Raw materials procurement strategies at the Ciota Ciara cave: new insight on land mobility in north-western Italy during Middle Palaeolithic

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Abstract

The importance of the Ciota Ciara cave for the understanding of the Middle Palaeolithic peopling of Piedmont (north-western Italy) is known since the 60s but it is just since 2009 that systematic and multidisciplinary archaeological excavations are ongoing at the site. In this region, studies about Palaeolithic are quite underdeveloped and the proposed research represents the first attempt to understand Middle Palaeolithic land mobility in the region. The lithic assemblage found is composed by 7046 artefacts and different raw materials are involved in the production of lithic artefacts. Vein quartz is the main exploited raw material in all the archaeological layers followed by spongolite, a local variety of chert, and by a better-quality grey/black flint. For these rocks the reduction sequences are complete while other raw materials are sporadically attested all along the sequence (opal, jasper and milonite) and probably exploited out of the site. Rhyolite and radiolarite are present in different proportions in all the archaeological levels and are represented almost exclusively by retouched tools and by small flakes belonging to the reshaping or re-sharpening of the tools' edges. The proposed research focuses on the identification of the supply areas of lithic raw materials in order to define the land mobility of the human groups that inhabited the cave during Middle Palaeolithic. The study involves both local and allochthonous raw materials to understand the mobility range on a local and sub-regional scale. Starting from the idea of evolutionary chain, a specific methodology has been developed for vein quartz, aimed at the identification of the most probable secondary sources exploited. For all the raw materials, field works and lab analysis (stereomicroscope observations, Scanning Electron Microscopy and µ-XRF analysis) have been set up. The results obtained show that several local primary and secondary deposits were exploited, located at few hundred meters from the site. Vein quartz was collected in secondary deposits at the base of the mount while rhyolite comes from secondary deposits located at about 2 km in a straight line from the site. Radiolarite was instead collected within deposits located at distance between 20 and 30 km from the Ciota Ciara cave giving the chance to formulate reliable hypothesis on the seasonal mobility of the Middle Palaeolithic hunter-gatherers of the Ciota Ciara cave.

Keywords

Ciota Ciara, Piedmont, Middle Palaeolithic, land mobility, raw materials supply areas

1. Introduction

The reconstruction of lithic raw material procurement strategies during Palaeolithic is essential to understand how hunter-gatherers groups managed to exploit local resources, which were their preferential routes for seasonal movements, and finally to formulate reliable hypothesis about their capability of satisfying long or short-term needs through the exploitation of local and non-local resources (Aubry et al., 2012; Borrazzo and Etchichury, 2010; de Grooth, 1997; Doronicheva et al., 2016; Ekshtain et al., 2017; Féblot-Augustins, 1997; Groucutt et al., 2017; Gurova et al., 2016; Kuhn, 1994, 1992; Martinez, 1991; Navazo et al., 2008; Navazo and Díez, 2008; Odell, 2000; Olivares et al., 2009; Vallejo Rodríguez et al., 2017; Wilson et al., 2018). Several studies agree upon the importance of characterizing the geographic environment to understand the subsistence strategies of Palaeolithic hunter-gatherers (e.g. Aubry et al., 2012; Bailey et al., 2011; Binford, 1979; Fernandes et al., 2008; Groucutt et al., 2017; Ortega and Maroto, 2001; Otte, 1991; Reynolds et al., 2011; Romagnoli et al., 2016; Roy Sunyer et al., 2017; Vaquero, 2007) and studies about raw materials show the connections between the rocks outcrops and the lithic artefacts recovered from the sites (Delage, 2003). As observed by Aubry et al. (2012), lithic raw materials reflect a small part of foraging activities of Palaeolithic human groups while other resources, maybe playing a more important role, are not accessible to our analysis due to taphonomic factors. So, it is through the study of raw material sources that we can define prehistoric territories and changes through time in pattern of resource exploitation (Aubry et al., 2012; Féblot-Augustins, 1997, 1993; Geneste, 1992; Picin and Carbonell, 2016; Turq et al., 2017).

The present work focuses on an area of north-western Italy where studies about Palaeolithic are quite underdeveloped and where the Ciota Ciara cave (Fig.1) represents at today the most important Palaeolithic site, the only one systematically excavated with a multidisciplinary approach (Angelucci et al., 2018; Arzarello et al., 2012; Berto et al., 2016; Buccheri et al., 2016). Through field works, microscopic observations and non-destructive lab analysis we characterized the lithic raw materials present in the archaeological record and we identified their primary and secondary outcrops as well as their most probable supply areas. Different methodologies have been applied depending on the peculiarities of each raw material. The aim of the proposed research is not only to identify the provenience of the allochthons raw materials present in the site but also to identify the primary outcrops and secondary deposits of the local lithic raw materials, far predominant in the lithic assemblage. In this way we can make hypothesis not only on seasonal movements on a regional scale (Kuhn, 1994, 1992; Spinapolice, 2012; Turq et al., 2017), but also on the mobility in the local environment during the seasonal frequentation of the site (Geneste, 1992; Roy Sunyer et al., 2017; Turq et al., 2013).

The results achieved, together with the technological (Daffara, 2017) and the functional study (Berruti, 2017) of the lithic assemblage, lead to a quite complete understanding of the modalities of frequentation of the Ciota Ciara cave and of the surrounding territories during Middle Palaeolithic.

1.1. The site

The Ciota Ciara cave is located in Piedmont, Monte Fenera's karst, an isolated relief (899 m a.s.l.) placed at the entrance of the Sesia valley in north-western Italy (Fig. 1). The cave opens on the west side of Monte Fenera at 670 m a.s.l. and it can be accessed both from a big triangular entrance, facing south-west (665 m a.s.l.), and from a secondary entrance facing west (670 m a.s.l.) (Brecciaroli Taborelli, 1995; Fedele, 1972, 1966) (Fig. 1). It is a still active karst cave developed over more than 80 meters on its principal axe, with a positive difference in height of 15 meters from the main entrance to the bottom (Fig. 2). The archaeological interest of the Ciota Ciara cave is known since the beginning of the XXth century (Conti, 1931) but systematic investigations started just in the 60s (Fedele, 1966) when some test pits were realized in the cave (Fig. 2) (Busa et al., 2005; Fedele, 1966). In the 90s, two brief excavation campaigns were carried out after the finding of two teeth within sediments transported outside the cave by water and identified as belonging to *H. neanderthalensis* (Busa et al., 2005; Villa and Giacobini, 2005, 1993).

Systematic and multidisciplinary investigations started again in 2009 and they are still on-going (Fig. 2). After the restoration of previous excavations, new researches focuses in the atrial part of the cave where a 2m thick sequence was unearthed (Angelucci et al., 2018). Four main stratigraphic units have been identified, each one corresponding to different modalities of frequentation of the site (Fig. 3) (Angelucci et al., 2018; Arzarello et al., 2012; Daffara et al., 2014). The paleo-environmental reconstruction, achieved through the palaeontological analysis of macro and micro mammals remains, shows that a woodland environment was predominant during the frequentation of the site but a slight climatic change is visible between level 13 and 14, from warmer to cold and humid environments: during the formation of level 14, the surroundings of the site were characterized by an open woodland environment with exposed rocks and within this unit are present different markers of cold climate like *Cricetus cricetus*, *Microtus* cf. *gregalis* and *Chionomys nivalis* (Berto et al., 2016). The large mammals' assemblage is dominated by carnivore remains in all the units (*Ursus spelaeus, Ursus arctos, Canis lupus, Vulpes vulpes, Meles meles, Martes martes, Lynx lynx, Panthera leo* and *Panthera pardus*) while the importance of herbivores (*Rupicapra rupicapra, Cervus elaphus,* cf. *Dama, Bos primigenius, Bos* sp., *Bos* vel. *Bison, Sus scrofa, Stephanorinus* sp.) grows considerably in level 14 (Berto et al., 2016; Cavicchi, 2018). Cut marks related to skinning activities and flesh extraction are attested on some *Ursus spelaeus* remains (Buccheri et al., 2016).

The lithic assemblage is composed by 7046 lithic artefacts. The technological study recently completed (Arzarello et al., 2012; Daffara, 2017; Daffara et al., 2014) shows that the technological behaviour is constant all along the sequence and that no significant differences are visible in the exploitation strategies of the different raw materials (Tab. 1).

Preliminary numerical dating results indicate that the human frequentation of the Ciota Ciara cave may date to the second half of the Middle Pleistocene (Berto et al., 2016; Cavicchi, 2018; Vietti, 2016).

1.2. Regional settings

In the southern Alps, Monte Fenera represents the widest and stratigraphically most important portion of the Mesozoic sedimentary cover (Fig. 4) (Bertolani, 1974; Bini and Zuccoli, 2005; Fantoni et al., 2005b, 2005a). The stratigraphic series of Monte Fenera is well documented and from the bottom to the top is made up of metamorphic rocks (*Scisti dei Laghi*), volcanic rocks (*Complesso vulcanico permiano*), and sedimentary rocks (*Arenarie grige di Fenera Annunziata, Dolomia di S. Salvatore, Brecce del Monte Fenera, Arenarie di S. Quirico, Calcari spongolitici* and Pliocene deposits) (Fig. 4) (Fantoni et al., 2005a):

Looking at the Alpine geological background, Monte Fenera is close to the connection between the Po plain subsiding and the Alps rising (Fantoni et al., 2005a). Two main tectonic lineaments cross the considered area: *Linea della Colma (LCo)* and *Linea della Cremosina (LCr)* (Fig. 4). They are linked to the Mesozoic extensional cycle and to the Alpine compressional cycle respectively. To them is connected a system of minor faults and diffused fracturing. (Fantoni et al., 2005b).

Quaternary deposits in the Monte Fenera area are of alluvial origin and are grouped in three main units: Pleistocene alluvial deposits, ancient and recent alluvial deposits (Bertolani, 1974; Fantoni, 1991). The fluvial terraces visible close to Fenera S. Giulio and Ara are Pleistocene alluvial deposits and are located between 420 and 400 m a.s.l., 60-80 m higher than the current plain. They are reddish silty and sandy deposits containing different kind of pebbles showing traces of glacial transport (Fig. 5). It is likely that the river formed these terraces through reworking of existing glacial deposits (Fantoni et al., 2005b). Ancient alluvial deposits are located 10 m higher than the current plain and are visible at the valley bottom and in some side valleys (Fig. 5). They are terraced gravelly deposits with sandy intercalations (Fantoni, 1991). Recent alluvial deposits correspond to the current Sesia and Strona river beds and are made up of gravelly-sandy and sandy deposits respectively (Fantoni, 1991) (Fig. 5)

2. Materials and methods

The entire lithic assemblage of the Ciota Ciara cave has been considered for the study of the supply areas of lithic raw materials. It consists of 7046 lithic artefacts divided in four stratigraphic units as shown in Tab. 1. In all the archaeological layers, vein quartz is the main exploited raw material, followed by other stones attested in different proportions in each level (Tab. 1).

The present work has been conducted in different phases and combining several approaches: petrographic characterization of the lithic raw materials, land surveys based on geological data, comparison between the samples collected and the archaeological materials achieved through geochemical analysis (e.g. Aubry et al., 2012; Fernandes et al., 2006; Gurova et al., 2016; Navazo et al., 2008; Nazaroff et al., 2013; Olivares et al., 2009; Spinapolice, 2012; Tarriño et al., 2015; Vallejo Rodríguez et al., 2017). The characterization of the raw materials has been carried out through a non-destructive methodology as not to damage the archaeological finds (e.g. Aubry et al., 2012; Barcelo, 1996; Bustillo et al., 2009; Navazo et al., 2008). Due to the different characteristics of the lithic raw materials involved, specific methodologies have been applied, in particular concerning vein quartz. For all the raw materials, stereomicroscope observations have been completed using a stereomicroscope in reflected light Optika SZ6745TR with magnification between 0.6x and 4.5x, equipped with an USB camera Moticam 2500 with a 5-megapixel resolution, a lens providing a further 2x magnification and a LED-72T light ring.

2.1. Vein quartz

The identification of vein quartz supply area has been completed in two phases: at first the analysis aimed to a precise characterization of vein quartz, identifying, at a microscopic level, all the elements useful to demonstrate or not the consistency between the lithic artefacts found in the site and vein quartz primary outcrops that the geologic literature locates in the surroundings of Monte Fenera (Sbisà, 2010). The presence, on vein quartz surfaces, of minerals and micas could indicate the degree of metamorphism typical of the environment where the quartz veins formed (e.g. D’Amico, 1973). This analysis has been completed through stereomicroscope observations while, for a better characterization of mineral and micas present on the surface of vein quartz geologic samples and artefacts, further analysis have been conducted using a Scanning Electon Microscope (SEM) ZEISS EVO40, 20Kw, 90 Pa, at variable pressure and LaB_6 filament with a 20pA probe current.

The presence of neocortical surfaces on vein quartz artefacts suggest that it was collected in the form of pebbles in secondary deposits (Arzarello et al., 2012; Daffara et al., 2014): a second step of analysis was the attempt to locate the vein quartz secondary deposits more probably exploited during Middle Palaeolithic at the Ciota Ciara cave. We started from the concept of “evolutionary chain”, elaborated for the identification of flint secondary deposits (Fernandes et al., 2007; Fernandes and Raynal, 2010, 2006): according to this methodology, the processes to which a raw material is subject from its formation to the place where it was collected by humans, leave on the cortical surfaces several traces and alterations that can be very informative about the procurement strategies of prehistoric hunter-gatherers (Daujeard et al., 2012; Fernandes et al., 2008). As alteration of a rock we refer to changes and modifications of its properties due to different processes started by natural agents and of physical, chemical or mechanical origin (Attal, 2003; Fernandes and Raynal, 2010, 2006; Stapert, 1976). Starting form this approach, a specific methodology has been elaborated for vein quartz, a raw material very different from flint and far more resistant to alterations (Venditti et al., 2016): the present work represents a preliminary approach to the identification of vein quartz secondary deposits, in the absence of similar studies.

At first a systematic survey activity has been completed with the collection of samples from different secondary deposits: current alluvial river deposits (i.e. Sesia river); current alluvial creek deposits (i.e. Strona creek); current alluvial stream deposits (i.e. Monte Fenera’s streams); Pleistocene alluvial deposits (i.e. remaining portions of fluvial terraces linked to the Sesia River) (Fig. 6) (Fantoni, 1991). All the secondary deposits have been photographed, sampled and located on a 1:15.000 map. The presence of other lithic raw materials in the same areas has also been highlighted. The samples collected, and the neocortical surfaces of the lithic artefacts found in the site have been analysed through macro and microscopic observations (stereomicroscope observation), taking into account several parameters: lithology (macrocrystalline or microcrystalline vein quartz), presence of micas, neocortex morphology and appearance, colour, polish degree, presence and morphology of striations and scratches, pression cones, impact traces, holes and fractures. The comparison between the results obtained from the geologic samples and from the archaeological materials gives interesting results about the location of vein quartz secondary deposits during the frequentation of the Ciota Ciara cave.

2.2. Other raw materials

As for vein quartz, the characterization of all the other lithic raw materials was carried out through non-destructive methodologies. At first, stereomicroscope observations of all the archaeological finds have been completed considering as diagnostic criteria for the identification of the different lithologies: texture, type of impurities, colour, presence and typology of micro-fossils (Luedtke, 1992). Then, land surveys based on the geological maps and on the data available have been set up (e.g. Aubry et al., 2012; Fernandes et al., 2008; Gurova et al., 2016; Navazo et al., 2008; Spinapolice, 2012; Vallejo Rodríguez et al., 2017). Geological data concerning the immediate surroundings of Monte Fenera and the Sesia valley have been updated in the last years thanks to the institution of the UNESCO Sesia Valgrande Geopark and specific works have been used to acquire the necessary knowledge for the territorial survey (e.g. Fantoni et al., 2005b, 2005a; Quick et al., 2003; Sinigoi et al., 2010). The updated geological maps of the area available at http://www.supervulcano.it/catografia.html have been consulted together with the digital version of the Italian geological map 1:10.000 available on the web site of *ISPRA – Istituto Superiore per la Protezione e la Ricerca Ambientale* (http://www.isprambiente.gov.it/it/cartografia). According to the information achieved from the geological cartography and to the results of the microscopic observation of the lithics from the Ciota Ciara cave, outcrops and probable secondary deposits of lithic resources have been identified. Another element considered in the choice of the area to be surveyed was that usually, during Middle Palaeolithic, the lithic resources collected and brought to the site were those located as close as possible to the site (Bourguignon et al., 2006; Delagnes et al., 2006; Féblot-Augustins, 1993; Fernandes et al., 2008; Jaubert and Delagnes, 2007; Locht and Goval, 2004; Meignen et al., 2009). During survey activities, samples of all the rocks that at a macroscopic observation were consistent with those present in the archaeological record have been collected, both from primary outcrops and from secondary deposits. Each surveyed area has been photographed and primary outcrops were positioned through GPS technology. All the samples collected have been observed at the stereomicroscope. When necessary, for a better characterization of the raw material, further studies have been completed through the Scanning Electron Microscope already employed for the analysis of vein quartz samples. Allochthonous raw materials, after the microscopic observation have been analysed through qualitative X-ray fluorescence (XRF) spectroscopy. For this analysis have been selected some samples from the archaeological record and geological samples that showed characteristics consistent with those of the lithic finds. This kind of analysis allow the characterization of the geochemical fingerprint of each lithic raw material regarding both its majority and minority components (Malyk-Selivanova et al., 1998; Milne et al., 2009; Tarriño et al., 2015). In this way, inclusions typical of a geographic area can be used to characterize particular outcrops and deposits and can be very helpful in provenience studies (Nazaroff et al., 2013). The XRF analysis has been carried out through an ARTAX portable µ-ED-XRF equipped with a He gas flush for the excitation and detection beam channel (West et al., 2012). The object to be examined is irradiated by a collimated X-ray beam between 200 and 1500 µm. This high-energy radiation incites element-specific X-ray fluorescence radiation in the sample. The intensity of this characteristic radiation is a measure of the quantity of the respective element in the sample. A cooled semi-conductor detector receives this characteristic X-ray radiation and converts it into current pulses which are amplified and digitised in the pre-amplifier and XSPV. The data from the microscopic observations and from the X-ray fluorescence analysis of the archaeological materials and of the geological samples have then been compared, thus identifying the geological formations where the lithic raw materials exploited at the Ciota Ciara cave were collected.

3. Results

For the Ciota Ciara cave, the identification of the supply areas of lithic raw materials represents a very important step in the definition of the economic behaviour and of the land mobility of the human groups frequenting the site during Middle Palaeolithic. The results achieved become even more significant considering that, as mentioned before, the Ciota Ciara cave is the only Palaeolithic site in Piedmont object of systematic and multidisciplinary researches.

3.1. Raw materials – general overview

The analysis completed on the lithic assemblage of the Ciota Ciara cave led to the identification of several lithic raw materials, attested in different proportion in each archaeological layer (Tab. 1). In S.U. 13 vein quartz represents the 86,3% of the lithic assemblage and we observe a general scarce diversity among the types of stone involved in lithic production: spongolite and flint are attested in similar proportion (6,5% and 5,8% respectively), rhyolite and radiolarite represent 0,1% and 0,9% of the lithic assemblage while a 0,3% of the lithic finds consist in hyalite, milonite and jasper products. In level 14 we observe an increase both in the number and in the variety of the raw materials. The importance of vein quartz decreases (78,3%) and grows the exploitation of other local and non-local resources (spongolite – 12,5%, flint – 5,3%, rhyolite 1,3%, radiolarite – 1,7%, other local raw materials - 1,0%). A further increase in the exploitation of spongolite is attested in level 15 where it represents 43,5% of the lithic assemblage while vein quartz is 51,5%. Flint decreases to 1,5% while all the other raw materials are present in proportion comparable to those of level 14: rhyolite – 1,1%, radiolarite – 1,3% and other local stones – 1,0%. Archaeological level 103 still show the predominance of vein quartz (54,2%) on the other lithic raw materials (spongolite – 31,7%, flint – 13,4%, rhyolite – 0,2%, other local raw materials – 0,5%).

3.2. Vein quartz primary outcrops

Concerning vein quartz, the first analysis conducted were aimed to a precise characterization of this rock, identifying all the elements useful to demonstrate the consistency between the lithic artefacts found in the site and vein quartz present in the primary outcrops and in the secondary deposits located at the base of the mount. The observation at the stereomicroscope in reflected light allowed to identify different elements useful for the comparison between archaeological vein quartz artefacts and the samples collected during survey activities. The presence, on some archaeological finds, of minerals identifiable, according to their colour and morphology, as chlorite and actinolite, indicates the formation of vein quartz in an environment characterized by a low metamorphic degree (Haldar and Tišljar, 2014). Other important elements for the definition of vein quartz sources is the presence of micas. Biotite and muscovite are visible on the neocortical surfaces of the archaeological vein quartz artefacts, confirming that they have been obtained through the exploitation of vein quartz formed in metamorphic rocks and in an environment with low metamorphic degree, linked to geologic faults (Haldar and Tišljar, 2014).

The same minerals and micas have been found on the surface of the vein quartz samples collected in different localities at the base of Monte Fenera, in correspondence of veins formed inside the igneous rocks of the Permian Volcanic Complex and in the hercynian metamorphic rocks, thus confirming the local origin of this raw material.

3.3. Vein quartz secondary deposits

Starting from similar works concerning flint assemblages (e.g. Fernandes et al., 2006; Fernandes and Raynal, 2010), the present work represents a first attempt to verify if the methodology elaborated for flint is adaptable and efficient also for vein quartz, given some methodological changes due to the different character of the raw material involved (Venditti et al., 2016).

3.3.1. Geological samples

145 samples were collected in different kind of secondary deposits. The analysis of their neocortical surfaces shows some differences between Pleistocene alluvial deposits (62 samples) and current alluvial deposits (78 samples); the latter are further divided in fluvial deposits (17 samples), creek deposits (13 samples) and stream deposits (48 samples).

The macrocrystalline and microcrystalline varieties of vein quartz seem to be equally represented in the different secondary deposits surveyed, making this parameter not particularly explanatory (Tab. 2). Micas are generally present in the samples collected and just concerning those from current alluvial deposits they are less represented, probably because of the intense transport and erosion (Tab. 2). The general morphology of the samples slightly varies depending on their provenience: an irregular morphology is prevailing in the current creek and stream alluvial deposits, while roundish and polygonal morphologies are most common in current fluvial deposits and in Pleistocene fluvial deposits (Tab. 2). The neocortex morphology is another varying parameter among the different kind of secondary deposits identified: due to the low intensity of transport, neocortical surfaces are absent or irregular in current alluvial creek and streams deposits; in current or Pleistocene alluvial deposits the neocortex surface is rounded or angular (Tab. 2). The neocortex appearance is an indicative parameter: current stream alluvial deposits differs from all the other secondary deposits considered with neocortical surfaces usually absent or irregular; samples collected in current creek alluvial deposits have smooth or irregular neocortical surfaces; for current fluvial and Pleistocene alluvial deposits smooth neocortical surfaces are clearly prevailing (Tab. 2). A not distinctive parameter is the neocortex colouring, while the polish degree varies significantly depending on the kind of secondary deposit (Tab. 2).

At a microscopic observation (Fig. 8), diagnostic traces are not frequent and quite difficult to interpret. Anyway, they can be useful for the identification of the secondary deposits since some traces are more or exclusively present on samples collected in certain kind of secondary deposit.

The results obtained allow to outline the main characteristics of vein quartz surfaces for each typology of secondary deposit surveyed:

- vein quartz samples from current river deposits (i.e. Sesia river) mainly have neocortical surfaces with a rounded or angular morphology, to a lesser extent it is irregular; neocortical surfaces are smooth, rarely irregular or rough; the neocortex has a high or medium polish degree; at a microscopic observation are present scratches, impact traces, linear traces on the rounded sections of the surface. 50% of the samples analysed present a yellowish surface alteration and rarely micas are preserved on neocortical surfaces (Tab. 2);
- vein quartz samples from current creek deposits (i.e. Strona creek), when neocortical surfaces are present, they often have a smooth appearance and a low polish degree; at a microscopic observation we observed the presence of incipient fractures; 50% of the samples analysed present a yellowish surface alteration and rarely micas are preserved on neocortical surfaces (Tab. 2);
- vein quartz samples from current streams deposits (i.e. Monte Fenera's streams), when neocortical surfaces are present, have always an irregular morphology and a low polish degree; at a microscopic observation impact traces and incipient fractures are visible; 50% of the samples analysed present a yellowish surface alteration and rarely micas are preserved on neocortical surfaces (Tab. 2);
- vein quartz samples from Pleistocene alluvial deposits (i.e. fluvial terraces) have neocortical surfaces with a morphology mainly angular and, to a lesser extent, rounded or irregular; the

appearance is almost always smooth, rarely irregular or rough; the polish degree is mainly medium; at a microscopic observation have been identified striations, scratches, impact traces, incipient fractures, lines on the rounded section of the surface; 50% of the samples analysed present a yellowish surface alteration and rarely micas are preserved on neocortical surfaces (Tab. 2).

3.3.2. Vein quartz lithic assemblage

After a general screening of the entire vein quartz assemblage of the Ciota Ciara cave, just the coordinate lithic artefacts, i.e. those with a length of at least 2 cm, have been considered suitable for the proposed study. Among them, those presenting neocortical surfaces have been selected, for a total of 247 lithic artefacts: 45 from S.U. 13, 150 from S.U. 14, 10 from S.U. 103 and 42 from S.U. 15. Also, four non-coordinate flakes from level 14 presenting a rather wide neocortical surface have been considered in this study. The proposed research involved then a total of 251 vein quartz artefacts. During the analysis, also the knapping surfaces have been observed at the stereomicroscope as to distinguish between alterations due to post-depositional processes and pre-depositional alterations linked to the evolutionary chain of the raw material (Fernandes et al., 2007; Fernandes and Raynal, 2010, 2006). Just the lithic artefacts from S.U. 15 have a certain degree of post-depositional alterations, mainly fluitation, visible in smoothed surfaces and rounded edges. These traces are clearly identifiable and distinguishable from pre-depositional traces.

The characteristics of the neocortical surfaces observed on vein quartz lithic artefacts (Fig. 9) allow to refer the collecting of the raw material to Pleistocene alluvial deposits and to current river deposits (Tab. 3). It was not always possible to clearly distinguish between these two kinds of deposits since they have similar characteristics. Anyway, they are clearly different from the other typologies of secondary deposits. Neocortical surfaces belonging to current creek deposits are barely represented just in level 13 and 14 while those belonging to current stream deposits are not represented in the sample analysed (Tab. 3). For some of the lithic artefacts analysed the belonging to one of the secondary deposits considered is uncertain especially concerning S.U. 15, strongly affected by post depositional alterations (Tab. 3).

3.4. Spongolite and other local raw materials

Beside vein quartz, the stereomicroscope observation of the artefacts found in the archaeological layers of the Ciota Ciara cave allowed to distinguish different rocks: spongolite, grey/black flint, opal, jasper and milonite. To make reliable hypothesis on the economic behaviour of the human groups that inhabited the cave during Middle Palaeolithic, it was clear that also the supply areas of these lithic raw materials had to be defined. Due to its importance in the archaeological record (Tab. 1), the fieldwork protocol elaborated was mainly aimed to the identification of spongolite primary and secondary deposits. According to the geological data available, spongolite outcrops at the top of the mount, over the belt of carbonate rocks where the caves develop (Fig. 4) (Fantoni and Fantoni, 1991; Fantoni et al., 2005b; Reghellin, 2004). The samples collected on the field and the archaeological materials have been compared through further stereomicroscope observations and, when necessary through SEM analysis. As the technological analysis underlined that most of the raw materials used to produce tools was collected in secondary deposits, this kind of sources has primarily been considered for the reconstruction of Middle Palaeolithic mobility. The results obtained led to the identification of chert-like rocks on Monte Fenera in an area located between 720 and 899 m a.s.l., with vertical variations in the lithological characteristics indicating variations in the Carbonate Compensation Depth (CCD) during sedimentation. The rocks identified during fieldworks and attested in the archaeological record are:

- spongolite, a sedimentary siliceous rock mainly composed by fossil remains of siliceous sponges (spicules). It forms in open sea environments through slow accumulation of sediments rich in spicules on the seabed. It is fine-grained and characterized by a homogeneous texture and high hardness with conchoidal fracture (D’Argenio et al., 2005).

In the archaeological record of the Ciota Ciara cave two kind of spongolite have been distinguished at the stereomicroscope and are characterized by a more or less pronounced porosity respectively (Fig.10). Primary spongolite outcrops are located on Monte Fenera between 816 and 841 m a.s.l. In this area, are visible stratified spongolitic limestones with a considerable siliceous component; black and marly spongolitic limestones, with a lesser siliceous component, outcrop between a whetstone quarry and the top of the mount (899 m a.s.l.). The same rocks have been found in secondary deposits not far from the Ciota Ciara cave and it seems likely that the collecting of spongolite slabs and blocks took place in similar contexts;

- grey/black flint, a better-quality variety of chert, barely present in levels 13 and 103 but more abundant in the other stratigraphic units (Tab. 1), has been localized on Monte Fenera at about 720 m a.s.l., close to a whetstone quarry: it appears in the form of well-defined cryptocrystalline grey nodules with optimal conchoidal fracture, but its distribution area is limited (Fig.11).

Other rocks, barely attested in the considered lithic assemblage have been identified during survey activities:

- hyalite, a variety of opal usually present in the form of patina or encrustations (Gottlicher et al., 1998). 21 lithic tools of the Ciota Ciara cave have been realized on a white and opaque raw material that at the microscopic analysis show an amorphous texture (Fig. 11) and which characteristics are consistent with those of the whitish crust present on a marly spongolite slab collected in a secondary deposit at 873 m a.s.l.;
- jasper, a rock resulting from the combination between calcedony and clayey sediments or residual clays (D'Argenio et al., 2005). It is present only in the lithic assemblage of level 14. A primary outcrop was found at the base of the mount in a former quartz quarry, at an altitude of 406 m a.s.l. (Fig.11).
- milonite, a metamorphic rock compact and resistant. It is usually found in long and narrow belts along a fault at low temperature, consistent with the lithologies present in the Monte Fenera area (D'Argenio et al., 2005; Fantoni et al., 2005b). In the same areas where spongolite secondary deposits were identified, some milonite blocks were found and the microscopic analysis confirmed that the samples collected are consistent with the pieces present in the lithic assemblage (Fig.11).

3.5. Allochthonous raw materials

Some of the raw materials identified in the archaeological levels of the Ciota Ciara cave are present in the assemblage mainly as finished tools or as small flakes with technological characteristics suggesting their belonging to the modification and rejuvenation of tool's edges (Daffara, 2017). For these raw materials, characterized by a homogeneous texture and by a good conchoidal fracture, an allochthonous origin has been hypothesise, both for their technological role in the lithic assemblage (Moncel, 2007) and for their petrographic characteristics. A first macroscopic observation led to the distinction between two different rocks of volcanic and sedimentary origin respectively. This preliminary subdivision has then been confirmed by microscopic observations.

3.5.1. Rhyolite

At a macroscopic observation, the lithic artefacts belonging to this group seem to have been realized on a fine-grained volcanic rock with a light-red colouring and conchoidal fracture, providing a very good control of the results of knapping activities and the production of tools with sharp edges. This rock is present in different proportion in all the archaeological layers of the Ciota Ciara cave (Tab. 1) and it is represented by retouched tools, flakes, debris, small flakes referable to the modification or rejuvenation of tools' edges and, to a lower extent, by cores (3). A total of 73 artefacts has been observed at different magnification at a stereomicroscope in reflected light (Fig. 12). The analysis highlights the presence of several millimeter-sized quartz and feldspar phenocryst dispersed in an aphanitic reddish matrix, thus confirming the volcanic origin of this rock and allowing to refer it to a variety of rhyolite.

According to the geological data available, the petrographic characteristics observed on the lithic artefacts of the Ciota Ciara cave, are consistent with the rhyolites described by Quick et al. (2003) which primary outcrops are located on the opposite bank of the Sesia river, at a distance of about 2 km in a straight line from the Ciota Ciara cave (Fig. 12). Since the characteristics of the smooth natural surfaces present on the rhyolite lithic artefacts of the Ciota Ciara cave show alterations consistent with a fluvial transport, i.e. fluvial neocortex, it is likely that rhyolite blanks for knapping activities were collected in secondary deposits. For this reason, survey activities have been carried out along the Sessera river and in correspondence of its confluence with the Sesia river (Fig. 12). During survey activities were collected rhyolite pebbles that at a macroscopic observation had characteristics consistent with those of the archaeological artefacts in terms of texture and colour. Their observation at the stereomicroscope in reflected light showed the presence of quartz phenocrysts in an aphanitic matrix (Fig. 12). From a petrographic point of view the samples are comparable to the rhyolite knapped at the Ciota Ciara cave. To further confirm the provenience of rhyolite from the outcrops located close to the Sessera river, a µ-XRF analysis has been carried out on a selected sample of five archaeological finds and on three of the geologic samples collected. The spectra presented in Fig. 12 show that the consistency between the rhyolite artefacts present in the lithic assemblage of the Ciota Ciara cave and the geologic samples, already highlighted by the petrographic observations, is confirmed by the geochemical analysis. The results obtained show that the rhyolite exploited at the Ciota Ciara cave during Middle Palaeolithic is of sub-local origin, it was collected in secondary deposits located at a distance of about 2 km from the site, probably during movements linked to other subsistence activities, and the production of tools took place mainly outside the cave, even if the presence of one core in S.U. 14 and of two cores in S.U. 15 suggest that occasionally rhyolite was knapped at the site.

3.5.2. Radiolarite

Tools and retouch flakes realized on a very good quality raw material, characterized by a red/dark-red colouring, are present in all the archaeological layers of the Ciota Ciara cave in different proportions (Tab. 1). 97 lithic artefacts have been observed at the stereomicroscope in reflected light at different magnifications (Fig. 13). The analysis highlights the presence, in all the considered artefacts, of transversal sections of radiolarians, which skeletal seem to have been substituted by calcedony. The matrix is generally red, homogeneous and do not present fissures or impurities, thus confirming the good quality of this raw material. According to the results obtained, the 97 artefacts have been identified as lithic tools made in radiolarite. The subsequent study of the geological maps revealed that the petrographic characteristics of the radiolarite present at the Ciota Ciara cave are consistent with those of the Lombardian Radiolarite Group, a Middle Jurassic formation which represent also the radiolarite outcrops nearest to the archaeological site (~25-30 Km in a straight line). (Sciunnach, 2007a). Radiolarites and siliceous limestones of the Lombardian basin consist of polychrome and well stratified flints, with intercalations of siliceous argillites, substituted in the upper part of the formation by red flint with radiolarians that can be found in layers or nodules within rose-coloured marly limestones or marls (Sciunnach, 2007a). From the bottom to the top, the Group is divided in two formations: Radiolarites of the Lombardian Radiolarite Group and Rosso ad Aptici (Sciunnach, 2007a). Its lateral boundaries are clear both eastward, in correspondence of the tectonic lineament of Valli Giudicatarie, and westward, in correspondence of the Lombard bank of the Maggiore Lake (Sciunnach, 2007a). Within the Radiolarites of the Lombardian Radiolarite Group, there are two facies (Sciunnach, 2007b): the lower ribbon facies, formed by polychrome radiolarite slabs, and the upper knobby facies, formed by radiolarite nodules mainly dark-red coloured (Sciunnach, 2007b). Considering that, usually, during Middle Palaeolithic, is unlikely to hypothesize a distance of more than a few tens of kilometres from the site for the collecting of lithic raw materials (e.g. Moncel, 2007), the nearest

area where radiolarite outcrops are indicated on the geological maps have been primarily object of survey activities. The selected area corresponds to a small mount located in Sangiano municipality, in western Lombardy (Fig. 13), ~30 km in a straight line from the Ciota Ciara cave and close to the eastern bank of the Maggiore lake. In this area, at an altitude between 397 and 420 m a.s.l., three samples, from the primary outcrop and from secondary deposits located near the outcrops, were collected and observed at the stereomicroscope in reflected light. The raw materials collected in the Sangiano area show petrographic characteristics like those of the archaeological materials previously analysed, with abundant radiolarians in a homogeneous reddish matrix (Fig. 13).
To verify the provenience of the radiolarites exploited at the Ciota Ciara cave from the formations belonging to the Lombardian Radiolarite Group, a μ-XRF analysis has been performed on a selected sample of four archaeological materials and on three geologic samples from Sangiano. The spectra presented in Fig. 13 show that the consistency between the radiolarite artefacts of the Ciota Ciara cave and the geologic samples collected is confirmed by the geochemical analysis. The results obtained clearly show that the radiolarite present at the Ciota Ciara cave was collected from outcrops and secondary deposits belonging to the Lombardian Radiolarite groups, that today are located at about 25-30 km from the site. The exploitation of this raw material took place in proximity of the outcrops or in places located along the path connecting the Ciota Ciara cave and other sites, still unknown and probably frequented during the year in the context of seasonal movements (Kuhn, 1994, 1992).

4. Discussion

For the Ciota Ciara cave, the identification of the supply areas of lithic raw materials (Fig. 14) represents a very important step in the definition of the economic behaviour and of the land mobility of the human groups frequenting the site during Middle Palaeolithic. The results achieved are also very important on a regional and sub-regional scale since no similar studies have been completed concerning coeval sites in north-western Italy.
As observed in several other European Middle Palaeolithic sites, in the considered lithic assemblage the use of local lithic resources is clearly dominant while allochthonous raw materials are attested in variable proportions in the different archaeological layers (Tab. 1) (Féblot-Augustins, 1997; Geneste, 1988; Roy Sunyer et al., 2017; Turq et al., 2017, 2013; Wilson et al., 2018). Despite the abundance of local raw materials in Middle Palaeolithic sites, their characterization and sourcing are rarely completed even if the identification of the places where they were collected could be very informative about human behaviour (Roy Sunyer et al., 2017). If the provenience of allochthonous raw materials gives information about regional movements, the precise location of supply areas of local lithic resources allow to make hypothesis about brief-scale movements linked to the phases of site frequentation and therefore more informative than allochthonous raw materials about human behaviour (Roy Sunyer et al., 2017).
At the Ciota Ciara cave most of the local raw materials (spongolite, grey/black flint, hyalite, jasper, milonite) were available in secondary deposits and primary outcrops located few hundred meters far from the site. Despite this, the most exploited raw material is vein quartz, which primary outcrops and secondary deposits are located at the base of Monte Fenera, at a distance of about 700 m in a straight line from the site. The choice of vein quartz can be linked to an easier access and a greater availability of this lithic resource or to a deliberate choice of the hunter-gatherers: grey/black flint, jasper and hyalite outcrops are rare while the results of knapping activities on spongolite are difficult to be managed (Marta Arzarello et al., 2012; Daffara et al., 2014). The prevalence of vein quartz can then be interpreted as a deliberate choice and its collecting could be correlated to brief movements linked to hunting or other subsistence activities during the periods of site frequentation.
Each of the considered archaeological layers show differences in the proportion of the different lithic raw materials (Tab. 1). Beside that, it is just in level 14 that a certain variety of lithic raw materials is exploited, attesting a growing importance of the lithic resources located in the vicinity of the site. The lithic assemblage of this level is the most abundant of the sequence and according to

technological, paleontological, archaeozoological and use-wear analysis, S.U. 14 corresponds to the phases of most intense frequentation of the cave (Arzarello et al., 2012; Berruti, 2017; Buccheri et al., 2016; Cavicchi, 2018; Daffara, 2017). The number of herbivorous remains, result of hunting activities, significantly increases in level 14 as well as the variety of activities identified through functional studies. In this level use-wear traces linked to long-lasting activities like skin processing have been observed, leading to the hypothesis that during the deposition of S.U. 14 the Ciota Ciara cave was inhabited more intensively and for longer periods (Berruti, 2017). According to the same studies, level 13 and 15 correspond to brief frequentations of the site, probably used as hunting camp. In these levels the technological analysis reveals a scarce technological variability (Daffara, 2017) and in level 13 a very limited variety of lithic resources is exploited (Tab. 1). Within the archaeological sequence of the Ciota Ciara cave, in level 15 spongolite significantly grows in importance: this change could be interpreted considering that during the deposition of level 15 we have important climatic changes (Angelucci et al., 2018) that could have had an impact on the availability of other local lithic resources, even concerning vein quartz.

The presence of allochthonous good-quality raw materials, represented at the Ciota Ciara cave by rhyolite and radiolarite, is another frequent characteristic of European Middle Palaeolithic sites: as well as in the considered lithic assemblage, they are present usually as finished tools with a high degree of edge rejuvenation (Bourguignon et al., 2004; Féblot-Augustins, 1999; Geneste, 1988; Jaubert and Delagnes, 2007; Kuhn, 1992; Meignen et al., 2009; Roy Sunyer et al., 2017; Turq et al., 2013; Wilson et al., 2018). According to the technological data (Daffara, 2017), the roles of rhyolite and radiolarite in the lithic assemblage of the Ciota Ciara cave is constant all along the sequence, testifying that the economic behaviour of these human groups did not undergo significant changes. Differences in the proportion of these raw materials in each archaeological layer seem to depend only on the intensity of the human frequentation of the site, probably linked to changing in the climatic and environmental conditions (Marta Arzarello et al., 2012; Berruti, 2017; Berto et al., 2016; Buccheri et al., 2016).

In all the archaeological layers, they were introduced as finished tools which edges have been rejuvenated several times before being discarded (Daffara, 2017). According to Kuhn (1992), they can be interpreted as part of "personal toolkits", versatile tools that could respond to any needs along the itinerary covered by the Middle Palaeolithic hunter-gatherers. They represent the capacity of predicting needs on a brief time-scale while the absence of evidence attesting the transport of cores or of unworked blanks in the Ciota Ciara cave seems to exclude the possibility of a long-term planning of future needs (Kuhn, 1992).

5. Conclusions

The data obtained from the definition of the supply areas of lithic raw materials, together with those achieved through the technological study of the lithic assemblage (Daffara, 2017; Daffara et al., 2014) indicate an articulated economic behaviour that includes a great knowledge of the natural resources available, both in the immediate surroundings of the site and on a sub-regional scale. The study about the identification of vein quartz secondary outcrops show that the concept of evolutionary chain (Fernandes et al., 2007; Fernandes and Raynal, 2010) is efficient also for vein quartz: some adaptations are needed due to the different characteristics of the raw material but the study of the mechanical alterations present on the natural surfaces of vein quartz artefacts led to a more precise understanding of the local mobility of the Middle Palaeolithic human groups of the Ciota Ciara cave. The identification of raw materials supply areas located nearby actual Lombardy (Fig. 14), suggests that these territories have been frequented more intensely than it was thought during Middle Palaeolithic. These data, together with the results of recent researches conducted in the region (Rubat Borel et al., 2016, 2013), underline the necessity of further systematic interventions aimed at the understanding of the Middle Palaeolithic settlement dynamics in this part of north-western Italy.

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Caption to Figures

Fig.1. Location of the Ciota Ciara cave. A: west side of Monte Fenera with position of the Ciota Ciara cave; B: interior of the cave.

Fig. 2. Ciota Ciara cave planimetry and section showing the areas investigated during the 50s and the 60s and detail of the present archaeological excavation (modified from Fedele, 1966).

Fig. 3. Stratigraphic sequence of the Ciota Ciara cave (Angelucci et al., 2018).

Fig. 4. Geological setting of Monte Fenera. Geological map of the Cusio-Biellese area (top) (Beltrando et al., 2015); geological map of the Monte Fenera area (bottom) (Dal Piaz, 1992): Base of *Serie dei laghi*: Gn=rose coloured orto-gneiss associated to para-gneiss; Permian vulcanite: V_1=aphyric quartz-bearing latitite and riodacitic grey-greenish lavas; V_2=reddish-brown felsic ryolithic alkaline lavas; V_3=yellowish ignimbrite; V_4=reddish ryolithic ignimbrite with flame-like structures and tuff; La=veins of lamprophyre; π=veins of granitic porphyry; q=hydrothermal quartz veins; sedimentary cover: T_1=limestone-marl, calcarenite and sandstone (Lower Trias); T_2=dolostone and dolomitic limestone (Middle-Upper Trias); L_1=calcirudite, crinoid calcarenite and red sandstones (Middle Lias); L_2=grey and black flinty limestone (Middle Lias); P_1 and P_2=Pliocene; Q=quaternary covers.

Fig. 5. Monte Fenera. Geologic sections: a’’’=Pleistocene alluvial deposits; a’’=ancient alluvial deposits; a’=recent and present alluvial deposits (from Fantoni, 1991).

Fig. 6. Typologies of secondary deposit considered. A: current alluvial river deposits (Sesia river); B: current alluvial creek deposits (Strona creek); C: current alluvial stream deposits (Monte Fenera’s streams); D: Pleistocene alluvial deposits (fluvial terraces linked to the Sesia River).

Fig. 7. Vein quartz artefacts. A, B: microcrystalline quartz with chlorite and actinolite; C, D: macrocrystalline quartz with micas (muscovite and biotite).

Fig. 8. Vein quartz neocortical surfaces (geologic samples). A, B: glacial strie; C: example of medium polished neocortical surface; D: incipient fractures; E: impact point; F: linear traces on the rounded portion of the neocortical surface.

Fig. 9. Vein quartz neocortical surfaces (vein quartz artefacts from the Ciota Ciara cave). A: medium polished neocortical surface; B: glacial strie; C: incipient fractures; D, E: impact points; F: linear traces on the rounded portion of the surface.

Fig. 10. Spongolite. A: primary outcrop of spongolitic limestone on Monte Fenera; B: porous spongolite collected on Monte Fenera; C: porous spongolite lithic artefact from the Ciota Ciara cave; D: less porous spongolite. In all the pictures, spicules are well visible.

Fig. 11. Other local raw materials present in secondary deposits and primary outcrops on Monte Fenera. A, B: grey flint primary outcrop; C: surface of a grey flint flake; D: amorphous structure of a hyalite flake; E: hyalite found in secondary position (encrustation on a spongolite slab); F: SEM image of a hyalite flake; G: surface of a milonite flake; H, I: different magnification of a milonite

sample; L: vein quartz and jasper secondary deposit at the base of Monte Fenera; M, N: different magnification of a jasper sample.

Fig. 12. Rhyolite characterization and supply areas. 1: geologic map of the left orographic side of the lower Sesia valley and surrounding territories. The red star indicates the location of Monte Fenera while the green dot the location of the area surveyed; 2: detail of the surveyed area, Monte Fenera is visible in the background; 3: rhyolite artefacts from S.U. 14 (A, B) and 15 (C, D). In all the pictures are visible millimetre-size quartz and feldspar phenocrysts; 4: rhyolite samples collected along the Sessera river. In the aphyric matrix are well visible quartz and feldspar phenocrysts; 5: μ-XRF spectra of a rhyolite sample from the Sessera river (top) and of two rhyolite tools.

Fig. 13. Radiolarite characterization and supply areas. 1: location of Monte Fenera (red star) and of the surveyed area (yellow dot); 2: Detail of the surveyed area in Sangiano municipality, VA (A), outcrop of the Lomabardian Radiolarite Group (B) and detail of a radiolarite nodule (C); 3: radiolarite artefacts from S.U. 14 (A, B) and S.U. 15 (C, D). In all the pictures are visible transversal sections of radiolarians and the homogeneous texture that characterize this sedimentary biogenic rock; 4: samples collected in Sangiano, VA. In both pictures are visible the homogeneous reddish matrix and the radiolarians skeletal; 5: μ-XRF spectra of a radiolarite sample from Sangiano, VA (top) and of two radiolarite tools.

Fig. 14. Map showing the location of the areas prospected and of the primary outcrops and secondary deposits of lithic raw materials identified. Red letters indicate the main geologic formations in the area: π = porphyries; γ = granites; gml = micaschists; mo = morainic deposits; q = pre-Würm glaciation floods; a = recent floods; C = Cretaceous formations (marls and limestones); g = Jurassic formations (limestones).

Tables

S.U.		*Vein quartz*	*Spongolite*	*Grey/black flint*	*Rhyolite*	*Radiolarite*	*Others*	*Total*
13	*Opp./SSDA*	395 - 44,4%	10 - 1,1%	25 - 2,8%	-	1	-	431 - 48,5%
	Levallois	11 - 1,2%	1 - 0,1%	-	-	-	-	12 - 1,3%
	Discoid	36 - 4,0%	9 - 1,0%	-	-	-	-	45 - 5,1%
	Komb. s.l..	4 - 0,4%	-	-	-	-	1	5 - 0,6%
	Indet.	28 - 3,1%	4 - 0,4%	-	1	1	-	34 - 3,8%
	Retouch fl.	17 - 1,9%	13 - 1,5%	4 - 0,4%	-	3	-	38 - 4,3%
	Debris	276 - 31,0%	21 - 2,4%	23 - 2,6%	-	3	2	324 - 36,4%
	Total	**767 - 86,3%**	**58 - 6,5%**	**52 - 5,8%**	**1 - 0,1%**	**8 - 0,9%**	**3 - 0,3%**	**889 – 100%**
14	*Opp./SSDA*	1508 - 37,9%	156 - 3,9%	73 - 1,8%	24 - 0,6%	7 - 0,2%	12 - 0,3%	1780 - 44,7%
	Levallois	142 - 3,6%	12 - 0,3%	8 - 0,2%	1 - 0,03%	14 - 0,4%	3 - 0,1%	180 - 4,5%
	Discoid	285 - 7,2%	26 - 0,7%	10 - 0,3%	7 - 0,2%	7 - 0,2%	4 - 0,1%	339 - 8,5%
	Komb. s.l.	19 - 0,5%	4 - 0,1%	1 - 0,03%	-	-	-	24 - 0,6%
	Indet.	296 - 7,4%	59 - 1,5%	20 - 0,5%	7 - 0,2%	4 - 0,1%	3 - 0,1%	389 - 9,8%
	Retouch fl.	62 - 1,6%	49 - 1,2%	35 - 0,9%	5 - 0,1%	21 - 0,5%	9 - 0,2%	181 - 4,5%
	Debris	807 - 20,3%	191 - 4,8%	63 - 1,6%	6 - 0,2%	14 - 0,4%	9 - 0,2%	1090 - 27,4%
	Total	**3119 - 78,3%**	**497 - 12,5%**	**210 - 5,3%**	**50 - 1,3%**	**67 - 1,7%**	**40 - 1,0%**	**3983 – 100%**
15	*Opp./SSDA*	423 - 24,1%	231 - 13,1%	8 - 0,5%	6 - 0,3%	6 - 0,3%	7 - 0,4%	681 - 38,8%
	Levallois	43 - 2,4%	17 - 1,0%	4 - 0,2%	1 - 0,1%	3 - 0,2%	-	68 - 3,9%
	Discoid	69 - 3,9%	35 - 2,0%	3 - 0,2%	2 - 0,1%	2 - 0,1%	1 - 0,1%	112 - 6,4%
	Komb. s.l.	4 - 0,2%	5 - 0,3%	-	-	-	-	9 - 0,5%
	Indet.	84 - 4,8%	84 - 4,8%	3 - 0,2%	2 - 0,1%	2 - 0,1%	-	175 - 10,0%
	Retouch fl.	17 - 1,0%	94 - 5,4%	5 - 0,3%	3 - 0,2%	4 - 0,2%	4 - 0,2%	127 - 7,2%
	Debris	265 - 15,1%	299 - 17,0%	4 - 0,2%	6 - 0,3%	5 - 0,3%	6 - 0,3%	585 - 33,3%
	Total	**905 - 51,5%**	**765 - 43,5%**	**27 - 1,5%**	**20 - 1,1%**	**22 - 1,3%**	**18 - 1,0%**	**1757 – 100%**
103	*Opp./SSDA*	90 - 21,6%	40 - 9,6%	27 - 6,5%	-	-	1 - 0,2%	158 - 37,9%
	Levallois	3 - 0,7%	1 - 02%	2 - 0,5%	-	-	-	6 - 1,4%
	Discoid	15 - 3,6%	5 - 1,2%	-	-	-	-	20 - 4,8%
	Indet.	24 - 5,8%	17 - 4,1%	5 - 1,2%	-	-	-	46 - 11,0%
	Retouch fl.	16 - 3,8%	11 - 2,6%	1 - 0,2%	1 - 0,2%	-	1 - 0,2%	30 - 7,2%
	Debris	78 - 18,7%	58 - 13,9%	21 - 5,0%	-	-	-	157 - 37,6%
	Total	**226 - 54,2%**	**132 - 31,7%**	**56 - 13,4%**	**1 - 0,2%**	**-**	**2 - 0,5%**	**417 – 100%**
Tot.		***5017 - 71,2%***	***1452 - 20,6%***	***345 - 4,9%***	***72 - 1,0%***	***97 - 1,4%***	***63 - 0,9%***	***7046 – 100%***

Tab. 1. Ciota Ciara cave, composition of the lithic assemblage. S.S.D.A = *Système par surface de débitage alterné* (Forestier, 1993) ; Levallois and discoid reduction sequences have been identified according to E. Boëda (1994, 1993); Kombewa *s.l.* refers to the definition of Tixier and Turq (1999).

		River deposits	***Creek deposits***	***Stream deposits***	***Pleistocene alluvial deposits***
Vein quartz typology	Macrocrystalline quartz	9 - 52,9%	5 - 38,5%	24 - 50,0%	34 - 54,8%
	Microcrystalline quartz	8 - 47,1%	8 - 61,5%	24 - 50,0%	28 - 45,2%
Presence of micas on the surface	Micas	4 - 23,5%	9 - 69,2%	25 - 52,1%	17 - 27,4%
	No micas	13 - 76,5%	4 - 30,8%	23 - 47,9%	45 - 76,2%
General morphology of the sample	Rounded	5 - 29,4%	3 - 23,1%	3 - 6,3%	12 - 19,4%
	Polygonal	5 - 29,4%	3 - 23,1%	3 - 6,3%	10 - 16,1%
	Irregular	7 - 41,2%	7 - 53,8%	42 - 87,5%	40 - 64,5%
Morphology of the neocortical surfaces	Rounded	8 - 47,1%	1 - 7,7%	6 - 12,5%	15 - 24,2%
	Angular	7 - 41,2%	4 - 30,8%	18 - 37,5%	41 - 66,1%
	Irregular	2 - 11,8%	8 - 61,5%	24 - 50,0%	6 - 9,7%
Appearance of the neocortical surfaces	Smooth	14 - 82,4%	7 - 53,8%	-	53 - 85,5%
	Rough	1 - 5,9%	-	-	3 - 4,8%
	Irregular	2 - 11,8%	6 - 46,2%	20 - 41,7%	6 - 9,7%
	Absent	-	-	28 - 58,3%	-
Polish degree	Low	-	11 - 84,6%	48 - 100%	7 - 11,9%
	Medium	6 - 35,3%	2 - 15,4%	-	46 - 78,0%
	High	11 - 64,7%	-	-	6 - 10,2%

Tab. 2. Characteristics of the vein quartz samples collected and of their neocortical surfaces according to the typology of the secondary deposits.

	S.U. 13	***S.U. 14***	***S.U. 15***	***S.U. 103***
Fluvial deposits	5 - 11,1%	41 - 27,0%	10 - 23,8%	1 - 10,0%
Creek deposits	2 - 4,4%	2 - 1,3%	-	-
Stream deposits	-	-	-	-
Pleistocene alluvial dep.	23 - 51,1%	22 - 14,5%	10 - 23,8%	3 - 30,0%
Pleistocene/river deposits	14 - 31,1%	78 -50,0%	16 - 38,1%	6 - 60,0%
Frost weathering fracture surfaces	-	2 - 1,3%	-	-
Indeterminate	1 - 2,2%	9 - 5,9%	6 - 14,3%	-
Total	45 - 100%	154 - 100%	42 - 100%	10 - 100%

Tab. 3. Identification of the typology of secondary deposits exploited during Middle Palaeolithic according to the characteristics of the neocortical surfaces of the vein quartz lithic artefacts of the Ciota Ciara cave