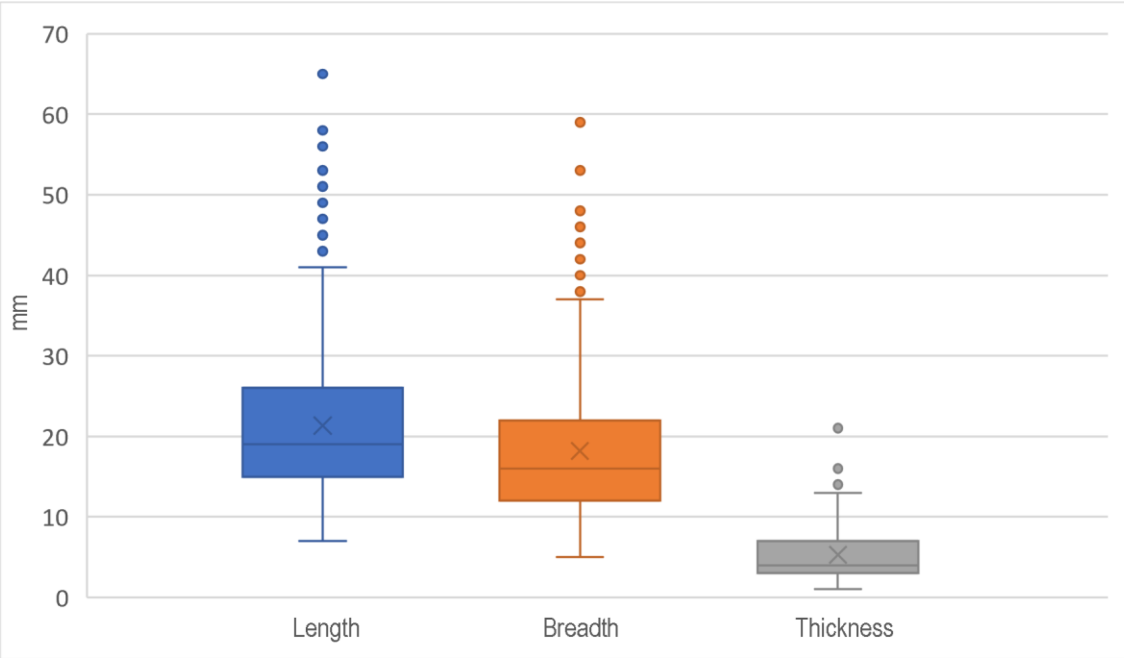


Fig. 10 - Boxplot showing the distribution (in mm) of length (blue), breadth (orange), and thickness (grey) in intact products.

Intact products are characterised by their small size (Fig. 10). Negatives of previous removals on the dorsal face are mainly unidirectional (37.5%), followed by the orthogonal (10%), bidirectional (8.6%) and perpendicular ones (7.5%) (Table 7). Debitage products show two ventral faces (13%) when they are from a flakeused as core and/or when they are made by bipolar technique (i.e., pieces with two ventral faces are typical stigmata of this technique, because two or more detachments can be produced simultaneously by a single strike, Collina et al. 2020).

There are more orthogonal than unidirectional dorsal scars only in the technological category of debordant flakes (Table 7). Most products show rectilinear profiles (44%) (Table 8), flat-bulbs (36.1%) and flat, linear, cortical, or crushed butts (Table 9). A number of products are the results of hinged (13%) and plunging accidents (3.7%), whilst Siret are very rare (Table 8).

The use of the bipolar technique on anvil has been recognized on 428 debitage products, making it the predominant flaking technique when compared to direct percussion which is attested by 127 pieces (Table 5, 9). However, about half of the products could not be attributed to a specific debitage technique due to the absence of distinctive features (e.g., Grimaldi et al., 2007; Guyodo and Marchand, 2005).

Considering the morphological and technological attributes of each type of debitage product more in detail (specific traits listed in Tables 7, 8, 9), we note that:i) flakes show mainly rectilinear profiles followed by wavy and convex profiles. Cross-section shapes are mostly triangular, followed by the trapezoidal types. Dorsal scar patterns are dominated by unidirectional removals; portions of ventral surfaces are also well represented. Distal terminations are feather in most cases, but there is also a low percentage of broken terminations. The frequency of plunging ends is very low among flakes, and some hinged ends are present and are more diffused than in the bladelets. The proximal part of flakes is characterized by flat butts and flat bulbs

ii) Elongated flakes mostly show rectilinear profiles, followed by the wavy and convex ones. Cross-section shapes are mainly triangular. Unidirectional removals dominate dorsal scar patterns. Distal terminations are feather in most cases. The frequency of plunging ends is very low, and some hinged accidents are present. The proximal part is characterised by flat or linear butts and flat bulbs. The most frequent identified technique in this category is the bipolar on anvil one.

iii) Blades and bladelets also mostly show rectilinear profiles, followed by wavy and convex ones. Cross-sections are mainly trapezoidal and triangular. In the blade category, however, trapezoidal cross-sections are dominant. Dorsal scars are mainly unidirectional, followed by the bidirectional pattern. Distal terminations are feather in most cases. The frequency of plunging ends is very low among bladelets and blades, and some hinged accidents are present only in bladelets. Flat butts and flat bulbs characterise the proximal part of this category. In bladelets a high frequency of linear butts can also be noted. The most frequent technique is the bipolar on anvil one, especially in bladelets. Based on their technical criteria, all the debitage products are consistent with the studied cores.

Production	**Blade**		**Bladelet**		**Flake**		**Elongated flake**		**Debordant flake**		**Cortical flake**		**Semicortical flake**		**Total**	
	N	%	**N**	%	**N**	%	**N**	%	**N**	%	**N**	%	**N**	%	**N**	**%**
Total	**37**	3.2	**45**	3.9	**904**	79.3	**107**	9.4	**29**	2.5	**7**	0.6	**11**	1.0	**1,140**	100
Cortex																
0	**35**	94.6	**43**	95.6	**838**	92.7	**98**	91.6	**7**	24.1	**0**	0	**0**	0	**1,021**	89.6
50 ≤%	**2**	5.4	**2**	4.4	**66**	7.3	**9**	8.4	**22**	75.9	**0**	0	**0**	0	**101**	8.9
> 50 %	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**11**	100.0	**11**	0.9

100%	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**7**	100	**0**	0	**7**	0.6
Cortex location																
Distal	**2**	5.4	**0**	0	**13**	1.4	**3**	2.8	**1**	3.4	**0**	0	**0**	0	**19**	1.7
Back	**0**	0	**1**	2.2	**7**	0.8	**1**	0.9	**20**	69.0	**0**	0	**0**	0	**29**	2.5
Lateral	**0**	0	**1**	2.2	**32**	3.5	**3**	2.8	**1**	3.4	**0**	0	**0**	0	**37**	3.2
Proximal	**0**	0	**0**	0	**14**	1.5	**2**	1.9	**0**	0	**0**	0	**0**	0	**16**	1.4
Semitotal	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**11**	100.0	**11**	1.0
Total	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**7**	100.0	**0**	0	**7**	0.6
Absent	**35**	94.6	**43**	95.6	**838**	92.7	**98**	91.6	**7**	24.1	**0**	0	**0**	0	**1,021**	89.6
Scar direction																
Unidirectional	**13**	35.1	**26**	57.8	**319**	35.3	**51**	47.7	**7**	24.1	**0**	0	**7**	63.6	**423**	37.5
Opposite bidirectional	**6**	16.2	**6**	13.3	**73**	8.1	**7**	6.5	**5**	17.2	**0**	0	**0**	0	**97**	8.6
Centripetal	**0**	0	**0**	0	**1**	0.1	**1**	0.9	**0**	0	**0**	0	**0**	0	**2**	0.2
Convergent	**0**	0	**0**	0	**12**	1.3	**3**	2.8	**0**	0	**0**	0	**0**	0	**15**	1.3
Multidirectional	**0**	0	**0**	0	**12**	1.3	**0**	0	**2**	6.9	**0**	0	**0**	0	**14**	1.2
Orthogonal	**3**	8.1	**6**	13.3	**85**	9.4	**12**	11.2	**6**	20.7	**0**	0	**0**	0	**112**	10
Perpendicular	**1**	2.7	**1**	2.2	**72**	8.0	**10**	9.3	**0**	0	**0**	0	**1**	9.1	**85**	7.5
Ventral	**3**	8.1	**3**	6.7	**131**	14.5	**8**	7.5	**1**	3.4	**0**	0	**0**	0	**146**	13
Indeterminate	**11**	29.7	**3**	6.7	**194**	21.5	**15**	14.0	**6**	20.7	**0**	0	**3**	27.3	**232**	20.6
Scar number																
1	**2**	5.4	**3**	6.7	**176**	19.5	**8**	7.5	**6**	20.7	**0**	0	**6**	54.5	**201**	17.6
2	**11**	29.7	**11**	24.4	**241**	26.7	**32**	29.9	**6**	20.7	**0**	0	**3**	27.3	**304**	26.7
3	**8**	21.6	**14**	31.1	**235**	26.0	**35**	32.7	**8**	27.6	**0**	0	**1**	9.1	**301**	26.4
4	**4**	10.8	**7**	15.6	**134**	14.8	**17**	15.9	**5**	17.2	**0**	0	**1**	9.1	**168**	14.7
> 4	**10**	27.0	**10**	22.2	**100**	11.1	**14**	13.1	**3**	10.3	**0**	0	**0**	0	**137**	12.0
Indeterminate	**2**	5.4	**0**	0	**14**	1.5	**1**	0.9	**1**	3.4	**0**	0	**0**	0	**18**	1.6

Table 7: Technological features on the dorsal face of the debitage products.

Production	Blade		Bladelet		Flake		Elongated flake		Debordant flake		Cortical flake		Semicortical flake		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Total	**37**	3.2	**45**	3.9	**904**	79.3	**107**	9.4	**29**	2.5	**7**	0.6	**11**	1.0	**1,140**	100
Cross-section shape (only intact pieces)																
Linear	0	0	**2**	5.3	**53**	12.4	**4**	3.9	**0**	0	**0**	0	**0**	0	**59**	9.4
Semicircular	**1**	4	**0**	0	**9**	2.28.11	**1**	1	**0**	0	**1**	33.3	**1**	12.5	**13**	2.1
Trapezoidal	**6**	24	**15**	39.5	**120**	28.1	**27**	26.2	**9**	36	**1**	33.3	**2**	25	**180**	28.6
Triangular	**17**	68	**19**	50	**214**	50.1	**68**	66	**14**	56	**0**	0	**5**	62.5	**337**	53.6.
Irregular	**1**	4	**2**	5..3	**31**	7.3	**3**	2.9	**2**	8	**1**	33.3	**0**	0	**40**	6.4
Longitudinal profile (only intact and proximal pieces)																
Concave	**1**	2.7	**3**	6.7	**16**	1.8	**6**	5.6	**0**	0	**0**	0	**0**	0	**26**	2.3
Convex	**6**	16.2	**6**	13.3	**83**	9.2	**14**	13.1	**7**	24.1	**0**	0	**1**	9.1	**117**	10.3
Rectilinear	**10**	27.0	**21**	46.7	**377**	41.7	**65**	60.7	**16**	55.2	**5**	71.4	**8**	72.7	**502**	44.0
Twisted	**4**	10.8	**4**	8.9	**8**	0.9	**5**	4.7	**0**	0	**0**	0	**0**	0	**21**	1.8
Wavy	**6**	16.2	**5**	11.1	**47**	5.2	**12**	11.2	**3**	10.3	**0**	0	**0**	0	**73**	6.4
Indeterminate	**0**	0	**0**	0	**1**	0.1	**1**	0.9	**0**	0	**0**	0	**0**	0	**2**	0.2
Distal termination																
Feather	**25**	67.6	**34**	75.6	**435**	48.1	**82**	76.6	**15**	51.7	**5**	71.4	**8**	72.7	**604**	53.0
Broken	**4**	10.8	**2**	4.4	**247**	27.3	**0**	0	**3**	10.3	**2**	28.6	**1**	9.1	**259**	22.7
Hinged	**0**	0.0	**5**	11.1	**128**	14.2	**12**	11.2	**2**	6.9	**0**	0	**1**	9.1	**148**	13.0
Crushed	**6**	16.2	**1**	2.2	**63**	7.0	**9**	8.4	**7**	24.1	**0**	0	**1**	9.1	**87**	7.6
Plunging	**2**	5.4	**3**	6.7	**31**	3.4	**4**	3.7	**2**	6.9	**0**	0	**0**	0	**42**	3.7
Integrity																
Intact	**25**	67,6	**38**	84,4	**427**	47,2	**103**	96,3	**25**	86,2	**3**	42,9	**8**	72,7	**629**	55,2
Composite	**0**	0	**0**	0	**152**	16,8	**0**	0	**1**	3,4	**1**	14,3	**0**	0	**154**	13,5
Distal	**7**	18,9	**4**	8,9	**97**	10,7	**4**	3,7	**1**	3,4	**1**	14,3	**0**	0	**114**	10
Proximal	**2**	5,4	**1**	2,2	**105**	11,6	**0**	0	**1**	3,4	**2**	28,6	**1**	9,1	**112**	9,8
Lateral	**1**	2,7	**1**	2,2	**91**	10,1	**0**	0	**0**	0	**0**	0	**2**	18,2	**95**	8,3
Mesial	**2**	5,4	**1**	2,2	**32**	3,5	**0**	0	**1**	3,4	**0**	0	**0**	0	**36**	3,2

Table 8: Morphological features and integrity of the debitage products.

Production	Blade		Bladelet		Flake		Elongated flake		Debordant flake		Cortical flake		Semicortical lake		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Total	37	3.2	45	3.9	904	79.3	107	9.4	29	2.5	7	0.6	11	1.0	1,140	100
Butt																
Flat	11	29.7	11	24.4	323	35.7	44	41.1	18	62.1	0	0	4	36.4	411	36.1
Linear	3	8.1	10	22.2	93	10.3	16	15.0	1	3.4	0	0	1	9.1	124	10.9
Crushed	3	8.1	6	13.3	61	6.7	9	8.4	1	3.4	0	0	1	9.1	81	7.1
Cortical	4	10.8	0	0	47	5.2	13	12.1	1	3.4	4	57.1	3	27.3	72	6.3
Dihedral	0	0	2	4.4	45	5.0	4	3.7	2	6.9	1	14.3	0	0	54	4.7
Facetted	0	0	1	2.2	3	0.3	0	0	0	0	0	0	0	0	4	0.4
Natural surface	0	0	1	2.2	17	1.9	3	2.8	1	3.4	0	0	1	9.1	23	2.0
Prepared	0	0	1	2.2	13	1.4	1	0.9	0	0	0	0	0	0	15	1.3
Punctiform	3	8.1	3	6.7	23	2.5	5	4.7	1	3.4	0	0	1	9.1	36	3.2
Absent	9	24.3	5	11.1	245	27.1	4	3.7	3	10.3	2	28.6	0	0	268	23.5
Indeterminate	4	10.8	5	11.1	34	3.8	8	7.5	1	3.4	0	0	0	0	52	4.6
Impact point																
Absent	11	29.7	6	13.3	265	29.3	9	8.4	3	10.3	2	28.6	0	0	296	26.0
Central	4	10.8	5	11.1	167	18.5	19	17.8	6	20.7	3	42.9	1	9.1	205	18.0
Diffuse	9	24.3	21	46.7	248	27.4	44	41.1	10	34.5	1	14.3	5	45.5	338	29.6
Lateral	9	24.3	9	20.0	176	19.5	25	23.4	9	31.0	1	14.3	5	45.5	234	20.5
Indeterminate	4	10.8	4	8.9	48	5.3	10	9.3	1	3.4	0	0	0	0	67	5.9
Bulb																
Absent	9	24.3	5	11.1	211	23.3	4	3.7	2	6.9	2	28.6	0	0	233	20.4
Dihedral	2	5.4	3	6.7	32	3.5	5	4.7	1	3.4	0	0	4	36.4	47	4.1
Double	0	0.0	1	2.2	4	0.4	0	0	2	6.9	0	0	0	0	7	0.6
Flat	21	56.8	31	68.9	501	55.4	81	75.7	16	55.2	4	57.1	6	54.5	660	57.9
Prominent	2	5.4	2	4.4	113	12.5	7	6.5	7	24.1	1	14.3	0	0	132	11.6
Indeterminate	3	8.1	3	6.6	43	4.7	10	9.4	1	3.4	0	0	1	9.1	61	5.4
Parasitical scar																
Absent	33	89.2	40	88.9	748	82.7	84	78.5	21	72.4	7	100.0	8	72.7	941	82.5
Present	4	10.8	5	11.1	156	17.3	23	21.5	8	27.6	0	0	3	27.3	199	17.5
Percussion technique																
Bipolar on anvil	12	32.4	30	66.7	319	35.3	53	49.5	6	20.7	2	28.6	6	54.5	428	37.5
Direct	7	18.9	5	11.1	94	10.4	8	7.5	9	31.0	2	28.6	2	18.2	127	11.1
Indeterminate	18	48.6	10	22.2	491	54.3	46	43.0	14	48.3	3	42.9	3	27.3	585	51.3

Table 9: Technological features on the proximal portion of the debitage products and percussion techniques.

4.5 – Retouched artefacts

In the lithic assemblage, 58 pieces were retouched (Table 10; Figs. 11, 12), using a variety of blanks: 37.9% are flakes, 12. 1% are elongated flakes, 7% are blades, 6.9% are microflakes-debris, and 3.4 % are cores. Denticulates (n. 21) and side-scrapers (n. 17) are the main represented tool types. End-scrapers (n. 3), and lunates (n. 8) are also present. Importantly, despite some standardised tools, the majority of these retouched items display irregular morphologies and are roughly modified.

Lunates are more standardised than the rest of retouched tools. These are mainly obtained from flakes (5 flakes and 3 bladelets - Fig. 10). The back of 4 lunates (3 bladelets and an elongated flake) was obtained by retouching only the distal and proximal ends, whereas the portion in between was slightly transformed or left unaltered (type B according to the classification proposed by Moroni et al., 2018). The back of the other 4 lunates was obtained by totally reducing one of the longest edges of the blank (type A - Moroni et al., 2018). The retouch is bipolar (n.1), direct (n. 4), alternate (n. 2) and inverse (n. 1).

	Blank								
Retouched artefacts	**Flakes**	**Blades**	**Micro-flakes_debris**	**Cores**	**Elongated flakes**	**Debordant flakes**	**Chunks**	**Tot**	**%**
Lunates	3	2	1		1	1		8	13.8
End-scrapers	3							3	5.2
Beaks					1			1	1.7
Denticulates	6	1	2	2	2	1	7	21	36.2
Undifferentiated abrupt retouched pieces	1							1	1.7
Backed blades					1			1	1.7
Side-scrapers	9	2			1	2	3	17	29.3
Truncated pieces		2	1		1			4	6.9
Indeterminate							2	2	3.4
Total	22	7	4	2	7	4	12	58	100
%	37.9	12.1	6.9	3.4	12.1	6.9	20.7	100	

Table. 10 - Retouched artefacts

Fig. 11 – Lunates.

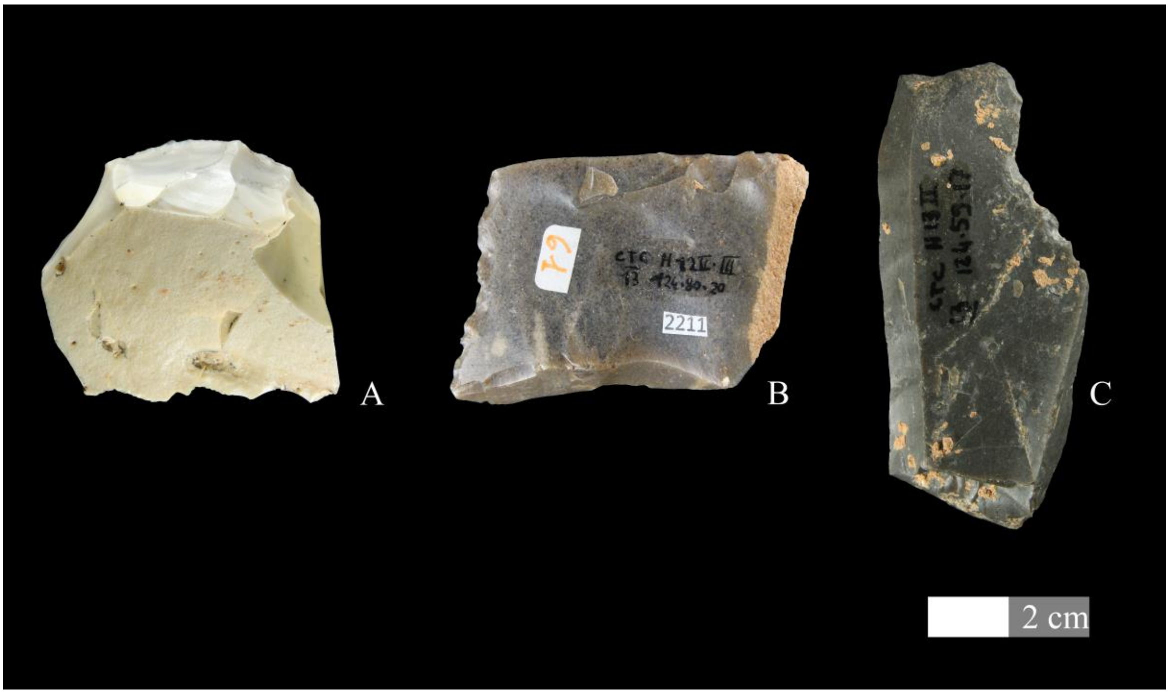


Fig. 12 – A: end-scraper; B, C: denticulates.

5. Discussion

5.1 Reduction sequences

The lithic assemblage of layer rpi displays a fresh surface status with virtually no patina. The distribution pattern by dimensional classes attests to a reasonably complete recovery of findings (e.g., inconsistent/null loss of items from sieving), giving at the same time indication of a well preserved context (Spagnolo et al., 2020a, 2020b), not altered by tractive phenomena (e.g., Spagnolo et al., 2020c). The high percentage of items in the first-dimensional class (58.8%) testifies that most of the lithic production was carried out in situ (e.g., Bertran et al., 2012).

The Uluzzian knappers mainly used locally collected fine-grained chert (Gambassini, 1997; Aureli et al., in preparation). The first phase of production (i.e., initialisation and decortication of the modules to be flaked) is scarcely documented at the site. It is therefore assumed that the original blocks were rough-cut at the source and only block fragments and possibly flakes to be used as cores were imported into the campsite (Fig. 13). The only conceptualisation identified in layer rpi is the additional one (Boëda, 2013). Based on the study of cores, the main method used is parallel planes (PP) followed by the orthogonal planes (OP) and semi-tournant (STR) ones with a predominant use of the bipolar percussion technique on anvil in PP and OP. Striking platforms are generally opened with a single stroke, or they are not prepared at all. Management of convexities is low, but half of the cores show a dihedron opposite the striking platform. This dihedron probably played a role in managing forces during production when the bipolar technique on anvil was used

(Arrighi et al., 2020b; Peresani et al., 2019). In the light of this, it will be essential to carry out experiments to understand if the dihedron was: i) already present on the selected raw material; ii) expressly created; or iii) a mere consequence of the use of the bipolar technique.
Most of the items produced belong to the technological category of flakes. This is followed by a secondary production of elongated flakes and bladelets. The products are characterised by their small dimensions and by a variability in morphology and edge delineation. Many products display rectilinear longitudinal profiles, flat bulbs and shattered butts.
Retouched tools (n. 58) play a marginal role compared to the possibility of directly using blanks as is. They mostly comprise denticulates, side-scrapers, end-scrapers and lunates, dimensionally variable and mainly obtained on flakes. Contrary to lunates, side-scrapers, end-scrapers and denticulates show a low degree of standardisation both in morphology and size. The shape of lunates was exclusively obtained by retouch. This is a characteristic shared by the Uluzzian groups as no ad hoc operating method has been identified for lunates in the debitage phase both at Castelcivita and in other Uluzzian contexts (e.g., Grotta del Cavallo, Moroni et al., 2018; Ranaldo et al., 2017; Riparo del Broion, Peresani et al, 2019).

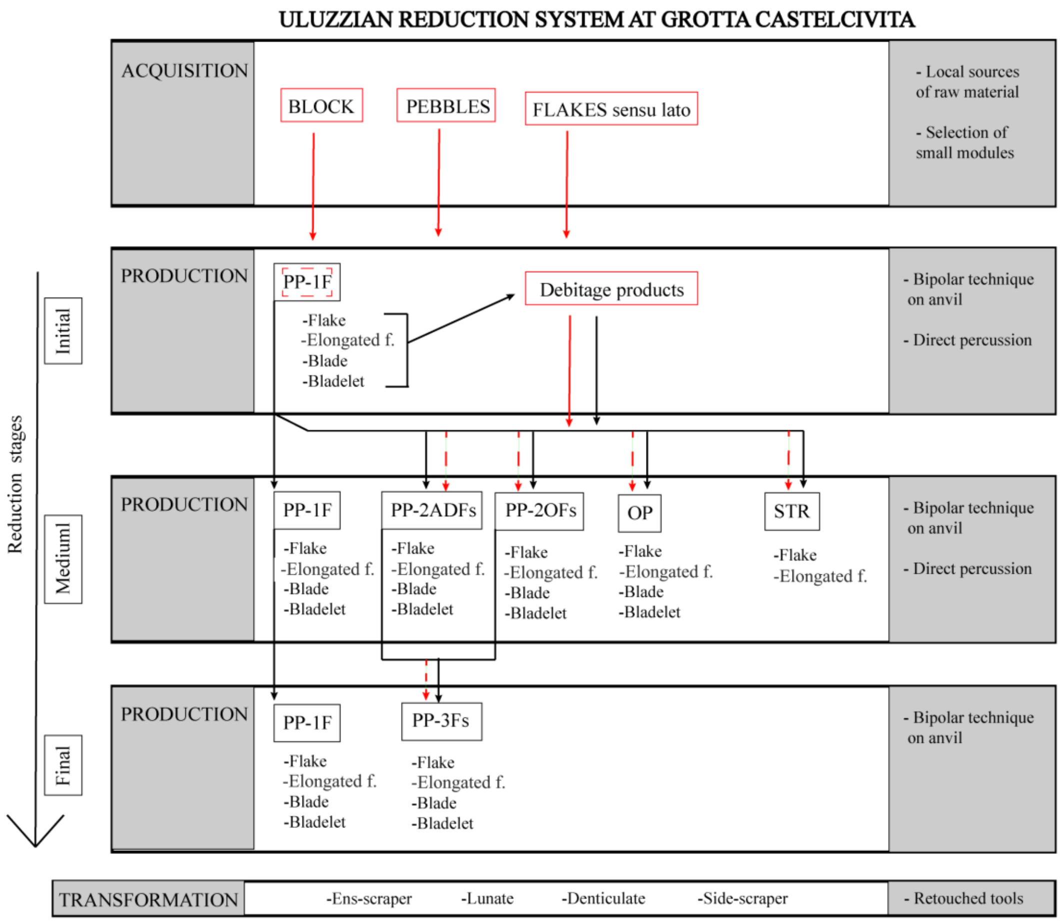


Fig. 13 - Reduction sequences of the lithic assemblage from Castelcivita, layer rpi with the various stages of cores mode of exploitation and debitage products. There are 3 types of core's reduction methods: parallel planes (PP), orthogonal planes (OP) and semi-tournant (STR). In the same reduction sequence both direct percussion and bipolar technique on anvil are used. The latter prevails in the final stages of core exploitation.

5.2 *Less is more:* a hypothesis on the Uluzzian technical behaviour

One of the most notable achievements of the present research based both on the analysis of the rpi lithic industry and from the direct knowledge of lithic assemblages from other already published Uluzzian sites (e.g., Grotta del Cavallo Moroni et al., 2018, Roccia San Sebastiano Collina et al., 2020, Uluzzo C ;;; Silvestrini et al., 2021), is that of having clearly and accurately identified and described the technological strategies chosen by the Uluzzian groups, thus creating the conditions for further investigations on the potential causes that triggered a certain kind of technological behaviour. At the heart of the Uluzzian production model, there is the idea " to do more with less," that is, to use the available resources in the most productive way. When we say "productive", we mean the highest number of products (be they flakes or blades) with a usable cutting edge that can be obtained in the shortest possible time span and by the lowest number of actions (strikes). The high productivity of the bipolar knapping in terms of quantity of extracted products and the low effort required to make them are well described in scientific literature (e.g. Hiscock 1996; Pargeter & Duke 2015; Morgan et al. 2015 Pargeter and de la Pena 2017; Horta et al. 2022).What we mean here with the term "time" is the distance (in terms of action/mental timespan) involved between the perception of the need (e.g., the necessity to cut a material) and its resolution (e.g., making the appropriate final tool for cutting) (Haidle, 2010; Kitahara-Frisch, 1993). In Table 7 we propose an expectation of less/more time involved in the different phases of the reduction sequence necessary to produce a lithic tool.

Activities	**Evidence**	**Time expectation**
Raw material procurement	Raw material procurement distances; quality, and characteristics of the raw material	Close to the site, local raw material = Less time Far from the site, exogenous raw material = More time
Initialisation and management of cores	Lithic technology, attribute analysis experimental flaking	Absent or approximative core initialisation and management of the convexities = Less time Careful core initialisation and management of the convexities = More time

Production of standardized end-products	Lithic technology, attribute analysis, experimental flaking	Low standardized end-product = Less time Very standardized end-product = More time
apprenticeship	Learning behaviour, lithic technology, attribute analysis, experimental flaking	Simple reduction sequence = Less time Complex reduction sequence = More time

Table 11: Activities involved in tool manufacturing, correlated with the available evidence and potential time expectation (less/more time).

In the Uluzzian sites, we often note that time devoted to movements related to raw material procurement was scarce. Employed lithotypes are mainly local (Grotta del Cavallo - Moroni et al., 2018; Uluzzo C - Silvestrini et al., 2021; Roccia San Sebastiano - Collina et al., 2020; Colle Rotondo - Villa et al., 2018; Castelcivita - this study; Broion, Fumane - Peresani et al., 2019), even when the raw material available near the sites is not of very good quality. The use of local lithic resources, independently from their characteristics, was certainly facilitated by the type of production which does not have specific technical requirements that could force the Uluzzian knappers to search for high-quality raw materials. Also, time spent on core initialisation, management and production is low in the Uluzzian due to the predominant use of the bipolar technique. Experimental studies have shown that using the bipolar technique in reduction does not require any special handling of angles or convexities or any preparation of a striking platform (Clarkson et al., 2018). In addition, some researchers report higher productivity from the use of bipolar knapping: when compared to the use of direct percussion, the amount of raw material required to obtain the same number of usable flakes is lower (Eren et al., 2013; Gurtov and Eren, 2014).

At Castelcivita, as in the rest of the Uluzzian sites, the knappers do not seem to look for specific techno-categories with set morphologies, and debitage products that derive from this kind of production are mainly small flakes and small blades/bladelets with a low degree of standardisation. Yet this does not affect the possibility of obtaining usable products with definite and recurring characteristics: straight profiles, absence of prominent bulbs, straight cutting edges, low thickness (Collina et al., 2020; Moroni et al., 2018).

Here we propose an interpretation of the Uluzzian system, which provides a new perspective on the productive organisation of lithic knapping and makes it possible to get:

- Short response times in relation to raw material requirements. This means that there are no constraints related to the raw material or volume to be exploited, as it is the method and technique of debitage itself that can be adapted to the available resources. The search for specific raw materials is, therefore, much less pressing.
- Less time required for a specific initialisation and management of volumes during knapping.

- Fewer number of technical and management flakes.
- Good reliability of the production process; despite the low degree of predetermination, it is possible to obtain products with specific characteristics (sharp edges, straight profiles, absence of prominent bulbs).
- Possible increased autonomy for beginner knappers (learning).

These arguments play in favour of little requirements and less time. The production system adopted by the Uluzzian knappers seeks to respond to demand promptly, without the need to be tied to the use of specific raw materials or to the aim of obtaining products characterized by recurring morphologies. The strength of this kind of conceptualisation is its versatility and the reduction of unnecessary energy costs without the loss of product efficiency (Collina et al. 2020; Marciani et al. 2020; Moroni et al., 2013; 2018; Riel Salvatore 2007; 2009; 2010). The low degree of standardisation of product's morphologies plays a key role, as it allowed the Uluzzian makers to overcome schematism and select only the best-performing products for the specific objective. However, even if standardization was not an objective of the production, clear ergonomic features were pursued which are valuable traits in the case of composite tools (Collina et al., 2020; Marciani et al., 2020; Moroni et al., 2018; Riel Salvatore, 2007), i.e., of multi-module implements whose insets have to to be rapidly produced and easily replaced in a short time. This hypothesis, and specifically the use of the Uluzzian micro-flakes in hunting technologies, is supported by archaeological, ethnographic, and experimental accounts (Chauchat et al., 1985; Crovetto et al., 1994; de la Peña et al., 2018; Le Brun-Ricalens, 2006; Riel-Salvatore, 2009; Shott, 1989; White, 1968 and references therein) and is, therefore, currently the object of use-wear and techno-functional investigations carried out on several items from Castelcivita.

6. Conclusions

This study provides a picture of the Uluzzian lithic technical behaviour through the detailed analysis of the reduction sequences put in place in layer rpi of Castelcivita. The whole process, from the raw materials procurement to the conceptualisation of reduction, use and abandonment of lithic artefacts, seems to be ruled by the need to save time and energy in order to obtain as many suitable products with as little effort as possible; or at least these are the effects of the adopted technical strategy, characterised by the prominent role of bipolar knapping on anvil. The production is conceptualised in order to be flexible. It takes advantage of the locally available resources in the most productive way, as it reduces the effort dedicated to normalising the production by avoiding the employment of controlled process of managing lateral, distal convexities and the standardisation of end-products. The low degree of standardisation of product morphologies is a peculiar character of this technology and offers the advantage of having a variety of products from which to select the most suitable ones for the required need. Therefore, the distinctive trait of the Uluzzian lithic production system is its versatility which does not diminish the products' efficiency. The reason for this behaviour lies in a choice of optimisation that could be synthesised in the concept "less is more".

However, this concept must be considered in a broader and multifaced context in which lithic production is only a small part of a much more complex technological apparatus able to produce also hafted tools and javelins and/or arrows to be used as hunting weapons (Sano et al., 2019). In particular, the making of mechanically delivered weapons implies expertise and time effort in various fields, from the processing of sophisticated adhesive compounds, to fletching (Fiore et al., 2019) and ballistics in general. In this scenario, lithic production represents the only segment of the entire manufacturing process in which it was possible to shorten production times without the entire tool losing efficiency and precision. While these points emphasize the high technological level possessed by the Uluzzian people, the same points also strengthen the idea of a potential need to reduce the time and energy devoted to tool manufacturing, compared to other tasks such as, for instance, territorial control and food procurement. But what are the causes that triggered this necessity? The authors of a recent paper speculate that
the systematic use of "low-cost" production strategies: "can occur as an adaptive response to an array of factors like climatic changes, population increase, competition among groups in terms of resource procurement and limited territory-expertise" (Moroni et al., 2018, p.150). However, directly relating the technical choices of a human group to external causal stimuli is particularly challenging and requires an in-depth analysis that takes into account several variables, such as site function, seasonality, geographical and environmental conditions not to mention the role most probably played by the techno-cultural tradition per se (Eren et al., 2013; Robinson and Sellet, 2018; Clarkson et al., 2018).

All these components need to be explored in the future in order to understand the degree to which each is involved in influencing the Uluzzian technical approach in lithic production to such extent.

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