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Santa Maria D'Agnano site (Puglia, Italy) *micromorphology and lithic study of the (SU4) Epigravettian SMA-Extern layer*

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ABSTRACT

The Epigravettian of Santa Maria d'Agnano site is represented by a SMA-Extern layer (SU4). The present study resorts to a micromorphological analysis to clarify the depositional and the post-depositional process of the open air site in front of the Santa Maria d'Agnano cave. Epigravettian samples from the open air level (SU4), spanning from 18013-17587 CalBC to 9752-9298 CalBC are analysed. Results show a complex microstructure due to the combination of the pedological deposition mode and the anthropogenic input. Variable amounts of centimetric sub-angular limestone confirm the deposition from the roof fall. Bone,charcoal fragments and micro-artefacts are present throughout the micromorphological column and are considered as indicators of human activity. The groundmass contains ferruginous pedofeatures such as nodules, mottles and coatings. The latter are derived from a local degraded soil in the immediate surroundings or may be formed *in situ*. Locally, spar and microspar were precipitated inside voids. Such features can probably be formed by the reprecipitation of carbonates after a partial dissolution of cryoclasts. These thin sections provide little evidence for anthropogenic input and a general event that includes soil phases.

The study of the lithic industry confirms the existence of a chronostratigraphy that spreads over a period of seven thousand years. In this culturally homogeneous context some changes can be noticed thanks to the more or less frequent presence of some tools. The background appears Epigravettian, since it is characterized throughout the chrono-sequence by the recurring presence of straight back points, Gravette type.

1. Introduction

The Santa Maria d'Agnano cave is situated in South East Italy (Puglia, Ostuni district) (Fig. 1A and C). It is an Italian archaeological site of major interest with regard to understanding the Upper Palaeolithic period from a regional scale to a wider continental scale. The cave appears like an important fracture located between 169.50 and 173 m high above the present sea level, offering a wide unbroken view over the Adriatic Sea (Fig. 1A).

A 16th-century fresco and the remains of a chapel, located under the entrance porch of the site, testify to the historic use of the cave. It served as a Christian sanctuary until the 18th century. It was dedicated to the Virgin Mary, hence its name Santa Maria d'Agnano. Since 1970, the date of the first survey, many later discoveries have given the site a prehistoric dimension imposing its name in prehistoric research (Coppola, 1981, 1983, 1992).

The data of Santa Maria d'Agnano concerning the Upper Palaeolithic result from two different places in the Eastern zone of the shelter (Fig. 1B):

- The first sector is 5 square meters large. In the specific place two Gravettian graves were discovered while studying a limestone breccia (Coppola, 2012; Coppola and Parise, 2005).
- The first grave Ostuni 1, (25589–25482 CalBC) corresponds to a young woman in her thirties in a late stage of pregnancy.
- The second female skeleton, Ostuni 2, (27364 - 26688 CalBC) was discovered next to the first One (Alciati et al., 2005; Vacca and Coppola, 1993). A palynological analysis was made during the searching of the grave containing Ostuni 1's skeleton (Renault-Miskovsky et al., 2000–2001).

Recently, Ostuni 1 and 2 were involved in a large DNA research program. The study involved 51 Eurasian specimens dating from 45000 to 7000 years old, including Ostuni 1 and Ostuni 2 (Fu et al., 2016). So,

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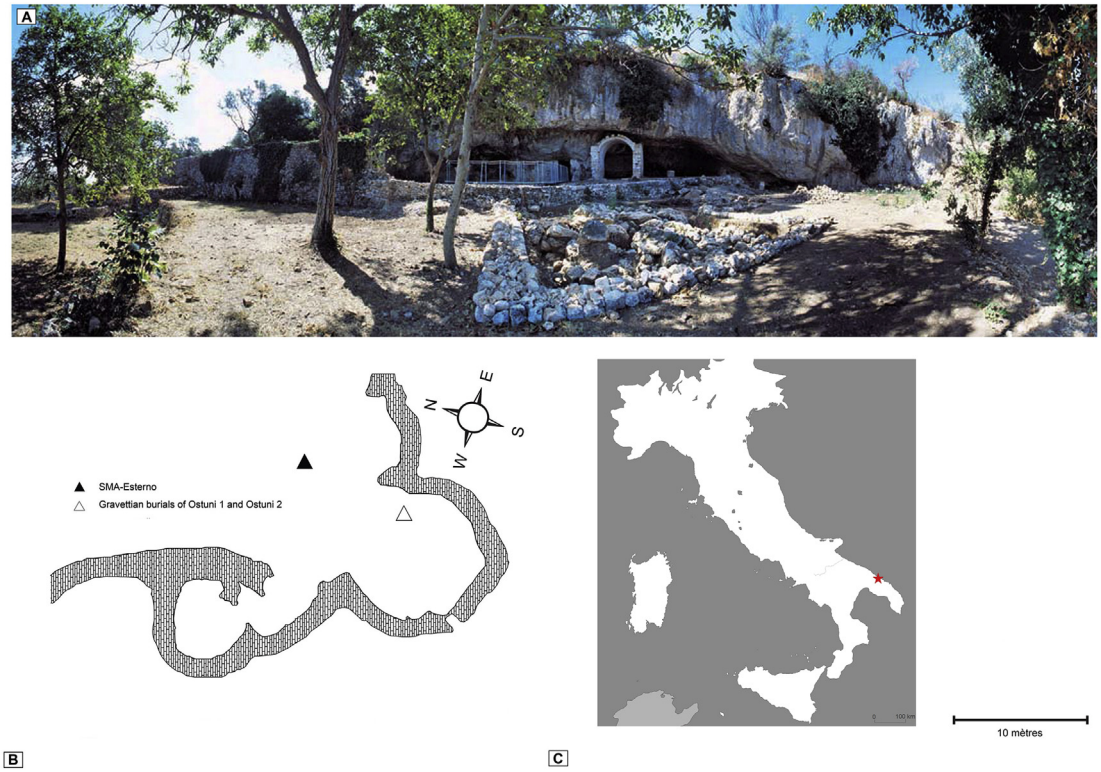

Fig. 1. General view of the Santa Maria d'Agnano site. A- Photograph taken from the Northeast (©E. Vacca). B- The black triangle indicates the location of the SMA-Extern zone (2007-2019 excavation), the white triangle shows the position of the Ostuni 1 and 2 graves (1991 excavation). The dotted parts correspond to historical superstructures. C- Map of Italy. The red star indicates the Santa Maria site.

Ostuni 1 and 2 are classified in the oldest Vestonice groups (from the Czech Republic) which also include specimens from Belgium, Italy, and Austria. After cross-checking with the archaeological data, all the specimens classified in this group belong to the Gravettian culture.

The lithic assemblage associated with the grave of Ostuni 1 consists of burins on retouched truncation and Gravette points (Bailles, 2012). It refers culturally to the middle Gravettian of the Adriatic coast of Italy.

- The second sector, called SMA-Extern (Santa Maria d'Agnano-Extern), corresponds to an area of 21 sq meters in front of the recent porch (Fig. 1B). It has been searched since 2007. At the moment, it shows a filling of traces of continuous human presence from 26000 BC to 10000 BC (Table 1).

Culturally these occupations are related to the Gravettian period, than around 18000 BC to the Epigravettian period. This contribution only concerns the Epigravettian layers of SMA-Extern, corresponding to the SU4 and SU6A.

The SMA-Extern area corresponds to the first meters in front of the cave, currently unprotected from the severe weather. The major axis is 7 m long, in an East-West direction (Fig. 2). This excavated area is bordered on its Northern side by a double face wall built in the 19 th century. Towards the South and the East, large limestone Rudist collapsed blocks reduce the potential excavation area. Between these blocks, rustic stone paving was added in the last century.

The micromorphological study of the column collected from the stratigraphic section at the level of SU4 and SU6A Epigravettian layers, represents the main contribution of this article. The high priority purpose is to identify the anthropic and/or natural parts of the dynamics of the SMA-Extern sediment.

It is also about comparing the collected paleoenvironmental data with those of the palynological study, carried out on the same location in the 2008 excavation. The latter had shown, throughout the

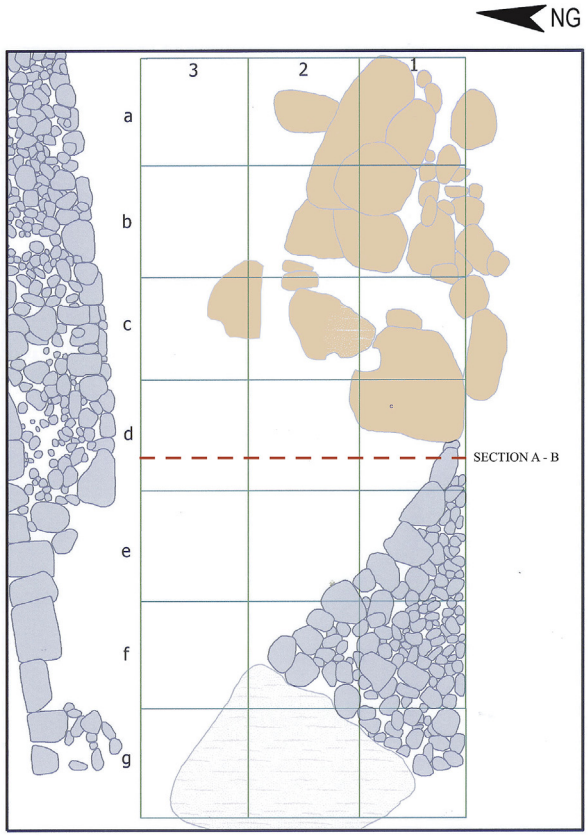

Fig. 2. SMA-Extern zone planimetry. Section A-B indicates the position of the stratigraphic cut and elements limiting the excavation area (collapse, subactual walls).

Epigravettian sequence “the presence of a bare landscape in keeping with a cold and dry climate” (Renault-Miskovsky et al. 2011, 2015).

Eventually, we can expect to get a more precise characterization of the paleoclimatic environment in the Puglia in the final stage of LGM (H1 and YD), 18000–10000 BC.

The final purpose will be to appraise how, in such paleoenvironmental contexts; the various chonocultures constituting the Epigravettian of the Puglia were positioned.

There are numerous Epigravettian sites in the Italian Peninsula. It is specifically the case of the Puglia, a region where the periodization of the chronoculture was confirmed by a number of excavations in the 1970s–1990s.

The Santa Maria d’Agnano cave can be added to a long, non-exhaustive list of sites, between 20000 and 10000 BC: The Cavallo (Palma di Cesnola, 1964), La Mura (Calattini, 2001), Romanelli (Laplace, 1966), Veneri di Parabita, Taurisano caves (Laplace, 1966), Cipolliane shelter (Gambassini, 1971).

With an occupation covering the Upper Paleolitic almost completely within a long stratigraphy, further comparisons with the Paglicci cave, a major site of the Puglia, can be made thanks to the SMA-Extern zone (Palma di Cesnola, 1983). Mount Gargano, located 250 km North of the Santa Maria d’Agnano cave and which harbours the Paglicci cave, provided most of the flint stone used by the SMA-Extern inhabitants.

2. Geological setting and stratigraphic sequences

2.1. SMA cave formations

The Santa Maria d’Agnano cave is originated in the karstification of the two main carbonated formations outcropping in the area “Calcare di Altamura” formation and “Calcare di Ostuni” formation. The “Calcare di Altamura” Formation (Coniacian-Lower Campanian) is composed of a succession of stratified beds, frequently divided into macro-fossileferous layers, marly clayey layers and low-energy shallow environments. The paleontological component consists of Cyanobacterium (*Aeolisaccus kotori*), algae (*Thaumatoporella*), Rudist, and benthic Foraminifera (*Dicyclina schlumbergeri*) (Luperto Sinni and Borgomano, 1989; Tucci and Morbidelli, 2004; Parise, 2012). The Ostuni formation (Upper Campanian-Maastrichtian) constituting the roof of the cave: microscopically the series shows typical characters of an edge association of biogenous limestone alternating with calcarenite and calcirudite. The biogenous limestones are characterized by very large Rudist. The calcarenite and calcirudite are rich in fragments of Corals, Echinoids, Gastropods and Oysters.

2.2. Description of the SMA cave entrance area

In this work, the site's investigated area corresponds to the SMA cave entrance (SMA external zone) which has been the subject of considerable analysis. The sediments of the open air excavation situated at the entry of the cave are rich in clay fraction. They are composed of elements coming from different origin such as micro-charcoals, micro-artefact stones, bone fragments, micro-vertebrate fragments and mollusc shells (*eobania*).

2.3. Stratigraphy of the SMA entrance area

During the excavation, the sediment filling of SMA-Extern zone revealed a succession of 4 stratigraphic units. Based on their color and their lithology, four stratigraphic units were identified called SU4A (−2.48 to −2.68 m), SU4B (−2.68 to −2.77 m), SU4C (−2.77 to −2.86 m) and SU6A (−2.86 to −2.78 m) (Fig. 3) (see Fig. 4).

The different levels were numbered with the code for the stratigraphic unit (SU) followed by a number indicating the different levels and a letter for the sublevels (for example SU4 is subdivided in three sublevels: SU4A, SU4B and SU4C).

Moreover SU4A was split into 2 sublevels: SU4A/upper rich in micro-charcoal and contrasting with SU4A/base characterized by a heterogeneous material containing micro-charcoal, artefacts, bone fragments and lithoclasts.

The SU4 level corresponds to an individual stratigraphic unit and yielded three sub-levels SU4C, SU4B and SU4A.The sub-levels SU4A and SU4C are grey reddish intercalated by a red discontinuous sublevel SU4B. This unit (SU4) consists of clayey sand punctuated by massive and individual rock falls towards the North of the area. Concentration of lithics, animal bones and charcoal was observed.

The basal layer, corresponding to SU6A, is brown-red color, heterogeneous with a clayey matrix rich in nodules and angular blocks. It is notched at the top by depressions and micro-ravines and showed a clear irregular surface corresponding to a discontinuity with the upper layer SU4C.

3. Chronology

The archaeological SU4 level is 35 cm thick and covers a time span of about 7 millennia. Some of the SU4 samples were selected for C14 dating (Table 1). Two dates came from SU4, which are 16745-16401 CalBC for the SU4C and 9752-9298 CalBC for the SU4A/upper. These dates correspond successively to the early Epigravettian and the final Epigravettian.

The SU6A, SU6B, SU7, SU8 and SU9 levels, underlying the SU4 level, were respectively attributed to the earliest Epigravettian and to the Late and Middle Gravettian. Radiometric analyses based on the ^{14}C isotope determine the date of the SU6A around 18013-17587 CalBC and the Epigravettian in the case of a normal vertical stratigraphy.

4. Materials and methods

In order to understand the lithology, the facies nature and the stratigraphy of the SU4, a column of sediment was extracted from d2/d3 zone and consolidated including the SU4 layer and other samples were extracted for granulometry analysis (Fig. 3, 4). The column was reinforced with gypsum bandages and was extracted from the section after the hardening of the plaster. In the laboratory of the European Center of Prehistory of Tautavel (France), the column was air dried and impregnated with artificial resin under vacuum. After the hardening of the resin, the column was cut into slices and nine thin sections (60 mm wide, 80 mm high) were prepared according to procedures described in Beckmann (1997). Thin sections were numbered with the code of Santa Maria d’Agnano-Extern. Micromorphological investigations were conducted with a polarizing microscope under plane polarized light (PPL) at magnifications of 20–400.

The description of the different components in thin sections followed Fitzpatrick micromorphological description of undisturbed soil formation (Fitzpatrick, 1984).

The identification of the organic remains were challenging because of the varying preservation and the random cuts through the different sectorial plane. Bullock and Stoops works, aid in the identification of the less preserved components (Bullock et al., 1985; Stoops, 2003).

Other publications (Courty et al., 1989; Courty and Fedoroff, 2002; Mallol, 2004) focusing on archaeological soil micromorphology and based on case studies as well as personal expertise, were considered in this work.

This micromorphological analysis is associated to a lithic industry study. This research work includes a typological analysis performed on 5985 artefacts belonging to SU4 level. This side of the research work will be based only on the 583 tools identified in this level increase our understanding of the classification lithic system of the Epigravettian in Puglia.

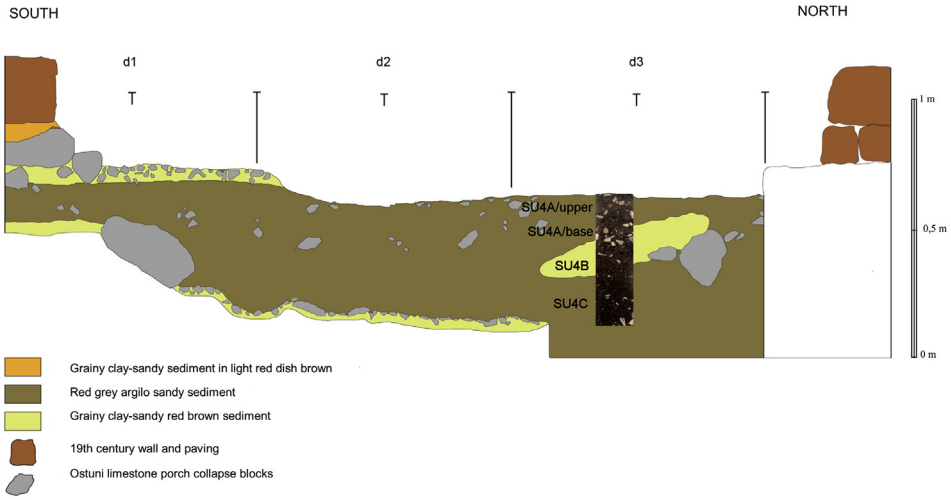

Fig. 3. SMA-Extern South-North stratigraphic cut with micromorphological column position.

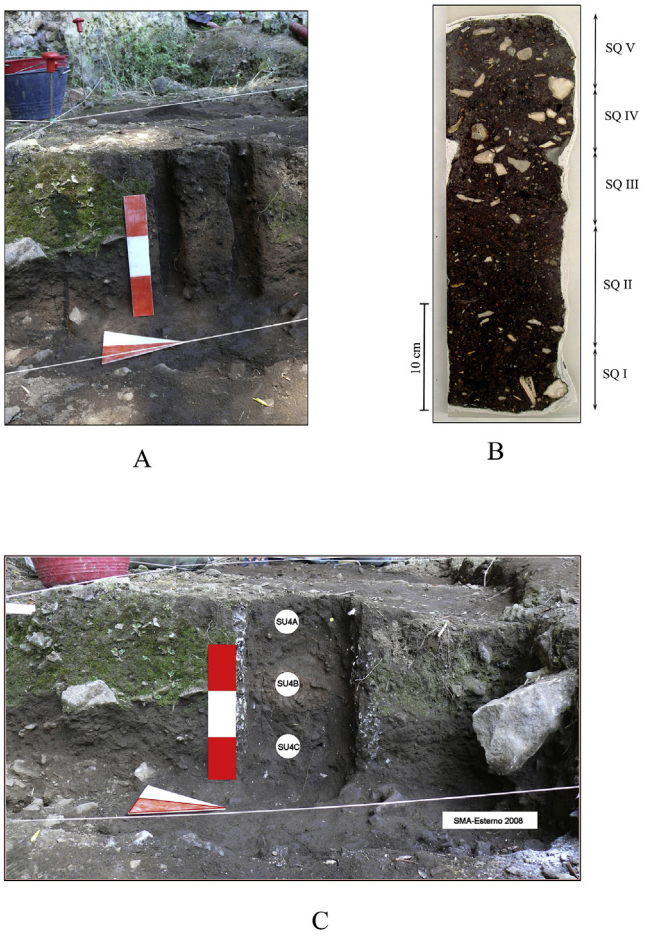

Fig. 4. A- Micromorphological column being extracted (2008). B-Sequence position (SQ) on the column. C- Stratigraphic cut after removal of the column

5. Results

5.1. Micromorphology

Here we present a summary of the micromorphological results relevant to the understanding of SU4 output (Figs. 5-9). Concise descriptions of each sequence are provided in Table 2.

The column is mainly formed of yellowish brown material (Fig. 3). Under high magnification a large part is dominated by ferruginous pedofeatures such as nodules, mottles and aggregates. Large fragments of limestone, bones and shells are also abundant and form individual sequences. Limestone elements of various centimetric sizes are frequent in the column, showing generally a chaotic arrangement. These elements show biogenic structures correspond to various kinds mollusc shells which may have dropped from the limestone forming Santa Maria d'Agnano karstic roof cavity. Charcoal fragments can be seen in the entire column. Thick coatings (ferruginous external orange layers) of fine material encasing coarse grains or aggregates are also observed.

For the lithological subdivision, we can spot only those that contain distinctive coarse elements, such as, limestone clasts which are less difficult to follow than the archaeological ones. In this way, the column has been subdivided into five individual lithostratigraphic sequences (from the base to the top): Sequence SQ I (SU6A/SU4C), Sequence SQ II (SU4C), Sequence SQ III (SU4B), Sequence SQ IV (SU4A/base) and Sequence SQ V (SU4A/upper). These sequences show variations in color, structure and especially in the organizations of limestone elements. The discontinuities between the different sequences weren't clearly expressed.

In the paragraphs below, these sequences are described and their micromorphology identified. The micromorphogical observations have been conducted, from base to top, in order to characterize each sequence.

Sequence SQ I (-2, 86 m to -2,78m) (Figs. 5 and 6).

The coarse/fine relative frequency distribution ranges from close-porphyric (Fig. 5 C, D, E, F) to double spaced porphyric (Fig. 5 A, B). The clay is yellowish-brown. Regarding porosity, different kinds of voids could be distinguished: vughs are abundant with some fissures and channels. The microstructure is complex. It is spongy with vughs, locally rich in aggregates which are separated by compound packing voids. The aggregated local microstructure is probably due to heavy bioturbation by soil mesofauna. The porosity is probably due to the bone dissolution. This kind of porosity is classified as macro-pore. Whereas some bones are affected by dissolution, others are still well preserved. The coarse biological fraction (bone fragments and mollusc shells) show a high degree of chemical dissolution up to the complete destruction of the shell/bone microstructures and the occurrence of phantoms. This sequence shows many ferruginous pedofeatures e. g. iron oxide nodules (Fig. 6 A, B), red coatings (Fig. 5. E, F) which are less abundant than in several subsequent sequences. Occasional microsparitic infillings are found in pores (Fig. 6 C, D, E).

Sequence SQ II (-2,78m to -2, 72 m) (Fig. 7).

The second sequence SQ II sediments are mainly composed of high amounts of biosparitic limestone gravel (Fig. 7A) and bone fragments

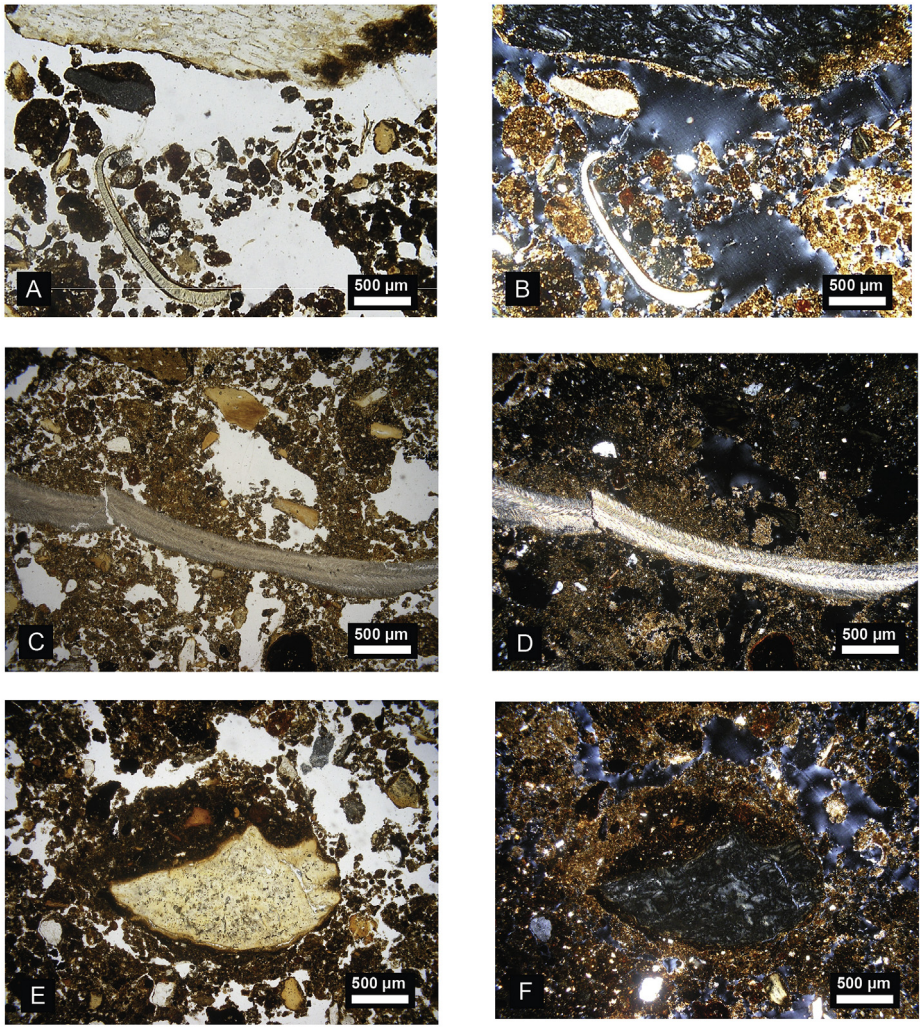

Fig. 5. Sequence SQ I. (A, B): Loose infillings of voids with rounded aggregates also including a coarse bone fragment (at thetop) and shell fragments. PPL, XPL. (C, D): Spongy microstructure. Continuity of the solid material broken by numerous voids locally interconnected. In the middle part a large broken shell fragment. PPL, XPL. (E, F): Bone fragment with ferruginous coatings of fine material. PPL, XPL.

(Fig. 7B) revealing local blocky morphologies. The clay is iron-rich, which makes its color turn from yellowish brown, reminding sequence I, to reddish-brown typical of sequence II, speckled with black micro-carbons. Clasts are sub-angular. We notice the abundance of bone and shell fragments and micro-carbons. The coarse/fine frequency distribution is single spaced porphyric to double spaced porphyric (poorly sorted 32%). These sediments are characteristic of highly porous material.

Thirty percent of the coarse elements are bone fragments (size varying from 1 mm to 5 mm) with different degrees of alteration. Some bone fragments are ferruginised. Two percent of the elements are shell fragments and micro-charcoal. The microstructure is complex, it's locally spongy. Regarding porosity, sequence SQ II sediments are generally loose and reveal channels fissures and vughs. The micro-organisation is heterogeneous showing a level of subangular limestone clasts more or less expressed.

We noticed the presence of an external typical coating with compound juxtaposed micro-laminated clay applied on most of the angular limestone clasts (Fig. 7A). They are regular in thickness along the entire length. Some calcitic detrial grains are trapped in the micro-laminations. We notice enrichment in ferruginous nodules, bone fragments and micro-charcoal towards the top in sequence SQ II. The upper part of sequence SQ II displays a gradual change to a fine textured deposit rich in coarse-intercalation (limestone clasts and bone fragments) integrated in the fine mass. The porosity changes from vughs, fissures and channel to spongy vughs (Fig. 7 C, D, E, F) with scarce channels.

Sequence SQ III (-2, 72 m to -2,65m) (Fig. 8).

The sequence SQ III is reddish brown, mainly composed of angular to sub-angular bone fragments (30% −40%). The microcarbons show local alterations. The microstructure is open-porphyric. This sequence is characterized by the proportion of the fine fraction that is larger compared to the coarse fraction. This sequence shows strong bioturbation by burrowing animals and roots. Root traces are frequent and occur as thin sub-cylindrical voids. Loose infilling of voids with aggregates and soil fragments was observed. Regarding porosity, it is spongy with vughs. There are minor proportions of channels and fissures. Thin coatings of iron are present around the different components (limestone clasts and bones) in the sediment. Some bones appear strongly altered but most of them are only slightly altered. Micro-bones, ferruginous nodules and micro-charcoal are abundant. Noteworthy is the higher proportions of ferruginous features (nodules and mottles) throughout this unit. The column is characterized by a constant presence of ferruginous nodules, particularly abundant in sequence SQ II and sequence SQ III. Nodules are the most common form of ferruginous pedofeatures. Three kinds of nodules were identified:

- (a) Typical red nodules (Fig. 8 C, D) showing an irregular outer shape with smooth to rough surfaces and sharp boundaries.

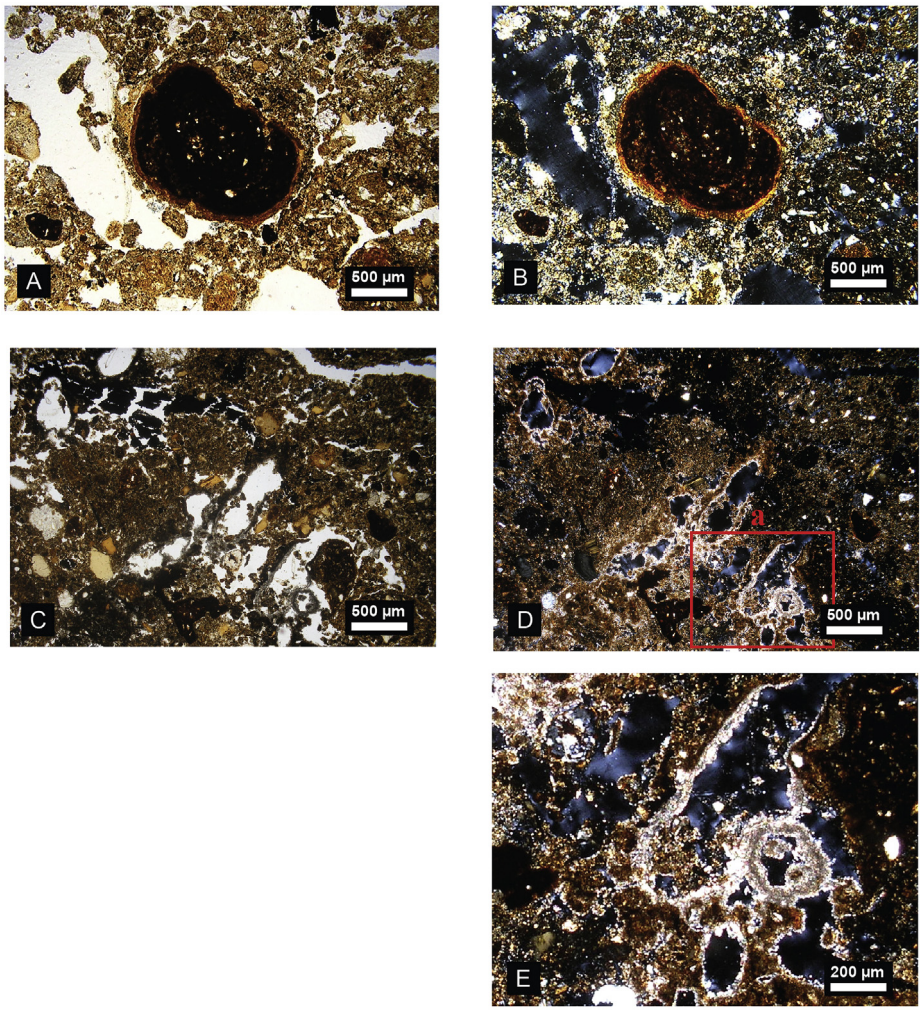

Fig. 6. Sequence SQ I: (A, B): Ferruginous nodule. PPL, XPL. (C,D): Spongy structure, abundance of micro-bone fragments and partially broken down micro-charcoal. PPL, XPL. E: Detailed view of D micro-sparitic to sparitic calcite infillings (note micro-sparite growing inside the void). XPL.

- (b) Concentric red nodules which are more or less round with smooth to round surfaces and generally sharp boundaries (Fig. 8 E, F). These nodules result from intermittent accretion of iron oxide constituting their cortex (Fig. 8 G, H).
- (c) Compound impregnative nodules (Fig. 8 A, B); regrouping more than one type of nodule to form a larger nodule unit.

Sequence SQ IV (-2,65m to -2,53m) (Fig. 9).

Sequence SQ IV shows various elements in common (anthropic and pedogenic) with sequence II. It is 12 cm thick and reveals a peculiar richness in angular to subangular blocky gravel. Gravel makes up most of the coarse material, up to 70%. The angular gravel probably comes from the cave wall or corresponds to lithic fragments.

The coarse/fine relative frequency distribution is porphyric. The color is dark yellowish-brown. The sequence is mainly composed of high amounts of fragments of reworked carbonate gravel, bone and micro-carbon. Bone fragments (Fig. 9 E, F) are generally well preserved (subangular to subrounded shape). Few altered and oxide bone fragments were identified. Regarding porosity, it is well expressed. It constitutes (20 %–30% of the entire sequence) and exhibits vughs, channels, fissures. Micro-sparitic infilling is growing inside voids (Fig. 9A, B, C, D) Large black charcoal particles, often with the wall structure preserved, are frequent.

In this sequence some elements show hypo-coatings. Overall, they show strong bioturbation by burrowing animals and roots. The bones are partially dissolved and show sparite infillings (Fig. 9 E, F).

Sequence SQ V (−2,53 m to2, 48 m).

Sequence SQ V is fine grained and is characterized by the abundance of micro-charcoal. Very fine dispersed iron oxides are observed on bone fragments and in the micromass of this sequence. The occurrence of heterogeneous kind of bone fragments normal and impregnated with iron oxide can be related to a pedofauna activity and a redistribution of the elements belonging to sequence SQ IV.

Here we go back to the issue of the integrity of the deposits and the remains they contain, and to how far they have been subjected to post-depositional displacement.

5.2. Industry (Fig. 10, Table 3)

5.2.1. Artefact description

In the first place, thanks to the typo-morphological study of SMA-Extern Epigravettian layers, we can follow the evolution of artefact associations within stratigraphy itself. On the other hand, it gives indications about the taphonomical parameters of the zone, thus indirectly confirming the dynamics of the deposit (Baills, 2015).

- The analysis of US6A lithic industry indicates that burins and backed bladelets are numerous unlike end scrapers which are rather scarce. On the other hand, backed points and geometric tools are quite frequent.

This lithic assemblage was also observed in the Puglia where it was

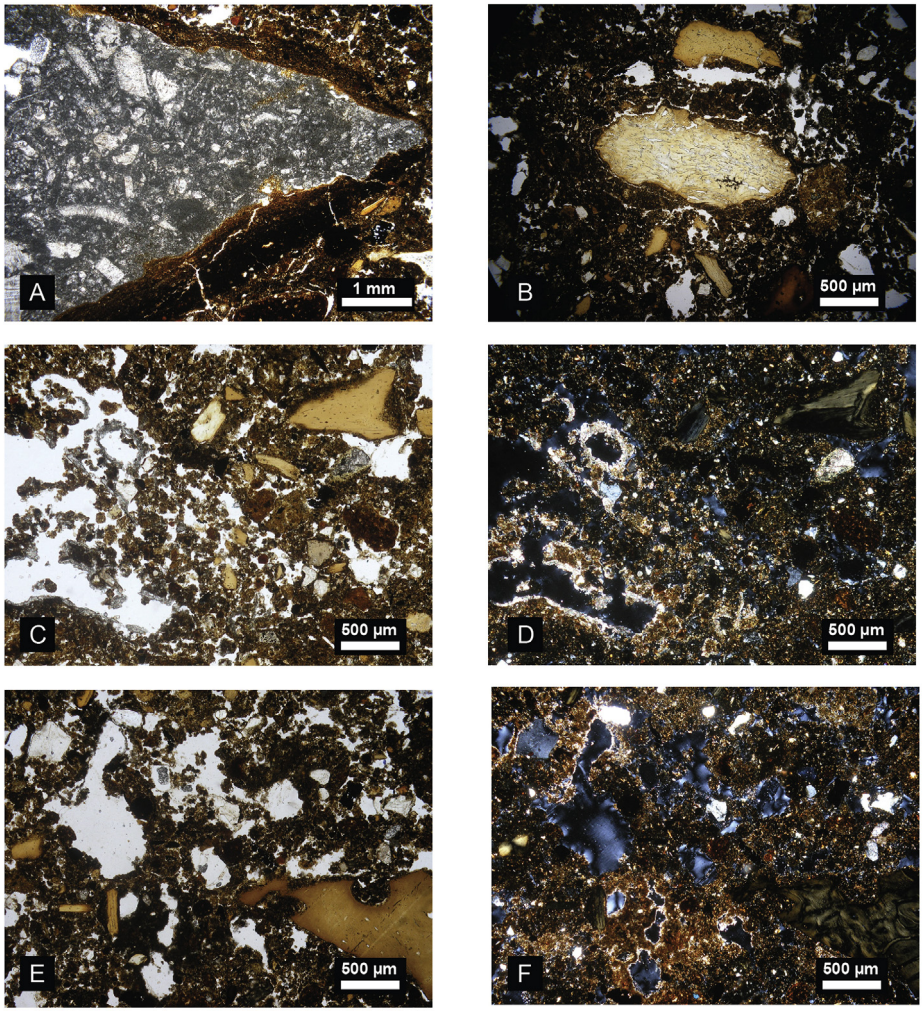

Fig. 7. Sequence SQ II (A, B): Limestone and bone fragments with layered orange ferruginous coatings. PPL. (C, D): Micro-sparitic to sparitic calcite infillings (note micro-sparite growing inside the void). PPL, XPL. (E, F): spongy structure and bone fragments. PPL, XPL.

attributed to the earlier Epigravettian, in Paglicci cave levels 10-11 (Lami and Palma Di Cesnola, 2005), in La Mura cave level 4, in Cipolliane shelter level 4.

- The SU4 level lithic industry is mainly made on lamellar supports relating it to the microlithic type. Many tools were backed edged. Among these straight-backed points, Gravette type, and backed blades are highly frequent. This kind of tools is generally widespread in the Epigravettian of the region (Palma di Cesnola, 2001) confirming the attribution of the SU4 level to the Epigravettian.

The SU4 lithic assemblage appears homogeneous, though with some differences, between the three sublevels (SU4A, SU4B and SU4C) were noticed (Table 3). At the base (SU4C) the industry is especially rich in backed bladelets, truncated backed bladelets and retouched bladelets. In this sublevel, the retouched blades show the highest frequency of the SU4 level. This category of tools reminds us of the last moments of the Early Epigravettian in the South East Adriatic area.

The SU4B lithic industry is rather atypical. The geometric tools show the highest frequency in the SU4, and the retouched blades and the denticulate tools are also frequent. This industry recalls the one of the Late Epigravettian of the region.

The base level SU4A lithic industry provides geometric tools and short end scrapers. This assemblage characterizes the Late Epigravettian abundantly present in the Southern part of Puglia, called Salento. The SU4A/upper level lithic industry shows typical circular shape micro end scrapers. In Puglia, they are always found in Romanellian contexts.

Considering the lithic tool layout and their normal stratigraphic location, the SU4 level can be initially considered as an organised stratigraphic body that can provide an interesting framework essential to the understanding of the archaeological context, the sediment input and the occupation history of the site.

5.2.2. Spatial organisation and taphonomy (Fig. 11)

The top of the US4A/upper was excavated before 2007, when the French team arrived at the site. The lithic small size remains (< 10 mm) have not been taken into account. Only the lithic remains of 10 mm and larger sizes were removed from the excavation, measured and analysed. The density analysis of the SU4A/base lithic remains enclosed between the wall and the blocks shows that the northern part of the excavated area corresponding to squares d2, d3, e2, e3, f2, f3 and g3 is rich in artefacts. A low concentration (1–10 artefatcs) was reported towards the South in squares a3, d2, c3 and c1. Squares b2 and b3 contain no artefacts. Compared to the lower layers SU4B and SU4C, SU4A is characterized by the largest amount of artefacts. In square d2, the average number of artefacts is over 100 per sq.

The US4B level doesn't show a special distribution, it is generally poor in artefacts. The lateral distribution shows 1 to 10 artefacts in a3 and b3 squares and 11 to 50 artefacts in d3, d2 and c2 squares.

The lateral distribution of SU4C artefacts displays the richness of square d3. The progressive decrease of the number of artefacts from a3

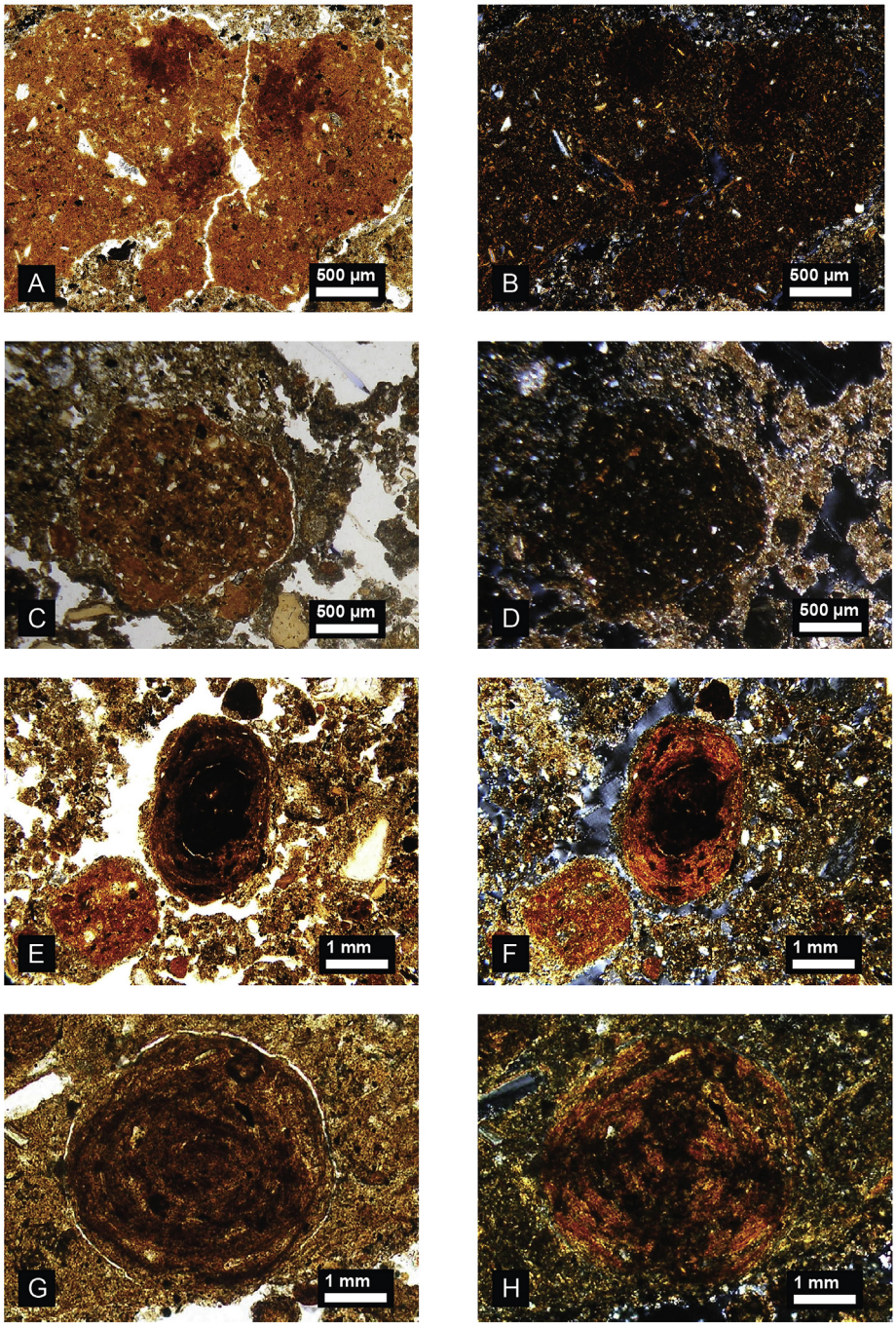

Fig. 8. Sequence SQ III. (A, B): Compound impregnative nodule. PPL,XPL. (C, D): Typical impregnative ferruginous nodules. (E, F): Nucleic concentric ferruginous nodule. PPL, XPL. (G, H): concentric ferruginous nodule. The presence of cross extinction lines is characteristic of continuous orientation of laminae. PPL, XPL

and a2 squares to d2 and d3 squares might indicate a dip of the layers towards the North confirmed by the richness in artefacts of square d3 (> 100).

The direction of the large size of the Ostuni Rudist limestone blocks collapsed from the Santa Maria porch and their situation in the northern part of the front site brings evidence of the natural dip of the layers towards the North. The vertical distribution of artefacts shows a normal continuity especially observed in both d3 and d2 squares in the SU4A low level, SU4B and SU4C levels. Compared to the other excavated squares in this area, the different spatial distributions attributed successively to SU4A, SU4B, US4C indicate the local richness of these squares in industry ranging from 10 to 100 artefacts.

6. Interpretation and discussion

The sediments in front of the cave provide numerous Data on the human activity. The sediment lithology and the anthropogenic remains shed light on the cave outer environment and contribute to elucidating the close relationship between the different components such as sediments, bones, artefacts and charcoal.

Detailed micromorphological observations allow the subdivision of unit SU4 into five sequences. Except for base one (SQ I), all the other sequences are characterized by the presence of micro-charcoal. Iron nodules and ferruginous hypocoatings were observed in the different sequences. They were the most significant in sequences SQ II and SQ III where the iron nodules were abundant and dispersed in the ground

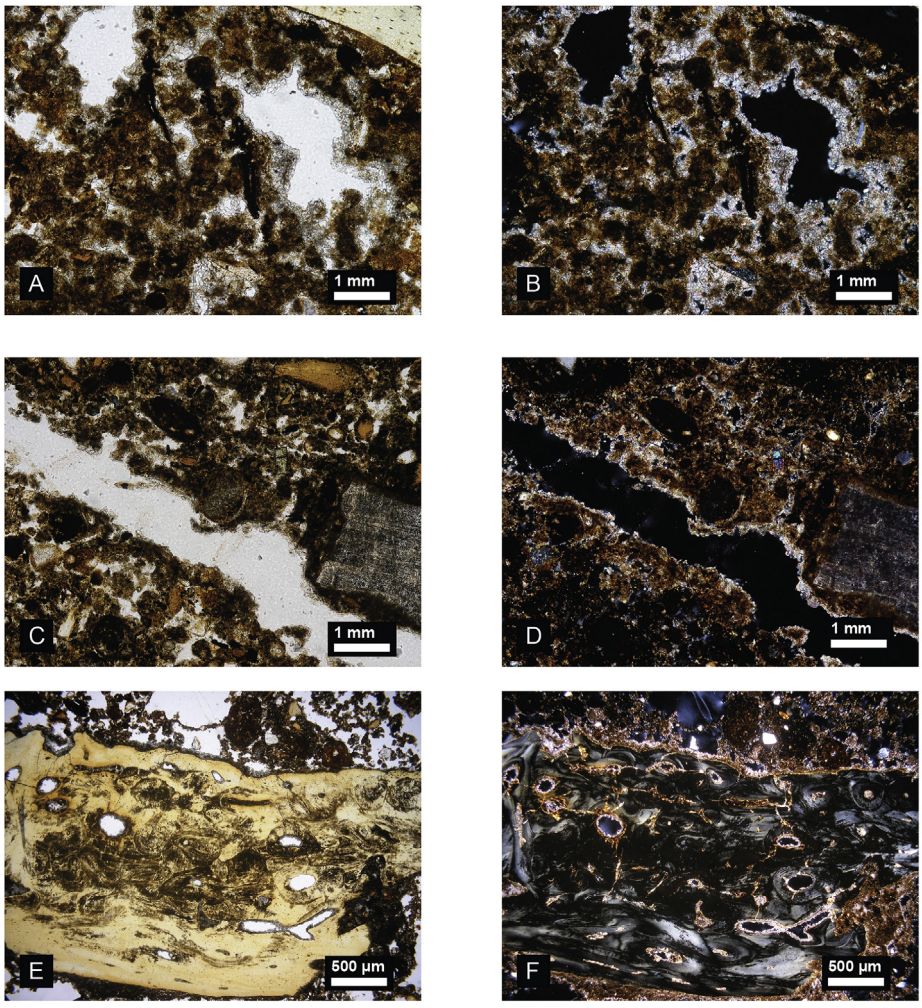

Fig. 9. Sequence SQ IV: Micro-sparitic infilling growing inside voids (A, E), planar voids (C, D) and bone tissue (E,F). PPL, XPL.

mass, which explains the reddish brown color of the SU4B sublevel.

Sequences SQ I, SQ III and SQ IV show significant post depositional bioturbation indicated by the vughs associated to fissures, channels and compound packing voids originated probably from worms and vegetation. Bone fragment presence was recorded in the different sequences. Their different size and their angular shape are in favour of their deposition by human activity (Mallol, 2004).

The microstratigraphic analysis of SU4 shows the stratigraphic SU6A/SU4C transition correspond to sequence SQ I, SU4C to SQ II, SQ III to SU4B, sequences SQ IV and SQ V correspond to SU4A. Each of the distinct sequences is characterized by appropriate micromorphological features and contents.

In order to understand the different phases of the sediment input and the origin of their components, before, during and after the episode of human activity, the different microfeatures are specified. As a result, many components such as bones, artefacts and charcoal were probably introduced by human activity. Moreover, the different components included mixture of natural and anthropogenic deposits. The human probably occupies the area near the cave entrance. Anthropogenic contribution can result from intentional, or unintentional, human acts. The micro-charcoal elements may be transformed and transported by post depositional processes. The presence of charcoal scattered in the different sequences, associated with bone remains and artefacts is a proof of human activities nearby. The presence of continental shell fragments can be attributed to their fragmentation later on during the occupation. The scarce number of complete shells and the absence of their accumulation may indicate their probable natural origin.

The presence of the SU4 unit, at the entry of the SMA cave, made the

Table 1
Calibrated C14 Dates of the SMA-Extern levels and Ostuni 1 and 2 graves (calibrated with OxCal v. 4.3).

Stratigraphic Units	Material and sampling date	Datation reference	Datation type	BP. Ages	Calibrated Ages CalBC*	Laboratory reference	Cultural Age
SU4A/upper	charcoal - 2007	LTL 2514A	AMS	9973 ± 55	9752–9298	CEDAD Mesagne Italy	Final Epigravettian
SU4C	charcoal - 2008	LTL 2786A	AMS	15255 ± 65	16745-16401	CEDAD Mesagne Italy	Early Epigravettian
SU6A	charcoal - 2007	LTL 2513A	AMS	16347 ± 65	18013-17587	CEDAD Mesagne Italy	Early Epigravettian
SU8	charcoal - 2007	LTL 1811A	AMS	23945 ± 110	26339-25779	CEDAD Mesagne Italy	Middle Gravettian
SU9	charcoal - 2017	LTL 16798A	AMS	22515 ± 100	25221-24549	CEDAD Mesagne Italy	Middle Gravettian
burial Ostuni1	human bone - 2011	S-EVA 12903	AMS	23446 ± 107	25859-25482	MPI EVA Leipzig Germany	Middle Gravettian
burial Ostuni 2	human bone - 2013	ETH-24006	AMS	24910 ± 125	27364-26688	ETH Zürich Switzerland	Middle Gravettian

Table 2
Summary of the micromorphological results with a concise description of each sequence relevant to the.

Sequences	Color	Distribution	Microstructure	Porosity	Components	**Post-depositional pedofeature**
SQ V (SU4A/upper) *−2,53m to 2,48m*	Brown	Close porphyric	Complex/massive to spongy	Few vughs	oxide bone abundance of micro-charcoal	Iron oxide nodules
SQ IV (SU4A/base) *−2,65m to 2,53m*	Dark yellowish-brown	Porphyric	Complex/spongy	Vughs channels fissures	Micro-charcoal, artefacts, bone fragments, lithoclasts	Sparite infillings Bone dissolution red coatings
SQ III (SU4B) *−2,72 m to -2,65m*	Reddish-brown	Porphyric open	Spongy	Vughs channels vesicles	Pellets, bone fragments, shell fragments, charbon	Abundant iron oxyde nodules Ferruginous hypo-coatings
SQ II (SU4C) *−2,78m to -2,72 m*	Reddish-brown	Porphyric open	Spongy	Vughs	Shell fragments Limestone clasts Bone fragments micro-charcoal	Abundant iron oxide nodules microlaminated red coatings
SQ I(SU6A/SU4C) *−2,86 m to -2,78m*	Yellowish brown	Close porphyric to double spaced porphyric	Complex/spongy/ locally aggregated	Vughs Fissures Channels compound packing voids	Bone fragments mollusk shells coprolithes	Red coatings, iron oxyde nodules Spar in channels Shell and bone dissolution

Table 3
Chronology and frequency tendency of the lithic industry in the SMA-Extern Epigravettian levels.

Tools/SU	SU46A	SU4C	SU4B	SU4A/base	SU4A/ upper	Tendency
Burins	4.1%	3.4%	2.2%	3.3%	0.0%	≈
End scapers	2.0%	3.9%	3.9%	5.8%	12.8%	↗
Truncated pieces	2.7%	1.5%	1.7%	1.9%	0.0%	↘
Borers	0.7%	0.5%	0.6%	0.7%	0.0%	≈
Backed points	15.6%	20.5%	24.7%	25.8%	16.0%	↗
Backed bladelets	42.9%	40.5%	36.5%	35.4%	31.9%	↘
Shouldered tools	3.4%	2.0%	1.1%	2.6%	3.2%	≈
Truncated backed bladelets	2.0%	4.4%	3.9%	3.5%	7.4%	↗
Geometric pieces	3.4%	2.0%	3.9%	3.1%	3.2%	≈
Leaf pieces	0.0%	0.5%	0.0%	0.0%	0.0%	≈
Points	3.4%	2.9%	2.2%	2.4%	1.1%	↘
Retouched blades	12.9%	11.2%	9.6%	9.2%	9.6%	↘
Side scapers	2.0%	2.4%	3.4%	2.8%	4.3%	↗
Raclettes	1.4%	1.5%	1.7%	0.7%	2.1%	≈
Denticulated tools	3.4%	2.9%	3.9%	2.6%	6.4%	≈
Splintered pieces	0.0%	0.0%	0.6%	0.1%	2.1%	↗
Total	***147***	***205***	***178***	***718***	***94***	***1342***

interpretation of the sediments very delicate. In fact, the occupations of the cave until the historic periods may have altered the integrity of the deposits. In this case, the inhabitant may have removed the sediment that had previously accumulated.

For example, a modern occupant might have cleaned the place, evacuating a considerable amount of previously deposited sediment from the cavern to make the chapel under the rock shelter and thrown it out onto the terrace in front of the site.

Sedimentary processes at the site might have influenced the cultural activities that could be practised and the degree of preservation of the cultural record just as the kinds of cultural activities may have had a strong influence on the sedimentary as observed by Farrand in other prehistoric sites (Farrand, 2001). SMA-Extern probably corresponds to the outside exogenic sediments such as inwashing of colluviums and soils. The topographic location of the SU4 level induced a confluence zone collecting runoff and local colluviums. This topographic setting implies a heavily reworked area in which erosional sedimentary features are frequent. The presence of heterogeneous material of soil aggregates and nodules with different colours and limpidity suggests that the deposition of soil sediments derived from older more evolved soils.

Nodules typically occur in hydromorphic soils of humid temperate climates. Iron nodules were characterized by accumulation of Fe-oxides that form coherent bodies. Nodules are formed within soil apparently starting as pores filling and presumably as a result of periodic changes due to seasonal changes in soil moisture status as indicated by authors (Sherman and Kanehiro, 1954; Folster, 1968; Blume and Schwertmann, 1969). Morphological differences in iron nodules are linked with age, origin and formation processes. Clay and iron illuviation are also recurrent features speaking of prominent water infiltration. The SU4 level seems to have been subject to a sedimentary dynamics involving leaching in humid climate. Noteworthy is the higher proportion of ferruginous features (nodules, mottles and ferruginous coatings) throughout sequences SQ II and SQ III. These ferruginous pedofeatures are commonly associated with poor soil drainage and an excess of water for some periods. This view fits well with the hypothesis that suggests a periodically humid climate. At a post depositional level, the main processes identified in thin sections are biologic bioturbation, clay illuviation, ferruginous oxide leaching, carbonate dissolution and precipitation. Alternating humid and dry seasons induce the dissolution of carbonates during wet periods and their precipitation during relatively dry ones.

The results largely confirm the original work of the excavators pointing the presence of a red layer (SU4B) which micromorphologically corresponds to sequences SQ II and SQ III rich in ferruginous pedofeatures. This layer deposition had probably occurred under more humid conditions than those of SQ I, SQ IV and SQ V.

Limestone clasts and bone fragments are common in sequences SQ II and SQ IV. These two sequences (SQ II and SQ IV) exhibit a more diverse composition whose sources are anthropic and pedologic. The different components of the sediment suggest that the latter was deposited by anthropic action (fire, production of artefacts). The absence of an obvious structure of the sediments and the presence of microvertebrate bones evokes the scarce reworking of the sediment.

On the other hand, the evolutionary chrono-cultural archaeostratigraphic highlights of SU4 lithic industries are consistent with the models proposed for the Epigravettian of the Puglia. It reinforces the conclusions of sedimentological and palynological analyses by pointing out the weakness of post-depositional reworking and rearrangements in the area of SMA-Extern. The archaeostratigraphy highlights the lithic associations which organize themselves according to assemblies that are consistent with internal periodization of the Italian Epigravettian.

7. Conclusion

The lithofacies study of the Santa Maria d'Agnano Epigravettian deposits located in front of the cave allowed the distinction of three stratigraphic sub-units: US6A/SU4C, SU4B and SU4A within SU4 unit.

Microstratigraphic investigations of SU4 level in front of Santa Maria d'Agnano cave (SMA-Extern) suggest further subdivisions of sediment layers: sequences SQ I, SQ II, SQ III, SQ IV and SQ V. Reddish brown ferruginous hypo-coatings of fine material, on limestone, have

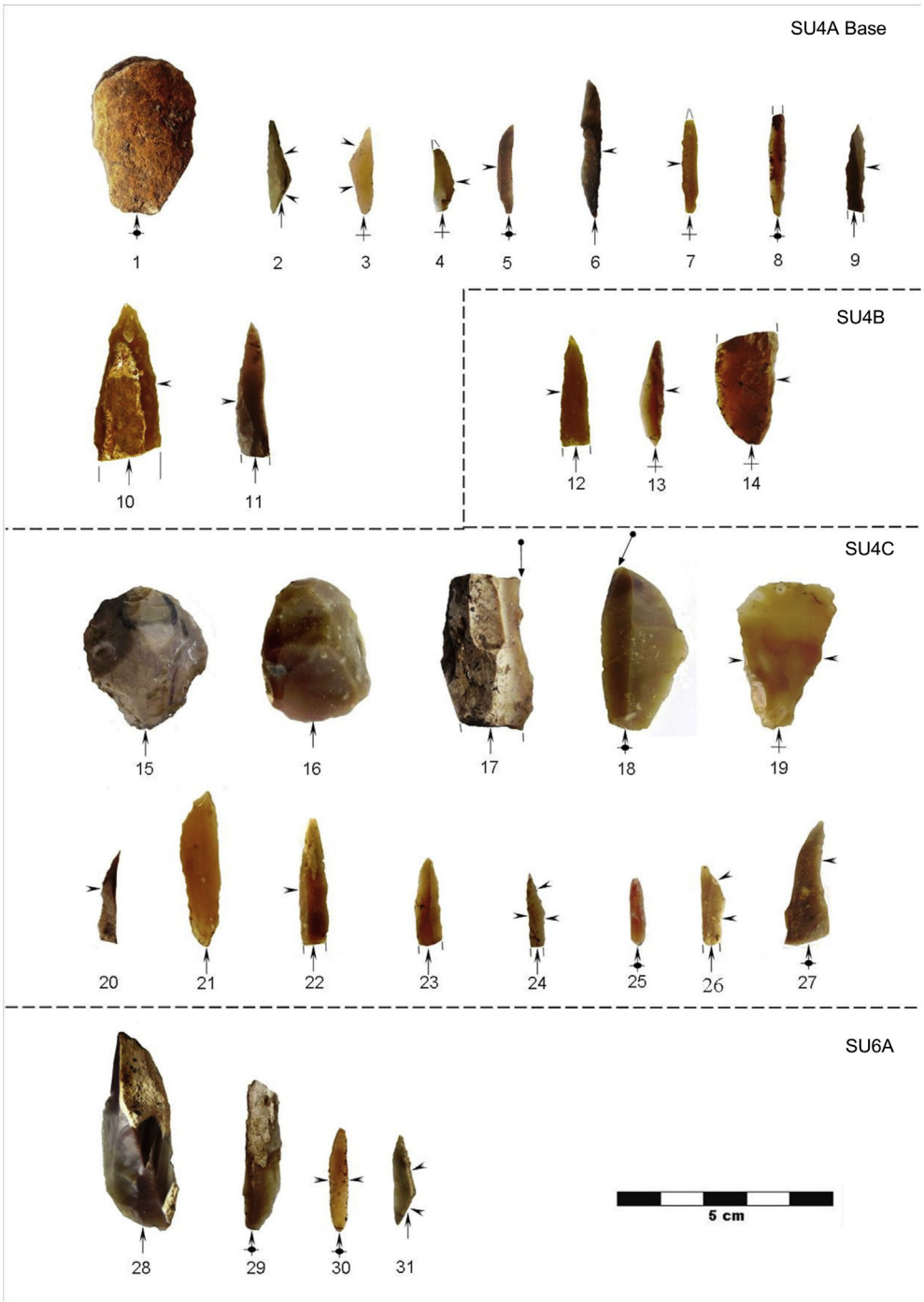

Fig. 10. Lithic industry from SU4 and SU6A levels of SMAExtern. End scarpers: n°1, 15, 16; burins: n°17, 18, 28; triangles: n°2, 3, 31 ; unifacial points: n°21 ; circle segments: n°4, 5 ; backed points: 6, 7, 9-13, 22, 30 ; bladelets with continuous retouch: 8, 25 ; backed bladelets : n°14, 29 ; piece with continuous retouch: n°19 ; retouched burin spall: n°20 ; bladelet: n°23 ; truncated backed points: n°24, 26 ; borer: n°27.► *symbol showing a backed edge*

been observed in sequences SQ II and SQ III spanning sub-unit SU4B. Ferruginous pedofeatures are commonly associated with poor soil drainage and an excess of water for some periods. Hypo-coatings are the most common form of coating associated with iron deposition. They vary in thickness and degree of iron impregnation (Bullock and al., 1985).

These iron oxides pedofeatures which are more prominent in sequences SQ II and SQ III are interpreted as indicative of likely paleo clay illuviation and rubefaction. The occurrence of diverse ferruginous pedofeatures, such as nodules and hypocoatings, are related to humidity and seasonal contrast. The different sequences show the presence of charcoal and bone fragments scattered and mixed within sediment of the SU4 layer. The good preservation and angularity of the micro charcoal indicate that these materials were the products of local combustion episodes by humans in the nearby environment of the cave. It may occur in the proximity of 3 m from the cave on average. The absence of a *strict sensu* fire place confirms that the source of the burning wasn't recorded through the thickness of the Epigravettian studied level. This result leads to our decision to extend the excavation beyond this area.

Thereby, our results, although they do not bring evidence of a fire place, demonstrate a typical Epigravettian association of artefacts. In

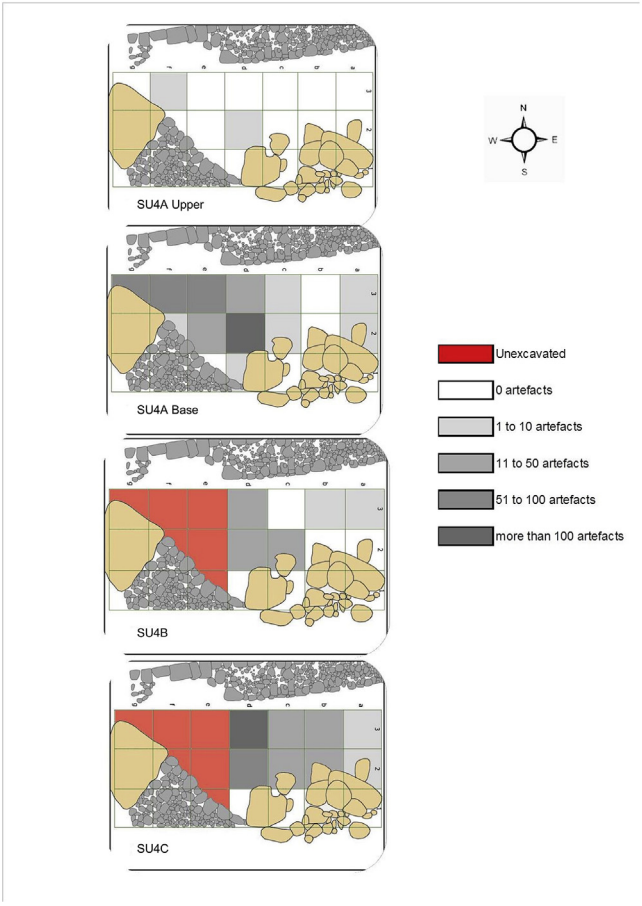

Fig. 11. Lithic small size remains planimetric distribution in the stratigraphic unities of SMA-Extern.

fact, in this SMA-Extern area, we find all the usual remains that were abandoned by the hunter-gatherers in the outlying areas on their habitat. This association strongly suggests that humans at that site had open air cooking activities. Our archeo-sedimentary study demonstrates that the composition of the deposits is best documented at a microscopic scale and will have a significant impact in providing information about the relationship of the humans with the site.

To conclude, we could infer that the deposition in SMA-Extern site consists of both natural processes marked by anthropogenic inputs and built up available sediment. Gravitation blocks of different sizes from the shelter were significantly present during this period.

In answer to the objectives defined in the introduction, the micromorphologic study shows a hardly troubled dynamic of sediment deposition in the SMA-Extern zone, associating both exterior natural and anthropic contributions, the latter ones related to neighbouring fire places. Culturally, the dynamic of the deposit perfectly reflects the inner structuration of the Puglia Epigravettian. Concerning the paleoclimatic environment, the micromorphologic study brings some variations in the global cold and dry atmosphere of the final LGM stage, clearly pointing out the existence of more humid and less rigorous episodes.

Declaration of competing interest

The authors declare that they have no conflict of interest.

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