New evidence for the Mousterian and Gravettian at Rio Secco Cave, Italy

Marco Peresani[1], Matteo Romandini[1], Rossella Duches[1], Camille Jéquier[1], Nicola Nannini[1], Andreas Pastoors[2], Andrea Picin[2], Isabell Schmidt[2], Manuel Vaquero[3], Gerd-Christian Weniger[2]

[1]University of Ferrara, Ferrara, Italy, [2]Neanderthal Museum, Mettmann, Germany, [3]Universitat Rovira y Virgili, Tarragona, Spain

The dearth of evidence for late Neanderthals in Europe reduces our ability to understand the demise of their species and the impact of the biological and cultural changes that resulted from the spread of anatomically modern humans. In this light, a recently investigated cave in the northern Adriatic region at the border between the Italian Alps and the Great Adriatic Plain provides useful data about the last Neanderthals between 46.0 and 42.1 ky CAL B.P. Their subsistence is inferred from zooarchaeological remains and patterns in Middle Palaeolithic lithic technology. Unexpected evidence of the ephemeral use of the cave during the early Upper Palaeolithic Gravettian period shows a change in lithic technology.

Keywords: Mousterian, Gravettian, Neanderthal demise, lithics, cave bears

Introduction

Within the northern regions of the Mediterranean basin, several sites dated to the end of the Middle Palaeolithic have produced data of variable relevance to the study of the last Neanderthals in Europe. One of these regions is the belt surrounding the present-day northern Adriatic Sea, which includes the Venetian region in the northern part of Italy and the Dalmatian coast of Croatia, and contains numerous Middle Palaeolithic sites in different ecological contexts (FIG. 1). Between the alluvial plain and the Prealps in Italy some key caves show repeated occupations where lithic production was integrated with the acquisition and consumption of food resources. These sites are characterized by their short and ephemeral use and their location in the vicinity of flint outcrops or at stops along seasonal routes (Peresani 2011).

Rio Secco Cave, discovered in the Carnic Prealps in 2002, provides new data for understanding Palaeolithic mobility, settlement patterns, and resource exploitation. The mountain zone in which the cave sits had been considered peripheral to the plain extending southward that was seasonally occupied by mobile hunter-gatherers in the Middle Palaeolithic.

Site Setting

Rio Secco Cave is situated at an elevation of 580 masl on the Pradis Plateau in the eastern part of the Carnic Prealps. The plateau is enclosed on three sides by mountains and on the south by foothills. The plateau faces the Friuli Plain, part of the uppermost belt of the Great Adriatic Plain that emerged during the Late Pleistocene with its maximum southern expansion during the Last Glacial Maximum (LGM) (Shackleton *et al.* 1984). Due to its geographic setting between the plain and the Prealps, the Pradis Plateau holds a strategic position, which may have facilitated Neanderthal and anatomically modern human (AMH) penetration into the alpine region and the upper Tagliamento Basin (FIG. 2).

The plateau is characterized by a gentle undulating landscape deriving mainly from the low dipping of the Cretaceous carbonate formations (Rudist limestone and Scaglia Rossa) and partly from the flysch that covers over one-third of the total surface (De Nardo 1999). Where the flysch permeates the substrate it supports the formation of a surface hydrographical system resulting in a landscape with typical fluvial features such as valleys, terraced surfaces, and thin alluvial sheets. The limestone bedrock, affected by karst degradation processes, produces an uneven microtopography with isolated blocks, peaks, and dolines along main fractures or tectonic discontinuities. The bedrock has a dense system of more than 200 explored cavities, some of which penetrate several kilometers while varying in depth by a few dozen meters (Cucchi and Finocchiaro 1981). The Cosa and Rio Secco waterways dissecting

Correspondence to: Marco Peresani, University of Ferrara, Dipartimento di Studi Umanistici, Sezione di Scienze Preistoriche e Antropologiche, Corso Ercole I d'Este 32, I-44100, Ferrara, Italy. Email: marco.peresani@unife.it

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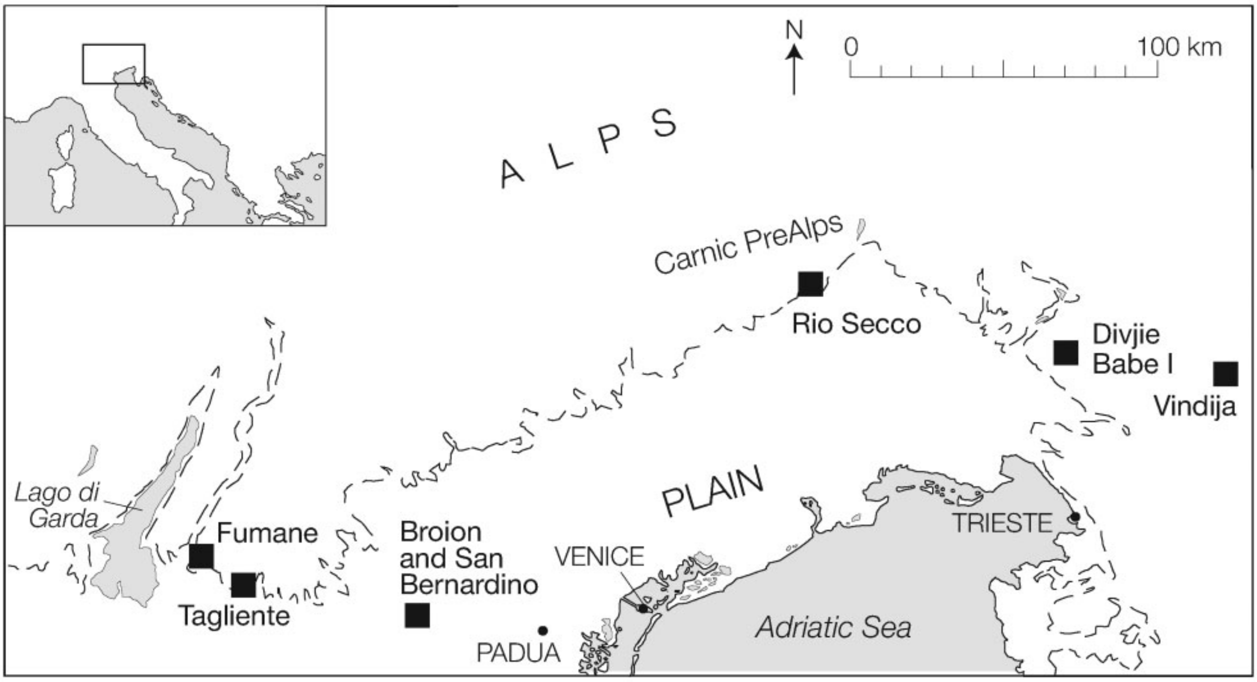

Figure 1 Map of the northern Adriatic region showing the positions of the Mousterian and Gravettian sites mentioned in the text.

the plateau run through deep and narrow gorges framed by a combination of tectonic uplift and karst and runoff erosional processes (FIG. 2). Along these gorges, several shelters and caves formed in the rock walls and along the base of walls when dolines collapsed. A few of them have been explored for the presence of Pleistocene deposits and have yielded Mousterian (Grotte Verdi) and Late Epigravettian (Grotte Verdi, Grotta del Clusantin) evidence for human use or habitation (Bartolomei *et al.* 1977; Corai 1980).

Excavations at Rio Secco Cave

Rio Secco Cave is ca. 20 m above the present-day streambed. Facing south, the shelter has a wide flat roof derived from the collapse of large slabs of limestone. The sheltered area is bounded by boulders at the entrance used recently to delimit a zone used by herders (FIGS. 3, 4). The gallery cave is 12 m deep. Below the cave mouth the fill forms a slopewash deposit thickening along the present-day dripline where boulders mark the probable position of the now-collapsed roof overhang.

In 2002 a test pit (GRS I) exposed a group of layers with Mousterian lithic artifacts and faunal remains dated to 42.2 ky CAL B.P. (Peresani and Gurioli 2007). This was followed by excavations from 2010 to 2012. A large sector (3 × 7 m) was opened in front of the cave, 6 m inside the present-day dripline (FIGS. 3, 4B). After reworked sediment in the back of the cave had been removed, the top of the Pleistocene fill was exposed, along with the traces of an old excavation in the southeastern sector of the cave. All sediments were excavated in 50 × 50 cm or 33 × 33 cm squares,

Figure 2 View to the south from the Pradis Plateau. The arrow marks the position of Rio Secco Cave in the gorge. The alluvial plain with the Tagliamento River in the center is on the horizon.

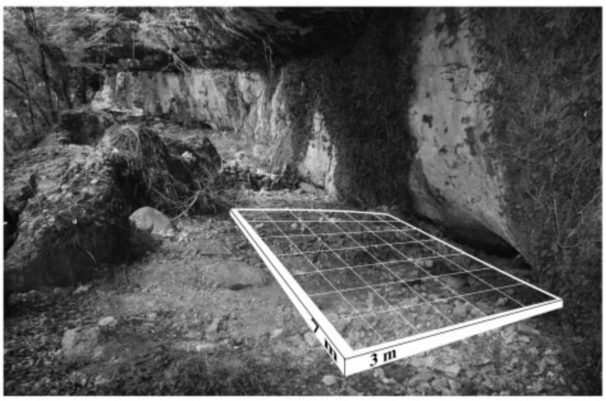

Figure 3 A view of Rio Secco Cave before the start of excavations (indicated by grid) in 2010.

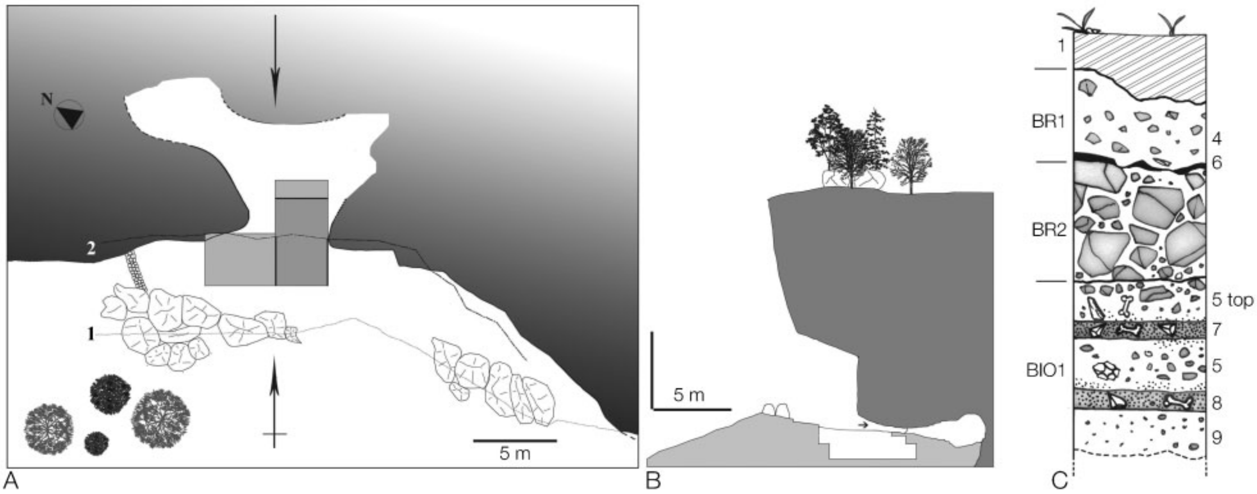

Figure 4 A) Plan view of Rio Secco Cave (line 1 is the external overhang and line 2 is the small cliff above the entrance to the cavity); B) Section of the site showing the position of the excavations; C) Summary of the stratigraphic sequence with numbered layers and macro-units.

depending on the density of the archaeological finds (charcoal, bones, and lithics) and in some cases (e.g., layer 4), they were removed in arbitrary levels. Three-dimensional piece-plotting using a total station recorded the positions for the following: flint flakes and cores $\geq$3 cm; bones $\geq$5 cm even if fragmented and including smaller fragments if found still connected to the main pieces; teeth and diagnostic fragments $\geq$5 cm (except micromammal and small avifaunal bones); charcoal, when large, compact, and well preserved; and worked pebbles, manuports, retouchers, and hammers. Undisturbed samples were taken systematically for analyses. Hearths were mapped and surveyed—as well as drawn—noting their stratigraphic relationships with underlying and overlying units, with descriptions of horizontal variations in composition and fabric. Each hearth was partially cut in order to examine its microstratigraphy and to take undisturbed samples.

Stratigraphy

The cave is filled with a suite of sedimentary layers of different shapes, compositions, and origins. A 2.6 m-thick sequence has been exposed so far, without yet reaching bedrock (FIG. 4C). These layers have been grouped into five macrostratigraphic units separated by erosional and sedimentary discontinuities with variable shapes and spatial arrangements. Each macro-unit could contain more than one sedimentary unit. From the top, the macro-units were progressively numbered 1, BR1, BR2, BIO1, and layer 8 as follows.

Macro-Unit 1

This is the most recent sedimentary unit beginning at the present-day surface and extending down to an erosional surface. It includes unit 2, previously described during the test pit excavation in 2002 (Peresani and Gurioli 2007). Thickness varies from 30 cm to over 100 cm, where there is also the evidence of two separate episodes during the last century when the surface was levelled. The composition is mostly stony, with a sequence of large, horizontal levels made by using small stones during historical times.

Macro-Unit BR1 (Breccia 1)

This unit was found across the entire excavated sector. Its lower boundary inclines in a southwesterly direction and includes layer 4 and an anthropogenic horizon with Upper Palaeolithic artifacts (layer 6) (online supplement: fig. A; http://www.maneyonline.com/doi/suppl/10.1179/0093469014Z.00000000098). Its most relevant features are the presence of stones at frequencies ranging from high to very high depending on the extent of degradation of boulders and local rockfall and the preponderance of fine-grained sediments with small stones (<5 cm) over coarse-grained sediments (in a ratio of 3:1). The stones are arranged horizontally, have angular to subangular outlines, and a few are fragments of the karst limestone pavement that originated from the collapse of the roof. The boundary with macro-unit BR2 is abrupt. The dark layer with organic matter and micro-charcoal was exposed over an area of 4 sq m, approximately 20 cm above the top of BR2; it is thin, planar, discontinuous, and contains few bones and lithics (FIG. 4C). It is dissected by marmot and perhaps other animal burrows which have displaced portions of the sediment. Nevertheless, at the entrance of the cave, it is better preserved and thickens as seen in the section cut by unauthorized excavations. The fabric of layer 6 sometimes shows alternation of different color lenses (grayish-brownish to grayish) with size-selected stones. In the squares where this layer is absent, the sediment has been removed in accordance with the arbitrary layers (labeled from 4a to 4f). Layer 6 correlates with spits 4c and 4d.

Macro-Unit BR2 (Breccia 2)

This is a massive and undifferentiated open-work stone-supported breccia made of angular boulders and stones randomly dispersed, with carbonate efflorescences on the lower faces. It lies in the external zone, but ends 1 m behind the dripline in the cavity's southeastern zone, where macro-unit BR1 directly overlies layer 5 top. Large patches are reworked by marmots, as demonstrated by an articulated skeleton of the mammal found within the tunnels and burrows and dens filled with massive, heterometric, porous, and loose sediment. At the base of this macro-unit is a whitish sandy discontinuous level of variable thickness, whose shape is determined by the forms of the lower boulders. This unit is archaeologically sterile.

Macro-Unit BIO1 (Bioturbation 1)

A set of sedimentary units below BR2 is grouped in this macro-unit due to the intense bioturbation caused by the activity of burrowing animals (marmots), which mixed the fine fraction, displacing portions of the anthropogenic sediment and scattering Mousterian flint implements, bones, and charcoal (online supplement: fig. B; http://www.maneyonline.com/doi/suppl/10.1179/0093469014Z.00000000098). At the top there is a brown horizon of variable thickness (layer 5 top), with small, smooth stones that are found throughout the dark brown loamy fine fraction. Sediments consist of stones and a loamy fine fraction of different colors (layer 5, lens 11) and portions, still in place or slightly deformed, of dark loamy horizons with organic material, bones, and lithic implements (layers 7 and 8) (FIG. 4C). Marmot and other animal dens and tunnels are filled up with sediments of different colors, porosities, and consistencies. The net of tunnels seems denser at the cave entrance than in the inner cavity. A brief description of the two anthropogenic layers, 7 and 8, follows.

LAYER 7

This layer was found only below the gallery and not in the external zone, where it was cut by the animal burrows. The upper boundary with layer 5 top is marked by an increasing frequency of bones and lithics, some of which also bear signatures of heating. The layer's thickness varies from 3 to 7 cm; the lower boundary is undulating and irregular; stones prevail but are middle to small sized. The fine fraction is loamy, dark yellowish-brown.

LAYER 8

This layer can be found in square H11-H12 and is 10 cm thick and loamy, with abundant sub angular or smoothed small stones, and fine undeveloped crumb structures. The layer contains many tiny pieces of conifer charcoal and small unburned and burned bones. Deformations, removals, and various marmot tunnels, and other bioturbations affect the layer. Layer 8 lies over layer 9, which is possibly a fifth macro-unit made of stones and yellowish brown sandy-loam having no charcoal or other finds.

Figure 5 The remnants of hearth US6_SI at the entrance to the cave; the white dots are boundary markers.

Since bedrock has not been reached the total depth of the cave fill remains unknown. The main mechanisms responsible for the formation of the excavated sediments are freeze-thawing and rock collapse. If we exclude level 9, for which a hypothesis about its genesis is yet to be formulated, the BIO1 sequence also has quartz-dominated fine fraction resulting from flysch degradation; reworked loam deposits may also occur. At the top of the BIO1 macro-unit, stone roundness and pedogenetic signatures record a low sedimentation rate. In the inner zone of the cave, the gap between BIO1 and BR1 is partially filled with BR2, here consisting of the dismantled walls and roof of the shelter (online supplement: fig. C; http://www.maneyonline.com/doi/suppl/10.1179/0093469014Z.00000000098). No trace of aeolian dust deposition has been detected. The deposition of loamy sediments combined with freezing-thawing has originated the unit BR1.

Hearths

The presence of disposed charcoal and burned bones and flints provides indirect evidence of the use of fire in BIO1. Layer 6 contains direct evidence of two hearths partially affected by postdepositional disturbances. US6_SI consists of an agglomeration of charcoal which is mostly disaggregated around a large piece of charred wood that lies on a thin level of small stones and a few smoothed clasts (FIG. 5). This hearth was disrupted by the unauthorized excavations in the back of the cave and by an animal burrower. Traces of ash are lacking, but there is a thin reddened horizon below the level of charcoal. A bone of a beaver (*Castor* sp.) with no traces of human modification was found close to the hearth. US6_SH is a small agglomeration of charcoal largely disturbed by several interlaced burrows. The middle features a reddened horizon with high concentrations of charcoal. Postdepositional disturbance removed the context information concerning associated bones and flints.

Radiocarbon Dates

In addition to the cut-marked bone found in layer 5 at the base of the test pit in 2002 (Peresani and Gurioli 2007), two other samples were submitted for dating. A large piece of charred wood from layer 8, square H11IV was considered appropriate for dating. Also suitable was the bone from the same layer but from square H12IV; it had cut marks and other clear traces of human modification. Collagen was submitted to ultrafiltration treatment and yielded a minimum radiocarbon age of 48 ky, whereas the charcoal provided an age consistent with the stratigraphy but at least 4 ky older than the date from layer 5 (TABLE 1). This lack of consistency in the Mousterian sequence is due to the different techniques used in the pretreatment of the samples. The higher level of stratigraphic detail achieved during the more recent field campaigns has convinced us to carry out, in the future, a new sampling program to confirm and refine the chronology of this part of the fill. In the stratigraphic sequence above, two small pieces of charcoal collected in layer 6 from square J11 provided dates spaced at a minimum of a few hundred years apart (TABLE 1), placing them in the Early Gravettian period. Again, the dates need confirmation because the sample pretreatment was different from the one used for the Mousterian samples.

Fauna

Every stratigraphic unit contained animal bones, some from the reworked sediment, and some with different ages and degrees of preservation. Other bones found in macro-units 1, BR1, and BR2 were not considered because they were of limited palaeontological relevance and were disturbed by burrowing activities. The colonization of the cave fill by burrowing animals (*Marmota marmota*) is clearly documented in BR1 and BR2 by features such as dens, chambers, and articulated skeletons. In the Gravettian, the faunal remains were few: ibex, chamois, and beaver.

Middle Palaeolithic faunal remains

The fauna come from layers 5 top, 7, 5, and 8, comprising a total of 4030 remains. As a consequence of the high fragmentation rate the identification at the taxonomic level was around 8%. This included recent marmot bones as the difference in preservation was easily visible. The marmot remains were fresh, while the remains ascribable to the Middle Palaeolithic layers had alterations such as root grooves, manganese coatings, and concretions.

Among the Middle Palaeolithic finds was one mandible of a hedgehog (*Erinaceus europeaus*) and 15 bones of birds determined only at the class level. Well-preserved bird remains are from raptors, big galliformes, and unidentified medium-sized birds. Lagomorphs are represented with a single bone of

Table 2 Fauna from layers 5 top, 5, 7, and 8.

Species	NISP	%
Carnivora		
Canis lupus	1	1.0
Vulpes vulpes	3	2.9
Ursus spelaeus	27	25.7
Ursus sp.	11	10.5
Martes martes	3	2.9
Meles meles	2	1.9
Mustela erminea	3	2.9
Mustelidae	2	1.9
Carnivora indet.	3	2.9
Total Carnivora	55	52.4
Ungulata		
Sus scrofa	2	1.9
cf. *Alces Alces*	1	1.0
Cervus elaphus	6	5.7
Capreolus capreolus	1	1.0
Cervidae indet.	4	3.8
Bos/Bison	3	2.9
Capra ibex	1	1.0
Rupicapra rupicapra	2	1.9
Caprinae indet.	1	1.0
Alces/Mgealoceros/Bison	2	1.9
Ungulata indet.	11	10.5
Total Ungulata	34	32.4
Aves	15	14.3
Erinaceus europaeus	1	1.0
Total	105	100.0

Table 1 AMS radiocarbon ages of charcoal and bone collagen from the Rio Secco Cave. From each context, all dated charcoal is from single fragments topographically positioned and archived. Four samples were pre-treated with different methods to eliminate contaminants: ABA for Poz-41207 and Poz-41208, ABOx-Sc for OxA-25359, ultrafiltration for OxA-25336. Calibration has been generated using OxCal (v. 4.1) and the INTCAL09 dataset (Reimer *et al.* 2009). GRSI is the larger of two pits excavated during the 2002 survey.

Context*	Material	Lab no.	^{14}C age B.P.	Age CAL B.P.
6, sq.J11, n.3	Charcoal	Poz-41207	27,080 ± 230	31,466–31,205
6, sq.J11, n.4	Charcoal	Poz-41208	28,300 ± 260	33,022–32,138
5, GRSI	Bone	LTL429A	37,790 ± 360	42,666–42,103
8, sq.H11IV, n.17	Charcoal	OxA-25359	42,000 ± 900	46,069–44,701
8, sq.H12IV, n.12	Bone	OxA-25336	>48,000	Infinite

* Layer, square, number

Lepus europaeus with no traces of human modification. If we exclude marmots, the remains of carnivores predominate over the remains of ungulates (TABLE 2). *Ursus spelaeus* is represented by cranio-caudal, axial, and appendicular elements. *Ursus* sp. was assigned when we could not distinguish cave bear from brown bear. Mustelids are represented by the marten (*Martes martes*), ermine (*Mustela erminea*), and badger (*Meles meles*). Canids are represented by at least one adult fox (*Vulpes vulpes*) and one adult wolf (*Canis lupus*).

Despite the low number of identifiable remains, the predominance of cervids over caprids and bovids is notable (TABLE 2). Cervids are represented by red deer (*Cervus elaphus*, determined by the cranial and appendicular skeleton elements), roe deer (*Capreolus capreolus*), and, presumably, elk (cf., *Alces alces*) based on the femoral shafts. Due to the absence of distinctive morphometric parts, the remains of *Bos/Bison* could not be precisely attributed to *Bos primigenius* or *Bison priscus*. The boar (*Sus scrofa*) is also present, as demonstrated by the discovery of a cranial bone and one thoracic vertebra. Caprids are represented by the chamois (*Rupicapra rupicapra*) and probable ibex (*Capra ibex*).

Excluding marmots, cranial remains (n=41) prevail, followed by limbs (n=7 for front limbs, n=21 for hind limbs), appendicular extremities (n=11), and trunk elements (n=7). Fragments of antler and horn are absent. Carnivores are clearly dominated by Ursidae, of which the remains of cranium and teeth are predominant (n=30), followed by limbs (n=12) from which the best preserved remains are the hind limbs (n=9), and their appendicular elements (n=8).

The bones exhibit a high degree of fragmentation due to postdepositional processes and human and carnivore activity. Evidence for the use of fire is provided by burnt remains (17%), some of which show traces of butchering. The best represented sizes are less than 3 cm long, with over half of the total remains (52.7%) being between 0.2 and 1.0 cm. Among the natural agents responsible for this reduction and other alterations one must take into account are trampling, root activity, and the deposition of dioxide manganese coatings. Weathering produced by rolling and corrosion was observed on 11.1% and 1.3%, respectively, of the remains. Traces of rodent gnawing are negligible (n=2), while small carnivores affected the shafts and epiphyses of marmots (n=19 altered, with pits and/or scoring) and of other species, including carnivores. Remains of small carnivores/mustelids (ermine and marten), which could have settled into the abandoned marmot galleries altering the remains there, are taphonomically distinguishable from other faunal remains such as those of large and medium mammals and are not considered to be part of the Pleistocene assemblage. The same does not hold for the hare bones, which show surface features comparable with the Middle Palaeolithic assemblage.

Human interest in ungulates is evidenced by cut marks on diaphyses, on three tibial shafts, and on the ventral portion of the lower jaw from a red deer. These cut marks, which document the stripping of the flesh and detachment of muscles (FIG. 6) are clearly distinguishable from the remains altered by animal activity. This is based on the low level of modification of the latter, but also by the position and the orientation of the deliberate striations, which differ from natural engravings produced from coarse sediments (Binford 1981, 1983; Brain 1981).

The remains of *Ursus spelaeus* and *Ursus* sp. from layers 7, 5, and 5 top show traces of butchering, skinning, and deliberate fracturing of the long bones (FIG. 7). A fragment of a cave bear radius shows a long cut mark and a shorter one oriented along the bone axis, demonstrating the detachment of the muscles between the radius and ulna. The other *Ursus* sp. fragments reveal an interest in meat acquisition, as confirmed by the typology and the orientation of cut marks on one femoral shaft and a rib. One phalanx is cut-marked on the dorsal face of the proximal epiphysis: the traces are short, in sequence, transverse to the main axis of the bone, and are assigned to one of the first phases of fur removal.

Lithic and Bone Tool Industries

In addition to charcoal and faunal remains with human modifications, the archaeological contents of BR1 and BIO1 also include numerous lithic artifacts ascribed to the Middle Palaeolithic (layers 5 top, 7, 5, 8) and to the Upper Palaeolithic (layer 6 and correlated [i.e., layer 4]). The preservation of the finds is acceptable, even if in most cases the edges of the flakes are modified by pseudo-retouch. In contrast, flake edges are well preserved from layer 6. Lithic provisioning concerned mostly flint from the carbonatic-dolomitic limestones in the Carnic Prealps (Carulli *et al.* 2000). Brownish, reddish, greenish, and dark gray/black flint nodules and beds are plentiful in the limestone but in spite of such relative abundance and their suitability for flaking, these fine-textured flints were not intensively exploited due to poor accessibility. The primary exposures are scattered on the highest mountain ridges and far from the main rivers. Sources of coarse pebbles and subrounded flint cobbles are found on river and stream gravel plains and in conglomerates in this region and in the Tagliamento Basin. These types of flint are represented in the lithic assemblages throughout the cultural sequence at Rio Secco Cave. One non-flint artifact was found, and a sidescraper made of flysch

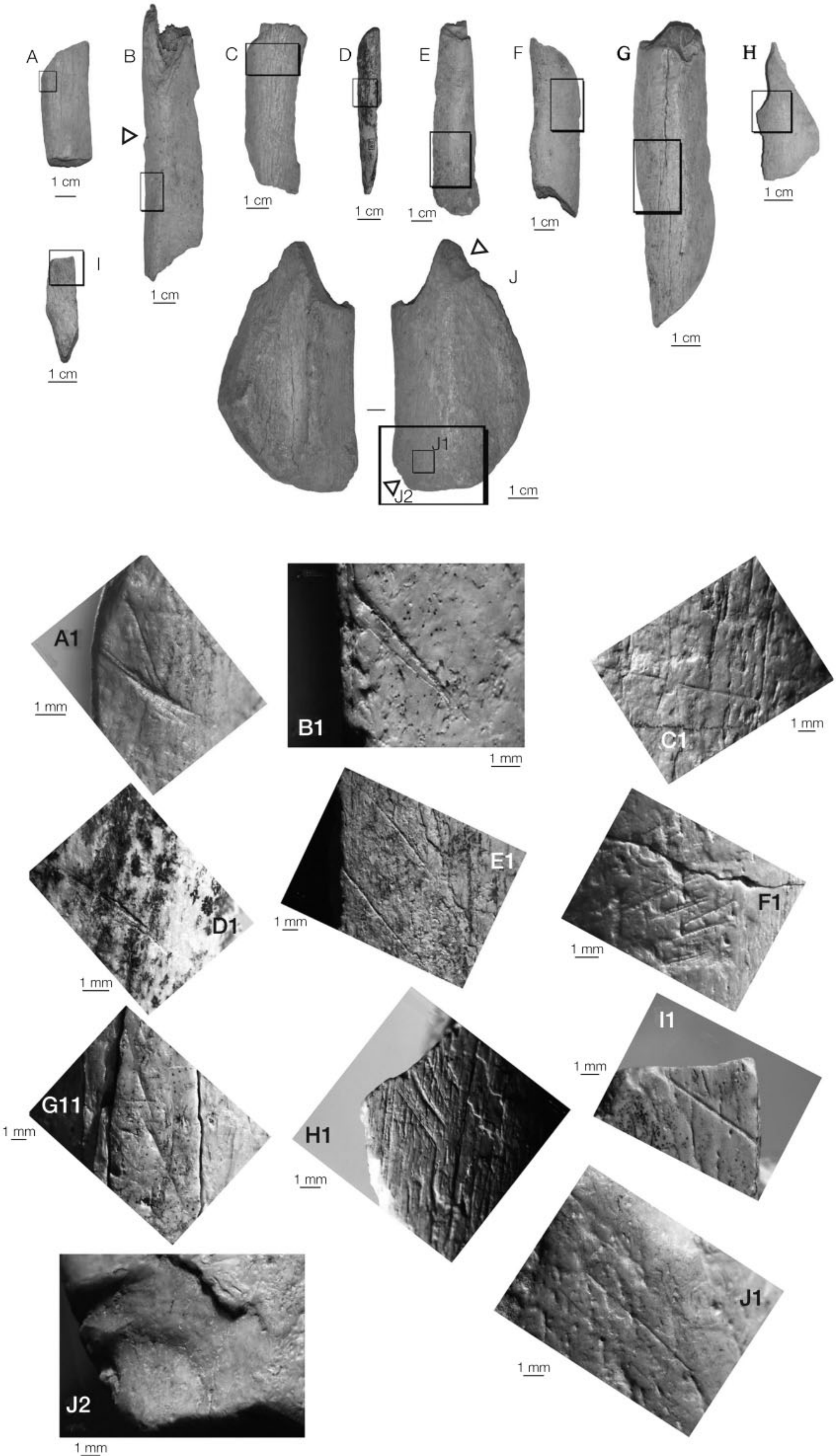
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Figure 6 A) Distal tibia of *Cervus elaphus* (A1=defleshing cut marks); B) Diaphysis of a large ungulate. The arrow shows the location of a percussion mark on the medullar face (B1=cut mark); C) Diaphysis of a large ungulate (C1=cut mark); D) Rib from a medium to large ungulate (D1=cut mark); E) Long bone from a medium to large mammal (E1=skinning/defleshing cut marks); F) Long bone from a large ungulate (F1=defleshing cut marks); G) Radius from *Alces, Megaloceros, or Bos/Bison* (G1=defleshing cut marks); H) Long bone from a large mammal (H1=cut marks); I) Long bone from a medium to large mammal (I1=cut mark); J) Tibia (distal shaft) from *Alces, Megaloceros*, or *Bos/Bison* (J1=cut marks, J2=percussion mark).

was discovered in the reworked deposits at the entrance of the cave. Flysch abounds in the Prealps and was possibly an easily accessible resource for immediate needs.

Mousterian lithic and bone artifacts

The lithic artifacts found in the Mousterian layers 5, 5 top, 7, and 8 include Levallois and discoidal core technological features (TABLE 3). Layer 8 contained two scrapers and a few flakes and fragments, all made of flint. The scraper is made on a cortical flake with a faceted butt (FIG. 8: 1). Among the flakes are a centripetally struck flake and a core-edge removal Levallois flake.

The excavation of layer 5 brought to light flakes, cores, and several lithic fragments (TABLE 3). A Levallois recurrent centripetal core was discovered in 2002 (Peresani and Gurioli 2007) (FIG. 8: 6). A core

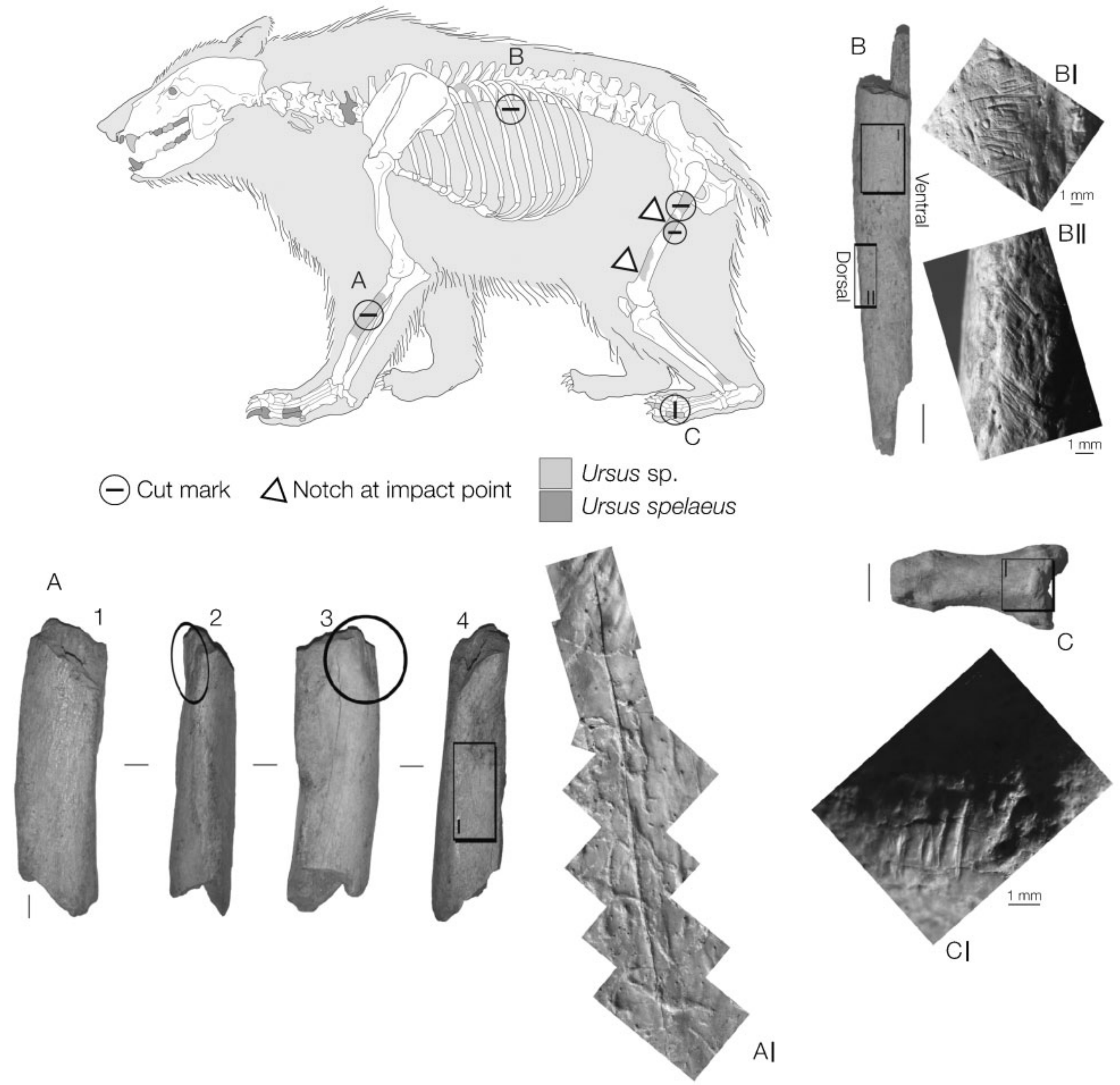

Figure 7 The anatomical elements represented in the ursid assemblage from layers 7, 5, and 5 top. A) Radius of *Ursus spelaeus* (A1=frontal view, A2=back-lateral view, A3=back view, A4=back-medial view, AI=defleshing cut mark); B) Right rib of *Ursus* sp. (BI=shaft with defleshing mark on the back-ventral face, BII=defleshing or skinning cut marks on the dorsal face); C) First phalanx of *Ursus* sp. (CI=skinning cut marks).

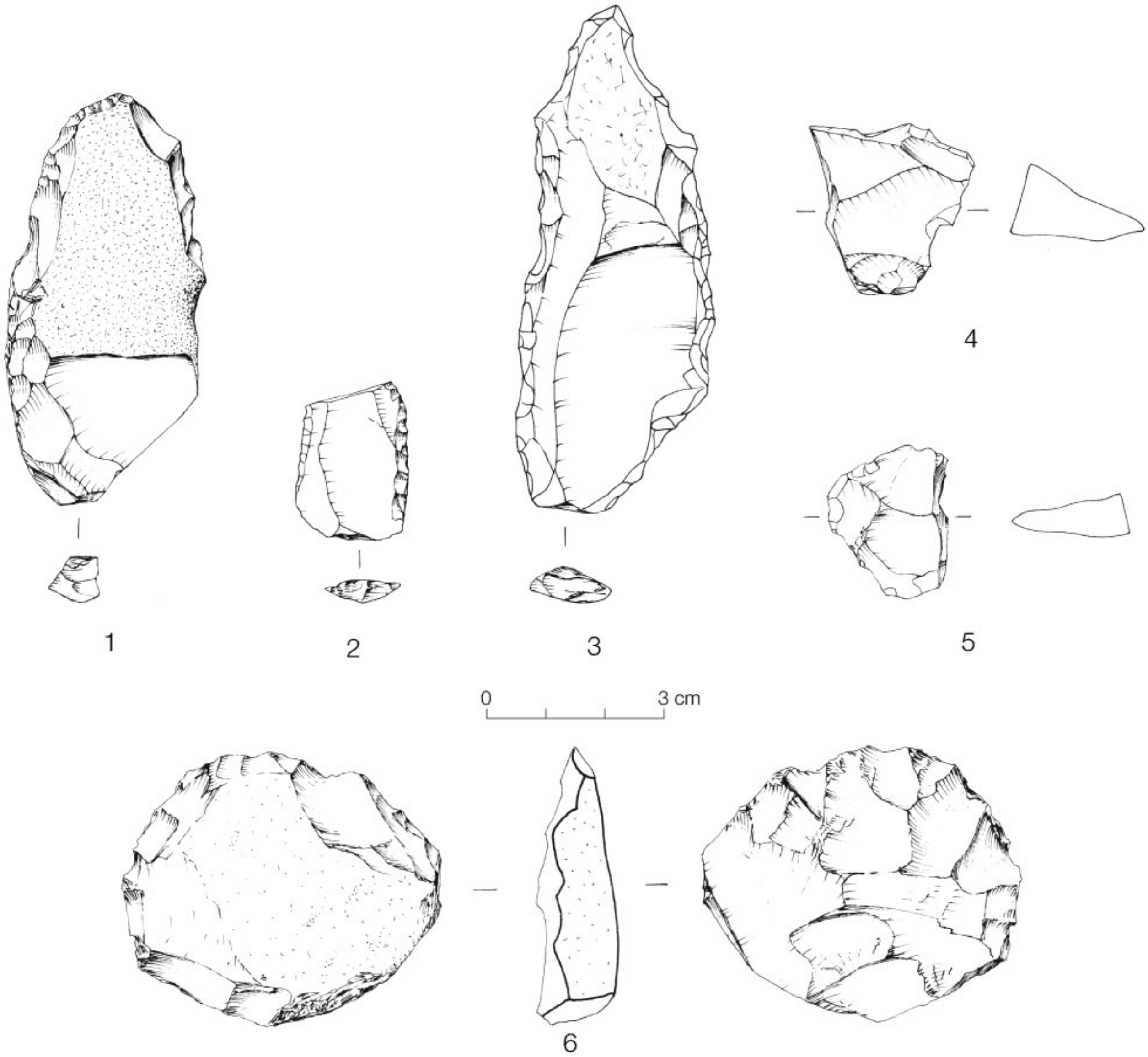

Figure 8 Mousterian lithic artifacts from layers 8 (1, 2) and 5 (3–6). 1) Scraper; 2) Fragment of a point/convergent scraper; 3) Scraper; 4–5) Core-edge removal flakes from a discoidal core; 6) Levallois centripetal core. Drawings by S. Muratori.

fragment and a few tiny knapping byproducts, the latter most likely related to core reduction, were also present in layer 5. The Levallois recurrent centripetal technique is documented by several diagnostic flakes. Among the other artifacts, byproducts resulting from Levallois unidirectional technology are present; one flake was modified into a sidescraper. Discoid technology was used to produce some core-edge removal flakes and two pseudo-Levallois points (FIG. 8: 4, 5). Among the retouched tools are three sidescrapers and one awl. Several tiny chips demonstrate that scrapers were produced and retouched before being discarded or taken away from the site.

The assemblage from layer 7 comprises flakes, flake fragments, and scrapers (FIG. 9). Sizes are small and the blanks include semi-cortical types; core-edge

Table 3 General composition of the lithic assemblages from layers 5 top, 7, 5, and 8.

Layer	Flakes	Discoid flakes	Levallois flakes	Discoidal cores	Levallois cores	Cores	Total flake+core
5 top	27	–	2	–	–	1	30
(retouched)	3	–	–	–	–	–	–
7	4	1	–	1	–	1	7
(retouched)	2	–	1	–	–	–	–
5	27	8	6	–	1	–	42
(retouched)	3	1	1	–	–	–	–
8	22	–	6	–	1	–	29
(retouched)	2	–	2	–	–	–	–
Total	80	9	14	1	2	2	108

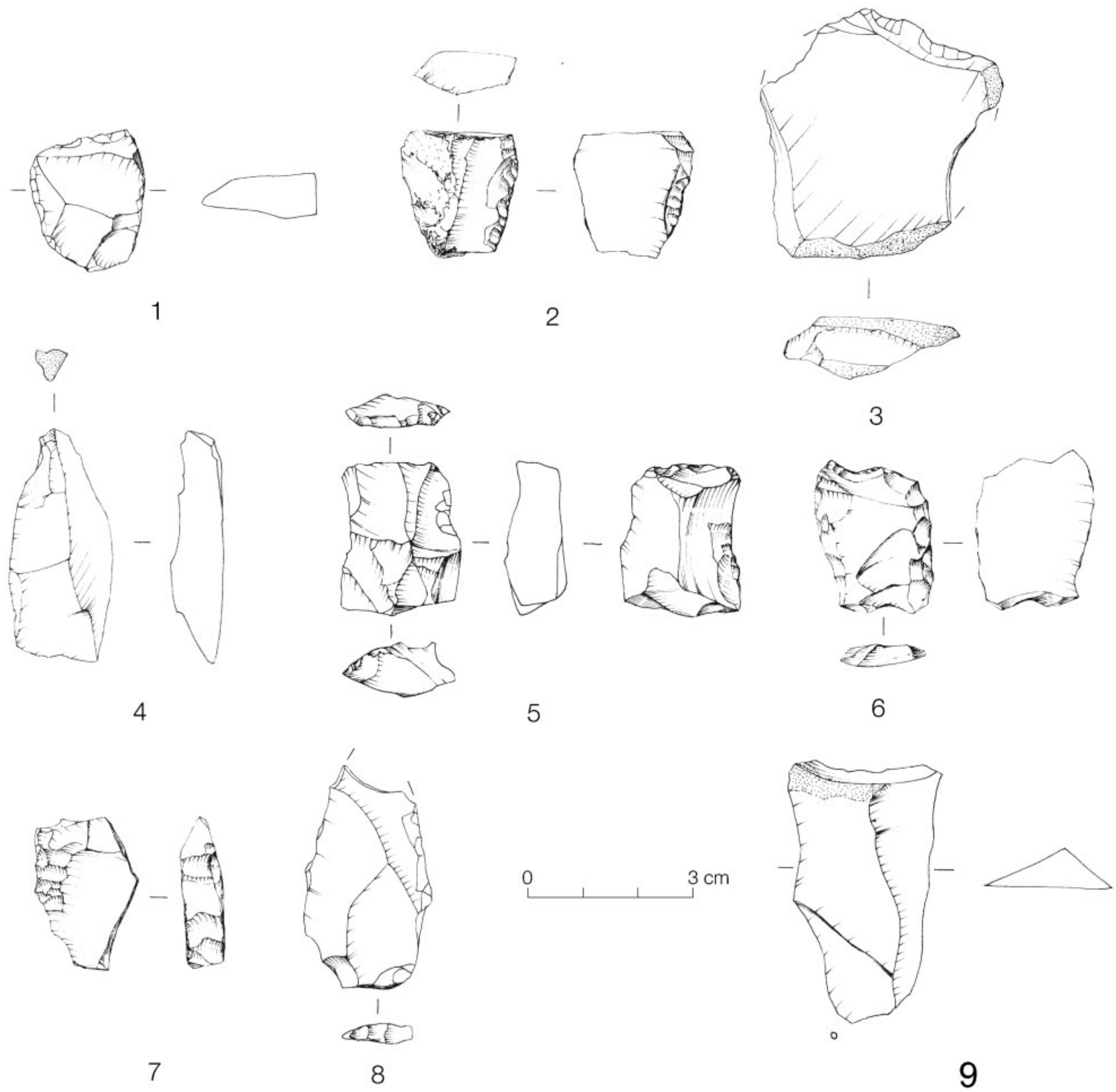

Figure 9 Lithic artifacts from layers 7 (1, 2) and 5 top (3–9). 1) Core-edge removal flake from a discoidal core; 2) Scraper shortened by distal truncation and thinned on the dorsal face; 3) Centripetal flake; 4) Blade from a core-on-flake; 5) Bladelet core; 6) Double scraper shortened by proximal truncation; 7) Flake with partial backing; 8) Levallois flake; 9) Flake with unipolar scars. Drawings by S. Muratori.

removal flakes are also present. Even though layer 5 top was explored only in an area of 2 sq m, it yielded clear evidence of technological variability including fragmentary centripetal Levallois flakes, thick tiny flakes with inclined butts possibly related to discoidal core technology, and one large centripetal flake with a flat, inclined butt. Three pieces show distinct features: a short blade struck from the ventral face of a core-on-flake (FIG. 9: 4), a short and flat bladelet core (FIG. 9: 5), and a flake bearing a partially retouched back opposite a thin edge having shallow, invasive retouch (FIG. 9: 7).

Two fragmented bones found in layers 5 and 5 top were used as retouchers (FIG. 10). One is a fragment of probable elk bone with a few retouch scars which do not overlap one another. This piece is partially damaged on the active end and therefore may have been part of a bigger fragment. Each retoucher has a single utilization zone. The absence of notches on both suggests they were little-used (Mozota Holgueras 2009). The striations on each bone shaft are quite deep and well-delineated, indicating considerable force was applied by a lithic artifact during its defleshing.

The Gravettian flint artifacts

The Gravettian finds comprise a few lithic artifacts, mostly coming from artificial spits 4a, 4b, 4c, 4d, and, to a lesser extent, from layer 6. The raw materials of the Gravettian lithics are different from the Mousterian assemblages. With the exception of five

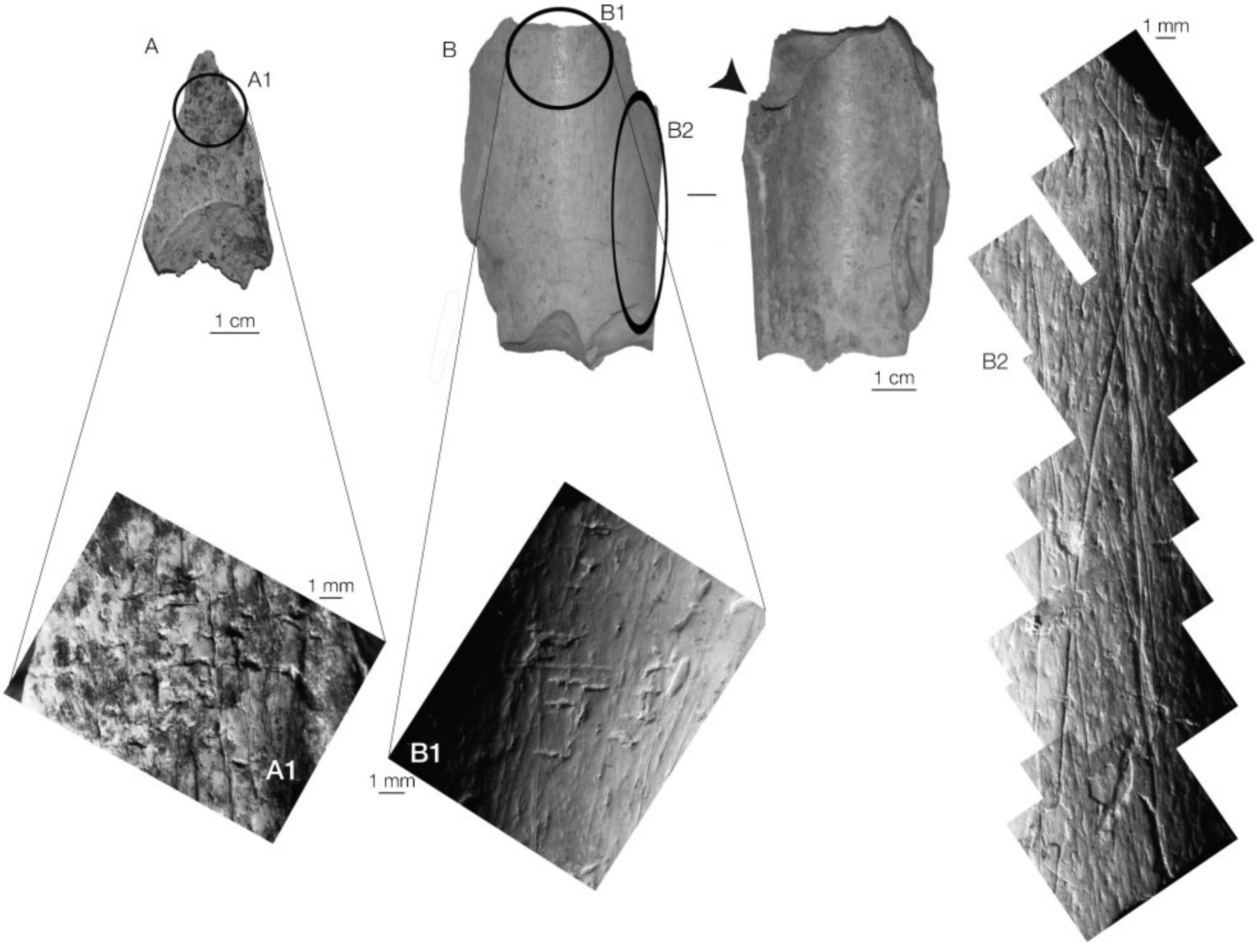

Figure 10 Fragmented long bones from large mammals used as retouchers from layers 5 (A) and 5 top (B). Observations were made using a Leica S6D stereomicroscope with a magnification of 10–64X. A1) Linear striations; B1) Single zone of utilization with few scars; B2) Insistent, continuous longitudinal scrapings.

undiagnostic pieces, the flints are mostly from exotic sources in the west, over 60 km away (Maiolica, Scaglia Rossa, Scaglia Variegata, Igne, and Eocene flint). Technologically, the assemblage is characterized by blade/bladelet production. Related pieces are flakes from the rejuvenation of core platforms and faces, and

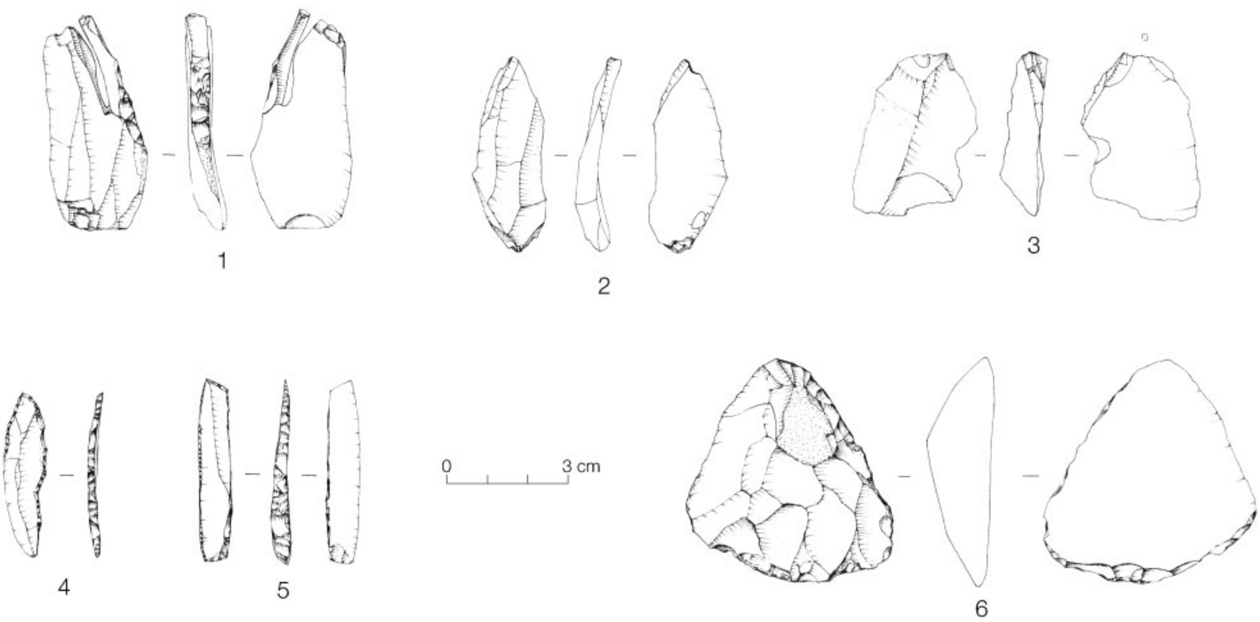

Figure 11 Gravettian lithic artifacts. 1–3) Burins, one with a refitted burin spall; 4) Unfinished backed point; 5) Double truncated backed bladelet; 6) Endscraper made on a large retouched flake. Drawings by S. Muratori.

fragmentary blades. The most significant tools are three burins made on truncation/rejuvenation blades (FIG. 11: 1–3). One burin has several burin spalls (one of which was refitted); for this reason it should be interpreted as a bladelet core. In addition, there are two endscrapers produced on cortical flakes, one of which is thick and large (FIG. 11: 6). Among the projectile pieces, we count one backed double truncated bladelet, one unfinished backed point (FIG. 11: 4, 5), and one undiagnostic fragment. Other pieces were found in the reworked sediments and include one bidirectional bladelet core with two faceted platforms and a semi-cortical blade detached using soft hammer percussion.

Discussion

Rio Secco Cave can help us understand the environmental context of human occupation in the northern part of the Adriatic Plain during the Marine Isotope Stage (MIS) 3. The presence of red deer and elk with roe deer and wild boar is indicative of forest vegetation and a marshy environment in the vicinity of the cave. The presence of bovids and caprids indicates the existence of patchy forests compatible with a mountain context. Cave bear were well adapted to this kind of environment, hibernating in cavities which also saw human habitation. Although still preliminary, our data confirm the intensive use by bears of Rio Secco Cave.

Our data does not support the Dansgaard-Oeschger (D-O) climatic alternation typical of MIS 3. The earliest date of the Mousterian occupation at Rio Secco falls between Greenland Interstadial (GI) 12 and Greenland Stadial (GS) 12, while the youngest correlates with GI11 (cf., Svennsson *et al.* 2006, 2008; Andersen *et al.* 2006). As mentioned above, the Mousterian date requires confirmation due to doubts concerning the position of the sample found during the 2002 test pit and the pretreatment decontamination. The ecological scenario for this interval fits zones 65–67 of the pollen core from Azzano X, located in the Friuli Plain 50 km southwest of the Pradis Plateau. The zonal vegetation of the plain includes open birch-conifer forests, xerophytic scrubs, and steppe, with broadleaved trees like *Betula*, *Salix,* and *A. glutinosa*, and an absence of warm-temperate vegetation. Phases of contraction of conifer forests and expansion of stepped communities alternate with mixed conifer (*Pinus* and *Picea*) and *Betula* forests (Pini *et al.* 2009).

For the first time in the extreme northeastern part of Italy and at the border with the Alps, Rio Secco Cave provides data which may be ascribed to the upper boundary of the Middle Palaeolithic, a period investigated heretofore only in neighboring regions (Peresani 2011; Karavanić and Janković 2006; Turk 1997). Traces of Neanderthal presence at Pradis confirms that they were interested in colonizing this small plateau. There is evidence of the hunting, butchering, and cooking of cervids, bovids, and caprids; their long bones were also modified to retouch flint tools. The exploitation of cave bears assumes a certain significance given the scarcity of comparable evidence from Mousterian times in the Alps.

Hunting and related activities have been largely recorded elsewhere in the Prealps, where faunal assemblages and taphonomic data indicate that the presence of hunted ungulates reconciles with the ecological conditions in the proximity of each specific site and correlates with climatic oscillations. San Bernardino Cave, Fumane Cave, and, presumably, Tagliente Rockshelter shared similar exploitation models with the selection of young adult and adult prey and of primary butchering. The main ungulates hunted during the final Mousterian were mostly red deer and roe deer with lesser numbers of chamois and ibex (Fiore *et al.* 2004; Thun-Hohenstein and Peretto 2005; Peresani *et al.* 2011) and limited exploitation of *Bos*/*Bison*, giant deer, elk, and boar. Marmots and some carnivores (bear and fox) were also exploited, perhaps for furs.

The lithic material found at the top of the sequence at Rio Secco Cave, in layers 7 and 5 top, includes retouched artifacts and a blade technology not present in the earlier units. The apparent tendency to abandon deep-rooted Neanderthal behavioral patterns—if Neanderthals were the makers of the record—should be taken into account when exploring the emergence of transitional techno-complexes in this region. The elongated Levallois blanks and blades at Rio Secco are similar to others in the Veneto region, such as at the San Bernardino (Peresani 1996) and Fumane caves, revealing how this process was well rooted in Mousterian lithic production. Levallois technology is recorded at Fumane across the late Mousterian sequence in layers A11, A10V, A10, A6, and A5 (Peresani 2012) and persists regardless of the different raw materials and the reduction sequence. Throughout the reduction sequence, the recurrent unidirectional technique was used to extract blades and a few points, before turning to the recurrent centripetal pattern at the end, a procedure used to optimize the exploitation of the remaining core. Unidirectional flakes, rather than centripetal, cortical, and other flake types, were shaped into sidescrapers, points (rarely), and notched implements.

Once shaped into retouched tools, these Levallois blades made up the personal equipment of Neanderthal hunter-gatherers at Rio Secco Cave and elsewhere. These implements can undergo several cycles of use and retouch. It remains to be determined whether or not semi-worked or already retouched pieces were brought to the site. There is evidence of more expeditious flake production involving centripetal Levallois and discoidal core reductions, processes requiring minor adjustments in the shaping of the cores, and providing consistency in flake production. An explanation for this is the small size of the flint cobbles/pebbles obtained in rivers or streams. Nevertheless, the use of semi-local materials like Soverzene flint did not prevent the extraction of Levallois blades. Comparable technological flexibility was noted at Fumane Cave where Levallois and discoidal technologies (Peresani 1998, 2012) were extensively used regardless of the raw material. Core reduction frequently required different choices and technical solutions, resulting in cores being modified to produce pseudo-Levallois points, backed flakes with thin opposite edges and subcircular, and quadrangular or triangular flakes shaped into simple and transverse scrapers, points, and denticulates.

Such evidence suggests the contemporaneous existence of different cultural traditions, which became prevalent in the Upper Adriatic region during the first half of MIS 3. Human mobility and possible contacts between the groups which settled on the Friuli Plain and the surrounding zones will be explored in the future through the analysis of flint sources, specifically of those at Maiolica.

During the final stages of the Middle Palaeolithic, caves and shelters in northern Italy were sites of lithic production, which was intimately integrated into the acquisition, processing, and consumption of animals. Ephemeral camps settled far from the primary mineral sources may have been part of a widespread settlement system. Rio Secco should be partly interpreted in this way, i.e., as a seasonal camp. Fragmentation of some reduction sequences can be viewed as evidence of the organization of economic activities related to the geographic location and function of this site.

Final Mousterian sites with comparable date ranges are rare and are scattered around the Upper Adriatic between the southeastern Alps and northern Dalmatia (Tozzi 1994; Karavanić 2004). Rio Secco is contemporary with layers 4 and 5 at Divje Babe I Cave on the Šebreljska Plateau, which correlate with GI12 (Blackwell *et al.* 2007). Lithic implements of this period are rare too but are made of local raw materials. The best-preserved pieces show features of Levallois unidirectional recurrent technology (Turk and Kavur 1997).

Moving east, in the Drava Basin, the Vindija Cave has a stratified sequence which covers the final Middle Palaeolithic and the Upper Palaeolithic. The layer contemporary with Rio Secco is G3. A cave bear bone has been U-Th dated to ca. 41 ky CAL B.P. and the collagens of two Neanderthal bones have yielded minimum ages of >45 ky and 42.3 ky CAL B.P., respectively (Krings *et al.* 2000; Serre *et al.* 2004). In Vindija's lithic assemblage, raw materials include quartz, tuff, sandstone, chert, and others that have been separated into two groups (Ahern *et al.* 2004) on the basis of their suitability for flaking. In the first group, coarsely textured stones were used to make thick and irregular flakes, while the second group, had a high incidence of retouched tools (scrapers) made on cortical and plain flakes, and a few blades. Levallois technology was not used for producing these blanks; flake technology was dominant, but there is also evidence of blade and bifacial technologies (Karavanić and Smith 1998). Above layer G3, layer G1 of Vindija has a mix of elements with very different chronologies: a split-based bone point, a Szeletian foliate, a cave bear bone dated to ca. 50.4 ky CAL B.P., and fragments of Mladeč points intruded from the top (Zilhão 2009).

At Rio Secco, the Gravettian evidence is scantier than the Mousterian evidence, probably because of infrequent visits to the cave. The backed pieces and the burins introduced to the site where they were then rejuvenated or used to produce bladelets. This was an expression of short-term occupation by hunter-gatherers equipped with retouched tools made of high quality flints collected outside the Carnic Prealps. The Gravettian visits fall in GI5, almost two millennia before the onset of the LGM, with the lower boundary proposed by Lambeck and colleagues (2002) and Shackleton and colleagues (2004) at 30 ky CAL B.P. In this region, the building phases of the Tagliamento glacial amphitheatre (Monegato *et al.* 2007) correlate with the replacement of peat-forming grass vegetation by xerophytic herbs and shrubs of the dry steppe in the Azzano X core (Pini *et al.* 2009), although conifers and shrubs persisted, albeit in reduced stands.

The evidence at Rio Secco of an initial phase of the Gravettian is a rare occurrence on the Adriatic slopes of the Italian peninsula (Broglio 1994; Broglio *et al.* 2005; Tozzi 2003). In addition to the site of Fonte delle Mattinate at the watershed of the Marche Appennine (Giaccio *et al.* 2004; Silvestrini *et al.* 2005), currently the best known Gravettian site is Grotta Paglicci in southern Italy, where layers 23 and 22 date from 33.0 to 31.0 ky CAL B.P. (Palma di Cesnola 1993). These two Gravettian assemblages include burins mostly of a simple type, endscrapers, and other tools as well as gravettes, microgravettes, and other backed points, among them possible fragments of points with basal and apical backed edges (fléchettes) (Borgia 2008; Palma di Cesnola 2004). To the north, near the boundary of the Great Adriatic Plain, the Gravettian is recorded only in the

Berici Hills, at Broion Cave, where human occupation dates to a few millennia later than that at Rio Secco (Broglio and Improta 1994–1995), and at del Broion Rockshelter, where levels 1b and 1bα have been dated to 33.3 and 32.5 ky CAL B.P. This shelter produced evidence of a marginal settlement used for hunting tasks, as inferred from the scarce endscrapers and burins and the several backed implements like points, frequently affected by impact fractures (De Stefani *et al.* 2005).

The absence of Gravettian settlements in the Eastern Alps and along the Drava and Sava basins may reflect a research bias rather than a gap in early human presence. To the northwest, along the Danube Basin and its tributaries in Central Europe, the sites of Willendorf II, Pavlov I, and Dolni Vestonice I and II have Early Gravettian deposits chronologically consistent with those found at Rio Secco Cave (Djindjian *et al.* 1999). Our fieldwork and laboratory studies will continue to provide new elements for reconstructing the factors leading to the presence of human groups around the Northern Adriatic rim.

Conclusions

Excavations at Rio Secco Cave have produced new data about the last Neanderthals in northeastern Italy. The faunal assemblage and Mousterian implements suggest that the cave users hunted in the forests marshes in the vicinity of the cave. Besides ungulates, cave bears were also exploited; such data provide new insights about Neanderthal-bear interactions. Tasks related to the exploitation of game and the working of different materials were presumably performed using flaked tools produced by the Levallois and discoidal core technologies. Some lithic artifacts at the top of the Mousterian sequence are unknown in the earlier units. The Palaeolithic inhabitants obtained lithic provisions from sources that were local and semi-local, suggesting that the personal equipment of Neanderthals was used both in and away from the cave. Such mobility, in turn, suggests possible contacts between groups settled in the Friuli Plain and surrounding zones, like the Venetian and Slovenian mountains. Finally, at Rio Secco a large gap separates the final Mousterian from the Gravettian, a rare occurrence in the northern Adriatic region. Artifacts date to the initial phase of this period and are few in number due to ephemeral visits to the cave by hunters. Tools show a change in patterns of lithic provisioning that indicates longer distances were covered in the Gravettian than in the Mousterian.

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Marco Peresani (Ph.D. 1993, University of Bologne) is a researcher in anthropology. His main interests are the Middle Palaeolithic–Upper Palaeolithic transition and Late Glacial to Early Holocene hunter-gatherer settlement dynamics in the Alps and central Italy. Lithic analysis is his primary research tool.

Matteo Romandini (Ph.D. 2012, University of Ferrara) carries out research on zooarchaeology and taphonomy in the northeastern part of Italy focusing on changes in human economy during the Middle Palaeolithic and the Upper Palaeolithic.

Rossella Duches (Ph.D. 2012, University of Ferrara) is a post-doctoral fellow at the Trento Science Museum. Her focus is on understanding settlement dynamics and hunting strategies of Epigravettian human groups.

Camille Jéquier (M.A. 2009, University of Ferrara) is involved in the technological analysis of osseous materials from Late Mousterian–Aurignacian sites in the Alps region.

Nicola Nannini (M.A. 2012, University of Ferrara) focuses his research on taphonomic and zooarcheological faunal evidence in the Venetian Prealps during the Middle and Upper Palaeolithic.

Andreas Pastoors (Ph.D. 1997, University of Cologne) is an independent researcher in Palaeolithic Archaeology. His main focus is on technology and Late Pleistocene art.

Andrea Picin (M.A. 2009, University of Tarragona) focuses his research on the Lower and Middle Palaeolithic lithic technologies.

Isabell Schmidt (Ph.D. 2013, University of Cologne) focuses her research on the lithic artifacts from southern European and southern African Palaeolithic contexts.

Manuel Vaquero (Ph.D. 1997, Rovira i Virgili University) is interested in Middle Palaeolithic, Upper Palaeolithic, and Mesolithic lithic technologies and settlement patterns.

Gerd-Christian Weniger (Habilitation 1991, University of Cologne) is a Palaeolithic archaeologist with a special interest in human land use and demography during the Upper Pleistocene in Europe, the Near East, and North Africa.

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