

M.A. IACONIS (*), G. BOSCHIAN (*)

GEOARCHAEOLOGY OF THE DEPOSITS OF GROTTA DEI PICCIONI AND GROTTA SANT'ANGELO (ABRUZZO, CENTRAL ITALY)

Abstract - Soil micromorphological studies were carried out recently on the sequences of two caves in Central Italy, in the Abruzzo area: Grotta Sant'Angelo and Grotta dei Piccioni. The results show that most of the sequences are made up of mixed stable and domestic deposits, and that the domestic component decreases from the Late Neolithic onwards. Though the use of these caves was supposed in the past to be mainly cultural because of the occurrence of peculiar objects and features, the geoarchaeological study showed that they were also intensively frequented by shepherds with their flocks. The use probably evolved through time, from dwelling for humans with their animals (Neolithic) to specialised stable for ovicaprines (Copper and Bronze Ages).

Key words - Agropastoral caves, soil micromorphology, Neolithic, Copper Age, Bronze Age, Abruzzo, Italy.

Riassunto - *Geoarcheologia dei depositi della Grotta dei Piccioni e della Grotta Sant'Angelo (Abruzzo, Italia centrale)*. Studi di micromorfologia dei suoli sono stati recentemente effettuati sulle sequenze di due grotte dell'Italia centrale, in Abruzzo: la Grotta Sant'Angelo e la Grotta dei Piccioni. I risultati mostrano che la maggior parte delle sequenze è costituita da depositi misti di stalla e di abitazione, e che la componente domestica diminuisce dal tardo Neolitico in avanti. Quantunque si supponesse in passato che l'uso di queste grotte fosse prevalentemente culturale a causa della presenza di oggetti e strutture particolari, lo studio geoarcheologico ha dimostrato che queste erano intensamente frequentate da pastori con le loro greggi. Probabilmente l'uso è evoluto nel tempo da abitazione e stalla (Neolitico) a stalla specializzata per ovicaprini (Età del Rame e del Bronzo).

Parole chiave - Grotte agropastorali, micromorfologia dei suoli, Neolitico, Età del Rame, Età del Bronzo, Abruzzo, Italia.

INTRODUCTION

Recent research on Holocene cave deposits in Northern Italy and nearby areas has underlined the importance of pastoral economy in prehistoric societies from the Neolithic onwards. The geoarchaeological study of several sequences has shown that most caves were used for stables, and that their deposits are mainly made up of (burned) herbivore droppings. These «pastoral» deposits share some peculiar basic characteristics that can be easily identified in the field and through soil micromorphological studies (Boschian, 2000; Boschian & Montagnari-Kokelj, 2000; J.-É. Brochier, 2002; J.-É. Brochier *et al.*, 1999; Canti, 1997, 1998, 2003; Courty

et al., 1992; Del Lucchese & Ottomano, 1996; Iaconis, 2002; Macphail *et al.*, 1997).

The aim of this work is to assess possible evidence of pastoral use at Grotta dei Piccioni di Bolognano and Grotta Sant'Angelo alla Montagna dei Fiori, through the (re-)examination of the geoarchaeological aspects of their deposits.

These two caves were excavated in the years 1957-1965 (Piccioni) (Cremonesi, 1976) and 1965-1968 (S. Angelo) (Di Fraia & Grifoni Cremonesi, 1996), and their sequences are benchmarks in the archaeological study of south-eastern Italy from the Neolithic to the Bronze Age; the assessment of their function within a model of land exploitation may shed new light on the peopling of the Abruzzo region in the Middle Holocene.

METHODS AND MATERIALS

The sequences of the two caves were sampled for soil micromorphological study, which is the most reliable method to assess the occurrence of indicators of pastoral practices. Undisturbed soil monoliths were collected – where possible – from key locations along profiles, where the deposit *versus* cultural *facies* relationships were best represented. These samples were collected about 40 years after the excavations; therefore, the location of the sampling points is not always perfectly referred to the old profiles, that suffered various types of decay. Despite such difficulties, the sampling is reliable, mostly because of the great accuracy of the old excavation journals and profile drawings.

At Grotta dei Piccioni, few profiles were preserved; a large part of these was covered by excavation waste of pot-hunters, or by the products of natural decay. Only 3 monoliths were collected, representing the Late Neolithic Ripoli *facies* and the overlying sterile level (Fig. 1). At Grotta Sant'Angelo, the excavation profiles were almost completely exposed even if badly damaged by pot-hunters; after reshaping and thorough cleaning, the most representative profile (BACG of the old excavations) was described at eye-scale and 9 monoliths were collected (Fig. 2). Only the Copper Age levels were not sampled, because of the very poor preservation of the profile at that depth.

The monoliths were impregnated by epoxy resin, and 90 x 65 mm thin sections were cut. These were examined by a polarising microscope under transmitted and reflected light; epifluorescence was also observed under UV and blue excitation.

(*) Dipartimento di Scienze archeologiche, Università di Pisa, via Santa Maria 53, Pisa, 56100, Italy.

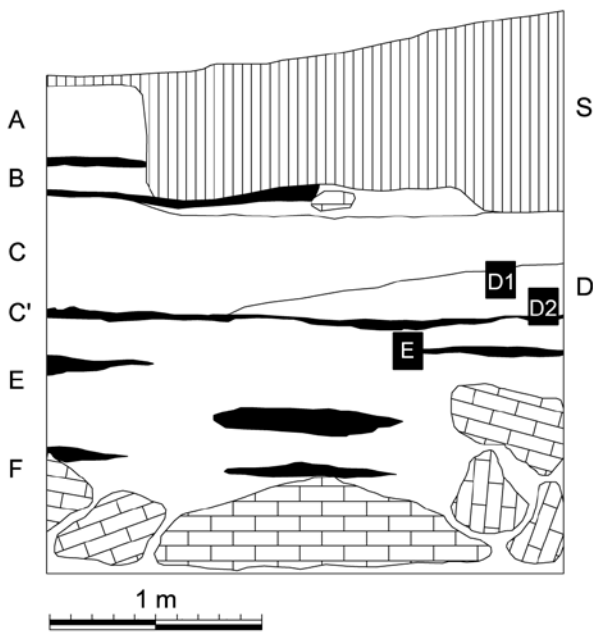


Fig. 1 - Grotta dei Piccioni. 1957-1965 excavations profile, sondage TR (redrawn from Cremonesi, 1976). S: mixed context; A: Recent and Bronze Age levels; B-C: Bronze Age levels; D: sterile level; E: Late Neolithic, Ripoli *facies* levels; F: Early Neolithic Impressa ware *facies* levels. Black rectangles: micromorphological samples.

The descriptive criteria are those of Stoops (2003). The peculiar characteristics of the stable sedimentary environment are described in accordance to informal standards derived from the basic works of Macphail *et al.* (1997), Canti (1997, 1998, 2003), and Brochier (2002).

The field descriptions follow the standard formalised in Catt (1991).

DESCRIPTION OF THE SEQUENCES

Grotta dei Piccioni

Most of the available information is derived from the old excavation reports (Cremonesi, 1976: 12-26), that are written in a 1950s perspective; nevertheless, the lithological units are accurately described and correlated throughout the excavation area.

Six principal layer groups (A-F) were identified, each divided into several spits; the sediments are mainly greyish to brownish, usually dusty, and often include several hearths; level D is typically light greyish to whitish, occurs through most of the excavation areas with variable thickness (0 to 40 cm), and is completely sterile. It lies between the Late Neolithic and the Copper Age levels.

These deposits cannot be directly ascribed to a typical «pastoral» *facies*, because the typical sequences of fine black and white layers are never reported; nevertheless,

it is likely that at least part of the several dark lenses described as hearths are indeed burned droppings. Such hypothesis is corroborated by their scattered distribution within the sequences and by the general appearance of some profiles (Cremonesi, 1976: Fig. 4, 5), that may resemble typical sequences of burned dung. It was also shown that dark lenses scattered within homogeneous greyish to brownish layers can be part of burned pastoral deposits, as in the Trieste Karst (Boschian & Montagnari-Kokelj, 2000) and in Istria (Croatia) (Boschian & Miracle, 2008).

Only levels D and E could be observed and sampled during the 1996 revision. D is typically made up of whitish to very light greyish sandy silt, rather compact and stoneless, with some fine laminae occurring at the bottom. E is made up of brown silty to sandy loam, with few unsorted angular stones; the aggregation is granular, well developed; bone and charcoal fragments are common. Their macroscopic aspect can fit well the colour, texture and structure of pastoral deposits.

The layer groups were ascribed to the following cultural phases: A) Recent and Bronze Age levels. B-C) Bronze Age levels, Pi50 4306 ± 105 ^{14}C BP (spit 10, Ferrara *et al.*, 1961). D) sterile level. E) Late Neolithic, Ripoli *facies* levels. F) Early Neolithic Impressa ware *facies* levels, Pi46 6247 ± 130 ^{14}C BP (spit 13, Ferrara *et al.*, 1961).

Grotta Sant'Angelo

Field observations carried out during the 1996 sampling integrated the accurate excavation log descriptions (Di Fraia & Grifoni Cremonesi, 1996) and previous sedimentological analyses by C. Arias (1996).

Summing up all the data, the Holocene sequence (levels 1-15) is mainly characterised by greyish to light reddish brown sandy silt levels, with few skeleton made up of angular, unsorted limestone gravel. Couples of white to light grey and black lenses and laminae, the white part overlying the black one, usually rather wide, are very common; these are rather thick in the lower half of the profile (Neolithic Impressa ware to Copper Age levels), and are evidently thinner in the upper part (Late Copper Age and Bronze Age levels).

The general appearance of the sequence resembles closely the «pastoral» cave deposits, with the typical interfingering of black and white layers and lenses. It is noteworthy that mostly very thick white strata (up to 30 cm) with few very thin black levels occur within the Neolithic to early Copper Age levels. Conversely, the Late Copper and Bronze Age levels are made up of rhythmically alternating black and white horizons that are approximately the same thickness, the white layers being slightly thicker than the black ones. Brown horizons are also frequently interfingering throughout the sequence, often associated with the bottom of the black ones.

The levels are culturally ascribed as follows: levels 1-2: Late Bronze Age «Età del Bronzo recente» and «Età del Bronzo finale». Levels 3-4: Early Bronze Age «protoappenninico» and «appenninico» *facies*. Levels 5-7: Copper Age. Levels 8-9: Late Neolithic «Ripoli» *facies*. Levels 10-12: Middle Neolithic «Catignano»

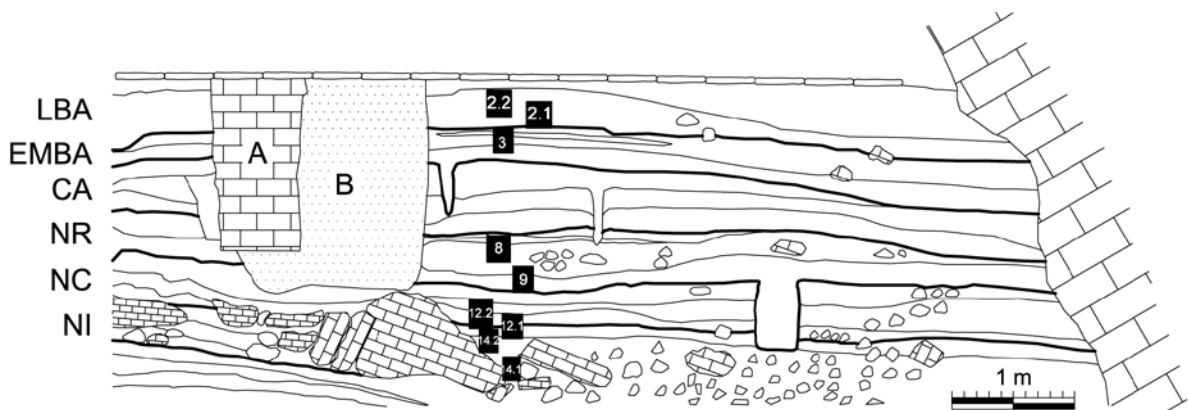


Fig. 2 - Grotta Sant'Angelo. 1965-1966 excavation profile, sondage BACG (redrawn from Di Fraia & Grifoni Cremonesi [eds.], 1996). A: brick-walled, 1880 AD burial; B: C. Rosa excavations, 1871; LBA: Late Bronze Age levels; EMBA: Early and Middle Bronze Age levels; CA: Copper Age levels; NR: Late Neolithic, Ripoli *facies* levels; NC: Middle Neolithic, Catignano-Scaloria Bassa *facies*; NI: Early Neolithic Impressa ware *facies*. Black rectangles: micromorphological samples.

Scaloria Bassa» *facies*. Levels 13-15: Early Neolithic «Impressa» ware *facies*. No datings are available.

SOIL MICROMORPHOLOGY

The most relevant soil micromorphological characteristics of the levels are described here, from the bottom upwards. It must be pointed out that the interpretation is somewhat biased, because of the high lateral variability of the lithologic units, that are not well represented by single samples.

Grotta dei Piccioni

Layer D is represented by two samples, one taken at the bottom, the other at the middle of its thickness.

P-TR-E

Fine granular aggregation, loosely packed. All the micromass is characterised by a large quantity of clay-to fine sand-size fragments of amorphous organic matter, which is the dominant component of the layer, and gives it a very dark colour, traces of vegetal tissue features are sometimes preserved within the larger fragments, that are sometimes dark brown to reddish (probably humified), and sometimes opaque black (charred). Charcoal is common, often in large fragments. Spherulites are frequent to common, sometimes with a dark core, and are randomly scattered throughout the sample. Phytoliths are few to very few, usually unarticulated. Micritic pseudomorphs on calcium oxalates are also common and well preserved. Coprolite features are few and small, usually made up of few parallel and wavy fibres, and do not show evident traces of ashing. Bone fragments and impregnations of amorphous phosphates seldom occur.

All these components are homogeneously and chaotically scattered throughout the section, suggesting

strong mixing of the layer. Only a few short and thin laminae of charred/humified organic matter and other components occur in a small area of the sample, and may represent partially preserved parts of the original structure of the sediment.

Mixed domestic and stable components occur within this layer, the former being apparently dominant over the latter.

P-TR-D2

Massive aggregation; almost voidless, with few sparse irregular vughs. The main component is ash, *i.e.* variously preserved micritic pseudomorphs on calcium oxalates and very fine micritic micromass. Spherulites are dominant, scattered throughout the sample. Very few minute fragments of amorphous organic matter are present. Few aggregates of *terra rossa*-like soil, often burned, also occur.

Thoroughly ashed and trampled stable layer.

P-TR-D1

Massive aggregation, compact to very compact; almost voidless at the bottom; few complex shape voids at the top. Well preserved traces of completely ashed coprolite features occur in the upper part of the sample; these are made up of long fibre fragments arranged in wavy bundles.

Calcareous spherulites and micritic pseudomorphs on calcium oxalates are dominant, homogeneously dispersed throughout the sample. Phytoliths are very few, usually unarticulated. Common aggregates of *terra rossa*-like soil occur in the bottom part.

All the components of the samples look completely ashed, and there is no trace of preserved organic matter or charcoal.

This level, represented by two samples, is an almost perfectly ashed and very strongly trampled stable level, with some preserved coprolite features at the top.

Grotta Sant'Angelo

SA14/2

Massive aggregation, rather compact; laminae of mineral grains and pedofeatures occur in some spots. The very dominant component is ash, *i.e.* variously preserved micritic pseudomorphs on calcium oxalates and irregular aggregates of micrite and microsparite, deriving from the weathering of ash. Spherulites are common to dominant. Coprolites made up of elongated parallel fibres are common, usually rather compacted. The overall appearance of the sample suggests that all the components are scattered throughout the sediment, suggesting some sort of mixing; locally developed thin laminae may derive from the trampling of some layered material, or may indicate that part of the deposits was not mixed. The abundance of ash, bone and charcoal, associated with a remarkable amount of spherulites and some coprolite features can be interpreted as a contemporaneous mixing of stable and domestic deposits, that later were trampled. Some layering can be detected, showing more mixing at the bottom of the sample.

Trampled stable (and domestic?) layer, rather mixed at the bottom.

SA14/1

The sample can be divided into three layers. The bottom one is fine granular, rather chaotic. The main component is ash, made up of common variously preserved micritic pseudomorphs on calcium oxalates and very dominant calcite, occurring as very fine micrite or micritic and microsparitic aggregates deriving from the weathering of ash. The amorphous organic matter is also very dominant, giving the whole mass a very dark and rather opaque aspect. Calcareous spherulites are common, seldom clustered. Aggregates of *terra rossa*-like soil are also present.

The middle layer is rather thin (about 1-1.5 cm) and made up of long and fine vegetal fibres, probably leaves or conifer needles, interbedded with thin and discontinuous horizons of micritic pseudomorphs on calcium oxalates, mainly resembling drusae and *Pinus*-like ash shapes.

The upper horizon is dominated by large fragments of more or less ashed coprolites, apparently made up of short and randomly dispersed fibres; some thin lenses of densely packed spherulites are interfingered within the coprolites. Spherulites are dominant, not only clustered, but also dispersed randomly throughout the mass. Micritic pseudomorphs on calcium oxalates are common, poorly preserved and weathered, so that micrite nodules are rather common.

The bottom layer of the sample resembles SA14/2, and indicates the mixing of stable and domestic sediments; the latter component is suggested also by the large quantity of amorphous organic matter, which is likely a by-product of the processing of vegetal matter. The middle and the top layers can probably be associated within a single stable layer, made up of a layer of leaf hay and/or litter overlain by moderately burned and not very strongly trampled ovicaprine droppings.

SA12/2

The aggregation is medium to fine granular, finer at the top. Three layers can be observed within this sample. The bottom one is made up of large subcircular coprolites, mostly with randomly oriented vegetal fibres. The organic matter of these coprolites is humified, and no (or very few) traces of micritic pseudomorphs on calcium oxalates or other ash can be detected. The amorphous organic matter is dominant, dispersed throughout the groundmass. Spherulites are also absent, while some phytoliths, usually articulated, occur in small clusters. The middle layer is made up almost only of charred or humified organic fibres, more or less well organised in coprolite features.

The upper layer is a rather chaotic mix of several components, partly organised in fine granular aggregates. Coprolite fragments are common, usually rather small and variously ashed or charred. Spherulites, often with a dark or even opaque core, are very common, as well as the micritic pseudomorphs on calcium oxalates, which are usually rather weathered and poorly preserved. Charcoal fragments, bone, amorphous organic matter and amorphous phosphate concretions are also rather common.

This sample is apparently similar to those observed in the underlying levels; the *facies* sequence is not the same, but this may be a consequence of the uncomplete sampling of the layers. The bottom and the middle horizons are stable layers, that include typically ovicaprine coprolites. The charred middle one corresponds to one of the black horizons observed at eye-scale, and the bottom one, which is completely dark under XPL, is apparently unburned, or only slightly burned. In this case, the amorphous organic matter would derive probably from the humification of the organic matter of the droppings. This is one of the very few levels where phytoliths occur; these are mostly articulated within remains of complex vegetal features, and indicate moderate disruption of the stable layer, probably within a penning area.

The upper horizon is a chaotic mix of domestic and stable components, that were thoroughly mixed by some sort of trampling or other sort of reworking.

SA12/1

Medium to fine granular aggregation, unsorted and rather loose. The sediment is a chaotic mix of several components that occur in various amounts and that are more or less homogeneously scattered throughout the sediment. Coprolites are usually small, and their structure is sometimes made up of long and undulating fibres. The spherulites are very dominant, sometimes clustered in swarms; the core is often dark or opaque. The ash remains are made up of common, well preserved micritic pseudomorphs on calcium oxalates and of very common micrite, frequently aggregated in irregular nodules. The amorphous organic matter is very dominant, in minute flakes to somewhat larger fragments that sometimes preserve small remains of vegetal tissue features. Phytoliths are few to frequent, non articulated. Bone fragments, charcoal and amorphous phosphate nodules are also frequent.

Domestic and stable components occur all together in similar quantities, thoroughly mixed and disrupted.

SA9

Massive aggregation; very few vughs. Fine laminae of pedofeatures organised in discontinuous bands are the most outstanding characteristic. These are mainly made up of single (or almost-single) components, and are organised in more or less rhythmical groups; the layers are usually discontinuous, so that the whole deck is made up of a complex interfingering of short lenses.

Three main types of laminae can be observed.

Short, millimetre or sub-millimetre thick lenses of shortly comminuted organic fibres, usually humified, mainly dark under XPL, including some spherulites and a few micrite or microsparite nodules.

Long and often continuous, several millimetre-thick layers of micritic pseudomorphs on calcium oxalates, fine micrite, and nodules of micrite and/or microsparite. Very bright under XPL. Spherulites are very few or absent.

Medium to long, sometimes discontinuous and millimetre-thick layers of closely packed spherulites. The cores of the spherulites are mostly black and opaque.

This very finely laminated layer is probably the result of a single combustion phase, in which several groups of levels of litter/hay and droppings were burned. The spherulites and the organic fibres should represent the droppings, whereas the micritic pseudomorphs on calcium oxalates may be the residue of some sort of leaf fodder (Haas *et al.*, 1998; Karg, 1998), made up of leaves, small branches and twigs.

SA8

Fine to very fine aggregation, with loosely packed aggregates. Traces of layering can be observed in some spots of the thin section.

Spherulites and ash are the most common components of the sediment. The former are dominant, often concentrated in clusters where few other components are present; ash is represented by common, more or less weathered micritic pseudomorphs on calcium oxalates, by micrite nodules and by few very fine micrite dust. The amorphous organic matter is common to dominant, occurring as very finely comminuted to relatively large crumbs and flakes and some vegetal tissue fragments. Charcoal occurs commonly; no coprolites or phytoliths were observed.

The products of domestic activities are apparently dominant on the stable ones, with a large quantity of amorphous organic matter that gives the layer a dark colour.

SA3

Coprolitic microstructure, rather fluffy and uncompact, made up of a chaotic arrangement of unsorted fragments of cattle-like coprolites. These can be humified (brown under PPL and dark under XPL), or ashed (colourless under PPL and very bright under XPL), with common dark core spherulites, micritic pseudomorphs on calcium oxalates, and micrite. Phytoliths are frequent to common.

The components of this sample are almost only coprolites, at various degrees of burning. These are usually cattle-like, even if it may be observed that these features may also be produced by goats (Boschian & Miracle, in press). Compaction and trampling are almost absent.

SA2/2

Massive aggregation. Laminae of basic components and pedofeatures are the outstanding characteristic of this layer. The laminae are usually continuous, with variable thickness and are made up of a limited number of components.

More or less densely packed micrite to microsparite grains, sometimes organised in irregular nodules, with common very fine micrite among the nodules. Whitish under PPL.

Thin and discontinuous, dense lenses of poorly preserved vegetal fibres, almost completely ashed and partly phosphatised; common very fine micrite. Light brown under PPL.

Irregular and undulating bands of *terra rossa*-like soil, with quartz, muscovite and clay. reddish brown under PPL, stipple speckled under XPL. Charred vegetal residues (wood, twigs etc.) are common; bone is rare. No spherulites and phytoliths have been observed.

No direct evidence of stabling can be detected within this sample, which is made up of layered wood ash.

SA2/1

Coprolitic microstructure, rather fluffy. Unsorted (up to 10 mm large) fragments of cattle-like coprolites, including long vegetal fibres organised in undulating bundles. Most of these coprolite fragments are dark under PPL, some others include also spherulites with dark core. Phytoliths are few, often still articulated. Calcite is very common, mostly as irregular nodules or aggregates that follow the vegetal fibres within the coprolite features; Micritic pseudomorphs on calcium oxalates are very few.

Thoroughly ashed, very well preserved cattle-like coprolites are the only component of this stable layer.

CONCLUSIONS

The soil micromorphological study of the sediments of these two caves shows that stable deposits, or domestic deposits that include reworked stable components, are by far the most common.

At Grotta Sant'Angelo, the mainly domestic deposits represent at least a half of the whole sediment volume in the *Impressa* and *Catignano facies* levels, where they are alternated with the «pure» stable ones. Later on, their importance decreases from the Late Neolithic *Ripoli facies* onwards, and the Bronze age levels are made up almost only of more or less thoroughly burnt coprolites.

The few samples from Grotta dei Piccioni integrate the Sant'Angelo data. Domestic deposits with some stabling evidence are associated with the *Ripoli facies*; conversely, the overlying sterile level (D, Late Neolithic or Copper Age), is made up of pure ashed co-

MNI (Wilkins, 1996). Nonetheless, this evidence can be considered as the result of cultural behaviour: animals may have been raised for purposes other than meat exploitation (wool, milk, or even status symbol), or – more easily – may have been slaughtered/butchered outside the cave. The composition of flocks and herds inferred from the archaeozoological study is in accordance to the soil micromorphological data, which indicate mostly sheep and goats in the Neolithic, and a progressive increase of cattle from the Copper Age. Some observations on the composition of the assemblage of cultural remains, mostly pottery and stone artefacts, partly corroborate these hypotheses, but also foment new arguments. The number of ceramic sherds, normalised against the sediment volume, is approximately the same from the Impressa to the Copper Age levels, with a significant decrease only in the Late Neolithic Ripoli layer; conversely, it suddenly grows to almost three times more during the Bronze Age (Fig. 3). The small number of pottery fragments may indicate a less intense frequentation of the cave during the Late Neolithic than during the earlier stages; in fact, it can also suggest that the use of the site was mostly pastoral, in contrast with the prominently domestic use during the Impressa and Catignano phases. Also the decreasing number of sickle elements from the Impressa to the Ripoli levels may suggest the shift from a mixed economy to a slightly more specialised exploitation of animal resources. Objects that directly testify to this economical behaviour, mostly milk boiling vessels and spinning wheels, occur from the Copper Age onwards.

A brief examination of the pottery types (Fig. 3) may suggest similar conclusions, because mostly depurated fragments occur during the Neolithic, while the coarse ones always dominate throughout the Copper and Bronze Ages; in accordance with such evidence, the groups of shepherds are supposed to have more vessels

made up of coarse pastes in their kit than the farmers. Unfortunately, this kit is also supposed to include less ceramic than skin/wood vessels, so that the sudden burst in the pottery quantity during the Bronze Age is in contrast with this model and needs a more complex explanation, which is probably connected to the peculiar spiritual context of the cave (Grifoni Cremonesi, 1996).

Summing up, it can be concluded that the studied caves were frequented by groups among which animal husbandry was a common practice, and that relied more and more on this resource from the Late Neolithic onwards, until they became part of a complex agropastoral economic system during the Bronze Age. This hypothesis may be corroborated by the study of the site distribution on the territory, aiming to ascertain the relationships between caves and open air settlements.

ACKNOWLEDGEMENTS

This work is a re-elaboration of the degree dissertation of M.A. Iaconis. The authors wish to thank professor Renata Grifoni Cremonesi for kindly reviewing the text and for her helpful comments about the general topics of this study.

REFERENCES

- Arias C., 1996. Analisi sedimentologica. In: Di Fraia T., Grifoni Cremonesi R. (eds.), *La grotta Sant'Angelo sulla Montagna dei Fiori* (Teramo): 23-26. Giardini, Pisa.
- Boschian G., Miracle P.T., 2008. Shepherds and caves in the Karst of Istria (Croatia). In: Boschian G. (ed.), *Proceedings of the Second International Conference on Soils and Archaeology*, 175-182, Pisa.
- Boschian G., 2000. New Data on the Pastoral Use of Caves in Italy. In: Biagi P. (ed.), *Volume in memoria di A.M. Radmilli. Soc. Preistoria Protostoria Friuli-Venezia Giulia Quad. 8* (2000): 63-72.
- Boschian G., Montagnari-Kokelj E., 2000. Prehistoric shepherds and caves in the Trieste Karst (Northeastern Italy). *Geoarchaeology* 15: 331-371.
- Brochier J.-É., 2002. Les sédiments anthropiques. Méthodes d'étude et perspectives. In: Miskovsky J.C. (ed.), *Géologie de la Préhistoire*: 459-477. Geopré, Paris.
- Brochier J.-L., Beeching A., Sidi Maamar H., Vital J., 1999. Les grottes bergeries des Préalpes et le pastoralisme alpin, durant la fin de la Préhistoire. In: Beeching A. (ed.), *Circulations et Identités Culturelles Alpines à la Fin de la Préhistoire - Matériaux pour un Étude*, *Travaux Centre Archéologie Préhistorique Valence* 2: 77-114. Centre d'Archéologie Préhistorique de Valence, Valence.
- Canti M.G., 1997. An investigation of microscopic calcareous spherulites from herbivore dung. *J. Archaeol. Sci.* 24: 219-231.
- Canti M.G., 1998. The micromorphological identification of faecal spherulites from archaeological and modern materials. *J. Archaeol. Sci.* 25: 435-444.
- Canti M.G., 2003. Aspects of the chemical and microscopic characteristics of plant ashes found in archaeological soils. *Catena* 54: 339-361.
- Catt J.A. (ed.), 1991. *Paleopedology Manual. Quaternary Int.* 6: 1-95.
- Courty M.A., Macphail R.I., Watzet J., 1992. Soil micromorphological indicators of pastoralism; with special reference to Arene Candide, Finale Ligure, Italy. In: Maggi R., Nisbet R., Barker G. (eds.), *Archeologia della pastorizia nell'Europa meridionale. Rivista Studi Liguri* 8: 127-150, Bordighera.
- Cremonesi G., 1976. *La Grotta dei Piccioni di Bolognano nel quadro delle culture dal neolitico all'età del bronzo in Abruzzo*. Pacini, Pisa.

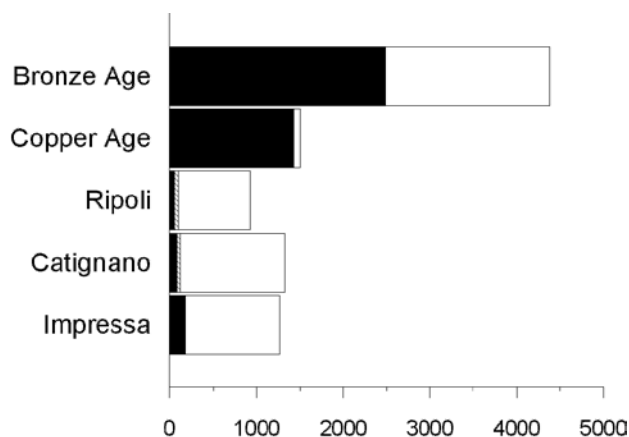


Fig. 3 - Grotta Sant'Angelo. Number of ceramic fragments, normalised against sediment volume. Black: coarse pottery; hatched: *figulina* pottery; white: fine pottery.

- Del Lucchese A., Ottomano C., 1996. Micromorphology of the Neolithic Sequence of Pian del Ciliégio Shelter (Savona-Italy). In: Castelletti L., Cremaschi M. (eds.), *Micromorphology of deposits of Anthropogenic Origin. Colloquium VI, XIII Congress of Prehistoric and Protohistoric Sciences, Forlì, September 8-14, 1996*: 151-160.
- Di Fraia T., Grifoni Cremonesi R. (eds.), 1996. *La grotta Sant'Angelo sulla Montagna dei Fiori (Teramo)*. Giardini, Pisa.
- Ferrara G., Fornaca Rinaldi G., Tongiorgi E., 1961. Carbon 14 dating in Pisa II. *Radiocarbon* 3 (1): 99.
- Grifoni Cremonesi R., 1996. Osservazioni sulle buche e sulla problematica dei culti. In: Di Fraia T., Grifoni Cremonesi R. (eds.), *La grotta Sant'Angelo sulla Montagna dei Fiori (Teramo)*: 305-337. Giardini, Pisa.
- Haas J.N., Karg S., Rasmussen P., 1998. Beech leaves and twigs used as winter fodder: examples from historic and prehistoric times. In: Charles M., Halstead P., Jones G. (eds.), *Fodder: archaeological, historical and ethnographic studies. Environmental Archaeology* 1: 81-86.
- Iaconis M.A., 2002. *I depositi di Grotta dei Piccioni (PE) e di Grotta S. Angelo (TE) - Studio Geoarcheologico*. Unpublished degree thesis. Università di Pisa, Facoltà di Lettere e Filosofia, Pisa.
- Karg S., 1998. Winter- and spring foddering of sheep/goat in the Bronze Age site of Fivà-Carera, Northern Italy. In: Charles M., Halstead P., Jones G. (eds.), *Fodder: archaeological, historical and ethnographic studies. Environmental Archaeology* 1: 87-94.
- Macphail R.I., Courty M.A., Hather J., Wattez J., Ryder M., Cameron N., Branch N.P., 1997. The soil micromorphological evidence of domestic occupation and stabling activities. In: Maggi R., Starnini E., Voytek B. (eds.), *Arene Candide: a functional and environmental assessment of the Holocene sequence (Excavations Bernabò Brea-Cardini 1940-50)*. Memorie Istituto Italiano Paleontologia Umana 5: 53-88, Roma.
- Stoops G., 2003. *Guidelines for analysis and description of soil and regolith thin sections*. Soil Science Society of America, Madison.
- Wilkins B., 1996. Le faune. In: Di Fraia T., Grifoni Cremonesi R. (eds.), *La grotta Sant'Angelo sulla Montagna dei Fiori (Teramo)*: 277-293. Giardini, Pisa.