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TAPHONOMIC ANALYSIS ON FOSSIL REMAINS FROM THE CIOTA CIARA CAVE (PIEDMONT, ITALY) AND NEW EVIDENCE OF CAVE BEAR AND WOLF EXPLOITATION WITH SIMPLE QUARTZ FLAKES BY NEANDERTHAL

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Abstract. The Ciota Ciara cave is located in the karst area of Monte Fenera (Borgosesia - VC) and, with the Ciotarun cave, it is the only Middle Palaeolithic site in Piedmont where the presence of *Homo neanderthalensis* has been confirmed by discoveries of human remains. Preliminary taphonomic and archaeozoological studies have been performed on a portion of the palaeontological remains from the Stratigraphic Unit 14 (1144 bones). The studies confirmed the presence of cut-marks on *Ursus spelaeus* and *Canis lupus*, made by lithic instruments. The position of the cut-marks on the bones can be related to skinning and butchery. An experimental butchery has been performed to test the efficiency of the tools made by local quartz during slaughtering activities. The archaeozoological analysis of the faunal remains of S.U. 14, identified cut-marks with weak peculiarities, probably due to the use of quartz tools. The analysis of the experimental collection allowed distinguishing between cut-marks made by quartz tools from those made by flint tools. A preliminary experimentation, conducted on more than 50 different cut-marks made with flakes of three different raw materials (vein quartz, quartzite and flint), allow us to hypothesize that it is possible to distinguish cut-marks made with unretouched flakes of different raw materials.

Introduction

The relationship between *Homo neanderthalensis* and *Ursus spelaeus* has been debated for a long time by researchers: until the first half of the XX century the abundant accumulation of cave bear bones in many sites was interpreted as a proof of Neanderthal men's activity (see d'Errico & Giacobini 1986 and citations therein). Koby (1951) recognised in natural processes the taphonomic origin of these bone accumulations in the European caves, and after Kurtén (1958) the use of the cave by bears for the mere purpose of winter hibernation was widely accepted. The general interpretation was that humans and cave bears were seasonally separated (de Lumley 1972). However, in some sites cave, bear exploitation has been effectively demonstrated: i.e., Erd (Hungary; Gabori-Csank 1968), Scladina Cave (Belgium; Abrams et al. 2014) and Nietoperzowa Cave (Poland; Wojtal 2007). In other sites, evidence of use of brown bear has been found: Biache-Saint-Vaast (France; Auguste 2002), Fate Cave (Italy; Valensi & Psathi 2004), Fumane Cave (Italy; Jéquier et al. 2012).

At the Ciota Ciara Cave (Borgosesia, Vc, Piedmont, Italy, Fig. 1) cut-marks have been found on some carnivores' bones, reopening the problem of human-carnivore interaction during the Pleistocene. During the archaeozoological analysis of 14 faunal remains from the Stratigraphic Unit 14 (S.U. 14), a number of cut-marks, showing some peculiarities, have been identified. We hypothesise that this could be related to the raw material used, i.e. vein quartz (Fernández-Jalvo & Cáceres 2010). To

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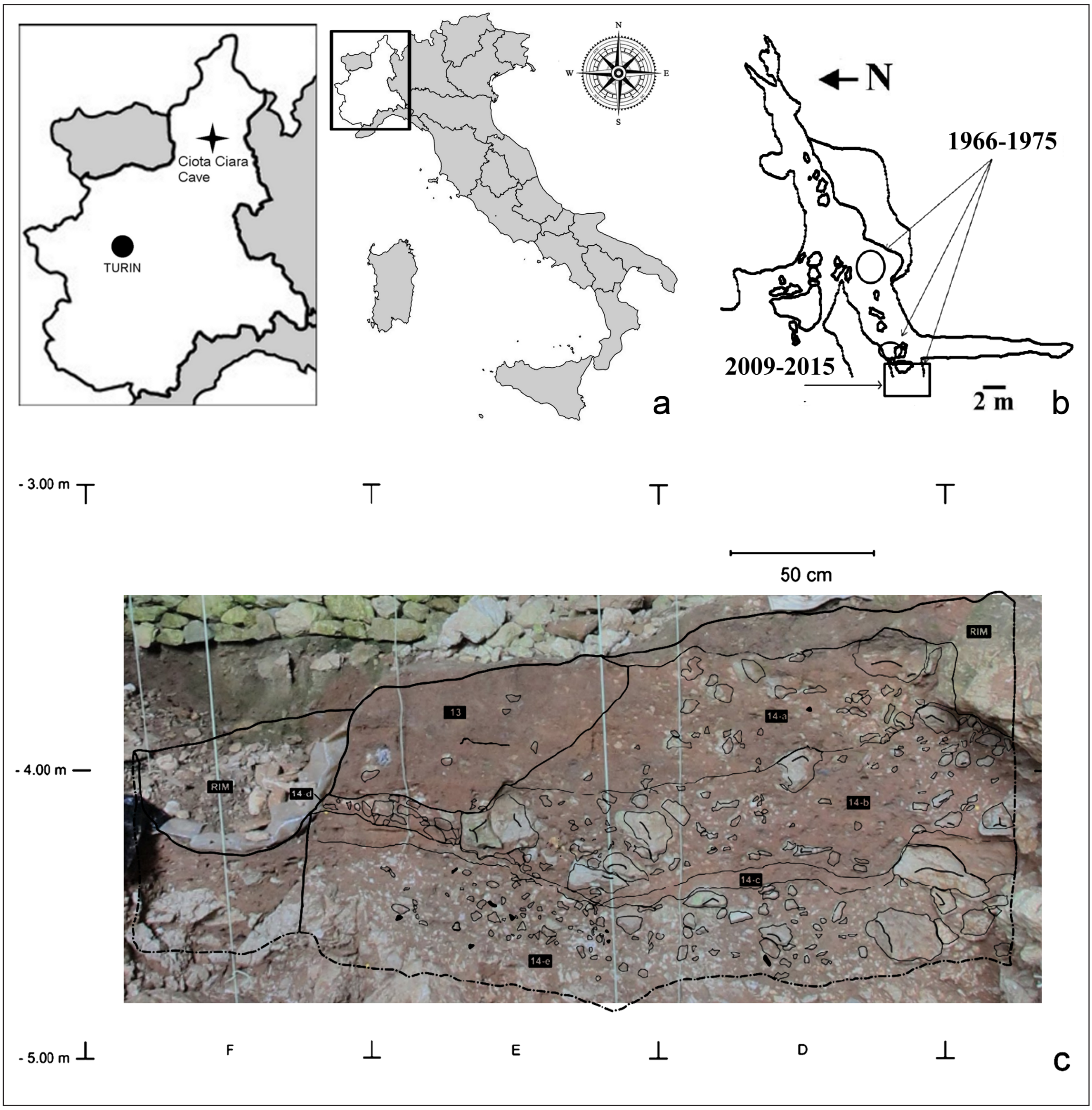

Fig. 1 - The Ciota Ciara Cave; a: location map of Monte Fenera (Piedmont, Italy) and the Ciota Ciara Cave; b: map of the excavation site; c: stratigraphy of the Nord section (modified from Angelucci et al. 2015).

confirm this hypothesis an experiment was carried out, performing butchering activities on animal carcasses using simple flakes of different raw material.

One objective of this research is the identification of possible morphological distinctions between cut-marks visible on bone surfaces produced by unretouched lithic tools made with different raw materials. This research was inspired also by the preliminary works on the differentiation of the cut-marks conducted by Fernández-Jalvo and Cáceres (Fernández-Jalvo & Cáceres 2010). The raw materials considered in this study are flint, vein quartz and quartzite. The choice of these raw materials is due to their wide use throughout the whole prehistory (e.g.: Lemorini et al. 2014; Daffara et al. 2014; Clemente & Gibaja 2009; Colonge & Mourre 2009; Lombera Hermida 2008; Brugal & Raposo 1999; Mourre 1996) and to the great differences in the edges morphology between vein quartz, quartzite, and flint tools.

	SU 103		SU 13		SU 14	
Taxon	NISP	MNI	NISP	MNI	NISP	MNI
Ursus spelaeus	33	5	232	9	989	18
Ursus arctos	15	1	24	2	17	2
Panthera leo	1	1			14	2
Panthera pardus					5	1
Lynx lynx			1	1	4	1
Canis lupus	1	1	8	1	11	2
Vulpes vulpes			2	2	3	1
Meles meles			6	1	2	1
Martes martes					1	1
Rupicapra rupicapra	3	1	9	2	26	2
Cervus elaphus			8	2	104	5
cf. *Dama*					1	1
Bos primigenius			1	1	1	1
Bos vel Bison			1	1	1	1
Stephanorhinus sp.					4	2
Sus scrofa					1	1
Marmota marmota					68	3
Erinaceus europaeus			3	1	1	1

Tab. 1 - Faunal remains in the Ciota Ciara Cave subdivided for Stratigraphic Unit. NISP: number of individual specimens; MNI: minimum number of individuals.

The site

The Ciota Ciara cave is located at 670 m a.s.l. in the karst complex of Monte Fenera (Borgosesia, Vercelli) (Fig. 1). The cave opens on the western side of the mountain. With other caves of the mount (i.e. Ciotarun cave), it represents one of the most important and complete evidence of the Palaeolithic of Piedmont. Since 2009, the University of Ferrara, in collaboration with *Soprintendenza Archeologia del Piemonte*, has carried out excavation campaigns, in the atrial area of the cave, that have led to the identification of five main S.U.s with faunal remains and lithic industries: namely 13, 14, 15, 103 and 140 S.U. (Angelucci et al. 2015) (Fig. 1c). The lithic assemblage is made of flakes, few retouched tools, cores, hammers and *débris*. Raw materials exploitation was achieved through the direct percussion technique and through various methods: S.S.D.A. (S*ystème par Surface de Débitage Alterné*, Forestier 1993), discoid and Levallois (Boëda 1988, 1993; Daffara et al. 2014). The small number of retouched tools reveals a further adaptation to the characteristics of the raw material: the retouch on quartz flakes is quite difficult and it does not permit to obtain stronger or more useful edges in comparison to the unretouched ones (Mourre 1996). Among the retouched tools, most of them are side-scrapers, lateral or convergent, followed by denticulates and notches (Daffara et al. 2014). Several raw materials are represented in different proportion: quartz is predominant, followed by spongolite, sandstone, mylonite, opal and allochthonous flint of high quality (Arzarello et al. 2012; Berruto 2011; Daffara et al. 2014). The archaeological record consists of various typologies of quartz: macro-crystalline pegmatite quartz, micro-crystalline pegmatite quartz and hyaline quartz. All these types of raw materials have been found, in secondary position in the proximity of the archaeological site, within 5 km range (Arzarello et al. 2013; Daffara et al. 2014). In the Ciota Ciara cave, 27 tools made with allochthonous red flint of unknown provenance were found (Arnaud et al. 2014). This red flint is different from the grey flint that can be found in nodules included in carbonate levels from 720 m a.s.l. to the top of Mount Fenera (Berruto 2011). Tools obtained from the local flint are not represented in the archaeological record of the Ciota Cara cave.

The faunal assemblage is dominated by *Ursus spelaeus*, occurring with many other species of mammals (Berto et al. 2016) (Tab. 1). The small mammal association from the Ciota Ciara cave (S.U. 13, 103 and 14) gives us information about the environment that surrounded the site and made it possible to establish the chronology of the site in the temperate-humid period of MIS 5 (80-70 ka) (Arnaud et al. 2014). The environment was characterized by deciduous woodland and, probably at the base of the mountain, by glades (Berto et al. 2016). The intersection between different habitats, as well as the presence of lithic raw materials and water sources, were the main factors that favoured the human occupation during the Late Pleistocene. The study of the faunal remains demonstrates a marked predominance of *U. spelaeus* in all the five stratigraphic units. The occurrence of several cubs of *U. spelaeus* suggests a recurring use of the cave as den (Berto et al. 2016).

Morphological variability of the cut-marks

Cut-marks are the result of butchering activities (Shipman & Rose 1983) and, therefore, a ubiquitous sign on the surfaces of the bones that have been processed for carcasses exploitation. The importance of cut-marks has been evident since the late 19th century (Lartet & Christy 1875) and their relation with slaughtering activities was highlighted by Martin during his studies on the French Mousterian site "la Quina" (Martin 1909, 1910), but it is only during the second half of the 20th century that specific studies on cut-marks began (Shipman 1986). Cut-marks can be identified by considering their relative location on the bone, due to the butchering activity (flesh removal, fur removal, disarticulation and evisceration) and their morphology, due to the tools involved (i.e. stone tools, bamboo tools, iron tools etc.). All butchering activities (flesh removal, fur removal, disarticulation and evisceration) leave different kind and patterns of marks on different skeletal elements and bone regions (Binford 1981; Nilssen 2000).

Concerning the morphology of the cut-marks, particular care has to be applied, since not only different tools can leave different marks, but also unretouched flakes produce morphologically different cut-marks depending on the activity (Moretti et al. 2015).

Shipman and Rose's research (Shipman & Rose 1983) allowed the clear distinction of cut-marks from all the other taphonomic alterations, but they did not distinguish the cut-marks morphology depending on the raw materials (obsidian, lava, flint, basalt and quartzite) used during the experimentation. Cut-marks made through flint flakes are well known in the archaeological contexts and are studied in detail by experimental archaeology (Walker & Long 1977; Shipman 1983; Galán & Domínguez-Rodrigo 2013), while a similar analysis on the different lithic raw materials involved in the butchering process is still lacking. Many studies focus on the identification of possible morphological distinctions of the cut-marks visible on the bones surface (e.g. Olsen & Shipman 1988; Schick & Toth 1993; Giacobini 1995; Greenfield 1999, 2006; Choi & Driwantoro 2007; West & Louys 2007; Bello & Soligo 2008; Bello et al. 2009; Domínguez-Rodrigo et al. 2009; de Juana et al. 2010; Yravedra et al. 2010). Several studies analyse the micromorphology of the cut-marks with the aim of differentiating the types of tools used to produce them; the most part focuses on the distinction between cut-marks produced with stone tools and cut-marks produced with various types of metal tools. These studies were usually carried out with optical microscopy and scanning electron microscopy (Olsen & Shipman 1988; Andrews 1990) and, more recently, through three-dimensional microscopes (Bello & Soligo 2008; Bello et al. 2011). Different studies demonstrated that there are morphological differences between cut-marks produced by metal or stone knives (Walker & Long 1977; Greenfield 1999), bamboo knives (West & Louys 2007), shell tools (Choi & Driwantoro 2007), and lithic handaxes (Bello et al. 2009; de Juana et al. 2010). These researches stated that the morphology of the edge of the tool is a factor that influences the characteristics of the cut-marks on the bone.

Species	NR	%
Ursus spelaeus	257	22.47
Ursus arctos	2	0.17
Canis lupus	7	0.61
Panthera leo	1	0.09
Lynx lynx	2	0.17
Martes martes	1	0.09
Mustelidae	1	0.09
Carnivora	1	0.09
Cervus elaphus	14	1.22
Bos primigenius	1	0.09
Rupicapra rupicapra	11	0.96
Cervidae	3	0.26
cf. *Dama*	1	0.09
Marmota marmota	40	3.50
Aves	1	0.09
Undet	801	70.02
TOTAL	1144	100.00

Tab. 2 - Faunal remains in the Ciota Ciara Cave founded from SU14 in 2013. NR: number of remains.

The most important factor that determines the edge morphology of a lithic tool is the raw material. Several use wear and technological studies show that lithic tools made with different lithic raw materials have unretouched edges with different characteristics (Lemorini et al. 2014; Daffara et al. 2014; Berruti & Arzarello 2012; Igreja 2009; Clemente & Gibaja 2009; Colonge & Mourre 2009; Lombera Hermida 2008; Mourre 1996).

Materials and methods

Archaeozoological study

The archaeozoological study of the faunal remains of the Ciota Ciara Cave, was conducted on 1144 bones from S.U. 14, corresponding to the total of the faunal remains recorded during the excavation campaign in 2013 (Tab. 2), 36% of the entire bone assemblage of the S.U. 14. This faunal sample comes from an excavation area of 8 square meters (F2, F3, F4, E3, E4, D2, D3, D4) placed in the atrium of the cave. The identifiable remains are subdivided in three groups according to the size of the mammals: large, medium and small. Mammal size groups are modified from Bunn et al. (1980) and Bunn (1986): 1) Very small size (<20 kg); 2) small size (20-100 kg); 3) medium size (100-300 kg); 4) large size (300-1000 kg); 5) very large size (> 1000 Kg). In the large size group were placed: adult *Ursus spelaeus*, *Ursus arctos*, *Panthera leo*, *Cervus elaphus*, *Stephanorinus* sp. and *Bos primigenius*. In the medium size group were placed: young *Ursus spelaeus*, *Canis lupus*, *Lynx lynx*, *Vulpes vulpes*, *Sus scrofa*, adult *Rupicapra rupicapra* and cf. *Dama*. In the small size group were placed: *Martes martes,* young *Rupicapra rupicapra,* and *Marmota marmota*.

On the sample were calculated the Minimum Number of Elements (MNE), or the minimum number of skeletal portion necessary to account for observed specimens, and the Minimal Animal Unit (MAU), obtained dividing MNE by the number of times the element occurs in a complete skeleton of the same animal.

The archaeozoological analysis of the archaeological sample was conducted in accordance with the literature (e.g. López-González et al. 2006; Marín-Arroyo et al. 2014; Cáceres et al. 2012; Fernández-Jalvo & Andrews 2003). The faunal remains of the Ciota Ciara cave are characterized by a frequent presence of post depositional alterations (Buccheri 2014; Angelucci et al. 2015), like trample marks, cracks, hydric abrasion, carnivores intervention, limestone concretions, deposition of manganese oxide and roots alterations. The identification of trampling marks is based on microscopic criteria described in Domínguez-Rodrigo et al. (2009). The deposition of manganese oxide is visible on the 99% of the remains, with different degrees of intensity and coverage. For this reason, the study of the deposition of manganese oxide was conducted according to López-González et al. (2006). The archaeozoological analysis of the faunal remains was carried out using four different stereomicroscopes: Carl Zeiss (10x / 20), Leica MZ8, Leica EZ4D, and Leica S6D with camera; one digital microscope, a Dinolight Am413T, and a Scanning Electron microscope SEM ZEISS EVO MA15-HR equipped by software OXFORD SmartMap EDS INCA Energy 250 X-Act for EDS chemical microanalysis (working set up: electron source LaB6 cathode, accelerating voltage 20 kV, variable pressure).

Experimental protocol

An experimental protocol was developed to verify the nature of the cut-marks. The experimental protocol has to be calibrated using the same raw materials and the same tools identified in the archaeological contexts (Moretti et al. 2015). The experimental protocol performed is devised to standardise all the operations and to minimize the variables of the process. The experimental butchery of a wild boar and of an adult rabbit was performed by two expert experimenters using tools made with three different raw materials: flint, vein quartz and quartzite.

The choice of vein quartz and flint was made in accordance with the raw materials used in the Ciota Ciara cave, and the choice of quartzite was made to provide a control parameter in the experiment. Vein quartz was collected in two different areas and in two different forms: pebbles and prismatic blocks. The first set of pebbles was collected in the creek that flows at the base of Monte Fenera (Vercelli, Piedmont), less than 5 km from the Ciota Ciara cave, from the same area whence, according to the studies conducted, came quartz pebbles used by the Neanderthals (Arzarello et al. 2012; Berruto 2011; Daffara et al. 2014). The second set of fine-grained quartzite pebbles was collected in the fluvial terrace of the Tejo river in Portugal.

The flint pebbles come from the Gargano promontory in the south of Italy. The use of this excellent raw material is documented in several Palaeolithic sites (e.g. the Paglicci cave and Pirro Nord; Arzarello et al. 2007; Palma di Cesnola 2006). This raw material was chosen for the granulometric similarity with the allochthonous flint (of unknown provenance) found in the Ciota Ciara cave.

The prismatic blocks were collected in the Sessera Valley where were found some flakes made in local vein quartz that testify to a prehistoric frequentation of this area (Berruti et al. 2016).

All the tools used during the experiment are unretouched flakes obtained through the S.S.D.A. method because it was the most employed in the Ciota Ciara cave and because there are just a few retouched tools (Angelucci et al. 2015; Arzarello et al. 2012; Daffara et al. 2014). In the experiment, lithic tools have been used on different anatomical portions of the carcasses in order to avoid interpretative errors (e.g. flint on right hind limb, quartzite on left hind limb, quartz on forelimb). Every action with every tool was marked to reconstruct the relation between the cut-marks and the type of lithic tool.

The wild boar carcass underwent a complete butchering process, whereas the rabbit carcass was already skinned, so the only action undertaken during the experimentation was the flesh removal.

After the experimental butchery, the bones were boiled until complete removal of the remaining periosteum and flesh. After this procedure, the bones were placed in a bath of alcohol (50%) and distilled water (50%) for 48 hours, and then washed with distilled water in an ultrasonic cleaner for 3 minutes. Microscopic analysis of the bones was conducted. The considered criteria, modified from Dominguez-Rodrigo et al. 2009, for the description of the cut-marks are: slope of the edge, bottom section of the groove, internal streaking, type of trait, morphology of the terminations, shoulder effect and presence of herzian cones.

The slope of the edge could be abrupt, half-abrupt or variable; the bottom section of the groove could be V shaped or U shaped; the internal streaking could be thin or wide; the trait could be simple, multiple or variable; the morphology of the termination could be Y-shaped or simple; the shoulder effect could be present or absent; the herzian cones could be present or absent.

Results

The experimental activities, conducted by two different operators, allowed to produce 56 different cut-marks on 20 different bones: 12 rabbit bones and 8 wild boar bones. The analysis was carried out considering various features to describe and to recognize the cut-marks. The slope of the edge is abrupt in flint cut-marks, half-abrupt in those by quartz and variable in those by quartzite. The bottom section of the groove left by flint is acute while the ones left by quartz and quartzite are obtuse. Flint leaves narrow internal striations, while quartz and quartzite leave wide internal striation. The shoulder effect is more common in quartz and quartzite cut-marks than in those from flint. The morphology of the cut-marks termination could be Y-shaped both for flint and quartz. The herzian cones are present in cut-marks made by flint and absent in those made by quartz and quartzite.

The skeletal representation of all taxa is low except in *Ursus spelaeus* (Tab. 3). The MNE

Anatomical element	*Ursus spelaeus*		*Ursus arctos*		*Canis lupus*		*Cervus elaphus*		*Rupicapra rupicapra*		*Bos primigenius*	
	MNE	MAU	MNE	MAU	MNE	MAU	MNE	MAU	MNE	MAU	MNE	MAU
Antler							3	1.5				
Skull	8	8					1	1				
Hemimandible	3	1.5										
Atlas	1	1										
Axis					1	1						
Cervical vertebra	1	0.2			2	0.4						
Thoracic vertebra	3	0.25										
Lumbar vertebra	3	0.42										
Rib	4	0.17										
Scapula	3	1.5										
Homer	5	2.5	1	0.5								
Radius	6	3										
Ulna	3	1.5			1	0.5						
Hamate	1	0.5										
Scaphoid	2	1					1	0.5			1	0.5
Scapholunar	5	2.5										
Trapezium	2	1										
Trapezoid							1	0.5				
I mc	4	2										
II mc	4	2										
III mc	3	1.5										
IV mc	1	0.5										
Pelvis	1	1			1	1			2	2		
Femur	9	4.5										
Patella	1	0.5	1	0.5								
Tibia	3	1.5										
Fibula	2	1										
Talus	7	3.5										
Calcaneus	2	1					1	0.5				
Cuboid	1	0.5										
Cubonavicular							1	0.5				
I cuneiform	2	1										
II cuneiform	1	0.5										
III cuneiform	2	1										
I mt	1	0.5										
II mt	3	1.5										
IV mt	2	1										
Metapodial	5	0.25					1	0.25	2	0.5		
I phalanx	21	1.05					1	0.13				
II phalanx	15	0.75					2	0.25	1	0.13		
III phalanx	12	0.6							1	0.13		

Tab. 3 - Anatomical elements in the sample. MNE: minimum number of elements; MAU: minimal animal unit.

and MAU evidences that appendicular elements are more abundant in the sample under study; the distal part of limb bones (metapodial, carpal/tarsals and phalanx) are the more abundant elements.

The study of the 1144 faunal remains has highlighted nine types of taphonomic alterations (Fig. 2): roots activities, cracking, carnivore intervention, deposition of manganese oxide, concretions, trampling marks, water abrasion (rounding and smoothing) and cut-marks (Tab. 4). Even so, in general, the taphonomical preservation of fossil assemblage is good.

Root marks are present on 730 remains, 63.81% of the sample examined; root marks that are white massive vermiculated trace, are located on both the surface and on fracture edges, and do not deeply penetrate the bones. Carnivores intervention was recognized on 54.81% of the sample; many bites are located on the fractured edge and on diaphysis without epiphysis; *U. spelaeus* is the species with more traces of carnivore interventions, equally reported on axial and appendicular skeleton. Cracking alteration was identified on 50.52% of the sample, to various degrees. Deposition of manganese oxide is detectable on 99.83% of the remains with different degrees of intensity and coverage; the manganese oxide pigmentation is present in a generalized, dispersed or massive form without any type of standardization, linked with the form, the size, the position and the taxonomy of the remains. The same

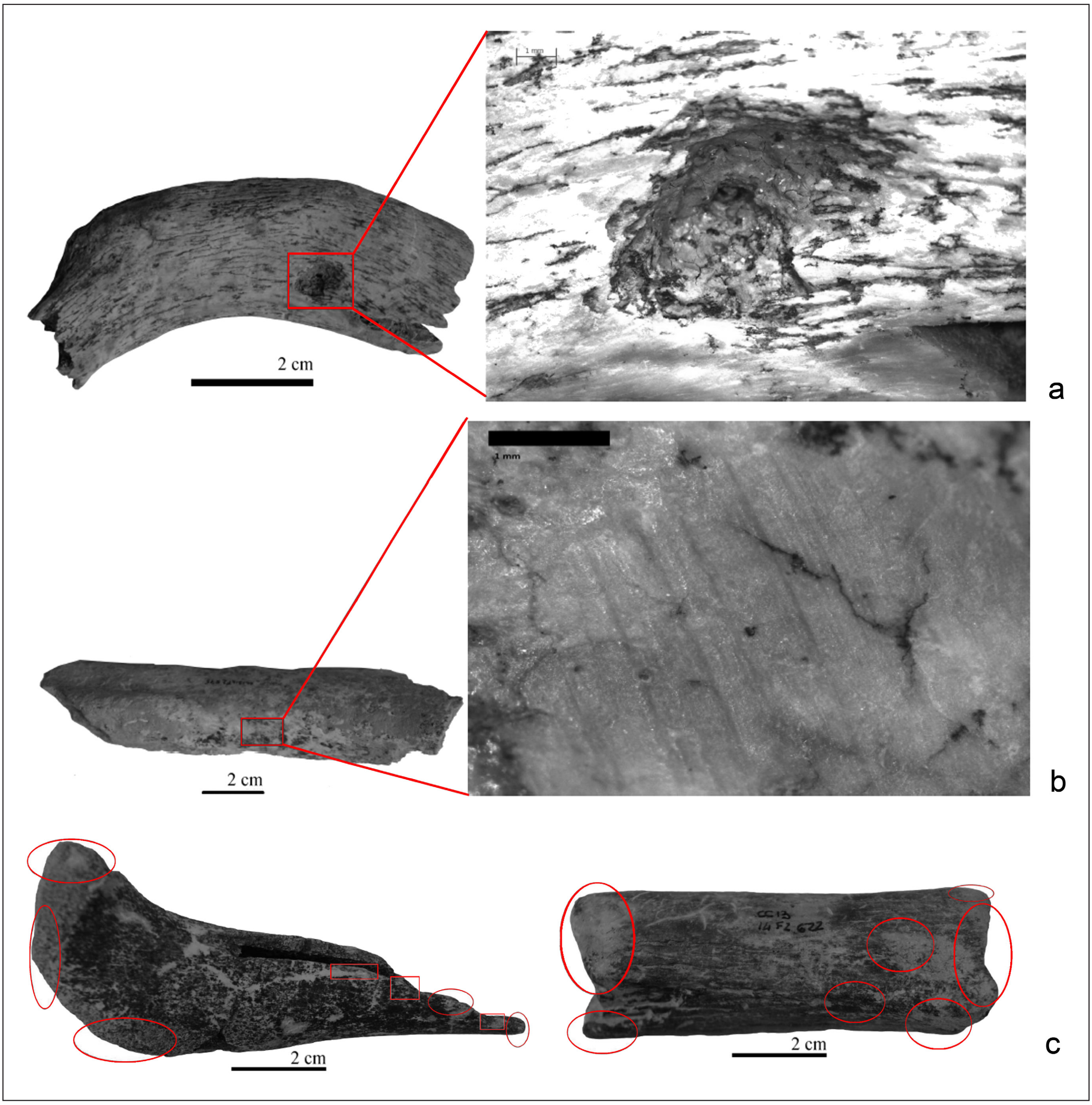

Fig. 2 - Taphonomic alterations; a: bite marks; b: trampling marks; c: hydric abrasion.

kind of distribution, without a clear pattern, characterizes also the concretions (22.46% of the faunal remains). Trample marks are present on 30.90% of the remains; trampling traces are randomly distributed on bones, without prevalence for dimension of the fragments. Water alterations are represented by smoothing and rounding on 28.49% of the considered remains; the hydric alteration is prevalent on fragments with length between one and four cm and with elevated degree of fossilization. Thirtyfive different bones, 2.97% of the sample analysed, show on the surfaces evidence of butchering. Twelve of them have been identified on taxonomy determinable bones of two different species: one *Canis lupus* and eleven *U. spelaeus* remains (Fig. 3). Half of the remains with cut-marks are undeterminable, but the other half are attributable to large or medium-sized animals (Tab. 5). The archaeozoological study of the cut-marks has allowed the identification of four different activities: flesh removal, evisceration, fur removal and disarticulation (Nilssen 2000) (Tab. 6).

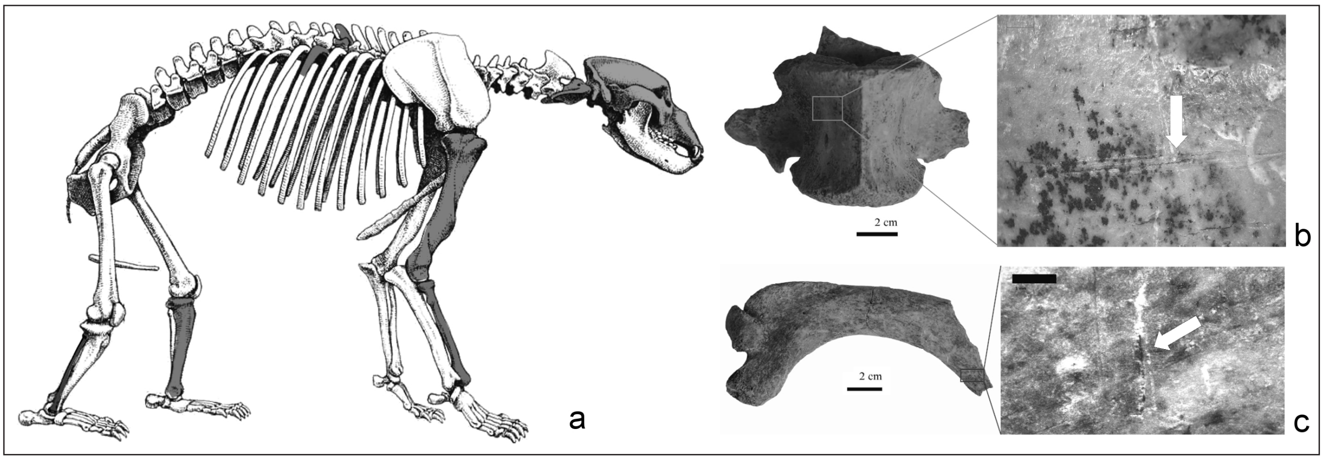

Fig. 3 - Cut-marks; a: location of cut-marks on *Ursus spelaeus*; b: fossil vertebra with cut mark; c: fossil rib with cut mark.

Taphonomic process	NR	%
Deposition Mn oxyde	1142	99.83
Roots alteration	730	63.81
Carnivores intervention	627	54.81
Cracking	578	50.52
Trampling	365	31.9
Hydric abrasion - rounding	326	28.49
Hydric abrasion - smoothing	326	28.49
Limestone concretion	259	22.46
Cut marks	34	2.97

Tab. 4 - Percentage of taphonomic processes. NR: number of remains.

Size	NR with CM	% CM	% Tot
Big	10	29.41	0.87
Medium	6	17.65	0.52
Small	1	2.94	0.09
Undetermined	17	50.00	1.49
TOTAL	34	100.00	2.97

Tab. 5 - Abundance of cut-marks subdivided for prey size.

The cut mark on *C. lupus* is located on the third cervical vertebra. The cut-marks on *U. spelaeus* are: on a skull fragment; on the atlas; on a thoracic vertebra; on a proximal part of a rib (Fig. 4); on two right humeri; on a right radius; on two left tibias; on a right fibula; on a right scapholunar.

Discussion

The experimental activities confirmed the presence of small differences and peculiarities between the cut-marks made with simple flakes of different raw material (Fernández-Jalvo & Cáceres 2010) (Tab. 7). The unretouched tools, used by the two operators for the same action, are differentiated only by their raw materials that generate cut-marks with different features (Fig. 5). These data suggest that the morphology of the cut-marks is linked with the raw material. The difference is probably due to the texture of the raw material that drives the characteristics of the functional edges (Fig. 6).

The texture of the raw material influences the possibility to obtain better functional edges, therefore amorphous rocks, are the best kind of raw material. Flint is an amorphous rock, so no preferential fracture plans are present, thus allowing to knap flint in a predetermined way and to obtain very sharp edges (Arzarello et al. 2011). Conversely, vein quartz is made by crystals. Its structure consists of a trigonal crystal system, and these characteristics made vein quartz more difficult to knap in order to obtain tools (Mourre 1996; Arzarello et al. 2011). The edge of a quartz tool is less strong than one made in flint, but very sharp. Quartzite is a meta-

	Flesh removal		Evisceration		Fur removal		Disarticulation	
Size	NR	%	NR	%	NR	%	NR	%
Big	5	14.71	1	2.94	3	8.83	1	2.94
Medium	4	11.76	1	2.94	1	2.94	1	2.94
Small	1	2.94	0	0.00	0	0.00	0	0.00
Undet.	14	41.18	0	0.00	2	5.88	0	0.00
TOTAL	24	70.59	2	5.88	6	17.65	2	5.88

Tab. 6 - Butchering operations subdivided for prey size. NR: number of remains.

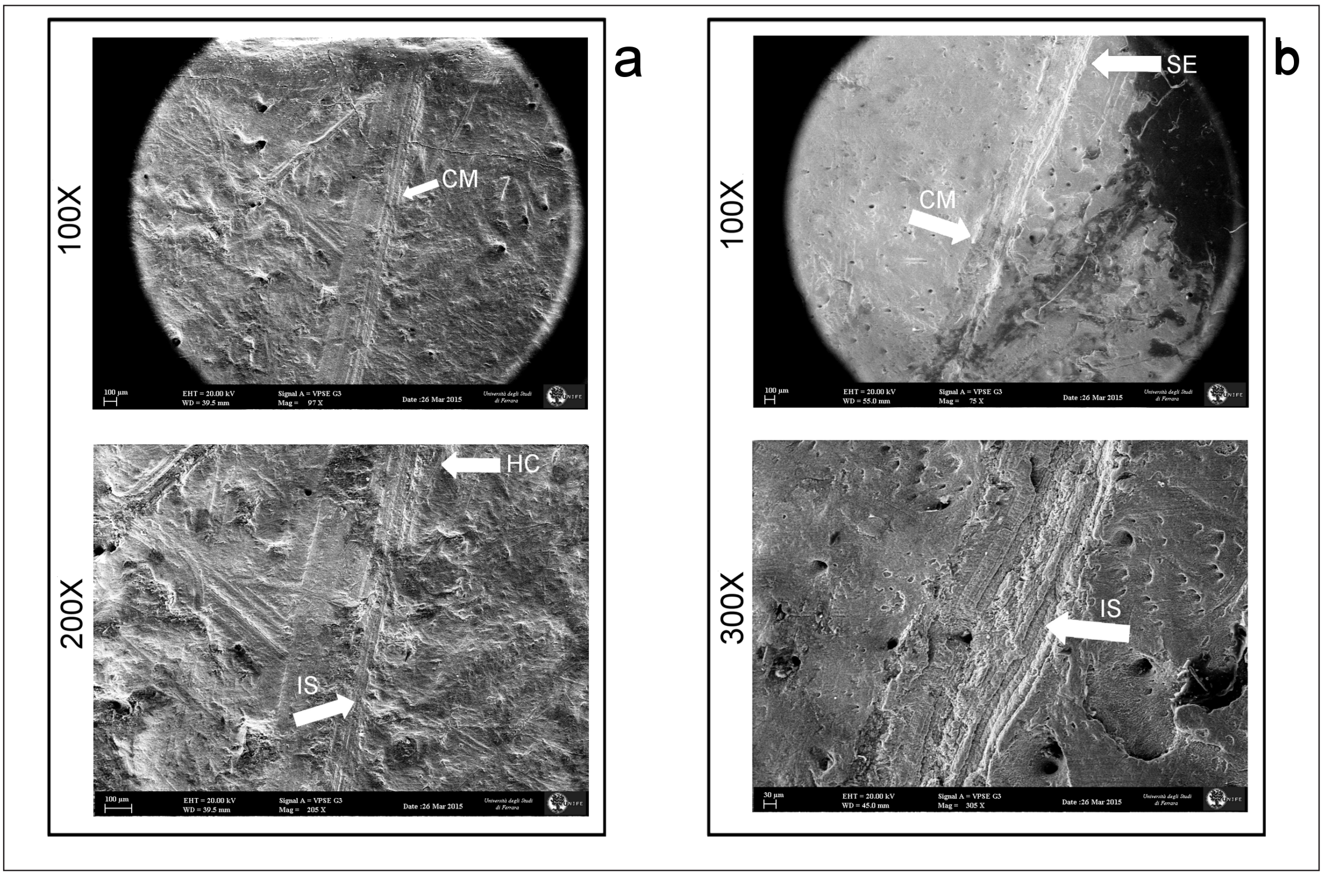

Fig. 4 - SEM images of cut-marks on fossil specimens from the Ciota Ciara Cave; a: cut mark on cave bear skull; b: cut mark on cave bear vertebra. CM: cut-marks; IS: internal streaking; HC: herzian cones; SE: shoulder effect.

morphic rock derived from quartz. The metamorphic process causes recrystallization and most or all of the original texture and sedimentary structures of the stone are erased (Arzarello et al. 2011). The analysis conducted also confirms that the cut-marks obtained through simple quartz flakes during the experimental activities present the same characteristics of those observed in the archaeological record of the Ciota Ciara cave.

The Ciota Ciara cave deposit has undergone many taphonomic modifications. The deposit of manganese oxide on the whole surface of the remains and with deep penetration on the bones suggests a local environment characterized by cavernous conditions of darkness and high humidity. In this environment, the abundant presence of superficial roots alterations can be attributable to the influence of outside environment (i.e. roots of plants that grew out of the cave) (Morlan 1980; Grayson 1988). Water action was important for the formation of the Ciota Ciara archaeological deposit; the presence of different degrees of hydraulic alterations, with combination of rounded surfaces and polish, identifiable on the remains allows us to assume the influence of a persistent transport with low energy, as confirmed by the lack of orientation of the finds. In the sample there are few finds showing a more marked degree of mineralization, and also that they were probably transported into the atrium from the inside of the cave by water. The concretions are due to precipitation of carbonate from the percolating water (Angelucci et al. 2015); in some cases, the concretions are subsequent the manganese deposit. The trampling marks observed on the Ciota Ciara fossil assemblage are characterized by multiple striae randomly distributed on the bone

Characteristics	Flint	Quartz	Quartzite
Slope of the edge	abrupted	half-abrupted	variable
Bottom section	V-shaped	V-shaped	U-shaped
Internal streaking	thin	wide	wide
Trait	single	multiple	irregular
Termination	Y- shaped	Y- shaped	\
Shoulder effect	X	X	X
Herzian cones	X	\	\

Tab. 7 - Features of cut-marks made with different raw material.

surface. The intense trampling activity is probably due to the frequent occupation of the cave by *U. spelaeus* (Asryan et al. 2014), as attested by presence of numerous cubs (Berto et al. 2016). The presence of carnivore interventions with bite on fracture edge and the absence of epiphysis could suggest both primary and secondary intervention by carnivores, with intense carcasses consumption.

The position and type of cut-marks are sufficient to assign the butchery activities. The data emerging from the archaeozoological studies prove that in the Ciota Ciara cave *U. spelaeus* was butchered by the Neanderthals and four activities can be observed: extraction of flesh masses, fur removal, disarticulation and evisceration. Concerning *U. spelaeus*, activity of fur removal was attested (Auguste 1995; Munzel & Conard 2004; Armand 2006) by the presence of cuts-marks on a skull and a scapholunar of *U. spelaeus*. *U. spelaeus* faunal remains present also traces of flesh extraction (Munzel & Conard 2004; Nilssen 2000). Those activities are attested by different traces: one scraping trace on the ventral side of a thoracic vertebra (vertebral body) and various scarification traces on two humeri and two tibias placed near the insertions of the muscle masses. Finally, the presence of cut-marks on the atlas dorsal face can be related to disarticulation or filleting activities (Nilssen 2000).

Concerning *C. lupus* an activity of disarticulation or filleting was attested by the presence of cut-marks on the third cervical vertebra (Nilssen 2000).

The defleshing of *U. spelaeus* by the Neanderthals is attested in few other European Middle Paleolithic sites: Biache-saint-Vaast (France) (Auguste 1995), Taubach (Germany) (Bratlund 1999), Scladina cave in Belgium (Abrams et al. 2014) and Nietoperzowa Cave in Poland (Wojtal 2007). In Scladina cave, in layer 5, cut-marks on different fragments of long bones were identified, but they were associated at the "*chaîne opératoire*" linked to bone working (Abrams et al. 2014). Mousterian sites with evidence of fur removal on *U. spelaeus* are Biache-Saint-Vaast (France) (Auguste 1995), La Madonna dell'Arma (Italy) (Cauche 2007), Taurach (Germany) (Bratlund 1999), Nietoperzowa Cave (Poland) (Wojtal 2007).

The data emerging from the taphonomic and archaeozoological studies of the S.U. 14 of the Ciota Ciara cave are in agreement with previous studies already published (Arzarello et al. 2012; Arzarello et al. 2013; Arnaud et al. 2014; Angelucci et al. 2015; Daffara et al. 2014; Berto et al. 2016). S.U. 14 is characterized by a lithic industry made with local raw materials with some elements made with alloch-

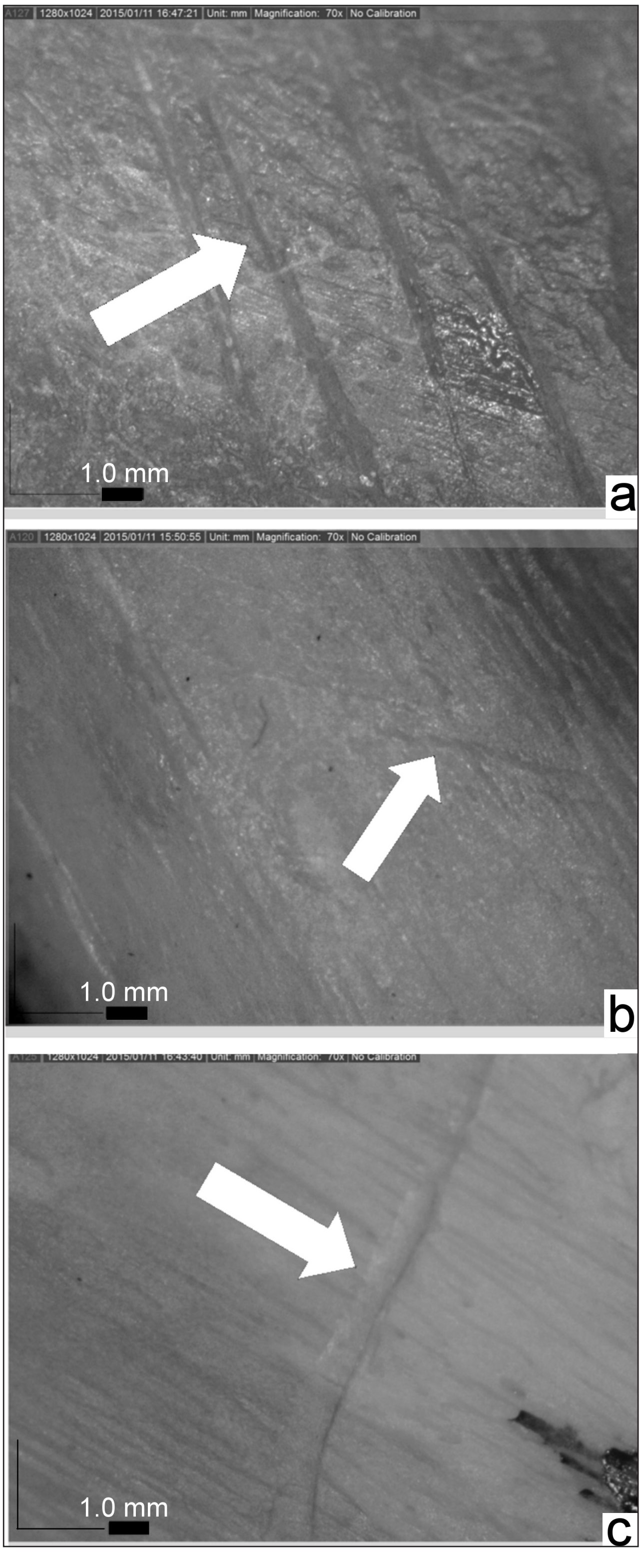

Fig. 5 - Cut-marks made with different raw material at optical microscope; a: cut mark made with flint; b: cut mark made with vein quartz; c: cut mark made with quartzite.

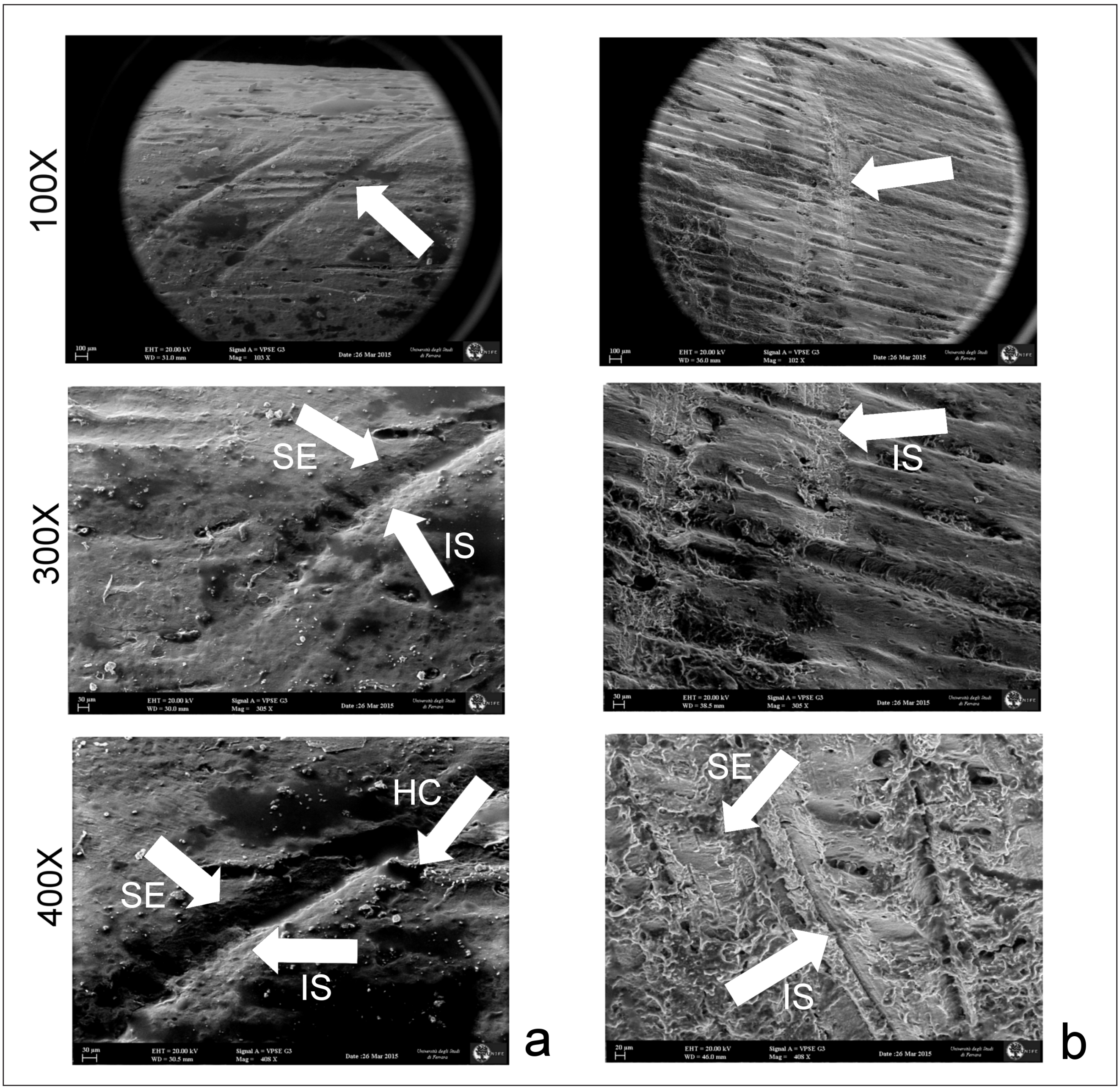

Fig. 6 - SEM images of cut-marks made with different raw material; a: cut mark made with vein quartz; b: cut mark made with quartzite. IS: internal streaking; HC: herzian cones; SE: shoulder effect.

thonous flint. The Neanderthal occupation in this S.U. has been defined as "more intense" than that of the S.U. above (Arnaud et al. 2014; Angelucci et al. 2015; Daffara et al. 2014). This interpretation is based on the presence of a hearth and on the greater differentiation of the raw materials.

Conclusions

This preliminary analysis demonstrates that it is possible to recognize the cut-marks left on bones surfaces by simple flakes made of different raw materials. In order to make this study more detailed and complete, it will be necessary to increase the experimental database and to include different typologies of tools in future works. Nevertheless, the possibility of obtaining information about the raw material used for butchering activities from the analysis of the cut-marks could be a useful instrument for future investigations. This kind of analysis can be useful in areas where the use of flint was scarce or absent, like the Piedmont area (Daffara et al. 2014; Berruti et al. 2016). In sites where the use of quartz was limited compared to other raw materials, a review of the cut-marks could reveal a more conspicuous use of quartz than previously supposed. The Ciota Ciara cave was intensely used as den by cave bear, as testified by the numerous cubs' bone remains. The abundance of cave bear remains in all the layers suggests that this species used the cave for long periods. The presence of cut-marks on cave bear bones suggests that the chronological partition of the occupation of the cave between men and bears, as suggested in previous studies (i.e. Daffara et al. 2014), wasn't that exclusive. The few bone remains with cut-marks suggest that bear exploitation was not intensive. The cave bear exploitation by Neanderthals is attested in some others European sites, but the Ciota Ciara cave represents the first Italian record of this activity.

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