THE APPLICATION OF MICROMORPHOLOGY ON ANTHROPOGENIC DEPOSITS IN IBERIAN PENINSULA

CURRENT RESEARCH AND FUTURE PERSPECTIVES

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RESUMEN Presentamos aquí una selección de ejemplos de estudios de caso que muestran el gran potencial de las técnicas micromorfológicas aplicadas en diferentes contextos, materiales y cronologías, pero centrados en la Península Ibérica. Los resultados preliminares obtenidos del análisis y la caracterización micromorfológica realizada en diferentes yacimientos arqueológicos del Norte, Sur y Este de España prueban en gran medida que la Geoarqueología, y la micromorfología en particular, tiene un gran potencial para responder preguntas relacionadas con las actividades humanas y las interacciones "humano-animal" en el registro arqueológico en una escala de alta resolución. Los casos presentados son 1) Abrigo de Socuevas (Pobes, Álava); 2) Abrigo de Martinarri (Obécuri, Treviño); 3) Cova del Coll Verdaguer (Barcelona); 4) Cueva de El Toro (Málaga); 5) Conchales mesolíticos en la costa atlántica de Iberia; 6) Ciudades romanas del sur hispano, con especial interés en el centro urbano de *Munigua*.

PALABRAS CLAVE Microarqueología, micromorfología, Península Ibérica, depósitos naturales/antrópicos, actividades humanas

ABSTRACT Here we present a selection of case-study examples showing the potential of micromorphological techniques in different contexts, materials and chronologies but centred in the Iberian Peninsula. The preliminary results obtained from the analysis and the micromorphological characterization in different archaeological sites from northern, southern and eastern Spain prove that geoarchaeology, and micromorphology in particular, has a great potential to answer questions related to the understanding of human activities and human-animal interactions in the archaeological record at a high resolution scale. The cases presented are: 1) Rock shelter of Socuevas (Pobes, Álava); 2) Rock shelter of Martinarri (Obécuri, Treviño); 3) Cova del Coll Verdaguer (Barcelona); 4) Cueva de El Toro (Málaga); 5) Mesolithic shell middens in the Atlantic coast of Iberia; 6) Roman cities of southern Spain, namely the urban centre of *Munigua*.

KEYWORDS Microarchaeology, micromorphology, Iberian Peninsula, natural/anthropogenic deposits, Human activities

INTRODUCTION

The microarchaeological preliminary results obtained from the analysis and the micromorphological characterization in different archaeological sites from northern, southern and eastern Spain are presented.
Micromorphology is a technique born to be applied to the field of soil science and soil survey in a microscopic scale. We find the first reference related to this subject in Walter L. Kubiena work "Micropedology" (1938) and the first appearance of the term "Micromorphology" in the work of J. Dalrymple: "The application of soil micromorphology to fossil soils and others deposits from archaeological sites" (1958). Since then this technique starts to be broadly used in the field of archaeology.
A basic definition refers to Micromorphology as the

"branch of soil science that is concerned with the description, interpretation and the measurement of components, features and fabrics in soils at a microscopic level" (Bullock *et al.*, 1985). Accordingly, micromorphological analysis of archaeological sediments provides a high-resolution sequence and evidence of site formation processes. The microscopic observations include shape, size, texture, fabric and pedogenic features of the sampled material (Courty *et al.*, 1989).
Both natural and anthropogenic deposits can be dissected by integrating macroscopic and microscopic evidence for obtaining complete information about the events that were at first invisible to the human eye. These anthropogenic deposits contain microscopic information about past human lifeways with equal if not greater value than other macroscopic facets of the archaeological record, such as for example bones, lithics and vegetal remains (Courty, 2001; Goldberg and Macphail, 2006; Berna *et al.*, 2007), which got trampled and embedded into the floor surface providing us with clues. Thus, this technique is particularly well suited to study the human events and activities that led to the anthropic deposits formation (Courty, 2001; Courty *et al.*, 1989; Goldberg and Berna 2010) and improve our understanding of taphonomic processes and paleoenvironmental records.
There are also different complementary geochemical techniques that can beapplied in this field, as Fourier Transform Infrared Spectroscopy (FTIR), X-ray Diffraction (XRD), Scanning Electron Microscopes (SEM), Energy-dispersive X-ray Spectroscopy (EDX) or some paleobotanical techniques like pollen and phytolith analysis. Samples of loose sediment that can be accurately related to the micromorphological samples give a detailed interpretation of human groups' activity in a site. Also, if we use them as a multi-proxy we may observe the human impact in the landscape throughout time.
The use of the Micromorphology can vary from chronologies, formations, structures and locations, with the final purpose of discussing issues imperceptible to the naked eye.

CASE STUDIES

The case-studies presented below are currently undertaken by the authors of this paper. The aim of this selection is to provide some examples of the potential of micromorphological techniques in contexts, materials and chronologies radically different between each other, but all centred in the Iberian Peninsula.

CASE-STUDY A: PLEISTOCENE TO HOLOCENE TRANSITION FROM THE SOCUEVAS AND MARTINARRI ROCK SHELTERS: A MICROMORPHOLOGICAL STUDY

Here we present the geoarchaeological preliminary results obtained from the analysis and stratigraphic, sedimentological and micromorphological characterization in the site of Socuevas (Pobes, Álava) and Martinarri (Obécuri, Treviño). The sites of Socuevas and Martinarri are rock shelters whose archaeological sequence covers from the end of the Pleistocene to the beginning of the Holocene, involving, culturally, the last Magdalenian and Mesolithic communities.

ROCK SHELTER OF SOCUEVAS (POBES, ÁLAVA)

The rock shelter of Socuevas opens in a wall of tertiary conglomerate of carbonate clasts, whose roof collapsed in the course of the transition between the Pleistocene and the Holocene (Alday and Cava, 2010) (figure 1).

ROCK SHELTER OF MARTINARRI (OBÉCURI, TREVIÑO)

The rock shelter of Martinarri has a considerable size and opens in a wall of sandstone. The roof, which currently reaches almost 3 meters long, covers an area of about 15 meters long and 3-4 depth. The Martinarri rock shelter is well preserved, resembling its prehistoric features: there are no apparent collapses or alterations; it is a shelter adequate for a small to medium size group of Magdalenian and Mesolithic societies (Alday *et al.*, 2012) (figure 2).
Near the rock shelters of Socuevas and Martinarri are found coetaneous sites: the archaeological site of Fuente Hoz, the open-air site of Berniollo, the rock shelter of Atxoste (Álava), Mendandia (Treviño) and Kanpanoste (Álava). All these archaeological sites are from the Upper Ebro Valley.

1. General view of the rock shelter of Socuevas.

2. General view of the rock shelter of Martinarri.

A MICROMORPHOLOGICAL APPROACH

Stratigraphy was defined according to the composition, texture, hardness and colouring of the sediments during the excavation works, differentiating dissimilar units and several sub-units. For the micromorphological analysis, several undisturbed sediments involving the different stratigraphic units of the site were sampled. At the same time, several samples of loose sediment of the site's units and sub-units were collected (we didn't include higher than 2 mm clasts), using X-ray diffraction and Geochemistry (XFR) to the sedimentary matrix analysis.

All this, together with the micromorphological study and the thin sections will complement the final results, according to the guidelines in Bullock *et al.* (1985) and Stoops (2003).

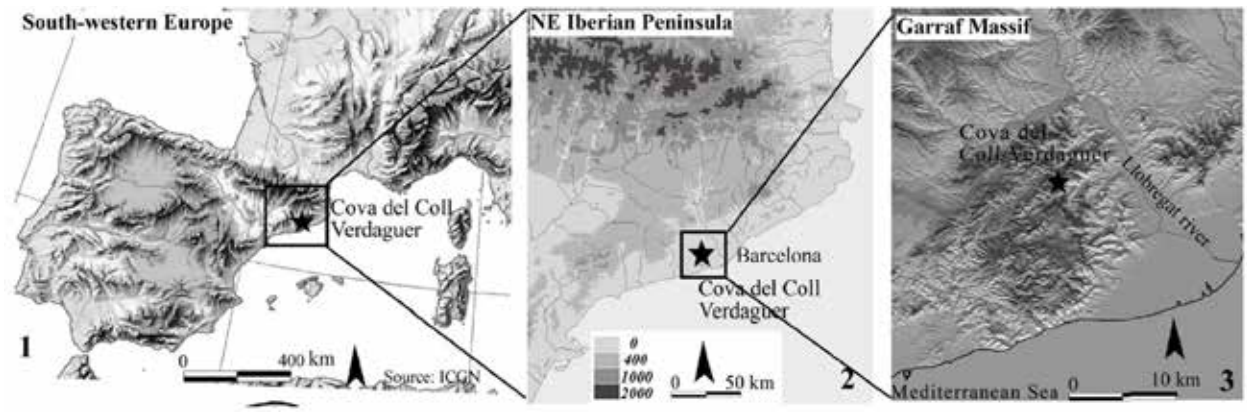
Results obtained from different analyses of the sedimentary matrix and their micromorphological study allowed a characterization and preliminary interpretation of the stratigraphic units in relation to their formation processes.

The micromorphological features of the different units are generally similar and are basically characterized by the presence of abundant pedogenic features, as the presence of bioturbation and remains of roots, as well as bioturbation, aggregates calcitic and excrements resulting from the activity of earthworms or the presence of land snails, with a high content of organic matter. These features give us the opportunity to interpret the various units as a sequence of growing soils formed by the development and amalgamation of soil vegetated on the sediments derived from the rocky substrate. The archaeological content observed is due to 2 different patterns. The first affects the Magdalenian levels, being characterized by a relative high concentration of bone fragments of rather large size and flint fragments, with a low presence of charcoals. However, Mesolithic levels have a high proportion of micro-charcoals (archaeologists detected here numerous structures of combustion) and bone fragments of small size and bivalve shells, as well as high concentration of organic matter. These differences could obey different types of patterns of human occupation from the rock shelters during the Magdalenian and the Mesolithic.

CASE-STUDY B: ORGANIC MATTER AND WASTE MATERIALS THROUGH MICROMORPHOLOGICAL ANALYSIS

ORGANIC MATTER AND WASTE MATERIALS

Organic matter and waste materials such as vegetal remains, charcoal, excrements, ashes, etc. are good indicators of human and animal activity in a site. Therefore, their analyses at a micro-scale are important for having accurate information of these deposits (Shillito and Matthews, 2013; Shillito *et al*., 2009). It is significant to remark that main research questions differ greatly if the samples context is a Pleistocene or a Holocene site. For instance, coprogenic and other waste material analyses are mainly focused to answer human-carnivore interaction questions for Pleistocene contexts and on domestication and herd management and diet for Holocene sites. To address these issues, we present a micromor-



3. (1) Location of Cova del Coll Verdaguer in south-western Europe. (2) Site location in the north-east of the Iberian Peninsula. (3) Regional location of the site in the Garraf Massif. Modified after (M. Sanz *et al.*, 2016).

phological investigation that analyses two different deposits with a high content of organic material as coprolites and dung pellets fragments: Cova del Coll Verdaguer (Barcelona, Spain) and Cueva de El Toro (Málaga, Spain). Our results exemplify the importance of characterizing archaeological organic rich deposits at a microstratigraphic scale of observation to achieve accurate biological and geological information hence, identify animal and human activity in a site.

COVA DEL COLL VERDAGUER (BARCELONA, SPAIN)

Cova del Coll Verdaguer is an Upper Pleistocene site (33.4 – 55 ky) located in the NE of the Iberian Peninsula (figure 3). The presence of similar factual evidence (fauna, stone tools, charcoal and coprolites) throughout the sequence, including the sedimentological features and close dating, supports the study of the three deposit episodes as a whole. A total of 305 coprolite remains were studied through a macroscopic analysis; based on their distinct morphologies (globular and tubular), two of these coprolites were processed for microscopic analysis. Sample 1 (CV-CEV-198) and sample 2 (CV-CEV- 204) were processed for thin section making and were observed under a binocular polarizing microscope (Olympus BX41) at 25×, 40×, 100×, 200× and up to 400× magnifications under plane-polarized light (PPL) and crossed-polarized light (XPL). Specific features, internal structure and composition were detailed according to the descriptive guidelines in Bullock *et al*. (1985), Courty *et al*. (1989) and Stoops (2003).

GLOBULAR MORPHOTYPE

The internal microstructure shows a ~1mm wide brownish dense cortex and an inner region with a massive, pale yellow phosphatic matrix, with some sand-sized quartz fragments. A few voids (related to digestive gas), some elongated pores and char (animal fat) can be observed. There are also partially phosphatized bone fragments and some calcitic pseudomorphs, consistent with mammalian hair ghost (Horwitz and Goldberg, 1989). No fecal spherulites, plant inclusions, or phytoliths were detected. The colour, basic constituents and internal fabric described above are compatible with those documented for hyena coprolites by Horwitz and Goldberg (1989) and Linseele *et al*. (2013).

TUBULAR MORPHOTYPE

The internal microstructure shows a thin (0.5 mm) brownish cortex and a massive, pale yellow phosphatic matrix, with very few fine sand-sized quartz grains. Common voids, related to digestive gas and elongated pores can be observed. The coprolites also contain subangular, partially phosphatized bone fragments (sharper and better preserved than those in previous described sample), indicating a low degree of bone digestion. Also, a much higher content in calcitic pseudomorphs (fur origin) is perceived. As in the sample above, this tubular morphotype presents the basic components and internal fabric of carnivore coprolites. Nevertheless, we observe some differences that indicate the coprolite may be associated with a carnivore species other than the hyena and may correspond to a medium-small sized carnivore (i.e. wolf, lynx or fox) (Sanz *et al.*, 2016).

CUEVA DE EL TORO (MÁLAGA, SPAIN)

Cueva de El Toro (6150-6110 cal BP) is a cave in southern Spain that has yielded a rich early and late Neolithic archaeological record (figure 4). The late Neolithic assemblage reflects specialized handcraft activity including in situ ceramic manufacture, textile production and food processing, along with sheep and goat penning, suggesting that the cave occupants and their domestic animals shared the same living space. The goal of the microstratigraphic investigation was to understand the layering of brown, black and white deposits in a much defined areas of the cave. The micromorphological study of nine thin sections prepared from seven undisturbed sediment blocks (collected from NE and S profiles of the inside of the cave) revealed these deposits formed by the accumulation of fresh dung, during the penning of animals, its subsequent drying, rummaging and mixing with the substrate, and anthropogenic burning of the penning floor. This sequence of events results in the following stratigraphic sequence: (1) a white ash layer generated by the burning of the dung (5 cm thick), (2) a black layer (2-3cm thick) representing charred dung and other (also charred) organic particles present on the stable floor and (3) a brown layer constituting unaffected or mildly rubified stable floor (2 cm) (Égüez *et al.*, 2014). Also, by the observation of its micro components (as charcoal remixed with ashes and fragments of coprolites with a high content of spherulites) we can confirm that these deposits are related to fumiers, where ovicaprine dung was burnt periodically, being then seasonally reused for stabling animals.

CASE-STUDY C: THE STUDY OF MESOLITHIC SHELL MIDDENS IN THE ATLANTIC COAST OF IBERIA THROUGH MICROFACIES ANALYSIS: A WORK IN PROGRESS

During the Mesolithic in the Iberian Peninsula, a particular type of anthropogenic deposits began to develop,

4. Geographical location of Cueva del Toro Neolithic site.

especially in the Atlantic coast: shell middens. Geoarchaeological research in these deposits has been extremely scarce. Only very recently, active research projects regarding shell middens in central and southern Portugal and Asturias (northern Spain) have included systematic geoarchaeological investigations in their frameworks, with modern methodologies, such as micromorphology. These are also the regions with the highest concentrations of shell middens in the Iberian Peninsula and two of the classic regions of the European Mesolithic (Gutiérrez-Zugasti *et al.,* 2011). Each region has quite distinct problematics.

Recent micromorphological analysis of shell-matrix layers and associated stratigraphy in Muge (Aldeias and Bicho, 2016) and Sado shell middens reveal that sedimentary microfacies characterization in thin section is an efficient way to recognize different actions and behaviours within the shell middens layers. These include shell tossing, grade of preservation of combustion features (if they are in-situ or reworked) or trampling surfaces. Also, it allows an accurate identification of several events of shells accumulations, which in most cases are impossible to discern in the field when excavating (figure 5). In other words, we can then know how the shell middens were "constructed" and ultimately why.

In Asturias, northern Spain, shell middens are radically different (González, 1982; Fano, 2004; Clark, 1976). These deposits are defined, in general, by a specific lithic technology, especially the so-called Asturian pick. From a geoarchaeological point of view, the most striking aspect of these deposits is that they are all cemented and adhered to the walls and ceilings of karstic cavities (figure 6). In these deposits is nearly impossible to undertake archaeological excavation. However, with micromorphology it is possible to access to the microcontexts preserved. One of the more interesting outcomes so far is the occurrence of terrigenous sediment trapped in the internal part of the limpets and in some rounded aggregates as well. Microscopically, this sediment contains typical anthropogenic debris associated with ashy layers, such as ash-rhombs, dusty charcoal, iron nodules, rubefied clay aggregates and small fragments of burnt shell. As a working hypothesis for now, this might be indicating that the shells were filled with this sediment in an anthropogenic deposit that does not exist in the present-day record anymore, but whose relicts are preserved in a secondary position. Therefore, we must be careful when interpreting, at site-scale, these deposits as the only remains of an original anthropogenic accumulation in primary position.

5. Detail of a profile of a shell midden of the Sado, Poças de São Bento (southern Portugal). Note the different composition of the shell-rich layers in terms of abundance, orientation, sediment colour or organic matter.

6. Typical Asturian shell midden (El Alloru, Asturias, northern Spain). The accumulation of anthropogenic material, mostly mollusc shells, is completely cemented by calcium carbonate precipitation.

CASE-STUDY D: URBAN TRANSFORMATION PROCESSES IN THE ROMAN CITIES OF SOUTHERN SPAIN: A HIGH-RESOLUTION APPROACH

Although microarchaeological techniques are being increasingly applied to European urban contexts, its application is far from systematic. This deficiency has led some authors to encourage researchers to focus attention on characterizing formation processes in historical, complex urban sites, expanding case studies both spatially and temporally (Shahack-Gross *et al.*, 2005). In this sense, the archaeological record of Roman cities – for its vitality, diversity and continuity of occupation – are excellent arenas to develop the direction of the technique. Geoarchaeology, and especially soil micromorphology, have much to contribute to the interpretation not only of site formation processes, but also the use of space, construction techniques, production processes, daily life and, consequently, human behaviour.

7. Public Roman Thermae of Munigua. Overview.

Here we show some of the first results of a research carried out in Roman urban contexts of southern Spain; a geoarchaeological study of the chronostratigraphic sequence of the public *thermae* of the Roman city of *Munigua*, Villanueva del Río y Minas, Sevilla (figure 7). Soil micromorphology, along with physico-chemical and geochemical analyses have revealed urban change dynamics marked by an initial use of space dedicated to metallurgical production and a later course of urban planning, construction of a *thermae* complex, and the life-cycle of this public building. The integrity of the archaeological record has allowed the use of new descriptive criteria for observing metallurgical by-products of lead and iron melting in thin section, offering new contextual information about production, technology and site formation processes. Sealing the metallurgical context, sedimentary soil crust formation talks about urban planning, which concluded with the construction of the public *thermae*. The studied sequence terminates with microstratigraphic evidence of the *thermae* transformation, once the bath function was lost in favour of metal recycling activities. Deposits are marked by aeolian sedimentation (quartz silt <60µm), which implies the intentional removal of the roof tiles, as well as the occurrence of re-smelting by-products. XRF allowed the characterization of geochemical anthropogenic inputs related to metallurgical processes. Phisico-chemical and soluble anions analyses have provided significant data about the diachronic use of that space. Thus, it permitted to assess abandonment and a later reuse of this public building for metal recycling purposes during Late Antiquity.

This study reaffirms that archaeological soil micromorphology, along with physico-chemical as well geochemistry, are powerful tools in order to decipher urban transformations processes, most of them not visible in the macroscopic record. Understanding the scope of these practises is essential to assess the morphology and topography of urban sites, especially during Late Antiquity.

FINAL REMARKS

We consider that the case-studies presented here prove that geoarchaeology, and micromorphology in particular, has great potential to enhance the completeness of the understanding of human activities record. The case--studies presented in this paper provide evidence that may times human activities leave relevant imprints for behavioural interpretations in the sediments, only discernible at microscopic scale. In conclusion, sediments must be considered archaeological artefacts just as any other material exhumed by excavation, for a correct interpretation of the archaeological record.

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