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The De Nadale Cave, a single layered Quina Mousterian site in the North of Italy

Die De Nadale Höhle, eine einphasige Fundstelle des Moustérien vom Typ Quina in Norditalien

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Abstract - This article presents the results of archaeological exploration at De Nadale Cave, a new Late Middle Palaeolithic site recently discovered in the Berici Hills, a karstic plateau in the north-east of Italy. A first survey and field campaigns have brought to light a small cavity almost totally filled with sediments embedding one single Mousterian layer sandwiched by sediments avoid of any relevant archaeological remains. A large herbivore tooth has been U-Th dated, with a minimum age of 70.2 +1/-0.9 ky BP. Several economic and cultural aspects make this site peculiar with respect to the others at the regional scale. The faunal remains record the abundance of large ungulates, mostly *Megaloceros giganteus*, but also *Cervus elaphus* and *Bos/Bison*. Their bone surfaces bear traces of human modification produced during skinning, dismembering, and fracturing of the carcasses and the long bone shafts for marrow recovery. There is a high number of bone retouchers in proportion to the fragmented shafts, used for shaping and rejuvenating different types of scrapers. The lithic industry shows typical Quina characteristics in its technology and typology, with several thin and thick scrapers made of non-local flint due to its absence in proximity of the site. On-going research will investigate in more detail a so specific evidence in the Middle Palaeolithic of the North-Adriatic rim.

***Zusammenfassung -** Der Beitrag stellt Ergebnisse von Sondagen in der neu entdeckten De Nadale Höhle vor. Es handelt sich um eine Fundstelle des späten Mittelpaläolithikums in den Berici-Bergen, einem Karstplateau in Nordostitalien. Im Rahmen einer ersten Ausgrabung wurde die vollständig mit Sediment gefüllt Höhle untersucht. Eingebettet in sterile Schichten wurde eine moustérienzeitliche Fundschicht angetroffen. Der Zahn eines großen Herbivoren aus der Fundschicht konnte mit Hilfe der Uran-Thorium-Methode auf ein Mindestalter von 70 200 +1 000/- 900 Jahre BP datiert werden. Einige technologische und kulturelle Besonderheiten zeichnen den Fundplatz im Vergleich zu anderen Fundplätzen in der Region aus. Die Faunenreste belegen das Vorkommen von großen Huftieren, hauptsächlich* Megalocerus giganteus *sowie* Cervus elaphus *und Boviden. Die Oberflächen der Knochen zeigen deutliche Schnitt- und Schlagspuren vom Häuten und Zerlegen der Tiere sowie vom Aufschlagen der Langknochen zur Markgewinnung. Im Vergleich zu den vorhandenen Schaftfragmenten liegt eine hohe Zahl von Knochenretuscheuren vor, die offenbar zur Formgebung und Nachschärfung verschiedener Schabertypen eingesetzt wurden. Das Steingeräteinventar weist typische Merkmale des Moustérien vom Typ Quina auf mit mehreren dünnen und dicken Schabern aus nicht-lokalem Silex. Weitere Untersuchungen sind geplant, um mehr Daten zur Beurteilung dieses mittelpaläolithischen Fundplatzes des nordadriatischen Bogens zu gewinnen.*

Keywords - Mousterian, zooarchaeology, lithic industry, cave, excavation, Berici Hills
Mousterien, Archäozoologie, Steinwerkzeuge, Höhle, Ausgrabung, Berici Berge

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Introduction

Neanderthal subsistence and Mousterian cultural variability play a leading role in studies related to human evolution in Europe. This is also true for the northern regions of the Mediterranean basin, where several sites dating to the late Middle Paleolithic have produced archaeological and zooarchaeological data of variable relevance (see papers in Bietti & Grimaldi 1996; Conard 2001; Mussi 2001; Conard & Delagnes 2004; Conard & Richter 2011). One of these regions is the belt surrounding the present-day Northern Adriatic Sea, which includes the Venetian region and the Dalmatian coast, with numerous sites framed in variable ecological contexts (Peresani 2001; Karavanić 2004; Peresani 2011; Peresani et al. 2014). Particularly between the alluvial plain and the Veneto Pre-Alps, some caves were repeatedly occupied, while others were occupied on a shorter and more ephemeral basis, consistant with the type of settlement subsystems which occur in environments ranging from the edge of the mountain zone to the lowlands of the sub-alpine region.

This scenario fits well with the Middle Palaeolithic evidence from Cuoléto De Nadale (from here De Nadale Cave), a recently discovered karst cavity providing potential interest for understanding markers of mobility, settlement dynamics and exploitation of resources at the junction between the alluvial plain and the sub-alpine region. Fieldwork, laboratory studies and datings have provided new elements to decipher the main factors driving Neanderthal groups to areas like this, considered peripheral to the settlement system of the North Adriatic plain.

Landscape Setting

The Berici hills are a carbonatic plateau extending for almost 200 km^2 in the sub-alpine region. They are situated south of Vicenza, isolated in the alluvial plain from other formations that are similar in constitution and morphology, like the Lessini Mountains, that are 3-4 kms to the north-west, separated by a stretch of open plains formed by the Astico and other river systems, and bordered by the Brenta megafan in the south-east. The river Bacchiglione runs through this megafan and is bound by the Euganean hills to its south-east.

The Berici is a karst landscape dissected by two main valleys, the Val Liona and the Fimon Valleys which separate it into two sectors. The eastern zone is a vast, articulated, tabular area which terminates abruptly towards the alluvial plain along its south-eastern side. The western zone is a gentle landscape conjoined with the alluvial plain (Mietto 2003). The major peaks are registered along the south-eastern margin at about 400 m a.s.l. and up to 444 m a.s.l. at the Altissimo Mount.

The Berici landscape underwent karstic and fluvio-karstic processes, at least since the Middle Miocene, leading to the formation of sinkholes, dry valleys systems with sinkholes and valley segments which evolved into large, closed basins (Sauro 2002). After an initial phase of fluvial erosion which occurred during the Middle-Upper Miocene, the area was subjected to tectonic up-lift in association with the lowering of the hydrologic drainage level at the end of the Miocene (Messinian). This promoted the formation of the present-day V-shaped, fluvio-karstic canyon-type valley system in various zones of the plateau, with active water springs in their inner zones, like those of the Calto valley. During the Upper Villafranchian, the vertical hydrologic drainage and the karst systems developed as a consequence of further uplifting, responsible for the lowering of the phreatic sub-terranean system and the deactivation of the suspended drainages. As a consequence of these processes, the inner karstic processes deactivated and the suspended cavities emptied.

The Middle Palaeolithic in the Berici Hills. Short presentation of the sites

Over 20 Mousterian open-air sites, caves or shelters have been discovered in the Berici Hills (Leonardi & Broglio 1962; Bertola & Peresani 2000; Duches & Peresani 2009; Peresani 2015) and in the Euganean Hills (Duches et al. 2008; Peresani 2013) (Fig. 1). The open-air sites are attested by lithic artefacts embedded in pedo-stratigraphic sequences (Monte Versa: Peresani 2000-2001) or found dispersed on the surface. They vary in morphological position, distance from lithic sources and techno-typological features of the lithic industry. While the sites on the Berici are distributed on the plateau at variable elevations, those on the Euganean are almost systematically located on carbonatic and marly carbonatic bedrocks with flint nodules, rather than on volcanic bedrocks. The absence of any stratigraphic context, archaeological deposit and faunal remains hinders any attempt at understanding their function. Only simple correlations, with the availability of lithic resources or with the morphology of the area, usually the top of hill or the edge of the terrace, at a position with dominance on the plain and the surrounding valleys, disclose the significance of these sites. The lithic industries are mainly composed of cores and Levallois products obtained either through preferential or recurrent method, and are larger in size than the comparable products found in caves. The tools have usually shallow, non-invasive retouches and their frequency in the total assemblage increases with distance from the flint exposures. The raw material most commonly used is flint contained in the cretaceous carbonatic

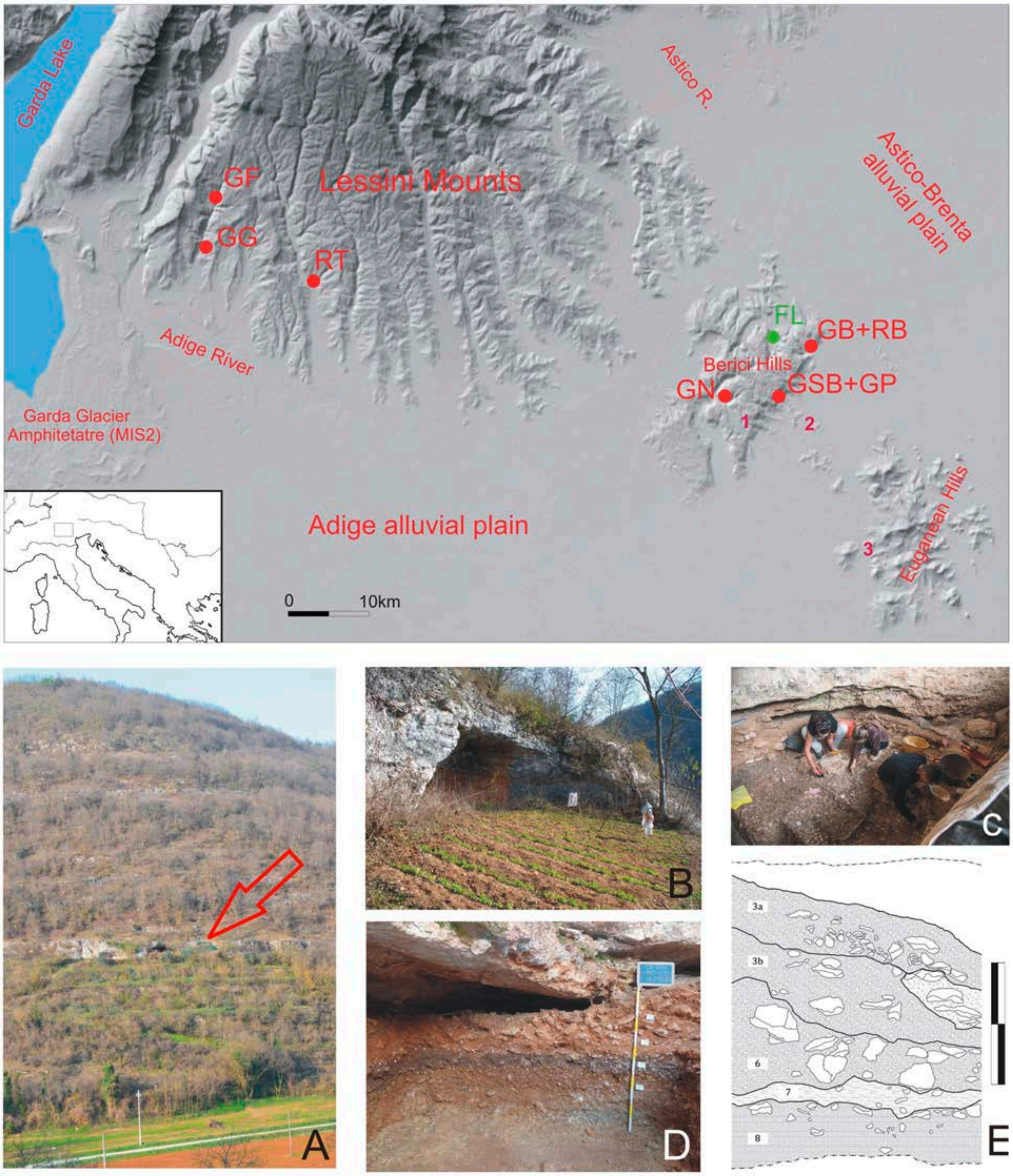


Fig. 1. Above, sketch map of part of north-east of Italy with location of De Nadale Cave (Grotta De Nadale-GN) and the other sites cited in the text: Fumane Cave (Grotta di Fumane-GF), Ghiacciaia Cave (Grotta della Ghiacciaia-GG), Tagliente Rockshelter (Ripato Tagliente-RT), Broion Cave and Broion Rockshelter (Grotta del Broion-GB and Riparo del Broion-RB), San Bernardino Cave and Paina Cave (Grotta Maggiore di San Bernardino-GSB and Grotta di Paina-GP); Gualivone and Monte del Cason (1), Monticello di Barbarano (2), Monte Versa (3). Below left, the Vecio Possibile Cave (Covolo del Vecio Possibile) and De Nadale cave (Cuoléto De Nadale) positioned at mid elevation along the southern slope of Monte Spiadi, indicated by the arrow (A); the site during the discovery in 2006 (B); the excavation of unit 7 exposed, with scattered bones and lithics; note the entrance of the cavity on the back (C); the N-W section showing unit 7 sandwiched by sterile deposits (D); drawing of the w section showing the inclination of unit 3 towards the entrance of the cave. Dotted lines show the roof and the bedrock of the cave (E).

Abb. 1. *Oben, Karte Nordostitaliens mit der De Nadale Höhle (GN) und anderen Fundplätzen der Region: Fumane (GF), Ghiacciala Höhle (GG), Abri Tagliente (RT), Brolon-Höhle (GB) und Brolon Abri (RB), San Bernadino Höhle (GSB) und Paina Höhle (GP), Gualivone und Monte del Cason (1), Monticello di Barbarano (2), Monte Versa (3). Unten links (A), (s. Pfeil) die Höhle Covolo de Vecio Possibile und die De Nadale Höhle, die beide im Mittelhang des Monte Spiadi liegen. Unten Mitte (B), die Höhle bei der Entdeckung 2006. Unten rechts (C), die Schicht 7 mit den Funden während der Ausgrabungen und dem verfüllten Höhleneingang im Hintergrund. Unten Mitte (D), Das N-W Profil mit der Fundschicht 7 eingeschlossen zwischen sterilen Sedimenten. Unten rechts (E), Zeichnung des Westprofils mit dem schrägen Verlauf der Schicht 3 in Richtung Höhleneingang; gepunktete Linien zeigen den anstehenden Fels und das Dach der Höhle an.*

formations - Maiolica, Scaglia Variegata Alpina and Scaglia Rossa, although some sites (Gualivone and Monte del Cason on the Berici Hills; Monte Versa on the Euganean Hills) attest to the exploitation of exogenous flint (oolithic, eocenic) provisioned in the Lessini Mountains.

Focusing on the several open-air sites in the Berici Hills, the Monticello di Barbarano has recently produced a large assemblage based on Levallois flake-making. The general computation records an evident imbalance in the number of retouched tools in comparison to the cores. The easy availability of the Scaglia Rossa flint at the top of the hill and its exclusive exploitation suggest that human activity was mostly addressed toward lithic production and the exportation of end-products and, possibly, tools (Duches & Peresani 2009). Techno-typological variability is shown in the lithic assemblages of Gualivone and Monte del Cason, firstly by the presence of scrapers with stepped-scaled retouch and secondly by artifacts produced by the discoid method applied to various types of flint (Bertola & Peresani 2000).

Caves and shelters are exclusively set along the eastern side of the Berici Hills, where Broion Cave and Broion Shelter (150 m a.s.l.), Paina Cave (335 m a.s.l.), Col de la Stria Cave and San Bernardino (Major and Minor) Caves open (Fig. 1). While the Paina, Col de la Stria and San Bernardino Minor Caves yielded few artefacts (Bartolomei et al. 1987-88), the Broion Shelter requires more extended excavations (De Stefani et al. 2005) and the Broion Cave and San Bernardino Major Cave have produced more complete evidence.

San Bernardino Major Cave preserves a Middle-Late Pleistocene sequence dated from 202 ± 30 ky BP (unit VIII) to 52 ± 5 ky (unit II) that records at least three climatic cycles initially characterized by damp-temperate climate with forests, followed by damper conditions with cooler fluctuations (Cassoli & Tagliacozzo 1994; Gruppioni 2003). Excavations carried out in the 1960s and in the 1980-90s recorded traces of human habitation across the whole sequence, more consistent in units VIII, VI, II, and sporadic in units VII, V and IV. Levallois lithic technology and economy relates to the suitability of two main categories of flint: one provisioned from the Scaglia Rossa exposures in the surroundings (1-5 km), generally showing low mechanical properties, and the second (Maiolica and Scaglia Variegata) coming from external sources in the Euganean Hills and the central-western Lessini (20 to 80 km), showing excellent properties. Reduction sequences on the locally-provisioned blocks/nodules were carried out on-site, and fractioned sequences of exogenous flint may have involved partially-exploited cores and the curation/rejuvenation of the retouched tools that were introduced into the cave at varying degrees of reduction. At a general level, flake-manufacture is characterized by intense core exploitation, yielding microlithic blanks. Levallois is the dominant flaking method in units VIII and VII (Picin et al. 2013), using primarily the recurrent centripetal modality in unit VIII and the unidirectional in unit VII. Lithic assemblages from units VI, V, IV and II exhibit several features that should be significant for inferring the different functions of the cave. Units VI and II share comparable designs in Levallois flake-making and in raw material economy (Peresani 1995-96; 1996), through intense exploitation that could be related to prolonged occupation, which is also indicated by the palaeo-living floors and related fireplaces.

At Broion Cave, traces of Mousterian site use span from late MIS5 to MIS3, and are represented by assemblages mostly composed of retouched tools. The wide geographic perspective, the peculiarities in human occupation, and the physical surroundings suggest that the cave was a specialized site placed at an intermediate position between two economic districts in terms of flint provisioning, the Euganean Hills and the Lessini Mountains. It was occupied repeatedly on a short-term basis by humans equipped with end-products and retouched implements, but also with partially exploited cores, that were introduced into the site as mobile caches (Peresani & Porraz 2004). The industry records ephemeral flake-making, limited to the shaping and curation of the retouched products and the high frequency of tools made of exogenous flint. Flake-making is largely dominated by the Levallois concept and its unipolar and centripetal modalities. On occasion, flake-making also involved the exploitation of flakes as cores. This behaviour is observed more or less across the entire sequence, within which the archaeological material is grouped into three main stratigraphic assemblages from ES4 to ES2 (Peresani & Porraz 2004).

The cave and the stratigraphic sequence

De Nadale Cave is located in the middle of the Berici Hills at 130 m a.s.l., along a steep cliff face that runs from the top of Spiadi Mount to the bottom of the Calto Valley. The whole side, up to the cave, was terraced for cultivation (Fig. 1B) in the past and partially maintained until recently. The hydrographic drainage system of this area features the initial segment of the Liona Valley with the confluence of other incisions currently supplied by springs from the west, where they are limited by the Pozzolo suspended valley, and from the north. The geometry and nature of the Calto valley bottom deposits are unknown, but it is probable that this depressed area (about 55 m a.s.l.) was characterized by moist or swampy environments with peaty deposits in the past, comparable to what is known along the Val Liona.

The cave opens to the south on a small cliff oriented west-east, where another cavity is located, the Cúolo De Nadale, larger than the former and converted into a habitation site during historic times

(Fig. 1A). The De Nadale Cave was first reported in 2006 by a collaborator of the University of Ferrara (Mr. G. Baruffato), who found mammal bones and lithic artifacts on the surface of reworked sediments resulting from cultivation and animal turbation (badger). Following the removal of the reworked sediments (unit 1rim) in 2013, which yielded a large number of bone fragments and a few lithic implements, the entrance of a small cavity 8 m long, almost completely filled by deposits, was discovered (Fig. 1C). The top of the fill does not show any trace of anthropic disturbance. Two excavation campaigns, in May and October 2014, were undertaken here.

A 1.5x1.5 m pit was opened in the western zone, exposing the deposits down to the bedrock. The deposits fill the cave almost completely, leaving a space of about 30 cm between their regularly flat surface and the vault. The excavation has highlighted a deep hole (unit 4) filled with rocks and located at the center of the shelter; its function is attributed to the preparation of the artificial terrace in order to serve agricultural purposes in the recent past. The excavations have exposed a short stratigraphic sequence, including one single anthropic layer (unit 7) sandwiched by sterile levels lying on a flat floor coincident with the horizontal bedding of the local carbonatic sandstone bedrock (Fig. 1D).

The geographic-ecological position of the site, the peculiarity of the archaeological evidence, the degree of preservation of the surfaces of the bones and of the stone tools, and the discovery of an unexplored cave have motivated plans for long-term research aimed at investigating the palaeontological and cultural content of this archive.

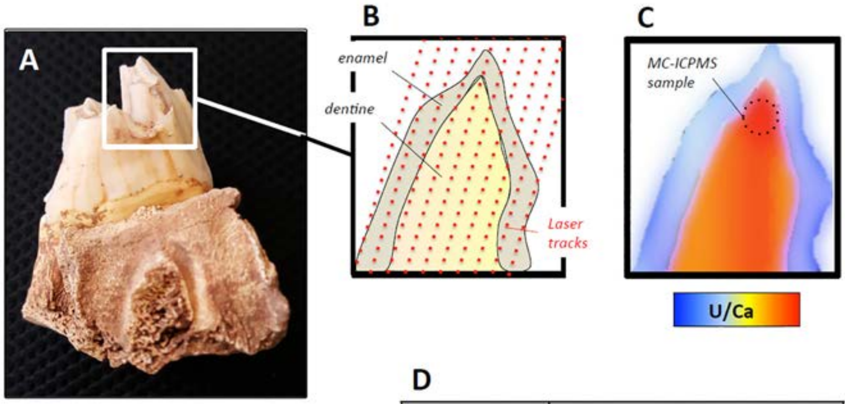
Given the still preliminary state of research, it is not possible to determine the original geometry of the Pleistocene deposits, nor to verify the spatial extension of the stratigraphic succession. However, the pit has exposed its most complete section on the west, where a group of units (3, 6, 7, 8) tilting to an angle of 15° to the north, is visible (Fig. 1E). Unit 3 is a thick layer alternating between stone supported layers and stony loamy-textured layers. This breccia is loose, made by carbonatic rocks of medium-large size (10-15 cm), tabular, and tilted according to the boundaries of the unit. The fine fraction is a coarse sand of a strong brown color, loose, and devoid of any palaeontological remains. Unit 3 covers unit 6, and is a stone-supported breccia composed of large sub-angular and tabular blocks (up to 25 cm), with sub-horizontal disposition. The second stratigraphic unit (7) is the Mousterian archaeological layer and consists of dark brown-gray silt loam with crumby aggregation and medium-small sized, sub-rounded rocks. This unit was also disturbed by badger dens, beyond the current limit of the excavation, inside the cave, along the wall. Aside from this, unit 7 is well preserved and extends into the cave. It has yielded hundreds of fragmented bones, mostly used as retouchers, flint implements and few tiny fragments of charcoal. About 40 cm underneath the lowest vault, a concentration of charcoals and burnt bones (structure 7SI) was interpreted as a residual hearth. Below unit 7, unit 8 is archaeologically sterile, even though a few flaked stones and bones were recovered at the top, close to the boundary with unit 7. This material has been attributed to unit 7. It is a loose stone-supported breccia with a silt-clay matrix and stones coated with blackish iron and manganese stains on their upper faces. The contact with the bedrock is affected by active dissolution and limited by residual clay (unit 9).

From this first field evidence, it is possible to infer that the aggradation of the sedimentary surfaces was a natural process with a modest anthropic contribution occurring probably during the Late Pleistocene. Rock collapse, frost-shattering, colluviation, and aeolian deposition which cannot be excluded, are the processes responsible of the formation of units 3, 6 and 8, followed by a local re-deposition of carbonate and a redistribution of the finest sedimentary fraction.

These processes were largely recognized in other cave sediments investigated in the Berici Plateau where they contributed to form Late Pleistocene infillings varying in thickness from 8 m at Broion Cave (Cremaschi 1990) to 1 m at Paina Cave (Bartolomei et al. 1987-1988). This variability in the volumes of deposits depends on different factors, particularly the size of the karst structure, the position and orientation of the shelter along the slope, the nature of the bedrock and of the sediments sealing it. At De Nadale Cave, sedimentary aggradation filled up the cavity limiting the record of any potential morphogenetic event after an unestimable lapse of time which started from the end of the deposition of anthropogenic unit 7. TL dating programs are in course with the aim to estimate the sedimentary rate and placing in time the Mousterian frequentations.

Uranium-series (U-Th) dating

The geochronology of the site was performed on the herbivore maxillary sample CN2014 recovered from unit 7, square N11d. A complete tooth still attached to the jawbone was selected for the Uranium-series (U-Th) dating protocol (Fig. 2A). U-Th dating of fossil remains is a direct absolute dating (Rae & Ivanovich 1986; Bischoff et al. 1988) based on the principle that all the uranium measured in the fossil bones and teeth comes from an uptake during burial. Thorium, a daughter isotope of uranium appearing as a decay product, is insoluble in water and therefore does not migrate with uranium into the fossils (Langmuir 1978). The U-Th age is therefore calculated by determining the ratio between the parent isotope 238U and the daughter isotopes 234U and 230Th. An accurate understanding of the U-uptake history is the key to a precise U-Th dating. Depending on the uptake process, either early, continued, fragmented or late in



D

	Sample	Error
U(ppm)	31.3	0.1
Th(ppm)	0.047	0.002
234/238	1.072	0.003
230/238	0.5117	0.003
230/232	1043	2
Age (ka)	**70.2**	**1/0.9**

Fig. 2. Unit 7. Picture of the maxillary tooth of a herbivore sampled for dating (A); location of the laser ablation tracks for the uranium and calcium distribution (B); map of the U/Ca ratio distribution across the sample and location of the sampling area for the MC-ICPMS solution dating protocol (C); table showing the results of the MC-ICPMS analyses, including the ratio of uranium decay chain and age of the sample (D).

Abb. 2. *Schicht 7. Großer Herbivorenzahn, der für die Datierung beprobt wurde (A). Zone an der die Laserablation durchgeführt wurde (B). Verteilung des U/CA Verhältnisses auf dem Zahn und Probenentnahmestelle für die MC-ICPMS Messung (C). Ergebnisse der MC-ICPMS Analyse und Altersschätzung der Probe (D).*

the burial, the age will vary considerably. The sample is carefully analysed for discrepancy in the uranium and thorium distribution as well as potential diagenetic effects (Fig. 2B). The teeth did not appear weathered, were not discoloured or showed any kind of alteration of the enamel. A first analysis of one of the teeth by LA-ICPMS at SCU-SOLARIS was performed for pre-assessment of uranium diffusion and other trace elements distribution (Sr, Ba, rare earth) using small mapping process (Austin et al. 2013). Using a diamond saw, we carefully sampled the dentine and the enamel in the area of the tooth where the ICPMS results showed homogenous results and higher uranium content (Fig. 2C). The sample was then crushed into a fine powder for MC-ICPMS solution analyses. Column chemistry was undertaken to isolate the uranium and thorium in the sample, before being spiked with the standard (236U and 229Th) for calibration purposes. All LA-ICPMS data are corrected for background, drift, while MC-ICPMS solution results were corrected for background, drift, tailing, SEM non-linearity and isotopic fractionation.

Trace elemental analyses showed that the uranium content is homogenous in the dentine area encapsulated between two enamel layers (Fig. 2C). This result supports the hypothesis of a straightforward uptake history. The uranium 238U distribution is uniform across the area with no apparent leaching or successive waves of uptakes (Grün et al. 2008) (Fig. 2C). The very small amount of detrital thorium across all the dentine is also a good indicator of the reliability of the results for this sample (Fig. 2D). The specimen appeared ideal for accurate U-Th dating, with a minimum age of 70.2 +1/-0.9 ky BP, which is most likely close to the true age of the sample.

Archaeological excavation

The archaeological unit 7 was excavated using a 33x33 cm grid due to the density of the finds (charcoal, bones and lithics). With regard to the other layers, 3 and 5 were excavated using arbitrary spits, 6 and 8 were excavated using a 1 sq.m grid, for recovering the sparse stones and bones embedded at the base and the top of the units respectively. Three-dimensional piece-plotting using total station, horizontal and vertical inclinations were recorded for flint flakes and cores ≥3 cm, bones ≥5 cm, even if fragmented, including smaller fragments in cases where they were still connected to the main piece, teeth and determinable fragments ≤5 cm, large and well preserved charcoal fragments, and bone retouchers. Undisturbed samples were taken systematically from the centre of each square for soil micromorphological, microstereoscopical and other analyses. Hearths or related structures were mapped, and partially excavated in order to examine their micro-stratigraphy as well as for taking undisturbed samples, and field notes were taken with regard to their lithological, pedological and stratigraphic relations.

Zooarchaeology

Taxonomic determination and zooarchaeological analysis were undertaken on the faunal remains of units 1rim and 7, this latter including materials from the base of unit 6 and the top of unit 8 close to the boundaries with unit 7. The most frequent taxa are giant deer (*Megaloceros giganteus*), red deer (*Cervus elaphus*) and bovids (*Bos/Bison, Bison priscus* and *Bos* cf. *primigenius*). Remains of cervids not identifiable to genus or species are also common (Fig. 3). Roe deer (*Capreolus capreolus*), chamois (*Rupicapra rupicapra*) and ibex (*Capra ibex*) are also present but in low quantities. Carnivores are scarce, among them, the most common is the bear (*Ursus* sp.; *Ursus spelaeus*), while wolf (*Canis lupus*) and fox (*Vulpes vulpes*) are represented by 3 fragments each. Birds are also present. This association reflects an open plains environment: bison and large-sized cervids are abundant on open grasslands in a generally cold-temperate climatic context. The presence of giant deer, red deer and aurochs can confirm this ecological context, while roe deer implies the existence of riparian zones bording ponds as in the case of the Calto area and the tributary valleys.

The taphonomic conditions reveal an excellent preservation of the osteological material, except natural alterations due to root dissolution, manganese oxide stains and concretions. The remains are well preserved and their surfaces show clear anthropic marks and corrosion pits, while exfoliation, carnivore and rodent gnawing are recorded to a lesser extent. Several remains were exposed to fire: 45.9 % show traces of burning, while the 8.4 % are calcined. Butchering traces have been detected on nearly half of the total number of bones larger than 5 cm: cut marks and scraping marks are present on 45.8 % of the determined fragments, percussion notches are seen on 1.9 % and spiral fractures, typical of fresh bone, were observed on 26.9 % of the shaft fragments. These anthropic traces are present only on ungulate bones, but come from almost every anatomical region (Figs. 4 and 5).

Small mammals

Small mammals recovered from unit 7 are few in number, but a preliminary analysis has identified 53 micromammal remains, with a minimum of 33 individuals, representing at least 11 taxa: two insectivores (*Talpa europaea* and *Sorex* gr. *araneus-samniticus*), one bat (*Myotis* sp.) and eight rodents (*Arvicola amphibius*, *Microtus arvalis*, *Microtus agrestis*, *Microtus* (*Terricola*) gr. *multiplex-subterraneus*, *Chionomys nivalis*, *Clethrionomys glareolus*, *Apodemus sylvaticus* and *Apodemus flavicollis*). This assemblage reflects a landscape dominated by open forests, as indicated by the vole species *M. arvalis*, *M. agrestis*,

Taxa	NISP	*% NISP*	MNI
Canis lupus	3	*1*	1
Vulpes vulpes	3	*1*	1
Ursus spelaeus	4	*1.3*	1
Ursus sp.	11	*3.5*	1
Carnivora indet.	1	*0.3*	
TOTAL Carnivora	22	*7.1*	4
Megaloceros giganteus	85	*27.2*	4
Cervus elaphus	82	*26.3*	6
Capreolus capreolus	14	*4.5*	2
Cervidae indet.	43	*13.8*	
Bison priscus	11	*3.5*	2
Bos cf. *primigenius*	1	*0.3*	1
Bos/Bison	48	*15.4*	4
Capra ibex	1	*0.3*	1
Rupicapra rupicapra	3	*1*	2
Caprinae indet.	2	*0.6*	
TOTAL Artiodactyla	290	*92.9*	22
TOTAL NISP	312	*100*	26
Indeterminate			
small-medium size Ungulata	3	*0.1*	
medium size Ungulata	80	*0.4*	
medium-large size Ungulata	246	*1.2*	
large size Ungulata	585	*2.8*	
ND size Ungulata	158	*0.7*	
small size mammals	8	*0.1*	
medium-large size mammals	23	*0.1*	
large size mammals	43	*0.2*	
ND size mammals	19445	*94.4*	
TOTAL indet.	20591	*100*	
Ichthyofauna	1		1
Unidentified birds	5		5
Aegypius cf. *monachus*	1		1
Total bird remains	6		6
Total NDR	319	*1.5*	33
TNR	20910	*100*	

Fig. 3. Unit 7. Number of large vertebrate recovered remains expressed in Number of Identified Specimens (NISP) and Minimum Number of Individuals (MNI).

Abb. 3. *Schicht 7. Häufigkeiten der Knochen von Wirbeltieren aus der Grabung, aufgeteilt nach der Anzahl der identifizierten Stücke (NISP) und nach der Mindestindividuenzahl (MNI).*

	Total NDR	CM/SM	PM	CM/SM + PM	PC	PC + CM/SM	BM	% BM	R	B + C	B + CM/SM	carnivore marks	
												GM	D
NDR	319	86	30	50	4	2	177	55.5	39	14	5	28	1
%		*27*	*9.4*	*15.7*	*1.3*	*0.6*	*55.5*		*12.2*	*4.4*	*1.6*	*8.8*	*0.3*
ND Ungulata	1072	475	43	35	224	30	826	77.1	48	286	164	29	
%		*44.3*	*4*	*3.3*	*20.9*	*2.8*	*77.1*		*4.5*	*26.7*	*15.3*	*2.7*	
ND mammals	19519	48			31		79	0.4	5	11344	28	5	2
%		*0.2*			*0.2*		*0.4*		*0*	*58.1*	*0.1*	*0*	*0*
TNR	20910	609	73	85	259	32	1082	5.2	92	11644	197		
%		*2.9*	*0.3*	*0.4*	*1.2*	*0.2*	*5.2*		*0.4*	*56*	*0.9*		

Fig. 4. Unit 7. Detail of the butchering marks, thermal alteration and carnivore marks observed on the bones surface. CM: cut marks, SM: scraping marks, PM: percussion marks, PC: percussion cone, BM: butchering marks, R: retouchers, B: burned-black/brown bones, C: calcined-grey/white bones, GM: gnawing marks, D: digested.

***Abb. 4.** Schicht 7. Häufigkeiten der beobachteten Oberflächenveränderungen. CM: Schnittspuren; SM: Kratzspuren; PM: Schlagspuren; PC: Schlagkegel; BM: Schlachtspuren; R: Retuscheure; B: angebrannte Knochen; C: Kalzinierte Knochen; GM: Fraßspuren; D: verdaute Knochen.*

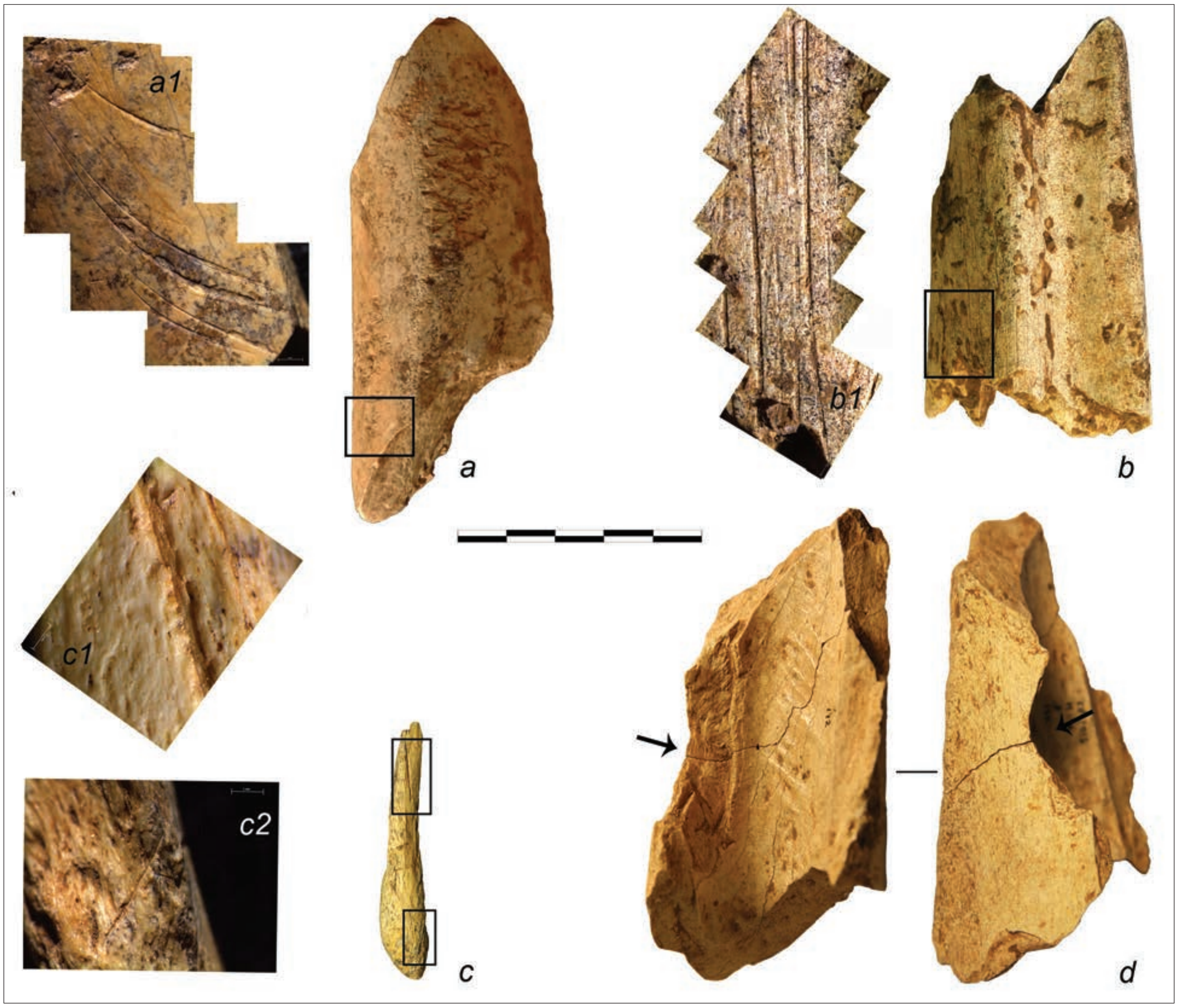


Fig. 5. Unit 7. *Bos/Bison* (a) left humerus with defleshing cut-marks and close-up (a1); *Megaloceros giganteus* (b) metatarsus with scraping marks and close-up (b1), (d) proximal humerus with percussion marks, indicated by arrows; *Cervus elaphus* (c) atrophic metapodial with butchering cut-marks and close-ups (c1, c2).

***Abb. 5.** Schicht 7.* Bos/Bison: *(a) linker Humerus mit Schnittspuren, (a1) vergrößert;* Megalocerus giganteus *(b) Metatarsus mit Schabespuren, (b1) vergrößert; (d) proximales Humerusfragment mit Schlagspuren (s. Pfeile);* Cervus elaphus *(c) Metapodialfragment mit Schnittspuren, (c1, c2) vergrößert.*

and *C. glareolus,* and the shrew, *S.* gr. *araneus-samniticus*, together with stable water-streams in the vicinity of the cave, as suggested by the presence of the water vole (*A. amphibius*).

Bone tools

As previously mentioned, the high number of bone retouchers is one of the most important features of the De Nadale Cave. A total of 204 tools have been identified so far, most of them from unit 7. To these items, we added the bones recovered from unit 1rim, assuming that this material was embedded in an original context comparable to unit 7 and then reworked by bioturbation. Surface preservation and morphometrical features of the bones are similar to the items from unit 7. These tools are made on bone flakes produced by the fragmentation of the long bone shafts of large ungulates, like *Megaloceros giganteus*, *Bos/Bison* and *Cervus elaphus* and, occasionally, *Rupicapra rupicapra* and *Capreolus capreolus* or, exceptionally, for the Middle Palaeolithic of this region, on a jaw of *Megaloceros giganteus*, which was used in two different areas. The hind limbs seem to have been preferentially selected, as tibia and femur have the highest representation among the anatomical portions at De Nadale Cave. The retouchers have mostly been retrieved from bones fractured in their fresh state, probably broken to obtain the bone marrow especially abundant in the long bones shafts. The processes of fracturation might however have followed a determined pattern in order to produce shafts that were fit to be used as bone retouchers. Indeed, their margins show typical green-bone fractures. Most of the retouchers bear only one imprinted area, although some specimens bear two or three. In one case, four areas have been recognised. The retouch-induced stigmata, consist of punctiform impressions, linear impressions, strias and notches (Fig. 6). They are found in small, concentrated areas, located near the extremities of the bone fragment. In some cases, the retouch-induced stigmata are super-imposed, and can be identified by their differing orientations. The retouchers were used with variable intensity, as shown by the type and density of the stigmata: shallow, sparse marks, mostly punctiform and linear impressions, or tools bearing deep marks and notches. Interestingly, in some instances, the retouch-induced stigmata seem to have been produced secondarily, when the bone was no longer in a fresh state. This implies that the moment of bone fragmentation in order to retrieve the bone marrow and the time of use of the shafts as bone retouchers are chronologically separated.

Lithic industry and retouched tools

The lithic assemblage of De Nadale Cave includes 386 artefacts, found in units 1rim, 3, 6, 7 and 8. A few lithics have been recovered at the base and top of units 6 and 8 respectively, close to the contact zone with unit 7. A similar situation was observed for the bones in these levels. All knapping products and by-products over 2x1cm size are included (Fig. 7). Technological and typological features make this industry different from the Mousterian of this region, especially with regard to the method adopted in core reduction, and the type of blanks and retouched tools. The identification of the concepts and the reduction procedures of the raw cobbles, and the way the platforms and knapping surfaces were managed are hindered due to the intense retouch the tools underwent, and the fragmentation of the reduction sequence. This latter is biased by the scarcity of the products issued from the initial and preparatory stages, in comparison to those related to the production and the management of the tools.

The most exploited raw material is the flint from the Cretaceous carbonatic formations, especially the Scaglia Rossa and Maiolica. There are also few artifacts made on Scaglia Variegata flint and, sporadically, on flints from the Jurassic oolitic limestones and the Tertiary carbonatic sandstones. As inferred from the examination of the surface features of the cortical flakes, the raw material was supplied as follows: Scaglia Rossa flint was collected in the form of weathered flat slabs or nodules directly from the primary outcrops, located at a minimum distance of 5 km from the site, in an area extending from the eastern Berici Hills to the Euganean Hills; Maiolica flint may have been collected from both primary exposures and gravel stream beds in the Central Lessini Mountains, 20-25 km to the north-west. Indeed, of the many zones considered suitable for supplying excellent fine textured and knappable rocks, the most surveyed were the western-central Lessini Mountains and the Euganean Hills in the alpine foreland. Except for some patches along the eastern Berici hillslope, a vast sector devoid of suitable rocks like the eastern Lessini reliefs, the alluvial plain, and the Berici Plateau (Antonelli et al. 1990; Bertola 1995-96) keeps these main districts separate. In these areas, river and stream gravel beds, glacial and fluvio-glacial deposits should be considered as the most probable source for the flints in the form of blocks, nodules, and pebbles, including the rounded cobbles contained in Oligocene-Miocene and Pleistocene clastic deposits, palaeosols and reworked soil sediments.

The scarcity of flakes with intact (n = 29/7.5 %) and fragmentary (n = 20/5.2 %) cortical cover (Fig. 7) is an expression of the occasional decortication of the blocks and nodules in an advanced stage of the reduction sequence, as suggested from their small mean size (25x19x6 mm in length, width and thickness respectively), but also of the selection of these artifacts as blanks for scrapers and other retouched tools introduced to the site. The intense reduction caused from the retouch makes their determination uncertain.

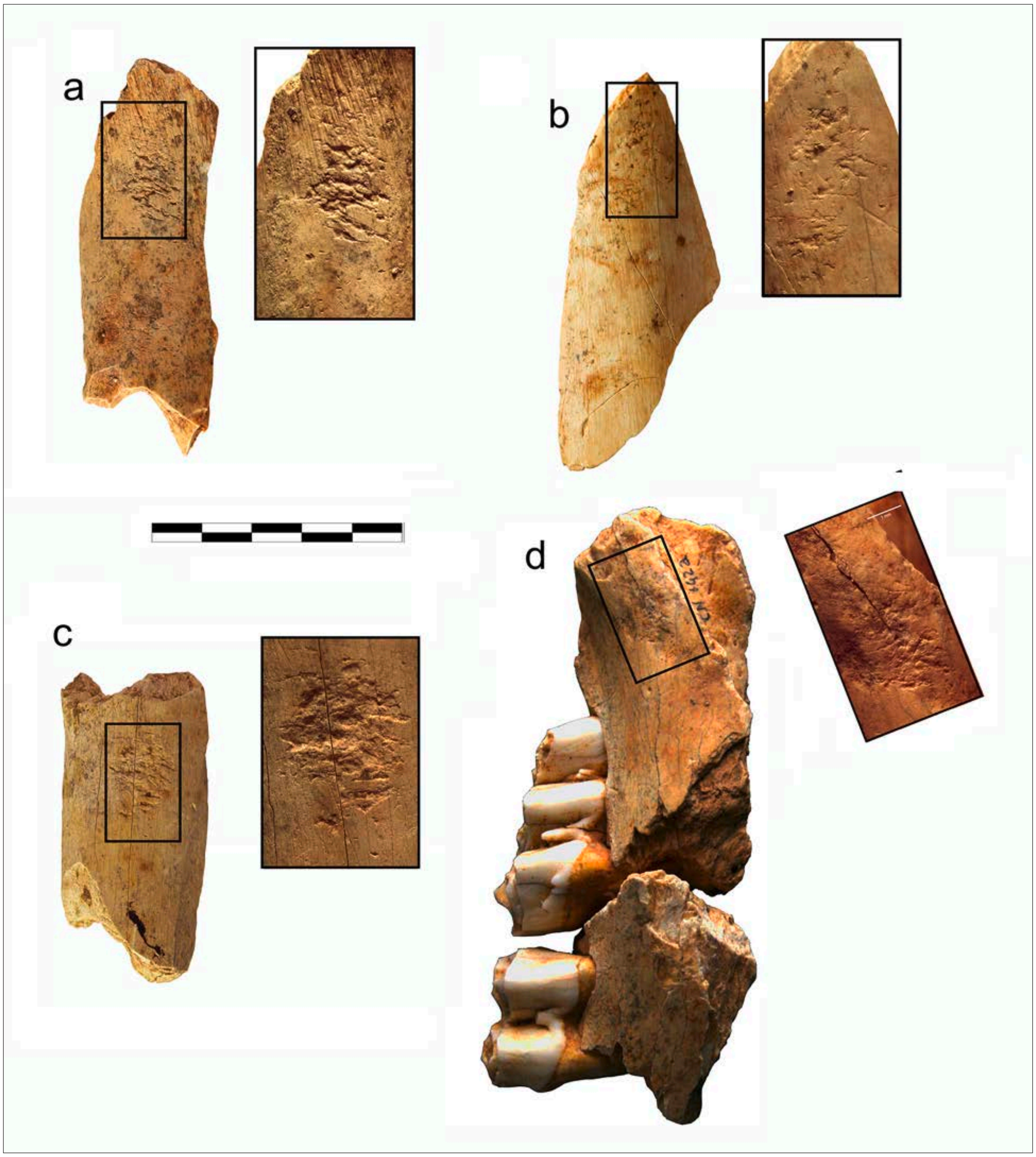


Fig. 6. Unit 7. Bone retouchers: (a) *Cervus elaphus*, left humerus, bearing punctual and linear impressions; (b) diaphysis of ungulate bearing punctual and retouch-induced striae; (c) diaphysis of ungulate bearing deep notches and punctual impressions; (d) *Megaloceros giganteus*, left mandible, bearing punctual and linear impressions and retouch-induced striae.

Abb. 6. *Schicht 7. Knochenretuscheure: (a)* Cervus elaphus, *linkes Humerusfragment mit punktförmigen und linearen Schlagmarken; (b) Fragment eines Huftierknochens mit punktförmigen und durch Retuschieren verursachten Marken; (c) Fragment eines Huftierknochens mit tiefen Kerben und punktförmigen Schlagmarken; (d)* Megalocerus giganteus, *linker Unterkiefer mit punktförmigen und linearen Schlagmarken sowie durch Retuschieren verursachten Marken.*

The full phase of production adapts to the original cobble morphology and involves the exploitation of more than one main flaking face, not necessary in an ordered way, but in allowing for each face to perform a different function: by flaking around surface A, which is basically wide and flat, surface B develops, which is adjacent and secant to A, forming an angle of 70° (Fig. 8). From surface B thick blanks were detached with an obtuse knapping angle, leading to an intense reduction of the core size at the cost of surface A. This was exploited by detaching larger and thinner flakes along a plane parallel to the core face, testified by the

Type			N	%
Primary products	Full production flakes		15	3.9
	Retouched tools	Scrapers	55	14.2
		Notches	5	1.3
		Points	4	1
		Other	14	3.6
By-Products	Cortical flakes		29	7.5
	Core management flakes		75	19.4
	Reparation flakes		10	2.6
	Knapping errors		21	5.4
Retouching or resharpening flakes			36	9.3
Kombewa-type flakes			18	4.7
Cores			20	5.2
Fragments	Non-cortical		37	9.6
	Cortical		21	5.4
Undetermined			26	6.7
Total			**386**	**100**

Fig. 7. Unit 7. Techno-typological composition of the lithic assemblage.

Abb. 7. *Schicht 7. Techno-typologische Zusammensetzung des lithischen Inventars.*

90° knapping angle. The achievement of the full operational system testifies to the adoption of a centripetal or at most bidirectional-orthogonal (rarely unidirectional) scheme on face A, where centripetal and core-edge removal flakes invade the exploitable surface. The blanks detached from face B are manufactured by striking the inner part of the peripheral edge on face A, which thus plays the role of a striking platform. Thick flakes are thus obtained. They also have a distinctive butt made of two flat or concave scars separated by a horizontal ridge. Sometimes, several knapping faces, adjacent to each other, can be opened from this platform. They reveal that the aim of the production sequence was to exploit the core to its full extent and overcome problems due to uncorrected knapping procedures or defections of the flint. Because of these changes, the core may assume a nearly polyhedral morphology.

Variants to this operational scheme correspond mainly to issues of suitability and versatility related to the properties of the raw material. For example, small slabs were exploited to obtain short, wide and thick flakes, along the maximum thickness of the blank, which were knapped from one or more natural flat platforms without changing the knapping face. According to Hiscock et al. (2009), this reduction scheme is comparable to the "slicing" method recognized in Quina technology assemblages of Dordogne, France. Also recorded, albeit with a lower frequency, is a Kombewa-type reduction aimed to reduce large flakes in order to obtain thin and often backed pieces.

Of the 93 primary knapping products, 83.9 % are retouched: most frequent are scrapers (52), followed by retouched flakes (14), retouched points (5) and notches (5) (Figs. 7 and 8). Of the scrapers, the most common are lateral scrapers, followed by transverse, lateral-transverse and convergent types, characterized by direct and scaled retouch. These tools were made on two types of flakes - short, wide and thick (32x28x11 mm on average) flakes, often cortical or bearing a cortical back, with a large knapping angle, which are the result of the exploitation of surface B or those from the exploitation of flat slabs, and, slim and thin (28x22x4 mm average) flakes, uncortical, sometimes with a knapped back, obtained from surface A or rarely, from thick flakes. With regard to the notches, it cannot be excluded that some are the outcome of the scraper resharpening, according to well-known practices in the Quina Mousterian (Verjux & Rousseau 1986).

Intense retouching is also suggested by 36 retouched flakes, generated during the primary shaping and the resharpening stages. Note that this amount is largely underestimated due to the incomplete analysis of the chips. Nevertheless, when compared to the elevated amount of bone retouchers, these chips contribute in suggesting that specialized tasks requiring tool production and maintenance occurred at this site. The majority of these products have been identified on the basis of features broadly known in literature: pronounced lip, diffused bulb, a tight angle between the butt and the upper face, and incessant micro-scarring on the dorsal surface; however, in the case of more invasive retouched flakes, recognized by a slight curvature on the distal portion which overtakes the tool's major convexity, they may have been selected as blanks for further tool production, with fine and marginal retouch.

The occurrence of some of these traits on the knapped products related to the stages of full production and core convexity maintenance poses a question on the knapping techniques adopted at De Nadale Cave. Even though the use of direct percussion with hard hammer has been indirectly identified, it cannot be excluded that even within the main production sequences some detachments have been carried out by direct percussion with soft hammer. This practice was primarily undertaken using animal bone tools, but the use of limestone pebbles, as attested from the French site of Jonzac (Roussel et al. 2009), must also be taken into account, where the high frequency of bone retouchers and residual by-products of such activity is comparable to the De Nadale Cave.

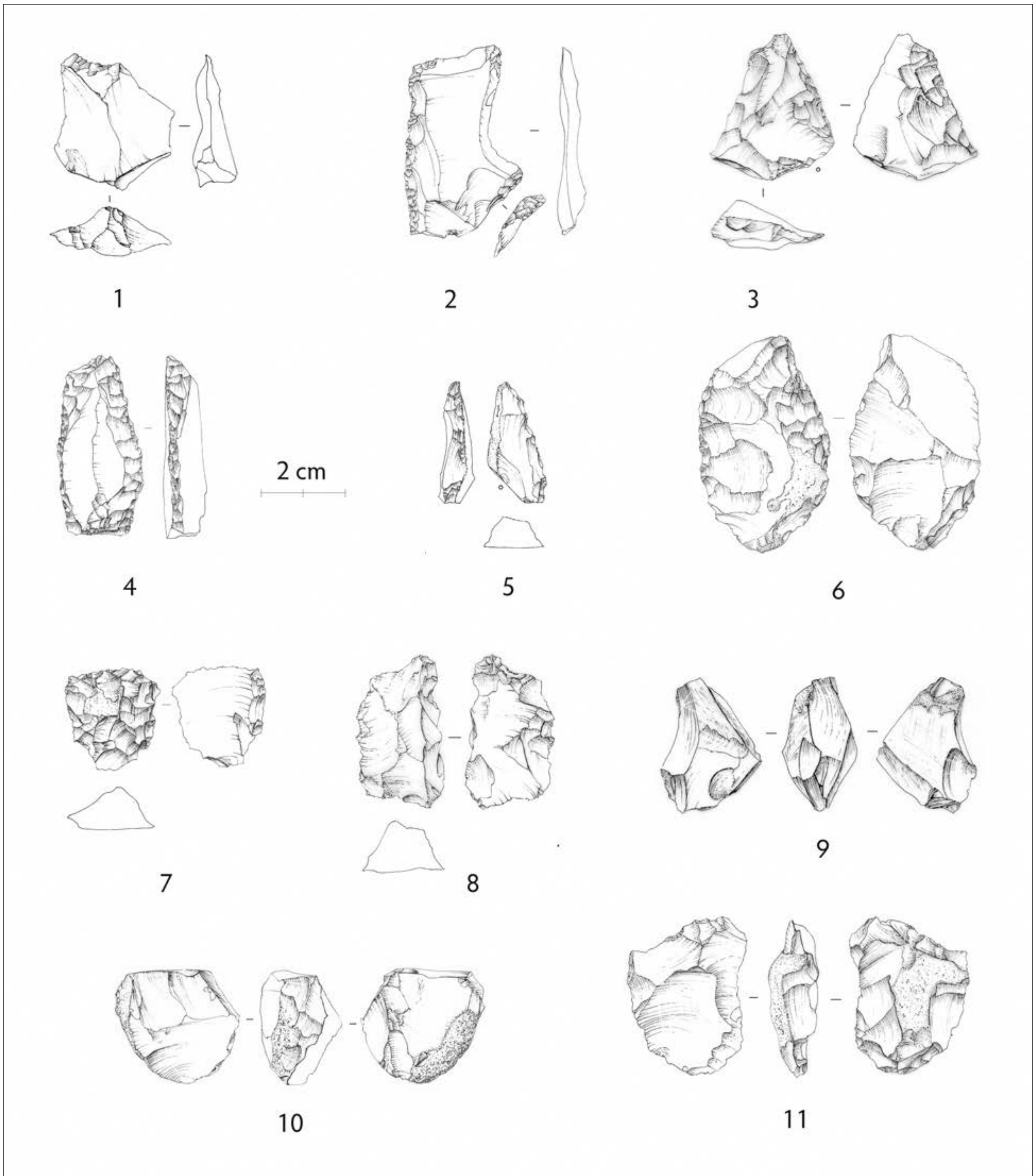


Fig. 8. Unit 7. Lithic artifacts: flake (1), scrapers (2-7), denticulate (8), cores (9-11); , ⅔ natural size; drawings M. Boldrin.

Abb. 8. *Schicht 7. Steinartefakte: Abschlag (1); Schaber (2-7); gezähntes Stück (8); Kerne (9-11); ⅔ natürliche Größe; Zeichnung M. Boldrin.*

De Nadale Cave in a regional late Middle Palaeolithic context

Based on the hunted faunal assemblage, the lithic economy, the bone industry and above all, the Quina assemblage, the evidence from the De Nadale Cave represents an unusual type of Neanderthal occupation during the Late Pleistocene of North-eastern Italy, at the onset of MIS4. The human frequentations occurred in an ecological context compatible with the cold environmental conditions of the Berici Hills, as defined by the Fimon pollen association (Pini et al. 2010). During the transition from the Early to the Middle Würm, no sharp decreases of Arboreal Pollen % (AP) have been detected from the pollen record. Rather, after a moderate decline of *Picea* sp., a mild oscillation enhanced prompt restoration and coeval strong expansion of *Betula* sp., *Alnus* sp. and *Tilia* sp. pollen. Nevertheless, the frequency of *Picea* sp. and *Betula* sp. follows the previous mild phase, possibly because of drier conditions but in coincidence of a further increase of steppic communities, giving origin to a mosaic of boreal forest and steppe (Pini et al. 2010).

Hunting and related activities are largely recorded along the Pre-Alpine belt, in accordance with the ecological conditions extant in proximity of each specific site, which shifted as a consequence of climatic oscillations during the Late Pleistocene (Fiore et al., 2004). Ungulates such as red and roe deer were mainly hunted, with the occasional occurrence of chamois and ibex (Fiore et al. 2004) and limited exploitation of bovids, giant deer, elk and, exceptionally, wild boar. San Bernardino Cave, Fumane Cave and presumably Tagliente Rockshelter share similar exploitation models based on the selection of young adult and adult individuals (Fiore et al. 2004; Thun-Hohenstein & Peretto 2005; Peresani et al. 2011). The De Nadale Cave diverges from this behavior in that it demonstrates that predation was mostly focused on large herbivores like aurochs, bison, giant deer and red-deer. This game possibly reflects the ecological variability around the cave, characterized by the co-existence of open environments on the Berici plateau and the possible presence of springs at the base of the Calto valley, similar to the marshy conditions typical of the inner valleys of this district and at the foot of the eastern slopes of the Berici hills.

Neanderthals entered the cave equipped with cores, large flakes and retouched tools. The preliminary considerations concern the composition of the lithic assemblage of unit 7, which records a flake volumetric concept unknown in the Berici Hill sites as well as an uncommon rate in retouched artifacts. Evidence of application of the Quina method is ephemeral around the North-Adriatic area, due to the large prevalence of Levallois technology in almost all the Mousterian sites (Peresani 2001; Karavanić 2004). The only sites currently known to have Quina assemblages are at Grotta di Fumane and Grotta della Ghiacciaia. At Fumane, a technological and typological break due to the replacement of the Levallois with the Quina assemblage occurs between units BR6 and BR3, still undated but embedded between layer BR11, TL dated to 55 ± 7 ky BP (Martini et al. 2001), and the set of layers A11-A9, where the latter has produced a minimal age of 47.6 ky BP (Peresani et al. 2008). Lithic and faunal remains were scattered in the proximity of single hearths as a result of repeated occupational events correlated to the consumption and discard of bones and lithics (Cremaschi et al. 2002; Peresani, 2012). The assemblage is almost exclusively composed of cortical and non-cortical large scrapers, a few flakes and cores. The flake-making focused either on large flakes with thin transverse edge, or short and thick flakes. Almost all the flakes have a backing opposed to the retouched edge. The scrapers have stepped-scaled retouch of third order or higher. They are of the simple, double, convergent, lateral-transverse, transverse or bifacial types. Quina scrapers are also present in layers 37-41 at Grotta della Ghiacciaia in the same valley of Fumane (Bertola et al. 1999). Radiometric dates and fine biostratigraphic resolution are not available, and no inferences for the chronological position of this industry can be provided currently.

Conclusions

The features identified at De Nadale Cave suggest that the unusual nature of the assemblage must be examined in comparison with excavations in progress and the refinement of techno-functional, spatial and zooarchaeological investigations. The provenance of the lithic raw materials offers a potential for comparisons between the sites in the Berici hills, which share similar locations, but differ in the lithic source areas and the techno-economic profiles. This gives the opportunity to make hypotheses on how these resources where managed at the regional level (Porraz & Peresani 2006), despite the technological behaviors were mostly based on the recurrent Levallois modalities (Peresani 1995-96, 2000-2001, 2001).

During the Late Middle Palaeolithic, the De Nadale Cave was part of a settlement system where lithic production was intimately integrated into the acquisition, processing and consumption of ungulates. In this scenario, some camps were settled far from the primary mineral sources. For this reason, sites located far from raw material sources should attract Paleolithic archaeologists interested in reconstructing the seasonal movements in the sub-Alpine area. Evidence of lithic tool production, split into separate phases, might suggest anticipation in human behavior, and the different ways these items were circulated, as correlates of the geographical location and function of the site. The deviation from the common deep-rooted technological patterns by Neanderthals should also be taken into account in exploring the variability of Mousterian techno-complexes in this region also viewed as a result of ecological factors.

We suggest that the De Nadale Cave should be used as a case study for understanding the complexity of Neanderthal behavior in a region where the Middle Palaeolithic is the focus of long-term research projects aimed at reconstructing movements and economies of Neanderthal populations. Additional excavations and analyses, both on the lithic industry and on the faunal remains, will cast new light on the site and clarify its relationship with the territory, the organization of the site itself, the activities, the hunting areas and the chronology of the occupation.

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