UNIVERSITAT ROVIRA I VIRGILI

CONTINUITIES AND DISCONTINUITIES DURING THE LATE MIDDLE PALAEOLITHIC AT THE OSCURUSCIUTO ROCK SHELTER (SOUTHERN ITALY). AN INTEGRATED STUDY OF LITHIC MANUFACTURE IN THE STRATA SU 15, SU 14, SU 13 AND SU 11

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TESIS DOCTORAL

2018

UNIVERSITAT ROVIRA i VIRGILI

IPHES
Institut Català de Paleoecologia Humana i Evolució Social

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UNIVERSITÀ DEGLI STUDI DI FERRARA
- EX LABORE FRUCTUS -

DOCTORAL THESIS

2018

UNIVERSITÀ DI SIENA 1240

Education and Culture
Erasmus Mundus

UNIVERSITAT ROVIRA i VIRGILI

IDQP
International Doctorate in Quaternary and Prehistory

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I STATE that the present study, entitled "**Continuities and discontinuities during the late Middle Palaeolithic at the Oscurusciuto rock shelter (southern Italy). An integrated study of lithic manufacture in the strata SU 15, SU 14, SU 13 and SU 11**.", presented by **GIULIA MARCIANI** for the award of the degree of Doctor, has been carried out under my supervision at the Departament d'Història i Història de l'Art of Universitat Rovira i Virgili.

Tarragona, 1/02/2018

Doctoral Thesis Supervisor/s

Robert Sala Ramos

Marta Arzarello

Acknowledgements

Arriving at the point of discussing a PhD thesis is a great personal and professional achievement. This would have been impossible, however, without all those people who helped and supported me during the years of studying, researching and writing the thesis you have before you.

This thesis was developed under the auspices of the International Doctorate Community Erasmus Mundus, as a joint project between the Universitat Rovira i Virgili of Tarragona, and the Università degli Studi di Ferrara, and I would like to acknowledge all those who made my enrolment in this programme possible.

First of all I would like to thank my tutors for their invaluable support, encouragement and advice without which this thesis would never had taken off: Marta Arzarello, Robert Sala Ramos, Annamaria Ronchitelli and Daniele Aureli. In particular, I would like to express my sincere gratitude, professional respect and admiration to Marta Arzarello for her ingenious problem solving capacity at all times, as well as to Robert Sala Ramos for his valuable advice, to Annamaria Ronchitelli, for her dedication to science while nevertheless allowing me to proceed in my own way with my work, never failing, however, to guide me in the right direction; and last but not least to Daniele Aureli for supplying me with a solid and extensive basis in lithic technology and for his patience when spending countless hours sorting and evaluating the stone manufactures.

To all the members of my thesis examination panel I would also like to express my deep-felt thanks for having accepted the task and willingly dedicated the necessary time and effort. Your comments, opinions and advice will be essential to the future development of my research, for which I thank in advance Marie Soressi, Annamaria Ronchitelli, Manuel Vaquero Rodríguez, Joseba Ríos Garaizar, Marco Peresani, Antoine Lourdeau and Eric Boëda.

Furthermore, this work has benefited from the support, encouragement and interesting discussions with many colleagues for which I would like to thank: the entire staff of U.R. Preistoria e Antropologia of the Dipartimento di Scienze Fisiche, della Terra e dell'Ambiente - Università di Siena. A very special thanks goes to Paolo Boscato, Adriana Moroni, Luca Maria Foresi. To my fellow colleagues and friends, Vincenzo Spagnolo, Sem Scaramucci, Simona Arrighi, Giulia Capecchi, Francesco Boschin, Jacopo Crezzini, Stefano Ricci, thank you for your untiring feedback and help. To Marcos César Pereira Santos, Daniele Aureli, Vincenzo Spagnolo and Sem Scaramucci for your precious help with the refittings and the RMU analysis of SU 14. To Daniele Aureli, Vincenzo Spagnolo, Roxane Rocca and Filomena Ranaldo for helping me with the refitting of the RMUs of SU 13. To Isak Ekberg, Stefano Ricci and Vincenzo Spagnolo for their help taking photos of the material.

A very special and genuine thanks goes out to the staff of the Università degli Studi di Ferrara, in particular Julie Arnaud, Dario Sigari, Sharada Channarayapatna, Ram Charan, Brunella Muttillo, Peppino Lembo, Claudio Berto and Guido Montanari Canini. Their warm welcome, help and advice, especially at the beginning of my PhD research, was essential.

I am also very grateful to the staff of the Universitat Rovira i Virgili and the IPHES (Institut Català de Paleoecologia Humana i Evolució Social); and for their immense help, advice, feedback, cooperation and, above all, friendship, especially during the last period of this thesis I warmly thank

Elodie Brisset, Malebogo Mvimi, Laxmi Tumung, Karina Chichkoya, Antonella Pedergnana, Marianela Chamacho, Madhavi Kunneriath, Nour Frikha Guidara, Marta Modolo and Lorenzo Fattorel. I also would also like to express my gratitude to Maria Gema Chacòn Navarro, Oscar Moreno, Laura Tormo Tristany, Claudia Iannicelli, Pedro Piñero, and Nuria Ibáñez López. Especially for supplying me with publications and interesting insights and perspectives, I thank Manuel Vaquero, Diego Lombao and Leonardo Carmignani, and further special thanks goes to Ignasi Pastò who is advising and guiding me as to the path to choose in the future.

During these last three years I have also benefited from interesting discussions with other colleagues and fellow archeologists, thus I would like to thank Antoine Lourdeau, the people form the Poparu project, and Roxane Rocca and Marina Pagli for their valuable comments. A big thank you also to Amelie Da Costa, whose PhD thesis arrived at an unexpected moment and proved an inspiration, while also indicating a solution to some thorny issues.

For the multilingual abstracts, I thank Birgitte Hoiberg Nielsen, Amelie Da Costa, Nuria Ibáñez López and Karina Chichkoya .

Special thanks goes to Otis Crandell, as editor of the 'Journal of Lithic Studies'; he accepted two of my papers and helped me a lot rewieving and editing them.

My most sincere gratitude and admiration goes to Birgitte Hoiberg Nielsen, who assisted me not only with the English version of this manuscript, but also motivated me and gave me further opportunities for resolving various issues through discussion. I owe a lot to her.

However, it goes without saying that I alone am responsible for the opinions expressed, as well as for any errors and omissions, for which I apologize in advance.

Living nomadically, I have been extremely fortunate to have had the logistical support of my dear friends Gianna Tinacci, Jamie Mancini, Sofia Palermo, Martina Mele, Federica Marras, Micaela Marras, Miriam Crichigno, Marta Arzarello, Graça Pereira and Anna Golinelli, who at various times put me up (and put up with me!) as a house guest.

Finally, being in company is better than being alone, and I have luckily never felt alone, great distances notwithstanding, therefore I warmly thank each and everyone from my extended family, especially Franceschino, Nonno Luccio, Chicca, Giorgio and, last but not least, all my friends, especially Doriana, Lucia, Ginevra e le Casacchine. Their uplifting company and unflinching support has made this PhD period so much more enjoyable.

Lastly, I would like to express my very profound gratitude to my family: to Rita, Filippo and Raffaele. That I am at last here today, at the discussion of my PhD thesis, that this thesis has come to life at all is only because of their unfailing support. They supported me all the way, doing everything possible to make it happen. They provided the economic security and safety net that make me capable of continuing my studies throughout all these years, they encouraged me during difficulties, and they always spurred me on in my curiosity wherever it took me. For all of this and surely much more, I thank you from the bottom of my heart.

And in all this, nobody has assisted, supported and sustained me more than Marcos … Elen sìla lumenn' omentielvo, aa' menle nauva calen ar' ta hwesta e' ale'quenle.

Multilingual abstracts

Continuities and discontinuities during the late Middle Palaeolithic at the Oscurusciuto rock shelter (southern Italy). An integrated study of lithic manufacture in the strata SU 15, SU 14, SU 13 and SU 11

This research aims to interpret the variations in the Neanderthal production and functionality of stone tools through analyses of lithic assemblages referable to the late Middle Palaeolithic of southern Italy. A key site for this purpose is the Oscurusciuto rock shelter, which is essential to the understanding of Neanderthal behaviour, as it offers a long, reliable deposit, about 6 m in depth, made up of several levels ranging between 42,724 ± 716 cal BP and 55 ± 2 kyrs (40Ar/39Ar). The explicit purpose of this research is to perform an integrated study of the lithic manufacture present in the lower section of the series so far investigated the Oscurusciuto rock shelter: SU 15, SU 14, SU 13 and SU 11. We want to individuate, from a diachronic point of view, the continuities and discontinuities of these lithic complexes.

We intend to achieve this purpose through an integrated study of the lithic material, which in turn allows for a description of the economic behaviour involved in the exploitation of the sources of lithic raw material, followed by a detailed description of the phases in the reduction sequence, as well as a definition of concepts, methods, dynamics and objectives of the debitage. This fundamental technological analysis is applied to all four levels: SU 15, SU 14, SU 13, and SU 11 (48,382 items). Based on the characteristics of the collected material, further studies have been undertaken, such as Raw Material Units plus refitting studies for SU 13 and SU 14, in order to better understand the fragmentation of the operative chain. Moreover, a techno-functional protocol has been developed regarding a selected group of items from SU 13, in order to deepen our comprehension of productional vs. functional tools.

The results demonstrate that these stratigraphic units show specific peculiarities in terms of lithic production systems, structural elements, spatial management, and type of occupation. SU 15 is a living floor in the course of which a phase of abandonment occurred, following which it was sealed by the deposition of the SU 14 tephra. The surface of the former is characterized by stone alignments which compose two definite structures. SU 14 is a layer of volcanic ash, about 60 cm thick, including a brief occupation during the deposition of tephra. SU 13 is a short palimpsest, which represents the first stable re-colonization of the site after the environmental impact caused by the volcanic ash deposition. In this layer ten aligned hearths were found. The overlying SU 11 is a big palimpsest characterized by the superimposition of tens of hearths, thus indicating a longer and more persistent occupation of the rock shelter.

Further characteristics regarding the lithic behavior of the Oscurusciuto rock shelter: the most utilized raw materials were pebbles of cherty limestone, jasper and chert originating from secondary local sources. The main reduction sequence was the recurrent levallois, unipolar and convergent, aimed at producing elongated and convergent tools. We also encountered additional debitage, aimed at producing flakes, blades and bladelets. The fragmentation of the reduction sequence, in several instances into import and/or export, demonstrates a certain mobility of the population within the surrounding territory. Finally, the techno-functional analysis allowed us to determine the great diversity regarding the structure and the potential function of the tools in SU 13. Thanks to the application of this combined method we were able to understand and describe not only the production of the lithic objects in question, but also the human reality out of which they were created.

Key words: Lithic technology, RMU, Neanderthal, Middle Palaeolithic, Southern Europe.

Continuïtats i discontinuïtats durant el Paleolític Mitjà Tardà a l' Abric Oscurusciuto (sud d'Itàlia). Un estudi integrat de eines lítica en els estrats SU 15, SU 14, SU 13 i SU 11

Aquesta investigació té com a objectiu interpretar les variacions en la producció Neanderthal, així com la funcionalitat de les eines de pedra mitjançant l'anàlisi de conjunts lítics dins l'últim Paleolític Mitjà del sud d'Itàlia. L'abric Oscurusciuto és clau per a la comprensió del comportament dels Neanderthals, ja que ofereix un dipòsit llarg i fiable, d'uns 6 m de profunditat, format per diversos nivells que oscil·len entre 42,724 ± 716 cal BP i 55 ± 2 kyrs (40Ar/39Ar). L'objectiu principal d'aquesta investigació és realitzar un estudi del conjunt d'eines de lítica, present a la secció inferior de la sèrie investigada fins ara en aquest jaciment: SU 15, SU 14, SU 13 i SU 11. Volem individualitzar, des d'un punt de vista diacrònic, les continuïtats i discontinuïtats d'aquests complexos lítics.

Tenim la intenció d'aconseguir aquest objectiu a través d'un estudi integrat del material lític que permetrà una descripció del comportament econòmic relacionat amb l'explotació de les fonts de matèria primera lítica, seguit d'una descripció detallada de les fases de la seqüència de reducció, així com una definició de conceptes, mètodes, dinàmiques i objectius de la talla. Aquesta anàlisi tecnològica fonamental s'aplica als quatre nivells: SU 15, SU 14, SU 13 i SU 11 (48,382 ítems). Basant-nos en les característiques del material recollit, s'han dut a terme diversos estudis: d'unitats de matèria primera (RMU) i de remuntatges per SU 13 i SU 14, per tal de comprendre millor la fragmentació de la cadena operativa. A més, s'ha desenvolupat un protocol tecno-funcional sobre un grup seleccionat de peces de la SEU 13, per tal d'aprofundir la nostra comprensió sobre la potencialitat les eines.

Els resultats demostren que aquestes unitats estratigràfiques mostren peculiaritats específiques en termes de sistemes de producció lítica, elements estructurals, distribució espacial i tipus d'ocupació. SU 15 és un sòl d'ocupació que mostra una fase d'abandó, després de la qual cosa va ser segellat per la deposició de la tova SU 14. La superfície de SU 15 es caracteritza per dues estructures definides per alineacions de pedres. SU 14 és un nivell de cendra volcànica, d'aproximadament 60 cm de gruix, que inclou una breu ocupació durant la deposició de la tova. SU 13 és un palimpsest curt, que representa la primera recolonització estable de l'ocupació després de l'impacte ambiental causat per la deposició de la tova. En aquest nivell es van trobar deu llars alineats. El SU 11 és un gran palimpsest caracteritzat per la superposició de desenes de fogars, això indica una ocupació més prolongada i més persistent de l'abric.

Altres característiques referents al comportament lític de l'abric Oscurusciuto són: les matèries primeres més utilitzades van ser els còdols de pedra calcària silícia, jaspi i sílex originats en fonts locals secundàries. La principal seqüència de reducció va ser el levallois recurrent, unipolar i convergent, destinat a produir eines allargades i convergents. També trobem seqüències de reducció addicionals amb l'objectiu de produir esclats i làmines. La fragmentació d'aquestes seqüències, en diversos casos degut a la importació i / o exportació, demostra una certa mobilitat de la població en el territori circumdant. Per últim, l'anàlisi tècnica-funcional ens va permetre determinar la gran diversitat pel que fa a l'estructura i la funció potencial de les eines a la SU 13. Gràcies a l'aplicació d'aquest mètode combinat, vam poder comprendre i descriure no només la producció dels objectes lítics en qüestió, sinó també la realitat humana en la qual van ser creats.

Paraules clau: tecnologia lítica, RMU, Neanderthals, Paleolític Mitjà, sud d'Europa

Continuidades y discontinuidades durante el Paleolítico medio tardío en el abrigo Oscurusciuto (sur de Italia). Un estudio integrado de hierramientas lítica en los estratos SU 15, SU 14, SU 13 y SU 11

Esta investigación tiene como objetivo interpretar las variaciones en la producción y la funcionalidad de herramientas de piedra de los Neanderthales a través del análisis de los conjuntos líticos referibles a la última parte del Paleolítico Medio del sur de Italia. Un sitio clave para este propósito es el abrigo Oscurusciuto. Este es esencial para la comprensión del comportamiento de los Neanderthales porque ofrece un depósito largo y confiable, de unos 6 m de profundidad. El mismo se encuentra formado por varios niveles que oscilan entre 42,724 ± 716 cal BP y 55 ± 2 kyrs (40Ar/39Ar). El propósito explícito de esta investigación es realizar un estudio integrado de las herramientas líticas presentes en la sección inferior de la serie hasta ahora investigada del abrigo Oscurusciuto: SU 15, SU 14, SU 13 y SU 11. Se pretende individualizar, desde un punto de vista diacrónico, las continuidades y discontinuidades de estos tecnocomplejos líticos.

Para lograr este propósito se realizará un estudio integrado del material lítico, que permita una descripción del comportamiento económico relacionado con la explotación de las fuentes de materias primas líticas. A continuación se efectuará, una descripción detallada de las fases de la secuencia de reducción, así como también una definición de conceptos, métodos, dinámicas y objetivos del debitage. Este análisis tecnológico fundamental se aplica a los cuatro niveles: SU 15, SU 14, SU 13 y SU 11 (48,382 ítems). Considerando las características del material recogido, se han llevado a cabo estudios adicionales, como Unidades de Materia Prima (RMU) y remontajes para SU 13 y SU 14, con el fin de comprender mejor la fragmentación de la cadena operativa. Además, se ha desarrollado un protocolo tecno-funcional sobre un grupo seleccionado de piezas de SU 13, con el fin de profundizar nuestra comprensión de la potencialidad de las herramientas.

Los resultados demuestran que estas unidades estratigráficas muestran peculiaridades específicas en términos de sistemas de producción lítica, elementos estructurales, manejo espacial y tipo de ocupación. SU 15 es una superficie de ocupación que muestra una fase de abandono, después de lo cual fue sellado por la deposición de la tefra SU 14. La superficie de SU 15 se caracteriza por dos estructuras definidas por alineaciones de piedras. SU 14 es un nivel de ceniza volcánica de aproximadamente 60 cm de espesor, que incluye una breve ocupación durante la deposición de la tefra. SU 13 es un palimpsesto corto, que representa la primera recolonización estable del sitio después del impacto ambiental causado por la deposición de la tefra En esta camada se han encontrado diez hogares alineados. SU 11 es un gran palimpsesto caracterizado por la superposición de decenas de hogares, lo que indica una ocupación más prolongada y persistente del abrigo.

Algunas características adicionales con respecto al comportamiento lítico del abrigo Oscurusciuto son: las materias primas más utilizadas fueron los guijarros de piedra caliza silícea, jaspe y sílex originados en fuentes locales secundarias. La principal secuencia de reducción fue el levallois recurrente, unipolar y convergente, destinado a producir herramientas alargadas y convergentes. También se encontraron debitages adicionales, destinados a la producción de lascas y laminas. La fragmentación de la secuencia de reducción, en varios casos en la importación y / o exportación, demuestra una cierta movilidad de la población en el territorio circundante. Por último, el análisis técnico-funcional permitió determinar la gran diversidad en cuanto a la estructura y la función potencial de las herramientas en SU 13. Gracias a la aplicación de estas metodologias combinadas método combinado, se pudo comprender y describir no solo la producción de los objetos líticos en cuestión, sino también la realidad humana en la que fueron creados.

Palabras clave: tecnología lítica, RMU, Neanderthales, Paleolítico Medio, sur de Europa.

Continuité et discontinuité durant le Paléolithique moyen récent dans l'abri sous roche d'Oscurusciuto (Sud de l'Italie). Une étude intégrée des assemblages lithiques des couches SU 15, SU 14, SU 13 et SU 11.

Cette recherche vise à interpréter la variabilité au sein des modes de productions et des fonctions des outils en pierre de Néandertal, à travers l'analyse d'assemblages lithiques du Paléolithique moyen récent dans le sud de l'Italie. L'abri sous roche d'Oscurusciuto, essentiel pour la compréhension des comportements de Néandertal, constitue un site clé pour aborder ce sujet, puisqu'il offre une longue et fiable séquence de dépôts, sur environ 6m d'épaisseur, composés de différents niveaux datés entre 42.724± 716 cal BP et 55.000 ± 2000 cal BP (40Ar/39Ar). L'objectif de cette recherche est de réaliser une étude intégrée des productions lithiques présentes dans la partie inférieure de la séquence fouillée dans l'abri d'Oscurusciuto : SU 15, SU 14, SU 13 et SU 11. Nous cherchons à mettre en évidence, via une vision diachronique, les continuités et discontinuités au sein de ces complexes lithiques.

Nous prétendons atteindre cet objectif grâce à une étude intégrée du matériel lithique, permettant ainsi une description des comportements économiques impliqués dans l'exploitation des sources de matière première, suivi par une description détaillée des phases de débitage, ainsi que la définition des concepts, méthodes, dynamiques et objectifs du débitage. Cette analyse technologique fondamentale a été appliquée à l'ensemble des quatre niveaux : SU 15, SU 14, SU 13 et SU 11 (48,382 artefacts). Sur la base des caractéristiques du matériel collecté, d'autres études ont également été menées telles que l'identification de *RMU-Raw Materiel Units* (Unités de Matière premières) ainsi que des remontages pour SU 13 et SU 14, dans le but de mieux comprendre la fragmentation de la chaine opératoire. De plus, une approche techno-fonctionnelle a été développée sur une sélection de pièces issues du niveau SU 13, afin d'approfondir notre compréhension des objectifs productionnels et fonctionnels.

Les résultats démontrent que ces unités stratigraphiques présentent chacune des particularités en termes de systèmes de production lithique, d'éléments structurels, de gestion spatiale et de type d'occupation. SU 15 est un sol d'occupation au cours duquel une phase d'abandon s'est produite. Il a été scellé par le dépôt de la couche de tephra de SU 14. La surface de SU 15 est caractérisée par des alignements en pierre qui définissent deux structures. S14 est un niveau de cendres volcaniques, d'environ 60 cm d'épaisseur, qui inclut une brève occupation durant la déposition du téphra. SU 13 est un court palimpseste qui présente la première ré-occupation stable du site après les modifications environnementales causées par les dépôts de cendres volcaniques. Dans ce niveau, 10 foyers alignés ont été mis au jour. Le niveau S 11 sus-jacent est un important palimpseste caractérisé par une superposition de dizaines de foyers, indiquant ainsi une occupation plus longue et constante de l'abri.

D'autres caractéristiques concernant les comportements liés aux matières lithiques dans l'abri d'Oscurusciuto ont été notées : les matières premières les plus utilisées étaient des galets de calcaire siliceux, de jaspe et de chert, originaires de sources secondaires locales. Le principal mode de débitage était le Levallois récurrent unipolaire et convergent visant à produire des outils allongés et convergents. Nous avons également identifié un débitage de type additionnel utilisé pour produire des éclats, des lames et des lamelles. La fragmentation des phases de production, avec plusieurs cas d'imports et/ou d'exports, montre une certaine mobilité de la population dans le territoire environnant. Enfin, l'analyse techno-fonctionnelle nous a permis de mettre en évidence la grande diversité de structures et de potentiels fonctionnels des outils du niveau SU 13. Grâce à l'application de l'ensemble de ces méthodes, nous avons été à même de comprendre et décrire les productions lithiques en question et également d'entrevoir la réalité humaine qui les a conçues.

Mots-clés : Technologie lithique ; RMU ; Néandertal ; Paléolithique moyen ; Sud de l'Europe.

Continuità e discontinuità durante il Paleolitico Medio al riparo l’Oscurusciuto (Italia meridionale). Uno studio integrato dei manufatti litici degli strati SU 15, SU 14, SU 13 e SU 11

Questa ricerca si propone di identificare i cambiamenti nella produzione e la funzionalità degli strumenti di pietra dei Neanderthaliani attraverso l'analisi dei complessi litici riferibili alla fine del Paleolitico Medio del Sud Italia. Un sito chiave per questo scopo è il riparo l’Oscurusciuto. Questi è essenziale per capire il comportamento dei Neanderthal perché offre un deposito lungo e affidabile, di circa 6 m di spessore, formato da diversi livelli databili tra 42.724 ± 716 BP cal e 55 ± 2 ky (40Ar / 39Ar). L’ obiettivo principale di questa ricerca è di svolgere uno studio integrato degli strumenti litici presenti nella parte inferiore della serie finora scavata all’ Oscurusciuto: SU 15, SU 14, SU 13 e SU 11. La ricerca si propone di individuare, da un punto di vista diacronico, le continuità e le discontinuità di questi tecno-complessi litici.

Per raggiungere questo scopo, è stato condotto uno studio integrato del materiale litico, che ha consentito una descrizione del comportamento economico legato allo sfruttamento delle fonti di approvigionamento delle materie prime. Successivamente, è stata effettuata una descrizione dettagliata delle fasi della sequenza di riduzione, comprensiva di definizione di concetti, metodi, dinamiche e obiettivi di debitage. Questa fondamentale analisi tecnologica è stata applicata ai quattro livelli: SU 15, SU 14, SU 13 e SU 11 (48,382 pezzi). Sulla base delle caratteristiche del materiale sono stati effettuati ulteriori studi ossia: ricerca di unità di materia prima litica (RMU) e rimontaggi per SU 13 e SU 14, al fine di una migliore comprensione della frammentazione della catena operativa. Inoltre, è stato sviluppato un protocollo tecno-funzionale su un gruppo selezionato di pezzi del SU 13, al fine di approfondire la nostra comprensione di questi strumenti da un punto di vista strutturale e potenziale funzione.

I risultati hanno dimostrato che queste unità stratigrafiche mostrano peculiarità specifiche in termini di sistemi di produzione litica, elementi strutturali, gestione spaziale e tipo di occupazione. SU 15 è un piano di occupazione che documenta una fase di abbandono, sigillato mediante la deposizione del tefra - SU 14. SU 15 è una superficie di abitato caratterizzata da due strutture circolari definite da file di pietre. SU 14 è un livello di cenere vulcanica di circa 60 cm di spessore, che include una breve occupazione durante la deposizione del tefra. SU 13 è un breve palinsesto, che rappresenta la prima ricolonizzazione stabile del sito dopo l'impatto ambientale causato dalla deposizione del tefra. In questo livello sono stati trovati dieci focolari allineati. SU 11 è un grande palinsesto caratterizzato dalla sovrapposizione di dozzine di focolari, a indicare un'occupazione più lunga e più persistente del riparo.

Per quanto riguarda il comportamento litico al riparo l’Oscurusciuto possiamo così riassumerlo: le materie prime più utilizzate sono i ciottoli di calcare siliceo, diaspro e selce di origine secondaria locale. La principale sequenza di riduzione è il levallois ricorrente, unipolare e convergente, destinato a produrre strumenti allungati e convergenti. Sono stati inoltre trovate produzioni addizionali, destinate alla produzione di schegge, lame lamelle. La frammentazione della sequenza di riduzione, in diverse azioni di importazione e / o esportazione, dimostra una certa mobilità della popolazione nel territorio circostante. Infine, l'analisi tecno-funzionale ha rivelato la grande diversità nella struttura e potenziale degli strumenti in SU 13. Attraverso l'applicazione di queste metodologie integrate è stato possibile comprendere non solo la produzione e la funzione degli oggetti litici in questione, ma anche la realtà umana in cui sono stati creati.

Parole chiave: tecnologia litica, RMU, Neanderthal, Paleolitico medio, Europa meridionale.

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I INTRODUCTION

1 The last Neanderthals and the Oscurusciuto rock shelter

The period between 60,000 and 40,000 years BP is crucial in prehistory, as it encompasses the period of the demise of *Homo neanderthalensis* and of the diffusion of groups of *Homo sapiens* in Eurasia. During the last decades, scholars have sought explanations for the great success of our species: why were we able to oust all other competitors? What were the cognitive and\or adaptive abilities responsible for this success (Mellars, 1991; Renfrew, 1996; Mithen, 1998; Potts, 1998; Mcbrearty and Brooks, 2000; Lewis-Williams, 2002; Henshilwood and Marean, 2003; Shea, 2011; Tryon and Faith, 2013; Roebroeks and Soressi, 2016)? Anatomically Modern Humans (AMH) are commonly referred to as the originators of so called “modern behaviour”. Comprising a combination of traits involving cultural innovations such as complex stone and bone technology, figurative art and production of symbolic artefacts, as well as burials with trousseau. This also includes complex settlement systems with architectural constructions, sophisticated hunting strategies comprehending the hunting of small prey, probably by means of traps, the introduction of fish and seafood in their diet, and the use of projectile weapons like bows and arrows (D’Errico et al., 2003a; Henshilwood and Marean, 2003; Mellars, 2004; 2006; D’Errico, 2007; Conard, 2010; Shea and Sisk, 2010; Shea, 2017). These innovations are considered so essential to the evolution of our species that they constitute a boundary in the periodization of Prehistory, i.e. the recurrent emergence of these modern traits signals the beginning of the Upper Palaeolithic in Europe.

The last part of the Middle Palaeolithic proves of particular interest not only with regard to the dynamics of AMH occupation, but also with regard to behaviours evidenced in the resident human population. The last inhabitants of the European Middle Palaeolithic were the Neanderthals, a species similar to sapiens, yet so different.

However, since they were first discovered and identified (in 1856, Neander valley, King, 1864) the opinions concerning their capabilities as well as their relationship with *sapiens* diverge greatly. For a long time Neanderthals were considered as hominoid, practically an ape-man, however in the last decades we have witnessed a re-evaluation of the Neanderthals to the point of considering them the alter ego of *sapiens*. What is fascinating with Neanderthals is that they had a relatively long lifespan as a population; emerging and evolving over a period of almost 300,000 years, spanning through glaciations and climate changes. During this long period of time their behavioural package (make-up) remained almost unchanged. The explanation for the consistency of the Neanderthal techno-complex could be that their way of life was eminently successful, and thus they never felt any need to change their material culture, or, on the contrary, that they were unable to change their behaviour (Tattersall, 2002; Wynn and Coolidge, 2004, Burke, 2012).

As for the emergence of elements of modernity appearing before *sapiens*, again scholars disagree. Neanderthals seem to have made burials (e.g Ohta et al., 1995; Beheydt, 2004; Dibble et al., 2015; Stiner, 2017), possibly with symbolic rituals e.g. the Shanidar flower burial (Leroi-Gourhan, 1975; Sommer, 1999). They apparently had some sort of aesthetic sense as expressed through the use of pigments, shells and feathers as ornaments (e.g D’Errico et al., 2003a; Zilhao et al., 2010; Peresani et al., 2011; 2013; Finlayson et al., 2012; Morin and Laroulandie, 2012; Romandini et al., 2014; Majkic et al., 2017). They are also considered responsible for figurative artefacts and musical instruments (e.g Chase and Nowell, 1998; Otte, 2000; Marquet and Lorblanchet, 2003; Morley, 2006; Soressi and D'Errico, 2007; Zilhão, 2007; Tuniz et al., 2012; Rodríguez-Vidal et al., 2014; Diedrich, 2015;). Undoubtedly, their resources management shows great knowledge of the environment (e.g. Perlès, 1991; Arzarello and Peretto, 2005; Porraz, 2005; Park, 2007; Peresani, 2012). Nevertheless, compared to *sapiens* they have been considered not as smart, not as creative and generally more static. Currently we are being flooded by new data and research, which seek to explain the disappearance of the Neanderthals and the emergence and diffusion of AMH, focusing on the relationship between the two with regard to behaviour, chronology and genetics (among others Gregory et al., 2017; Hublin, 2017; Kolodny and Feldman, 2017; Mccoy et al., 2017; Nielsen et al., 2017; Smith, 2017; Weyrich et al., 2017a; Zanolli et al., 2017; Hofmann et al, 2018a; 2018b).

In order to understand this decisive period it is necessary to comprehend the identity or identities of the last Neanderthals. Understanding their behaviour is essential to the evaluation of their material culture, which includes all tangible products of the human behaviour (Shea, 2017). The most abundant cache available to archaeological assessment is lithic material. Indeed, due to their durability, flaked lithic artefacts are the most abundant traces of past behaviour; they represent not only functional tools, they also preserve upon them traces of the actions that have been carried out on them. Being universally dispersed in time and space, lithic tools are exceptionally suited to the study of the infinite variability of human behaviour.

Considering the traces and the processes involved in producing, using and ultimately discarding lithic tools, we are able to identify and compare several different realities, referable either to groups of Neanderthals at the same site, or to groups of Neanderthals in different environments, and even to two different species as is the case with Neanderthals and AMH. It was our explicit purpose to compare several realities, in order to understand why people resolved problems in different ways under similar circumstances, and vice versa why people resolved problems in similar ways under different circumstances. This research seeks to interpret the variations in the Neanderthal production and functionality of stone tools through analyses of lithic assemblages referable to the late Middle Palaeolithic of Italy.

To be able to use lithic tools in order to understand human behaviour it is necessary to pose some basic questions, following which the best approach is may be chosen. Over the last decade the methods to study lithics, especially regarding the Middle Palaeolithic, have experienced important methodological renewal thanks to the evolution and diffusion of technological approaches, experimental archaeology, and computer science. Moreover, the synthesis of several fields of science has lead to exploring the connection between lithic tools and the strategies of territory exploitation, intra-site spatial organization, and mobility patterns within territories. New approaches try to look further beyond the objects, imagining symbolic and cognitive meanings hidden inside lithic tools.

In this debate concerning the late Middle Palaeolithic, the Italian Peninsula seems to have played an important role. Thus, owing to its peculiar morphology and geographical position: a long and narrow strip of land, surrounded by the Mediterranean Sea, a peripheral appendix to the European continent, and only a few km from the coast of Africa and the Balkans, Italy may in effect have been a *cul de sac* in the settlement dynamics of humans and animals. Owing to its position, it may also have served as a refuge during the stadia glacial period. Furthermore, Italy consists of highly variable and fragmented landscapes characterized by great geomorphological variety, such as the Apennine mountain chain, which divides the peninsula in a north-south direction; hilly and plain landscapes; as well as extensive coastal areas along the entire peninsula, surrounded by the Ionian, Adriatic and Tyrrhenian seas. These geomorphological features supplied a wide range of available resources and provided for a mosaic-like populating of the Peninsula over time. The situation is even more challenging with regard to the region of Puglia (southern Italy), which is situated very close to the coast of Greece and Albania, enabling migration and early arrivals from cultures connected to the first groups of *Homo sapiens* (Uluzzian, about 45,000 – 44,000 BP) (Benazzi et al. 2011; Moroni et al., 2013, *in press*).

The region of Puglia, during the Mousterian age, had a particular context owing to its location in the far South-eastern corner of Italy. It stands at a crossroads between distinct areas in the south of Italy: the south (the Salento) and north of Puglia (the area of Murge and the Gargano promontory) and, finally, the area of the Gulf of Taranto and the region of Basilicata. A key site in the centre of Puglia is the Oscurusciuto rock shelter, which is essential to the understanding of the Neanderthals subsistence and settlement strategies, as it offers a long, reliable deposit, about 6 m in depth, made up of several levels of Middle Palaeolithic occupation. The series so far investigated (from SU 1 to SU 15) range between 42,724±716 cal BP (Beta 181165 AMS) (SU 1) and 55 ± 2 kyrs (40Ar/39Ar) (SU 14 – tephra identified as the Mount Epomeo Ischia green tuff (Allen et al., 2000).

This research comprises the integrated study of the lower section of the series so far investigated at the Oscurusciuto rock shelter: SU 15, SU 14, SU 13 and SU 11. These stratigraphic units are particularly important in the reconstruction of Neanderthal behaviour, given that each of them has yielded decisive material showing peculiarities in terms of structural elements, spatial management, type of occupation and lithic production systems. SU 15 is a living floor in which a phase of abandonment has been recorded, sealed by the deposition of the SU 14 tephra. This surface is characterized by stone alignments defining two structures. SU 14 is an almost sterile layer about 60 cm thick, consisting of volcanic ash. Traces of a brief frequentation can be seen only a few centimetres below the top of the layer. SU 13 is a short palimpsest, which represents the first stable re-colonization of the site after the environmental impact caused by the volcanic ash deposition. In this layer 10 aligned hearths were found, which divide the site into areas devoted to different activities. The overlying SU 11 is a palimpsest about 30 cm thick, characterized by the superimposition of tens of hearths.

2 Formulating research questions

The main questions we are proposing to answer are:

I. What are the continuities and discontinuities at the Oscurusciuto rock shelter?
II. Did the last Neanderthals possess a uniform or a fragmented technological identity?

The first question is specific as to the key site examined, whereas the second aims at placing the Oscurusciuto rock shelter in a wider context.

<u>What are the continuities and discontinuities at the Oscurusciuto rock shelter?</u>

At Oscurusciuto we are presented with a closed system, that is to say, a defined space: the area inside the rock shelter together with its very well preserved archaeological deposits. It consists of a well-defined environment: the ravine of Ginosa which is rich in knappable lithic raw material and the occurrence in loco of hunted preys. Furthermore it offers a relatively well-defined timeframe: the period between 42,000 and 55,000 years BP.

In addition it provides us with abundant previous studies: research at Oscurusciuto has been carried out since 1998, thus we have at our disposal several previous works about lithics, fauna remains, spatial management and hearths (Ranaldo, 2005; 2017; Boscato and Ronchitelli, 2006; 2017; Villa et al., 2009; Boscato et al., 2011; Ronchitelli et al., 2011; 2014; Boscato and Crezzini, 2012; Spagnolo, 2013; 2017; Marciani, 2013; Marciani et al., 2016; *in press*; Spagnolo et al., 2016; Ranaldo et al., 2017).

Consequently, at Oscurusciuto we have the opportunity of studying Neanderthal occupation over time in one unified location, within a well-defined time scale and encompassing four structurally different levels in terms of archaeological evidence and occupation. Within this circumscribed limits, we want to individuate, from a diachronic point of view, the continuities and discontinuities of these lithic complexes. To be precise: what role does the lithic manufacture play? Do lithic complexes show recurring elements in the four levels taken into consideration? Why are they constant? Do the lithic complexes show divergent features? What is the meaning of these divergences? What intentions and\or necessities caused the variability of these lithic complexes?

We intend to achieve this purpose through an integrated study of the lithic material comprising the description of the economic behaviour involved in the identification, acquisition and exploitation of the sources of lithic raw material, followed by a description of the phases of the reduction sequence, the definition of concepts, methods, dynamics and objectives of the debitage. This basic technological analysis was applied to all the four levels: SU 15, SU 14, SU 13, and SU 11 (a total number of 48,382 items have been studied).

Based on the characteristics of the collected material, further studies have been undertaken, such as Raw Material Unit analysis and refitting studies for SU 13 and SU 14, in order to better understand the fragmentation of the operative chain, the mobility pattern, and the use and functionality of the spaces. Moreover, a techno-functional protocol was developed on a selected group of items from SU 13 in order to deepen our comprehension of productional vs. functional tools.

It is to be noted that at Oscurusciuto we have the unique opportunity of studying the evolution of an occupation affected by a strong environmental event concretized in the volcanic eruption of Mount Epomeo (Ischia), the archaeological evidence of which is seen in the deposition of tephra. In the four selected levels, we can observe a settlement before, during and after the tephra event. That is to say, level 15 represent the abandonment before the event, level 14 is a short and brief occupation during the deposition of tephra, while level 13 is the first stable re-colonization of the site after the tephra deposition, and level 11 represents a longer and more persistent occupation of the rock shelter.

<u>Did the last Neanderthals possess a uniform or a fragmented technological identity?</u>

The results from Oscurusciuto were compared to the data of contemporary sites in the Italian peninsula in order to obtain a complete and updated picture of the lithic technical variability of the late Middle Palaeolithic in Italy, in particular at the end of MIS 3, namely between 60,000 and 40,000 years BP.

The comparative analysis was based on the available bibliography and aimed at highlighting similarities and divergences in the lithic techno-complex, incorporating adaptive responses to environmental aspects of technological choices affected by contextual necessities.

We wanted to identify recurrent patterns related to the way humans interacted with the natural resources available to them. Precisely we intend to detect the most utilized type of reduction sequence, the type of block on which these procedures were performed, the most frequent target objects sought by these reduction sequences, and ascertain if these end-products were obtained by similar or different reduction sequences, and if they were retouched or not (if yes what were the most frequent types of retouched tools). Finally, we wanted to ascertain the extent to which the peculiarities and differences of each region influenced these technological choices.

3 The structure of the study

This thesis is a synthesis between the traditional structure a thesis, and the new way of doing a thesis, i.e. join the papers produced during the PhD period. I follow the traditional structure in as much as the work consists of, introduction, theoretical basis, methods and material, site background, results, discussion and conclusion, while as part of the results I present the three papers which are in course of publication and regard the subject in question (two already published, one accepted).

By doing so I maintain the integrity of this work, which was conceived as a unique research, while, at the same time, I follow current conventions, presenting a part of my results in the form of papers, i.e. peer-reviewed results thus ensuring the scientific value of this work.

Therefore, following this introductory chapter (I), the study is organized as follows.

<u>Part one.</u>

In chapter II, a theoretical basis of the study of the technics and in particular about the study of stone tools conceive as a technical object is presented. Then I found necessary to develop a methodological excursus of the methods used for studying lithic tools including French and Anglophonic literature.

Chapters III present the site of Oscurusciuto, its location and environment, the complete stratigraphic sequence and research history. Going deeper in the previews studies (encompassing data, environment, fauna, hearth and lithic analysis) and finally the description of the four chosen levels.

Chapter IV presents a detailed presentation of the methodology, study attributes and procedures used in the analysis.

<u>Part two.</u>

Chapter V, VI, VII, VIII, and IX present the data analysis. The data set is analysed quantitatively and qualitatively and these first-hand results are presented. The first result chapter (V) present the material of all the levels, their state of preservation and raw material identification. Then, each result chapter is concentrated to one level: chapter VI deals with SU 15, chapter VII deals with SU 14, chapter VIII deals with SU 13, and chapter IX deals SU 11. These chapters follow the same internal structure (raw material analysis, production and peculiar studies, final overview) making the exception of chapter VIII. The former chapter is focused on the analysis of the level 13 whose technological study was the subject of my Master thesis, so for this chapter, I have chosen to present the results in the form of extrats from the 3 papers which are in course of publication.

Part three.

The following chapters focus on the discussion of these data. Chapter X focus on the continuities and discontinuities of lithic manufacture and occupation at the Oscurusciuto rock shelter. It addresses the first research question (see above).

Chapter XI relates to the second research question: a general review of the inter-regional context with the aim of defining the lithic behaviour of the last Neanderthals.

Finally, chapter XII sums up the work and provides a more general conclusion, and possible future directions of research are indicated.

At the end of the thesis I annexed the completed version of the 3 published papers plus their supplementary materials.

Part one

Basis of the work

II LITHIC STUDIES: THEORETICAL BASIS

1 Concerning the tools

1.1 Lithic tools as technical objects

A stone or lithic tool is an instrument crafted by man in order to solve a present or future need. The first evidence of lithic stone tool production harks back to at least 3.3 MA years BP in Africa (Roche et al., 1999; Semaw, 2000; McPherron et al., 2010; Harmand et al., 2015). As during this period several species were living in this area it is still unknown which one actually crafted these tools. Today there are studies proving that some kinds of non-human primates (*Pan paniscus, Pan troglodytes, australopitecinae*) could have or have actually did make flaked instruments, although it is still open to discussion the degree of abstraction necessary to envisage a particular need, and consequently invent an instrument that might solve it (Anderson et al., 1983; Boesch and Boesch, 1983; Morgan and Abwe, 2006; Mercader et al., 2007; Carvalho et al., 2008; 2009; Toth and Schick, 2009; Bril et al., 2012; 2015; Visalberghi et al., 2015).

The main difference between human and non-human primates in making tools is in fact that the non-human producer uses\makes a tool to respond to an immediate need, whereas humans might use\make a tool even without having a pressing problem to solve, i.e. they make tools foreseeing a future necessity (Emery and Clayton, 2004; Suddendorf and Corballis, 2007; Stout et al., 2008; Stout, 2011). Moreover, humans are unable to survive without tools, as they gradually become more and more dependent on these prosthesis (Mauss, 1936). While other animals can solve their needs just by means of their body or simple and immediate tools (e.g. birds using sticks, or apes using stones to crack nuts) (birds: Hunt, 1996; Weir et al., 2002; Emery and Clayton, 2004; Suddendorf and Corballis, 2007; apes: Anderson et al., 1983; Boesch and Boesch, 1983; Morgan and Abwe, 2006; Mercader et al., 2007; Carvalho et al., 2008), humans are the only animals that need to find or construct instruments, external objects (as applied to their own body) to modify their environment in order to survive.

During the prehistoric time, we must assume that a variety of materials were used to build tools, e.g. wood, bones, seashells, ivory, animal hides and natural fibres. However, due to their perishable nature archaeological traces of these materials are very few. On the other hand, what has remained until today, and in abundance, are utensils made of stone. Because of their un-perishable nature, lithic artefacts are the most ancient evidence of human craftsmanship; they are found all over the Earth and have accompanied humankind since their emergence. This is the reason why it is impossible to study the material culture of prehistoric peoples without getting involved in lithic studies.

Let us just start from the beginning: stone tools are instruments, but how can an instrument be of essential importance for the understanding of the differences among human cultures? Utensils are objects made by man, they could work of art, they could be sacred objects but their first aim was to solve a problem. Which means that they are primarily technical objects. This does not rule out aesthetic value or divine functions, however, but neither do these interfere with their principal aim (Simondon, 2017 [1982]).

"Technique" comes from the ancient Greek word τέχνη – *téchne*, which means art, ability, know how. In the Aristotelian perception of the World, *téchne* means the art of using the material as well as the art creating the object. Thus the action of modifying a raw block to create a tool, and with this tool to modify another material, and so on, is the essence of a technical object. Rohopol in his definition of "technique" included the utility, the artificiality and the functionality. A technical object must be useful: its purpose is to solve a present or future problem. It must be artificial in the sense that must be created, and lastly it must be functional: i.e. it forms part of a certain procedure, which has a concrete output (Rohopol, 1979). Based on his reflections we can define the study of material culture as the study of technique understood as the essential combination of artefact, man and action (Simondon, 1958; Leroi-Gourhan, 1964; Rohopol, 1979; Geneste, 1991).

There is a close relationship between the technical instrument, and its creator, man. Actually, each element (man and instrument) could be the subject and the object in this relation. So we have the man who can be the subject that actually made the instrument (man as subject = manufacturer). In addition, man is the object of the action when he uses the instrument created by himself or by somebody else (man as object = user). From this point of view, the artefact is the final product, the envisaged target objective in the process of manufacturing (instrument as the subject = production objective). Alternatively, it could also be the means by which man can modify the natural material (instrument as object = tool). The essence of a technical object is that it allows us to perform a modification on a material, it allows us to change its state (Simondon, 2017 [1968]). This definition could be applicable to lithic tools, because it is true that man, by means of the flaking activity, has in fact produced a usable instrument which can also be used to modify other materials (e.g. a flake can kill a prey). Even a simple pebble used as a hammerstone, in the hand of man could become a tool capable of striking another stone and creating flakes. In this case it is the selection and the gesture employed by man which turns a simple pebble into a tool (hammerstone) (Mauss, 1936; Leroi-Gourhan, 1964; Mello et al., 2007).

Physical and mechanical laws govern the action of flaking, thus a certain stone when hit breaks with a conchoidal fracture and produces a flake. It is possible to manage and manipulate the flaking activity so that it produces a pre-determined, pre-imagined object. The action of flaking is governed by the natural law of cause-effect based on evidence, consequently the knapping action is predictable. Thus it possible to determine the human action involved in creating the object. Moreover, with our methods we can recreate the action of the prehistoric knapper, and in that process understand their planning and their procedures when manufacturing their tools (e.g. if a flake has 3 scars on its dorsal face it was necessary to perform 3 strikes).

The fascinating thing about stone is that every action is permanent. With glass or metal you can melt it down again if made mistakes in the production, or when it is no longer useful, start all over again. With stone tools this is not possible. Any transformative action performed on a stone tool is permanent, or at least the mistakes or the reshaping of the tool will be forever evident. A connection between the people who made the artefacts and us is created, in fact, we are able to ascertain that a prehistoric artisan wanted to realize a predetermined tool, but that something in the flaking process went wrong which resulted in an accidental product. We are finally able to detect the accident, which is essentially any unforeseen event, anything that occurs unintentionally. We are even able to see if a tool was used for one thing, and later rearranged to be used for something else. Recycling is a behaviour that can be detected and which has strong behavioural significance (cultural importance, scarcity of raw material, etc.) (Kelly, 1988; Dibble and Rolland, 1992; Amick, 2007; Hiscock, 2009; Vaquero, 2011; Vaquero et al., 2012; 2015; Kuhn, 2014; Romagnoli, 2015; Romagnoli et al., 2016).

1.2 Lithic tools inside a network of relationships

A technical object or more to the point the idea of technicity, forms part of networks of relationships. Their inter-connections could be spatially or temporally significant. Spatially in the sense that a technical object acts in relation to other contemporaneous objects. Temporally in the sense that an object possesses in itself the memory of its first creation, in addition to the other forms that it has assumed over time. The concept of technicity encompasses all the form of existence, as well as all the different implications and functions of an object in relation to other objects (Boëda, 2013; Simondon, 1958).

Following this idea a lithic object, which is a technical object, should be perceived not just on its own as part of the network of links within which it was produced. The network in question is made up of the sum of inter-connections between objects, humans and the environment, that is to say: the raw materials, the locations of the outcrops of raw material, the implication of using one raw material rather than of another etc. The description of all these interactions includes the producers of the tools, the gestures that they performed, the know-how necessary to knap and obtain predetermined target objects, the gestures used in flake, the social position of the artisans in the society, the necessity that pushed them to realize the instruments. Moreover, the correlation with other products and other tools made from different materials are all part of the network of relationships we need to describe in order to fully comprehend the final object.

Understanding technical objects means not seeing them only as simple utilitarian objects, a means through which an aim is realized, but also considering the object as a depositary of a human reality a bearer and custodian of deeper knowledge regarding social dynamics, behavioural decisions, and cognitive meaning. This implies that, inside the object is viewed as a long series of crystallized actions, trials, errors and combined knowledge realized by an intentional and voluntary act (Fogaça and Boëda, 2006). The technical object is thus a concrete assemblage of schemes upon a material support (Simondon, 1958).

Studying a technical object, is actually the literal translation of the word technology (from ancient Greek τέχνη – *téchne* meaning art and λόγος - *lógos* meaning study) meaning insights gained into the relationship between man and objects, each one considered as a single entity, as part of a determinate society, as an objective part of a network of objects and relations, as an object containing certain functioning schemes, and finally as a vehicle for a synthesis of a previous network of objects.

A technical object is a crafted object derived from an open creative process. In other words, the object grows out of the idealization, gradual adaptation, formation, and combination of various parts, which, if broken, could be substituted. This pre-empts the idea of complex tools, for which pieces could be made to stock and if broken could be repaired or substituted (Simondon, 2017 [1961]). Tools with interchangeable and substitutable pieces constitute preliminary standardization of some products during Prehistory, if the tool is built as a composite instrument made out of several assembled pieces of different raw materials and just one of the components gets broken and subsequently replaced. The standardization of the components allows for the substitution of the broken element only. A further stage is the creation of tools with replaceable pieces, and adaptable tools which respond to a variety of applications.

The creation of separate components adaptable to various sets of tools implied the development of a network of people trading with each other. The various steps in the production of technical objects could happen in a single place or could be spatially and geographically distributed. Hence landscape is not considered anymore as just the natural background for human action, but, on the contrary it gains in significance and become an active element in the network of technical objects. Thus the natural environment plays a key part in human dynamics (Binford, 2001; Simondon, 2017 [1961]). In the case of lithic tools, the landscape becomes a "lithoscapes" (curtesy of Soressi) as there are various strategic places for the acquisition of key raw materials, outcrops of lithic material and certain kinds of wood. The places for producing the tools, the places for assembling them, and, finally the places where pieces or assembled products were traded, all become integrated part of the "anthropic" landscape.

1.3 Lithic tools as a palimpsest of unities and significance

A technical object is geometrically and mechanically intended as a ensemble of forms in function. In fact "*after its idealization, the real object is realized in a neutral raw material which is a slave of the morphology, guided by the intention of the creator*" (Simondon 2017 [1961] p. 321). In other words, a technical object is preceded by an idealized solution to a problem, which is then realized through mechanical procedures. Thus, it consists of the assemblage of disparate units which cooperate in the realization of an action. In practical terms, technical objects are made out of several discrete units which can be combined in different ways. In theory, each unity gains a certain position as a result of a series of choices. Each single unit, which constitutes a tool, incorporates a great amount of significance (Boëda, 2013).

The realization of an abstract project aiming at solving a concrete necessity embodied in the technical object, is an opportunity for man to act and modify reality. Moreover, the significance of a tool lies not only in its practical use, but also in the motivation, constraints and choices which led the craftsman to construct it in a certain way. The object holds a multitude of meanings, which includes aesthetic values, harmony in the gesture and in the procedure of producing it.

A lithic object is a palimpsest of information expressed in an infinite variety of forms, and the functions that it fulfilled over time. Lithic tools fulfil requirements assigned to them by humans in a determinate cultural and natural environment. In actual fact, the interaction between natural landscape (type, kind, and availability of raw material…) and human needs (nutritional needs, perception and management of the landscape, social and religious aspects…), synergically combined, determines the variability of lithic techno-complexes (Fogaça and Boëda, 2006).

To sum up, a lithic tool is a residual trace of human behaviour (Binford, 2001). It is a palimpsest of unities, relations and significances. Above all, a lithic tool is a technical object and technicity is not a marginal characteristic of humans. Technicity is fundamental to the understanding of the relationship between humans and the external World. That is the main reason which led us to study lithics tools.

2 Main approaches in understanding lithic tools

In order to comprehend the people behind the stone tool making process, it is necessary to focus on precise questions and decide the best method to resolve these issues. During the last two centuries, scholars have developed several ways of studying ancient populations by means of lithic tools, and those approaches were in turn influenced by their philosophical and historical backgrounds. In this section, we would like to give a brief excursus on these approaches, linking them to the methods applied in this thesis.

2.1 Typologies

For many years, researchers used the morphometric and technical features of the retouched pieces as the main classificatory criteria. Based on the these criteria, they developed classifications of these tools, convinced that an evolution of their shapes corresponded to a certain cultural development. Typological approaches were applied to several sites in order to encompass greater spatial and chronological range (among others: de Mortillet, 1873; Pigorini, 1903; Breuil, 1937; Peyrony, 1946; Bordes, 1961; Radmilli, 1963; Broglio and Kozlowski, 1986; Palma di Cesnola, 1993; 2001; Broglio, 1998; Parenti, 2001).

A particular mention must be given to the typologies developed by François Bordes and George Laplace (Bordes, 1961; Laplace, 1957; 1964a; 1964b). The typological classification of these two scholars arose from two different ontological models. On the one hand Bordes realized a typologic list (mainly applicable to the tools of the Lower and Middle Palaeolithic) which catalogued tool types, comprising the recurrent shapes of all the pieces that he had studied so far (Bordes, 1961).

On the other hand, in Laplace’s classificatory system, tool types were defined according to a combination of their specific attributes; such as morphological and typometric features, type, amplitude, progression and orientation of the retouch, plus its position in relation to the technological axis of the object (Laplace, 1957; 1964a; 1964b). These two scientists’ research created a homogeneous vocabulary which is still used for studying retouched pieces from the Palaeolithic.

Using these classifications scholars attempted to interpret the variations in shape from a behavioural viewpoint. Some scholars proposed a functional interpretation (Binford, 1973; 1989), others an evolutional explanation (Mellars, 1969; 1970; 1986; 1988), an environmental interpretation (Rolland, 1981; 1988; 1990), or a reduction value, in the sense that different types could actually be identical but at a different stage of use (Dibble, 1984; 1988; 1995). Furthermore, other scholars pointed out the importance of the natural surroundings in determining the range of variations in the shape of the tools (Dibble and Rolland, 1992; Rolland and Dibble, 1990).

During the last 10 years, we have noted a growing interest directed at the shape of tools, this time approaching them with cutting-edge technologies, thus greatly facilitating the gathering of objective data and their interpretation by means of statistical models. These methods comprise morphometric studies, such as three-dimensional scanning techniques (Grosman et al. 2008), and geometric morphometric methods (Franco et al., 2005, Cardillo, 2010; Iovita, 2011; Iovita and McPherron, 2011; Okumura and Araujo, 2014; Cardillo et al., 2015; 2016; Chacón et al., 2016). These new techniques have allowed quantitative descriptions of the variations in shape, as well as more objective and testable results.

The great advantage of these typological approaches is that they have established a common phraseology, and apart from rendering data more comparable and objective (especially as far as morphometric studies are concerned, see above), they have validated chrono-cultural classifications of object shape variations over time. However, a consistent drawback remains, i.e. that these studies provide a very limited view with regard to the inner range of variations of the entire complex (as could be ascertained after analysing only parts of the collection).

Or, more to the point, we still need to answer the question: why did the shape of objects change over time? What was the reason for those several different forms? How were these objects produced? In typological approaches the attention of the researcher is often limited to the tools, and we risk neglecting the toolmakers themselves.

2.2 Technological approaches

In order to study lithic manufacture in its comprehensiveness, and not just a selection of items, scholars developed several technological approaches, mainly based on the reconstruction of the reduction sequence, which is the sequence of technical operations leading to the production of a lithic artefact. In this way it is possible to study the dynamic production process of lithic tools, reconstructing their emergence starting with the simple raw block, then proceeding to the final object and eventually reaching the point when it is discarded.

In Europe the notion of the "*chaine opératoire*" was mainly developed by Leroi-Gourhan (Leroi-Gourhan, 1964) who was influenced by ideas deriving from the ethnological and anthropological sciences (Mauss, 1934; 1947; Lemonnier, 1986). The *chaine opératoire* consists in putting into spatio-temporal order the actions involved in conceptualizing and producing the object. The process could be divided into several phases: the selection and acquisition of the raw material, the initialization and structuration of the core, the management of the convexities, the production and maintenance of the convexities, the eventual transformation by retouch of the products; finally the utilization, and at the end the abandonment and possible reuse, reshaping, and recycling of the object. This descriptive, process-oriented approach also emerged in Nord America under the name of "reduction sequence" (Muto, 1971; Bradley, 1975; Collins, 1975).

Considering the high mobility of hunters and gatherers, we should keep in mind that the reduction sequence phases could either occur in a unified time-space entity (e.g. the space of the settlement), or in various places and over a period of time, e.g. decortication at the acquisition site, and followed by production and use at the settlement (Geneste, 1985; 1989; 1990; 1991a; Bourguignon, 1997; Bourguignon et al., 2006b; Soressi and Geneste, 2011; Turq et al., 2013, 2017; Marciani et al., 2016). The time dimension could thus vary or be extended, e.g. the whole sequence happening in one day, or the object was produced, but not used until a period of time had elapsed. Whereas it is possible to envisage a certain geographical fragmentation, understanding the temporal fragmentation is much more complicated.

Thanks to the subsectioning of these phases, it is possible to interpret the tools from a dynamic perspective, which enambles us to consider a multitude of variables linked to the handcrafting of the objects, e.g. environmental and cultural constraints. The merit of this approach lies in its extreme adaptability and flexibility, which is the reason why it was applied, and continues to be so, by generation of scholars in a variety of contexts (among others in Europe: Perlès, 1980; 1991; Pelegrin, 1986; Pelegrin et al., 1988; Geneste, 1989; 1991a; Boëda, 1990; Boëda et al., 1990; Forestier, 1993; Révillion and Tuffreau, 1994; Révillion, 1995; Bourguignon, 1997; Peresani, 1998a; 2003; Inizan et al., 1999; Gouédo, 1999; Soressi, 1999; 2002; 2005; Arzarello, 2003; Slimak, 2003; Thiebaut, 2005; Delagnes et al., 2007; Sorresi and Geneste; 2011; Aureli, 2012; Marciani, 2013. In North America \ Australia: Bradley, 1982; Nelson, 1991; Sellet, 1993; Bleed, 2001; Hiscock and Attenbrow, 2003; Holdaway et al., 2004; Hiscock, 2007. In South America: Bueno, 2001; Fogaça, 2001; Dias, 2003; Santos, 2012).

Subsequently, each scholar implemented this method focusing on a particular aspects, such as the role of the environment in the acquisition of the raw material, the geographical and temporal fragmentation of the reduction sequence, and the interpretation supplied by experimental archaeology and ethnoarchaeology.

The relation between the variations in lithic techno-complex and the supply and the circulation chain of lithic raw materials was examined in order to gain insight into the mobility patterns and land management of hunters and gatherers. It was possible to establish a relationship between the behavioural and economic choices of prehistoric populations, which were linked to the quality and the location of raw materials which in turn are strictly connected to the geological and geomorphological configuration of the region (Porraz, 2005; Porraz and Negrino, 2008). In some case it was possible to reach a great degree of specificity when distinguishing between "economic zones" and identifying patterns of toll-stone transportation over distances (Europe: Geneste, 1989; Peresani, 2001; 2006; 2009; Arzarello, 2003b; Porraz, 2005; Arzarello et al., 2006; Porraz and Peresani, 2006; Moncel et al., 2007; Spinapolice, 2008; Cancellieri, 2010; Boscato et al., 2011; Carmignani, 2011; Romagnoli, 2012; Scaramucci, 2012; Leger, 2012; Tomasso, 2014; Grimaldi and Santaniello, 2014; Santaniello, 2016; Nicoud et al., 2016. North America\ New Zealand \ Australia: Torrence, 1983; Bamforth, 1986; 1990; 1991; Bleed, 1986; Holdaway and Douglass, 2012).

In the USA particular attention was paid to both the degree of care used in the manufacture of stone tools, to the availability and quality of raw the material (Andrefsky, 1994; 2009), as well as to other factors - such as portability and usefulness - which led to the specific design of a particular lithic tool (Nelson, 1991; Kuhn, 1995; Schiffer and Skibo, 1997; Schiffer et al., 2001).

Subsequently, thanks to experimental archaeology, several scholars have focused on the practical techniques of debitage and the intrinsic range of variety in each production process (Turq 1989; Delagnes 1991; Bourguignon 1996; Shea et al. 2015; Eren et al. 2016), on the characteristic quality of the various kinds of raw material (Perlès, 1980), and on the specific utilization of particular tools, such as small tools (Aureli et al., 2016). A line of experimentation is also devoted to evaluating possible reasons for the variations in shape and quantity regarding products obtained from a single core (Eren et al., 2016).

With English-speaking scholars, a more anthropological approach prevailed. This meant giving priority to examining and interpreting those cultural and ethnic factors that influenced both production choices and the dynamics of subsistence, settlement and mobility in ancient societies. The investigations with this epistemological background produced ethnographic models which were based on the observation of actual communities (Gould et al., 1971; Binford, 1977; 1979; 1986; Sackett, 1982; Torrence, 1983; Binford and O'Connell, 1984; Flenniken, 1984; Shott, 1986; Hayden, 1987).

Among the technological approaches, the Logical Analytical System which is quite diffused on the Iberian Peninsula remains to be considered. Influenced by the analytical typology of Laplace (Laplace, 1964; 1974), and the systemic view of Clarke (Clarke, 1968), Eudald Carbonell developed a systematic and process-oriented reading of the lithic complex, conceived as a combination of characteristics (Carbonell et al., 1983; 1992, and subsequent specifications Rodríguez, 1997; Vergès, 2002; Ollé, 2003).

From this point of view, a lithic tool is the product of the interrelation of three components: the morphotechnical, the morphopotential, and the morphofunctional ones. The first (the morphotechnical component) refers to the production process, which defines the morphology of the final artefacts. The second (the morphopotential component) provides information about the potential actions inherent in a particular lithic morphology (Airvaux, 1987). And the third (the morphofunctional component) studies the use-wear of the lithic tools in order to establish their actual use (Rodriguez, 1997). Hence, if we focus on the production we find similarities between the reduction sequence and the morphotechnical component, and regarding the morphopotential components we find similarities with the techno-functional analysis (treated extensively in paragraph 2.4 of this chapter), and finally we find that the morphofunctional component and the use-wear analysis correspond completely (see paragraph 2.5 of this chapter).

In spite of some differences and discrepancies, all the afore-mentioned technological approaches study the lithic complex in its entirety, trying to understand how variations relate to specific proxies, and they give valuable insight into the human factor in the production. As far as this work is concerned I shall from now on refer to this descriptive process with the term "reduction sequence" assuming for all the practical purposes that the French *chaine opératoire* and the other afore-mentioned terms, in spite of their particularities, refer to the same process (Shott, 2003; Tostevin, 2011).

2.3 The techno-structural approach

As a further development of the technological approach, we shallconsider the techno-structural approach. Apart from the reconstruction of the reduction sequence, this approach aims to identify a cognitive logic in the production giving more emphasis to the productive potential, i.e. what is the final aim of the production? The particular features that the artisan wanted to create are the constraints that drive the whole reduction sequence. Moreover, the diachronic virtue of this method is to allowed re-creating the evolution of the volumetric structure ultimately linked to the object that they pursued (Boëda, 2013).

The techno-structural approach is the method of examining lithic industries developed by Eric Boëda in the course of his career. It became publicly accessible in 2013 in his work: "*Techno-logique & Technologie. Une Paléo-histoire des objets lithiques tranchants"*. Depending on the management of the block to be flaked, its volumetric and structural analysis, and the products aimed at, Boëda instituted an initial division between additional (I) and integrated (II) core types.

<u>I Additional core type</u>

The additional core type comprehends those items where not the whole volume of the block is utilized as a core, i.e. the block is made up of two independent parts: one is the active volume; the used portion i.e. the core in *sensu stricto*, whereas the other one is the passive volume, the block portion which is not necessary for the realization of objective. Thus, in an additional core it is possible to have two or more useful volumes (cores) in the same block, which means two or more series of blank extractions completely independent of each other (Figure 1).

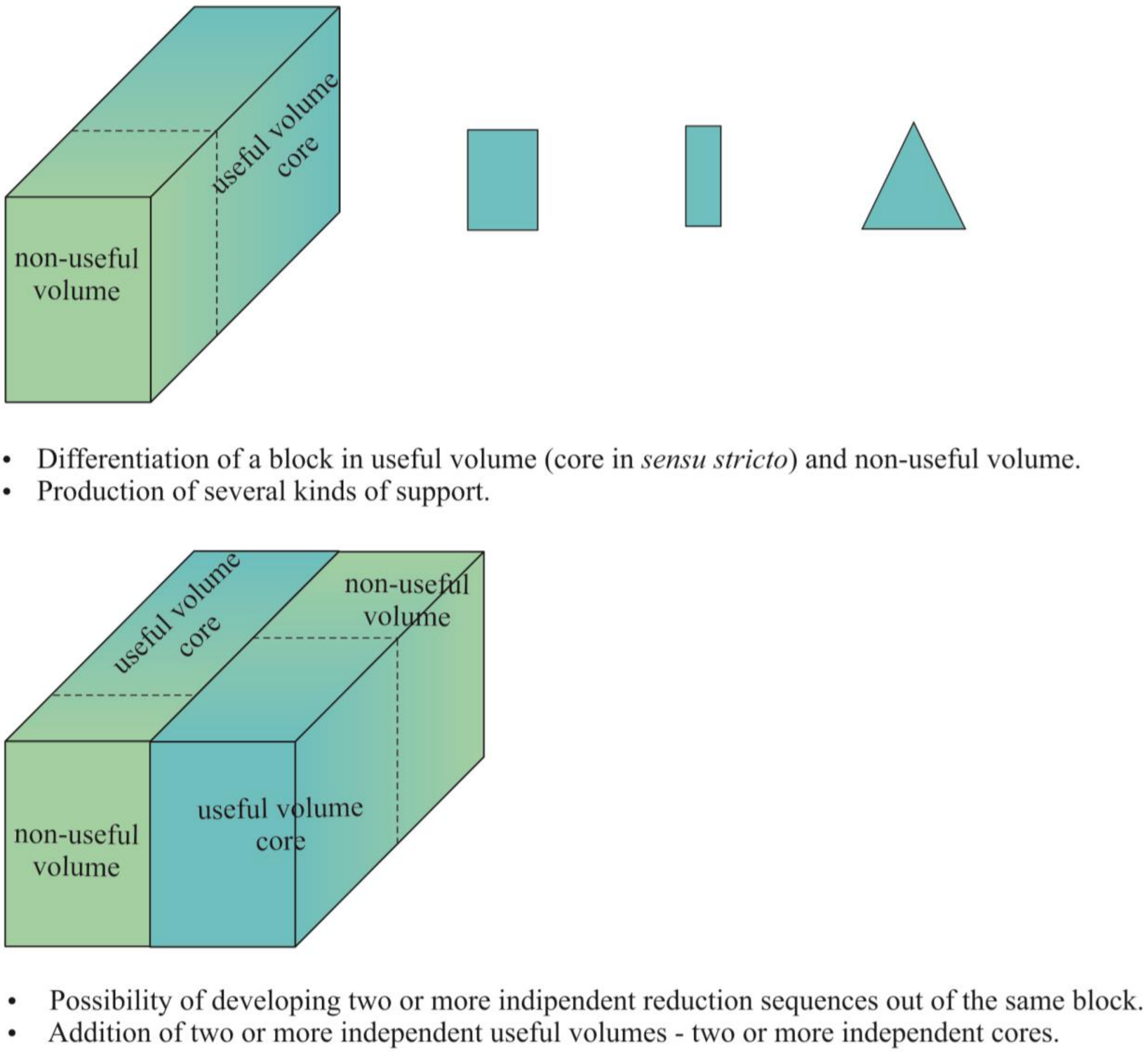
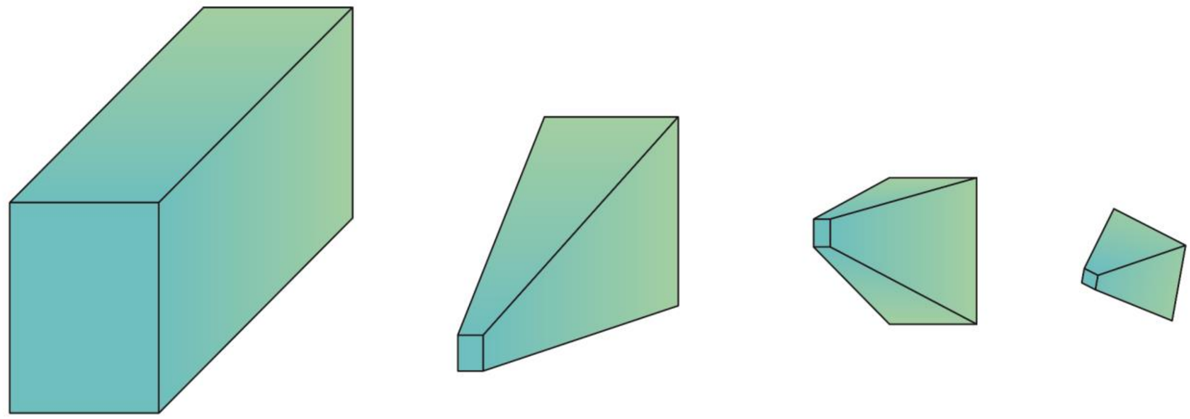


Figure 1: Features of additional cores.

The additional core are not homothetic (from Ancient Greek ὁμο- homo-, “same” + θέσις thésis, “setting, placement, arrangement”) i.e. their shape changes during the reduction process (Figure 2). The additional cores products are usually less standardized than the ones obtained by integrated types.



- Non-homothetic: during the reduction of the core its shape does not mantain the same shape.

Figure 2: Non-homothetic characteristics of additional cores.

According to the degree of predetermination regarding the target object and the amount of effort employed in managing the block, additional cores can be divided into four main types: A, B, C, D (Table 1).

Type A comprises the cores where there is neither any preparation of the striking platform, nor of the debitage surface, namely the debitage is realized from entirely natural surfaces. The aim is to produce just one flake with one single cutting edge and no other predetermined characteristics. Usually this type of specimen leaves weak traces in archaeological records (Boëda, 2013).

Type B comprises the cores where there is neither any preparation of the striking platform, nor of the debitage surface, however, a block is selected which allows for a series of removals, the aims being to produce one or more flakes (usually no more than three). The possibility of recurrence predetermines some features of the target product, such as cutting edge delineation, angles and morphology. Their occurrence in archaeological records is limited (Roche et al., 1999; Delagnes and Roche, 2005; Boëda, 2013).

Type C comprises cores characterized by the absence of initialization and configuration phases, consequently debitage surface is unprepared, but the striking platform could be roughly prepared. Moreover, the selection of the block plays an important role as this allows for a series of predetermined blanks (Boëda, 2013).

According to the aims of the debitage in question, it is possible to divide type C into C1, if it aims at producing flakes, and C2 if it aims at producing blades. Thus **type C1** is related to the debitage of orthogonal planes and opportunistic surface exploitation, *system par surface de débitage alterné* - SSDA (Forestier, 1993; Ashton et al., 1994; Peretto et al., 1998; Li, 2011), whereas **type C2** is commonly related to laminar production (Heinzelin and Haesaerts, 1983; Guilbaud and Carpentier, 1995; Boëda, 1997; Johnson and McBrearty, 2010, Da Costa 2017; Lourdeau et al.2017).

Type D comprises cores characterized by a phase of initialization and configuration of the block before extracting one or more blanks. Thus, both striking platform and debitage surface are prepared to predetermine the target object. The objectives produced by these reduction sequences are predetermined blanks. Note the possibility of creating a variety of end-products (Boëda 2013).

According to the aims of the debitage employed it is possible to divide type D into D1 (which produces flakes), and D2 (which produces blades) and D 3 (which produces convergent flakes).

Type D1: is related to a kombewa reduction sequence (Owen, 1938a; 1938b, 1939; Bordes, 1961a) and proto-levallois, Victoria west, para-levallois, unipolar, bipolar and centripetal surfaces debitage, among others (Tixier, 1956; Bordes, 1961a; Otte et al., 1990; Boëda et al., 1996a; 1996b; Boëda, 1997; de Lumley and Barsky, 2004; Vallin et al., 2006).

Type D2 is related to laminar and lamellar debitage (Karlin and Ploux, 1994; Revillon 1995, Nespoulet, 2000; Bon, 2002; Schmider, 2002; Boëda and Bonilauri, 2006; Bordes, 2006; Bordes and Shidrang, 2009; Boëda et al., 2015; Da Costa 2017; Lourdeau et al.2017).

Type D3 is of a centripetal, discoid type, debitage of axial plan, and aims at producing triangular flakes (Boëda, 1991; Inizan et al., 1995; Bourguignon and Turq, 2003; Locht et al., 2003).

As far as the Middle Palaeolithic is concerned, and in particular the collection from the Oscurusciuto rock shelter, only some additional core types are represented (B, C1, D1, C2, D2, D3).

Core	Type	Objective	Characteristics
Additional core	Type A	One flake	NO initialization NO convexities management
	Type B	One or more flakes	YES Selection of the raw block NO initialization NO convexities management
	Type C	C1 One or more flakes C2 One or more blade	YES Selection of the raw block YES initialization YES preparation of the striking platform NO preparation of the debitage surface
	Type D	D1 One or more flakes D2 One or more blade D3 One or more convergent items	YES Selection of the raw block YES initialization YES preparation of the striking platform YES preparation of the debitage surface

Table 1: Synthetic view of the main distinctive features of additional cores.

<u>II Integrated core types</u>

The integrated types comprise those items where the entire volume is utilized as a core, i.e. the whole volume of a core is involved in the realization of products. The core in its entirety is an integral part of a comprehensive productional synergy. Moreover, great effort is invested in the first phases of initialization and configuration of the core. From the very beginning of the reduction, the knapper is working towards realizing in stone a specific, predetermined product. Integrated cores are thus able to produce a recurrent series of products following a high degree of pre-planning (Boëda, 2013) (Figure 3).

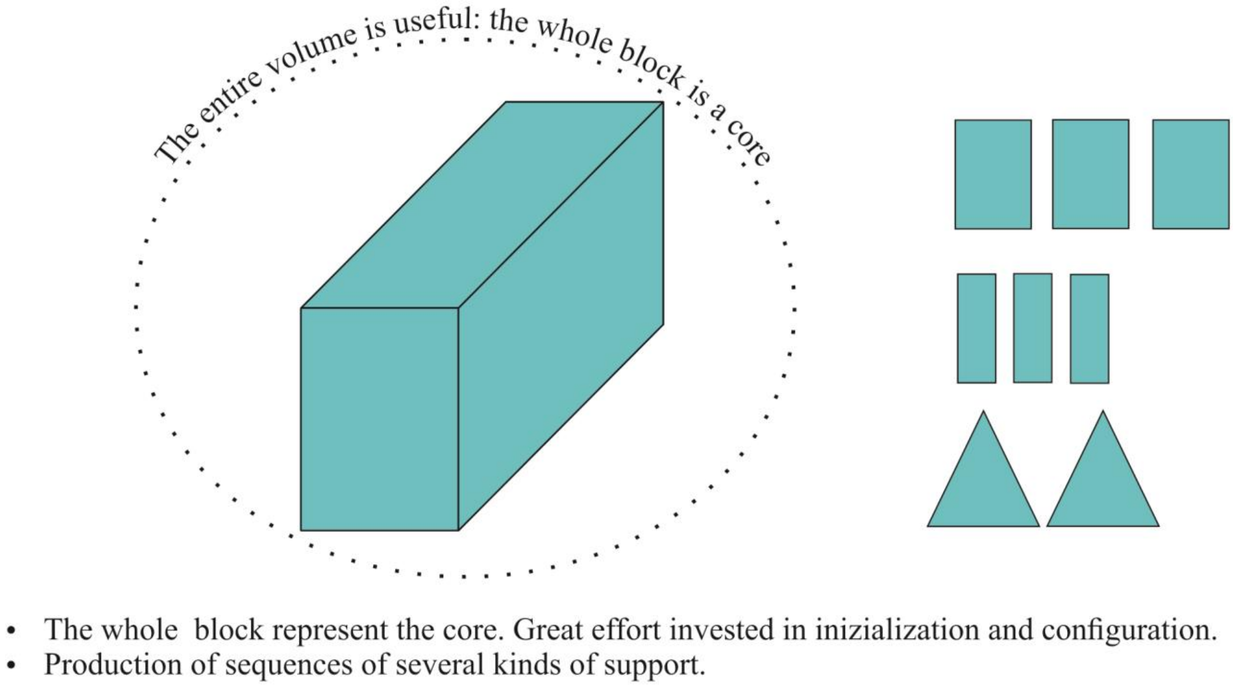


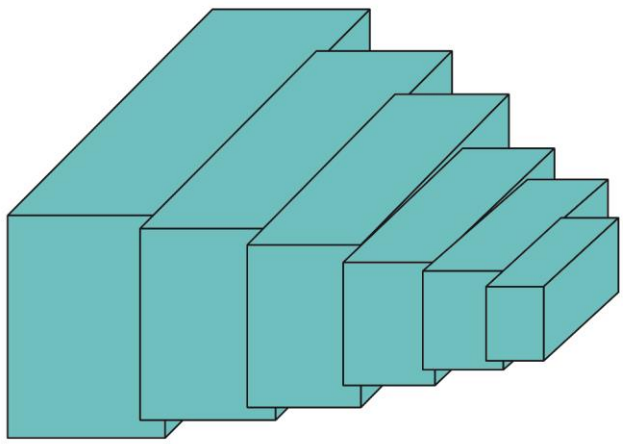
Figure 3: Features of integrated cores.

The integrated core structure could be either non- homothetic or homothetic.

The non-homothetic type comprises the cores where the whole volume is equally exploited with a comprehensive idea of reduction in mind but the shape of the core does not retain the same morphology throughout the reduction sequence. Its integral quality is borne out in the exploitation of the entire volume in a coherent manner, and by the sets of products maintaining the auto-correlation of the core. The shape of the core is susceptible to change (Boëda, 2013).

The homothetic structure falls into two different types: homothetic with continuous debitage, or homothetic with a re-configuration phase, which is my personal translation of *structure intégrée de caractère homothétique avec phase de réinitialisation.* I have deliberately translated *réinitialisation* with “re-configuration” and not with the word “re-initialization” because I understand the initialization phase as comprising only the first phases of cortex removals plus the construction of a preliminary striking platform. Whereas with configuration I mean the subsequent stages in the managing of the core (Frick and Herkert, 2014).

Homothetic with continuous debitage means that the initial shape of the core after initialization is virtually maintained until the exploitation of the reserve of raw material is completed, provided there are no knapping mistakes, with no necessity of re-configuring the convexities of the core. In this kind of core after the initial preparation each negative operates to predetermine the subsequent removal, maintaining the right convexity, thus enabling a continuous production which does not alter the shape of the core. Herein lies the auto-configuration propriety of these cores (Figure 4).



- Homothetic: during the reduction sequence the core mantains its shape.
- Homothetic with continuous debitage.

Figure 4: Homothetic with continuous debitage.

Homothetic with a re-configuration phase means that after the production of a series of target objects a re-configuration of the core is required, to re-create the right convexities in order to pursue a further generation of removal series, and so on (Figure 5).

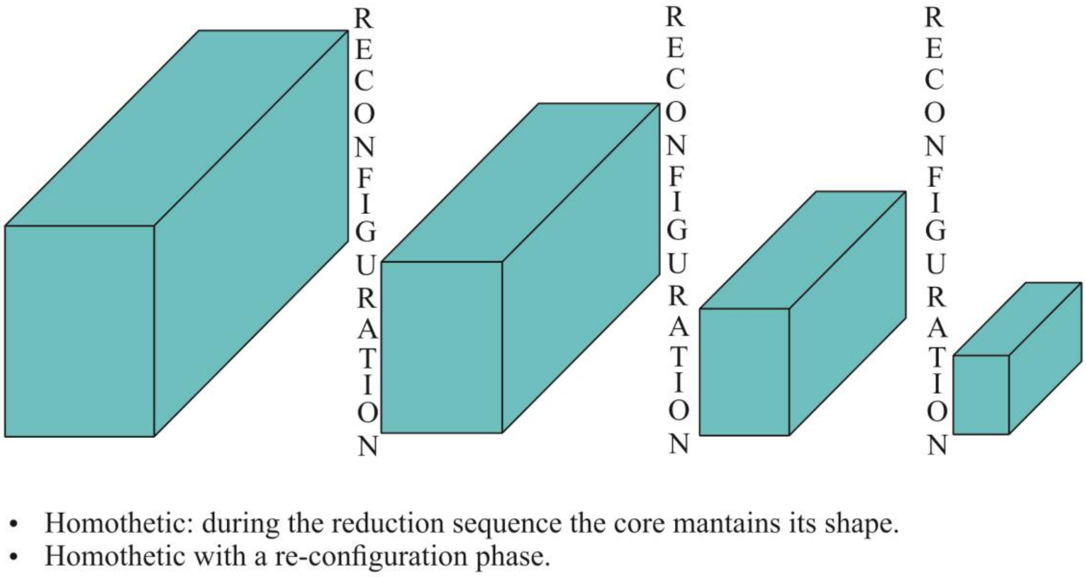


Figure 5: Homothetic with a re-configuration phase.

The integrated core type comprises two main types: E and F (Table 2).

Type E comprises a recurrent sequence of removals aimed at re-establishing the convexities of the core in order to produce a set of desired end - products. Type E is divided into E1 and E2, where **E1** is the discoid debitage aiming at producing a set of four characteristic flakes: debordant flakes and pseudo-levallois points produced by cordal strikes, and quadrangular flakes, plus flakes which are wider than long produced by means of centripetal strikes (Boëda, 1993; Locht and Swinnen, 1994; Peresani, 1998a; 1998b; 2003; Mourre, 2003; Slimak, 2003; Terradas, 2003; Slimak et al., 2004)

The **E2** is the pyramidal debitage, whose objective is blades and convergent blades (Spencer and Gillen, 1912; Garrod, 1956; Garrod and Kirkbride, 1961; Jelínek, 1975, 1981; 1982; 1990; Bordes, 1976; Marks and Volkman, 1983; Boëda, 1993; Meignen, 1994).

Type F consists in managing the entire block so that a specific technical feature is realized, which could be maintained by the removals until the end of the reduction process. Type F is divided into F1, F2 and F3. Thus **F1** is levallois (Boëda, 1986; 1988; 1990; 1993; 1994; Boëda et al., 1990; Nami, 1993; Morello, 2005); while **F2** comprises laminar and lamellar debitage typical of the Upper Palaeolithic (Dauvois, 1976); and finally there is **F3**, which is the reduction of rounded pebbles (Colani, 1927; 1929; Laj Pannocchia, 1950; Hou et al., 2000; Boëda and Hou, 2011; Boëda et al., 2011). At the Oscurusciuto rock shelter only example of levallois (F1) and discoidal (E1) production was recovered.

Type F1 comprises both the preferential and the recurrent levallois concept, as defined by the Boëda parameters (Boëda, 1990; 1995; 2013) (Figure 6)

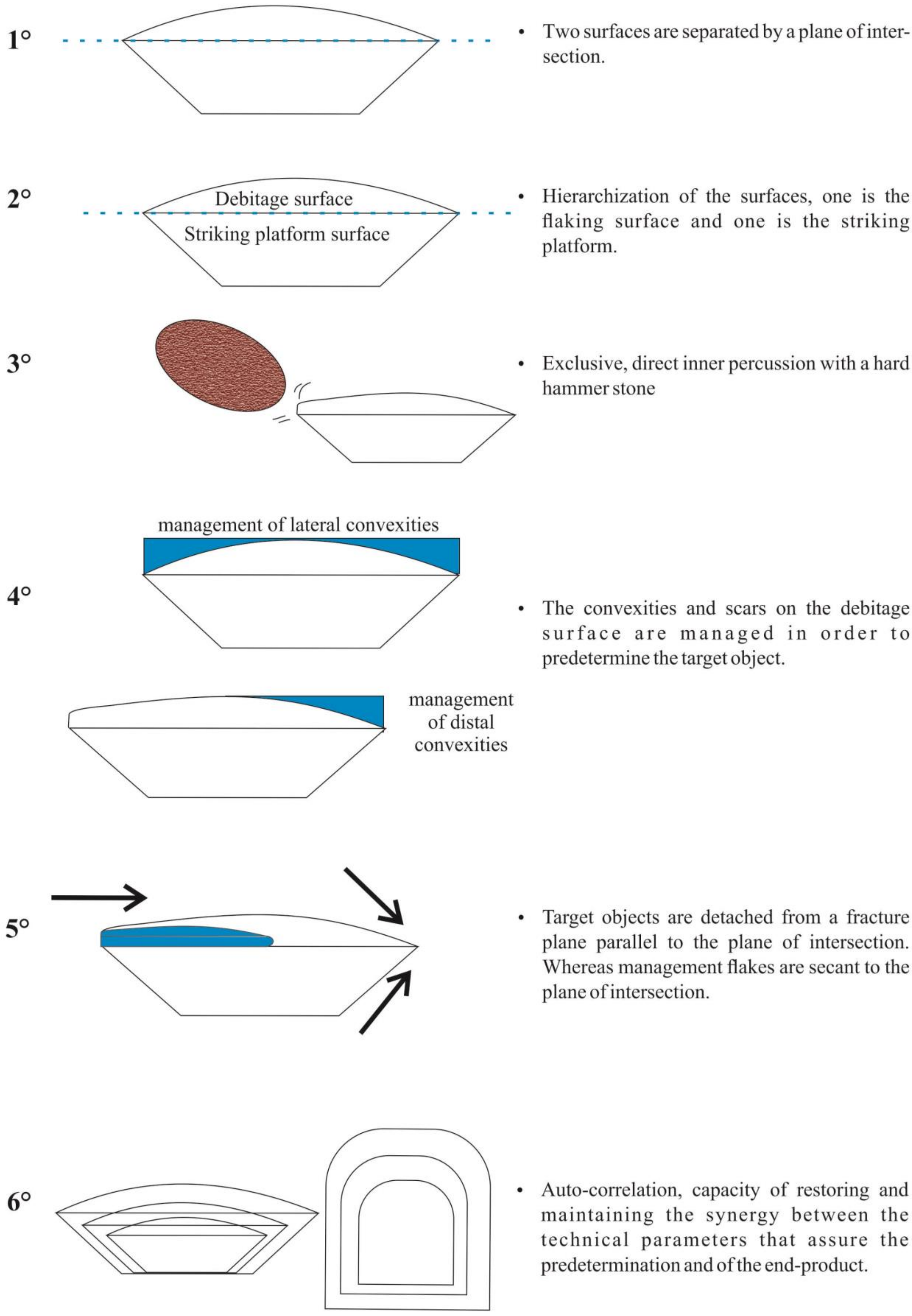


Figure 6: Typical criteria of levallois.

Core	Type	Sub-type
Integral core	Type E	E1 Discoidal debitage
		E2 Piramidal debitage
	Type F	F1 Levallois debitage
		F2 Laminar debitage
		F3 Splitting pebbles

Table 2: Synthetic view of integral core types.

This approach (Boëda, 2013) allows for a greater variety and subtlety, avoiding the classification of cores on the sole basis of shape without considering them as a result of completely different reduction sequences. Similarly, cores of different shapes could be the result of identical reduction schemes. Furthermore this approach allows us to consider technological parameters in combination with behavioural factors. Thus the differentiation of types is based on evidence produced by specific human actions, on the basis of which we can describe the degree of predetermination in obtaining the target object and the degree of pre-planning in the selection of blocks and in the management of the flaking activity. Specifically as regards additional core types, the great advantage of this approach and the ensuing classification is that when we decompose the core into "unities of exploitation" we recognize that discrete technological unities could coexist in the same block or, on the other hand could be found in different blocks.

2.4 The techno-functional approach

In the techno-functional approach, a tool is defined as an object consisting of three main parts: *partie transformative*, *partie transmettrice* and *partie préhensée* (1. transformative part, 2. transmitting part and 3. prehensile part). These parts are defined as techno-functional unities: the UTFt - transformative techno-functional unity corresponds to the active portion of the tools plus the contact edge, which enters into contact with and modifies the material; the UTFp - the prehensile techno-functional unity, is the handle which is in contact with the user with or without an intermediary body (hand-held instruments vs. hafted ones). Between those there is the transmitting techno-functional unity (UTFtr), which is conceived as the intermediate factor transmitting the force from the handle to the active edge (Boëda, 1991; 1997; 2001; 2013; Lepot, 1993) (Figure 7).

Thus these three techno-functional unities are as indispensable for the tool operation\implementation as is the synergy, their working-together (from Greek συνέργω - *sunergo*, from σύν *sun* - 'together' + ἔργω *ergo* 'work') which makes the tool capable of realizing an action. Identifying these parts and understanding their synergy enables us to understand the potential capacity of each single tool. Furthermore, in addition to prehensile, active and transmitting parts, we should not forget that the specific gesture involved is indispensable for the proper functioning of the tool, whereby we mean the kind of action as well as the actual movement involved in producing the tool, both of which justified it from a technical point of view (Leroi Gourhan, 1973).

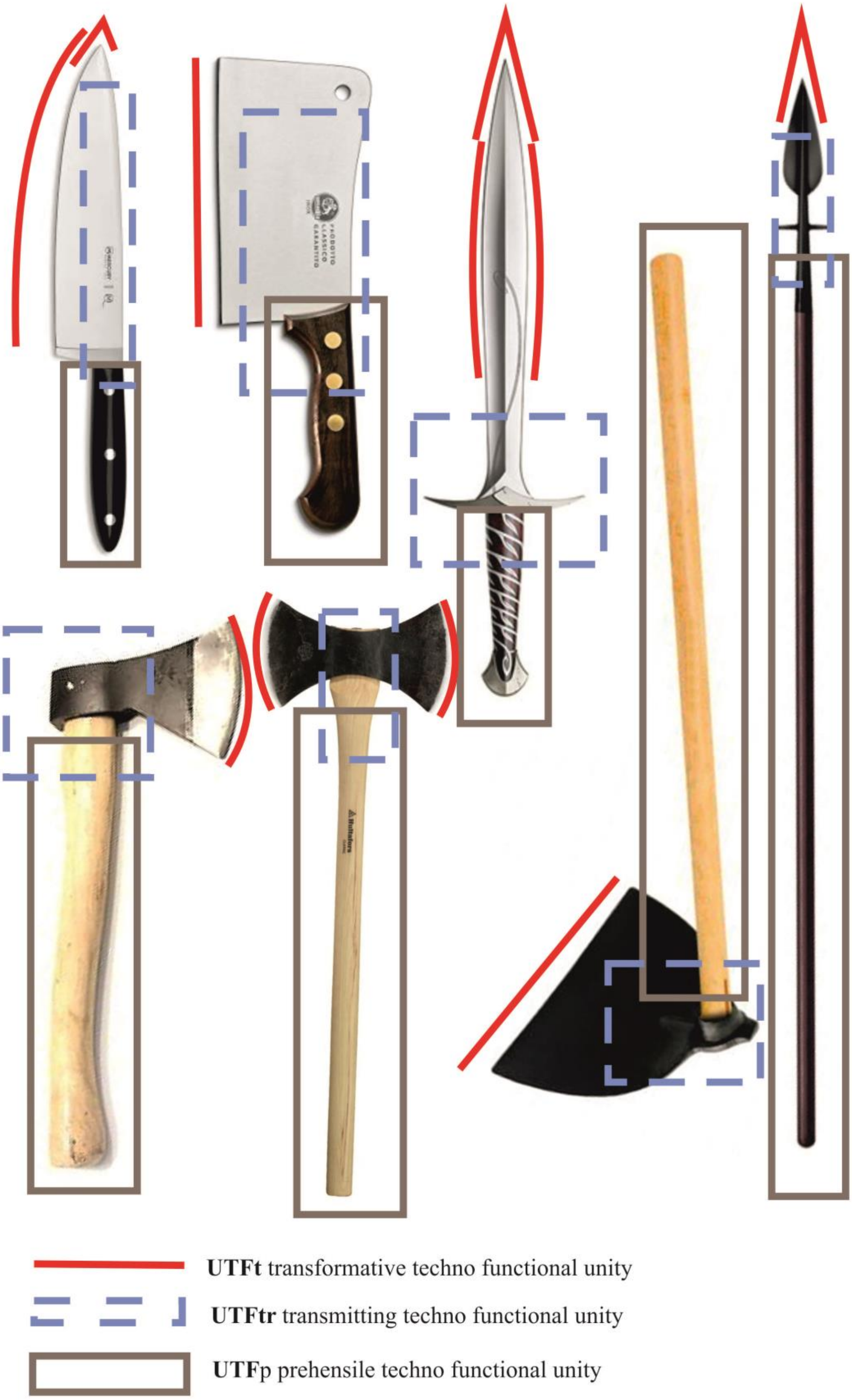


Figure 7: Tool components: transformative part, transmitting part and prehensile part.

This approach, upgraded during the years, has proved its extensive value and applicability in quite diverse contexts ranging from the Lower Palaeolithic to the Mesolithic as well as in several geographical contexts (Bourguignon, 1997; Soriano, 2000; Hoeltz, 2005; Mello, 2005; Pagli, 2005; Viana, 2005; Fogaça, 2006; Koehler, 2009; Li, 2009; Bonilauri, 2010; Lourdeau, 2010; Nicoud, 2011; Bodin, 2011; Chevrier, 2012; Rocca, 2013; Lucas, 2014; Aureli et al., 2015; 2016; Boëda et al., 2015; De Weyer, 2016; Pedergnana, 2017; Da Costa, 2017).

As previously mentioned possible parallels could be found with the morphopotential component analysis proposed by the Logical Analytical System (Airvaux 1987; Carbonell et al., 1983, 1992; Rodriguez 1997; Ollé, 2003; Vergès, 2003). The morphopotential component is defined as the theoretical capacity of intervention on specific morphotechnical structures, identified on the basis of the morphology of the objects, and of the measurement of angles of edges (Airvaux, 1987).

Owing to the numerous valuable references and the clearness of the criteria, in this work we have chosen as our basic orientation the French references (Bonilauri, 2010, Lourdeau, 2010; Boëda, 2013; Da Costa, 2017).

2.5 The use-wear analysis

Scholars have employed microscopic studies in order to ascertain the actual function that stone tools fulfilled in prehistoric times. The translation of Semenov's "Prehistoric technology" into English (Semenov, 1964) strongly influenced the development of "traceology", a new discipline based on microscopic observations of the use-wear traces found on the surface of stone tools.

Over time, in Europe and in the Americas, research employing various types of technical equipment flourished and lead to new questions being posed (Tringham et al., 1974; Keeley, 1974; 1980; Anderson-Gerfaud, 1981; Vaughan, 1981; Mansur-Franchomme, 1981; Pitts and Keeley, 1981; Moss, 1983; Plisson, 1985; Beyries, 1987; Iovita et al., 2014; Pedergnana, 2017).

Currently microwear analysis is based on two main levels of magnification, the low-power approach employing low magnification (Tringham et al., 1974; Odell and Odell-Vereecken, 1980; Odell, 1981, Lemorini, 2000; Plisson, 2007; Rots, 2010), and the high-power approach, where use-wear traces are observed under higher magnification (Keeley, 1980; Plisson, 1985; Van Gijn, 2010).

Moreover, the current trend is to performed controlled experiments in order to create a reference collection comprising variations in the types of traces, the development of traces over time, the traces left by different materials, and those left from different actions. A further advantage of the realization of experimental use-wear reference collections was that they ensured a higher degree of reliability in the interpretation of wear proposed by scholars (Rots, 2010; Fernández-Marchena and Ollé, 2016; Pedergnana, 2017).

2.6 Toward multidisciplinary approaches

A great variety of data and methods are currently employed, and the trend is toward combining and complementing different methods in order to progressively add further elements to prehistoric times. This multidisciplinary approach has been applied not only to lithic studies (e.g. the combination of technology plus techno-functional and use-wear analysis), it is also seen in the integration of other fields of science when incorporating faunal, lithic, GIS, and experimental elements into the interpretation.

Techno-functional + Use-wear analyses combined

In the development of lithic studies it is to be noted that the so called *techno-tracéo-fonctionnel* approach (Bonilauri, 2010, Pag. 74) proposes to integrate the techno-functional analysis (section 2.4) with the use-wear analysis (section 2.5).

The techno-functional analysis enables us to understand the technical intention of the craftsman through detailing the recurrent structure of the objects (based on the specific combination of different techno-functional units) and consequently to describe their functional potential. Subsequently, this hypothesis can then be verified or rejected by the use-wear analysis. In some cases, e.g. where traces on the objects are few or missing, integrating the use-wear analysis with the techno-functional analysis allows us to identify with greater certainty the potentially used edge and may act as a proxy for the selection of the sample. Thus it becomes possible to gain a comprehensive understanding of the lithic tools both from a structural and functional point of view.

The results obtained by a combination of these two approaches are very positive, as evidenced in the high matching score between the data from each analysis (Bonilauri, 2010; Aureli et al., 2015; 2016; Boëda et al., 2015; Marciani et al., *in press*).

Technology + Zooarcheology.

Integrated studies combining technological and zooarchaeological data have focused on understanding the subsistence economy of hunter-gatherer peoples in relation to the techniques and strategies mostly widely employed while hunting (Costamagno, 2001a; 2001b; Costamagno et al., 2006; Villa et al., 2009; Rendu, 2010; Kuntz and Costamagno, 2011; Boscato and Crezzini, 2012; Langlais et al., 2012; Rendu et al., 2012).

These studies determined the various ways of capturing and exploiting faunas, what type of hunting was practised, and which parts of the carcasses of prey animals were actually introduced into the sites (Costamagno, 2003; Delagnes and Rendu, 2011). Moreover, they shed light on the type of subsistence and on the settlement patterns of Neanderthals in relation to both hunting strategies and seasonal activities (Rendu, 2010; Niven et al. 2012). This multidisciplinary approach has rendered significant results regarding the technological diversity and the organizational strategies of Palaeolithic societies (Geneste, 1991b; Bourguignon et al., 2006b; Delagnes and Rendu, 2011; Langlais et al., 2012).

Technology + Spatial analysis (GIS)

A fundamental contribution to the understanding of archaeological contexts is provided by the spatial analysis. On a large scale and in a territorial context, it is possible to define models for the reconstruction of an ancient landscape, based on topographical, geological, geomorphological, paleoecological, paleoenvironmental and paleoclimatic sources. In other terms, the regional studies allows for the identification of the hunter-gatherers' play-ranges, the economic strategies in relation to the lithic sources acquisition and, generally the mobility strategies of these groups (Castel, 2003; Richter, 2006; Bernard-Guelle et al., 2008; Boscato and Wierer, 2009; Bataille, 2010; Daujeard and Moncel, 2010; Fernández-Laso et al., 2011; García Antón et al., 2011; Neruda, 2012; Ekshtain et al., 2014; Magnin, 2015; Rios-Garaizar and Moreno, 2015; Tarriño et al., 2015; Gurova et al., 2016; White et al., 2016; Wierer et al., 2016; Fano et al., 2016; Finkel et al., 2016; Roy Sunyer et al., 2017; Spagnolo, 2017; Turq et al., 2017).

At an intra-site scale, it is furthermore possible to identify what type of space management was employed by prehistoric populations over a given period of time (notably in the case living floors or short-lived palimpsests) (Vaquero et al., 2001; Vallverdu et al., 2005; Vaquero, 2008; Malinsky-Buller et al., 2011; Rivals et al., 2012; Rosell et al., 2012; 2017; Spagnolo, 2012; 2017; Vallverdú et al., 2012; Vaquero et al., 2012a; 2012b; de la Torre et al., 2012; Henry, 2012; Machado et al., 2013; 2015; Bisson et al., 2014; Ortiz Nieto-Márquez et al., 2014; Vicente et al., 2014; Chacón et al., 2015; Bargalló et al., 2016; Martínez-Moreno et al., 2016; Polo-Díaz et al., 2016; Sañudo et al., 2016; Spagnolo et al., 2016; Gopher et al., 2016; Machado and Pérez, 2016; Modolo and Rosell, 2017; Neruda, 2017; Ortiz Nieto-Márquez and Baena Preysler, 2017; López-Ortega et al., 2017)

2.7 Raw Material Units

The idea of sorting lithic material in order to find items of the same raw material, originating from the exact same raw block is an approach known in bibliography under several acronyms.

UMPL (Unità di Materia Prima Litica) used in Italy (Arzarello et al., 2011).

RMU (Raw Material Unit), used in European literature (Roebroeks, 1988; Vaquero et al., 2001; Uthmeier, 2006; Schurmans, 2007; Vaquero, 2008; Vallverdú et al., 2010; López-Ortega et al., 2011; Carbonell, 2012; Romagnoli, 2012; Spagnolo, 2012; Vaquero et al., 2012a; 2012b; Turq et al., 2013; Machado et al., 2013; 2016; Marciani, 2013; Moncel et al., 2014; Chacón et al., 2015; Spagnolo et al., 2016; Marciani et al., 2016; Vaquero and Romagnoli, 2017).

MANA or MAN (Minimum Analytical Nodule Analysis) in American literature (Larson and Ingbar, 1992; Larson, 1994; Larson and Komfeld, 1997; Bruce, 2001; Larson and Finley, 2004; Hall, 2004; Hall and Larson, 2004; Byrnes, 2009; Cooper and Meltzer, 2009; Douglass, 2010; 2011; Hurst et al., 2010; 2016; Yoshikawa, 2011; Knell, 2012; White, 2012; Miller, 2016; Scerri et al., 2016; Hurst and Johnson, 2017).

An RMU can be defined as the material outcome of a knapping event, or as a series of knapping events carried out on a specific nodule (Roebroeks, 1988; Vaquero, 2008 Moncel et al., 2014). It permits dividing up the lithic complex into its smallest units, thus encompassing each of the single raw nodules introduced into the site. An RMU can provide information analogous to the “Minimum Number of Individuals” in a faunal assemblage. Thus, an RMU provide informayions about the number of raw blocks brought into the site.

These data form the basis for two separate interpretations: from a spatial\temporal point of view, and from a technological perspective. Considering the RMU in the spatio\temporal dimension means dividing up the occupation into its smallest temporal units, enabling us to discuss the temporal dynamics involved in the formation of lithic assemblages and thus contributing to highlighting the role of time in the variability of the collections (Vaquero, 2008; Vaquero et al., 2012). The technological value of the RMU lay in the efficiency of this method in identifying the fragmentation of reduction sequences.

The advantages and potentialities of the RMU increase with the combined application of spatial analysis, systematic search for refittings and conjoints, and the cortex evaluation method. The latter indicates the number of nodules introduced into the site, taking into account the quantity of cortex on the surfaces of flakes and cores (Dibble et al. 2005; Douglass et al 2008; Holdaway et al. 2010; Lin et al. 2015 and further implementation Ditchfield, 2016a; 2016b).

3 My point of view

The current rapid development of science increases specialization within each branch of knowledge. Although this tendency is in its essence positive because it represents an advancement of science, it is also a drawback because it produces extremely specialized disciplines and consequently very specialized researchers, the risk being that we lose the general perspective. In order to avoid this we must implement a combination of methods and employ multidisciplinary teams of scholars.

With regard to this thesis I thus employ (among other methods) a reconstruction of the reduction sequence using the technological approach plus the techno structural method, which is especially suited to describe the volumetric structure of the core. The reduction sequence and the economic management of raw material are then combined with the RMU analysis and the refitting approach. For the retouched objects I used Laplace's nomenclature but not his typologic approach in its entirety because in this way we get a better overall view of the types of objects, and this is very helpful when comparing the evidence from Oscurusciuto with the Italian bibliography. Moreover, I employed a techno-functional approach to a selected group of target objects.

Although these approaches refer to different methods, the ultimate purpose is an in-depth understanding of stone tools, and through that of the human behaviour that produced them.

In conclusion, I would like to point out that we did not pose the question what the stone could say about its producer, the point is rather what we want to know about the stone tools, what we are actually searching for, thus what the questions are we want to pose to the stone tools. On the basis of those questions, we then decide upon an approach, or better a mixture of approaches, whose integrated results might be able to resolve our queries. Depending on the context we then proceed to find the best way to make the stone tools tell their stories. Therefore, the real objective for us as archaeologists is to finds the best combination of methods which will make stones do the talking, telling their own stories, as it were (Figure 8). Stories of production, uses, behaviours and habits of the people that made them.

Figure 8: A speaking stone (!).

(source:https://42.files.wordpress.com/2015/12/bzslmupiqaevza3.jpg?w=529).

III THE OSCURUSCIUTO ROCK SHELTER

The Oscurusciuto site is a Middle Palaeolithic rock shelter with little coverage capacity due to collapse of the overhang of the shelter (Figure 9). So far the current extension of the whole archaeological deposit is $60m^2$, with a thickness of more than 6 meters. Its stratigraphic sequence is made up of 27 main sub-horizontal layers, whose extension downwards increases gradually, because in the shelter the hill erosion had damaged the deposit, especially the upper layers.

Figure 9: Panoramic view of the Ginosa ravine and the Oscurusciuto rock shelter (red arrow).

Photo: A. Ronchitelli.

1 Location

The site is located in the region of Puglia, Southern Italy, namely in the ravine of Ginosa near the homonymous municipality (Ginosa) within the Taranto province. The site is located into the Pleistocene calcarenite geological formation (Calcareniti di Gravina), and is situated at about 15 meters from the current bottom of the ravine, and at an elevation of 235 m above sea level (Figure 10). The Ionic coastline is noe found about 20 km from the site (Figure 10).
The location of Oscurusciuto is of primary importance, as this rock shelter is located in the central part of Puglia, constituting a crossroads between different areas of southern Italy: Salento (south), Murge and Gargano (north), plus the area of the Gulf of Taranto and Basilicata. This region also seemed to be crucial in the first diffusion of the Anatomically Modern Human in Europe (Moroni et al., 2013; *in press*).

2 Etymology of the name

The name of the site is a toponymy arising from the name of the ravine: *Valle dell'Arciprete l'Oscurusciuto*. Incidentally, in Italian the sound of "Oscurusciuto" recalls a local dialectal adjective *scurè*, which means "dark" or "shadows"; and the verb *scurèssce*, which means "becoming night or dark" (Gigli, 1982, p. 135) As local people note, in the Oscurusciuto area there is a dense vegetation of tall trees casting shadows on the ravine. This could be a plausible ethymological interpretation of the name of the site.

Figure 10: localization of the Oscurusciuto rock shelter (red circle).

(Modified from Google Maps).

3 Geomorphological and geological settings

The area where the Oscurusciuto rock shelter is located corresponds to the border area between the Murge and the Fossa Bradanica (Figure 11). This implies that the geomorphological structure of the territory was affected, on the one hand by the effects of the tectonic process linked to the Apennine orogeny, and on the other hand by the phenomena of erosion and accumulation typical of the Pleistocene marine regression and, consequently, the variations in water level and range of the Lucan paleo-rivers (Boenzi et al., 1971; 1976).

In the area of Ginosa the most ancient formation is the Calcare di Altamura (Upper Cretaceous) on which stands the marine series of the Fossa Bradanica (Pleistocene), which comprise the Calcareniti di Gravina and the Argille subappennine. Upon the Argille are found in normal stratigraphic succession the features of a regressive Pleistocene series encompassing Sabbie di Monte Marano, Calcareniti di Monte Castiglione, and the Conglomerato d'Irsina, which concludes the sedimentary series. On these Pleistocene strata stand flaps of coastal deposits arranged in terraces which becomes progressively more recent in the direction towards the sea. These deposits point to stages of intermittent withdrawal of the coastline during a relatively recent period of marine regression. Carved into these Pleistocene marine sediments we find the river beds of the Bradano, Basento, Cavone and Lama rivers. On their river banks and those of tributaries are found flaps of alluvial deposits in the form of terraces (Pleistocene). Moreover, similar recent and actual deposits are found downriver, until the coastal plain where we encounter dunes and expanses of sand (Holocene) (Boenzi et al., 1971; 1976). A schematic overview of these lithological formations is presented in the following table (Table 3) (Boenzi et al., 1971; 1976).

Figure 11: Geological composition of the area of Ginosa.

(The actual position of Oscurusciuto rock shelter is indicated by the red circle)(Modified from Carta geologica d'Italia alla scala 1:100,000 Foglio 201 Matera).

Formation	Origin	Description	Chronology	Major outcrops
Calcare di Altamura\ Altamura limestone	Marine	Stratified granular white limestone with Rudiste	Upper Cretaceus (Senonian-Maastrichtian)	Murge of Matera, Laterza and Castellaneta
Calcareniti di Gravina \ Ravine Calcarenite	Marine	Roughly cemented yellowish white fossiliferous calcarenites	Pleistocene (Calabrian)	Murge of Matera, Laterza, Ginosa and Castellaneta
Argille Subappennine \ Subappennine clay	Marine	Silty marnic gray light blue clays	Pleistocene (Calabrian)	Monescaglioso
Sabbie di Monte Marano \ Monte Marano sand	Marine	Calciferous, yellow, quarz sand on cemented places	Pleistocene (Calabrian)	Upper portions of Fossa Bradanica hills
Calcareniti di Monte Castiglione \ Monte Castiglione calcarenite	Marine	Compact, coarse, yellow-pinkish calcarenites	Pleistocene (Calabrian)	Murge of Matera, Laterza
Conglomerato d'Irsina \ Irsina conglomerate	Marine	Reddish polygenic conglomerate	Pleistocene (Calabrian)	Murge of Matera, Laterza
Terraced marine deposits	Marine	Terraced marine deposits at various heights	Pleistocene (Sicilian-Thyrrenian)	
Terraced alluvial deposits	Continental	Gravel with silty sandy lens or sandy pebbly deposit	Pleistocene	long the basin of Bradano, Basento and Cavone
Recent alluvional deposits	Continental	Clay sandy and gravel deposits	Holocene	Bradano, Basento and Cavone fluvial plains
Existing costal sand dunes and beaches	Continental	Sand	Holocene	Costal sea shore
Existing alluvial deposits	Continental	Pebbles and sand	Holocene	Bradano, Basento and Cavone recent valley

Table 3: Description of the geological formations of the area of Ginosa.

The Oscurusciuto rock shelter stands in the Southern part of Murge, the so-called Tarantine Murge. The site opens towards the Ginosa ravine, whose first section is headed from north to south and its middle and final section from north-west to south-east. The ravines are crevice-shaped valleys, more than 100 m deep, carved into the calcarenite, with steep walls, which distance up to 200 m from each other, and they only carry water during rainy seasons. Today the Ginosa ravine forms part of the protected nature reserve the *Parco naturale Terra delle Gravine*.

This ravine formation is the result of a combination of several phenomena: the watercourses gradually carved into the Plio-Pleistocene cover deposits, finally reaching and eroding the limestone of the substrate, thus shaping the deep crevice of the ravine (Boenzi et al., 1971; 1976).

From a morphological point of view, the landscape now visible had already been formed towards the end of the Upper Pleistocene, which means that the people occupying the Oscurusciuto rock shelter during MIS 3 had been living in a landscape quite similar to the one that we see today, i.e. a landscape dominated by lowland and mountains of medium height with alternating ravines.

This geomorphological background also favoured both the presence of caves as well as shelters and the rich availability in loco of limestone and siliceous resources. Pebbles of various lithological nature, originating from the Apennine formation make up the formation of Conglomerato d'Irsina. Remarkable the presence of pebbles of radiolarite and crystalline rocks, such as granites and quartzite, found in the conglomerate deposits alternating with layers of Cenozoic sandstone from the Lucan Apennine (Boenzi et al., 1971; 1976). Together with the presence of plateaux, coastal floodplains as well as suitable grazing lands a few kilometres from the site, all of these would have made the shelter a place of potential attraction for Neanderthal groups (Marciani, 2013; Marciani et al., 2016; Spagnolo, 2017).

4 Research history

Research, investigation and excavation at the Oscurusciuto rock shelter have been carried out since 1998 until the present day by the U.R. Preistoria e Antropologia under the Dipartimento di Scienze Fisiche, della Terra e dell'Ambiente - University of Siena, on behalf of the Soprintendenza Archeologia Belle Arti e Paesaggio per le Province di Brindisi, Lecce e Taranto.

In the summer of 1997 lithic artefacts and bones at the Oscurusciuto were first discovered by locals, who then contacted prof. Annamaria Ronchitelli, prof. Paolo Boscato and prof. Paolo Gambassini from the University of Siena (Figure 12). After a first inspection of the site the researchers understood the great potential of archaeological deposits and decided to incorporate the Oscurusciuto rock shelter in their investigation regarding the Middle Palaeolithic occupation of Southern Italy.

Figure 12: From the first survey at Oscurusciuto in September 1997.

In the first picture A.Ronchitelli, P.Boscato, P.Gambassini, C.A. Bartoli, P.Di Canio and L. Miceli. In the second picture P. Gambassini on the north-western corner of the rock shelter. (Photo R. Mattia).

The first interventions were the excavation of a trial trench in order to identify the stratigraphic sequence, and the removal of all reworked sediment and humus in order to gain a better comprehension of the complete extension of the deposit (1998, 1999 fieldwork) (Figure 13). With the arrival of the new millennium the proper excavation began, during the following ten years (from 2000 to 2011 except for 2008) the staff of prof. Ronchitelli and prof. Boscato excavated the upper part of the sequence, consisting of the levels of occupation SU 1, SU 2, SU 3, SU 4, SU 7, SU 8, SU 9, SU 11, SU 13.

Figure 13: the complete deposit of Oscurusciuto after removal of humus and reworked sediment.

On the right in the photo the trial trench. On the left A. Ronchitelli, P. Gambassini, G. Marroni, D. Santoro and P. Di Canio (Photo P.Boscato 1999).

In 2012 the excavation of the big level of tephra (SU 14) started, attributing a clear chronological marker to the sequences. The excavation of this level, consisting of 60 cm of volcanic ashes, lasted 2 years. During the two successive years 2014 and 2015 the researchers proceeded with the excavation of the living floord level (SU 15) sealed by the level of tephra. Due to the very compact nature of the level SU 16 and its huge importance for Middle Palaeolithic records, after a first "scraping" of its surface (SU 15), the level was left untouched.

From during the end of 2015, and throughout 2016 and 2017, the attention of the researchers was focused on a stratigraphic baulk in order to determine the relation between the structures on the level 15 and the shelter wall.

5 Stratigraphic sequence

Since 1998 (the first year of excavation) till now, nine main Middle Palaeolithic occupation phases have been investigated, corresponding to the first 3 meters of the sequence. All the levels are characterized by a great abundance of lithic artefacts, faunal remains and combustion structures. Excavations targeted about half of the deposit and reached the surface of SU 16 (left un-excavated). The stratigraphic deposit consists of a rich sequence of sub-horizontal layers, exposed along the erosion surface of the slope (Figure 14).

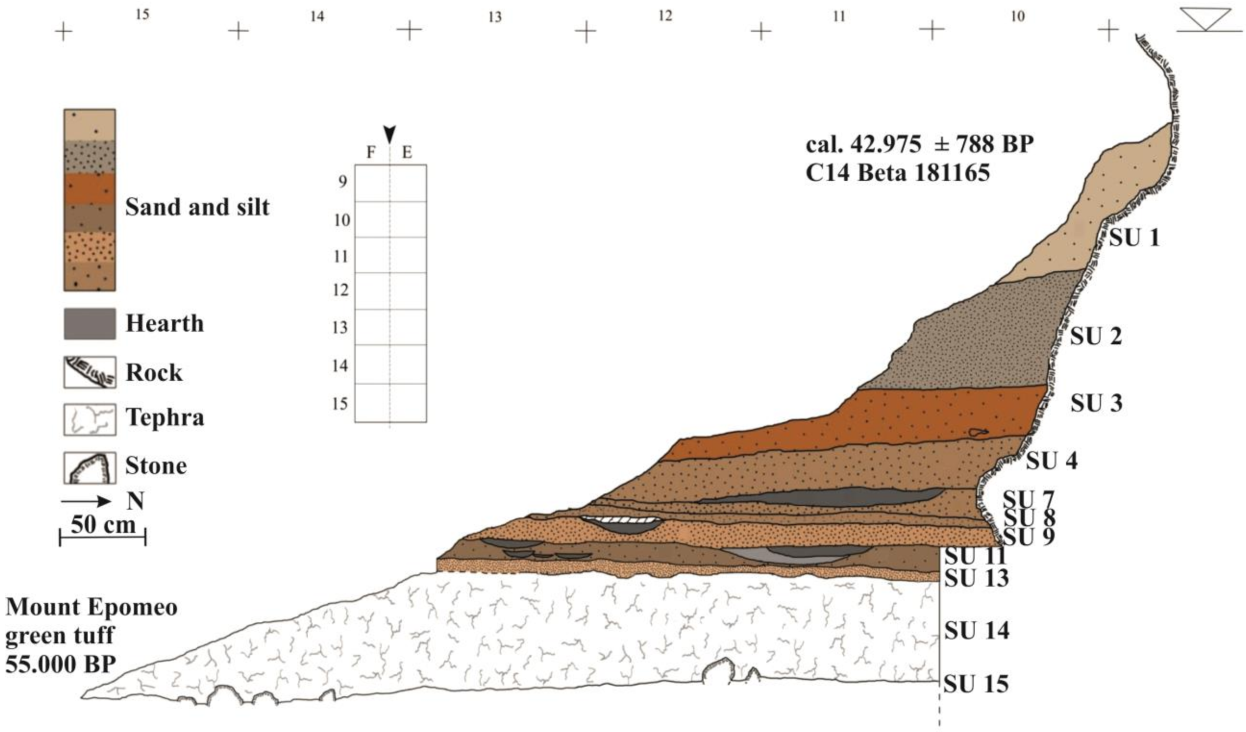


Figure 14: Oscurusciuto stratigraphic sequence. (Drawings. P. Boscato; A. Ronchitelli modified).

Starting from the top of the sequence, SU 1 and SU 2 are the remanents of two big levels almost completely destroyed by erosion. The levels SU 3 and SU 4 are sandy, silty deposits, followed by the layers from SU 7 to SU 13, consisting of coarse sand, and characterized by the presence of several hearths. SU 14 is a huge deposit of tephra which sealed the living-floor of SU 15, preserving the circular structures on its surface (Table 4). The lower part of the series from SU 16 to SU 27, discovered by the trial trench, is made up of sediment and blocks resulting from the collapse of the rock shelter vault. A preliminary examination of these levels showed the presence of lithic material, hearths and another level of tephra, currently under investigation (Boscato and Ronchitelli 2017, Ranaldo et al. 2017). The description of the levels up to SU 15 is provided by the following table (Table 4) (Marciani, 2013; Spagnolo, 2017).

Level	Description	Archaeological evidences
SU 1	Yellowish light grey (10 YR 6/4) breccia consisting of hard limestone with fragments of calcarenite and sandy matrix. Its average thickness is almost 70 cm and it is quite inclined with a dip towards to N/NE (147 ° N 12 ° N/NE).	Archaeological material is abundant but only a small part of the layer is preserved due to erosion.
SU 2	Dark yellowish brown (10 YR 3/6) breccia consisting of hard limestone with fragments of calcarenite and abundant sandy matrix. Its average thickness is 43 cm, where it is well preserved, but just 2 cm where it is eroded.	Archaeological material is present less abundantly than in SU 1 but, as with SU 1, only a small part of the layer is preserved due to erosion.
SU 3	Compact, dark brown (7,5 YR 4/6) of reddish yellow shade (5 YR 4/6) sand with fragments of calcarenite and a few pebbles. The layer is sub-horizontal and its thickness is between 2 and 33 cm.	The layer is almost completely sterile in its upper part, anthropic material appears in its base.
SU 4	Brittle dark yellowish brown (10 YR 4/4) sand mixed with small pebbles and abundant blocks of both limestone and calcarenite. Its approximate thickness is between 2 and 35 cm. The layer is sub-horizontal with a slight dip towards NE (124 ° N 4 ° E).	It is a great palimpsest with several occupations. The abundant presence of limestone and calcarenite blocks lead us to think that they could have been part of structures similar to the ones in SU 15 but less well-preserved. The archaeological material is very abundant.
SU 7	Slightly cemented, compact, dark yellowish brown (10 YR 4/4) sand with gravel component. Its thickness ranges between 2 and 17 cm. The layer is sub-horizontal with a slight dip towards N / NE (110 ° N 5 ° N / NE).	It is a thin layer with one unique big hearth SU 6 (Ø approximately 2 m) placed in the NW corner of the shelter. Archaeological material is not very abundant.
SU 8	Compact, dark brown (7.5 YR 4/6) sand with gravel component and calcarenitic blocks, with a thickness ranging between 1 and 8 cm. The layer is sub-horizontal with a slight dip towards N / NW (78 ° N 6 ° N / NW).	It is a palimpsest lacking in any structures or hearths but with presence of quite abundant archaeological material.
SU 9	Compact dark brown not homogeneous (7.5 YR 4/6) sand, with a thickness ranging between 2 and 16 cm. The layer is sub-horizontal with a slight dip towards N / NW (71 ° N 7 ° N / NW).	It is a palimpsest with several medium-sized hearths (Ø approximately 50 cm) which create two parallel alignments along the NE-SW axis. Archaeological material is abundant.

Level	Description	Archaeological evidences
SU 11	Compact, dark yellowish brown (10 YR 3/4) sand, with a thickness ranging between 1 and 18 cm, it was excavated in 3 artificial cuts. The layer is sub-horizontal with a slight dip towards N / NW (74 ° N 8 ° N / NW).	It is a big palimpsest in which there are a substantial number of hearths with two different sizes: small ones (Ø approximately 20-30 cm) and medium ones (Ø approximately 50 cm). The archaeological material is very abundant.
SU 13	Sandy compact yellowish brown (10 YR 5/6) deposit mixed with pyroclastic sediment. Its thickness ranges between 3 and 11 cm, it was excavated in 2 artificial cuts. The layer is sub-horizontal with a slight dip towards N / NW (68 ° N 6 ° N / NW).	Short palimpsest with 9 small hearths (Ø approximately 20-30 cm) and 1 of medium size (Ø approximately 50 cm). They are aligned along an NE-SW axis. The archaeological material is quite abundant.
SU 14	Pyroclastic light yellowish brown (2.5Y 6/4) deposit, with a thickness of 60 cm. The layer is sub-horizontal with a slight dip towards N (90 ° N 5 ° N).	It is a tephra layer. Almost sterile in the totality of its thickness except from a small occupation (recognizable by a few fragments of bones and some lithic artefacts) up to 15 cm from the top of the layer. Traces of evident structures are absent.
SU 15	Compact light grey (7.5 YR 8/1) deposit made up of sand and silt with elements of calcarenites and limestone. SU 15 is the living-floor on the top of layer SU 16 (not excavated).	It is a very well preserved living-floor sealed by the level of tephra. On its surface there are two circular structures made up of an alignment of stones (Ø approximately 2 m). Quite abundant archaeological material is visible on its top.

Table 4: Description and archaeological evidence of Oscurusciuto levels up to and including SU 15.

(Highlighted the level object of this thesis).

6 Published material

6.1 Dates

The chronological margins of the Neanderthal occupation of the rock shelter are based on two dates. The first, obtained by the C14 method, refers to the bottom of SU 1, which is datable to 38,500 ± 900 BP, cal. 42,724 ± 716 BP Beta 181165 (Ramsey and Lee, 2013). The second derives from the identification of the tephra layer (SU 14) as Mount Epomeo green tuff (Marciani et al., 2016; Spagnolo et al., 2016) datable to about 55,000 BP (Allen et al., 2000).

Therefore, based on these dates, the stratigraphic sequence of the upper part of Oscurusciuto (SU 14-SU 1) encompasses a time span of approximately 13,000 years collocated to the period between

40,000 and 55,000 years BP. This period corresponds to the first half of MIS 3, namely the last phase of the Middle Palaeolithic, which borders on the disappearance of the Neanderthals and the first diffusion of the Anatomically Modern Humans in Southern Italy and subsequently in Europe (Moroni et al. 2013*; in press*; Higham et al. 2014).

6.2 Environment

As for the reconstruction of the environment near the rock shelter, information is available thanks to the sedimentary record of Lago Grande di Monticchio. This lake is situated in the volcanic crater on the western flank of Monte Vulture, the Basilicata region, Southern Italy and is found approximately 100 km to the NW from Oscurusciuto as the crow flies.

The sedimentological records of Lago Grande di Monticchio provide sedimentary testimony starting from the formation of the lake, which can be correlated to calendar year chronology. The Marker Tephra 9 (MT-9) has its origin in one of the Ischia volcanoes, and its stratigraphic position suggests a correlation with the eruption of Mount Epomeo green tuff. Thus the TM-9 of Monticchio can be correlated with the SU 14 of Oscurusciuto.

The palynological records of Lago Grande di Monticchio for the period between 40,000 and 55,000 BP register a fluctuation from a very cold and dry to a relatively moister climate as temperatures decreased (Table 5) (Creer and Morris, 1996; Watts, 1996; Allen et al., 2000; Watts et al., 2000; Wulf et al., 2004; 2012; Tomlinson et al., 2014).

Period	Winter temperature	Moisture availability	Vegetation
50,000 - 42,000 BP	Very cold, cold	Arid moist	*Betula-Quercus* woodland at first, replaced by *Quercus-Abies* woodland. *Betula* and *Pinus* continuously present.
53,800 - 50,000 BP	Cold	Very arid	*Artemisia-Gramineae* steppe with C*henopodiaceae* and *Caryophyllaceae* and regional *Pinus*.
56,200 - 53,000 BP	Very cold	Very arid, arid	Steppe with occasional *Quercus* and *Fagus* woods, plus *Pinus* and *Juniperus*

Table 5: Paleoenvironmental associations. Modified from (Allen et al., 2000).

6.3 Fauna

The paleobotanical profile based on the samples from Monticchio is very coherent with the faunal association found at Oscurusciuto. Indeed the variation in the faunal association shows both little paleoclimatic fluctuation as well as the coexistence of different biomes, possibly related to a micro-

scale landscape variability linked to the ravine environment. Essentially the studied samples (from SU 15 to SU 1) show that the Neanderthal hunters exploited two different environments: a forest-steppe area, probably present on the hilly relief, and a more humid territory with wood cover, inside the ravine (Boscato and Crezzini, 2012; Boscato, 2017).
The faunal association shows a variation through the stratigraphic sequence, which can be divided into three phases. The first, from SU 15 to SU 4, is characterized by a high frequency of *Bos primigenius,* whose highest density occurrence is registered in SU 8 with 84,4% of the sample. This was associated with *Cervus elaphus*, *Dama dama*, *Capreolus capreolus*, *Equus ferus*, and occasional appearances of *Capra ibex* and *Rupicapra rupicapra*. In the second phase, practically the SU 3, there is a sharp variation in the presence of ungulates, possibly related to a drier, cooler climate. Thus the evidence of *Bos primigenius* and *Dama dama* becomes scarcer, whereas indications of the presence of *Equus ferus* augment significantly. Rhino appears intermittently. In the third phase, the upper part of the series (SU 2 and SU 1), *Bos primigenius* is again the most widely found prey, though not appearing as frequently as at the lower levels. A greater number of *cervidae* is also registered which testifies a denser wood cover, evidence of improved climatic conditions (Boscato and Crezzini, 2012; Boscato, 2017).

Based on taxonomic and taphonomic studies, the Neanderthals'hunting strategies at Oscurusciuto are very interesting. Firstly, the identification of the age of the prey at the moment of killing suggests that adult prey was carefully selected. Secondly, there is also a priority as to which part of the carcass was introduced into the site. Thus remains of limbs and skulls are found in abundance, whereas ribs and vertebrae are almost absent. Consequently we may hypothesise that prey's axial portion was left at the killing site (Boscato and Crezzini, 2012; Boscato, 2017).

Finally, consistent finds of long bones split are most probably related to the extraction of marrow. Whereas the scarcity of epiphysis of articular bones, containing much spongy material and fat could be explained by their use as fuel or travel provisions (Boscato and Crezzini, 2012; Boscato, 2017).

6.4 Hearths

As previously mentioned, the central portion of the stratigraphic sequence of Oscurusciuto is characterized by the presence of hearths. These combustion structures indicate a two-fold arrangement of the space.

As a matter of fact, we have noted a certain consistency in the dimensions and spatial patterns of the hearths at the lower levels (SU 13, SU 11 and SU 9). Here the hearths were of two dimensional typologies: small (with diameters of about 20 cm) and medium-sized (with around 50 cm in diameter). In these SUs most of the hearths were aligned along an axis which constituted a sort of belt at the centre of the rock shelter. The alignment of the hearths separated the area in two zones: one from the wall of the rock shelter until the hearth cluster, and the other from the hearths alignment until the area outside the rock shelter. These hearths could be partially lit simultaneously constituting a small protected area from between the rock shelter wall and until the line of hearths (Boscato and Ronchitelli, 2008, 2017; Spagnolo, 2013; Spagnolo et al., 2016).

In the upper level SU 7 a big hearth (2 m wide) was located in the N-W corner of the shelter in the exact corner against the wall subsequently left empty in the upper levels. This arrangement of the big hearth only allowed for the use of the outer space in the shelter (Boscato and Ronchitelli, 2008, 2017; Spagnolo, 2013; Spagnolo et al., 2016).

These different morphologies, as well as the peculiarities in the management of the internal space, may be linked to several modalities in the use of fire. Micromorphology studies which might resolve these issues are still in progress at the Department of Archeology, Simon Fraser University, Burnaby, British Columbia, Canada (F. Berna).

6.5 Lithic material

The lithic collection from Oscurusciuto shows substantial uniformity even though each level demonstrates individual peculiarities. The acquisition of raw material was local, i.e. the Oscurusciuto Neanderthals used pebbles of radiolarite, chert, cherty limestone and quartz sandstone sourced from the terraces and areas near the site. The recurrent levallois is the most documented debitage concept, especially in its unipolar modality, with the objective of producing elongated supports, both convergent and non. A secondary debitage is a volumetric exploitation, aimed at producing bladelets.

As the research stands now, the upper levels, i.e. SU 1, SU 4 and SU 8, have as yet been only partially studied (Boscato et al., 2011; Ranaldo, 2005; Ranaldo et al. 2017; Ronchitelli et al., 2011; Villa et al., 2009), whereas the lower part so far excavated is the object of this research (Marciani, 2013; Marciani et al., 2016; Spagnolo et al., 2016).

In the SU 1 and SU 4 the most frequently used debitage concept is the recurrent unipolar levallois method, whereas the bipolar modality is less represented. In the last phases of debitage, the production modality would sometimes change from the unipolar to the centripetal or preferential modality. Also represented is the volumetric method. The discoid production mode is occasionally present in SU 4 but completely absent in SU 1. Most of the cores in these two layers are completely exploited (Ranaldo et al., 2017).

The principal aim of the levallois debitage is the production of elongated flakes, that is to say obtaining elongated shapes is the aim from the very beginning, as demonstrated in the selection of oblong pebbles and the presence of long cortical flakes. The striking platform is prepared when initiating the debitage, whereas the lateral convexities, during the first phase, are managed through the exportation of debordant cortical flakes, which might likewise have been the aim of the debitage. Only in a second phase are the lateral convexities managed by way of peripheral detachment. The same tendency has been ascertained regarding the production of points, always less frequent than the flakes with parallel sides. As the end product and final objective of this debitage we find flakes obtained through centripetal or preferential modality (Ranaldo et al., 2017).

Independent blade/bladelet volumetric debitage has also been documented, although these occur less frequently. In this case, the technical objective is elongated shapes, variable in thickness and showing flat butts. Usually, these blades are thicker than the levallois products. Also represented is a generic unipolar surface debitage which lacks the technical sophistication of the levallois technique. The most abundant retouched tools are convex side-scrapers as well as points with different morphologies, whereas denticulates are less numerous. The supports usually retouched are blades and flakes from both volumetric and levallois debitage (Ranaldo et al., 2017).

The lithic production in the SU 8 can be associated with the production found in the upper levels (SU 1, SU 4). The recurrent levallois debitage is dominant and there is volumetric production aimed at producing bladelets, plus a more generic debitage of surfaces. Almost non-existent are items originating from discoid debitage. Among the retouched tools, scrapers prevail, then denticulate and points are also present. The final products are long flakes and convergent flakes debitage (Ranaldo et al. 2017).

A selection of convergent tools from these levels (SU 1, SU 2, SU 4 and SU8) was designated for analysis, applying a use-wear approach in order to understand more about the functionality of those tools. As a result of these studies the selected Oscurusciuto points seem to have been intended and utilized more as multi-functional tools rather than potential spear points (Villa et al., 2009; Ronchitelli et al., 2011a).

7 Selected levels

This research focuses on the lower section of the Oscurusciuto series so far investigated: SU 15, SU 14, SU 13 and SU 11 (Figure 15). These stratigraphic units are particularly interesting in the reconstruction of Neanderthal behaviour because of their peculiarities in terms of structural elements, spatial management, type of occupation and lithic production systems.

SU 15 is a living floor characterized by stone alignments constituting two possible structures, and recording an abandonment phase sealed by the deposition of the SU 14 tephra. SU 14 is an almost sterile layer about 60 cm thick, consisting of volcanic ash. Traces of a short frequentation can be seen only a few centimetres below the top of the layer. SU 13 is a short palimpsest which represents the first stable re-colonization of the site after the ash deposition. The overlying SU 11 is a palimpsest about 30 cm thick, characterized by the superimposition of tens of hearths.

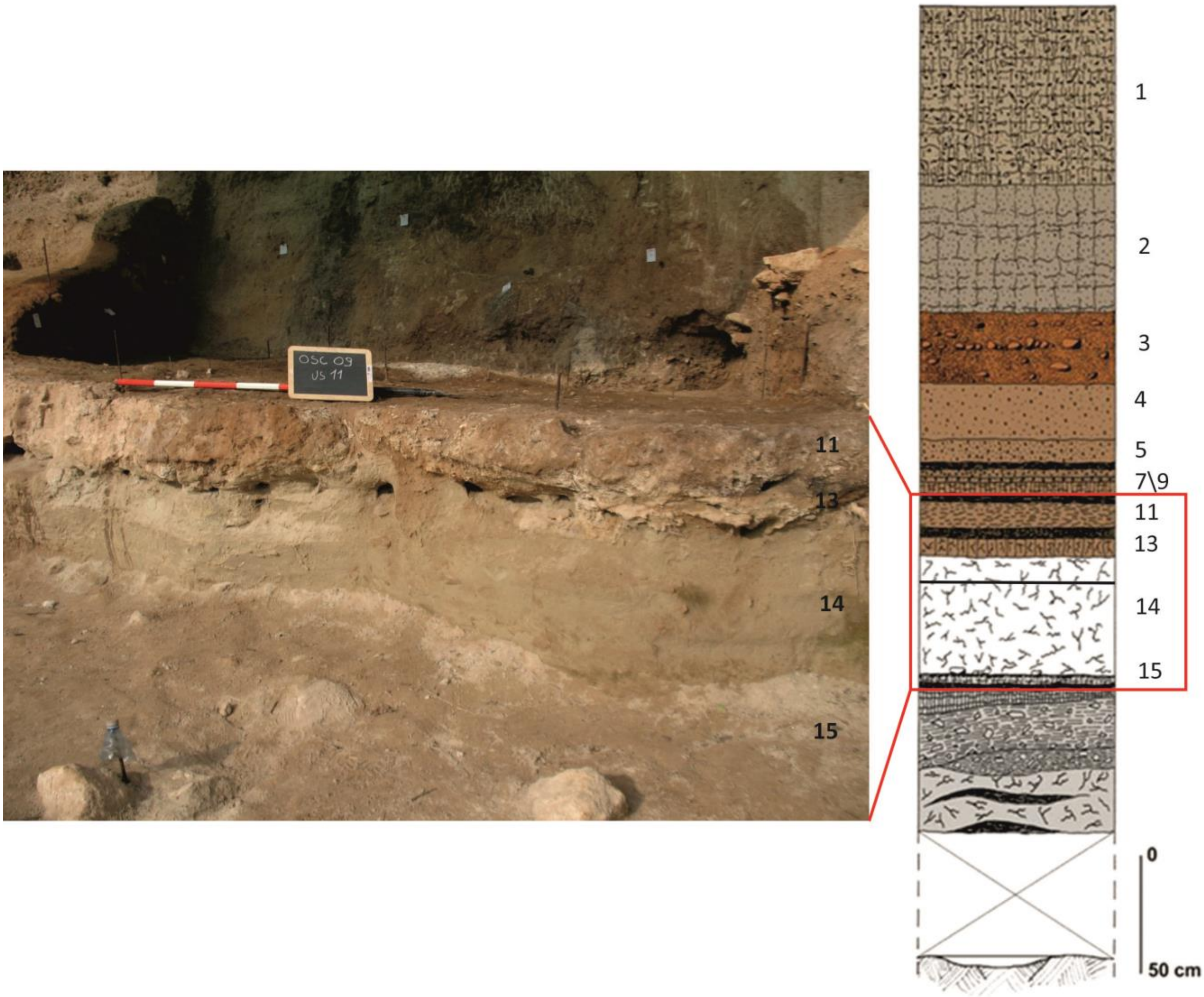


Figure 15: Stratigraphic sequence of Oscurusciuto and four levels of occupation studied in this work.

SU 15, SU 14, SU 13 and SU 11. (Photo and drawing P.Boscato, modified).

7.1 SU 15: the living-floor

Figure 16: Detail of the structure of the living-floor.

SU 15 (Figure 16) is a living floor sealed by the thick deposit of tephra SU 14, which gives a *terminus ante quem* of 55,000 years BP to the occupation. The level represents a phase of abandonment before the catastrophic event of the volcanic ashes deposition.

The peculiarity of this living-floor, exposed over an area of 18 square meters, is represented by the presence of stone alignments referable to two structures. The first comprises a 2 meters wide semicircle standing against the north wall of the shelter, the second covers a similar area and is located to the left of the first structure. Moreover, the first structure presents two small clusters made of 3-4 stones each on the top of small depression, which could be interpreted as structure aimed at accommodating poles. The archaeological remains are more abundant along and outside the perimeter of the structures. In addition, in correspondence with the stones, the living-floor is characterized by a slight but clear relief, whereas the internal area of the structures encompasses a depressed area with few anthropic remains (Ronchitelli et al., 2014).

The preliminary study of the faunal remains, mostly fragments of diaphysis and portions of mandibles and maxillaries, has determined the presence of at least one *Cervus elaphus* and a minimum number of 5 individuals of *Bos primigenius* of various ages (Ronchitelli et al., 2014).

7.2 SU 14: the tephra occupation

Figure 17: SU 14, the tephra layer (Photo P.Boscato).

SU 14 (Figure 17) is a level of 60 cm of tephra, identified as the green tuff of Mt. Epomeo from the island of Ischia (Marciani et al., 2016; Spagnolo et al., 2016).

This eruption happened 55,000 years BP (Allen et al., 2000). It was a violent explosion causing the catastrophic collapse of the Ischia islands, as well as massive submarine avalanches of debris and possible tsunami events (Chiocci and de Alteriis, 2006).

Tephra and crypto-tephra layers are sediments deposited within a very short time range (considered as an instantaneous process for most research purposes) over large areas, thus permitting correlations among different archives. Establishing their presence in Quaternary successions is consequently very relevant because they constitute independent time markers. Their abundance both in the Mediterranean Sea (Keller et al., 1978; Federman and Carey, 1980; Paterne et al., 1988; Narcisi and Vezzoli, 1999; Siani et al., 2004) and in terrestrial archives (including Italian volcanic lakes, Greek and Turkish lakes, and Bulgarian, Greeks and Italian cave sites); (Narcisi and Vezzoli, 1999; Seymour et al., 2004; St. Seymour and Christanis, 1995; Wulf et al., 2004) enabled the construction and update of distribution maps of these markers and thus the realization of a high-resolution tephro-stratigraphy (Paterne et al., 1986; Wagner et al., 2008).

The analysis of the tephra also permits estimates as to the volume of the erupted material, and consequently an assessment of the ecological and climatic impact of the explosive events in question (Narcisi and Vezzoli, 1999). Intense magmatic fragmentation during explosive volcanic eruptions produces huge amounts of pyroclastic material, which, after injection into the atmosphere, is dispersed as convective columns and umbrella clouds, or transported close to the ground in form of pyroclastic density currents. Irrespective of the eruptive mechanism or the eruption intensity, the fine-grained particles (i.e. ash, which comprises 2 mm particles) usually affect wide areas around volcanic centres, generating notable alterations of ecosystems (Haeckel et al., 2001) and hydrological regimes (Stewart et al., 2006), and causing severe damage in both proximal and medial areas (Blong, 1984; Giaccio et al., 2008).

The extent of green tuff from the Mt. Epomeo eruption raises questions regarding its impact on the human communities along the Tyrrhenian coastal zone, as well as on all the other communities living in the regions affected by the fall-out of volcanic ash. So far green tuff from the Mt. Epomeo has been recovered in 6 markers, localized in several regions of southern Italy: 1) around the volcanos (Mt.Epomeo Ischia); 2) the lake sequence of San Gregorio - S16 (Munno and Petrosino, 2007); 3) the marine deposit in the Tyrrhenian Sea - C18 (Paterne et al., 1988; 2008); 4) the rock shelter site of Oscurusciuto (the SU 14 marker currently under study by R. Sulplizio, Università degli Studi di Bari); 5) the lake sequence of Lago Grande di Monticchio - TM-19 (Wulf et al., 2006); 6) the marine deposit of Ionic Sea -Y7 (Keller et al., 1978; Giaccio et al., 2008) (Figure 18).

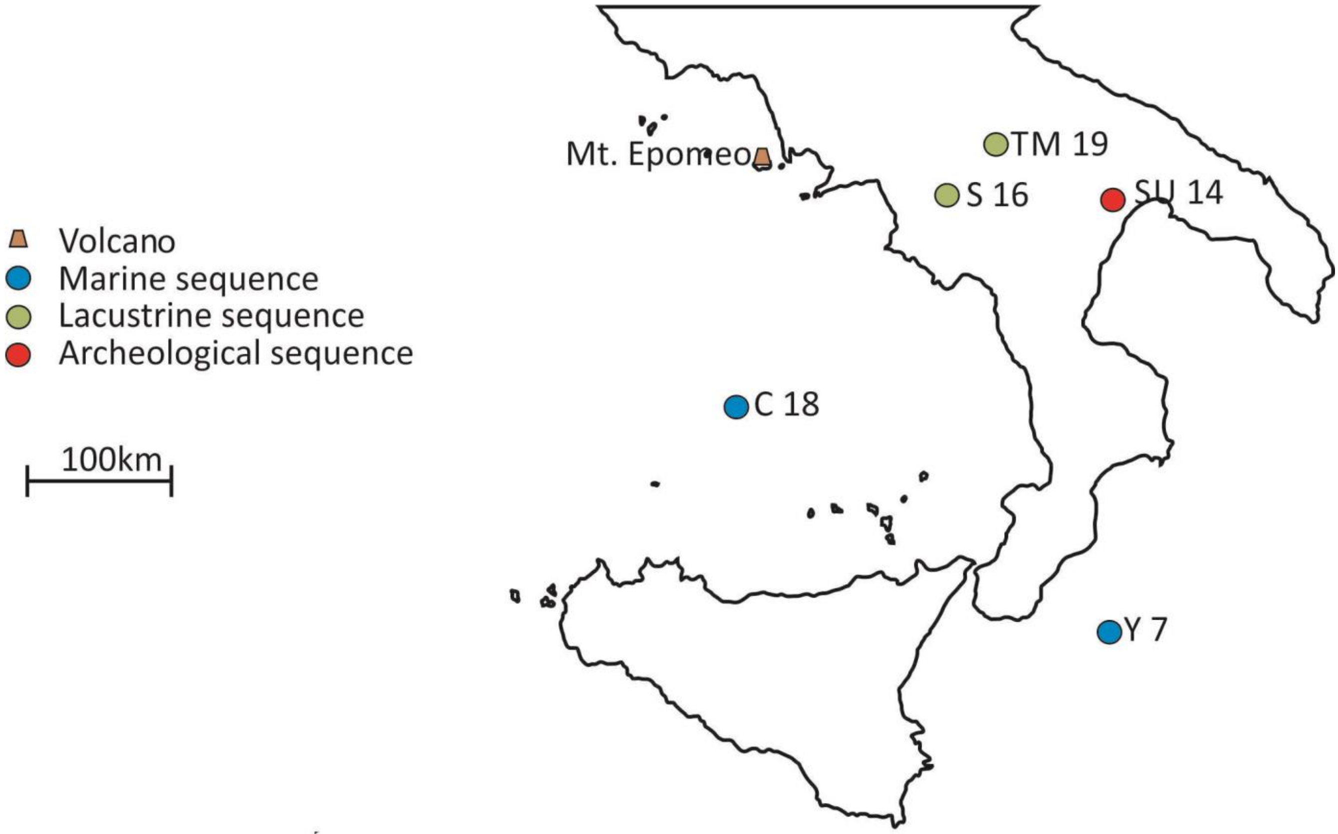


Figure 18: Distribution of tephra marker green tuff from the Mount Epomeo, Ischia.

1) Mt.Epomeo volcano Ischia, 2) S16 lake sequence of San Gregorio, 3) C18 marine deposit in the Tyrrhenian Sea, 4) SU 14 rock shelter site of Oscurusciuto, 5) TM-19 lake sequence of Lago Grande di Monticchio, 6) Y7 marine deposit in the Ionian Sea.

At Oscurusciuto SU 14 the deposit consisted in a lower part of volcanic ash in primary deposition, whereas the upper part consisted of ash in secondary deposition. In the upper portion it presented laminated structure. In order to better understand the characteristics of this deposition, micro-stratigraphic analysis of tephra samples is currently under investigation (F. Berna, at the Department of Archeology, Simon Fraser University, Burnaby, British Columbia, Canada).

The level was excavated to an extension of 14 square meters, and compared to the other layers of the rock shelter, it is almost sterile, except for some archaeological material collected in the upper part of the layer (between approximately 5 and 15 cm from the top of the level). The determined faunal remains are three teeth of *Bos primigenius* attributable to three different individuals (an adult, a sub-adult and a juvenile) (Boscato, personal communication). There were no recognizable structures or hearths. We may therefore conclude that SU 14 represents a brief occupation of the rock shelter during the period when the volcanic ash was falling.

7.3 SU 13: the short palimpsest

Figure 19: SU 13, the short palimpsest (Photo: P.Boscato).

SU 13 (Figure 19) consists of a sedimentary interface between the SU 11, the sandy layer above, and the SU 14, the proper tephra deposit. It represents the first stable re-colonization of the rock shelter which occurred during the final phase of the volcanic ash deposition.

It is a short palimpsest and it has not been excavated to its full extension because it is partly destroyed by erosion. Two parts were left untouched as a stratigraphic baulk, and the layer in question was excavated to the extension of 11 square meters. The level is characterized by the presence of quite abundant faunal remains; however, only six elements were identified, due to high fracture grade (1 = *Equus ferus* and 5 = *Bos primigenius*) (Spagnolo et al. 2016).

Above SU 13 we exposed a darker accumulation of ash named SU 79 and a series of structured hearths collocated in prepared depressions (SU 12, SU 74, SU 75, SU 76, SU 77, SU 78, SU 80, SU 83A, SU 83B, SU 84, SU 82). They seem to have been arranged in a line, dividing the space of the rock shelter into two portions: inside and outside the line of fires (Spagnolo et al., 2016).

7.4 SU 11: the long palimpsest

Figure 20: SU 11, the big palimpsest (Photo P.Boscato).

SU 11 (Figure 20) is a thick level excavated to an extension of approximately 11 square meters. Its thickness is not homogenous, there is a difference between the northern part, where it measures between 1 and 13 cm, and the southern part where it measures more than 20 cm. The layer was excavated in two artificial cuts in the northern part, and three in the southern part.

The determinable faunal remains amount to 74, with a significant number of *Bos primigenius* followed by *Equus ferus* and, to a minor extent, *Cervus elaphus* and *Dama dama*.

More than 34 hearths were found in a complex context (partially or wholly superimposed) concentrated mostly in the southern part of the level. They are divided into two major dimensional classes: medium-sized (between 40 and 50 cm), located in the upper part of the level, and small-sized (between 20 and 30 cm), concentrated in the lower part of the layer.

These considerations make us infer that SU 11 presents a concentration of occupational events, compared to the other levels, it is a big palimpsest with an extremely elevated quantity of archaeological remains. While SU 13 corresponds to a short palimpsest, i.e.it is the product of a set of events taking place within a short period of time, SU 11, on the other hand, seems to be a palimpsest encompassing a longer period of time and comprising several short palimpsests. Disentangling the single sets of activities that constitute this level is a great challenge which can only be tackled by means of a multidisciplinary approach (Spagnolo et al., 2016; Spagnolo, 2017).

IV METHOD

In order to study the lithic tools in their conceptual, structural and functional dynamics, and subsequently the Neanderthal behaviour and management of the material and space at Oscurusciuto, a multidisciplinary approach was applied. In this chapter we are going to describe the methods of study as well as the procedure of analysis involved in the present research. The practical and theoretical methodologies applied have been specifically adapted to the peculiarities of the Oscurusciuto collections.

The approach used in this thesis encompassed the four following steps (Table 6):

Step I. A technological analysis was carried out as the main base for the study of the four levels in order to gain comprehensive and comparable data regarding the phase of lithic production. This step included:

- The identification of sources of lithic raw material, as well as the description of the dynamics of acquisition and exploitation of the lithic raw material involved.
- An attributal analysis of all the individual objects aimed at producing quantifiable statistical data.
- A qualitative analysis of cores and their extracted flakes in order to understand the volumetric concepts, methods, dynamics and objectives of the debitage, comprehending the reduction strategies and their goals.
- Refitting study where possible to describe and better appreciate the knapping behaviour involved.

All the pieces found in SU 15, SU 14, SU 13 and SU 11 (48,385pieces) were considered in this first step.

Step II. The Raw Material Unit (RMU) approach was applied only to the two levels, SU 13 and SU 14, because their occupational characteristics permitted an effective application of this method. The RMU approach allows us to retrace and recompose the individual block introduced into the site, and in the process to obtain information on the economy of the raw material, the fragmentation of the operative chain, and possibly the time-sequences of occupation. The material was sorted based on its physical characteristics, and individual items originating from the same pebbles were identified. In order to better define the lithotypes a small reference collection was set up and a few samples were petrographically analysed (L. Foresi at the University of Siena), and we concluded that the RMU method yields more effective results when combined with refitting. A selection of pieces from SU 13 (1,770 pieces) and SU 14 (601 pieces) was considered in this second phase.

Step III. The techno-functional analysis was applied to a single selection of objects from SU 13. It was a result of a combination/integration of techno-functional and use-wear analysis. The first was implemented to globally describe each target object, identifying each single techno-functional unity (prehensive and transformative parts), whereas the second was implemented to reveal the way in which these devices had been used, proceeding to identify the activity involved (e.g. piercing, cutting and/or scraping), and the type of material (vegetable/animal, soft/hard) on which these activities had been carried out. The combined use of these two approaches allowed us to ascertain the intention of the prehistoric craftsmen, the gestures and procedures involved in making the objects, and the way they had been used (use-wear analysis were undertaken by S. Arrighi at U.R. Preistoria e Antropologia, the University of Siena). A selection of target flakes from SU 13 (315 pieces) was considered in this third phase.

Step IV. The comparative analysis. Following the analysis above, the results from Oscurusciuto were compared to the data of contemporaneous sites in the Italian peninsula in order to obtain a more complete picture of the late Middle Palaeolithic in Italy. The bibliographic references are based on main scientific publications such as journal papers, master and PhD theses, conference proceedings and other subject-specific publications. All the data were registered and standardized in an Access database.

This study was conceived as a part of the investigation conducted by the U.R. Preistoria e Antropologia (University of Siena) at the Oscurusciuto rock shelter. All the data resulting from the analysis of those lithic objects have subsequently been interpreted in a geo-database especially created for the analysis of the Oscurusciuto collection. The development of the geo-database is the subject of the Master and PhD thesis V. Spagnolo (Spagnolo, 2013; 2017), and further work by same (Spagnolo et al., 2016). This research had as its main goals to identify possible activity areas, as well as to describe the management of the intra-site space (Table 6).

The integration of several methods, the consistent organization of data, and the inter-disciplinary coordination by scholars of this research was essential in realizing a comprehensive investigation aimed at a more detailed understanding of Neanderthal behaviour at Oscurusciuto (Figure 21).

Method	Objective	Analyzed material	Complementary study
I. Technological analysis + Refitting	Reconstruction of reduction sequences	48,385 items (SU 15,14, 13, 11)	Petrographic reference (L.Foresi) GIS analysis (V.Spagnolo)
II. RMU approach + Refitting	Understand the economy of raw material	1,770 items (SU 13) 601 items (SU 14)	GIS analysis (V.Spagnolo)
III. Techno-functional approach	Tools potentiality and use	315 items (SU 13)	Use-wear analysis (S.Arrighi)
IV. Comparative study	Larger view of Oscurusciuto	Bibliographic references	

Table 6: Synthetic table of methods, objectives and material basis parts for this work.

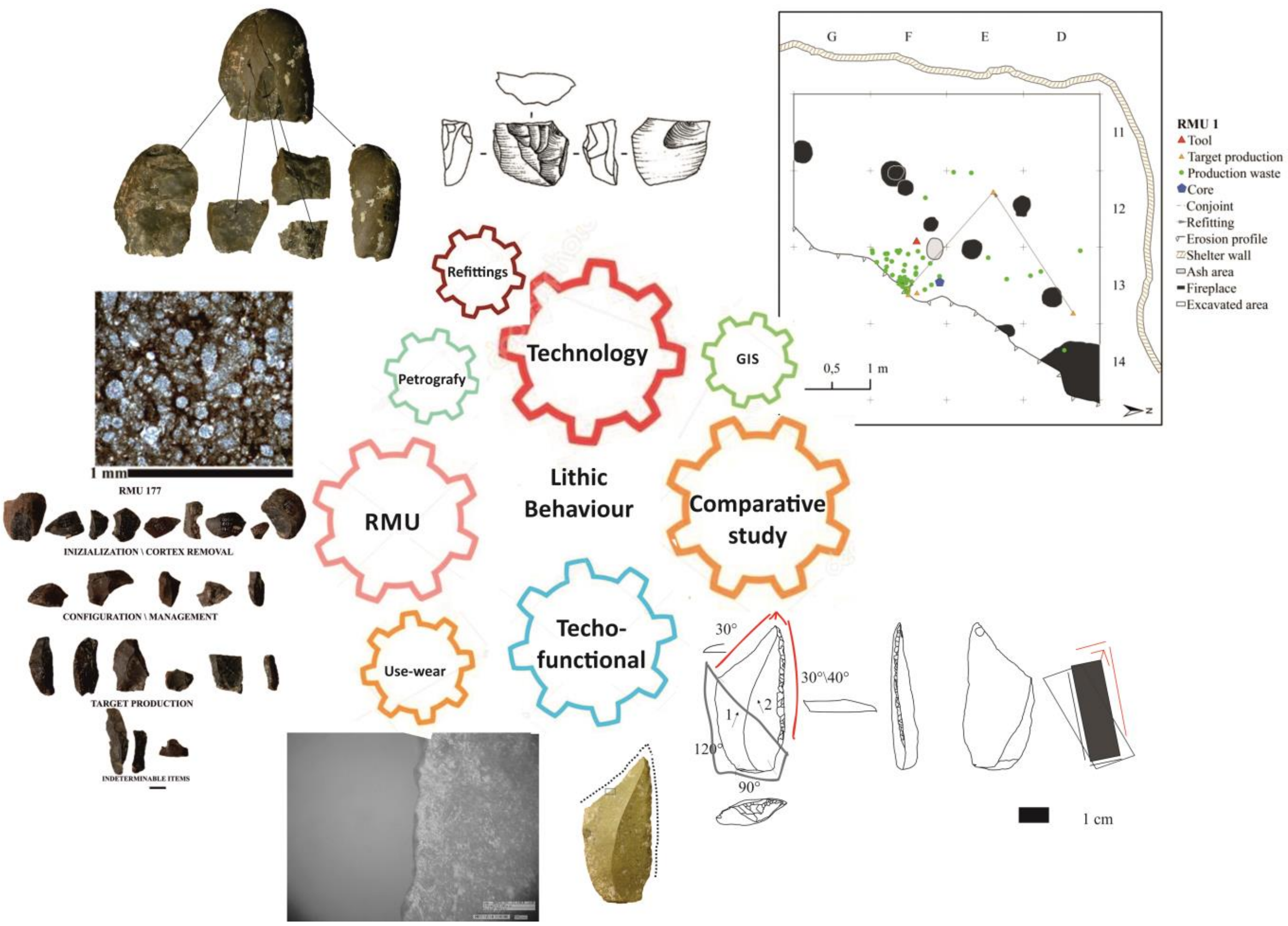


Figure 21: The integrated method.

1 Technological analysis: understanding the production process

The main goal of the technological analysis is to understand all facets of the production of lithic tools, taking into account the whole techno-economic production process, including each step of the reduction sequence (Cresswell and Hanning, 1983; Pelegrin et al., 1988; Geneste, 1991a; 1991b; 2010; Perlès, 1991; Inizan et al., 1995). To achieve this aim every item was analysed separately, i.e. all its features were registered in an Access database specifically set up to suit the peculiarities of the collection in question. The parameters employed in this process encompassed the following specifications (see below).

1.1 General attributes

<u>Identification and excavation provenance.</u>

This includes the identification number (ID number); the coordinate number (attributed to the Cartesian coordinates X,Y and height Z); the inventory code of the boxes; the grid code (C12, C14, D11, D12, D13, D14, D15, E11, E12, E13, E14, E15, E16, F11, F12, F13, F14, F15, G10, G11, G12, G13, G14, G15); the sub-grid code (SU 14, SU 13 and SU 11 was dug out in sub-grids of 50x50 cm, named I II III IV; whereas the living-floor SU 15 was dug out in by sub-grids of 25x25 cm, with letters from A to R attached to them); and the SU number comprehending for each layer all the hearths therein: SU 15 dug out in one cut; SU 14 dug out in two cuts: 14tg 1, 14 tg 2; SU 13 dug out in two cuts: 13/1, 13/2; plus the hearths therein: 12, 76, 77, 78, 79, 80, 81, 82, 83, 84; SU 11 dug out in three cuts 11\1, 11\2, 11\3; plus the hearths therein 10, 12, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 53\1, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71 A, 71, 72, 73, 77, 81, 86, 87.

<u>Raw material characteristics.</u>

This comprehends the raw material litho-type, such as chert, jasper, cherty limestone, limestone, quartz sandstone; as well as their granulometry: fine or coarse; and the type of basic material shape: pebble, nodule, tabular.

<u>Dimensional attributes.</u>

By this we mean the dimensional class (DC), based on the area of each single piece: DC 1: 0 – 50 mm^2, DC 2: 50 – 100 mm^2, DC 3: 100 – 150 mm^2, DC 4: 150 – 200 mm^2, DC 5: > 200 mm^2 (Figure 22). These size classes are essential for the spatial analysis, as they allow us to identify possible activity zones and to verify if there was a sorting process of the material due to water flow. The items larger than the second DC were also measured according to their technological axes. When this was not possible, the longest measure is conventionally regarded as the height. Height, width and thickness are expressed in mm.

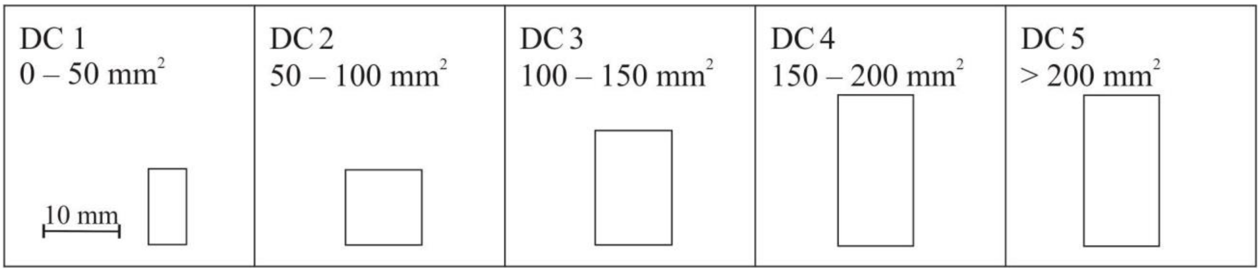


Figure 22: Dimensional Classes.

<u>State of preservation.</u>

This describes the integrity of the item: if the item is not intact, the location of the accidental damage is indicated. Thus we describe the items as “broken top”, “broken base”, “broken side” if the item is intact except for only a small missing fragment, whereas it is considered a “distal fragment”, “mesial fragment”, “proximal fragment”, “lateral fragment” or “composite fragment” if a larger part of the piece is missing. The description of the preservational state also includes stating the presence of alterations, be it by means of fire or alterations of the edges due to probable use (macro-traces) The latter is an evaluation made with the naked eye, further study would be needed to consolidate the attribution accorded to these traces.

<u>Refitting data.</u>

This indicates if there are refittings – i.e. if the fitting items are part of the same sequence of flake removals (Larson and Ingbar, 1992), or if there are conjoins – i.e. if it is one single broken item that can be fitted together again (Larson and Ingbar, 1992). Furthermore, the ID number of the elements that can be refitted\conjoined are recorded, and in the case of refitting, the chronology of detachment is noted.

Retouch information.

In the case of retouched items, their typological class according to Laplace (1964) is listed. The outline of the retouch could be rectilinear, convex, concave and denticulate; and the position of the retouch on the items: lateral (if it is positioned on the right or on left side of the blank), transversal (if it is positioned on the distal part of the item) and proximal (if it is positioned on the butt or at the proximal end of the item). We also indicate the direction of the retouch: direct or indirect (Laplace 1964).

Technological classes.

Comprising: flakes, cores, pebbles, micro-flakes (integral flakes of the 1-2 DC), debris (fragmented or altered items of the 1-2-3 DC), undetermined (fragmented or altered items comprises only pieces of the 4-5 DC).

1.2 Core attributes

In order to understand the technological and volumetric concept of debitage, particular attention was given to cores, each of which had a separate analysis sheet with a drawing and a detailed description, explaining its peculiar genesis.

Types and morphology of block.

The kind of raw block used as a base object for flaking is indicated: pebble, nodule, tabular, flake, fragment etc. The volumetry of the initial shape: cylinder, cube, parallelepiped, lenticular etc. N.B. A flake could be used as support for a levallois or any additional debitage. We refer to the production as “kombewa” when on the flake there is only one strike without any further action or paramether defining the production.

Volumetric conception of exploitation.

This indicates the volumetric structure of each single core based on the classification by Boëda (2013). Cores could be additional or integrated. If they are additional we indicate the type: B; C1, C2, D1, D2, D3. If they are integrated we indicate E1, F1 (see Chapter II, section 2.3 techno-structural approach).

Methods\dynamics of debitage

In the case of levallois debitage it is possible to distinguish between various methods, i.e. to describe the sequence of operations that lead to a certain end, or -in other words- the technical process interposed between an objective and the actual finalization of the target object (preferential, recurrent with unipolar, bipolar, convergent or centripetal arrangement) (Boëda 1994; 1995; 2013), see figure below (Figure 23).

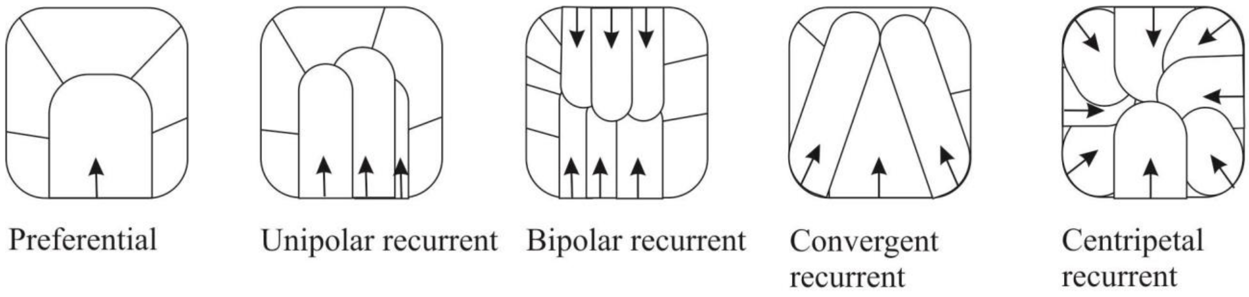


Figure 23: The levallois methods of debitage.

Hierarchy of surfaces

Here we indicate if the surfaces of the core were hierarchized (one surface is exploited as debitage surface and the others as striking platforms – typical criteria of levallois cores F1); or not hierarchized (if all the surfaces of the core were used both as debitage surface and striking platform).

Striking platforms organization.

We consider the type, position and, mode of preparation of the striking platform (S\P). There are two main type of S\P: partial and peripheral. In the partial modality the removals are detached using a striking platform positioned at one end of a core. Considering the position of the striking platform\-s in relation to the cores, the partial exploitation can be identified as unipolar (only one S\P), bipolar (two opposite S\P), or orthogonal (two orthogonal S\P). Other possibilities are a combination of these modalities (Figure 24).

The peripheral modality indicates that the removals were detached using platforms with a larger periphery than one side of the core. It could have an equal extension all around the core (referred to as peripheral S\P) or it could extend only to one side of the core (semi-peripheral S\P) (Figure 24).

The mode of preparation of the striking platform indicates how it is prepared: with one detachment; with several detachments; with or without abrasion of the border of the core; or without any preparation: in this case the detachment starts from a natural surface (cortex, neocortex, etc.).

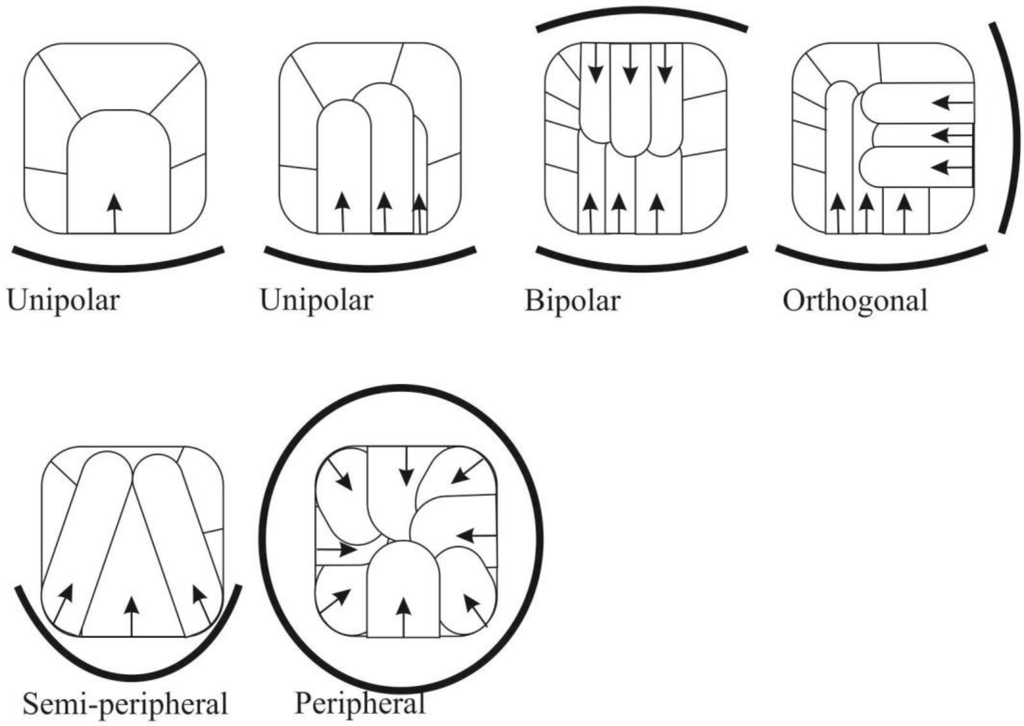


Figure 24: Types of striking platforms.

We have to keep in mind that the term "orthogonal" is used to describe several things: it can indicate the **location** of a striking platform, but also the **relation** between the section planes of a core and also the **directions** of the removals on the debitage surface. In order to avoid misunderstandings even though the terms "perpendicular" and "orthogonal" are geometrically synonymous, in this dissertation we have used them to refer to two different situations.

The former (perpendicular) indicates the location of the striking platform in respect to the debitage surface, e.g. in a levallois debitage with a unipolar striking platform the location of the striking platform is perpendicular to the debitage surface (Figure 25),

whereas the latter (orthogonal) refers to the relation between the section planes, e.g. in an additional debitage the plane of the striking platform is orthogonal to the plane of the debitage surface (Figure 25).

To refer to the third possibility (the directions of the removals on the debitage surface) we use the terms orthogonal always specifying that we are referring to the directions of the removals.

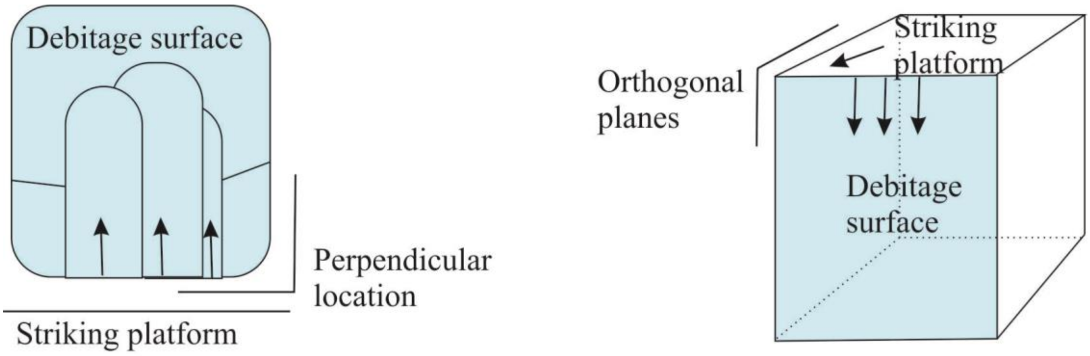


Figure 25: Perpendicular vs. orthogonal.

<u>Diacritical analysis.</u>

Employed in order to identify the chronological order of the knapping scars and their function in the debitage (Dauvois, 1976; Inizan et al., 1995).

The number, direction, chronology and function of each negative on the surface of the debitage were listed.

<u>Reason for the abandonment of the core itself.</u>

This is an open record with the indication of various possible explanations for the abandonment of the core; i.e. a flaking accident\mistake, or the complete exploitation of the material reserve, etc.

1.3 Flake attributes

As to flakes, the analysis includes:

<u>Volumetric concept of debitage.</u>

We indicate the type of debitage which produced each individual flake. This could be additional (C1, D1, C2, D2, D3) or integrated debitage (E1, F) (Boëda, 2013). However, identifying the concept of debitage which produced the flake is sometimes a hard if not impossible task. In fact, flakes obtained by different reduction sequences may show similar or even identical technical characteristics. It is not always possible to define with certainty the technical provenance of a flake without understanding the whole process of debitage (Boëda, 1991). The flakes to which we are unable to attribute a type of debitage are categorized as “undetermined”.

<u>Technological categories and their features.</u>

This is a chronological description of the function of each flake (F) during the course of the debitage (especially with regard to levallois production). The technological categories are as follows:

- Completely cortical F: F with 100% of cortex coverage, the function of which is to open up the surface to further debitage, (in French *eclat entame*).
- Semi cortical F: F the cortex coverage is between 99% and 50%. Its function is to regulate the convexities and angles of a core, and to continue opening up the block.

- Management F: all the flakes that are produced when regulating the convexities and angles of a core with a less than 50% of cortex coverage.
- Target F: is the predetermined objective of the debitage, this could be with or without cortex coverage. In this case indicate the following flakes as the objective of debitage:
    - Convergent F: blank with a convergent edge.
    - Flakes, long F and blades (blanks with at least 2 parallels\ pseudo-parallel cutting edges). We distinguish between them by means of the ratio between height\ width. If the ratio is between 0 and 1.5, it is a flake; if the ratio is between 1.6 and 2, it is a long F, and if the ratio is above than 2.1, it is a blade (Laplace, 1964; Bagolini, 1971). Consequently, in this dissertation the definition of "blade" is based purely on dimensional parameters, it has nothing to do with the type of debitage.
    - Bladelet, if a blank is a blade smaller than 2 cm.
    - Backed F (in French *eclat débordante*), a blank with at least one cutting edge opposed to a back, cortical or created by flaking (Bordes, 1961a).
- Pseudo-levallois point, which is a particular case because this type of flake could be a target objective of a reduction sequence (e.g. a discoid production), or a management flake from another context (e.g. centripetal levallois). The function of this type of flake can be ascertained only on the basis of the context in which it is found.
- Undetermined F are all the flakes which are too altered or too fragmented to allow us to determine their proper function in the knapping activity.

In the case of the recurrent levallois production, on the basis of the appearance of the cortex, and the diacritical analysis of surface detachments from the target flake, it is possible to identify the "generation of debitage" which means the sequences of debitage of target objects in a reduction scheme. Target objectives belong to one of four types (Boëda, 1995; Bonilauri, 2010; Carmignani, 2011).

- Type 1 is the first target flake in a recurrent sequence of debitage.
- Type 2 is the second target flake in a recurrent sequence of debitage. On the dorsal face of the flake the negative of target flakes of type 1 and other management removals are discernable.
- Type 3 is the target flake which is detached after the target flake type 2, and on its surface the negatives of the two previous types of flakes are discernible.
- Type 0 is a particular case, being the first target flake detached in a sequence of removals, with the presence of cortex (Figure 26).

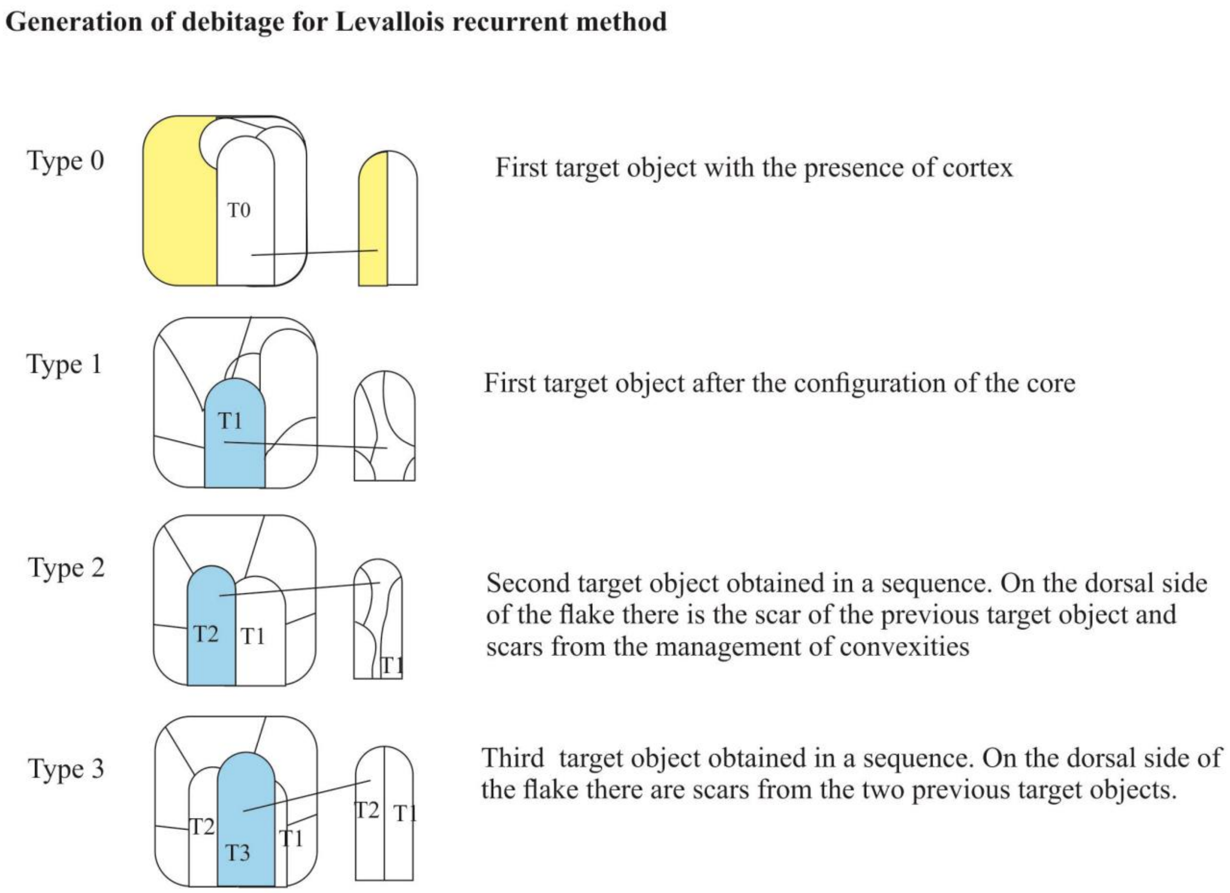


Figure 26: Types of flakes appertaining to the generation of debitage in the recurrent levallois.

Presence and position of cortex.

For the extension of the cortex on the dorsal side of flakes, we use the following descriptors: from 0 to 1\4, from 1\4 to half, from half to A 3\4, from 3\4 to total. If less than half of the surface of the artefact is covered by cortex, the position is indicated: proximal, distal, lateral, lateral back, or central.

Morphological features.

The morphology of the flake is described as follows: oval, circular, half-circular, triangular, rectangular, quadrangular, trapezoidal, irregular, or fan-shaped. Symmetry is indicated referring to the technological axis. Section shape is indicated as: irregular, rectangular trapeze, trapeze, triangular, rectangular, half circles, or linear. The presence of flaking accidents is likewise noted: siret, plunging, hinged, natural surface, or exploded.

Diacritical analysis

A diacritical analysis is employed in order to identify the chronological order of the scars and their function in the debitage process (Dauvois, 1976; Inizan et al., 1995). The orientation is noted: unipolar, bipolar, orthogonal, centripetal, convergent, multidirectional, undetermined, ventral face\kombewa. Number of previous negatives removals, as well as number of previous negatives accidents are likewise indicated.

Percussion attributes.

The type of butt is described: cortical, flat, facetted, facetted *chapeau de gendarme*, dihedral, point form, linear, undetermined or absent, as well as the position of the impact point: lateral, central, undetermined or absent. The type of bulbs is noted: not prominent, prominent, and/or double.

2 Raw Material Unit analysis: understanding the economy of the production process

A Raw Material Unit – RMU is the material outcome of a knapping event, or a series of knapping events carried out on a specific nodule (Roebroeks, 1988). This permits dividing up the lithic complex into its smallest components, which are each of the single raw pebbles introduced into the site.

In practical terms, the RMU analysis implies spreading out on a table all the material and categorizing it on the basis of litho-type. The deeply altered material and the very small pieces are excluded in the analysis, due to the difficulty of identifying diagnostic characteristics. Subsequently we identify groups of artefacts belonging to a single pebble representing a block or an RMU (Figure 27). The sorting criteria are based on the macroscopic characteristics of lithic artefacts comprehending the presence of alterations, the texture, thickness and colour of the cortex, and the colour of the inner surface of each piece, as well as the technological coherence within each set of pieces.

Among these, colour is a relatively less reliable parameter, since thermic alterations can determine significant colour transformations, and each nodule can present a variation of colours in its inner part. The presence of patina on the surface of some items makes this step even more difficult, so for a better understanding of possible affinities between pieces, we used to wet them. By doing so we were able to detect characteristics that were imperceptible on the dry artefacts.

Figure 27: Example of a RMU, subdivided according to the technological function of each flake.

In this case it is the RMU 177 of Oscurusciuto SU 13.

Completing these procedures took a number of operators several months, but this effort rendered very good results, as we were able to identify a conspicuous number of conjoins and refittings, which may be considered further proof of the reliability of the RMU analysis.

Since the methodology of interpreting, every single nodule relies on subjective estimates, in order to render the analysis more objective, we introduced some additional parameters to evaluate the degree of reliability of each RMU analysis. The estimation of the reliability degree of the RMU was calculated based on the evaluation of the “Refitting Ratio”, the “Variability of the Raw Material”, and the “Uniqueness of the Raw Material”. To wit, the Refitting Ratio expresses the ratio between the number of conjoined or refitted items and the total quantity of elements in the RMU. The Variability of Raw Material represented the degree of internal variability in each single block of raw material (this can be homogeneous or inhomogeneous). The Uniqueness of the Raw Material constituted the degree of inter-RMU variability, namely the formal similarity between different RMUs (these can be unique or not unique). Each parameter has its own numeric value, following which the level of reliability was calculated on the basis of their arithmetical sum (Marciani, 2013; Spagnolo, 2013; Spagnolo et al., 2016).

To record the data in a systematic manner, we developed an Access database enabling us to connect the record of each single nodule with the records of all the pieces comprised in it.

3 Techno-functional analysis: understanding the tool

After understanding the phases related to the production of lithic implements, in this section our aims is to improve the study of target objects. We selected the SU 13, which demonstrated a clear set of debitage goals: flakes, convergent flakes and backed flakes as results of unipolar and convergent levallois.

In this work, we aimed to determine and to understand the way in which the target objects of Oscurusciuto were probably hafted (direct or indirect hafting) and used, i.e. describing which part of these objects would have been the active part (UTFt), and which part the prehensile one (UTFp). The identification, localization and characterization of UTFt and UTFp were achieved through empirical observation of the object and collection of pertinent objective data (edge angles; delineations of surfaces, profile and edges; planes of intersections of surfaces, etc.).

As the identification of the transmitting part is much more difficult, we considered together the prehensile and transmitting part of the object in this work (Soriano, 2000, Boëda, 2001; Bonilauri, 2010; Lourdeau, 2010; Da Costa, 2017; Pedergnana, 2017).

In practical terms, the data collection proceeded as follows: all the target objects of SU 13 (the technological analysis having already been completed, we only selected the pieces already identified as target objects of the debitage) were spread out on a table, and a first selection took place: all the pieces which were too fragmented or where the technical characteristics were not sufficient were excluded from the study. In this way, of 385 target objects we ended up selecting 315 pieces.

Then every single object was studied, photographed and finally drawn upon the basis of their photos using Corel Draw X6 and employing the graphic tablet Wacom Cintique Companion II. In this way, all the information necessary for the identification of UTFt and UTFp were registered in different layers of the program. The superimposition of layers allowed us to present an open and dynamic vision of the pieces and sometimes to propose several possible interpretations for the same pieces.

The particular form of the analysis comprehended taking photos of 5 sides of the pieces, and making a diacritical drawing of them. Finally, all the techno-functional features were reported (Figure 28).

Figure 28: Techno-functional analysis figure of the piece ID 400 from Oscurusciuto SU 13.

Subsequently, we registered all the parameters necessary to define the UTFt and the UTFp in the Access database. The general information describing the target objects was registered on the first page of the database. Consequently, thanks to the inter-related links of the Acces program, we developed two further pages: one to record the UTFt characteristics and the other for the UTFp. Each target object could be support of more than one UTFt and UTFp, correlated to the record of one single piece, thus there might be one or more corresponding records of UTFt and UTFp.

3.1 Definition of the blank

General identification.

ID artefact.

Production-aim.

The target objects of the reduction sequence (based on technological analysis) are: flakes, long flakes, blades, convergent flakes, backed flakes and bladelets.

Technical blank.

The definition of the blank is essential for the definition of a tool. A blank means the support on which the TFUt and TFUp are created. At Oscurusciuto SU 13 we defined blanks on the basis of four parameters: shape of the piece, elongation index, dimension and section.

The shape of the piece is rectangular when there are two parallel\sub parallel cutting edges plus a transversal edge, or two parallel\sub parallel edges: one sharp and the other backed, with or without a transversal edge. Alternatively, it is described as triangular when there are two convergent cutting edges that make a convergent distal end (Figure 29).

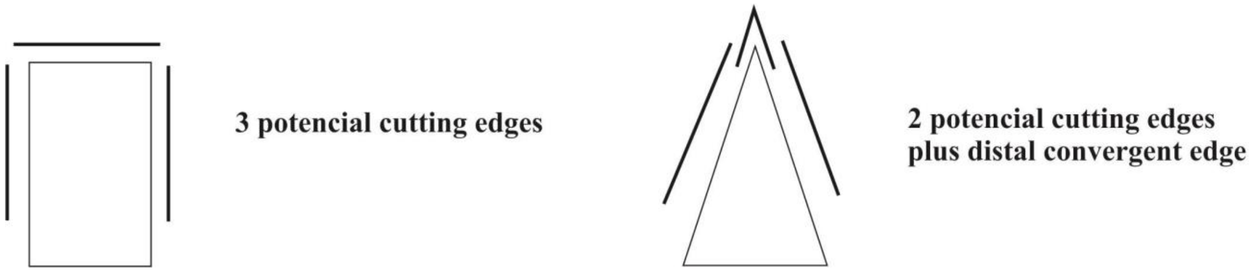


Figure 29: Definition of shapes.

The elongation index, given as the ratio between height and width (Figure 30).

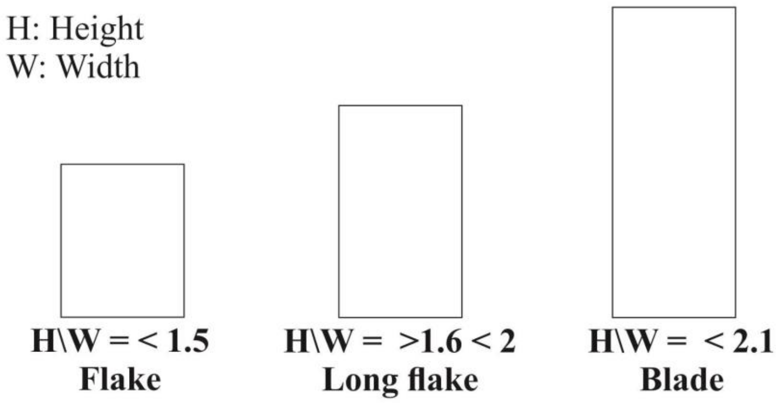


Figure 30: Definition of elongation index.

The dimensional classification of the pieces is based on the graphic of the dispersion in the height of the pieces of Oscurusciuto SU 13. I define a piece as ”small” if its maximum height is ≤ 20 mm, “medium” if it is between 21 and 34 mm and “big” if it is ≥ 35 mm (Figure 31).

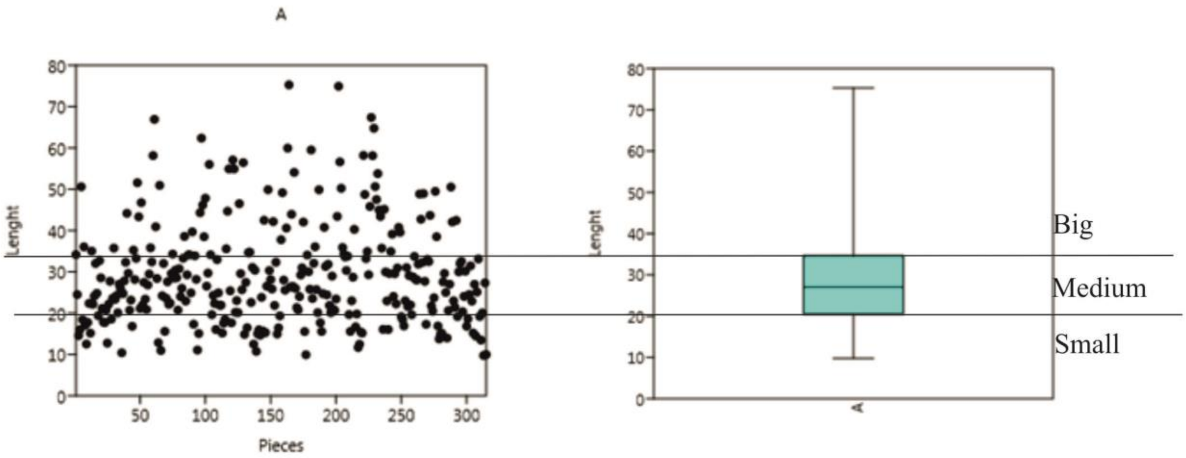


Figure 31: Definition of size.

Points dispersion graph and box plot of the height of pieces showing the most significant dimensional classes (Graphs realize with Past 3.16).

The section of the piece describes the shape of the item as well as the number of cutting edges. Thus triangular and trapezoidal shapes have two cutting edges, whereas a rectangular triangle and a rectangular trapeze have only one cutting edge (Figure 32).

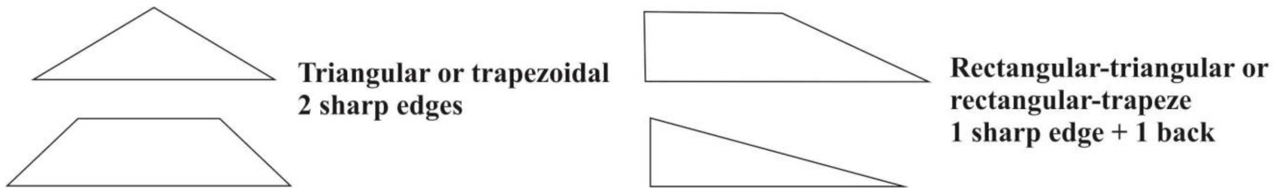


Figure 32: Definition of the section.

3.2 Transformative parts (UTFt)

A UTFt is determined by the presence of homogeneous and regular technical parameters on a pieces edges or on a portion of it.

<u>General identification and quantity.</u>

UTFt ID number. If on a piece there is more than one UTFt, they are registered as UTFt I, II, III and so on.

<u>Definition of UTFt types.</u>

The UTFt type could be cutting edge, and trihedron.

The cutting edge is a dihedron made up by the intersection of two surfaces, delineated by a regular plane section and a cutting angle (Lepot, 1993; Soriano, 2000). Actually, there are two angles to consider: the contact angle (CA) and the piercing angle (PA). The former (CA) refers to the angle of the first portion of the tool entering into contact with the material, the latter (PA) is the prosecution of this angle. CA and PA could coincide, and have the same measurements (n.b: not retouched pieces) alternatively, they could differ when the edges of the piece are modified, i.e. when the angle touching the material and the angle actually entering it are different. (Figure 33) (Lourdeau, 2010).

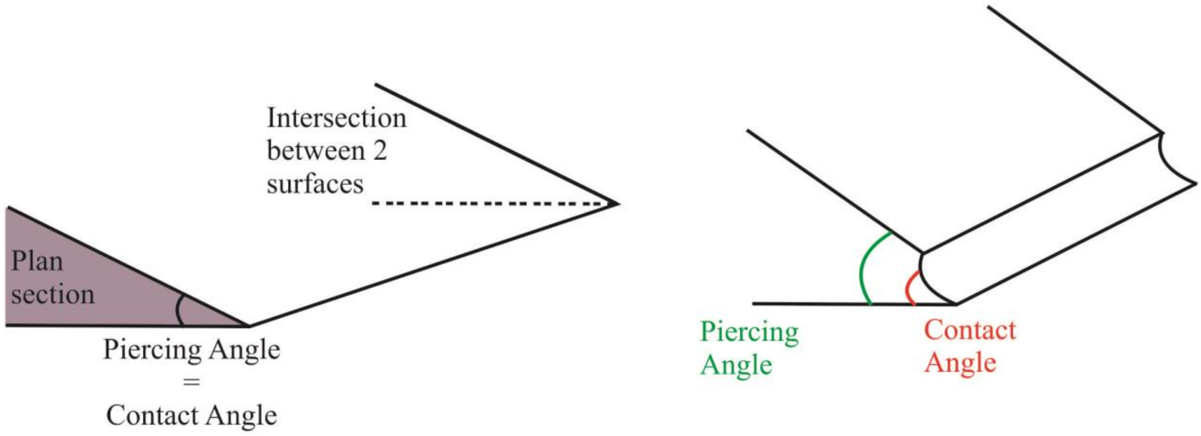


Figure 33: Types of UTFt: cutting edge.

When defining the cutting edges we consider their location (distal, mesial, proximal, mesio-distal, mesio-proximal; left or right) (Figure 34); furthermore, delineation (the frontal view could be: rectilinear, convex, concave and denticulate; the profile view could be: rectilinear, convex and wavy) (Figure 35, 36); and finally extension (expressed in mm); angles and surface relations (Plane/Plane, Plan/Convex, Plan/Concave, Convex/Convex, Concave/Concave) (Figure 37) (Lepot, 1993; Boëda, 1997; 2001; Bonilauri, 2010; Lourdeau, 2010; Lucas, 2014; Da Costa, 2017).

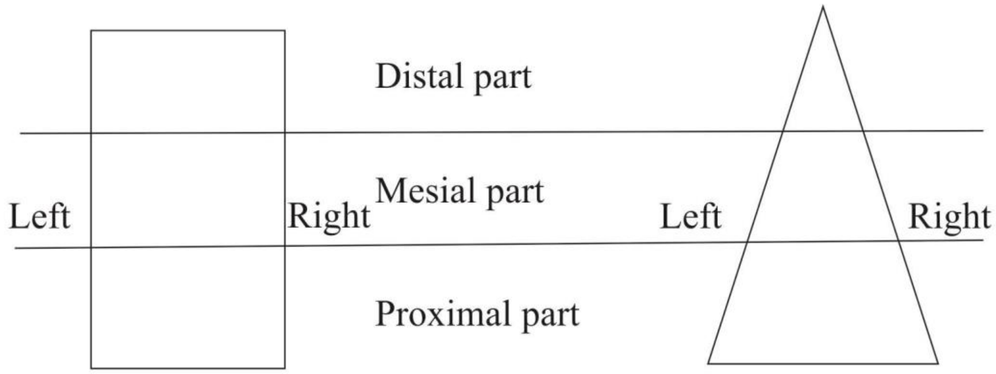


Figure 34: Location of UTF.

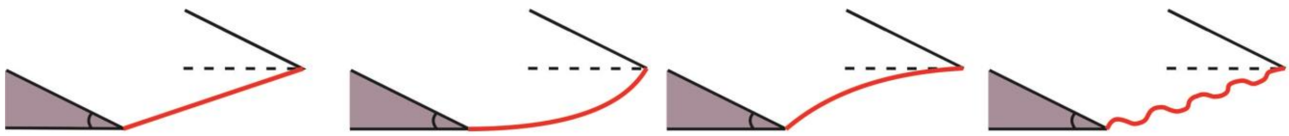


Figure 35: Frontal delineations of UTFt cutting edge.

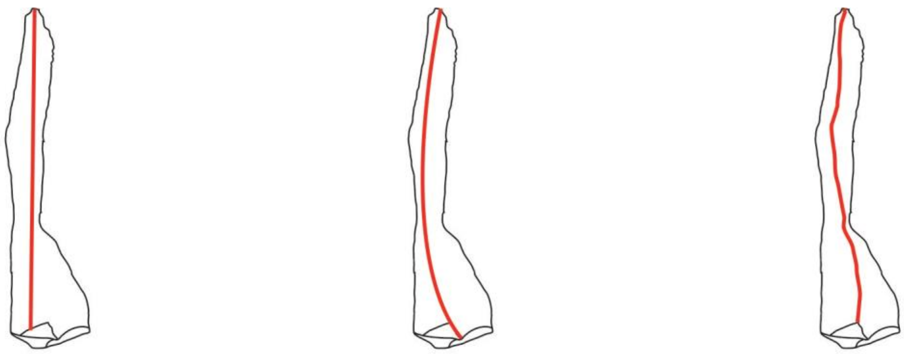


Figure 36: Lateral delineations of UTFt cutting edge.

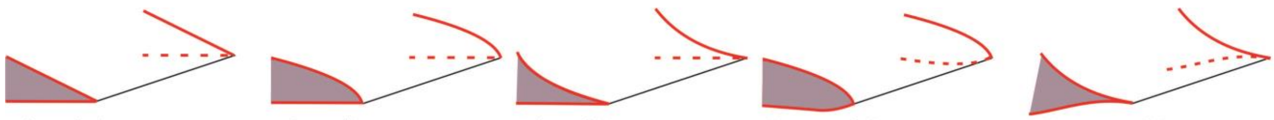


Figure 37: Surface relations of UTFt cutting edge.

Trihedron

Trihedron is defined as a geometric figure composed of three planes meeting in a single vertex (Figure 38). As TFUt the trihedron is a punctual TFU, which means that it does not have an extension, but it can be combined with cutting edges. In order to define the trihedron we consider its location (Figure 34), surface relations (Figure 37), and both angles, the one consisting of the dorsal and ventral surfaces (which coincide with the plane section) and the one consisting of the two sides of the pieces, which we call the openness angle (Figure 38) (Rocca, 2013; Aureli et al., 2016).

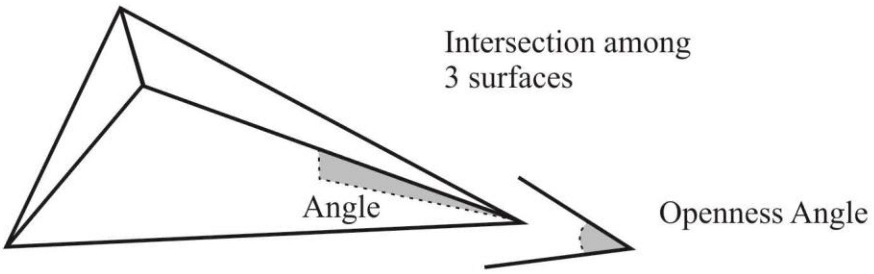


Figure 38: Type of UTFt: trihedron.

If there are macro-traces visible (to the naked eye or through a magnifying glass), we note their position and extension. If there is more than one UTFt on the same blank we register the kind of relation existing between them: contiguous if the two (or more UTF) are in an adjacent position and in contact, or opposed if the two (or more UTF) are facing each other (Figure 39).

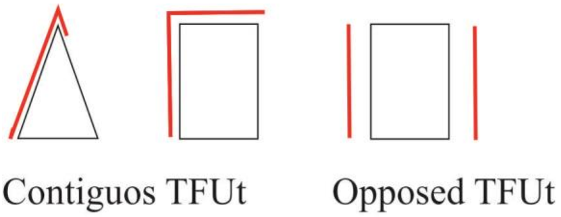


Figure 39: TFUt interrelations.

3.3 Prehensile parts (UTFp)

A UTFp is usually defined in relation to the UTFt (Lepot, 1993; Soriano, 2000; Mello, 2005; Lourdeau, 2010; Rocca, 2013; Da Costa 2017) or thanks to the presence of use-wear studies (Bonilauri, 2010).

<u>General identification and quantity.</u>

UTFp ID number, but when on a piece there is more than one UTFp, they are registered as UTFp I, II, III and so on.

<u>Definition of UTFp type.</u>

In the absence of evident grip-traces or adhesive ditto we consider as potential UTFp all the 90° sides of a piece, such as backed sides, cortical sides, or the back created by a hinged accident or a siret fracture, and more in general any discontinuous and irregular edges (Soriano, 2000). The butt is also considered as a potential grip, in fact, in particular regarding the levallois *chapeau de gendarme* the ergonomic features of its shape and the proximal part of the flake have already been ascertained in experimental studies (Baena Preysler et al., 2016).

We also describe the location, angles and extension of UTFp. We should especially point out the interrelations and combinations between backed sides, which are essential parameters when defining the structure of the tool (Figure 40) (Marciani et al. *in press*; Da Costa, 2017).

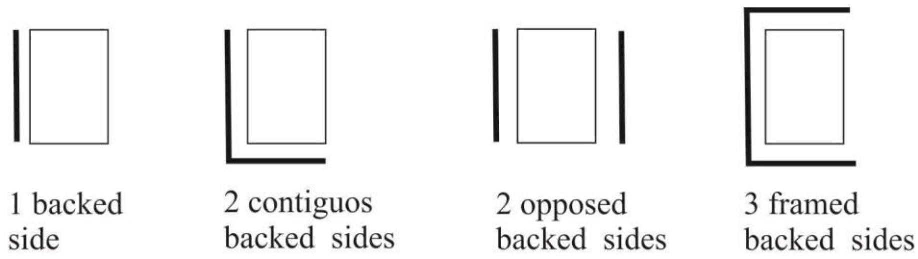


Figure 40: Backed sides interrelations.

<u>Techno-type</u>

The definition of techno-functional groups or techno-types is based on the recurrent combination between UTFt and UTFp in a particular support. After analysing each single piece, understanding the functionality of each single UTF, we identified groups of pieces which share the same structural and functional features, pieces which on the same blank show the same organization of UTF (Marciani et al. *in press*).

In this way, we were able to interpret the techno-functional structure of each tool. Subsequently, we had to test our hypotheses on the effective function and hafting of these tools in Prehistoric times. S. Arrighi studied the microscopic traces on these objects investigating the use-wear and polishing of these tools. The observations were made by means of a 3D digital microscope Hirox KH 7700, property of the University of Siena. For the LPA analysis the device was equipped with a MX-G 5040Z body and an AD-5040 Lows lens, for HPA examinations with an MXG-10C body and an OL 140 II lens (the results of these analyses are listed in paper 2 of this thesis).

4 Reference section

After this analytical work which enabled us to better understand the production of lithic tools and gave us an idea of the economic management of the raw material, as well as insight into tool structure and function at Oscurusciuto, we decided to compare these data with other available references.

In order to build a consistent reference section, main scientific publications were examined, the chronological boundary being the late Middle Palaeolithic (end of MIS 3) namely between 60,000 and 40,000 years BP. As a geographical boundary I selected the areas occupied by Neanderthals in the Italian peninsula. In this thesis I deliberately did not consider the transitional cultures or the Aurignacian culture related to modern Humans. This because the aim of this work was to study the Oscurusciuto rock shelter sequence, and since there are no traces of modern human occupation at Oscurusicuto, I decided to restrict this work to the investigation of the lithic technology of the last Neanderthals.

Once the data collection had begun, I realized that there were problems in the form of nomenclature and terminology, mostly due to the different methods applied in the study of lithic assemblages. Another problem was comparing chronological data collected through different methods. To be able to compare these data I decided to homogenize them, standardizing the terminology to the one employed in the study of Oscurusciuto, and then to extrapolate from the publications regarding other sites only the required information.

All the data was registered and standardized in an Access database especially realized for this research. The criteria employed to refer to the general characterization of the site and its location (name of the site, type of site, geographical coordinates, state, region, levels, the presence of human remains and fauna).

I then considered the chronology (MIS, direct dating, indirect dating, relative chronology, dating methods). Finally, I focused on the lithic collection, which is the main object of this work. I considered the concept, method of debitage and target product. Then I considered the type of the most commonly used raw material and the type of initial block (pebbles, nodules, tabular or others). To be able to work simultaneously on different levels of the same site, I generated a separate record describing each archaeological level examined.

5 Legend of symbols used for the graphics section

For technological analysis, we used the following symbols (Figure 41).

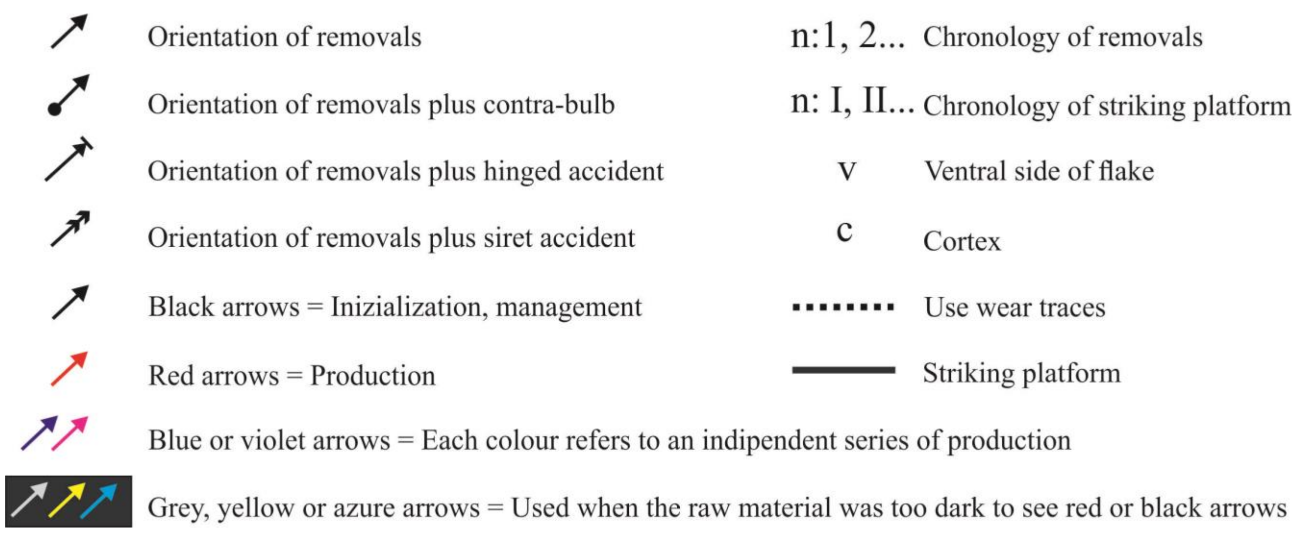


Figure 41: Symbols used in the technological analysis.

For techno-functional analysis we use the following symbols (Figure 42).

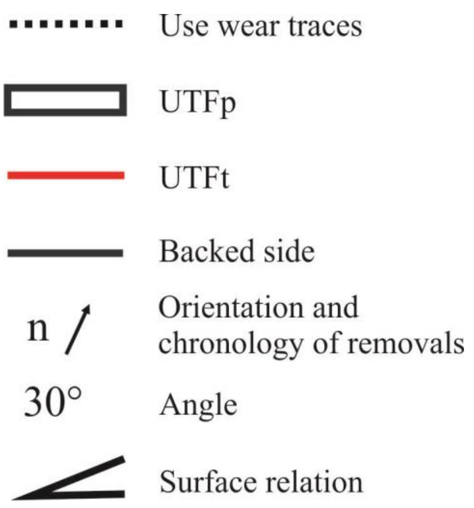


Figure 42: Symbols used in the techno-functional analysis.

For the overview diagram we use the following symbols (Figure 43).

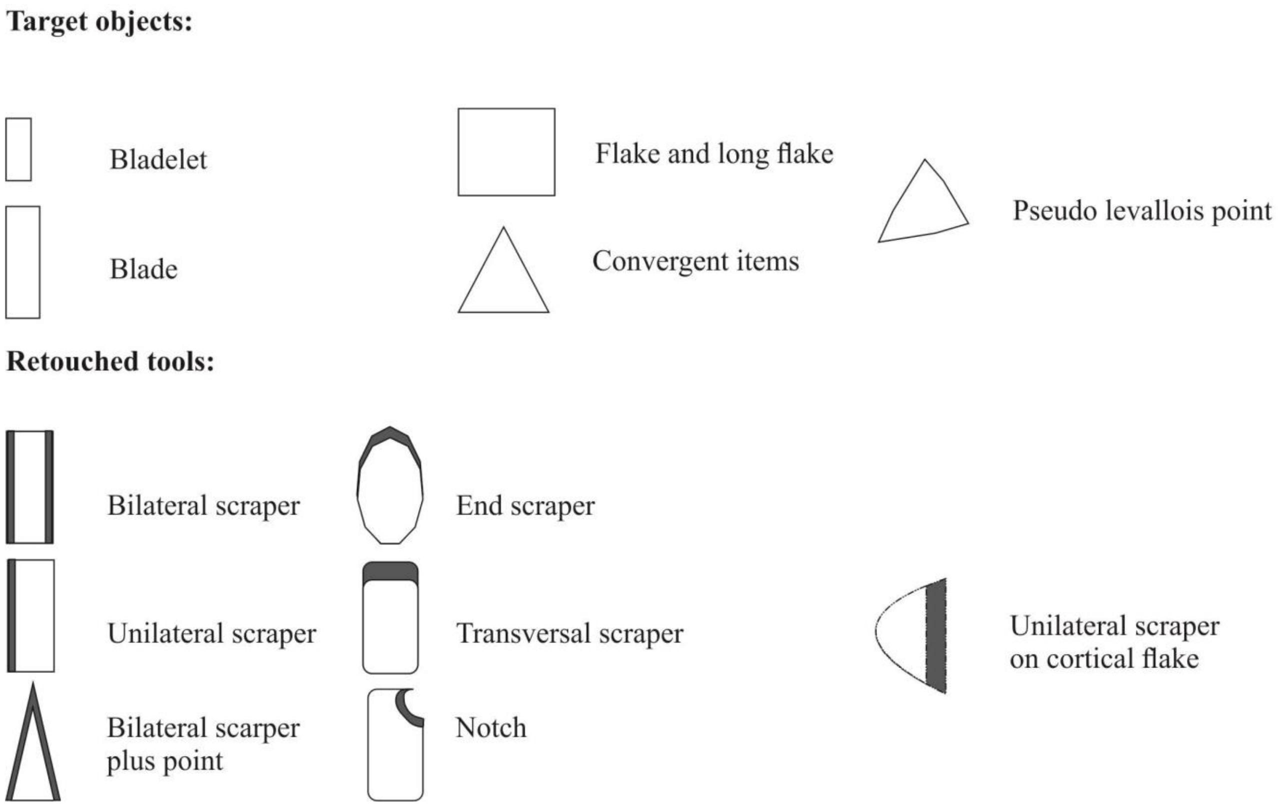


Figure 43: Symbols used in the overview sections.

6 Conclusions

The work developed in part one of this thesis involved in solely creating the right preconditions to the actual study of the artefacts was perhaps disproportionate; on the other hand it allowed us/me to define and understand the actual generation and utilization of the same with a greater degree of certainty and control.

Part two

Results

V MATERIAL

1 Quantity and quality

The four levels which are the object of this thesis encompass a huge quantity of lithic material. A total number of 48,385 items have been inventoried and studied during these three years (Table 7).

SU	Total	%
15	5992	12.4
14	3833	7.9
13	7504	15.5
11	31056	64.2
Total	**48385**	100.0

Table 7: Number of items in each SU.

The greater majority of the items are included in the first (44.1%) and the second (22.8%) dimensional classes (DC). This data is not surprising as it is well-known that flaking activity produces huge quantities of tiny pieces (Table 7).

The percentage of fragmented items is very high, especially in the first and second DC, the rate of fragmentation progressively decreasing constituting less than half of the sample for the largest of the DC (the fifth dimensional class – 49. 2%) (Table 8).

DC	SU 15		SU 14		SU 13		SU 11		Total		%
	n.	**%**	**n.**	**%**	**n.**	**%**	**n.**	**%**	**n.**	**%**	**frag.**
1	3555	59.3	2524	65.9	4236	56.4	11028	35.5	21343	44.1	70.5
2	782	13.1	543	14.2	1413	18.8	8276	26.6	11014	22.8	63.9
3	384	6.4	229	6.0	528	7.0	3873	12.5	5014	10.4	61.4
4	191	3.2	120	3.1	261	3.5	2078	6.7	2650	5.5	62.4
5	1080	18.0	417	10.9	1066	14.2	5801	18.7	8364	17.3	49.2
Total	**5992**	100.0	**3833**	100.0	**7504**	100.0	**31056**	100.0	**48385**	100.0	63.9
% frag.	76.6		67.2		50.3		64.4		63.9		

Table 8:The dimensional classes with their relative percentage of fragmented pieces.

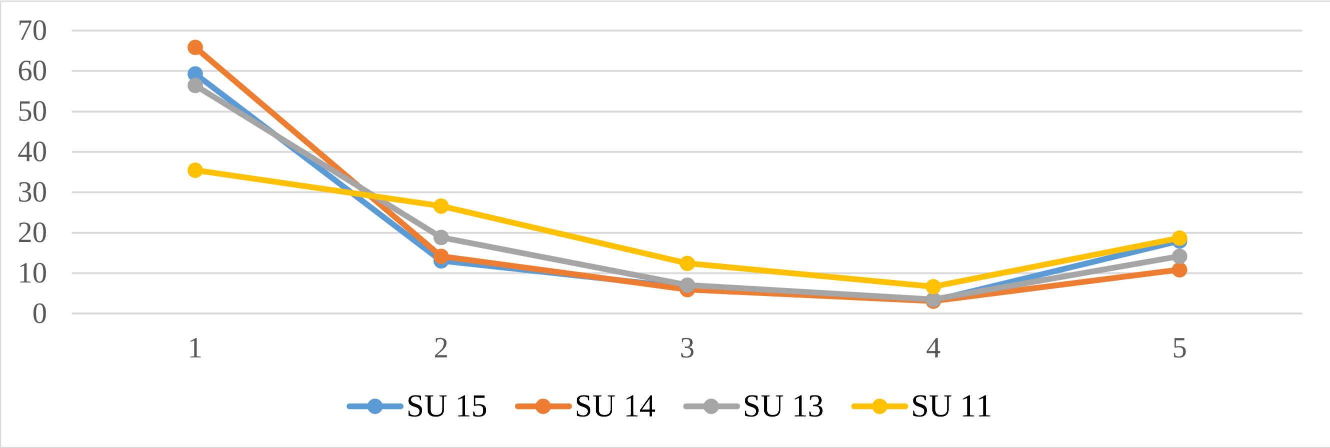


Figure 44: Dimensional classes, line graph.

Y axis = percentage of pieces, X axis = dimensional class, each line representing a SU.

The line graph (figure 44) shows the trends of the dimensional classes regarding the items from each SU. We note that SU 15, SU 14 and SU 11 have similar trends: the highest values represents the items of DC 1, then it abruptly decreases in the 2 DC, flattening out between the DC 3 and DC 4 and finishing with a slight increase in the 5 DC.

While the SU 11 shows the same trend, i.e. a higher percentage of pieces of the 1 DC, followed by a slight decrease in the 2, 3 and 4 DC and terminating in an increase of the 5 DC. In this case, however, the percentage of pieces in the 1 DC is comparatively lower compared to the other levels.

The recovered objects are mostly in a very good state of preservation, the edges are fresh, with well-preserved macro-traces that are visible even to the naked eye (Table 9). Use-wear analysis on a selected groups of items is still ongoing (by S. Arrighi).

SU	SU 15	SU 14	SU 13	SU 11	Total
Macro-traces:	442	131	221	1682	2476

Table 9: Presence of micro traces.

A slight colour alteration is present on the cherty limestone items however, this does not affect their evaluation because the alteration is quite constant and very clearly recognizable. Double patina or floated alterations due to water influence are absent.

Due to the presence of several hearths in the examined levels, some artefacts show evidence of fire alteration (alterations in colour: reddish or darker hues, cupped holes, and drying-out of the items). In the following table, we relate the presence of fire alterations to the presence and the number of hearths in the level in question (Table 10).

Fire alteration	SU 15	SU 14	SU 13	SU 11	Total
No	5935	3798	7262	29343	46338
Yes	57	35	242	1713	2047
Presence\number of hearths	0	0	10	>34	>44
Total	5992	3833	7504	31056	48385

Table 10: Fire alteration, number of hearths in each level.

This symbol > (major) (Table 10) indicates that the number of hearths is most probably larger than the one indicated in the table, as during excavation it was not possible to identify the exact limits of each fireplace due to the high quantity of superimposed hearths. The levels showing a large number of hearths also yielded a greater number of items with combustion traces (Figure 45).

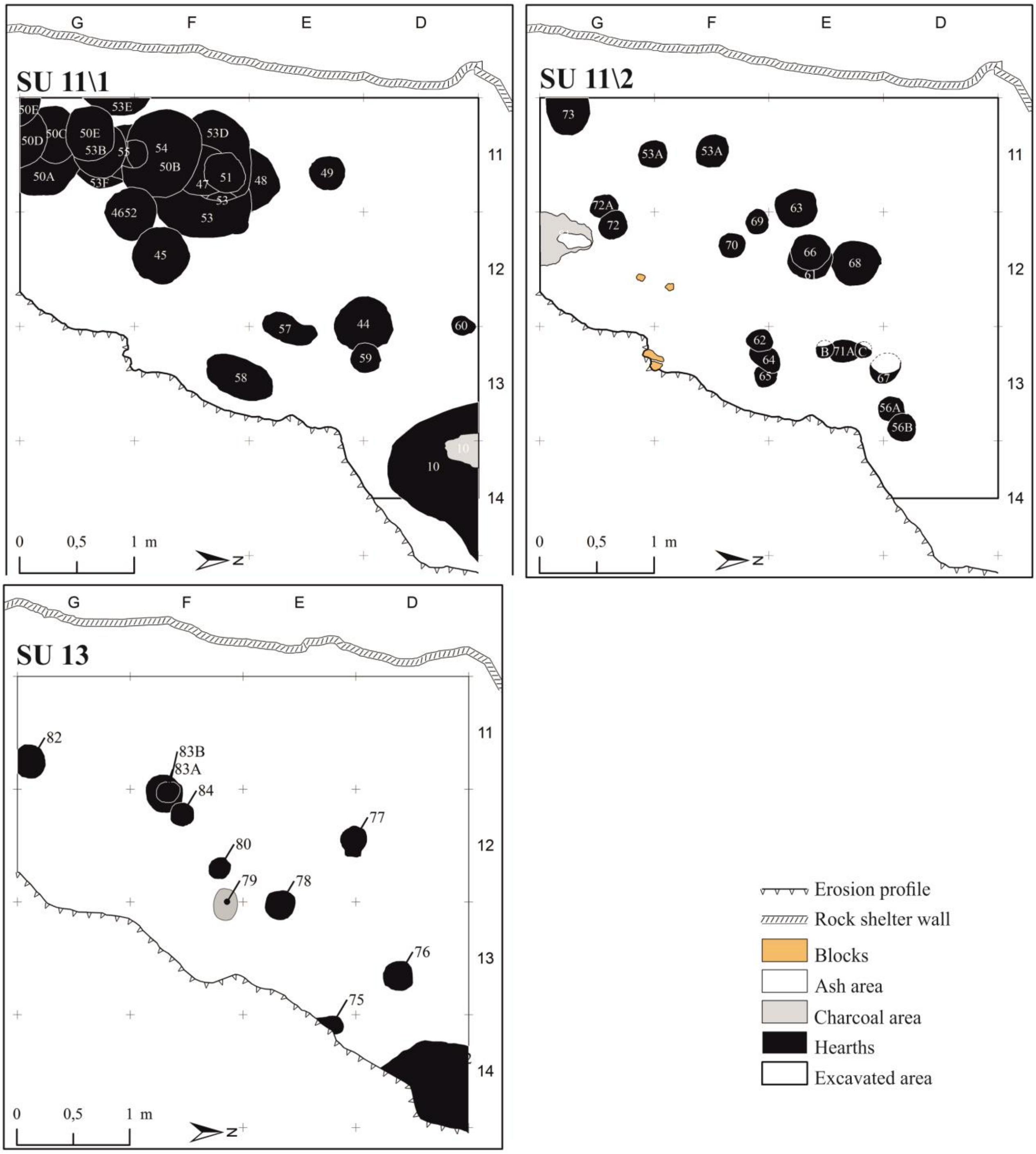


Figure 45: Planimetries of Su 11 (cut 1 and 2) and SU 13 (Modified by Spagnolo 2017).

Generally, the lithic complex shows an interesting and heterogeneous technical composition, and almost the totality of the items originates from debitage production (Table 11). The presence of raw pebbles, hammerstone, micro flakes and debris proves that knapping activity took place in situ (Table 11).

Technological classes	SU 15		SU 14		SU 13		SU 11		Total	
	n.	%	n.	%	n.	%	n.	%	n.	%
Pebbles	30	0.5	4	0.1	8	0.1	31	0.1	**73**	0.2
Cores	53	0.9	13	0.3	33	0.4	175	0.6	**274**	0.6
Hammerstone	2	0.0	4	0.1	0	0.0	4	0.0	**10**	0.0
Flakes	1204	20.1	592	15.4	1528	20.4	6992	22.5	**10316**	21.3
Micro flakes\Debris	4564	76.2	3176	82.9	5815	77.5	22354	72.0	**35909**	74.2
Undetermined	139	2.3	44	1.1	120	1.6	1500	4.8	**1803**	3.7
Total	**5992**	100.0	**3833**	100.0	**7504**	100.0	**31056**	100.0	**48385**	100.0

Table 11: technological classes.

NB: micro flakes and debris are comprised in the 1-2-3 DC, respectively entire or fragmented; undetermined comprises only items from the 4-5 DC (for more clarification see chapter IV paragraph 1.1 General attributes).

Not surprisingly, the great majority of the items falls in the classes of micro-flakes and debris, representing 74.2 % of the assemblage. This great quantity of items is significant because it show that knapping and\or retoucing activity took place in situ. If plotted and interpreted via a geodatabase showing activity areas devoted to diverse actions this might provide further insight. As it is, this data constitutes a "background noise" preventing the appreciation of other data, which is why as far as the qualitative technological analysis is concerned - we shall limit ourselves to the other 10,714 items (highlighted in green - Table 11). This, in our opinion, allows a better understanding of the dynamics in the production of lithic tools at Oscurusciuto. The technical characteristics of each level will be presented in the chapter devoted to the results regarding each single layer.

The amount of retouched pieces at Oscurusciuto is unquestionably low, only 1% of the complex was retouched (Table 12 last line). In the four studied levels the class most selected to be retouched was flakes (Table 12).

Technological classes	SU 15		SU 14		SU 13		SU 11		Total	
	n.	%	n.	%	n.	%	n.	%	n.	%
Pebbles	0	0.0	0	0.0	0	0.0	2	0.5	**2**	0.4
Cores	2	3.1	0	0.0	0	0.0	4	1.0	**6**	1.2
Flakes	57	89.1	19	90.5	30	88.2	350	90.7	**456**	90.3
Micro flakes\Debris	0	0.0	2	9.5	3	8.8	9	2.3	**14**	2.8
Undetermined	5	7.8	0	0.0	1	2.9	21	5.4	**27**	5.3
Total of retouched pieces	**64**	100.0	**21**	100.0	**34**	100.0	**386**	100.0	**505**	100.0
Total	**5992**	**1.1**	**3833**	**0.5**	**7504**	**0.5**	**31056**	**1.2**	**48385**	**1.0**

Table 12: Number of retouched pieces realized on the technological classes.

The first total (and percentage) represent the amount of retouched pieces. The second total refers to all the items of each level and the percentage of the retouched items in each level.

2 Raw materials: reference collection

To be able to categorize the raw material which was used at Oscurusciuto, we created a small reference collection based on material still available today at the Ginosa ravine terraces. Furthermore, we performed preliminary experimets to test the knappable qualities of each material, and thin sections from various samples of material in order to create a collection of cleary distinguishable raw materials. The collection of raw material is not comprehensive, and it only aimed at facilitating the identification of the major classes of knappable raw material. In fact, the supply being local and from secondary sources, we did not feel able to make conclusions regarding outcrops or distances between primary sources and the rock shelter.

We identified five main classes of raw materials: jasper, cherty limestone, chert, limestone and quartz sandstone. On the one hand, chert, limestone and quartz sandstone were clearly identifiable without microanalysis, on the other hand, we had some problems in the classification of jasper and cherty limestone. Consequently we decided to proceed with a microanalysis. Eight flakes belonging to the Oscurusciuto mixed items (*rimaneggiato*) were selected to be sampled in order to realize a number of thin sections. These pieces were photographed and subjected to a technological analysis following which, Dott. Terrosi produced the thin sections. Subsequently, Prof. Foresi made the analysis and the attribution of these samples. Three pieces were finally analysed employing a SEM microscope (all these analyses were kindly performed by the colleagues of the Sezione di Scienze della Terra, Dipartimento di Scienze Fisiche, della Terra e dell'Ambiente, at Università di Siena).

Following the description of these litho-types, their macroscopic characteristics (microscopic for the ones that were sampled), knappable qualities, and geological features were listed.

2.1 Cherty limestone

Macroscopically, the cherty limestone litho-type displays great variety. The items from this class show both fine and rough granulometry, and their texture is dense and homogeneous. Major variation is found in colour; in fact, with items presenting several hues of green, grey and yellow (Figure 46). Some items are bi-coloured or three-coloured, showing one exterior colour, whereas a few cm below the cortex the colour changes again, to change abrubtly yet again to another colour in the centre of the item (Figure 46).

Pebbles of cherty limestone are very hard to flake; using a hard hammerstone it is necessary to apply quite a great amount of force to split it. Consequently, the bulbs on the flake remains very prominent, and it is sometimes necessary to strike several times to obtain the desired product. In the archaeological material this behaviour is evidenced in the items showing prominent bulbs, and in some cases even double bulbs are recorded.

Cherty limestone is found at Oscurusciuto in the form of pebbles originating from secondary sources.

Figure 46: Varieties of cherty limestone, archaeological items, macroscopic view.

The following four samples were attributed by Prof. Foresi to the macro class of cherty limestone based on their microscopic features, on the absence of radiolarians and the presence of silica.

The samples 1, 2 and 7 present homogeneous texture, absence of radiolarians and presence of small black spots (Figure 47, 48, 49). In sample 2 there are planktonic foraminifera (Figure 48). Sample 5 has a very fine, grey matrix with sporadic radiolarians and a grey nodules of crossed nichol, and its colour is different from the previous three samples (samples 1, 2, and 7) (Figure 50).

The samples 1, 5 and 7 were further analysed by means of the SEM microscope in order to verify the presence\absence of calcite. This analysis clearly showed that calcite was almost absent in all the samples. On the other hand, all samples showed a great amount of siliceous components (especially samples 1 and 7), as well as abundant chlorite and phyllosilicates. In all the samples there are several oxides: in sample 1 titanium oxides were identified; whereas in sample 5 iron oxides, manganese, barium sulphates and sulphides were identified. In sample 7 iron oxides were recovered.

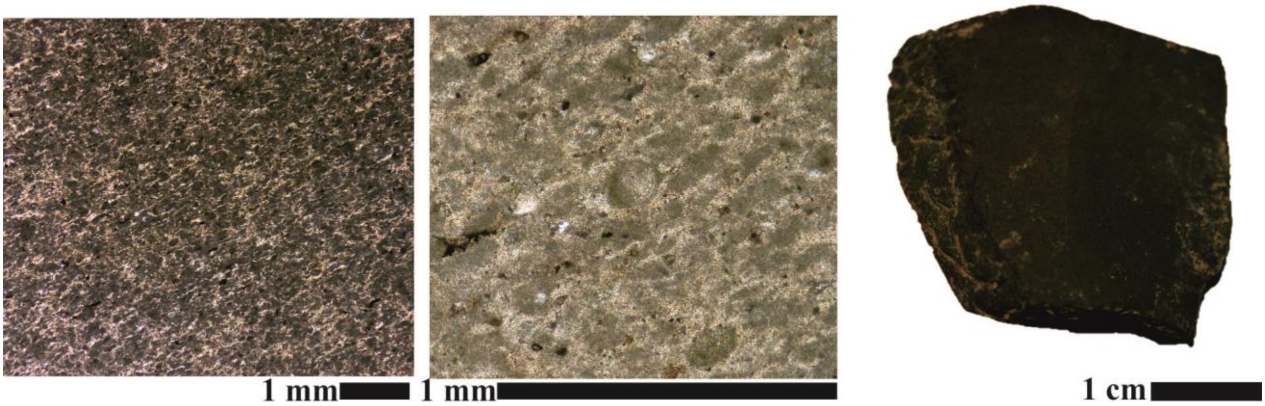


Figure 47: Cherty limestone sample 1, thin sections and macroscopic view.

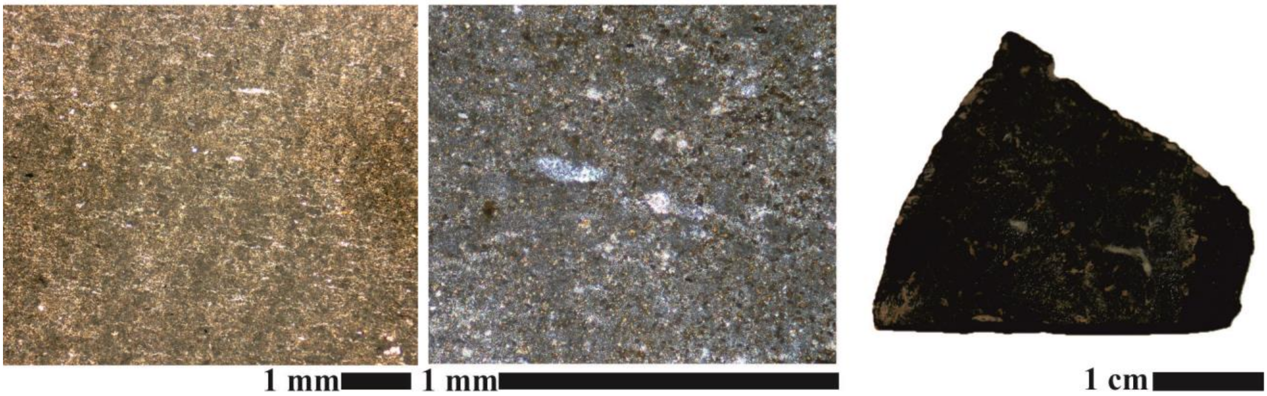


Figure 48: Cherty limestone sample 2, thin sections and macroscopic view.

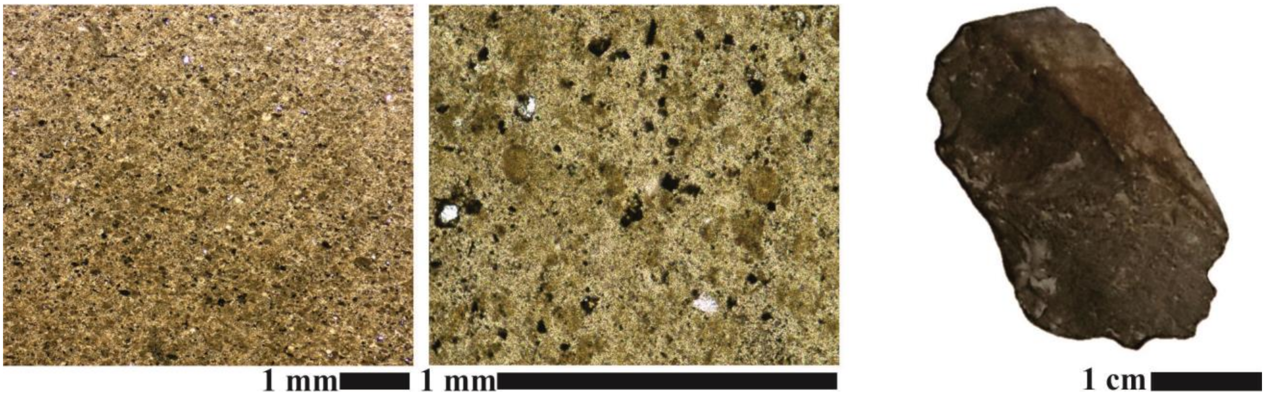


Figure 49: Cherty limestone sample 7, thin sections and macroscopic view.

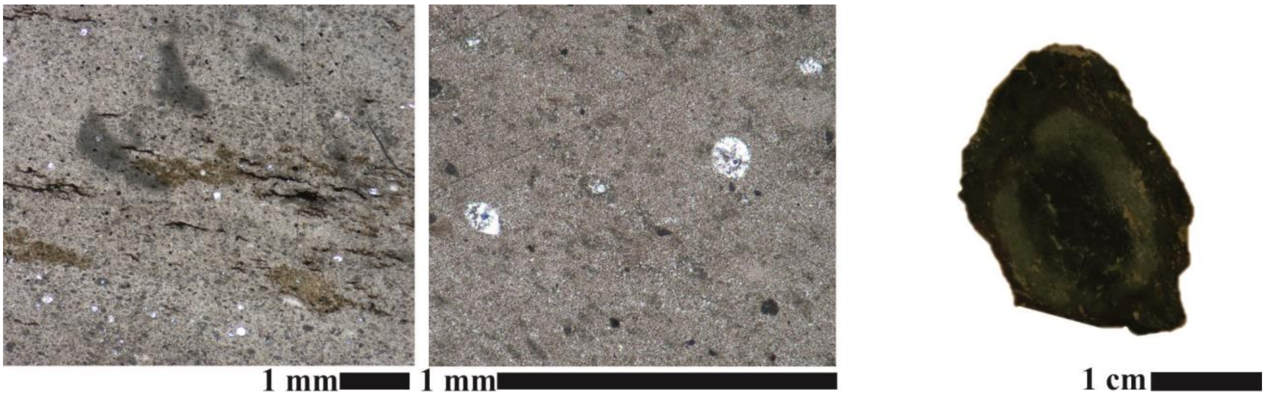


Figure 50: Cherty limestone sample 5, thin sections and macroscopic view.

2.2 Jasper

Macroscopically the jasper litho-type is represented in a clearly defined group of items characterized by a homogeneously dense, opaque and slightly translucent texture. The surface of these items is smooth. The most frequent colours is red, green or a combination of hues of of both colours in the same piece (Figure 51), whereas yellow was rare. The cortex of these pieces is very smooth, thin (between 1 and 3 mm) and homogeneous.

Pebbles of jasper are not very hard to flake; especially with the more homogeneous ones, the strikes easily produce flakes as the impact strike is easly controlled. The technological examination of these pieces is very easy, as the scars on their surface are clearly readable, and features like lancets and percussion waves are clearly visible too.

This type of rock comes from the solidification of oceanic red mud mixed with radiolarians; their red colour is caused by the presence of oxide.

Figure 51: Varieties of jasper, archaeological items, macroscopic view.

The samples 3, 4, 6, 8, despite their differences, are clearly defined as jasper (Figure 52, 53, 54, 55).

In sample 3 two strata are visible, one lighter and one darker. Especially in the darker stratum, the reddish one, whitish spherical forms (spumellaria radiolarians) are clearly visible (Figure 52).

Sample 4 is a jasper similar to the previous one, but presenting a thin, detritus filament (Figure 53).

Sample 6 is similar to the previous two sections, and contains a great amount of dispersed radiolarians (Figure 54).

Sample 8 is clearly jasper with a large and dense dispersion of radiolarians (radiolarite lithotype), where the elongated forms seem to be of a nassellaria type (Figure 55).

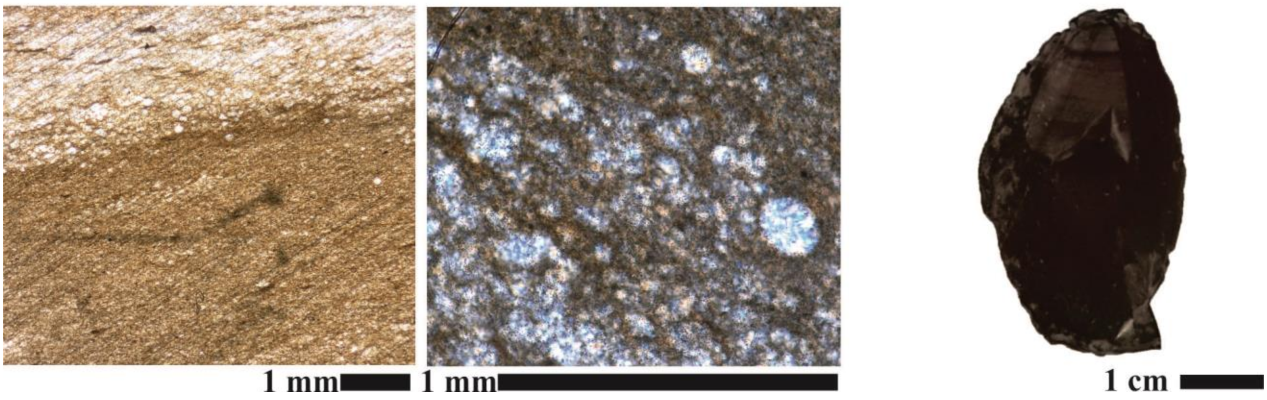


Figure 52: Jasper, sample 3, thin sections and macroscopic view.

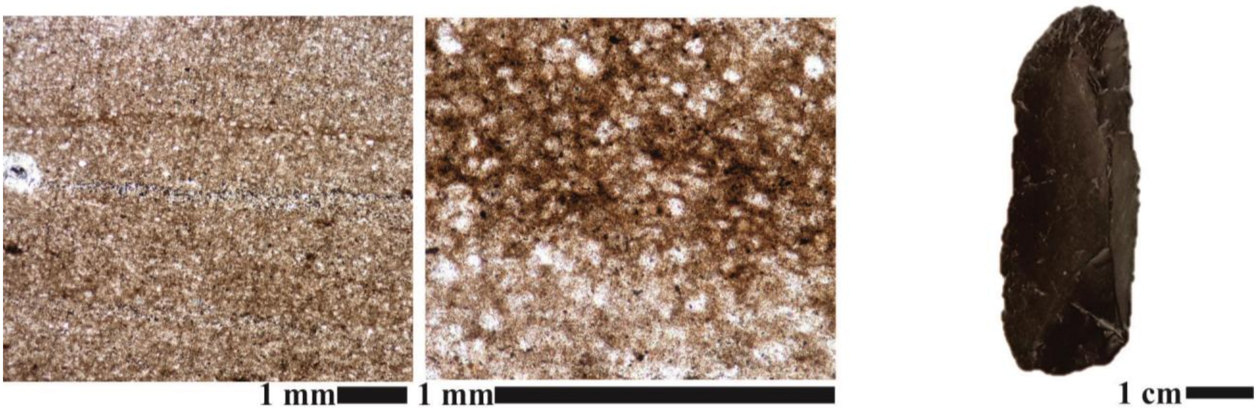


Figure 53: Jasper, sample 4, thin sections and macroscopic view.

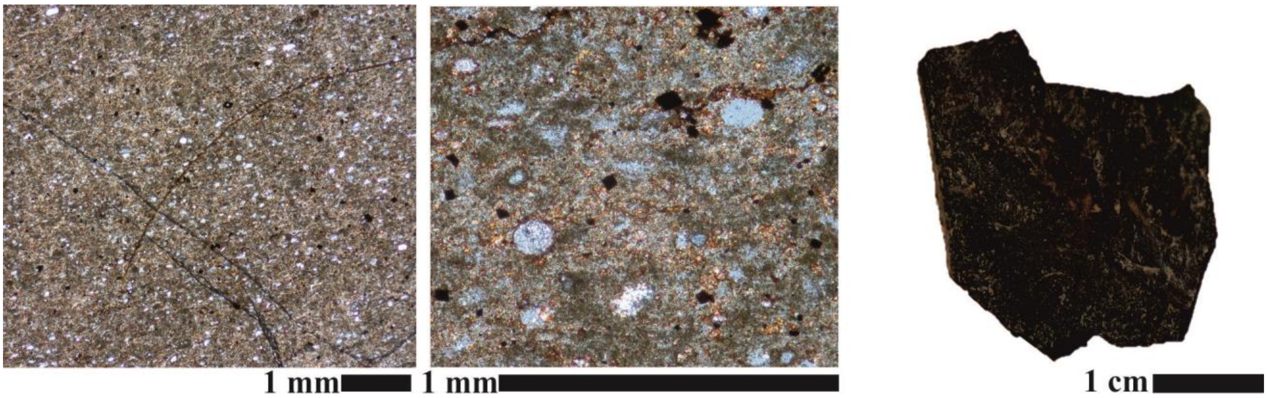


Figure 54: Jasper, sample 6, thin sections and macroscopic view.

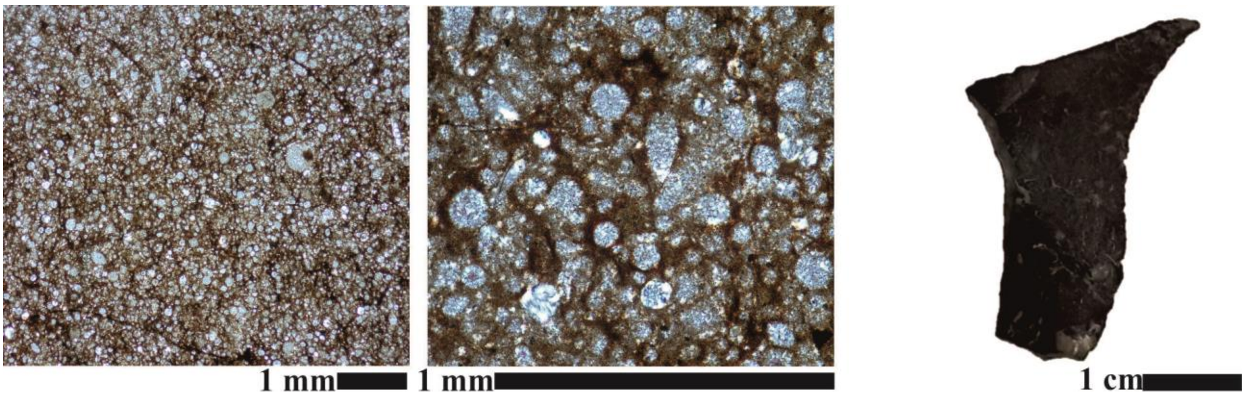


Figure 55: Jasper, sample 8, thin sections and macroscopic view.

2.3 Chert

Chert is composed of fine-grained silica, characterized by a semi-vitreous to dull lustre. The texture is dense and homogeneous, usually with a fine granulometry. Its colour at Oscurusciuto is white, pink, light blue or green, sometimes black or dark blue (Figure 56). The cortex of these items can be smooth or rough and oscillates between a few mm to 5 mm.

Pebbles of chert are not very hard to flake. As with jasper, the knapping activity is easily controlled and examination is relatively simple.

Chert is a sedimentary rock originating from the deposition of silica. At Oscurusciuto it was found in the form of pebbles.

Figure 56: Varieties of chert, archaeological items, macroscopic view.

2.4 Quartz sandstone

The class of quartz sandstone is represented by a group of items characterized by a rough granulometry and by the clear presence of a great abundance of quartz grains. These items present a variety of colours: yellow, light grey and light blue, but the majority presents dark hues of blue, black and red (Figure 57).

Pebbles of quartz sandstone are very hard to flake, not least because of the presence of numerous internal fracture planes. From a technological point of view these objects are quite complicated to examine, especially with regard to the orientation of the negatives.

This type of rock comes in the form of pebbles from secondary sources.

Figure 57: Varieties of quartz sandstone, archaeological items, macroscopic view.

2.5 Limestone

The items of limestone show homogenous chalky surfaces, colours being usually lighter hues of yellow, orange or white (Figure 58).

Their knappable qualities are not very good, as they are brittle, and consequently it is difficult to realize the desired object. As for the technological examination, their homogeneous, chalky surfaces sometimes impede a proper interpretation of the direction of the strikes. Objects of this raw material were not very numerous.

Figure 58: Varieties of limestone, archaeological items, macroscopic view.

3 Provenance

The supply of the five main classes of raw material found at Oscurusciuto was strictly local. The pebbles were found in the secondary formation of the marine and fluvial terrace deposits near the site. The pebbles of cherty limestone, jasper, chert and quartz sandstone could be sourced from the conglomeratic formation in a sandy limestone matrix or along the fluvial bed. Their geological origins are identified as the Conglomerato D'Irsina, located in the Murge di Matera e di Laterza and along the Bradano valley (Boenzi et al., 1971) (Figure 59).

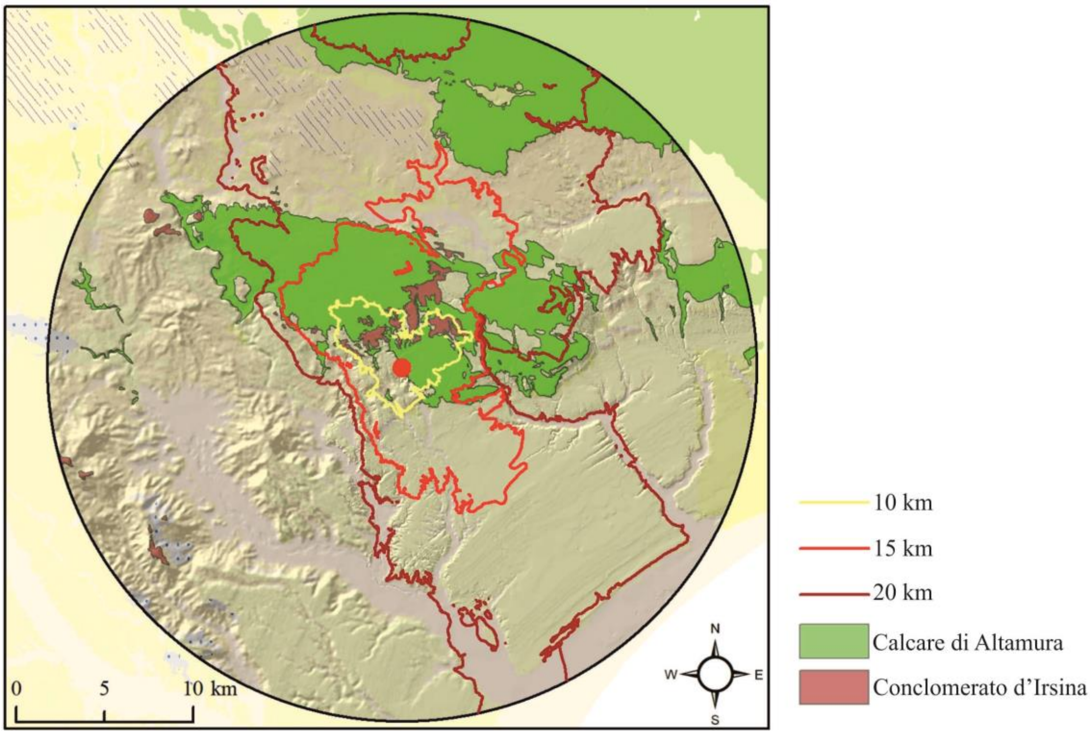


Figure 59: Outrcops of the geological sources of raw material (modified from Spagnolo, 2017).

4 Raw materials at the Oscurusciuto rock shelter

The most common raw material at Oscurusciuto in the four levels examined was cherty limestone (46%) followed by jasper (33%) (we did not consider the pieces of the 1 and 2 DC). (Figure 60).

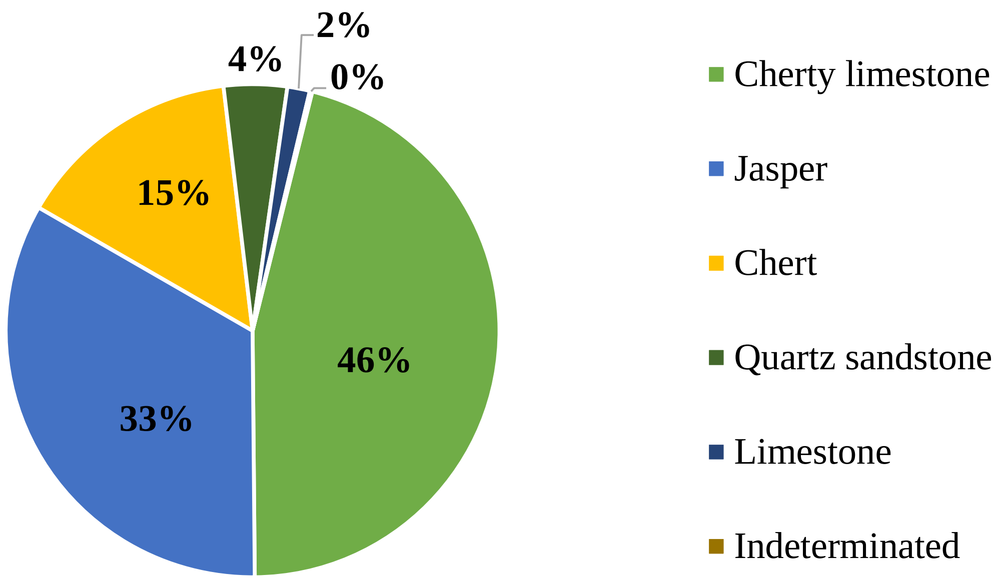


Figure 60: Percentage of utilized raw material in levels 15, 14, 13, 11 at Oscurusciuto.

Numbers of items classified by type of raw material: (Table 13)

Raw material	SU 15		SU 14		SU 13		SU 11		Total	
	n.	%	n.	%	n.	%	n.	%	n.	%
Cherty limestone	653	45.9	265	34.6	776	41.8	5567	47.4	7261	46.0
Jasper	457	32.1	333	43.5	629	33.9	3867	32.9	5286	33.5
Chert	201	14.1	137	17.9	335	18.1	1666	14.2	2339	14.8
Quartz sandstone	105	7.4	10	1.3	69	3.7	470	4.0	654	4.1
Limestone	8	0.6	21	2.7	46	2.5	156	1.3	231	1.5
Undeterminedd	0	0.0	0	0.0	0	0.0	26	0.2	26	0.2
Total	1424	100.0	766	100.0	1855	100.0	11752	100.0	15797	100.0

Table 13: Type of raw material in each level.

We note (Figure 61) that SU 15 SU 14 and SU 11 have as the most represented raw material cherty limestone with a similar percentage in each level (SU 15 = 45.8%; SU 13 = 41.8%; and SU 11 = 47.4 %) followed by jasper, again with a similar percentage (SU 15 = 32.1 %; SU 13 = 33.9 %; and SU 11 = 32.9 %). On the other hand, level 14 shows the exact opposite proportion: a predominance of jasper (43.5%) followed by cherty limestone (34.8%). The items made from chert represent approximately 14% of the total number, with similar percentages for SU 15, SU 11, SU 14 and SU 13.

The percentages of quartz sandstone and limestone vary greatly in the four levels, however, items are present only in very marginal quantities.

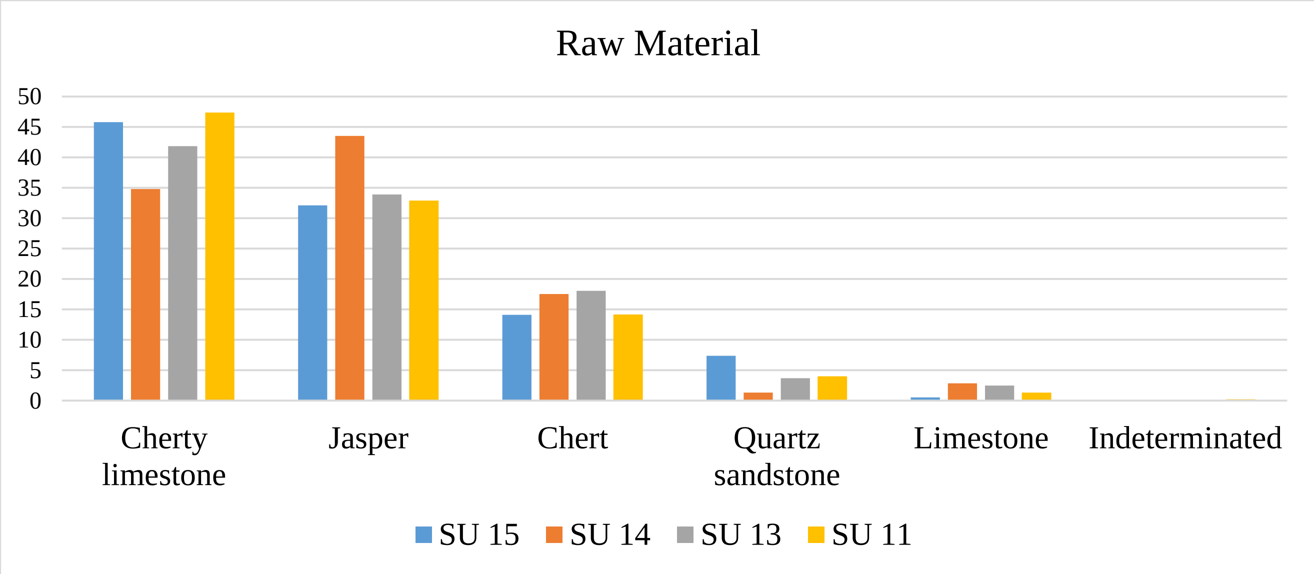


Figure 61: Bar graph of raw material by percentage.

VI SU 15

The lithic collection of the SU 15 of the Oscurusciuto rock shelter is made up of 5,993 items. It is to be noted that this material is found at the top of the excavated level. The most common raw material was cherty limestone followed by jasper. Chert and quartz sandstone are represented in minor quantities. The presence of limestone is not significant (for further information see chapter V, paragraph 4). The intentional selection of fine-grained material is evident (96.1% of the collection).

These raw materials were selected in the form of pebbles. In order to define their approximate dimensions we placed the pebbles whitin specific dimensional categories. Then, we also considered the dimension of pieces that could provide an“indirect measure” of the initial dimension of the pebble, which are the cores in their first phases of exploitation, as well as the completely cortical flakes (Table 14).

Class	Height Min	Height Max	Height Medium	Width Min	Width Max	Width Medium	Total
Initial core	35	48	42.5	20	47	31.5	7
Pebbles	13	57	37.1	14	38	26.4	30
Completely cortical flakes	18	35	26.4	17	36	24.8	7

Table 14: Minimum, maximum and average dimensions of initial cores, pebbles and completely cortical flakes.

(Please note that for the average measures all the pieces of each category were considered).

In this layer we note a clear selection of rather small pebbles, even smaller than 6 cm x 4 cm, where at the same time there is also quite a high variation of dimensions and shapes: in fact, oblong, angular as well as lenticular pebbles are all present.

1 Reduction sequences

The items from SU 15 were divided into categories based on their technical features in order to understand their place and role in the reduction sequence, see the following table of technological categories (microflakes, debris and undetermined items do not appear = 4,704 pieces) (Table 15).

Technological classes	SU 15	
	n.	**%**
Pebbles	30	2.3
Cores	53	4.1
Hammerstones	2	0.2
Completely cortical flakes	8	0.6
Semi-cortical flakes	192	14.9
Management flakes	581	45.1
Target flakes	423	32.8
Total	**1289**	100.0

Table 15: Technological categories.

Consistent with the presence of a high quantity of debitage waste is the presence of management, cortical and target flakes. These data indicate that the knapping activity took place in situ from the first phases of decortication of the pebbles. Of course, we must be careful not to overinterpret this data saying that only complete reduction sequences appear in this level, but we can affirm at least that all the phases of various fragmented reduction sequences occurred at the site (Marciani et al. 2016; Spagnolo et al. 2016).

We found one hammerstone with clear traces of use (Figure 62-A), and another possible hammerstone presenting on its surface evident traces of reddening and cupped holes caused by fire (Figure 62-B). It was not possible to identify the specific cause of these traces, whether they were the result of direct or indirect exposition to fire, or of intentional or unintentional action.

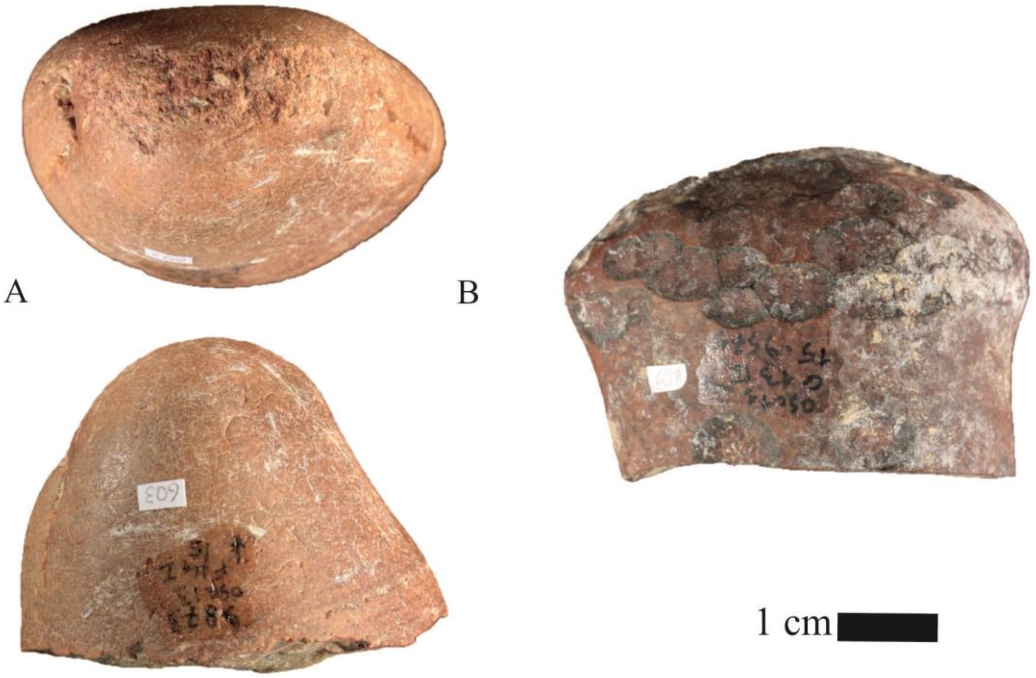


Figure 62: A. Hammerstone, B. pebble with clear traces of fire.

Based on the technical features of flakes and cores it was possible to determine the main concept of debitage employed in this level which is predominantly levallois - F1, followed by various other types of additional debitage - B C1 D1 D2 - (Table 16).

Concept	Flake		Core		Total	
	n.	%	n.	%	n.	%
Levallois F1	776	64.5	12	22.6	788	62.7
Additional B C1 D1	39	3.2	15	28.3	54	4.3
Additional D2	12	1.0	6	11.3	18	1.4
Kombewa B	4	0.3	2	3.8	6	0.5
Undetermined	373	31.0	18	34.0	391	31.1
Total	**1204**	100.0	**53**	100.0	1257	100.0

Table 16: Technological classes and reduction concepts.

The levallois concept prevails with 776 flakes and 12 cores. The objective of this debitage are flakes, long flakes, blades, convergent supports and backed pieces. The presence of additional operational schemes was identified in 72 pieces. Interesting is the presence of 15 additional cores for flakes and 6 additional cores for blades. It is to be noted that additional B C1 D1 refer to the production of flakes, whereas additional C2 D2 refer to the production of blades (for further explanation see chapter II, the paragraph 2.3 Techno-structural approach).

The great quantity of flakes of undetermined concept is made up of cortical flakes that do not yield enough technical parameters for the identification of their reduction concept. Especially in this case, where the raw block is pebbles for both procedures, the initial phase of decortication occur in a similar way for both levallois and additional concepts for technical reasons. Moreover, in this level we note a clear initial selection of the volume of the blanks, which translates into a very short first phase of management and configuration.

We should also bear in mind that the levallois reduction sequences are longer than the additional ones. Because of their peculiar characteristics levallois cores are able to produce recurrent series of end products, whereas the additional cores produce only one (or few) short series of end products before being abandoned.

We note an purposeful selection of raw material in accordance with the selected reduction concept: cherty limestone prevails for the levallois and additional D2 types, whereas jasper prevails for the additional B C1 D1 production (Table 17).

Raw material \ debitage concept	Levallois F1		Additional B C1 D1		Additional D2		Kombewa B		Undetermined		Total	
	n.	%	n.	%	n.	%	n.	%	n.	%	n.	%
Cherty limestone	398	50.6	17	31.5	8	44.4	2	33.3	144	36.6	569	45.3
Jasper	229	29.1	27	50.0	7	38.9	1	16.7	153	38.9	417	33.2
Chert	96	12.2	8	14.8	3	16.7	3	50.0	60	15.3	170	13.5
Quartz sandstone	65	8.3	2	3.7	0	0.0	0	0.0	29	7.4	96	7.6
Limestone	0	0.0	0	0.0	0	0.0	0	0.0	5	1.3	5	0.4
Total	786	100.0	54	100.0	18	100.0	6	100.0	393	100.0	**1257**	100.0

Table 17: Distribution of debitage concept in relation to raw material.

Another factor is the initial selection of the volume of the block to be flaked. For the levallois debitage F1 we note a preference for pebbles of oblong or lenticular shape or for cortical flakes which already possess the convexities facilitating a levallois production. For the additional debitage - B C1 D1 D2 – a choice of pieces of pebbles or fragments of flake prevails, thus indicating a clear preference for items with orthogonal angle caused by fracture or by internal natural fragmentation planes (Table 18).

Type of block \debitage concept	Levallois F1		Additional B C1 D1		Additional D2		Kombewa B		Undetermined		Total	
	n.	%	n.	%	n.	%	n.	%	n.	%	n.	%
Pebbles	8	66.7	5	33.3	5	83.3	0	0.0	0	0.0	18	34.0
Pieces of pebbles	1	8.3	9	60.0	1	16.7	0	0.0	0	0.0	11	20.8
Fragments of flakes	0	0.0	0	0.0	0	0.0	2	100.0	0	0.0	2	3.8
Cortical flakes	2	16.7	1	6.7	0	0.0	0	0.0	0	0.0	3	5.7
Undetermined	1	8.3	0	0.0	0	0.0	0	0.0	18	100.0	19	35.8
Total	12	100.0	15	100.0	6	100.0	2	100.0	18	100.0	53	100.0

Table 18: Selection of block type according to debitage concept.

After this overall view regarding the various concept of debitage of level 15, in the following sections we will focus on each concept of debitage as defined by its structural conception and objectives.

2 Levallois debitage

For this section we have evaluated 12 cores and 776 flakes (Table 19).

Concept	Flake		Core		Total	
	n.	%	n.	%	n.	%
Unipolar	576	74.2	8	66.7	584	74.1
Convergent	182	23.5	3	25.0	185	23.5
Centripetal	2	0.3	0	0.0	2	0.3
Undetermined	16	2.1	1	8.3	17	2.2
Total	**776**	100.0	**12**	100.0	**788**	100.0

Table 19: Modality of levallois production as applied to flakes and cores.

2.1 Core structure

The cores evaluated in this section are the result of a levallois debitage because they respect the criteria of Boëda (Boëda 1994, 2013).

Usually levallois cores are the result of a long and accurate first phase dedicated to the management of the lateral and distal convexities. In the majority of the levallois cores at Oscurusciuto this phase has been rendered almost totally superfluous by a clearful selection of the initial blanks. In fact, the blocks to be flaked are in most cases pebbles, which already by nature have the convexities necessary for the initial production phases of target objects immediately after the cortex removal.

The flakes which present contra-bulbs and scars on the cores are very numerous which indicates that hard hammerstones were utilized. This data is consistent with the presence of two hammerstones in the level.

2.2 Selection and initialization

In the case of Oscurusciuto the selection phase is of paramount importance. The initial blocks, which already posses the right convexities were opened by one or more strikes in order to create a striking platform, and this was subsequently followed by the extraction of cortical flakes from the surfaces of debitage.

The flakes involved in this first phase are completely cortical and semi-cortical flakes. As almost all the raw blocks utilized at Oscurusciuto were pebbles, these flakes could pertain either to a levallois or to another additional debitage, therefore we did not make any attribution.

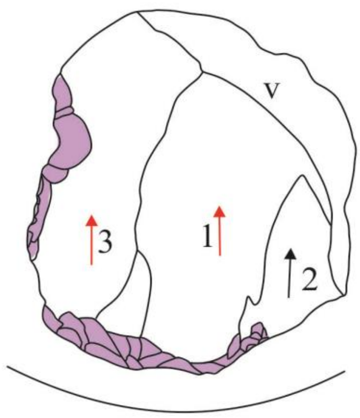
As for the 12 cores evaluated, 2 are made on cortical flakes, one is made of cherty limestone and the other of quartz sandstone, both of them completely exploited (Figure 63 and 65). Eight cores are made starting from pebbles, seven of which are made of jasper and only one of cherty limestone. Only one of these cores is completely exploited whereas the others are in a medium (Figure 66) or initial (Figure 64) stage of exploitation.

2. 3 Production

The striking platforms are always prepared, for the unipolar levallois only one striking platform perpendicular to the direction of the stroke is employed (Figure 63 and 64). For the convergent levallois the striking platforms are semi-peripheral, occupying a larger portion of the core (Figure 65 and 66). The target objects are items with two long lateral parallel cutting edges, convergent items and items with one backed side. From the dimension of cores, and the scars of removals on them, we conclude that both long and short flakes were the objective of the debitage.

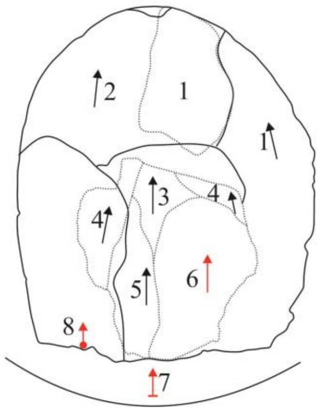
While unipolar production prevails, we should keep in mind that as for the cores, what we have is just the remains of the last action developed on them. As the levallois is a recurrent concept we assume that the core could have been produced both with the convergent and the unipolar modality.

These are general considerations with regard to the production but as each core has its own story of genesis we decided to enclose some analysis sheets with a description of each of them. After the unipolar (Figure 63 and 64) and convergent (Figure 65 and 66) cores we listed a core which represents a “hybrid”, i.e. after a completed production following the levallois criteria the debitage shifted to additional production. This is the case with the core ID 10580. After a convergent levallois production, the lateral convexities which are typical of levallois sequences were destroyed and were followed by a series of strokes aimed at producing bladelets (additional D2) (Figure 67). This behaviour is registered only for this core in this level, but numerous similar cases have been ascertained in the upper levels at Oscurusciuto, especially in SU 11 (chapter IX).



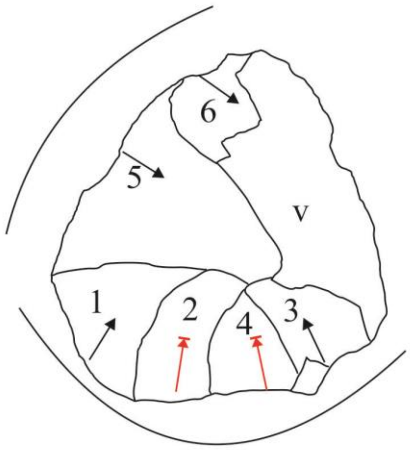
Selection	Cortical flake.
Striking platform	Unipolar, prepared with several small removals.
Production	After a careful preparation of the striking platform, the removal 1 is identified as the first target object, followed by the strokes 2, and the 3 which are also regarded as target objects. The last activity carried out on this core is the lateral and proximal removal of small flakes, which coul be interpreted as a retouched action.
Target object	Long flakes.

Figure 63: ID 9692, unipolar levallois core plus retouched action F1.



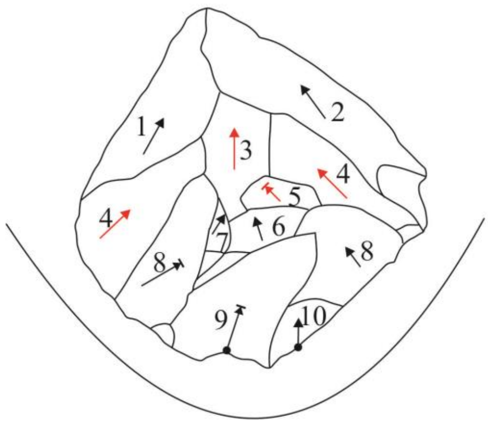
Selection	Pebble.
Striking platform	Unipolar, prepared with several removals.
Production	1 = removal aimed at managing the lateral convexity of the core. When hitting an inner natural fragmentation plane, fragment 1 was detached. In spite of the evidently bad stone quality, the reduction continued. 2, 3, 4, 4, 5 = removals aimed at managing the core convexity. 6, 7 , 8 = target objects. The removal 8 hit the inner fragmentation plane and produced the breakage of the core into 3 pieces which led to abandoning the reduction process.
Target object	Long flakes, backed long flakes.

Figure 64: ID 10392, 10623, refitting set. Unipolar levallois core F1.



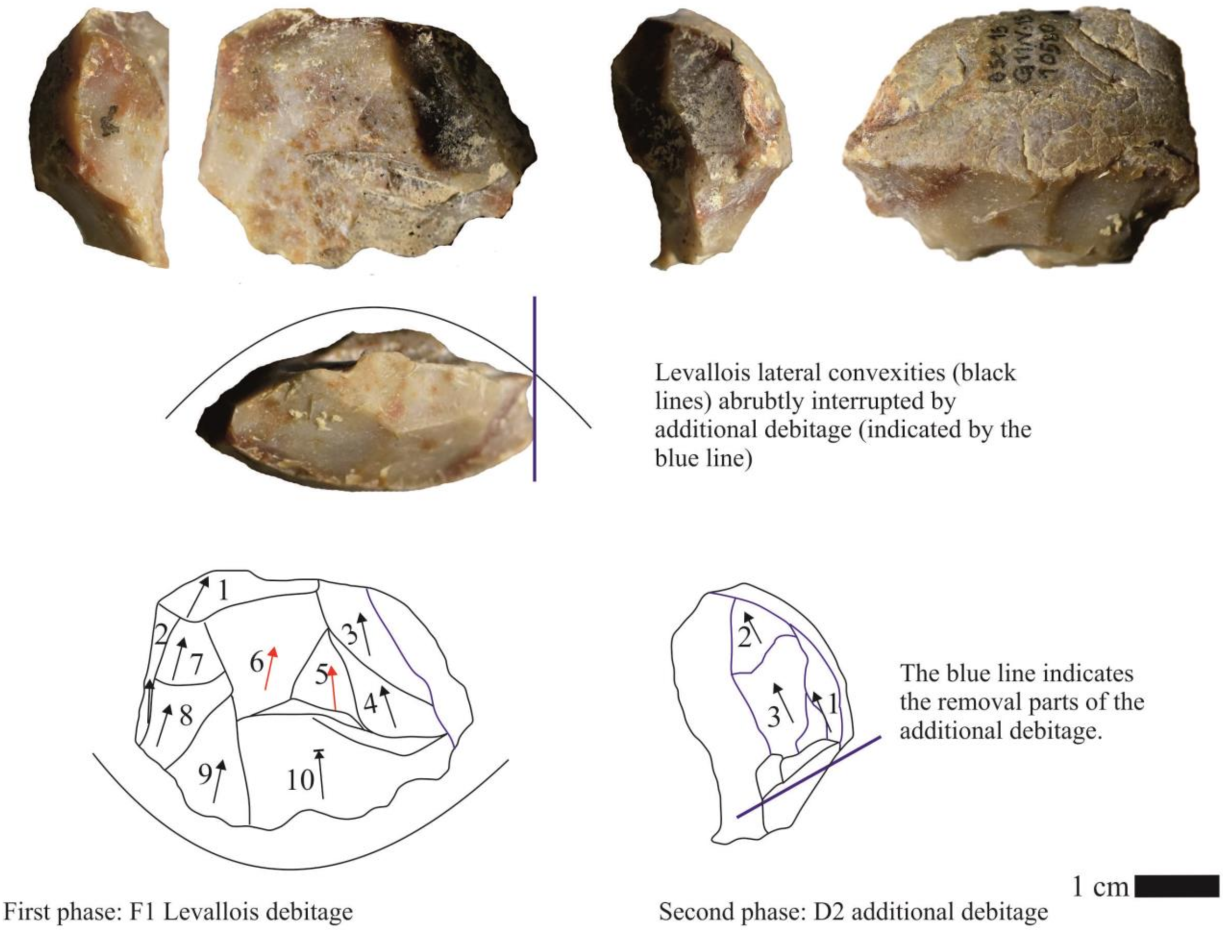
Selection	Cortical flake.
Striking platform	Semi-peripheral, prepared with small removals.
Production	1, 2, 3 4 = removals aimed at managing the convergences. 2, 4 hinged accidents. 5, 6 unsuccessful attempt rectify the damage which ultimatly led to the abandonment of the core.
Target object	Convergent flake.

Figure 65: ID 10199, convergent levallois core F1.



Selection	Pebble.
Striking platform	Semi-peripheral, prepared with small removals.
Production	1, 2 = convexities management. 3, 4, 4 = researched production. 5 = attempted researched production ending in a hinged accident. 6, 7, 8, 8 = convexities management. 9 = grave hinged accident wich led to the abandonment of the core.
Target object	Flakes and convergent flakes.

Figure 66: ID 9423, convergent levallois core F1.



Selection	Pebble.
Striking platform	Semi-peripheral, prepared with several small removals.
Production	1, 2, 3, 4 = decortication and management of lateral and distal convexities. 5, 6 = target production. 7, 8, 9 = very thin removals, maybe aimed at managing the left convexities which were too thick compared to the right ones. 10 = hinged accident.
Target object	Convergent flakes.

Selection	Pebble.
Striking platform	Unipolar, prepared with one removal. Orthogonal to the removals on the debitage surface.
Production	1, 2, 3= initialization of additional debitage. Opening and preparation of the right convexities.
Target object	Possibly bladelets, but the core was abandoned before producing its objectives.

Figure 67: ID 10580, convergent levallois core plus additional debitage F1+ D2.

2.4 Target product

From 776 levallois flakes, 403 were target objects of the production. The levallois production in the SU 15 mainly produced long objects, both backed, convergent, followed by blades, long flakes and flakes (Figure 68). Their shape is mainly trapezoidal for the backed and unspecified (flakes, long flakes and blades) objects, and triangular for the convergent ones. These target items do not present great cortex coverage: in most cases the cortex does not surpass 50% of the overall coverage. The backed pieces are mainly produced in the first phases of the reduction sequence; whereas the convergent and other unspecified objects were produced at every stage of the production (as the first target object, the second or third object in a recurrent sequence of production). The backed objects mostly present two or three scars on the dorsal surface, whereas the convergent and other ones might have in excess of three removals on their dorsal face. The direction of the removals are convergent for the convergent flakes and mainly unipolar for the backed and unspecified ones.

The butts are always prepared with one or several strikes for the backed items, with impact points in a lateral position. For the convergent pieces the butts are facetted or dihedral with a central impact point, and for the unspecified items the butt is prepared mainly with one stroke, sometimes more, and the impact point could be both central or lateral. All the pieces have a prominent bulb, which indicates the use of direct techniques with a hard hammerstone. These technical features are synthetized in the following table (Table 20)

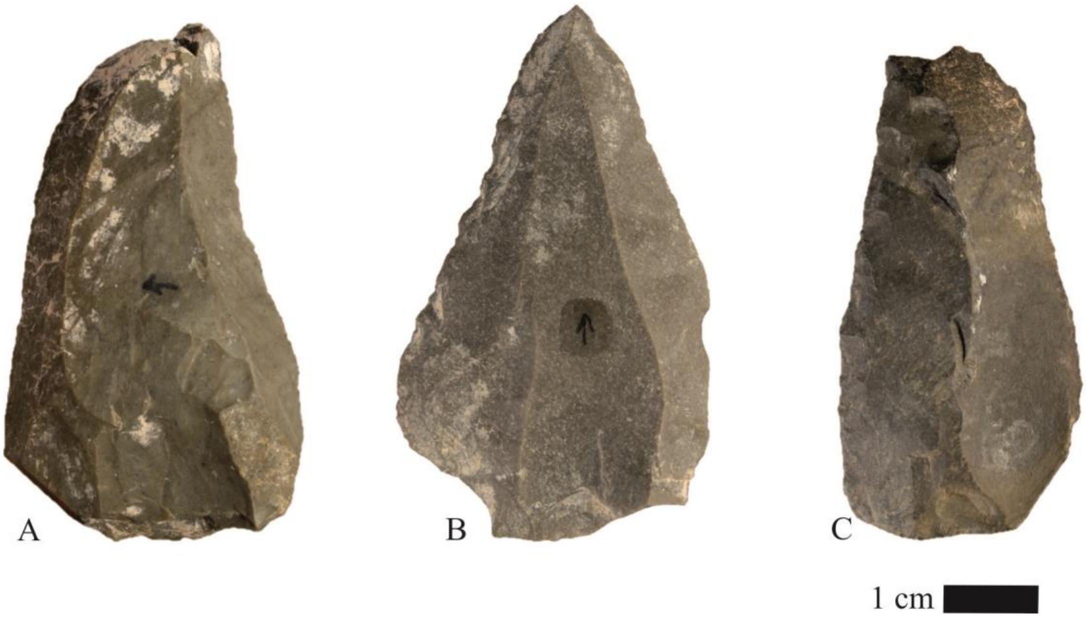


Figure 68: Levallois target objects (A: Backed long flake, B: Convergent long flake, C: Blade).

Target objects	Backed items			Convergent items			Unspecified items			Total
	Backed blades	**Backed flakes**	**Backed long flakes**	**Convergent blades**	**Convergent flakes**	**Convergent long flakes**	**Blades**	**Flakes**	**Long flakes**	
Total	**26**	**12**	**50**	**11**	**5**	**48**	**53**	**43**	**155**	**403**
Morphology	Trapeze	Trapeze	Trapeze	Triangular	Trapeze\Triangular	Triangular	Trapeze	Trapeze	Trapeze	\
Symmetry%	65.4	50.0	66.0	100.0	80.0	83.3	84.9	86.0	86.5	81.1
Section shape	Trapeze	Trapeze	Trapeze	Trapeze	Trapeze	Trapeze	Trapeze\Triangular	Trapeze	Trapeze\Triangular	\
Cortex coverage ≤ 50 %	84.6	100.0	98.0	100.0	100.0	97.9	96.2	100.0	98.7	97.5
Cortex location	Back	Back	Back	Absent	Absent	Absent	Absent	Absent	Absent	\
Scar direction	Unipolar	Unipolar	Unipolar	Convergent	Convergent	Convergent	Unipolar	Unipolar	Unipolar	\
Scar number	Two, three	Two, three	Two, three	Four	Three	Three	Three, four	Two, three	Two, three	
Generation of debitage	T0	T0	T0	T1	T3	T0-T1-T3	T3	T3	T3	
Butt	Flat, prepared	Flat, prepared	Flat, prepared	Flat, faceted	Dihedral	Dihedral, faceted	Flat, prepared	Flat	Flat, prepared	75%
Impact point	Lateral	Central, lateral	Lateral, central	Central	Central	Central	Central	Central, lateral	Central	75%
Bulb	Prominent	Prominent	Prominent	Prominent	Prominent	Prominent	Prominent	Prominent	Prominent	75%
Macro traces %	65.4	33.3	60.0	100.0	40.0	85.4	66.0	34.9	63.2	62.8

Table 20: Comparative table of levallois target objectives.

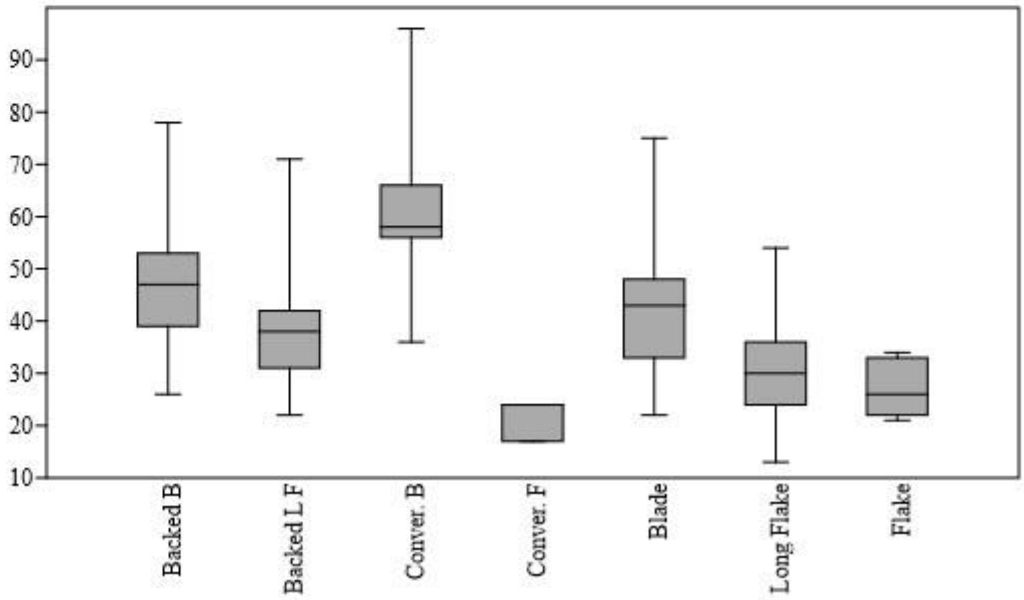


Figure 69: Box plot of the dimensional dispersion of target objects.

(In the graph only entire pieces are considered, hinged accidents and fragmented items are excluded. The dimension taken into consideration is the length expressed in mm).

In the case of dimensional variations in the piece we have indicated the maximum length of the entire piece according to its technological axis. The box plot shows that each category has its own dimensional variations, in particular the convergent pieces are significantly distinct from the other classes as the majority of them is smaller (for flakes) and bigger (for blades) than the other pieces. The class of flakes is quite homogeneous and smaller than the other pieces. Moreover, the backed blades, backed long flakes and blades have quite similar major dimensions, whereas long flakes are located between this last group and the flakes (Figure 69).

3 Additional debitage aimed at producing flakes, C1, D1

In this section 39 flakes and 15 cores of additional debitage - C1 D1 are evaluated. The definition of the types is based on the degree of predetermination with regard to the target pieces and the degree of control during the production. Group C1 consists of a group of cores that uses the natural convexities of a block in the production of target objects. The phase of initialization and management of the convexities coincides with the selection of the block, but a preparation of the striking platform is present. Group D consists of a group of cores whose striking platforms and right convexities are managed and prepared in order to obtain target flakes.

In both cases the series of debitage are usually not very numerous; the core was mostly abandoned after the production of one target flake (though there was still a reserve of material), or another part of the item was utilized. These additional cores are created by adding several distinct and independent sequences of debitage (Figure 70).

3.1 Core structure

Additional cores vary considerably as far as shape, management of convexities and ultimate target objects are concerned. However, in this collection, we note a preselection of raw blocks with a natural orthogonal plane. On this globular volume each face is prepared independently. On the one hand, there are cores with just one production series developed on only one or two faces of the cube (Figure 70), on the other hand, there are cores with two or more production series involving several faces of the block (Figure 70).

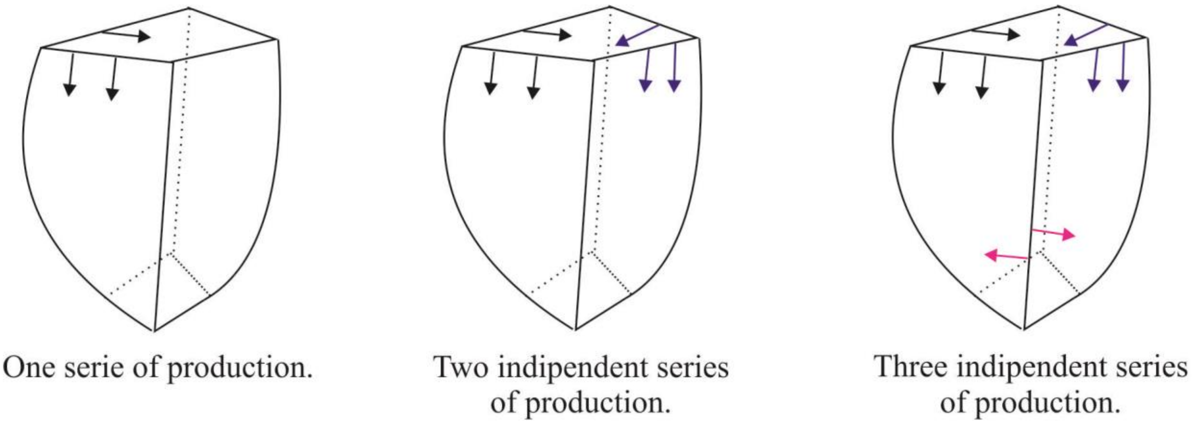


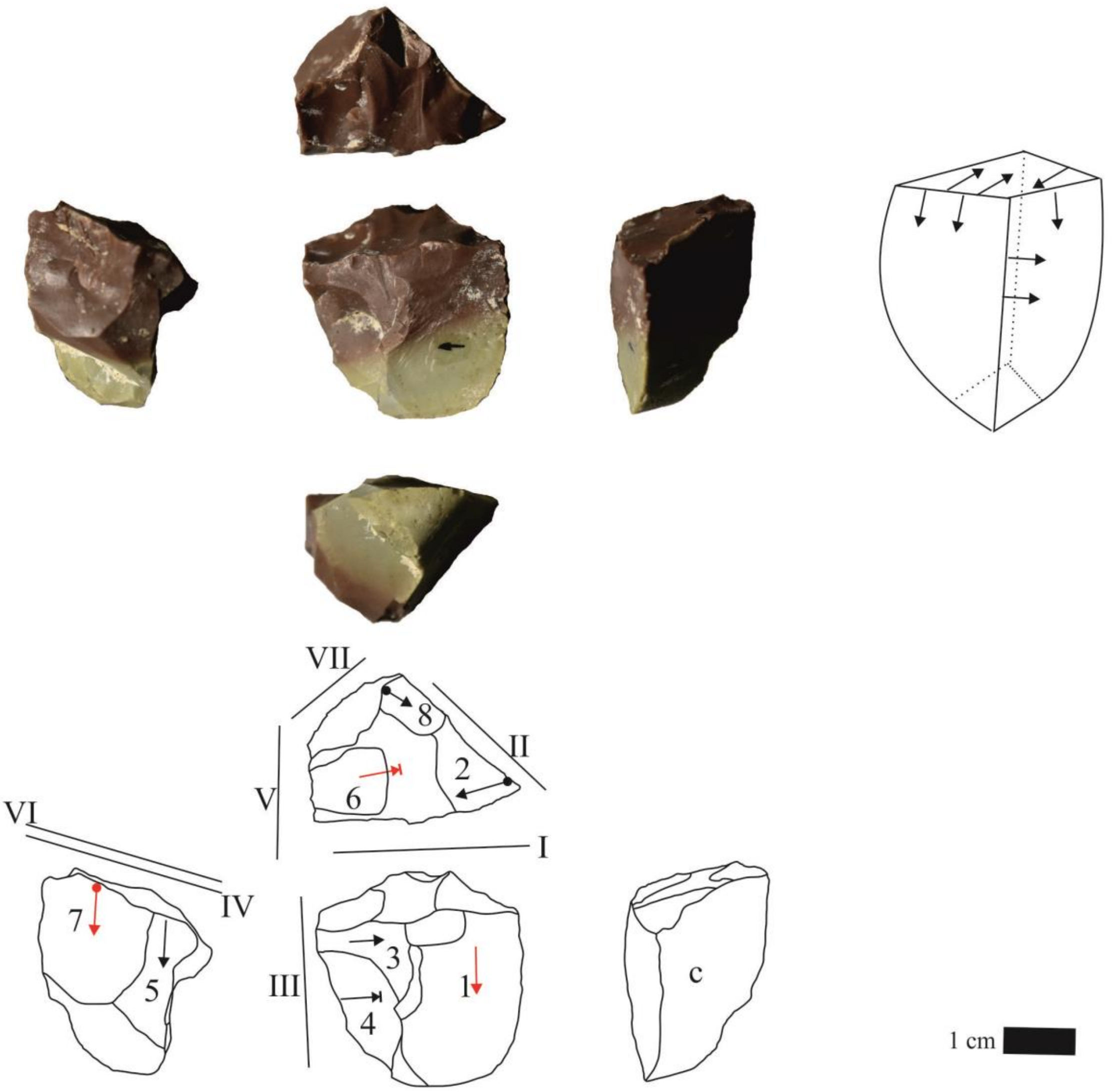
Figure 70: Schematic representation of the additional cores C1 and D1 (flake production).

3.2 Selection and initialization

In core type C1 the selection and initialization coincide because at the moment of choosing the raw block to be flaked the artisan selected the block that already presented the convexities that they needed, whereas, in core type D1 there is a management phase of the convexities. Furthermore, in the analysed collection we noted a selection of broken pieces of pebbles, or pebbles with inner fracture planes (Figure 70, 71). We concluded that the initial objects prepared for this production were very different from the lenticular or oblong pebbles chosen for the levallois production. In the former case (additional C1 D1), the selection prioritized items presenting one or two orthogonal planes.

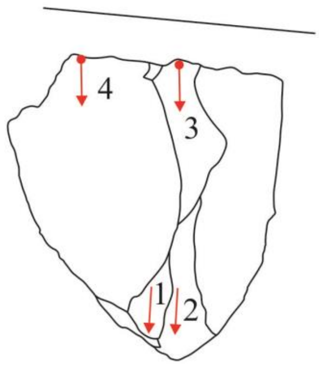
3.3 Production

When preparing the striking platforms, they are opened with only one stroke, orthogonal to the debitage surface. Then management flakes and target flakes are removed. These flakes are not very standardized, the only clear feature they have in common being the flat or cortical butt.



Selection	Piece of pebble with a inner natural fracture plane.
Striking platform	Unipolar, prepared with one single removal, ortoghonal to the surface of debitage, each removal has its own striking platform.
Production	Four independent production series : A- 1 = First removal from a no longer existing striking platform, target object. B- 2 = second removal from a cortical striking platform. C- 3, 4 = removal detached from a no longer existing striking platform (cancelled out by removal 5), n.4 is an hinged accident. Each face of the core was indipendently used as striking platform and debitage surface. D- 5 = preparation of the striking plane. 6 = Attempt to obtain a target flake, hinged accident. 7 = Attempt to obtain a target flake, interception of a inner plane of the raw material. These last 3 removals could be related to each other in a dynamic sequence of alternate debitages (n. 5 prepared the striking platform for n. 6 which respectively prepared the striking platform for n. 7).

Figure 71: ID 10693, additional core C1.



Selection	Piece of pebble with an inner natural fracture plane.
Striking platform	Unipolar, prepared with one single removal orthogonal to the surface of debitage.
Production	1, 2, 3, 4 = target objects. The core is abandoned in a medium stage of exploitation.
Target object	Flakes.

Figure 72: ID 75, additional core D1, one production series.

4 Additional debitage aimed at producing blades, D2

Twelve blades and 6 cores represent the additional D2 production type. Group D2 comprehends all the cores whose striking platforms and convexities are managed and prepared in order to obtain blades.

4.1 Core structure

We noted a selection of raw blocks with a natural orthogonal plane, like in the C1 and D1 types. Based on the volumetric structure, the number of exploited faces, and the series of debitage we could identify two modalities of exploitation of D2 cores: one exploited an initial oval block and the other an angular block (Figure 72, 73, 74, 75).

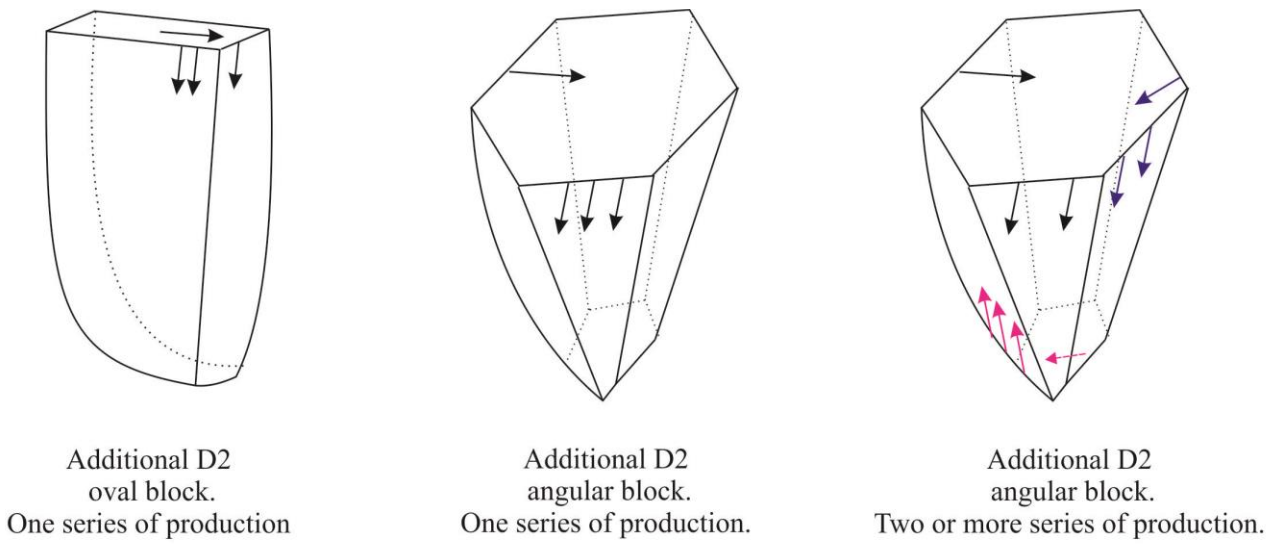


Figure 73: Schematic representation of additional D2 cores (blade production).

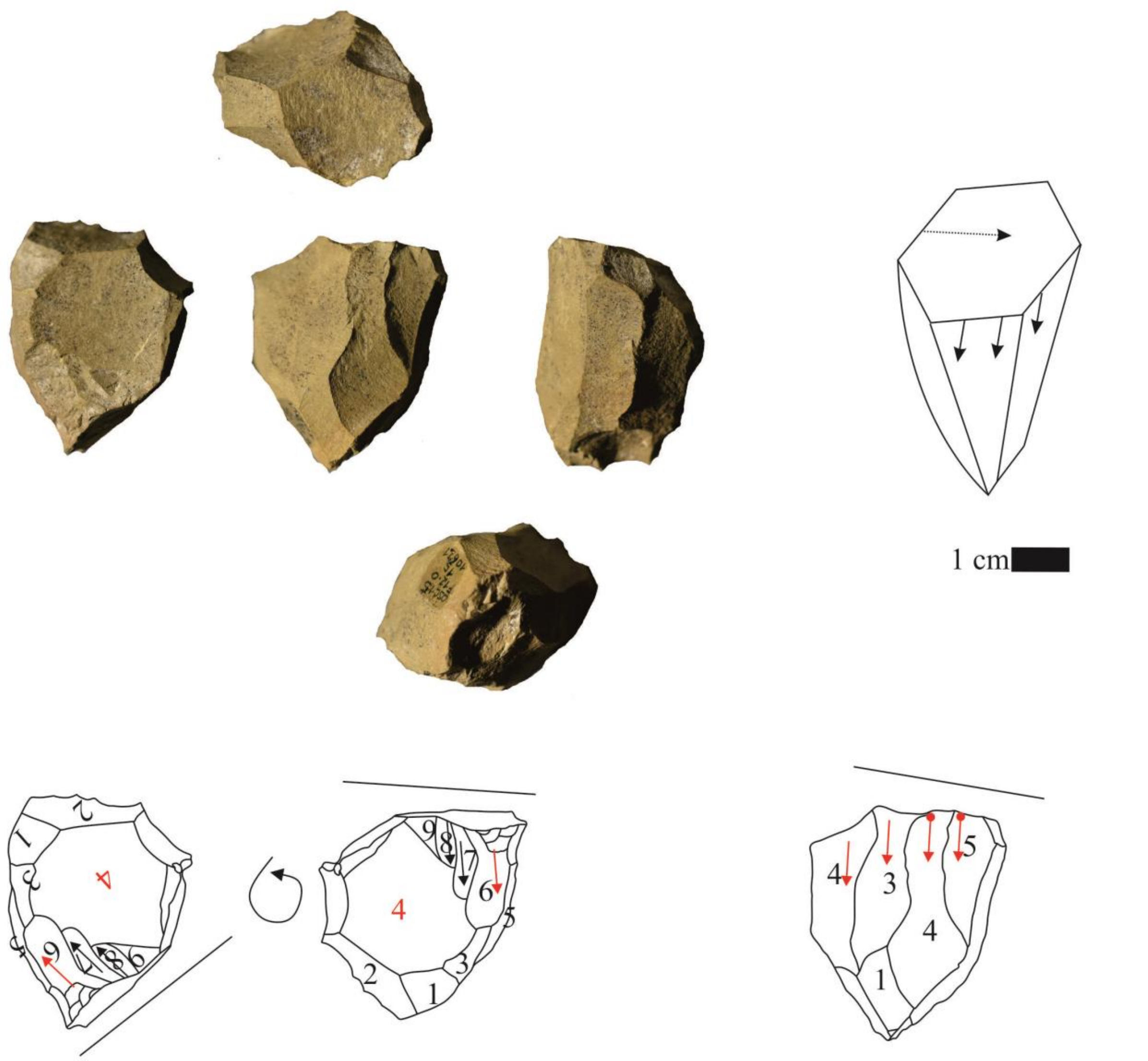
4.2 Selection and initialization

In this type of debitage the selected raw block already possesses by nature at least one orthogonal plane made up of an inner fracture plane of the block, or an angular surface which could be cortical, or created by a previous removal. We noted the selection of two main volumetric structure: an oval one (Figure 75, 76) and an angular one (Figure 74). The striking platforms were prepared by one or two strokes orthogonal to the debitage surface.

4.3 Production

After the preparation of the striking platform, the convexities are roughly managed by one or two removals and the target objects are produced. Usually, for this kind of debitage the extraction starts from the thin side of the block and only subsequently involving its larger side (Figure 75, 76).

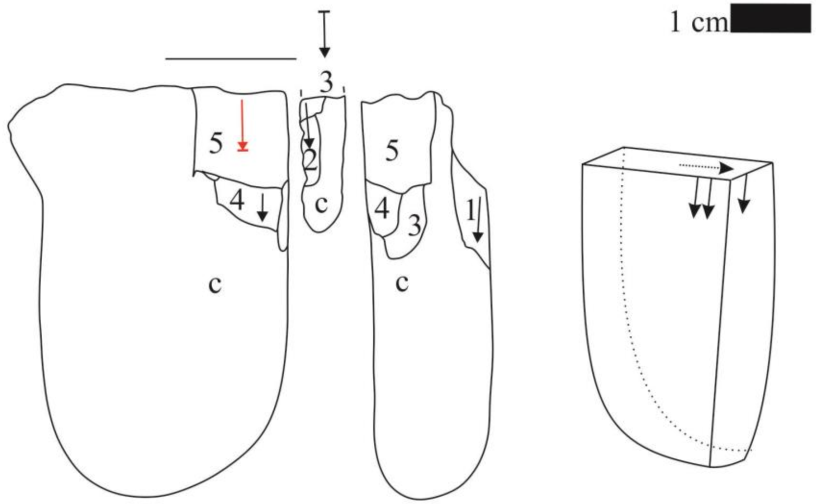
An emblematic and useful case in order to understand the idea of additional core production is represented by the core ID 9451 where there are two additional and separate series of debitage: the first sequence of D2 (aimed at producing blades) followed by a sequence of C1 (aimed at producing flakes) (Figure 76).



Selection	Angular fragment?
Striking platform	Unipolar, orthogonal to the surface of debitage.
Production	1, 2, 3 = management of the convexieties. 4 = target object, large flake. 5, 6 = target object blade, hinged accident. 7, 8, 9 = attempts to restore the convexities. The production continued on another face of the core
Target object	Flake and blade.

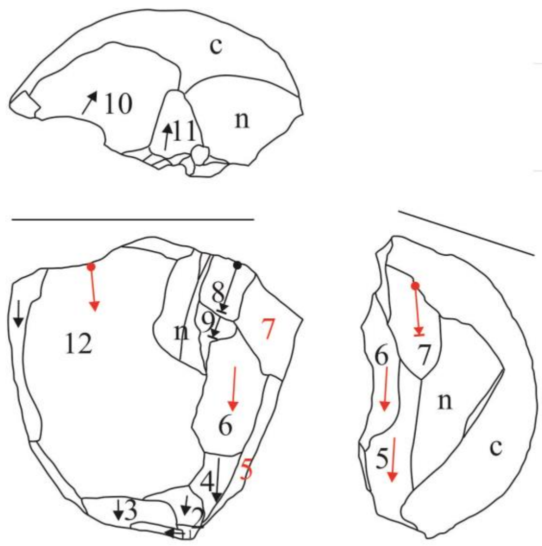
Selection	Angular fragment, previous core.
Striking platform	Unipolar, orthogonal to the surface of debitage.
Production	1, 2 = management of the convexities. 3, 4, 4, 5 = target products.
Target object	Blade.

Figure 74: ID 10621, additional core D2 (angular block).



Selection	Piece of flat pebble.
Striking platform	Unipolar, orthogonal to the surface of debitage.
Production	1 = detached along an inner natural fragmentation plane. 2, 3, 4 = removals of the cortex, the aim being to prepare the convexities in order to obtain the target object n.5. 5 = hinged accident of target object, preventing its realization. The core is abandoned at an initial stage of exploitation.
Target object	Blade.

Figure 75: ID 9420, 9421, 370. Initial additional core D2 (oval block).



Selection	Piece of pebble with inner fracture plane.
Striking platform	Unipolar, orthogonal to the surface of debitage.
Production	A- First series of debitage, aiming at producing blades exploiting the thin side of the support. 1, 2, 3 = initial stage, preparation of distal convexities. 4, 5, 6, 7, 8, 9 = strokes producing detachments from a not prepared striking platform, utilizing an inner natural fragmentation plane of the pebble. 5, 6, 7 = target objects. B- Second series of debitage aiming at producing flakes from the thick side of the pebble.10, 11 = Opening of a new striking platform. 12 = target flake that intercepted an inner fragmentation plane. The core is abandoned at an initial stage of exploitation.
Target object	Blade and flake.

Figure 76: ID 9451, additional core D2 + C1 (oval block).

5 Other additional production

We noted the presence of two additional cores of type B - kombewa with no preparation of the convexities nor of the striking platform in order to obtain a single flake. In this case, the raw blocks utilized for knapping were flake fragments. The technical parameters of these target flakes are not predetermined so these items could be easily confused with flakes produced by other kind of debitage.

Another type of debitage is the additional B of one stroke, found on 3 blocks where all the convexities were already naturally present. On those three cores only a single flake was removed. In these three cores no standardization of the volumetric structure is present, the initial blocks are pebble fragments of very different shapes.

6 Retouched tools

In the SU 15, only 64 pieces have been retouched, of which 57 are flakes, 5 undetermined fragments and 2 cores. Exept for two retouched pieces made on blades produced by additional debitage all the other retouched tools are made on levallois supports. There is a clear prevalence of lateral scrapers, followed by bilateral scrapers and bilateral scrapers plus point (Figure 77). On the target object the retouch is mainly found on long flakes, convergent long flakes, and convergent blades (Table 21). The unilateral scrapers are mainly made from long flakes, followed by backed long flakes and management flakes. The majority of bilateral scraper plus point are made from pieces that were already convergent through debitage, in particular convergent blades. Finally the bilateral scrapers are mainly produced from blades (Table 21).

Typology\ Technological category	Unilateral scrapers		Bilateral scrapers +point		Bilateral scrapers		Transversal scrapers		Undetermined		Total	
	n.	%	n.	%	n.	%	n.	%	n.	%	n.	%
Backed blades	3	8.8	1	9.1	0	0.0	0	0.0	0	0.0	**4**	6.3
Backed flakes	2	5.9	0	0.0	0	0.0	0	0.0	0	0.0	**2**	3.1
Backed long flakes	4	11.8	0	0.0	0	0.0	1	25.0	0	0.0	**5**	7.8
Convergent blades	2	5.9	5	45.5	1	11.1	0	0.0	0	0.0	**8**	12.5
Convergent long flakes	5	14.7	2	18.2	2	22.2	0	0.0	0	0.0	**9**	14.1
Blades	2	5.9	1	9.1	3	33.3	0	0.0	0	0.0	**6**	9.4
Flakes	2	5.9	0	0.0	0	0.0	0	0.0	0	0.0	**2**	3.1
Long flakes	7	20.6	0	0.0	2	22.2	0	0.0	0	0.0	**9**	14.1
Semi-cortical flakes	3	8.8	0	0.0	0	0.0	1	25.0	0	0.0	**4**	6.3
Management flakes	4	11.8	1	9.1	0	0.0	2	50.0	1	16.7	**8**	12.5
Cores	0	0.0	0	0.0	0	0.0	0	0.0	2	33.3	**2**	3.1
Undetermined	0	0.0	1	9.1	1	11.1	0	0.0	3	50.0	**5**	7.8
Total	**34**	100.0	**11**	100.0	**9**	100.0	**4**	100.0	**6**	100.0	**64**	100.0

Table 21: Retouched recurrences.

Figure 77: Retouched pieces.

a: bilateral scrapers; b: unilateral scraper; c bilateral scraper plus point.

7 Overview of SU 15: economy of raw material and production

In the SU 15, we noted the presence of knapping activity in situ; the raw blocks introduced into the site are pebbles of various dimensions and shapes. We noted a clear difference in volume between the pebbles selected for the levallois production, and the ones utilized for additional debitage. For the levallois production oblong or lenticular pebbles, or big cortical flakes were chosen. For the additional debitage, pieces of pebbles and broken pieces of flakes were chosen. In these latter blocks the preference for pieces with a natural angular side is evident. Another main structural difference between the levallois and additional debitage is that the former exploited pebbles using two hierarchized faces separated by a fracture plan; whereas the latter exploited more than one faces of the pebbles without any hierarchization (Figure 78).

The levallois cores were mostly abandoned in the medium or last phases of debitage, whereas the additional cores were abandoned after one or two production series with a reserve of material still present in the block. In additional debitage the series are usually very short: after the production of one target flake the core is abandoned, or another part of it is utilized for a separate production series.

When we take the various cores into account, understanding their concept of debitage is relativelystraight forward. On the other hand it is much more difficult attributing the various flakes to a debitage concept. In fact, it is a hard task to identify a product of additional debitage, because the target objective is rarely predetermined and control is minimal, not least because of the possible overlap between the target object of the levallois and additional production in this level.

However, even though it is sometimes impossible to identify which kind of production to attribute to each flake, it is still essential to determine which kind of debitage created the cores because it gives important information regarding the structural management of them and consequently cognitive insight into e.g. the determining role of the preselection of raw blocks in the various levels. To sum up, we noted that identical target objects could be the result of different reduction sequences, which had been adapted and developed on different raw blocks.

As for the retouched items, most of the transformation activity was performed on items that had already been target objects of debitage. The most common retouched tool is scrapers, lateral or bilateral, on convergent supports, and mostly bilateral scrapers plus point (Figure 78).

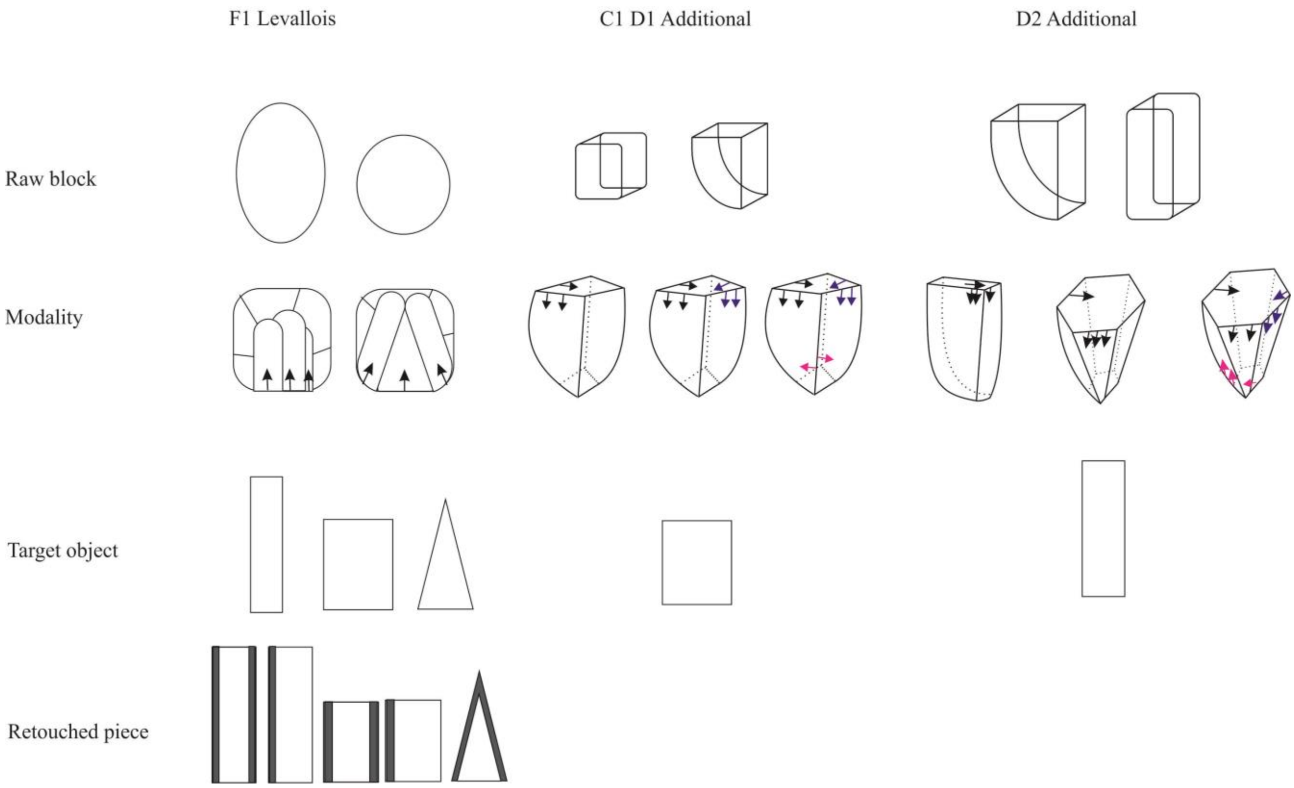


Figure 78: Reduction sequences at SU 15.

VII SU 14

The layer SU 14 held 3,833 lithic implements. This is the only level of the four studied where the most common raw material is jasper, followed by cherty limestone and chert plus an irrelevant quantity of quartz sandstone and limestone (for further information see chapter V, paragraph 4). In the case of this level there is likewise a clear predominance of fine-grained material (96.4% of the collection).

These raw materials were introduced in the form of small oblong and globular pebbles. For an estimation of the dimensions of the introduced pebbles we examined pebbles, the RMU 2 (= complete refitted items), and completely cortical flakes (Table 22, Figure 79, 80). The selection of raw blocks to be flaked had a dimension between approximatelly 2 and 5 cm.

Class	Height Min	Height Max	Height Medium	Width Min	Width Max	Width Medium	Tot al
RMU 2	46	46	46	37	37	37	1
Pebbles	38	66	51.75	22	35	29.5	4
Completely cortical flakes	21	23	22	17	34	25.5	2

Table 22: Minimum, maximum and average dimensions of RMU 2, pebbles and completely cortical flakes.

(Please note that the average measurements comprehend all the pieces within each classification).

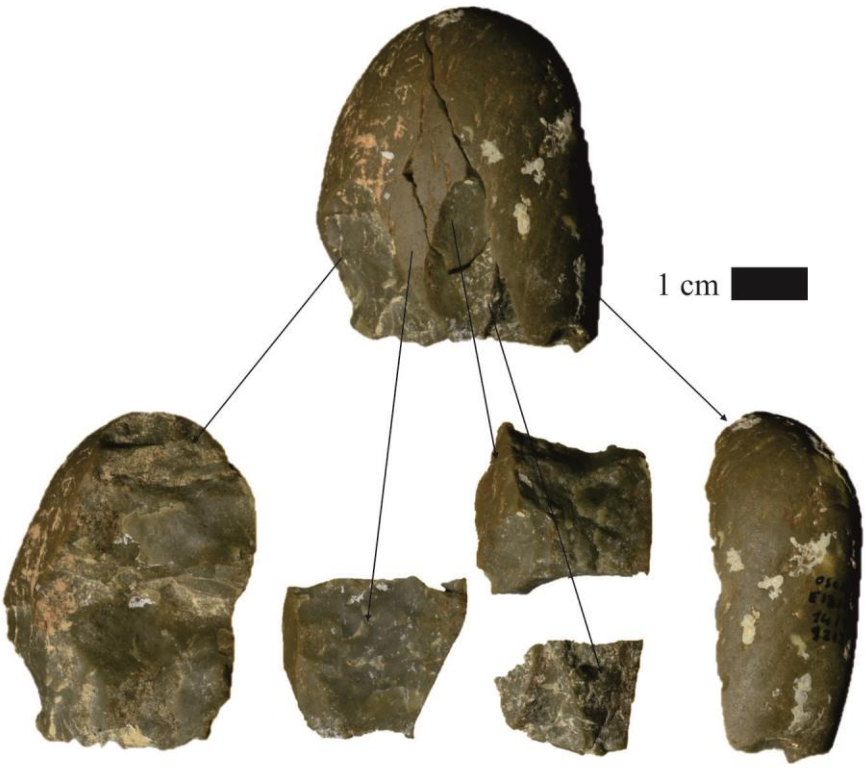


Figure 79: RMU 2, a refitted item, which constitutes an almost complete pebble.

Figure 80: Imported pebbles.

1 Reduction sequences

The pieces of the SU 14 were subdivided into the following technological classes according to their technical features (microflakes, debris and undetermined items were excluded = 3,220 pieces) (Table 23).

Technological classes	SU 14	
	n.	**%**
Pebbles	4	0.7
Cores	13	2.1
Hammerstones	4	0.7
Completely cortical flakes	2	0.3
Semi-cortical flakes	108	17.6
Management flakes	343	56.0
Target flakes	139	22.7
Total	**613**	100.0

Table 23: Technological classes.

The data present evidence of knapping activity in situ, further validated by the presence of four hammerstones with clear traces of use (Figure 81). There is a predominance of management flakes followed by target and semi cortical flakes.

Figure 81: Hammerstones.

According to the technical characteristics of the flakes and cores we have identified the main debitage concept levallois, in 342 flakes and 3 cores, but there are also several examples of additional debitage (Table 24). It is interesting to note that as for cortical or semi-cortical flakes which in the other levels are listed as undetermined, in this level we were able to attribute these items to the debitage that actually produced them, thanks to the RMU analysis and the copious number of refitted items.

Concept	Flakes		Cores		Total	
	n.	%	n.	%	n.	%
Levallois F1	449	75.8	4	30.8	453	74.9
Additional B C1 D1	48	8.1	5	38.5	53	8.8
Additional D2	13	2.2	4	30.8	17	2.8
Kombewa B	3	0.5	0	0.0	3	0.5
Undetermined	79	13.3	0	0.0	79	13.1
Total	**592**	100	**13**	100.0	**605**	100

Table 24: Technological classes related to reduction concept.

Jasper followed by cherty limestone is the preferred raw material for the levallois and additional D2 debitage, whereas there is a slight preference for cherty limestone followed by jasper for the additional B, C1, D1 debitage (Table 25). All the cores are completely exploited or at a medium stage of exploitation.

Raw material \debitage concept	Levallois F1		Additional B C1 D1		Additional D2		Kombewa B		Undetermined		Total	
	n.	%	n.	%	n.	%	n.	%	n.	%	n.	%
Cherty limestone	159	35.1	25	47.2	6	35.3	0	0.0	28	35.4	218	36.0
Jasper	187	41.3	23	43.4	10	58.8	3	100.0	28	35.4	251	41.5
Chert	104	23.0	3	5.7	1	5.9	0	0.0	9	11.4	117	19.3
Quartz sandstone	2	0.4	2	3.8	0	0.0	0	0.0	3	3.8	7	1.2
Limestone	1	0.2	0	0.0	0	0.0	0	0.0	11	13.9	12	2.0
Total	453	100.0	53	100.0	17	100.0	3	100.0	79	100.0	605	100

Table 25: Distribution of raw material according to debitage concept.

2 Levallois debitage

For this section, we examined 4 cores and 449 flakes (Table 26).

Concept	Flakes		Cores		Total	
	n.	%	n.	%	n.	%
Unipolar	313	69.7	1	25.0	314	69.3
Convergent	71	15.8	2	50.0	73	16.1
Centripetal	1	0.22	1	25.0	2	0.4
Undetermined	64	14.3	0	0.0	64	14.1
Total	**449**	100	**4**	100.0	453	100.0

Table 26: Modality of levallois production in flakes and cores.

2.1 Core structure

These cores are classified as levallois according to the parameters defined by Boëda (1994, 2013). As in the other levels, the stage of initialization and preparation coincided with the selection of those raw blocks which already presented the natural convexities necessary to start the debitage.

2.2 Selection, initialization and production

Thanks to the abundance of refitted objects and RMU we gained a more complete insight into some phases of the reduction sequence, such as the unipolar levallois initialization of the pebbles. The pebbles selected for levallois debitage were flat and of lenticular or oblong shape (Figure 84). After the opening of a striking platform usually with one or two strokes, the reduction proceeded with a unipolar extraction of flakes, first two or three cortical flakes and finally one target product (usually a blade, convergent or not) (Figure 82, 83, 84). In figure 82 we see the initialization phase of a big pebble, after the opening of the striking platform, followed by a sequence of four unipolar removals: the role of n.1 (a siret accident) and n. 2 is opening the debitage surface, then follows n. 3, a target object, and n. 4, also a target object, consisting of another siret accident.

Figure 83 represents the initialization phase of another pebble: the striking platform is prepared with several small removals, the debitage surface is opened with two unipolar removals (n.1 and n.2), followed by a series of removals aimed at managing the convexities (n. 3, n. 4, n. 5), in order finally to produce a target blade (n.6). Due to the strong stroke with a hard hammerstone on the ventral face of flake n.6, a small incidental flake was accidentally detached.

These four levallois cores are completely exploited, and it is interesting to note how this last stage of the reduction sequence was managed: in the case of the convergent levallois the core was abandoned due to the hinged accidents (Figure 84), whereas in the case of figure 85, the last reduction stage of a centripetal levallois core was managed with an additional production.

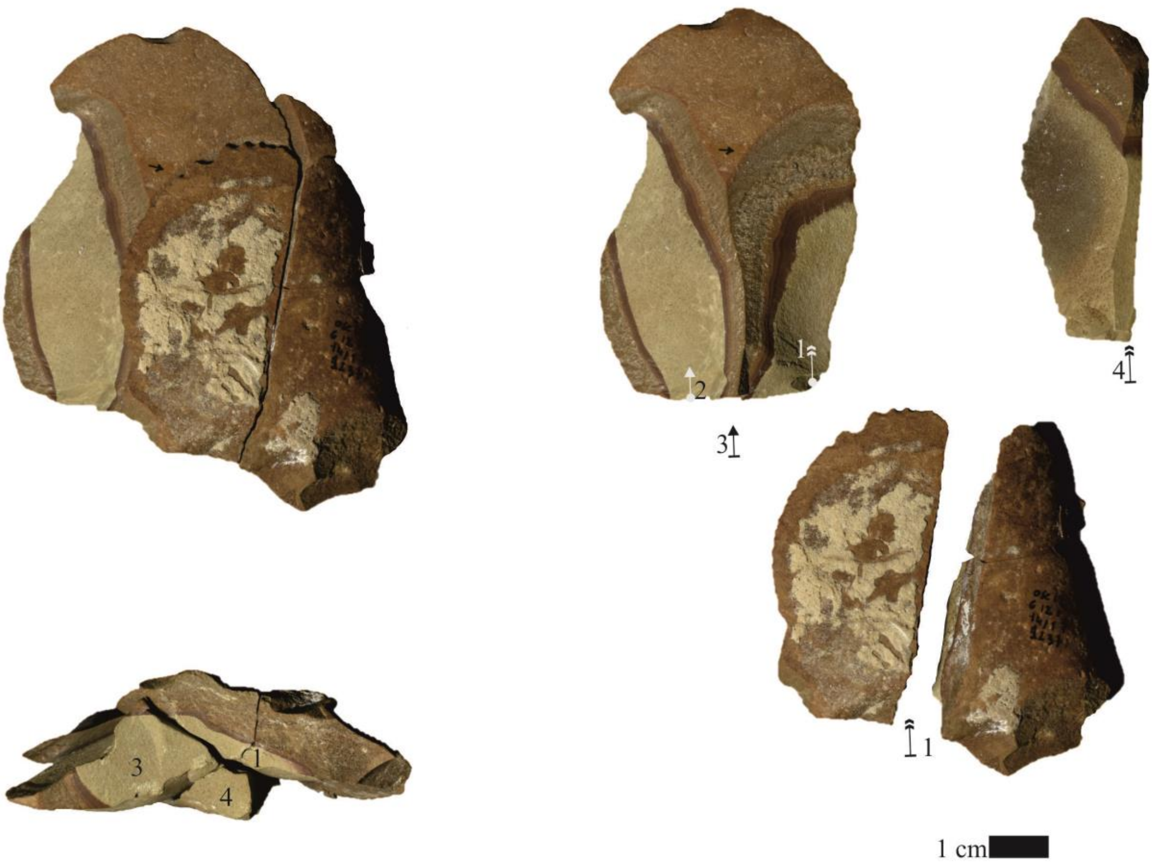


Figure 82: Refitting set of RMU 1, decortication plus two siret accidents.

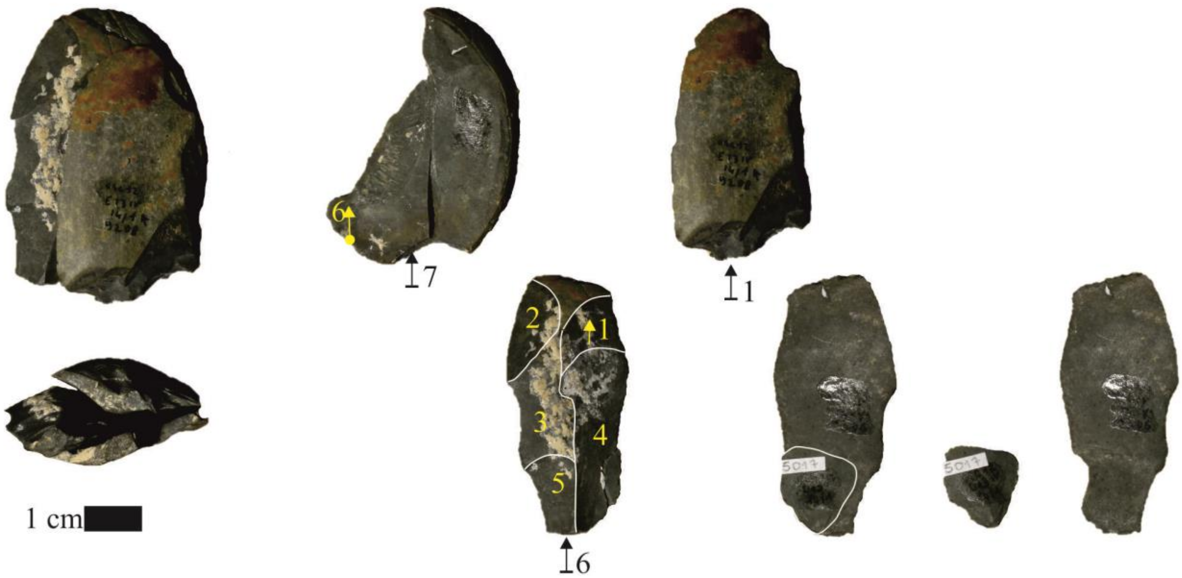
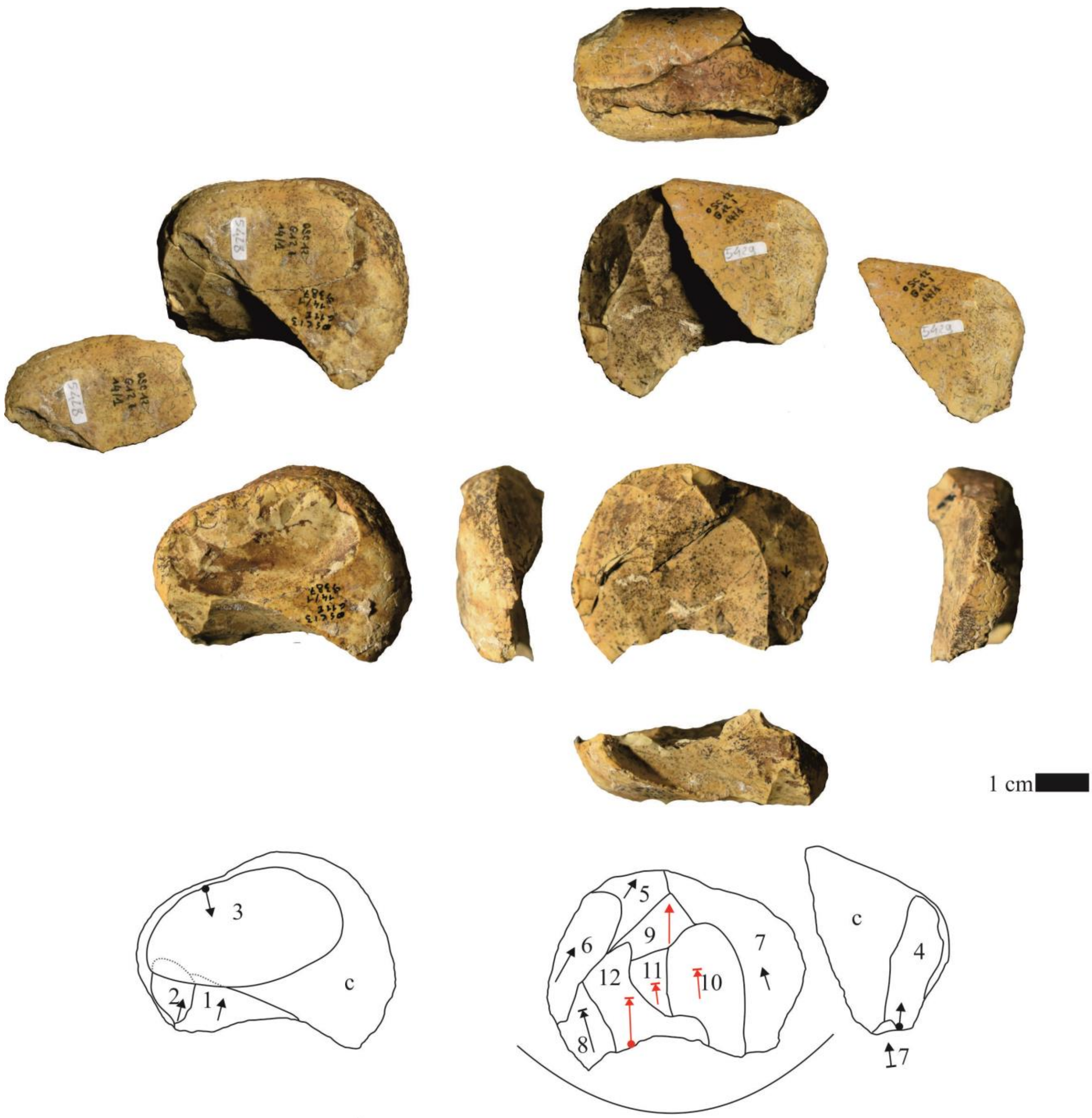


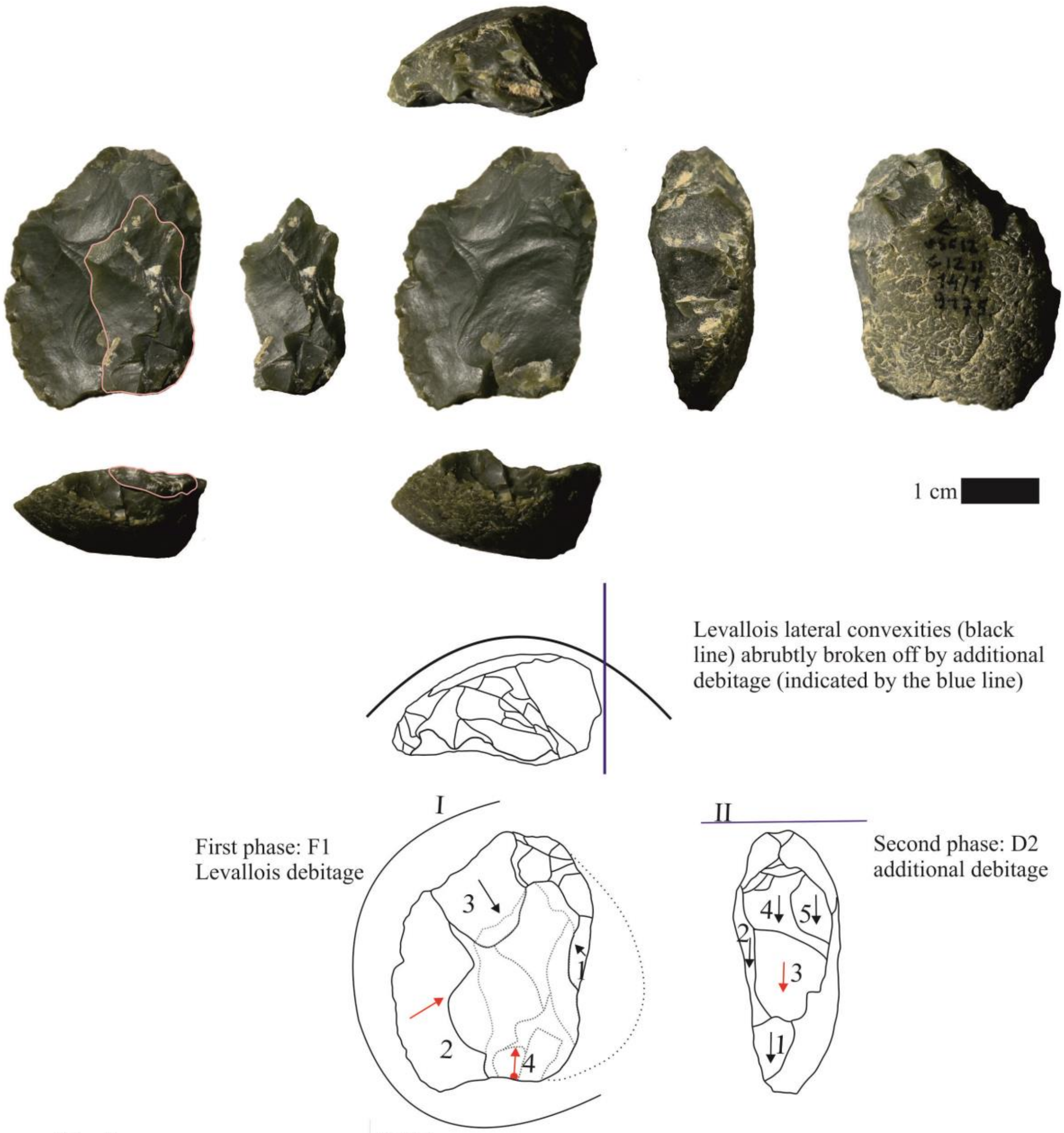
Figure 83: Refitting set of RMU 40, decortication and production.

(Traces of employment of hard hammerstone given by the small incidental flakes).



Selection	Pebble.
Striking platform	Semi-peripheral, prepared with small removals.
Production	1, 2, 3 = Opening of the debitage surface, interception of inner fragmentation plane of the pebble. The pebble was turned on the other side and a recurrent convergent levallois reduction took place. 4, 5, 6, 7,8 = decortication and convexities management. 9 = researched production, convergent flake. 10 = researched production, flake. 11, 12 = hinged accidents which led to the abandonment of the core.
Target object	Flakes and convergent flakes.

Figure 84: Refitting set and core of RMU 99, convergent levallois F1.



Selection	Pebble.
Striking platform	I: Peripheral, prepared with several removals. II: Orthogonal to the debitage surface, prepared with several removals .
Production	First phase- Centripetal levallois, after the preparation of the striking platform (I), a production of 3 flakes (1, 2, 3), and a target flake (4) took place. Second phase- After the levallois production, the convexities of levallois were abrubtly broken off by the opening of a distal striking platform on the right side of the core. Subsequently a series of elongated supports were realized.
Target object	Flakes and blades.

Figure 85: Refitting set and core of RMU 84, centripetal levallois plus additional debitage F1+D2.

2.3 Target product

Of 449 levallois flakes found in this level, 139 were the objective of this debitage. The technical features of these target items are presented in the following table (Table 27). In the production of elongated supports those with mainly trapezoidal and triangular shapes prevail. These target items do not present extensive cortex coverage, in fact, the convergent and unspecified items were produced mostly at an advanced stage of exploitation of the core, whereas the backed pieces stem from an initial stage of exploitation. The direction of the removals is convergent for the convergent flakes, and mainly unipolar for the other items. Backed items mostly show one, two or three scars on the dorsal surface, whereas the convergent and unspecified ones have from two to six removals on their dorsal face.

The butts are always prepared with one (flat) or several strokes (2 = dihedral, 3-4 = prepared; > than 4 = faccetted). The backed items have lateral impact points, the convergent ones central impact points and for the other items the impact point could be either central or lateral. All the pieces have a prominent bulb, which is an indication of the use of direct techniques with a hard hammerstone.

Target objects	Backed items			Convergent items			Unspecified items			Total
	backed blades	backed flakes	backed long flakes	convergent blades	convergent flakes	convergent long flakes	blades	flakes	long flakes	
Total number	**8**	**9**	**18**	**3**	**2**	**10**	**17**	**28**	**44**	**139**
Morphology	Trapeze	Trapeze	Trapeze	Triangle	Trapeze, triangle	Triangle	Trapeze	Trapeze	Trapeze	\
Symmetric %	25.0	71.4	66.7	100.0	50.0	90.0	69.2	88.9	85.4	77.7
Section shape	Triangle	Trapeze	Trapeze	Trapeze	Triangle. Trapeze	Trapeze	Triangle	Trapeze	Triangle	\
Cortex ≤ 50%surface	87.5	88.9	94.4	100.0	100.0	100.0	100.0	96.4	100.0	97.1
Cortex location	Back	Back	Back	Absent	Back, distal	Absent	Back	Absent	Absent	\
Scar direction	Unipolar	Unipolar	Unipolar	Convergent	Convergent, unipolar	Convergent	Unipolar	Unipolar	Unipolar	\
Scar number	One, two	two	One, two three	Four	Two, six	three, four	Two, three	Two, three, four	Two, three, four	\
Generation of debitage	T0	T0	T0	T2	T0	T2, T3	T0	T3	T3, T0	\
Butt	Flat	Flat, dihedral	Flat	Flat, prepared	Dihedral	Facetted	Flat, prepared	Facetted, flat, prepared	Flat, prepared, facetted	\
Impact point	Lateral	Lateral	Central, Lateral	Central	Central	Central	Central, Lateral	Central	Central	\
Bulb	Prominent	Prominent	Prominent	Prominent	Prominent	Prominent	Prominent	Prominent	Prominent	\
Macro traces %	50.0	0.0	27.8	100.0	0.0	60.0	66.7	35.7	45.5	41.7

Table 27: Comparative table of target objects.

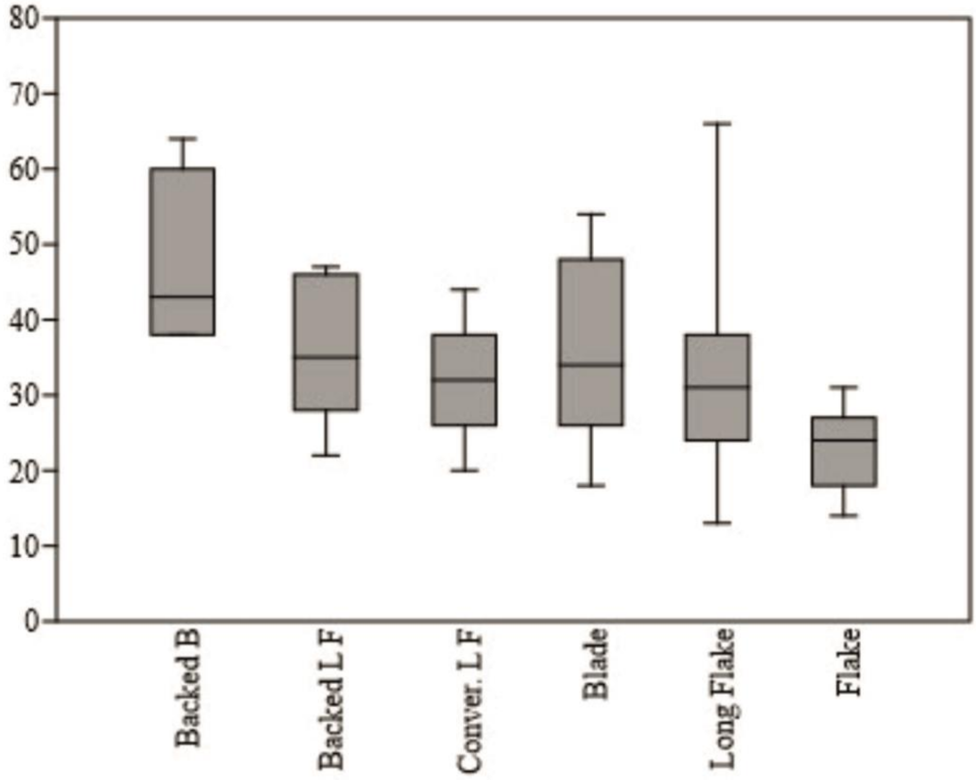


Figure 86: Box plot of the dimensional dispersion of target items.

(The graph only shows entire items; hinged accidents and fragmented items are excluded. The dimension indicated is the length expressed in mm).

The backed items have quite homogeneous dimensions (Figure 86). The convergent long flakes have very regular dimensional variations (Figure 86, 87). The other items show an interesting pattern: blades and flakes have quite homogeneous dimensions, whereas long flakes vary greatly in length comprehending pieces from 2 to 7 cm (Figure 86). Moreover, we note that even though all the pieces show very homogeneous dimensional variations, the greatest difference is between flakes and backed blades.

Figure 87: Target objects (convergent pieces).

3. Additional debitage aimed at producing flakes and blades (C1, D1, D2)

3.1 Core structure

In this section we have juxtaposed type C1, C2 and D2 because, apart from their peculiarities (the objective - flakes or blades - and the degree of predetermination) they all possess the same volumetric structure. The raw blocks selected to be flaked are globular, oblong pebbles opened with one single stroke in an orthogonal direction (Figure 88). In the first case, only one side of the block is exploited in the production (Figure 88, 89, 90, 91), in the second case, two independent series of debitage occur,one on each sides of the block (Figure 88), and in the third case one series of debitage exploits two sides of the core, taking advantage of the central rib\angle of the block (Figure 88, 92).

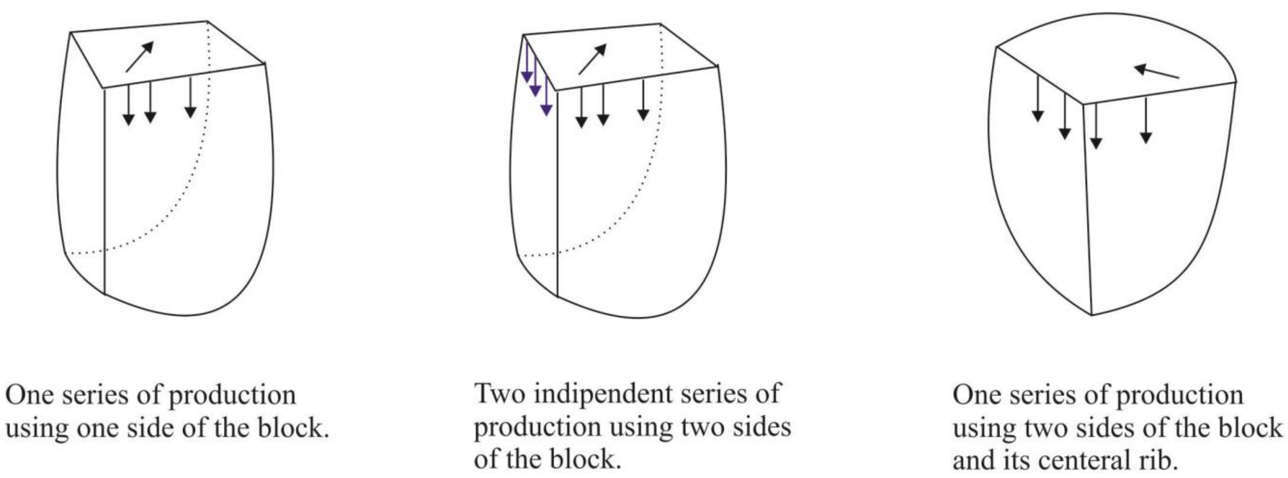
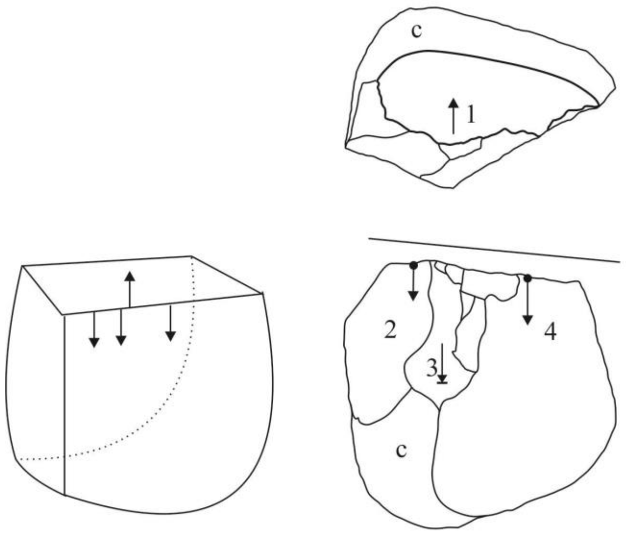


Figure 88: Schematic representation of additional debitage.

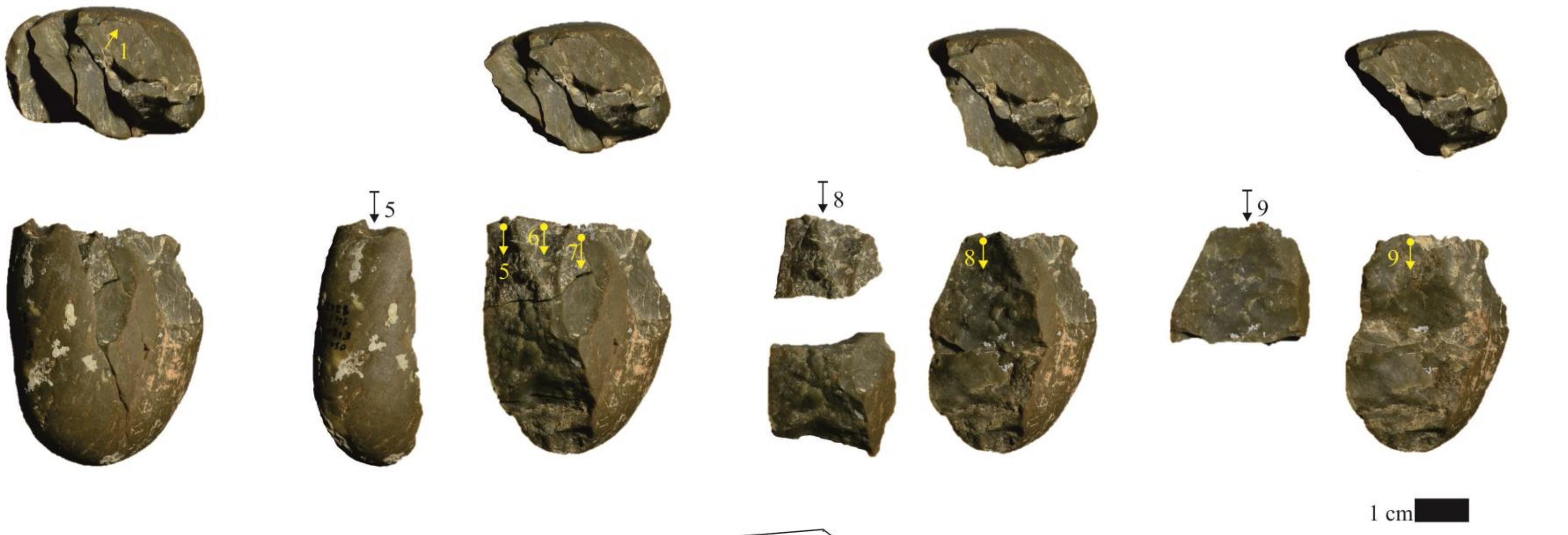
3.2 Selection, initialization and production

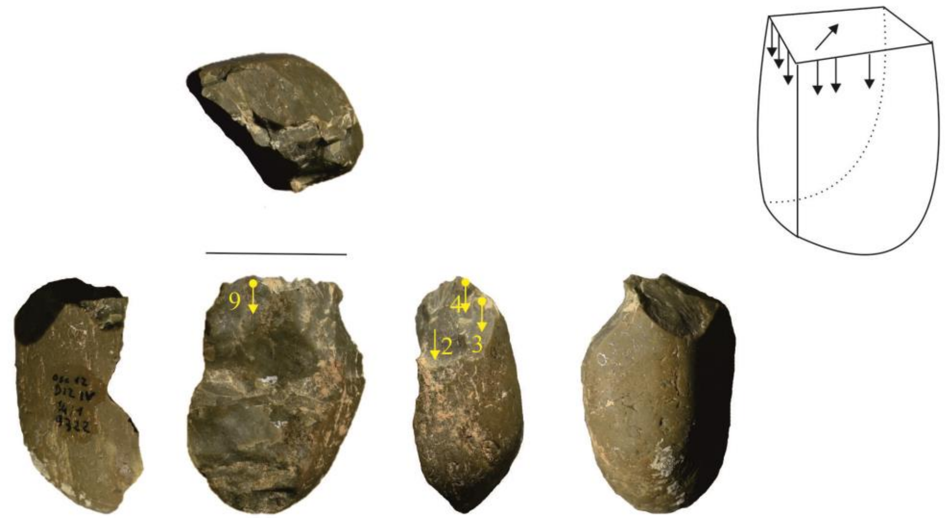
The selected pebbles were opened with a single stroke, orthogonal to the debitage surface (Figure 89, 90, 91, 92), followed by one or two production series, with no further preparation of the striking platform or management of the convexities, the aim of this debitages being flakes (Figure 91) or blades (Figure 90).



Selection	Pebble.
Striking platform	Orthogonal to the surface of debitage, opened with one stroke 1.
Production	2, 3, 4 = initialization, decortication. 3 is an hinged accident 4 intercepts an inner fragmentation plane of the pebble. Consequently the pebble was abandoned whithout having yielded a target production.
Target object	

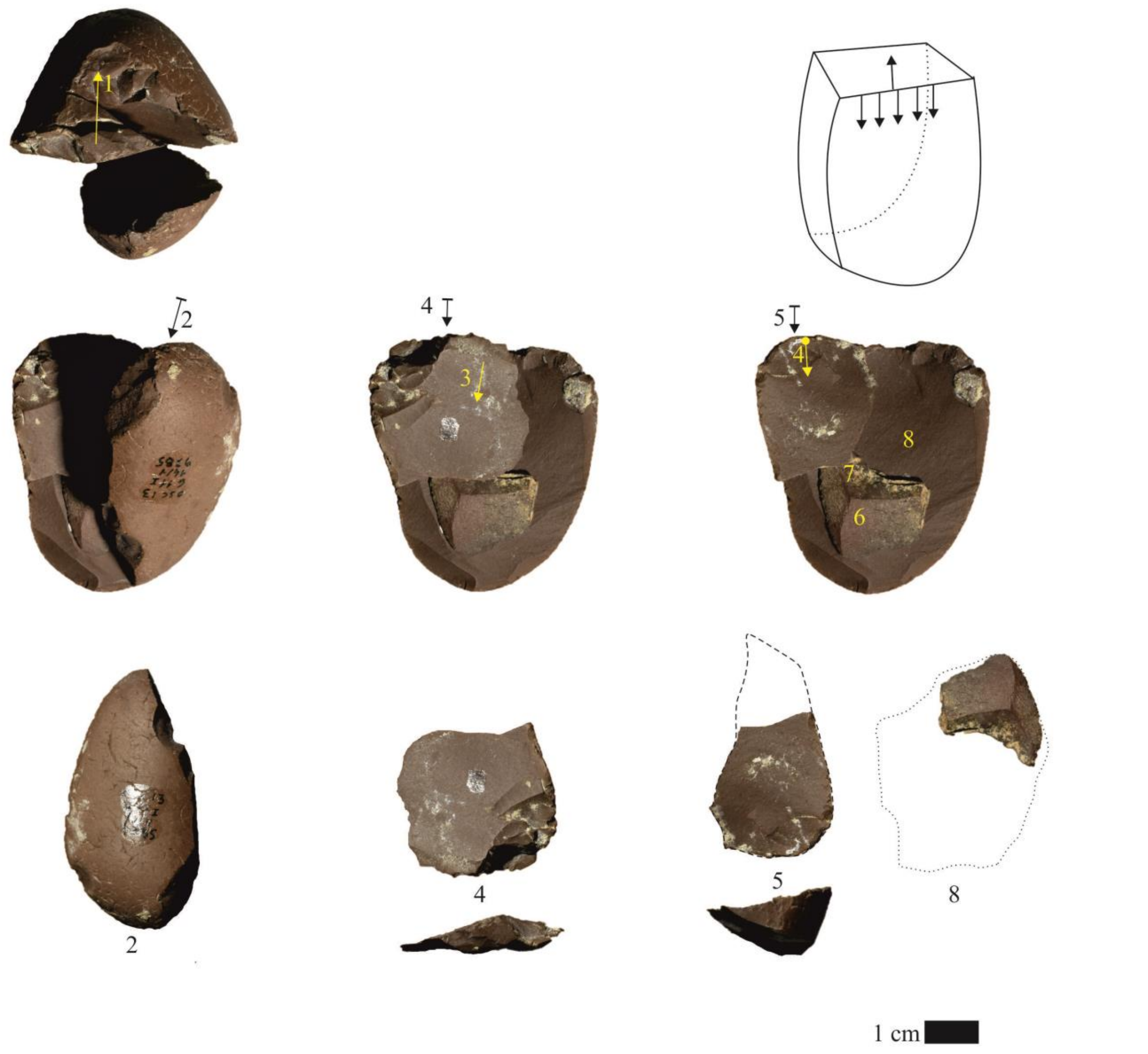
Figure 89: ID, 9350, additional core D 1\2.

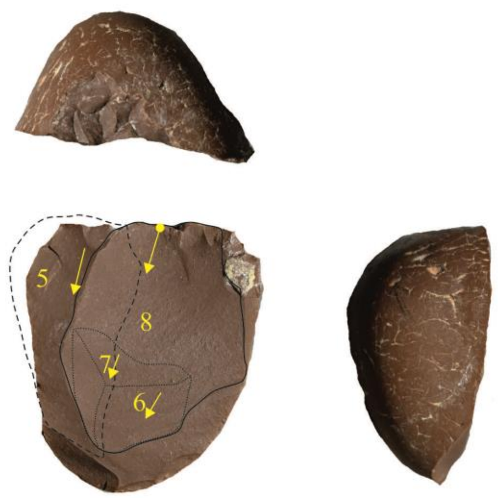




Selection	Pebble.
Striking platform	Orthogonal to the surface of debitage, opened with one stroke, 1.
Production	2, 3, 4 = initialization, decortication on the thin side of the pebble. 5, 6, 7 = decortication of the thick side of the pebble. 8,9 = attempts to obtain blades, interception of an inner fragmentation plane. The core was abandoned because of the bad quality of the raw material, without producing any target object .
Target object	Blade.

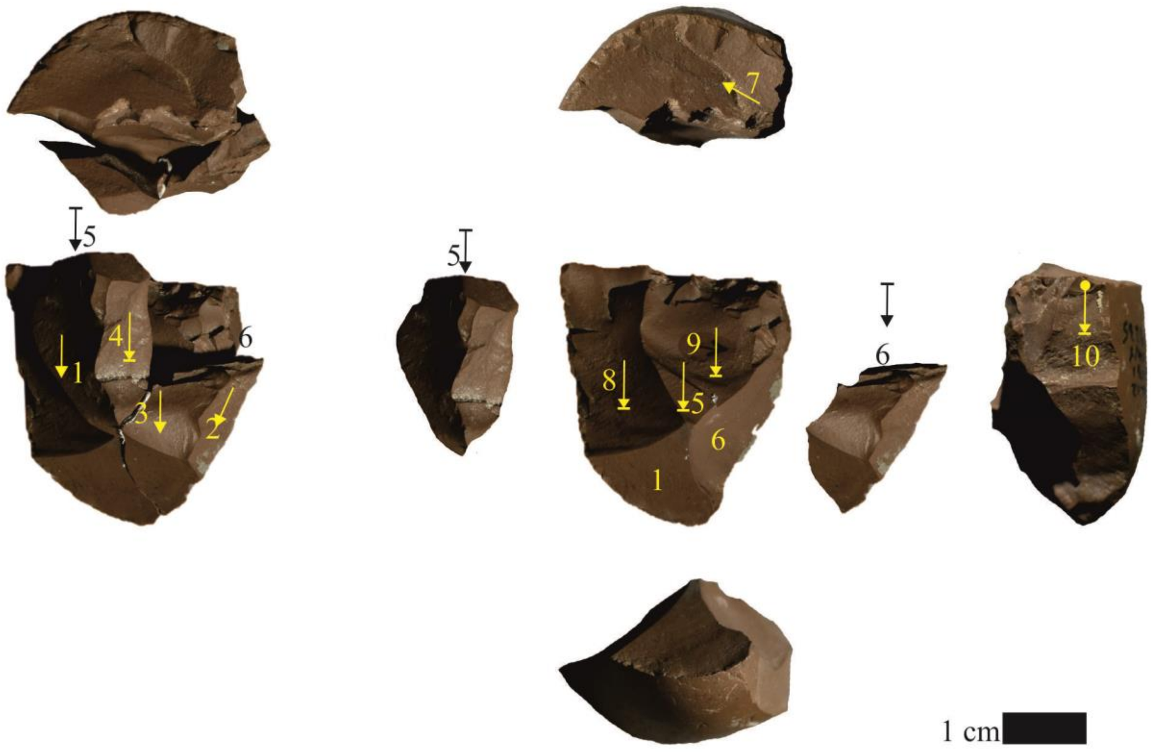
Figure 90: Refitting set and core of RMU 2, additional reduction sequence D2.

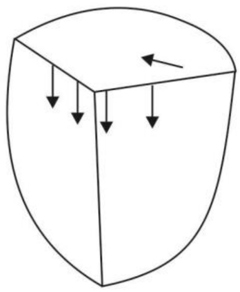




Selection	Pebble.
Striking platform	Orthogonal to the surface of debitage, opened with one stroke, 1.
Production	2 = initialization, decortication. ...missing flakes. Recurrent production of target flakes without any other preparation of the convexities nor of the striking platform (3, 4, 5, 6, 7, 8). Core abandonment in a medium stage of exploitation.
Target object	Flake.

Figure 91: Refitting set and core of RMU 46, additional reduction sequence D1.





Selection	Pebble.
Striking platform	Orthogonal to the surface of debitage, opened with one stroke.
Production	Two production series with the same idea\objective and stroke sequence. The first sequence produced the removals 1, 2, 3, 4, 5, 6, utilizing an orthogonal striking platform, 4, 5 are hinged accidents. 7 re-opening of the striking platform, production of the flakes 8, 9. 10 being a hinged accident, which led to abandonment of the core.
Target object	

Figure 92: Refitting set, and core of RMU 125, additional core D1\2.

4 Retouched tools

In the SU 14, only 21 pieces have been retouched.They were target flakes, management flakes, semi-cortical flakes and undetermined fragments. All the pieces, exept for two semi-cortical flakes produced by additional debitage, are made on levallois supports. There is a clear predominance of unilateral scrapers and undetermined items (Table 28). The retouch is found not only on target objects, but mainly on management and semi-cortical flakes, which is an interesting difference to the other levels (Table 28, Figure 93) althought retouch is also present on target flakes (Figure 94).

Typology\ Technological category	**Unilateral scrapers**	**Unilateral scrapers +point**	**Bilateral scrapers +point**	**Bilateral scrapers**	**Transve rsal scrapers**	**End scraper s**	**Unde termi ned**	**Tota l**
Backed blades	1	0	0	0	0	0	0	**1**
Backed long flakes	0	0	0	0	0	0	1	**1**
Convergent blades	0	1	0	0	0	0	0	**1**
Blades	0	0	0	0	0	0	1	**1**
Flakes	0	0	0	0	1	0	0	**1**
Long flakes	0	0	1	0	1	0	2	**4**
Semi-cortical flakes	3	0	0	0	0	1	0	**4**
Management flakes	2	0	0	1	0	1	1	**5**
Undetermined	1	0	0	0	0	0	2	**3**
Total	**7**	**1**	**1**	**1**	**2**	**2**	**7**	**21**

Table 28: Retouched recurrences.

Figure 93: Retouched tools, lateral scrapers on cortical flakes.

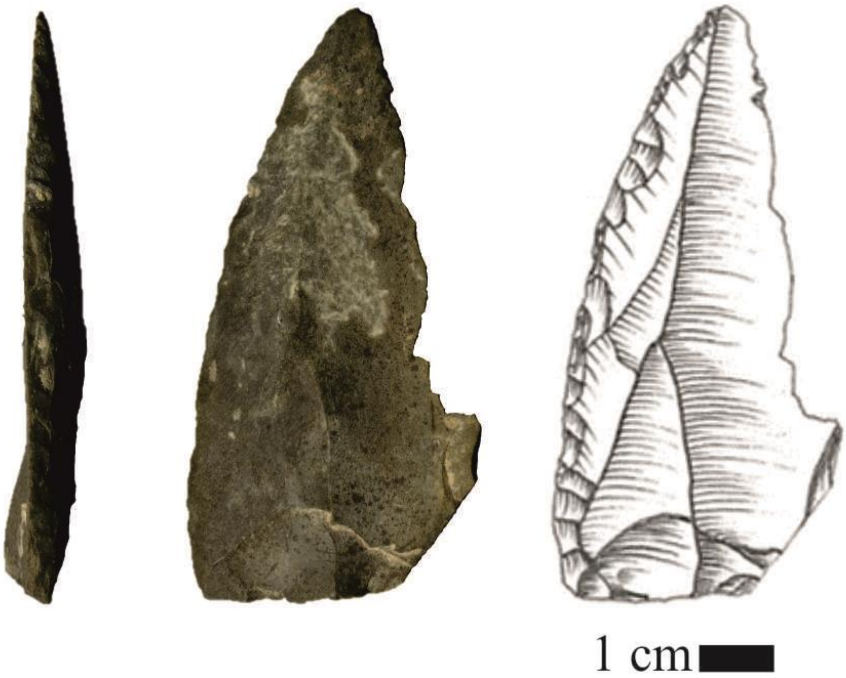


Figure 94: Retouched tool, lateral scraper on convergent blade.

5 Refitting

In the SU 14, thirtysix refitting and conjoint sets are present consisting of 116 items in all (19% of the collection without counting microflakes and undetermined fragments - 613 pieces). The majority of sets is made up of 2 or 3 pieces, followed by groups of 4 and 5 pieces and finally a few groups made up of a conspicuous number of pieces (8 or 10) (Figure 95).

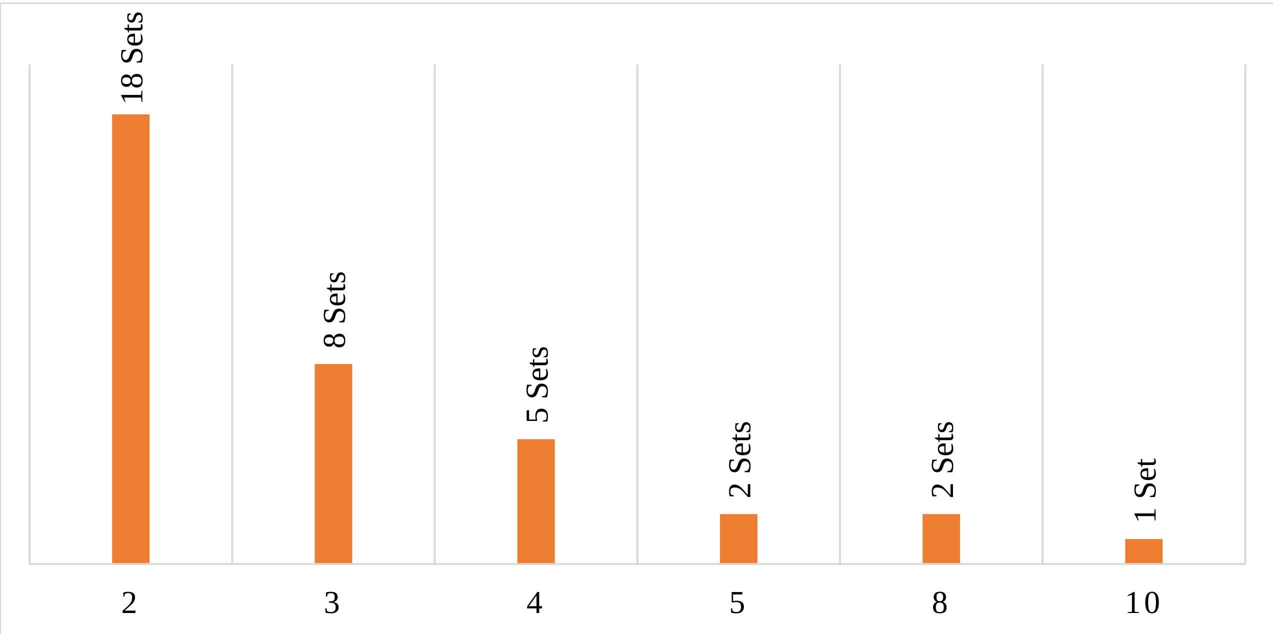


Figure 95: Bar graph showing the quantity of pieces included in the refitting sets.

The refitting sets are very valuable for the understanding of the reduction sequences as they are able to prove or disprove hypotheses made on the basis of the reconstruction of the "virtual" reduction sequence and the technological analysis. The refitting sets are thus indispensable to the understanding of the chronological stages in the production process, which might otherwise be misinterpreted. For this reason, the same refitting sets were also presented in the section regarding the reduction sequences in order to explain some aspects, such as the dimensions of the pebbles introduced into the site (Figure 79, Figure 90); the actual management and succession of stages during the reduction sequence (Figure 82, 83, 90-92), and the actual shapes of some fragmented flakes (Figure 91).

Refitting plays a crucial role in the understanding of the debitage concept of the cortical flakes, and consequently of the initialization stage of debitage (Figure 82, 83). In recurrent levallois production aimed at producing convergent, backed and elongated items, the debitage started with the removal of two or three cortical flakes. After this preparation it was possible to follow up with a further production of supports with very few adjustments (Figure 96, 97, 98).

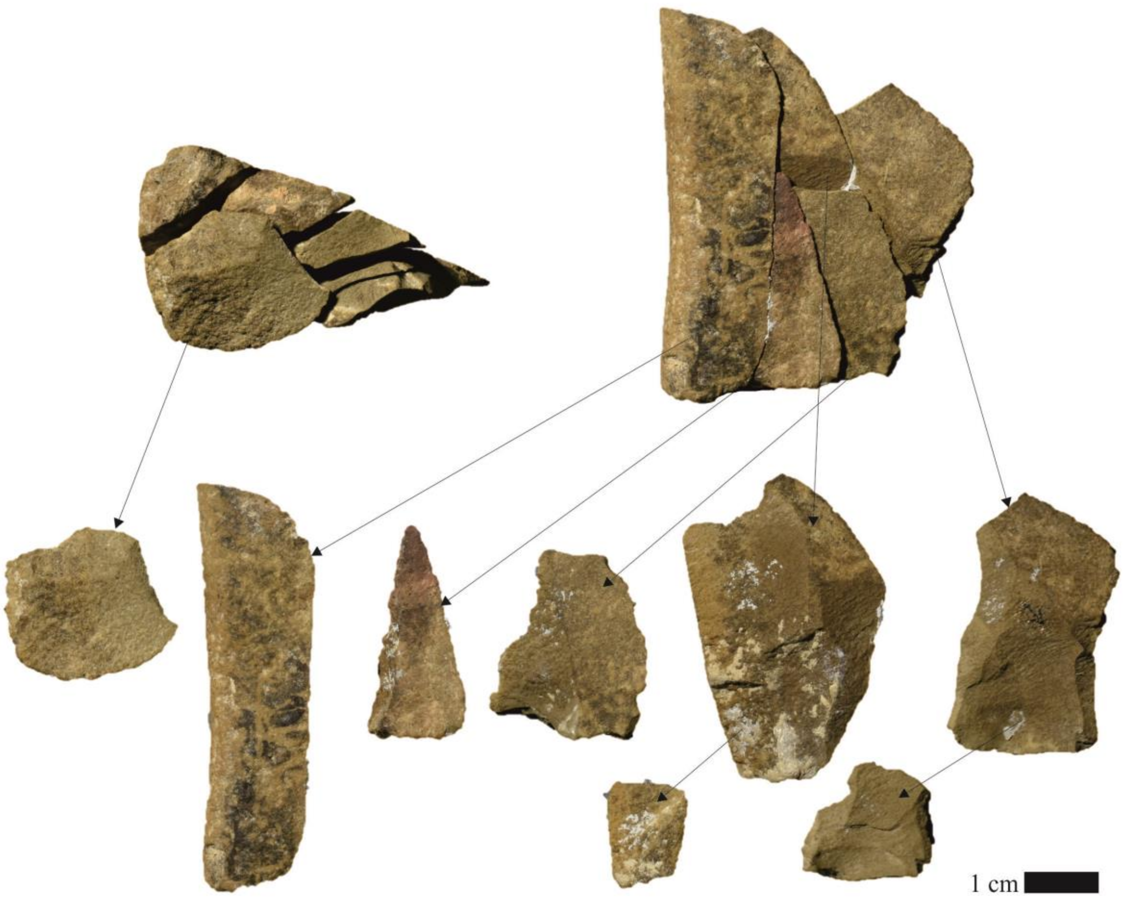


Figure 96: Refitting set of RMU 41, initialization and production.

Figure 97: Refitting set of RMU 80, levallois initialization and production.

Figure 98: Refitting set of RMU 77, levallois initialization and production.

In addition to their important role in the interpretation of the chronology and development of the stages in the reduction sequence, the identification of refitting and conjoint sets is essential for the RMU analysis. In this work we can only indicate the potentialities of the refitting procedure in the interpretation of the technological and the RMU analysis, however, these data will be further analyzed and interpreted by means of a GIS platform.

The combined usefulness of technological analysis, refitting, RMU analysis plus GIS interpretation was tested on the SU 13 and is presented in chapter VIII - paper 1 and 3 of this work (summary in the following chapter, complete published papers in the appendix).

6 Raw Material Unit analysis

Although the area has not been completely excavated, in the SU 14 we found 124 RMUs, numbering 537 items (87% of the collection excluding microflakes and undetermined fragments - 613 pieces); further 29 RMUs presenting refitting sets. Sometimes an RMU corresponds to the refitting set (e.g. Figure 92, 98), whereas in other cases there could be pieces that correspond to the same RMU but they cannot be refitted (Figure 99).

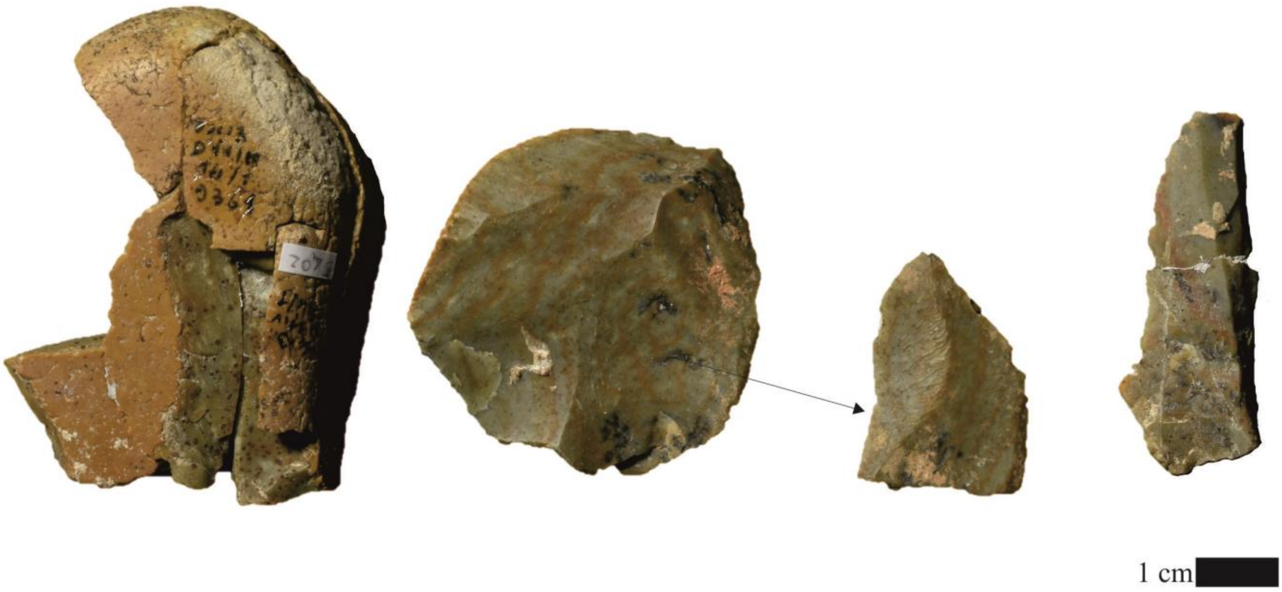


Figure 99: RMU 80, levallois initialization and production..

We noted an almost equal number of RMUs composed of only one item, and composed of from two to five items, followed by groups with between 6 and 10 items, RMUs made up of 11 and 20 items, and finally the larger than 21 items (Table 29). The most predominant raw material is jasper, followed by chert and cherty limestone (Table 29).

Number of pieces in each RMU	Jasper		Chert		Cherty limestone		Quartz sandstone		Limestone		Total RMU	
	n.	%	n.	%	n.	%	n.	%	n.	%	n.	%
1	21	35.0	13	46.4	11	35.5	2	50	0	0	47	37.9
2 to 5	21	35.0	11	39.3	10	32.3	2	50	0	0	44	35.5
6 to 10	12	20.0	2	7.1	4	12.9	0	0	0	0	18	14.5
11 to 20	5	8.3	1	3.6	4	12.9	0	0	1	100	11	8.9
21 to 35	1	1.7	1	3.6	2	6.5	0	0	0	0	4	3.2
Total	60	100.0	28	100.0	31	100.0	4	100	1	100	124	100.0

Table 29: Number of pieces in each RMU, and number of pieces and RMU for each type of raw material.

Each RMU is made up of different pieces which played a particular role in the reduction sequence. Considering the number of pieces in each RMU and the role played by each flake we can make inferences as to the behaviour involved (Table 30). In order to identify the role of the flakes in the reduction process we defined the various stages of the reduction sequence:

- The first stage is the initialization of the pebble, which corresponds to the removal of the cortex (D = Decortication).
- The second stage consists in managing the convexities through production of flakes (M = Management).
- The third stage is the actual production of target objects (T = Target objects), and when possible (recurrent levallois debitage) we identify the generation of debitage (T0, T1 = first target objects; T2, T3 = target object obtained at an advanced stage of the reduction sequence).
- The fourth and final stage is represented by the residual waste of the sequence, i.e. the completely exploited cores (A = Abandonment).

ID RMU	N. items	R. set	D	M	T	G	A	Description
1	14	x	x	x	xr	t0-t1		Complete reduction sequence without core
2	6	x	x	x	xr	t0	x	Complete reduction sequence with core
3	4		x	x				Decortication and management in situ
4	30		x	x	x	t0-t3		Complete reduction sequence without core
5	10	x	x	x	xr	t0-t3		Complete reduction sequence without core
6	9	x	x	x	x	t0		Complete reduction sequence without core
7	15	x	x	x	xr	t0		Complete reduction sequence without core
8	4				x	t3		Target flakes
9	1				x	t0		Target flake
10	1		x					Only one cortical flake
11	7		x	x	r			Complete reduction sequence without core
12	1				xr	t0		Target flake
13	1				x	t0		Target flake
14	1		x					Only one cortical flake

ID RMU	N. items	R. set	D	M	T	G	A	Description
15	4	x	x	x				Decortication and management in situ
16	2			x	x	t0		Decortication outside, production in situ
17	1						x	Exploited core
18	1				x	t3		Target flake
19	11	x	x	x	x	t0-t3		Complete reduction sequence without core
20	6		x	x	x	t1		Complete reduction sequence without core
21	8	x		x				Only management in situ
22	4		x	x	x	t0		Complete reduction sequence without core
23	5				xr	t0-t3		Target flake
24	9	x	x	x			x	Decortication, management and core in situ
25	7		x	x	r			Complete reduction sequence without core
26	1		x					Only one cortical flake
27	1				x	t0		Target flake
28	1			x				Only management in situ
29	1			x				Only management in situ
30	1							Hammerstone
32	1				x	t0		Target flake
33	2			x	x	t3		Decortication outside, production in situ
34	12	x	x	x	x	t3		Complete reduction sequence without core
37	2			x				Only management in situ
38	2			x	r			Decortication outside, production in situ
39	8	x		x	x	t0		Decortication outside, production in situ
40	6	x	x	x				Decortication and management in situ
41	14	x	x	x	x	t0-t3		Complete reduction sequence without core
42	16			x	x	t0-t3		Decortication outside, production in situ
43	3		x	x				Decortication and management in situ
44	2		x					Only one cortical flake
45	5		x	x				Decortication and management in situ
46	11	x	x	x	x	t0-t3	x	Complete reduction sequence with core
47	1				x	t3		Target flake
48	3		x	x	x	t3		Complete reduction sequence without core
49	3	x	x				x	Complete reduction sequence with core
50	1				x	t3		Target flake
51	1				xr	t2		Target flake
52	1				x	t2		Target flake
53	19		x	x	xr	t0-t3	x	Complete reduction sequence with core
55	1		x					Only one cortical flake
56	3		x	x	xr	t2		Complete reduction sequence without core
57	2		x		x	t3		Target flake
58	9		x	x	xr	t3		Complete reduction sequence without core
59	11		x	x	x	t0-t3		Complete reduction sequence without core
60	4		x	x				Decortication and management in situ

ID RMU	N. items	R. set	D	M	T	G	A	Description
61	2			x	xr	t2		Decortication outside, production in situ
62	1				x	t0		Target flake
63	2	x		x			x	Only one complete exploited core
64	4			x				Only management in situ
65	4			x				Only management in situ
66	1			x				Only management in situ
68	4			x	x	t0		Decortication outside, production in situ
69	1			x				Only management in situ
70	8			x	x	t0		Decortication outside, production in situ
71	1		x		r			Only one cortical flake
72	1				x	t0		Target flake
73	1				x	t2		Target flake
74	5	x	x	x	x	t0		Complete reduction sequence without core
75	4			x	x	t0-t3		Decortication outside, production in situ
76	5	x	x	x				Decortication and management in situ
77	19	x	x	x	x	t0-t3		Complete reduction sequence without core
78	6		x	x	x	t0		Complete reduction sequence without core
79	3		x	x				Decortication and management in situ
80	28	x	x	x	x	t0-t3		Complete reduction sequence without core
81	5		x	x	x	t0		Complete reduction sequence without core
82	1						x	Only one complete exploited core
83	1		x					Only one cortical flake
84	4	x	x	x			x	Decortication, management and core in situ
85	1		x		r			Only one cortical flake
86	1				x	t3		Target flake
87	2			x				Only management in situ
88	4		x	x	x	t3		Complete reduction sequence without core
89	1				x	t0		Target flake
90	27			x	x	t0-t3		Decortication outside, production in situ
91	1				x	t0		Target flake
92	6	x	x	x				Decortication and management in situ
93	1							Hammerstone
94	1							Hammerstone
95	1				x	t3		Target flake
97	4			x				Only management in situ
98	2			x			x	Only completely exploited core
99	8	x	x	x			x	Decortication, management and core in situ
100	1				x	t1		Target flake
101	1		x					Only one cortical flake
102	5		x	x	x	t0		Complete reduction sequence without core
103	1				x			Target flake
104	13		x	x				Decortication and management in situ

ID RMU	N. items	R. set	D	M	T	G	A	Description
105	2			x				Only management in situ
106	1							Pebble
107	1							Pebble
108	1							Hammerstone
109	1							Pebble
110	1							Pebble
112	3			x	x	t2		Decortication outside, production in situ
113	35	x	x	x	x	t0		Complete reduction sequence without core
114	1			x	r			Target flake
115	1		x					Only one cortical flake
117	6	x		x	x	t0-t3		Decortication outside, production in situ
118	1						1	Only one completely exploited core
119	2				x	t0-t3		Target flake
120	1				x	t1		Target flake
121	2		x	x				Decortication and management in situ
122	1			x				Only management in situ
124	1			x				Only management in situ
125	5	x	x	x	x	t0	x	Complete reduction sequence with core
126	3			x	x	t3		Decortication outside, production in situ
127	7	x	x	x	x	t0		Complete reduction sequence without core
128	2			x				Only management in situ
129	2			x				Only management in situ
130	7	x	x	x	x	t0-t3		Complete reduction sequence without core
131	5			x	x	t0-t3		Decortication outside, production in situ
133	3		x	x				Decortication and management in situ
190	4	x	x	x	x			Complete reduction sequence without core

Table 30: Description of the technological composition of each RMU.

ID RMU = Identification number of each set of items appertaining to the RMU; N. items = number of pieces in each RMU; R. set = presence of refitting and conjoint sets; D = Decortication; M = management, T = target object; G = generation of debitage; A: core.

On the basis of this evidence, i.e. the number of pieces and their role in the reduction sequence (Table 30), we propose the following behavioural explanation (Table 31).

RMU composition	Behavioural explanation	N. of RMU
Pebble	Acquisition	4
Hammerstone	In situ flaking	4
Complete reduction sequence without core	In situ production	27
Complete reduction sequence	In situ production	5
Decortication outside, production in situ	Import-Semi-worked items	14
Target flake	Import-Finished tool	25
Only one cortical flake	Test \ Export-Pebbles	10
Decortication and management in situ	Export-Finished tool \ Semi-worked items	12
Decortication, management and core in situ	Export-Finished tool	3
Only complete exploited core	Waste	5
Only management in situ	Undetermined	15
Total		**124**

Table 31: Technological composition of RMUs, their explanation in terms of human behaviour and number of RMUs supporting the evidence.

The action of introducing material from outside to inside the rock shelter (Import) is documented in several RMUs with different technological compositions. Into the site were introduced: raw pebbles, hammerstones, and RMUs where all the stages of the reduction sequence are present, which indicates that the entire reduction of these pebbles occurred inside the rock shelter, since their decortication stage, followed by the production of the target objects, its eventual use, and its abandonment.

There is evidence of introduction into the site of semi-worked items, namely pebbles that were opened and initialized elsewhere and whose production continued inside the rock shelter.

Some items (retouched tools and target objects) were introduced into the site as already finished tools, which means that their production occurred elsewhere. It is interesting that the majority of these items were produced at a later stage of full debitage (their generation of debitage is T3) and they might be classified as oversized in comparison with the target products obtained in situ.

The transport of objects from inside to outside the rock shelter (Export) is also attested in this level by several RMU groups. The exportation of target objects produced inside the rock shelter to elsewhere is attested partly by the presence of reduction waste material, partly by the absence of the resulting target object. It is also documented that the exportation of semi-worked materials means the decortication and peraphs even the production of the first generation of target products occurred on site, and that subsequently these items were exported from the site, as cores at a middle stage of exploitation.

Finally, we have an interesting example of behaviour, i.e. the presence of only one completely cortical flake which is interpreted as a testing of the raw material, opening it, seeing its quality and then taking away the entire opened pebble.

Four RMUs consist of only completely exploited cores, indicating the waste of debitage. Lastly, it was not possible to visualize a behavioural interpretation for the RMUs composed of only a few management flakes.

7 Overview of SU 14: economy of raw material and reduction sequences

The activity in SU 14 was identified as knapping in situ, introducing raw blocks into the site (oblong and globular pebbles) which subsequently underwent both levallois and additional debitage. The levallois cores were exploited until depletion, whereas the additional ones were abandoned after one or two series of production. There is an almost complete overlap between the target object of the levallois and additional production. The activity of transformation by retouch occurs on both target pieces and to an equal extent on management and cortical flakes. The most common retouched tools are scrapers; lateral or bilateral (Figure 100).

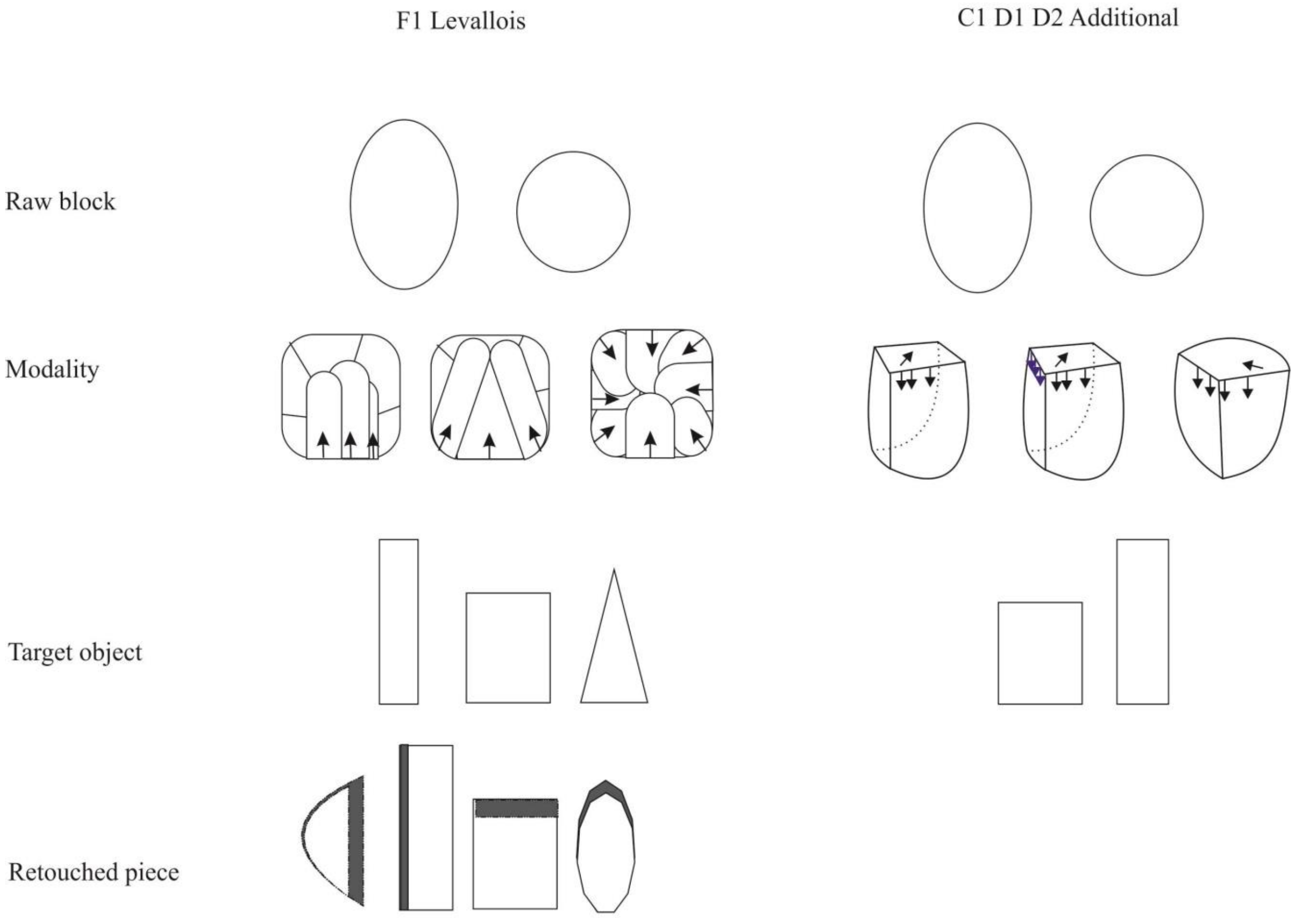


Figure 100: Reduction sequences in SU 14.

The conbination of technological approach, RMU analysis, and refitting studies has yielded more precise and complete insights into the technical behaviour behind the productive activities ascertained in the level in question. The complex of level 14 is made up of several istances of introduction and exportation of material at various stages of the reduction sequence. Further analysis will focus on extending these insights in a spatial sense, analysing the RMUs as unities of action \ activity.

Based on previous studies we arrived at the following scenario: in the SU 14 there was an introduction of pebbles reduced by a levallois debitage. After preliminary testing some pieces were exported from the site, while other pebbles were reduced with the unipolar, convergent or centripetal levallois concept until the the reduction of the pebble was finalized. Some items were exported from the site after the first stage of decortication or after the production of a first generation of target products. Furthermore, we documented the export of some target objects whose entire reduction occurred in the rock shelter. Some levallois cores were introduced into the site as semi-worked pieces, their decortication having happened in another location (Figure 98).

Along with this levallois debitage, we noted the presence of complete reduction sequences of additional debitage of C1, C2, D2 (Figure 98).

The boundary between D1, D2 is sometimes clear, but in other cases it is not. That is to say, when the cores suffer accidents, we have to presume the desired end-product but we do not have solid evidence. Cores represent the ultimate moment of the reduction sequence, and when they are abandoned it is usually due to some errors, subsequently we do not know their full productive life (unless in the presence of RMUs and refittings). It is thus difficult to identify the intention as well as the actual outcome.

It is important to note that both the levallois and the additional debitage pursued the same objectives: the production of blades, long flakes, flakes, convergent items and backed items. We can affirm that levallois production took place, and we found some typo-type levallois target objects possessing exactly the same features as the objects obtained by a levallois reduction sequence, although they were obtained employing a different reduction concept. However, in order to fully understand such a lithic complex, it is indispensable to study all the pieces contained in it.

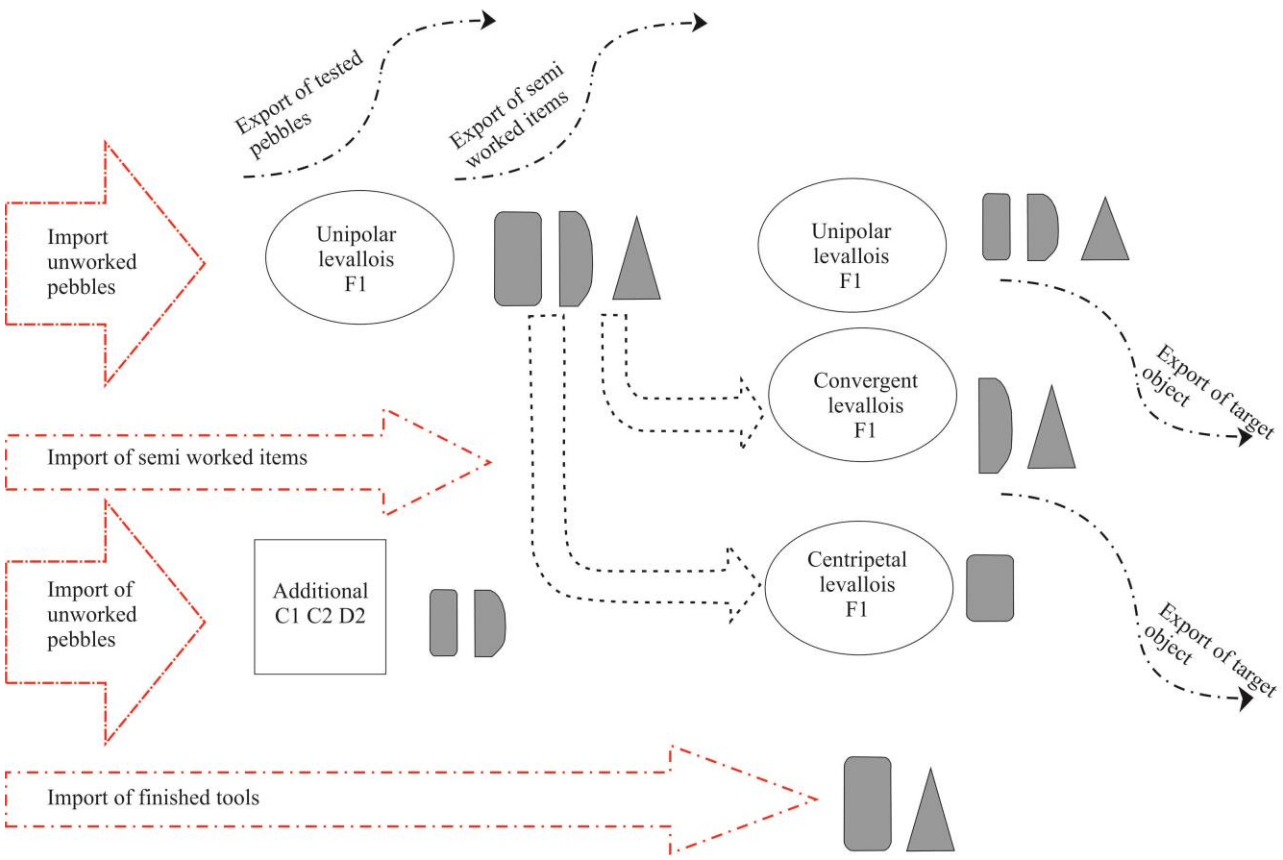


Figure 101: Subdivision of the fragmentation reduction sequences in SU 14.

VIII SU 13

1 Chapter structure

This chapter has a different structure compared to the other chapters presenting the tabled results. The explanation is that a basic technological analysis of the material of SU 13 had already been completed before embarking on this PhD. As a matter of fact, a study of the reduction sequences of the SU 13 was the subject of my Master thesis "*The lithic assemblage of the US 13 at the Middle Palaeolithic site of Oscurusciuto (Ginosa , Taranto , Southern Italy): Technological studies*" discussed in September 2013 (Master in Quaternary and Prehistory, Erasmus Mundus).

While working on this PhD (2015-2017), I extended my study of the SU 13 beyond the lithic production to also include the potentiality of the stone tools and the raw material economy. Moreover, I integrated my data with those of other scholars involved in the study of the Oscurusciuto site, i.e. the GIS interpretation aimed at determining the modalities of space management and the recognition of single activities (realized by V. Spagnolo), a taxonomic and taphonomic investigation on the faunal remains (realized by P. Boscato), a micromorphological analysis of the hearths and the assessment of the spatial implication of these features (realized by F. Berna), and finally a use-wear analysis of the lithic tools (realized by S. Arrighi).

This multidisciplinary approach was developed in order to gain more well-founded insight into the Neanderthal behaviour and occupation of the site. For these reasons, I decided to present these data in the form of the papers published in collaboration with the other researchers involved in the study of Oscurusciuto.

This chapter thus consists of extracts of three papers, focusing on their results and conclusions. This was decided so as to avoid repetition (i.e. the description of methodologies and the site). The complete texts of the three papers as they were published can be found in the appendix to this manuscript.

The first two papers focus on the lithic material whereas the third concentrates on the interpretation of the occupation of the level 13. First we presented an analysis of reduction sequences, concept, methods and target objective of the debitage, focusing on the fragmentation of the reduction sequence and correlated evidence in the archaeological record (Paper 1, Marciani et al. 2016). Secondly, we studied the target objects interpreting the different components of the tools and their use employing a combined techno-functional and use-wear approach (Paper 2, Marciani et al. *in press*). Finally, we evaluated the level from a diachronic point of view, proposing a way to disentangle the palimpsest in single events of occupation (Paper 3, Spagnolo et al. 2016).

Being extracts from other papers (Marciani et al. 2016; *in press*; Spagnolo et al. 2016) the paragraph index number correspond to those of the paper quoted, werease the layout of tables and text follows the one used in the present thesis. For a complete version of these works plus their supplementary materials and bibliographic references, see the appendix.

Paper 1: Reduction sequences and import-export activities

Middle Palaeolithic technical behaviour: Material import-export and Levallois production at the SU 13 of Oscurusciuto rock shelter, Southern Italy.

MARCIANI, G., Spagnolo, V., Aureli, D., Ranaldo, F., Boscato, P., Ronchitelli, 2016, Journal of Lithic Studies, vol. 3, nr. 2, p. xx-xx doi:10.2218/jls.v3i2.1414.

1. Introduction and background

The fragmentation of the reduction sequences is a behaviour already attested in other Middle Palaeolithic sites (Bataille 2006; Bourguignon *et al.* 2004; Moncel *et al.* 2014; Neruda 2010; 2012; Romagnoli 2015; Spagnolo *et al.*2016; Turq *et al.* 2013; Uthmeier 2006; Vaquero 2008; Vaquero *et al.* 2001; 2012a; 2012b). It proves the capacity of Neanderthals for adopting flexible strategies of occupation and use of the land, and it is also an indicator of their mobile nature. The different stages of acquisition, transport, knapping and abandonment of lithic implements, identified individually or together in the same archaeological record, suggest that the strategies related to the management of lithic materials are different and developed independently from each other (Fernández-Laso *et al.* 2011; Turq *et al.* 2013).

It is clear that the lithic material imported to a site was introduced in various ways: as raw blocks, as half-finished objects, or as already manufactured tools. The export of tools and their abandonment on site as waste material has also been documented. The complexity related to the mobility of lithic objects is directly linked to the spatial, temporal and social domains (Turq *et al.* 2013). This means that even though lithic objects appear together in the same archaeological record they are associated with various geographical places. They could be introduced in a site as a result of different episodes temporally distant from each other. Moreover, they could also indicate social processes in the groups using the region.

Another technical behaviour, which often occurs simultaneously with fragmented reduction sequences, is the recycling of ancient production waste, reusing it as supports for knapping with the aim at obtaining new tools. This behaviour is not universally recognized, and a debate is ongoing especially in archaeological literature (Romagnoli 2015; Vaquero 2011; Vaquero *et al.* 2012; 2015;). In terms of land use, the recycling behaviour could be related to the scarcity of good raw material in the region and thus emphasizing the need to reuse the same tools rearranged many times to different tasks and necessities (Amick 2007; Close 1996; Dibble & Rolland 1992; Hiscock 2009; Kelly 1988). Alternatively, it could be a specific strategy related to occasional and expedient behaviour or unplanned necessity (Vaquero *et al.* 2012). This characteristic is usually encountered in populations of high mobility within a given territory (Kuhn 2014; Romagnoli 2012; Romagnoli *et al.* 2015).

Although the data are still partial and there are few studies employing a techno-economic approach, Middle Palaeolithic populations of southern Italy (we mainly consider the region of Puglia in this paper) stand out for their high adaptability and flexibility of the knapping scheme as well as for their mobility in the territory (Carmignani 2010; 2011; Marciani 2013; Romagnoli 2012; 2015; Romagnoli *et al.* 2015; Spinapolice 2012;).

In this paper, we aim to examine the Oscurusciuto rock shelter, which is located in the ravine of Ginosa - Taranto in the region of Puglia, southern Italy. The site presents several anthropic layers with a lithic production of a predominantly unipolar levallois method (Boscato *et al.* 2011; Lazzeri 2005; Marciani 2013; Ranaldo 2005; Ronchitelli *et al.* 2011; Spagnolo *et al.* 2016; Villa *et al.* 2009).

There are several current studies regarding this site, and the principal aim of our research is to provide an integrated and complete data-set concerning the Neanderthal behaviour on site: their production strategies, trade and use of lithic tools; their space management as well as their subsistence strategies, all related to the local environment.

Specifically, the main goal of this paper is to understand the technical behaviour of Neanderthals in the Stratigraphic Unit 13 (SU 13). Consequently the study integrates various methods applied in lithic studies, among others the technological approach, to obtain information about the techniques and methods of knapping in the manufacturing of target flakes. The Raw Material Units (RMU) method, used to identify individual events of raw material introduction into the site, has supplied more detailed interpretations of individual choices regarding the management of the stone material involved. Moreover, refittings and conjoints are crucial to fully understand the technological behaviour in question, and also to underscore the reliability of each RMU (Marciani 2013; Spagnolo 2013; Spagnolo *et al.* 2016).

3.1. Lithic production

In this SU, 7504 lithic artefacts were found. Their preservation condition is very good and their edges are fresh, though the surfaces of the artefacts show a slight patina caused by chemical alteration. Due to the presence of hearths, some artefacts show various degrees of alteration by fire: 212 elements have been identified with clear burn traces.

The raw material imported into the Oscurusciuto site is characterized by great macroscopic variation. As in all the upper stratigraphic units, the dominant raw materials are jasper and siliceous limestone in their fine granulometry, found in the form of pebbles, which can still be found on the sea-terraces and river deposits around the site (at present within one km from the site) (Table 1).

Raw material	Quantity	%
Fine and medium jasper	1287	37.0
Fine chert	261	7.5
Medium chert	344	9.9
Quartz sandstone	161	4.6
Limestone	70	2.0
Siliceous limestone	1356	39.0
Total	**3479**	**100**

Table 1. Lithological classes. 4025 pieces were excluded from the table, because of their tiny dimension (mostly micro flakes and debris of the first and second DC).

The pebbles imported into the site show a standardized selection of volume (oblongs, oval pebbles), which plays an important role in the choice of the debitage technique. Notably this morphology is particularly suited to the levallois concept, mainly employed at the site. In the conglomerates still visible today nearby the site, there are pebbles with various dimension and shapes, from rather small (between 2 and 3 cm) with angular shape to quite large (more than 10 cm) with oval and globular shape. As the research stands now it is not possible to indicate the dimensions of the pebbles used by prehistoric people at the Oscurusciuto, but we do know that completely exploited cores have dimensions ranging between 4 and 5 cm. The few pebbles imported as raw material measure between 3 and 4 cm and the only core abandoned at the beginning of its debitage measures 7 x 5 cm.

There is evidence of knapping activity at the site, as revealed by a huge amount of micro-flakes (2212) and debris (3446) (debitage waste). This is also highlighted by a spatial analysis suggesting the presence of drop zones (Spagnolo *et al.* 2016). The technological categories of the lithic collection (Table 2) show that all the phases of the *chaîne opératoire* are represented in compatible proportions to the knapping activity. Completely-cortical flakes (20) and semi-cortical flakes (266) attest to the very early stages of production, *i.e.* the opening of the pebble. The management (667), target (344) and retouched (30) flakes indicate the production phase. Finally the cores represent the abandonment. This data might lead to misinterpretations of the lithic complex, suggesting that several completed reduction sequences had been carried out at the site. This is not the case, in fact thanks to the combined technological studies and the analysis of the RMUs it is possible to point to a more complex and fragmented picture. The lithic collection consists of an addition of various events of manufacture, management, importation and exportation of lithic material at different stages of production, leading to the conclusion that the archaeological record under investigation is a palimpsest of different actions or events (Hallos 2005; López-Ortega *et al.* 2015; Machado *et al.* 2013; 2015; Rios-Garaizar *et al.* 2015; Spagnolo *et al.* 2016; Vallverdù *et al.* 2005; 2010; Vaquero 2008; Vaquero *et al.* 2001; 2012b).

Only two kinds of debitage were employed in level 13: the levallois concept (documented on the bases of 575 flakes and 18 cores) and the volumetric reduction sequence (15 flakes and 6 cores). All the other flakes (*e.g.*, cortical flakes, undetermined flakes) and cores do not show enough technical parameters to enamble identification of other mode of debitage.

In total, 33 cores have been found. They represent 0,4% of the analysed produce (Table 3). The group of undetermined cores is made up of pieces that are in the early stages of exploitation or appear too fragmented. Those pieces do not have the technical characteristics needed to define their concept of debitage. Eighteen cores refer to the levallois concept. Some of them, which appear too exploited, exclude the definition of the method of production (indeterminable levallois), whereas the others have been divided equally into unipolar or convergent levallois.

Technological category	Quantity	%
Pebbles	9	0,1
Completely-cortical flakes	20	0,3
Semi-cortical flakes	263	3,5
Management flakes	667	8,9
Micro-flakes	2212	29,5
Undetermined flakes	203	2,7
Target flakes	344	4,6
Retouched tools	30	0,4
Cores	33	0,4
Undetermined pieces	277	3,7
Debris	3446	45,9
Total	**7504**	**100**

Table 2. Technological composition.

Concept		Quantity
Levallois	Unipolar	5
Levallois	Convergent	6
Levallois	Undetermined	7
Volumetric		6
Undetermined		9

Table 3. Core concepts.

3.1.1. Levallois reduction sequence

The first phase attested is the selection of blocks, whose morphology and convexity enable the initialization of the core by means of the levallois concept without a proper phase of preparation of the core. After the striking platform opening, follows the cortex removal of the surface of debitage by means of two or three unipolar extractions. Some instances of refitting attest that these unipolar semi-cortical flakes are already the first generation of target objects. Moreover, they also possess the technical characteristics to install the necessary convexity and guide ribs for the next generation of target flakes.

Subsequently, the presence of flakes involved in the management of lateral and distal convexities have been attested, in preparation of a striking platform and in order to generally manage the cores (management flakes; undetermined flakes, micro-flakes). These flakes are meant to create the technical characteristics needed to allow for the extraction of other predetermined items. The objects that Neanderthals sought to produce here were flakes, backed flakes and convergent flakes. Some of these flakes, besides being target products (predetermined), also have the function of predetermining and re-establishing the right convexity for successive removals (Figure 4).

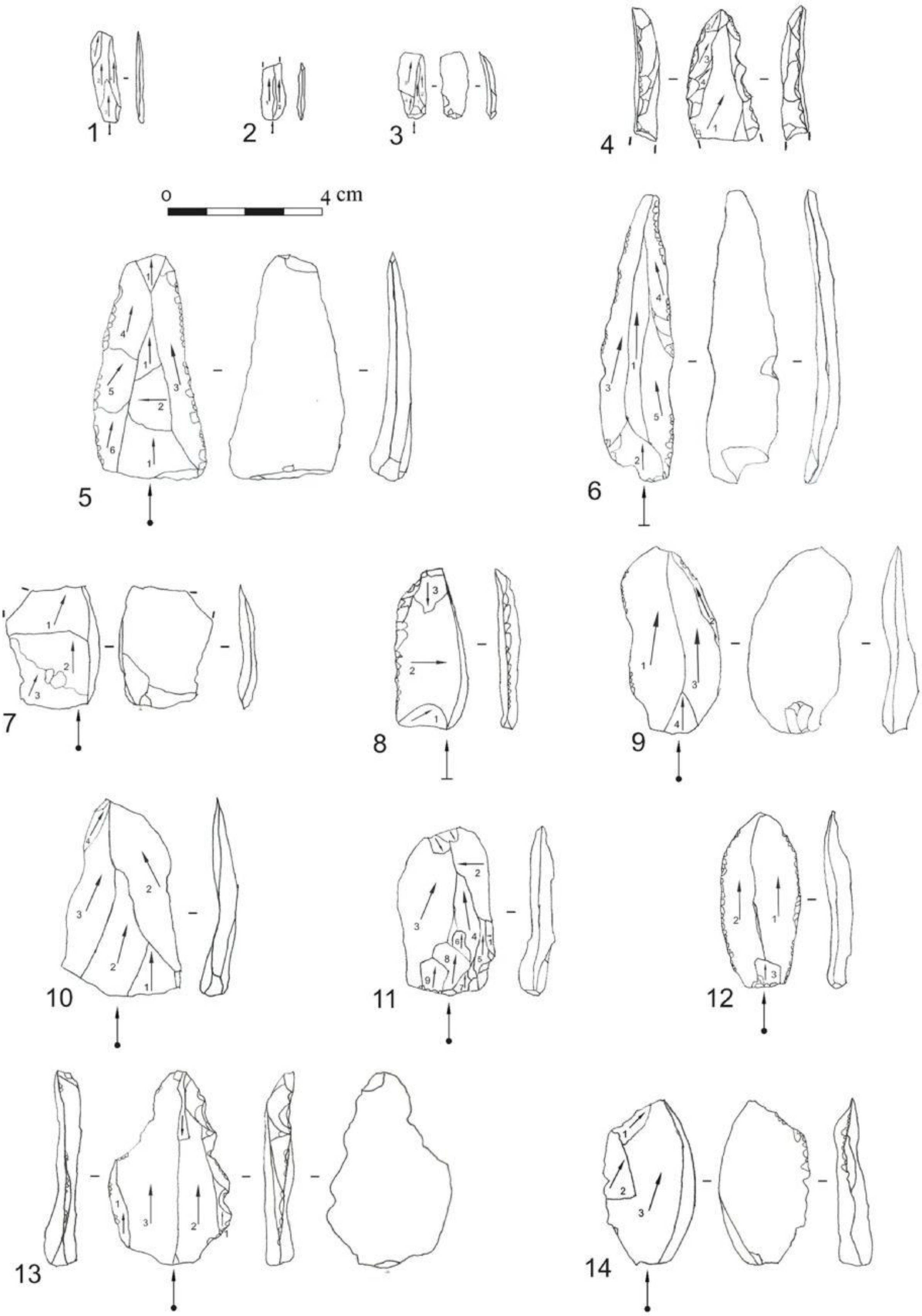


Figure 4. Drawing of target flakes and retouched tools.

1, 2, 3: bladelets, target objective of volumetric production; 4: retouched tool: denticulate point; 5, 6, 10: convergent flakes target objective of levallois production; 7, 8, 14: backed flakes, target objective of levallois production; 9, 11, 12: flakes, target objective of levallois production; 13: retouched tool: denticulate scraper.

The most used blanks for the levallois debitage are pebbles and a few completely cortical flakes. Thanks to a diacritical analysis, it is possible to determine that the cores, although incidentally, were used until the exhaustion of the reserve of raw material: they were finally abandoned only after repeated rescue attempts. In many cases after a hinged accident a lot of other strokes are performed in order to remove the accident and carry on with the knapping activity (Buonsanto 2012, Buonsanto & Peretto 2012). This behaviour is attested on the base of 7 cores. Only one core was abandoned with no further rescue attempt, due to an error in the early stages of exploitation.

In the unipolar levallois process, it is common to have one or more partial striking platforms, one of which is used for the extraction of target products, *i.e.* flakes, backed flakes and convergent flakes. The other striking platform, usually on the left, is utilized for the management of distal and lateral convexities by removing small orthogonal flakes. On the right, the craftsman knapped in order to obtain debordant cortical flakes, which are both predetermined and predetermining, playing indeed a double role: they manage the convexities but they are also target objectives. On the contrary, in the convergent levallois process, the plan of percussion is a large partial one, and both the management and the production of flakes take place from the same striking platform. That means that both researched flake and management flake come from the same striking platform (Figure 5). As for the unipolar modality the target products of the convergent levallois production are convergent flakes and backed flakes. The levallois production at this level of Oscurusciuto is recurrent, for this reason, just on the base of the diacritical study of the scar on flakes, is not always possible to recognize a clear break between the two modalities (unipolar and convergent). Leading to the conclusion that convergent and baked flakes could be the aim of both modalities.

The transformation process is evident in the retouched items. Only 30 pieces proved to have been retouched and this is a tiny number compared to the amount of pieces from the production as a whole. Therefore, it is clear that at this point Neanderthals did not feel the need to retouch the supports, but used the sharp edges directly obtained by debitage. The technological category mostly thought to have been selected for retouching is the flake, with a total number of 15 tools, 5 tools made on convergent flakes (Table 4).

Consequently, it can be stated that the majority of the retouched pieces have been made on target flakes (Figure 4). However, there are also a few retouched tools made from managing flakes, such as cortical and generic flakes. The most common retouched tool is the side-scraper with 13 items (Table 4), the majority of which were obtained from the category of flakes and backed flakes.

3.1.2. Volumetric reduction sequences

Compared to the levallois concept, the volumetric exploitation is marginal (Table 3), indeed only 10 bladelets, 5 bladelets management flakes and 6 cores attest to the presence of this production process. The volumetric debitage consists of short reduction sequences made exclusively on flakes or fragments. These blanks were chosen because of their technical characteristics, which permit the production of bladelets without a real preparation of the core. The knappers took advantage of the ribs, angles and convexities already partially present on these pieces to initialize the core. What is interesting is that the volumetric cores were usually abandoned before the real production phase.

Thanks to the diacritical analysis of those cores it was possible to ascertain that they were aimed at producing bladelets (Figure 4). We can summarize the technical parameters of bladelets as follows: pseudo rectangular and symmetrical morphology support, presence of central guide rib and usually two unipolar detachments for side management (Figure 4). These bladelets were not retouched.

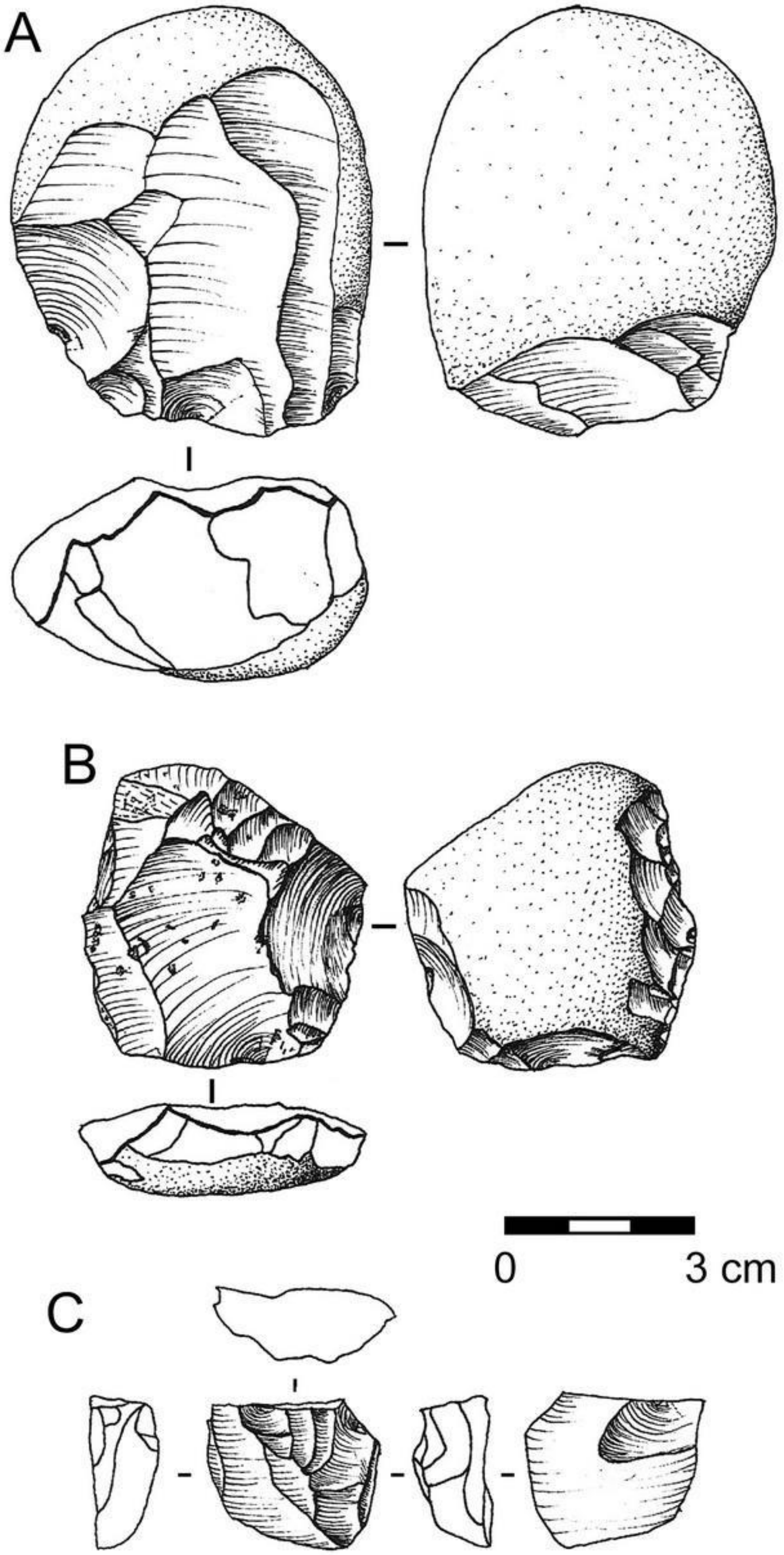


Figure 5. Drawing of cores. A: unipolar levallois; B: convergent levallois; C: Volumetric.

Technological category	Notch	Denticulate scraper	Lateral scraper	Denticulate point	End scraper	Retouched fragment	Quantity
Cortical F	1		2				3
Management F	1	1					2
Flakes	1	3	6	1	2	2	15
Convergent F			2	1		2	5
Backed F			3				3
Undetermined						2	2
Total	**3**	**4**	**13**	**2**	**2**	**6**	**30**

Table 4. Retouched tools and technological category.

3.2. Target objectives: Flakes, backed flakes, convergent flakes, bladelets

The levallois reduction sequence is an integrated concept that allows for production of a great quantity of predetermined products with specific characteristics and dimensions (Boëda 2013). In this section we evaluate the recurrent features of these target objects in order to identify what technical characteristics were sought for each type.

Generally, the target object has quite constant characteristics, summarized in Table 5. Notably, there are rectangular symmetrical bladelets; oval and trapezoidal, often symmetrical flakes; oval backed flakes; and triangular convergent, even asymmetrical, flakes. The sections are generally triangular, but in some cases trapezoidal for flakes and convergent flakes, and the shape is rectangular trapeze for backed flakes. The cortex is absent or slightly invasive for all categories, except for the backed flakes, 80% of which have a dorsal cortex. This particular feature of the backed flakes may indicate that these items were created to present a sharp side opposite a backed cortical side, which was very useful as a prehensile part. All types of flakes have rather unipolar negatives, except for the convergent one, in which the negatives are convergent. The number of negatives fluctuates between two and four.

Characteristic	Bladelets	Flake	Backed flakes	Convergent flakes
Total number	26	200	37	88
Morphology	rectangular	oval; trapezoidal	oval	triangular
Symmetric	92%	64%	59%	44%
Section shape	triangular	triangular; trapezoidal	triangle; rectangular trapeze	triangular; trapezoidal
Cortex until half of the surface	4%	23%	81%	7%
Cortex localization	Distal	lateral	dorsal	lateral
Scar directions	Unipolar	unipolar	unipolar	convergent
Scar number	2; 3	3; 2; 4	2; 3;4	3; 4; 2
Butt	flat; point-form	facetted; flat	facetted; flat	facetted; chapeau de gendarme; flat
Impact point	central	central	lateral	central
Bulb	not prominent	prominent	not prominent	prominent

Table 5. Target products main characteristic

The butts are flat and point-shaped for bladelets, facetted and flat for the other types of flakes, and facetted *chapeau de gendarme* for the convergent flakes. The impact points are central, with the exception of the backed flakes, which have lateral impact points. The flakes and convergent flakes have prominent bulbs, while bladelets and backed flakes have no prominent bulbs.

From the dimensional point of view the levallois products show very variable dimensions, ranging from rather small items (1.5 cm in length) to quite large ones (7.5 cm in length). This dimensional variety is due to the recurrent nature of the levallois process, which enables a continuous production of flakes without a restructuration of the core, producing the same type of target flakes in a variety of dimensions. This leads to a progressive reduction of the cores, and thus of their products. On the other hand, the items resulting from volumetric production show a certain dimensional consistency: the ratio between length and width is almost the same for all pieces. This might be interpreted as a wish to produce bladelets of only one size, whereas the former production method testifies to the need of producing items of different sizes.

The graph (Figure 6) shows the distribution of values referable to the elongation index of the four categories of target flakes identified in the SU 13. Flakes and convergent flakes have lower and more concentrated elongation index values than bladelets and backed flakes, which are longer but with a greater variation in the elongation index.

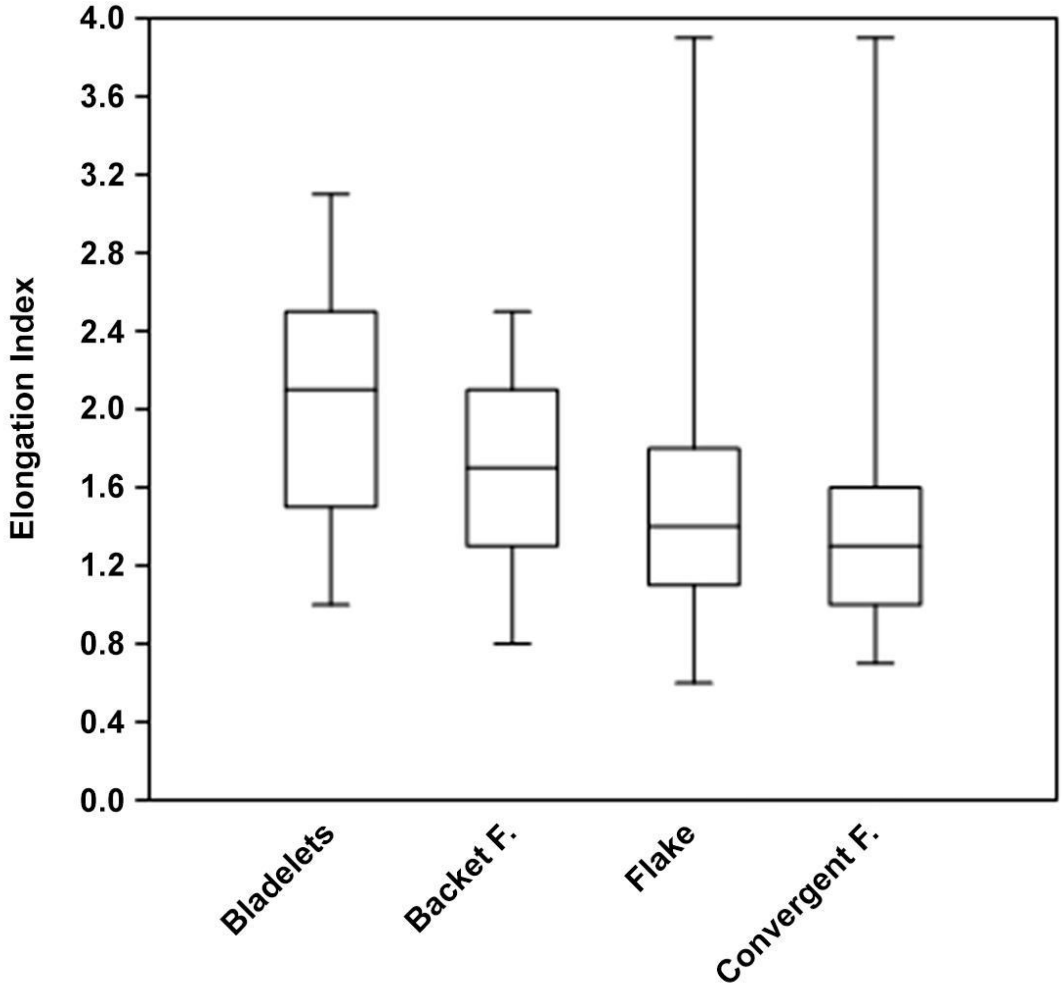


Figure 6: Elongation Index for target flakes. Bladelets (N = 26), backed flakes (N = 37), flakes (N = 200) and convergent flakes (N = 88).

3.3. RMU: Import, export

Despite the limitations posed by the incompleteness of the excavated area and by the fact that not all the material is comprised in the RMU (5197 pieces of first and second DC are excluded), we were able to identify a great number of RMU: 279 RMU made up of 1770 pieces, and of this group 128 formed 53 refitting or conjoint sets. Each RMU is made up of many or few pieces and they also show variations in their technological composition. A great number of RMUs consist of one or a few pieces (max 5 items), whereas there are few RMUs with many items (Table 6).

Quantity of pieces in each RMU	Fine and medium Jasper	Fine chert	Limestone	Medium chert	Quartz sandstone	Siliceous limestone	Total RMU
pieces	679	98	16	263	144	570	
1	30	2	6	14		48	100
2 to 5	31	7	1	20	1	39	99
6 to 20	21	2	1	13	1	23	61
21 to 40	8			1	2		11
41 to 60	2	1		1		2	6
> 60					1	1	2
Total RMU	**92**	**12**	**8**	**49**	**5**	**113**	**279**

Table 6: Quantity of pieces in each RMU, and number of pieces and RMU for each raw material.

From a technological point of view the target or the retouched objects are part of the RMUs consisting of just one piece or few pieces. That means that all the reduction sequences of these pieces might have occurred outside the rock shelter, consequently these pieces could have been introduced into the site as already finished objects, thus they could be considered imported items. Some of the cores (most of them almost depleted) also belong to this first group of RMUs with few pieces. The absence of the target product belonging to these cores make us hypothesise that the finished tools were exported from the site. The few RMUs, where all the phases of the reduction sequences are simultaneously represented, give us the evidence to support the idea that those RMUs were introduced into the site as raw pebbles, which were then knapped, finishing the product completely at the site (Spagnolo *et al.*2016).

On close examination, considering the number of pieces in each RMU and their technological composition (*i.e.* the type of flake and how many pieces relate to the different phases of the reduction sequence: acquisition = pebbles; management = management flakes and micro-flakes; production = target flakes; abandonment = completely exploited cores) it is possible to obtain a accurate and detailed definition (Table 7).

The importation of material from outside to inside the rock shelter (Import) is documented by the presence of imported pebbles (7 RMUs) and target flakes (47 RMUs). It is also possible to envisage the import of semi-worked objects based on 47 RMUs, which include all stages of the reduction sequence excluding the cortex removal, which necessarily occurred elsewhere (Table 7).

The transport of objects from the site to the outside (Export) is attested by the RMUs with incomplete reduction sequences. The presence of 40 RMUs made up only of completely-cortical and semi-cortical flakes, leads us to suppose that the first phase of pebbles opening and decortication took place at the site. Later these pebbles were exported from the site as semi-worked pieces (1°stage). Two RMUs, composed only of management pieces, indicate the export of semi-finished items in a more advanced stage of reduction (2°stage). Moreover the presence of 24 RMUs composed of numerous elements of cortex removal and management but lacking target objects suggests the export of these finished tools.

Furthermore there are 9 RMUs in which all stages of the reduction sequence are attested in situ and 49 RMUs where all phases of the reduction sequence except for cores are represented. The cores can usually be reused, removed from the site or treated as waste. In both the former cases it is assumed that the above 58 RMUs were introduced in level US 13 as pebbles and entirely knapped inside the rock shelter from the first stages of debitage until abandonment.

RMU composition	Behavioral explanation	N. of RMU
Pebble	Acquisition	7
Target flake and core	Import-Finished tool	4
Target flake	Import-Finished tool	34
Decortex and target flake	Import-Finished tool	8
Decortex, target flake and core	Import-Finished tool	1
Outside decortex, inside production	Import-Semi-worked items	47
Decortex and management in situ	Export-Finished tool	23
Management and core	Export-Semi-worked items	2
Decortex, management and core in situ	Export-Finished tool	1
Only inside decortex	Export-Semi-worked items	40
Complete reduction sequence without core	In situ production	49
Complete reduction sequence	In situ production	9
Only completely exploited core	Waste	9
Only inside management	Undetermined	45
Total		**279**

Table 7: Technological composition of RMU, their explanation in terms of human behaviour and number of RMUs that support this evidence.

Nine RMUs are made up of only completely exploited cores, indicating the abandonment and waste of debitage. Finally for 45 RMUs (made up of management flakes) it was not possible to envisage a behavioural interpretation.

4. Discussion and conclusions

To sum up, the technical behaviour of Neanderthals at level 13 of Oscurusciuto shows a great degree of fragmentation in the reduction sequences. The record is made up of several instances of introduction of lithic material at different stages of manufacturing. Pieces were introduced in the form of rough objects (pebbles), as well as semi-finished items, and as finished tools.

As a result of technological analysis and the study of the RMUs we are able to propose a scenario of how the Neanderthal production of lithic material occurred at the Oscurusciuto level 13. Once pebbles had been imported, there is a unipolar levallois process of cortex removal and a first- generation of unipolar flakes, followed by a phase of core-restructuration in order to get a second generation of unipolar supports, or a restructuration in a convergent levallois process, concluded by a convergent production. However, convergent levallois cores may also have been introduced into the site as semi-worked pieces. The same scenario is valid for the volumetric cores which, made from flakes or fragments, may have been imported into the site as semi-worked items, or which may simply have been broken fragments resulting from in situ knapping. Furthermore, tools have been imported into the site as finished objects while, in return, some finished objects have been exported from the site. At some point, some tested pebbles and semi-manufactured pieces were likewise exported from the site (Figure 7).

The fragmentation of the *chaîne opératoire* in several instances of import or export demonstrate the palimpsest nature of the level which is made up of different events happening one after another. This also indicates a certain mobility of the population within this territory. In other words, there would then necessarily be other sites where the complementary phases of the reduction sequences have taken place, or where the respective target products were utilized and abandoned.

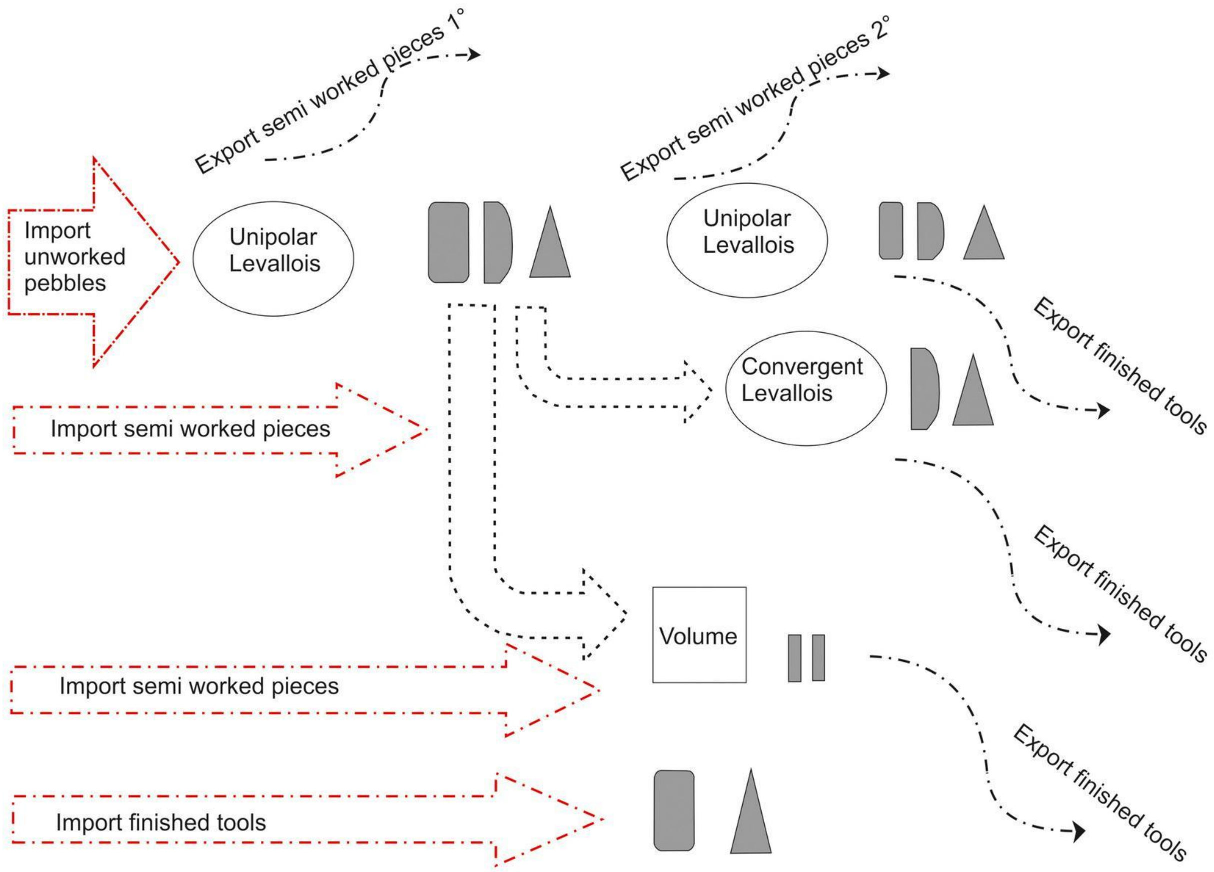


Figure 7. Fragmented reduction sequences. The grey silhouettes represent the target flakes (big rectangle = flakes; triangle = convergent flakes; half oval = backed flakes; small rectangle = bladelets).

Not far from Oscurusciuto in the peninsula of Salento, more precisely in the layer L of Grotta del Cavallo (at the end of MIS, 5 beginning of MIS 4), a high degree of mobility in the territory is attested for Neanderthal populations on the basis of a different archaeological record. Together with the fragmentation of the reduction sequences, it also demonstrates the recycling of lithic tools. This evidence consists of pieces with double patinas, exogenous raw material and objects characterized by a large investment in retouching. This behaviour is interpreted as an occasional practice performed in response to unplanned needs (Romagnoli 2012; 2015).

Having reached these conclusions, new questions and problems arise. We have noted that the target flakes could be both the main objects resulting from import and export, as well as the ultimate goal of the whole process of debitage. But what exactly was their role in the society where they were produced? Since they represented a great technical investment, were the objects meant to have a comparatively long life? In order to adequately answer these questions it is necessary to perform techno-functional and use-wear analysis. Subsequently,, these data will be analysed using the GIS platform to gain specific information on the functionality of the spaces.

The results obtained studying the RMUs invite us to continue in this direction. In fact, we decided to carry out a specific experimental protocol with the aim to further verify the interpretation given on the basis of the study of the RMUs

Paper 2: Structure and use of target objects

Middle Palaeolithic lithic tools. Techno-functional and use-wear analysis of target objects from SU 13 at the Oscurusciuto rock shelter, Southern Italy.

MARCIANI, G., Arrighi, S., Aureli, D., Spagnolo, V., Boscato, P., Ronchitelli, *In press.* Journal of Lithic Studies.

1. Introduction

The Oscurusciuto site is a Middle Palaeolithic rock shelter located in Southern Italy with a very rich record, essential for the definition of the technical behaviour of Neanderthals, as related both to the management of the raw material of the territory and the crafting and use of lithic tools. The lithic collections of Oscurusciuto show substantial uniformity even though each level displays its own peculiarity. The acquisition of raw material is local; Neanderthals used pebbles of jasper, chert, cherty limestone and quartz sandstone available in the terraces and areas near the site. The recurrent levallois method is the most commonly noted concept of debitage especially in its unipolar modality aiming at producing elongated supports, both convergent or not. Furthermore, there is additional volumetric exploitation aiming at producing bladelets (Boscato et al., 2011; Marciani, 2013; Marciani et al., 2016; Ranaldo, 2005; 2017; Ronchitelli et al., 2011; Spagnolo, 2013; 2017; Spagnolo et al., 2016; Villa et al., 2009).

As it is widely known, the levallois reduction sequence is an integrated concept that allows for a production of a great quantity of predetermined products with specific characteristics and dimensions (Boëda, 1991; 1993; 1994; 1995; 2013; Schlanger, 1996; Van Peer, 1992). The degree of predetermination of this concept regards both obtaining of a certain quantity of target products (resulting from the lineal\preferential or recurrent levallois debitage) and their quality (Boëda, 1991; 1993; 1994; 1995; 2013). It also testifies to a specific economic strategy with regard to the maximization of cutting edge productivity obtained from cores (Brantingham and Kuhn, 2001; Lycett and Eren, 2013).

The levallois production at the Oscurusciuto stratigraphic unit 13 was aimed at producing a clear set of debitage goals: flakes, convergent flakes and backed flakes. In previous studies we have noted the peculiar and recurrent features of these objects and their particular role in the economy of the level (Marciani, 2013; Marciani et al., 2016). We assumed that these target objects had been imported as finished objects into the site, or had resulted from an in situ debitage process (Marciani, 2013; Marciani et al., 2016; Spagnolo et al., 2016).

As the target objects are the answer to specific needs and necessities which motivated the flaking activity itself (Boëda, 2013), we examined the role played by levallois target objects in the society where they were produced. In particular, our main objective for this work was to focus on the levallois target flakes produced at Oscurusciuto SU 13. We wanted to test (1) if the target objects of a reduction sequence (the production aim), were actually used by Neanderthals to perform their activities (the functional aim); (2) if each production aim corresponded to a single functional aim i.e. each tool was used solely for one activity, or, on the contrary, used for a multitude of purposes; and finally (3) if tools used for a specific activity also had a specific structure.

To accomplish these goals we integrated techno-functional and use-wear analyses: the first was implemented to globally comprehend each tool, identifying each single techno-functional unity (prehensile and transformative portions), whereas the second revealed the way in which these tools had been used, proceeding to identify the activity involved (e.g. piercing, cutting and/or scraping), and the type of material (vegetable/animal, soft/hard) on which these activities were carried out.

From a methodological point of view, we note that both techno-functional and use-wear analyses have been applied on several lithic assemblages coming from diverse archaeological contexts and periods (e.g. Boëda, 1997; 2001; Soriano, 2000; Da Costa, 2017; Lourdeau, 2010;), however, few works have attempted to combine them (Aureli et al., 2015; 2016; Boëda et al., 2015; Bonilauri, 2010; Pedergnana, 2017). In the case of the site of Ficoncella (Rome – Italy; dated back to 500,000 years BP), the combined use of techno-functional and use-wear approaches was essential to determine the technical structure and the peculiarities of active unities (trihedral, mini-rostrum and brute cutting edge) barely described before in lower Palaeolithic literature (Aureli et al., 2015; 2016). Another outstanding example is the case of Umm el Tlel site (central Syria – dated back to 40,000 years BP). Here the authors were able to evidencethe technical role of the bladelets. These very well-known tools actually resulted from different production systems, performed several tasks, and were hafted in different ways (Boëda et al., 2015).

The challenging point about the applying these two approaches togheter is that there is an added value by their combined use. In fact, the technological analysis permits us to understand the production procedure of lithic tools, and the techno-functional analysis allowed us to understand the structure of the tool, as well as the functional potential of the parts constituting the tool. Finally, the use-wear analysis verifies or rejects the hypoteses. Tracceologists can also use the techno-functional study as a proxy for the selection of their samples, i.e. defining the significant criteria to select the pieces to analyse, and examining traces guided by technical questions. It is worth remembering that these approaches work in a continuous dialogue, comparing and integrating the observations coming each approach.

As a matter of fact our contribution with this paper is to demonstrate the complementarity and added value of combination of these approaches, which produce new and stimulating insights into “the ways of existing” of prehistoric technical objects (*Du mode d’existence des objets techniques* Simondon, 1958)

4. Results

4.1. Blank

The majority of blanks (almost 50% of the complex) are of medium size (Table 1). Based on the elongation index, the main objects pursued were flakes (Table 2) and most of them could be considered as rectangular (with at least two cutting edges) (Table 3); 34 pieces have a backed side (Table 4).

Size	N.
Big	77

Medium	148
Small	87
Total	**312**

Table 1: Size of target objects.

Elongation Index	N.
Blade	52
Long Flake	71
Flake	189
Total	**312**

Table 2: Elongation index of target objects.

Shape	N.
Rectangular	270
Triangular	42
Total	**312**

Table 3: Shape of target objects.

Section	N.
Trapezoidal\triangular	278
Rectangular trapeze or triangle	34
Total	**312**

Table 4: Section of target objects.

Combining these technical traits, we obtained the blanks on which the active and prehensile parts of the instrument are imposed (Figure 7). The majority of Oscurusciuto SU 13 target objectives of levallois debitage are rectangular flakes of medium and small size, followed by rectangular big and medium long flakes and big blades. We note that elongated products are mostly big and medium sized, whereas flakes are mostly small. Convergent flakes are scarcely represented, no matter what the size. Except for convergent medium flakes (19 pieces), other sizes do account for more than ten unities (Figure 7).

According to these characteristics, we can make a sub-divide the macro-class of blanks into: type-blank A, B or C. Type-blank A is made by rectangular blanks with one cutting edge opposed to a backed side. This group contains small, medium and big rectangular flakes, long flakes and blades with rectangular-trapeze and triangular-trapeze sections, which means one cutting edge opposed to a back (34 pieces). Type-blank B is a rectangular blank with at least two cutting edges. This group comprehends small, medium and big rectangular flakes, long flakes and blades with trapezoidal and triangular sections, which means pieces with at least 2 cutting edges (233 pieces). Type-blank C is a convergent blank with at least two cutting edges. This group comprehends small, medium and big convergent flakes, long flakes and blades with trapezoidal and triangular sections, which means pieces with at least 2 cutting edges (42 pieces).

Having defined these three classes of blanks, in this paper, we decided to focus only of the type-blank A in order to give extensive attention to each category (further work will focus on the other two blank types, B and C) (Figure 7).

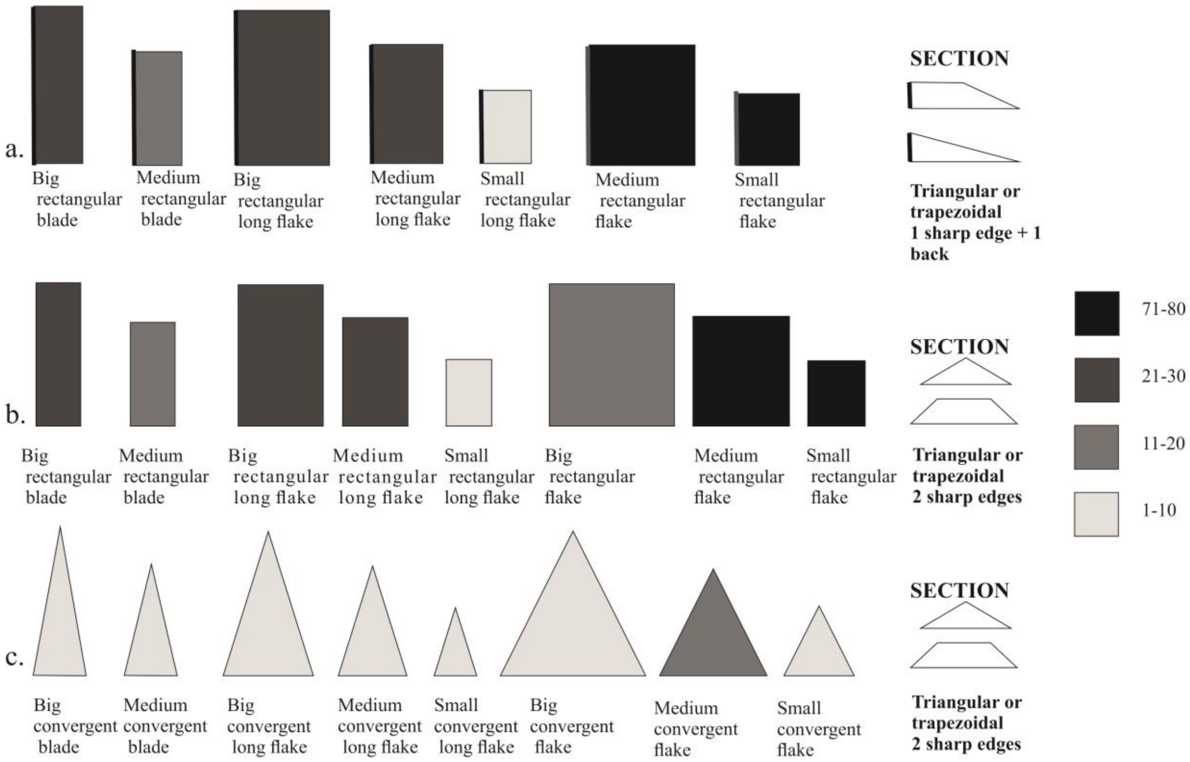


Figure 7: a: Type-blank A rectangular blanks with one cutting edge opposed to a backed side. b: Type-blank B: rectangular blanks with at least two cutting edge. c: Type-blank C: convergent blanks with at least two cutting edges (the scale of colour indicates the number of items: darker = more frequent and lighter = less frequent).

4.2 Type-blank A

Type-blank A encompassed 34 pieces, most of them elongated supports (blades or long flakes) (Table 5).

Blank	**Quantity**
Big blade	8
Medium blade	5
Big long flake	6
Medium long flake	2
Small long flake	1
Medium flake	9
Small flake	3
Total	**34**

Table 5: Type-blank A rectangular blanks with one cutting edge opposed to a backed side

On these supports are imposed several UTFt: 21 UTFt trihedrons (from now UTFt T or just T) and 39 UTFt cutting edges (from now UTFt C or just C) (Table 6).

The most represented UTFt is the cutting edge. It could be found alone, in association with a trihedron, or with other cutting edges (Table 7). The majority of cutting edges show a rectilinear delineation, less represented are denticulate, convex and concave delineations (Table 6). Usually cutting edges are in a lateral position (32) and occupy 3\4 or the totality of the edge of the tool.

The 21 UTFt trihedron are made up by 3 planes encompassing the dorsal and ventral faces of the flakes plus the butt, or plus a third face constituted by a rib made up of two negatives on the dorsal surface or of a broken part of the flakes, which lets us suppose an intentional use of the fracture. Consequently, these UTFt are slightly difficult to identify, as their features (when the rib or butt is the third face), mostly occur during the production of the pieces and not through a real intentional action (like in the case of intentional fracture). This issue could have caused an overestimation of this UTFt.

The UTFp are found in several different combinations: the most relevant one is the presence of 2 backed sides (most of them proximal plus lateral) and the 3 backed sides that actually forms a frame around the piece (from now on we referred to as backed side with D) (Table 6, Table 7).

UTF types		Quantity
UTFt	Rectilinear cutting edge	30
	Denticulate cutting edge	5
	Convex cutting edge	3
	Concave cutting edge	1
	Trihedron	21
UTFp	1 backed side	2
	2 backed sides	19
	3 backed sides	13

Table 6: presence of UTFt and UTFp.

Going into more detail, we focused on the combination between the active parts (UTFt C and UTFt T), plus their association with the prehensile parts (UTFp). In this way we were able to individuate classes of tools that have the same structure (techno-type). For the nomenclature, we describe each tool based on the combination of UTFt and UTFp (UTFt cutting edge = C, UTFt Trihedron = T; UTFp backed side = D), the repetition of each of the latter represents the frequency of the unity. The techno-type is indicated with a letter and the sub-type is indicated by a number. It this way each piece is described by a code i.e. CDD-A1 means a piece with one UTFt cutting edge: C + two backed sides: DD, belonging to techno-type A, subtype 1.

We recognized 5 techno-types, presenting a variety of sub-types (Figure 8, Table 7). To sum up the most common techno-type was A: 1 Cutting edge + 2 backed sides (CDD), present in sub-types 1, 2, 3, 4 and 5. Sub-types 1, 2, 4, and 5 have the cutting edge opposed to the lateral backed side, whereas subtype 3 is the only one that has just one cutting edge in a transversal position (Figure 8, Table 7).

Highly represented is also techno-type D: cutting edge + 3 backed sides (CDDD), whose peculiarity is the 3 backed sides constituting a frame for the cutting edge. Not surprisingly this is where we find the major number of trihedrons as the backed side is actually the third surface t of the trihedron itself. The pieces of techno-type B: 1 Cutting edge + 1 backed side (CD), are peculiar because in both cases the UTFp is made trough retouch. Finally, we have only one case of techno-type E: 1 Trihedron + 3 backed sides (TDDD). This piece is very interesting as it is the smallest tool in the collection; here the intention of creating 3 backed sides as the prehensile part leaving free only the distal trihedron becomes clear. This is also the only case were the trihedron is found alone and not connected with other UTFts (Figure 8, Table 7).

Techno - Type and Sub - Type	N. of Pieces	Plus UTFt trihedron
A: 1 Cutting edge + 2 backed sides (CDD)	**13**	**3**
A.1 Cutting edge with denticulate delineation	3	1
A.2 Cutting edge with rectilinear delineation	6	2
A.3 Cutting edge with transversal position (rectilinear)	1	0
A.4 Cutting edge with convex delineation	2	0
A.5 Cutting edge with concave delineation	1	0
B: 1 Cutting edge + 1 backed side (CD)	**2**	**0**
C: 2 Cutting edge + 2 backed sides (CCDD)	**6**	**3**
C.1 Contiguous cutting edges	4	1
C.2 Separated cutting edges	2	2
D: 1 Cutting edge + 3 backed sides (CDDD)	**12**	**12**
D.1 Cutting edge with denticulate delineation	2	1
D.2 Cutting edge with rectilinear delineation	9	9
D.3 Cutting edge with convex delineation	1	2
E: 1 Trihedron + 3 backed sides (TDDD)	**1**	**1**

Table 7: Techno-type and subtype defined by the combination of UTFt and UTFp. The column "plus UTF trihedron" indicates how many trihedrons are present on the pieces (please note that this column refers to the number of UTFt Triherdons and not the number of pieces).

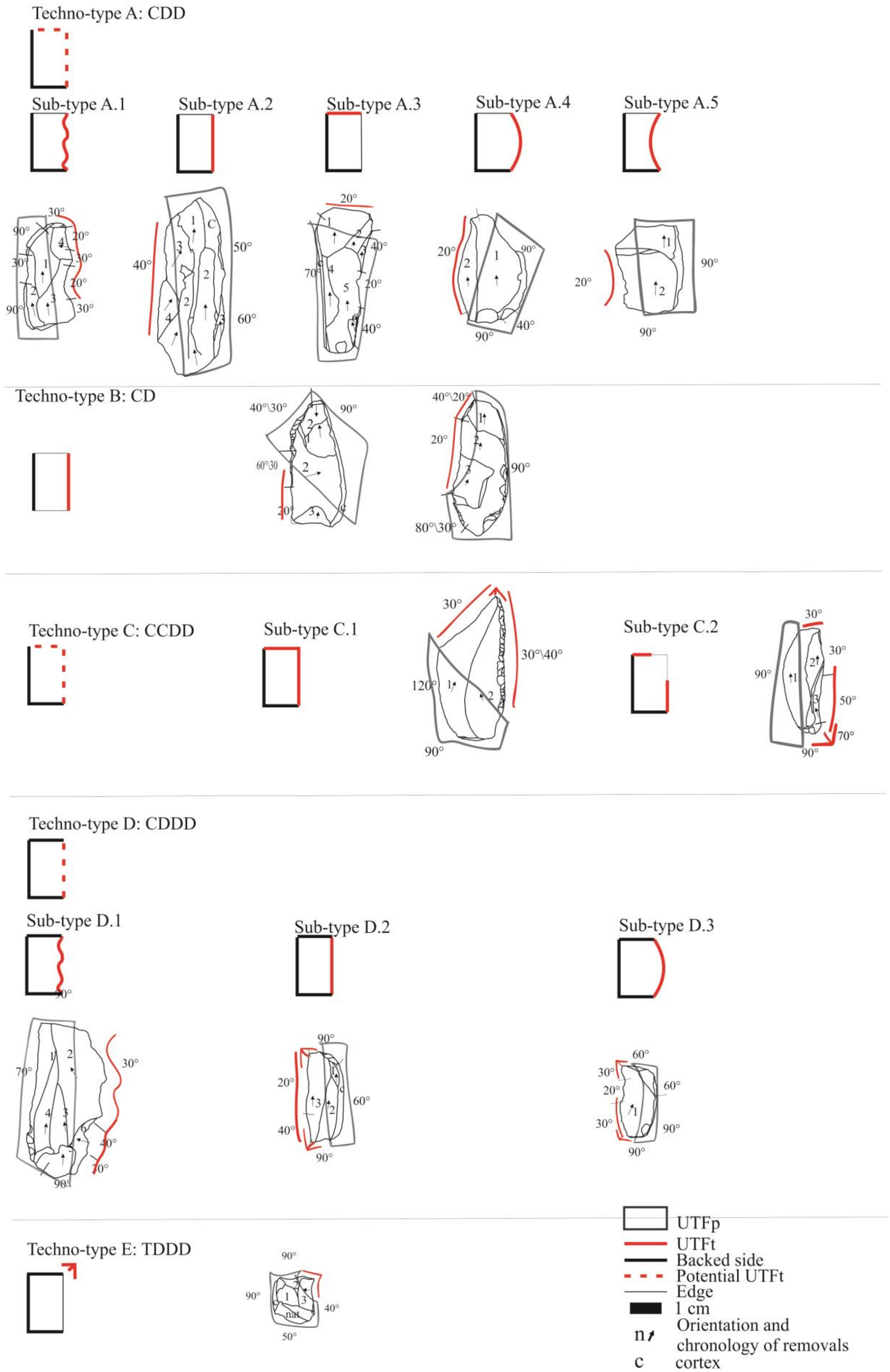


Figure 8: Schematic overview of techno-type and sub-type, plus examples of tools for each category.

These above-mentioned techno-types and sub-types could be found on various blanks. Starting from the blade, these pieces are found in big and medium sizes; generally, we note a recurrence of 2 baked sides and an opposite cutting edge. Incidentally, each tool has its own peculiarities; they are supports for different sub-types (Table 7, Figure 8, 9, 10). The case of the pieces ID 919 and ID 989 (techno-type B) is interesting because the retouch is implemented to improve the adherence potential of the grip, and it is adjacent to the cutting edge opposed to the backed side. This configuration of the tool introduces the hypothesis of a hafting (Figure 9).

Considering the medium blade, the pieces ID 852 and ID 853 refits, in this case it is interesting that the same structuration of the tool is created from the same core. Namely, pieces that technologically play the role of predetermining-predetermined pieces from a techno-functional point of view present identical prehensile and transformative parts (sub-type C2) (Table 7, Figure 8; Figure 10).

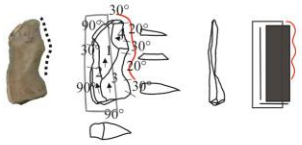
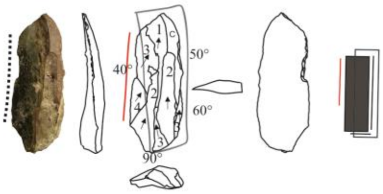
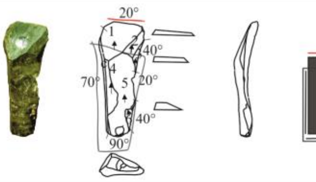
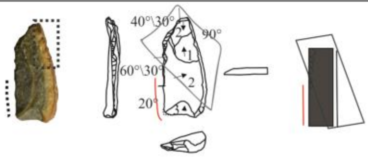
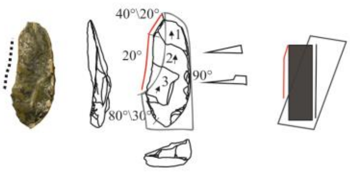
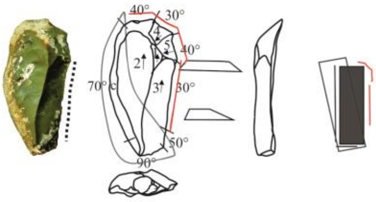
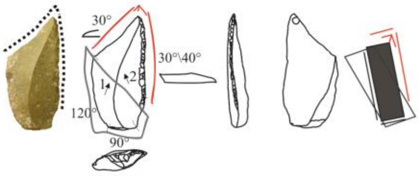
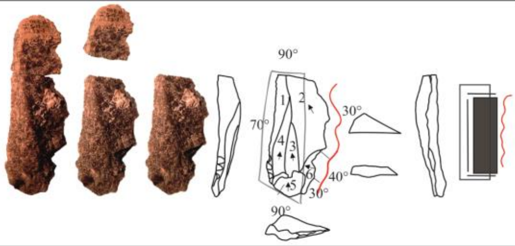
ID pieces	Big blade	Techno-type sub-type	Use wear description
ID 28		CDD-A1 	UTFt C: Longitudinal motion on soft material
ID 983		CDD-A2 	UTFt C: Longitudinal motion on semi hard material, wood
ID 959		CDD-A3 	
ID 919		CD-B 	UTFt C: Transversal motion on soft material UTFp: Prehensile trace
ID 989		CD-B 	UTFt C: Longitudinal motion on soft material, meat
ID 633		CCDD-C1 	UTFt C: Longitudinal motion on hard material
ID 1384		CCDD-C1 + T 	UTFt C, UTFt C: Longitudinal motion UTFt T: Rotative motion on semi hard material, animal
ID 213		CDDD-D1 	

Figure 9: techno-functional analysis and description of use-wear traces on the big blades.

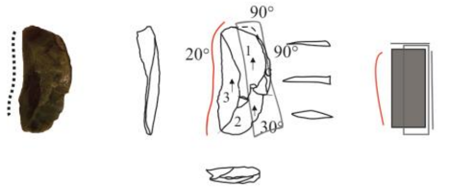
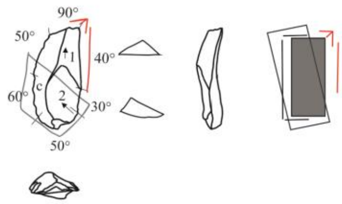
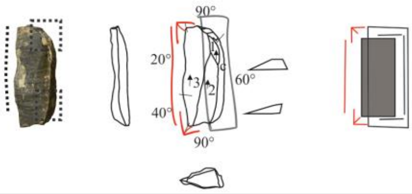
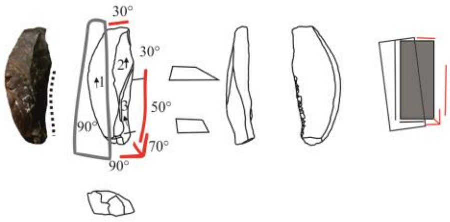
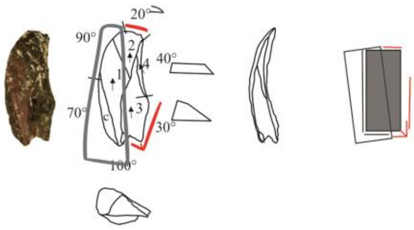
ID Pieces	Medium Blades	Techno-type sub- type	Use wear description
ID 400		CDD-A4 	UTFt C: Longitudinal motion on soft material
ID 495		CDDD-D2 +T 	
ID 1020		CDDD-D2 +T+T 	UTFt C: Longitudinal motion on hard material UTFp: Prehensile trace
ID 852		CCDD-C2 +T 	UTFt C: Transversal motion on soft material, wood
ID 853		CCDD-C2 +T 	Use wear traces UTFp UTFt Backed side 1 cm n Orientation and chronology of removals

Figure 10: techno-functional analysis and description of use-wear traces on the medium blades.

As for the long flakes, we encountered specimens of every size: big, medium, and small in varying numbers (Figures 11, 12). This is the blank with the most variations in techno-types, in fact of 9 pieces we noted 8 different sub-types (Table 7, Figures 8, 11, 12).

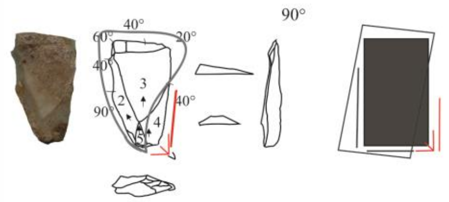
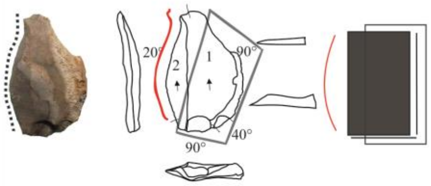
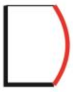
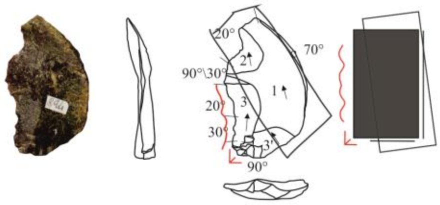
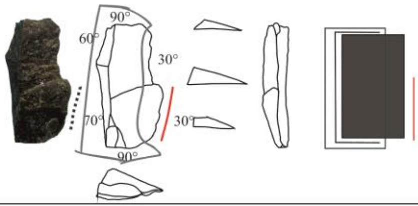
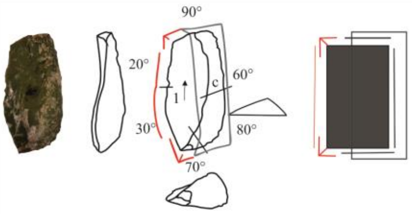
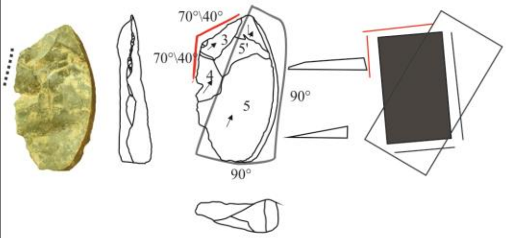
ID Pieces	Big long flakes	Techno-type Sub-type	Use wear description
ID 47		CDD-A2 +T 	
ID 320		CDD-A4 	UTFt C: Longitudinal motion on soft material, vegetal
ID 894		CDD-A1 +T 	
ID 165		CDDD-D2 	UTFt C: Longitudinal motion on hard material
ID 636		CDDD-D2 +T+T 	
ID 1632		CCDD-C1 	UTFt C: Transversal motion on hard material Use wear traces UTFp UTFt Backed side 1 cm n Orientation and chronology of removals

Figure 11: techno-functional analysis and description of use-wear traces on the big long flakes.

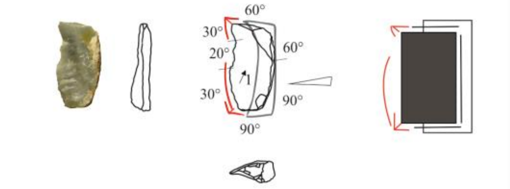
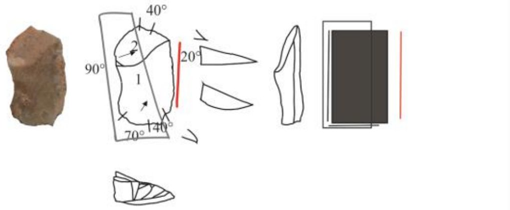
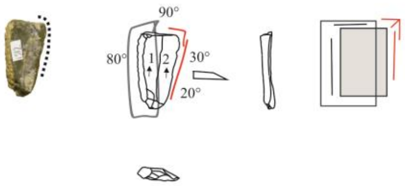
ID Pieces	Medium long flake	Techno-type sub-type	Use wear description
ID 1628		CDDD-D3 +T+T 	
ID 318		CDD-A2 	
ID Pieces	**Small long flakes**	**Techno-type sub-type**	**Use wear description**
ID 1512		CDD-A2 +T 	UTFt C: Longitudinal motion on hard material Use wear traces UTFp UTFt Backed side 1 cm n Orientation and chronology of removals

Figure 12: techno-functional analysis and description of use-wear traces on the medium long flakes and small long flakes.

Flakes are represented only in small and medium sizes (Figures 13, 14). The main defining feature in these pieces from is the presence of 3 framed backed sides (techno-type D) (Table 7, Figure 13). Probably because of their small dimensions these small pieces represent a particular prehensile need that could only be met by the 3 backed sides.

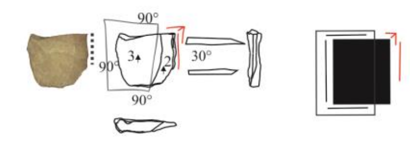
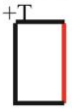
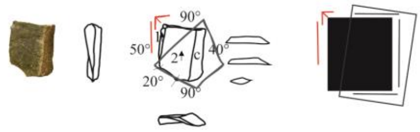
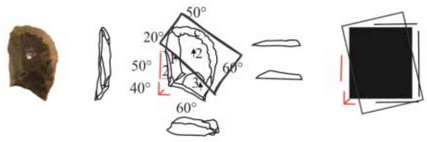
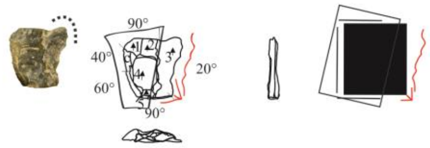
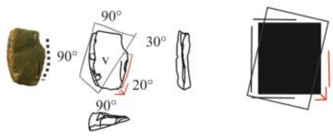
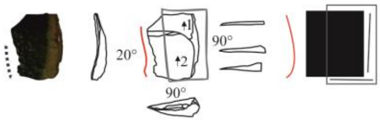
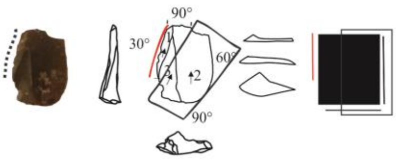
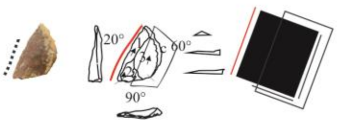
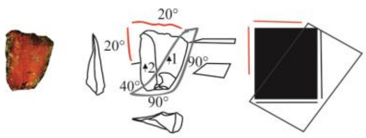
ID Pieces	Medium flakes	Techno-type Sub-type	Use wear description
ID 371		CDDD-D2 +T 	UTFt C: Transversal motion on hard material, wood
ID 712		CDDD-D2 +T 	
ID 632		CDDD-D2 +T 	
ID 991		CDDD-D1 +T 	UTFt C: Longitudinal motion on soft material
ID 1012		CDDD-D2 +T 	UTFt C: Longitudinal and transversal motion on hard material, wood
ID 82		CDD-A5 	UTFt C: Longitudinal motion on semi hard material, animal
ID 531		CDD-A2 	UTFt C: Longitudinal motion on hard material
ID 906		CDD-A2 	UTFt C: Longitudinal motion on semi hard material, animal, dry skin
ID 846		CCDD-C1 	Use wear traces UTFp UTFt Backed side 1 cm n Orientation and chronology of removals

Figure 13: techno-functional analysis and description of use-wear traces on the medium flakes.

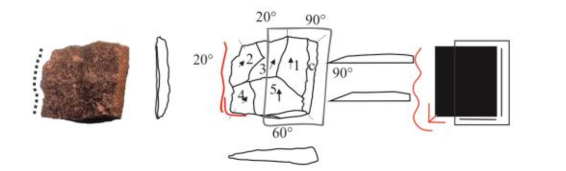
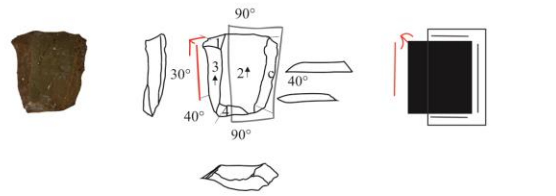
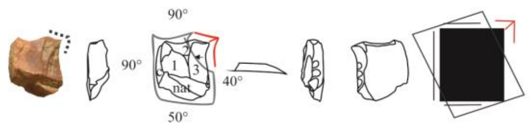
ID Pieces	Small flakes	Techno-type sub-type	Use wear description
ID 214		CDD-A1 +T 	UTFt C: Longitudinal motion on hard material
ID 414		CDDD-D2 +T 	
ID 882		TDDD-E 	UTFt T: Carving on hard material Use wear traces UTFp UTFt Backed side 1 cm n Orientation and chronology of removals

Figure 14: techno-functional analysis and description of use-wear traces on the small flakes.

4.3 Use-wear analysis

Of the examined sample (34), 21 tools show evidence of use, 9 pieces display unclear or uncertain traces because of post-depositional modifications, 4 artefacts do not reveal use-wear at all. We noted that in the majority of the cases use-wear traces were found on the portion of the pieces subject to techno-functional analysis. Just in one case traces were found on another edge which was not recognized by techno-functional analysis (ID 991, Figure 13). In other cases, there was not enough microscopic evidence to prove the UTF reading.

Going more into detail, 22 UTFt were used, in particular we noted to 20 cutting edges (UTFt C) and 2 trihedrons (UTFt T). In addition, traces were visible on 2 UTFp. Each artefact showed evident traces on only one UTFt, with the exception of the piece ID 1384 where its 3 UTFt showed traces (Table 9, Figure 15).

Due to the fact that micro-wear traces (polishes) are by nature not very evident, for several pieces it was inferred only the action carried out and general information about the hardness of the worked material. Nevertheless, as a general functional scene, we may deduce that the techno- type analysed was regularly used for various tasks (Table 8, Table 9). The tools were used for processing hard (9), semi-hard (8) and soft materials (5). Such a variety is confirmed also when worked materials have been detected, as both vegetal (4) and animal tissues (4) were processed (Figure 15).

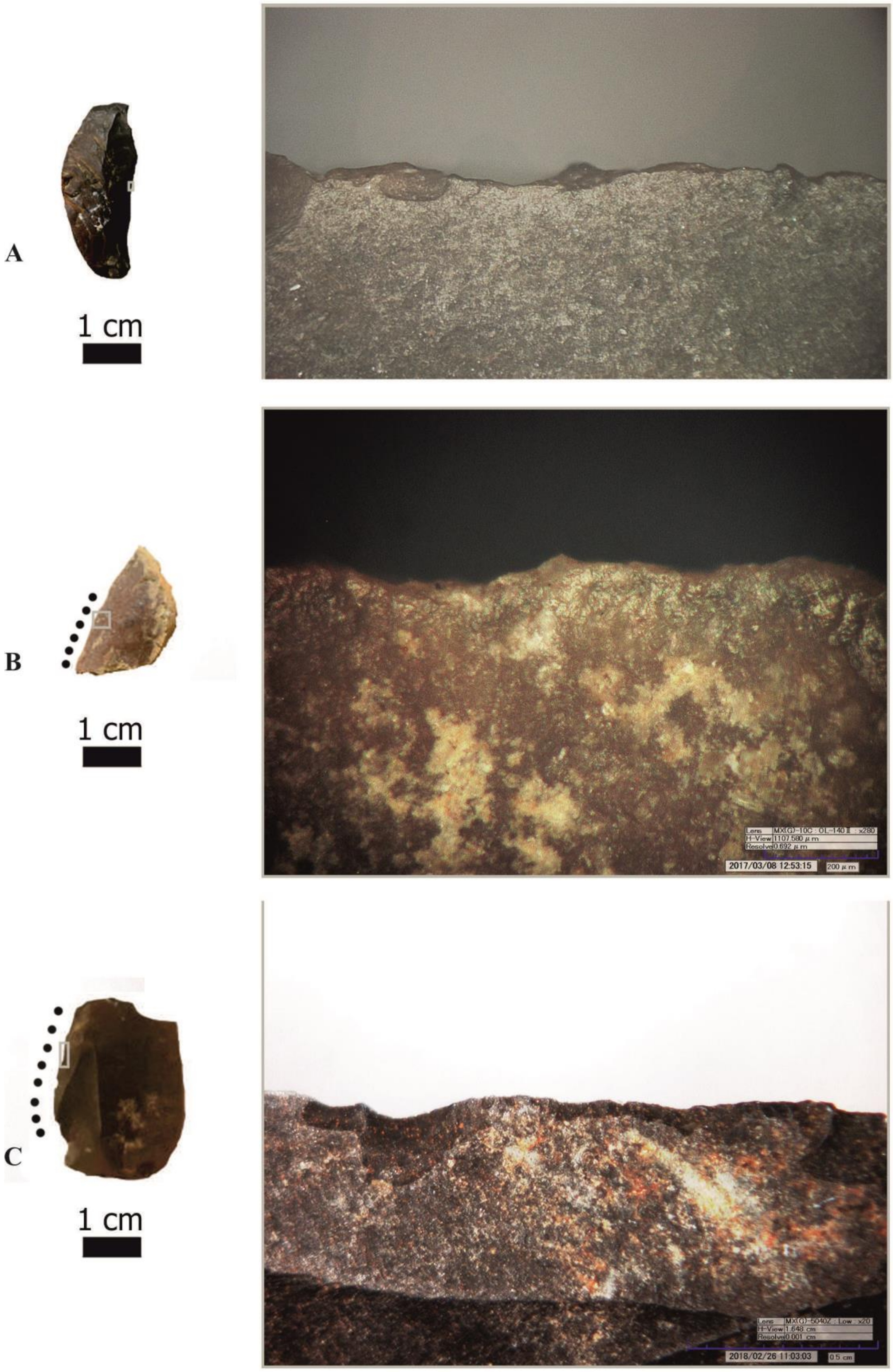


Figure 15: A: ID 852 - use-wear polish interpreted as origination from processing soft wood (the scale bar is 500 µm); B: ID 906 - edge rounding associated with use-wear polish from cutting dry skin (the scale bar is 200 µm); ID 531 - edge scarring related to cutting hard material (the scale bar is 0,5 cm).

UTFt C are used mainly for longitudinal actions and to a lesser extent in transversal movements. The transversal actions are carried out by cutting edges with wider angles, in particular when hard materials were processed. Comparing worked materials and motions, we may conclude that the transversal actions were mostly performed on hard material, while the longitudinal ones on all types of material (Table 8, 9, Figures from 9 to 14).

Few items are employed in mixed actions. A single UTFt C, of the flake ID 1012, was used with both longitudinal and transversal movements for processing vegetal material, whereas two different UTFt C of the big blade ID 1384 were both used for longitudinal actions and UTFt T was employed in a rotational motion. In both cases animal tissue was processed (Figure 16, Table 8, 9).

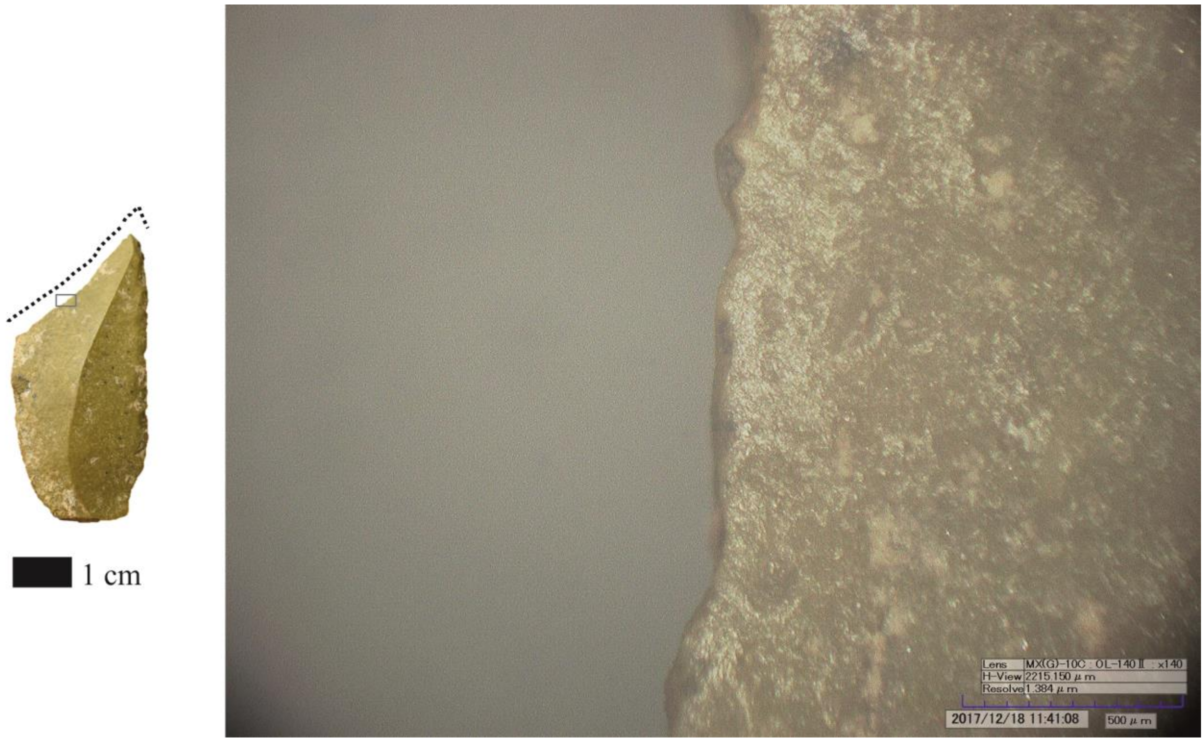


Figure 16: Use-wear polish on the big blade ID 1384 (the scale bar is 500 μm.).

By means of a techno-functional analysis, 21 trihedrons were identified, but traces were found on only two UTFt T of which one was involved in a rotational motion (pieces ID 1384 – Figure 9) and the other in a longitudinal action (pieces ID 882 - Figure 17) (Table 8, 9). These tools were used for processing hard and semi-hard material.

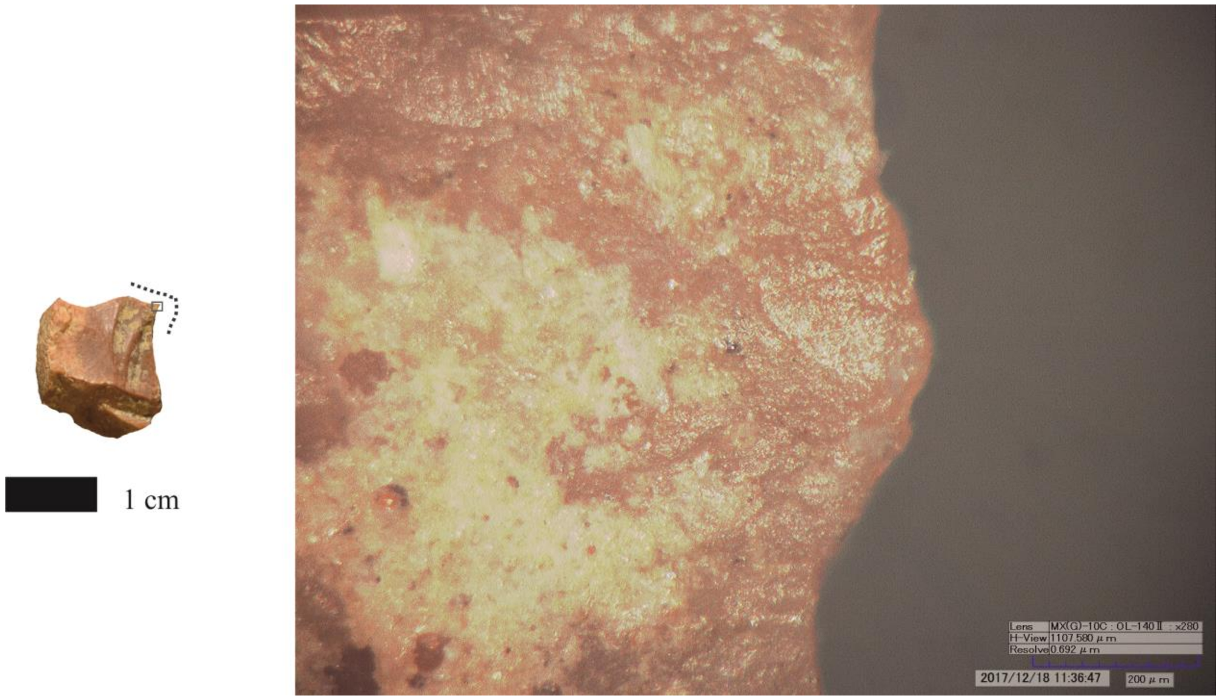


Figure 17: Use-wear polish associated with edge rounding of the small flake ID 882 (the scale bar is 200 µm).

Evidence of probable hafting traces on UTFp is detected on two pieces (ID 1020 and ID 919), confirming the hypothesis of the techno-functional analysis. In both cases, the traces are located on the backed sides of the tools (Figures 9, 10).

Type of material and UTF	Longitudinal motion		Transversal motion		Rotational motion		Long+trans motion		Total
	UTFt C	UTFt T	UTFt C	UTFt T	UTFt C	UTFt T	UTFt C	UTFt T	
Soft	2		1						**3**
Semi-hard	5								**5**
Hard	3	1	2						**6**
Wood	1		1				1		**3**
Herbaceous plants	1								**1**
Soft animal tissues	1								**1**
Semi-hard animal tissues	2					1			**3**
Total	**15**	**1**	**4**		**0**	**1**	**1**	**0**	**22**

Table 8: correlation between transformative parts (UTFt C: cutting edge and UTFt T: trihedron), movement and worked material.

5 Combined use of techno-functional and use-wear analysis

The result obtained by the combined use of the techno-functional and use-wear analysis gives a consistent result. In fact, in the sampled pieces, we note that in the majority of the pieces the use-wear analysis confirmed the interpretation given in the techno-functional study.

We note that sometimes the same techno-type are made on different blanks, as in the case of sub-type A2 and D2, a recurrent combination in almost all blanks. Then again, other techno-types seem to be specific to some blanks, such as techno-type B. Moreover, some blanks are supports for several techno-types, e.g. the big blades are structured in quite a number of different combinations, and they seem to be made to purpose unique tools. In contrast, other blanks support few techno-types, as is the case with medium flakes where most of them support the techno-type D (Table 9).

A very remarkable fact is that the techno-types are consistent with their actual use, in fact we noted that some techno-types were used for specific activities, as is the case with techno-type A, which is mostly used for cutting (longitudinal movement). On the other hand, there are techno-types, such as C and D, which are employed in a variety of activities, such as cutting and scraping (respectively longitudinal and transversal movements). In addition, some techno-types met a particular need, as is the case with the techno-type E, which can be considered *unicum* in the collection both from a structural and a functional point of view, in fact this piece (a UTFt T framed by 3 backed sides) was used for carving (Figure 17). Finally, in techno-type B a very specific construction of the piece (made also by retouch) does not correspond to the same activity, one is used for scraping and the other for cutting, however, both pieces are related to butchering activities (Figure 9).

Techno-type	Sub-type	N.	BLANK							Action	Material	Angles	ID pieces
			BB	MB	BL	ML	SL	MF	SF				
A: CDD n13	A.1	3	1		1				1	cut	soft, hard	20°, 20°-30°	28, 894, 214
	A.2	6	1		1	1	1	2		cut	semi hard, hard	20°, 30°, 20°-30°, 40°	983, 47, 318, 1512, 531, 906
	A.3	1	1							\	\	20°	959
	A.4	2		1	1					cut	soft	20°	400, 320
	A.5	1						1		cut	semi hard,	20°	82
B: CD n.2	B	2	2							scrape, cut	soft	20°	919, 989
C: CCDD n.6	C.1	4	2		1			1		cut, scrape	semi hard, hard	20°, 30°, 40°	633, 1384, 1632, 846
	C.2	2		2						scrape	soft	20°,30°, 50°	852, 853
D: CDDD n.12	D.1	2	1					1		cut, carve	soft	20°, 30°-40°	213, 991
	D.2	9		2	2			4	1	cut, scrape	semi hard, hard	20°- 40°, 20°-40°, 30°, 40°, 50°	495,102, 165, 636, 371, 712, 632, 1012,414
	D.3	1				1				\	\	30°	1628
E: TDDD n.1	E	1							1	carve	hard		882
Total		34	8	5	6	2	1	9	3			\	\

Table 9: Synthetic table of techno-types and sub-types.

(C: cutting edge, T: trihedron: D: backed side; n. refers to the total number of pieces of each type), how they are disposed on the blank, plus information regarding the use: action, worked material and angles of the active edge (for the blank: BB: big blade, MB: medium blade, BL: big long flake, ML: medium long flake, SL: small long flake, MF: medium flake, SF: small flake).

6 Conclusions

A first methodological observation was that the integrated use of techno-functional analysis and use-wear analysis yields consistently matching results to the benefit of both technologists and tracceologists. Thanks to this combined method we get much closer to the human realities where there were several needs to solve, sometimes simultaneously, and several tools to be manufactured.

This work answered to the three main queries posed at the beginning of this research.

1. We proved that the target objects (production aims) were also actually used as functional objects (functional aims), i.e. a large number of items shows use-wears.
2. We noted that each production aim actually comprised several techno-types employed for different purposes. Namely, through the technological approach we learned that the production aim was flakes, convergent flakes and backed flakes. Thanks to this study, we realized great diversity in both structure and functionality of these tools, noting that to each class of target objects corresponds a set of different functional objects, as each category actually comprises several blanks, and each blanck could be the support for several techno-types.
3. Finally, we also proved that tools with a specific structure aimed to solve a specific task.

The encouraging results of this study motivated us to continue in this direction, analysing the other two categories (type-blank B and C) in order to obtain a larger set of statistically significant data.

Lastly, one question remains: the trihedron was identified by techno-functional analysis but presented traces in only 2 cases. For this reason, we want to know why there is such little evidence of usage on these pieces. Is it because the action did not leave strong visible traces, or because this part was not used? We could also hypothesise an artificial increase due to possibly misleading criteria of identification. To be able to answer these questions we are planning to set up an experimental protocol to verify the functional potential of the trihedron, possibly applying more restrictive criteria for its identification, i.e. the technical criteria present on the two items which showed clear use-wear traces.

Paper 3: Diachronic dissection of the palimpsest

Between hearths and volcanic ash: The SU 13 palimpsest of the Oscurusciuto rock shelter (Ginosa - Southern Italy): Analytical and interpretative questions.

Spagnolo, V., MARCIANI, G., Aureli, D., Berna, F., Boscato, P., Ranaldo, F., Ronchitelli, A. 2016, Quaternary International, 417: 105-121. doi:10.1016/j.quaint.2015.11.046.

1. Introduction

The palimpsest problem in archaeology has become one of the main themes of scientific debate, due to the "flattening-effect" of an unknown number of individual events, with an unknown life span, into a single layer. Currently, the solution focuses on achieving a high resolution in the data analysis, in order to understand more accurately the cultural, social and economic dynamics in the archaeological context (quoting a few recent papers: Vaquero, 2008; Bailey and Galanidou, 2009; Malinsky-Buller et al., 2011; Carbonell I Roura, 2012; de la Torre et al., 2012; Henry, 2012; Rosell et al., 2012; Machado et al., 2013; Mallol et al., 2013; Bisson et al., 2014). In these works, a new orientation in research is evident, emerging from the improvement of analytical techniques. Beyond the identification of single (short-term) occupational episodes, the "goal for future research is to transcend this descriptive label, as these may enclose diverse historical dynamics whose explanation can be sought by taking a close look into the specific activities performed and their role within a territorial context" (Machado et al., 2013: 2272).

This paper focuses on the "dissection" of a Middle Palaeolithic palimpsest (SU 13) from the Oscurusciuto rock shelter (Ginosa, Taranto, Southern Italy). In the context of the rich stratigraphic sequence of the Oscurusciuto rock shelter, SU 13 constitutes a privileged context for the setting up of an analytical protocol for palimpsest analyses. The crucial elements of SU 13 are its strati-graphic position (a sedimentological unit located between a dated sterile tephra level underneath and subsequent occupation levels), its extension (wider than the upper levels), the presence of hearths structures and a fairly low quantity of materials. This has made it easier to develop an integrated study aimed at understanding this palimpsest.

The main goal was to obtain a high temporal resolution of the activities recorded in this archaeological layer, in order to understand how those activities constitute a palimpsest. Furthermore, a second purpose was the identification of individual episodes of occupation, recognizable by the integrated study of material culture. These data may shed light on a research line which allows a different and innovative approach to dealing with the study of the economic and settlement strategies of Neanderthal groups.

A multidisciplinary approach has been necessary in order to fulfil our objectives. As a first analytical step, the level of integrity of the layer was verified through the study of the state of preservation of the anthropic remains and microstratigraphy of the hearths e and through the chi-squared analysis of the faunal remains and lithic industry distribution. The following steps e the technological study of the lithic industry, the individuation of the RMUs, refittings and co-joints, and spatial analysis e have made it possible to individuate single activities which took place within the layer. From the integration of these methods it has been possible to obtain a complete view of the activities making up the palimpsest of this Stratigraphic Unit.

3. Methods

The palimpsest analysis was aimed at an accurate reconstruction of the economic, social and cultural aspects as they emerge from the archaeological evidence. In order to achieve this objective, a multidisciplinary analytical protocol was conducted, comprising combustion features microstratigraphy, faunal analysis, lithic technological studies (including RMUs and lithic refitting/conjoin), and finally spatial studies.

The microstratigraphical study of the hearths was designed to individuate human activities associated with the management and combustion conditions of such features. The study of the fauna has led to the identification of the represented species, of the anatomical elements and their fragmentation conditions. The study of the lithic industry with the RMU method was set up in order to identify the minimum number of raw material units introduced in the site. The results of these studies were then fed into a GIS platform which was created for testing the state of preservation of the layer. This took into account the physical state of lithics, the microstratigraphy of hearths, the presence/absence of biotic alterations and the analysis of the density maps of micro-remains in relation to the morphology of the layer in order to verify whether the distribution of the various categories of materials followed a given organization or was purely random (chi square test). This was done in order to obtain a high temporal resolution interpretation of the activities sequence which took place in SU 13 (spatial patterning of RMUs, distance between refittings, microstratigraphy of hearths).

3.1. Hearths: microstratigraphic analysis

Intact sediment blocks were collected from hearths SU 12, SU 77, SU 78, SU 80, SU 82, and SU 83. The blocks were embedded with polyester resin and processed into petrographic thin sections. The thin sections were analyzed by petrographic microscopy and Fourier transform infrared microspectrometry (m-FTIR) using a Thermo iN10 XM imaging FTIR microscope. Soil micromorphology descriptions were conducted following the criteria indicated in Stoops (2003). The integration of petrography, soil micromorphology and m-FTIR for the analysis of thin sections of intact archaeological deposits allows us to untangle the natural and cultural processes occurring in archaeological sites (Goldberg and Berna, 2010). In fact, the geogenic, biogenic, and anthropogenic components are best identified at the microscopic scale, as are the transport, deposition and diagenetic processes (Goldberg and Macphail, 2006). In particular, the micromorphological study of hearths and other combustion features allows for the identification of human activities associated with their management (e.g., pitting, fueling) and intentional and unintentional modifications such as ash removal and dumping, rake out, trampling and scuffing (Goldberg and Berna, 2010). By FTIR it is possible to identify and characterize the crystalline state of organic and inorganic phases composing bone (i.e., collagen and carbonate-hydroxyl apatite), soil (e.g., clay minerals, carbonates, sulphates, phosphates, nitrates) and wood ash (e.g., pyrogenic calcite, charcoal, and opaline phytoliths) (Weiner, 2010). Moreover, m-FTIR enables the estimation of temperature reached by bone, carbonates, and soil inclusions and consequently allows the reconstruction of combustion conditions of a given hearth (Berna and Goldberg, 2007; Berna et al., 2012). The microstratigraphic analyses at Oscurusciuto rock shelter were focused on the identification of soil microfabric units (Stoops, 2003) composing the overall matrix of SU 13 and the components of the different combustion features (i.e., SU 12, SU 77, SU 78, SU 80, SU 82 and SU 83) included in SU 13.

3.2. Faunal analysis

Faunal remains of SU 13 were divided into two qualitative classes (burned and unburned) and four dimensional classes (1e3 cm, 3e6 cm, 6e10 cm, >10 cm). Taxonomic data could only be recorded for a few remains, due to the high degree of fragmentation.

3.3. Lithic analysis: definition of a method to individuate more reliable RMUs

The study of lithic finds was based on the Raw Material Unit (RMU) approach (Roebroeks, 1988; Hall and Larson, 2004; Uthmeier, 2006; Vaquero, 2008; Romagnoli, 2012; Vaquero et al., 2012; White, 2012; Machado et al., 2013).

This approach permits the isolation of groups of lithic items pertinent to a single lithic unit\block, in this case pebbles. In this way it is possible to quantify the minimum number of raw materials brought into the site and to identify knapping, use and discard episodes and eventual importation or exportation of tools in order to have a clearer comprehension of the reduction sequence. A most effective result is obtained with an extensive programme of recognizing refittings and conjoins (Larson and Ingbar, 1992; Schurmans, 2007) as well as technological and spatial analysis of the pieces integrating each RMU. An advantage of this method is the ability to identify the post-depositional translocation of lithic remains, which enhances correct detection of single human occupation episodes and different functional areas (Machado et al., 2013). The lithic finds were classified in five-dimensional classes (1e50 mm2, 51e100 mm2, 101e150 mm2, 151e200 mm2, >200 mm2).

Different lithic groups (RMUs) were established, based on macroscopic traits of the lithic artifacts such as cortex color and thickness, texture, color, inclusions and opacity. A limitation on the application of this method is encountered when there are burnt, patinated or altered pieces, when there are tiny specimens or when the raw material is too homogeneous and impossible to separate.

While RMU identification is currently a well consolidated practice in Paleolithic research, the subjectivity involved in their determination seems to be a problematic factor. For this reason a protocol was developed to evaluate the reliability of each RMU. At first, the undetermined elements of the lithic assemblage were removed ("undetermined" is defined as altered or tiny items smaller than 50 mm2). Then the remainder of the assemblage was divided into lithological categories according to the type and granulometry of the lithic raw material here defined: CL ¼ 1 fine grained jasper; CL 2 ¼ fine grained chert; CL 3 ¼ middle grained jasper; CL 4 ¼ middle grained chert; CL 5

¼ middle grained siliceous limestone; CL 6 ¼ middle grained limestone; CL 7 ¼ coarse grained chert; CL 8 ¼ coarse grained siliceous limestone; CL 9 ¼ middle grained quartzarenite; CL 10 ¼ coarse grained quartzarenite; CL 11 ¼ coarse grained limestone; CL 12 ¼ undetermined. Consequently, based on macroscopic similarity within each lithological category, the RMUs were identified.

The estimation of the reliability degree of the RMU (excellent, good or bad) was based on the evaluation of some parameters, each with its own numeric value: “Refitting Ratio”, “Variability of Raw Material”, “Uniqueness of Raw Material”. The Refitting Ratio expressed the ratio between the number of conjoined or refitted items and the total quantity of elements in the RMU. The Variability of Raw Material represented the degree of internal variability in each single block of raw material (that can be homogeneous or inhomogeneous). The Uniqueness of Raw Material constituted the degree of inter-RMU variability, in other words the formal similarity between different RMUs (that can be unique or not unique). The level of reliability was calculated on the basis of the arithmetical sum of the above listed parameters (Marciani, 2013; Spagnolo, 2013).

3.4. Taphonomy and spatial analysis

The elaboration of spatial data was performed using ArcGIS® 10.2, with a specifically designed geodatabase (Spagnolo, 2013). The preservation degree of SU 13 was tested. The considered parameters for this test included the state of a lithic's edges (fresh or floated), the micro-stratigraphy of hearths, the presence/ absence of biotic alterations, the chi-square test for the spatial pattern evaluation, the analysis of micro-flakes and micro-fragment accumulations in relation to the surface morphology of SU 13, the length of the refitting/conjoint lines and, finally, the spatial patterns of the RMUs (e.g. Dini and Moriconi, 2004: 52e57; Goldberg and Macphail, 2006: 42e84; Mallol et al., 2010, 2013; Drennan, 2009: 181e195; Stevenson, 1991; Bertran et al., 2012).

The chi-square test was performed in order to assess if the distribution modalities of the archaeological and faunal materials within the excavated area reflected a pattern of some kind or fell within a random statistical oscillation. The real distribution was compared with an expected distribution defined with the Poisson function (null hypothesis) corresponding to a random distribution with a 99.999% confidence interval. The test was performed in order to test the clustering rate of the lithic finds and faunal remains (Drennan, 2009: 181e195). Quadrants with an integrity level <88% were discarded in order not to distort the results of the test. As the test made use of real quantities, it required quantitatively comparable sampled areas in order to be effective. This led us to exclude the quadrants which were too eroded as the material within them would be strongly underestimated in the test.

In some sectors, most artifacts were recovered by sieving (in particular all the lithics smaller than 200 mm2), so the only spatial reference known for these pieces is the quadrant (50 50 cm) of origin. The visualization of the lithic and faunal remains distribution pattern is allowed by adopting a random positioning strategy (ArcGIS® 10.2\Data management tools\Create random points) for the items recovered by sieving. For the other artifacts, the real coordinates were taken into consideration. In this manner, the realization of a micro-flake density map was also possible. The error in the randomly positioned points is negligible when the positioning cells (50 50 cm in this context) are smaller than the spatial phenomena under investigation. The scatters produced by lithic reduction activities are in the same dimensional module of the excavation grid (Vidale, 1992: 158e160; Vaquero and Pasto, 2001; Jones, 2008; Olausson, 2010; Bertran et al., 2012, 2015).

Starting from the distribution maps, the spatial patterns of the main categories of evidence (burned faunal remains, dimensional classes of unburned faunal remains, dimensional classes and technological categories of lithic finds and reliable RMUs with at least 10 items) were analyzed using Ripley's K function (Bevan and Conolly, 2006; Schwarz and Mount, 2006; Winter-Livneh et al., 2010). This tool was used in order to illustrate the relationship between the clustering or the dispersion of feature centroids and the neighborhood size changes (ArcGIS® 10.2\Spatial statistics tools\Multi-Distance Spatial Cluster Analysis). Density maps were also produced for these categories, using the kernel algorithm (with search radius at 0.25 m).

The premise that the weak slope of the SU 13 surface was in itself a potentially important factor for context preservation was investigated. In particular we examined whether stream flow, overland flow, scuffage and/or trampling (Stevenson, 1991; Bertran et al., 2012, 2015) might have influenced the assemblage spatial configuration. For this purpose, the Dimensional Classes maps and, in particular, the micro-flake accumulations shapes were evaluated in relation to the contours line based on the Digital Elevation Model of SU 13 (Figs. 3 and 4).

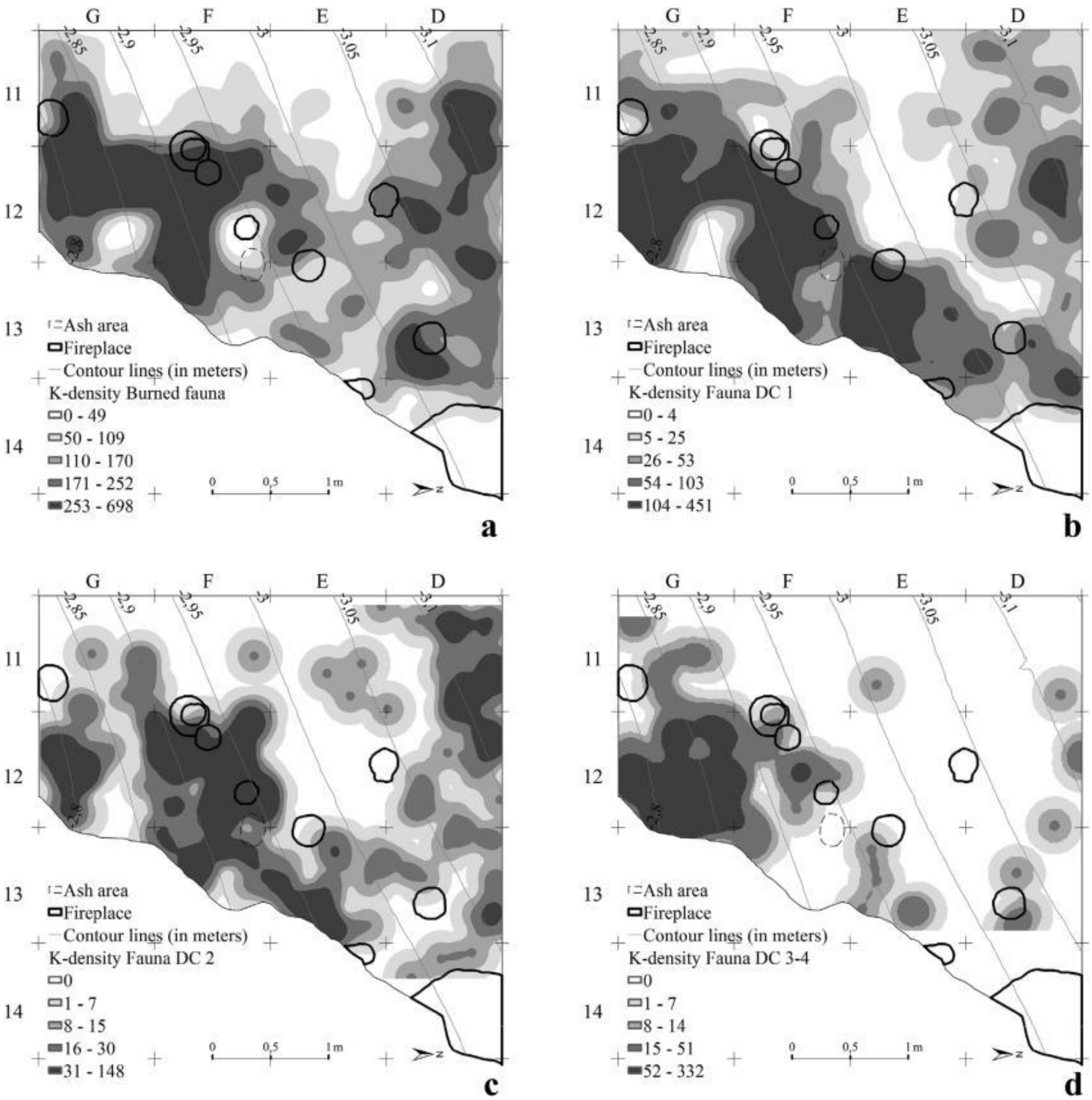


Fig. 3. Density maps for the burned faunal remains (a) and for the Dimensional Classes of the unburned faunal remains: DC 1 ¼ 1e3 cm (b), DC 2 ¼ 3e6 cm (c), DC 3e4 > 6 cm (d).

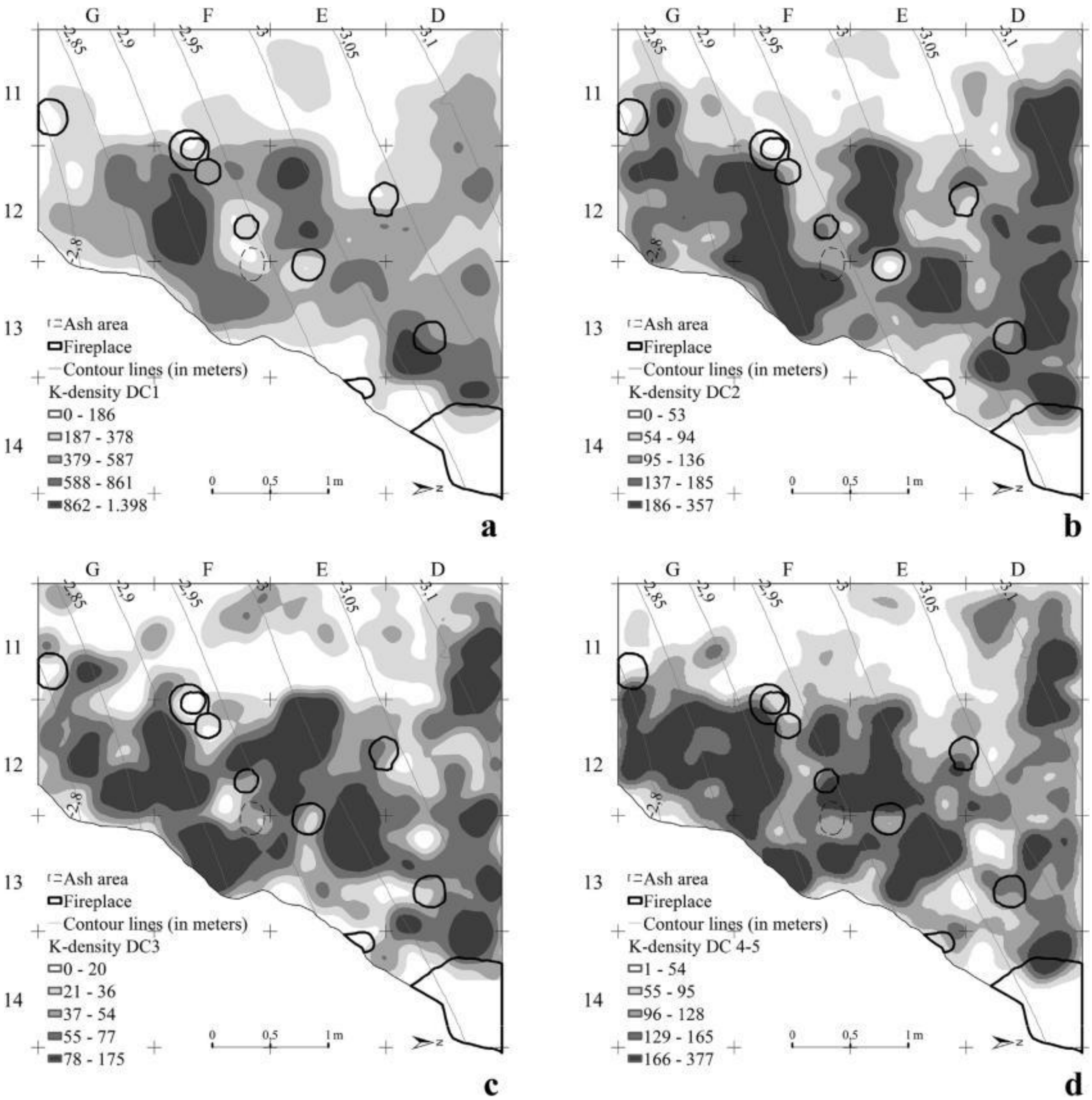


Fig. 4. Density maps the Dimensional Classes of lithic finds: a) 1e50 mm^2; b) 50e100 mm^2; c) 100e150 mm^2; d) >150 mm^2.

In order to carry out the analysis of the refitting patterns, it was necessary to assess how far the inaccuracy of the random positioning could generate a misreading of the refitting/conjoint lines length pattern. There were three possible scenarios: 1) both the related artifact had known coordinates; 2) only one artifact in the pair had known coordinates; 3) both the related artifacts were randomly positioned. In the first case, the distance between the refitted elements was represented by the simple line, without error. In the second case, the error range evaluation was made measuring the minimum and maximum distances from the known point to the quadrant of the refitted artifact with unknown coordinates. In the last case, the minimum and maximum distances between the quadrants of the refitted artifact were calculated. The average values (between Max and min) were reported on a scatter-plot graph with error bars (difference between Max and mean) (Fig. S1).

RMU analysis is a powerful tool for dissecting palimpsests, because of its potential capacity to achieve a high resolution view of activities carried out at the site (Vaquero, 2008, 2011; Lopez-Ortega et al., 2011; Machado et al., 2011, 2013; Carbonell I Roura, 2012; Vaquero et al., 2012). The spatial component of the RMU can help significantly in this analytical operation. For this reason some specific maps were produced for RMUs with at least 10 artifacts and good/excellent reliability degrees. In line with the results of Ripley's K function, vertical distributions of the aforementioned RMUs were grouped by spatial pattern and analyzed.

4. Results

4.1. SU 13 and hearths microstratigraphy

The micromorphological investigation of six (SU 12, SU 77, SU 78, SU 80, SU 82 and SU 83) of the ten excavated hearths revealed the presence of several micro-fabric units (mFUs) and sub-units (see Fig. 5, S2 and S3). These are:

mFU1 (Fig. 5a) e a fairly well preserved light tan volcanic tuff with characteristic needle and tubular glass crystals (Epomeo green tuff). mFU1 is the major component of the basal Stratigraphic Unit at the site (i.e., SU 14) and appears as cm-size aggregates (e.g., in SU 77 and SU 82, Fig. S3) and as burrow fill (e.g., SU 80, Fig. S3) in the micro-Stratigraphic Units forming the hearths.

mFU2 (Fig. 5b) e a slightly altered volcanic tuff with iron-rich amorphous clay, found dispersed in the ground mass and co-precipitated with micrite in mm-size laminae and domains. mFU2 also contains variable amounts of quartz fine sand, micrite silt and sand, amorphous organic matter, plus subangular charred and uncharred bone fragments. mFU2 composes the bottom microStratigraphic Unit underlying SU 77 (Fig. S3).

mFU3 (Fig. 5c) e a colluvium supported by the mFU2 fine matrix and containing heterogeneous angular to rounded gravel, inclusive of local lithology (micritic and fossiliferous limestone, flowstone, etc.), exotic raw materials such as chalcedony chert and jasper (e.g., SU 78 e Fig. S2b), and fragments of charred and uncharred bone (Fig. S2b, S2c, and Fig. S3), coprolites (Fig. S2b), and charred and humified plant materials (Fig. S2c). mFU3 is the most common.

micro-fabric unit and represents the rock shelter basal deposit formed by the weathering of the underlying tephra and the colluviation of local rock and soil fragments with anthropogenic manuports (Fig. S2 and Fig. S3). mFU3 is diffusely cemented by micritic precipitate (Fig. 5c) and is found at the base of the hearths and also capping the wood ash layers in SU 12, SU 77, SU 78, SU 82, SU 83 (Fig. S2 and Fig. S3). mFU3a (Fig. S2b and Fig. S2c) is very similar in general composition and structure to mFU3, the only difference being that it is darker in color (dark brown). The darker color appears to be caused by a discoloration of the fine fraction possibly due to redox reaction of the iron compounds contained in the clay minerals and micrite due to the combustion of overlying fuel. mFU3a occurs in SUs 77, 78, 80, and 83 (Fig. S2 and Fig. S3). mFU3b (Fig. 5d) is very similar to mFU3 and mFU3a but shows a blackish brown color. The specific color of mFU3b appears to correlate to an increase in the abundance of partially decayed charcoal and micro-charcoal fragments with respect to mFU3 and 3a. mFU3b includes a microlayer of SU 12 (Fig. S3) and a burrow of SU 82 (Fig. S3).

mFU4 (Fig. S2) e light gray to blackish gray laminated micrite (Fig. S2b and Fig. S2c) with domains of oxalate pseudomorphs (i.e., “wood ash” e Fig. S2d), ashed and charred plant remains, and a few charcoal and bone fragments (calcined, charred, and uncharred). No grass phytoliths were observed in mFU4, thus it appears to be derived from the combustion of woody and brush plant tissues. mFU4 has been found in SU 78 (Fig. S2) and highly broken up and reworked (mFU4a) in SU 12, SU 80 and SU 83 (Fig. S3). In summary the six hearths appear to be composed of wood ash layers (mFU4 and mFU4a) overlying or mixing within not discolored and dis-coloured substratum (i.e., SU 13) composed of mFU1, mFU2, and mFU3.

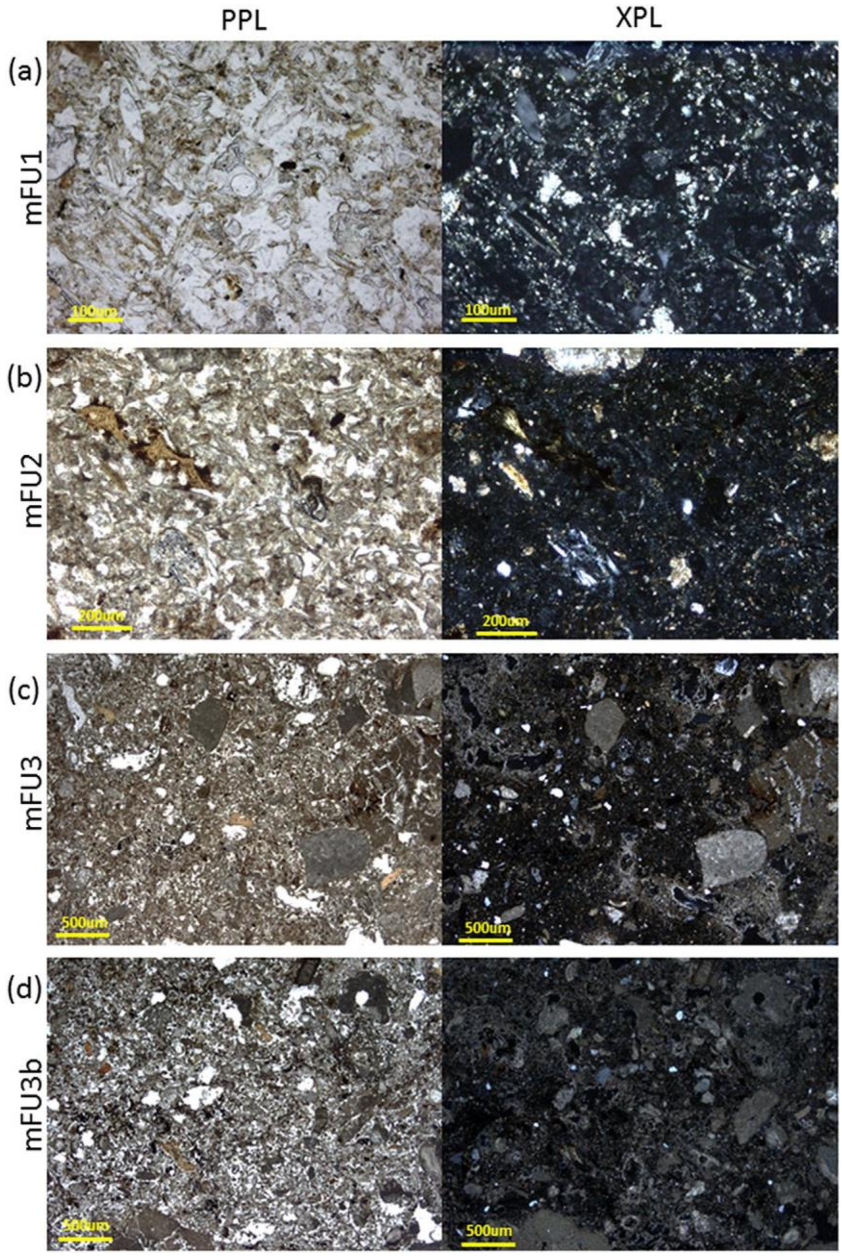


Fig. 5. Representative photomicrographs in plane-(PPL) and cross-(XPL) polarised light of: (a) micro-fabric unit 1 (mFU1) from burrow in SU 80; (b) micro-fabric unit 2 (mFU2) from the bottom of SU 77; (c) micro-fabric unit 3 (mFU3) from the base of SU 80; (d) micro-fabric unit 3b (mFU3b) with abundant micro-fragments of charred plant materials from SU 12. Note in the XPL microphotographs the micritic cementation of the groundmass and the microsparitic coatings and hypo-coatings of voids and channels.

4.1.1. Syn- and post-depositional processes

At the microscopic scale the deposits show evidence of intense syn-depositional bioturbation. The diffuse intrapedal granular microstructure (Fig. 5c, d and Fig. S2c) suggests that the deposits

were reworked by the trophic action of organisms such as earth-worms and mites. Horizontal and vertical passage features, rhizoliths in particular, broken boundaries and deformation features (e.g., SU 77) are commonly observable in the thin sections (Fig. S2b and Fig. S3). Micromorphological analysis shows evidence of at least two major processes of deposit cementation by calcium carbonate (Fig. 5aed and Fig. S3): (1) a syn-depositional formation of micritic calcite precipitating diffusely in the groundmass; (2) a post-depositional formation of microsparitic infillings, coatings and hypocoatings of chambers, vaugs and channels. Bioturbation and carbonation of the sediments disturbed and obliterated the microscopic spatial organization of the original constituents. The precipitation and crystallization of calcite associated with the alkalinity of the soil solution appears to have particularly affected the preservation of the charcoal (e.g., in SU 80 e Fig. S3). On the other hand evidence of heavy trampling (human) is very limited. In fact most of the large flat-lying objects observed in thin sections (Fig. S3) do not show sign of being trampled. This observation suggests that the physical impact on the site and the hearths by the human group occupying the shelter had limited effects at the microscopic scale.

4.1.2. Hearths and palimpsest

Here we briefly report the results from the analysis of three hearths (SU 12, SU 78, and SU 83) that are most informative for the reconstruction of the palimpsest evolution of SU 13.

SU 12. The micromorphological analysis of sample OSC127 (Fig. S3) collected from SU 12 shows the presence of four microStratigraphic Units and several passage features (burrows). The top unit is composed of rock shelter deposit (mFU3) that caps a heavily reworked wood ash deposit (mFU4a). The ashes appear to lie directly on top of a rock shelter stable surface revealed by the presence of flat-lying gravel size fragments of bone (m-FTIR ¼ heated < 500 C) and chert (Fig. S3). The sediment underneath the reworked wood ash deposit is blackish brown and contains abundant amounts of weathered micro-charcoal (mFU3b e Fig. 5d). m-FTIR analysis also indicates that the associated fine fraction of the sediment did not reach temperatures above 500 C. The portion of hearth SU 12 analyzed thus appears to be the remains of reworked wood ash lying on the rock shelter surface (i.e. SU 13) above the remains of decomposing, partially uncombusted fuel from an older combustion event shallowly buried in SU 13.

SU 78. In the thin section prepared from sample OSC140 from SU 78, four superimposed microstratigraphic layers cut by several passage features are observable (Fig. S2). Here a 5 mm thick layer of fairly well-preserved laminated wood ash is overlying a sharp and irregular boundary of a shallow pit (Fig. S2c). The sediment underneath the wood ash layer is discolored but does not contain major quantities of charcoal nor does m-FTIR analysis show that it was heated diffusely above 500 C. It thus appears that the analyzed portion of SU 78 is the remains of a hearth fueled on top of the SU 13 with a small amount of woody material that underwent complete combustion. The wood ash layer appears to be capped by more rock shelter deposits (i.e., SU 13), suggesting that this specific location was used very briefly, and possibly refueled a few times only.

SU 83. The thin section prepared from sample OSC146 shows that portions of hearth SU 83 are composed of two major micro-stratigraphic layers (Fig. S3). The top layer is composed of a ca. 1e2 cm thick heavily reworked wood ash deposit (mFU4a) containing partially calcined bone fragments (m-FTIR ¼ heated above 500 C but below 800 C). The boundary between the reworked wood ash layer and the underlying anthropogenic rock shelter deposit is sharp but extremely irregular. Moreover the shape of the boundary corresponding to the area sampled by the thin section is convex, suggesting that the hearth was not prepared in a pit. It thus appears that SU 83 was prepared on the irregular surface of the rock shelter (i.e., SU 13) and, with respect to the other hearths so far analyzed, it was fueled with a larger quantity of wood and other combustible materials and may have reached higher temperatures. A screening by m-FTIR of bone fragments (N ¼ 67) observed in the six available thin sections shows that only a small percentage (8%) reached temperatures above 700 C, suggesting that burning of bone was mainly accidental or due to disposal in the fire and that bone was probably not used as fuel (Thery-Parisot and Costamagno, 2005).

4.1.3. General consideration of site formation processes

The microstratigraphic analysis of the six hearths (i.e., SU 12, SU 77, SU 78, SU 80, SU 82 and SU 83) shows that all of them belong (as sub-Stratigraphic Units) to the same Stratigraphic Unit (i.e., SU 13) formed as a result of weathering of the underlying Mt. Epomeo green tuff and colluviation of geogenic and anthropogenic components. The geogenic components include rock fragments from the local lithostartigraphic column (micritic limestone, flowstone, calcarenite, and fossiliferous limestone) and soil aggregates formed above the ravine from the weathering of the Calcare di Altamura formation. The anthropogenic components include bone fragments (uncharred, charred, and partially calcined), charred wood (charcoal), angular chert fragments (debitage) and wood ash. The diffuse character of the majority of the observed microstratigraphic boundaries and the lack of observable erosional unconformity strongly suggest that the depositional processes of the SU 13 at Oscurusciuto rock shelter were dominated by sediment aggradation and cementation (e.g., brecciation) processes. Human activities appear not to have contrasted with the sediment build up but rather to have contributed to it with the introduction of wood ash, lithic raw materials, and bones.

4.2. Faunal analysis

From a total of 4660 skeletal elements collected, 4236 (90.1%) have a length between 1 and 3 cm. There are several fragments (n. 1935) with traces of combustion which are mostly constituted by small sized elements (1e3 cm: 95.2%). From the fillings of the combustion structures 88 bone fragments (all burned) were recovered; these have lengths between 1 and 6 cm (Table 1). Overall, the fragments larger than 6 cm number 121: they are mostly represented by portions of the diaphysis of long bones

	1-3 cm	3-6 cm	6-10 cm	>10 cm	TOT
SU 13	4236	303	110	11	4660

Table 1: Fauna dimensional classes.

These highly fragmented samples permitted the taxonomic determination of only six remains: Equus ferus, a proximal epiphysis of metacarpal; Bos primigenius, two teeth (a molar and an incisor), a distal epiphysis of radius-ulna, a fragment of a meta-carpal diaphysis and a distal fragment of a first phalanx. The bones were covered by a thin layer of carbonate concretion that prevented taphonomic analysis of surfaces.

Such a strong rate of bone fragmentation, probably aimed at the extraction of marrow (Boscato and Crezzini, 2012a), is found across the whole area of the shelter investigated so far.

Regarding the palaeo-environmental reconstruction, SU 13 is part of a group of Stratigraphic Units belonging to the same climatic phase (SU 15 to SU 4), moderately temperate and arid, characterized by a large extension of wooded grassland. Within this phase, hunting by Neanderthals was almost exclusively directed towards ungulates and particularly towards aurochs (Boscato and Crezzini, 2012b).

4.3. Lithic assemblage

In the layer there are 7504 lithic items which all show a fresh state of preservation and it is possible to observe a high frequency of refitting within short distances. The most utilized raw materials were siliceous limestone, jasper and chert in their fine granulometry (Table 2). The starting blocks of raw material were oblong pebbles coming from secondary local sources. The main reduction sequence was the recurrent levallois, unipolar and convergent, designed to produce elongated and convergent flakes. There was also present a marginal volumetric debitage for the production of bladelets. A total number of 279 RMUs were identified, made up of 1770 pieces and 56 refitting and conjoins sets formed of 134 pieces. Table S1 shows the description of some reliable and representative RMUs relevant for the understanding of the technological and spatial behavior identified at SU 13.

Raw material	Granulometry	N.	%
Jasper	Fine	1207	16.1
Chert	Fine	261	3.5
Jasper	Middle	80	1.1
Chert	Middle	314	4.2
Siliceous Limestone	Middle	1305	17.4
Limestone	Middle	37	0.5
Chert	Coarse	30	0.4
Siliceous Limestone	Coarse	51	0.7
Quartzarenite	Middle	137	1.8
Quartzarenite	Coarse	24	0.3
Limestone	Coarse	33	0.4
Undetermined		4025	53.6
Total		7504	100.0

Table 2: Lithological classes.

Despite the limitation due to the incompleteness of the excavated area, it was possible, thanks to the combination of technological analysis and study of the RMUs, to recognize the fragmentation of the reduction sequence. A large number of RMUs, consisting of one or a few elements of target products and retouched tools, leads us to hypothesize the import of finished objects (Fig. S4).

RMUs with many items are few in number and represent simultaneously all the technological phases of the reduction sequence with a predominance of management e as attested by RMUs 1, 56, 137, 177 (Fig. S5, Fig. S6, Fig. S7, Fig. S8). In these case the entire reduction sequence seems to have occurred at the site. It is just as interesting to note that most of the cores, often entirely exploited, form part of RMUs with few elements, leading us to the hypothesis of possible exports of target products (Fig. 6).

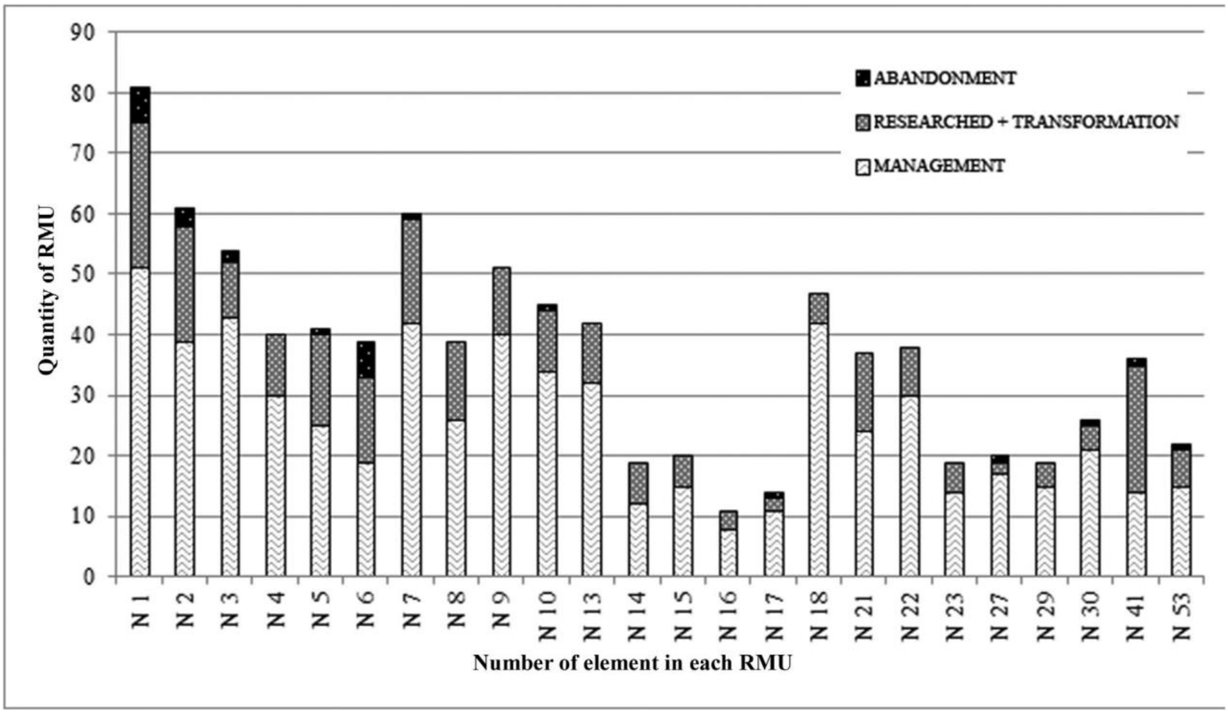


Fig. 6. Quantity and composition of each RMU. The graph shows on the X axes the number of objects for each RMU and on the Y axes the quantity of RMUs having the number of elements expressed on the X axes. The different patterning of the columns indicate, on the other hand, the technological composition of RMUs: abandonment, target þ transformation and management. These definitions refer to the technological phases of the reduction sequence of the lithic tools. "Abandonment" refers to cores, "researched" refers to all flakes which were the objective of production (in this case elongated, convergent and backed flakes as well as bladelets), "transformation" refers to retouched flakes. "Management" comprises all the flakes necessary to remove the cortex and to manage the technical knapping parameters needed for the production of target flakes.

4.4. Taphonomy and spatial analysis

4.4.1. Taphonomy

The absence of mammals' burrows or of root imprints, the fresh state of the lithic edges and the virtual integrity of the hearths suggest a very good state of preservation of SU 13.

Other parameters allow us to reach the same conclusion. The chi-square test, used to assess the clustering degree of the archaeological remains gave the result of 1489.81. This value is rather higher than the expected one for a random distribution (127.32 at probability level 0.001). Therefore, a non-random spatial pattern can be asserted. Using Ripley's K function, different spatial patterns are found among the Dimensional Classes of the lithic finds: clustered for those smaller than 50 mm2, quite random for the items bigger than 50 mm2 (Fig. S9). Behind this configuration, a size-sorting effect due to water flow can be ruled out. A downslope increase in fine-grained debris is not found, and in particular the position and shape of the smallest lithic find accumulations are not conditioned by the surface morphology of SU 13 (Figs. 3 and 4). This data is consistent with the slope analysis of the SU 13 surface, that highlights a sub-horizontal layer with a weak slope (less than 5).

4.4.2. RMU

With regard to the refitting analysis a clear predominance of short distances is evident (Fig. S1). Usually these distances are shorter than 1.5 m.

In the lithic assemblage there are 30 RMUs with at least 10 items with a good or excellent degree of reliability. The Ripley's K-function results from this sample (Fig. S10, Fig. S11, Fig. S12) indicate that almost 1/5 of these RMUs have a highly clustered pattern from a radius distance band of between 0.5 and 0.6 m (RMUs: 1, 56, 137, 143, 193, 283) (Fig. 7 and Fig. 8). The agglomerations are concentrated around the hearths in the central part of the excavated area: only RMU 137 appears mainly focused on hearth SU 12 (or on SU 76), in the northern part of the excavated area. In the other case random (RMUs: 9, 12, 31, 55, 64, 91, 132, 134, 146, 177, 197, 263, 264, 269, 279) (Figs. 7 and 8) and dispersed (RMUs: 53, 66, 96, 136, 139, 161, 255, 259, 280) patterns are recognizable. Nevertheless, by visual analysis, it is possible to get “disordered clusters”, beside some random pattern. For example, in RMUs 12 and 177, both with a statistically random pattern, it is easy to recognize a lot of small agglomerates. The spatial organization of the technological phases of RMU 177, in particular, is very interesting: while the cortex removal, production flakes and undetermined items are distributed in small agglomerates in the central and northern part of the excavated area, the target flakes are localized only in a small group around hearth SU 82, in the southern part of the excavated area (Fig. 8). Along with the high frequency of short refittings/conjoints, the presence of significant numbers of clustered patterns among the RMUs could be related to good preservation of the activity areas.

The vertical distribution of the items in these RMUs was evaluated where at least 3 elements of each RMU had the actual co-ordinates recorded. On the profile NeS of the excavated area, the scatter-plot highlights a good coincidence between the lying plane of these RMUs and the altitude of SU 13 (Figs. 2 and 9).

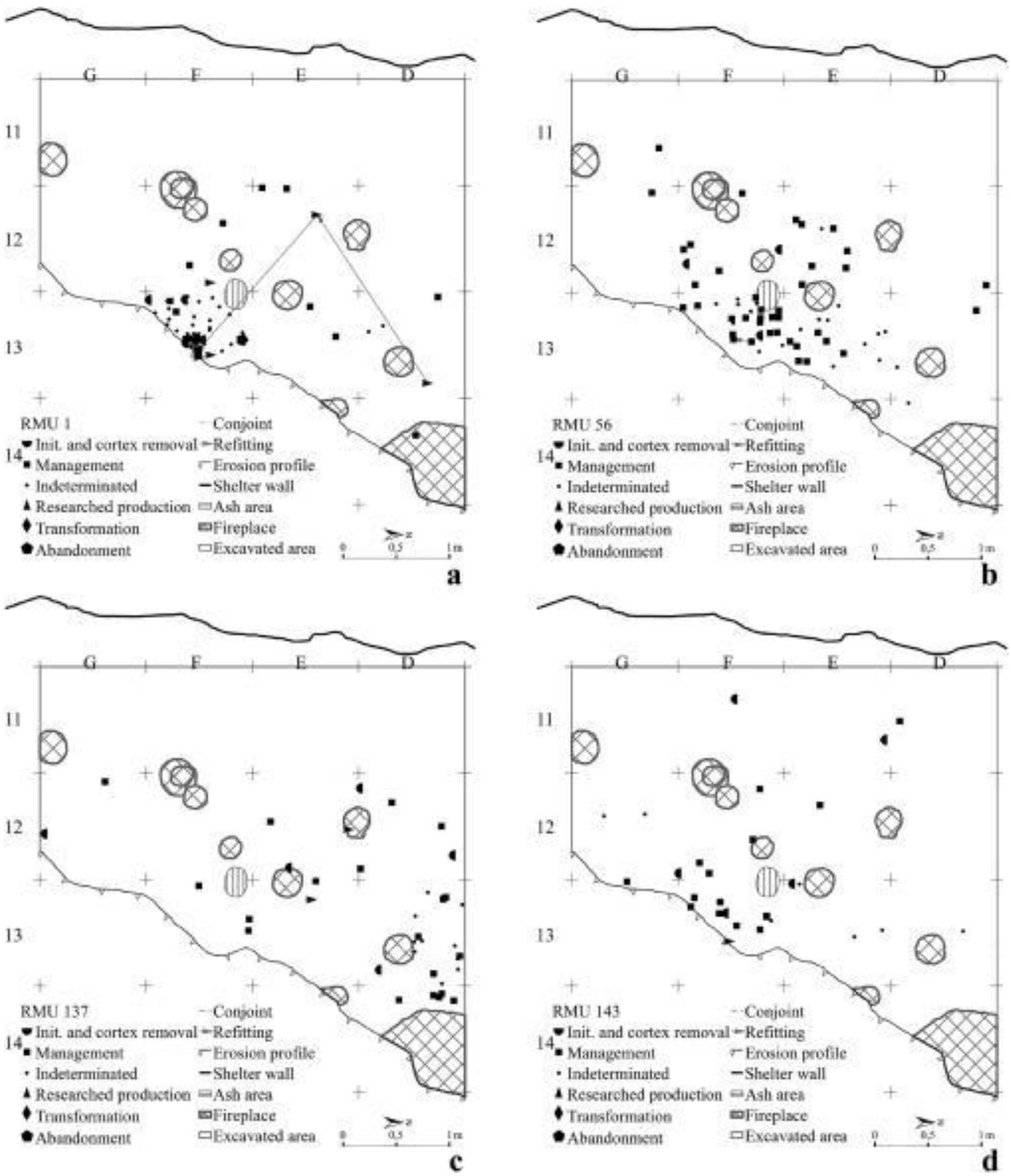


Fig. 7. Planimetry of the RMU 1 (a), RMU 56 (b), RMU 137 (c), RMU 143 (d).

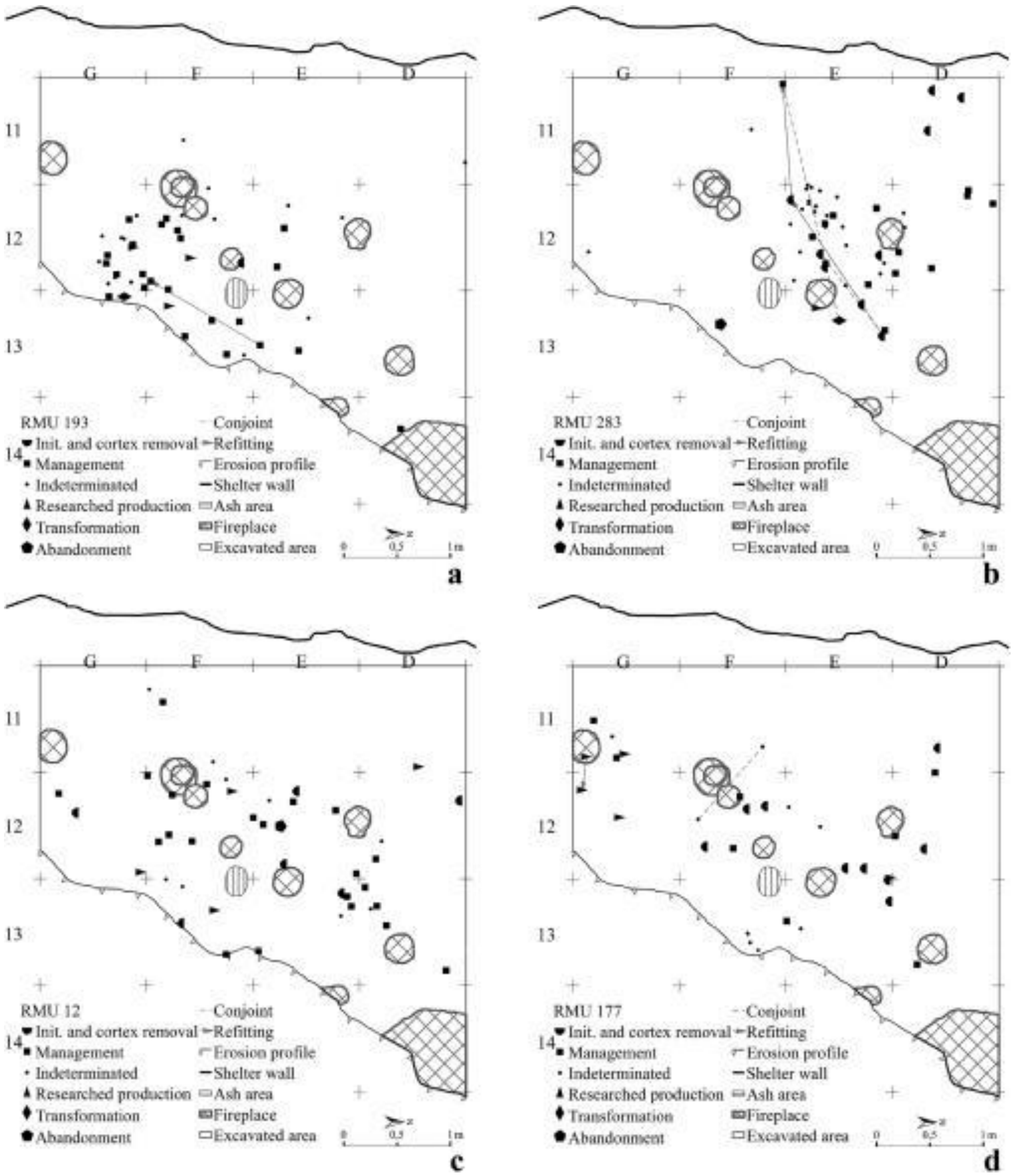


Fig. 8. Planimetry of the RMU 193 (a), RMU 283 (b), RMU 12 (c), RMU 177 (d).

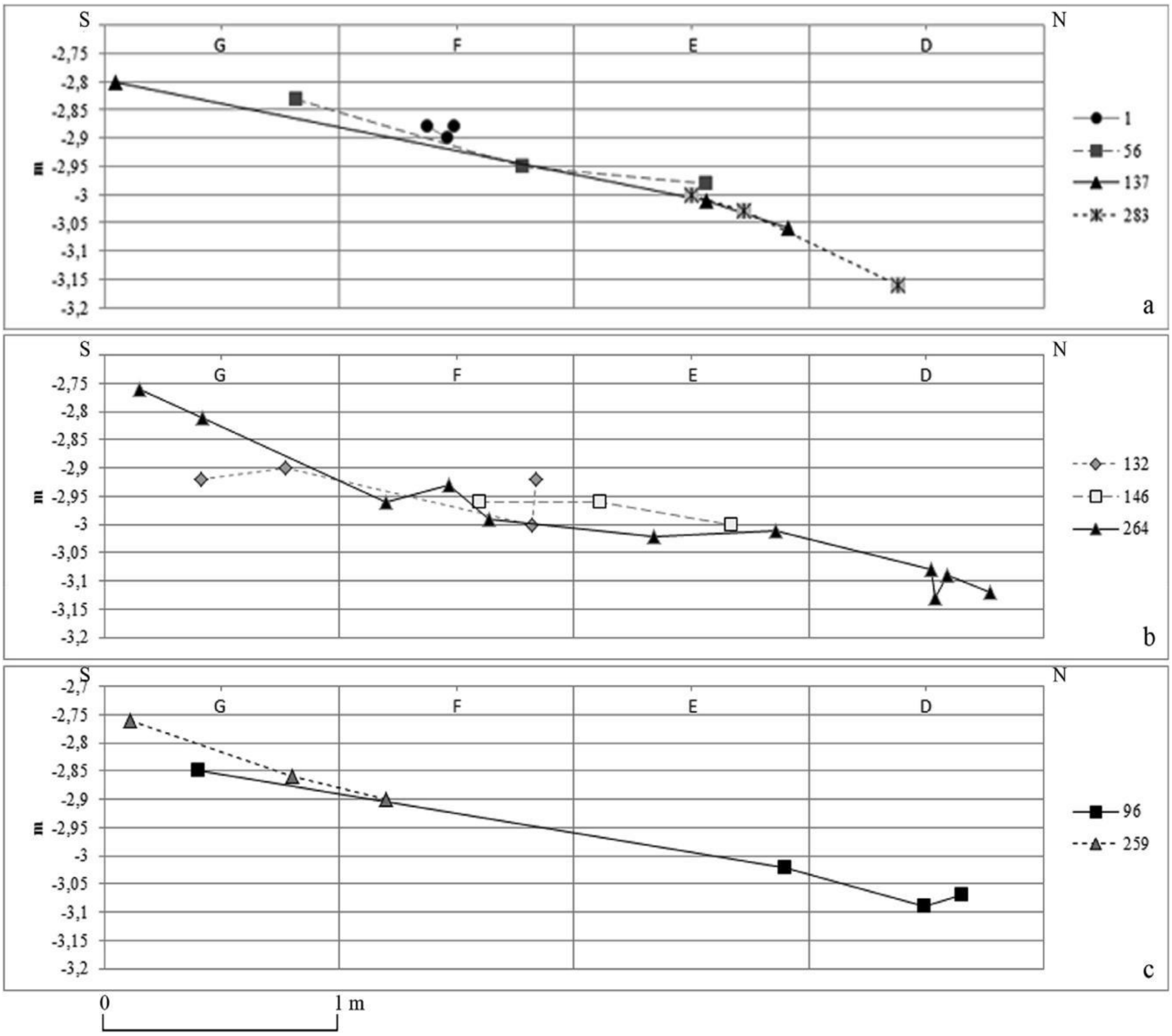


Fig. 9. Vertical distribution on the NeS profile of the items in the clustered RMU (a), random RMU (b), dispersed RMU (c).

Another interesting point derived from the RMU analysis consists in the relationship between the spatial pattern, the number of items for RMU and their technological composition. In order to analyse further, two technological macro-categories were created: the first one consisting of the "tools" (target products, retouched tools and items with macro-traces) and the second of the production "waste" (initialization and cortex removal flakes, management flakes and undetermined). Due to the complete exploitation of their volume, the few cores were included in the second category. As shown by the scatter-plot graph, there is a clear difference in the RMUs' dimension and technological composition compared with their spatial pattern. The clustered RMUs have a large number of items and a strong representation of production waste in relation to tools. On the contrary, the dispersed RMUs have few items and tend to exhibit an overrepresentation of tools instead of waste. The random patterned RMUs, as expected, show some mixed characters (Fig. 10).

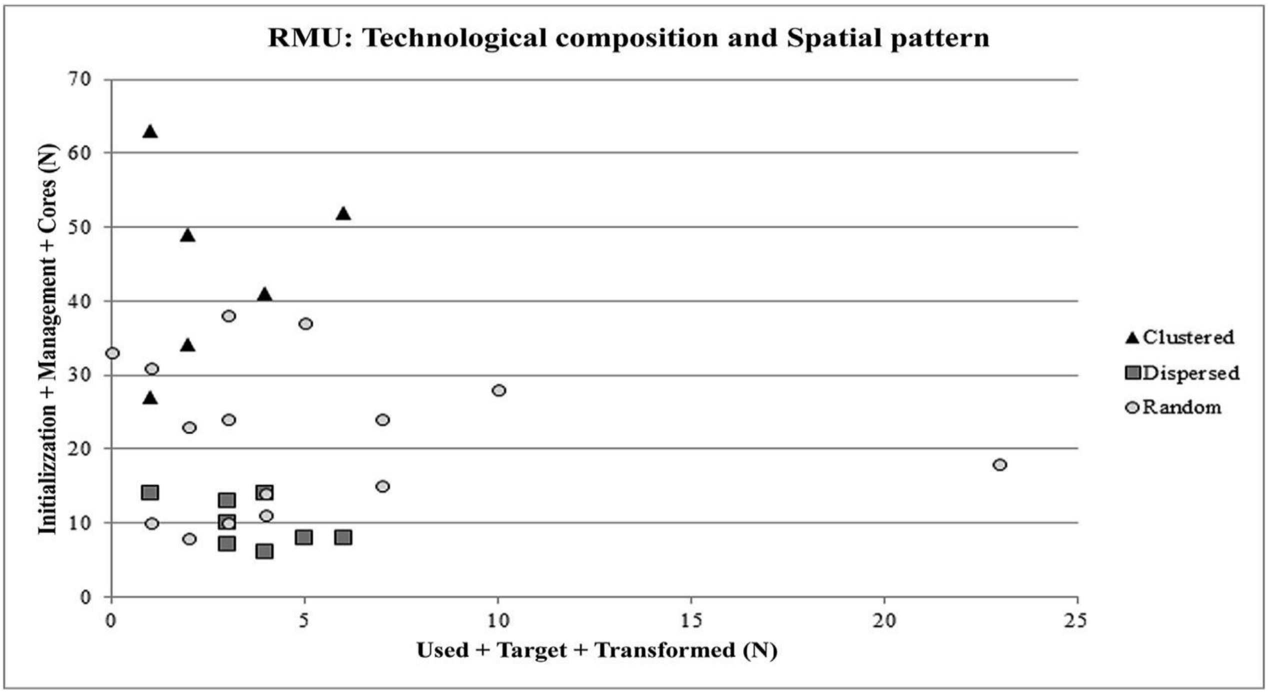


Fig. 10. Technological composition of the different spatial patterns of RMUs.

4.4.3. Spatial organization

Through the analysis of the density maps of lithic and faunal remains, a clear distinction between the inner part of the rock shelter and the outer is recognizable. The area enclosed between the rock shelter wall and the hearths' alignment (about 4 m2 including the small unexcavated stratigraphic baulk against the wall) is characterized by the almost total absence of lithic finds and faunal remains. The other area (about 8 m2), delimited at North and South by unexcavated stratigraphic baulks, is interrupted by the erosion front (in the eastern part). In this area, the presence of the hearth and the massive amount of anthropic remains, well-structured in some distinct agglomerates, is the distinctive feature (Figs. 3 and 4).

Computation of the distances between the hearths (from the respective centroids) highlight a significant recurrence of median values around 1.63 m: the same distance between the rock shelter wall and the hearths nearest to each other (1.3e1.6 m). A recurrent pattern related to the hearths consists in the distance from their centroids to the nearest accumulations of lithic finds smaller than 50 mm2 and faunal remains smaller than 3 cm, which is 70 cm.

5. Discussion

With its material culture, ecofacts, and hearth feature SU 13 is an interesting context for studying the settlement and economic strategies of the Neanderthals in Oscurusciuto rock shelter.

Microstratigraphic investigation suggests that a series of hearths were lit on the surface of the local deposit composed of weathering Epomeo tuff and colluviated degrading local limestone. The absence of large scale burrows and carnivore activities, erosion or flooding, and the general integrity of the hearths resulting from one or a few combustion episodes enable the recognition of the exceptional state of preservation of the layer. The in loco availability of subsistence sources (hunting prey) and of knappable raw ma-terials contributed to the attractiveness of the site. The lithic industry is dominated by convergent and unipolar levallois production. This was designed to obtain convergent and backed long flakes, whereas the volumetric production of bladelets was marginal. The fragmentation of the reduction sequences and the on-site absence of some phases of the chaine operatoire suggests that these activities were carried out elsewhere, entailing a certain mobility of the Neanderthal population of the Oscurusciuto. The mobility of the hunters is also attested by faunal remains: the lack of vertebrae and ribs in the shelter points suggests the dismembering of carcasses at killing sites and the transportation to the shelter of the limbs and crania of the killed animals.

The patterns observed in the spatial distribution of lithic and faunal remains are clearly not random, and they mainly reflect the outcome of anthropogenic activities. Zones of Organized Activity (Allue et al., 1993) are clearly recognizable on the basis of the strong recurrence of the same space-functional modules. In SU 13 the strong recurrence of hearth dimensional modules allows the identification of quite defined spatial patterns. These hearths constitute an alignment that acts as a “barrier” and divides the deposit into an internal part (enclosed within the alignment and the wall of the shelter) and an outer part including the hearths (incomplete as partially removed by erosion slope). This pattern is further emphasized by the distribution of lithic and faunal remains. The density gradients of various analyzed categories bring out a clear distinction between the inner area (characterized by an almost complete absence of findings) and external area (with a high density of artifacts). Moreover, in the external area, an additional configuration (discernible thanks to the density maps) shows a different organization of the northern half of the outside area compared to the southern half (Figs. 3 and 4).

It is significant that spatial patterns differ according to specific categories of data. Regarding dimensional classes, for example, opposite patterns are observed between lithic and fauna. While lithic finds tend to be clustered in the smaller dimensional classes (with configurations of random type in the remaining ones), the faunal remains show a pattern strongly clustered in major size classes, while the smaller classes and the burnt remains are more likely to show a random distribution. Likewise, among the lithic technological classes, only cores and retouched pieces have a clustered distribution as to a minor extent do the used tools. This evidence is the result of overlapping different events, which are classifiable in the palimpsest model: a modular repetition of the same pattern of use of the space are flanked by partial dislocation spaces which, at least in part, allow the identification of individual activity.

Thanks to the RMU technique it is possible to get a high temporal resolution, clearly identifying not only individual events, but also the temporal meaning of some spatial patterns. Indeed the analysis of RMUs revealed a rather complex scenario, not only according to the technological composition of the lithic assemblage, but also regarding the sequences of activity identified at the site.

Taking into account the spatial distribution patterns of the reliable RMU with at least 10 items, it is possible to recognize three distinct spatial patterns: clustered, random and dispersed. Also a different technological composition corresponds to this spatial distribution of the RMUs. On the basis of these two elements it is possible to individuate a different temporal value to the three spatial patterns: the clustered pattern corresponds to a final sub-phase of occupation; the random pattern to an intermediate sub-phase and the dispersed pattern to an initial subphase of the occupation.

The RMUs with few elements, a high frequency of tools (compared to waste) and more dispersed spatial patterns, from a temporal point of view, can be interpreted as the product of a rather long time between the production of the object and their burial. This means that such materials having been exposed longer to voluntary (activity areas maintenance, selection of tools used outside of the production areas) and involuntary (trampling, scuffing) factors of translocation are more dispersed on the surface of the layer. This category of scattered RMUs indicates an initial moment of the individual phase of occupation. A possible behavioral explanation of the technological composition and spatial patterns of these RMU could consist in the fact that, while waste was more easily dispersed (for both involuntary and voluntary factors), the tools would be maintained because of their major technical investment and their essential utility in daily occupations.

The RMUs with a high number of elements and a technological composition consisting of only a few tools and concentrated spatial patterns may indicate a short interval of time between production and burial, suggesting the final events before abandonment of the site. Hardly surprisingly is the low number of target products related to these RMUs, since some of them may have been removed at the time of departure (exports). In terms of space, the first product of flaking activity is the drop-zone, a rather compact agglomeration consisting basically of production waste (e.g. Binford, 1983; Stevenson, 1991; Vidale, 1992: 158e175; Vaquero and Pasto, 2001; Jones, 2008; Olausson, 2010; Bertran et al., 2012, 2015; Henry, 2012). While the cores (especially if still exploitable) may remain spatially correlated with the drop-zone, the set of tools could also be moved to a working area different from the one for flaking (Fig. 11).

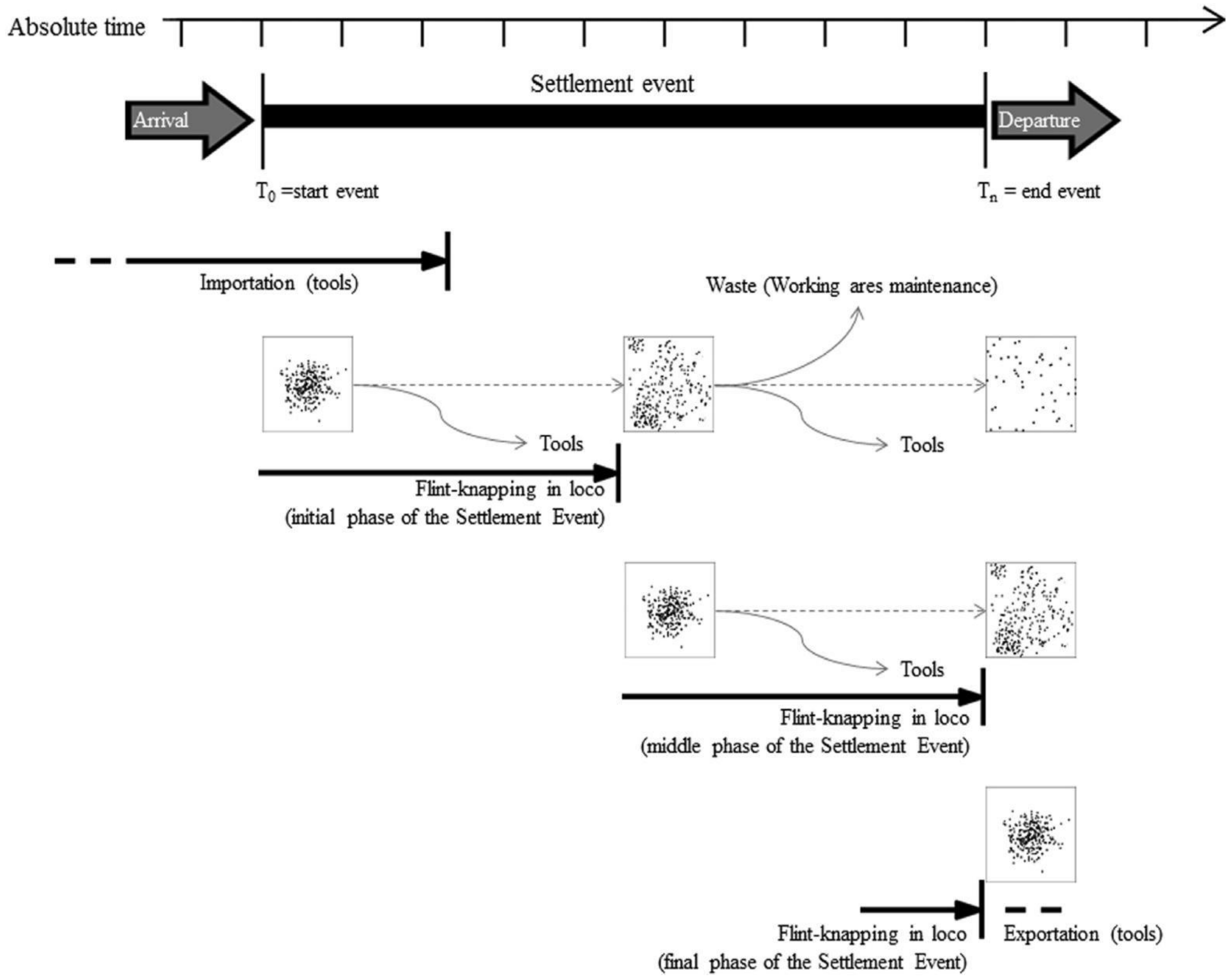


Fig. 11. Possible temporal meaning of the spatial pattern of the RMUs.The image shows the spatial configuration of the technological composition of RMUs within the site in relation to the length of the occupational event. An 'occupational event' is meant as the elapsed time between the arrival and departure of a human group, indicated by different activities of finished stone tool importation (importation tools) and the introduction of knappable raw materials, recognizable through the RMU analysis. The different spatial distribution of RMUs (clustered, random, dispersed), as it can be recognized at the site, can be put in relation to the time elapsed between the introduction of the RMUs and the abandonment of the site.

The remaining RMUs with random patterns (or semi-clustered), as suggested by all technological and spatial parameters, in temporal terms could be intermediate moments between the initial and final occupation.

One aspect which is worth noting concerns the distribution of structures in SU 13. The combustion structures are concentrated in the top part of the layer, except for hearth SU 82, which is found inside the unit, set within a small pit which partially cuts into the underlying SU 14. It is thus possible to infer an initial sporadic frequentation followed by a more stable occupation with the setting up of aligned hearths. In this regard it is particularly significant that the RMUs with concentrated pat-terns gravitate around the central area of the site (only one seems to have as its focus the hearth SU 12, in the north). This could suggest a strong chronological proximity between these RMUs, which could then all refer to the same end-event rather than an event of settlement. Also significant is RMU 177, with a random spatial pattern, since an original decomposed drop-zone is clearly distinguishable (made up almost exclusively of waste) in the central part of the excavated area and a small accumulation composed almost exclusively of target objects is seen around the hearth SU 82 (the first combustion structure set in the layer).

6. Conclusion

Finally, a series of clues lead us to interpret SU 13 as the product of a series of individual events referable to a rather short period, which presumably could be ascribed to the same human group. The spatial data of the RMUs seems to suggest the existence of brief events during a single phase of occupation, which can be seen by the gravitation of almost all concentrated RMUs in the same area. The presence of a stratigraphic overlap of two hearths and the hearth SU 82 (built before the other combustion structures) suggests a succession of at least two events separated in time, but not necessarily of an alternation between phases of occupation and phases of abandonment. The alternation of two events is also suggested by the distribution of hearths within the SU, where they all concentrate in the top part of the layer (except for hearth SU 82). But the vertical distribution of artefacts and the recurrence of the same spatial patterns do not seem to justify the hypothesis of a possible sequence of occupation events interspersed with phases of abandonment.

In conclusion, SU 13 can almost certainly be assessed as a short palimpsest (i.e. the product of a set of events taking place in a small period of time). As the research stands now, it remains difficult to define which kind of occupation is reflected by this short palimpsest. Both the hypothesis of at least two (if not most) occupational events being separated by brief hiatuses, and the hypothesis of a single settlement event seem equally plausible.

Having realized the validity of this integrated method of analysis it is our intention to carry on with the study of the other levels of the site so as to have a diachronic vision of the occupation modalities and of the organization of the living space by the Neanderthal populations of the Ginosa ravine.

IX SU 11

The layer SU 11 consists of 31,056 lithic items, a huge quantity of material which was collected over several years of fieldwork in a layer that because of its thickness was excavated in 3 artificial cuts. In this dissertation, we decided to examine all the items together, and at later time, after an evaluation of the spatial distribution of the pieces, we will decide if and how to divide this collection into further sub-complexes.

The preferred raw material was cherty limestone, followed by jasper and chert; quartz sandstone is less utilized. Limestone is marginally represented (for further information see chapter V, paragraph 4). As was the case with the other levels, the intentional selection of fine-grained material is evident (93.8 % of the collection). In order to make approximate estimates of the dimensions of the imported raw pebbles we considered the dimension of pebbles, the core at the initial stage of exploitation, and the completely cortical flakes (Table 32).

Class	Height Min	Height Max	Height Medium	Width Min	Width Max	Width Mediaum	Tot al
Initial cores	19	54	29.1	13	44	25.7	12
Pebbles	28	82	44.2	23	69	35.1	7
Completely cortical flakes	10	58	23.4	13	63	22.2	38

Table 32: Minimum, maximum and average dimensions of cores, pebbles and completely cortical flakes.

(Please note that for the average measures all the pieces of each category were considered).

The initial blocks used for debitage are pebbles, fragments of pebbles and flakes whose dimensions range from very small blocks (2 cm) to quite big ones (6 – 8 cm). The initial shapes of the pebble were globular, oblong and lenticular.

1 Reduction sequences

According to their technical features and role in the reduction sequence the items of SU 11 were classified in the following technological categories (in the table we did not consider the microflakes, debris and undetermined items – 23,854 pieces) (Table 33).

Technological classes	SU 11 n.	SU 11 %
Pebbles	31	0.4
Cores	175	2.4
Hammerstones	4	0.1
Completely-cortical flakes	41	0.6
Semi-cortical flakes	842	11.7
Management flakes	3503	48.6
Striking Platforms	220	3.1
Target flakes	2219	30.8
Undetermined flakes	167	2.3
Total	**7202**	100.0

Table 33: Technological classes.

Technologically speaking the entire collection is related to debitage reduction sequences with a predominance of management, target and cortical flakes, plus four hammerstones (Figure 102) (Table 33).

Figure 102: Hammerstones.

Based on the technical characteristics of the flakes and cores it was possible to ascertain that the main concept of debitage in this level, was levallois - F1, followed by various other types of additional debitage - B C1 D1 D2 D3 (Table 34).

Concept	Flake		Core		Total	
	n.	%	n.	%	n.	%
Levallois F1	5297	75.8	73	41.7	5370	74.9
Additional C1 D1	155	2.2	42	24.0	197	2.7
Additional C2 D2	96	1.4	14	8.0	110	1.5
Additional D3	0	0.0	7	4.0	7	0.1
Discoid	11	0.2	1	0.6	12	0.2
Kombewa B	38	0.5	9	5.1	47	0.7
Undetermined	1395	20.0	29	16.6	1424	19.9
Total	**6992**	100.0	**175**	100.0	7167	100.0

Table 34: Technological classes and reduction concept

Possibly due to the larger quantity of material, we can affirm that at this level there is a clear additional production aimed at producing flakes, and another aimed at producing blades and bladelets, plus sporadic appearances of discoid and Kombewa items (Table 34). The majority of undetermined cores is actually fragments of cores, fire-damaged items, or cores at a very initial stage of exploitation to which it was not possible to attribute an intended debitage concept. The great number of undetermined flakes consisted mainly of cortical flakes.

Although almost half of the pieces were of cherty limestone, we noted a specific preference with regard to raw material for the additional debitage C2 D2, and in this case, the most common raw material was chert, followed by jasper, whereas in the other cases it was cherty limestone, followed by jasper (Table 35).

Raw mat\concept	F1		C1 D1		C2 D2		D3		E1		K-B		Indet.		Total	
	n.	%	n.	%	n.	%	n.	%	n.	%	n.	%	n.	%	n.	%
Cherty limestone	2716	50.6	81	41.1	26	23.6	4	57.1	8	66.7	24	51.1	681	47.8	3540	49.4
Jasper	1626	30.3	82	41.6	37	33.6	2	28.6	2	16.7	13	27.7	430	30.2	2192	30.6
Chert	768	14.3	27	13.7	40	36.4	1	14.3	2	16.7	9	19.1	229	16.1	1076	15.0
Quartz sandstone	231	4.3	5	2.5	4	3.6	0	0.0	0	0.0	1	2.1	46	3.2	287	4.0
Limestone	26	0.5	2	1.0	0	0.0	0	0.0	0	0.0	0	0.0	32	2.2	60	0.8
Undetermined	3	0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	6	0.4	9	0.1
Total	5370	100.0	197	100.0	110	100.0	7	100.0	12	100.0	47	100.0	1424	100.0	7167	100.0

Table 35:Distribution of raw material according to debitage concept. (K-B means Kombewa debitage-B).

Another factor to consider is the initial selection of the volume of the block to be flaked. For the levallois debitage F1 the choice of pebbles of oblong or lenticular shape prevails. Wherease for the additional debitage - C1 D1 the selection of pieces of pebbles and pebbles, and flakes for Kombewa B prevail. For the additional debitage - C2 D2 the use of pebbles, both of lenticular and globular shape, prevail (Table 36). Regarding the degree of exploitation, the majority of levallois cores are completely exploited, whereas the additional cores are usually abandoned at a medium or late stage of exploitation.

Raw mat\conc	F1		B C1 D1		C2 D2		D3		E1		K-B		Indet.		Total	
	n.	%	n.	%	n.	%	n.	%	n.	%	n.	%	n.	%	n.	%
Pebbles	62	84.9	17	40.5	6	42.9	2	28.6	0	0.0	0	0.0	1	3.4	88	50.3
pieces of pebbles	0	0.0	18	42.9	4	28.6	3	42.9	0	0.0	0	0.0	2	6.9	27	15.4
Flakes	10	13.7	4	9.5	0	0.0	0	0.0	0	0.0	5	55.6	1	3.4	20	11.4
fragment of flakes	0	0.0	0	0.0	4	28.6	2	28.6	0	0.0	4	44.4	0	0.0	10	5.7
Undetermined	1	1.4	3	7.1	0	0.0	0	0.0	1	100.0	0	0.0	25	86.2	30	17.1
Total	73	100.0	42	100.0	14	100.0	7	100.0	1	100.0	9	100.0	29	100.0	175	100.0

Table 36: Raw blocks used for each type of debitage

2 Levallois debitage

For this section we examined 73 cores and 5,297 flakes (Table 37, 38). In the case of level SU 11 we had a significant quantity of material which allowed for a clear definition of events, which at the other levels could only been outlined, such as the passage from unipolar to convergent levallois. In fact, on the one hand the use of both modalities (unipolar and convergent) in the reduction of the same core is documented, and on the other hand we also found cores which from the very beginning had been reduced by either convergent or unipolar modality only.

Another interesting fact is the presence of preferential and centripetal modalities. These two types of reduction occur in the later stages of debitage, that is to say when the reserve of material is almost depleted in which case the reduction switches from unipolar\convergent to preferential or centripetal (Table 37, 38).

Moreover, we noted the presence of some particular cases with the following reduction combination:

- Levallois + levallois = when there are two levallois reduction sequences on the same raw block.
- Levallois + additional = when a raw block was reduced at a first stage employing the as levallois debitage, and then further exploited at a second stage employing additional debitage (Table 38) (for further specification see the following paragraphs).

Concept	Flake	
	n.	%
Unipolar	3503	66.1
Convergent	723	13.6
Unipolar\convergent	369	7.0
Centripetal	54	1.0
Undetermined	648	12.2
Preferential	0	0.0
Total	**5297**	100.0

Table 37: Levallos debitage flakes.

Concept	Core	
	n.	%
Unipolar	18	24.7
Convergent	18	24.7
Centripetal	5	6.8
Undetermined	11	15.1
Preferential	2	2.7
Levallois + additional	12	16.4
Levallois + levallois	3	4.1
Unipolar\convergent	4	5.5
Total	**73**	100.0

Table 38: Levallois debitage cores.

2.1 Cores structure

The cores that respect the six criteria expressed by Boëda (1994, 2013) are defined as levallois.

2.2 Selection and initialization

As at the other levels, the stage of initialization and preparation coincides with the selection of raw blocks already possessing the natural convexities necessary to start the debitage, i.e. pebbles (84.9 %) (e.g. Figures 103, 105, 106) and flakes, usually cortical flakes (13.7 %) (Table 36).

2.3 Production

As for the modality of production, we noted that in the unipolar production the single striking platform is mostly perpendicular to the debitage surface, or there are two striking platforms, one perpendicular to the direction of debitage, and the other on one side of the pebble. From the perpendicular striking platform the target flakes are detached, whereas from the lateral one the management of distal and lateral convexities occurs (Figure 105 and 106). The target objects are flakes with two lateral, long-lineal cutting edges and flakes with one backed side. We noted that pebbles used in the unipolar levallois production were usually bigger than the ones used for the convergent levallois.

The convergent levallois production could follow upon a unipolar initialization or a first generation of unipolar products, or it could be employed directly from the beginning of the reduction process. In the latter case, the selection of the raw blocks falls on small globular pebbles (Figure 103, 107, 108) with a clear recurrent pattern of reductions, which could be synthetized in three main steps:

- Step 1. the opening up of a semi-peripheral striking platform on the proximal portion of the core with several small removals presenting an angle between the striking platform and the debitage surface < than 90° (usually between 50° and 70°).
- Step 2. two convergent strokes on the debitage surface in order to remove the cortex and manage the lateral and distal convexities.
- Step 3. recurrent series of extractions of target objects (convergent flakes).

Figure 103: Convergent levallois cores in various raw materials.

(Cherty limestone, white chert, green jasper, red jasper, orange chert).

In the former case (in a unipolar plus convergent reduction sequence), the target products are elongated convergent blades and long flakes, whereas in the latter (convergent levallois reduction sequence) the products are larger convergent flakes (Figure 103, 104, 107, 108).

Figure 104: Convergent target flakes.

Generally the centripetal and preferential levallois are the last actions carried out on the core before its abandonment, in order to produce one last small flake. In the case of the centripetal levallois, the striking platform is peripheral (Figure 109, 110), whereas for the preferential it could either be peripheral or semi peripheral (Figure 111).

A peculiar case is the occurrence of levallois debitage plus additional debitage (levallois+additional). This procedure was already encountered in SU 14 and SU 15 as a sporadic phenomenon. However, it is at this level that it takes the form of a generally utilized procedure, i.e. quite often at the end of the levallois debitage when the reserve of material is reduced, the integrity of the levallois production is abruptly broken off, introducing additional debitage actions which prevent the continuation of the levallois.

In some cases this action is just a management of the lateral convexities with no further production, a procedure which is very similar to a retouch activity which transforms the core into a tool (Figure 114). In other cases the production switches from levallois into an additional production procedure (Figure 112). Sometimes this step implies the use of the bipolar technique, possibly because of the very small dimensions of the core. The underlying reason for this modus operandi is still under investigation (use-wear analysis on the core\tools).

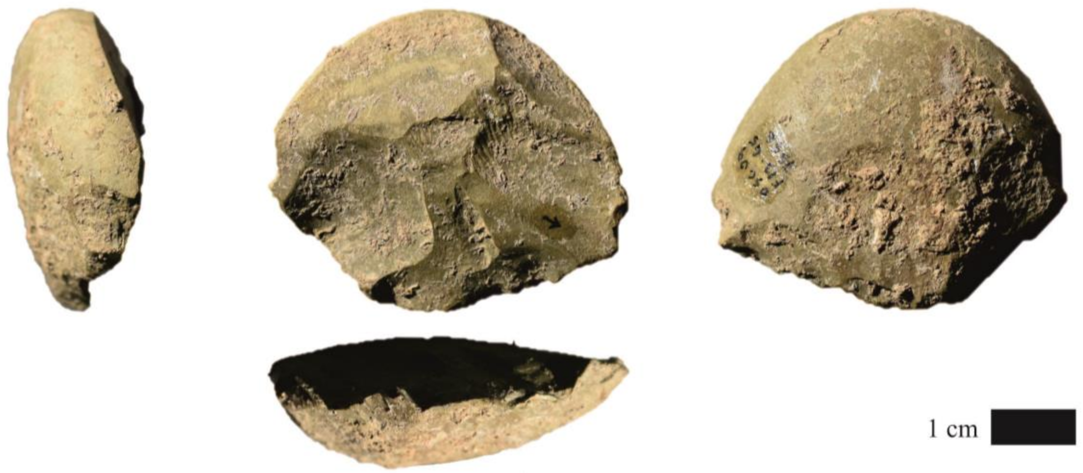
Another odd case is the presence of three cores with two complete levallois reduction sequences on the same core, namely one performed on one side of the pebble, and one on the other side. These reductions respect all the parameters of the levallois conception, right up to the idea of hierarchization of the debitage because there are no alternations of sides during the reduction sequence (as with discoid production), rather the two reduction sequences are employed one after the other (Figure 113, 114). However, one important feature is that the idea of integrity is not respected, something which is actually fundamental to the definition of the levallois mode of production. This may thus be regardered as one of the very rare cases (if not the only case) of an additional use of levallois (this issue will be elaborated further in the discussion section, chapter X, paragraph 1).

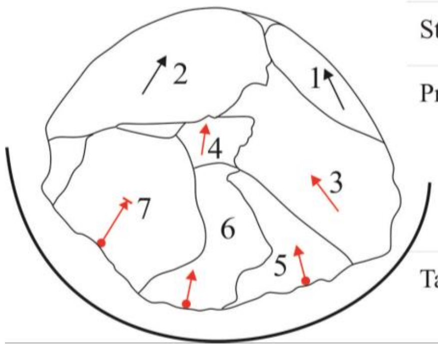
Selection	Pebble.
Striking platform	I: Unipolar, prepared with several small removals - for the extraction of target flakes. II: Perpendicular to the debitage of target flakes - for removals aimed at managing lateral convexities.
Production	1', 2, 3 = management of the lateral convexities. 1, 4, 5, 5' = series of target removals. Abandonment of the core due to the hinged accidents and its complete exploitation.
Target object	Long flakes and flakes.

Figure 105: ID 32, unipolar levallois core F1.

Selection	Pebble.
Striking platform	I: Unipolar, prepared with several small removals - for the extraction of target flakes. II: Perpendicular to the debitage of target flakes - for removals aimed at managing lateral convexities.
Production	1, 2 = management of the distal and lateral convexities. 2, 3, 4, 5 = series of target removals.
Target object	Long flakes and flakes.

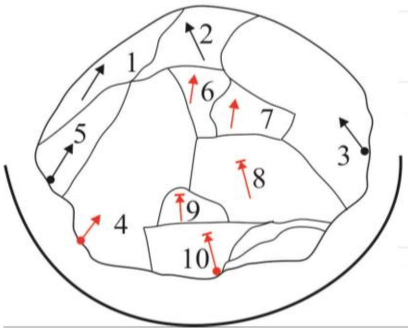
Figure 106: ID 4382, unipolar levallois core F1.





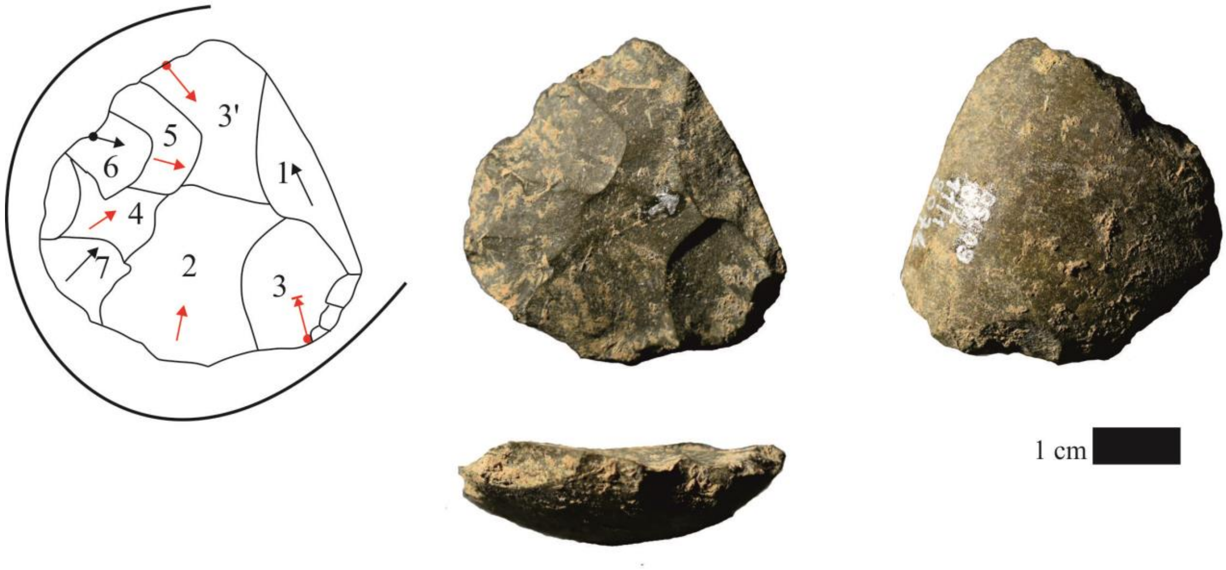
Selection	Pebble.
Striking platform	Semi-peripheral, prepared with small removals.
Production	1, 2 = decortication and managment of the convexities. 2, 4 hinged accidents. 3, 4, 5, 6, 7 = recurrent series of target flakes. 7 is a hinged accident determining the abandonment of the core.
Target object	Convergent flakes.

Figure 108: ID 7841, convergent levallois core F1.



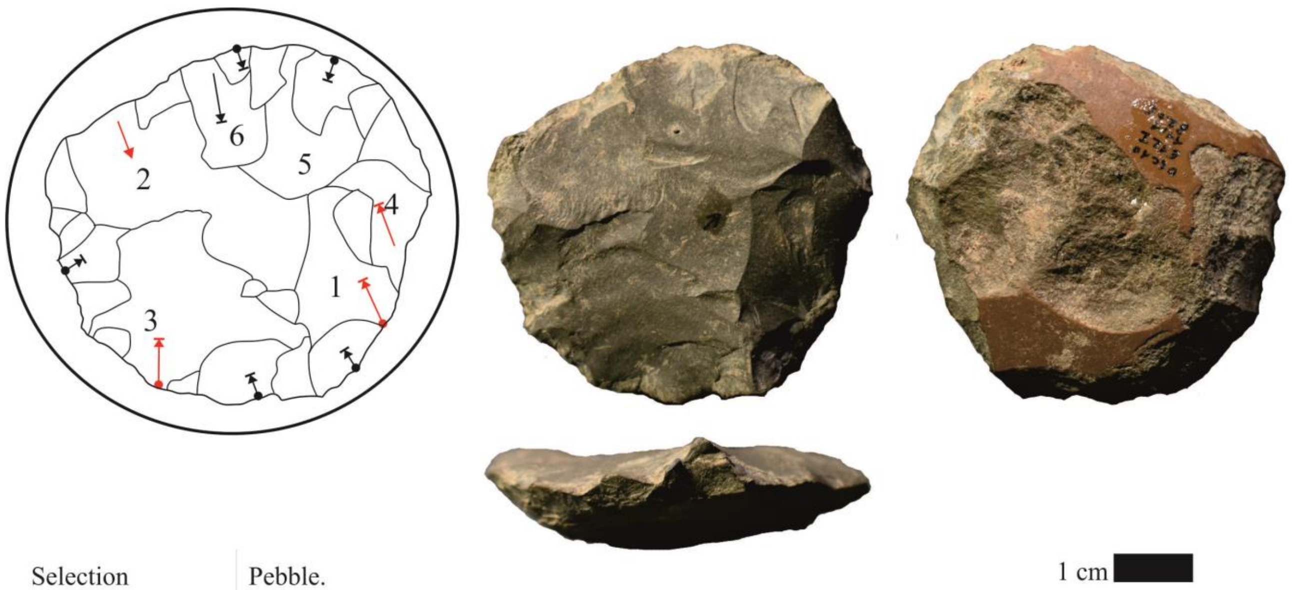
Selection	Pebble.
Striking platform	Semi-peripheral, prepared with few small removals.
Production	1, 2, 3 = decortication and managment of the convexities. 4, 6, 7 = recurrent series of target flakes. 8, 9, 10 = attempts to obtain target flakes, hinged accidents determining the abandonment of the core.
Target object	Convergent flakes.

Figure 107: ID 7556, convergent levallois core F1.



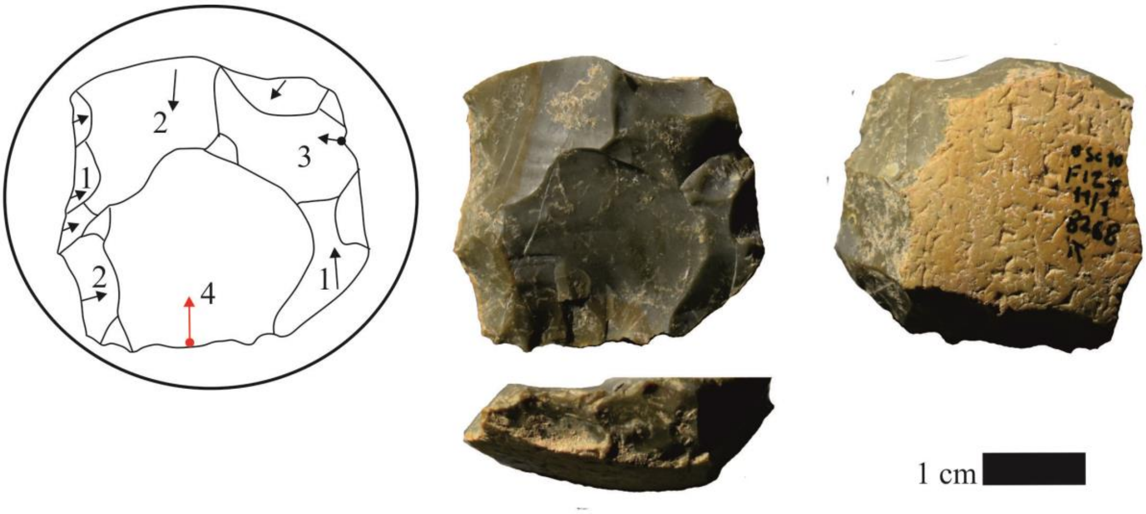
Selection	Pebble.
Striking platform	Semi-peripheral, prepared with small removals.
Production	The core is in its last stage of exploitation. 2, 3, 3', 4, 5 = recurrent series of target flakes.
Target object	Flakes.

Figure 109: ID 8074, completely exploited centripetal levallois core F1.



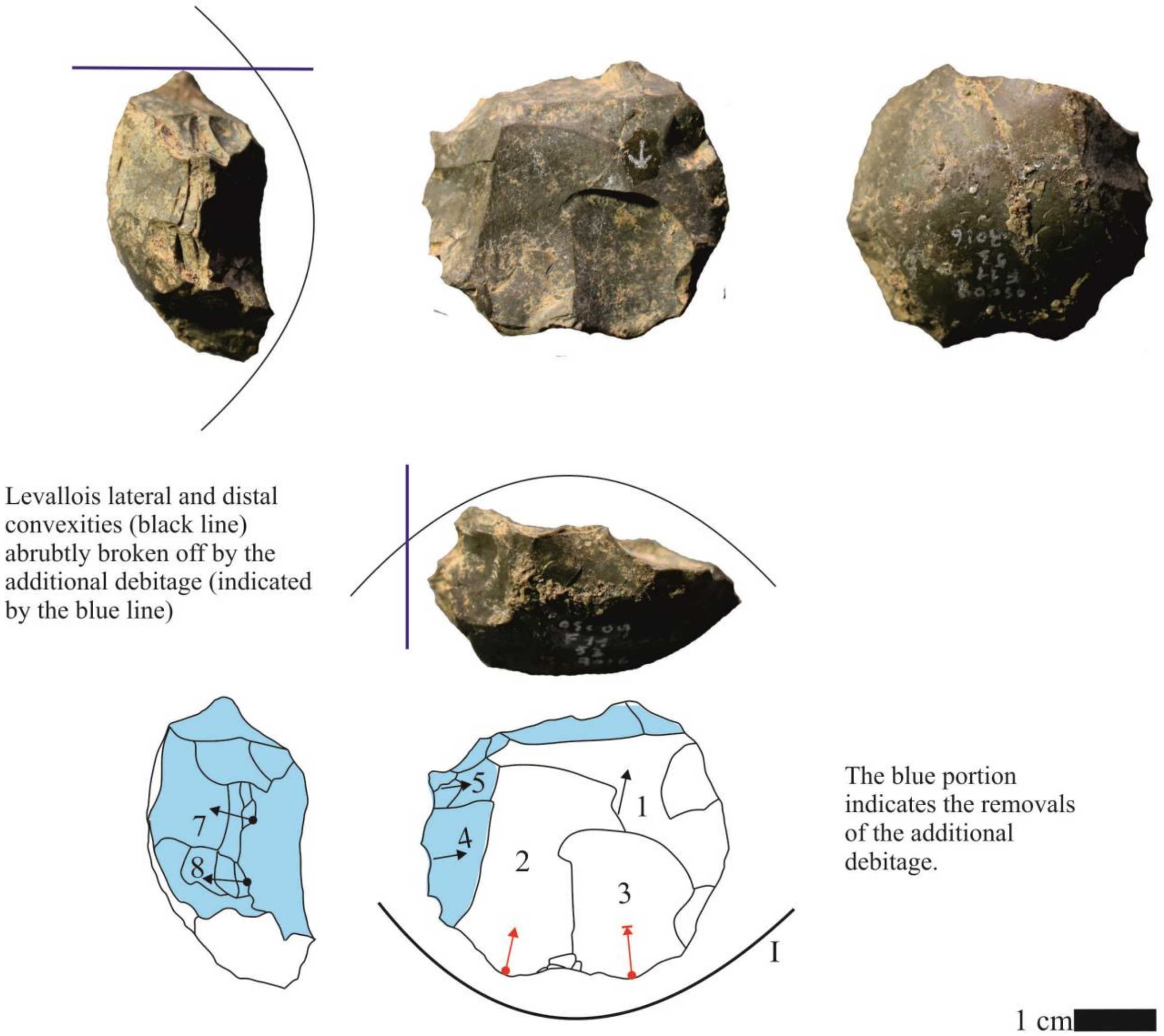
Selection	Pebble.
Striking platform	Peripheral, prepared with small removals.
Production	The core is in its last stage of exploitation. 1, 2, 3, 4, 5 = attempts to produce a last series of target flakes. Along the whole perimeter of the core attempts to produce flakes ending with several hinged accidents.
Target object	Flakes.

Figure 110: ID 8206, completely exploited centripetal levallois core F1.



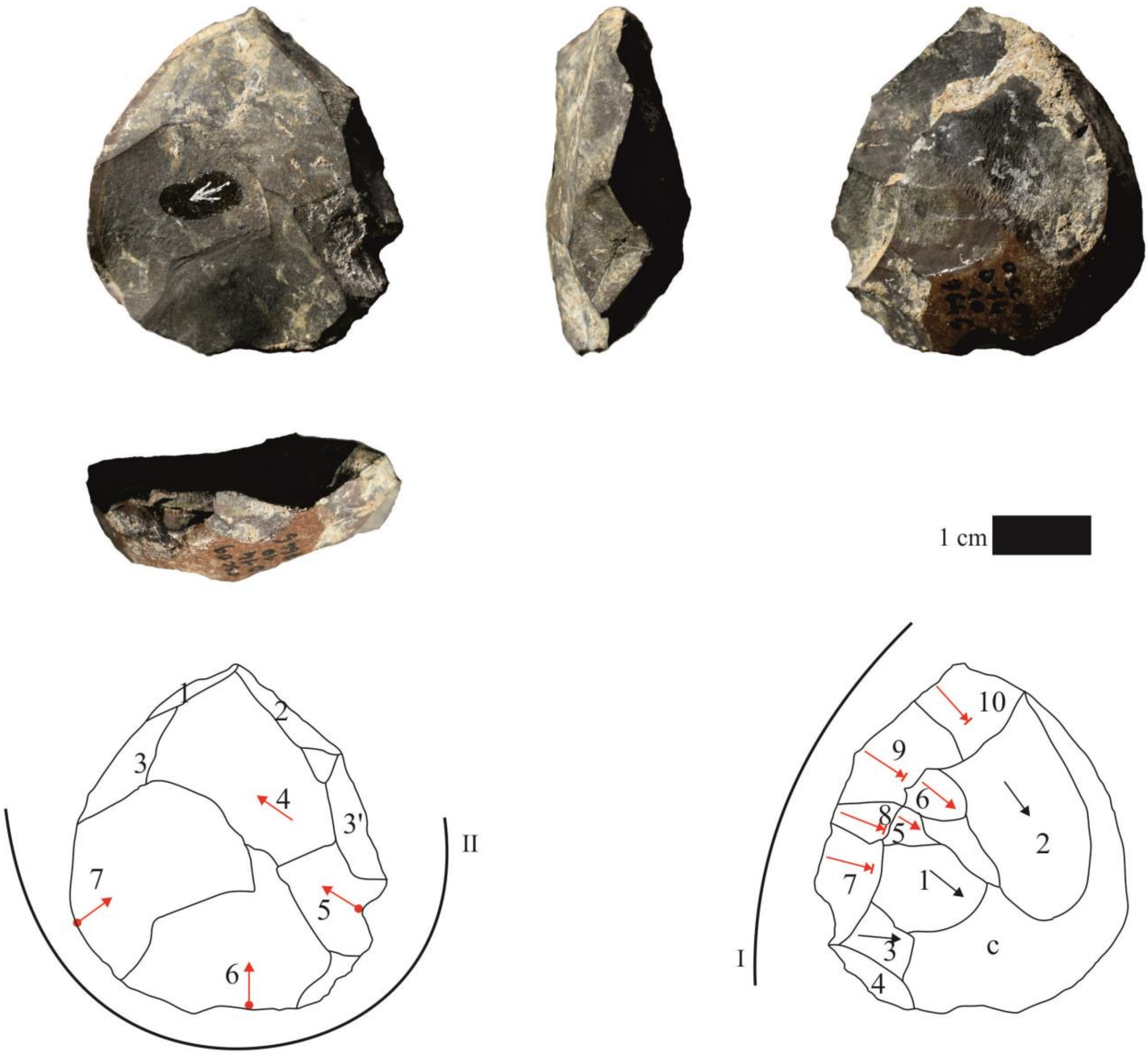
Selection	Pebble.
Striking platform	Peripheral striking platform prepared with several small removals.
Production	1, 2, 3 = management of the lateral and distal convexities. 4 = one last target flake.
Target object	Flake.

Figure 111: ID 8268, preferential levallois core F1.



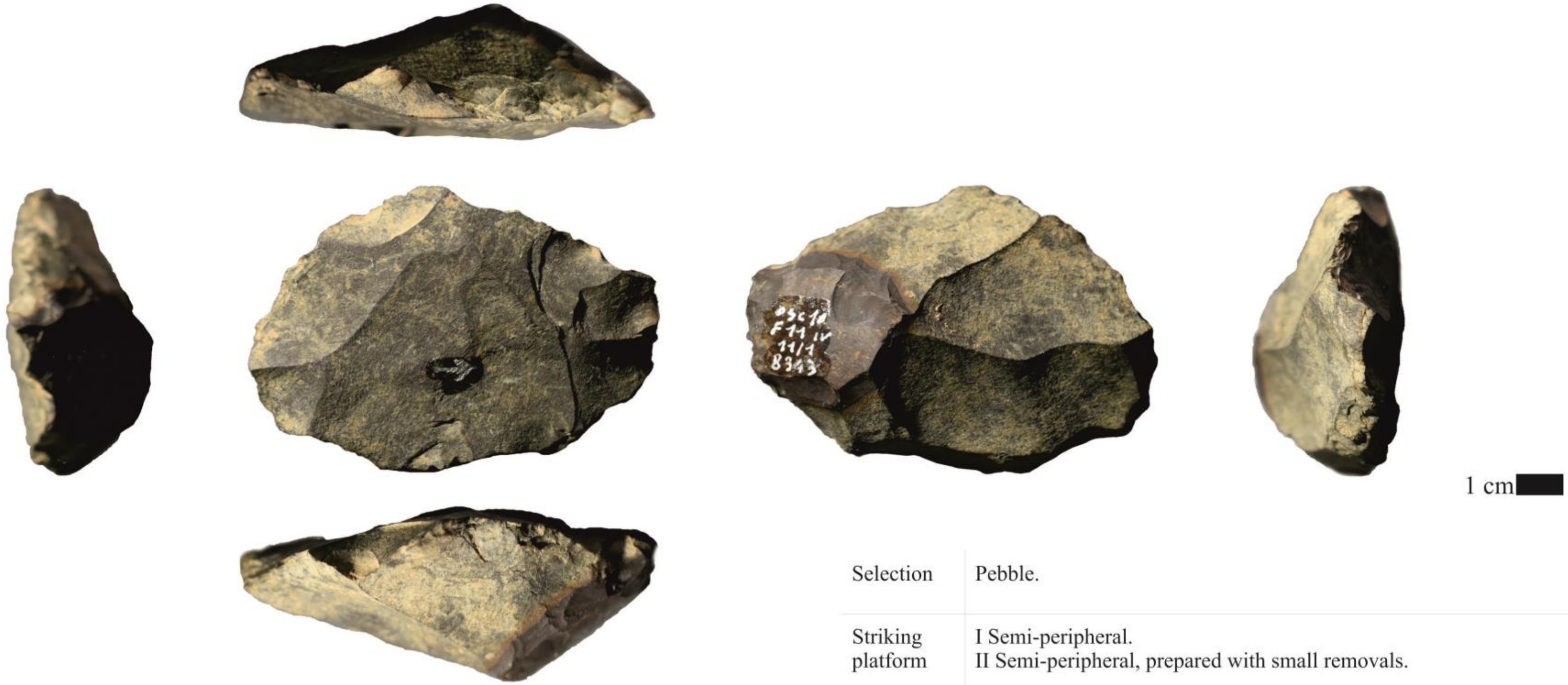
Selection	Pebble.
Striking platform	I: Semi-peripheral, prepared with several small removals. 4, 5 = Removals aimed at preparing a striking platform for additional debitage.
Production	1, 2, 3 = removals by means of unipolar levallois debitage, abruptly broken off by the removals 4, 5 preparing the striking platform for additional debitage performed on the side of the core (removals 7 and 8).
Target object	Flake.

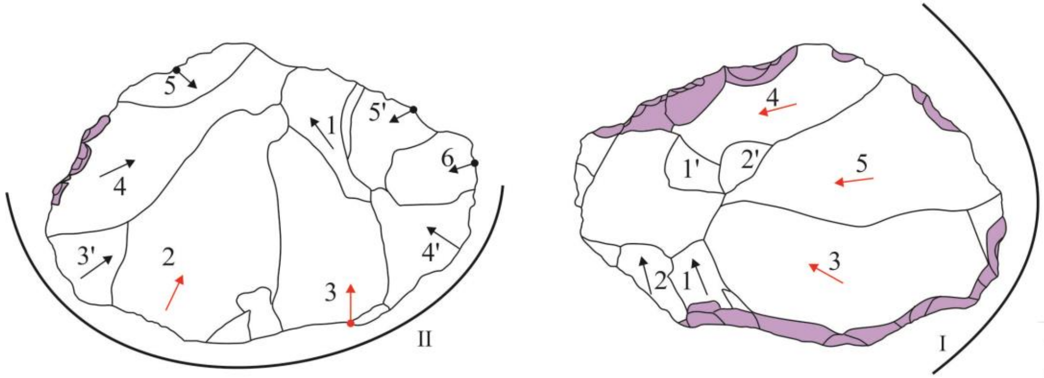
Figure 112: ID 8016, unipolar levallois plus additional debitage F1+C1.



Selection	Pebble.
Striking platform	I Partial. II Semi-peripheral, prepared with small removals.
Production	Two indipendent series of ‘levallois’ production on each side of the pebble. 1, 2, 3 4 = cortex removal, management of convexities. 5, 6 = attempts at target production. 7, 8, 9, 10 = hinged accidents. B: Convergent levallois, the core was turned on the other side and after the preparation of the striking platformn, an indipendent series of reduction was undertaken. 1, 2, 3, 4 = management of convexities 5, 6, 7 = convergent target products.
Target object	Flakes and convergent items.

Figure 113: ID 7645, core with double levallois exploitation (additional use of levallois).





Selection	Pebble.
Striking platform	I Semi-peripheral. II Semi-peripheral, prepared with small removals.
Production	Two indipendent series of ‘levallois’production on each side of the pebble, A: Convergent levallois. 1, 2 ,1', 2' = cortex removals, management of convexities. 3, 4, 5 = target production. B: Convergent levallois, the core was turned on the other side and an indipendent series of reduction was undertaken. 1 = management of convexities. 2, 3 = convergent target products. 3', 4, 5; 4, 5' 6 = preparation of the lateral convexities. C: Preparation or transformation? the removals hilighted in lilac are the last activity performed on the core, they could be interpreted as preparation of the striking platform or as retouch. The core was abandoned at a medium stage of exploitation.
Target object	Backed blades and convergent pieces.

Figure 114: ID 8343, core with double levallois exploitation (additional use of levallois) and possible retouch.

2.4 Target product

The target objects of levallois debitage in the SU 11 number 2,134 items. The majority of the production can be defined as elongated objects, such as long flakes, blades, convergent long flakes and backed long flakes (Figure 115). These items have trapezoidal (backed pieces, flakes, blades and long flakes) and convergent shapes (convergent pieces). The backed items are usually not symmetric, whereas the other items mostly are. These target items do not present a great quantity of cortex coverage (in most cases the cortex is absent) and in the case of backed pieces the cortex is present only on the backed side of the items. The direction of the removals is convergent for the convergent items and mainly unipolar for the backed items and other blades, flakes and long flakes. On the dorsal side of the backed items there are usually two and three removals, three removals for the convergent items and between two and four for the other blades, flakes and long flakes. The backed items are produced mainly in the first phases of the reduction sequence; whereas the convergent and unspecified items were produced at every stage of the production (as the first, the second or the third target object in a recurrent sequence of target production).

The butts are always prepared with one or several strokes for the backed items, the convergent pieces showing a predominance of facetted and dihedral butts, whereas flakes, blades and long flakes have flat prepared and facetted butts. The impact points are lateral for the backed items and mostly central in other cases. Almost the totality of the pieces have prominent bulbs. These technical features are listed in the following table (Table 39)

Figure 115: Target objects from SU 11 (blade, backed blade, convergent long flake).

Target objects	Backed items			Convergent items			Unspecified items			Total
	backed blades	backed flakes	backed long flakes	convergent blades	convergent flakes	convergent long flakes	blades	flakes	long flakes	
Total number	**86**	**59**	**241**	**38**	**54**	**262**	**243**	**377**	**774**	**2134**
Morphology	Trapeze	Trapeze	Trapeze	Triangle	Trapeze, triangle	Triangle	Trapeze	Trapeze	Trapeze	\
Symmetric %	41.9	45.9	35.9	76.9	66.7	66.0	69.1	64.5	65.9	62.1
Section shape	Triangle	Trapeze	Trapeze, Triangle	Trapeze, Triangle	Trapeze	Trapeze	Trapeze, Triangle	Trapeze, Triangle	Trapeze, Triangle	\
Cortex coverage ≤ 50%	91.9	100.0	98.4	97.4	100.0	100.0	97.2	100.0	97.7	98.2
Cortex location	Back	Back	Back	Absent	Absent	Absent	Absent	Absent	Absent	\
Scar directions	Unipolar	Unipolar	Unipolar	Convergent	Convergent	Convergent	Unipolar	Unipolar	Unipolar	\
Scar numbers	Two, Three	Two, one	Two, Three	Three, four	Three	Three	Two, three, four	three, two, four	three, two, four	\
Generation of debitage	T0	T0,T1	T0	T3	T3,T1	T1,T3	T3	T3	T3	\
Butt	Flat, prepared	prepared, flat	Flat, prepared	Faceted, dihedral	Faceted, dihedral	facetted, flat	Flat, prepared	Flat, facetted, prepared	Flat, facetted, prepared	\
Impact point	Lateral	Lateral, central	Lateral, central	Central	Central	Central	Central	Central	Central	\
Bulb	Prominent, not prominent	Prominent	Prominent	Prominent	Prominent	Prominent	not prominent	Prominent	Prominent	\
Macro traces %	62.8	24.6	47.3	89.7	37.0	60.3	61.3	38.9	48.3	48.1

Table 39: Technical features of target objects

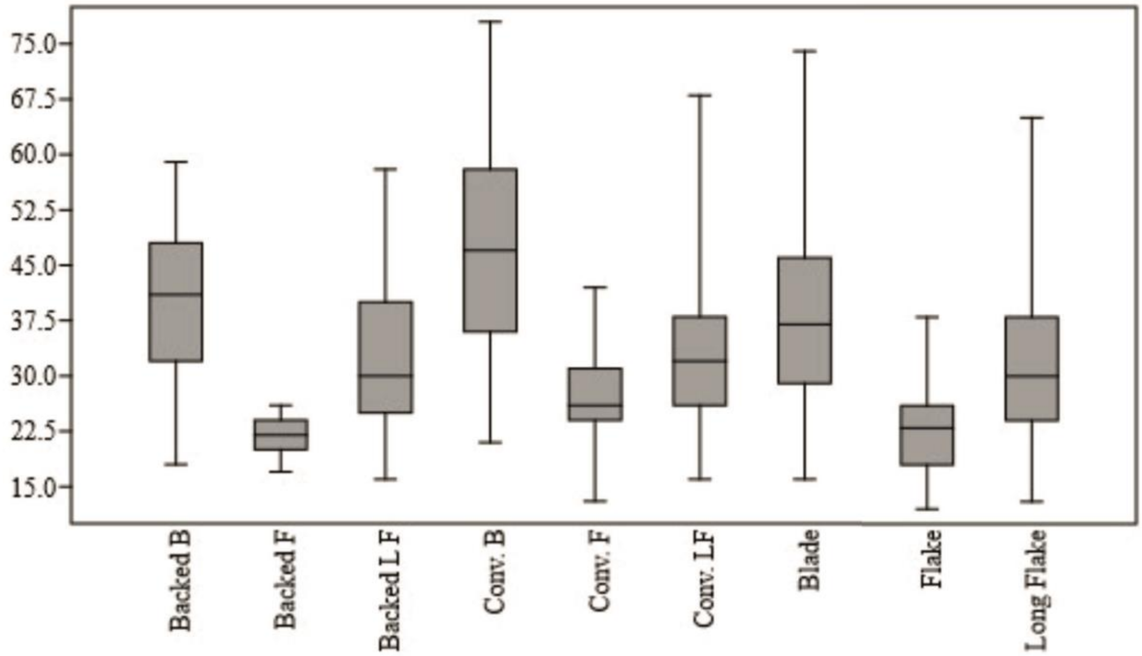


Figure 116: Box plot of dimensional variations of target objects in SU 11.

(In the graph only entire items are listed, hinged accidents and fragmented items are excluded. The dimension evaluated is the length expressed in mm).

Due to the great number of items at this level, the variation in length of the target objects is considerable (Figure 116). All technological classes show quite a big range of variation, which is caused by the recurrent character of the levallois debitage, producing identical items of different dimensions. The majority of the pieces falls between 2 and 4 cm (e.g. flakes Figure 117), these measurements being particularly consistent for the long flakes whose central boxes almost completely overlap. The classes of blades, convergent blades and backed blades are the longest classes, werease the backed flakes mostly present smaller dimensions.

Figure 117: Target object SU 11: flakes.

3 Additional debitage aimed at producing flakes C1 D1

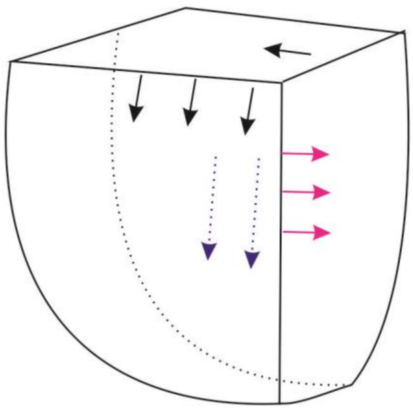
In SU 11 there are 42 cores and 155 flakes produced by additional debitage of type C1 and D1 (Table 34).

3.1 Core structure

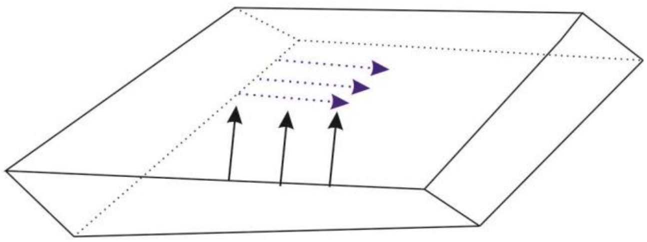
These additional cores have the common characteristics of producing flakes, with a management only of the striking platform in the case of the type C, and both striking platform and debitage surface in the case of type D. In this level of Oscurusciuto we noted two main volumetric structures, one exploiting a globular volume (similar to the one found in other levels) and the other a lenticular volume such as the one from levallois debitage.

The first is a debitage that involves one or more planes of a globular raw pebble, it could be developed in one series of production involving only on one or two faces of the block, or there could be cores with more than two independent series of production involving several faces of the block.

The second possibility is a debitage performed on one side of a flat volume. In some cases it would be similar to a raw block and the modalities of levallois debitage. However, the main difference lay in the their productive potential, i.e. levallois is an integrated concept able to produce several series of products, whereas the latter is an additional debitage, and after one production series most of the time the core is abandoned or another portion of it it utilized. Another difference is given by the angles between the surface of debitage and the striking platform which in this additional debitage is almost orthogonal compared to the levallois, where the angles are inferior to 90°. (Figure 118).



One or more indipendent series of production using several sides of the block.



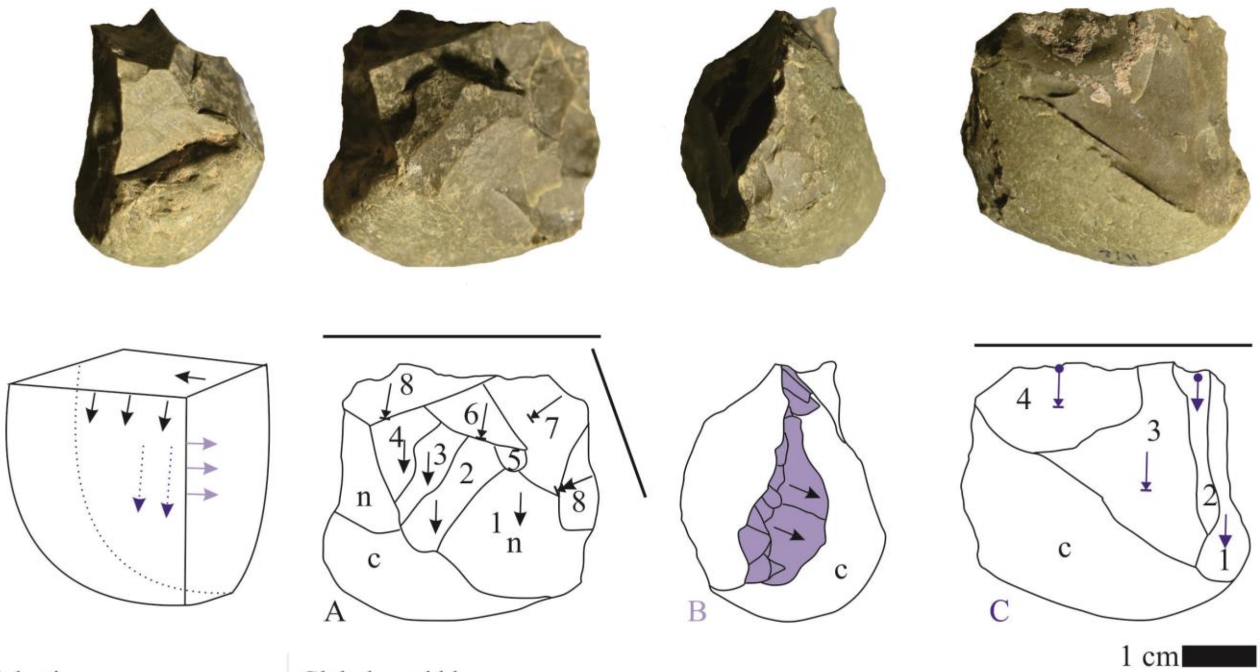
One or more indipendent series of removals setteled on a flat raw block.

Figure 118: Schematic representation of the additional cores C1 and D1 (flakes production).

3.2 Selection, inizialization and production

For this kind of production were selected pebbles with globular shape, or with flat morphology and pieces of pebbles with inner fracture plane. The volume that were choose for this kind of production are globular and thicker than the ones chosen for levallois debitage. When preparing the striking platform it is opened with one or two strikes orthogonal to the debitage surface (Figure 119).

In level 11 we observed a great variety of additional productions modalities. It seems that every angle suitable for knapping was used to remove flakes. We found coreswith several productive lives, which were abandoned only after a repeated removal attempts on it (behaviour documented in the quantity of hinged accidents both on core and on the dorsal surface of flakes) (Figure 121, 125). Moreover, on some cores an action like a preparation of a striking platform has been documented as the last activity performed on the core, which makes us hypothesise the possibility of a conversion of roles, that is to say, from a core the piece became a retouched tool (Figure 119). In order to resolve this issue use-wear analysis are ongoing.



Selection	Globular pebble.
Striking platform	Unipolar, orthogonal to the surface of debitage.
Production	A- There is a first series of debitage aimed at producing flakes on one side of the pebble. 1. It intercepted a inner fracture plane, whereupon the reduction continued with the removals 2, 3, 4, 5 and the hinged accidents 6, 7, 8. B- Having used as striking platform the removals 7 and 8 there was a series of small removals which could be interpreted as retouch actions. C- Indipendent series of reduction on the other side of the pebble aimed at producing flakes 1, 2, 3, 4. The last two removal are hinged accidents.
Target object	Flake.

Figure 119: ID 4375, additional core C1, plus possible retouched action.

4 Additional debitage aimed at producing blades and bladelets C2 D2

The group C2 and D2 whose aim was to produce blades and bladelets comprehends 14 cores and 96 flaked pieces (Table 34).

4.1 Core structure

The cores of this type are mainly developed employing two kinds of debitage, one is performed on oval blocks usually starting on the thinner side and subsequently passing to the frontal larger side. In this case one or more sequences of debitage are performed. A second possibility is the extraction of a continuous series of items from the frontal side of the core (Figure 120).

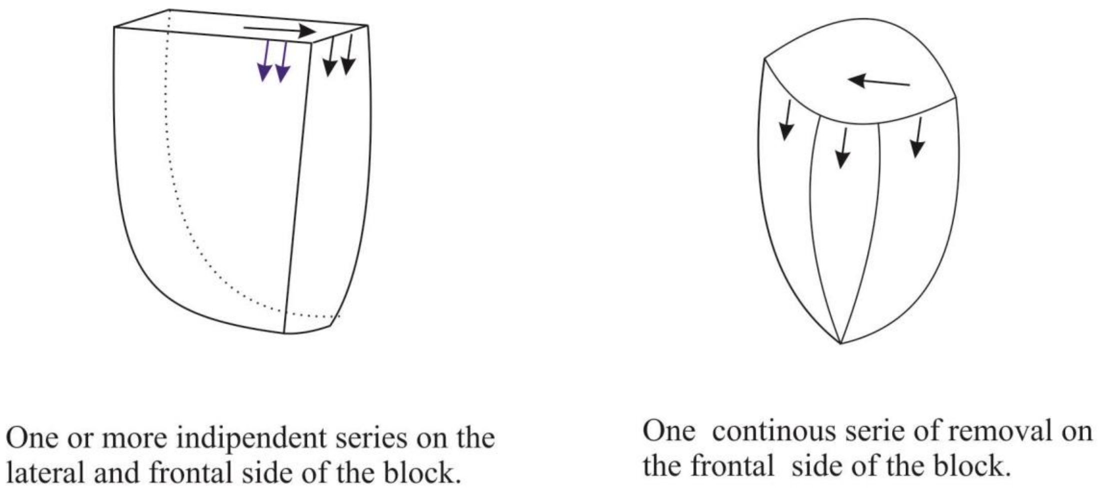
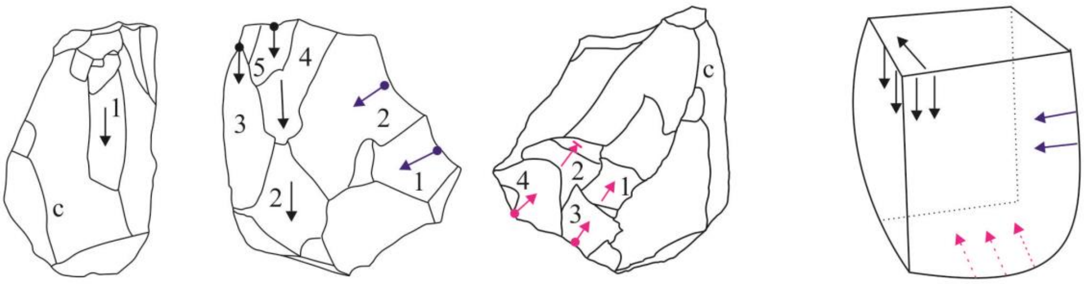


Figure 120: Schematic representation of the additional cores C2 and D2.

4.2 Selection, initialization and production

The blocks selected for this kind of production are oblong and globular pebbles, the striking platform is opened by one or two strikes, in some cases only one side of the volume of the core is exploited, whereas in other cases the exploitation start on the thinner side of the core, subsequently continuing on the thicker part (Figure 121, 122). What is interesting, as stated in the previous paragraph, is that in many cases one core is exploited employing one or more types of production (Figure 121, 125).

The target objectives of this debitage are mainly bladelets, which actually determine the choice of initialization in these reduction sequences, starting on the thinner side of the raw block.



Selection	Piece of pebble.
Striking platform	Orthogonal to the surface of debitage.
Production	On the piece of pebble (which might previously have been used as a core), there are three independent reduction sequences: A, B and C. The first aim was to produce blade\bladelets, whereas the objective of B and C was flakes. A: after the opening of the striking platform, n.1 n.2 are removals aimed at removing the cortex and managing the distal convexities to obtain a blade: 3. Then 4 and 5 are two attempts to continue the reduction sequence, ending in hinged accidents. B: Detachment of the flakes 1 and 2 from another striking platform. C: Finally form the side that was used as debitage surface in the first two reduction sequences there is a sequence of four removals ending in hinged accidents.
Target object	Blade \ Bladelets and flakes.

Figure 121: ID 4, additional core C2+C1.

Selection	Pebble.
Striking platform	Unipolar, orthogonal to the surface of debitage.
Production	1, 2, 3, 4 = removals aimed at removing the cortex and manging the convexities in order to produce bladelets. 5, 6 , 7, 8, 9 = series of hinged accidents.
Target object	Bladelets

Figure 122: ID 4400, additional core D2.

5 Additional debitage aimed at producing point D3

This concept was individuated on the basis of 7 cores, the levallois debitage overlapping completely the flakes produced by this kind of debitage.

5.1 Core structure

In this type of core the block already has the lateral convexities necessary to produce one convergent piece, or two lateral strokes where used to manage the lateral convexities in order to obtain a convergent item (Figure 123).

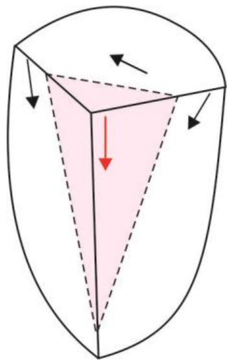
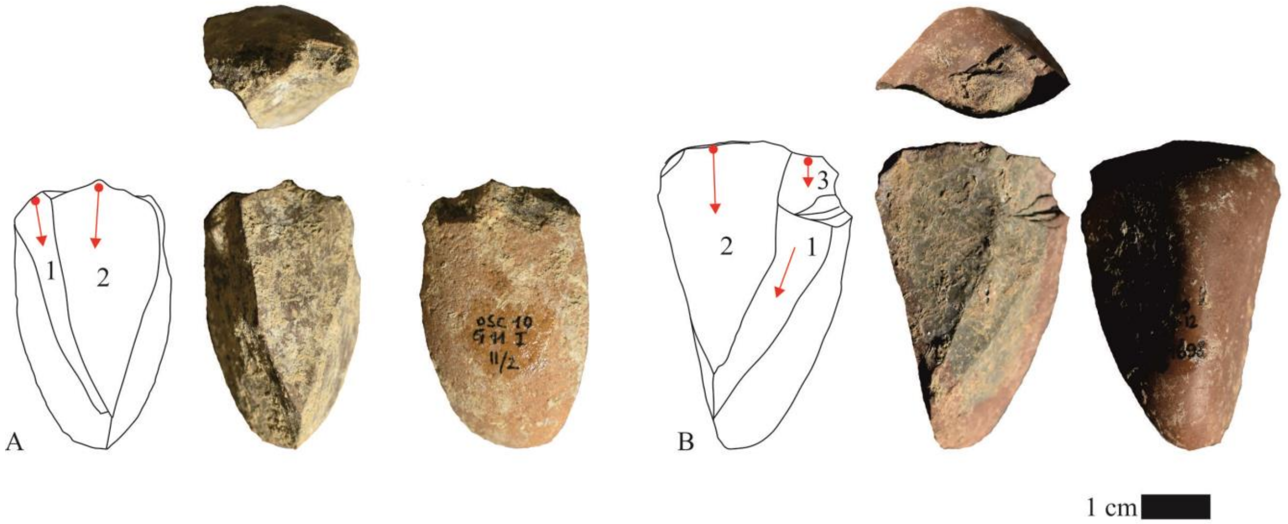


Figure 123: Schematic representation of the additional core D3.

5.2 Selection, initialization and production

In this level at Oscurusciuto there is a clear selection of triangular raw blocks in order to obtain triangular supports. In some cases (such as figure 124 A and B) the raw piece of pebble already posses the lateral convexities necessary to produce the two convergent blades. In other cases (such as figure 125) two convergent removals create the convexities necessary to detach the target object. After this debitage there is a second series of removals on the surface of the former striking platform, again the objective being on a thinner module. After this reduction the core is turned over again and a further sequence of removals occurs on the side of the core until the almost complete depletion of the core itself (Figure 125). What is clear in this type of core is the modular character of the additional core, namely in the case of figure 125, where one type of reduction sequence is performed, then another part of the core is involved in the debitage, and then again a third part.



Selection	In both cases there is a selection of a triangular piece of pebble with convexities already suited to detaching a flake.
Striking platform	Orthogonal to the surface of debitage, opened with four (A) or two (B) strikes.
Production	After preparation of the striking platform, two long convergent target flakes are detached (1, 2 of cores A and B). In core B there is an attempt of extracting another flake 3 which ended in a hinged accident.
Target object	Convergent long flakes.

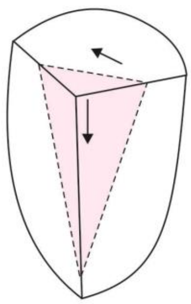
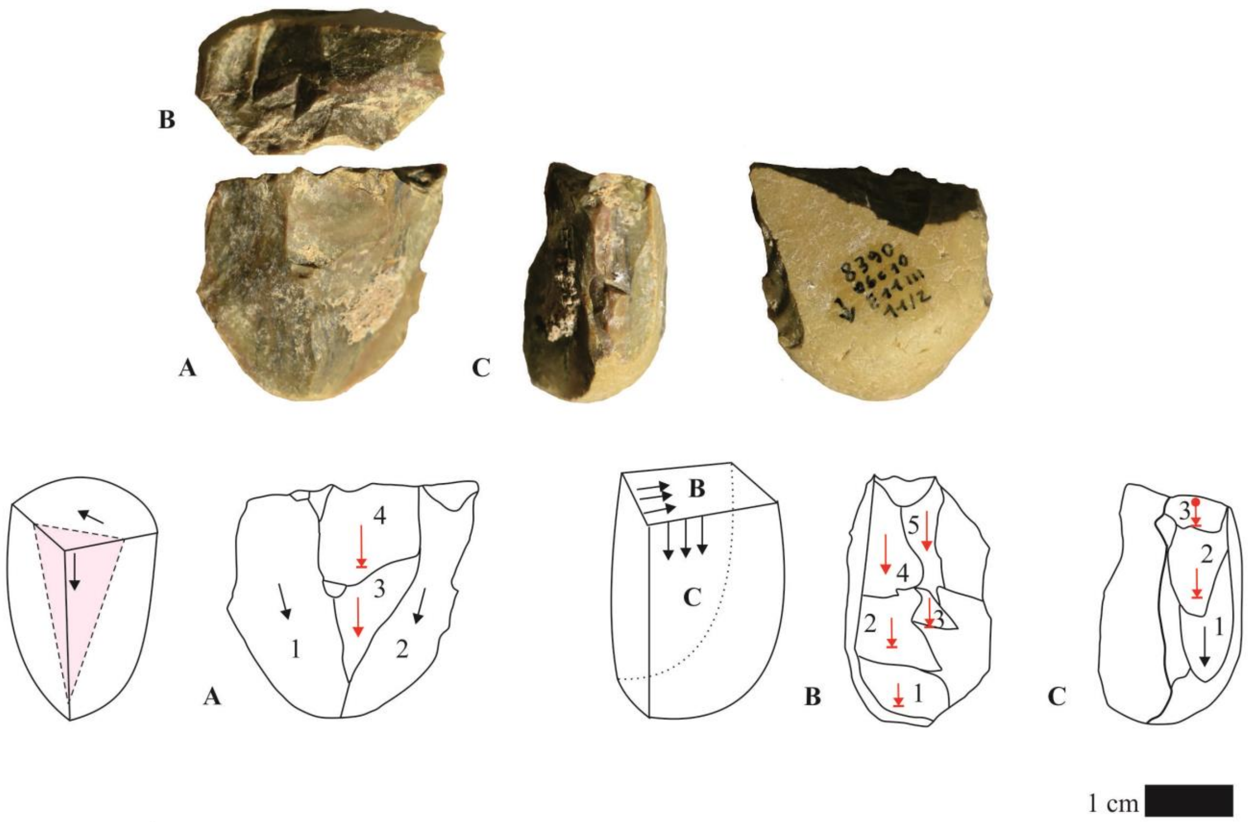


Figure 124: ID 7698, 4389 additional core type D3.



Selection	Pebble.
Striking platform	A, B, C = Striking platfrom orthogonal to the debitage surface.
Production	On the pebble there are three independent reduction sequences: A, B and C. The first aimed to produce convergent items, whereas the objective of B and C was bladelets. A: after the opening of the striking platform, n.1 n.2 are removals aimed at removing the cortex and managing the convexities to obtain a convergent long flake: 3. 4 is an attempt to obtain another convergent long flake ending in a hinged accident. After this accident the core was not abandoned, on the contrary, the striking platform of the reduction series A becomes the surface of debitage in reduction sequence B. B: Extraction of at least 5 long flakes, of which 3 are hinged accidents. Again, this surface of debitage is used as a striking platform in the subsequent reduction sequence C performed on the side of the core. C: n. 1 removing the cortex, 2, 3 attempts to obtain bladelets, ending in hinged accidents.
Target object	A: Convergent long flakes. B, C: bladelets.

Figure 125: ID 8390, additional core D3 + C2.

6 Additional debitage E1 discoid

The group E1 is an integrated concept coinciding with discoid debitage. In this level of Oscurusciuto only one core and 11 flakes pertaining to this concept were found so it is actually a very rare and insignificant production.

6.1 Core structure

The structure of the discoid core is define by six main paramethers, which are synthesized as follow (Boëda, 1993) (Figure 126).

1. The volume of the core is defined by two asymmetrical intersecting convex surfaces delimited by an intersection plane.
2. The two surfaces are not hierarchized, which means that they could be both striking platform and debitage surface, alternating their role during the same reduction sequence.
3. The debitage surface is managed in order to obtain predetermined objects which again predetermine the following removals, managing the peripheral convexities.
4. The striking platform of the predetermined removals must always be oriented according to the debitage surface. Consequently the limit created by the intersection of these two surfaces is perpendicular to the debitage axis of the predetermined removals.
5. The fracture planes of the predetermined and predetermining removals are secant.
6. Direct percussion with hard hammerstone. The percussion axis of the predetermined removals must be perpendicular to the surface receiving the impact.

The 11 flakes found in this level are very characteristic products of discoid debitage namely, pseudo-levallois points and debordant flakes.

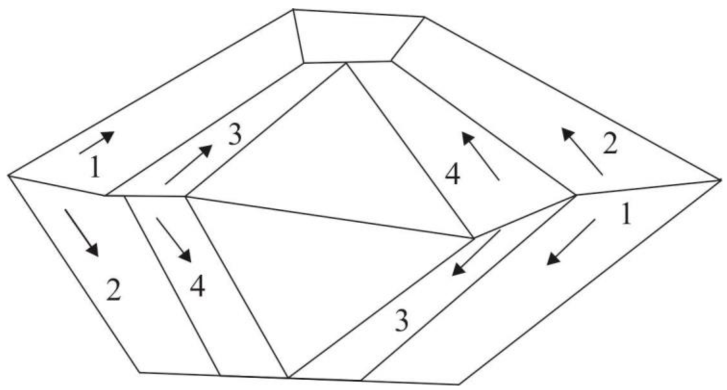


Figure 126: Schematic representation of the additional core E1 discoid reduction scheme.

6.2 Selection, initialization and production

The only core reduced with discoid debitage is very exploited and for this reason it is no longer possible to ascertain the initial shape of the raw block. The removals alternated on the two surfaces but in this very advanced stage of exploitation several hinged accidents prevented the continuation of the reduction (Figure 127).

Selection	The core is in a very advanced state of debitage, it is not possible to ascertain the nature of the raw block.
Striking platform	Secant, each removal is the striking platform for the subsequent detachment.
Production	This is the last stage of a discoidal debitage.
Target object	Flakes.

Figure 127: ID 8550, discoid core E1.

7 Retouched tools

In SU 11 there are 386 retouched pieces mainly unilateral scarpers, followed by points and bilateral scrapers (Table 40, Figure 128). Each of these categories is subdivided into specific categories according to the further specification of the retouch (Table 41). We also note that there is a great quantity of fragmented retouched pieces and undetermined pieces, namely pieces that were retouched but the transformation action was not aimed at producing a formal tool (Table 40, 41). Moreover, on same items actions aimed at modifying the edges or the prehensile part of the tools are documented. A techno-functional protocol will be developed for these pieces in order to better define the nature of these cases of retouch.

The majority of the retouched tools is made on levallois supports (254 items), followed by 107 other examples of undetermined production concept, and 25 pieces produced by additional debitage (of which 16 were blades and 9 flakes).

Typology	Specific category	N.	%
Unilateral scraper 124	Unilateral scraper	121	31.3
	Unilateral + transversal scraper	2	0.5
	Unilateral scraper + notch	1	0.3
Bilateral scraper 54	Bilateral scraper	49	12.7
	Bilateral + transversal scraper	3	0.8
	Bilateral + end scraper	2	0.5
Point 75	Point	50	13.0
	Bilateral scraper + point	15	3.9
	Unilateral + point	10	2.6
Transversal scraper	Transversal scraper	15	3.9
End scraper	End scraper	10	2.6
Notch	Notch	11	2.8
Other	Undetermined	57	14.8
	Retouched fragment	40	10.4
Total		386	100.0

Table 40: Typology of retouched pieces.

Almost 60% of the examples of retouch is made on target objects (Table 41, first 9 lines), the highest percentage being long flakes, blades and convergent long flakes. Incidentally, there is also a considerable number of retouch adjustments performed on undetermined and management flakes (respectively 18.4% and 12.4%). The majority of scrapers (unilateral and bilateral) are made out of long flakes and blades, the points were made mostly out of pieces that were already convergent (convergent long flakes and blades) plus a significant quantity made out of general blades, which means that in these cases the retouch was more invasive in order to define the convergent edge of the support (Figure 128). It is remarkable that the other retouched tools (transversal, end scrapers and notches) were mainly made out of management flakes, as well as out of other unspecified supports.

Typology\ Technological category	Unilateral scrapers		Bilateral scrapers		Points		Transversal scrapers		End scrapers		Notchs		Others		Total	
	n.	%	n.	%	n.	%	n.	%	n.	%	n.	%	n.	%	n.	%
Backed blade	5	4.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	5	1.3
Backed long flake	13	10.5	2	3.7	1	1.3	0	0.0	0	0.0	1	9.1	1	1.0	18	4.7
Backed flake	2	1.6	0	0.0	0	0.0	1	6.7	0	0.0	0	0.0	1	1.0	4	1.0
Convergent blade	1	0.8	2	3.7	10	13.3	0	0.0	0	0.0	0	0.0	0	0.0	13	3.4
Convergent long flake	2	1.6	3	5.6	25	33.3	0	0.0	0	0.0	1	9.1	7	7.2	38	9.8
Convergent flake	2	1.6	1	1.9	4	5.3	0	0.0	0	0.0	0	0.0	1	1.0	8	2.1
Blade	16	12.9	9	16.7	11	14.7	0	0.0	1	10.0	0	0.0	6	6.2	43	11.1
Long flake	27	21.8	20	37.0	6	8.0	2	13.3	3	30.0	1	9.1	9	9.3	68	17.6
Flake	15	12.1	8	14.8	3	4.0	2	13.3	0	0.0	2	18.2	4	4.1	34	8.8
Completely cortical flake	2	1.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	0.5
Semi-cortical flake	13	10.5	3	5.6	3	4.0	0	0.0	0	0.0	2	18.2	7	7.2	28	7.3
Management flake	13	10.5	0	0.0	3	4.0	7	46.7	2	20.0	3	27.3	20	20.6	48	12.4
Undetermined	13	10.5	6	11.1	9	12.0	3	20.0	4	40.0	1	9.1	35	36.1	71	18.4
Core	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	4	4.1	4	1.0
Pebble	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	2.1	2	0.5
Total	124	100.0	54	100.0	75	100.0	15	100.0	10	100.0	11	100.0	97	100.0	386	100.0

Table 41: Retouched recurrences.

Figure 128: Retouched pieces (a: points; b: unilateral scrapers; c: bilateral scrapers).

8 Overview of SU 11: economy of raw material and reduction sequences

To sum up, in SU 11 the reduction sequences follow various patterns, both levallois and a great variety of additional methods. Right from the beginning of the debitage we note a goal-oriented selection of the volumetry of the raw material specifically suited to each kind of reduction sequence. Oblong and lenticular pebbles for levallois, angular pebbles, or fragments with inner fracture planes for the additional debitage C1, D1, as well as flat and lenticular pebbles. Angular pebbles for the additional debitage C2 D2 and finally triangular fragments or pebbles for the additional debitage D3. To these divergences in terms of shape correspond a diversities in terms of raw material in fact the additional D2 occurs mainly on chert and jasper, whereas the other concepts occur mainly on cherty limestone and jasper.

The levallois debitage implies long series of reductions, and the cores were mostly abandoned in the medium or last phases of debitage. In these cases also the additional cores where abandoned in their medium or final stages of debitage because there are several short production series (3 or 4) on each core. Notable in this level is the high number of sequences on the same core, in particular we note the occurrence of levallois cores that become additional at the end of their productive life.

The levallois production is the dominant concept; nevertheless a certain variety in the modality and in the objectives of this debitage is notable. Levallois is present mainly in its unipolar and convergent modalities, moreover, the presence of centripetal and preferential modalities is also documented at the end of the reduction sequence. This is aimed at producing blades, long flakes, convergent flakes (long and short), and backed flakes (long and short).

The additional debitage C1 D1 aims at producing quadrangular flakes, and as they are usually much thicker than the ones produced by levallois concept, they are also less standardized. The additional debitage C2 D2 is solely aimed at producing blades and bladelets. The additional debitage D3 produces convergent flakes which are actually typo-levallois points (Boëda, 2013), so it was not possible to individualize these supports.

As for the retouched pieces, most of the transformation activity involved the items that were already target objects of the debitage. The most common retouched tool is a scraper, lateral or bilateral and points. The majority of the retouch adjustments occured of levallois items (Figure 129).

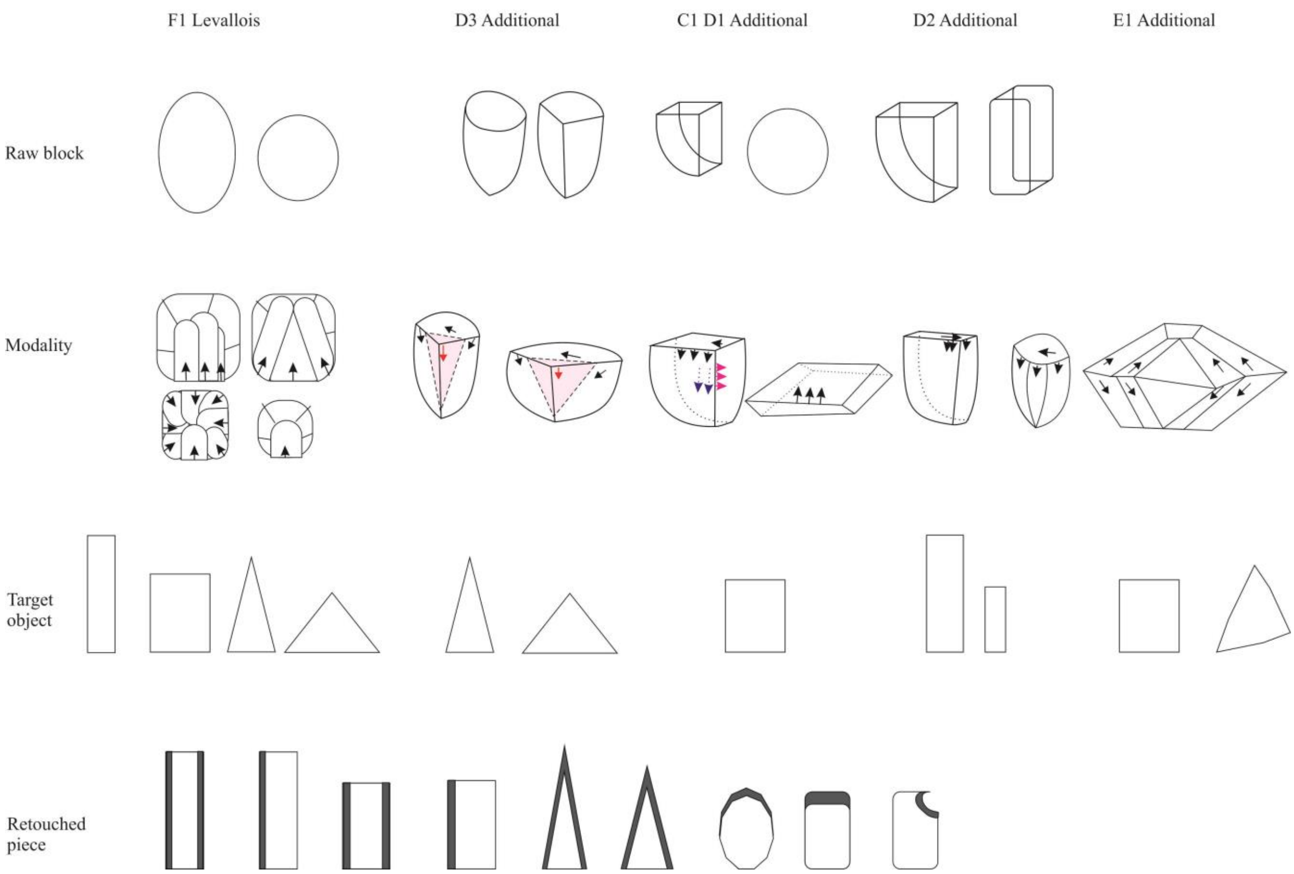


Figure 129: Reduction sequences at SU 11.

Part three

Discussions

X CONTINUITIES AND DISCONTINOUITIES AT THE OSCURUSCIUTO

1 Premise: levallois, non-levallois and additional debitage

Before starting the discussion and the comparison of the four levels in question, we need to specify the role and the definition of what levallois at Oscurusciuto is.

As is widely accepted by the prehistories scientific community a production is defined as “levallois” if it respects the 6 criteria introduced by Boëda in several works (e.g. Boëda, 1994; 2013). These criteria were defined and described based on French sites and production. Subsequently, they were encountered in several sites at different locations, demonstrating the same basic common characteristics, in addition to other local peculiarities.

In this particular case the levallois reduction at Oscurusciuto occurs on pebbles as initial raw blocks, which means that most on the times there is a lack of a real first phase of initialization of the cores, i.e. an absence of management of the lateral and distal convexities of the cores. Thus the initialization of the cores coincides with the selection of those pebbles, in which the convexities suitable for a levallois production are already naturally present. We attribute great importance to this selection\initialization because we reckon that this selection/sorting of the raw block at an initial stage is evidence of an intention based on exactly that concept, i.e. levallois.

The levallois cores at Oscurusciuto fall into two clearly defined groups, according to the initial shapes of the pebbles: oblong and lenticular pebbles for unipolar levallois, and globular pebbles for convergent levallois. Moreover, there is a consistent preparation of striking platforms, and during the reduction the lateral convexities are managed by the extraction of backed pieces. On this stage follows a production of target objects, and this kind of production is recurrent until the abandonment of the core at the point when the reserve of raw material is exhausted. This, consequently, points to an initial integrated concept behind the reduction as a whole.

To sum up, the levallois production at Oscurusciuto has a different kind of initialization from the levallois production, which is not based on pebbles, but the integral idea of the six Boëda criteria is respected. For this reason in this dissertation, we consider the Oscurusciuto complex to be levallois.

In addition, apart from the levallois production concept, there are several other types of additional debitage aimed at producing flakes, blades and points, exploiting one or more sides of the raw block, with one or more short production series. What is clear in these types of cores is the modular character of the additional debitage, i.e. first there is a reduction sequence, then another part of the core undergoes a debitage, and sometimes even for a third time yet another part of the block is independently involved in another sequence of debitage.

The great potential of this kind of description is that we can isolate the single sequences of debitage. We realized that in the additional cores there might be several additional cores in the same block, i.e. an active and a passive volume are present within the same core. This is the main conceptual basis for distinguishing between additional and levallois concept. A further difference between levallois and additional debitage is the productive potential, namely the potential number of target objects. The levallois debitage has the potential of producing several series of predetermined target products without any preparation of its convexities because of the inherent idea of integrity and homothety. Additional debitage, on the contrary, produces only one or few series of products.

In order to be able to recognize additional cores, we noted the specific selection of a certain shape of pebbles as an important discerning feature. Thus, the blocks selected to be reduced by additional debitage are more angular pebbles and\or other blocks which already have an orthogonal plane. Moreover, there is a clear difference in angles between the striking platform and the debitage surface. In levallois reduction this angle is less than 90°, usually between 50° and 70°, whereas in the additional cores the angle usually coincides with 90°.

However, even though the definition of levallois reduction at Oscurusciuto is clear, as are the conceptual differences between additional and levallois debitage, actually distinguishing between the two when faced with practical examples is a hard task, and it becomes even more challenging when between them occur passages.

We noted the presence of different reduction sequences on one core (thanks to the diacritical analysis of cores and RMU studies), a reduction could thus start as levallois and at the end change to additional, i.e. an additional reduction activity took place on part of the levallois core. This could be interpreted as a final activity occurring as the last action on a core, but as we saw examples of tiny, extremely reduced cores that still respected all the parameters for levallois debitage and a consistent number of cores where the aformentioned passage is documented, we assumed this to be intentional behaviour. The more so because there are levallois cores which at a medium stage of exploitation become additional.

Another odd case is the presence of cores with two complete levallois reduction sequences occurring on the same core, namely one performed on one side of the pebble, and one on the other. These reductions respect all the parameters of the levallois concept, down to the idea of hierarchization of the debitage, because there is no deviation or alternation of plan (such as in discoid production), the two productions happened one after the other. However, defining these cores as levallois might not be very appropriate, because the idea of the integrity of the core is lost. But if we consider the productions on both sides separately, in both cases all the structural criteria to define these cores as levallois as well as the steps of production are respected. In this case we envisaged the idea of considering these cores as additional use of levallois debitage, i.e. considering just one side of the core to be levallois, but as both sides of the core underwent levallois reduction it is actually an addition of two independent levallois reduction sequences on the same block.

Considering the totality of the target objects at Oscurusciuto, there is a huge number of levallois items stemming from levallois reduction sequences, as compared to a well-defined group of items stemming from additional debitage. In addition we saw another group resulting from additional debitage but possessing exactly the same technical features as the items produced by levallois debitage. That is the case with the typo-levallois points produced by the additional debitage D3. Those whose objectives are points typologically present exactly the same traits as levallois, but productionally they are not. In point of fact, in many cases the same support could be produced both by levallois and additional debitage, but the conceptualization or in other words the premeditation involved in its production is different.

It could be interesting to determine what influenced what. Did the craftsman adapt their know-how to the initial block in order to obtain a predefined target object? Or was there an initial selection of the raw block which predetermined the type of reduction to be undertaken? It might not be possible to obtain a proper answer to this but the main point remains the same: the final goal justifies the choice of either concept.

To conclude: in my opinion this approach (Boëda, 2013) is essential in order to reveal the cognitive implications related to the knapping activity, given that we are interested in understanding the behaviour of prehistoric peoples by means of their lithic tools rather that just describing the items found.

2 Lithic behaviour

In general, lithic behaviour of the lower portion of the Oscurusciuto rock shelter is characterized by more continuities than discontinuities, in other words there is a high degree of consistency, especially as for the selection of raw blocks, which are exclusively pebbles originating from local secondary sources. The selected pebbles were of cherty limestone, jasper and chert of fine granulometry for SU 15, SU 13 and SU 11, whereas the most utilized raw material in SU 14 was jasper, followed by cherty limestone. There is a great uniformity in the use of chert, quartz sandstone and limestone which were found in almost the same percentage in all the levels in question (Figure 130).

Another clear similarity is in the concept of debitage, in fact, in all the levels there is the same percentage of pieces obtained by unipolar levallois as well as by convergent levallois. Also the additional reduction aimed at realizing blades and bladelets is represented with the same low percentage in all the four levels. A divergent element is constituted by another type of additional debitage: additional debitage aiming at producing flakes, which is documented in all the levels with the exception of SU 13. Moreover, level 11 (the SU with the most abundant number of items) is the only one where other types of debitage are represented. Firstly, we note the presence of the debitage D3, the additional reduction aimed at obtaining typo-point levallois, a rare example of discoid debitage, plus other modalities of levallois at the final stages of the debitage (in the table listed as "other") (Figure 130).

The main pursued objective of debitage were long flakes in SU 15, SU 14 and SU 11, and flakes in SU 13 and SU 11. Blades, convergent blades and backed blades are always present with almost the same percentage in all the levels. In general, in SU 15, SU 14 and SU 11 there is a preference towards the production of elongated pieces (also in their convergent and backed forms), whereas in SU 13 there is a preference towards comparatively shorter items (flakes, convergent flakes) (Figure 130).

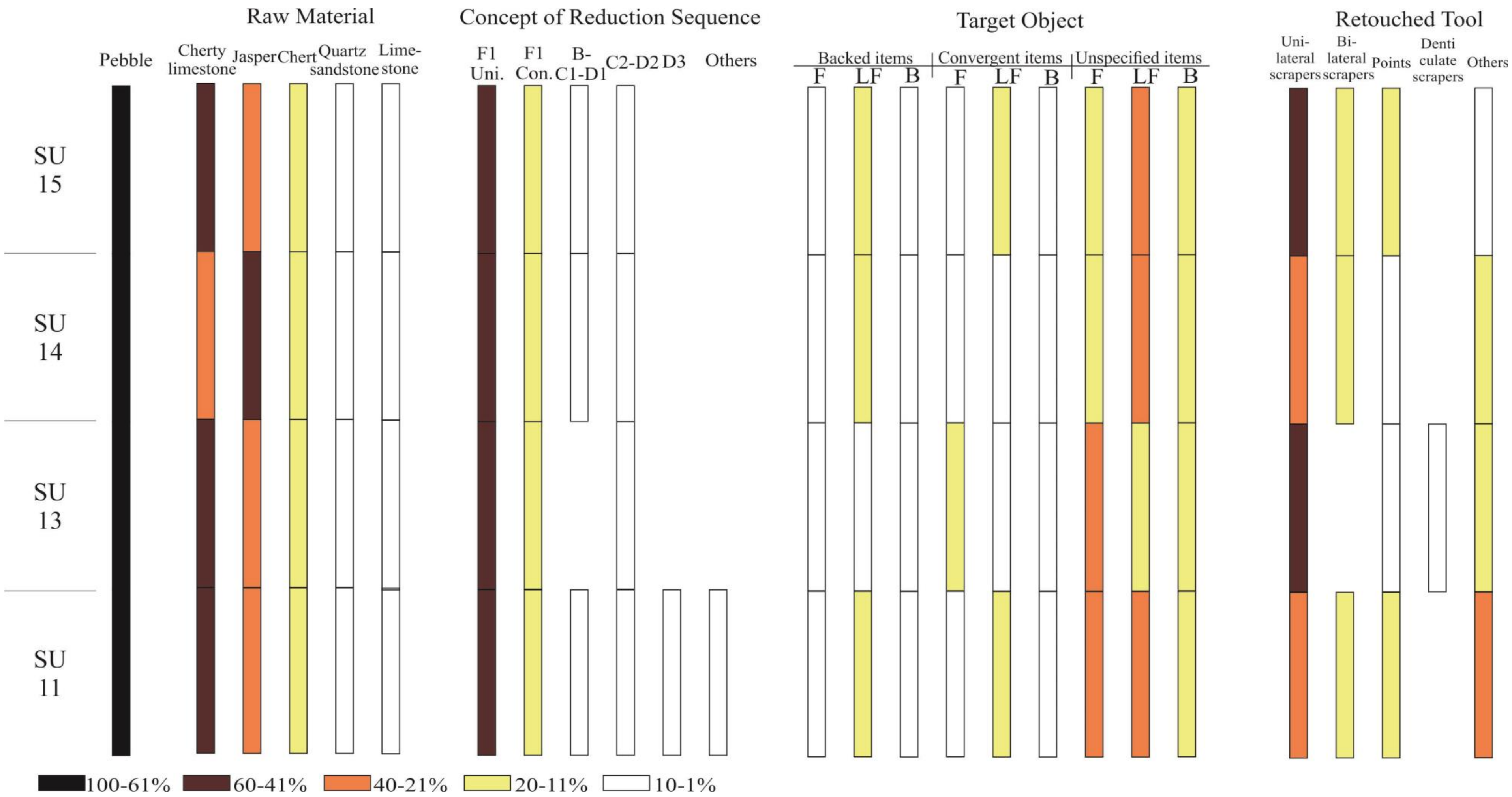


Figure 130: Syntesis of lithic behaviour at Oscurusciuto SU 11, SU 13, SU 14, SU 15.

In the first column we depict the raw block on which the debitage was performed; in the second group of columns we show the type of exploited raw material (cherty limestone, jasper, chert, quartz sandstone, limestone). In the third group we show the concept of the reduction sequence (F1 = levallois; B-C1-D1 = additional debitage aiming at producing flakes; C2-D2= additional debitage aiming at producing blades and bladelets; D3 additional debitage aiming at producing points; and finally "other" = comprehending e.g. discoid, kombewa). The fourth group shows the target objects (F = flake, LF = long flake, B = blade). Finally, in the fifth group we show the types of retouched tools.

As far as the dimensions of these target objects are concerned we note that in all categories the variations span from a few cm (2-3 cm) to quite big pieces (10-12 cm). However, the greater number is between 3 and 4.5 cm for the level SU 13; between 3 and 4 cm for SU 14 and between 2 and 4 cm for the SU 11. In SU 13 and SU 14 the flakes have the smallest dimensions of the target items. The target items of SU 15 measure between 3 and 4 cm. Incidentally, not all target pieces in this level show this consistency, in fact the dimensional variations of SU 15 show a particular pattern of distribution, as there are some pieces that fall completely outside the range of the other target items. Thus, the convergent flakes are significantly smaller than the other pieces, and the convergent blades are significantly bigger. This could be related to the production and the particular use envisaged for these objects. Another possible explanation could be the nature of the level, in fact SU 15 is an incomplete palimpsest consisting of only the top of the level 16, i.e. it corresponds to the first 2 cm of the level below, which again corresponds to the upper portion of an unexcavated palimpsest.

The retouched tools represent only a minority of the collections, however, they represent the most diverse aspect of the collections in question, in fact even though there is a strong representation of unilateral scrapers, mainly in SU 15 and SU 13, the other tools are bilateral scarpers in all the levels except SU 13, and points are found in greater numbers in SU 14 and SU 13. The denticulate scarpers were found in SU 13. The category “other”comprehends a series of various transformed tools, whose percentage are not statistically significant in comparison to the ones previously mentioned. However, we must point out that the “other” retouched tools in SU 15 also comprises transversal scrapers. In SU 14 both transversal and end scrapers are present. In SU 13 end scrapers and notches are present. And finally there is a notable diversity in SU 11, with end scrapers, transversal scrapers, notches and retouched fragments all present (Figure 130).

An interesting fact is that in all the levels the main objects selected to be retouched were levallois items. This might suggest that the effort involved in the production of these pieces continued even after their finalized production, possibly meaning that these tools were destined to a longer life. SU 14 is the only level where there is a very low number of retouched pieces and most of them are made of management flakes or even of cortical flakes, possibly indicating a brief use of the rock shelter during this occupation.

Finally, the techno-functional analysis, which was only performed on selected classes of pieces from SU 13, showed the great potential of this method, enabling us to better understand these tools from their structural as well as functional point of view. Moreover, the interpretation based on the techno-functional analysis was underscored by the use-wear analysis, i.e. the items that were considered belonging to a specific techo-type were then actually used for that specific purpose. In fact we note that some techno-types were used for specific activities. On the other hand, there are techno-types implemented in a range of different activities. In addition to some techno-types which solved a particular and unique need both from a structural and a functional point of view.

Going into such great detail regarding the extended life of the stone tools, we found that we gained such extensive and detailed knowledge that we intend to expand this pilot experiment to include a larger number of items from other levels, in other words we want to continue applying the combination of technological, techno-functional and use-wear analysis.

Regarding the fragmentation of the reduction sequence, the two levels studied with a high degree of detail obtained by the refitting and RMU studies disclose some differences in the two occupations. As already shown by the technological study (Figure 130), the raw blocks imported into the site to be flaked are pebbles. In both levels some reduction sequences occur in all their stages at the site. Consequently, it seems clear that in both levels the activity of knapping in situ is widely attested. This is also corroborated in SU 14 by the occurrence of hammerstones (Figure 131).

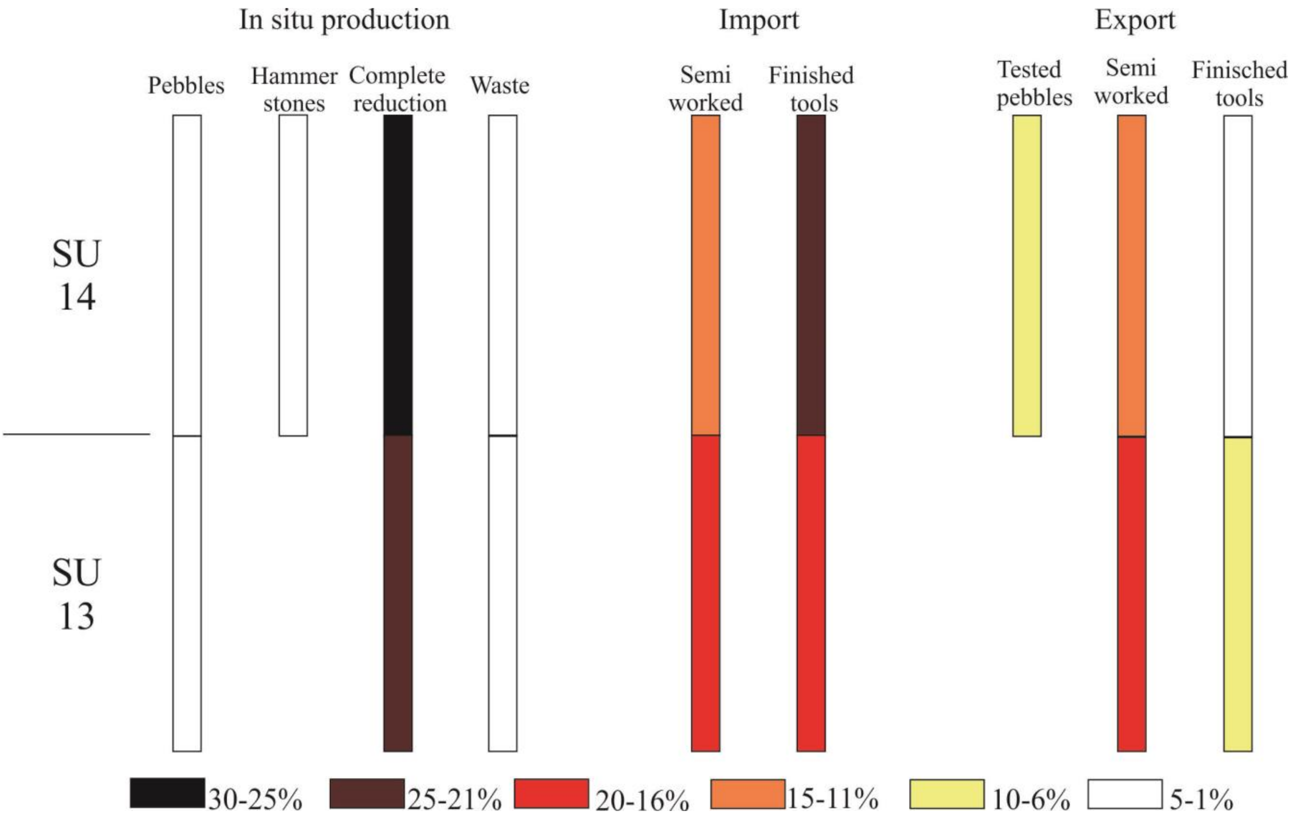


Figure 131: Continuities and discontinuities of SU 14 and SU 13.

The first group shows the percentages of RMU whose technological composition evidences knapping in situ. The second group evidences import activity. And the third shows evidence of export activity.

An essential difference between the two levels is the activity of import and export. In fact, focusing on import we noted that in both levels target objects were imported (and abandoned) after having been introduced into the site as finished objects. This evidence is represented with the highest percentage in the SU 14. On the contrary, the percentage of semi-worked pieces introduced here in lower than is SU 13 (Figure 131).

In addition, regarding exportation, the number of exported semi-worked items or finished tools is lower in SU 14. Incidentally, this level shows something which is not documented at all in SU 13, i.e. the testing of pebbles. The RMU analysis showed groups consisting of only one complete cortical flake. As a matter of fact, only the tested pebbles were exported from the site (Figure 131).

Given these data, a possible explanation of for this is the diverse behaviour documented in the two levels of occupation. SU 13 is a short palimpsest whose occupation consists in the use and reuse of the space. The behaviour ascertained in SU 14 seems to be related to a brief occupation of the rock shelter, where people came, bringing with them some material, tested the raw pebbles, performed some knapping in situ and then went away.

In both cases evidence of fragmentation of the reduction sequence indicates a certain flexibility of the populations who performed their activities here, not only whitin the space of the rock shelter, but possibly also along the entire ravine of Oscurusciuto and even further beyond. This evidence of fragmentation of the reduction sequence further suggests a certain mobility whithin the surrounding territory, and, necessarily, the existence of others areas where the other missing stages of the reduction sequence must have occurred.

3 Occupational behaviour

The results obtained through the study of the lithic complex were integrated with the study of the faunal remains, and the analysis of the space with geo-statistical software in order to obtain a more complete understanding of the type of occupation belonging to each level. These integrated studies indicated that the stratigraphic units in question show continuities and discrepancies not only in terms of lithic production systems, but also in terms of structural elements, spatial management, and consequently type of settlement (Table 42).

The four levels show quite a constant presence of fauna association, characterized by a predominance of *Bos primigenius,* present in all four levels, whereas *Cervus elaphus* and *Dama dama* are found only in SU 15 and SU 11, and is found togheter with *Equus ferus* only in SU 13 and SU 11. From an environmental point of view these taxa indicate the same environment, i.e. possibly forest steppe on the hilly reliefs, and more humid territory characterized by wood-land inside the ravine (Table 42).

Joining the data from the lithic behaviour, with those of the faunal remains and the spatial evidence, we note that the examined levels of Oscurusciuto show different occupational behaviour.

Apart from their peculiarities SU 15, SU 13 and SU 11 may be interpreted as relatively long settlements during which various domestic activities took place. On the contrary, the SU 14 shows a different picture. It seems to represent a brief and unstable occupation. This level represents an exception to what happened before the tephra event and after. In fact SU 15 demonstrates a settlement identity that is quite different from the ones of SU 13 and 11, in which from an occupational point of view there is a clear similarity in the subdivision of the inner space of the rock shelter, as regards the shape, dimensions and locations of the hearths.

To be more precise, the SU 15 is a living floor in which a phase of abandonment is recorded; it is the upper part of a palimpsest, which has still not been excavated. However, in this level a great quantity of lithic material and faunal remains (not totally fragmented as in the other levels) has been documented, which indicates a long permanence in the place. This is also corroborated by the presence of two structures formed out of stone alignments.

SU 13 and SU 11 are two palimpsests showing several occupations following the tephra event. SU 13 is a short palimpsest made up of at least two occupational events, which represent the first stable re-colonization of the site after the environmental impact caused by the volcanic ash deposition. The overlying SU 11 is a palimpsest about 30 cm thick, characterized by the superimposition of more than 35 hearths, again aligned in a similar pattern to that of the SU 13. The presence of a similar use and functionalization of the space, the consistencies in the management of lithic and animal resources indicate an extraordinary element of continuity between these two levels.

Material evidences		**SU 15**	**SU 14**	**SU 13**	**SU 11**
Surface (m^2)		~ 18	~ 14	~ 11	~ 11
FAUNA	**Determined**	45	3	6	74
	Items	*Bos primigenius* 39 *Cervus elaphus* 2 *Dama dama* 3 *Lepus sp* 1	*Bos primigenius* 3	*Bos primigenius* 5 *Equus ferus* 1	*Bos primigenius* 64 *Cervus elaphus* 5 *Dama dama* 3 *Capreolus capreolus* 1 *Equus ferus* 1
LITHIC	**Items**	5,992	3,833	7,504	31,056
	Production	Pebbles Cherty limestone F1, C1, C2 Long objects Unilateral scrapers	Pebbles Jasper F1, C1, C2 Long objects Unilateral scrapers	Pebbles Cherty limestone F1, C2 Short and long objects Unilateral scrapers	Pebbles Cherty limestone F1, C1, C2, D3, E1 Long objects Unilateral scrapers
SPACE	**Structure**	Yes	No	No	No
	Hearths	No	No	Yes	Yes
	Activity areas	Knapping areas Butchering areas Sleeping areas ?	?	Knapping areas Butchering areas Sleeping area Cleaning of the space	Knapping areas Sleeping areas ?
OCCUPATIONAL BEHAVIOUR		Living floor = End of a settlement event	Tephra = Brief occupation	Short palimpsest = Stable re-colonization of the site	Long palimpsest = Persistent occupation of the site

Table 42: Occupational behaviour at Oscurusciuto SU 11, SU 13, SU 14, SU 15. (? means that the data are still incomplete).

Compared to that, the SU 14 is an almost sterile layer about 60 cm thick, consisting of volcanic ash. Traces of a brief occupation can be seen only a few centimetres below the top of the layer. Even though spatial studies are still ongoing we may preliminarily ascertain that SU 14 is a layer characterized by short-lived occupation. This interpretation is determined by the absence of evident structures indicating a more persistent use of the space, i.e. hearths, or permanent structures, and unconsistent evidence of faunal remains. The lithic behaviour, already discussed in previous sections, also indicates a precise use of the site. People used this rock shelter to perform specific activities related to the testing of pebbles, the decortication of other pebbles whereupon they exported these semi-worked items from the rock shelter.

The absence of recycling or reusing activity is another indicator of the short time of occupation. Especially in SU 11, which is the longest occupation, we note the presence of cores reused several times in various reduction sequences, cores with two productional lives (the case of levallois + levallois, or levallois + additional) and even a change in the state of the tools, from core to instrument. These all demonstrate behaviour where there is correspondence between the site and the souce of raw material, i.e. the material discarded at the site is subsequently reused. These activities, are indicators of a prolonged use of the lithic material, and consequently of a prolonged occupation, something which is not documented in SU 14. Moreover, also the retouched tools corroborate this interpretation. This is the only level where there is a very low number of retouched items and most of them were made of management flakes or even of cortical flakes, i.e. items which require less investiment in their crafting.

A possible explanation for the brief nature of the occupation of SU 14 could be the tephra event itself, in other words these activities were carried out while the volcanic ash was settling. Consequently we may suppose that after some brief necessary activity, the people of Oscurusciuto left the rock shelter in order to look for a better place to settle.

SU 15 and SU 14 have their own individual characteristics, whereas SU 13 and SU 11 are very similar, and it will be interesting to study these similarities in further detail. We may hypothesize that SU 11 is made out of several SU 13, consequently it should be very interesting to disentangle the occupation of SU 11. As already said the lithic material of SU 11 number 31,056 items and they have all been studied for this thesis. It will be a challenging task to subdivide this material into sequences of occupation. The vertical distribution of the pieces suggests that level 11 is actually made up of two sub-levels (Spagnolo, 2017). Thus, a further development of this PhD would be to test the subdivision of this material to see if these preliminairly noted differences in the lithic material from this level bear out our proposed new substratification.

4 The entire stratigraphic sequence of Oscurusciuto

These four levels represent the lowest sections of the occupation of Oscurusciuto so far excavated. It will be interesting to continue the studies of the lithic material and gather further insight into the occupations and behaviour at Oscurusciuto, given the interesting informational potential of the site (Table 43).

As for the upper layer, related to more recent periods, we note that the occupational peculiarities of SU 13 and SU 11 seem to be similar to those of SU 9, another palimpsest with abundant material and an alignment of hearths. This pattern changes as levels get younger, thus SU 8 is characterized by scarcity of material and the absence of hearths and structures. The level above, SU 7, is characterized by a huge hearth in a corner of the rock shelter. The sequence is closed by SU 4 and SU 3, characterized by possible structures and SU 2 and SU 1 whose original extension had been damaged through erosion (Table 43, Figure 132). The rock shelter has only been excavated down to and including level 15; however, from an initial test-pit it is clear that there is another level of tephra and other layers with a rich concentration of material indicating other occupations (Figure 134).

Level	Evidence	Reference
SU 1	Dated to 38,500±900 BP, cal 42,724 ±716 BP Beta 181165. Fauna: *Bos primigenius.* Lithic: Pebbles, F1, C2; long objects. Space: very eroded.	Ranaldo, 2005; Villa et al. 2009; Boscato et al. 2011; Ronchitelli et al. 2011; Boscato and Crezzini, 2012; Ranaldo, 2017.
SU 2	Fauna: *Bos primigenius.* Lithic: preliminary studies Pebbles, F1, long and convergent objects. Space: very eroded.	Villa et al. 2009; Boscato et al. 2011; Ronchitelli et al 2011; Boscato and Crezzini, 2012; Ranaldo, 2017.
SU 3	Fauna: *Equus ferus.* Lithic: Not studied yet. Space: \	Boscato et al. 2011; Boscato and Crezzini, 2012.
SU 4	Fauna: *Bos primigenius*, *Cervus elaphus.* Lithic: Preliminar studies: Pebbles, F1, E1, long and convergent objects. Space: structures.	Boscato et al. 2011; Boscato and Crezzini, 2012; Ranaldo, 2017.
SU 7	Fauna: *Bos primigenius*, *Dama dama.* Lithic: Not studied yet. Space: Big hearth.	Boscato and Crezzini, 2012; Boscato and Ronchitelli, 2017.
SU 8	Fauna: *Bos primigenius*, *Dama dama.* Lithic: Preliminar studies, Pebbles, F1, long and convergent objects. Space: \	Villa et al. 2009; Ronchitelli et al 2011; Boscato and Crezzini, 2012.
SU 9	Fauna: *Bos primigenius*, *Cervus elaphus.* Lithic: Not studied yet. Space: alignment of hearths.	Boscato and Crezzini, 2012; Boscato and Ronchitelli, 2017.
SU 11	Fauna: *Bos primigenius*, *Cervus elaphus.* Lithic: Pebble; Cherty limestone; F1, C1, C2, D3, E1; Long objects; Unilateral scraper. Space: alignment of hearths.	Boscato and Ronchitelli, 2017; Spagnolo, 2017.
SU 13	Fauna: *Bos primigenius*, Equus ferus. Lithic: Pebble; Cherty limestone; F1, C2; Short and long objects; Unilateral scrapers. Space: alignment of hearths.	Marciani, 2013; Marciani et al. 2016; Marciani et al. *In press*; Spagnolo, 2013; 2017; Spagnolo et al. 2016; Boscato and Ronchitelli 2017.
SU 14	Dated to 55,000 BP Fauna: *Bos primigenius.* Lithic: Pebbles; Jasper, F1, C1, C2; Long objects; Unilateral scraper. Space: \	
SU 15	Fauna: *Bos primigenius*, *Cervus elaphus.* Lithic: Pebbles, Cherty limestone; F1, C1, C2; Long objects; Unilateral scrapers. Space: structures.	Ronchitelli et al. 2014.
Limit so far excavated		

Table 43: Complete stratigraphic sequence of Oscurusciuto.

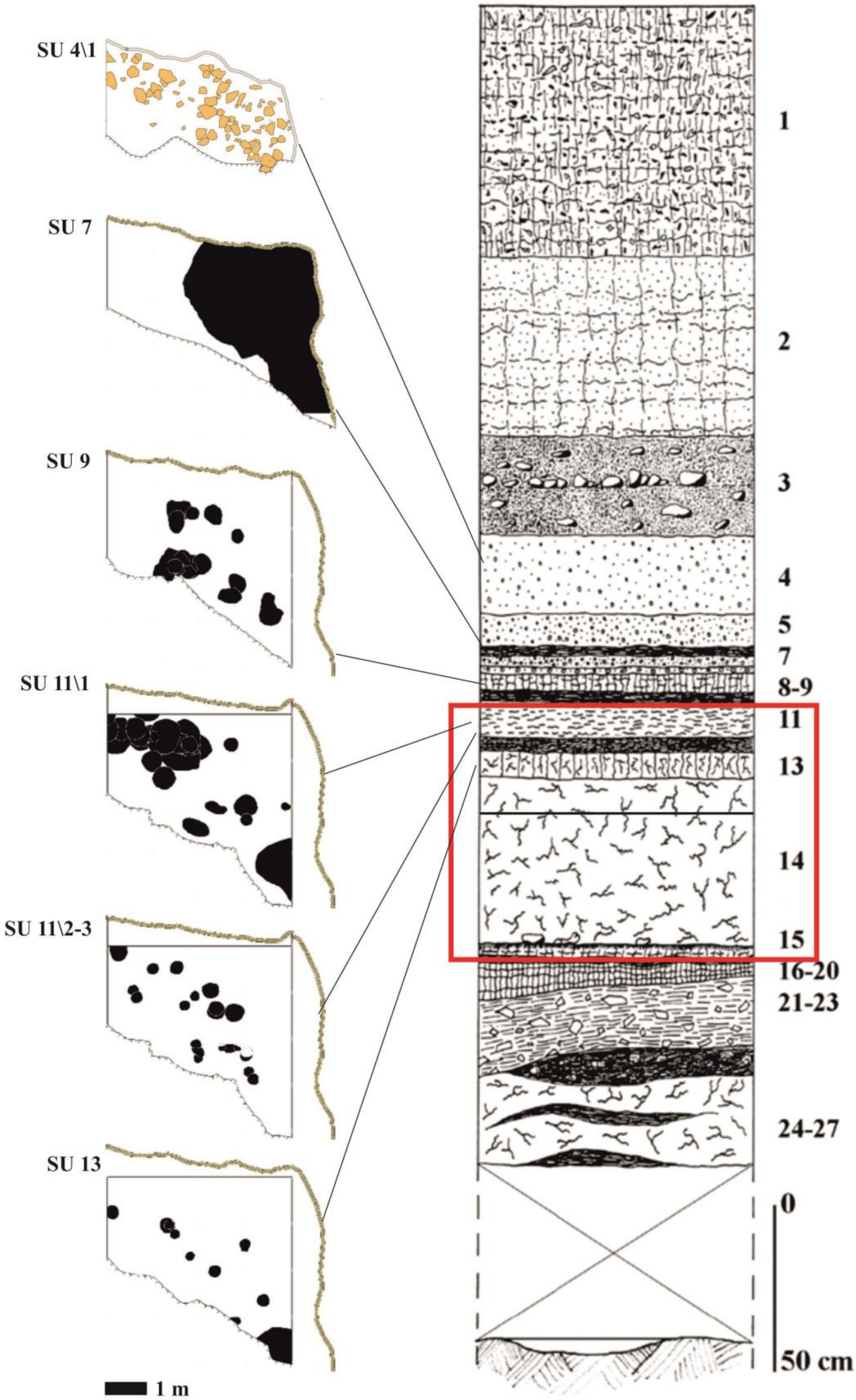


Figure 132: Oscurusciuto, complete stratigraphic sequence and planimetries.

(Drawing P. Boscato and V. Spagnolo).

XI THE LATE MIDDLE PALAEOLITHIC

1 Geographic location of the sites

The late Middle Palaeolithic in Italy, and specifically the period between 60,000 and 40,000 years BP, is known through almost 40 sites, mainly caves and rock shelters (Figure 133).

Figure 133: Distribution of the main sites between 60,000 and 40,000 years BP.

Given the location of the sites (Figure 133) we concluded that the last Neanderthal occupations in Italy did not follow any homogeneous pattern, it is more like a mosaic with many missing pieces whose evidence may be lost. In fact we have to consider the map in figure 133 partial, it might well only indicate the state of the art of current research, influenced by the preservation processes of the various sites and their accessibility.

Some areas present a concentration of sites, whereas in other zones there is a complete absence of sites. Proceeding from the north, we note the presence of two agglomerations, one in the northeast of Italy (corresponding to the sites from 2 to 7), and the other situated toward the north west, corresponding to the region of Liguria and northern Tuscany (sites from 9 to 19). The sites of Generosa and Ghiacciaia (1 and 8) are in an isolated position toward the north. The area between these two agglomerations (almost corresponding to the region of Emilia Romagna) did not report any sites, and neither did the entire mountain chain of the Apennines and all the regions along the Adriatic coastline (Figure 133).

A further important cluster is located in central Italy (comprehending the sites from between 20 and 26) corresponding to the parts of Tuscany and Latium on the Tyrrhenian Sea, plus the quite isolated site of the Reali cave in Molise (27) (Figure 133).

Two groups characterize southern Italy: the first is a little cluster toward the west, the second is a consistent group located in the east. The southwestern area is characterized by four main sites (from 28 to 31), and the final great concentration is located in south-east Italy, corresponding to the region of Puglia (from 33 to 37). The Oscurusciuto rock shelter (32) is located in the extreme northern part of this latter agglomeration, situated in a central position between Salento (south), Murge and Gargano (north), the area of the Gulf of Taranto, and the sites on the western coast of Italy (Figure 133).

For bibliographic references, please see Table 44 at the end of this chapter.

2 Chronological distribution

In the following figure (Figure 134) we propose a synthetic chronological view of the main sites of the late Middle Palaeolithic of Italy, based on datations and main debitage concepts. The absolute data are indicated with a straight unbroken line, whereas sites referring to the later period of Middle Palaeolithic but lacking a precise chronological framework are indicated with a dotted line. In the figure, we only considered the duration of the occupation (for more detail see Table 44 at the end of this chapter). Moreover, we have indicated the reduction concept utilized in the lithic production (F1, E1, CD1, CD2) (Figure 134).

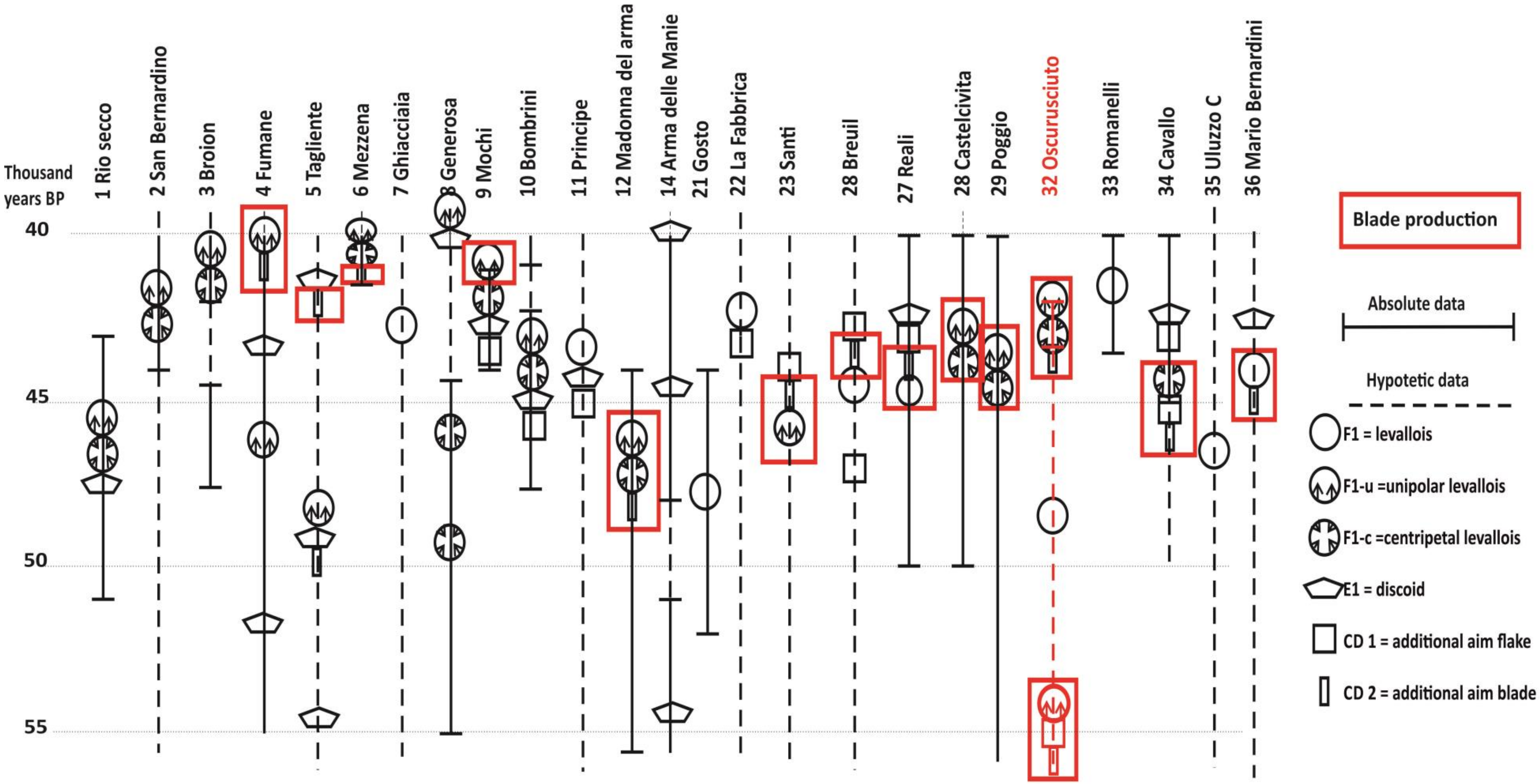


Figure 134: Chronological frame and debitage concept in main sites between 60,000 and 40,000 years BP

We note great discontinuity in the available data, not least regarding the chronological distribution of the sites, i.e. there are sites with numerous certain datations, and others with few or none. In some cases it was possible to ascertain at least one absolute chronology, and in some cases even the entire sequence was dated (e.g. the Fumane and the Cavallo caves), whereas other sites were dated only on the basis of faunal or geological correlations (Figure 134). The method of dating employed was mainly C14, but also TL, U/h, OSL, and ESR. For the Oscurusciuto, we had two datations, an absolute of 42,000 years BP, and a relative of 55,000 BP obtained throught the identification of the tephra layer SU 14 as ash from the Mount Epomeo green tuff eruption (Figure 134).

In general the majority of the dated sites of the late Middle Palaeolithic of Italy are concentrated between 40,000 and 45,000 years BP, followed by the group dated between 45,000 and 50,000 years BP. The four levels of Oscurusciuto, the object of this dissertation, are chronologically located in a timeframe where few other sites are located (e.g. Fumane, Arma delle Manie).

3 Lithic production concept at the end of MIS 3

In order to give a comprehensive view of the lithic production during the MIS 3 we had to interpret the available bibliography standardizing the vocabulary and concepts (Boëda, 2013) to be able to utilize them in this thesis. Thus as for levallois and discoid production there was general uniformity, whereas with other production modes the task of “unifying” the vocabulary was a bit more difficult, so in order not to misrepresent the data we created large categories, i.e. additional CD 1 for the production of flakes, and additional CD 2 referring to laminar and lamellar production (Figure 134).

Discoid debitage is referred to as E1. We refer to the levallois concept as F1, and more specifically F1-u for recurrent unipolar levallois; F1-c for recurrent centripetal levallois. In all the references listed the preferential levallois only occurs as a collateral production sometimes utilized at the end of the reduction sequence, therefore we did not consider it in our synthesis (Figures 134, 135).

Proceeding with the comparison we considered C1 D1 (CD1), to be additional debitage, aiming at producing flakes. All the production which is neither levallois nor discoid and aimed at producing flakes is decribed in the bibliography as SSDA, kombewa, kombewa *sensu latu*, or opportunistic (Figure 134, 135). All the types of debitage aimed at producing blades and bladelets are labelled in the references as: volumetric debitage, semi-turning debitage, orthogonal debitage code-named C2, D2 (CD2) (Figure 134, 135).

As already said, for the these last two categories (CD1 and CD2), due to the extension and complexity of the available references we did not enter into major detail. Without a doubt it would be possible to define the degree of preparation in each production and surely to obtain a better overall comprehension through further studies.We might be able to define further sub-categories, evaluating the initial exploited block, or on the basis of the management and the organization of the debitage, but in this thesis we have limited ourselves to an initial general overview.

From a diachronic point of view we note that the period between aproximatelly 55,000 and 50,000 years BP is represented by the evidence of few sites mainly dominated by discoid production. The period between aproximatelly 50,000 and 45,000 years BP is characterized by the simultaneous presence of several concepts of debitage, both levallois, discoid, and additional debitage aimed at producing flakes and blades. There are cases where levallois, dicoid and additional were founded together (e.g. Tagliente), whereas there are also cases whith a clear preference for one of them (e.g. levallois at Gosto and discoid at Arma delle Manie). Finally, the period between aproximately 45,000 and 40,000 years BP is represented by many different sites located along the whole peninsula, and from a behavioural point of view they are characterized by a variety of debitage concepts, mainly devoted to producing blades. In this context Oscurusciuto seems to be quite unique because it is carcaterized by a production oriented towards elongated products from 55,000 years BP onwards.

The production of blades is also known from other sites: as a product of levallois debitage it is mainly founded at Fumane, Mochi, Poggio, Castelcivita, and Mario Bernardini. On the other hand the production of blades by additional CD2 debitage is documented in Fumane, Madonna dell’Arma, Santi, Breuil and Reali. The sporadic production of bladelets is documented at the sites of Fumane, Santi, Oscurusciuto and Cavallo. Blades and bladelets were produced utilizing both levallois and additional methods, adapting and controlling the reduction sequences to suit a variety of raw blocks, such as pebbles, tabular and nodules.

The preference towards a laminar and even lamellar production at the end of the Middle Paleolithic is a trend registered not only in Italy but also in the rest of Europe, and it is turning into a hot topic in current scientific prehistoric debate, not least because of the possible role of elongated products in the dynamics of the transition to the Upper Palaeolithic, as well as in the supposed replacement of Neanderthal by AMH (Zwyns, 2012; Moroni et al., 2013; Gennai, 2016; Carmignani, 2017).

From a geographical and synchronic point of view, the levallois concept is the most utilized reduction method found in Italy attributable to the MIS 3. It is widely utilized in almost all the sites on the peninsula in all its modalities, especially the recurrent ones. The reduction mode is applied to a great variety of raw blocks, such as pebbles, nodules, and tabular. The only exception to this dominance of levallois seems to be the northwestern part of Italy (the Ligurian - Provenzal arch) where, even though levallois was the most dominant production in the previous period, in the following period considered here there is a dominance or almost complete prevalence of discoid debitage (see e.g. Arma delle Manie V-VI). The discoid debitage also characterizes the final period of some sites in Puglia such as the Cavallo and Mario Bernardini caves.

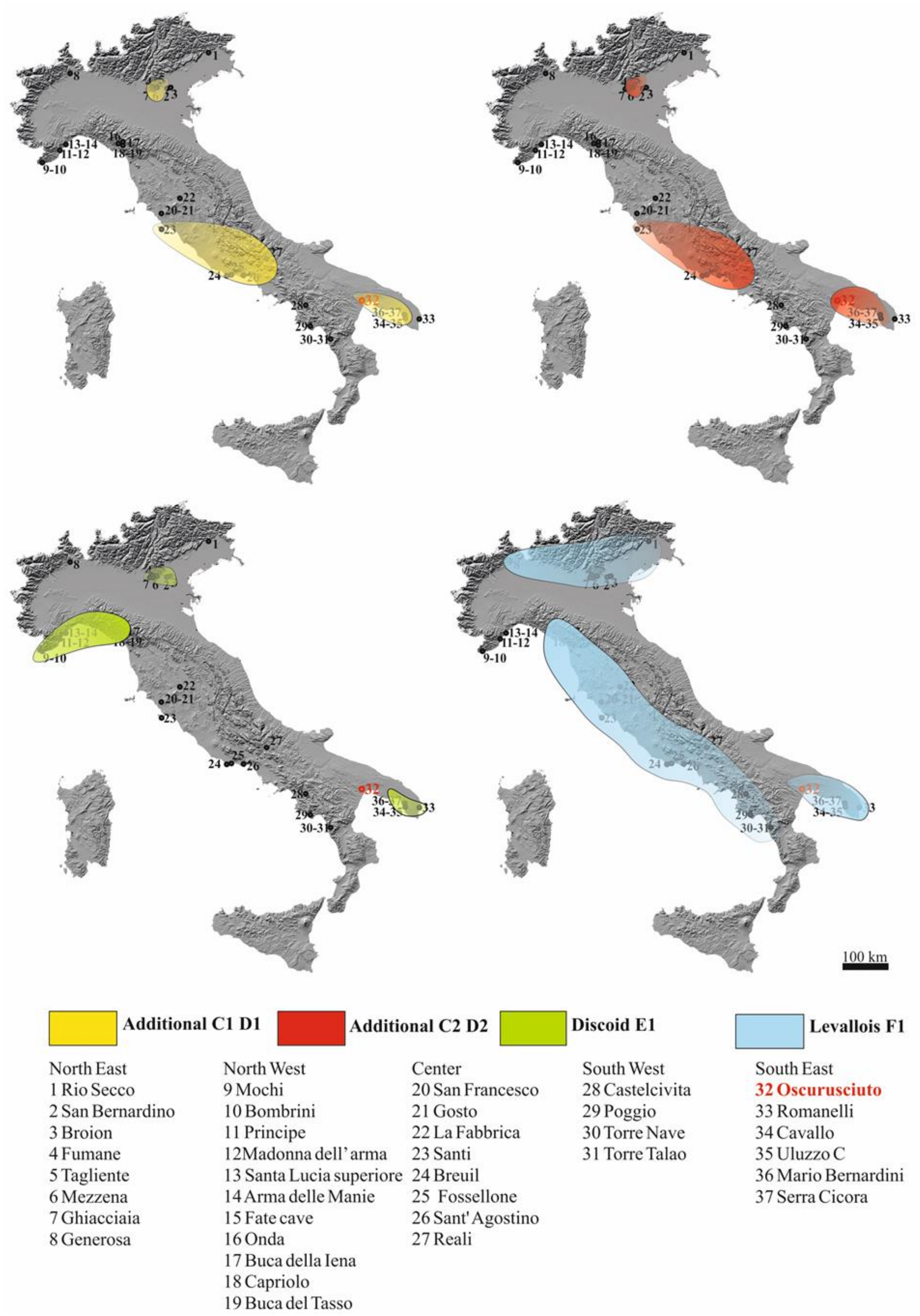


Figure 135: Overview of the main concepts of debitage in use between 60,000 and 40,000 years BP

Possibly due to its less recognizable character the additional debitage aimed at producing flakes or blades, was found only at the sites where detailed technological studies were undertaken such as at the sites of Fumane, Tagliente caves and the Mochi rock shelter in northern Italy, The Reali and Santi cave in central Italy, and the Oscurusciuto rock shelter, the Cavallo and the Mario Bernardini caves in southern Italy.

The northeast of Italy is characterized by the dominant presence of levallois debitage, together or intermittent with discoid debitage, plus additional reduction aimed at producing blades and flakes. The levallois debitage is mostly of the unipolar modality, turning orthogonal or preferential in the last stages of debitage. Moreover, debitage aimed at producing blades is documented at Fumane and Tagliente sites.

The northwestern region, corresponding to the Ligurian sites, is characterized by discoid production, sometimes in association with a few levallois elements. Notable the presence of laminar debitage at the Mochi rock shelter.

Central Italy can be divided into two main parts according to type of production: one group of sites characterized by the prevalence of levallois production, and a cluster referring to the sites of the so-called "pontinian" industries. The first group consists of the sites of La Fabbrica, Gosto, Buca della Iena, Capriolo, Buca del Tasso, Onda and S. Francesco, all caves with a dominant levallois production. Notably at at La Fabbrica and Gosto two independent levallois reduction sequences occur, one unipolar in order to obtain elongated and convergent products, and the other recurrent centripetal in order to obtain big flakes.

The second group consists of the sites located in Lazio, mainly represented by the Breuil and Fossellone caves plus the site of the Santi cave located in Tuscany on the Mount Argentario. The characteristic uniting these sites is their geomorphological nature, i.e. they are caves on cliffs now overlooking the sea, moreover in both cases the raw blocks are quite small pebbles. These sites are characterized by a recurrent unipolar levallois production where the first phase of initialization corresponds to the selection of the raw blocks, which in this case (as also at Oscurusciuto) were small pebbles, even smaller than the ones used at Oscurusciuto, resulting in a production of only one or two generations of target objects. Parallel to this production there was also an additional debitage aimed at producing blades and bladelets. The boundary between what is unipolar levallois and what is additional is very difficult to define. In this case we characterized them according to the available bibliography, bearing in mind that overlapping between unipolar levallois and additional debitage could have occurred, in the cases where the additional debitage was aimed at producing techno-type levallois target products (Figures 134,135).

The sites located in southern Italy are characterized by a predominance of levallois debitage utilizing recurrent unipolar and/or convergent modalities which toward the end of the reduction sequence usually changed to a centripetal or preferential modality. This pattern is mainly found at Poggio, Castelcivita, Oscurusciuto, Cavallo and Mario Bernardini sites.

The concepts of debitage identified at Cavallo, levels FIIIe and FIIId, are levallois and additional CD 2 debitage just like at Oscurusciuto. In both sites there is a tendency towards producing elongated end-products, although the procedure utilized in order to obtain them is very different. The levallois reduction sequence at Oscurusciuto (not only the level in question in this thesis SU 11-13-14-15, but also SU 1 and SU 4) was mainly directed at obtaining elongated products (blades and long flakes) by means of unipolar and convergent modalities; whereas at Cavallo (FIIIe – FIIId) the main target objects of the levallois reduction were quadrangular flakes obtained through the centripetal modality. The additional debitage is well attested and aimed at the production of blades at Cavallo and intermittently represented and mainly aimed at producing blades and bladelets at Oscurusciuto.

An important difference between the two sites is the nature and shape of the raw blocks. At Oscurusciuto the initial blocks are pebbles both for additional and levallois debitage, whereas at Cavallo the pebbles are exploited by means of centripetal levallois (flake production), and with occasional discoid debitage in the upper layers (FIIIa, FII, FI). This is important proof that the initial shape of the raw material (e.g. pebble, nodule, tabule) does not represent a constraint in the production on the contrary, the intentional choice of the raw blocks was determined by the target object which the debitage was directed at.

Althought very different, Oscurusciuto and Cavallo are key sites to understanding the production of the last Neanderthals in Italy, not least because of the tendency toward the production of elongated products. Starting about 55,000 years BP, this preference towards the production of elongated target objects (blade and bladelets), as already said, is well documented all over the Italian peninsula and also in the rest of Europe.

N.	**Site**	**Reference**
1	Rio Secco	Peresani, 2009; Peresani et al., 2013b; 2014; Talamo et al., 2014.
2	San Bernardino	Peresani, 1996; 2009; Gruppioni, 2003; Fiore et al., 2004; Picin et al., 2013; Peresani et al., 2015.
3	Broion	Fiore et al., 2004; Peresani and Porraz, 2004; Porraz and Peresani, 2006; Peresani, 2009.
4	Fumane	Gruppioni, 2003; Higham et al., 2009; Peresani, 2009; 2011; 2012; Gennai, 2016.
5	Tagliente	Arzarello, 2003; Peresani, 2009; Bianchi, 2011; Buonsanto, 2012.
6	Mezzena	Giunti et al., 2008; Longo et al., 2012; Talamo et al., 2014
7	Ghiacciaia	Bertola et al., 1999; Arzarello 2003; Peresani 2010.
8	Generosa	Bona et al., 2007; Peresani, 2009; 2011
9	Mochi	Laplace, 1977; Kuhn and Stiner, 1992; Yamada, 2004; Mehidi, 2005; Douka et al., 2012; Grimaldi and Santaniello, 2014; Grimaldi et. al., 2014; Rossoni-Notter et al., 2017.
10	Bombrini	Arobba and Caramiello, 2009; Riel-Salvatore et al., 2013; Benazzi et al., 2015; Rossoni-Notter et al., 2017.
11	Principe	Negrino and Tozzi 2008; Rossoni Notter et al. 2017.
12	Madonna del arma	Cauche, 2007; Rossoni Notter et al. 2017.
13	Santa Lucia superiore	Cauche, 2007; Rossoni Notter et al. 2017.
14	Arma delle Manie	Cauche, 1996; 2007; Mehidi, 2005; Leger, 2012; Rossoni Notter et al. 2017.

15	Fate	Falgueres et al1990; Negrino Tozzi 2008; Rossoni Notter et al. 2017.
16	Onda	Pitti and Tozzi, 1971; Palma di Cesnola, 2001; Dini and Koehler, 2009; Casini, 2013
17	Buca della Iena	Pitti and Tozzi, 1971; Palma di Cesnola, 2001; Dini and Koehler, 2009; Casini, 2013.
18	Capriolo	Pitti and Tozzi, 1971; Palma di Cesnola, 2001; Dini and Koehler, 2009; Casini, 2013.
19	Buca del Tasso	Pitti and Tozzi, 1971; Palma di Cesnola, 2001; Dini and Koehler, 2009; Casini, 2013.
20	S. Francesco	Boscato et al., 1991
21	Gosto	Boscato et al., 1991
22	La Fabbrica	Dini et al., 2007; Dini and Tozzi, 2012
23	Santi	[oroni et al. 2008
24	Breuil	Rossetti and Zanzi, 1990; Bietti and Grimaldi, 1991; Grimaldi, 1996; Lemorini, 2000; Grimaldi and Spinapolice, 2010; Grimaldi and Santaniello, 2014
25	Fossellone	Vitagliano, 2007; Vitagliano and Bruno, 2012.
26	S. Agostino	Laj Pannocchia, 1950; Tozzi, 1970; Kuhn, 1992.
27	Reali	Arzarello et al., 2004; Rufo, 2008; Peretto, 2012.
28	Castelcivita	Gambassini, 1997; Giaccio et al., 2008; De Stefani et al., 2012; Douka et al., 2014; Higham et al., 2014.
29	Poggio	Caramia and Gambassini, 2006; Boscato et al., 2009.
30	Torre Nave	Bulgarelli, 1972; Spinapolice, 2002.
31	Torre Talao	Spinapolice, 2002.
32	Oscurusciuto	Boscato et al 2011; Ronchitelli et al 2011; Marciani 2013; Spagnolo et al 2016; Marciani et.al. 2016, in press; Ranaldo 2017.
33	Romanelli	Piperno, 1974; Spinapolice, 2009; Sardella et al., 2014.
34	Cavallo	Benazzi et al., 2011; Carmignani, 2011; 2017; Romagnoli, 2012; Fabbri et al., 2016; Zanchetta et al., 2018; Moroni et al. *In press.*
35	Uluzzo C	Borzatti von Löwenstern, 1966; Spinapolice, 2008.
36	Mario Bernardini	Borzatti von Löwenstern, 1970; Spinapolice, 2008; Carmignani, 2011; Romagnoli, 2012.
37	Serra Cicora	Campetti, 1986; Spinapolice, 2008.

Table 44: References for the images and texts in this chapter.

XII Conclusion

1 SOME ANSWERS

This work set out to resolve two main issues: one regarding the interconnected four levels at Oscurusicuto (SU 15-14-13-11) and the other related to the behaviour of the last Neanderthals in Italy. We shall give a brief summary of the objectives in which we succeeded plus indicate some future paths that further research might undertake.

1.1 What are the continuities and discontinuities at the Oscurusciuto rock shelter?

The results indicated that the stratigraphic units in question (SU 15-14-13-11) show peculiarities in terms of lithic production systems, structural elements, spatial management, and type of occupation.

Regarding, the lithic behaviour of these four levels at the Oscurusciuto rock shelter we note the presence of some very consistent elements, i.e. that the most utilized raw materials were siliceous limestone, jasper and chert in their fine granulometry, and that the initial blocks of raw material were oblong pebbles coming from secondary local sources. The main reduction sequence was the recurrent levallois, unipolar and convergent, aimed at producing elongated and convergent tools. We also encountered several types of additional debitage, aimed at producing both flakes, blades and bladelets.

On the other hand, we also encountered some discontinuities concerning details in the debitage production, such as the absence of additional debitage producing flakes in SU 13, and the SU 11 was presented the greatest variety with regard to both the type of reduction sequence and the typology of retouched tools.

The techno-functional analysis showed great diversity as to structure and potential function of the tools in SU 13. Thanks to the application of this method (combined with use-wear analysis), we were able to describe and interpret not only the production of the lithic objects in question, but also the human reality out of which they were created.

As for the type of occupation present in the four levels in question we ascertained that SU 15 is a living floor in which a phase of abandonment is recorded which was then sealed by the deposition of the SU 14 tephra. The surface of level SU 14 is characterized by stone alignments defining two significant structures.

SU 14 is an almost sterile layer about 60 cm thick, consisting of volcanic ash. Traces of a brief occupation can be seen only a few centimetres below the top of the layer. SU 14 thus represents a brief occupation characterized by a lithic behaviour indicating immediate necessity, expressed in the action of testing the pebbles, the making of the tools and the exportation of the needed tools and raw material.

SU 13 is a short palimpsest which represents the first stable re-colonization of the site after the momentous environmental impact caused by the volcanic ash deposition. In this layer 10 aligned hearths were found, which divide the site into areas devoted to different activities. Finally, the overlaying level SU 11 is a palimpsest about 30 cm thick, characterized by the superimposition of tens of hearths.

In the levels SU 14 and SU 13, thanks to the application of RMU and refitting studies it was possible to document the fragmentation of the reduction sequence, which in several instances was divided into import and/or export, demonstrating a certain mobility of the population within the surrounding territory. This in spite of a lithic collection dominated by the levallois concept, habitually regarded as a more “sedentary” reduction sequence as opposed to the Quina, which is considered a sign of mobility (Romagnoli et al 2015, 2016, Vaquero et al. 2016).

Moreover, the SU 13 and SU 11 show continuity and consistency in the mode of occupation of the space as even after the tephra event the same modality and location hearths persisted as did a, similar division of the space as well as knapping activities related to the hearths.

As the research stands now, we are still unable to define the circumstances of the deposition of tephra, and the extent to which it influenced the inhabitants of Oscurusciuto and those of the Ginosa ravine. In the four selected levels we can establish a settlement before, during and after the tephra event, but further studies are needed to evaluate the exact impact of the environmental event, identified as the volcanic eruption of Mount Epomeo (Ischia).

1.2 Did the last Neanderthals possess a uniform or a fragmented technological identity?

The late Middle Palaeolithic in Italy, i.e. between 60,000 and 40,000 years BP is documented through almost 40 caves and rock shelter sites, characterized by an inhomogeneous geographical distribution, chronological framework and especially type and extent of research. The current state of the art regarding studies of the end of the Middle Palaeolithic is in fact a major determinant of this synthesis. We therefore hope that the research undertaken here has bridged someof the voids, and propose the following scenario regarding the late Middle Palaeolithic.

Geographically we recognize five main clusters of sites: the first two located in northern Italy (west and east), the third in central western Italy (along the Tyrrhenian coastline), and the fourth and fifth in southern Italy (west and east). Oscurusciuto is on the western edge of the last agglomeration and located in a key position between the other sites in southern and central Italy.

From a chronological point of view the availability of quite detailed and precise data for some sites and more sporadic and less accurate for others have led to discrepancies in the appreciation of the chronology of the sites. However, we can observe that some site have extensive stratigraphic sequences with variations in the utilized reduction sequences (e.g. Cavallo, Fumane caves), whereas others like Oscurusciuto present more well-defined cultural continuities.

Generally, the levallois reduction sequence is the most utilized in Italy during the MIS 3. It is widely documented at almost all the sites of Italy, in a variety of modalities, especially the recurrent ones. The production is adapted to a great variety of raw blocks, i.e. pebbles, nodules, and tabular. The levallois target objects are the ones that are most frequently imported into the site, and also the ones that are most often retouched.

The only exception seems to be the north western area of Italy (the Ligurian - Provenzal arch) where the dominant production is the discoid debitage. The latter also characterizes the final chronological section of some sites in Puglia such as the Cavallo and Mario Bernardini caves.

The Oscurusciuto site is very representative of the late Middle Palaeolithic in southern Italy with its large predominance of levallois debitage (as also at the Cavallo, Castelcivita and Poggio sites). On the other hand, it also presents some unique features, such as a great versatility in the technical behaviour of human groups during the Middle Palaeolithic. Finally, it is a clear example of the tendency towards a laminar and even lamellar production which is a characteristic of the end of the Middle Palaeolithic.

From a methodological point of view the methods and approaches utilized in this thesis permitted to note that beside the great presence in the Italian late Middle Paleolithic of a quite well known levallois and discoid production, there is aslo a general trend of additional debitages aimed at producing different target products. Even if more difficult to perceive, these productions are not collateral but they are found in many sites and they deserve to be further analysed.

2 MORE QUESTIONS

2.1 General issues

The results obtained present us with a variety of new research questions.

One interesting research project could be to continue the studies at the Oscurusciuto rock shelter applying the same combination of methods, i.e. comparing the lithic collections and the behavioural occupation of the other levels. Especially the upper part of the stratigraphy, 42,000, BP is a challenging period in this region because a few km from the Oscurusciuto, on the peninsula of Salento, we find the first settlement of *Homo sapiens* with its Uluzzian techno-complex.

From a methodological point of view, it would be necessary to extent the studies, adding complementary approaches, such as the statistical management of data, which would facilitate computation of extensive numerical data and their comparative interpretation.

Another point to consider is the evaluation of the fragmentation of the operational chain. Thus it would be desiderable to develop mathematical methods of depicting and interpreting the RMU and finally evaluating the totality of the material exported\imported into\from the site.

2.2 Specific issues

A further development of present research would be to proceed in analysing the refitting and, more in general, the material from level SU 15 in a GIS software in order to identify possible activity areas. Moreover, the presence in this SU of cores with a final retouch and some percussion traces could indicate possible recycling of some items. These interesting issues merit further investigation.

Further effort will be dedicated to the RMU analysis and refitting of SU 14 in GIS software in order to understand the settlement dynamics during the deposition of volcanic ash.

The discrepancies in occupational behaviour in the layers SU 14, SU 13 and SU 11 are notable, it seems that SU 14 represents a single brief occupational event, where upon the 13 represents a short palimpsest made up of several events. Finally, the SU 11 is made up of several occupational events. The discussion regarding the types of different behaviour evidenced by Neanderthals will be further developed.

Finally, thanks to the combination of techno-functional and use-wear analysis, we have realized the particular role and importance of some tools in the Neanderthal tool kit. The issues regarding the production and utilization of small tools will be further analysed in subsequent works.

In conclusion, I would like to end this manuscript with a pun. The name Oscurusicuto etymologically means “becoming dark or shadowy”, and in Italian the sound of “Oscurusciuto” points to the word *sconosciuto,* which means “unknown, mysterious or stranger”. If something is unknown, it means that it is obscure, that it is in the shadows. Consequently, if the main objective of this research is to shed light on the mysterious inhabitants of Oscurusciuto, our goal can be described as:

… *Scoprire lo sconosciuto dell’Oscurusciuto*!

The Road goes ever on and on

Down from the door where it began.

Now far ahead the Road has gone,

And I must follow, if I can,

Pursuing it with eager feet,

Until it joins some larger way

Where many paths and errands meet.

And wither then? I cannot say.

...a journey new begin…

J.R.R. Tolkien

Appendix

Paper 1: Reduction sequences, import-export and RMU

MARCIANI, G., Spagnolo, V., Aureli, D., Ranaldo, F., Boscato, P., Ronchitelli, 2016, Middle Palaeolithic technical behaviour: Material import-export and Levallois production at the SU 13 of Oscurusciuto rock shelter, Southern Italy. Journal of Lithic Studies, vol. 3, nr. 2, p. xx-xx doi:10.2218/jls.v3i2.1414.

Presented at:

10th International Symposium on Knappable Materials. "On the rocks".

University of Barcellona. 7-15 September 2015.

Session 3 Chaîne opératoire: Stone tool production and processing techniques.

http://www.ub.edu/ubtv/video/middle-Palaeolithic-technical-behavior-at-the-su-13-of-oscurusciuto-rock-shelter-southern-italy-giulia-marciani

Middle Palaeolithic technical behaviour: Material import-export and Levallois production at the SU 13 of Oscurusciuto rock shelter, Southern Italy

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Abstract:

The Oscurusciuto rock shelter, located in southern Italy (Puglia), has yielded a long Middle Palaeolithic stratigraphy rich in lithic assemblages, fireplaces and faunal remains, attesting Neanderthal occupation during the MIS 3. This paper is focused on the stratigraphic unit 13, consisting of a sandy compact deposit mixed with pyroclastic sediment above a thick level of tephra-US 14, identified as Mt. Epomeo green tuff (dated Ar/Ar ~ 55 ka).

Level 13 represents the first stable human occupation after the deposition of tephra. Our goal was to examine the lithic assemblage of this stratigraphic unit by means of an interdisciplinary approach (technology, RMU, refitting program) in order to identify the economic behaviour and technical strategies of Neanderthals occupying the stratigraphic unit 13 of Oscurusciuto.

The technical strategies applied indicate fragmentation of the reduction processes, as well as probable events of importation and exportation of objects. The lithic material were introduced at different stages of manufacturing. Pieces were introduced in the form of rough objects (pebbles), as well as semi-finished items, and as finished tools. This fragmentation of the *chaîne opératoire* also demonstrate the palimpsest nature of the level which is made up of different events happening one after another.

The main concept of debitage was Levallois, generally realized on local jasper and siliceous limestone pebbles or cortical flakes. Jasper and siliceous limestone flakes, backed flakes and convergent flakes were the technological objectives of the debitage. A marginal volumetric debitage aimed at producing bladelets was also attested.

Keywords: Middle Palaeolithic; Neanderthals; technical behaviour; lithic; southern Italy

Journal of Lithic Studies (2016) vol. 3, nr. 2, p. xx-xx doi:10.2218/jls.v3i2.1414

Published by the School of History, Classics and Archaeology, University of Edinburgh
ISSN: 2055-0472. URL: http://journals.ed.ac.uk/lithicstudies/

1. Introduction and background

The fragmentation of the reduction sequences is a behaviour already attested in other Middle Palaeolithic sites (Bataille 2006; Bourguignon *et al.* 2004; Moncel *et al.* 2014; Neruda 2010; 2012; Romagnoli 2015; Spagnolo *et al.*2016; Turq *et al.* 2013; Uthmeier 2006; Vaquero 2008; Vaquero *et al.* 2001; 2012a; 2012b). It proves the capacity of Neanderthals for adopting flexible strategies of occupation and use of the land and it is also an indicator of their mobile nature. The different stages of acquisition, transport, knapping and abandonment of lithic implements, identified individually or together in the same archaeological record, suggest that the strategies related to the management of lithic materials are different and independent from each other (Fernández-Laso *et al.* 2011; Turq *et al.* 2013).

It is clear that the lithic material imported to a site was introduced in various ways: as raw blocks, as half-finished objects, or as already manufactured tools. The export of tools and their abandonment on site as waste material has also been documented. The complexity related to the mobility of lithic objects is directly linked to the spatial, temporal and social domains (Turq *et al.* 2013). This means that even though lithic objects appear together in the same archaeological record they are associated with various geographical places. They could be introduced in a site during different episodes temporally far from each other. Moreover they could also indicate some social process of the groups using the region.

Another technical behaviour, which is often simultaneously present with fragmented reduction sequences, is the recycling of ancient waste resulting from production and reusing it as support for knapping and obtaining new tools. This behaviour, especially regarding its recognition, is very debated in archaeological literature (Romagnoli 2015; Vaquero 2011; Vaquero *et al.* 2012; 2015;). In terms of land use, the behaviour of recycling could be related to the scarcity of good raw material in the region and thus it substantiates the need to reuse the same tools rearranged many times for different tasks and necessities (Amick 2007; Close 1996; Dibble & Rolland 1992; Hiscock 2009; Kelly 1988). Alternatively, it could be a specific strategy, which relates to occasional and expedient behaviour and unplanned necessity (Vaquero *et al.* 2012). This is a characteristic usually encountered in populations with high mobility in the territory (Kuhn 2014; Romagnoli 2012; Romagnoli *et al.* 2015).

Although the data are still partial and there are few studies with techno-economic approach, Middle Palaeolithic populations of southern Italy (we mainly consider the region of Puglia in this paper) stand out for their high adaptability and flexibility of the knapping scheme and for their mobility in the territory (Carmignani 2010; 2011; Marciani 2013; Romagnoli 2012; 2015; Romagnoli *et al.* 2015; Spinapolice 2012;).

In this paper, we aim to examine the Oscurusciuto rock shelter, which is located in the ravine of Ginosa - Taranto in the region of Puglia, southern Italy. The site presents several anthropic layers with a lithic production of a predominantly unipolar Levallois method (Boscato *et al.* 2011; Lazzeri 2005; Marciani 2013; Ranaldo 2005; Ronchitelli *et al.* 2011; Spagnolo *et al.* 2016; Villa *et al.* 2009).

There are several current studies on this site, and the principal aim of our research is to provide an integrate and complete data-set concerning the Neanderthal behaviour on site: their strategies of production, trade and use of lithic tools; their management of space as well as their subsistence strategies, all related to environment.

Specifically, the main goal of this paper is to understand the technical behaviour of Neanderthals in the Stratigraphic Unit 13 (SU 13). Consequently the study integrates various types of lithic studies, among others the technological approach, to obtain information about the techniques and methods of knapping and the manufacturing of target flakes. The Raw Material Units (RMU) method, used to identify individual events of raw material introduction into the site, has permitted us to supply more detailed interpretations of individual choices regarding the management of the stone material involved. Moreover refittings and conjoints are crucial to fully understand the technological behaviour in question, and also to measure the reliability of each RMU (Marciani 2013; Spagnolo 2013; Spagnolo *et al.* 2016).

1.1. The site

Research, investigation and excavation at the Oscurusciuto rock shelter have been carried out since 1998 until the present day by the U.R. Preistoria e Antropologia under the Dipartimento di Scienze Fisiche, della Terra e dell'Ambiente - University of Siena, Italy.

The Oscurusciuto rock shelter opens into the Pleistocene calcarenite, at about 15 meters from the current bottom of the ravine, standing at an elevation of 235 m asl (Figure 1). The Ionic coast line is currently at about 20 km from the site.

Figure 1.The Oscurusciuto rockshelter in the northern side of the ravine of Ginosa. (Photo by P. Boscato.)

The location of the site plays a primary role, as this rock shelter is located in the central part of Puglia, which represents a crossroads for different areas of southern Italy: Salento (south), Murge and Gargano (north), plus the area of the Gulf of Taranto and Basilicata (Figure 2a). This region also seems to be crucial for the first diffusion of the Anatomically Modern Human in Europe (Moroni *et al.* 2013).

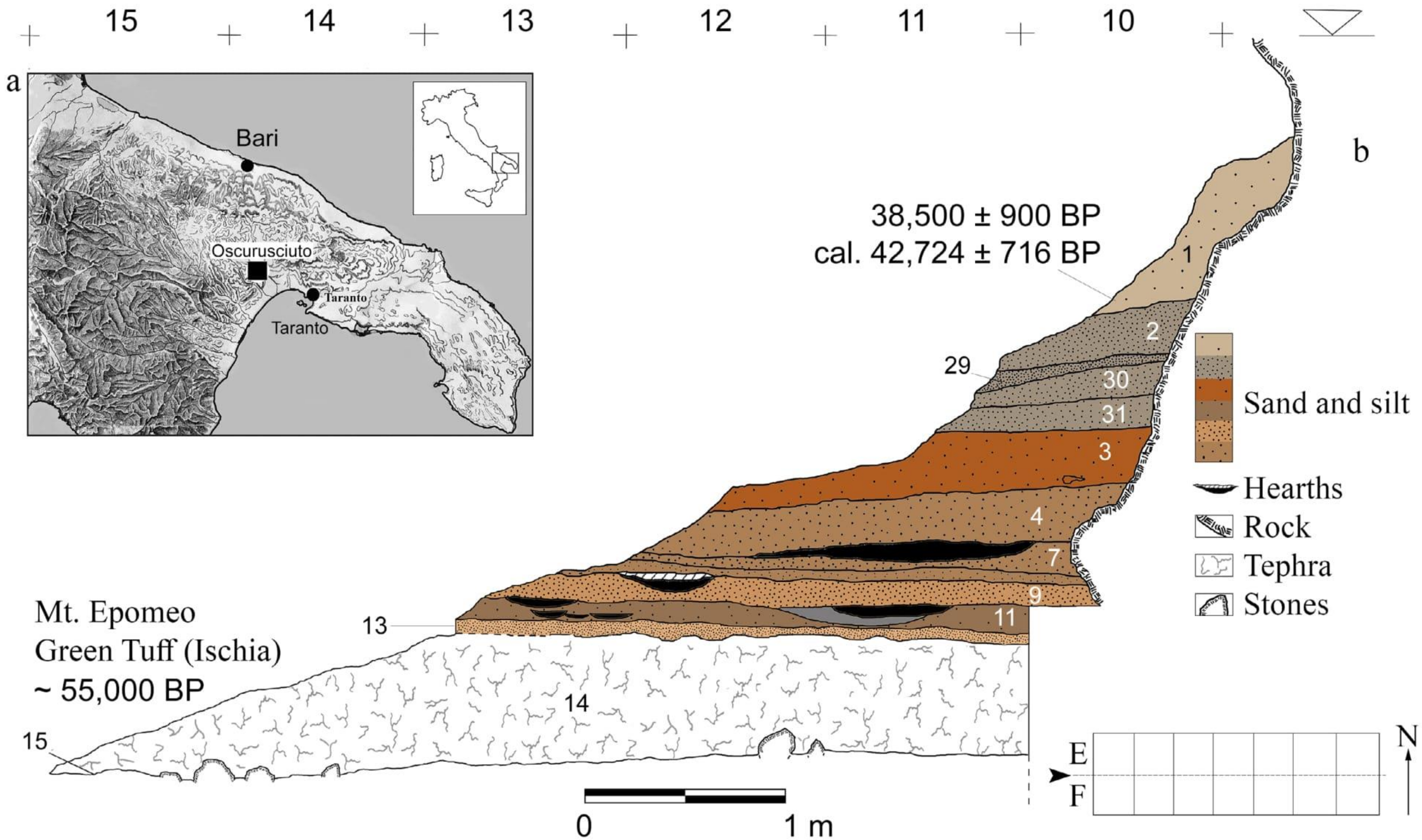

Figure 2. Localization (a) and stratigraphic sequence (so far excavated) of the Oscurusciuto rock shelter (b). (Relief map by P. Boscato; drawing by A. Ronchitelli).

At some point the original shelter vault collapsed, leaving today only a little coverage above the site. The deposit consists of approximately 60 sq m at the base, reaching a depth of 6 m in its central part so far excavated. The stratigraphic sequence is made up of several horizontal levels (Figure 2b), which refer to the final stage of Middle Palaeolithic: the date of the lower part of SU 1 is 38.500 ± 900 BP - AMS, Beta 181165; cal. 42.724 ± 716 BP (for calibration see OxCal v4.2.4 Ramsey & Lee 2013). The tephra deposit SU 14 was attributed to the green tuff of Mount Epomeo Ischia, identified in the stratigraphic series of Monticchio, dated to ~ 55 ky BP (Allen *et al.* 2000).

The data corresponding to the first part of MIS 3 indicate a period characterized by rather cold and dry climatic fluctuations. The faunal remains from the lower part of the analysed deposit (SU 15 to SU 4), exclusively attributed to human activities, are characterized by high frequencies of *Bos primigenius*, in association with *Cervus elaphus*, *Dama dama*, *Capreolus capreolus*, *Equus ferus* and by rare appearances of *Capra ibex* and *Rupicapra*. Sporadic remains of carnivores, *Panthera leo* and *Canis lupus,* have also been found. In the upper units the amount of deer and horse is more frequent (Boscato & Crezzini 2012; Spagnolo *et al.* 2016). The faunal association dominated by these taxa indicate that the environment was forest steppe with limited wooden coverage areas.

Regarding the lithic industry of the site, the units so far excavated (SU 15 to SU 1) are characterized by a great predominance of the Levallois concept. The lithic material from the upper levels SU 1 and SU 4 was mainly produced employing the recurrent unipolar Levallois method, the bipolar modality being less represented. In the last phases of debitage, the production could change from unipolar to centripetal modality. The principal aim of production was to realise elongated flakes sometimes retouched. Among those, scrapers are dominant, followed by denticulates and points. Also represented a volumetric orthogonal method (Boscato *et al.* 2011). The lithic production of the SU 8 can be assimilated to the upper layer, consisting predominantly of Levallois production, with reduced presence of volumetric debitage and insignificant discoid production. During the last phases of debitage, the Levallois cores were rearranged in a centripetal or preferential production, aimed at producing flakes (Ranaldo 2005; Ronchitelli *et al.* 2011; Villa *et al.* 2009).

The middle and lower part of the investigated stratigraphic sequence yielded many occurrences of combustion structures. In the SU 13, SU 11 and SU 9 the hearths have two dimensional typologies: small (with diameters of about 20 cm) and large (around 50 cm in diameter). In these stratigraphic units most hearths are located in a belt, separated from the rock shelter wall. In the SU 7 a big hearth (2 m wide) is located in the N-W corner of the shelter. Data suggest that this rock shelter was repeatedly used by Neanderthals during that period; especially in the upper layer there is a significantly different evidence of management of space, with a dissimilar disposition and type of hearths (Boscato & Ronchitelli 2008). SU 13 represents the first stable occupation after the deposition of tephra, SU 14 attests the deposition of tephra with a sporadic and rapid occupation at the end of its accumulation, and SU 15 documents the phases of abandonment of a living floor with evidence of structures.

The SU 13 consists of a compact sediment of sand and small amounts of tephra (that upward progressively rarefy) with small pieces of calcarenite, resulting from the collapse of the shelter walls. This level is a short palimpsest and it has not been excavated in its full extension because partly destroyed by erosion. Two parts were left untouched as a stratigraphic balk, so the layer was excavated for the extension of 11 square meters (Figure 3). The level is characterized by the presence of 10 hearths and quite a lot of faunal remains; however, only six elements were identified, due to high fracture grade (1 = *Equus ferus* and 5 = *Bos primigenius*) (Spagnolo *et al.* 2016).

Figure 3. The top of SU 13. (Photo by P. Boscato.)

2. Material and Methods

The lithic assemblage from SU 13 of the Oscurusciuto rock shelter was analysed using technological analytic methods in order to define the techno-economic processes and technological sequences (Boëda 1982; 1993; 1994;, 2013; Forestier 1993; Geneste 1991; Inizan *et al.* 1999; Leroi Gourhan 1943; Revillion & Tuffreau 1994).

As a first step, the lithic material was divided into five dimensional classes (DC) (first: 1-50 mm^2, second: 51-100 mm^2, third: 101-150 mm^2, fourth: 151-200 mm^2, fifth: > 200 mm^2) on the basis of the area covered by each specimen size. These size classes are necessary for the spatial analysis, in order to identify eventual activity areas and to verify if there was sorting processes of the material due to water flow. The items larger than the second DC were also measured according to their technological axes. Subsequently, all the material was sorted according to the nature and granulometry of the raw material (chert, jasper, siliceous limestone, limestone and quartz sandstone).

Finally, all the technological characteristics of each piece were considered and registered in an Access Database. We took into consideration the technological classes: flakes, cores, pebbles, micro flakes (integral flakes of the first and second DC), debris (fragmented pieces of the first and second DC) and indeterminate fragments (fragmented or altered pieces of the third, fourth and fifth DC). For the flake class we individuated the concept and method of debitage. Then considering the role of each flake (F) during the debitage we were able to recognize the technological categories: predetermining F, predetermined F and indeterminate F. The category of predetermining F includes: completely cortical F (100% of cortex coverage), semi-cortical F (between 99% and 50% of cortex coverage) and management F (all the flakes that are involved in regulating the convexities and angles of a core with less than 50% of cortex coverage). The category of predetermined F encompasses the target F, which are the predetermined objective of the debitage (with or without cortex coverage). Finally the indeterminable F are all the flakes which are too altered or too fragmented to determine their proper role in the knapping activity.

As far as the flakes were concerned, we considered the amount and localization of cortex; the presence of alteration (chemical, post depositional or due to fire) and retouch or traces. We also considered their morphological aspects (morphology, symmetry and section shape); the number and orientation of dorsal scars; the type of butt and bulb; and finally the position of impact point.

A more detailed study on the core was also performed. For this analysis we took into consideration the kind and morphology of support; the volumetric conception of the exploitation; the hierarchy of surfaces; the type, location and way of preparation of the striking platform; the number and direction of the negatives on the surface of debitage; and the possible reason for the abandonment of the core itself.

This technological study was implemented by Raw Material Units analysis (RMU) (also known as MANA: Minimum Analytical Nodule Analysis in American literature), in addition to an intensive program of refits based on the material, in order to identify the technical events from a spatio-temporal perspective (RMU: Chacón *et al.* 2015;Cziesla 1990; López-Ortega *et al.* 2011; 2015; Machado *et al.* 2013; 2015; Marciani 2013; Roebroeks 1988; Romagnoli 2012; Schurmans 2007; Spagnolo 2013; Spagnolo *et al.* 2016; Uthmeier 2006; Vallverdù *et al.* 2010; Vaquero 2008; Vaquero *et al.* 2001; 2012a; 2012b; 2015; MANA: Bruce 2001; Byrnes 2009; Cooper & Melzer 2009; Douglass 2010; Hall 2004; Hall & Larson 2004; Hurst *et al.* 2010; Knell 2012; Larson 1994; Larson & Ingbar 1992; Larson & Finley 2004; Larson & Kornfeld 1997; Miller 2016; Scerri *et al.* 2016; White 2012; Yoshikawa 2010).

To perform the RMU analysis lithic artefacts were sorted on the base of their macroscopic traits such as cortex colour and thickness, texture, colour, inclusions and opacity. Burnt, patinated or altered pieces and tiny specimens were excluded from this analysis.

A RMU can be defined as the material outcome of a knapping event, or as a series of knapping events carried out from a specific nodule (Moncel *et al.* 2014; Roebroeks 1988; Vaquero 2008). It permits dissecting the lithic complex into its smallest units, which are each of the single raw nodules introduced into the site. These data can be useful for two kinds of interpretation: from a spatial-temporal point of view, or from a technological perspective. The role of the RMU in a spatial context and its temporal significance have already been presented in a recent paper (Spagnolo *et al.*2016), hence we will focus on the technological value of RMU analysis and in particular on its functionality in the identification of the fragmentation of reduction sequences.

This methodology has previously been applied to other Middle Palaeolithic contexts (Chacón *et al.* 2015; Machado *et al.* 2011; 2013; 2015; Marciani 2013; Moncel *et al.* 2014; Spagnolo 2013; Spagnolo *et al.* 2016; Turq *et al.* 2013; Vaquero *et al.* 2012a; 2012b; 2015).

3. Results

3.1. Lithic production

In this SU, 7504 lithic artefacts were found. Their preservation condition is very good and their edges are fresh, though the artefacts surfaces show a slight patina caused by chemical alteration. Due to the presence of hearths, some artefacts show various degrees of alteration by fire: 212 elements have been identified with clear burn traces.

The raw material imported into the Oscurusciuto site is characterized by great macroscopic variability. As in all the upper stratigraphic units, the dominant raw materials are jasper and siliceous limestone in their fine granulometry, found in the form of pebbles, which can still be found on the sea-terraces and river deposits around the site (nowadays almost between few tens of meters and 1 km far from the site) (Table 1).

Table 1. Lithological classes. 4025 pieces, because of their tiny dimension (mostly micro flakes and debris of the first and second DC), are excluded from the table.

Raw material	Quantity	%
Fine and medium jasper	1287	37.0
Fine chert	261	7.5
Medium chert	344	9.9
Quartz sandstone	161	4.6
Limestone	70	2.0
Siliceous limestone	1356	39.0
Total	**3479**	**100**

The pebbles imported into the site show a standardized selection of volume (oblongs, oval pebbles), which plays an important role in the choice of the debitage technique. Notably, this morphology is particularly suited to the Levallois concept mainly used at the site. In the conglomerates still visible today nearby the site, there are pebbles with various dimension and shapes. From rather small (between 2 and 3 cm) with angular shape to quite large (more than 10 cm) with oval and globular shape. As the research stand now it is not possible to give an estimation of the dimension of the pebbles used by prehistoric people at the Oscurusciuto, but what we know is that completely exploited cores have dimension that range between 4 and 5 cm. The few pebbles imported as raw material measure between 3 and 4 cm and the only core abandoned at the beginning of its debitage measure 7 x 5 cm.

There is evidence of knapping activity at the site, as revealed by the great presence of micro-flakes (2212) and debris (3446) (debitage waste). This is also highlighted by the spatial analysis that suggests the presence of drop zones (Spagnolo *et al.* 2016). The technological categories of the lithic collection (Table 2) show that all the phases of the *chaîne opératoire* are represented in compatible proportions to the knapping activity. Completely-cortical flakes (20) and semi-cortical flakes (266) attest to the very early stages of production, *i.e.* the opening of the pebble. The management (667), target (344) and retouched (30) flakes indicate the production phase. Finally the cores represent the abandonment. This data may lead to a misinterpretation of the lithic complex because it might make us conclude that several completed reduction sequences had been carried out at the site. This is not the case, in fact thanks to the combined technological studies and the analysis of the RMUs it is possible to point to a more complex and fragmented picture. The lithic collection consists of an addition of various events of manufacture, management, importation and exportation of the lithic material at different stages of production, leading to the conclusion that the archaeological record under investigation is a palimpsest of different actions or events (Hallos 2005; López-Ortega *et al.* 2015; Machado *et al.* 2013; 2015; Rios-Garaizar *et al.* 2015; Spagnolo *et al.* 2016; Vallverdù *et al.* 2005; 2010; Vaquero 2008; Vaquero *et al.* 2001; 2012b).

Just two kinds of debitage were utilized at the level 13: the Levallois concept (documented on the bases of 575 flakes and 18 cores) and the volumetric reduction sequence (15 flakes and 6 cores). All the other flakes (*e.g.*, cortical flakes, indeterminable flakes) and cores do not show enough technical parameters to be able to identify other mode of debitage.

In total, 33 cores have been found. They represent 0,4% of the analysed produce (Table 3).

The group of indeterminable cores is made up of pieces that are in the early stages of exploitation or appear too fragmented. Those pieces do not have the technical characteristics needed to define their concept of debitage. Eighteen cores refer to the Levallois concept. Some of them, which appear too exploited, do not allow the definition of a method of production (indeterminate Levallois). Whereas the others have been equally divided into unipolar or convergent Levallois.

Table 2. Technological composition.

Technological category	Quantity	%
Pebbles	9	0,1
Completely-cortical flakes	20	0,3
Semi-cortical flakes	263	3,5
Management flakes	667	8,9
Micro-flakes	2212	29,5
Indeterminate flakes	203	2,7
Target flakes	344	4,6
Retouched tools	30	0,4
Cores	33	0,4
Indeterminable pieces	277	3,7
Debris	3446	45,9
Total	**7504**	**100**

Table 3. Core concepts.

Concept		Quantity
Levallois	Unipolar	5
Levallois	Convergent	6
Levallois	Indeterminate	7
Volumetric		6
Indeterminable		9
Total		**33**

3.1.1. Levallois reduction sequence

The first phase attested is the selection of supports, whose morphology and convexity enable the initialization of the core by means of the Levallois concept without a proper phase of preparation of the core. After the striking platform opening, follows the cortex removal of the surface of debitage by means of two or three unipolar extractions. Some instances of refitting attest that these unipolar semi-cortical flakes are already the first generation of target objects. Moreover, they also possess the technical characteristic to install the convexity and the guide ribs for the next generation of target flakes.

Subsequently, the presence of flakes involved in the management of lateral and distal convexities have been attested, in preparation of a striking platform and in order to generally manage the cores (management flakes; indeterminate flakes, micro-flakes). These flakes are meant to create the technical characteristic needed to allow the extraction of other predetermined items. The objects that Neanderthals sought to produce here were flakes, backed flakes and convergent flakes. Some of these flakes, besides being target products (predetermined), also have the function of predetermining and re-establishing the right convexity for successive removals (Figure 4).

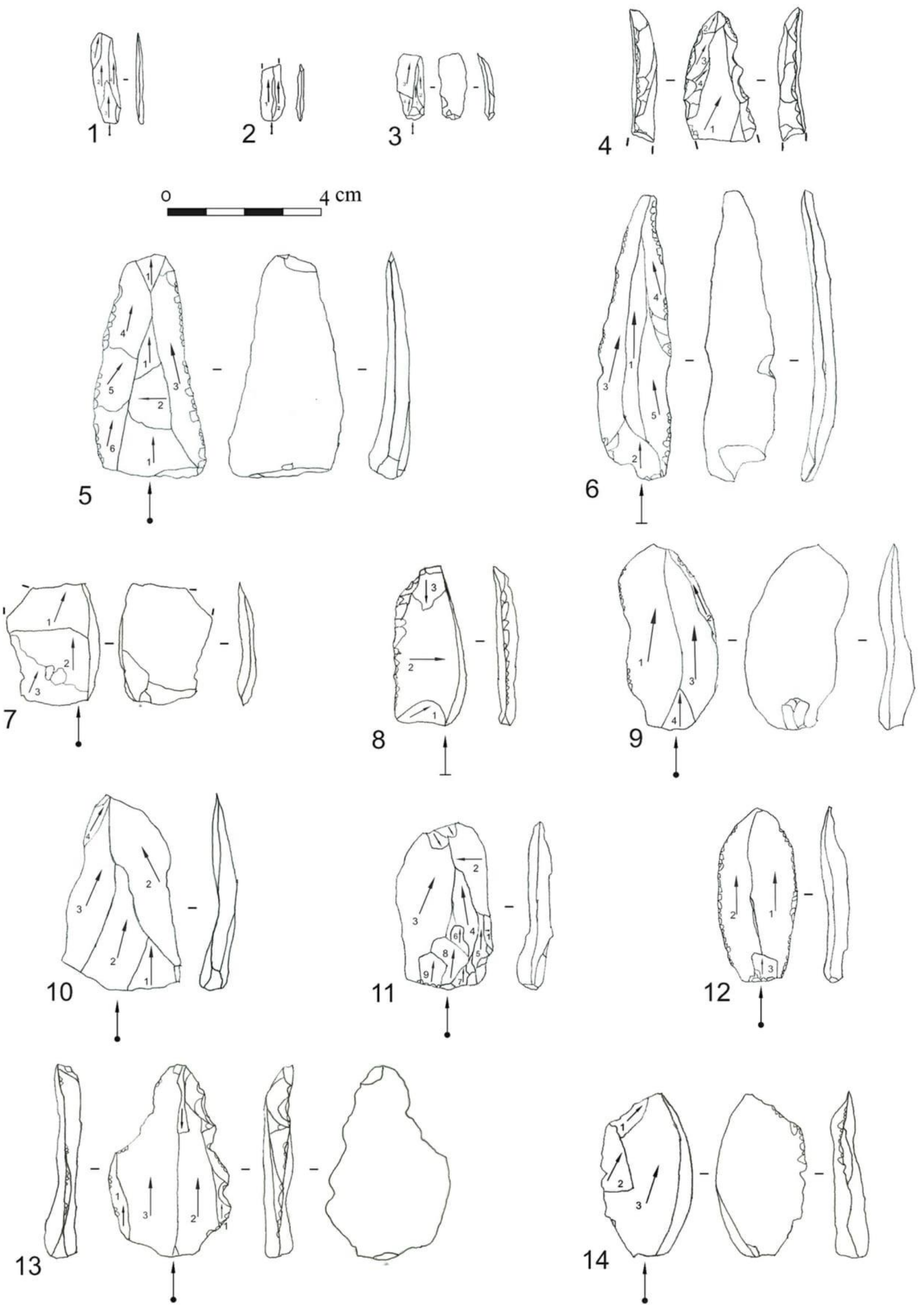

Figure 4. Drawing of target flakes and retouched tools. 1, 2, 3: bladelets, target objective of volumetric production; 4: retouched tool: denticulate point; 5, 6, 10: convergent flakes target objective of Levallois production; 7, 8, 14: backed flakes, target objective of Levallois production; 9,11,12: flakes, target objective of Levallois production; 13: retouched tool: denticulate scraper.

The most used blanks for the Levallois debitage are pebbles and few completely cortical flakes. Thanks to a diacritical analysis, it is possible to determine that the cores, although incidentally, were used until the exhaustion of the reserve of raw material: they were finally abandoned only after repeated rescue attempts. In many cases after a hinged incident there are a lot of other strike performed in order to remove the incident and carry on with the knapping activity (Buonsanto 2012, Buonsanto & Peretto 2012). This behaviour is attested on the base of 7 cores. Only one core was abandoned with no further rescue attempt, due to an error in the early stages of exploitation.

In the unipolar Levallois process, it is common to have one or more partial striking platforms, one of which is used for the extraction of target products, *i.e.* flakes, backed flakes and convergent flakes. The other striking platform, usually on the left, is utilized for the management of distal and lateral convexity by removing little orthogonal flakes. On the right, the craftsman knapped in order to obtain debordant cortical flakes, which are both predetermined and predetermining, playing indeed a double role: they manage the convexities but they are also target objectives. On the contrary, in the convergent Levallois process, the plan of percussion is a large partial one, and both the management and the production of flakes take place from the same striking platform. That means that both researched flake and management flake come from the same striking platform (Figure 5). As for the unipolar modality the target products of the convergent Levallois production are convergent flakes and backed flakes. The Levallois production at this level of Oscurusciuto is recurrent, for this reason, just on the base of the diacritical study of the scar on flakes, is not always possible to recognize a clear break between the two modalities (unipolar and convergent). Leading to the conclusion that convergent and baked flakes could be the aim of both modalities.

The transformation process is evident in the retouched items. Only 30 pieces proved to have been retouched and this is a tiny number compared to the amount of pieces from the production as a whole. Therefore, it is clear that at this point Neanderthals did not feel the need to retouch the supports, but used the sharp edges directly obtained by debitage. The technological category mostly thought to have been selected for retouching is the flake, with a total number of 15 tools, 5 tools made on convergent flakes (Table 4).

Consequently, it can be stated that the majority of the retouched pieces have been made on target flakes (Figure 4). However, there are also a few retouched tools made for managing flakes, such as cortical and generic flakes. The most common retouched tool is the side-scraper with 13 items (Table 4), the majority of which were obtained from the category of flakes and backed flakes.

3.1.2. Volumetric reduction sequences

Compared to the Levallois concept, the volumetric exploitation is merely marginal (Table 3), indeed only 10 bladelets, 5 bladelets management flakes and 6 cores attest to the presence of this production process. The volumetric debitage consists of short reduction sequences made exclusively on flakes or fragments. These blanks were chosen because of their technical characteristics, which permit the production of bladelets without a real preparation of the core. The knappers took advantage of the ribs, angles and convexities partially already present on these pieces to initialize the core. What is interesting is that usually the volumetric cores are abandoned before the phase of real production.

Thanks to the diacritical analysis of those cores it was possible to ascertain that they were aimed at producing bladelets (Figure 4). We can summarize the technical parameters of bladelets as follows: pseudo rectangular and symmetrical morphology support, presence of central guide rib and usually two unipolar detachments for side management (Figure 4). These bladelets were not retouched.

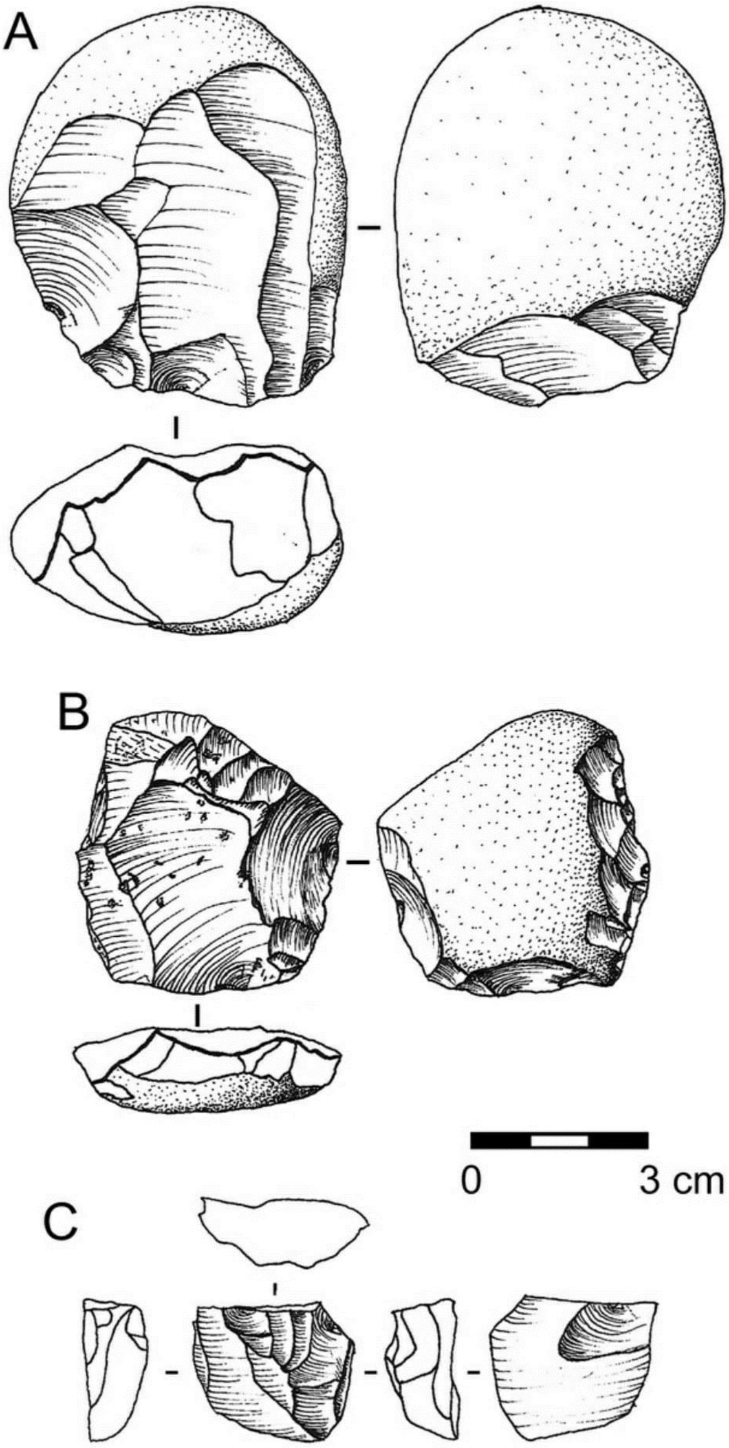

Figure 5. Drawing of cores. A: unipolar Levallois; B: convergent Levallois; C: Volumetric.

Table 4. Retouched tools and technological category.

Technological category	Notch	Denticulate scraper	Lateral scraper	Denticulate point	End scraper	Retouched fragment	Quantity
Cortical F	1		2				3
Management F	1	1					2
Flakes	1	3	6	1	2	2	15
Convergent F			2	1		2	5
Backed F			3				3
Indeterminable						2	2
Total	**3**	**4**	**13**	**2**	**2**	**6**	**30**

3.2. Target objectives: Flakes, backed flakes, convergent flakes, bladelets

The Levallois reduction sequence is an integrate concept that allows production of a great quantity of predetermined products with specific characteristics and dimensions (Boëda 2013). In this section we would like to evaluate the recurrent features of these target objects in order to identify what technical characteristics were sought for each type.

Generally, the target object has quite constant characteristics, which are summarized in Table 5. Notably, there are rectangular symmetrical bladelets; oval and trapezoidal, often symmetrical flakes; oval backed flakes; and triangular convergent, even asymmetrical, flakes. The sections are generally triangular, but in some cases trapezoidal for flakes and convergent flakes, and in shape of rectangular trapeze for backed flakes. The cortex is absent or slightly invasive for all categories, except for the backed flakes, 80% of which have a dorsal cortex. This particular feature of the backed flakes may indicate that these items were created to present a sharp side opposite a backed cortical side, which was very useful as a prehensile part. All types of flakes have rather unipolar negatives, except for the convergent one, in which the negatives are convergent. The number of negatives fluctuates between 2 and 4.

Table 5. Target products main characteristic

Characteristic	Bladelets	Flake	Backed flakes	Convergent flakes
Total number	26	200	37	88
Morphology	rectangular	oval; trapezoidal	oval	triangular
Symmetric	92%	64%	59%	44%
Section shape	triangular	triangular; trapezoidal	triangle; rectangular trapeze	triangular; trapezoidal
Cortex until half of the surface	4%	23%	81%	7%
Cortex localization	distal	lateral	dorsal	lateral
Scar directions	unipolar	unipolar	unipolar	convergent
Scar number	2; 3	3; 2; 4	2; 3;4	3; 4; 2
Butt	flat; point-form	facetted; flat	facetted; flat	facetted; chapeau de gendarme; flat
Impact point	central	central	lateral	central
Bulb	not prominent	prominent	not prominent	prominent

The butts are flat and point-shaped for bladelets, faceted and flat for the other types of flakes, and faceted *chapeau de gendarme* for the convergent flakes. The impact points are central, with the exception of the backed flakes which have lateral impact points. The flakes and convergent flakes have prominent bulbs, while bladelets and backed flakes have no prominent bulb.

From the dimensional point of view the Levallois products show very variable dimensions, ranging from rather small items (1.5 cm in length) to quite large ones (7.5 cm in length). This dimensional variability is due to the recurrent nature of the Levallois process, which enables a continuous production of flakes without a restructuration of the core, producing the same type of target flakes in a variety of dimensions. This leads to a progressive reduction of the cores, and thus of their products. On the other hand, the items resulting from volumetric production show a certain dimensional consistency: the ratio between length and width is almost the same for all pieces. This might be interpreted as a wish to produce bladelets of only one size, whereas the former production method testifies to the need of producing items of different sizes.

The graph (Figure 6) shows the distribution of values of the elongation index of the four categories of target flakes identified at the SU 13. Flakes and convergent flakes have elongation index values lower and more concentrated than bladelets and backed flakes, which are longer but with a higher variation of elongation index.

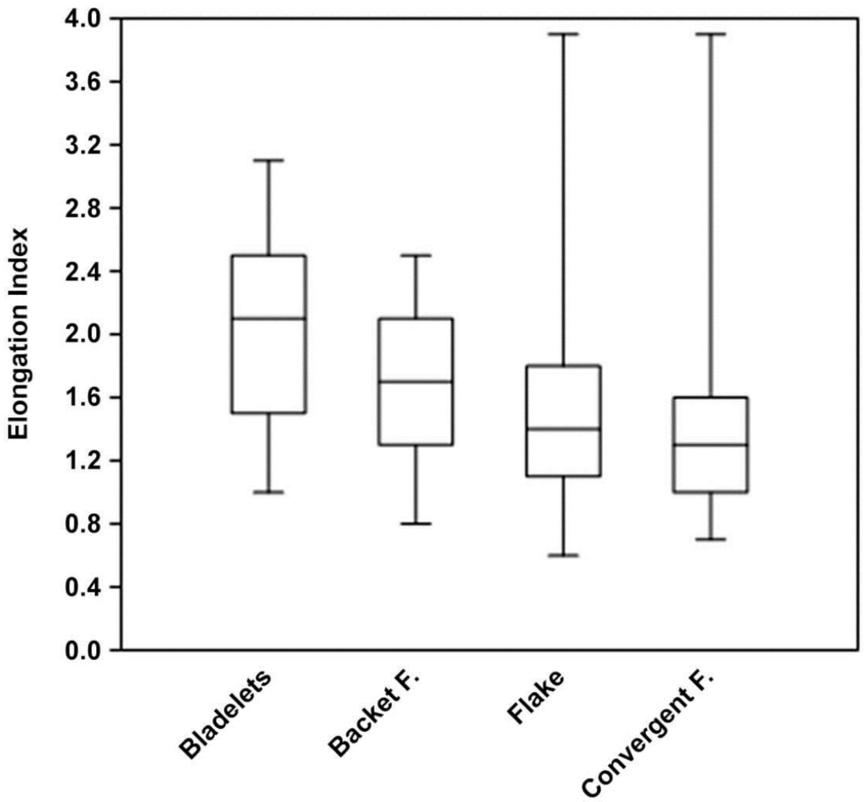

Figure 6: Elongation Index target flakes. Bladelets (N = 26), backed flakes (N = 37), flakes (N = 200) and convergent flakes (N = 88).

3.3. RMU: Import, export

Despite the limitations posed by the incompleteness of the excavated area and by the fact that not all the materials are comprised in the RMU (5197 pieces of first and second DC are excluded), we were able to identify a great number of RMU: 279 RMU made up of 1770 pieces, and of this group 128 formed 53 refitting or conjoint sets. Each RMU is made up of many or few pieces and they also show variations in their technological composition. A great number of RMUs consist of one or a few pieces (max 5 items), whereas there are few RMUs with many items (Table 6).

Table 6: Quantity of pieces in each RMU, and amount of pieces and RMU for each raw material.

Quantity of pieces in each RMU	Fine and medium jasper	Fine chert	Limestone	Medium chert	Quartz sandstone	Siliceous limestone	Total RMU
pieces	679	98	16	263	144	570	
1	30	2	6	14		48	100
2 to 5	31	7	1	20	1	39	99
6 to 20	21	2	1	13	1	23	61
21 to 40	8			1	2		11
41 to 60	2	1		1		2	6
> 60					1	1	2
Total RMU	**92**	**12**	**8**	**49**	**5**	**113**	**279**

From a technological point of view the target or the retouched objects are part of the RMUs consisting of just one piece or few pieces. That means that all the reduction sequences of these pieces might have occurred outside the rock shelter, consequently these pieces could have been introduced into the site as already finished objects, thus they could be considered imported items. Some of the cores (most of them almost depleted) also belong to this first group of RMUs with few pieces. The absence of the target product belonging to these cores make us hypothesise that the finished tools were exported from the site. The few RMUs, where all the phases of the reduction sequences are simultaneously represented, give us the evidence to support the idea that some RMUs were introduced into the site as raw pebbles, which were then knapped completely at the site (Spagnolo *et al.*2016).

On a close examination, considering the number of pieces in each RMU and their technological composition (*i.e.* which type and how many pieces relate to the different phases of the reduction sequence: acquisition = pebbles; management = management flakes and micro-flakes; production = target flakes; abandonment = completely exploited cores) it is possible to gain a higher and more detailed definition (Table 7).

The importation of materials from outside to inside the rock shelter (Import) is documented by the presence of imported pebbles (7 RMUs) and target flakes (47 RMUs). It is also possible to envisage the import of semi-worked objects based on 47 RMUs, which include all stages of the reduction sequence excluding the cortex removal, which necessarily occurred elsewhere (Table 7).

The transport of objects from the site to the outside (Export) is attested by the RMUs with incomplete reduction sequences. The presence of 40 RMUs made up only of completely-cortical and semi-cortical flakes, leads us to suppose that the first phase of pebbles opening and decortication took place at the site. Later these pebbles were exported from the site as semi-worked pieces (1°stage). Two RMUs, composed only of management pieces, indicate the export of semi-finished items related to a more advanced stage of the reduction (2°stage). Moreover the presence of 24 RMUs composed of numerous elements of cortex removal and management but lacking target objects suggests the export of these finished tools.

Furthermore there are 9 RMUs in which all stages of the reduction sequence are attested in situ and 49 RMUs where all phases of the reduction sequence except for cores are represented. The cores usually can be reused, removed from the site or treated as waste. In both the former cases it is assumed that the above 58 RMUs were introduced in level US 13 as pebbles and entirely knapped inside the rock shelter from the first stages of debitage until abandonment.

Table 7: Technological composition of RMU, their explanation in terms of human behaviour and number of RMU that support this evidence.

RMU composition	Behavioral explanation	N. of RMU
Pebble	Acquisition	7
Target flake and core	Import-Finished tool	4
Target flake	Import-Finished tool	34
Decortex and target flake	Import-Finished tool	8
Decortex, target flake and core	Import-Finished tool	1
Outside decortex, inside production	Import-Semi worked items	47
Decortex and management in situ	Export-Finished tool	23
Management and core	Export-Semi worked items	2
Decortex, management and core in situ	Export-Finished tool	1
Just inside decortex	Export-Semi worked items	40
Complete reduction sequence without core	In situ production	49
Complete reduction sequence	In situ production	9
Only complete exploited core	Waste	9
Just inside management	Indeterminable	45
Total		**279**

Nine RMUs are made only by completely exploited cores indicating the abandonment and waste of debitage. Finally for 45 RMUs (made up of management flakes) it was not possible to envisage a behavioural interpretation.

4. Discussion and conclusions

To sum up, the technical behaviour of Neanderthals at level 13 of Oscurusciuto shows a great degree of fragmentation of the reduction sequences. The record is made up of several instances of introduction of lithic material at different stages of manufacturing. Pieces were introduced in the form of rough objects (pebbles), as well as semi-finished items, and as finished tools.

As a result of technological analysis and the study of the RMUs we are able to propose a scenario of how the Neanderthal production of lithic material occurred at the Oscurusciuto level 13. Once pebbles had been imported, there is a unipolar Levallois process of cortex removal and a first-generation of unipolar flakes, then followed a phase of core-restructuration in order to get a second generation of unipolar supports, or a restructuration in a convergent Levallois process, concluded by a convergent production. However, convergent Levallois cores may also have been introduced to the site as semi-worked pieces. The same scenario is valid for the volumetric cores which, made from flakes or fragments, may have been imported into the site as semi-worked items, or which may simply have been broken fragments resulting from in situ knapping. Furthermore, tools have been imported into the site as finished objects while, in return, some finished objects have been exported from the site. At some point, also some tested pebbles and semi-manufactured pieces were exported from the site (Figure 7).

The fragmentation of the *chaîne opératoire* in several instances of import or export demonstrate the palimpsest nature of the level which is made up of different events happening one after another. This also indicates a certain mobility of the population in this territory. In other words, there would then necessarily be other sites where the complementary phases of the reduction sequences have taken place, or where the respective target products were utilized and abandoned.

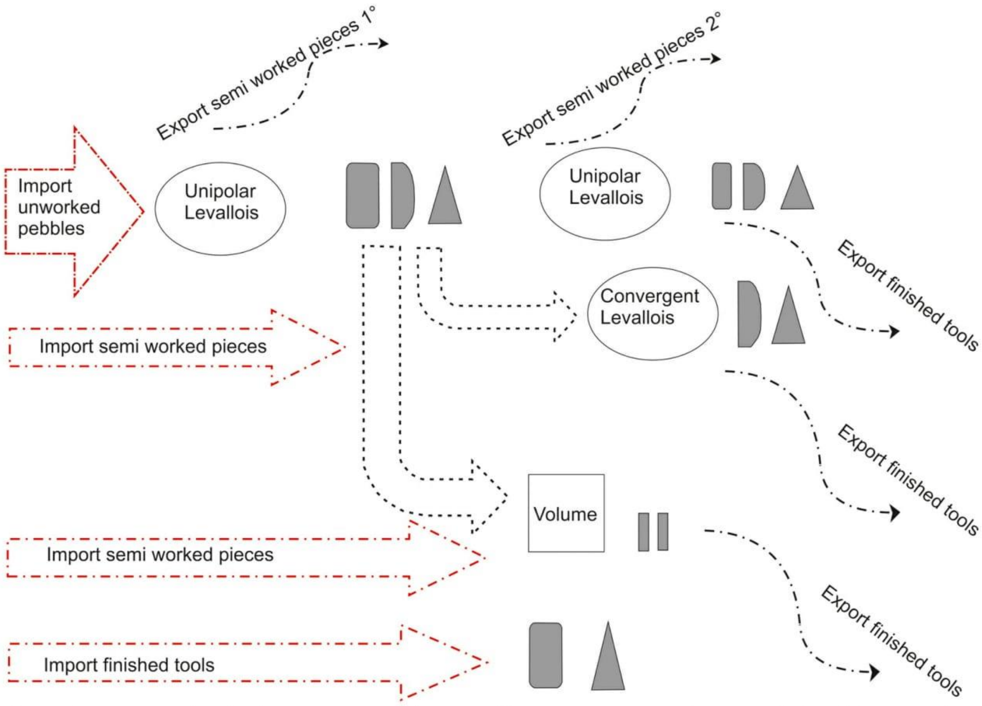

Figure 7. Fragmented reduction sequences. The grey silhouettes represent the target flakes (big rectangle = flakes; triangle = convergent flakes; half oval = backed flakes; small rectangle = bladelets).

Not far from Oscurusciuto in the peninsula of Salento, more precisely in the layer L of Grotta del Cavallo (at the end of MIS, 5 beginning of MIS 4), a high degree of mobility in the territory is attested for Neanderthal populations on the basis of a different archaeological record. Together with the fragmentation of the reduction sequences, it also demonstrates the recycling of lithic tools. This evidence is proved by the presence of pieces with double patinas, exogenous raw materials and objects characterized by a large investment in retouching. This behaviour is interpreted as an occasional practice performed in response to unplanned needs (Romagnoli 2012; 2015).

Having reached some conclusions, new questions and problems arise. We have noted that the target flakes could be both the main objects in actions of import and export, as well as the ultimate goal of the whole process of debitage. But what exactly was their role in the society where they were produced? Since they represented a great technical investment, were they objects meant to have a comparatively long life? In order that these questions are adequately answered it is necessary to perform techno-functional and use wear analysis. Afterwards, these data will be analysed in the GIS platform to gain specific information on the functionality of the spaces.

The results obtained with the study of RMUs invite us to continue in this direction. In fact, we decided to carry out a specific experimental protocol with the aim to further verify the interpretation given on the basis of the study of the RMUs.

Acknowledgements

The authors are indebted to the Soprintendenza Archeologia della Puglia, Municipality of Ginosa, Onlus CESQ, to Piero di Canio and to all the students and colleagues (Claudia Abruzzese, Francesco Boschin, Silvana Condemi, Jacopo Crezzini, Elena D'Itria, Stefania Mainieri, Giulia Musella, María José Peñalver Puerta, Marco Serradimigni) who participated, together with the authors, in the excavation of 2011. We would like to warmly acknowledge Brigitte Hoiberg Nilsen and Sharada Channarayapatna for proofreading this article. This paper was presented at 10th International Symposium on Knappable Materials On the rocks held in University of Barcelona between 7 and 15 September 2015. We would like to acknowledge Marta Arzarello, Claire Gaillard, Luca Foresi, Marcos César Pereira Santos, Sem Scaramucci, Antoine Lourdeau, Lucia Dallafior the session organizers Killian Driscoll and Didac Roman and the two anonymous reefers that provide precious advice to enrich this paper.

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Paper 2: Target objects, techno-functional and use-wear analysis

MARCIANI, G., Arrighi, S., Aureli, D., Spagnolo, V., Boscato, P., Ronchitelli, Middle Palaeolithic lithic tools. Techno-functional and use-wear analysis of target objects from SU 13 at the Oscurusciuto rock shelter, Southern Italy. Journal of Lithic Studies.

Presented at:

11 th International Symposium on Knappable Materials. "From tool stone to stone tools"

Buenos Aires, Argentina 7-12 November 2017.

Session 2 Production and maintenance of stone tools: How were stone tools made and maintained?

Middle Palaeolithic lithic tools. Techno-functional and use-wear analysis of target objects from SU 13 at the Oscurusciuto rock shelter, Southern Italy.

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Abstract:

The Oscurusciuto rock shelter (Ginosa, Puglia, southern Italy) is a Middle Palaeolithic site characterized by a significant stratigraphy made up by several anthropic levels. The stratigraphic unit 13, consisting of a sandy compact deposit mixed with pyroclastic sediment, is a short palimpsest situated on a layer of tephra, identified as Mt. Epomeo green tuff (dated Ar/Ar ~ 55 ka BP).
From a technological point of view, the aims of the production were backed flakes, convergent flakes, and other flakes obtained by means of a levallois debitage, plus (less represented) bladelets produced by an additional volumetric reduction system.
Our aim in this research was to examine a selection of the above-mentioned target objects produced by debitage in order to understand the manufacture and life-cycle of each single tool from a dynamic perspective.
We integrated techno-functional and use-wear analyses: the first was implemented to globally comprehend each tool, identifying each single techno-functional unity (prehensile and transformative portions), whereas the second revealed the way in which these tools had been used, proceeding to identify the activity involved (e.g. piercing, cutting and/or scraping), and the type of material (vegetable/animal, soft/hard) on which these activities had been carried out. The combined use of these two approaches allows us to ascertain the intention of the prehistoric craftsmen, the gestures and procedures involved in making the tools, and the way they had been used. From one single object we are thus able to reconstruct a series of complex behaviours, encompassing the creation, the life-cycle and finally the 'death' or repurposing of the tool in question.

Keywords: Technical Behaviour; Techno-functional approach; Use-wear analysis; Middle Palaeolithic; Neanderthals; Western Europe

1. Introduction

The Oscurusciuto site is a Middle Palaeolithic rock shelter located in Southern Italy with a very rich record, essential for the definition of the technical behaviour of Neanderthals, as related both to the management of the raw material of the territory and the crafting and use of lithic tools. The lithic collections of Oscurusciuto show substantial uniformity even though each level displays its own peculiarity. The acquisition of raw material is local; Neanderthals used pebbles of jasper, chert, cherty limestone and quartz sandstone available in the terraces and areas near the site. The recurrent levallois method is the most commonly noted concept of debitage especially in its unipolar modality aiming at producing elongated supports, both convergent or not. Furthermore, there is additional volumetric exploitation aiming at producing bladelets (Boscato et al., 2011; Marciani, 2013; Marciani et al., 2016; Ranaldo, 2005; 2017; Ronchitelli et al., 2011; Spagnolo, 2013; 2017; Spagnolo et al., 2016; Villa et al., 2009).

As it is widely known, the levallois reduction sequence is an integrated concept that allows for a production of a great quantity of predetermined products with specific characteristics and dimensions (Boëda, 1991; 1993; 1994; 1995; 2013; Schlanger, 1996; Van Peer, 1992). The degree of predetermination of this concept regards both obtaining of a certain quantity of target products (resulting from the lineal\preferential or recurrent levallois debitage) and their quality (Boëda, 1991; 1993; 1994; 1995; 2013). It also testifies to a specific economic strategy with regard to the maximization of cutting edge productivity obtained from cores (Brantingham and Kuhn, 2001; Lycett and Eren, 2013).

The levallois production at the Oscurusciuto stratigraphic unit 13 was aimed at producing a clear set of debitage goals: flakes, convergent flakes and backed flakes. In previous studies we have noted the peculiar and recurrent features of these objects and their particular role in the economy of the level (Marciani, 2013; Marciani et al., 2016). We assumed that these target objects had been imported as finished objects into the site, or had resulted from an in situ debitage process (Marciani, 2013; Marciani et al., 2016; Spagnolo et al., 2016).

As the target objects are the answer to specific needs and necessities which motivated the flaking activity itself (Boëda, 2013), we examined the role played by levallois target objects in the society where they were produced. In particular, our main objective for this work was to focus on the levallois target flakes produced at Oscurusciuto SU 13. We wanted to test (1) if the target objects of a reduction sequence (the production aim), were actually used by Neanderthals to perform their activities (the functional aim); (2) if each production aim corresponded to a single functional aim i.e. each tool was used solely for one activity, or, on the contrary, used for a multitude of purposes; and finally (3) if tools used for a specific activity also had a specific structure.

To accomplish these goals we integrated techno-functional and use-wear analyses: the first was implemented to globally comprehend each tool, identifying each single techno-functional unity (prehensile and transformative portions), whereas the second revealed the way in which these tools had been used, proceeding to identify the activity involved (e.g. piercing, cutting and/or scraping), and the type of material (vegetable/animal, soft/hard) on which these activities were carried out.

From a methodological point of view, we note that both techno-functional and use-wear analyses have been applied on several lithic assemblages coming from diverse archaeological contexts and periods (e.g. Boëda, 1997; 2001; Soriano, 2000; Da Costa, 2017; Lourdeau, 2010), however, few works have attempted to combine them (Aureli et al., 2015; 2016; Boëda et al., 2015; Bonilauri, 2010; Pedergnana, 2017). In the case of the site of Ficoncella (Rome – Italy; dated back to 500,000 years BP), the combined use of techno-functional and use-wear approaches was essential to determine the technical structure and the peculiarities of active unities (trihedral, mini-rostrum and brute cutting edge) barely described before in lower Palaeolithic literature (Aureli et al., 2015; 2016). Another outstanding example is the case of Umm el Tlel site (central Syria – dated back to 40,000 years BP). Here the authors were able to evidencethe technical role of the bladelets. These very well-known tools actually resulted from different production systems, performed several tasks, and were hafted in different ways (Boëda et al., 2015).

The challenging point about the applying these two approaches together is that there is an added value by their combined use. In fact, the technological analysis permits us to understand the production procedure of lithic tools, and the techno-functional analysis allowed us to understand the structure of the tool, as well as the functional potential of the parts constituting the tool. Finally, the use-wear analysis verifies or rejects the hypotheses. Tracceologists can also use the techno-functional study as a proxy for the selection of their samples, i.e. defining the significant criteria to select the pieces to analyse, and examining traces guided by technical questions. It is worth remembering that these approaches work in a continuous dialogue, comparing and integrating the observations coming from each approach.

As a matter of fact our contribution with this paper is to demonstrate the complementarity and added value of combination of these approaches, which produce new and stimulating insights into "the ways of existing" of prehistoric technical objects (*Du mode d'existence des objets techniques* Simondon, 1958)

2. The site

The Oscurusciuto rock shelter is situated in the region of Puglia, Southern Italy, namely in the ravine of Ginosa (Taranto) (Figure 1).

Figure 1: panoramic view of the ravine of Ginosa, in the red circle the Oscurusciuto rock shelter (Photo A. Ronchitelli).

The site, opened into the Pleistocene calcarenite (*Calcareniti di Gravina*), stands at an elevation of 235 m above sea level, at about 15 meters from the current bottom of the ravine, and at about 20 km far from the actual Ionic coastline (Figure 2).

Figure 2: Location of Oscurusciuto (Modified from Google Maps).

The archaeological deposit measures 60 m^2 at its base, and has a thickness of more than 6 meters. This sequence extension downwards gradually increases because the hill erosion damaged the deposit in the shelter, especially on the upper layers (Figure 3). Since 1998 until the present day, the first 3 meters of the sequence corresponding to nine main Middle Palaeolithic occupation phases have been investigated by the U.R. “Preistoria e Antropologia” under the “Dipartimento di Scienze Fisiche, della Terra e dell’Ambiente - University of Siena, Italy”.

The chronological limits of the Neanderthal occupation of the rock shelter are obtained by two dates. The first, obtained by the C14 method (on collagen), is referred to the bottom of SU 1 which is datable to 38,500 ± 900 BP, cal. 42,724 ± 716 BP Beta 181165 (Ramsey and Lee, 2013; Reimer et al., 2013). The former derives from the identification of the tephra layer (SU 14) as Mount Epomeo green tuff (Marciani et al., 2016; Spagnolo et al., 2016) datable to about 55,000 BP (Allen et al., 2000).

The faunal associations found at Oscurusciuto are characterized by the main presence of *Bos primigenius, Equus ferus, Cervus elaphus* and *Dama dama* in different variations and associations, which show both little paleo-climatic fluctuations and the coexistence of different biomes, possibly related to a micro-scale landscape variability linked to the ravine environment. Essentially, the studied samples (from SU 15 to SU 1) show that the Neanderthal hunters exploited two different environments: a forest-steppe area, probably present on the hilly relieves, and a moister territory with wooden coverage, inside the ravine (Boscato and Crezzini, 2012; Boscato, 2017).

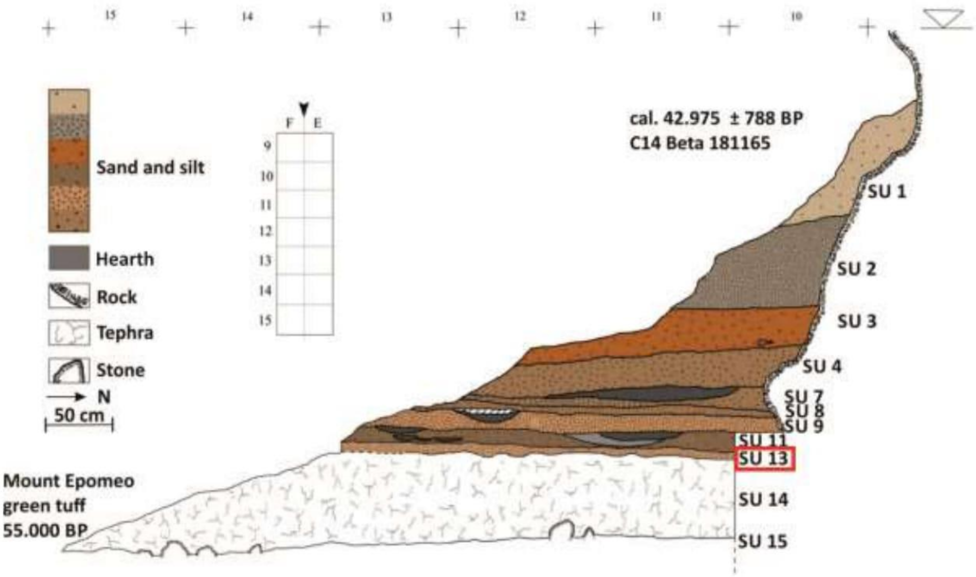


Figure 3: Stratigraphic sequence of the upper portion of Oscurusciuto rock shelter (sequence so far excavated) (Relief made by P. Boscato; draw A. Ronchitelli).

SU 13 (Figure 4) consists of the sedimentary interface between the SU 11, sandy layer above, and the SU 14, the proper tephra deposit. It represents the first stable re-colonization of the rock shelter which occurred during the final phase of volcanic ashes deposition (Marciani et al., 2016; Spagnolo et al., 2016) (Figure 3). It is a short palimpsest excavated for the extension of 11 square meters. The level is characterized by the presence of quite abundant faunal remains; however, only six elements were identified, due to high fracture grade (1 = *Equus ferus* and 5 = *Bos primigenius*). Above SU 13 a series of structured hearts made in prepared dimple was exposed which seems to be arranged in a line that divides the space of the rock shelter into two portions: inside and outside the line of fires (Spagnolo et al., 2016).

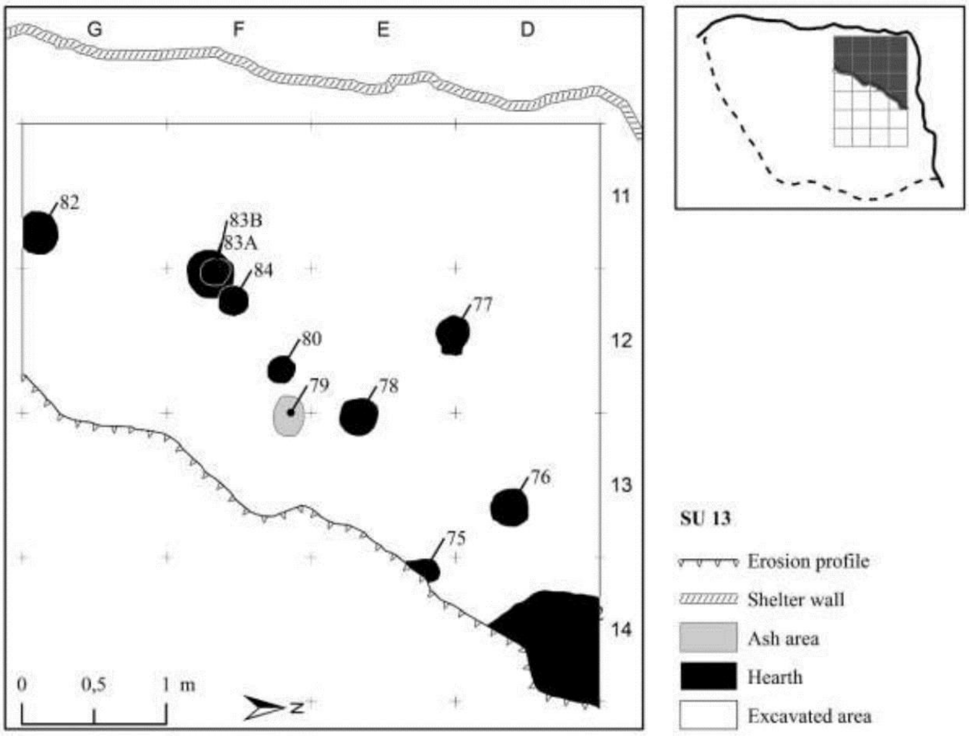


Figure 4: SU 13 planimetry (Relief made by Boscato, draw by Spagnolo).

3. Material and Methods

3.1 Lithic production

In SU 13, 7504 well preserved lithic artefacts were found. As in all the upper stratigraphic units, the dominant raw materials are jasper and cherty limestone in their fine granulometry, found in the form of pebbles, which can still be found on the sea-terraces and river deposits around the site (nowadays almost between few tens of meters and over than 20 km far from the site) (Marciani, 2013; Marciani et al., 2016).

The occupation of SU 13 is a short palimpsest that was possible to disentangle in at least two (if not most) settlement events (Spagnolo et al., 2016; Spagnolo, 2017). The lithic collection corroborates this idea because there are several fragmented reduction sequences. Namely, the lithic material was entered into the site at different stages of debitage, which means in the form of rough objects (pebbles), or as semi-finished items (decortication happened outside the rock shelter), and as finished tools (target objects or retouched tools). However, there is evidence of pieces exported from the site, especially the target objects. Only 30 pieces have been retouched (Marciani et al., 2016).

Only two concepts of debitage were utilized at the level 13: the levallois concept and the additional volumetric reduction sequence. Namely, the latter refers to an additional production aimed at producing bladelets where the striking platform is prepared but the convexities are not prepared and only the natural convexities of the raw block are used, i.e. C2 type of cores according to Boëda classification (Boëda, 2013).

In this paper, we will focus only on the levallois products: flakes, convergent flakes and backed flakes. From a totality of 385 target pieces (Marciani, 2013; Marciani et al., 2016) we selected 312 target objects with clearly recognizable technical features (fragmented or post-depositional altered pieces were excluded from the study).

In the text we refer to the objective of debitage\end-products with the expression “target objects” (target flakes, target blade, ecc.) because we think that even if not very common in bibliography it expresses very well the strong degree of intentionality used in order to produce them.

3.2 Techno-functional analysis

The techno-functional analysis is the study of the structure and potentiality of tools which are defined as objects consisting of three main parts: transformative part, transmitting part and prehensile part. These parts are defined as techno-functional unities: the UTFt - transformative techno-functional unit corresponds to the active portion of the tools plus the edge, which is the part which actually enters into contact and modifies the material; the UTFp - prehensile techno-functional unit is the holding portion. Between them, there is the transmitting techno-functional units (UTFtr) which is conceived as an intermediate section that drives the force from the handle to the active portion (Boëda, 1997; 2001; 2013; Bonilauri, 2010; Da Costa, 2017; Lepot, 1993; Lourdeau, 2010; 2015; Soriano, 2000).

The techno-functional unities are indispensable for a tool to work, as is the synergy between them that makes the tool able to realize an action. Identifying these parts and understanding their synergy allows us to understand the potential capacity of each single tool. Furthermore, in addition to prehensile, active and transmitting parts, we should not forget the role of the gesture. Namely, the specific gesture involved in moving a tool is indispensable for the proper functioning of the tool, whereby we mean the kind of action, as well as the actual movement, both of which made the tool technically worthwhile (Leroi Gourhan, 1973).

The identification, location and characterization of UTFt and UTFp lay in empirical observation of the objects and collection of objective data. Whereas the identification of the transmitting part is much more difficult to perceive, for this reason in this work we consider together the prehensile and transmitting parts (Boëda, 2001; Bonilauri, 2010; Da Costa, 2017; Lourdeau, 2010; Soriano, 2000).

After analysing each single piece, comprising the identification, characterization and localization of each UTF, we have identified groups of pieces that share the same structural composition, i.e. techno-type. Going more in detail, a techno-type is defined by pieces with the same number and characteristic UTFt; and the same position and number of UTFp. The sub-types are inner variations of techno-types in our case expressed by the delineation and position of cutting edges. After defining the techno-types and sub-types, i.e. the combination of UTFt and UTFp, we have identified how these combinations were arranged on each blank.

3.2.1 Defining the blank

The blank is actually the support on which the UTFt and UTFp are installed. At Oscurusciuto SU 13 we defined blanks on the basis of four parameters: shape, section, elongation index and size of the pieces.

The shape could be rectangular, when there are 2 parallel\sub parallel edges plus a transversal edge (these edges could be sharp of backed; in this group trapezoidal and oval shapes are also considered); or triangular when there are 2 edges converging into a point (Figure 5). The section of the piece takes into consideration the section-shape of the items but also the number of cutting edges. This means that triangular and trapezoidal pieces have 2 cutting edges, whereas rectangular-triangle and rectangular-trapeze have only one cutting edge opposed to a backed side (Figure 5). The elongation index is given by the ratio between height and width. If the result is less than 1,4 it is a flake, if the result is comprised between 1,5 and 2 it is a long flake, if the result is major then 2,1 it is a blade (Figure 5). The size of the pieces is based on the graphic of dispersion of the height of these pieces of Oscurusciuto SU 13. We define a piece as “small” if its maximum height is until 20 mm, “medium” if it is comprised between 21 and 34 mm and “big” if its height is higher than 35 mm (Figure 5).

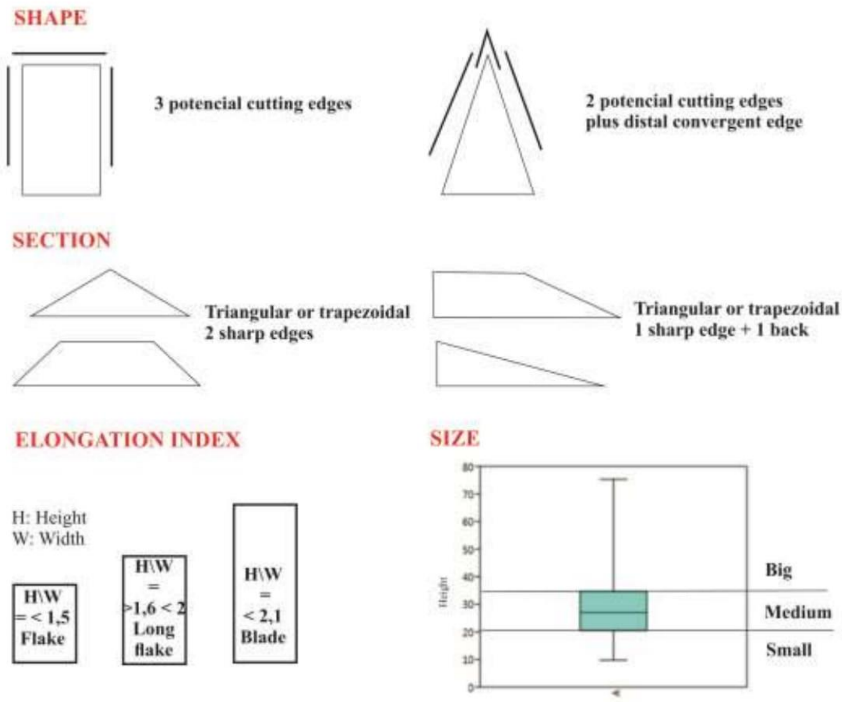


Figure 5: Shape, section, elongation index and size of the pieces (the size is based on the height of the pieces box plot realized with Past 3.16).

3.2.2 Defining Transformative parts (UTFt)

We identified two types of UTFt: the cutting edge and the trihedron. The cutting edge is a dihedron made up by the intersection of two surfaces, which delimits a plan section and an angle able to cut (Lepot, 1993; Soriano, 2000). In order to define the cutting edges we consider its delineation (from frontal and profile view, which could be: rectilinear, convex, concave and denticulate), location (distal, mesial, proximal, mesio-distal, mesio-proximal; left or right), extension (expressed in mm) angles, and surfaces relation (Plan/Plan; Convex/Plan; Concave/Plan; Convex/Convex; Concave/Concave) (Abruzzese et al., 2016; Boëda, 1997; 2001; Bonilauri, 2010; Da Costa, 2017; Lepot, 1993; Lourdeau, 2010; Lucas, 2014).

The trihedron is defined as a geometric figure composed of three planes meeting at a single vertex. As UTFt the trihedron is a punctual UTF, which means that it does not have an extension. In order to define the trihedron we consider its location, surface relations, angles, that is the angle made by the surfaces (section plan between ventral and dorsal surface of the item) and the openness angles which is the angle made by the two lateral sides (left and right side of the items) (Aureli et al., 2016; Rocca, 2013) (Figure 6).

If there is more than one UTFt on the same blank we register which kind of relation exists between them: contiguous if the two (or more UTF) are in an adjacent position and in contact between them, and opposed if the two (or more UTF) are in front of each other. All the parameters are considered with the flake oriented in the technological axis.

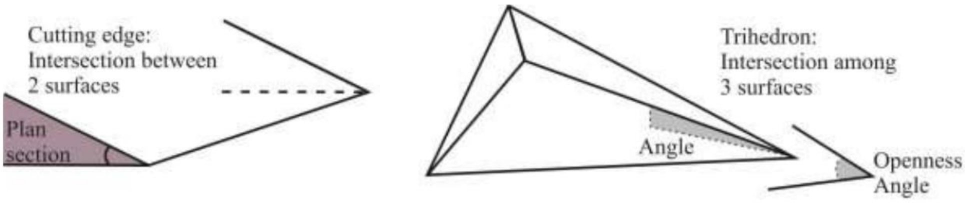


Figure 6: UTFt cutting edge and UTFt trihedron.

3.2.3 Defining Prehensile parts (UTFp)

In the absence of evident grip-traces or glue residues, so far, we consider as potential UTFp all the backed sides, the cortical edges and more in general a discontinuous and irregular edge (Soriano, 2000). The butt is also considered as potential grip, in fact especially for levallois *chapeau de gendarme*, the ergonomic features of its shape are already attested in experimental studies (Baena Preysler et al., 2016). We consider the thickness, location, angles and extension of UTFp. A notable parameter when defining the structure of a tool is the relation between backed sides i.e. a single backed side, two continuous backed sides, two opposed backed sides, or three framed backed sides (Da Costa, 2017).

3.3 Use-wear analysis

The use-wear analysis was performed on 34 items identified as Type-blank A (see paragraph 4.1). The study was carried out by means of both the low power approach (LPA) (Odell, 1981; Odell and Odell-Vereecken, 1980; Tringham et al., 1974, and for more recent discussions or applications see Lemorini, 2000; Plisson, 2007; Rots, 2010) and the high power approach (HPA) (Keeley, 1980; Plisson, 1985; Van Gijn, 2010).

LPA is focused on analysis and interpretation of macro use-wear (edge-removals, edge-rounding) while HPA is based on the observation of micro use-wear (micro edge-rounding, polishes, striations).

Macro use-wear was observed at low magnification (20x - 80x) by means of a Hirox KH 7700 3D digital microscope, using a MX-G 5040Z body equipped with an AD-5040Lows and an AD-5040HS lens. Micro-wear analysis was performed using the mentioned Hirox microscope fitted out with a MXG-10C body and an OL-140II lens (140x- 480x). The microscope enables us to obtain in-focused pictures through the overlapping of planes taken at different focus levels (Arrighi et al., 2016; Moretti et al., 2015).

The traces on the archaeological lithic tools were interpreted by means of the comparison with the experimental reference collection of the U.R. Preistoria e Antropologia - University of Siena, Italy.

4. Results

4.1. Blank

The majority of blanks (almost 50% of the complex) are of medium size (Table 1). Based on the elongation index, the main objects pursued were flakes (Table 2) and most of them could be considered as rectangular (with at least two cutting edges) (Table 3); 34 pieces have a backed side (Table 4).

Size	N.
Big	77
Medium	148
Small	87
Total	**312**

Table 1: Size of target objects.

Elongation Index	N.
Blade	52
Long Flake	71
Flake	189
Total	**312**

Table 2: Elongation index of target objects.

Shape	N.
Rectangular	270
Triangular	42
Total	**312**

Table 3: Shape of target objects.

Section	N.
Trapezoidal\triangular	278
Rectangular trapeze or triangle	34
Total	**312**

Table 4: Section of target objects.

Combining these technical traits, we obtained the blanks on which the active and prehensile parts of the instrument are imposed (Figure 7). The majority of Oscurusciuto SU 13 target objectives of levallois debitage are rectangular flakes of medium and small size, followed by rectangular big and medium long flakes and big blades. We note that elongated products are mostly big and medium sized, whereas flakes are mostly small. Convergent flakes are scarcely represented, no matter what the size. Except for convergent medium flakes (19 pieces), other sizes do account for more than ten unities (Figure 7).

According to these characteristics, we can make a sub-divide the macro-class of blanks into: type-blank A, B or C. Type-blank A is made by rectangular blanks with one cutting edge opposed to a backed side. This group contains small, medium and big rectangular flakes, long flakes and blades with rectangular-trapeze and triangular-trapeze sections, which means one cutting edge opposed to a back (34 pieces). Type-blank B is a rectangular blank with at least two cutting edges. This group comprehends small, medium and big rectangular flakes, long flakes and blades with trapezoidal and triangular sections, which means pieces with at least 2 cutting edges (233 pieces). Type-blank C is a convergent blank with at least two cutting edges. This group comprehends small, medium and big convergent flakes, long flakes and blades with trapezoidal and triangular sections, which means pieces with at least 2 cutting edges (42 pieces).

Having defined these three classes of blanks, in this paper, we decided to focus only of the type-blank A in order to give extensive attention to each category (further work will focus on the other two blank types, B and C) (Figure 7).

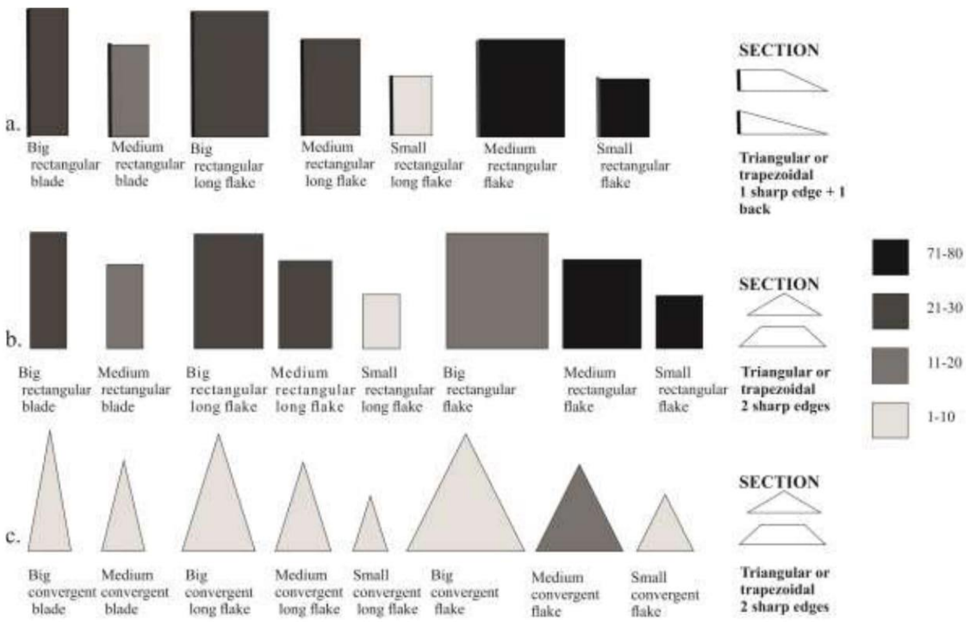


Figure 7: a: Type-blank A rectangular blanks with one cutting edge opposed to a backed side. b: Type-blank B: rectangular blanks with at least two cutting edge. c: Type-blank C: convergent blanks with at least two cutting edges (the scale of colour indicates the number of items: darker = more frequent and lighter = less frequent).

4.2 Type-blank A

Type-blank A encompassed 34 pieces, most of them elongated supports (blades or long flakes) (Table 5).

Blank	**Quantity**
Big blade	8
Medium blade	5
Big long flake	6
Medium long flake	2
Small long flake	1
Medium flake	9
Small flake	3
Total	**34**

Table 5: Type-blank A rectangular blanks with one cutting edge opposed to a backed side

On these supports are imposed several UTFt: 21 UTFt trihedrons (from now UTFt T or just T) and 39 UTFt cutting edges (from now UTFt C or just C) (Table 6).

The most represented UTFt is the cutting edge. It could be found alone, in association with a trihedron, or with other cutting edges (Table 7). The majority of cutting edges show a rectilinear delineation, less represented are denticulate, convex and concave delineations (Table 6). Usually cutting edges are in a lateral position (32) and occupy 3\4 or the totality of the edge of the tool.

The 21 UTFt trihedron are made up by 3 planes encompassing the dorsal and ventral faces of the flakes plus the butt, or plus a third face constituted by a rib made up of two negatives on the dorsal surface or of a broken part of the flakes, which lets us suppose an intentional use of the fracture. Consequently, these UTFt are slightly difficult to identify, as their features (when the rib or butt is the third face), mostly occur during the production of the pieces and not through a real intentional action (like in the case of intentional fracture). This issue could have caused an overestimation of this UTFt.

The UTFp are found in several different combinations: the most relevant one is the presence of 2 backed sides (most of them proximal plus lateral) and the 3 backed sides that actually forms a frame around the piece (from now on we referred to as backed side with D) (Table 6, Table 7).

	UTF types	**Quantity**
UTFt	Rectilinear cutting edge	30
	Denticulate cutting edge	5
	Convex cutting edge	3
	Concave cutting edge	1
	Trihedron	21
UTFp	1 backed side	2
	2 backed sides	19
	3 backed sides	13

Table 6: presence of UTFt and UTFp.

Going into more detail, we focused on the combination between the active parts (UTFt C and UTFt T), plus their association with the prehensile parts (UTFp). In this way we were able to individuate classes of tools that have the same structure (techno-type). For the nomenclature, we describe each tool based on the combination of UTFt and UTFp (UTFt cutting edge = C, UTFt Trihedron = T; UTFp backed side = D), the repetition of each of the latter represents the frequency of the unity. The techno-type is indicated with a letter and the sub-type is indicated by a number. It this way each piece is described by a code i.e. CDD-A1 means a piece with one UTFt cutting edge: C + two backed sides: DD, belonging to techno-type A, subtype 1.

We recognized 5 techno-types, presenting a variety of sub-types (Figure 8, Table 7). To sum up the most common techno-type was A: 1 Cutting edge + 2 backed sides (CDD), present in sub-types 1, 2, 3, 4 and 5. Sub-types 1, 2, 4, and 5 have the cutting edge opposed to the lateral backed side, whereas subtype 3 is the only one that has just one cutting edge in a transversal position (Figure 8, Table 7).

Highly represented is also techno-type D: cutting edge + 3 backed sides (CDDD), whose peculiarity is the 3 backed sides constituting a frame for the cutting edge. Not surprisingly, this is where we find the major number of trihedrons as the backed side is actually the third surface t of the trihedron itself. The pieces of techno-type B: 1 Cutting edge + 1 backed side (CD), are peculiar because in both cases the UTFp is made through retouch. Finally, we have only one case of techno-type E: 1 Trihedron + 3 backed sides (TDDD). This piece is very interesting as it is the smallest tool in the collection; here the intention of creating 3 backed sides as the prehensile part leaving free only the distal trihedron becomes clear. This is also the only case were the trihedron is found alone and not connected with other UTFts (Figure 8, Table 7).

Techno - Type and Sub - Type	N. of Pieces	Plus UTFt trihedron
A: 1 Cutting edge + 2 backed sides (CDD)	**13**	**3**
A.1 Cutting edge with denticulate delineation	3	1
A.2 Cutting edge with rectilinear delineation	6	2
A.3 Cutting edge with transversal position (rectilinear)	1	0
A.4 Cutting edge with convex delineation	2	0
A.5 Cutting edge with concave delineation	1	0
B: 1 Cutting edge + 1 backed side (CD)	**2**	**0**
C: 2 Cutting edge + 2 backed sides (CCDD)	**6**	**3**
C.1 Contiguous cutting edges	4	1
C.2 Separated cutting edges	2	2
D: 1 Cutting edge + 3 backed sides (CDDD)	**12**	**12**
D.1 Cutting edge with denticulate delineation	2	1
D.2 Cutting edge with rectilinear delineation	9	9
D.3 Cutting edge with convex delineation	1	2
E: 1 Trihedron + 3 backed sides (TDDD)	**1**	**1**

Table 7: Techno-type and subtype defined by the combination of UTFt and UTFp. The column "plus UTF trihedron" indicates how many trihedrons are present on the pieces (please note that this column refers to the number of UTFt Triherdons and not the number of pieces).

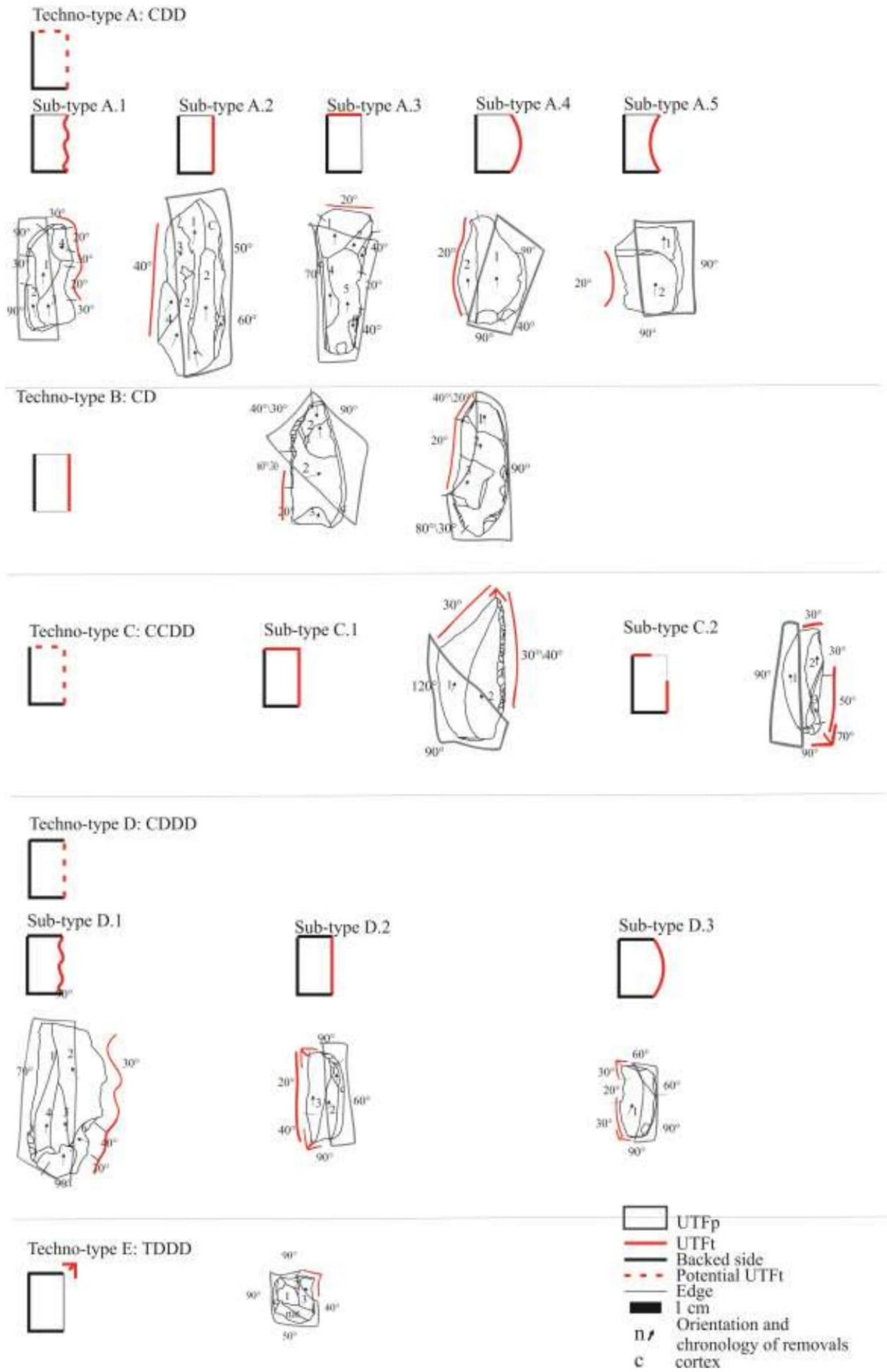


Figure 8: Schematic overview of techno-type and sub-type, plus examples of tools for each category.

These above-mentioned techno-types and sub-types could be found on various blanks. Starting from the blade, these pieces are found in big and medium sizes; generally, we note a recurrence of 2 baked sides and an opposite cutting edge. Incidentally, each tool has its own peculiarities; they are supports for different sub-types (Table 7, Figure 8, 9, 10). The case of the pieces ID 919 and ID 989 (techno-type B) is interesting because the retouch is implemented to improve the adherence potential of the grip, and it is adjacent to the cutting edge opposed to the backed side. This configuration of the tool introduces the hypothesis of a hafting (Figure 9).

Considering the medium blade, the pieces ID 852 and ID 853 refits, in this case it is interesting that the same structuration of the tool is created from the same core. Namely, pieces that technologically play the role of predetermining-predetermined pieces from a techno-functional point of view present identical prehensile and transformative parts (sub-type C2) (Table 7, Figure 8; Figure 10).

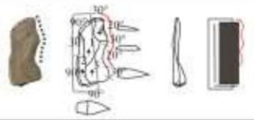
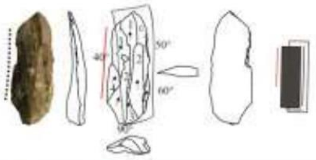
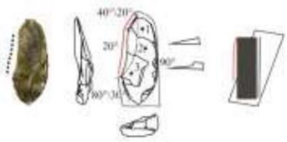
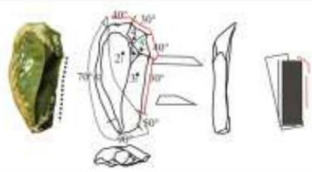
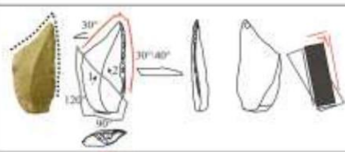
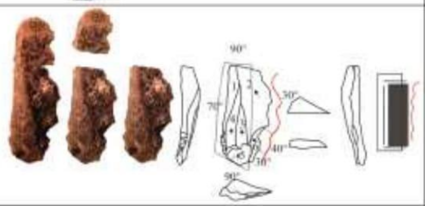
ID pieces	Big blade	Techno-type sub-type	Use wear description
ID 28		CDD-A1	UTFt C: Longitudinal motion on soft material
ID 983		CDD-A2	UTFt C: Longitudinal motion on semi hard material, wood
ID 959		CDD-A3	
ID 919		CD-B	UTFt C: Transversal motion on soft material UTFp: Prehensile trace
ID 989		CD-B	UTFt C: Longitudinal motion on soft material, meat
ID 633		CCDD-C1	UTFt C: Longitudinal motion on hard material
ID 1384		CCDD-C1 + T	UTFt C, UTFt C: Longitudinal motion UTFt T: Rotative motion on semi hard material, animal
ID 213		CDDD-D1	Use wear traces UTFp UTFt Backed side 1 cm n Orientation and chronology of removals

Figure 9: techno-functional analysis and description of use-wear traces on the big blades.

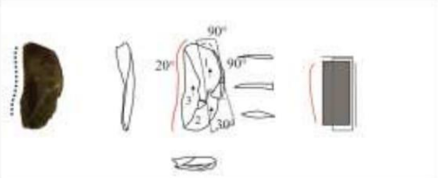
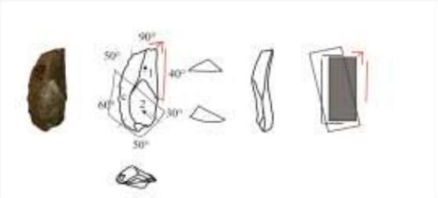
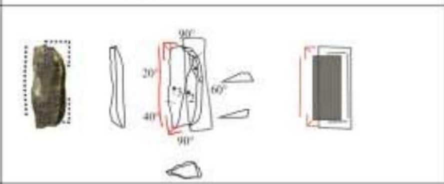
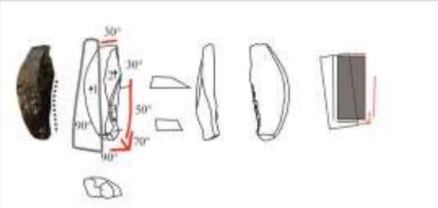
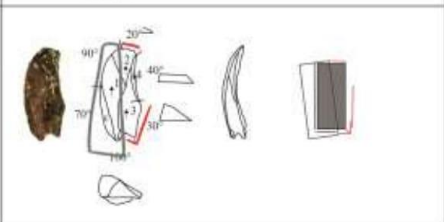
ID Pieces	Medium Blades	Techno-type sub- type	Use wear description
ID 400		CDD-A4	UTFt C: Longitudinal motion on soft material
ID 495		CDDD-D2 +T	
ID 1020		CDDD-D2 +T+T	UTFt C: Longitudinal motion on hard material UTFp: Prehensile trace
ID 852		CCDD-C2 +T	UTFt C: Transversal motion on soft material, wood
ID 853		CCDD-C2 +T	Use wear traces UTFp UTFt Backed side 1 cm Orientation and chronology of removals

Figure 10: techno-functional analysis and description of use-wear traces on the medium blades.

As for the long flakes, we encountered specimens of every size: big, medium, and small in varying numbers (Figures 11, 12). This is the blank with the most variations in techno-types, in fact of 9 pieces we noted 8 different sub-types (Table 7, Figures 8, 11, 12).

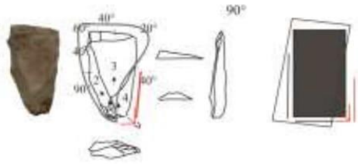
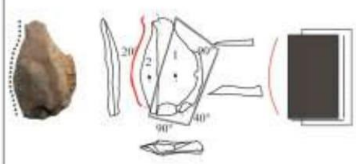
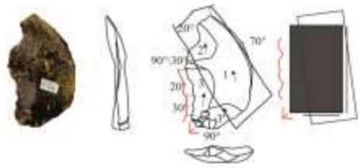
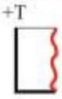
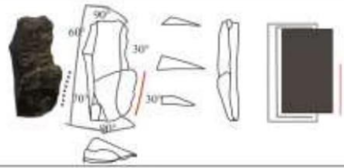
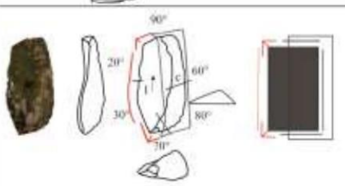
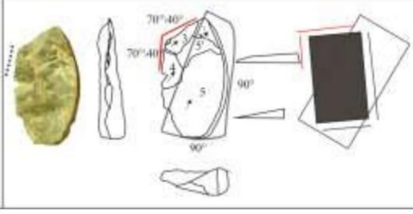
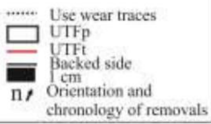
ID Pieces	Big long flakes	Techno-type Sub-type	Use wear description
ID 47		CDD-A2 +T 	
ID 320		CDD-A4 	UTFt C: Longitudinal motion on soft material, vegetal
ID 894		CDD-A1 +T 	
ID 165		CDDD-D2 	UTFt C: Longitudinal motion on hard material
ID 636		CDDD-D2 +T+T 	
ID 1632		CCDD-C1 	UTFt C: Transversal motion on hard material 

Figure 11: techno-functional analysis and description of use-wear traces on the big long flakes.

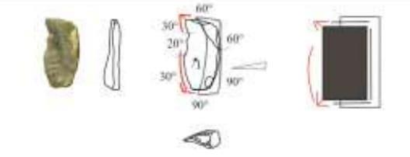
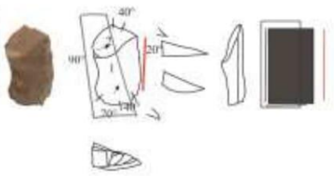
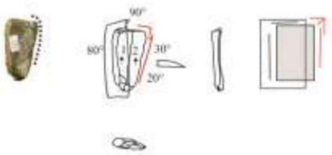
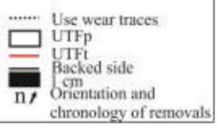
ID Pieces	Medium long flake	Techno-type sub-type	Use wear description
ID 1628		CDDD-D3 +T+T 	
ID 318		CDD-A2 	
ID Pieces	**Small long flakes**	**Techno-type sub-type**	**Use wear description**
ID 1512		CDD-A2 +T 	UTFt C: Longitudinal motion on hard material 

Figure 12: techno-functional analysis and description of use-wear traces on the medium long flakes and small long flakes.

Flakes are represented only in small and medium sizes (Figures 13, 14). The main defining feature in these pieces from is the presence of 3 framed backed sides (techno-type D) (Table 7, Figure 13). Probably because of their small dimensions these small pieces represent a particular prehensile need that could only be met by the 3 backed sides.

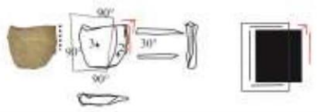
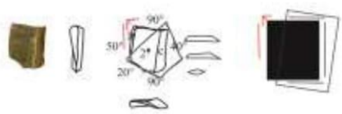
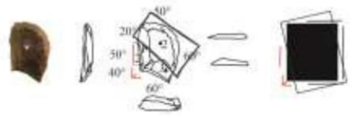
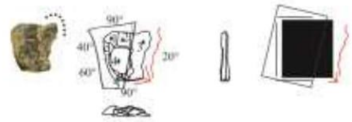
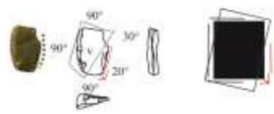
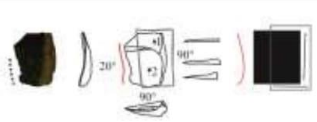
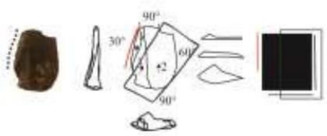
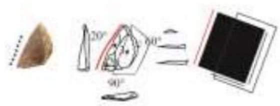
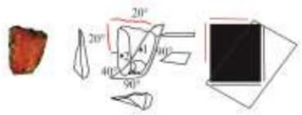
ID Pieces	Medium flakes	Techno-type Sub-type	Use wear description
ID 371		CDDD-D2 +T	UTFt C: Transversal motion on hard material, wood
ID 712		CDDD-D2 +T	
ID 632		CDDD-D2 +T	
ID 991		CDDD-D1 +T	UTFt C: Longitudinal motion on soft material
ID 1012		CDDD-D2 +T	UTFt C: Longitudinal and transversal motion on hard material, wood
ID 82		CDD-A5	UTFt C: Longitudinal motion on semi hard material, animal
ID 531		CDD-A2	UTFt C: Longitudinal motion on hard material
ID 906		CDD-A2	UTFt C: Longitudinal motion on semi hard material, animal, dry skin
ID 846		CCDD-C1	Use wear traces UTFp UTFt Backed side 1 cm Orientation and chronology of removals

Figure 13: techno-functional analysis and description of use-wear traces on the medium flakes.

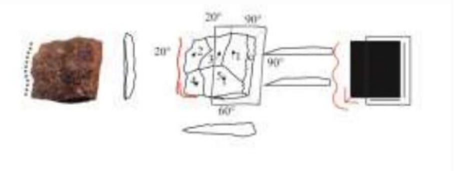
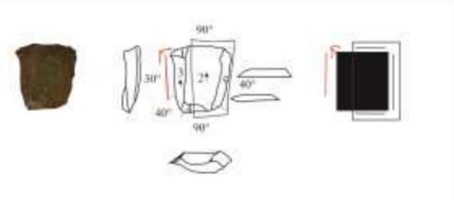
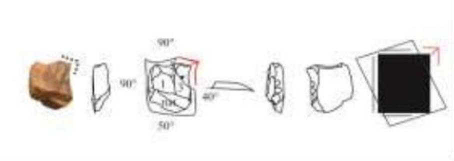
ID Pieces	Small flakes	Techno-type sub-type	Use wear description
ID 214		CDD-A1 +T	UTFt C: Longitudinal motion on hard material
ID 414		CDDD-D2 +T	
ID 882		TDDD-E	UTFt T: Carving on hard material Use wear traces UTFp UTFt Backed side 1 cm Orientation and chronology of removals

Figure 14: techno-functional analysis and description of use-wear traces on the small flakes.

4.3 Use-wear analysis

Of the examined sample (34), 21 tools show evidence of use, 9 pieces display unclear or uncertain traces because of post-depositional modifications, 4 artefacts do not reveal use-wear at all. We noted that in the majority of the cases use-wear traces were found on the portion of the pieces subject to techno-functional analysis. Just in one case traces were found on another edge which was not recognized by techno-functional analysis (ID 991, Figure 13). In other cases, there was not enough microscopic evidence to prove the UTF reading.

Going more into detail, 22 UTFt were used, in particular we noted to 20 cutting edges (UTFt C) and 2 trihedrons (UTFt T). In addition, traces were visible on 2 UTFp. Each artefact showed evident traces on only one UTFt, with the exception of the piece ID 1384 where its 3 UTFt showed traces (Table 9, Figure 15).

Due to the fact that micro-wear traces (polishes) are by nature not very evident, for several pieces it was inferred only the action carried out and general information about the hardness of the worked material. Nevertheless, as a general functional scene, we may deduce that the techno- type analysed was regularly used for various tasks (Table 8, Table 9). The tools were used for processing hard (9), semi-hard (8) and soft materials (5). Such a variety is confirmed also when worked materials have been detected, as both vegetal (4) and animal tissues (4) were processed (Figure 15).

Figure 15: A: ID 852 - use-wear polish interpreted as origination from processing soft wood (the scale bar is 500 µm); B: ID 906 - edge rounding associated with use-wear polish from cutting dry skin (the scale bar is 200 µm); ID 531 - edge scarring related to cutting hard material (the scale bar is 0,5 cm).

UTFt C are used mainly for longitudinal actions and to a lesser extent in transversal movements. The transversal actions are carried out by cutting edges with wider angles, in particular when hard materials were processed. Comparing worked materials and motions, we may conclude that the transversal actions were mostly performed on hard material, while the longitudinal ones on all types of material (Table 8, 9, Figures from 9 to 14).

Few items are employed in mixed actions. A single UTFt C, of the flake ID 1012, was used with both longitudinal and transversal movements for processing vegetal material, whereas two different UTFt C of the big blade ID 1384 were both used for longitudinal actions and UTFt T was employed in a rotational motion. In both cases animal tissue was processed (Figure 16, Table 8, 9).

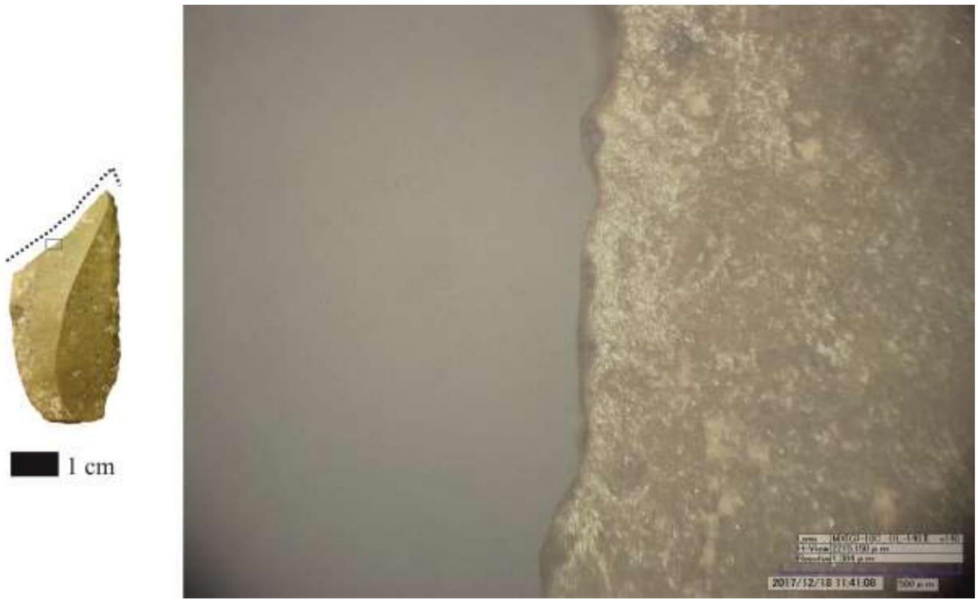


Figure 16: Use-wear polish on the big blade ID 1384 (the scale bar is 500 µm.).

By means of a techno-functional analysis, 21 trihedrons were identified, but traces were found on only two UTFt T of which one was involved in a rotational motion (pieces ID 1384 – Figure 9) and the other in a longitudinal action (pieces ID 882 - Figure 17) (Table 8, 9). These tools were used for processing hard and semi-hard material.

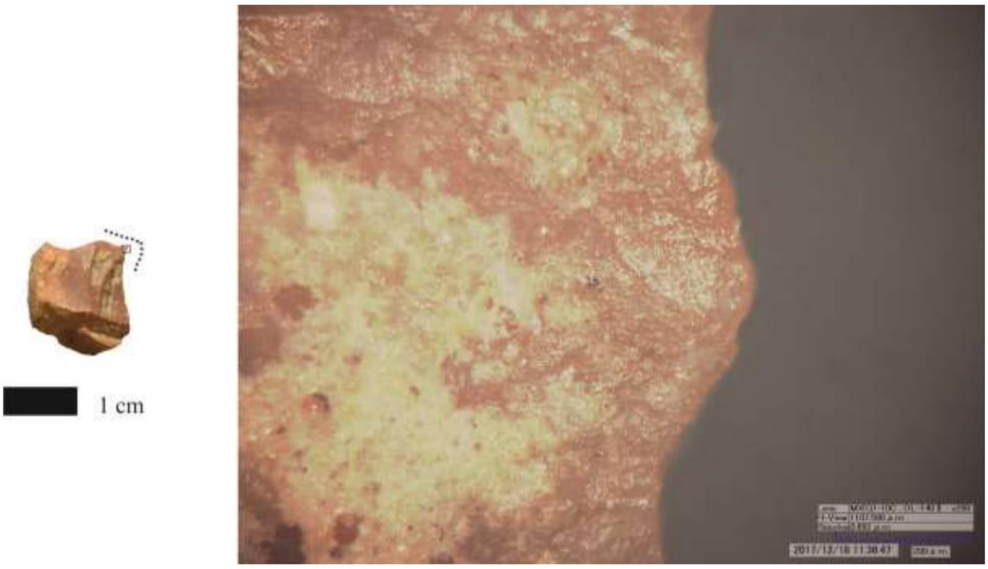


Figure 17: Use-wear polish associated with edge rounding of the small flake ID 882 (the scale bar is 200 µm).

Evidence of probable hafting traces on UTFp is detected on two pieces (ID 1020 and ID 919), confirming the hypothesis of the techno-functional analysis. In both cases, the traces are located on the backed sides of the tools (Figures 9, 10).

Type of material and UTF	**Longitudinal motion**		**Transversal motion**		**Rotational motion**		**Long+trans motion**		**Total**
	UTFt C	**UTFt T**	**UTFt C**	**UTFt T**	**UTFt C**	**UTFt T**	**UTFt C**	**UTFt T**	
Soft	2		1						**3**
Semi-hard	5								**5**
Hard	3	1	2						**6**
Wood	1		1				1		**3**
Herbaceous plants	1								**1**
Soft animal tissues	1								**1**
Semi-hard animal tissues	2					1			**3**
Total	**15**	**1**	**4**		**0**	**1**	**1**	**0**	**22**

Table 8: correlation between transformative parts (UTFt C: cutting edge and UTFt T: trihedron), movement and worked material.

5 Combined use of techno-functional and use-wear analysis

The result obtained by the combined use of the techno-functional and use-wear analysis gives a consistent result. In fact, in the sampled pieces, we note that in the majority of the pieces the use-wear analysis confirmed the interpretation given in the techno-functional study.

We note that sometimes the same techno-type are made on different blanks, as in the case of sub-type A2 and D2, a recurrent combination in almost all blanks. Then again, other techno-types seem to be specific to some blanks, such as techno-type B. Moreover, some blanks are supports for several techno-types, e.g. the big blades are structured in quite a number of different combinations, and they seem to be made to purpose unique tools. In contrast, other blanks support few techno-types, as is the case with medium flakes where most of them support the techno-type D (Table 9).

A very remarkable fact is that the techno-types are consistent with their actual use, in fact we noted that some techno-types were used for specific activities, as is the case with techno-type A, which is mostly used for cutting (longitudinal movement). On the other hand, there are techno-types, such as C and D, which are employed in a variety of activities, such as cutting and scraping (respectively longitudinal and transversal movements). In addition, some techno-types met a particular need, as is the case with the techno-type E, which can be considered *unicum* in the collection both from a structural and a functional point of view, in fact this piece (a UTFt T framed by 3 backed sides) was used for carving (Figure 17). Finally, in techno-type B a very specific construction of the piece (made also by retouch) does not correspond to the same activity, one is used for scraping and the other for cutting, however, both pieces are related to butchering activities (Figure 9).

Techno-type	Sub-type	N.	BLANK							Action	Material	Angles	ID pieces
			BB	MB	BL	ML	SL	MF	SF				
A: CDD n13	A.1	3	1		1				1	cut	soft, hard	20°, 20°-30°	28, 894, 214
	A.2	6	1		1	1	1	2		cut	semi hard, hard	20°, 30°, 20°-30°, 40°	983, 47, 318, 1512, 531, 906
	A.3	1	1							\	\	20°	959
	A.4	2		1	1					cut	soft	20°	400, 320
	A.5	1						1		cut	semi hard,	20°	82
B: CD n.2	B	2	2							scrape, cut	soft	20°	919, 989
C: CCDD n.6	C.1	4	2		1			1		cut, scrape	semi hard, hard	20°, 30°, 40°	633, 1384, 1632, 846
	C.2	2		2						scrape	soft	20°,30°, 50°	852, 853
D: CDDD n.12	D.1	2	1					1		cut, carve	soft	20°, 30°-40°	213, 991
	D.2	9		2	2			4	1	cut, scrape	semi hard, hard	20°- 40°, 20°-40°, 30°, 40°, 50°	495,102, 165, 636, 371, 712, 632, 1012,414
	D.3	1				1				\	\	30°	1628
E: TDDD n.1	E	1							1	carve	hard		882
Total		34	8	5	6	2	1	9	3			\	\

Table 9: Synthetic table of techno-types and sub-types.

(C: cutting edge, T: trihedron: D: backed side; n. refers to the total number of pieces of each type), how they are disposed on the blank, plus information regarding the use: action, worked material and angles of the active edge (for the blank: BB: big blade, MB: medium blade, BL: big long flake, ML: medium long flake, SL: small long flake, MF: medium flake, SF: small flake).

6 Conclusions

A first methodological observation was that the integrated use of techno-functional analysis and use-wear analysis yields consistently matching results to the benefit of both technologists and tracceologists. Thanks to this combined method we get much closer to the human realities where there were several needs to solve, sometimes simultaneously, and several tools to be manufactured.

This work answered to the three main queries posed at the beginning of this research.

1. We proved that the target objects (production aims) were also actually used as functional objects (functional aims), i.e. a large number of items shows use-wears.
2. We noted that each production aim actually comprised several techno-types employed for different purposes. Namely, through the technological approach we learned that the production aim was flakes, convergent flakes and backed flakes. Thanks to this study, we realized great diversity in both structure and functionality of these tools, noting that to each class of target objects corresponds a set of different functional objects, as each category actually comprises several blanks, and each blank could be the support for several techno-types.
3. Finally, we also proved that tools with a specific structure aimed to solve a specific task.

The encouraging results of this study motivated us to continue in this direction, analysing the other two categories (type-blank B and C) in order to obtain a larger set of statistically significant data.

Lastly, one question remains: the trihedron was identified by techno-functional analysis but presented traces in only 2 cases. For this reason, we want to know why there is such little evidence of usage on these pieces. Is it because the action did not leave strong visible traces, or because this part was not used? We could also hypothesise an artificial increase due to possibly misleading criteria of identification. To be able to answer these questions we are planning to set up an experimental protocol to verify the functional potential of the trihedron, possibly applying more restrictive criteria for its identification, i.e. the technical criteria present on the two items which showed clear use-wear traces.

Acknowledgements

The authors are indebted to the Soprintendenza Archeologia, Belle Arti e Paesaggio per le province di Brindisi, Lecce e Taranto, Municipality of Ginosa, Onlus CESQ, to Piero di Canio and to all the students and colleagues who participated, together with the authors, in the excavation of 2011. This paper was presented at 11th International Symposium on Knappable Materials held in University of Buenos Aires between 7 and 12 November 2017. We would like to warmly acknowledge Roxane Rocca, Marcos César Pereira Santos, Birgitte Hoiberg Nielsen and the two reviewers Antonella Pedergnana and Amelie Da Costa for their precious and helpful advice. We thanks also the session organizers Leslye Valenzuela, Otis Crandell, and Patrick Julig.

Authors contribution

Giulia Marciani performed the technological and techno-functional analysis supervised by Daniele Aureli. Simona Arrighi performed the use-wear analysis. Vincenzo Spagnolo is responsible for the planimetries and spatial data. Paolo Boscato analyzed the faunal remains, and is the director of the excavation together with Annamaria Ronchitelli.

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Paper 3: Diachronic dissection of the palimpsest

Spagnolo, V., MARCIANI, G., Aureli, D., Berna, F., Boscato, P., Ranaldo, F., Ronchitelli, A. 2016, Between hearths and volcanic ash: The SU 13 palimpsest of the Oscurusciuto rock shelter (Ginosa - Southern Italy): Analytical and interpretative questions. Quaternary International, 417: 105-121. doi:10.1016/j.quaint.2015.11.046.

Presented at:

XVII Mundial Congress of Prehistoric and Protohistoric Sciences 2014.

Burgos, Spain. 1-7 September 2014

Session session B55: Advances in Archaeological palimpsest dissection

Quaternary International 417 (2016) 105–121

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Between hearths and volcanic ash: The SU 13 palimpsest of the Oscurusciuto rock shelter (Ginosa – Southern Italy): Analytical and interpretative questions

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ARTICLE INFO

Article history:
Available online 15 December 2015

Keywords:
Middle Palaeolithic
Palimpsest
Raw material units
GIS
Hearths

ABSTRACT

The Oscurusciuto rock shelter, located in the ravine of Ginosa (Taranto), is one of the key sites for the study of Neanderthal groups in Southern Italy. The rich stratigraphic sequence of the site, which is ascribable entirely to the Middle Palaeolithic, is rich in anthropic remains and combustion structures, attesting occupation by Neanderthals during MIS 3. This paper is focused on the study of Stratigraphic Unit (SU) 13, made up of a compact sandy sediment mixed with pyroclastic sediment derived from the underlying tephra level (SU 14). The latter has been identified as Monte Epomeo green tuff (dated Ar/Ar 55 ± 2 ka). The first stable human occupation of the shelter after tephra deposition is represented by unit 13. Our aim here is that of separating the Stratigraphic Unit into its main components so as to obtain a high temporal resolution on the activities which took place in this SU, and to reconstruct the individual events which formed the palimpsest. In order to fulfil these objectives, a multidisciplinary approach was needed through which data could be integrated from the microstratigraphy of the hearths; from the technological study of the lithic industries; from the individuation of the Raw Material Units (RMUs); from refitting and co-joining and from spatial analysis (GIS science/tool). The integration of these analytical methods reveals that SU 13 of the Oscurusciuto rock shelter was the product of a series of events ascribable to a short time span. This layer was formed by sediment aggradation and cementation (e.g., brecciation) processes. Human activities contributed to the sediment build up with the introduction of wood ash, lithic raw materials and bones. The results show the importance of using integrated research methods in order to identify short anthropic events within a palimpsest.

1. Introduction

The palimpsest problem in archaeology has become one of the main themes of scientific debate, due to the "flattening-effect" of an unknown number of individual events, with an unknown life span, into a single layer. Currently, the solution focuses on achieving a high resolution in the data analysis, in order to understand more accurately the cultural, social and economic dynamics in the archaeological context (quoting a few recent papers: Vaquero, 2008; Bailey and Galanidou, 2009; Malinsky-Buller et al., 2011; Carbonell I Roura, 2012; de la Torre et al., 2012; Henry, 2012; Rosell et al., 2012; Machado et al., 2013; Mallol et al., 2013; Bisson et al., 2014). In these works, a new orientation in research is evident, emerging from the improvement of analytical techniques. Beyond the identification of single (short-term) occupational episodes, the "goal for future research is to transcend this descriptive label, as these may enclose diverse historical dynamics whose explanation can be sought by taking a close look into the specific activities performed and their role within a territorial context" (Machado et al., 2013: 2272).

This paper focuses on the "dissection" of a Middle Palaeolithic palimpsest (SU 13) from the Oscurusciuto rock shelter (Ginosa,

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http://dx.doi.org/10.1016/j.quaint.2015.11.046
1040-6182/

Taranto, Southern Italy). In the context of the rich stratigraphic sequence of the Oscurusciuto rock shelter, SU 13 constitutes a privileged context for the setting up of an analytical protocol for palimpsest analyses. The crucial elements of SU 13 are its stratigraphic position (a sedimentological unit located between a dated sterile tephra level underneath and subsequent occupation levels), its extension (wider than the upper levels), the presence of hearths structures and a fairly low quantity of materials. This has made it easier to develop an integrated study aimed at understanding this palimpsest.

The main goal was to obtain a high temporal resolution of the activities recorded in this archaeological layer, in order to understand how those activities constitute a palimpsest. Furthermore, a second purpose was the identification of individual episodes of occupation, recognizable by the integrated study of material culture. These data may shed light on a research line which allows a different and innovative approach to dealing with the study of the economic and settlement strategies of Neanderthal groups.

A multidisciplinary approach has been necessary in order to fulfil our objectives. As a first analytical step, the level of integrity of the layer was verified through the study of the state of preservation of the anthropic remains and microstratigraphy of the hearths — and through the chi-squared analysis of the faunal remains and lithic industry distribution. The following steps — the technological study of the lithic industry, the individuation of the RMUs, refittings and co-joints, and spatial analysis — have made it possible to individuate single activities which took place within the layer. From the integration of these methods it has been possible to obtain a complete view of the activities making up the palimpsest of this Stratigraphic Unit.

2. The Oscurusciuto rock shelter

The Oscurusciuto rock shelter is located in the ravine of Ginosa (TA), in southern Italy, at 235 m above sea level. The geomorphological background of this site favored both the presence of caves and shelters and the rich availability *in loco* of limestone and siliceous resources (such as quartz, quartzarenite, siliceous limestone, chert and jasper) contained in the form of pebbles within conglomerate terraces. Together with the presence of plateaux and coastal flood plains, areas suited for the grazing of herbivores a few kilometres from the site, this would have made the shelter a place of potential attraction for Neanderthal groups.

Excavations at the Oscurusciuto rock shelter began in 1998 and, up to now, nine Middle Palaeolithic occupation phases have been investigated, corresponding to the first 3 m of the stratigraphy. All the levels are characterized by a great abundance of lithic and faunal remains. The discovery of a living floor (SU 15) is of particular importance. Still under exploration, this is sealed by tephra (SU 14) and is characterized by the presence of structures defined by stones. The current extension of the whole Oscurusciuto deposit is 60 m^2, with a stratigraphy over 6 m deep, but the sequence is eroded, particularly in the upper strata (Fig. 1). The chronological limits, at present, are obtained by two dates: the first is a ^{14}C date, referred to the bottom of SU 1, of 38,500 ± 900 BP — AMS, Beta 181165; cal. 42,724 ± 716 BP (Bronk Ramsev and Lee, 2013). The second derives from the identification of the tephra layer (SU 14) as Mount Epomeo green tuff, dated to about 55 ka BP (Allen et al., 2000). Therefore the upper part of the stratigraphic sequence refers to the final phase of the Middle Palaeolithic, an epoch close to that of the disappearance of Neanderthals in Southern Italy, which is presently a central topic of scientific debate (Higham et al., 2014).

Regarding the lithic industry of the units so far excavated, the unipolar Levallois production system is predominant (Villa et al., 2009; Boscato et al., 2011; Ronchitelli et al., 2011). The faunal remains in the lower part of the analyzed deposit (SU 15 to SU 4), exclusively attributed to human activities, are characterized by high frequencies of *Bos primigenius*, which indicates a particular type of open environment and forest steppe, in association with *Cervus elaphus*, *Dama dama*, *Capreolus capreolus*, *Equus ferus* and rare appearances of *Capra ibex* and *Rupicapra* sp. Sporadic remains of carnivores: *Panthera leo*, and *Canis lupus* are present, too. The upper units refer to a more temperate and moist phase, since the number of cervids is higher (Boscato and Crezzini, 2012a). In the middle and lower part of the investigated stratigraphic sequence many combustion structures were found. In SU 13, SU 11 and SU 9 the hearths had two dimensional typologies: little (with diameters of about 20 cm) and larger (with around 50 cm in diameter). In these SUs most hearths were located along a belt separated from the rock shelter wall. In SU 7 a large hearth (2 m wide) was located in the N—W corner of the shelter (Boscato and Ronchitelli, 2008).

The Oscurusciuto rock shelter can be considered as a key site for the Palaeolithic peopling of Apulia and Lucania. This is because of its geographic position (between the eastern and western regions of southern Italy), its long stratigraphic sequence, the good preservation of structures with spatial organization and the large quantity of preserved remains.

The first permanent settlement of the site after the deposition of the Mt. Epomeo green tuff is recorded in Stratigraphic Unit 13, which is the subject of this paper (Fig. 2). This SU is characterized by the presence of hearths and by the activity of lithic knapping and butchering. SU 13 consists of compact sediment, created by the stirring of the underlying tephra (SU 14) and sand, with rare small pieces of calcarenite. On the other hand, the intensively anthropized upper Stratigraphic Unit shows a loamy sand matrix. The layer is a sub-horizontal stratum with a weak slope. It is probably preserved for about 20 m^2, but the excavated area amounts to about 11 m^2. The median thickness is 10 cm, with a variability between 20 cm (in the outer part of the stratum) and 1 cm (in the inner part of the stratum, at the contact with the rock shelter wall). The lithic and faunal archaeological remains are distributed along the whole thickness of the layer, without any evident secondary separation levels.

In SU 13 ten hearths (Fig. 2) were identified: nine have a subcircular shape (about 20 cm in diameter). Only one, SU 12, (Fig. 2), placed on the erosional line, is bigger and probably it is made up by an overlapping of different hearths. Nine hearths were placed on the top portion of SU 13, whereas only SU 82 (Fig. 2) was within the layer. There is only one stratigraphic overlap between hearths: SU 84 and SU 83B are upon SU 83A (Fig. 2). No stratigraphic relationship is attested between SU 84 and SU 83B. SU 79 is an accumulation of ash found in the central part of the excavated area (Fig. 2).

Among the many Middle Palaeolithic sites of Apulia and Lucania, the long stratigraphic sequence of the Cavallo cave (the reference site for the whole of Southern Italy, located at about 120 km from Oscurusciuto) shows Final Mousterian levels (MIS3) with faunal associations similar to those of Oscurusciuto (Sarti et al., 2000). An initial phase characterized by the diffusion of wooded grassland with a large presence of aurochs is recorded (FIIIe). This is followed by a temperate phase with a notable increase in fallow deer (FIIId-FIIIa) and by a third phase, the most recent one, with a more arid climate, with relatively abundant aurochs and horse (FII-FI). As in the Oscurusciuto, the degree of bone fragmentation at this site is also high (Boscato and Crezzini, 2012b). Levels FIIIe and FIIId of the Cavallo cave fall within the same chronological horizon as SU 13 at the Oscurusciuto (about 50,000 BP). Nonetheless, the production methods show differences alongside certain analogies. It is important to underline the sheer difference between the two sites as to the raw materials employed: pebbles at the Oscurusciuto and small slabs (“lastrine”) at the Cavallo.

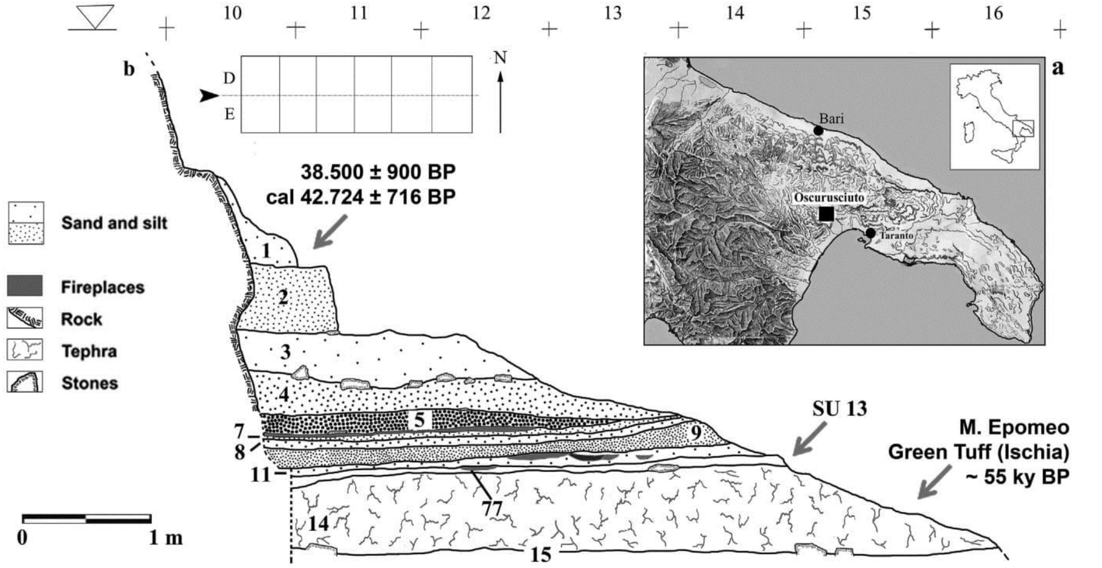

Fig. 1. Localization of the site (a) and stratigraphic sequence of the Oscurusciuto rock shelter (b). Relief P. Boscato, drawing A. Ronchitelli.

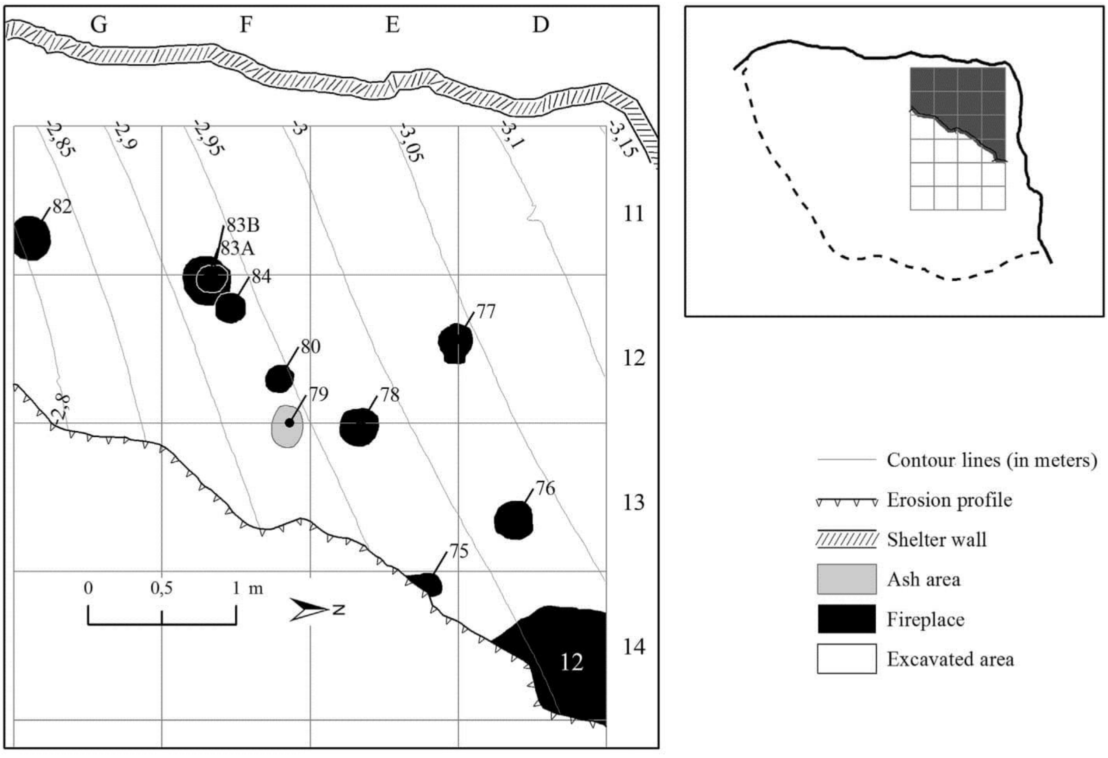

Fig. 2. Stratigraphic Unit 13, excavated area. Relief: P. Boscato, drawing: A. Ronchitelli, V. Spagnolo.

Whereas at the Oscurusciuto the most recurrent Levallois modalities are the unipolar and convergent ones, alongside a marginal presence of the volumetric method for the production of bladelets, at the Cavallo cave, the most frequent Levallois modalities are the centripetal and uni-bipolar ones, associated with a large volumetric production for the extraction of blade-bladelets, obtained through a different management of volumes (Carmignani, 2010, 2011).

3. Methods

The palimpsest analysis was aimed at an accurate reconstruction of the economic, social and cultural aspects as they emerge from the archaeological evidence. In order to achieve this objective, a multidisciplinary analytical protocol was conducted, comprising combustion features microstratigraphy, faunal analysis, lithic technological studies (including RMUs and lithic refitting/conjoin), and finally spatial studies.

The microstratigraphical study of the hearths was designed to individuate human activities associated with the management and combustion conditions of such features. The study of the fauna has led to the identification of the represented species, of the anatomical elements and their fragmentation conditions. The study of the lithic industry with the RMU method was set up in order to identify the minimum number of raw material units introduced in the site. The results of these studies were then fed into a GIS platform which was created for testing the state of preservation of the layer. This took into account the physical state of lithics, the microstratigraphy of hearths, the presence/absence of biotic alterations and the analysis of the density maps of micro-remains in relation to the morphology of the layer in order to verify whether the distribution of the various categories of materials followed a given organization or was purely random (chi square test). This was done in order to obtain a high temporal resolution interpretation of the activities sequence which took place in SU 13 (spatial patterning of RMUs, distance between refittings, microstratigraphy of hearths).

3.1. Hearths: microstratigraphic analysis

Intact sediment blocks were collected from hearths SU 12, SU 77, SU 78, SU 80, SU 82, and SU 83. The blocks were embedded with polyester resin and processed into petrographic thin sections. The thin sections were analyzed by petrographic microscopy and Fourier transform infrared microspectrometry (m-FTIR) using a Thermo iN10 XM imaging FTIR microscope. Soil micromorphology descriptions were conducted following the criteria indicated in Stoops (2003). The integration of petrography, soil micromorphology and m-FTIR for the analysis of thin sections of intact archaeological deposits allows us to untangle the natural and cultural processes occurring in archaeological sites (Goldberg and Berna, 2010). In fact, the geogenic, biogenic, and anthropogenic components are best identified at the microscopic scale, as are the transport, deposition and diagenetic processes (Goldberg and Macphail, 2006). In particular, the micromorphological study of hearths and other combustion features allows for the identification of human activities associated with their management (e.g., pitting, fueling) and intentional and unintentional modifications such as ash removal and dumping, rake out, trampling and scuffing (Goldberg and Berna, 2010). By FTIR it is possible to identify and characterize the crystalline state of organic and inorganic phases composing bone (i.e., collagen and carbonate-hydroxyl apatite), soil (e.g., clay minerals, carbonates, sulphates, phosphates, nitrates) and wood ash (e.g., pyrogenic calcite, charcoal, and opaline phytoliths) (Weiner, 2010). Moreover, m-FTIR enables the estimation of temperature reached by bone, carbonates, and soil inclusions and consequently allows the reconstruction of combustion conditions of a given hearth (Berna and Goldberg, 2007; Berna et al., 2012). The microstratigraphic analyses at Oscurusciuto rock shelter were focused on the identification of soil microfabric units (Stoops, 2003) composing the overall matrix of SU 13 and the components of the different combustion features (i.e., SU 12, SU 77, SU 78, SU 80, SU 82 and SU 83) included in SU 13.

3.2. Faunal analysis

Faunal remains of SU 13 were divided into two qualitative classes (burned and unburned) and four dimensional classes (1–3 cm, 3–6 cm, 6–10 cm, >10 cm). Taxonomic data could only be recorded for a few remains, due to the high degree of fragmentation.

3.3. Lithic analysis: definition of a method to individuate more reliable RMUs

The study of lithic finds was based on the Raw Material Unit (RMU) approach (Roebroeks, 1988; Hall and Larson, 2004; Uthmeier, 2006; Vaquero, 2008; Romagnoli, 2012; Vaquero et al., 2012; White, 2012; Machado et al., 2013).

This approach permits the isolation of groups of lithic items pertinent to a single lithic unit\block, in this case pebbles. In this way it is possible to quantify the minimum number of raw materials brought into the site and to identify knapping, use and discard episodes and eventual importation or exportation of tools in order to have a clearer comprehension of the reduction sequence. A most effective result is obtained with an extensive programme of recognizing refittings and conjoins (Larson and Ingbar, 1992; Schurmans, 2007) as well as technological and spatial analysis of the pieces integrating each RMU. An advantage of this method is the ability to identify the post-depositional translocation of lithic remains, which enhances correct detection of single human occupation episodes and different functional areas (Machado et al., 2013).

The lithic finds were classified in five dimensional classes (1–50 mm^2, 51–100 mm^2, 101–150 mm^2, 151–200 mm^2, >200 mm^2).

Different lithic groups (RMUs) were established, based on macroscopic traits of the lithic artifacts such as cortex color and thickness, texture, color, inclusions and opacity. A limitation on the application of this method is encountered when there are burnt, patinated or altered pieces, when there are tiny specimens or when the raw material is too homogeneous and impossible to separate.

While RMU identification is currently a well consolidated practice in Paleolithic research, the subjectivity involved in their determination seems to be a problematic factor. For this reason a protocol was developed to evaluate the reliability of each RMU. At first, the indeterminable elements of the lithic assemblage were removed ("indeterminable" is defined as altered or tiny items smaller than 50 mm^2). Then the remainder of the assemblage was divided into lithological categories according to the type and granulometry of the lithic raw material here defined: CL = 1 fine grained jasper; CL 2 = fine grained chert; CL 3 = middle grained jasper; CL 4 = middle grained chert; CL 5 = middle grained siliceous limestone; CL 6 = middle grained limestone; CL 7 = coarse grained chert; CL 8 = coarse grained siliceous limestone; CL 9 = middle grained quartzarenite; CL 10 = coarse grained quartzarenite; CL 11 = coarse grained limestone; CL 12 = indeterminate. Consequently, based on macroscopic similarity within each lithological category, the RMUs were identified.

The estimation of the reliability degree of the RMU (excellent, good or bad) was based on the evaluation of some parameters, each with its own numeric value: "Refitting Ratio", "Variability of Raw

Material", "Uniqueness of Raw Material". The Refitting Ratio expressed the ratio between the number of conjoined or refitted items and the total quantity of elements in the RMU. The Variability of Raw Material represented the degree of internal variability in each single block of raw material (that can be homogeneous or inhomogeneous). The Uniqueness of Raw Material constituted the degree of inter-RMU variability, in other words the formal similarity between different RMUs (that can be unique or not unique). The level of reliability was calculated on the basis of the arithmetical sum of the above listed parameters (Marciani, 2013; Spagnolo, 2013).

3.4. Taphonomy and spatial analysis

The elaboration of spatial data was performed using ArcGIS® 10.2, with a specifically designed geodatabase (Spagnolo, 2013).

The preservation degree of SU 13 was tested. The considered parameters for this test included the state of a lithic's edges (fresh or floated), the micro-stratigraphy of hearths, the presence/absence of biotic alterations, the chi-square test for the spatial pattern evaluation, the analysis of micro-flakes and micro-fragment accumulations in relation to the surface morphology of SU 13, the length of the refitting/conjoint lines and, finally, the spatial patterns of the RMUs (e.g. Dini and Moriconi, 2004: 52–57; Goldberg and Macphail, 2006: 42–84; Mallol et al., 2010, 2013; Drennan, 2009: 181–195; Stevenson, 1991; Bertran et al., 2012).

The chi-square test was performed in order to assess if the distribution modalities of the archaeological and faunal materials within the excavated area reflected a pattern of some kind or fell within a random statistical oscillation. The real distribution was compared with an expected distribution defined with the Poisson function (null hypothesis) corresponding to a random distribution with a 99.999% confidence interval. The test was performed in order to test the clustering rate of the lithic finds and faunal remains (Drennan, 2009: 181–195). Quadrants with an integrity level <88% were discarded in order not to distort the results of the test. As the test made use of real quantities, it required quantitatively comparable sampled areas in order to be effective. This led us to exclude the quadrants which were too eroded as the material within them would be strongly underestimated in the test.

In some sectors, most artifacts were recovered by sieving (in particular all the lithics smaller than 200 mm^2), so the only spatial reference known for these pieces is the quadrant (50 × 50 cm) of origin. The visualization of the lithic and faunal remains distribution pattern is allowed by adopting a random positioning strategy (ArcGIS® 10.2\Data management tools\Create random points) for the items recovered by sieving. For the other artifacts, the real coordinates were taken into consideration. In this manner, the realization of a micro-flake density map was also possible. The error in the randomly positioned points is negligible when the positioning cells (50 × 50 cm in this context) are smaller than the spatial phenomena under investigation. The scatters produced by lithic reduction activities are in the same dimensional module of the excavation grid (Vidale, 1992: 158–160; Vaquero and Pastò, 2001; Jones, 2008; Olausson, 2010; Bertran et al., 2012, 2015).

Starting from the distribution maps, the spatial patterns of the main categories of evidence (burned faunal remains, dimensional classes of unburned faunal remains, dimensional classes and technological categories of lithic finds and reliable RMUs with at least 10 items) were analyzed using Ripley's K function (Bevan and Conolly, 2006; Schwarz and Mount, 2006; Winter-Livneh et al., 2010). This tool was used in order to illustrate the relationship between the clustering or the dispersion of feature centroids and the neighborhood size changes (ArcGIS® 10.2\Spatial statistics tools\Multi-Distance Spatial Cluster Analysis). Density maps were also produced for these categories, using the kernel algorithm (with search radius at 0.25 m).

The premise that the weak slope of the SU 13 surface was in itself a potentially important factor for context preservation was investigated. In particular we examined whether stream flow, overland flow, scuffage and/or trampling (Stevenson, 1991; Bertran et al., 2012, 2015) might have influenced the assemblage spatial configuration. For this purpose, the Dimensional Classes maps and, in particular, the micro-flake accumulations shapes were evaluated in relation to the contours line based on the Digital Elevation Model of SU 13 (Figs. 3 and 4).

In order to carry out the analysis of the refitting patterns, it was necessary to assess how far the inaccuracy of the random positioning could generate a misreading of the refitting/conjoint lines length pattern. There were three possible scenarios: 1) both the related artifact had known coordinates; 2) only one artifact in the pair had known coordinates; 3) both the related artifacts were randomly positioned. In the first case, the distance between the refitted elements was represented by the simple line, without error. In the second case, the error range evaluation was made measuring the minimum and maximum distances from the known point to the quadrant of the refitted artifact with unknown coordinates. In the last case, the minimum and maximum distances between the quadrants of the refitted artifact were calculated. The average values (between Max and min) were reported on a scatter-plot graph with error bars (difference between Max and mean) (Fig. S1).

RMU analysis is a powerful tool for dissecting palimpsests, because of its potential capacity to achieve a high resolution view of activities carried out at the site (Vaquero, 2008, 2011; López-Ortega et al., 2011; Machado et al., 2011, 2013; Carbonell I Roura, 2012; Vaquero et al., 2012). The spatial component of the RMU can help significantly in this analytical operation. For this reason some specific maps were produced for RMUs with at least 10 artifacts and good/excellent reliability degrees. In line with the results of Ripley's K function, vertical distributions of the aforementioned RMUs were grouped by spatial pattern and analyzed.

4. Results

4.1. SU 13 and hearths microstratigraphy

The micromorphological investigation of six (SU 12, SU 77, SU 78, SU 80, SU 82 and SU 83) of the ten excavated hearths revealed the presence of several micro-fabric units (mFUs) and sub-units (see Fig. 5, S2 and S3). These are:

mFU1 (Fig. 5a) – a fairly well preserved light tan volcanic tuff with characteristic needle and tubular glass crystals (Epomeo green tuff). mFU1 is the major component of the basal Stratigraphic Unit at the site (i.e., SU 14) and appears as cm-size aggregates (e.g., in SU 77 and SU 82, Fig. S3) and as burrow fill (e.g., SU 80, Fig. S3) in the micro-Stratigraphic Units forming the hearths.

mFU2 (Fig. 5b) – a slightly altered volcanic tuff with iron rich amorphous clay, found dispersed in the ground mass and co-precipitated with micrite in mm-size laminae and domains. mFU2 also contains variable amounts of quartz fine sand, micrite silt and sand, amorphous organic matter, plus subangular charred and uncharred bone fragments. mFU2 composes the bottom microStratigraphic Unit underlying SU 77 (Fig. S3).

mFU3 (Fig. 5c) – a colluvium supported by the mFU2 fine matrix and containing heterogeneous angular to rounded gravel, inclusive of local lithology (micritic and fossiliferous limestone, flowstone, etc.), exotic raw materials such as chalcedony chert and jasper (e.g., SU 78 – Fig. S2b), and fragments of charred and uncharred bone (Fig. S2b, S2c, and Fig. S3), coprolites (Fig. S2b), and charred and humified plant materials (Fig. S2c). mFU3 is the most common

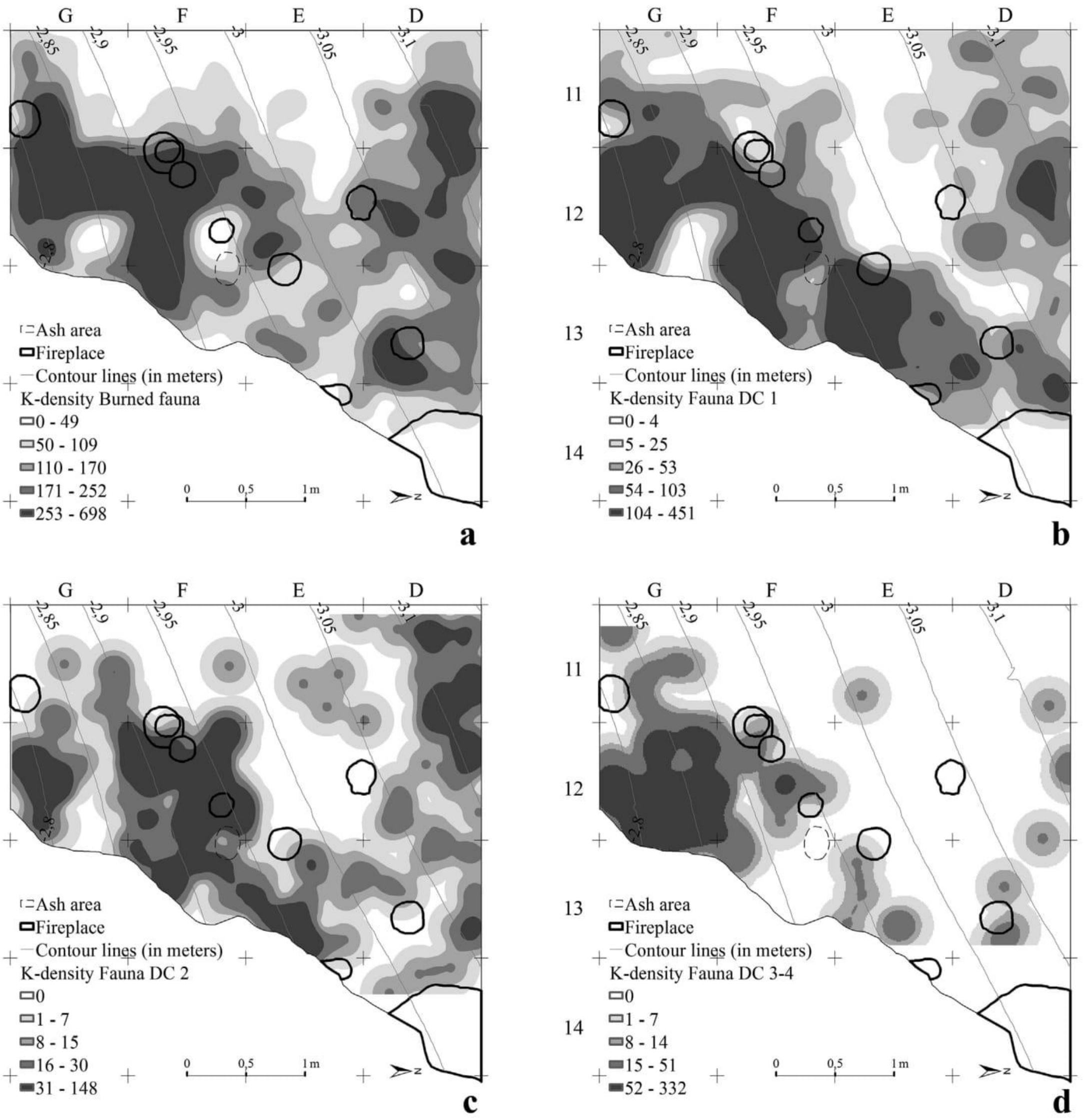

Fig. 3. Density maps for the burned faunal remains (a) and for the Dimensional Classes of the unburned faunal remains: DC 1 = 1–3 cm (b), DC 2 = 3–6 cm (c), DC 3–4 > 6 cm (d).

micro-fabric unit and represents the rock shelter basal deposit formed by the weathering of the underlying tephra and the colluviation of local rock and soil fragments with anthropogenic manuports (Fig. S2 and Fig. S3). mFU3 is diffusely cemented by micritic precipitate (Fig. 5c) and is found at the base of the hearths and also capping the wood ash layers in SU 12, SU 77, SU 78, SU 82, SU 83 (Fig. S2 and Fig. S3). mFU3a (Fig. S2b and Fig. S2c) is very similar in general composition and structure to mFU3, the only difference being that it is darker in color (dark brown). The darker color appears to be caused by a discoloration of the fine fraction possibly due to redox reaction of the iron compounds contained in the clay minerals and micrite due to the combustion of overlying fuel. mFU3a occurs in SUs 77, 78, 80, and 83 (Fig. S2 and Fig. S3). mFU3b (Fig. 5d) is very similar to mFU3 and mFU3a but shows a blackish brown color. The specific color of mFU3b appears to correlate to an increase in the abundance of partially decayed charcoal and micro-charcoal fragments with respect to mFU3 and 3a. mFU3b includes a microlayer of SU 12 (Fig. S3) and a burrow of SU 82 (Fig. S3).

mFU4 (Fig. S2) – light gray to blackish gray laminated micrite (Fig. S2b and Fig. S2c) with domains of oxalate pseudomorphs (i.e., "wood ash" – Fig. S2d), ashed and charred plant remains, and a few charcoal and bone fragments (calcined, charred, and uncharred). No grass phytoliths were observed in mFU4, thus it appears to

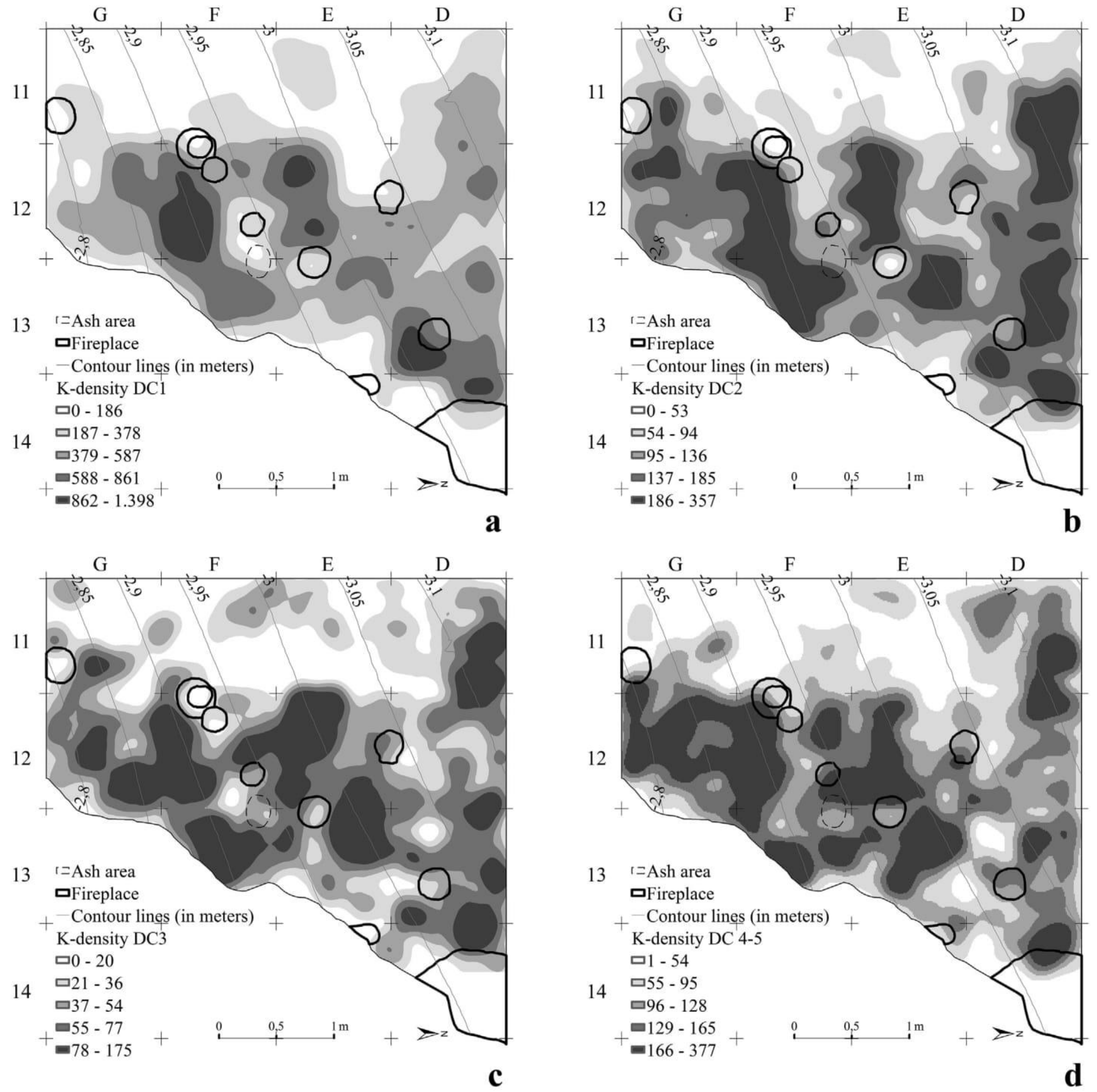

Fig. 4. Density maps the Dimensional Classes of lithic finds: a) 1–50 mm^2; b) 50–100 mm^2; c) 100–150 mm^2; d) >150 mm^2.

be derived from the combustion of woody and brush plant tissues. mFU4 has been found in SU 78 (Fig. S2) and highly broken up and reworked (mFU4a) in SU 12, SU 80 and SU 83 (Fig. S3). In summary the six hearths appear to be composed of wood ash layers (mFU4 and mFU4a) overlying or mixing within not discolored and discolored substratum (i.e., SU 13) composed of mFU1, mFU2, and mFU3.

4.1.1. Syn- and post-depositional processes

At the microscopic scale the deposits show evidence of intense syn-depositional bioturbation. The diffuse intrapedal granular microstructure (Fig. 5c, d and Fig. S2c) suggests that the deposits were reworked by the trophic action of organisms such as earthworms and mites. Horizontal and vertical passage features, rhizoliths in particular, broken boundaries and deformation features (e.g., SU 77) are commonly observable in the thin sections (Fig. S2b and Fig. S3). Micromorphological analysis shows evidence of at least two major processes of deposit cementation by calcium carbonate (Fig. 5a–d and Fig. S3): (1) a syn-depositional formation of micritic calcite precipitating diffusely in the ground mass; (2) a post-depositional formation of microsparitic infillings, coatings and hypocoatings of chambers, vaugs and channels. Bioturbation and carbonation of the sediments disturbed and obliterated the microscopic spatial organization of the original constituents. The

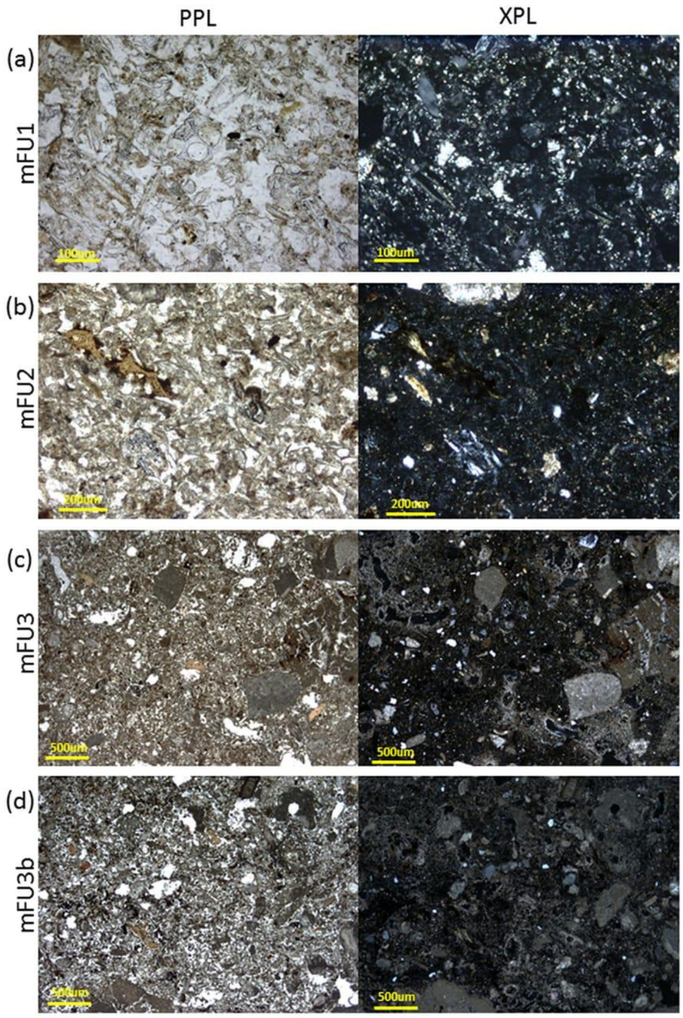

Fig. 5. Representative photomicrographs in plane-(PPL) and cross-(XPL) polarised light of: (a) micro-fabric unit 1 (mFU1) from burrow in SU 80; (b) micro-fabric unit 2 (mFU2) from the bottom of SU 77; (c) micro-fabric unit 3 (mFU3) from the base of SU 80; (d) micro-fabric unit 3b (mFU3b) with abundant micro-fragments of charred plant materials from SU 12. Note in the XPL microphotographs the micritic cementation of the groundmass and the microsparitic coatings and hypo-coatings of voids and channels.

precipitation and crystallization of calcite associated with the alkalinity of the soil solution appears to have particularly affected the preservation of the charcoal (e.g., in SU 80 – Fig. S3). On the other hand evidence of heavy trampling (human) is very limited. In fact most of the large flat-lying objects observed in thin sections (Fig. S3) do not show sign of being trampled. This observation suggests that the physical impact on the site and the hearths by the human group occupying the shelter had limited effects at the microscopic scale.

4.1.2. Hearths and palimpsest

Here we briefly report the results from the analysis of three hearths (SU 12, SU 78, and SU 83) that are most informative for the reconstruction of the palimpsest evolution of SU 13.

SU 12. The micromorphological analysis of sample OSC127 (Fig. S3) collected from SU 12 shows the presence of four microStratigraphic Units and several passage features (burrows). The top unit is composed of rock shelter deposit (mFU3) that caps a heavily reworked wood ash deposit (mFU4a). The ashes appear to lie directly on top of a rock shelter stable surface revealed by the presence of flat-lying gravel size fragments of bone (m-FTIR = heated < 500 °C) and chert (Fig. S3). The sediment underneath the reworked wood ash deposit is blackish brown and contains abundant amounts of weathered micro-charcoal (mFU3b – Fig. 5d). m-FTIR analysis also indicates that the associated fine fraction of the sediment did not reach temperatures above 500 °C. The portion of hearth SU 12 analyzed thus appears to be the remains of reworked wood ash lying on the rock shelter surface (i.e. SU 13) above the remains of decomposing, partially uncombusted fuel from an older combustion event shallowly buried in SU 13.

SU 78. In the thin section prepared from sample OSC140 from SU 78, four superimposed microstratigraphic layers cut by several passage features are observable (Fig. S2). Here a 5 mm thick layer of fairly well-preserved laminated wood ash is overlying a sharp and irregular boundary of a shallow pit (Fig. S2c). The sediment underneath the wood ash layer is discolored but does not contain major quantities of charcoal nor does m-FTIR analysis show that it was heated diffusely above 500 °C. It thus appears that the analyzed portion of SU 78 is the remains of a hearth fueled on top of the SU 13 with a small amount of woody material that underwent complete combustion. The wood ash layer appears to be capped by more rock shelter deposits (i.e., SU 13), suggesting that this specific location was used very briefly, and possibly refueled a few times only.

SU 83. The thin section prepared from sample OSC146 shows that portions of hearth SU 83 are composed of two major microstratigraphic layers (Fig. S3). The top layer is composed of a ca. 1–2 cm thick heavily reworked wood ash deposit (mFU4a) containing partially calcined bone fragments (m-FTIR = heated above 500 °C but below 800 °C). The boundary between the reworked wood ash layer and the underlying anthropogenic rock shelter deposit is sharp but extremely irregular. Moreover the shape of the boundary corresponding to the area sampled by the thin section is convex, suggesting that the hearth was not prepared in a pit. It thus appears that SU 83 was prepared on the irregular surface of the rock shelter (i.e., SU 13) and, with respect to the other hearths so far analyzed, it was fueled with a larger quantity of wood and other combustible materials and may have reached higher temperatures. A screening by m-FTIR of bone fragments (N = 67) observed in the six available thin sections shows that only a small percentage (8%) reached temperatures above 700 °C, suggesting that burning of bone was mainly accidental or due to disposal in the fire and that bone was probably not used as fuel (Théry-Parisot and Costamagno, 2005).

4.1.3. General consideration of site formation processes

The microstratigraphic analysis of the six hearths (i.e., SU 12, SU 77, SU 78, SU 80, SU 82 and SU 83) shows that all of them belong (as sub-Stratigraphic Units) to the same Stratigraphic Unit (i.e., SU 13) formed as a result of weathering of the underlying Mt. Epomeo green tuff and colluviation of geogenic and anthropogenic components. The geogenic components include rock fragments from the local lithostartigraphic column (micritic limestone, flowstone, calcarenite, and fossiliferous limestone) and soil aggregates formed above the ravine from the weathering of the Calcare di Altamura formation. The anthropogenic components include bone fragments (uncharred, charred, and partially calcined), charred wood (charcoal), angular chert fragments (débitage) and wood ash. The diffuse character of the majority of the observed microstratigraphic boundaries and the lack of observable erosional unconformity strongly suggest that the depositional processes of the SU 13 at Oscurusciuto rock shelter were dominated by sediment aggradation and cementation (e.g., brecciation) processes. Human activities appear not to have contrasted with the sediment build up but rather to have contributed to it with the introduction of wood ash, lithic raw materials, and bones.

4.2. Faunal analysis

From a total of 4660 skeletal elements collected, 4236 (90.1%) have a length between 1 and 3 cm. There are several fragments (n. 1935) with traces of combustion which are mostly constituted by small sized elements (1–3 cm: 95.2%). From the fillings of the combustion structures 88 bone fragments (all burned) were recovered; these have lengths between 1 and 6 cm (Table 1). Overall, the fragments larger than 6 cm number 121: they are mostly represented by portions of the diaphysis of long bones.

Table 1
Fauna dimensional classes.

	1–3 cm	3–6 cm	6–10 cm	>10 cm	TOT
SU 13	4236	303	110	11	4660

These highly fragmented samples permitted the taxonomic determination of only six remains: *Equus ferus*, a proximal epiphysis of metacarpal; *Bos primigenius*, two teeth (a molar and an incisor), a distal epiphysis of radius-ulna, a fragment of a metacarpal diaphysis and a distal fragment of a first phalanx. The bones were covered by a thin layer of carbonate concretion that prevented taphonomic analysis of surfaces.

Such a strong rate of bone fragmentation, probably aimed at the extraction of marrow (Boscato and Crezzini, 2012a), is found across the whole area of the shelter investigated so far.

Regarding the palaeo-environmental reconstruction, SU 13 is part of a group of Stratigraphic Units belonging to the same climatic phase (SU 15 to SU 4), moderately temperate and arid, characterized by a large extension of wooded grassland. Within this phase, hunting by Neanderthals was almost exclusively directed towards ungulates and particularly towards aurochs (Boscato and Crezzini, 2012b).

4.3. Lithic assemblage

In the layer there are 7504 lithic items which all show a fresh state of preservation and it is possible to observe a high frequency of refitting within short distances. The most utilized raw materials were siliceous limestone, jasper and chert in their fine granulometry (Table 2). The starting blocks of raw material were oblong pebbles coming from secondary local sources. The main reduction sequence was the recurrent Levallois, unipolar and convergent, designed to produce elongated and convergent flakes. There was also present a marginal volumetric debitage for the production of bladelets. A total number of 279 RMUs were identified, made up of 1770 pieces and 56 refitting and conjoins sets formed of 134 pieces. Table S1 shows the description of some reliable and representative RMUs relevant for the understanding of the technological and spatial behavior identified at SU 13.

Table 2
Lithological classes.

Raw material	Granulometry	N.	%
Jasper	Fine	1207	16.1
Chert	Fine	261	3.5
Jasper	Middle	80	1.1
Chert	Middle	314	4.2
Siliceous Limestone	Middle	1305	17.4
Limestone	Middle	37	0.5
Chert	Coarse	30	0.4
Siliceous Limestone	Coarse	51	0.7
Quartzarenite	Middle	137	1.8
Quartzarenite	Coarse	24	0.3
Limestone	Coarse	33	0.4
Indeterminate		4025	53.6
Total		7504	100.0

Despite the limitation due to the incompleteness of the excavated area, it was possible, thanks to the combination of technological analysis and study of the RMUs, to recognize the fragmentation of the reduction sequence. A large number of RMUs, consisting of one or a few elements of target products and retouched tools, leads us to hypothesize the import of finished objects (Fig. S4).

RMUs with many items are few in number and represent simultaneously all the technological phases of the reduction sequence with a predominance of management – as attested by RMUs 1, 56, 137, 177 (Fig. S5, Fig. S6, Fig. S7, Fig. S8). In these cases the entire reduction sequence seems to have occurred at the site. It is just as interesting to note that most of the cores, often entirely exploited, form part of RMUs with few elements, leading us to the hypothesis of possible exports of target products (Fig. 6).

4.4. *Taphonomy and spatial analysis*

4.4.1. *Taphonomy*

The absence of mammals' burrows or of root imprints, the fresh state of the lithic edges and the virtual integrity of the hearths suggest a very good state of preservation of SU 13.

Other parameters allow us to reach the same conclusion. The chi-square test, used to assess the clustering degree of the archaeological remains gave the result of 1489.81. This value is rather higher than the expected one for a random distribution (127.32 at probability level 0.001). Therefore, a non-random spatial pattern can be asserted. Using Ripley's K function, different spatial patterns are found among the Dimensional Classes of the lithic finds: clustered for those smaller than 50 mm^2, quite random for the items bigger than 50 mm^2 (Fig. S9). Behind this configuration, a size-sorting effect due to water flow can be ruled out. A downslope increase in fine-grained debris is not found, and in particular the position and shape of the smallest lithic find accumulations are not conditioned by the surface morphology of SU 13 (Figs. 3 and 4). This data is consistent with the slope analysis of the SU 13 surface, that highlights a sub-horizontal layer with a weak slope (less than 5°).

4.4.2. *RMU*

With regard to the refitting analysis a clear predominance of short distances is evident (Fig. S1). Usually these distances are shorter than 1.5 m.

In the lithic assemblage there are 30 RMUs with at least 10 items with a good or excellent degree of reliability. The Ripley's K-function results from this sample (Fig. S10, Fig. S11, Fig. S12) indicate that almost 1/5 of these RMUs have a highly clustered pattern from a radius distance band of between 0.5 and 0.6 m (RMUs: 1, 56, 137, 143, 193, 283) (Fig. 7 and Fig. 8). The agglomerations are concentrated around the hearths in the central part of the excavated area: only RMU 137 appears mainly focused on hearth SU 12 (or on SU 76), in the northern part of the excavated area. In the other cases random (RMUs: 9, 12, 31, 55, 64, 91, 132, 134, 146, 177, 197, 263, 264, 269, 279) (Figs. 7 and 8) and dispersed (RMUs: 53, 66, 96, 136, 139, 161, 255, 259, 280) patterns are recognizable. Nevertheless, by visual analysis, it is possible to get "disordered clusters", beside some random pattern. For example, in RMUs 12 and 177, both with a statistically random pattern, it is easy to recognize a lot of small agglomerates. The spatial organization of the technological phases of RMU 177, in particular, is very interesting: while the cortex removal, production flakes and indeterminate items are distributed in small agglomerates in the central and northern part of the excavated area, the target flakes are localized only in a small group

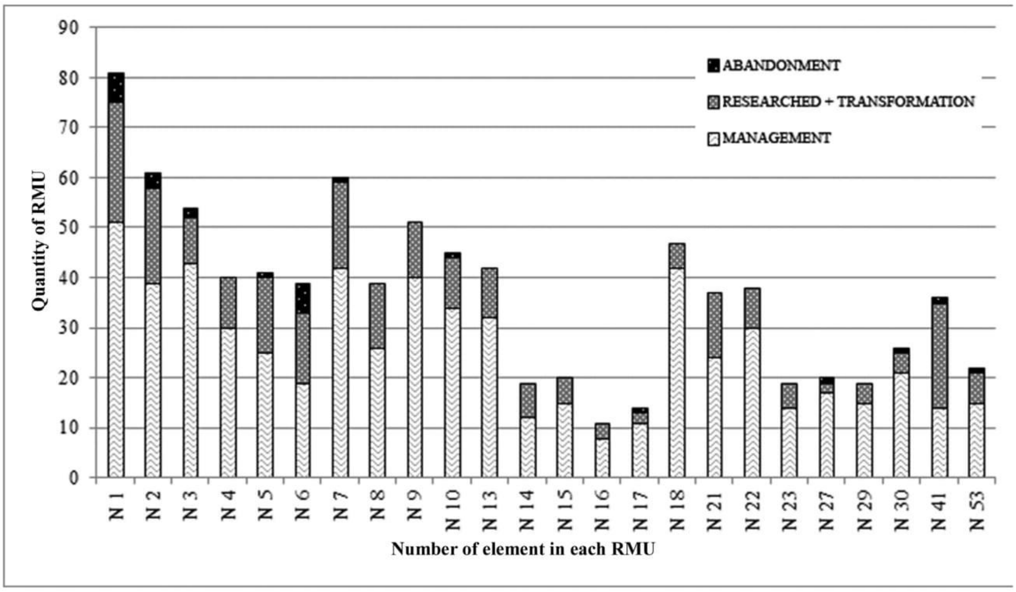

Fig. 6. Quantity and composition of each RMU. The graph shows on the X axes the number of objects for each RMU and on the Y axes the quantity of RMUs having the number of elements expressed on the the X axes. The different patterning of the columns indicate, on the other hand, the technological composition of RMUs: abandonment, target + transformation and management. These definitions refer to the technological phases of the reduction sequence of the lithic tools. "Abandonment" refers to cores, "researched" refers to all flakes which were the objective of production (in this case elongated, convergent and backed flakes as well as bladelets), "transformation" refers to retouched flakes. "Management" comprises all the flakes necessary to remove the cortex and to manage the technical knapping parameters needed for the production of target flakes.

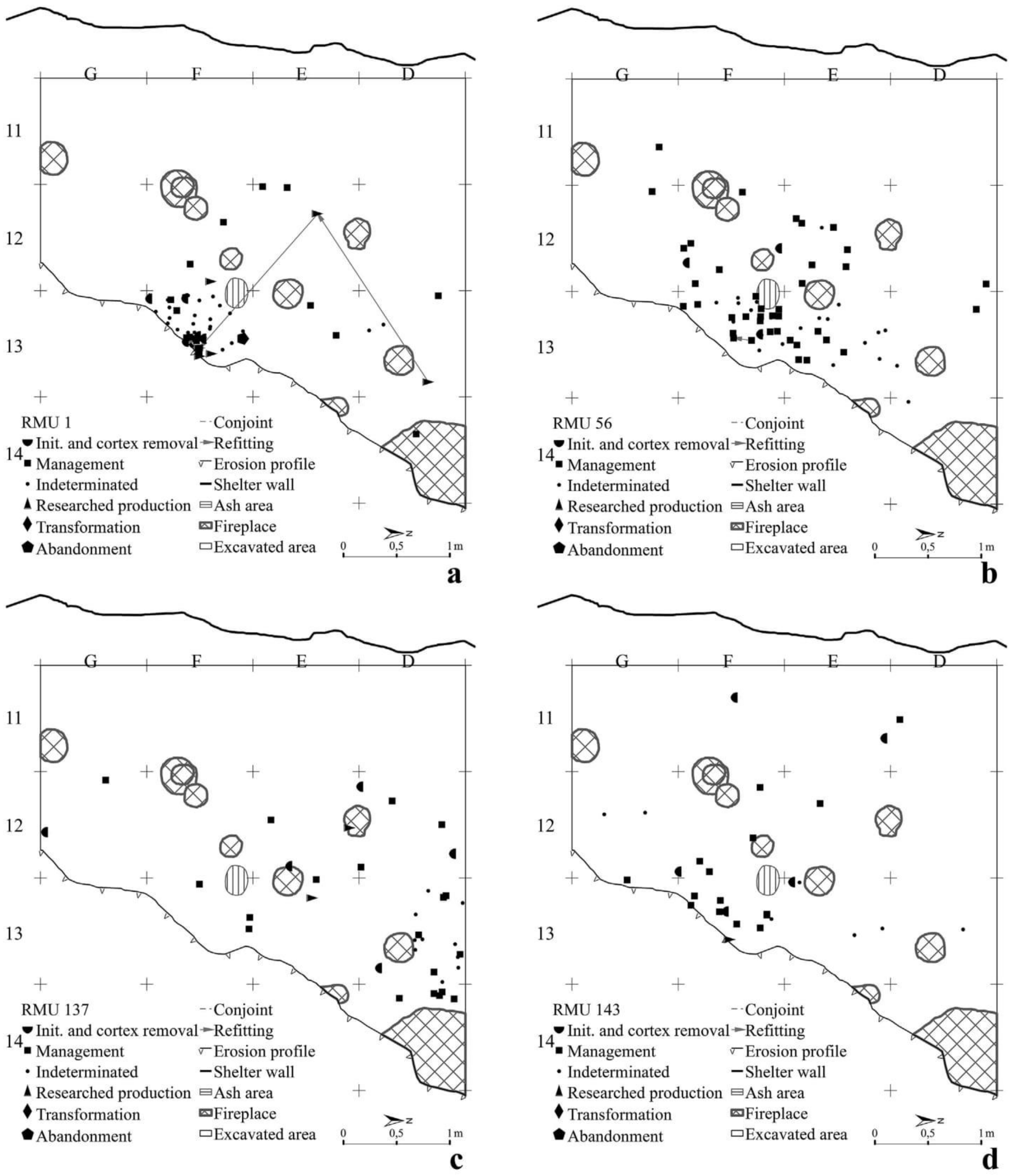

Fig. 7. Planimetry of the RMU 1 (a), RMU 56 (b), RMU 137 (c), RMU 143 (d).

around hearth SU 82, in the southern part of the excavated area (Fig. 8). Along with the high frequency of short refittings/conjoints, the presence of significant numbers of clustered patterns among the RMUs could be related to good preservation of the activity areas.

The vertical distribution of the items in these RMUs was evaluated where at least 3 elements of each RMU had the actual coordinates recorded. On the profile N–S of the excavated area, the scatter-plot highlights a good coincidence between the lying plane of these RMUs and the altitude of SU 13 (Figs. 2 and 9).

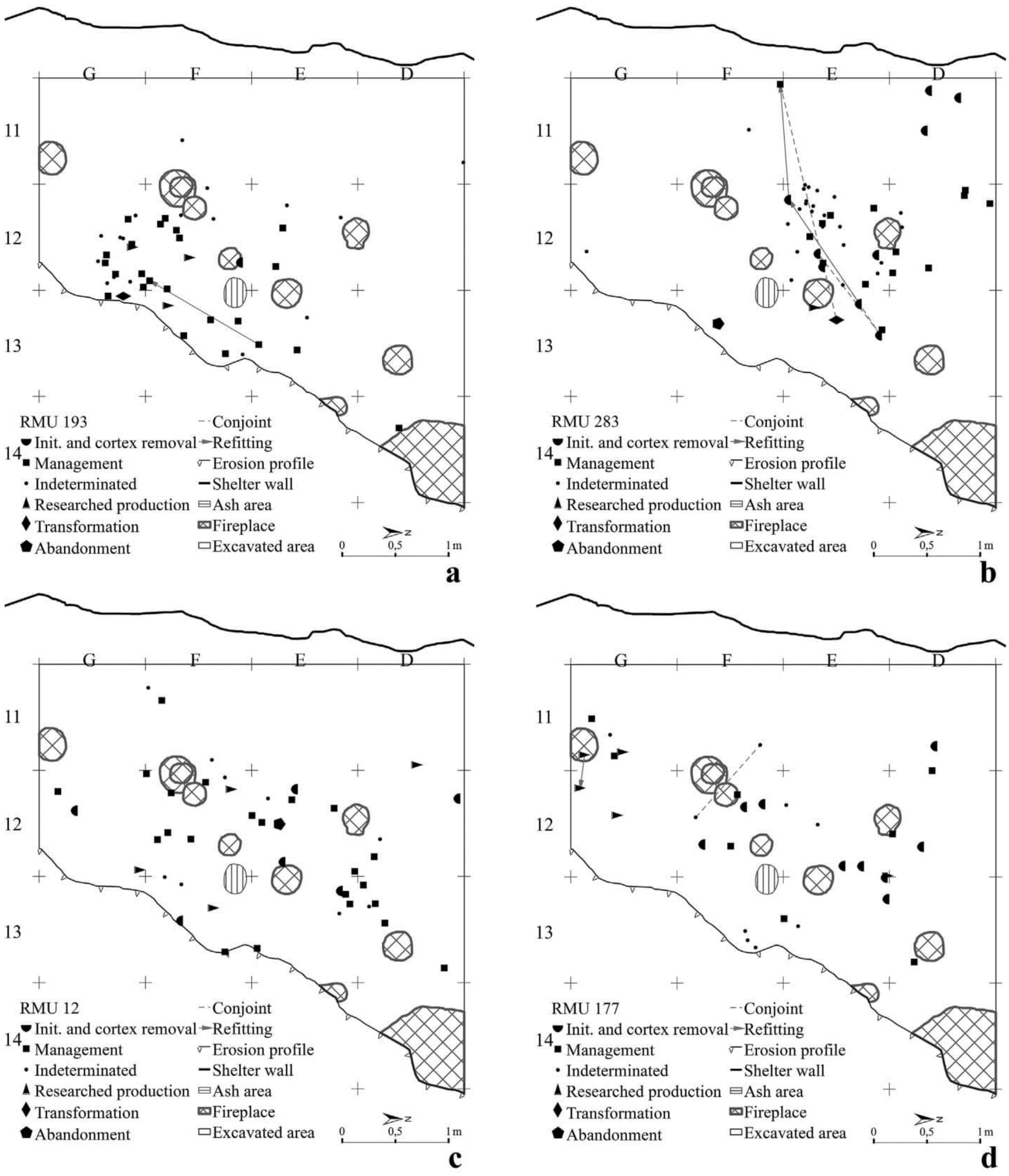

Fig. 8. Planimetry of the RMU 193 (a), RMU 283 (b), RMU 12 (c), RMU 177 (d).

Another interesting point derived from the RMU analysis consists in the relationship between the spatial pattern, the number of items for RMU and their technological composition. In order to analyse further, two technological macro-categories were created: the first one consisting of the "tools" (target products, retouched tools and items with macro-traces) and the second of the production "waste" (initialization and cortex removal flakes, management flakes and indeterminate). Due to the complete exploitation of their

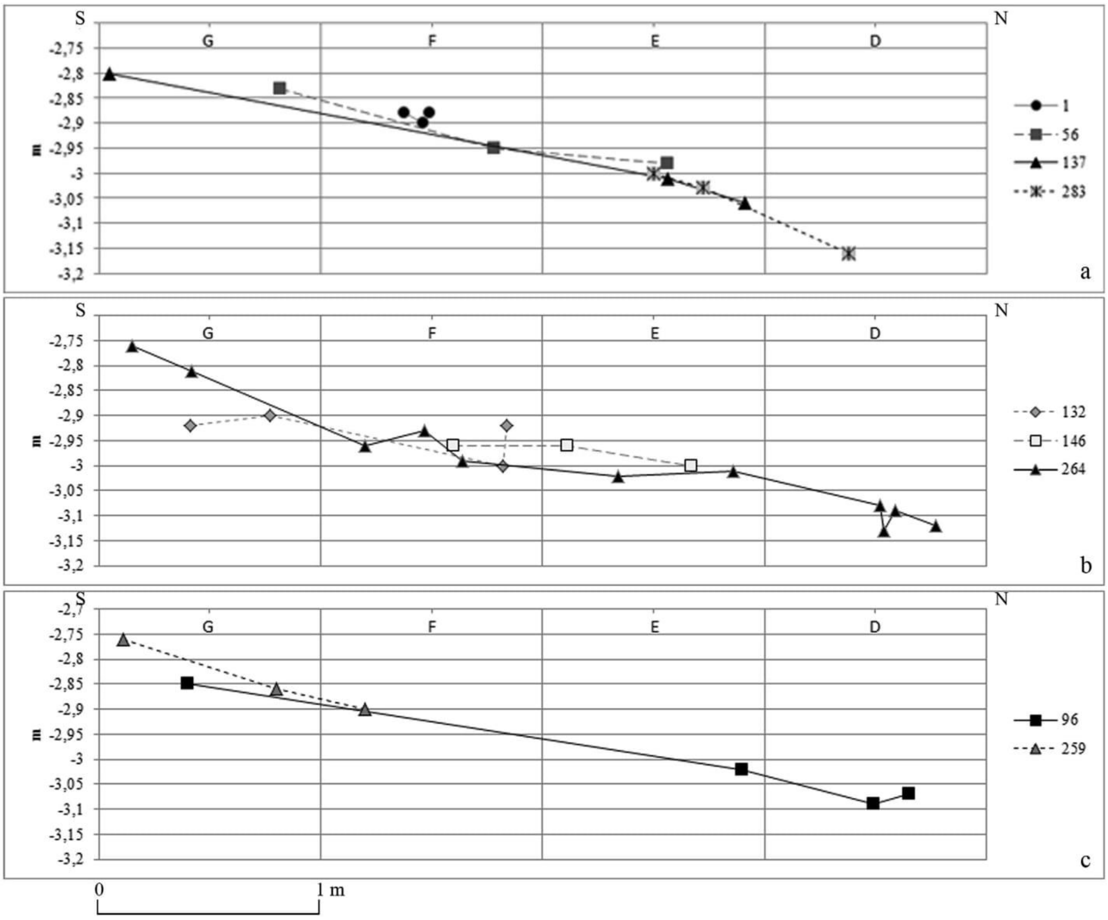

Fig. 9. Vertical distribution on the N–S profile of the items in the clustered RMU (a), random RMU (b), dispersed RMU (c).

volume, the few cores were included in the second category. As shown by the scatter-plot graph, there is a clear difference in the RMUs' dimension and technological composition compared with their spatial pattern. The clustered RMUs have a large number of items and a strong representation of production waste in relation to tools. On the contrary, the dispersed RMUs have few items and tend to exhibit an overrepresentation of tools instead of waste. The random patterned RMUs, as expected, show some mixed characters (Fig. 10).

4.4.3. Spatial organization

Through the analysis of the density maps of lithic and faunal remains, a clear distinction between the inner part of the rock shelter and the outer is recognizable. The area enclosed between the rock shelter wall and the hearths' alignment (about 4 m^2 including the small unexcavated stratigraphic baulk against the wall) is characterized by the almost total absence of lithic finds and faunal remains. The other area (about 8 m^2), delimited at North and South by unexcavated stratigraphic baulks, is interrupted by the erosion front (in the eastern part). In this area, the presence of the hearth and the massive amount of anthropic remains, well-structured in some distinct agglomerates, is the distinctive feature (Figs. 3 and 4).

Computation of the distances between the hearths (from the respective centroids) highlight a significant recurrence of median values around 1.63 m: the same distance between the rock shelter wall and the hearths nearest to each other (1.3–1.6 m). A recurrent pattern related to the hearths consists in the distance from their centroids to the nearest accumulations of lithic finds smaller than 50 mm^2 and faunal remains smaller than 3 cm, which is 70 cm.

5. Discussion

With its material culture, ecofacts, and hearth feature SU 13 is an interesting context for studying the settlement and economic strategies of the Neanderthals in Oscurusciuto rock shelter.

Microstratigraphic investigation suggests that a series of hearths were lit on the surface of the local deposit composed of weathering Epomeo tuff and colluviated degrading local limestone. The absence of large scale burrows and carnivore activities, erosion or flooding, and the general integrity of the hearths resulting from one or a few combustion episodes enable the recognition of the

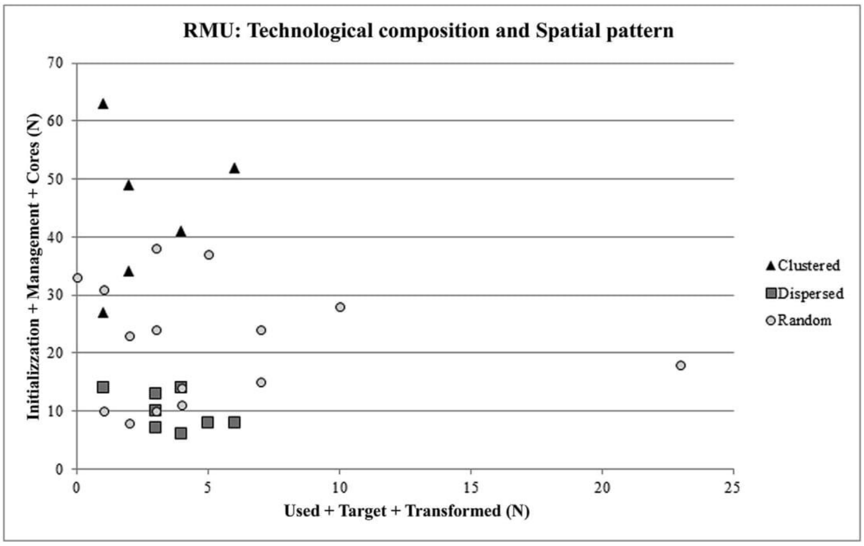

Fig. 10. Technological composition of the different spatial patterns of RMUs.

exceptional state of preservation of the layer. The *in loco* availability of subsistence sources (hunting prey) and of knappable raw materials contributed to the attractiveness of the site. The lithic industry is dominated by convergent and unipolar levallois production. This was designed to obtain convergent and backed long flakes, whereas the volumetric production of bladelets was marginal. The fragmentation of the reduction sequences and the on-site absence of some phases of the *châine opératoire* suggests that these activities were carried out elsewhere, entailing a certain mobility of the Neanderthal population of the Oscurusciuto. The mobility of the hunters is also attested by faunal remains: the lack of vertebrae and ribs in the shelter points suggests the dismembering of carcasses at killing sites and the transportation to the shelter of the limbs and crania of the killed animals.

The patterns observed in the spatial distribution of lithic and faunal remains are clearly not random, and they mainly reflect the outcome of anthropogenic activities. Zones of Organized Activity (Allué et al., 1993) are clearly recognizable on the basis of the strong recurrence of the same space-functional modules. In SU 13 the strong recurrence of hearth dimensional modules allows the identification of quite defined spatial patterns. These hearths constitute an alignment that acts as a “barrier” and divides the deposit into an internal part (enclosed within the alignment and the wall of the shelter) and an outer part including the hearths (incomplete as partially removed by erosion slope). This pattern is further emphasized by the distribution of lithic and faunal remains. The density gradients of various analyzed categories bring out a clear distinction between the inner area (characterized by an almost complete absence of findings) and external area (with a high density of artifacts). Moreover, in the external area, an additional configuration (discernible thanks to the density maps) shows a different organization of the northern half of the outside area compared to the southern half (Figs. 3 and 4).

It is significant that spatial patterns differ according to specific categories of data. Regarding dimensional classes, for example, opposite patterns are observed between lithic and fauna. While lithic finds tend to be clustered in the smaller dimensional classes (with configurations of random type in the remaining ones), the faunal remains show a pattern strongly clustered in major size classes, while the smaller classes and the burnt remains are more likely to show a random distribution. Likewise, among the lithic technological classes, only cores and retouched pieces have a clustered distribution as to a minor extent do the used tools. This evidence is the result of overlapping different events, which are classifiable in the palimpsest model: a modular repetition of the same pattern of use of the space are flanked by partial dislocation spaces which, at least in part, allow the identification of individual activity.

Thanks to the RMU technique it is possible to get a high temporal resolution, clearly identifying not only individual events, but also the temporal meaning of some spatial patterns. Indeed the analysis of RMUs revealed a rather complex scenario, not only according to the technological composition of the lithic assemblage, but also regarding the sequences of activity identified at the site.

Taking into account the spatial distribution patterns of the reliable RMU with at least 10 items, it is possible to recognize three distinct spatial patterns: clustered, random and dispersed. Also a different technological composition corresponds to this spatial distribution of the RMUs. On the basis of these two elements it is possible to individuate a different temporal value to the three spatial patterns: the clustered pattern corresponds to a final subphase of occupation; the random pattern to an intermediate subphase and the dispersed pattern to an initial subphase of the occupation.

The RMUs with few elements, a high frequency of tools (compared to waste) and more dispersed spatial patterns, from a temporal point of view, can be interpreted as the product of a rather long time between the production of the object and their burial. This means that such materials having been exposed longer to voluntary (activity areas maintenance, selection of tools used outside of the production areas) and involuntary (trampling, scuffing) factors of translocation are more dispersed on the surface of the layer. This category of scattered RMUs indicates an initial moment of the individual phase of occupation. A possible behavioral explanation of the technological composition and spatial patterns of these RMU could consist in the fact that, while waste was more easily dispersed (for both involuntary and voluntary factors), the tools would be maintained because of their major technical investment and their essential utility in daily occupations.

The RMUs with a high number of elements and a technological composition consisting of only a few tools and concentrated spatial patterns may indicate a short interval of time between production and burial, suggesting the final events before abandonment of the site. Hardly surprisingly is the low number of target products related to these RMUs, since some of them may have been removed at the time of departure (exports). In terms of space, the first product of flaking activity is the drop-zone, a rather compact agglomeration consisting basically of production waste (e.g. Binford, 1983; Stevenson, 1991; Vidale, 1992: 158–175; Vaquero and Pastò, 2001; Jones, 2008; Olausson, 2010; Bertran et al., 2012, 2015; Henry, 2012). While the cores (especially if still exploitable) may remain spatially correlated with the drop-zone, the set of tools could also be moved to a working area different from the one for flaking (Fig. 11).

The remaining RMUs with random patterns (or semi-clustered), as suggested by all technological and spatial parameters, in temporal terms could be intermediate moments between the initial and final occupation.

One aspect which is worth noting concerns the distribution of structures in SU 13. The combustion structures are concentrated in the top part of the layer, except for hearth SU 82, which is found inside the unit, set within a small pit which partially cuts into the underlying SU 14. It is thus possible to infer an initial sporadic frequentation followed by a more stable occupation with the setting up of aligned hearths. In this regard it is particularly significant that the RMUs with concentrated patterns gravitate around the central area of the site (only one seems to have as its focus the hearth SU 12, in the north). This could suggest a strong chronological proximity between these RMUs, which could then all refer to the same end-event rather than an event of settlement. Also significant is RMU 177, with a random spatial pattern, since an original decomposed drop-zone is clearly distinguishable (made up almost exclusively of waste) in the central part of the excavated area and a small accumulation composed almost exclusively of target objects is seen

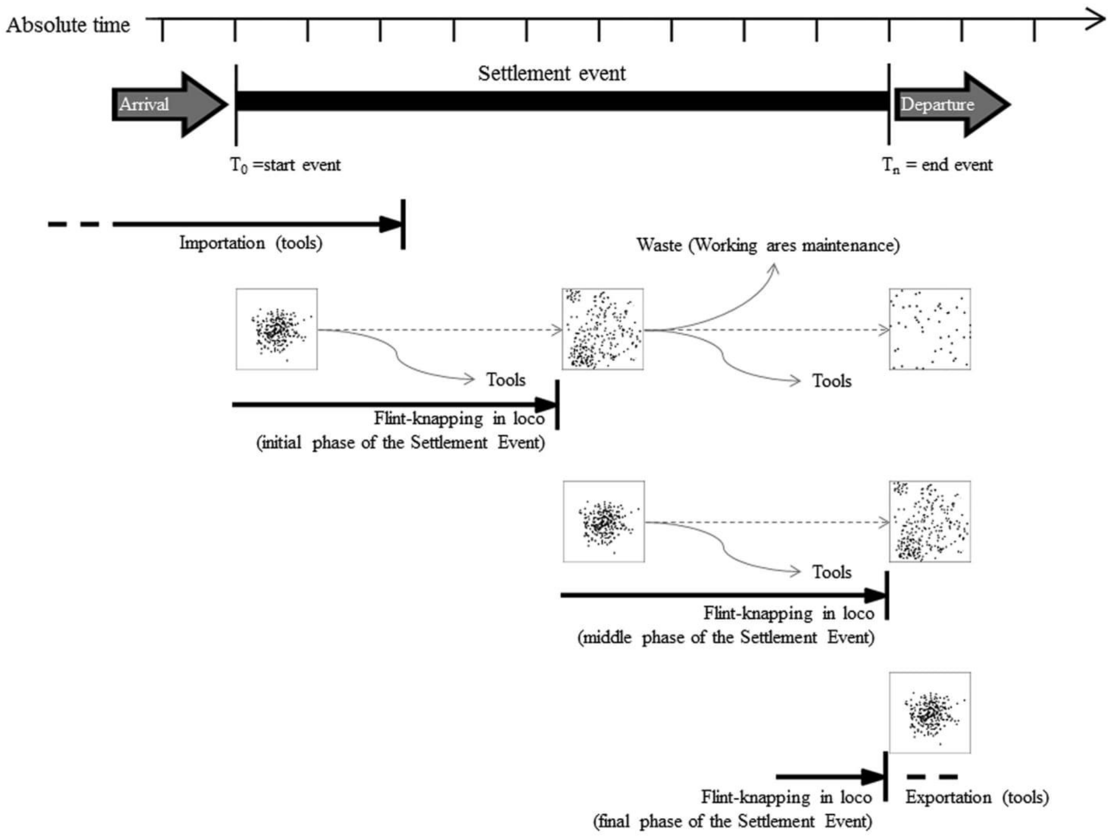

Fig. 11. Possible temporal meaning of the spatial pattern of the RMUs.The image shows the spatial configuration of the technological composition of RMUs within the site in relation to the length of the occupational event. An 'occupational event' is meant as the elapsed time between the arrival and departure of a human group, indicated by different activities of finished stone tool importation (importation tools) and the introduction of knappable raw materials, recognizable through the RMU analysis. The different spatial distribution of RMUs (clustered, random, dispersed), as it can be recognized at the site, can be put in relation to the time elapsed between the introduction of the RMUs and the abandonment of the site.

around the hearth SU 82 (the first combustion structure set in the layer).

6. Conclusion

Finally, a series of clues lead us to interpret SU 13 as the product of a series of individual events referable to a rather short period, which presumably could be ascribed to the same human group. The spatial data of the RMUs seems to suggest the existence of brief events during a single phase of occupation, which can be seen by the gravitation of almost all concentrated RMUs in the same area. The presence of a stratigraphic overlap of two hearths and the hearth SU 82 (built before the other combustion structures) suggests a succession of at least two events separated in time, but not necessarily of an alternation between phases of occupation and phases of abandonment. The alternation of two events is also suggested by the distribution of hearths within the SU, where they all concentrate in the top part of the layer (except for hearth SU 82). But the vertical distribution of artifacts and the recurrence of the same spatial patterns does not seem to justify the hypothesis of a possible sequence of occupation events interspersed with phases of abandonment.

In conclusion, SU 13 can almost certainly be assessed as a short palimpsest (i.e. the product of a set of events taking place in a small period of time). As the research stands now, it remains difficult to define which kind of occupation is reflected by this short palimpsest. Both the hypothesis of at least two (if not most) occupational events being separated by brief hiatuses, and the hypothesis of a single settlement event seem equally plausible.

Having realized the validity of this integrated method of analysis it is our intention to carry on with the study of the other levels of the site so as to have a diachronic vision of the occupation modalities and of the organization of the living space by the Neanderthal populations of the Ginosa ravine.

Author contribution

Annamaria Ronchitelli is the coordinator of the research with Paolo Boscato. The study of the lithic industry is part of Giulia Marciani's Masters thesis. The spatial analyses are based on Vincenzo Spagnolo's Masters thesis. Both of them were supervised by Daniele Aureli and Filomena Ranaldo. The micro morphological study of the hearths was undertaken by Francesco Berna.

Acknowledgments

The research was carried out by the Dipartimento di Scienze Fisiche, della Terra e dell'Ambiente – U.R. Preistoria e Antropologia of the University of Siena (Italy) with the partnership of Soprintendenza Archeologia della Puglia, the local Section of Legambiente and the Municipality of Ginosa. The authors are indebted to the Municipality of Ginosa, Onlus CESQ, to Piero di Canio and to all the students who participated in the excavation of 2011. Sem Scaramucci and Nigel Packer are warmly acknowledged for their help in the English version of this paper. FB would like to acknowledge the work contribution of Ginevra Toniolo and the financial support from the Canada Social Sciences and Humanities Research Council (Grant # SSHRC 2013-000546). We would like to thank the anonymous reviewers for their advice which helped us to enrich the paper. This paper was presented at session B55-Advances in Archaeological palimpsest dissection, XVII UISPP World Congress held in Burgos (Spain) in September 2014 and organized by C. Mallol and C. Hernández.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.quaint.2015.11.046.

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Supplementary Information

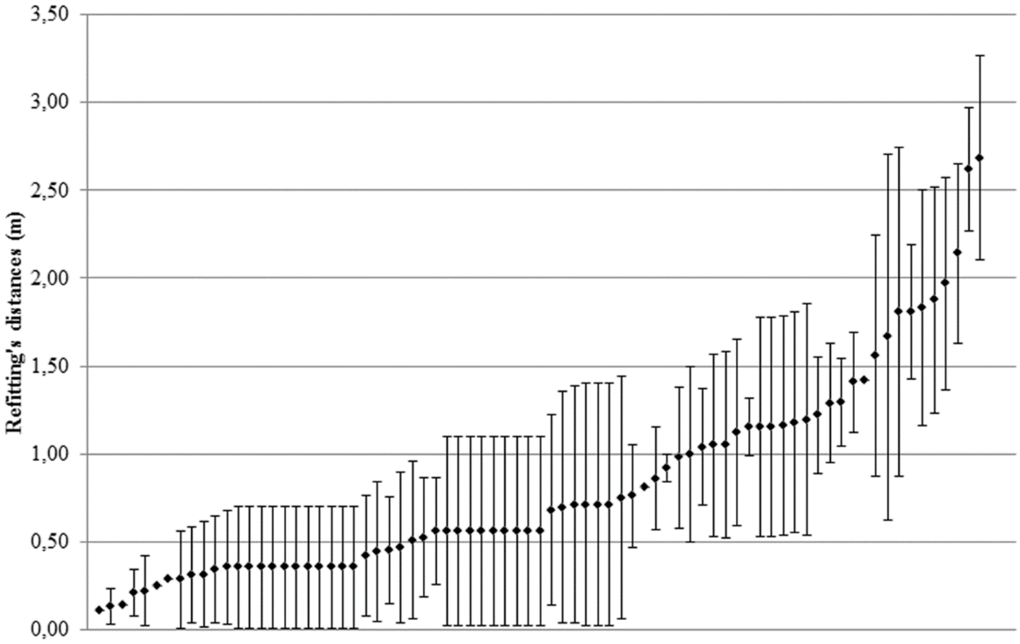

Fig. S1: Refitting distances with error bars.

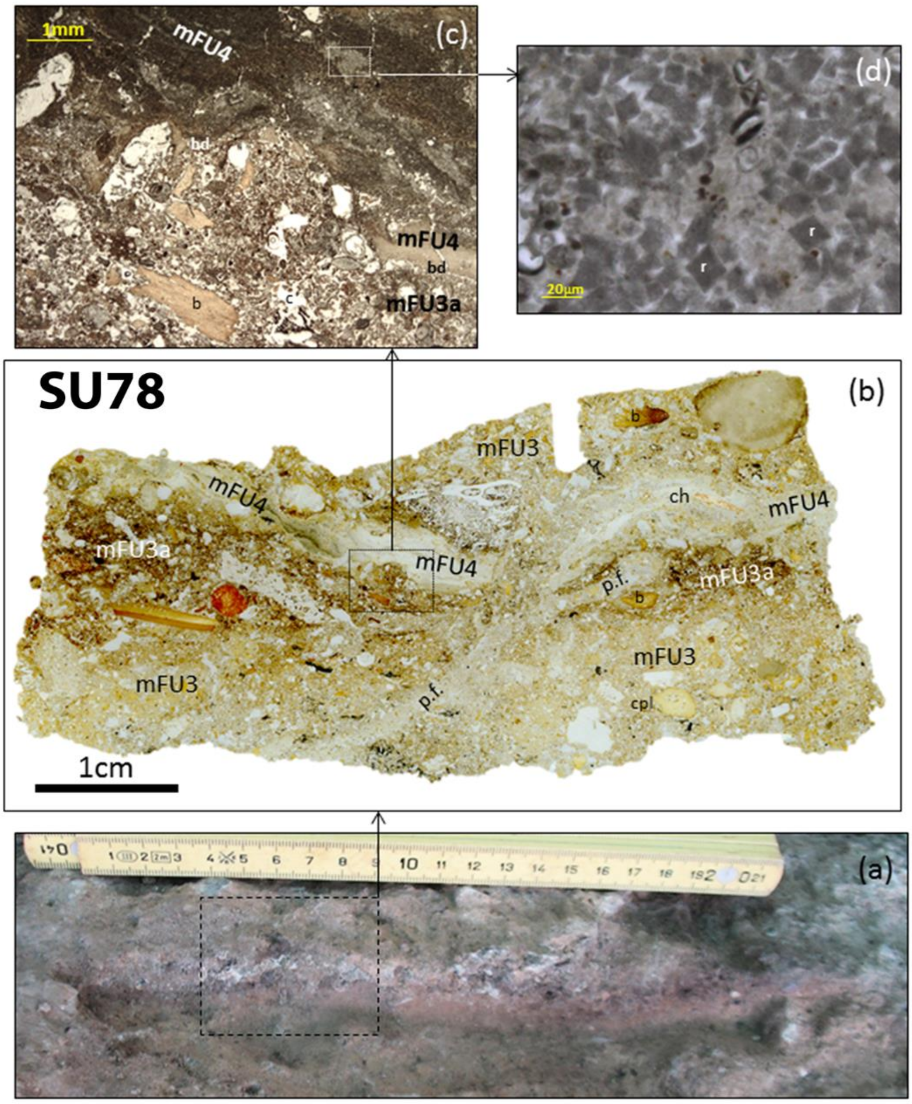

Fig. S2: Close-up photograph of the (micro) stratigraphic profile of hearth SU 78; (b) Scan of a petrographic thin section processed from an intact block sampled in correspondence of the box in figure (a). Note several micro-fabric units (mFU), a chert flake (ch) deposited in the wood ash layer (mFU4), bone fragments (b), a coprolite (cpl) in the rock shelter deposit (mFU3), and the passage features (p.f.) cutting through 3 mFU; (c) Photomicrograph (plane-polarised light) of the micro-stratigraphic boundary between the laminated wood ash layer (mFU4) and the underlying dark brown rock shelter deposit (mFU3a). Note the sharp but irregular boundary (bd) between the two mFUs. Bone (b) and weathered charcoal (c) fragments are abundant in mFU3a; (d) Photomicrograph from the boxed area in figure (c) showing a domain of wood ash characterized by the presence of rhomb shaped oxalate pseudomorphs composed of pyrogenic calcite (r).

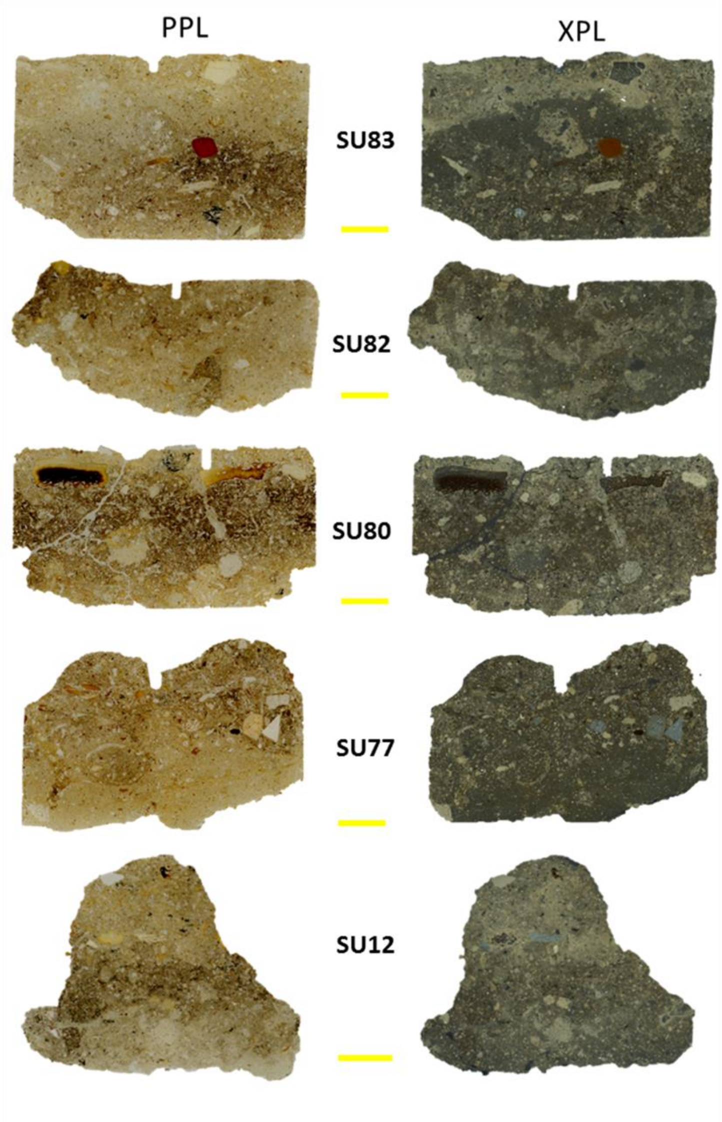

Fig. S3: Cut-outs of the digital scans in plane-(PPL) and cross-(XPL) polarised light of the petrographic thin sections prepared from intact blocks of hearths SU 12, SU 77, SU 80, SU 82, and SU 83. Note the wood ash layers at the top and the underlying discolored layers diffusing into lighter color rock shelter sediment.

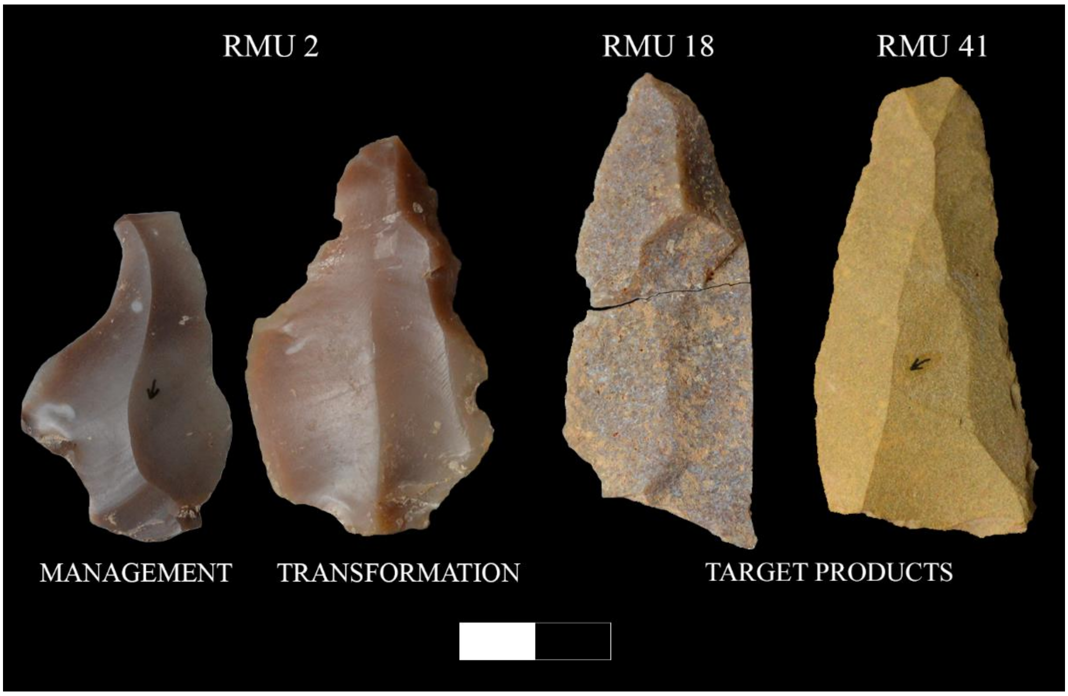

Fig. S4: Photo imported RMU. RMU 41 consists of a single target piece, a long convergent flake, made in a variability of siliceous limestone unique in the level. RMU 2 where two items, a Levallois retouched flakeand a debordant flake in a very fine texture flint (probably imported). RMU 18 two fragments of an elongated flake.

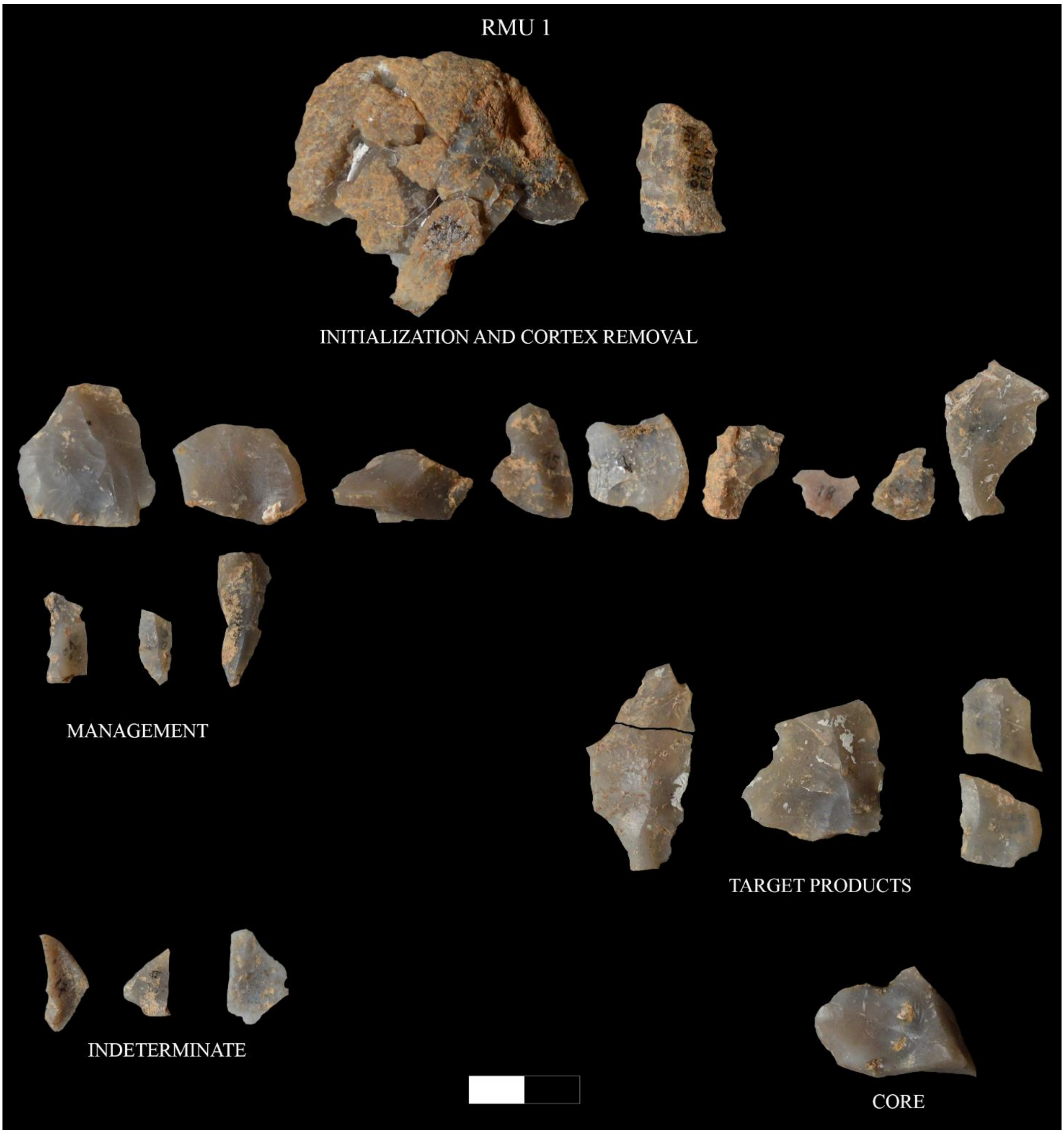

Fig. S5: Photo RMU 1. 34 micro-flakes and micro-fragments are not included in the photo.

Fig. S6: Photo RMU 56. 46 micro-flakes and micro-fragments are not included in the photo.

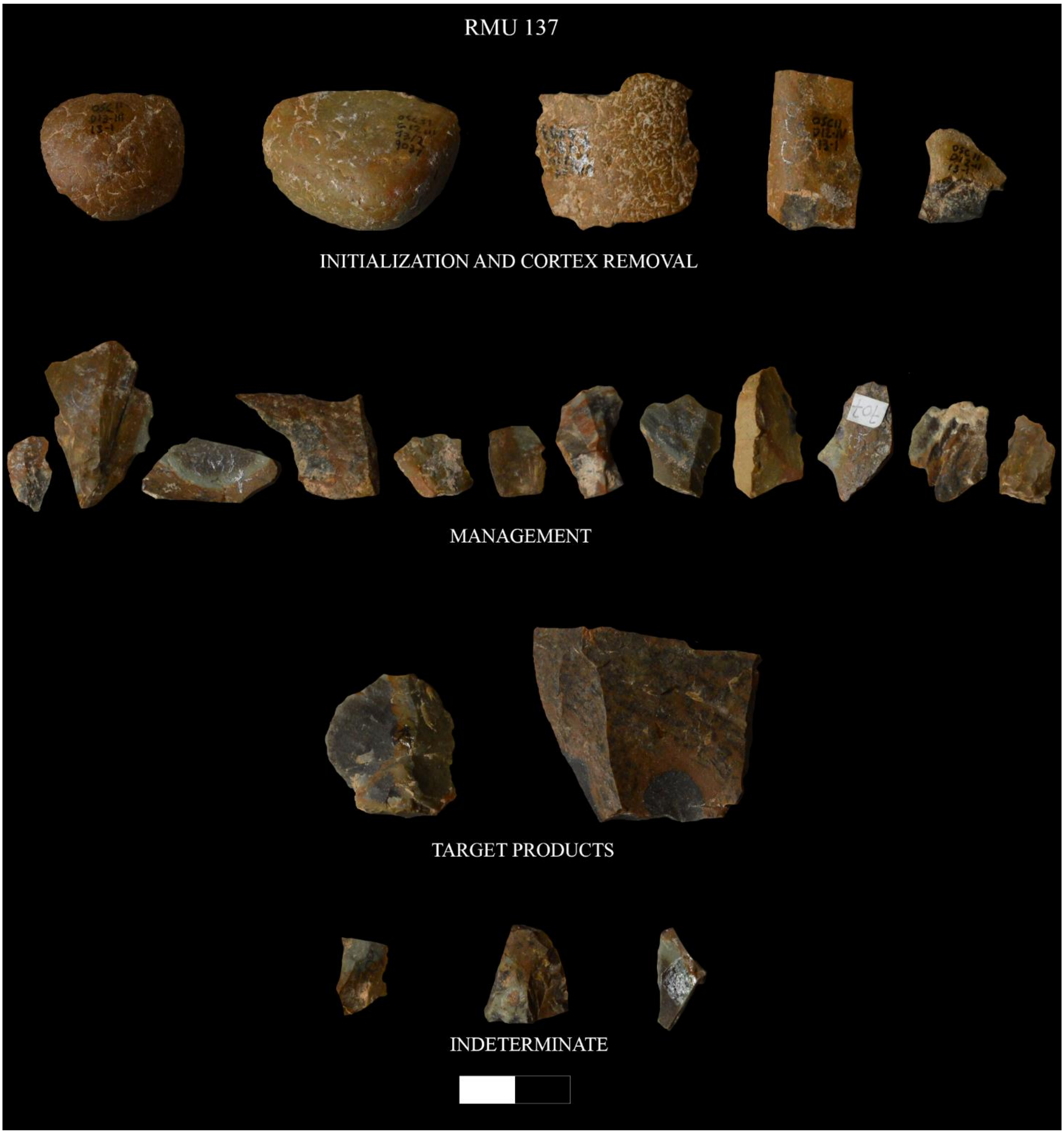

Fig. S7: Photo RMU 137. 14 micro-flakes and micro-fragments are not included in the photo.

Fig. S8: Photo RMU 177. 8 micro-flakes and micro-fragments are not included in the photo.

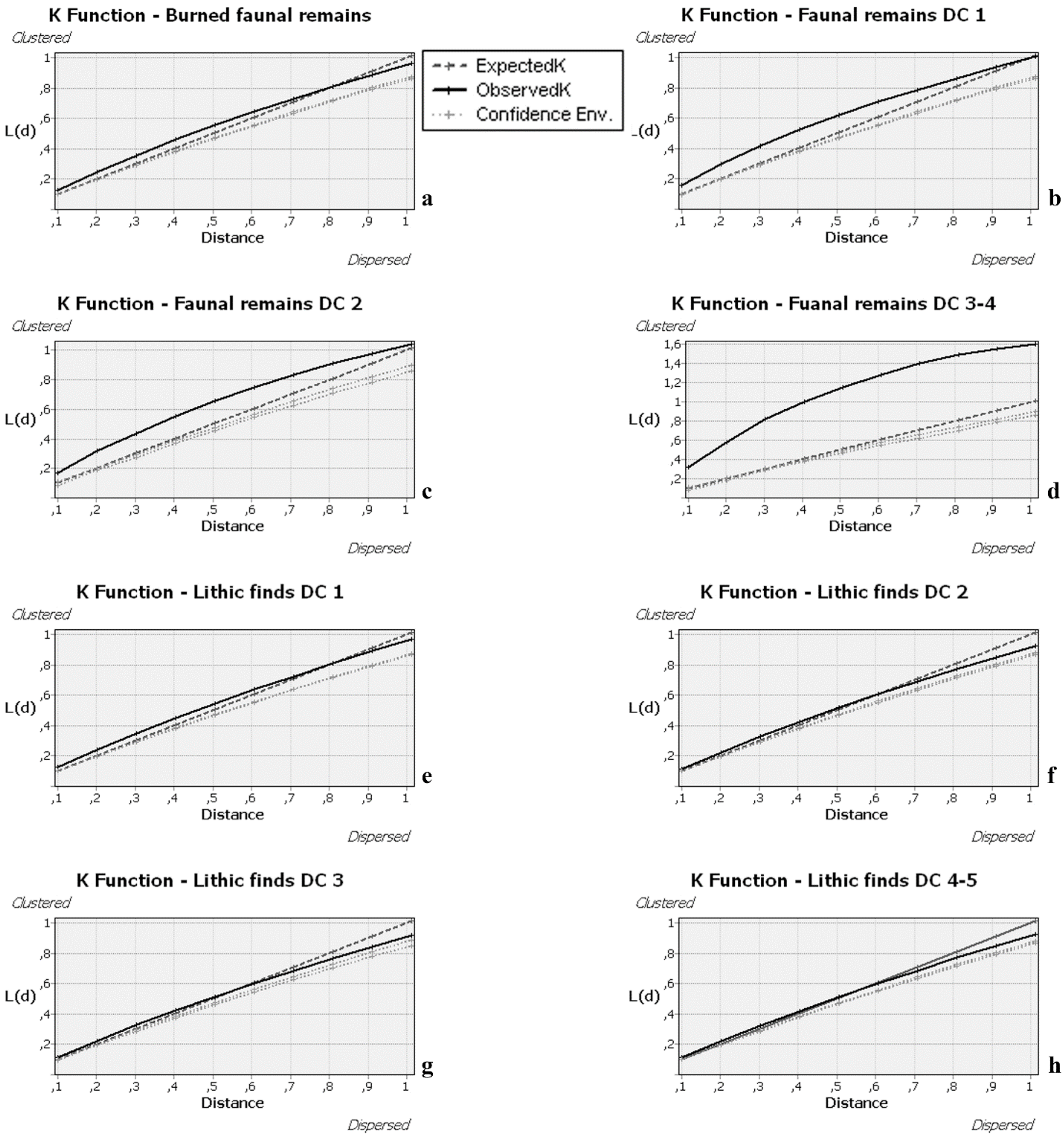

Fig. S9: K function of the burned faunal remains (a), Dimensional Classes of faunal remains (b-d) and Dimensional Classes of lithic finds (e-h).

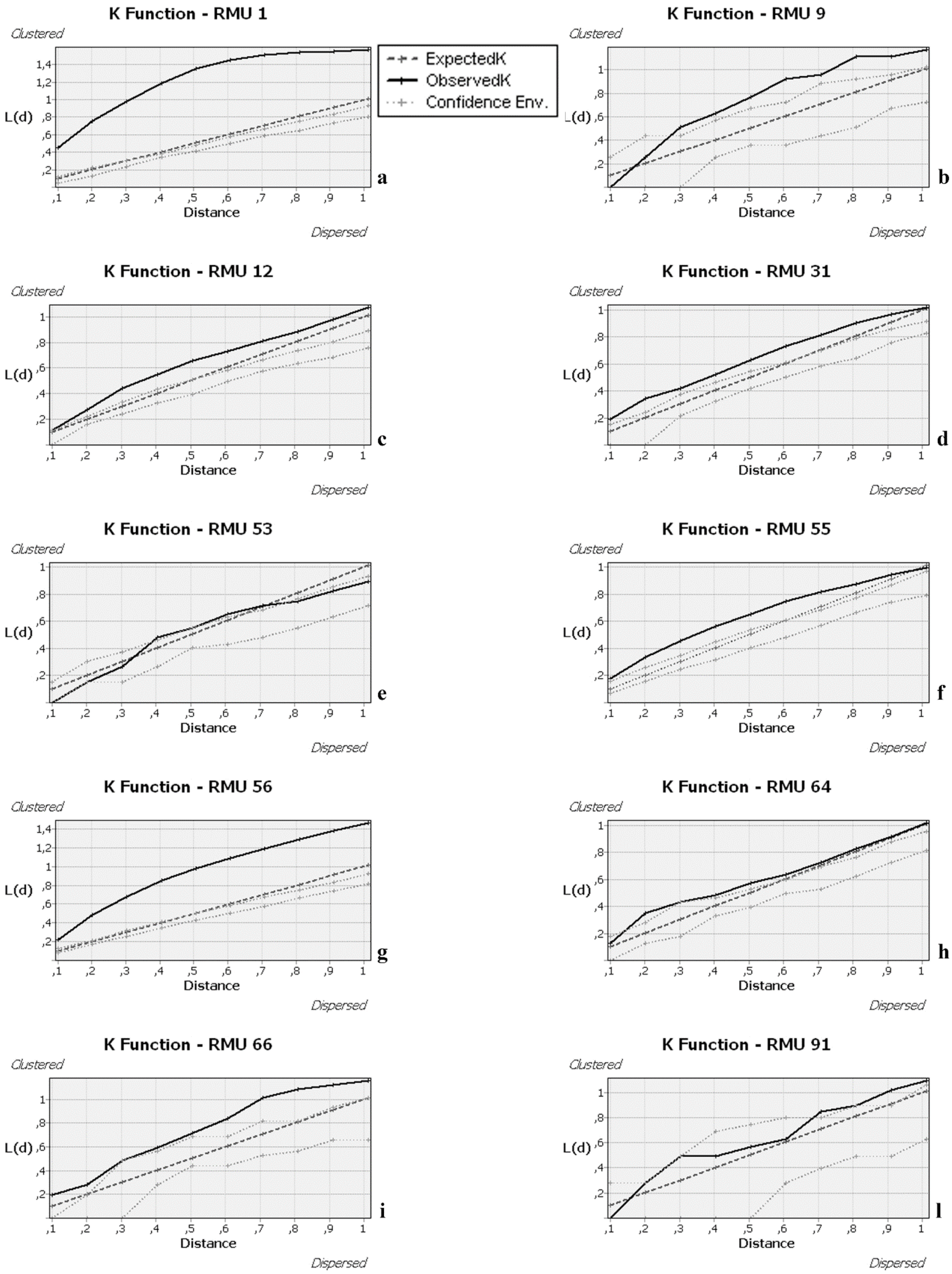

Fig. S10: K function of the RMU 1 (a), RMU 9 (b), RMU 12 (c), RMU 31 (d), RMU 53 (e), RMU 55 (f), RMU 56 (g), RMU 64 (h), RMU 66 (i), RMU 91 (l).

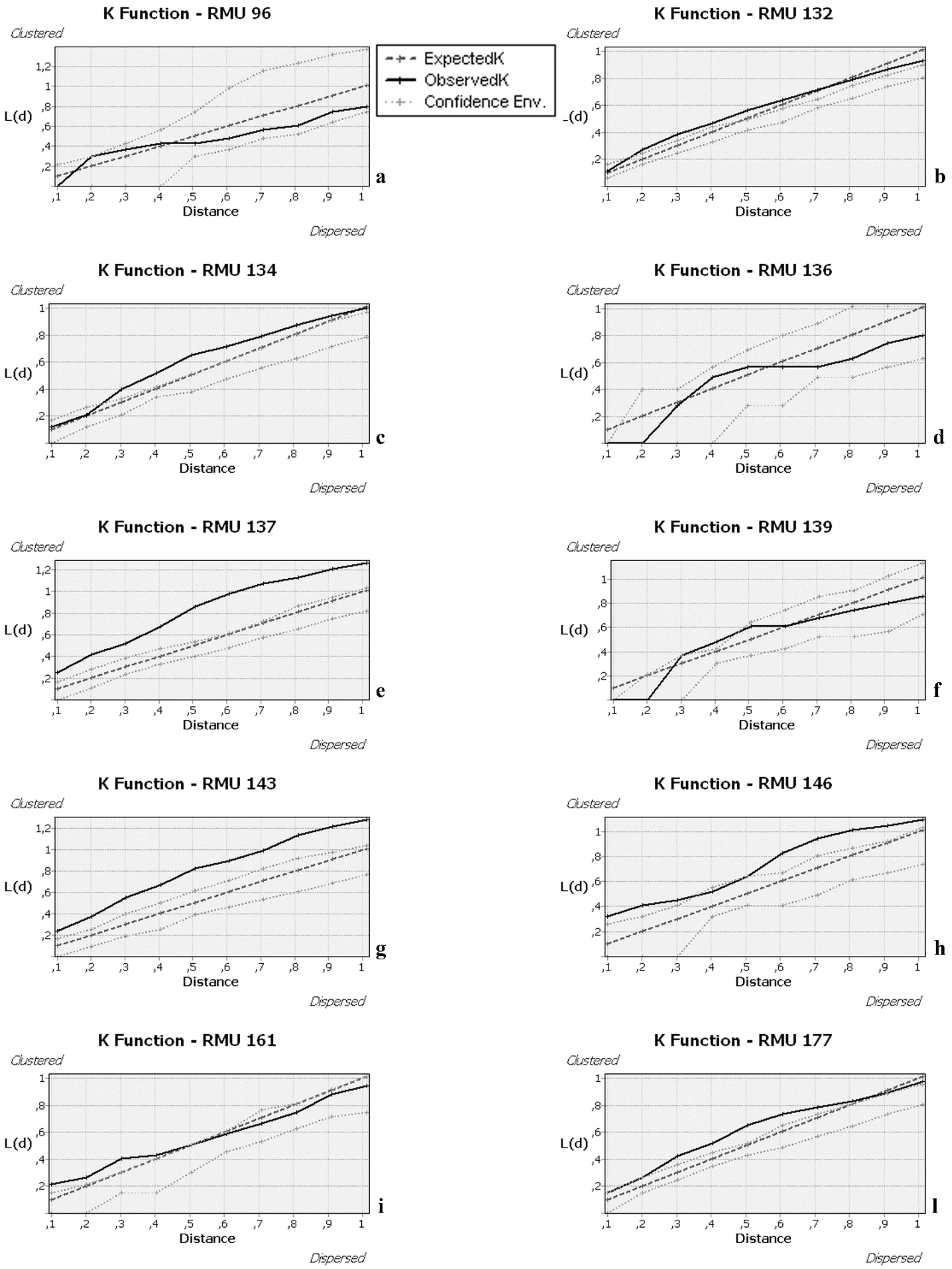

Fig. S11: K function of the RMU 96 (a), RMU 132 (b), RMU 134 (c), RMU 136 (d), RMU 137 (e), RMU 139 (f), RMU 143 (g), RMU 146 (h), RMU 161 (i), RMU 177 (l).

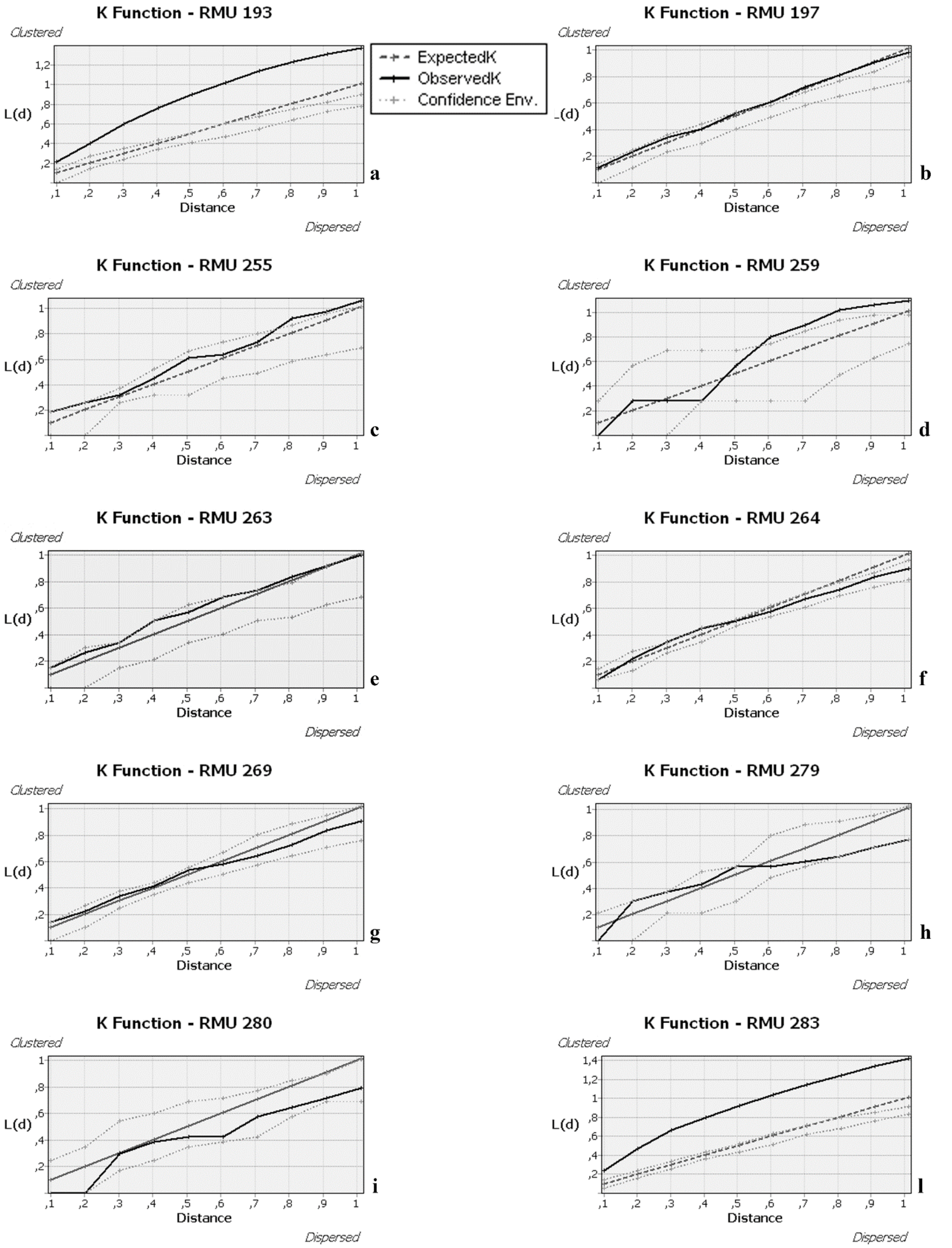

Fig. S12: K function of the RMU 193 (a), RMU 197 (b), RMU 255 (c), RMU 263 (d), RMU 259 (e), RMU 264 (f), RMU 269 (g), RMU 279 (h), RMU 280 (i), RMU 283 (l).

RMU	Ref. N.	Description of raw material					Technological composition						
		Lithological Class	Cortex Thickness	Cortex Texture	Cortex Color	Surface Color	C	M	P	T	A	I	TOT
1	7	Fine chert	Thin	Rough	Grey	Light grey	3	18	6	0	1	30	58
2	0	Fine chert	\	\	\	Pinkish grey	0	1	0	1	0	0	2
9	0	Fine chert	Thick	Rough	Grey	Grey	1	8	1	0	0	1	11
12	0	Middle chert	Thin	Smooth	Whitish	Grey	5	23	4	0	1	9	42
18	2	Middle chert	\	\	\	Grey	0	0	2	0	0	0	2
31	0	Middle chert	Thin	Smooth	Brown	Light green	1	16	2	0	1	5	25
41	0	Middle siliceous limestone	\	\	\	Yellow	0	0	1	0	0	0	1
53	0	Middle chert	Thick	Smooth	Yellow	Yellow green	0	11	3	0	0	4	18
55	2	Fine quartzarenite	Thin	Smooth	Beige	Dark grey greenish	3	17	9	1	0	8	38
56	2	Middle quartzarenite	Thin	Smooth	Greenish brown	Olive green	3	37	0	0	0	22	62
64	0	Middle quartzarenite	Thin	Smooth	Brownish	Pinkish grey	0	11	3	3	0	5	22
66	0	Coarse chert	Thin	Smooth	Beige	Brown	1	3	5	0	0	5	14
91	2	Middle siliceous limestone	Thin	Rough	Brown	Dark olive green	3	4	1	0	0	2	10
96	2	Middle siliceous limestone	Thin	Smooth	Olive green	Olive green	2	5	3	0	0	3	13
132	0	Fine jasper	Thin	Rough	Greenish	Green	1	24	3	0	0	13	41
134	0	Fine jasper	Thin	Rough	Green	Green	1	15	1	0	0	15	32
136	0	Fine jasper	Thin	Rough	Bluish green	Bluish grey	2	2	2	0	0	4	10
137	0	Fine jasper	Thin	Smooth	Reddish grey blue	Black brown green	5	19	2	0	0	10	36
139	0	Fine jasper	Thin	Rough	Yellow green	Black green red	0	9	2	0	0	3	14
143	0	Fine jasper	Thin	Smooth	Yellow orange	Greenish yellow	5	15	1	0	0	7	28
146	2	Middle siliceous limestone	Thin	Smooth	Light brown green	Greenish grey reddish brown	1	8	4	0	0	2	15
161	0	Fine jasper	Thin	Smooth	Brown	Brown	1	11	3	0	0	3	18
177	4	Fine jasper	Thin	Smooth	Brown	Reddish brown	9	8	5	0	0	9	31
193	2	Middle siliceous limestone	Thin	Smooth	Beige	Black striped dark green	1	23	3	1	0	17	45
197	0	Fine jasper	Thin	Smooth	Light green	Black striped green	3	11	0	0	0	19	33
255	0	Middle siliceous limestone	Thin	Smooth	Brown	Bluish brown	0	6	1	0	0	8	15
259	0	Fine jasper	Thin	Smooth	Greenish	Brown inner part greenish	0	2	3	0	0	5	10
263	0	Middle siliceous limestone	Thin	Smooth	Brown	Bluish brown	1	6	2	0	0	9	18
264	0	Middle siliceous limestone	Thin	Smooth	Black	Black	1	13	19	2	1	5	41
269	0	Fine jasper	Thin	Smooth	Light brown	Black orange striped green	7	10	2	0	1	7	27
279	0	Fine jasper	Thin	Smooth	Brownish yellow	Green	1	8	2	1	0	1	13
280	0	Fine jasper	Thin	Smooth	Greenish	Green	2	6	3	0	0	5	16
283	0	Fine jasper	Thin	Rough	Yellow	Green	7	16	1	1	1	25	51

Table. S1: RMUs description. Ref.n.= number of refitted pieces; C= cortical flakes; M management of convexities flakes; P= aims of the reduction sequences (target objects); A = Phase of abandon which means cores; I= undetermined items; TOT= total number of pieces.

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