

Fire-places, frequentations and the environmental setting of the final Mousterian at Grotta di Fumane: a report from the 2006-2008 research.

Feuerstellen, Wiederbegehungen und Umweltverhältnisse des späten Moustérien der Grotta di Fumane: Zwischenbericht der Forschungen von 2006 bis 2008.

Marco PERESANI^{1*}, Julia CHRZAVZEZ², Alice DANTI³, Martina DE MARCH¹, Rossella DUCHES¹, Fabio GURIOLI¹, Simona MURATORI¹, Matteo ROMANDINI¹, Luca TROMBINO³ & Antonio TAGLIACCOZZO⁴

¹Università di Ferrara, Dipartimento di Biologia ed Evoluzione, Sezione di Paleobiologia, Antropologia e Preistoria, Corso Ercole I d'Este, 32, I-44100 Ferrara.

²CEPAM- UMR 6130 CNRS. Université Nice Sophia Antipolis, Campus Saint-Jean-d'Angély, SJA3, 24, avenue des Diables Bleus, F-06357 Nice Cedex 4.

³Università di Milano, Dipartimento di Scienze della Terra «Ardito Desio», Via Mangiagalli 34, I-20133 Milano.

⁴Soprintendenza al Museo Nazionale Preistorico Etnografico "L. Pigorini", Sezione di Paleontologia del Quaternario e Archeozoologia, P.le G. Marconi 14, I-00144 Rome.

ABSTRACT - The excavations campaigns carried out in 2006-08 at Grotta di Fumane enabled the extensive exploration of the final Mousterian layers and, at the same time, to start the first large-scale research of the valuable archaeological record preserved at the cave entrance. The present work provides a preliminary assessment of the results from several anthropogenic signatures recovered from the complex of units A5-A6. Marked differences between A5-A5+A6 and A6 are shown in the density and number of certain signatures, as a consequence of changes in settlement dynamics. Combustion structures are numerous in A6, a layer which yielded thousands of artefacts and ecofacts. Conversely, anthropogenic signatures in A5 are scarce. Red deer, ungulate and some carnivore bones are exclusively of cultural origin.

ZUSAMMENFASSUNG - Die Ausgrabungen von 2006 bis 2008 in der Grotta di Fumane ermöglichten die eingehende Erforschung der späten Phase des Moustérien, datiert auf 44-43 ky BP. Parallel dazu konnten die ersten umfassenden Studien über die reichen archäologischen Funde aus dem Eingangsbereich der Höhle begonnen werden. Die vorliegende Arbeit präsentiert einen Teil der Hinterlassenschaften des Menschen aus den Einheiten A5-A6, in welchen deutliche Unterschiede in der Nutzung der Höhle ablesbar sind. Während in der Schicht A6 zahlreiche Feuerstellen und eine hohe Anzahl an Artefakten gefunden wurde, sind die Spuren des Menschen in der Schicht A5 deutlich geringer ausgeprägt, gleichzeitig bleibt das Spektrum der Fauna und der Steinartefakte weitgehend unverändert. Die Reste von Hirschen, weiteren Huftieren und von einigen Raubtieren sind fast ausschließlich auf Aktivitäten des Menschen zurückzuführen. Zahlreiche Knochen- und Geweihreste weisen Retuschen auf oder wurden als Retuscheure verwendet.

KEYWORDS - Mousterian, hearth, MIS3, environment, Italy.
Moustérien, Feuerstelle, MIS3, Umwelt, Italien

Introductory remarks

The impressive quantity of evidence from the human occupation at Grotta di Fumane is still at an early stage of analysis and not yet ready to use as a valuable index for planning large-scale exploration of this key site. Even though after twenty years of excavation the cave entrance that was occupied by Aurignacians and Uluzzians been fully investigated, there is still much work to be done in the sediment-filled tunnels and the levels dating to the final Middle Palaeolithic. The

excellent preservation of structures as well as stone and bone remains, will certainly help to reconstruct the cultural formation processes. Research during the last five years has overturned wide-held views in the study of Neanderthal subsistence and behaviour. However, much data, other than a few aspects of lithic technology, remains to be published even at a preliminary stage (Peresani 2008; in press). Thus, this paper aims to provide a first report on three years of field campaigns carried out to explore a complex of final Mousterian occupations, just below the Uluzzian levels.

*corresponding author:
marco.peresani@unife.it

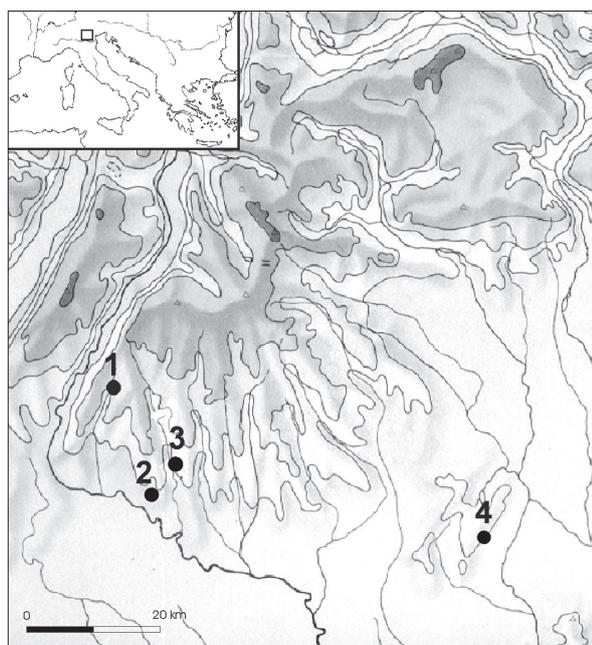


Fig. 1. Map of the north-eastern part of Italy showing the Middle Palaeolithic sites mentioned in the text: 1 - Grotta Fumane and Grotta Ghiacciaia; 2 - Riparo Mezzena; 3 - Riparo Tagliente; 4 - Grotta San Bernardino.

Abb. 1. Karte von Nordost-Italien mit den im Text erwähnten mittelpaläolithischen Fundstellen: 1 - Grotta Fumane und Grotta Ghiacciaia; 2 - Riparo Mezzena; 3 - Riparo Tagliente; 4 - Grotta San Bernardino.

Grotta di Fumane and the aims of the 2006-2008 fieldwork

Grotta di Fumane is located at 350 m asl in the Western Monti Lessini, one of the high-plateaux of the Veneto Pre-Alps in the north-eastern region of Italy (Fig. 1). Its entrance is below a rock cliff, on the left slope of a small tributary valley stream flowing eastwards to the main Fumane Valley. The cave is part of a fossil karst system formed during the Neogene in the Ooliti di San Vigilio carbonaceous sandstone (Upper Lias), a formation made of two alternating facies of a thick body of Oolitic Sandstone with typical cross laminations and of a micritic bank, separated by a discontinuity. In the valley bottom where the cavity opens, this kind of formation is extensively dolomitized. The karst complex was a vast cavity or pit, with walls still partly visible and connected with the upper floors by three tunnels excavated into the micritic bank: a large tunnel named B, a secondary small one still unexplored (tunnel C) on the left, and a third one (A) which links with B (Fig. 2). Tunnels A and B comprise the main shelter in the left zone protected by the sandstone, but unstable due to a system of fractures disposed almost parallel to the rock wall overhanging the cave for 20 m above. This intense fissuring suggests that access to the cavity was positioned a few metres further outside than the present-day.

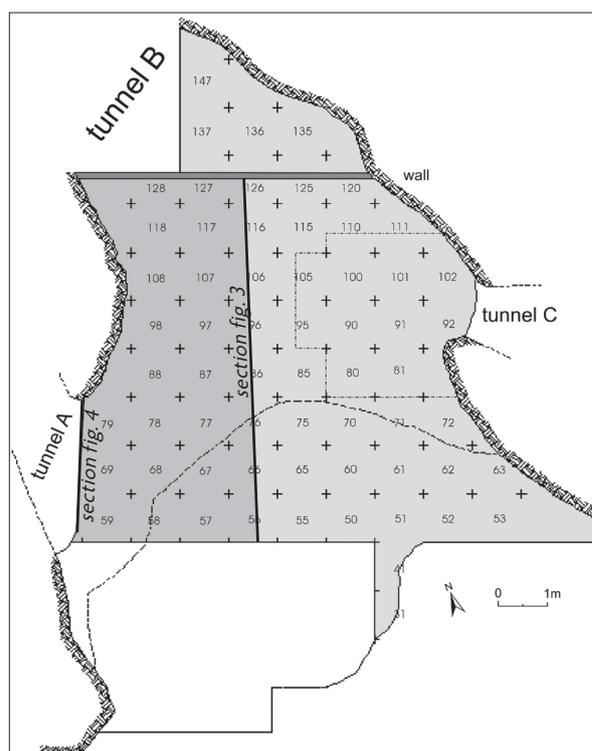


Fig. 2. Plan of the cave entrance and the lateral tunnels showing the grid and the excavation zones of the stratigraphic complex A5-A6: light gray = the zone excavated before 2006; darker gray = the zone excavated from 2006-2008. Solid lines outline the sagittal section drawn in figures 3 and 4. The present-day drip line is projected to the ground by the dotted line. The wall closing tunnel B runs from square 129 to 120.

Abb. 2. Plan des Höhleneingangs und der seitlichen Tunnel mit den Planquadraten und der Grabungsfläche der stratigraphischen Komplexe A5-A6: hellgrau = Planquadrate vor 2006 ausgegraben; dunkelgrau = Grabungsfläche von 2006-2008. Durchgezogene Linien zeigen die Sagittalschnitte an, die in Abb. 3 und 4 dargestellt sind. Gepunktete Linie stellt heutige Tropfkante dar. Die Wand, die den Tunnel B verschliesst, erstreckt sich von den Quadraten 129 bis 120.

Partially explored in the 1990s, the whole complex of cavities preserves a sedimentary sequence 12 m thick divided into four main macro-units labelled S, BR, A and D (Cremaschi et al. 2005) with evidence of a much more intense human occupation documented in macro-unit A, which includes several horizontal layers from A13 to A1 (Fig. 3). Mousterian living floors are found in A11, A10, A9(+A8), A6-A5, Uluzzian in A4 and A3, and Proto-Aurignacian in A2 and A1. In terms of the MP-UP transition, a finely layered sedimentary succession covers the final Mousterian, the Uluzzian and the first Aurignacian which are very well preserved within layers formed by frost-shattered breccia, aeolian silt and sands. From layer A2 up, dwelling structures, lithic assemblages, bone and antler tools, painted stones and pierced mollusc shells mark the arrival of the first Aurignacians into this region with a clear discontinuity with the former cultural entities (Bertola et al. 2009; Broglio et al. 2005, 2009).

The main aim of the 2006-2008 fieldwork was to examine the internal arrangement of the anthropogenic units over a large surface which required three field

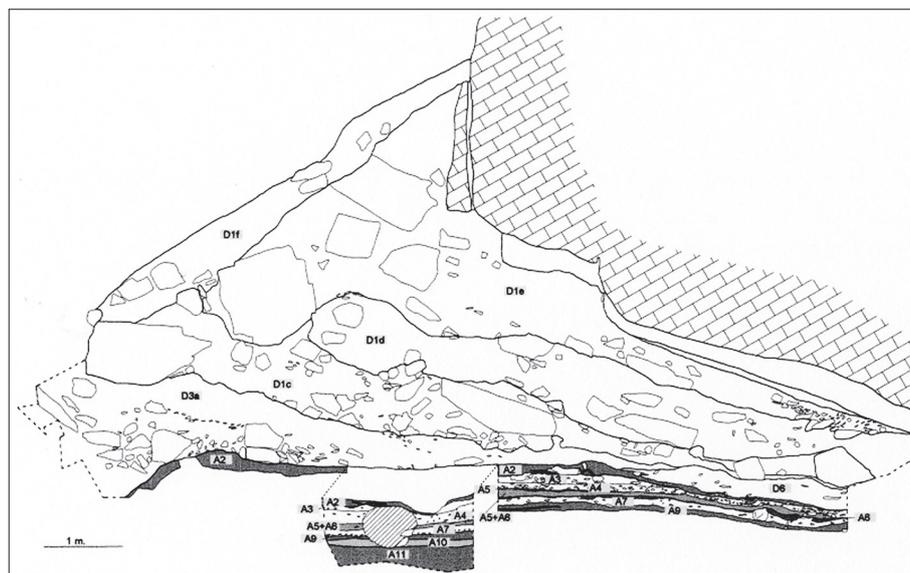


Fig. 3. Sketch of sagittal section of the cave with evidence of the late Mousterian (A11-A5), Uluzzian (A4-A3) and earliest Aurignacian layers (A2) and of their variable content in archaeological remains (increasing from light gray to dark gray and black) (by M. Cremaschi & M. Peresani, redrawn by S. Muratori).

Abb. 3. Skizze des Sagittalschnittes (siehe Abb. 2) mit vorhandenen Schichten des späten Moustérien (A11-A5), Uluzzien (A4 - A3) und des frühesten Aurignacien (A2) und deren unterschiedlicher Funddichte (zunehmend von hellgrau über dunkelgrau nach schwarz) (Skizze: M. Cremaschi & M. Peresani, umgezeichnet: S. Muratori).

campaigns each lasting two to three months. Reasons that led to the decision to expose the whole surface of the main chamber in a single step are: 1) to allow the definitive recording of the two main sequences of the cave, one exposed to the south-east along the 1992 trench (units S, BR and A up to A3; Figs. 2 & 3) and the other located at the entrance of tunnel A (units A and D), and to complete the exploration of the final Mousterian layers of very high density in stones and bones and in combustion structures as shown from explorative trenches dug in 1989-90 and 1995.

Furthermore, in 2001-2002 excavations of the stratigraphic complex A5-A6 were carried out in the left sector of the cave entrance and had brought to light layer A6 with its high degree of anthropogenic activity. This was shown by the presence of organic matter, charcoal, bones mostly of ungulates bearing clear traces of deliberate modifications, in association with a lithic industry composed of primary products, by-products and scores of retouched tools. The main interest of the new fieldwork was therefore to check the existence of a supposedly complementary zone in the most micro-topographically elevated part of the cavity. As this was the most southerly exposed zone, it might have been subject to specific human use and to a variety of natural or cultural sedimentary processes.

The 2006 fieldwork aimed to complete the excavation of the Uluzzian A3 and A4 layers started in 2005 and the exploration of the stratigraphic assemblage A5-A6, which lasted for the three successive campaigns. In detail, the work in 2006 focused on A5 and its complex combustion structures, but also on A5+A6 and A6. Digging up the whole of layer A6

required three years of fieldwork, with a major effort in 2007 when several hearths and dumped material were brought to light. The aim of the 2008 campaign was to complete the removal of the residual portion of A6 and of its combustion structures in squares 58, 59 and 69.

Besides the fieldwork, the three years were also dedicated to the study of lithics and bones recovered from previous work. Other than combustion structures, there were analyses on samples taken from the anthracological and faunal populations. Results are presented here at a preliminary level. Combustion structures and the sediments which make-up the different facies of A6 have been the subject of micromorphological studies (Danti 2008-09). Anthracological analyses have been used to determine taxonomy and reconstruct the taphonomical history of a small charcoal sample taken from sediments, in order to get indices for comparisons between Uluzzian and Aurignacian levels (Chravzez 2006). A sample of the bone material was selected for zooarchaeological analyses from the bulk of the faunal assemblage found in the eastern sector of the cave-entrance during the 1995, 2001 and 2002 campaigns (De March 2006-07). On the sample studied so far, taphonomic analysis has been carried out in order to identify the agents that are responsible for the accumulation of the faunal assemblage. A goal to be pursued in future papers is the chronometric refinement of the ^{14}C data set of all the layers concerned here (Peresani et al. 2008), which have been partly re-dated after ABOX treatment to 44.2-43.0 ky calBP (A5 and A5+A6: 39.8-42.3 ky ^{14}C BP; Higham et al. 2009).

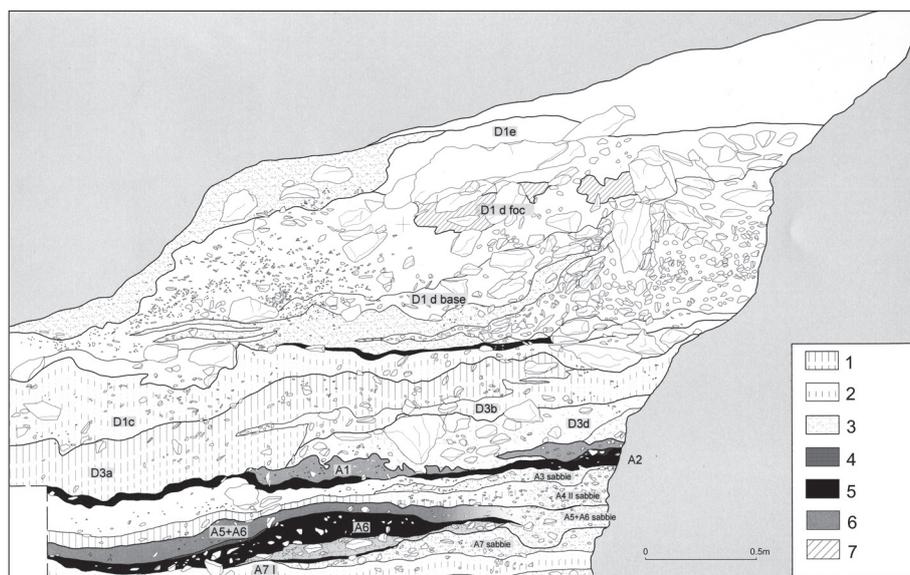


Fig. 4. Section showing the stratigraphic sequence exposed at the entrance of tunnel A (by M. Peresani & S. Muratori).

Abb. 4. Schnitt mit den stratigraphischen Einheiten am Eingang des Tunnels A (Zeichnung: M. Peresani & S. Muratori).

This article therefore aims to present the evidence achieved from the field and post-excavation studies, and provide a first basis for drawing inferences about the formation processes and human behaviour.

The evidence from the field

Excavation: sectors, phases, methods and documentation

Excavations were conducted in the right zone of the cave entrance over a total area of 25 m², where the final Mousterian layers are exposed (Fig. 2). The work in 2006 focused on units TettoA5, A5 and A5+A6. Many hearths were discovered and structures A5_S I and A5_S II were completely removed, while A5_S III was partially excavated. In 2007, excavation of unit A5+A6 and structures A5_S III and A5_S IV was completed, but not of A6, which was only partially excavated. This task was accomplished during the 2008 campaign.

All the layers were excavated on 33x33 cm squares and the material (bones and lithics) was either directly positioned using the total station or recovered from flotation and wet sieving. During the removal of the most anthropogenic layers, undisturbed samples were taken systematically from the centre of each square for micromorphological, microstereoscopic and other routine analyses. Clear structures recognized in the field were manually mapped and surveyed as well as drawn with the stratigraphic relationship with underlying and overlying units, together with observations and descriptions on lateral variations in composition and fabric. Each structure was partially excavated to expose one or more sections for examining the stratigraphy and possibly taking undisturbed samples.

Ash and other material were collected separately for chemical and mineralogical analyses.

Field description of the sedimentary units of the A5-A6 complex

The sedimentary units of the A5-A6 complex cover the whole cave entrance and remain currently visible in the main section, in tunnel A (Fig. 4), behind the protective wall in tunnel B and on the sections exposed in the main chamber. A5 and A6 are defined on the basis of lithological features (stoniness, aeolian fine fraction and sand lenses) and indications of anthropogenic activity, shown by variable darkening of sediment and high organic content, as well as an abundance of lithics, bones and charred vegetational residues. The thin, flat charcoal layer A5 is separated from A6 by a loose stony layer with a loamy fine fraction labelled as A5+A6. The dark layer A6 is recognizable over the whole excavated zone, with constant dense indications of anthropogenic activity. The lower boundary is abrupt with A7 and is lightly undulating with some large and shallow basins, though unrelated to any evident structures.

Some discontinuities affect the whole sedimentary body or sometimes are restricted to a few units (Figs. 7 & 8.1): a line of marmot burrows goes through squares 66 and 67; next to the rock wall various zones with irregular boundaries show gaps in A6, which are replaced by sand bodies or by the overlying unit (i.e. A5+A6 breccia) and lie directly over A7.

Layer A5

Unit A5 has been exposed over 7 m² in the zone under tunnels A and B. Moving from tunnel A, the upper boundary is sub-horizontal in squares 69 and 89 and,

behind a discontinuity, regularly slopes 4-5° ESE and becomes undulating and stepped, particularly in squares 68-69 than elsewhere, with steps of 5-6 cm. The boundary becomes more regular, sloping towards the ESE in squares 57-67, 56-66.

As a whole, indication of anthropogenic activity is low, the sediment is almost totally natural, charcoal fragments are dispersed and larger than 2 cm, but archaeological remains are rare, except around hearth A5_SIII. The anthropogenic signatures are greater in the most elevated zones such as squares 69 and 89, as shown by the organic fraction and the increasing charcoal content, whereas some of the lowest densities of bone and flint occur in the adjoining squares to the south. A second scatter of faunal remains and flakes occurs in square 57, in a zone bordered by a vertical slab.

Layer A5BR

The variability in sedimentary facies is shown by this context made of loose stone-supported breccia with angular clasts (< 10 cm) sometimes still conjoined but divided by frost fractures, horizontally arranged in respect to the stratigraphic boundary. It has been exposed in squares 86-87, 76-77, 66-67 and ends as a straight line on the western edge, but curved on the eastern edge, where it thins to a line of stones lying on sands with a darker, charred fine fraction and a few scattered bones and artefacts. The stones are dispersed and the dark brown loamy fraction is dominant. Rare flint and bones lie at the top of the layer, but are not embedded in it. Hence, A5BR records a collapse event with repeated frost, in a sedimentary context related to the morphology and the lithology of the vault, which nowadays has retreated, but once was still coated with the same micritic facies that produced the frost-shattered stones.

Layer A5+A6

This label corresponds to the layer sandwiched by levels A5 and A6, regardless of the discontinuity and the absence in the innermost square of the former level. The thickness of A5+A6 is usually 10cm, thinner in the innermost squares (126-128) but thicker beyond the present-day drip-line and close to tunnel A. Various sedimentary facies are linked to different microsedimentary contexts: at the cave-mouth, A5+A6 is a monogranular layer composed of frost-shattered stones with a sandy fine fraction in the innermost zone (squares 129, 128, 127); in squares 97 and 107 there are loose stones (A5+A6breccia II) which directly overlie A7, where A6 is missing; in the zone protected by the junction of tunnels A and B, stones are rare to absent and sand prevails (A5+A6sabbie). In the outermost belt, well beyond the present-day drip-line (squares 56 and 57), A5+A6 is mainly loamy with variable sand content, that is sometimes concentrated in lenses alternating with laminae of reworked aeolian silt; stones are small and scarce. A5+A6sabbie fills a

basin 80 cm wide in squares 77 and 78, where the large hearth A5_SIII lies. In the outermost squares 56 and 57 where unit A5 is missing, the upper boundary of A5+A6 has a WNW-ESE oriented axis, slopes southwards with a 10 cm step to the north, due to deformation pressures caused by two boulders in A3 and A4. Again in these squares, the layer shows light pedogenic features such as a soil crumb structure, high bioporosity and corroded stone surfaces. Artefacts and ecofacts are dispersed and do not show any significant relationship.

Layer A6

The part of unit A6 exposed during the three field campaigns covers an area of 14 m² if we exclude the zones where this context is missing or has been removed by marmot burrowing. First, there are a series of discontinuities seen in squares 107 and 97 and along the cave wall in squares 79 and 99 marked either by a clear or a frayed boundary which thins to expose A7. The gap in 107 and 97 is arranged in accordance with the upper boundary with rare lithic artefacts including discoid flakes and rare charcoal. No deliberate traces of anthropic excavation are visible and nor is there bioturbation or deformation caused by collapsed sediments. Thickness gradually increases from the inner (i.e. squares 128 and 129, 3-4 cm) to the outer zone, where it reaches 10 cm. The organic content and charred vegetation remains is high, even though the frequency of lithics and bones decreases in the sector with the hearths and the other structures, in comparison to the innermost zone. Charcoal abounds, particularly in squares 67-68 and 77-78, and there are reddened horizons and discontinuous fine ash layers, with almost all bones varying from burnt to calcined and the few flakes showing heat shattering.

Different facies contribute to the thickness of A6. Beyond the present-day drip-line, the fine fraction becomes almost the only sedimentary component, with an increase in aeolian silt balancing the decreased number and size of stones. Therefore, the latter abound in the southernmost zone under tunnel A, square 59, where they form a stony lens (A6breccia) which contains the archaeological layer. Again in this zone, in squares 59 and 69, a thin sandy lens (A6sabbie) separates structures A6_SXVIII-A6_SXX from structure A6_SXIX. These aggradations are due also to the overlapping of hearths. Furthermore, in square 77 the surface of A7 is covered by a thin layer of medium to large fractured bones, which are separated from A6 by a layer of sand and loose, crushed, tiny stones. A separation between different sedimentary events was also visible in structure A6_SVI, where a lens of crushed, tiny stones with a major sand content occurred between A6 and a second anthropogenic level with flakes and bones scattered at its base. As with A5+A6, in the outermost belt, A6 displays shallow pedogenic features such as a soil crumb structure, intense bioporosity and corroded stone surfaces. The

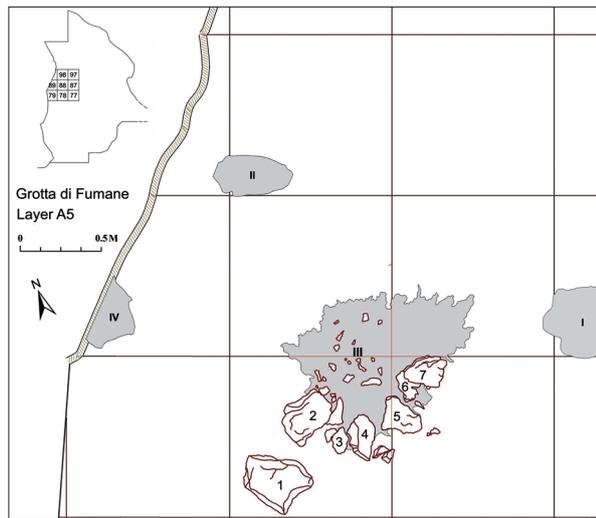


Fig. 5. Plan showing the position of the hearths (I, II, III, IV) in layer A5 (drawing E. Cocca, S. Muratori, M. Peresani & S. Tinazzo).

Abb. 5. Plan mit den verschiedenen Feuerstellen (I, II, III, IV) der Schicht A5 (Zeichnung E. Cocca, S. Muratori, M. Peresani & S. Tinazzo).

spatial distribution of these features shows a weathering boundary running diagonally across the excavation grid separating a southern pedogenic zone from a northern area with primary sedimentary contexts.

Hearths, dumps of burnt residues and other structures

Layers A5 and A6 contain various accumulations, most of which can be ascribed to the lighting of combustion structures and to other tasks broadly related to human subsistence. In the sector excavated during the three campaigns, A5 has yielded a few structures which are variably complex, positioned either near the cave wall or at the centre under the vault formed by tunnels A and B (Figs. 5 & 6). In contrast, only one structure has been found in A5+A6, whereas 21 have been discovered within A6 (Fig. 7). This excludes a thin charcoal level (A6_S1) interpreted during the 2002 excavation as a dump of burnt residues at the base of the layer.

Layer A5 A5_S1

The structure was found in square 86 and was firstly exposed during the 1990s in the large axial section that divided the cave fill in two. It is made of heated reddish-brown clayey-loam, compact and massive, overlain by a thin layer with abundant charcoal, mainly scattered within a 4-5 cm wide rim. It has been interpreted as a combustion structure, lying on a very thin layer of loam, covering a breccia.

A5_SII

It is a combustion zone positioned in square 98, 40 cm from the wall, broadly circular, dispersing to the east

with irregular and lobate boundaries. It is associated with charcoal accumulations, many of which have little structure, and is marked by a red horizon on the sands beneath.

A5_SIII

This feature reflects complex evidence of an area used for combustion but also for other tasks presumably tied to the hearth (Figs. 6.1-6.4). Various elements highlight the distinctiveness of the feature compared to the surrounding sediment of layer A5 and the other structures A5_S1, A5_SII, A5_SIV- A5_SVII. The initial accumulation of this complex was the deposition of a loamy lens, which was excavated to form a shallow basin in which occurred the first structure, as perhaps a hearth or a dump of burnt material, which was then covered by a thin detritic level. A second phase over the whole area shows the construction of a large hearth partially enclosed by slabs and associated with subsistence activities, indicated by a surrounding scatter of bones and flint tools.

- The massive loamy lens, named A5I, extends across squares 78 and 77; it contains charcoal and a few flints, slopes northwards and is sub-ovate in shape with an E-W axis. Towards the south it borders A5, and towards the west abuts stones 1, 2 and 3.
- In a restricted sector, A5I is cut by a shallow basin a few cm deep, covered by a 1cm thick charcoal coating, presumably reflecting the first combustion structure or the accumulation of burnt material. This level is then covered by a dark brown loamy level (level 6) with little evidence of pedality and rare, dispersed charcoal which covers the basin and scatter on the northern side.
- Level 6 is buried by a 1cm level composed of sand with rubble, altered at intervals by reddening caused by combustion during the second phase.
- The second combustion structure is recorded from a layer (level 4) made of large to medium charred wood arranged on the ground, sometimes several cms thick, or with little structure. It is 40 cm wide, continuous in the northern zone and coated by a veil of ash (level 3) in square 78c. Level 4 has a clear northern boundary, but to the south it partly penetrates between the slabs. It contains fragments of heated stones and burnt bones, amongst which there is a spongy bone fragment. The reddened horizon beneath is discontinuous, irregular on the plan and limited to the north quadrant.
- Eight stones - squared slabs and fragments of dolomitized local limestone with sharp or lightly rounded ridges, sometimes with a thin calcrite coating on the lower face - depict a semicircle on the southern side around level 4 (Fig. 5). Layer A5 and level 4 lay on the side of slabs 1 and 2 (level 4 also on slab 6). Slab 7 covers level 4. In contrast, slabs 4 and 5 and partially 3 plunge into A5I and together form a broad flat surface where the top



Fig. 6. Hearths and dumps of combusted material from Layer A5: 1) view of the cave entrance and structure A5_SIII; 2) structure A5_SIII viewed from the inner cave; 3) detail of the southern border of A5_SIII with the loamy massive layer A5I; 4) A5_SIII with level 6 exposed under the easternmost slab; 5) structure A5_SV; 6) the charcoal accumulation A5_SVII.

Abb. 6. Feuerstellen und deren Ausräumungen von Schicht A5: 1) Ansicht des Höhleneingangs und Struktur A5_SIII; 2) Struktur A5_SIII von innen gesehen; 3) Detail des südlichen Rands von A5_SIII mit der dicken Lehmschicht A5I; 4) A5_SIII mit Einheit/Lage 6 freigelegt unterhalb der Platte; 5) Struktur A5_SV; 6) Holzkohleakkumulation A5_SVII.

- of A5I slopes down to the north.
- To the western side of the structure there are a few lithic artefacts (mainly retouched tools), fragments of bone diaphyses and abundant charcoal.
A layer of sparse stones covers either the structure

(where it has been named level 2) or its western sector (here labelled level 7) where it lies on slab 2.

Besides reflecting tasks broadly related to combustion and subsistence, the stratigraphic composition of this structure provides evidence of deliberate

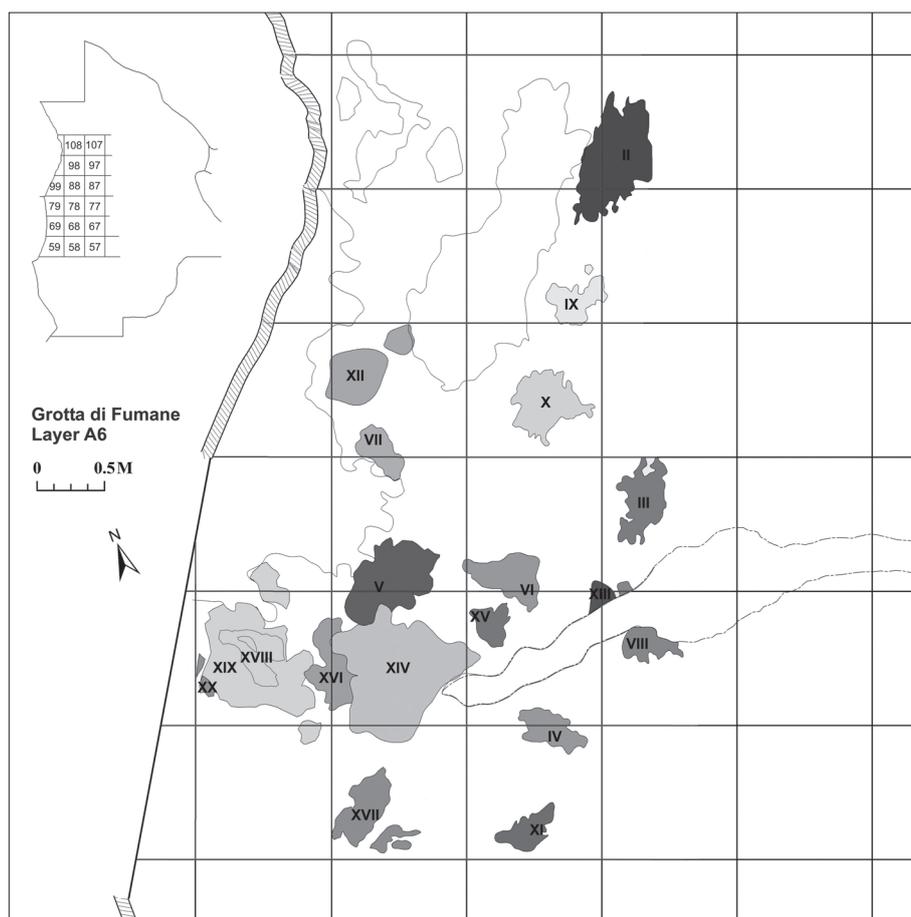


Fig. 7. Plan showing the position of the hearths and other structures in layer A6. Discontinuities are depicted by the light gray line, marmot tunnel by the dashed line (drawing E. Cocca, S. Muratori & M. Peresani).

Abb. 7. Plan mit den verschiedenen Feuerstellen und anderen Strukturen in Schicht A6. Unterbrechungen sind als hellgraue Linie angezeigt, Murmeltiergang durch gestrichelte Linie (Zeichnung: E. Cocca, S. Muratori & M. Peresani).

arrangement of the ground surface and attempts to stabilize the loamy substrate in this zone of the shelter. As a matter of fact, if the first combustion structure or dump of charred wood fragments within a shallow basin occurred prior to a period of abandonment after which a second structure was organized (levels 4, 3 and 2), then the deliberate positioning of the few slabs seems isolated from lens A5I. This lens deformed upwards incorporating the base of some slabs within the lens and forming extrusions at the base of slab 5. Nevertheless, the diversity observed in the two groups of slabs, 1, 2 and 3 (similar to one another), 4 and 5 (coated by microcalcrete), and the position of stone 7 over level 4 suggests that different events occurred with first a phase of preparation, then a second and possibly third phase after the second combustion structure was abandoned, to create a horizontal, stable zone from a previous one in the deformed ground.

A5_SIV

This flat small hearth tilts gently eastwards towards the cave wall in square 89. It is marked by the exposure at intervals of a reddened horizon formed on a single layer of stones c. 5 cm thick, some of which are calcined. This horizon is covered by a thin, dark layer with a little charcoal and burnt flint.

A5_SV

A charcoal level 1 cm or less thick, scattered at the periphery with microcharcoal and ash towards the centre, but with no trace of reddening either on the sediment or stones (Fig. 6.5). Those stones at the centre of the structure are coated with a thin very dark greyish-brown organic film. It has been interpreted as the dump from a hearth.

A5_SVI

SVI denotes a group of lithic artefacts, bones and charcoal deposited in a 1 m wide basin uncovered in square 78i after structure III and A5I had been removed. To this group has also been added a bison epiphysis partially buried by slab 2 of structure III.

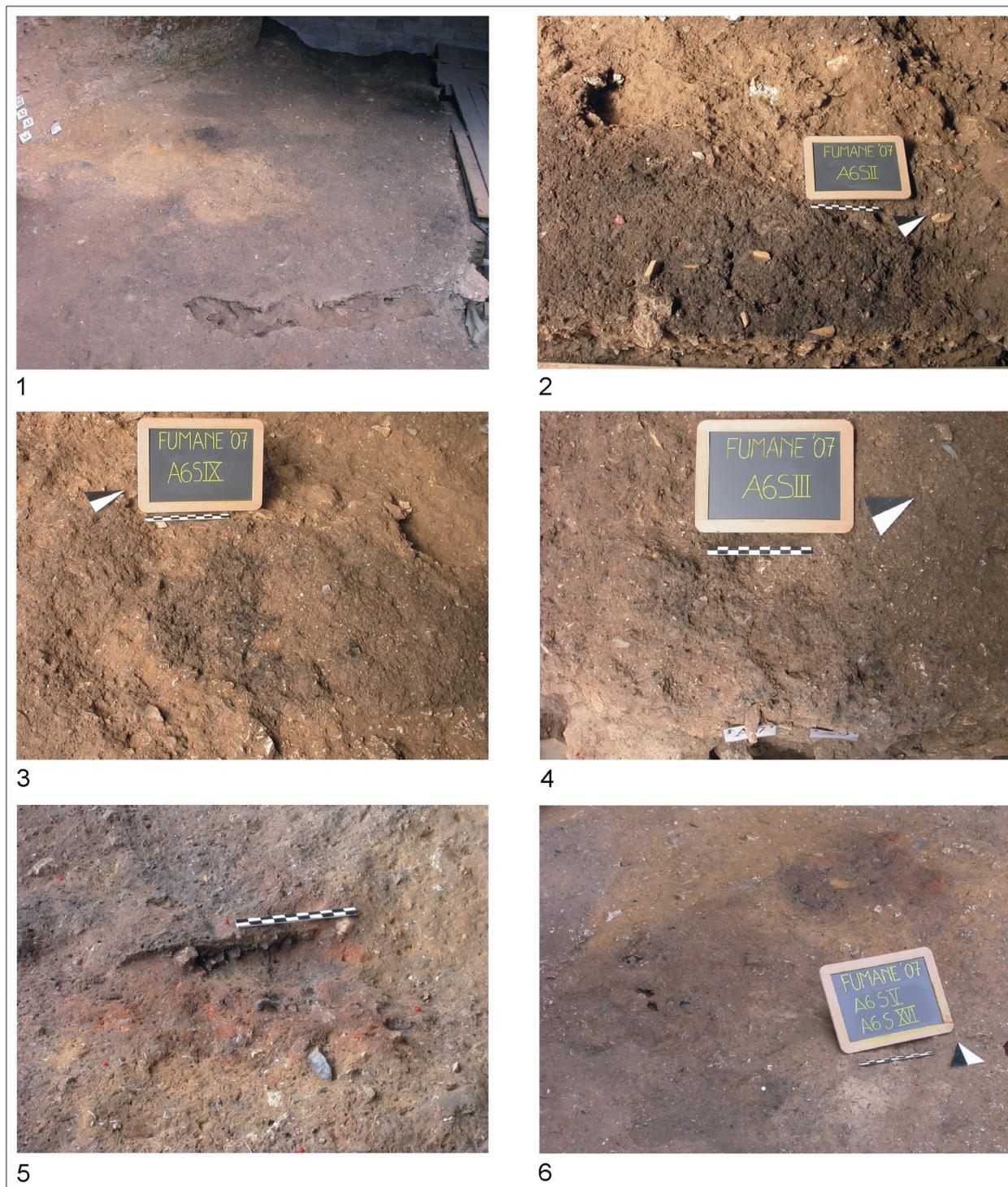


Fig. 8. Hearths and dumps of combusted material from layer A6: 1) view from SW of the cave entrance with exposure of layer A6, a few hearths, gaps in A6, a marmot tunnel; 2) structure A6_SII; 3) the A6_SIX charcoal accumulation; 4) structure A6_SIII; 5) view from the N of the section cut in hearth A6_SV; 6) structures A6_SV and A6_SXVI.

Abb. 8. Feuerstellen und deren Ausräumungen von Schicht A6: 1) Ansicht von Südwesten des Höhleneingangs mit offengelegter Schicht A6, einigen Feuerstellen, Lücken in der Schicht A6 und ein Murmeltiergang; 2) Struktur A6_SII; 3) Holzkohleakkumulation A6_SIX; 4) Struktur A6_SIII; 5) Schnitt durch die Feuerstelle A6_SV von Norden gesehen; 6) Strukturen A6_SV und A6_SXVI.

A5_SVII

This is an accumulation of charcoal lying on A5BR in square 66 which surrounds the stones overlying A6 (Fig. 6.6). It is associated with either reddened horizons or with particular arrangements of stones and the substrate.

Layer A5+A6 A5+A6_SVIII

This is a small group of charcoal less than 1 cm thick, located in square 67 g, arranged in a single level with the highest density towards the north and scattered within a 4-5 cm large rim. At the periphery, it is associated with lithic artefacts and unburnt bone.

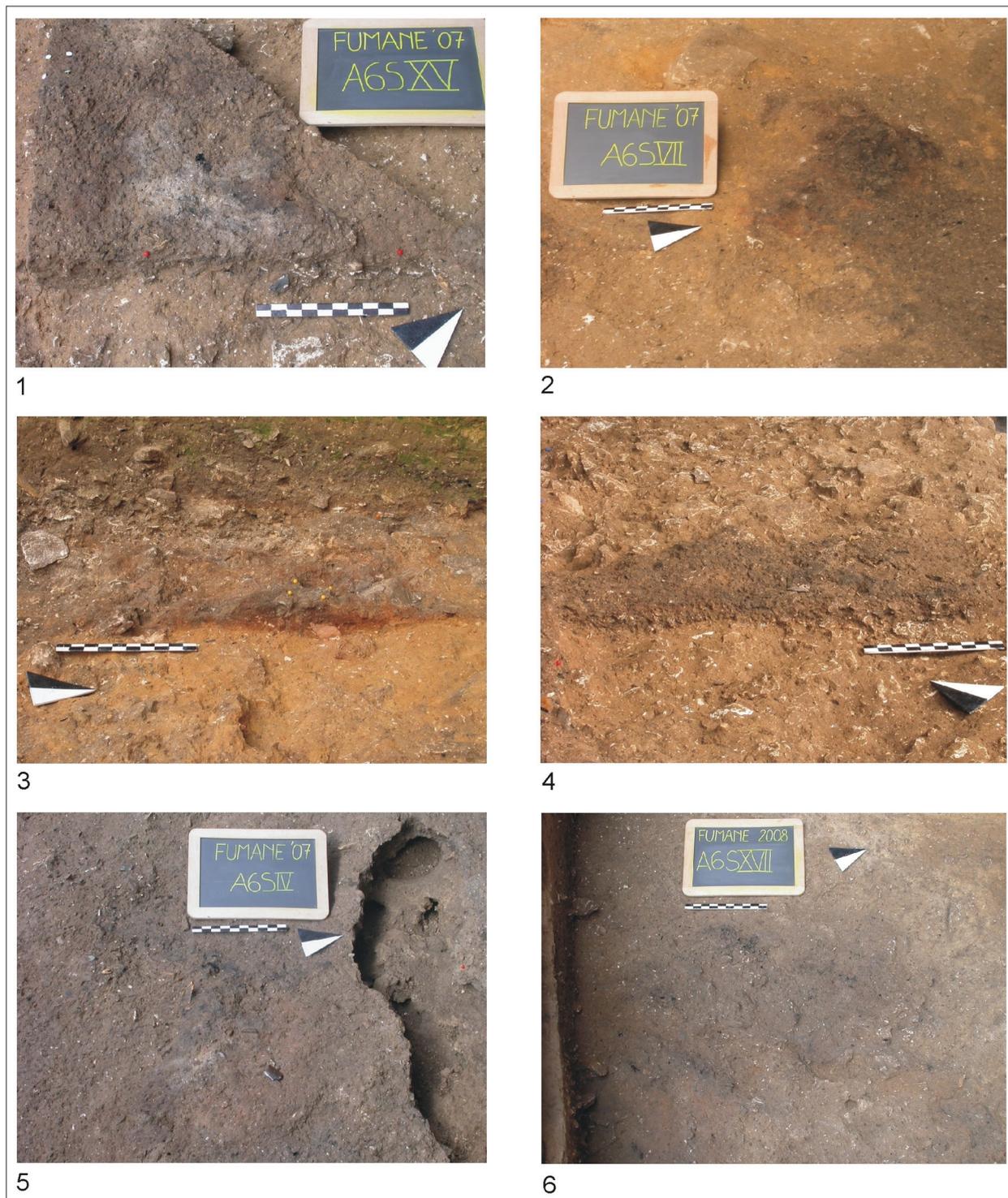


Fig. 9. Hearths and dumps of combusted material from layer A6: 1) ash in A6_SXV; 2) structure A6_SVII; 3) view from the east of the section cut in A6_SXIX; 4) view from the south of the section cut in structure A6_SX overlying layer A7; 5) structure A6_SIV at the top of layer A6; 6) structure A6_SXVII.

Abb. 9. Feuerstellen und deren Ausräumungen von Schicht A6: 1) Asche in A6_SXV; 2) Struktur A6_SVII; 3) Schnitt durch A6_SXIX von Osten gesehen; 4) Schnitt durch A6_SX von Süden gesehen, sowie darüberliegende Schicht A7; 5) Struktur A6_SIV am Oberrand von Schicht A6; 6) Struktur A6_SXVII.

Layer A6

A6_SII

This structure was partially exposed during the 1996 fieldwork, in squares 106 and 96 (Fig. 8.2). It is embedded in A6, as it is covered by <1 cm thick brown horizon (A6tetto) and lies over a dark brown level

with artefacts and ecofacts overlying A7. SII is a dense accumulation of 1 cm thick charcoal forming a continuous level, with a N-S elongation and uneven borders. It is associated with a very thin ash level almost devoid of charcoal. Bones and flints are

scattered on the structure, disposed N-S and tilted in accordance with the microrelief. A flint refits with a flake 50 cm towards the south. Due to the lack of red mottling in the substrate, this structure should probably be interpreted as a dump of combusted residues.

A6_SIII

SIII is a hearth with lobate boundaries both on the horizontal and vertical scales. It lies on a brown, thin horizon, with dispersed charcoal from earlier anthropogenic activity (Fig. 8.4). The structure has a shallow reddened horizon partially overlain by 1-2 cm of sands with charcoal and ash, denser in some areas.

A6_SIV

This structure 0.5 m² in size was uncovered after A5+A6 had been removed (Fig. 9.5). It is characterized by a red horizon, with dense tiny charcoal fragments and ash at the side of the central area. Due to its position at the top of A6, it records one of the last human occupations before the unit was buried.

A6_SV

The presumed extension of this combustion structure is about 50 cm in diameter, estimated on the basis of the reddened and charred sediments observed in squares 68 and 78 (Fig. 8.6). It lies on sand studded with anthropogenic sediment. The horizontal boundary is dispersed with the sand to the north, whereas to the south it is marked by the edge of A6. At the base, the hearth has a 2-3 cm thick, reddened horizon with burnt material, bones, charcoal and calcined stones that record the first phase of lighting. This was followed by a second phase responsible for heating and reddening the earlier micro-sedimentary sequence (Fig. 8.5). The first horizon lies below a dark, organic 1 cm thick level including at the top a 1 cm thick bed of macrocharcoal (2-3 cm) and above it, a thick layer of ash.

This dark level displays features partly relating to the activity of a combustion structure (charcoal, burnt flint and bones) and partly with the usual anthropogenic sedimentation of A6 (the fabric and the unburnt stones and bones). It is interpreted as a much earlier abandoned structure, from the earliest occupations, which was then cleaned or partially removed by later activities or various natural processes. A charcoal level, found on the yellow sands to the west, was limited to the outline of structure SV and may be associated with it. Furthermore, the whole complex was altered at the top by the heating of the hearth A6_SXIV.

A6_SVI

This combustion structure was found at the top of A6 after A5+A6 was removed. It is represented by a reddened horizon surrounded with a charcoal rim with fragments of burnt bone. Boundaries are irregular.

A6_SVII

This hearth diagonally crosses squares 78 and 88 and has a bi-lobate shape with a larger rounded zone clearly outlined by the yellow sands (A7sabbie), from which it separates with a level of dispersed, discontinuous charcoal, less than 1 cm in size. This level may be ascribed to a probable frequentation preceding the structure (Fig. 9.2). The base of the hearth is a red horizon partly covered by an organic, charcoal level, with ash and small stones (max. 4 cm) partly calcined. The microrelief is flat, consistent with the sloping of the substrate. No evident accumulations or depressions have been noted. The stratigraphic relationship with A6 shows that this layer overlies the east side of the hearth.

A6_SVIII

SVIII was found after A5+A6 was removed in squares 66 and 76. The marmot tunnel divides it to southern and northern parts. It is a continuous accumulation of fragmented charcoal reduced to small grains and associated with a zone of scattered charcoal, ash, few burnt bones and occasional heated flints. This level lies on a loamy compact layer, which is reddened and almost circular, with fragmented burnt bones. It buries A6.

A6_SIX

This level consists of a single spreading (1-2 cm) of large charcoal fragments clearly positioned over A7 and covered by A6 (Fig. 8.3). It is irregularly outlined, sub-circular with marked lobes and a clear boundary. The charcoal shows different degrees of preservation, being denser in the central zone where the fragments form an almost continuous layer with the presence of a few burnt bones. Traces of bioturbation are visible.

A6_SX

It is a hearth 0.25 m² large (Fig. 9.4) with a red zone in the middle surrounded by an organic charcoal level characterized by extremely frayed external boundaries. The surface is flat with no undulations or folding, except a shallow slope towards the east in the western part.

A6_SXI

This combustion structure clearly overlies A7 and is buried by A6. It is almost circular with a variably wide rim made of dark sediment with rare, tiny charcoal fragments and bones, mostly burnt. A reddening affected the top 5-6 cm of A7 as a flat-convex lens, thickest at the centre. Burnt bones are scattered at the boundaries of the structure. Other reddish zones are distributed and isolated within the dark rim. The southern boundary is truncated by the burrow. The way the different facies are arranged suggests disturbance in a NW-SE direction leading to the compression of the two horizons. No depressions or specific soil arrangements have been noted.

A6_SXII

SXII has been exposed after A6 was just excavated for few mm in square 88. It is characterized by two groups of material, one with charcoal positioned towards the NE and named SXIIb, the other with charcoal and reddish earth, visible at intervals and labelled SXIIa. It lies directly over the sands and stones of A7, and is extremely thin. The formation of an anthropogenic horizon seems to precede the activation of SXIIa.

A6_SXIII

At the base of A6 where the squares 66/76 and 67/77 cross, a sub-circular zone has been found and appears to be partly cut by the burrow. The structure has a reddish horizon which affects A7 but is not associated with ash or charcoal accumulations.

A6_SXIV

This structure was discovered after A5+A6 was removed and the top of A6 was exposed in square 68, but was mainly exposed during the excavation of structure SV. It is a vast complex composed of a circular combustion zone about 1 m² in size, with reddened sediment and an accumulation of tiny charcoal fragments and lumps of carbon towards the east. To the west there is less reddening and the boundaries are less clear. The hearth was therefore ignited on A6 and, partly over the microstratigraphic complex of the combustion structure SV.

A6_SXV

It is composed of ash in square 67 associated with a very dark-brown level with fragmented charcoal, few weathered flints and burnt bones and a reddish horizon which affects laterally an isolated sandy lens overlying the lower part of A6 (Fig. 9.1). This accumulation is considered separate to the adjacent SVI. A6_SXV actually extended to the west, as an elongated shape with irregular boundaries caused by displacement and deformation of the original combustion structure.

A6_SXVI

This hearth lies at the base of the anthropogenic complex and is marked by a reddish horizon which has altered A7sabbie. It was found after the removal of SXIV and A6. On the southernmost side the boundary is truncated by a tunnel burrow which caused the partial collapse of A6 and the partial erosion of the reddened horizon. In addition, the latter was affected by intense bioturbation which reworked different fractions (sands and organic dark sediment, with tiny and dispersed charcoal fragments).

A6_SXVII

The original extension of this hearth found in square 58 was disturbed, with its outline on an elongated WSW-ENE axis caused by compression and stretching (Fig. 9.6). It is composed of three subunits: a peripheral accumulation of centimetre-sized macrocharcoal (1),

in transition with a continuous level of dark earth of variable thickness with microcharcoal (2) and a thin reddish horizon (3). Within the area depicted by the hearth there are discontinuities caused by post-depositional disturbance, which divides the structure into two parts, stretching the levels, trusting and displacing them. Once the microcharcoal level was removed, a group of grey flint flakes probably from the same raw material nodule was uncovered together with several bones and one red flake, embedded in the soil. In the surrounding area the charcoal of level 1 emerges, which seems to precede the deposition of the flint.

A6_SXVIII

SXVIII is located in square 69e and lies on A6 which in this zone is 7-8 cm thick over A7sabbie. It is a combustion structure, deeply deformed and only partially preserved, characterized by an irregular elongated shape on a W-E axis, with clear boundaries both to the north where mixed sands and stones occur in a transitional zone with A7 and A7sabbie, and to the south where it has a boundary with A6. The latter has a low anthropogenic content within a 20-30 cm wide belt. At the base there is a reddish horizon, particularly clear at the western edge, which is affected by bioturbation and covered by a dark, crumbly level with microcharcoal and several fragments of heated stone.

A6_SXIX

This structure has been exposed at the base of A6 and was placed on the exposed surface of A7sabbie. It included a main combustion zone and various dumps of burnt residues, which take up a large part of square 69. The zone is delimited by the sands to the east, by the level ground on the sands and stones to the north, to the west by the stones whose frequency increases towards the tunnel A and to the south by the stepped edge of the sand body. The central combustion zone is marked by a clear, large, but discontinuous reddened horizon, up to 5 cm thick, studded with tiny burrows, limited by steps and small slopes and coated by a thin dark, loamy sub-horizon (Fig. 9.3). The frequent stones on the west side are positioned horizontally or in accordance with the microrelief of the slopes, and some are calcined and reddened, while others are shattered. There are burnt bones and a few other bones in the charcoal accumulations at the eastern and northern sides of the structure. Two satellite accumulations, SXIX.1 and SXIX.2, also contain macrocharcoal, even though rare, and a few heated flints. A third structure, SXIX.5, seems to be a second burning area as suggested by the dark, lightly reddened horizon.

A6_SXX

It was found in square 69g-d after the removal of A6. This structure is composed of two parts, the first

being a reddish horizon within the yellow sands and covered by a dark, charcoal level, the second being a dark level made of fine unidentifiable charcoal, dispersed within the matrix, with various burnt organic and inorganic fragments.

A6_SXXI

This structure, marked by a concentration of burnt residues in square 59c, is circular and limited on the west side by a line of up-tilted stones. Charcoal, burnt bones, flint and heated stones are contained in a level thickening westwards, the lowest boundary of which slopes at ca. 18°-20° and is shown by flints and burnt bones positioned in accordance with the microrelief.

A6_SXXII

It is a combustion structure placed at the base of A6 across the squares 79g/Z70i, in a degraded area subjected to possible erosion of the anthropogenic unit. Degradation is also due to bioturbation, which occurs to a greater degree towards the south. A red 1cm thick horizon is visible with partially calcined stones, which originated in A7sabbie and were partially covered by a level with tiny charcoal fragments, extending eastwards for 10 cm².

Basic micromorphological features

Micromorphological analysis has been initially restricted to A6. This first study has provided data on the sedimentary processes and the inferred palaeoclimatic. In addition, it has provided information on the syn- and post-depositional processes which occurred during the human occupations. Eighteen thin sections have been observed under polarizing microscope and described following the standard guidelines of Stoops (2003; Danti 2008-09).

The coarse fraction is composed of rock fragments (dolomite limestone and oolitic limestone), dolomite sand (from the chemical dissolution of the bedrock), quartz and mica minerals. The first two elements, rock fragments and dolomite sands, represent the autochthonous material, while quartz and muscovite are allochthonous aeolian material. Coarse angular limestone *debris* (common size: coarse sand to fine gravel) is usually abundant, while dolomite sand, was deposited either by run-off water from the inner karst system (tunnel A) or by surface microdissolution of the tunnel A vault. Aeolian quartz and muscovite are a minor component in the sedimentary aggradation. The *debris* is commonly explained as repeated freeze-thaw cycles (Goldberg & Macphail 2006).

Frost induced microstructures and cryogenic features are very common, such as coarse cappings (Figs. 10.1 & 10.2), lenticular shaped coarse fragments, platy (stacks of aggregates horizontally elongated and separated by planar voids) or "banded" microstructures (Fig. 10.3). These features are generated by ice lens segregation in sediment material during periods of

frost activity (Van Vliet-Lanoë 1998). Samples from the inner part of the cave show frequent coarse cappings (unsorted) on coarse fragments of bones and rocks, and very few calcite reprecipitation features (coatings, hypocoatings on voids, groundmass impregnations, alteromorphs) (Fig. 10.4). Thin sections from the central area of the cave are characterised by frequent coarse cappings associated with a well expressed "banded" microstructure (ice lens traces), indicating ice as the principal post-depositional agent.

In the cave entrance, calcite features show little increase while coarse cappings decrease.

Anorthic red rounded nodules with mosaic speckled b-fabric and mineral grains included, have been found in nearly all of the A6 thin sections. These kinds of aggregate can be interpreted as colluvial features (reworked soil material) transported into the site from the slopes above the cave.

With respect to the underlying A7, which is marked by aeolian deposition and absence of cryogenic pedofeatures, all the micromorphological evidence suggests increase in soil cryoturbation and increase in water supply (calcite dissolution and precipitation).

Micromorphology has also provided some contribution in characterizing the combustion features. Some samples taken from the combustion structures recognised in the field have micritic lenses, just a few millimetres thick, described as aggregates composed of calcite crystals, massive calcite, mixed with charcoal fragments, burnt and partially burnt bone fragments, and characterised by loose and crumbly microstructures. The rhomboidal calcite crystals conserved in these ashy levels are calcium oxalate pseudomorphs on calcite (Fig. 10.5). Calcium oxalate crystals have wood and leaves as the main components; during combustion they are chemically replaced by calcite and they keep their shape up to 500 °C (Courty et al. 1989). Another indicator of burning intensity is the colour of the bones, which are normally pale yellow to reddish brown. Bones fragments are typically a medium to fine sand size fraction in the ashy levels, which suggests the use of fine fragmented bones as fuel. It is important to note that secondary calcite re-precipitation features are always connected with these ashy levels. Part of the original calcite in the ash has been reworked and re-precipitated, by solution, and redeposited as hypocoatings, coatings in voids and impregnations into the groundmass.

Other elements have been identified in order to work out the anthropogenic contribution as syn- and post-depositional agents. Human activities contributed to the sedimentary record with materials like bones, flints, charcoal and ash (Fig. 10.6). The b-fabric is often hidden by the abundance of charred organic material. Generally, bones, flints and rock fragments show planar disposition; these elements accumulated over a flat surface probably caused by human trampling.

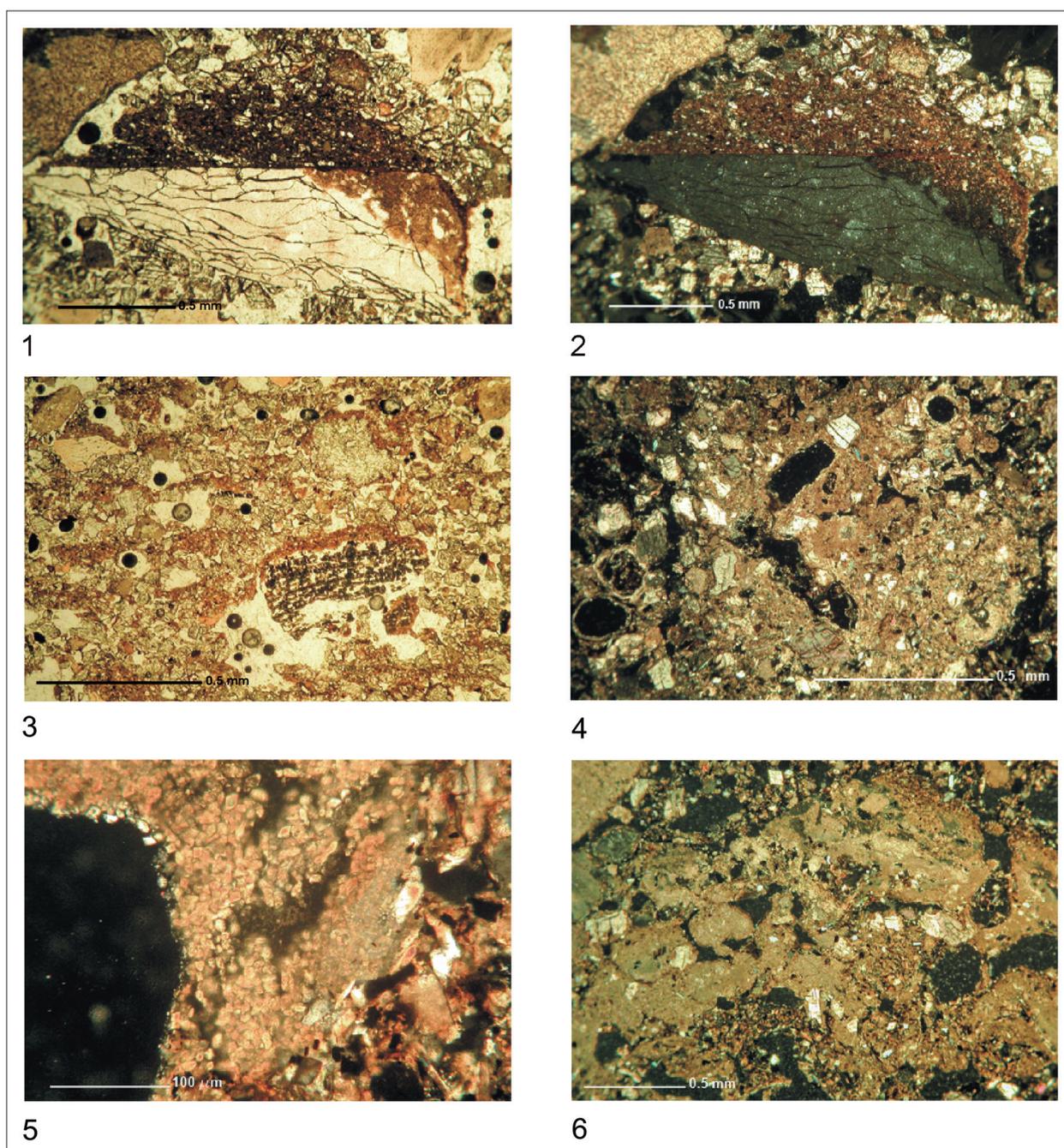


Fig. 10. Micrographs of thin sections from layer A6: 1) coarse capping on flint (ppl, 2.5x); 2) coarse capping on flint (xpl, 2.5x); 3) “banded” microstructure (ppl, 1.6x) ; 4) calcite impregnations in groundmass, alteromorphs, coatings and hypocoatings on voids (xpl, 2.5x); 5) calcite pseudomorphs (xpl, 25x); 6) ash level (xpl, 1.6x).

Abb. 10. Mikroskopische Ansichten von Dünnschliffen von Schicht A6: 1) Silex mit capping (Frostspuren), Parallele Polarisation (ppl); 2) Silex mit capping, Gekreuzte Polarisation (xpl); 3) Gebänderte Mikrostruktur (ppl); 4) Kalzitimpregnationen in der Matrix, mit Verwitterungsspuren, Porenbelägen und Hypocoatings (xpl); 5) Kalzitpseudomorphosen (xpl); 6) Ascheniveau (xpl).

Initial data on the ecological context inferred from charcoal and mammal remains

Charcoal remains

All the levels yielded abundant anthracological material. In 2006, we took up the study of anthracological samples from A5, A5+A6, A6 and the A6/A7 interface: 752 fragments were observed under optical reflection microscope (charcoal was manually broken following

the three anatomical planes of wood and identified (Fig. 11) using wood anatomy atlases (Schweingruber 1990; Vernet et al. 2001) and the reference collection of CEPAM laboratory (CNRS, UMR 6130, Nice, France).

The anthracological assemblage is largely dominated by *Picea/Larix* (probably the common European larch, *Larix decidua* Mill.; Fig. 12). *Picea* and *Larix* are difficult to distinguish, but on the basis of tenuous anatomical criteria (Talon 1997) as well as biogeographic criteria (Maspero 1998-1999), we believe the charcoal

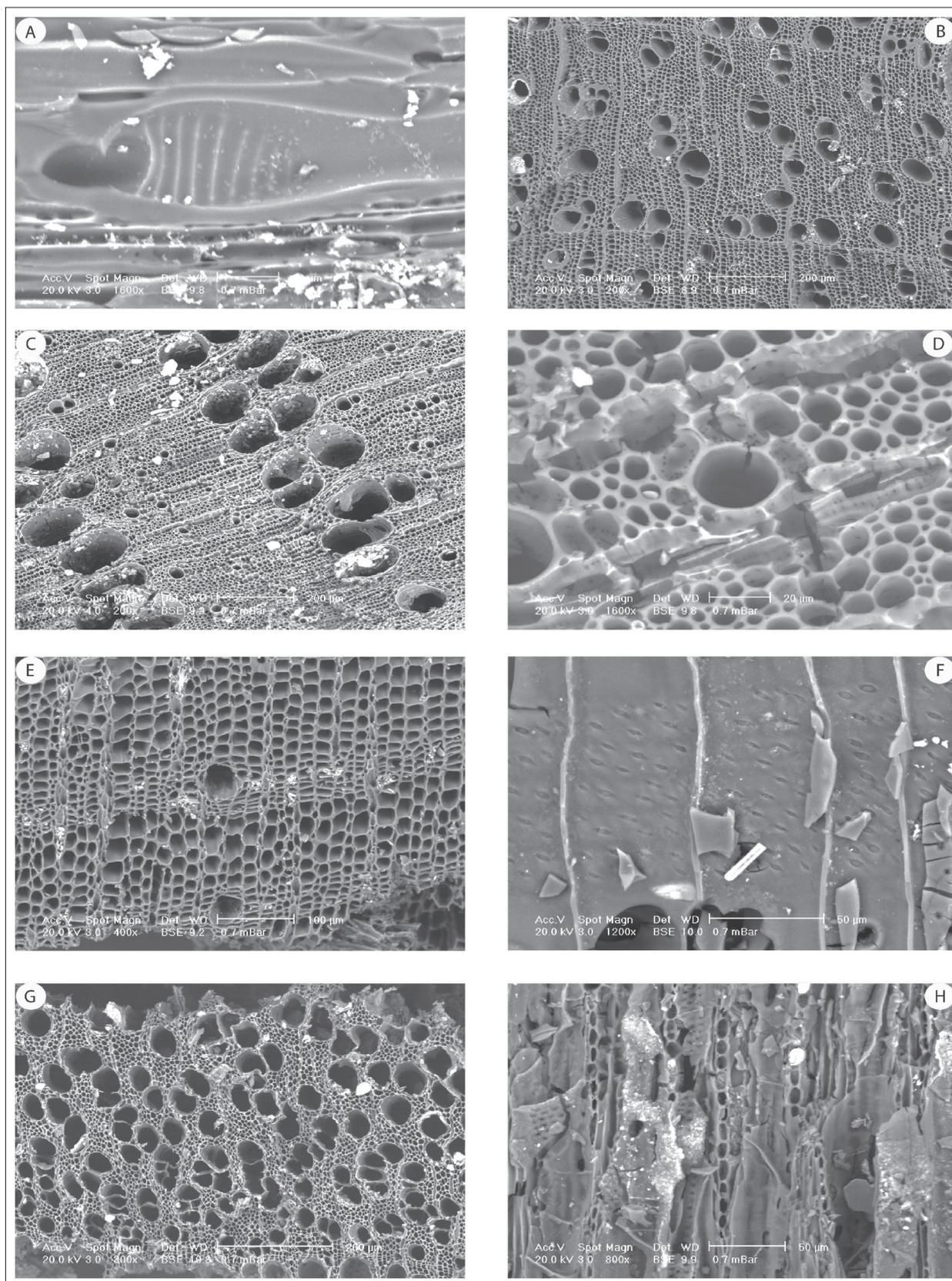


Fig. 11. SEM Micrographs of main charcoal taxa. A) *Betula pendula*, scalariform perforation plate, radial section; B) *Betula pubescens*, transversal section; C) *Fraxinus excelsior*, transversal section; D) *Fraxinus excelsior*, transversal section; E) *Larix decidua*, transversal section; F) *Larix decidua*, radial section; G) *Salix* sp., transversal section; H) *Salix* sp., tangential section.

Abb. 11. SEM Aufnahmen der wichtigsten Holzkohletaxa. A) *Betula pendula*, leiterförmige Durchbrechungen, radiale Schnittfläche; B) *Betula pubescens*, transversale Schnittfläche; C) *Fraxinus excelsior*, transversale Schnittfläche; D) *Fraxinus excelsior*, transversale Schnittfläche; E) *Larix decidua*, transversale Schnittfläche; F) *Larix decidua*, radiale Schnittfläche; G) *Salix* sp., transversale Schnittfläche; H) *Salix* sp., tangentiale Schnittfläche.

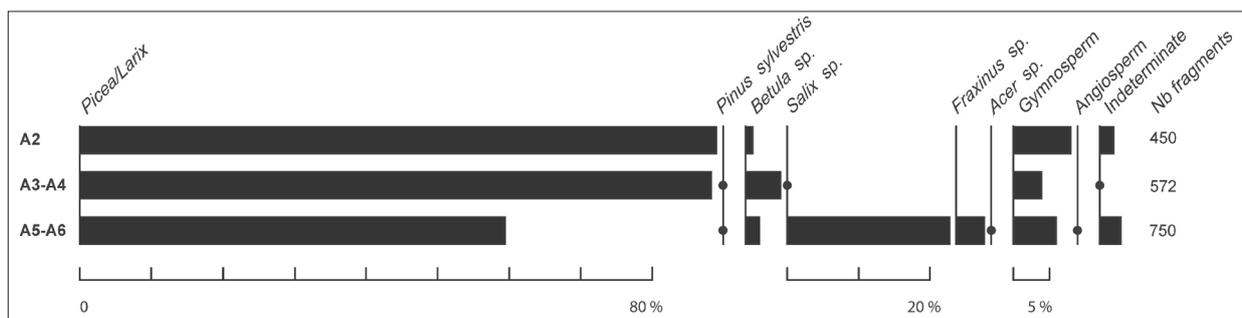


Fig. 12. Anthracological diagram showing the relative frequencies of taxa in the charcoal assemblage across the Mousterian (A6-A5), Uluzzian (A4-A3), Aurignacian (A2) sequence.

Abb. 12. Holzkohlendiagramm mit den relativen Häufigkeiten der verschiedenen Taxa vom Moustérien (A6-A5), über das Uluzzien (A4-A3) bis zum Aurignacien (A2).

pertains to *Larix decidua*, which is also identified by palynology at the regional level (Kaltenrieder et al. 2009). This taxon amounts to 59.6% of the studied sample, but we cannot exclude the possibility that the occurrence may be even more important. Indeed, 6.4% of the sample was identified as coniferous wood, but it showed significant anatomical alterations that didn't allow precise determination. This charcoal

might in part also belong to the genus *Larix*. Other taxa are willow (*Salix*, 23.3%), ash (4.1%, principally *Fraxinus excelsior*, but also *Fraxinus ornus/angustifolia*), birch (1.7%, *Betula* sp.), maple (*Acer* sp., 0.3%) and two fragments of pine (*Pinus sylvestris* type). *Pinus* is almost completely absent throughout the sequence. Maspero (1998-99) had already noted the decline of this taxon from A10, and its later disappearance in the

	A5-A5+A6		A6	
	NISP	%	NISP	%
<i>Canis lupus</i>			2	0.8
<i>Vulpes vulpes</i>	7	6.0	7	2.8
<i>Ursus</i> sp.	1	0.9	1	0.4
<i>Ursus</i> cf. <i>arctos</i>	3	2.6	2	0.8
<i>Ursus</i> cf. <i>spelaeus</i>	1	0.9		
Carnivora	2	1.7	2	0.8
<i>Megaloceros giganteus</i>	2	1.7	2	0.8
cf. <i>Megaloceros giganteus</i>	1	0.9		
<i>Alces alces</i>			1	0.4
cf. <i>Alces alces</i>			1	0.4
<i>Alces alces/Megaloceros giganteus</i>	2	1.7	3	1.2
<i>Cervus elaphus</i>	70	60.3	128	51.6
cf. <i>Cervus elaphus</i>	4	3.4	16	6.5
<i>Cervus elaphus/Megaloceros giganteus</i>			5	2.0
<i>Capreolus capreolus</i>	5	4.3	44	17.8
cf. <i>Capreolus capreolus</i>	1	0.9		
Cervidae			4	1.6
<i>Capreolus capreolus/Rupicapra rupicapra</i>	1	0.9		
<i>Bos/Bison</i>	2	1.7		
<i>Capra ibex</i>	9	7.7	12	4.9
cf. <i>Capra ibex</i>	1	0.9	8	3.2
<i>Rupicapra rupicapra</i>	2	1.7	9	3.6
cf. <i>Rupicapra rupicapra</i>	1	0.9	1	0.4
<i>Rupicapra rupicapra/Capra ibex</i>	1	0.9		
Total determinable remains	116	100.0	248	100.0

Fig. 13. Species present in the two units „A5-A5+A6“ and „A6“. (NISP = Number of Identified Specimen).

Abb. 13. Vorhandene Tierarten in den beiden Einheiten „A5-A5+A6“ and „A6“. (NISP = Anzahl identifizierter Reste).

record at the expense of *Larix*. This suggests an initial change to relatively more temperate and humid conditions. In the last Mousterian levels (A6, A5), larch clearly dominated the woody landscape, probably growing on the slopes up to the tree-line. The larch forests are still associated with mesophilous hardwoods which develop in valley bottoms and in wetter areas and/or on peat. Progressively, these temperate species decreased till they disappear in A4, suggesting the establishment of colder and maybe dryer climatic conditions after the Mousterian (Fig. 12).

Mammals

So far, the macromammal assemblage is composed of 39 149 specimens, with a total weight of 12.462 kg. The high fragmentation rate is due to the over 80% of pieces smaller than 2 cm, whereas only 1% of the bones are taxonomically determinable. Due to the uncertainty caused by similarities at species level, some of them have been grouped as possibly two or more animals (e.g. *Cervus elaphus*/*Megaloceros giganteus*, *Alces alces*/*Megaloceros giganteus*, *Bos/Bison*, Cervidae, Carnivora).

From A5 and A5+A6 which have been grouped together, 116 bones have been determined, which represents 0.5% of the total assemblage (Fig. 13). Red deer (*Cervus elaphus*) is the most frequent species with 74 remains, followed by ibex (*Capra ibex*) with 10 fragments, roe deer (*Capreolus capreolus*), chamois (*Rupicapra rupicapra*), giant-deer (*Megaloceros giganteus*) and bovid. The few remains of bovid have not been distinguished between *Bos* and *Bison*. The incidence of carnivores, fox (*Vulpes vulpes*) and Ursidae (3 bones of *Ursus* cf. *arctos* and one of *Ursus* cf. *spelaeus*), is low.

The total amount of determinable bones in A6 is 248. The faunal composition is more or less the same as above, although the presence of the elk is recorded (*Alces alces*). Again, red deer is the most represented

species with 144 bones. The second species is roe deer, followed by ibex and chamois. In addition, two pieces have been attributed to the giant-deer and two to the elk. The identified carnivores are fox, wolf and bear (Ursidae).

Considering the natural traces and in particular the rare number of smoothed or abraded specimens, the faunal material is still likely to be in primary context or at least subject to very little displacement. The scarcity of traces from carnivore activity and the consistent number of bones with anthropogenic marks suggest that human activity can be defined as the main and fundamental agent in the accumulation of the faunal remains (Fig. 14). In both A5-A5+A6 and A6, cut marks represent more than 90% of the butchery traces and they have been recognized also on very small fragments (Fig. 15). Most of the time they are deep and located particularly at the joining of tendons, ligaments and muscles. Cut marks are located mainly along the diaphysis and are due to skinning, defleshing and removal of tendons. Traces left by lithic tools at the joints (carpus and tarsus) are from disarticulation. Traces of butchery activity found on a few bear remains deserve particular attention.

Intentional breakage is testified by the presence of 134 percussion cones (Fig. 14), 80 in A5-A5+A6 and 54 in A6. In both groups, the numerous remains with percussion notches and impact scars provide evidence for intensive collection of marrow. From the study of the anthropogenic marks, we infer that red deer was the most exploited animal and the whole carcass was transported into the site and then butchered. Moreover, cut marks and percussion notches observed on anatomical elements of other species suggest that hunting was not limited to a single taxon.

In A5-A5+A6, cut marks caused by lithic tools have been recognized on a cuboid of *Ursus* sp. and a fragment of ulna referable to *Ursus* cf. *arctos*. They

	A5-A5+A6	A6	TOTAL
NB with cut marks	124	224	348
NB with percussion notches	5	18	23
NB with cut marks and percussion notches	2	22	24
NB with percussion notches related to fracturation attempts	1	3	4
NB with cut marks and percussion notches related to fracturation attempts	3	1	4
NB with percussion notches and percussion notches related to fracturation attempts		2	2
NB with traces of butchery activity	135	270	405
Total NB with cut marks	129	249	375
NB with cutmarks %	96	92	93
Total NB with percussion notches	7	44	51
NB with percussion notches %	5.2	16	13
Percussion cones	80	54	134

Fig. 14. Tabulation of the anthropogenic traces observed on the bones.

Abb. 14. Auflistung der anthropogen verursachten Spuren auf den Knochen.

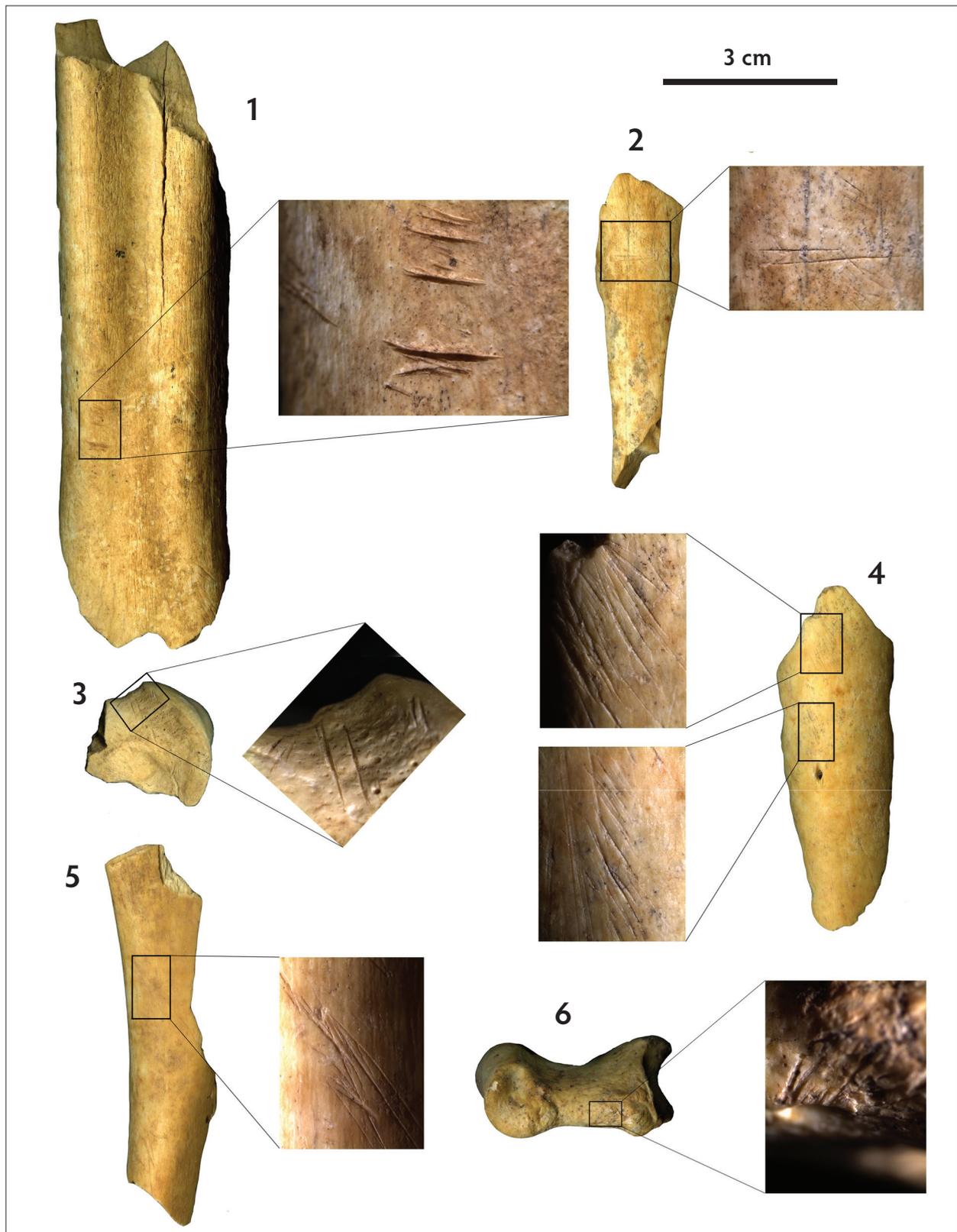


Fig. 15. Examples of traces produced during exploitation of ungulate and carnivore carcasses: 1) metapodial of *Cervus elaphus*, cut marks produced from skinning, 2) metacarpus of *Rupicapra rupicapra*, cut marks from skinning and probably collecting of tendons, 3) 2nd phalanx of *Cervus elaphus*, cut marks from skinning, 4) femur of *Capreolus capreolus*, cut marks from defleshing, 5) radius of *Capra ibex*, cut marks from defleshing, 6) 2nd phalanx of *Ursus cf. arctos*, cut marks from skinning.

Abb. 15. Beispiele von Schlacht- und Zerlegungsspuren an Knochen von Huftieren und Raubtieren: 1) Metapodium von *Cervus elaphus*, Schnittspuren entstanden beim Häuten, 2) Mittelhandknochen von *Rupicapra rupicapra*, Schnittspuren entstanden beim Häuten und wahrscheinlich bei Entnahme der Sehnen, 3) Phalanx 2 von *Cervus elaphus*, Schnittspuren entstanden beim Häuten, 4) Femur von *Capreolus capreolus*, Schnittspuren vom Entfleischen, 5) Radius von *Capra ibex*, Schnittspuren vom Entfleischen, 6) Phalanx 2 von *Ursus cf. arctos*, Schnittspuren vom Häuten.

belong to two different individuals, respectively a young one and an adult. In A6, cut marks have only been identified on a single specimen, a second phalanx (hind limb) of *Ursus cf. arctos*.

Considering the data gained from the preliminary observations on the degree of tooth wear and eruption and the state of epiphyseal fusing of red deer and ibex, it is possible to assume that the site was more regularly occupied between the end of spring and the beginning of autumn, and only occasionally during winter. Moreover, the presence of bones belonging to foetals, also with cut marks from lithic tools, provides a secure seasonal indication and suggests that human occupation usually began during spring.

Discussion and interpretation

Formation processes and aggradation of anthropogenic units

From the field evidence, it is possible to infer even if at a preliminary level, the nature and type of processes which led to the formation of the A5-A6 stratigraphic complex. The duration of this formation remains unknown due to the lack of radiocarbon dates from the lowermost layer. At a general level, data suggest that certain sedimentary processes alternatively prevailed over others, first starting with A6, followed by natural aggradation with a modest anthropogenic contribution, and finally leading to a new human occupation responsible for the A5 sediments with their structures, associated artefacts and ecofacts. Nevertheless, this phase differs from the previous ones due to the low number and type of anthropogenic signatures, which are restricted to hearth A5_SIII, to other small structures, and to dispersed bones and artefacts also in layer A5+A6.

These processes and the formation dynamics of each unit are here initially reconstructed in the light of the taphonomic and geoarchaeological analyses, starting with the first data obtained from this work. Concerning the earliest context, A6, evidence confirms the purely anthropogenic origin for the remains and combustion structures scattered within a specific zone that is relatively poor in bones and flakes, therefore being comparable to the central-eastern zone of the cave entrance (Fig. 2). The latter, together with the innermost zone, could have been used for a range of tasks broadly related to lithic production, tool shaping and curation, with the exploitation of ungulates, particularly red-deer, brought complete into the cave. Such remains form a palimpsest that has currently only been partly disentangled from the number and position of the combustion structures and various charcoal accumulations discovered in the more topographically elevated zone. Their position within this sedimentary body may occur at the interface with the underlying A7, within, or at the top of A6, so that the rhythm of

accumulation rests on the formation of each hearth and possible related tasks. By now, any estimate of the type and scale of these tasks rests on the number of hearths, but is biased by the palimpsest at the cave-entrance. Lithic and organic remains thus result from repeated occupations of the same zone, contrary to that inferred from the record of A5, where anthropogenic sedimentation is more sparse and differentiated by comparison to A6.

Lithic analyses demonstrate that Levallois production played a pivotal role in the technological system throughout the whole stratigraphic complex. Nevertheless, other than the large number of end-products, cores and various flakes from core shaping and maintenance, several artefacts can be ascribed to other methods attributed, at the moment, to discoidal and blade volumetric concepts. In addition to these methods there are a few examples of unorganized knapping, which are vaguely centripetal or arranged multidirectionally. Concerning Levallois, its production is based on a main operational sequence and to a much lesser extent a secondary aim to exploit the ventral face of large cortical flakes. The endproducts are mostly blades, sometimes pointed, and occasionally flakes with a less regular shape and smaller than the blades. The sporadic production of bladelets and discoidal flakes does not outweigh the main tendency of using elongated Levallois blanks and other by-products for shaping into simple or convergent scrapers, and points. These are the basic retouched tools, in addition to a few notches and denticulates (Peresani in press).

If we exclude the broad characteristics of ungulates and the Levallois industry, other relevant elements make A5 different from A6. One of these elements is the complex of hearth A5_SIII, interpreted as a change in the cave-use, but also other minor structures record a varied rhythm in human occupation. Given the frequency of points and convergent tools compared to A6, these differences must be assessed in the future through targeted studies. Layer A5+A6 records an increasing rate in natural sedimentation, leading to sands accumulating in the western zone as much as stones and stone layers in the cave-mouth. This caused some bones and artefacts to be displaced from A5 to A5+A6 but not into A6, as suggested by a few refitting flakes (Centi 2008-09; Di Taranto 2009-10).

These changes in the aggradation rate of the sedimentary surface, whether or not it is related to the rate of human occupation, can be interpreted as a result of climate forcing. The rhythm of this change will be assessed after the new chronometric (age of A6), sedimentological and palaeobiological (micromammals) analyses are completed.

The ecological context and its exploitation: initial comparisons

Differences in the mammal species reflect the environmental variability around the site and suggest

the existence of wooded zones with open spaces under cool-temperate climatic conditions (*Cervus elaphus* associated with *Capreolus capreolus* and *Megaloceros giganteus*). *Vulpes vulpes* and *Ursus arctos* also provide similar signatures. These palaeo-ecological indices fit the avifaunal composition, mostly made of birds from open and rocky habitats and from alpine forest habitat (Peresani et al. 2011) and support the previous studies carried out throughout the MP-UP transitional sequence (Cassoli & Tagliacozzo 1994a), because in A11-A10 cervids gradually increased conversely to species typical of open spaces, thus providing evidence for climate change towards temperate-moist conditions. These conditions remained till the cooling in layer A3 (Uluzzian), as shown by the presence of glutton (*Gulo gulo*), leopard (*Panthera pardus*) and hyena (*Crocuta crocuta*) from the carnivores, with bison (*Bison priscus*) and woolly rhino (*Coelodonta antiquitatis*) from the ungulates. From A2 (Aurignacian), climate abruptly turned to cool and dry conditions which supported the spread of steppe-like and alpine grassland, but with persistent wooded zones. Ibex and chamois increased, marmot and alpine hare made their appearance together with some mustelids such as the ermine and weasel, the arctic fox (cf. *Alopex lagopus*) and the wolf (*Canis lupus*) from the canids, and lynx (*Lynx lynx*).

Such evolution is also indicated by the anthracological assemblage by the progressive reduction of mesophilous trees and riparian vegetation which disappeared in A4. However this shift should be interpreted with caution because it could also reflect a change in the wood gathering areas. Furthermore, it is possible that larch is over-represented in the anthracological sample due to the importance of the natural pruning of conifers. The availability and abundance of larch wood in proximity to the site could have led to its preferential gathering at the expense of hardwood species.

Both datasets from the fauna and anthracology therefore reflect the same type of development from milder conditions in A11 to cooler ones in A4 and especially in A2. Nevertheless, the faunal data indicate the persistence of wetlands in A2 which are not shown by the anthracological assemblage, although a change in resource strategy may partly explain the different results. If it is assumed that there are different territories for hunting and gathering wood for fuel, charred wood would reflect the local environment while the fauna would reflect a more regional picture.

Fumane cave is consistent with other faunal sites of NE Italy like Riparo Tagliente (Thun-Hohenstein et al. 2001), Riparo Mezzena (Thun-Hohenstein et al. in press), Grotta Ghiacciaia (Bertola et al. 1999) and Grotta San Bernardino (Cassoli & Tagliacozzo 1994b), where *Cervus elaphus* and *Capra ibex* are the most represented prey-species, but they are missing at both Grotta Ghiacciaia and Riparo Mezzena. *Capreolus capreolus* and *Rupicapra rupicapra* are

either abundant or absent. There are only a few *Megaloceros giganteus*, *Alces alces*, *Sus scrofa* and *Bos/Bison*, while *Equus caballus* is very rare. Among the carnivores *Ursus arctos* and *U. spelaeus*, *Vulpes vulpes*, *Canis lupus* and mustelids are always present. Taphonomic traces suggest that hunting took place in the surroundings of the site, focusing on ungulates and above all red-deer. Predation focused on adult or young-adult individuals. Hare, beaver and carnivores like bear, fox and mustelids were probably hunted for their fur.

Final considerations and perspectives

The huge set of data from field evidence and preliminary studies carried out on the anthracological and archaeozoological assemblages from the stratigraphic complex A5-A6, increases our perspectives on the investigation of Neanderthal behaviour. First, the attempt to disentangle the A6 palimpsest by estimating the anthropogenic sedimentation rate and thereby reconstructing the spatial and temporal organisation of the economic activities will help as a future reference for the interpretation of similar contexts within the lower layers of macro-unit A. At the same time, such complex evidence allows an assessment of the change in settlement dynamics observed in A5 and other Mousterian and Uluzzian levels, whose degree of anthropogenic signatures is weak. Nevertheless, refinements are required from micro-palaeontological analyses and further chronometric dates to reconstruct the palaeoclimatic context for this evidence.

Specific studies will concentrate on the use of wood fuel and the setting of the hearths. These two economic and functional tasks have to be interpreted in terms of the rhythm of human occupation, subsistence strategies and manufacturing tasks. In accordance with this, further details are needed to determine the seasonality of red deer hunting and how much it was supplemented by the predation of other ungulates and occasionally carnivores. Also lithic production demands further details, as some similarities between the A5-A6 complex and others at Fumane or elsewhere have been observed in the reduction sequences.

ACKNOWLEDGMENTS: Research at Fumane is directed by the University of Ferrara and University of Milano I in the framework of a long-term project supported by the Superintendent for Archaeological Heritage of Veneto, the Venetian Region, the Cariverona Foundation, the Comunità Montana della Lessinia, the Fumane Municipality and a private Company (Roberto Gardina Enterprise). The authors are grateful to Nicholas Ashton for improvements made on the English style of the manuscript and to two anonymous readers for the revisions recommended to the original manuscript.

Literature cited

- Bertola, S., Peresani, M., Peretto, C. & Thun Hohenstein, U. (1999). Le site Paléolithique moyen de la Grotta della Ghiacciaia (Préalpes de Vénétie, Italie du Nord). *L'Anthropologie* 103 (3): 377-390.
- Bertola, S., Broglio, A., Gurioli, F., De Vecchi, G., Facciolo, A., Fiore, I., Tagliacozzo, A. & Pallecchi, P. (2009). Le territoire des chasseurs aurignaciens dans les Prealpes de la Vénétie: l'exemple de la Grotte de Fumane. In: F. Djindjian, J. K. Kozłowski & N. Bicho (Eds.) *Le concept de territoire dans le Paléolithique supérieur européen*. British Archaeological Reports, International Series 1938: 167-181.
- Broglio, A., Bertola, S., De Stefani, M., Marini, D., Lemorini, C. & Rossetti, P. (2005). La production lamellaire et les armatures lamellaires de l'Aurignacien ancien de la Grotte de Fumane (Monts Lessini, Vénétie). In: F. Le Brun-Ricalens (Ed.) *Production lamellaires attribuées à l'Aurignacien*. Musée National d'Histoire et d'Art, Luxembourg, 415-436.
- Broglio, A., De Stefani, M., Gurioli, F., Pallecchi, P., Giachi, G., Higham, T. & Brock, F. (2009). L'art aurignacien dans la décoration de la Grotte de Fumane. *L'Anthropologie* 113: 753-761.
- Cassoli, P. & Tagliacozzo, A. (1994a). Considerazioni paleontologiche, paleoecologiche e archeozoologiche sui macromammiferi e gli uccelli dei livelli del Pleistocene superiore del Riparo di Fumane (VR) scavi 1988-91. *Bollettino del Museo Civico di Storia Naturale di Verona* 23: 85-117.
- Cassoli, P. & Tagliacozzo, A. (1994b). I resti ossei di macromammiferi, uccelli e pesci della Grotta di San Bernardino sui Colli Berici (VI): considerazioni paleoecologiche, paleoecologiche e cronologiche. *Bollettino di Paleontologia Italiana* 85: 1-71.
- Centi, L. (2008-2009). *L'ultimo Levallois: tecno-economia della produzione litica e organizzazione spaziale nel complesso A5-A6 (50.000 anni BP) di Grotta di Fumane (Verona). Studio di due varietà selcifere*. Graduate Dissertation, University of Ferrara.
- Chrzavetz, J. (2006). *Collecte du Bois et paléoenvironnements au Paléolithique. Apport méthodologique et étude de cas. La Grotte de Fumane dans les préalpes italiennes*. Master II dissertation, Université Paris I Pantheon-Sorbonne, Environnement et Archéologie.
- Courty, M. A., Goldberg, P. & Macphail, R. (1989). *Soils and micromorphology in archaeology*. Cambridge University Press, Cambridge.
- Cremaschi, M., Ferraro, F., Peresani, M. & Tagliacozzo, A. (2005). Il sito: nuovi contributi sulla stratigrafia, la cronologia, le faune a macromammiferi e le industrie del paleolitico antico. In: A. Broglio & G. Dalmeri (Eds.) *Pitture paleolitiche nelle Prealpi Venete: Grotta di Fumane e Riparo Dalmeri*. Memorie Museo Civico di Storia Naturale di Verona, 2ª serie, Sezione Scienze dell'Uomo, 9: 12-22.
- Danti, A. (2008-09). *Aspetti micromorfologici dell'unità A6 (Mousteriano finale) della Grotta di Fumane (VR)*. Master Dissertation, University of Milano.
- De March, M. (2006-2007). *Studio archeozoologico di un campione del complesso faunistico delle unità mousteriane A5+A6 della Grotta di Fumane (VR). Prime considerazioni sulle strategie di sussistenza degli ultimi neandertaliani in Italia settentrionale*. Graduate Dissertation, University of Venice, Faculty of Letter and Philosophy.
- Di Taranto, E. (2009-10). *L'ultimo Levallois. Tecno-economia e organizzazione spaziale della produzione litica nel complesso A5-A6 (45-44 Ka BP) della Grotta di Fumane (Verona). Studio della Scaglia Rossa*. Facoltà di Scienze MM.FF.NN., Corso di Laurea Specialistica in Scienze Preistoriche.
- Goldberg, P. & Macphail, R. (2006). *Practical and theoretical geoarchaeology*. Blackwell Publishing.
- Higham, T. F. G., Brock, F., Peresani, M., Broglio, A., Wood, R. & Douka, K. (2009). Problems with radiocarbon dating the Middle and Upper Palaeolithic transition in Italy. *Quaternary Science Reviews* 28: 1257-1267.
- Kaltenrieder, P., Belis, C. A., Hofstetter, S., Ammann, B., Ravazzi, C. & Tinner, W. (2009). Environmental and climatic conditions at a potential Glacial refugial site of tree species near the Southern Alpine glaciers. New insights from multiproxy sedimentary studies at Lago della Costa (Euganean Hills, North-eastern Italy). *Quaternary Science Reviews* 28: 2647-2662.
- Maspero A. (1998-99). Ricostruzione del paesaggio vegetale attorno alla grotta di Fumane durante il Paleolitico. *Annuario storico della Valpolicella* XVIII: 19-26.
- Peresani, M. (2008). A new cultural frontier for the last Neanderthals: the Uluzzian in Northern Italy. *Current Anthropology* 49 (4): 725-731.
- Peresani, M. (in press). Fifty thousand years of flint knapping and tool shaping across the Mousterian and Uluzzian sequence of Fumane cave. In: Carbonnell, M., Gema, M., Vaquero (Eds.) *The Neanderthal Home: Spatial and Social Behaviours*. *Quaternary International*.
- Peresani, M., Cremaschi, M., Ferraro, F., Falguères, Ch., Bahain, J.-J., Gruppioni, G., Sibilia, E., Quarta, G., Calcagnile, L. & Dolo, J.-M. (2008). Age of the final Middle Palaeolithic and Uluzzian levels at Fumane Cave, Northern Italy, using ¹⁴C, ESR, ²³⁴U/²³⁰Th and thermoluminescence methods. *Journal of Archaeological Science* 35: 2986-2996.
- Peresani, M., Fiore, I., Gala, M., Romandini, M. & Tagliacozzo, A. (2011). Late Neanderthals and the intentional removal of feathers as evidenced from bird bone taphonomy at Fumane cave 44ky BP, Italy. *Proceedings National Academy of Science* 108: 3888-3893.
- Schweingruber, F. H. (1990). *Anatomie europäischer Hölzer*. Haupt, Stuttgart.
- Stoops, G. (2003). *Guidelines for analysis and description of soil and regolith thin sections*. Soil Science Society of America, Inc. Madison, Wisconsin, USA.
- Talon, B. (1997). Étude anatomique et comparative de charbons de bois de *Larix decidua* Mill. et de *Picea abies* (L.) Karst. *Comptes Rendus de l'Académie des Sciences - Séries III - Sciences de la Vie* 320 (7): 581-588.
- Thun Hohenstein, U., Malerba, G., Giacobini, G. & Peretto, C. (2001). New contribution to the taphonomic analysis of the faunal remains from the Mousterian levels of Riparo Tagliente (Verona). *Atti XIII Congresso Antropologi Italiani*, 39-44.
- Thun Hohenstein U., Parere V., Sala B., Giunti P. & Longo L., (in press). Faunal exploitation at Riparo Mezzena (VR, Italy). In: E. Delson & E. Sargis (Eds.) *Vertebrate Paleobiology and Paleoanthropology: International Conferences of Archaeozoology, Paris 2010*. New York: Springer.
- Van Vliet-Lanoë, B. (1998). Frost and soils. Implications for paleosols, paleoclimates and stratigraphy. *Catena* 34: 157-183.
- Vernet, J.-L., Ogereau, P., Figueiral, I., Machado, Y. C. & Uzquiano, P. (2001). *Guide d'identification des charbons de bois préhistoriques et récents. Sud-ouest de l'Europe : France, péninsule ibérique et îles Canaries*. CNRS Éditions, Paris.