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

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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).

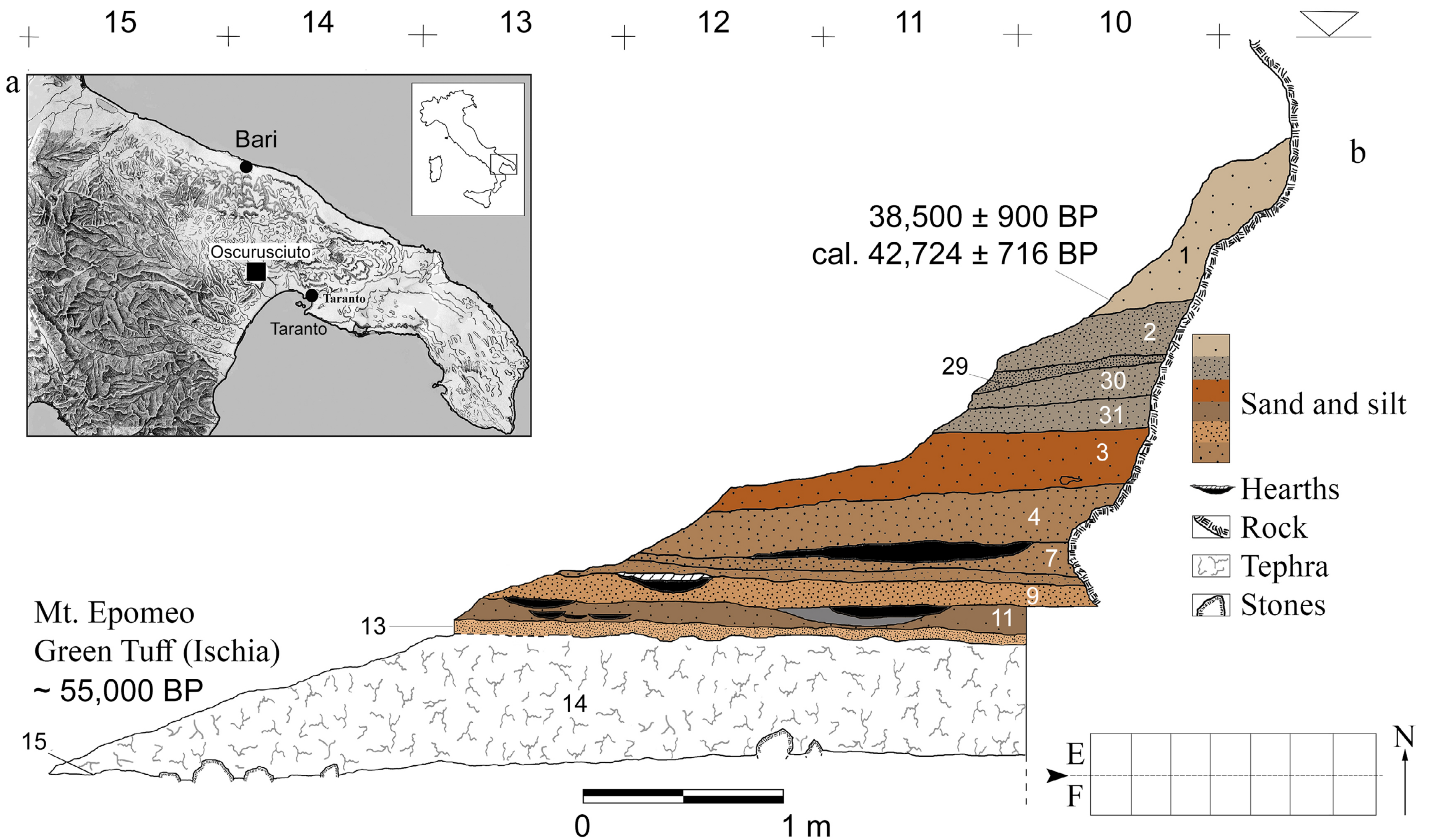

Figure 2. Localization (a) and stratigraphic sequence (so far excavated) of the Oscurusciuto rock shelter (b). (Relief map by P. Boscato; drawing by A. Ronchitelli).

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).

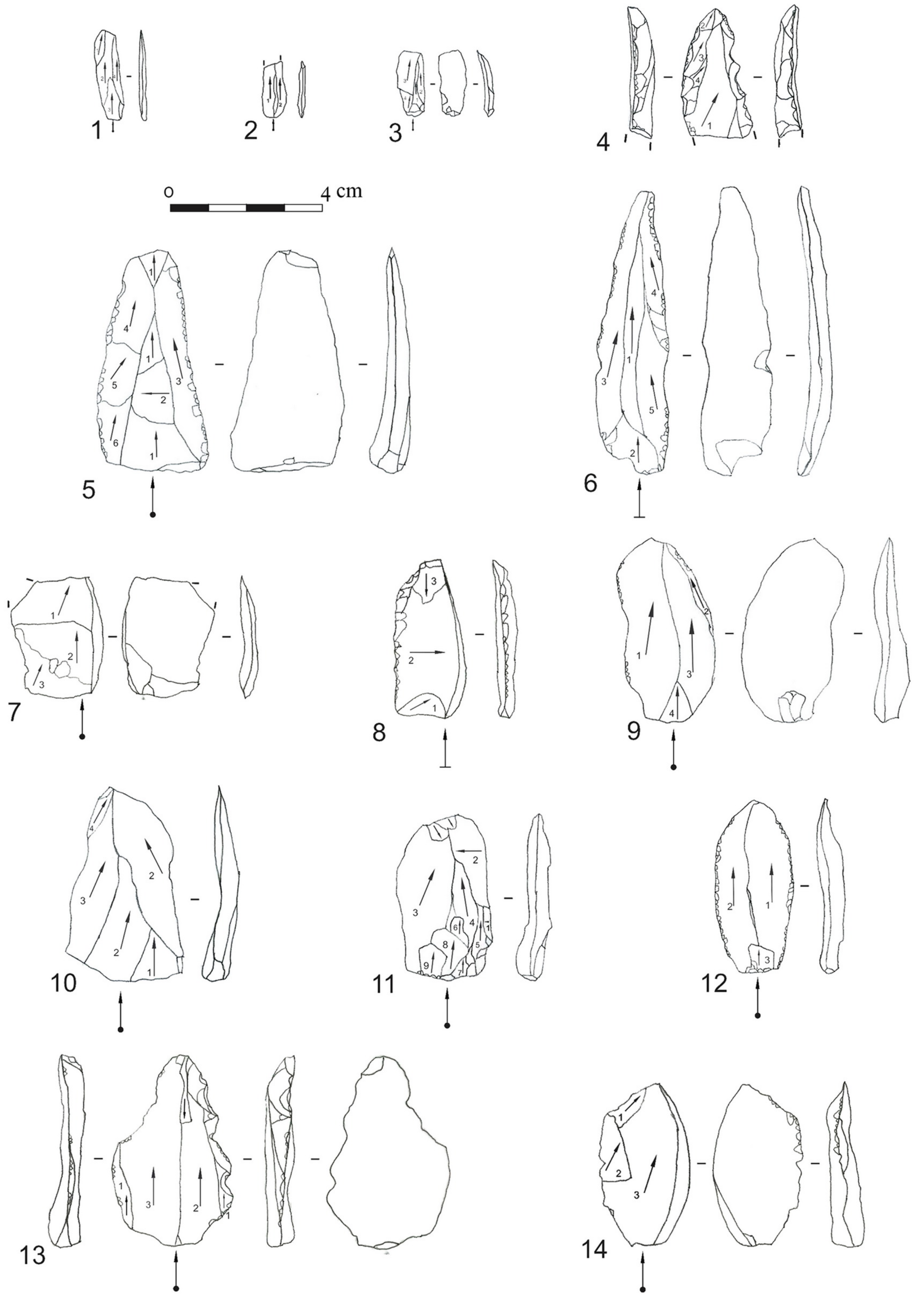

Figure 4. Drawing of target flakes and retouched tools. 1, 2, 3: bladelets, target objective of volumetric production; 4: retouched tool: denticulate point; 5, 6, 10: convergent flakes target objective of Levallois production; 7, 8, 14: backed flakes, target objective of Levallois production; 9,11,12: 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.

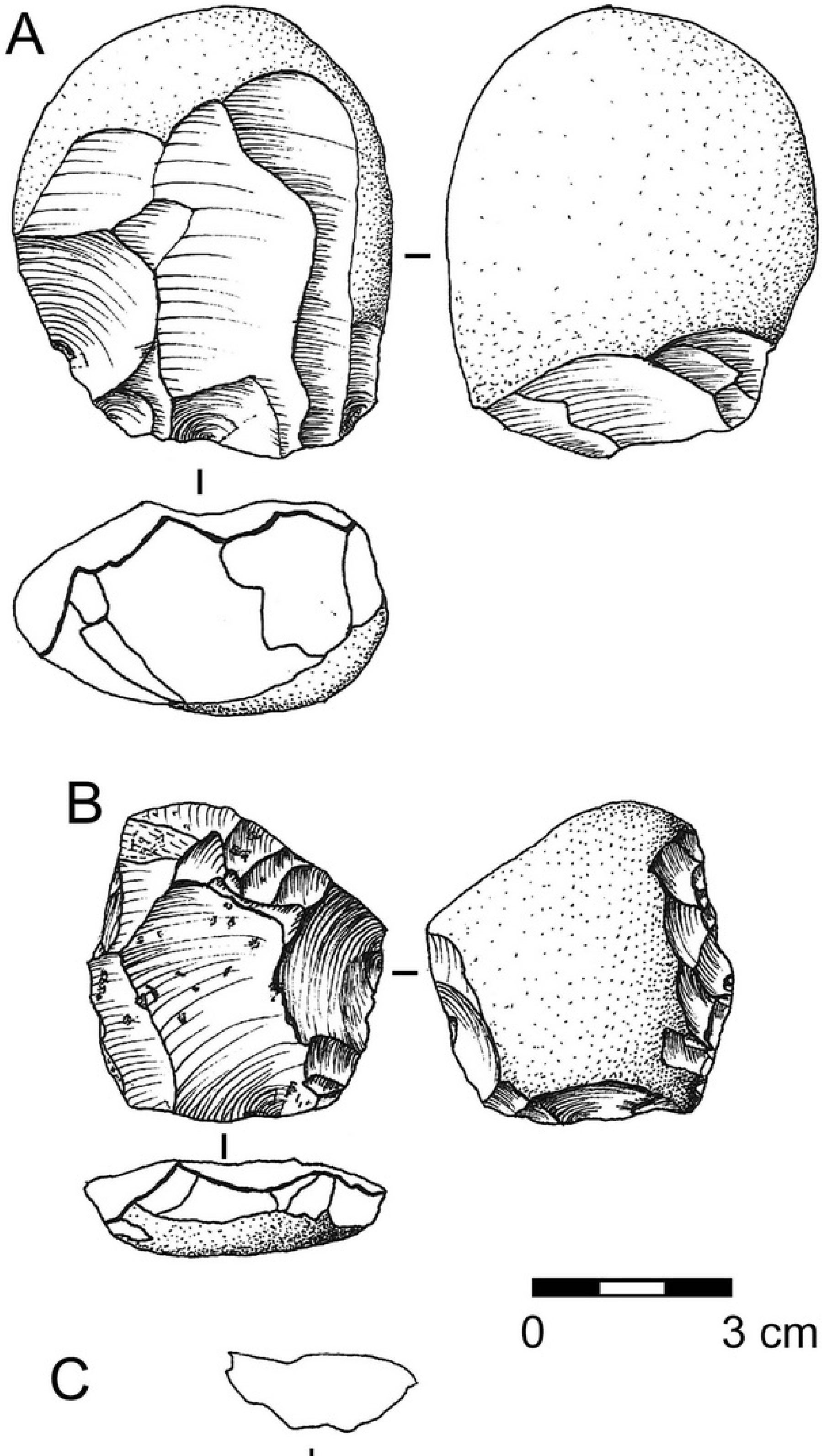

Figure 5. Drawing of cores. A: unipolar Levallois; B: convergent Levallois; C: Volumetric.

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.

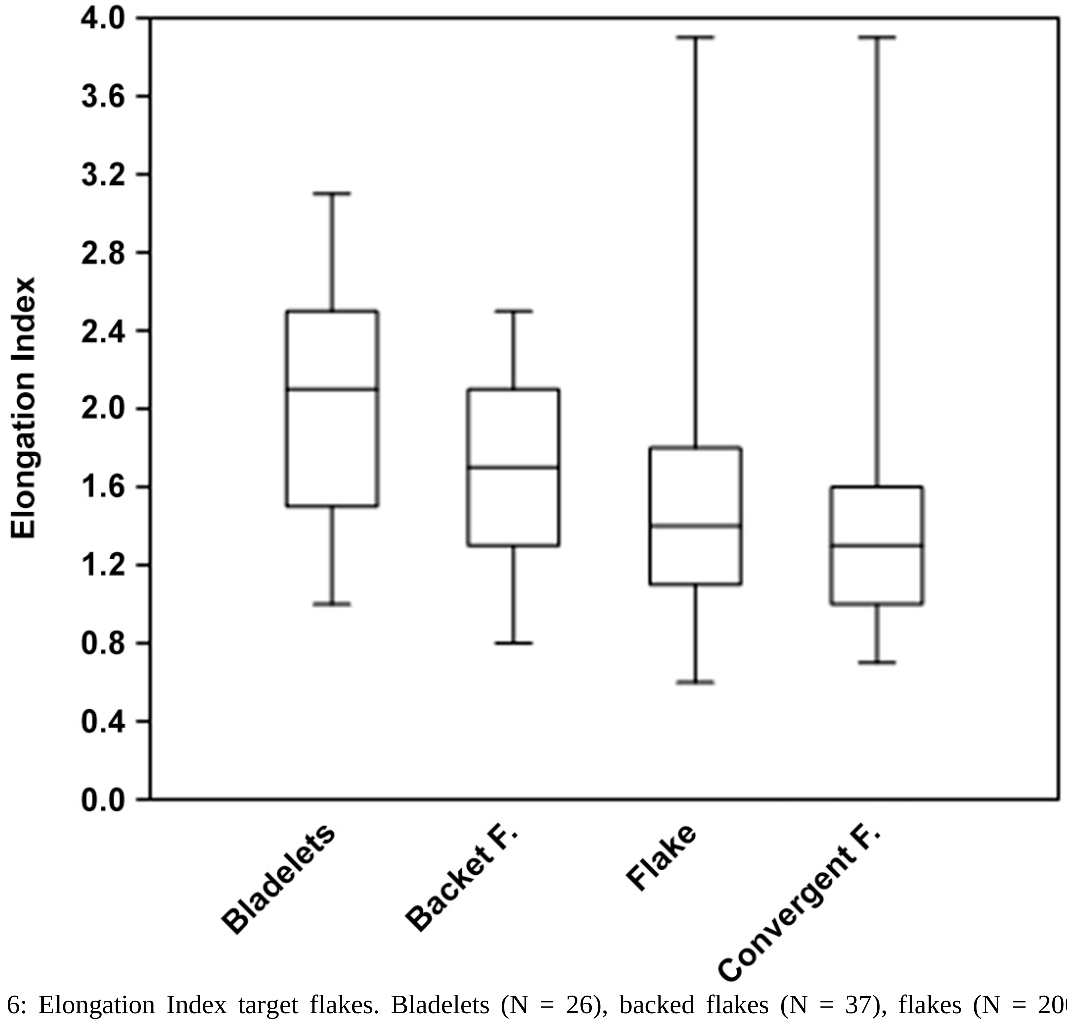

Figure 6: Elongation Index target flakes. Bladelets (N = 26), backed flakes (N = 37), flakes (N = 200) and convergent flakes (N = 88).

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.

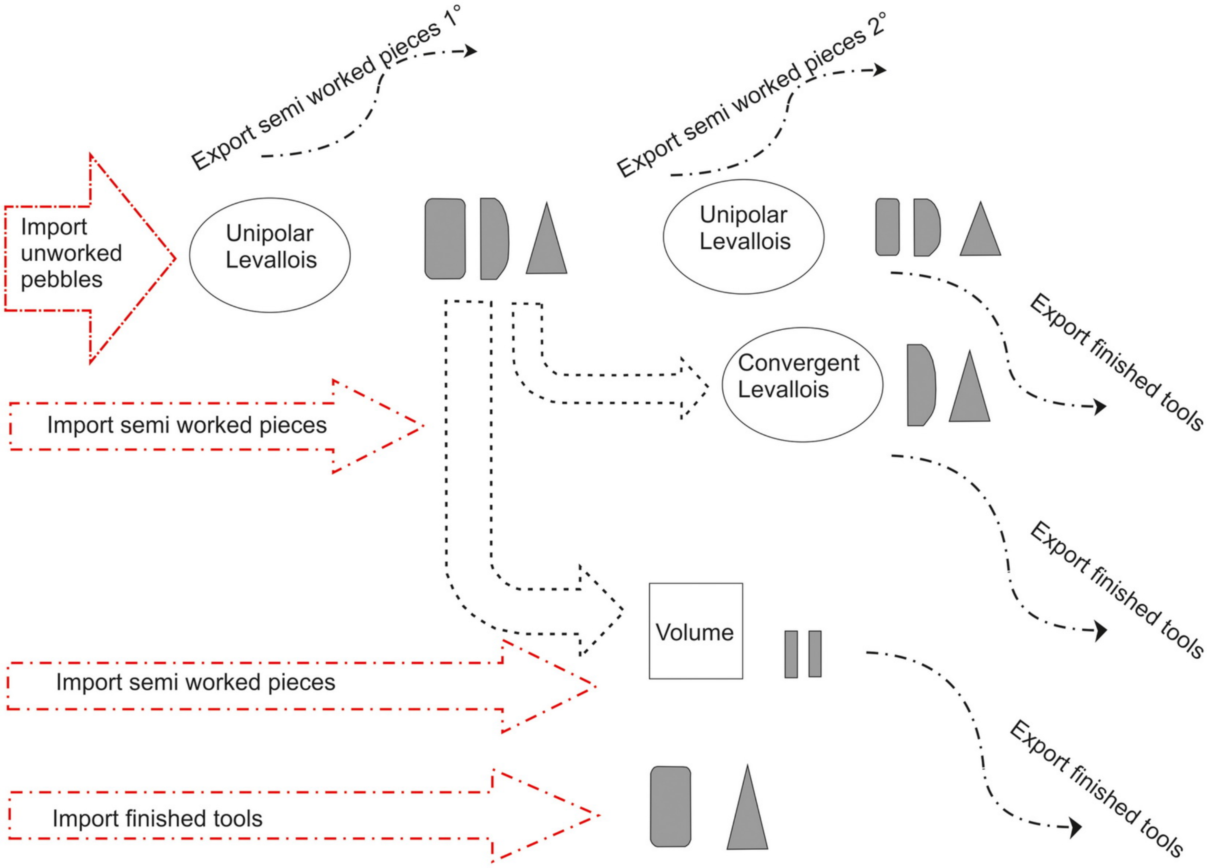

Figure 7. Fragmented reduction sequences. The grey silhouettes represent the target flakes (big rectangle = flakes; triangle = convergent flakes; half oval = backed flakes; small rectangle = bladelets).

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.

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