Technology and use of a Middle Palaeolithic toolkit. The example of the Ciota Ciara cave (NW Italy)

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Abstract

A technological and functional approach has been used to face the study of the lithic artefacts made in allochthonous raw materials from level 14 of the Ciota Ciara cave. The site it is the only reliable source of information about the Middle Palaeolithic peopling of north-western Italy. According to the results coming from different studies, the level 14 attests the phases of most intense frequentation of the cave, and it is the layer where allochthonous lithic raw materials are better represented. In a technological context already described as markedly opportunistic, where reduction sequences are strongly adapted to the characteristics of the local rocks available in the surrounding of the site, some tools and unretouched flake, made in raw materials collected at a distance between 2 and 30 km, have been introduced in the site. The present work is aimed to the understanding of the role of these artefacts within the technological organization of the Neanderthal groups that inhabited the cave. The obtained results indicate that these “exotic” artefacts were part of the mobile toolkit of the human groups of the Ciota Ciara cave and that they were multifunctional tools extensively used for different activities (mainly butchering activities). The obtained data led also to some observations about the technology of these Neanderthal groups and on their capability in terms of planning and forecasting during land mobility.

1 Introduction

Since the term “personal gear” was introduced (Binford 1979) and a first systematic definition of “mobile toolkit” (Kuhn 1994) was proposed, the presence, in an archaeological lithic assemblage, of artefacts attesting a certain land mobility of the hunter-gatherers groups has been considered as an important and interesting component of the technology of foraging populations. During the years, it became more and more widespread the awareness that the technological and functional characteristics of the artefacts provide information not only about what went on at that place, but also about the processes that took place in other parts of the territory usually frequented by the hunter-gatherers groups (Cahen et al. 1979; Kelly 1988; Nelson 1991; Kuhn 1992, 1994, 2020; Shott 1996; Shimelmitz and Kuhn 2018; Martín-Viveros et al. 2020; Picin et al. 2020). Groups characterized by a certain mobility on the landscape have a minimal transported toolkit, needed to complete tasks or satisfy needs during their movements, being them seasonal or daily. The composition of the mobile toolkit depends on different factors like the frequency and the scale of the mobility or the availability of lithic raw materials and, based upon ethnographic data, some characteristics can be considered as common and diagnostic to define a Palaeolithic mobile toolkit: multifunctionality, transportability (i.e., a mobile toolkit is composed by a limited number of tools usually small and light) and maintainability (Kuhn 1994). A thorough technological study cannot be able to leave this pivotal aspect out of consideration since it allows to interpret the technology observed in a site by placing it in a broader framework that includes mobility on the territory and the ability of hunter-gatherers groups to deal with specific needs.

In Middle Palaeolithic contexts, blanks issued from the exploitation of non-local raw materials have been usually interpreted as part of mobile toolkits (Geneste 1988; Féblot-Augustins 1997; Porraz 2009; Turq et al. 2013; Picin et al. 2020) as well as the intensity of retouch has been considered as an indicator of transport through the landscape (Dibble 1987, 1995; Andrefsky Jr. 2006). Technological analysis led to the identification of mobile toolkits in several Palaeolithic contexts (Kuhn 1992; Moncel et al. 2009; Porraz 2009; Machado et al. 2017; Vaquero et al. 2019; Picin et al. 2020) but, as already pointed out by Martín-Viveros et al. (2020), a multidisciplinary approach to the study of this component is essential to go deep in the understanding and interpretation of mobility patterns and land-use of prehistoric groups. Another debate is that opposing expedient and curated behaviour (Binford 1977, 1979). In lithic technology, curated and planned behaviours have been identified when lithic tools are produced in advance, for future needs, and when whey attest a high technological investment in manufacture and maintenance; in these sense, mobile toolkits become an important component of curated technological behaviours and have been considered proper of prehistoric groups characterized by a high mobility (e.g. Bamforth 1986; Bleed 1986; Kelly 1988; Kuhn 1992; Andrefsky Jr. 2009). On the other hand, expedient behaviour is usually linked to a low technological investment in the production and maintenance of lithic artefacts; they are produced when the need arises and are discarded in the same place; this behaviour has been linked to a reduced mobility and to a great availability of lithic raw materials in the surrounding of the site (Nelson 1991; Andrefsky Jr. 2009). This dichotomy has been debated in several works in the last decades and the concepts of curation and expediency have been applied and declined differently by scholars (e.g. Torrence 1983; Bamforth 1986; Bleed 1986; Kelly 1988; Nelson 1991; Kuhn 1992, 1994; Féblot-Augustins 1993; Shott 1996; Turq et al. 2013; Shimelmitz and Kuhn 2018; Romagnoli et al. 2018; Martín-Viveros et al. 2020; Picin et al. 2020).

In this study we propose a technological and functional study of the lithic artefacts issued from the exploitation of allochthonous raw materials coming from level 14 of the Ciota Ciara cave (NW Italy). In this lithic assemblage, the exploitation of local rocks is clearly predominant, but a small number of products is realized on allochthonous raw materials, which supply areas are located between 2 and 30 km from the site. During the technological study (Daffara 2018) some questions arose, and the aim of this work is to answer that questions through a multidisciplinary approach that involves both lithic technology and use-wear analysis: in an archaeological context dominated by the exploitation of local raw materials, easily available in the surrounding of the site (Daffara et al. 2019), why retouched and unretouched flakes made in allochthonous rocks have been introduced? Are there any differences in the reduction sequences or in the use of these blanks if compared with the local component of the lithic? Finally, how can we interpret the presence of these transported tools in the context of the ongoing debate about expedient and curated behaviour?

2 The Site

The Ciota Ciara cave is part of Monte Fenera's karst, an isolated relief (899 m a.s.l.) in north-western Italy (Fig. 1). Thanks to the research conducted since 2009, it is the most important Palaeolithic site in the region and the only one systematically excavated with a multidisciplinary approach. The cave opens at 670 m a.s.l. on the west side of Monte Fenera and it can be accessed both from a big triangular entrance, facing south west, and from a secondary entrance facing west, originated by the collapse of the cave wall and enlarged by the removal of a big boulder (Fedele 1966). Ciota Ciara is a still active karstic cave developed over more than 80 m on its principal axe, with a positive difference in height of 15 m from the main entrance to the bottom. On the big main sector, straight and oriented NE-SW, is inserted a short branch going to the secondary entrance: the area where the two branches cross is a huge and wide space, enlarged during the years by dissolution and collapse of big boulders from the rock walls (Testa 2005) (Fig. 1). The archaeological and palaeontological interest of the cave is known since the beginning of the XXth century (Conti 1931) but archaeological researches with a clear scientific purpose started just in the 60s, when some test pits where realized in the internal part of the cave (Fedele 1966; Busa et al. 2005; Gambari 2005) (Fig. 1). In the 90s, the finding of two teeth within sediments transported outside the cave by water and attributed to *H. neanderthalensis* again attracted the interest of researchers towards the Ciota Ciara cave, leading to two short excavation campaigns located in the atrial part of the cave (Villa and Giacobini 1993, 2005; Gambari 2005). After a fifteen years hiatus, in 2009 the University of Ferrara started systematic and multidisciplinary archaeological excavations at the Ciota Ciara cave. The new excavations focus in the atrial part of the cave, where a 2m thick sequence was unearthed (Angelucci et al. 2019). In this area, four main stratigraphic units have been identified (103, 13, 14, 15), each one corresponding to different modalities of frequentation of the site (Arzarello et al. 2012; Angelucci et al. 2019; Daffara et al. 2021) (Fig. 2). Preliminary numerical dating indicate that the human frequentation of the atrial part of the Ciota Ciara cave may date to the second half of the Middle Pleistocene (Vietti 2016).

From 2018, a new excavation area located in the internal part of the cave is being investigated (Fig. 1) and studies about geoarchaeology, lithics and palaeontology are ongoing.

Concerning the frequentation of the atrial sector, data from palaeontological studies of macro e micro mammals remains state that the palaeoenvironment is dominated by a woodland environment; a slight climatic change is visible between S.U. 13 and S.U. 14, from warmer to cold and humid conditions. S.U. 14 is characterized by different markers of cold climate like *Cricetus cricetus*, *Microtus* cf. *gregalis* and *Chionomys nivalis* thus indicating an open woodland environment with exposed rocks (Berto et al. 2016). Concerning the large mammals' assemblage, it is dominated by carnivores, particularly by *Ursus spelaeus*, in all the archaeological layers. The importance of herbivores like *Rupicapra rupicapra, Cervus elaphus*, cf. *Dama, Bos primigenius, Bos* sp., *Bos* vel. *Bison, Sus scrofa* and *Stephanorinus* sp. increases in S.U. 14 (Berto et al. 2016; Cavicchi 2018). Besides numerous herbivore remains, also some *Ursus spaeleus* bones have cut marks related to skinning activities and flesh extraction (Buccheri et al. 2016).

2.1 The lithic assemblage of the Ciota Ciara cave: technological and functional overview

The lithic assemblage issued from the atrial sector of the Ciota Ciara cave counts 7106 lithic artefacts and it is characterized by the predominant exploitation of vein quartz (70,6%), followed by a local chert (spongolite – 21,1%) and by other rocks both of local (grey flint – 4,9%) and allochthonous (radiolarite – 1,4% and rhyolite – 1,0%) origin (Table 1). Other local rocks like mylonite are sporadically attested in the lithic assemblage (Arzarello et al. 2012; Daffara et al. 2019, 2021). The vein quartz was collected in secondary deposits at the base of Monte Fenera, while spongolite and grey flint primary outcrops and secondary deposits are located a few hundred meters from the site, at the top of Monte Fenera; the rhyolite was collected in secondary position at about 2 Km in a straight line from the Ciota Ciara cave, on the opposite side of the Sesia valley, while the radiolarite comes from outcrops and secondary deposits located at about 25–30 km from the site (Daffara et al. 2019) (Fig. 3). The reduction sequences identified at the Ciota Ciara cave include opportunistic, Levallois and discoid exploitation strategies together with a sporadic presence of Kombewa *s.l.* debitage (Boëda 1993, 1994; Inizan et al. 1999; Tixier and Turq 1999; Peresani 2003). The knapping activities took place in the site for the most represented raw materials, as indicated by the important presence of vein quartz and spongolite cores and debris (Table 2), while the other local rocks were probably knapped out of the site or in an area not documented by excavation activities. According to the technological analysis conducted, rhyolite and radiolarite can be interpreted as complementary lithic resources, as they are present in the considered lithic assemblage mainly as tools, which edges have been intensively rejuvenated, and as flakes issued from the re-shaping of the tools' edges (Daffara et al. 2021).

Table 1

	Quartz	**Spongolite**	**Grey flint**	**Rhyolite**	**Radiolarite**	**Others**	**Total**
S.U. 13	768	59	52	1	8	3	**891**
	86,2%	6,6%	5,8%	0,1%	0,9%	0,3%	
S.U. 14	3119	508	210	50	67	45	**3999**
	78%	12,7%	5,3%	1,3%	1,7%	1,1%	
S.U. 15	905	793	28	21	22	19	**1788**
	50,6%	44,4%	1,6%	1,2%	1,2%	1,1%	
S.U. 103	227	141	57	1	-	2	**428**
	53%	32,9%	13,3%	0,2%		0,4%	
Total	**5019**	**1501**	**347**	**73**	**97**	**69**	**7106**
	70,6%	**21,1%**	**4,9%**	**1%**	**1,4%**	**1%**	

Ciota Ciara cave. Proportion of the lithic raw materials exploited in each archaeological layer

Table 2

Raw material		SU 103	SU 13	SU 14	SU 15	Total
Quartz	Cores	7–1,6%	31–3,5%	111–2,8%	20–1,1%	169–2,4%
	Flakes	136–31,8%	444–49,8%	2150–53,8%	611–34,2%	3341–47%
	Retouched tools	5–1,2%	16–1,8%	50–1,3%	9–0,5%	80–1,1%
	Debris	78–18,2%	276–31,0%	807–20,2%	265–14,8%	1426–20,1%
	Unworked blanks	1–0,2%	1–0,1%	1–0,03%	-	3–0,04%
Spongolite	Cores	5–1,2%	1–0,1%	17–0,4%	31–1,7%	54–0,8%
	Flakes	68–15,9%	33–3,7%	280–7,0%	429–24%	810–11,4%
	Retouched tools	1–0,2%	2–0,2%	9–0,2%	9–0,5%	21–0,3%
	Debris	58–13,6%	22–2,5%	191–4,8%	299–16,7%	570–8%
	Unworked blanks	9–2,1%	-	11–0,3%	25–1,4%	45–0,6%
Grey flint	Cores	1–0,2%	-	3–0,1%	-	4–0,1%
	Flakes	31–7,2%	30–3,4%	139–3,5%	20–1,1%	220–3,1%
	Retouched tools	3–0,7%	1–0,1%	5–0,1%	3–0,2%	12–0,2%
	Debris	21–4,9%	21–2,4%	63–1,6%	4–0,2%	109–1,5%
	Unworked blanks	1–0,2%	-	-	1–0,1%	2–0,03%
Rhyolite	Cores	-	-	1–0,03%	2–0,1%	3–0,04%
	Flakes	1–0,2%	1–0,1%	37–0,9%	12–0,7%	51–0,7%
	Retouched tools	-	-	6–0,2%	1–0,1%	7–0,1%
	Debris	-	-	6–0,2%	6–0,3%	12–0,2%
	Unworked blanks	-	-	-	-	

Ciota Ciara cave. General composition of the lithic assemblage of the atrial sector.

Raw material		SU 103	SU 13	SU 14	SU 15	Total
Radiolarite	Cores	-	-	-	-	-
	Flakes	-	4–0,4%	50–1,3%	12–0,7%	66–0,9%
	Retouched tools	-	2–0,2%	3–0,1%	5–0,3%	10–0,1%
	Debris	-	3–0,3%	14–0,4%	5–0,3%	22–0,3%
	Unworked blanks	-	-	-	-	-
Others	Cores	-	1–0,1%	-	1–0,1%	2–0,03%
	Flakes	2–0,5%	1–0,1%	30–0,8%	10–0,6%	43–0,6%
	Retouched tools	-	-	1–0,03%	-	1–0,01%
	Debris	-	1–0,1%	9–0,2%	6–0,3%	16–0,2%
	Unworked blanks	-	-	5–0,1%	2–0,1%	7–0,1%
Total		428	891	3999	1788	7106

Ciota Ciara cave. General composition of the lithic assemblage of the atrial sector.

Opportunistic reduction strategies are clearly predominant in all the archaeological levels for all the raw materials. These reduction sequences have been reconstructed in detail for vein quartz and spongolite and they are generally short, with a frequent use of natural and neocortical surfaces as striking platforms; cores are discarded when the convexities suitable for knapping are exhausted. In most cases just two adjacent, orthogonal or opposed striking platforms are exploited, while multidirectional reduction strategies are rare. Levallois (preferential and recurrent centripetal) and discoid reduction sequences are well documented all along the sequence and applied on different raw materials (vein quartz, spongolite, grey flint, radiolarite and rhyolite). Concerning vein quartz and spongolite, they share some features that have been interpreted as adaptations to the characteristics of these raw materials: shortness of the reduction sequences with cores abandoned after one phase of exploitation; frequent use of natural striking platforms; phases of core shaping that are absent or very hurried. Levallois and discoid cores are chosen among blanks with suitable natural convexities and their morphology strongly influences the dimensions of the final products. For other raw materials like radiolarite and grey flint, Levallois reduction sequences have been hypothesized as more articulated, even if incomplete (Daffara et al. 2021).

The technological data about the lithic assemblage of the Ciota Ciara cave attests a quite complex technological behaviour, that includes a deep knowledge of the natural resources available on a regional scale and of the mechanical properties of the different raw materials. This behaviour did not change significantly during the different phases of human frequentation of the site: in the different archaeological layers the same reduction sequences are attested, with the same characteristics and with the preferential use of pebbles and slabs as cores and a very limited debitage on flake. The availability and quality of the rocks present in the local environment is the main factor affecting the strategies of tools production and the development of the reduction sequences (Andrefsky Jr. 1994).

The use-wear analysis carried out on the lithic assemblages from SS.UU. 13 and 14 show that there was no difference in the use of the lithic artefacts according to the method they were issued from. Even between Levallois and discoid blanks there are not clear differences in terms of type of actions and activities carried out (Daffara et al. 2021). Some differences have however been noticed between these two levels concerning the types and the varieties of activities carried out. In level 13, the use-wear analysis shows a low variety of activities performed in the site and the predominance of the processing of secondary products, not related to the direct achievement of food resources: i.e. fresh and dry wood working, with a small representation of traces related to carcass processing (Arzarello et al. 2012); these kind of activities could be linked to the production and maintenance of spears or of other objects of daily use (Hardy 2018). In level 14, traces linked to animal carcass processing are frequent, with representation of different phases of carcass exploitation (butchering, filleting, work of fresh and dry hide, bone and soft animal tissue working, periosteum removal); less frequent is the processing of woody and non woody plants (Daffara et al. 2021). Combining these data with the results of archaeozoological and paleontological studies, that underline in level 14 a significative increase in the number of both herbivorous remains (Berto et al. 2016; Cavicchi 2018) and of cut-marks on bones (Buccheri et al. 2016), it seems that level 13 could be the result of short and repeated human frequentations probably linked to hunting activities (Arzarello et al. 2012; Daffara et al. 2014) while level 14 is the result of longer frequentations, characterized by a more complex set of activities and with evidence of practice of long-lasting workings (i.e. hide working).

3 Materials And Methods

3.1 Materials

The proposed research concerns the technological and functional analysis of the lithic artefacts realized in rhyolite and radiolarite (117) coming from SU 14 (Table 1), excavated on an area of about 9 m^2 in the atrial sector of the Ciota Ciara cave. This level represents the phases of most intense frequentation of the cave during Middle Palaeolithic (Arzarello et al. 2012; Buccheri et al. 2016; Cavicchi 2018; Daffara et al. 2021), with a lithic assemblage counting a total of 3999 lithic artefacts realized through the exploitation of local and allochthonous raw materials, among which vein quartz is the main raw material (78,0%), followed by spongolite (12,7%) grey flint (5,3%) and other local rocks (1,1%) (Table 1). SU 14 is the archaeological level of where allochthonous raw materials are more represented (1,7% and 1,3% respectively) (Table 1) and where their role in the economy of the Middle Palaeolithic human groups is better assessable.

The study of this component of the lithic assemblage of the Ciota Ciara cave is important for the understanding and the interpretation of the economy, the mobility and the subsistence strategies of the Middle Palaeolithic human groups frequenting north-western Italy, a sector of the Italian peninsula where data about Palaeolithic are scarce and where the general knowledge of the Palaeolithic peopling is very fragmented.

3.2 Methodology for the technological and the use-wear analysis

The technological study is based on the concept of *chaîne opératoire* (Leroi-Gourhan 1964; Tixier 1978; Pelegrin et al. 1988; Geneste 1991). The analysis starts with the technological reading of each object (core, flake, retouched tool, debris) then continues with the authentication of the relationship of the different products of the *chaîne opératoire*. For flakes, different technological features have been considered: characteristics of the butt and of the ventral face, sizes, presence, and types of knapping accidents. Retouched tools have been classified according to the typological list developed by Bordes (1961). The direction of the scars on the upper face and the presence and position of natural surfaces were used to identify the knapping methods and the phases of core reduction. The definition of each method refers to Inizan et al. (1999) for opportunistic exploitation strategies (i.e. the exploitation of a core according to a unipolar, bipolar or multidirectional sequence of removals), to Tixier and Turq (1999) for Kombewa *s.l.* knapping strategies (i.e. the production of several flakes, from varied edges of the core-on-flake) and on Boëda (1993, 1994) for Levallois and discoid methods. As for the latter, specific works discussing issues and problems linked to their definition and identification have been considered (Dibble and Bar-Yosef 1995; Chazan 1997; Peresani 2003; Moncel et al. 2020).

To select the artefacts for the use-wear analysis two criteria were applied: the presence of at least one functional edge, identified according to the criteria developed by Terradillos-Bernal and Marcos Rodríguez-Álvarez (2017), and surface preservation (i.e., absence of marked post-depositional surface modifications – PDSMs) (Levi Sala 1986). The functional study began with the preliminary evaluation of the state of preservation of all the considered lithic artefacts (117) in order to identify the different post-depositional alterations and to exclude from the analysis all the items with strong PDSMs. Each selected artefact was carefully washed for 3 min in a mixture of demineralized water (75%) and alcohol (25%) in an ultrasonic tank and open air-dried. The study of the use-wears was carried out using an integrated approach consisting in the combination of the low power approach (LPA) (Odell and Cowan 1986) with the high power approach (HPA) (Keeley 1980). Different works (Moss 1983; Beyries 1987; Ziggioti and Ziggiotti 2011; Berruti and Arzarello 2012; Berruti and Daffara 2014; Lemorini et al. 2014; Van Gijn and VanGijn 2014; Cruz and Berruti 2015; Wilkins et al. 2015; Berruti et al. 2020; Daffara et al. 2021) show that the combined use of these two approaches is more effective and productive for the identification and interpretation of use-wears. The low power approach provides information about the potential activities carried out (e.g., cutting, scraping, piercing, etc.) and allows the identification of the hardness of the worked materials, that are divided according to the following categories: soft (e.g., animal soft tissue, herbaceous plants and some tubers), medium (e.g., fresh wood and hide) and hard (e.g., bone, horn, antler, dry wood and stone). There are also some materials with an intermediate hardness or resistance, such as medium/soft materials (e.g. fresh hide, wet soft wood) and medium/hard materials (e.g. soft wood, wet antler) (Semenov 1964; Tringham et al. 1974; Odell 1981; Lemorini et al. 2006, 2014). The high-power approach is the study of micro-edge rounding, polishes, abrasions, and striations. This kind of analysis provides a more detailed understanding of the activities carried out and supports the diagnosis of the processed materials (e.g. Keeley 1980; Ziggioti 2005; Lemorini et al. 2006, 2014; Rots 2010; Van Gijn 2014). The combined approach here used has already been successfully applied by different scholars on lithic artefacts realized with different raw materials such as flint, chert, obsidian, quartz and quartzite (Plisson et al. 2008; Clemente-Conte and Gibaja Bao 2009; Lemorini et al. 2014; Berruti and Cura 2016; Berruti et al. 2016; Daffara et al. 2018, 2021).

The use-wear analysis of the rhyolite and radiolarite artefacts from level 14 of the Ciota Ciara cave was conducted using different microscopes: a stereoscopic microscope Seben Incognita III with magnification from 20x to 80x, a Leica EZ4 HD stereoscopic microscope with magnification from 8x to 40x, a Microscope Camera Dinolight Am413T (low power approach analysis) and a metallographic microscope Optika B 600 Met supplied with oculars 10x and five objectives PLAN IOS MET (5-10-20-50-100x) (high-power approach analysis).

To reduce the intensity of the fastidious glare, typical of quartz-rich raw materials like rhyolite (Igreja; Clemente-Conte and Gibaja Bao 2009; Gibaja et al. 2009; Lemorini et al. 2014; Berruti et al. 2016; Berruti 2017; Daffara et al. 2018), the metallographic microscope was equipped with a Differential Interference Contrast Microscopy (also known as Nomarski filter) (Igreja; Knutsson et al. 2015). Adobe Photoshop CS6 Portable (© Adobe) software was used for image processing since it allows a single image to be built up from several photos taken at different depths of field.

3.3 The experimental collection

There are several works based on experimental studies (Keeley 1980; Texier et al. 1998; Lemorini 2000; Ziggioti 2005; Galán et al. 2009; Claud et al. 2013; Cristiani et al. 2016) that provide ample scope for reference and comparison for the proposed research. However, a focused experimental activity remains crucial for an efficient use-wear analysis, since it allows to acquire more precise data on the purpose of the processing, on the gestures, on the relationship between the morphology of the artefact and its effectiveness with respect to the processed material. Concerning the Ciota Ciara cave, to create the experimental collection necessary for the use-wear analysis of the lithic tools of S.U. 14 issued from the exploitation of allochthonous rocks, a specific experimental protocol was developed, starting from the production of rhyolite and flint lithic artefacts. As far as rhyolite is concerned, the same kind of rhyolite attested in the archaeological assemblage was used to produce 11 opportunistic flakes. As for radiolarite, the 11 experimental flakes used are issued from the exploitation of a flint opportunistic core; the flint chosen for the experimental activity shares with the one attested at the Ciota Ciara cave similar characteristics in terms of granulometry: indeed, it is known that different kind of flint, with similar granulometry, retain similar traces (Keeley 1980; Lemorini 2000).

Then, the activities carried out at the Ciota Ciara cave (S.U. 14) were hypothesized on the basis of previous technological, archeozoological and functional studies (Arzarello et al. 2012; Berruti and Arzarello 2012; Buccheri et al. 2016; Daffara et al. 2021) and on the comparison with other Middle Palaeolithic contexts (e.g. Hardy 2004; Daujeard et al. 2014; Picin and Carbonell 2016a; Spagnolo et al. 2019; Berruti et al. 2020). Based on these data, the following activities were included in the experimental work: peeling actions, fresh skin scraping, dry skin cutting, bone scraping and periosteum removal, cutting and debarking of fresh and dry wood, slaughtering, filleting, cutting, and scraping work on antler. This experimental protocol aims to standardize the operations and to minimize the variables of the process, like time of use and number of actions carried out; each experimental item was used to perform a single action for 5 or 10 minutes. For each flake, the time of use, the direction of the gesture and the material worked were recorded. After the experiments, each artefact was carefully washed with warm water and soap, and then it was washed for 3 minutes in a mixture of demineralized water (75%) and alcohol (25%) in an ultrasonic tank and open air dried. Each artefact was then analyzed following the same protocol described above and applied to the archaeological materials (Fig. 4).

4 Results

4.1 Technology

The state of preservation of the assemblage here considered can be described as good; 40,0% (20) of rhyolite artefacts do not have any surface alterations, and the proportion improves for the radiolarite assemblage, where 85,0% (57) of the artefacts presents not altered surfaces. In accordance with geoarchaeological data (Angelucci et al. 2019), the most represented post depositional alterations are linked to water circulation: roundings of the blank's surfaces affect 27 rhyolite artefacts (54,0%) and 2 radiolarite artefacts (3,0%). White patina is present, but it is never very developed; it affects 4 radiolarite (6,0%) and 1 rhyolite (2,0%) implements. The intensity and development of these alterations is not so strong to prevent the technological analysis and the reading of the knapping scars on the surfaces. The rate of fragmentation is quite low: 39 (58,2%) radiolarite and 21 (42,0%) rhyolite artefacts are complete or just a small part of them (less than 25%) is missing.

For both raw materials, the only technique employed is direct percussion by hard hammer.

Rhyolite assemblage is composed by 50 artefacts, of which 37 are flakes, 6 are retouched tools, 6 are debris and 1 is a fragmented opportunistic core; on the other hand, radiolarite assemblage is composed by 67 artefacts, of which 50 are flakes, 3 are retouched tools and 14 are debris (Table 2).

The presence of debris indicates that part of the *chaîne opératoire* took place in the site, but the complete absence of radiolarite cores suggest that the phases of core exploitation were completed out of the site; according to the composition of the radiolarite flake assemblage (Table 3) we can hypothesize that radiolarite flakes were introduced in the site as finished products (retouched or unretouched) and that just the retouch or reshaping of the tools' edges was completed in the site, as shown by the presence of a good number of retouch flakes; the production of debris could then belong to this part of the radiolarite *chaîne opératoire* or to fragmentation during using. The presence of one rhyolite core could indicate that this rock, collected in a range of about 2 km from the site (Fig. 3), was sporadically exploited in the site (Table 2). Another element that needs to be considered is that differently from what observed for the other raw materials exploited (except for grey local flint) in level 14, unworked blanks are not attested for the considered rocks (Table 2).

Table 3

	Rhyolite	**Radiolarite**	**Total**
Unretouched flakes	32–74,4%	28–53,8%	60–63,1%
Retouched tools	6–13,9%	3–5,8%	9–9,5%
Retouch flakes	5–11,6%	21–40,4%	26–27,4%
Total	43–100%	52–100%	95– 100%

Ciota Ciara cave (S.U. 14). Technological composition of the rhyolite and radiolarite flake assemblage

Rhyolite and radiolarite products (Fig. 5) can be divided, according to their technological features, in the following groups: unretouched flakes, retouched tools and flakes issued from the reshaping of the tools' edges (Table 3). Unretouched flakes are issued from opportunistic, recurrent centripetal Levallois and discoid reduction strategies; as already pointed out (Daffara et al. 2021), this data shows that these rocks were exploited in the same way as the local rocks (vein quartz, spongolite, grey flint), according to a technological behaviour that can be considered as repetitive during all the phases of human frequentation of the site during Middle Palaeolithic.

Rhyolite flakes issued from opportunistic reduction sequences are the majority (23–53,5%); for them, flat and natural butts are attested representing respectively 65,1% (15) and 4,3% (1); a natural surface is just in one case present on the dorsal face of an opportunistic flake, while the negatives of previous removals mainly follow a unipolar direction (69,6% – 16), even if bipolar (8,7% – 2), crossed (8,7% – 2), orthogonal (8,7% – 2) and convergent (4,3% – 1) negatives are attested. The almost complete absence of natural (cortical) surfaces on the dorsal face of the opportunistic flakes is a further element assessing that the first phases of core exploitation were completed out of the site. The predominance of unipolar knapping scars and of flat butts let us suppose that opportunistic reduction strategies started from not prepared surfaces, with the production of flakes until the exhaustion of the useful convexity; just rarely, probably when pebbles of biggest dimensions are involved, this first unipolar exploitation phase was followed by a further production of rhyolite flakes through the exploitation of an adjacent, opposed, or orthogonal debitage surface. The only rhyolite core attested in the assemblage is fragmented and exhausted and it shows the use of two adjacent striking platforms to produce three not-standardized flakes. Concerning rhyolite, recurrent centripetal Levallois is attested just by one flake with centripetal negatives on the dorsal face and linear butt. The discoid method is better represented (7 flakes – 16,3%): discoid flakes have flat butts and centripetal or crossed negatives on the dorsal face. The reduced sample of items attesting the presence of Levallois, and discoid knapping sequences do not allow to make hypothesis about the development of the different phases of core exploitation.

The radiolarite flake assemblage show the predominance of recurrent centripetal Levallois products (27,0% – 14): of them, 8 have flat butts, 2 have dihedral butts, 2 have faceted butts and 2 are fragmented flake missing their proximal part. Even in the absence of cores, the presence of prepared butts (faceted and dihedral) indicated that phases of core configuration came before the Levallois production. The absence of cores and of flakes belonging to core configuration and management, indicates that just finished Levallois products were transported in the site and that all the knapping sequence was completed elsewhere.

The use of opportunistic reduction strategies on radiolarite is attested by 7 flakes (13,5%) with unipolar (6 flakes) and bipolar (1 flake) negatives on the dorsal face; when present, butts are flat (3) and linear (1). One flake has a natural surface on its dorsal face (lateral part). 7 flakes of the considered radiolarite assemblage are issued from discoid reduction strategies and have flat or linear butts. The number of opportunistic and discoid radiolarite products is however too small to propose hypothesis about the characteristic and development of these reduction sequences.

The knapping methods is indeterminate for a total of 10 rhyolite and radiolarite flakes, of which 9 are fragments and 1 is a tool (Quinson point) where the several phases of edge modification do not allow to identify knapping scars useful for the identification of the knapping method.

Rhyolite and radiolarite retouched tools (6 and 3 respectively) correspond to simple scrapers, denticulates, notches and a Quinson point (Fig. 5). Retouch is always semi-abrupt, and mainly direct (5 tools), localized on one side of the flake. A radiolarite rectilinear side-scraper and the Quinson point show different generations of retouch and have a retouch that can be defined as invasive.

Retouch flakes represent a significative proportion of the rhyolite and radiolarite lithic assemblage of level 14, corresponding to 11,6% (5 flakes) and to 40,4% (21 flakes) respectively. This group is composed by small flakes (Fig. 6), reduced in length and with small butts (flat, linear or punctiform) that are issued from the modification or rejuvenation of the edges of the flakes. As mentioned before, the retouched tools present in the considered assemblage show a preferential use of direct retouch: this observation finds comparison in the technological characteristics of the retouch flakes butts, that are often produced from a ventral face of a flake.

4.2 Experimental results

Concerning the experimental collection, the characteristics of the use-wear traces identified on radiolarite artefacts are comparable to those present in literature (e.g. Lemorini and Cristiani 2002; Lemorini et al. 2006; Solodenko et al. 2015; Visentin et al. 2016; Daffara et al. 2021) (Fig. 4). On the other hand, the analysis of the experimental collection led to interesting observations concerning rhyolite, that generally has a reaction to use like that of flint but with some peculiar differences. The experimentation shows that the edges of rhyolite tools get rounded and broke faster than the tools made in radiolarite, especially when used on hard materials. Edge removals are however present and permit to identify the hardness and the direction of the gesture. Micro-traces are identifiable on the quartz crystals when they are present on the active edges of the tools (Fig. 4): in these cases, it is possible to identify the material worked following the same procedure used for the quartz crystals in quartzite lithic tools (Gibaja et al. 2002; Clemente-Conte and Gibaja Bao 2009; Igreja 2009; Lemorini et al. 2014; Berruti and Cura 2016). The crystals of quartz can be easily identified because they usually have vitreous lustre, they are colorless or milky\grey colored with a crystalline habitus usually prismatic or massive (Rogers 1935).

4.3 Use-wear analysis

86 finds were selected for the use wear analysis: 32 are made in rhyolite and 54 in radiolarite; of these, according to the technological study (Daffara 2018), 9 are formal tools, 26 are retouch flakes and 53 are debitage products issued from different methods: opportunistic, Levallois and discoid.

On the analyzed sample 87 different traces on 52 different lithic artefacts have been identified (Table 4). Concerning radiolarite artefacts, traces of use have been identified on 34 elements, including a retouched tool, a simple rectilinear sidescraper, 12 retouch flakes and 22 simple flakes (Fig. 7–8). On the rhyolite lithic artefacts, traces of use have been identified on 18 findings, including 3 retouched tools (a denticulate, a simple convex sidescraper, and a notch,), 2 retouch flakes and 13 simple flakes (Fig. 7–8). As indicated in Table 4 the longitudinal action is the most represented in the analyzed sample. Looking at the type of worked material, Table 4 shows the predominance of butchering activities followed by fresh wood, hard animal materials, and skin processing. Considering the traces of use for which it was not possible to accurately determine the material processed, we note that the processing of hard materials prevails, followed by that of medium hard and finally of soft materials. In general, it appears that the activities related to the processing of animal carcasses (butchering activities, bone and soft animal tissue processing) are undoubtedly the most represented. Retouch flakes (Table 5), have traces mostly belonging to the exploitation of animal carcasses, followed by traces linked to wood and skin processing; only in two cases it was not possible to precisely identify the material processed. Considering the type of action carried out, we can observe that transverse and longitudinal actions are equivalent. As far as the formal tools (Table 6) are concerned, in our opinion the sample is too small (4 artefacts) to risk any interpretation.

Table 4

Material worked	**Radiolarite**			**Rhyolite**			**Tot.**	**%**
	T.	*L..*	*Indet.*	*T..*	*L..*	*Indet.*		
Soft animal tissue	2	-	-	-	1	-	3	3%
Butchering	4	5	1	1	1	1	13	15%
Fresh wood	4	3	-	-	1	-	8	9%
Hard animal materials	1	3	1	-	-	-	5	6%
Skin	2	2	-	-	-	-	4	5%
Bone	-	1	-	1	-	1	3	3%
Indet.	-	-	1	-	-	-	1	1%
Soft	3	2	0	2	1	-	8	9%
Medium soft	4	2	0	2	2	-	10	11%
Medium hard	1	4	0	3	6	-	14	16%
Hard	2	10	0	2	4	-	18	21%
Tot.	**23**	**32**	**3**	**11**	**16**	**2**	**87**	**100,0**
Tot. for raw material	**58**			**29**				

Ciota Ciara cave (S.U. 14). Use-wear traces found on the 86 lithic artefacts analyzed, grouped by action, worked material and raw materials. A total of 87 different traces on 52 different lithic artefacts have been identified. T. = Transversal action; L. = Longitudinal action

Table 5

Material	Radiolarite			Rhyolite			Tot.	%
	T.	*L.*	*Indet.*	*T..*	*L.*	*Indet.*		
Soft animal tissue	2	-	-	-	1	-	3	17
Butchering	2	2	1	1	-	-	6	33
Fresh wood	1	-	-	-	-	-	1	6
Antler	1	2	-	-	-	-	3	17
Frash skin	1	1	-	-	-	-	2	11
Soft	1	-	-	-	-	-	1	6
Medium Soft	-	-	-	-	-	-	-	-
Medium Hard	-	-	-	-	–		-	-
Hard	-	2	-	-	-	-	2	11
Tot.	8	7	1	1	1	0	18	100,0
Tot. for raw material	16			2				

Ciota Ciara cave (S.U. 14). Use-wear traces identified on the retouch flakes (16 elements), grouped by action, worked material and raw material. T. = Transversal action; L. = Longitudinal action

Table 6

Material	Radiolarite		Rhyolite		Tot.
	T.	*L..*	*T..*	*L..*	
Soft	-	-	-	1	1
Medium Soft	-	-	-	-	-
Medium Hard	-	-	1	-	1
Hard	2	-	-	1	3
Tot.	**2**	-	**2**	**2**	**5**
Tot. for raw material	**2**		**3**		

Ciota Ciara cave (S.U. 14). Use-wear traces identified on the retouched tools (4 elements), grouped by action, worked material and raw material. T. = Transversal action; L. = Longitudinal action

5 Discussion

The data obtained from the technological analysis indicate that in the lithic assemblage of S.U. 14 of the Ciota Ciara cave, rhyolite and radiolarite have the same role of complementary lithic resources. As shown by previous technological studies (Arzarello et al. 2012; Daffara et al. 2021), local raw materials and in particular vein quartz and spongolite, that are the most represented in the assemblage (Table 1), are exploited according to reduction strategies that can be considered as expeditive: the knapper takes advantage of natural convexities and surfaces present on vein quartz pebbles and spongolite slabs to obtain flakes with cutting edges, no matter shape and dimensions of the final blanks. Even Levallois and discoid knapping strategies are developed according to this opportunistic behaviour and are characterized by a low technological investment in the phase of core shaping and maintenance. Concerning rhyolite, the observations made about the opportunistic component of the lithic industry, show some similarities concerning the shortness of the reduction sequences and the use of not prepared surfaces. On the other hand, radiolarite Levallois flakes indicate the presence of a certain degree of core configuration, even if an accurate reconstruction of the different reduction strategies is not achievable due to the reduced number of radiolarite blanks and the complete absence of cores. The main factor determining these technological differences in the treatment of the different rocks, observed also when the local grey flint is involved (Daffara et al. 2021), is the adaptation of the reduction sequences to the characteristics of the raw materials (Mourre 1994; de Lombera-Hermida 2009; Tallavaara et al. 2010). If we put local rocks on one side and allochthonous rocks on the other, from a technological point of view the main difference lies in the frequency of use of retouching (Fig. 9). On local raw materials retouch is poorly represented and when present it consist of just one and slightly invasive phase of edge modification. For rhyolite and radiolarite, the rejuvenation and modification of the tools edges is far more frequent and suggest a repeated and intense use of these tools. In addition, the presence in S.U. 14 of several retouch flakes indicates that the use and rejuvenation of rhyolite and radiolarite tools took place quite frequently in the site, even if local rocks are abundant and easily available in the immediate surroundings of the Ciota Ciara cave.

The functional analysis of the lithic artefacts issued from the exploitation of allochthonous raw materials confirms the intense use of these tools and allowed to recognize the activities carried out with them, highlighting what seems to be some preferential choice to develop specific activities. The considered assemblage is characterized by a fair variety of activities which can be mainly traced back to two practices: 1. the processing of animal carcasses (i.e., slaughtering activities, filleting of flesh masses, skin working, scraping of fresh bone); 2. the exploitation of vegetal resources, which are represented by the processing of dry and fresh wood and by herbaceous plants working. In addition to these activities, it is also attested the processing of animal materials: some use-wears, based on the comparison with the experimental collection, have been interpreted as belonging to the processing of dry hard animal materials and, probably, dry skin. Observing the recognized activities in relation to the type of raw material used (Fig. 10–11), it is possible to note a prevalence of longitudinal actions on hard material concerning radiolarite artefacts. This type of activity refers to operations of cut and confirms the tendency to use radiolarite for this kind of working. Indeed, as we observed during the experimentation, the edges of rhyolite flakes tend to break soon if used on hard materials, thus making this raw material less effective than radiolarite for these activities. In general, the rhyolite flakes have less use-wear traces than those made in radiolarite (Table 4–5). During the experimental activity it was observed that the performance of the rhyolite flakes was always inferior to that of flint blanks, i.e., it was more difficult to complete all the planned activities with the rhyolite implements, compared to the same actions carried out with flint. This consideration could explain why the archaeological rhyolite flakes are less intensely exploited than those in radiolarite. In the analyzed archaeological record, four artefacts show traces referable to different processed materials (three unretouched flakes in radiolarite and one unretouched flake in rhyolite). The presence of this type of "complex" traces corresponds to a repeated use of the object, characteristic suggested also by the technological data that underline a more intense exploitation of lithic products in allochthonous raw material if compared to vein quartz or spongolite artefacts (Arzarello et al. 2012; Daffara et al. 2021).

However, the fact that an object has been used for different activities does not imply that it was conceived as part of a mobile toolkit (Kuhn, 1994). On the other hand, functional versatility, transportability and the potential life of the object are the three variables, that in relation to each other, in terms of costs/benefits, contribute to define toolkits in the archaeological records (e.g. Cahen et al. 1979; Cahen and Keeley 1980; Kuhn 1992, 1994; Stiner and Kuhn 1992; Porraz 2009; Romagnoli et al. 2018; Shimelmitz and Kuhn 2018; Martín-Viveros et al. 2020; Picin et al. 2020).

As mentioned before, the concept of toolkit is linked to the behavior, common in Paleolithic hunter-gatherer groups, of carrying a limited number of tools, necessary for various needs, during short or long journeys (Delagnes and Meignen 2006).

At the Ciota Ciara cave the functional versatility is attested by the large number of traces of use identified on rhyolite and radiolarite artefacts (Table 4); moreover, it is interesting to note that the set of use-wears present on these finds covers most of the activities identified in the functional study of the lithic artefacts made in local rocks. The results of that study indicate that flakes and retouched tools made in local rocks (vein quartz, spongolite and grey flint) were mainly used to perform butchering activities and secondly for the processing of vegetal materials, with no differences between unretouched flakes and retouched tools or among blanks issued from different knapping methods (Daffara et al. 2021). Tools and flakes made in allochthonous rocks were used to carry out the same activities that were completed with the artifacts made of local raw materials. This data are comparable to those reported in the study conducted on the toolkit coming from the M level of Abric Romaní, where, beside a differential degree of use-intensity between the imported tools and those knapped at the site, no functional differences have been identified concerning the performed tasks (Martín-Viveros et al. 2020).

Concerning portability, it is realistic to suppose that the general reduced dimensions of the allochthonous lithic industry (Fig. 6) represent an advantage in terms of weight (Kuhn 1994). The presence of use-wears also on very small flakes confirms the intense exploitation of the artefacts made in allochthonous raw materials, particularly radiolarite, and indicates that small flakes were commonly used to complete different tasks.

According to the model developed by S. Kuhn (Stiner and Kuhn 1992; Kuhn 1994), the most durable tools with the greatest possible use are those that allow, through retouching, to revive the functional margins, and therefore to be used longer before the flake runs out. This study identified traces of use on over half of the retouch flakes analyzed (57%) and no recurrent association of activities was found: this data confirms the functional variability of those retouched tools. Considering all these data together, we can realistically suppose that rhyolite and radiolarite blanks were introduced in the site as part of the mobile toolkit of the Neanderthal groups that inhabited the Ciota Ciara cave during the deposition of the SU 14. But in what form were these products introduced to the site? To answer this tricky question, several elements need to be considered. Kuhn hypothesizes two possible models: the first that foresees the working on the place of extraction to have finished objects; the second supposes the extraction and transport of cores that allow, subsequently, to obtain flakes that were used for immediate purposes and re-sharpened as needed (Kuhn 1994; Shimelmitz and Kuhn 2018). The technological study carried out led to the identification of only one rhyolite core, while no radiolarite cores are attested in the assemblage. Debris, which presence suggests the practice of knapping activities in the site, are also very few (Table 2), while it is well attested the presence and use of retouched tools and retouch flakes (Table 3-5-6). As for the retouch flakes, a refitting between two of them was also identified, thus confirming that the use and rejuvenation of tools in allochthonous rocks were also performed in the site. Probably, the presence of debris should be linked to these activities than to core exploitation. The functional study conducted also indicates the use of small, unretouched flakes, of which 15 are recurrent centripetal Levallois flakes. We can then hypothesize the transport within the site of finished products in the form of small, unretouched flakes and retouched tools, and, just sporadically, of small cores. The significative presence of Levallois radiolarite flakes in the Ciota Ciara toolkit is particularly interesting as the presence of this type of product in the toolkits has already been reported by other scholars and for different European Middle Palaeolithic contexts (Jaubert et al. 1990; Stiner and Kuhn 1992; Kuhn 1994; Henry 1995; Hovers 2009; Moncel et al. 2014; Picin and Carbonell 2016; Turq et al. 2017; Shimelmitz and Kuhn 2018): Levallois blanks and retouched tools made on them seems to be commonly transported over long distances, more frequently than other kind of artefacts, probably because they are usually thin and light and for that more suitable for transport.

A final question concerns the contextualization of the technological features observed at the Ciota Ciara cave in the broad debate opposing curated and planned technologies on one side and expedient technologies on the other. As observed by S. Kuhn (1992) the movement of lithic artefacts over long distances could reflect the existence of a planned strategy but other information are needed to clearly state the nature of the planned behaviour. He also underlines that if the artefacts made in allochthonous rocks present in a site are just highly portable blanks like tools and small cores, then they probably represent the usual movement and discard of curated toolkits (Kuhn 1992). This seems to be the case of the Cota Ciara cave, where the exotic component of the lithic assemblage of S.U. 14 is composed by small flakes, retouched tools and one small core. However, there is an important factor that we should consider and that concerns lithic raw materials. In the surrounding of the site knappable rocks are easily and abundantly available in different sizes and morphologies: vein quartz pebbles and blocks, spongolite slabs (Daffara et al. 2019). The main issues with this rocks is the scarce control on the result of knapping activity, due to the frequent presence of internal cleavage planes, and the short functional life of the edges of the tools made in this rocks (Arzarello et al. 2012; Daffara et al. 2021). Here we should focus the attention for the interpretation of the exotic component of the lithic assemblage here considered. The lithic assemblage of S.U. 14 is the result of several and repeated human frequentations, probably of seasonal nature; as already pointed out (Daffara et al. 2021) the general technological behaviour can be defined as expedient, being clearly characterized by a low technological investment in all the phases of the reduction sequences (i.e. core configuration, blanks production, core maintenance, tool manufacture rejuvenation). In this context, the introduction in the site of unretouched flakes and of tools made in allochthonous and better-quality rocks could be interpreted as a planned behaviour, aimed at satisfying the need for more durable and efficient tools during the periods of staying at the Ciota Ciara cave. Obviously it is not possible to exclude that the pink-red colour of the two rocks could constitute an "unusually beautiful" element for the Neanderthals who occupied the cave (Moncel et al. 2012; Radovčić et al. 2016). That is, it is not possible to exclude that there was also an aesthetic component in the choice.

6 Conclusion

The data here presented and discussed are very important for the understanding of the technology and the strategies of land mobility of the Neandertal groups that inhabited the Ciota Ciara cave during Middle Pleistocene. This kind of data takes on even more importance if we consider that the Ciota Ciara cave is the only reliable source of information for the Middle Palaeolithic peopling of the whole north-western Italy. The technological and functional study conducted highlights interesting elements not only for what concerns the specific context under study but also about broad and debated issues in Palaeolithic studies. The Ciota Ciara cave level 14 have a lithic assemblage that for what concerns the exploitation of local rocks can be easily and clearly identified as issued from an expedient technological behaviour (Arzarello et al. 2012; Daffara et al. 2021); on the other hand evidence of a curated technology (Binford 1979; Kuhn 1992, 1994) is visible in the effort and in the high technological investment visible in the production and maintenance of tools made in allochthonous rocks; moreover, the introduction of flakes, retouched tools and of a small core made in these rocks, which quality is better than those available in the local environment, paves the way for the identification of planned strategies during land mobility (Kuhn 1992). The general picture therefore appears more complex than the pause on the dichotomy between expedient and curated behaviours suggests; with the progress of research and the increasingly frequent use of multidisciplinary approaches to the study of lithic industries, the technological choices and strategies of mobility on the territory put into action during Middle Palaeolithic appear increasingly nuanced and articulated (Vaquero et al. 2012; Turq et al. 2013; Machado et al. 2017; Romagnoli et al. 2018; Vaquero and Romagnoli 2018; Spagnolo et al. 2019; Martín-Viveros et al. 2020; Picin et al. 2020). The Neandertal groups of the Ciota Ciara cave show a great adaptability to the environmental constraints and their technology clearly reflects this capability. Further studies on the lithic assemblage of the Ciota

Ciara cave will provide more data that will allow a more complete and reliable interpretation of the lithic assemblage also in a diachronic perspective.

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Authors contribution

Conceptualization: GLFB.; methodology: GLFB, SD; formal analysis: GLFB, PF, SD; writing - original draft preparation, review, and editing: MA, GLFB, SD, PF; Supervision: MA

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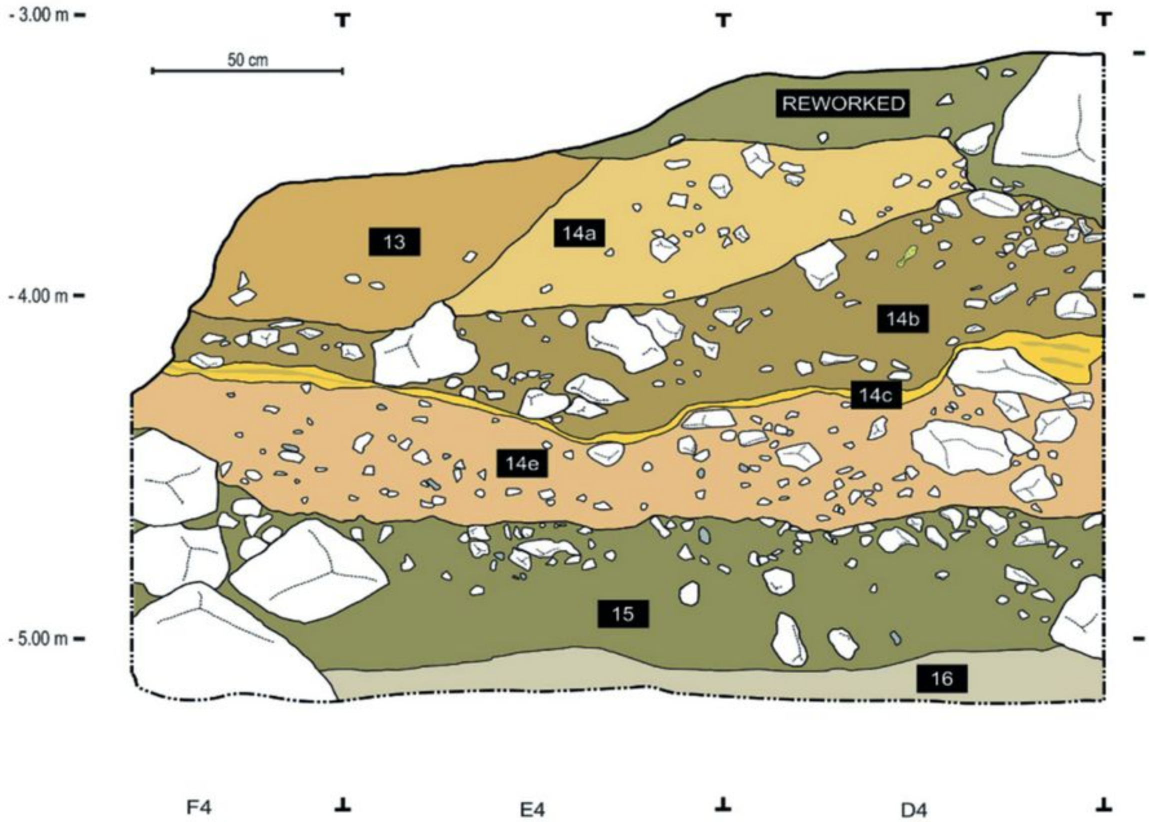
Figures

Figure 1

(A) South-western entrance of the Ciota Ciara cave; (B) Location of Monte Fenera and, on the right, view of the west side of the mount; (C) Planimetry of the Ciota Ciara cave showing the areas investigated during the 50s and the 60s and detail of the excavated area in the atrial sector of the cave



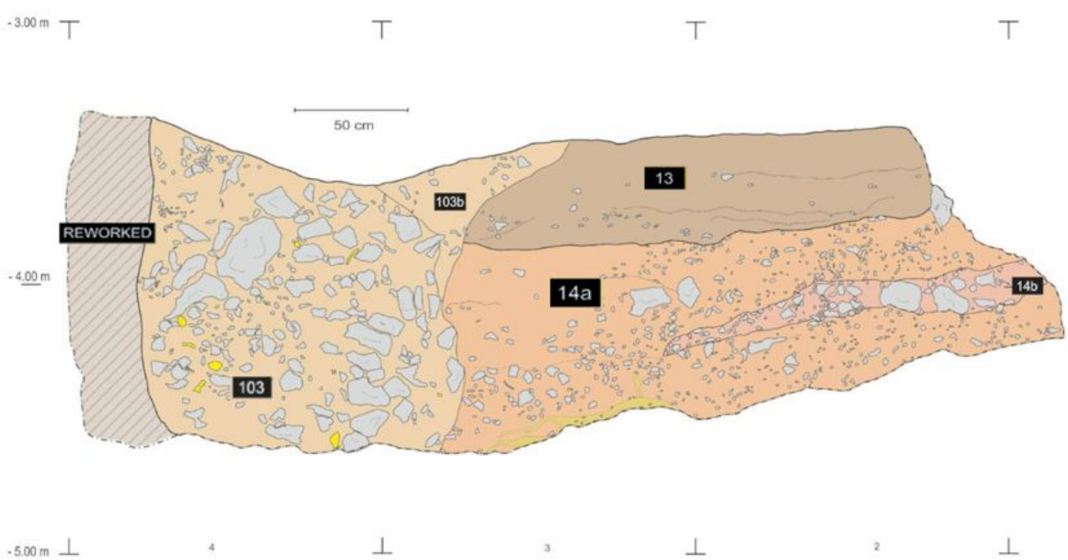


Figure 2

Stratigraphy of the Ciota Ciara cave, atrial sector. Top: north section (from Angelucci et al. 2019) where level 16 corresponds to a sterile level lying upon the bed rock; bottom: west section (from Zambaldi 2015)

Figure 3

Location of the supply areas of lithic raw materials (modified from Daffara et al. 2019)

Figure 4

a) Experimental activity on antler; b) experimental activity on dry skin; c) experimental activity on wood; d) experimental flake S08 radiolarite, 16x magnification: continue edge removals, little deep, 10 min work on antler; e) experimental flake S22 rhyolite, magnification 200x: specific traces with domed topography and rounding, 10 min work on antler; f) Experimental flake S09 radiolarite, 100x magnification: small and continuous edge removals in the shape of a crescent with traces of polishing from the edge, uneven and closed texture, 15 min work on antler; g) experimental flake S17 radiolarite, 20x magnification: small and continuous edge removals with elongated shape, 15 min work on antler; h) experimental flake S02 rhyolite, 20x magnification: large and continuous edge removals , not very intrusive; 5 min work on dry wood; i) experimental flake S10 radiolarite, 30x magnification: large and continuous edge removals in the shape of a crescent, not very intrusive with traces of rounding of the edge, 10 min work on fresh skin.

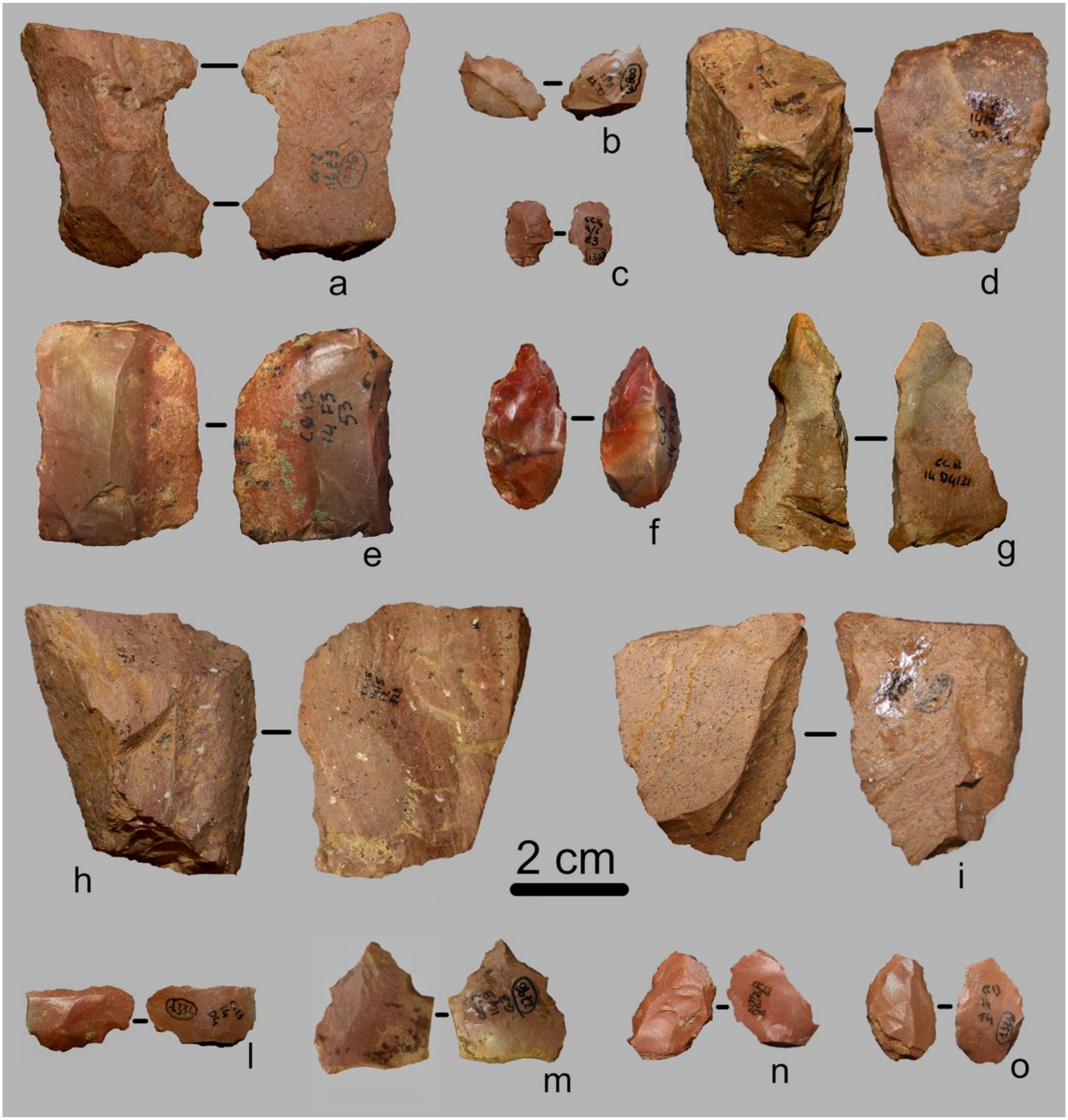


Figure 5

Radiolarite and rhyolite lithic artefacts from level 14 of the Cota Ciara cave: a) retouched notch on a rhyolite opportunistic flake; b-c) radiolarite retouch flake; d) discoid rhyolite flake; e) rectilinear side-scraper on a radiolarite opportunistic flake; f) Quinson point on a radiolarite flake; g) lateral fragment of a denticulate on a discoid rhyolite flake; h) opportunistic rhyolite flake; i) convex side-scarper on an opportunistic rhyolite flake; l) discoid radiolarite flake; m) recurrent centripetal Levallois flake in radiolarite affected by rounding; n-o) recurrent centripetal Levallois flakes in radiolarite;

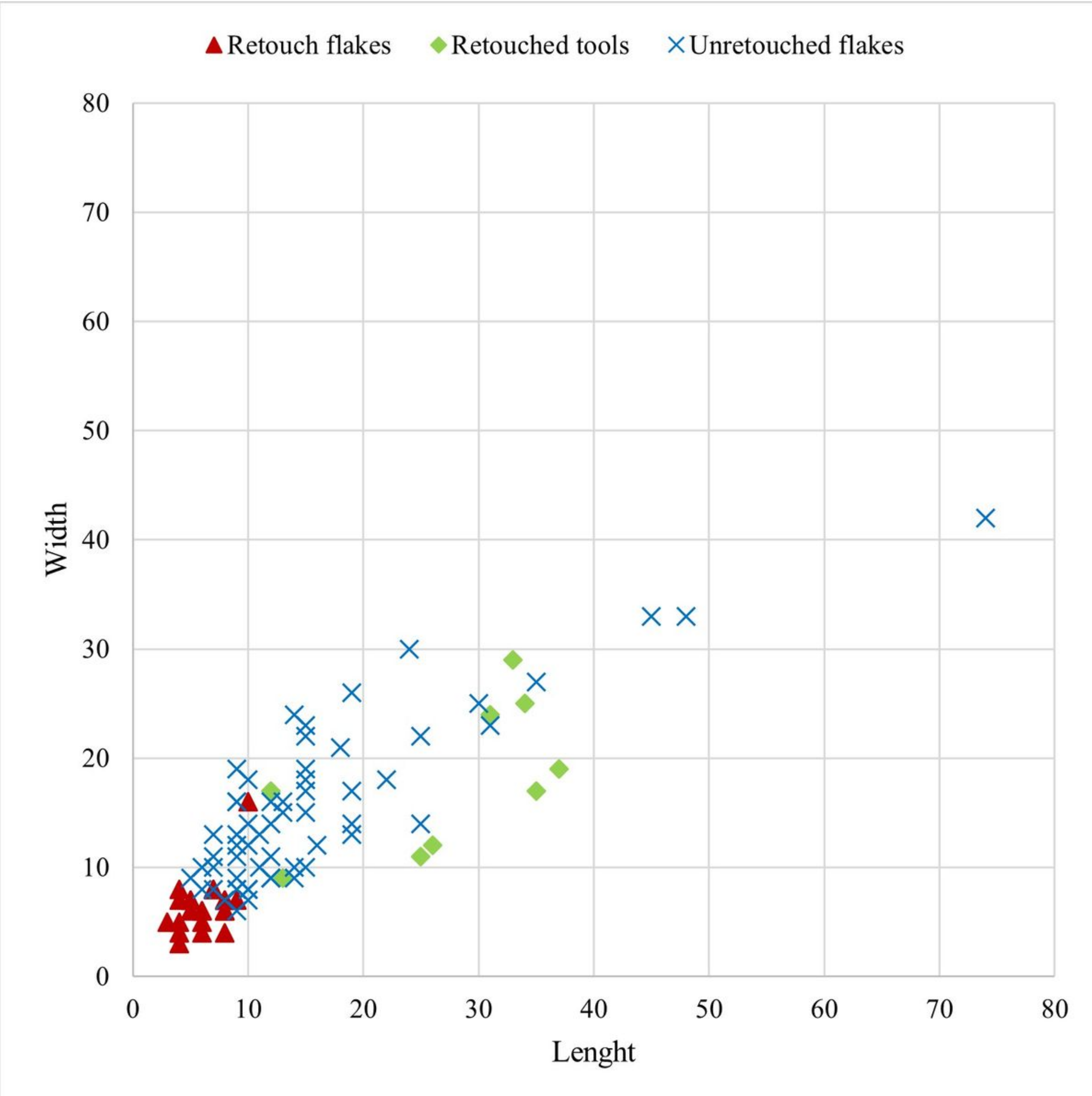


Figure 6

Dimensional analysis of radiolarite and rhyolite flakes from level 14 of the Ciota Ciara cave. Fragmented flakes have been excluded from the study

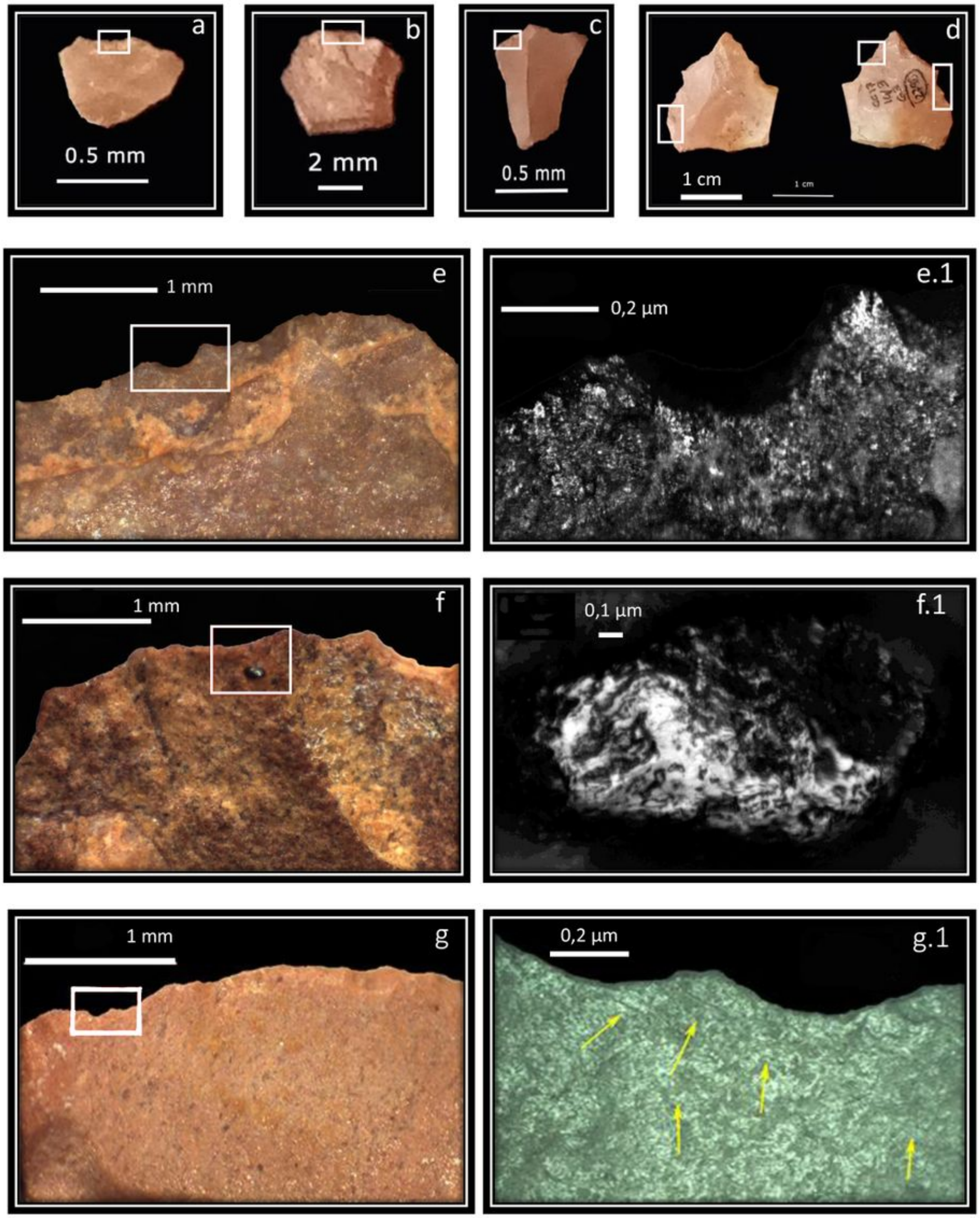


Figure 7

a) Retouch flake (CC14.F3.2774), radiolarite, enlarged area in figure e and e.1: the flake has traces of soft animal tissue working; b) retouch flake (CC14.D3.2637), rhyolite, enlarged area in figure f and f.1, the flake has traces of butchering activities; c) radiolarite flake (CC14.D3.2664), enlarged area in figure g and g.1: the flake has traces of butchering activities; d) radiolarite flake (CC14.G3.2798), enlarged area in Fig. 9 (h, i, l and m): the flake has traces of butchering activities; e) CC14.F3.2774 - magnification 30x: large and deep edge removals, developed mainly on the dorsal face; e.1) CC14.F3.2774 - magnification 100x: polishing with compact texture and regular profile; f) CC14.D3.2637 - magnification 30x: large, shallow and irregular edge removals; f.1) CC14.D3.2637 - magnification 500x: zoom of the crystal of quartz in figure f: widespread rounding associated with plastic deformation and roughness, micro holes and large scars; g) CC14.D3.2664 - magnification 30x: large and deep edge removals; g.1) CC14.D3.2664 - magnification 100x: striae (indicated by arrows), diffuse rounding and development of a weft polishing not very compact and with an irregular profile

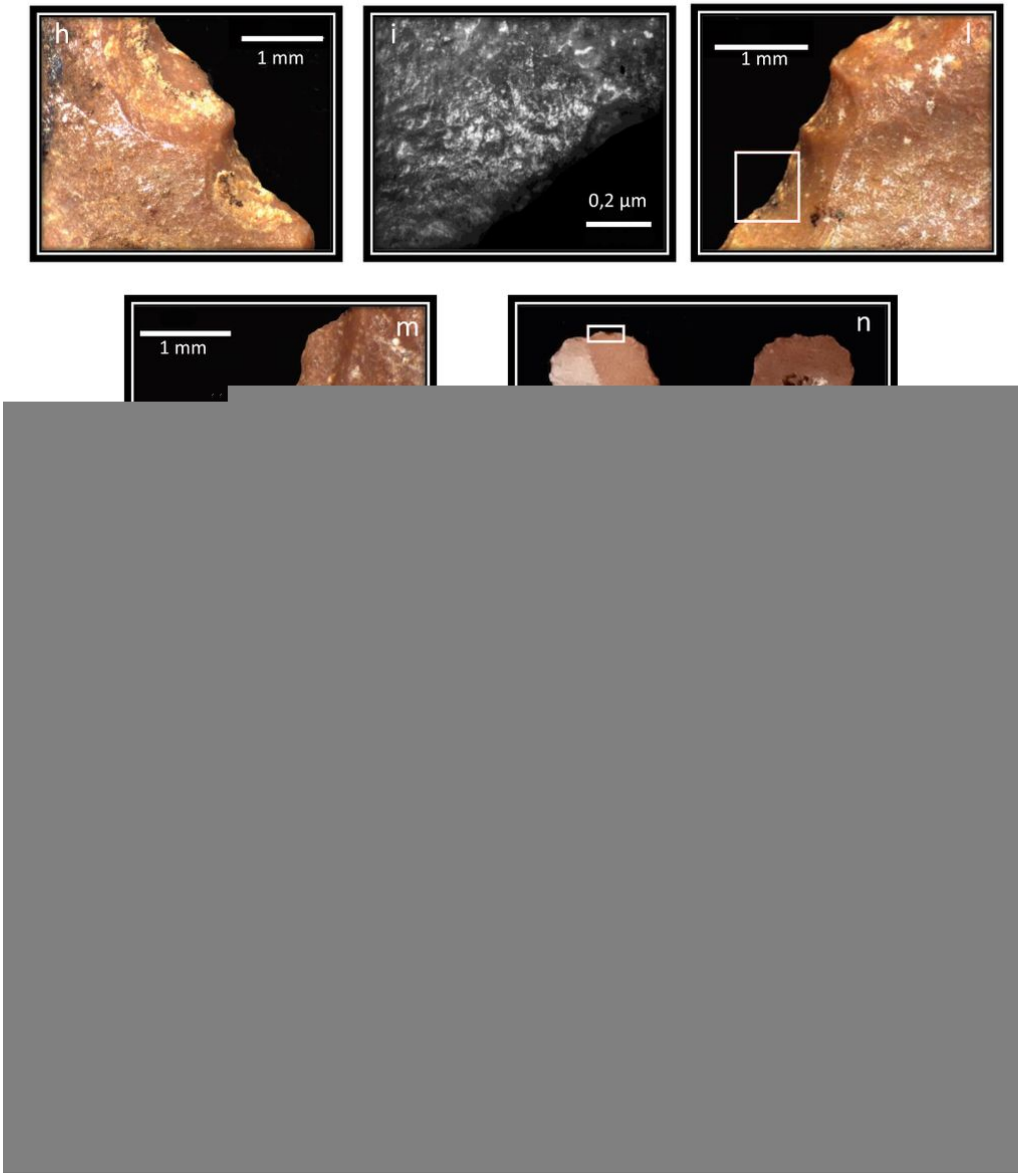


Figure 8

h) CC14.G3.2798 - magnification 30x of figure 8d: large edge removals, quite deep and located on both faces; i) CC14.G3.2798 - magnification 100x of the area in figure l: on two small edge removals, there is a polish with a textured closed and an irregular profile; l) CC14.G3.2798 - magnification 30x of figure 8d: wide and narrow edge removals with snap termination, developed on both faces; m) CC14.G3.2798 - magnification 30x: wide and narrow edge removals present on both sides of the flake, with uneven distribution; n) radiolarite flake (CC14.E3.1347), enlarged areas in figure o, p, q and r: the artefact has traces of hard or medium hard material working (wood working); o) CC14.E3.1347 - magnification 20x: wide edge removals, discontinuous and very intrusive, visible on both sides; p) CC14.E3.1347 - magnification 100x,\ zoom of the area in the rectangle in figure o: intrusive polish with closed plot and jagged profile; q) CC14.E3.1347 - magnification 20x: wide edge removals, discontinuous and very intrusive, visible on both sides; r) CC14.E3.1347 - magnification 20x: wide edge removals, discontinuous and very intrusive, visible on both sides.

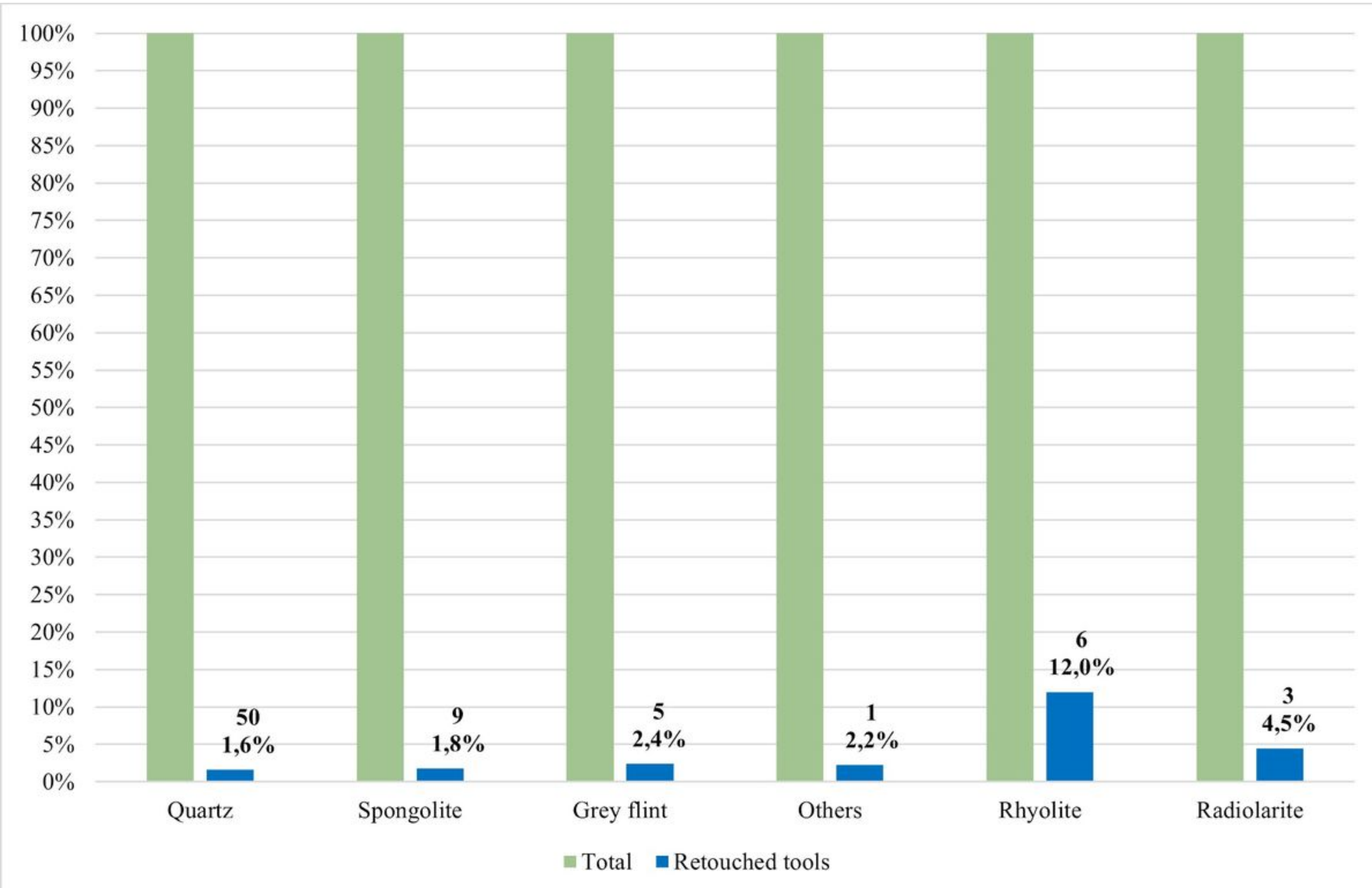


Figure 9

Graph showing the proportion of retouched tools for each raw material exploited at the Ciota Ciara cave, S.U. 14.

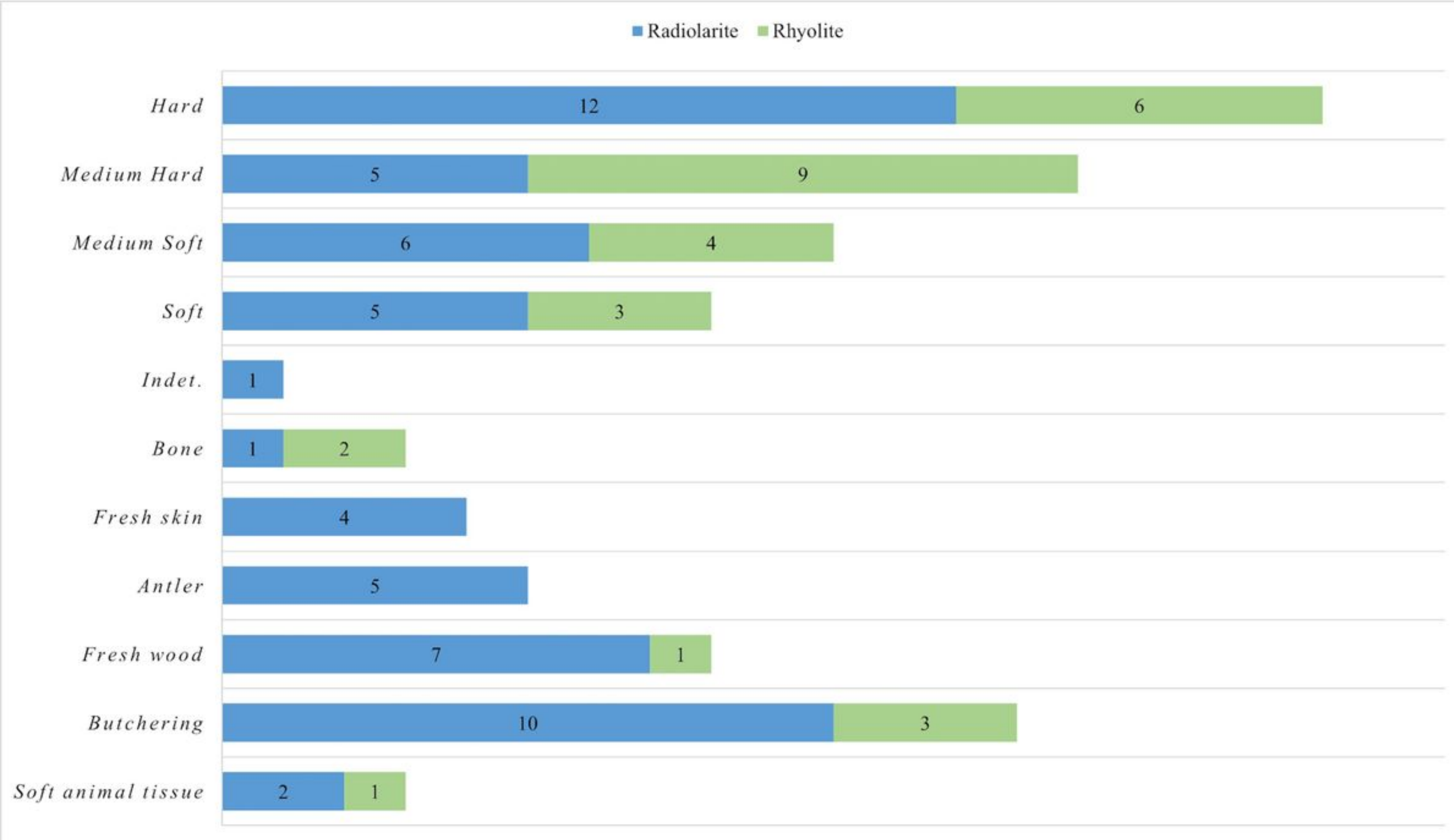


Figure 10

Graph showing the processed materials in relation to the lithic raw material

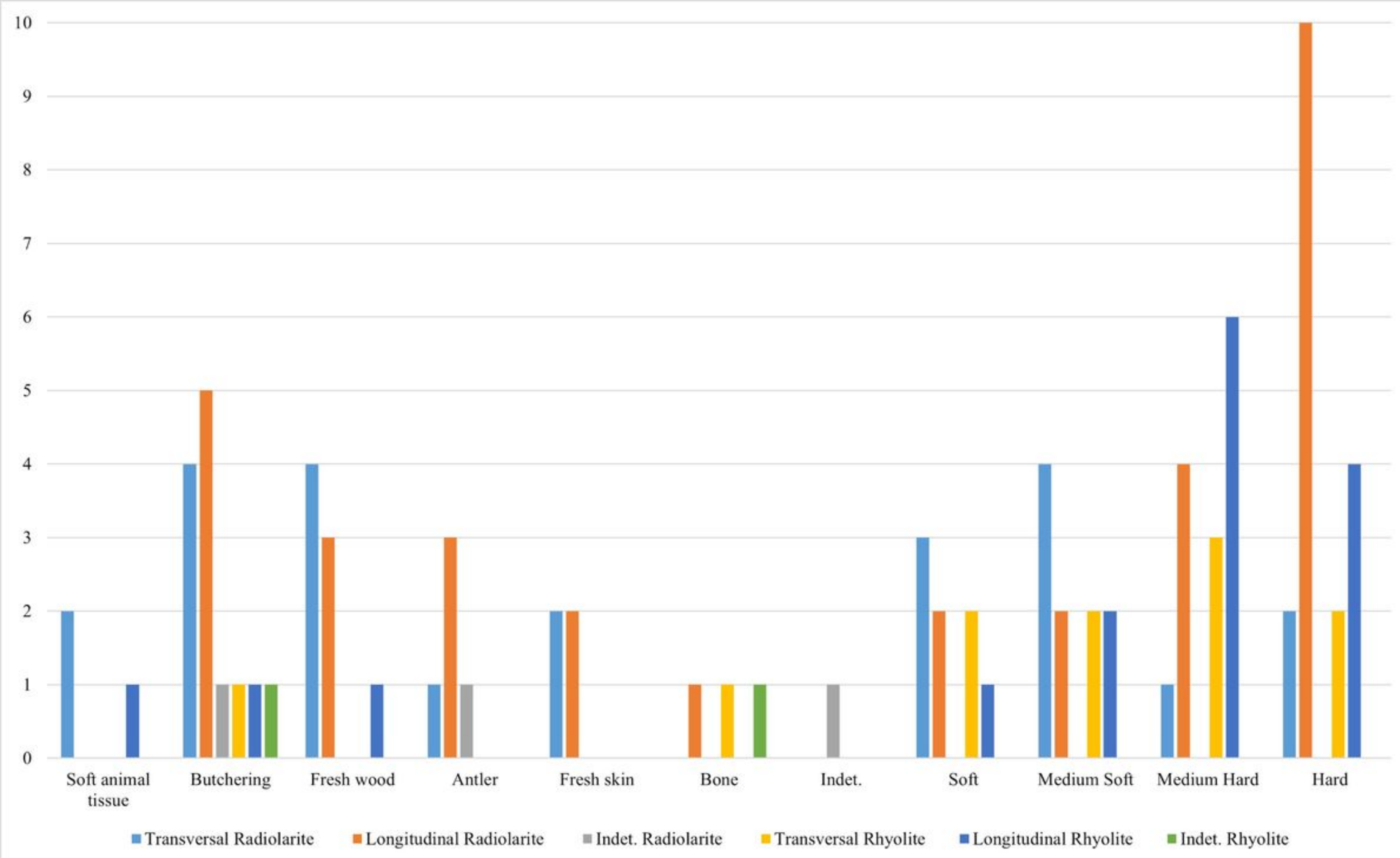


Figure 11

Graph showing the processed materials in relation to the type of action and the lithic raw material