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Prehistoric herding facilities: site formation processes and archaeological dynamics in Cova Gran de Santa Linya (Southeastern Prepyrenees, Iberia)

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ABSTRACT

Prehistoric pen accumulations in rockshelters and caves are indicators of the history of pastoralism beginning in the Neolithic period. This paper characterises the stabling practices and the syn/post-depositional processes identified in Cova Gran de Santa Linya through a combination of micromorphological and stratigraphic analyses and radiometric dating of the pen deposits recorded at the site. The study confirms the cyclical stabling of ovicaprids in the rockshelter. Other activities, such as the repeated burning of residues, add to our understanding of pen management and the upkeep of pen deposits in the past. The topographic characteristics and extensive use of the site over a long period of time, along with contextual data from other cave sites in the South Pyrenean mountain range where pen deposits have been documented, allow discussion of the role played by Cova Gran in long distance transhumant herding between the Ebro Basin and the Pyrenees during the past, which includes routes that have operated almost until the present day.

1. Introduction: the origins of pastoralism in the Southern Pyrenees

Pastoralism, a way of life followed by many groups in the present day as well as in the past, has encompassed an extraordinary variety of relationships between animals and humans across time and space. Such practices do not relate exclusively to subsistence activities but are embedded within a web of dynamic interactions between the environment and humans that affect the social organisations of these groups. The Mediterranean area is not an exception; pastoralism has been a central community activity until recently (e.g., Maggi et al., 1990; Harris, 1996; Barker 2005).

Interest in the study of this activity has been encouraged by a growing body of research on the organisational complexity of such a lifestyle. Historical sources indicate that regular seasonal movements of herds of thousands of animals took place in the Pyrenees from the Roman period through the Middle Ages (Laffont, 2006 and references therein). Recently, researchers have used census and cartographic reports as documentary background for ethnographic and sociological studies analysing the socio-economic impact of movements along routes on the Pyrenean slopes connecting the Ebro Basin with the Pyrenean Massif. These transhumant circuits involve distances greater than 100 km and ascents of more than 1500 m in a mountainous environment that is often rugged and difficult to access. Along with long distance movements, local movements of small herds were also implemented during the summer to reduce grazing pressure on croplands as a key strategy for maintaining the structure of traditional communities in this area that combined agriculture and pastoralism (Vila Valentí 1950; Costa 1987; Roigé, 1995).

The creation of long and short distance regional and local routes implies the coordination and maintenance of a network of points across the landscape to guarantee the continuity of these activities through time. Stone enclosures that have been preserved in rockshelters and caves associated with livestock corralling are an expression of this logistical strategy. Although it has been

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suggested that long distance routes on the northern slopes of the Pyrenees were established during the Early Neolithic (Geddes, 1983), many of the elements integrated into the dynamics of such activities, as evidenced by historic and ethnographic sources, are not easily transferred to the past (Halstead, 1987; Barker, 1990; Cleary and Smith, 1990; Brochier et al., 1992; Chang, 1993).

Despite these limitations, archaeology contributes significantly to the study of the temporal dimensions of this activity. Archaeological attributes and a growing literature on the sedimentological dynamics of accumulation and management of residues resulting from livestock stabling have generated a rich material record for the identification of prehistoric sites that were specialised for activities related to pastoralism (Brochier, 1983a; Angelucci et al., 2009; Polo Díaz, 2010; Macphail and Cruise, 2001).

Microscopic analyses of sediments are essential in the characterisation of enclosure deposits and the identification of corralled animals, associated plant remains and management of residues through intentional burning. Furthermore, these attributes enable definition of seasonal use and/or site specialisation (Beeching and Moulin, 1983; Brochier, 1983b, 1990, 1996; Courty et al., 1991; Canti, 2003a,b). Micromorphological studies are also useful for the analysis of site formation processes and in the detection of karstic syn/post-depositional processes that affected pen deposits in caves and rockshelters (Polo Díaz and Fernández Eraso, 2010). In terms of site formation processes, micromorphological data may be interrelated with zooarchaeological studies (e.g., Helmer, 1984; Helmer et al., 2005; Tagliacozzo, 2005) and palaeobotanical analyses (e.g., Akeret et al., 1999; Badal, 1999; Brochier et al., 1998; Cabanes et al., 2007; Rasmussen, 1993) to provide rich complementary data. In contrast, animal pens are usually poor in pottery, bone or lithic artefacts, which often complicates their chrono-cultural adscription (Fernández Eraso et al., 2002; Polo Díaz, 2010).

The current study presents stratigraphic, microstratigraphic, radiometric and contextual data on the Holocene deposits at Cova Gran de Santa Linya (Southern Prepyrenees, Iberian Peninsula). The results highlight the cyclical use of the site as a pen and allow analysis of the role of the site in the regional context where other caves and rockshelters were used for similar purposes in the past (Angelucci et al., 2009) (Fig. 1).

2. Cova Gran site

Cova Gran de Santa Linya ($X = 318{,}541$, $Y = 4{,}643{,}877$, UTM H31N, ETRS89) is located on the outer Marginal Sierras of the Southern slopes of the Eastern Pyrenees (Lleida, Spain) (Fig. 1). The regional geology features Mesozoic facies with a Tertiary cover overlying Triassic evaporitic materials. The site is in the Bona Formation (Late Cretaceous), which consists of bioclastic limestones, calcarenites, sandstones and bioconstructions, corresponding to a shallow-marine carbonate platform (Simó, 2004).

This south-facing rockshelter is 92 m wide and 83 m deep and has a 25-m-high semi-vaulted roof (Fig. 2). Cova Gran is 385 m a.s.l. and is located at the bottom of the Sant Miquel ravine, a tributary of the Noguera-Pallaresa river (Fig. 1). The Sant Miquel ravine forms a small V-shaped valley more than 250 m deep that developed where the Bona Formation and the Upper Triassic evaporites came into contact. In this area, the ravine describes an incised meander, and Cova Gran developed on its concave side, coinciding with a limestone area that was weakened by faulting.

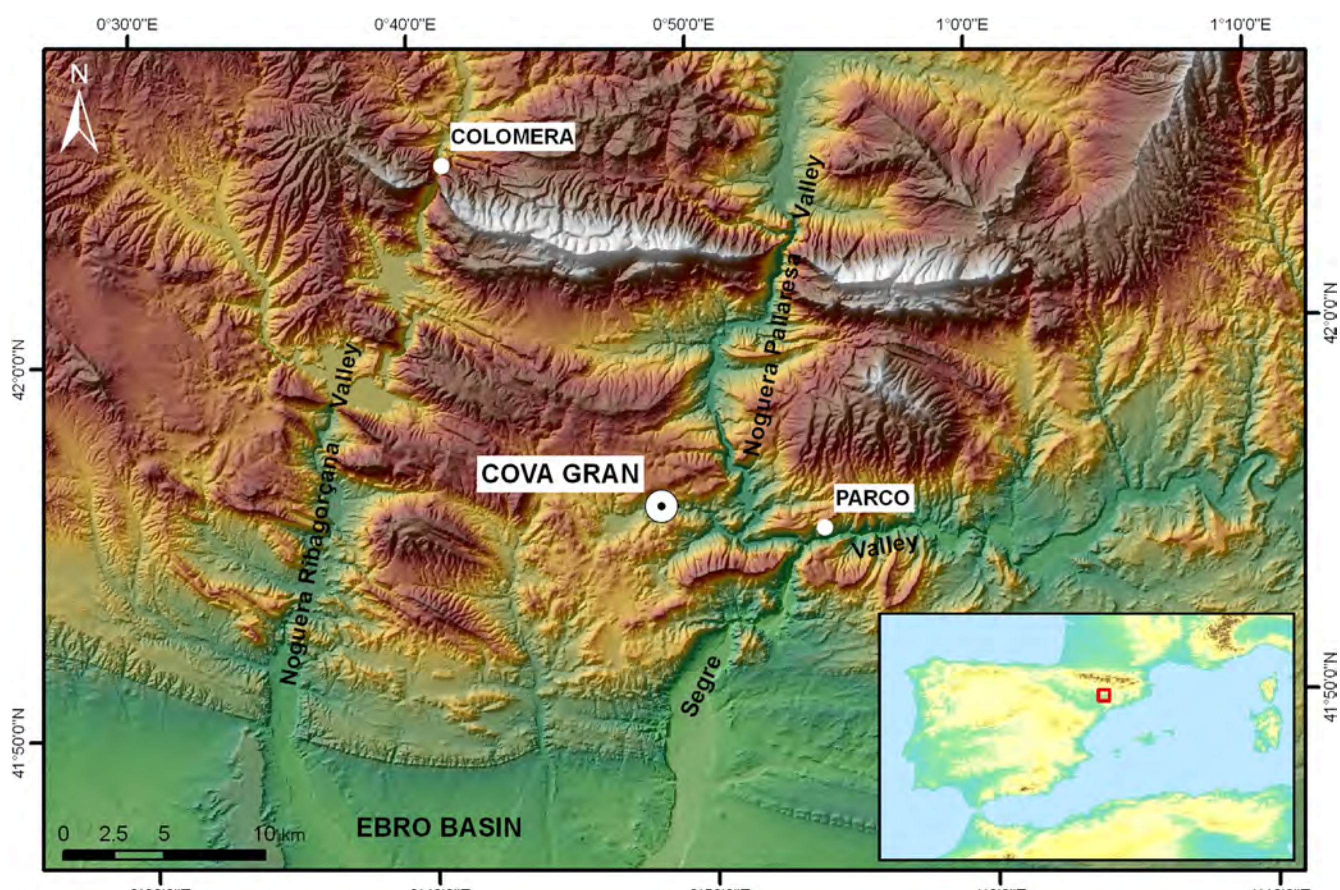

Fig. 1. Geographic context of Cova Gran and sites mentioned in the text.

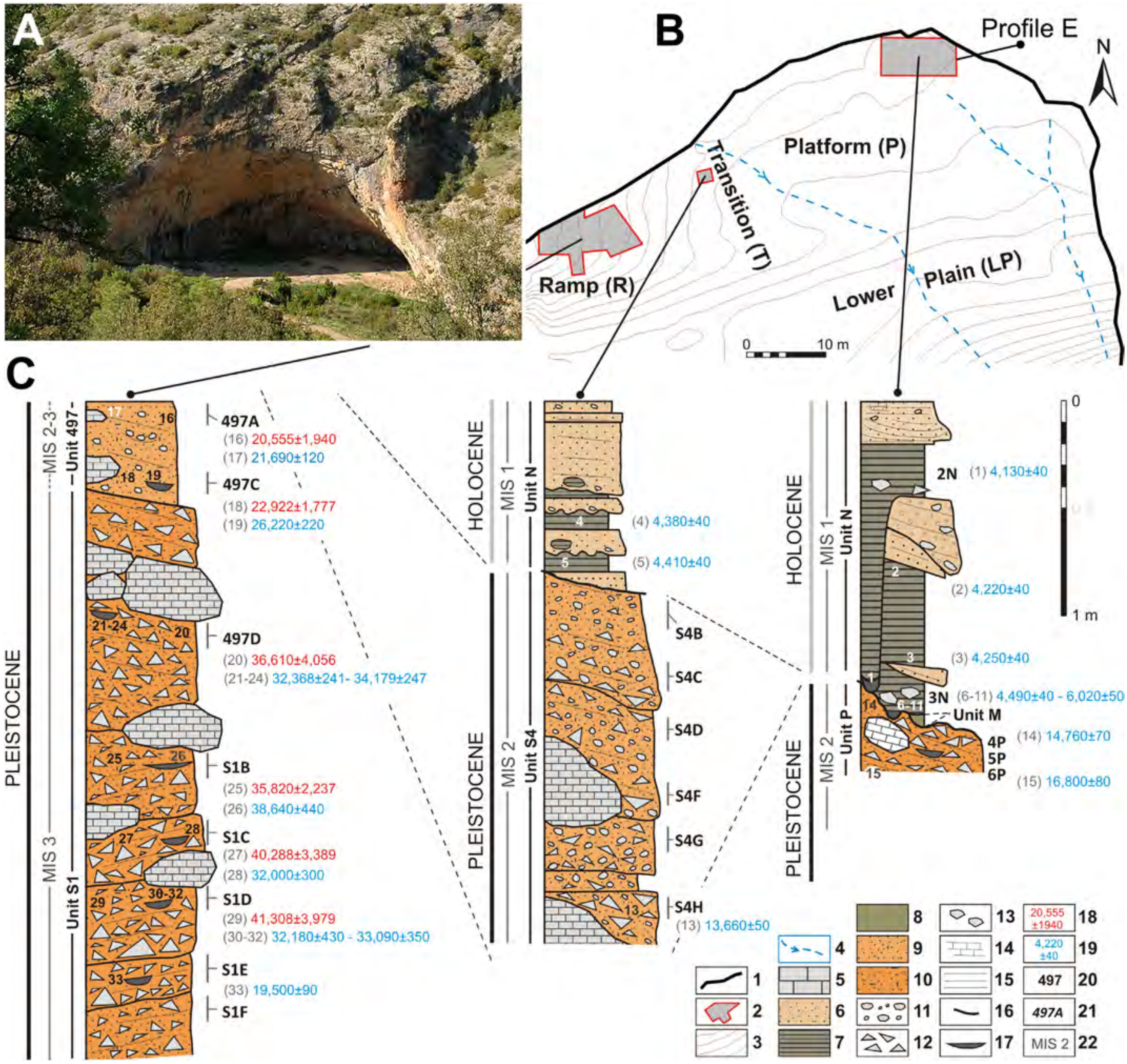

Fig. 2. Site of Cova Gran de Santa Linya: A) General view of Cova Gran; B) Topography and excavated areas. Legend: 1, limestone bedrock; 2, excavated areas; 3, topographic contour lines (0.5 m); 4, drainage channels. Location of profile E in sector P has been indicated (see Fig. 4). C) General stratigraphic sequence. Legend: 1, limestone bedrock; 2, excavated areas; 3, topographic contours (0.5 m); 4, drainage channels; 5, limestone blocks; 6, sands; 7, pen accumulations; 8, sands and clays; 9, clays and sands; 10, sands, clays and silts; 11, rounded and subrounded clasts; 12, angular and subangular clasts; 13, archaeological blocks; 14, carbonate concretions; 15, bedding; 16, discontinuity; 17, hearths; 18, TL data; 19, ^{14}C data; 20, stratigraphic unit; 21, archaeological level; 22, MIS.

The site area is divided into four sectors based on the particular sedimentary infill found in each one of them (Fig. 2). On the Western side, the ramp sector (R) has been preserved on gravitational deposits. These sediments overlie two large blocks that cover alluvial gravels. The ramp is 9 m above the riverbed and slopes downwards to the East to a transitional sector (T) that becomes a platform (P) located +3 m above the riverbed. Recently, sandy sediments covered the surface of sector P, which extends towards a lower plane (LP) affected by the course of the current stream (Fig. 2). The thickness of deposits, estimated using electrical resistivity tomography, varies from 2.6 to 4.5 m near the rockshelter wall to 7–9 m in the central areas of the site (Martínez-Moreno et al., 2008).

Cova Gran has a long cultural history covering the last 50,000 years (Mora et al., 2011). The oldest Pleistocene sediments, dating between 50 and 30 ky and with the Middle Palaeolithic and Early Upper Palaeolithic occupations, have been preserved in sector R (Martínez-Moreno et al., 2010). The stratigraphic context indicates a deposit of autochthonous formation that preserves the interaction between anthropic occupations and formation of the deposit with good resolution (Benito-Calvo et al., 2009).

In sectors P and T, the top of the Pleistocene deposits is affected by a strong erosional surface and is covered by the Holocene sequence (Fig. 2). So far, excavations undertaken in the Holocene sequence have identified two stratigraphic units (units M and N) (Fig. 2). Unit M, at the base, is composed of massive or discontinuous medium-bedded sandy sediments that include areas of subangular clasts. The archaeological content of this unit is attributed chronologically and culturally to the Magdalenian during the end of Marine Isotopic Stage MIS 2. Unit M is overlaid by unit N, where Neolithic, Bell Beaker and Bronze Age occupations were identified (Mora et al., 2011).

3. Materials and methods

Samples for micromorphological and sedimentological analyses and radiocarbon dating were collected from profile E of sector P (Fig. 2B) in which two superimposed stabling accumulations, interspersed with several runoff facies, were identified. The thickness of the uppermost pen accumulation ranges between 10 and 15 cm (Nb), while the lowermost accumulation ranges between 25 and 50 cm (Nd1) (Fig. 3A). The pen area stretches over a surface of at least 35 m^2, and the continuity of this facies has been observed in all profiles of the excavated area (Fig. 3B).

The stratigraphic sequence was recorded using aerial photography and lithostratigraphic descriptions of the sediment texture, structure and composition. In the laboratory, samples were sieved and subjected to XRD, and the organic content was calculated.

Eight oriented blocks of undisturbed sediments were collected in kubiena tins from profile E to document the microstratigraphy of each facies that was macroscopically identified (Fig. 4A & B). The samples were oven-dried, hardened and processed into petrographic thin sections (25–30 μm) in the micromorphology facility of the University of Lleida. The slides were observed with a petrographic microscope at magnifications between 10 and 400× using Plane Polarised light (PPL), Crossed Polarised Light (XPL) and Oblique Incident Light (OIL) applying international standard terminology (Bullock et al., 1985; Courty et al., 1989; Stoops, 2003). Facies and microfacies criteria commonly used in geology and

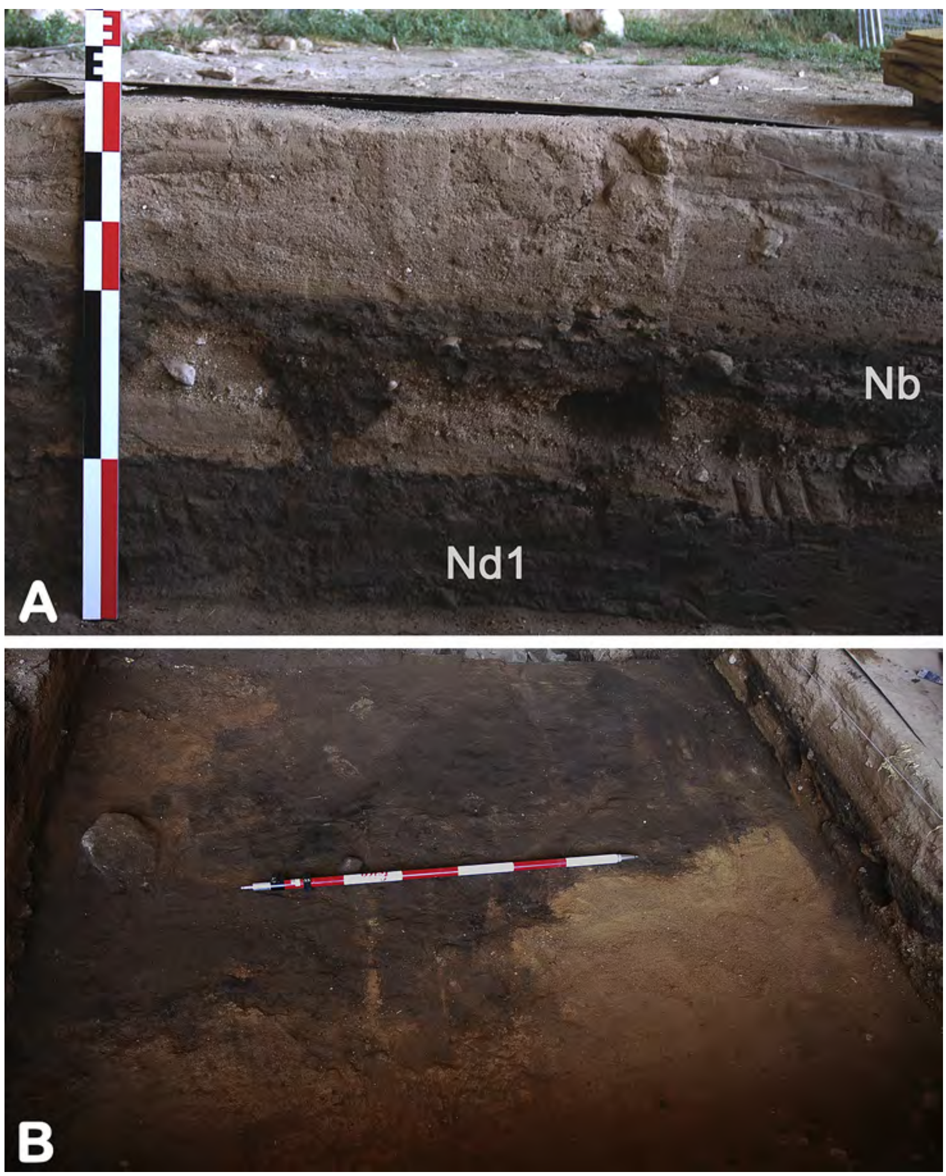

Fig. 3. General view of sector P. A) Pens Nb and Nd1 interstratified with karstic reactivation (Nc1/Nc2) (see Fig. 4). B) Excavation of the roof of the Nd1 pen in which *in situ* combustion residues and sands corresponding to runoff cycles Nc1/Nc2 were detected. The lateral continuity of pen Nb is visible along profiles N and S of the excavation surface.

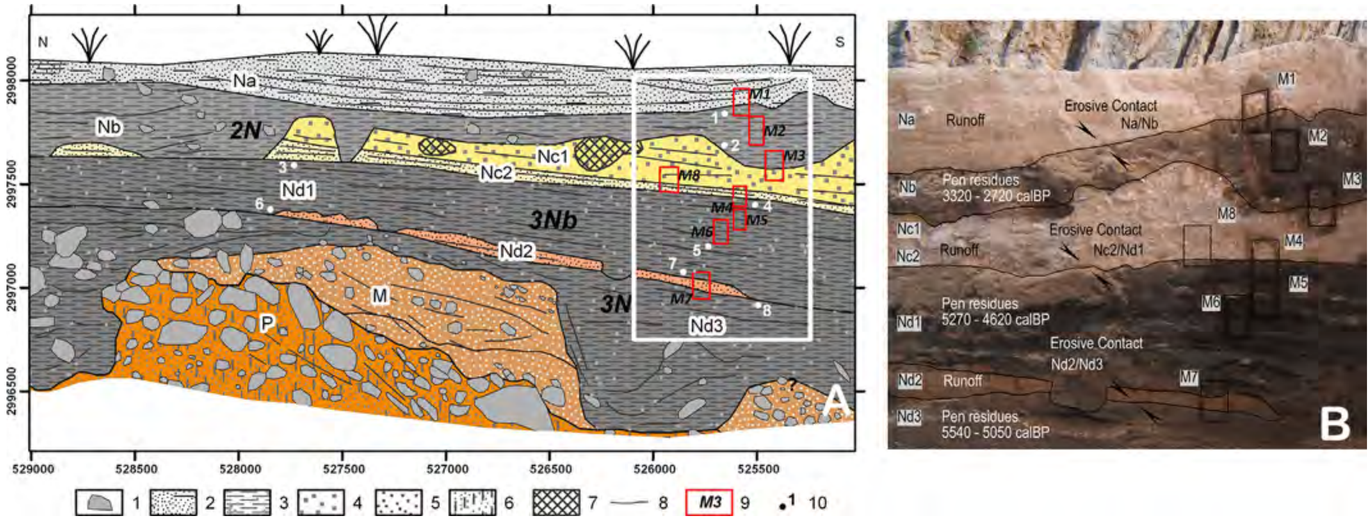

Fig. 4. General view of profile E. A) Stratigraphic section of profile E (N–S). Legend: 1, limestone blocks and larger clasts; 2, fine and medium sands; 3, pen residues with detritic sediments; 4, coarse sands and fine pebbles; 6, massive and medium bedded sands; 7, rabbit holes; 8, bedding; 9, micromorphological samples; 10, radiocarbon samples. B) Detail of the area studied for this work in profile E.

archaeology were applied for stratigraphical identification (Courty et al., 1989).

To obtain a chronometric record for the sequence, points that were linked to stratigraphic markers that corresponded to the roof and base of the pens were selected, particularly the runoff levels that separated the stabling phases. When possible, samples for micromorphology were collected adjacent to the undisturbed sediment blocks to temporally correlate the microfacies identified. The aim was to ascertain the average time for sedimentation rates and identify possible temporal discontinuities in the sequence. Eight samples were dated with ^{14}C AMS following the protocols established by Beta Analytics. The samples, which were collected in 10-ml test tubes, contained sediments rich in organic material and were subjected to an acid-washing pretreatment (A-wash). If the sample contained isolated charcoals that were suitable for dating, they were treated with acid/alkali/acid (AAA) (http://www.radiocarbon.com/pretreatment-carbon-dating.htm#Acid (accessed 20.10.12)).

4. Stratigraphy of profile E

Unit N is composed of a succession of dark, fine deposits interspersed with water current events represented by sands and pebbles that occasionally included sediment aggregates from the erosion of the pens (Fig. 4A & B). The maximum thickness of the unit is found in sector P, where the base of the unit is formed by a thinly bedded accumulation of pen residues (Nd3) with local blocks and subangular clasts associated with archaeological structures (hearths and pits).

Unit N increases in thickness towards the West of the site, filling the vertical depressions that had eroded the basal units M and P. The upper contact of the unit is abrupt and flat, giving rise to a thin layer of sands (Nd2), usually laminated, where medium-sized sands predominate. This sandy layer is discontinuous and eroded in some places by the upper pen accumulation (Nd1). Nd1, which is similar to Nd3, consists of loamy sediments that increase in thickness towards the Southwest. Overlying these sediments and separated by an abrupt, flat contact, two water current events with cross-stratification and laminations are documented (Nc1 and Nc2). Nc1 consists of fine and medium sands, while Nc2 comprises coarse sands and very fine and fine limestone pebbles. Several rabbit holes were also documented in this layer. Resting on these detritic layers, a third stabling facies accumulated (Nb). There is a slight increase in detritic material in this third pen accumulation, which is 65% sand. The top of the sequence is composed of a sandy layer of massive, channel and laminated facies with local carbonate concretions that were most likely related to detritus falling from the cavity roof.

Layer geometry displays an overlapping relationship in which younger beds successively overlap older beds from South to North. In addition, the sedimentation of the water current layers suggest a North to South flow related to springs that formed in the rockshelter interior during wetter periods. In general, the mineralogical composition of the different layers is similar: calcite and quartz are the main minerals, followed by phylosilicates to a lesser degree, with traces of dolomite, feldspar, plagioclase, gypsum and Fe oxides. The pen accumulations have a mean organic content between 1.6 and 2.5%.

5. Micromorphological analysis

Thirty-six individual microstratigraphic units were identified in the eight thin sections analysed. These microfacies documented pen accumulations in levels Nb (M1, M2, M3) and Nd1 (M4, M5, M6, M7), runoff episodes in levels Nc1 (M3 and M8), Nc2 (M8) and Nd2 (M7) and the sharp boundaries between the pen and runoff facies (Table 1, Fig. 4).

Five stabling microfacies types were defined based on similarities in groundmass, microstructure, organic and inorganic composition and pedofeatures (Fig. 5) (Polo Díaz, 2010). The analysis of these microfacies yields evidence for sheep/goat penning, mainly in the form of completely or partially combusted residues. Post-depositional physico-mechanical alterations are present in the form of bio-reworking, compaction, erosive contacts and runoff features. Diagenesis did not significantly affect the sediment. The main micromorphological features of each microfacies type are detailed in Table 2. To facilitate discussion, the results of the microfacies study are presented in the following subsections.

5.1. Mineralised pen residues

These are greyish coloured, silty and mainly mineralised accumulations resulting from the intense thermal alteration of the groundmass at high temperatures (M5 microfacies 10.1). Fragments

Table 1
Microstratigraphic, stratigraphic and cultural correlations of sector P, profile E.

Thin section	Microfacies (from top to bottom of the sample)	Microfacies type	Sedimentary facies type	Stratigraphic levels	Cronometric span	Archeological phase
M1	M1 microfacies 1	Runoff	Runoff	Na		
	M1 microfacies 2	Mineralizated Pen Residues (Ash) + Runoff	Contact runoff/pen	Contact Na/Nb		
	M1 microfacies 3	Mineralizated Pen Residues (Ash)	Pen	Nb	3320–2720 calBP	Early Bronze/Bell Beaker
M2	M2 microfacies 3	Mineralizated Pen Residues (Ash)				
	M2 microfacies 4	Mineralizated Pen Residues (Ash) + Runoff	Diffuse boundary pen/ runoff			
M3	M3 microfacies 4	Mineralizated Pen Residues (Ash) + Runoff	Contact pen/runoff	Nb/Nc1		
M4	M4 microfacies 5.1	Runoff	Runoff	Nc1		
M8	M8 microfacies 5.1	Runoff	Runoff	Nc1		
M4	M4 microfacies 5	Runoff	Runoff	Nc2		
M8	M8 microfacies 5	Runoff	Runoff	Nc2		
M4	M4 microfacies 6	Charred Pen Residues	Contact runoff/pen	Nc2/Nd1		
M8	M8 microfacies 6	Charred Pen Residues	Contact runoff/pen	Nc2/Nd1		
M4	M4 microfacies 7	Rubified Pen Residues	Pen	Nd1	5050–4620 calBP	Late Neolithic
	M4 microfacies 8	Mineralizated Pen Residues (Ash)				
	M4 microfacies 9	Mineralizated Pen Residues (Ash) + bio-reworking + detrital material				
M5	M5 microfacies 9	Mineralizated Pen Residues (Ash) + bio-reworking				
	M5 microfacies 10.2	Mineralizated Pen Residues (Ash) + compaction				
	M5 microfacies 10.1	Mineralizated Pen Residues (Ash) + wood ash				
	M5 microfacies 10	Mineralizated Pen Residues (Ash)				
	M5 microfacies 11	Charred Pen Residues				
	M5 microfacies 12	Rubified Pen Residues				
	M5 microfacies 13.1	Mineralizated Pen Residues (Ash) + bio-reworking + detrital material				
M6	M6 microfacies 13	Herb. Excrem. Ash				
	M6 microfacies 14	Charred Pen Residues				
	M6 microfacies 15	Rubified Pen Residues				
	M6 microfacies 16.1	Mineralizated Pen Residues (Ash) + compaction				
	M6 microfacies 16	Mineralizated Pen Residues (Ash)				
	M6 microfacies 17	Charred/Rubified Pen Residues				
	M6 microfacies 18	Mineralizated Pen Residues (Ash)				
	M6 microfacies 19	Charred/Rubified Pen Residues				
	M6 microfacies 20	Mineralizated Pen Residues (Ash)				
	M6 microfacies 21	Charred/Rubified Pen Residues				
M7	M7 microfacies 22	Mineralizated Pen Residues (Ash)				
	M7 microfacies 23	Charred/Rubified Pen Residues				
	M7 microfacies 24	Runoff	Runoff	Nd2		
	M7 microfacies 24.1	Charred/Rubified Pen Residues + Runoff	Contact runoff/pen	Contact Nd2/Nd3		

of herbivore excrement, phosphate-rich plant aggregates with a concentration of calcium spherulites, are common and mostly strongly mineralised, suggesting combustion temperatures above 600 °C (Bergadà, 1998). Charred fragments also form part of some of these microfacies along with other excremental material made exclusively of an amorphous phosphatic compound. The fragment sizes of the remains range between 150 and 8000 μm. The internal structure of many of the excremental fragments shows a convoluted pattern suggesting ovi-caprine origin (Courty et al., 1991; Polo Díaz, 2010) (Fig. 6a).

Calcium spherulites, biomineralised calcium carbonate associated with herbivore excrement (Canti, 2003a), are abundant in these microfacies. In general, spherulites are embedded in fragments of excrement, although they can also be found dispersed in

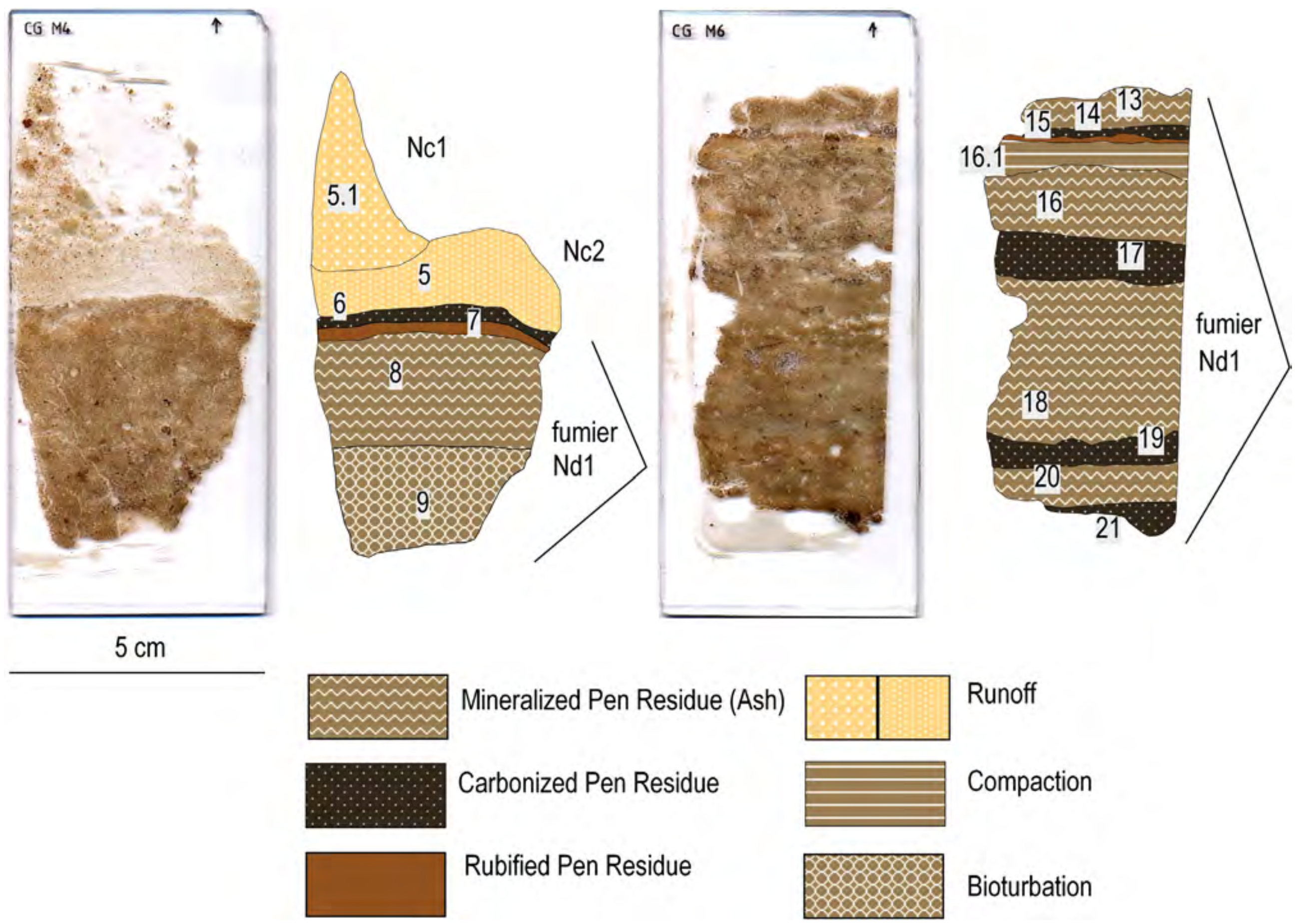

Fig. 5. Microfacies of samples M4 and M6 from Nd1 pen facies. In these samples, 4 microfacies type were identified: mineralised pen residue, carbonised and rubified pen residue and runoff accumulation. Note intense compaction from animal trampling at the top of the ashy accumulation in sample M6. Sample M4 displays the following microstratigraphical sequence from bottom to top: Microfacies 9, ashy residue showing post-depositional bioturbation and detrital accumulation; Microfacies 8, well preserved mineralised pen residue; Microfacies 7–6, partially burnt residues from a later combustion episode; Microfacies 5–5.1, runoff sediments on top of the sequence. The microstratigraphic sequence observed in this sample illustrates erosion of the Nd1 pen accumulation by water circulation. Note how ashes from the top part of the combustion structure have been removed leaving only the charred residues of the combustion structure. Sharp/erosive contact between the pen and the overlying runoff microfacies is clearly visible.

the groundmass (Fig. 6b, c). Whole and fragmented ovicaprid coprolites along with milk molar teeth from young sheep and goats, considered to be relevant evidence for the contextualisation of pen deposits (Helmer, 1984; Brochier et al., 1992), were recovered during the excavation process at Cova Gran.

The remains of domestic fauna are commonly found in pen deposits. However, unlike high amounts of coprolites, this evidence does not constitute direct proof of live animals at the site and hence cannot necessarily be considered to be directly related to the stabling of animals (Boschian and Montagnari-Kokelj, 2000). Domestic fauna recorded at Cova Gran is scarce, and the isolated bone fragments of ovicaprids, *Bos taurus* and *Sus* sp., registered at the site could be related to supplies brought to the site for human consumption. Mineral remains of vegetal origin are common, especially calcitic pseudomorphs from druse, which is abundant in leaf remains (Brochier, 1996), and other siliceous residues of varied morphologies. Elongated siliceous phytoliths, often associated with grasses (Piperno, 1988), are rare and appear dispersed in the matrix or embedded in excremental aggregates (Fig. 6d). The presence of woody plant remains, in the form of prismatic calcitic pseudomorphs and cellular relicts (Brochier, 1983b; Wattez, 1992; Canti, 2003a,b), are only significant in one of the samples (M5 microfacies 10.1).

Depending on the degree of alteration, ashy accumulations can be grouped into well preserved ashes of enclosure remains and ashes that have been affected by the mechanical processes of runoff, compaction or bioturbation.

The well preserved enclosure ashes exhibit the homogeneous combustion of all components of the matrix with little input of bedrock fragments and coarse organic material. These characteristics, along with their stratigraphic position in the sequence of enclosing combustion cycles over partially burned remains, indicate accumulations in the primary position (Polo Díaz, 2010) (M5 microfacies 10, 10.1, 10.2 and 13.1, M6 microfacies 13, 16, 16.1, 18 and 20, M7 microfacies 22). From a taphonomic perspective and degree of preservation, these microfacies can be considered as cultural microfacies *sensu stricto* (Wattez, 1992).

Ashes affected by post-depositional runoff processes show abundant bedrock fragments and soil fauna activity. Their appearance is relatively heterogeneous and variable and can be located either below runoff microfacies (M7 microfacies 24, 24.1) or above the microfacies of well preserved ashes (M1 microfacies 2, M7 microfacies 22).

These accumulations, which are the result of reworked combustion remains, comprise a variable mixture of unsorted subangular and well rounded bedrock fragments that have been unequally combusted and affected by water circulation, along with intense bioturbation.

Bioturbation is often associated with runoff microfacies (M3 microfacies 4) (Fig. 6e), although it has also been noted in reworked

Table 2
Micromorphological descriptions of the microfacies types of pen deposits at Cova Gran.

Microfacies type	Colour thickness	Groundmass microstructure porosity	Mineral coarse – fine	Organic coarse – fine	Pedofeatures	Complex features
Mineralised Pen Residues (Ash)	7.5 YR 5/1–7.5 YR 4/1 Grey 1–6 cm	c/f 63 μm; ratio: 2/98–30/90 Relative distribution: Porphyric Calcitic–Crystallitic b-fabric Spongy/Platy Microstructure 10–35% Voids	Limestone fragments •/••/••• Calcitic biospheroids •/•• Si vesicular residue •/•• Si articulated phytoliths aggregates • Quartz •/•• Plagioclase, Pyroxene • Calcitic crust • Prismatic pseudomorphs T Excremental spherulites ••• Calcitic pseudomorphs (from druses) •/••• Droplets •	Charcoal •/•• Charred excrement fragments • Charred bone • Charred plant fragments • Amorphous yellow T/••• Amorphous black T	Calcitic hypocoatings T/••• Mn nodules • P–Ca hypocoatings T	Herbivore excrements •/•••• Mineralised/ charred/ amorphous phosphatised Convolute pattern/ non distinctive 150–8000 μm
Charred-Rubified Pen Residues	7.5 YR 2.5/1 Black 7.5 YR 4/3 Reddish Brown 0.3–1 cm 0.5 cm	c/f 63 μm; ratio: 2/98–25/75 25/75–50/50 Relative distribution: Porphyric Calcitic–Crystallitic b-fabric Spongy/Platy Microstructure 40–50% Voids	Limestone fragments T/• Calcitic crust T/• Quartz •/••• Excremental spherulites•••/•••• Calcium oxalates (druses) ••• Calcitic pseudomorphs •/••	Long articulated plant aggregates •• Charcoal, Parenchyma•• Bone T Amorphous yellow • Amorphous black •	Granular bioaggregates •• P hypocoatings •• P–Ca hypocoatings • Fe–Mn staining ••/•••• Fe–Mn hypocoatings • P–Ca–Fe hypocoatings •	Herbivore excrements •• Charred/rubified
Mineralised Pen Residues (Ash) + Runoff	7.5 YR 4/1–7.5 YR 4/2–7.5 YR 5/4 Dark Grey, Brown 3–18 cm	c/f 63 μm; ratio: 40/60–70/50 Relative distribution: Porphyric Calcitic–Crystallitic b-fabric Spongy/Crumb/Granular Microstructure 40–50% Voids	Si articulated phytoliths aggregates • Si vesicular residue T Quartz •• Plagioclase, Pyroxene • Ophite • Limestone fragments •/••• Sediment aggregates • Calcitic crust fragments •• Calcitic biospheroids •/•• Excremental spherulites T/•• Calcitic pseudomorphs (from druses) T/•• Droplets T/•	Charred excrement fragments • Charred bone • Charred plant fragments • Amorphous yellow • Amorphous black •	Ca hypocoatings •/•• Ca–P hypocoatings • Ca–P–Fe hypocoatings • Mn nodules • Fe dots and stainings •	Herbivore excrements •/•• Mineralised
Runoff	7.5 YR 4/6–7.5 YR 5/4–7.5 YR 5/6 Brown 5–32 cm	c/f 63 μm; ratio: 2/98–0/100 Relative distribution: Coarse Monic Calcitic–Crystallitic b-fabric Monic Microstructure 30–40% Voids	Quartz ••/••• Plagioclase, Pyroxene • Ophite • Limestone fragments ••/••• Sediment aggregates •• Calcitic crust ••/••• Calcitic biospheroids •/•• Calcium oxalates (druses) T/• Excremental spherulites T/• Calcitic pseudomorphs (from druses) T/•	Charcoal, Parenchyma • Charred bone • Amorphous yellow T Amorphous black T	Ca hypocoatings •/•• Ca–P hypocoatings • Ca–P–Fe hypocoatings • Mn nodules • Fe dots and stainings •	Residual excremental features •

Frequency related to a proportional area of the thin section (Bullock et al., 1985): T, Trace; • Very Few/VF (>5%); •• Few/F (5–15%); ••• Frequent/F (15–30%); •••• Common/C (30–50%); ••••• Dominant/D (50–70%); //Frequency class for textural pedofeatures (Bullock et al., 1985): • Rare (<2%); •• Occasional (2–5%); ••• Frequent (5–10%) ; •••• Common (10–20%); •••• Many (>20%).

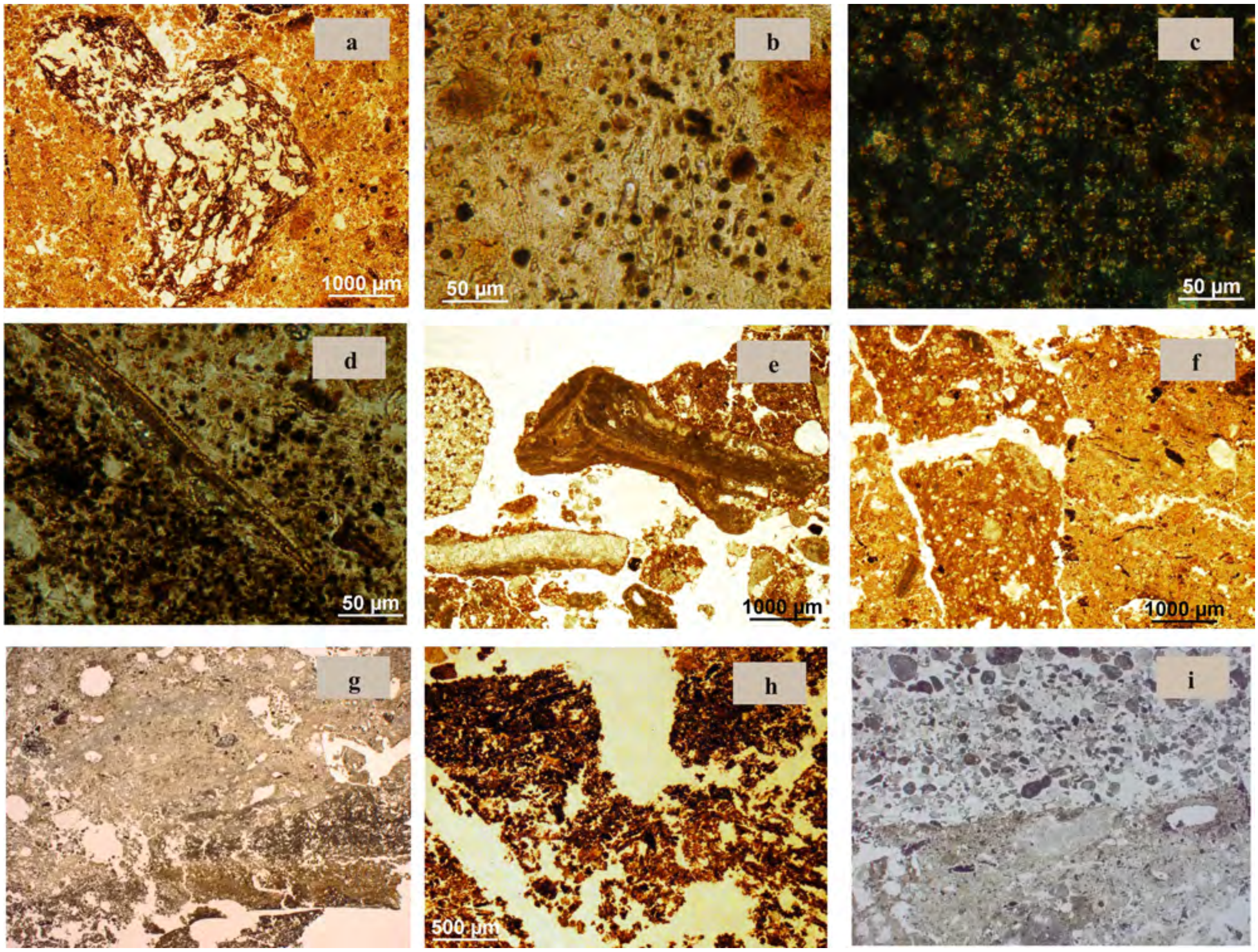

Fig. 6. Microfeatures of pen accumulations at Cova Gran: a) M6 microfacies 17, charred ovi-caprine excrement fragment. Note characteristic convoluted pattern and spongy microstructure of the feature. PPL. b) M2 microfacies 3, detail of highly mineralised herbivore excrement fragment in ashy microfacies. Note darkened calcium spherulites from combustion. PPL. c) Same photomicrograph under XPL. d) M5 microfacies 10, detail of mineralised excrement fragment in ashy matrix containing long silica phytoliths. PPL. e) M3 microfacies 4, runoff microfacies. Bio-reworked aggregates and calcitic features from dissolution and reprecipitation of carbonated solutions. PPL. f) M2 microfacies 3, detail of compaction feature. Note fissured matrix and subhorizontal porosity from animal trampling. PPL. g) M6 microfacies 13–15, combustion structure in primary position consisting of mineralised and charred residues (top and bottom part of the image, respectively). PPL. h) M5 microfacies 11, carbonised and rubified accumulation. PPL. i) M4 microfacies 5–6, erosive contact between pen and runoff microfacies (bottom and top part of the image, respectively). PPL.

ashy accumulations and in the upper part of relatively undisturbed ash microfacies (M4, M5 microfacies 9, M5 microfacies 13.1).

Earthworm activity, granular aggregations, significant matrix porosity and the presence of calcite spheroids (Bergadà, 1993; Canti, 2003b; Canti and Piearce, 2003) indicate exposure of the sediments to stable surface environmental conditions.

The presence of bioturbation features in runoff microfacies suggest discontinuity in the accumulation of detrital material from karstic phenomena. In addition, pen residues that were reworked by soil fauna, which were observed in some microfacies before they were affected by water circulation, are evidence of a temporary disruption in stabling activities, at least in the area of the rockshelter where they are found.

The alternation of pen-related accumulative episodes and karst-related water current events with evidence of bioturbation suggest that the depositional/taphonomic dynamics involved in the formation processes of the sedimentary sequence in Cova Gran had a temporal/seasonal character and affected both the anthropogenic episodes and the environmental events occurring at the site.

The compaction of pen floors is due to trampling by animals in the enclosure (Courty et al., 1991). In Cova Gran, compaction tends to affect all ash microfacies, albeit more pronounced in some than others (M5 microfacies 10.2, M6 microfacies 16.1) (Fig. 6f). The identification of intense compaction features in the upper part of the ash accumulations suggests trampling by pen animals during a later stabling episode at the site. Intense alteration of pottery remains, which were recorded as small, broken fragments with slightly rounded edges, microchipping and flaking along the edges, supports this hypothesis (Nielsen, 1991).

The intensity with which some ash accumulations have been affected by runoff, bioturbation and compaction processes sanctions their taphonomic classification as *residual* or *relict* cultural microfacies (Wattez, 1992).

5.2. Carbonised and rubified pen residues

These correspond to charred residues located below ash accumulations (Fig. 6g) and are composed of excrement and plant remains that are partially burned, carbonised and/or rubified, exhibiting a blackish or reddish brown colour (Fig. 6h). They are silty in texture with a spongy microstructure due to the concentration of excrement within them. As seen in the samples analysed, the compacted nature of these microfacies makes it difficult to identify individual fragments of excrement, which prevents identification of the particular herbivore species indicated by them. Chambers and channels, which are common, are the product of biological activity due to the exposure of residues to surface environmental conditions after accumulation. The characteristics of biological activity, including calcitic spheroids, show a degree of combustion similar to the groundmass and are in the primary position, which indicates that combustion occurred after the sediment was exposed. These microfacies have been noted in 5 samples (M4 microfacies 6–7, M5 microfacies 11–12, M6 microfacies 14–15–17–19, 21, M7 microfacies 23).

5.3. *Runoff microfacies*

The sediment includes sands (≤1500 μm approx.) and gravels (≤2 cm approx.) and is dominated by the coarse mineral fraction composed of rounded sediment aggregates, quartz grains, plagioclase and ofite and calcitic crust fragments (Fig. 6i). Calcium oxalates (druses), calcitic pseudomorphs, calcium spherulites, and silica phytoliths originating from eroded adjacent microfacies including ash residues are dispersed in the rare fine fraction. The organic contribution is very sparse and contains fragments of charcoal, parenchymal tissue and bone. Bones are often intensively bleached, have a characteristic whitish colour, and are extremely porous as a result of the mechanical erosion of bone tissue by water (Hedges and Millard, 1995). Contact between successive layers of the runoff facies (Nc1-Nc2) is clear-cut (M4 microfacies 5.1., 5, M8 microfacies 5.1., 5) with a subhorizontal grain orientation (usually poorly sorted and subangular-subrounded in shape) that suggests the relatively rapid settling of local sediments. Sharp boundaries between the runoff and stabling facies, along with sand accumulations that are in contact with combustion structures that are missing their top ash microfacies, indicate erosive discontinuities (M1 microfacies 1–2, M4 microfacies 5–6, M7 microfacies 24–24.1.) (Fig. 6g).

6. Chronometry and archaeological context profile E

Eight ^{14}C BP dates were calibrated at 2σ with the IntCal 09 curve, and the results and graphic representation were obtained using the Oxcal v.4.1 programme (Bronk Ramsey, 2009) (Table 3, Fig. 7). These calibrated intervals are variable depending upon the statistical error (σ) of the datings obtained from the laboratory, expressed in BP years. The samples from the top part of the sequence (samples #1–5) display calibrated datings younger than 250 yr, while the samples from the bottom part of the sequence (#6–8) are approximately 400 yr. The variability observed in samples #6–8 creates certain ambiguity over the chronometry of the bottom part of the sequence, which could be related to fluctuations during the interval 4600–4400 BP detected in the calibration curve (Reimer et al., 2004: Fig. A11).

Despite this constraint and the limited number of dates in this series, we suggest that the radiometric resolution and the correlation between the stratigraphic position of the samples and the temporal range provide a consistent chronometric context for the discussion of site formation processes that affect the archaeological layers and stratigraphy of profile E.

A cultural adscription of the pen accumulations in Cova Gran is challenging due to the scarcity of the artefact assemblage. However, excavation revealed three archaeological units corresponding to different chrono-cultural phases.

The dates obtained for the 2 stabling facies Nb and Nd1 reveal a significant time interval. Level Nb accumulated over a period of at least 400 calendar years (3320–2720 calBP) and was subsequently eroded by an event of water current sands (Na) that removed the uppermost part of the accumulation. The Nb layer, archaeologically designated level 2N, is generally very poor in artefacts, although some pottery shards with decorative motifs indicating the Bell Beaker and Early Bronze Periods were recovered (Fig. 8). Several fragments of special vessels pierced with small holes, usually considered to be cheese-strainers (Bogucki, 1984), are also part of the material record. The time span across which level 2N lies (3300–2700 calBP) can be correlated to the pottery types documented, which have also been recorded at other sites in this zone (Oms et al., 2008). This phase corresponds to the repeated use of this sector as a pen area.

Radiocarbon results show a temporal gap between Nb and Nd1 of at least 700 years (4620–3960 calBP), which corresponds to a cycle of water current sands recorded discontinuously along the profile (Nc1 and Nc2). This process indicates an intense circulation of water that eroded the roof of Nd1. The dates obtained from the roof and base of Nd1 indicate that the preserved section fluctuated across approximately 600 calendar years (5270–4620 calBP). Dates from the roof of Nd3 narrow the temporal range so that it is possible to propose that the preserved pen represents 350 years (between 5050 and 4700 calBP). This interval should be considered as a minimum age because the uppermost part of Nd1 was disturbed by the Nc1/Nc2 erosive phase.

Nd1, or archaeological level 3Nb, falls between 5050 and 4600 calBP and indicates the repeated use of this area of the rockshelter as a pen (Table 1). This layer contains a limited number of artefacts, among which a few pottery fragments are attributable to the Late Neolithic period.

Below this sequence, another sedimentary cycle of stabling deposits developed (Nd3) beginning at approximately 5050 calBP. The geometry of this sedimentary level is complex and requires future study because no precise geological and micromorphological data are available at present. Equally important is to provide further radiometric data to define the broad span that layer Nd3 seems to present. The archaeological level 3N formed within the sedimentary cycle Nd3 below the Nd2 erosive phase. Although analysis of this phase is beyond the scope of the present work, it is worth

Table 3
Radiocarbon series of profile E.

#	# Lab	Sample	^{14}C	δ	^{13}C‰	Laboratory treatment	CalBP p (95%)	Stratigraphic context	Archaeological level	Thin section box sample
1	Beta 305459	Charcoal	2980	30	−23.5	AAA	3320–3066	Roof Nb, below Na	2N	Roof M1
2	Beta 305460	Organic sediment	3550	30	−25.9	A wash	3959–3721	Base Nb, above Nc1		
3	Beta-262454	Organic sediment	4220	40	−25.4	A wash	4858–4623	Roof Nd1, below Nc2	3Nb	
4	Beta 305461	Organic sediment	4290	40	−26.1	A wash	4972–4728	Nd1		Base M4
5	Beta-260860	Organic sediment	4250	40	NA	A wash	4875–4628	Nd1		Base M6
6	Beta 305462	Organic sediment	4450	40	−26.1	A wash	5288–4881	Base Nd1, above Nd2		
7	Beta 305463	Organic sediment	4420	30	−26.1	A wash	5270–4870	Base Nd1, above Nd2		Roof M7
8	Beta 305464	Charcoal	4560	40	−26.2	AAA	5440–5051	Roof Nd3, below Nd2	3N	

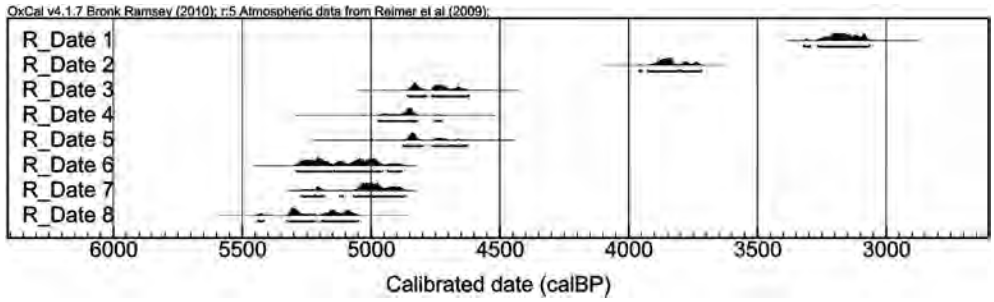

Fig. 7. Chronometric intervals of the ^{14}C series of the sector P profile. The stratigraphic position of dates refer to Fig. 4.

noting that this part of the sequence displays strong fluctuations in thickness (between 10 and 80 cm), with some dips corresponding to pits filled with pen sediments (Fig. 4). Excavation revealed 9 hearths, 14 pits and 8 post holes. The material culture associated with these structures is neither indicative of a single occupation nor a single chrono-cultural period but places them at least in the Late Neolithic period based on pottery that is attributable to the *Véraza* style, a tradition present on both sides of the Eastern Pyrenees (Guilaine, 1980). Nevertheless, a fragment of *Cardial* pottery corresponding to the late Early Neolithic was found in one of the pits (Fig. 8). Radiocarbon data confirms that this palimpsest was made between 7000 and 5050 calBP (Mora et al., 2011).

7. Dynamics and human behaviour in sector P pens

Micromorphological analysis enables characterisation of the cultural activities carried out at Cova Gran – enclosure of herbivores – together with appraisal of the effects of cyclical water circulation on the waste accumulation after deposition. Correlation of microstratigraphical and sedimentary data, radiometric series and archaeological markers allow definition of the chrono-cultural context of herding practices in Cova Gran (Table 1).

Formation processes of the sequence are determined by sedimentary dynamics alternating vertical accretion of burnt stabling residues and erosive runoff events associated with the reactivation of the karstic system at the site.

On a macroscopic level, the use of fire as an anthropic process is not as clear in this sequence as it is in other analogous deposits (Polo Díaz and Fernández Eraso, 2010); nevertheless, micromorphological analyses show it to be an active agent in the configuration of the deposit (Table 1).

The sedimentary pattern characterised by burnt excrement, charred at the bottom and mineralised (ash) on top, defines combustion episodes of waste material in pen deposits (Brochier, 1996; Polo Díaz, 2010). At Cova Gran, this pattern is preserved in its original stratigraphic position as suggested by the sharp boundaries and internal homogeneity displayed by each of the microfacies of the combustion structures recorded.

The alternation of successive *in situ* combustion structures and runoff events with a temporal/seasonal character, as suggested by micromorphological analysis, allows the definition of these accumulations of pen residues as polycyclic (Wattez, 1992).

Eleven combustion episodes were distinguished in the samples analysed. Four of them are either represented by the top part of the combustion structure, namely ashes (M1 microfacies 1, M2 microfacies 2, M2 and M3 microfacies 4.1–4), or by the lower part of the burning episode as charred excrement crust (M4 microfacies 6–7). The remaining combustion structures are complete, though they show differing degrees of preservation.

Sample M5 presents a particularly well preserved combustion structure. The charred excrement at the bottom is strongly compacted and is rich in bioturbation features and bedrock fragments, especially compared to the ashy accumulation at the top. The same microstratigraphic characteristics are evident in the overlying M5-M4 (microfacies 9) and underlying M6 (microfacies 15–14–13) and M5 (microfacies 13.1). This pattern suggests that, at some point, the bottom part of this combustion structure was the floor of the pen, compacted by the trampling of animals kept at the site and subsequently exposed to surface conditions before further waste material was added on top to set the entire accumulation on fire (Polo Díaz, 2010).

The repeated use of fire in prehistoric herding facilities has been linked to the reduction of the volume of residues (Brochier, 2005) and cleaning practices (Macphail, 1997). Ethnographically, burning stable residues is directed at eliminating parasites and avoiding the spread of disease between animals because burning takes place between stabling episodes, immediately before the animals are moved back into the cave or rockshelter (Brochier et al., 1992). This practice has been identified at Neolithic sites using microstratigraphic analysis (Polo Díaz, 2010).

In addition to microstratigraphic indicators, other evidence, although limited, has been recovered from pens Nb and Nd1 in Coval Gran: coprolites, shed milk teeth and artefacts normally associated with pens (Brochier et al., 1992). Confirmation that this site functioned as a livestock pen area in the past allows certain inferences to be made.

Chronometrically, it can be established that the sector analysed in this article was formed over approximately 2000 years, although the vertical accumulation of the deposit has been affected by erosive processes. The series of dates between the first and second pen episodes (Nb and Nd1) indicates a gap of at least 700 years, suggesting that a significant time interval of this sequence was not preserved in the excavated area. Micromorphological evidence of pen-related combustion structures strongly affected by water circulation along with the sharp microstratigraphical contacts between the pen and runoff microfacies support this hypothesis.

Such a diachronic gap is not inconsistent with pottery stylistic attributes: Bell Beaker and Early Bronze Age pottery was recovered in Nb (archaeological level 2N), whereas level 3N (Nd3) is Late Neolithic. A gap of approximately 1000 years, indicated by the water erosion of levels Nc1/Nc2, corresponds to the development of the Late Neolithic Period. It should not be forgotten that these occupations are preserved in other areas of the site; thus, pen deposits with a temporal range similar to that in Nd1 have been identified in the roof of sector T, more than 20 m away (see Fig. 2C) (Mora et al., 2011). This suggests that repeated stabling episodes occurred in different parts of Cova Gran (a shelter of more than 2500 m^2). It should also be noted that pens preserved in profile E of sector P are greater than 35 m^2 with a thickness of 2 m (if Nd3 is included) and that these sediments show continuity in adjacent areas, potentially extending over large areas of the shelter (Figs. 3 and 4).

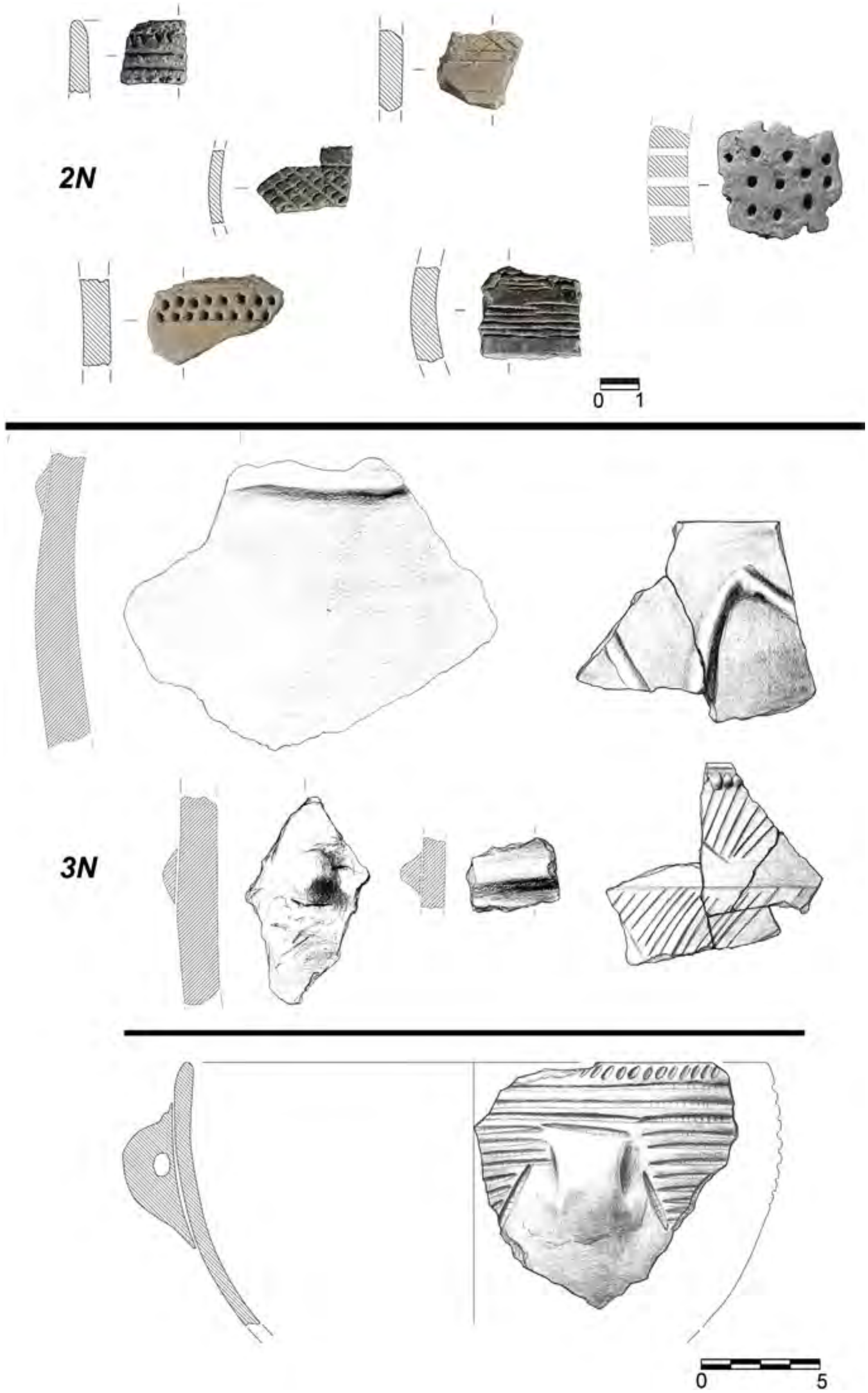

Fig. 8. Pottery shards from archaeological layers 2N and 3N. Top: pottery shards with Bell Beaker decorations and a fragment of a cheese-strainer (Late Chalcolithic-Early Bronze). Centre: Middle-Late Neolithic pottery. Bottom: Fragment with *Cardial* motifs (Early Neolithic).

The implications of this volume of residues in terms of herd size and rhythm are difficult to assess. Some of the factors that need to be considered are herd size, regularity and duration of stabling episodes (Angelucci et al., 2009), significant reduction in the volume of burned material during combustion, and cyclical removal of residues from the central pen area (Boschian and Montagnari-Kokelj, 2000).

It is assumed that pastoral systems tend to be the result of various and opportunistic circumstances (Brochier et al., 1992). Such an assumption implies that these deposits represent the accumulation of a number of indeterminate events occurring over long periods of time. Depending on specific needs and situations, which are difficult to determine archaeologically, it is possible that there were periods when the shelter was not used between abandonment and later reuse.

The phases of combustion may be one approach to assessing the rhythm of occupation. Indeed, if the 11 burning episodes determined through micromorphological analyses are compared to the chronological span represented by these deposits, it seems that the burning of residues is a recurrent activity but was carried out at the site on a sporadic basis. This implies that either the use of the rockshelter as herding facility was discontinuous or that the combustion of waste occurred only when it was considered necessary for cleaning purposes. In the latter case, it can be inferred that each identified combustion structure most likely brings together residues from several stabling episodes.

The presence of wall enclosures such as those identified in the Neolithic levels of Uzzo and Fontbregoua (Brochier et al., 1992) or the preparation of floors as described in Neolithic sites in the Peloponnese (Karkanas, 2006) can indicate intense use of these places. At present, such occupation arrangements have not been observed at Cova Gran. However, the fact that the excavated area corresponds to the interior of a pen cannot be dismissed and opens the possibility for the documentation of perishable materials in the form of stake fences and postholes in adjacent areas of the rockshelter (Fernández Eraso, 2002, 2008). Although stone enclosures or posts indicate the presence of specialised spaces, effective enclosures can be constructed with organic materials that leave no physical traces and are difficult to identify (Brochier, 2005).

The evidence of water circulation in the rockshelter is an important environmental factor affecting the stratigraphic sequence at Cova Gran from a taphonomic point of view. Such erosive processes indicate a fairly constant circulation of water that cause a sedimentary gap of approximately 800 years between NB and Nd1. It has been proposed that intense water circulation can be related to the abandonment of prehistoric enclosures (Perrin et al., 2002). On the contrary, at Cova Gran, the availability of fresh water within the rockshelter could have encouraged the occupation of the site given the extension of the deposit and the possibility of relocation for humans and animals to the site when needed.

8. Pens and prehistoric pastoralists in the southeastern Prepyrenees

The evidence that this site was repeatedly occupied allows an analysis of the possible role played by Cova Gran in the development of Prehistoric pastoralist circuits. Although analyses of Prehistoric transhumant networks on the slopes of the North Pyrenees are available (Geddes, 1983; Brochier, 2005), this process is not well known for the Southern Pyrenean slopes. The identification of pen deposits in Cova Gran and other nearby caves, such as Cova del Parco and Cova Colomera (Bergadà, 1998; Oms et al., 2008; Angelucci et al., 2009), (see Fig. 1), allows the investigation of the origins of herding routes in northeastern Iberia.

As indicated above, Cova Gran is a large rockshelter that is geographically located at the bottom of a lateral valley with ready access to the Sant Miquel stream, which was connected to the main hydrographic system during the Holocene. Such a location constitutes an important link in connecting the Pyrenees and the Ebro Basin. However, the settling of nearby Prehistoric caves where pen deposits have also been identified, such as Cova del Parco and Cova Colomera, seems to differ from that observed at Cova Gran in terms of strategic location (Fig. 9).

Parco is a rockshelter associated with a small cavity located in the interior of a gorge 120 m above the Segre river, in an elevated position but not difficult to access (Fig. 9B). With a surface area of 150 m^2, the rockshelter is encircled by a rock wall dating to the historic period and shows sequential Pleniglacial, Late Glacial and Holocene occupations. There is a long diachronic sequence of occupation that includes the late Early Neolithic, Late Neolithic, Bell Beaker and Early Bronze periods although these contexts are not

Fig. 9. Topographic positions of Cova Gran (A), Cova del Parco (B), and Cova Colomera (C).

well studied (Petit, 1996). Micromorphological analyses of sediments from a pit revealed the presence of burned ovicaprid excrement, which was interpreted as an indication that the rockshelter functioned as an animal pen in the later Early Neolithic period (Bergadà, 1998).

Colomera is a large cavity located on the scenic Montrebei cliff, 160 m above the bed of the Noguera-Ribargorçana river, a topographic position indicating difficult access to the cave (Fig. 9C). Pottery suggests the reuse of the cavity during the later Early Neolithic, Late Neolithic, Bell Beaker and Early Bronze Age. Macroscopic observations of the excavated surface (13 m^2) indicate multiple stratified stabling facies (one some 30 cm thick) in which *in situ* combustion activities were identified. In a late Early Neolithic level in the cave interior, a number of excavated post holes defined a possible enclosure of 30 m^2 (Oms et al., 2008).

Between them, these three nearby sites cover a substantial period of time, spanning the Early and Late Neolithic, Bell Beaker and Early Bronze Age. Some questions that should be considered are whether herding activities were seasonally concentrated at these sites and whether they served as specialised *satellites* attached to a nearby village. It has been suggested that these sheepfold caves served as settlements for shepherds and their flocks. However, although seasonal transhumance may have been important, it was most likely localised and part of a mixed agricultural economy rather than geared towards specialised production for exchange (Miracle and Forenbaher, 2005). Information from archaeological pottery and bones are key to assessing the potential relationships between pens and possible nearby agricultural sites (Helmer et al., 2005).

The topographic positions of sites such as Parco and Colomera suggest that they could have served different purposes than those proposed for Cova Gran (Fig. 8). While it cannot be dismissed that sites located in areas high above gorges with difficult access could have been used in regional circuits, it seems more likely that these types of sites were part of local scale activities linked to agrarian settlements. The use of Cova Gran in short distance movements cannot be ruled out; however, we propose that the site could have alternatively been used as an enclosure for large herds as part of a wider network involving regional pastoral movements.

In the organisation of transhumant circuits, herders or those who moved and/or stabled herds had to bear in mind factors such as the size and capacity of these caves and rockshelters, their topographic position and accessibility, abundance and ready access to essential resources such as water or fodder, or their regional affiliation. These factors must be integrated when analysing the potential existence of a network of communities related to long distance movements during the Neolithic Period between the Ebro Basin and the inner Pyrenees.

Of interest from this viewpoint are the pen deposits associated with hearths and storage pits at Balma Margineda, a rockshelter in the interior of the Axial Pyrenees at 990 m a.s.l. above the Valira river. This late Early Neolithic level was interpreted as a seasonal enclosure used by pastoralists (Guilaine and Martzluff, 1995).

The existence of sites such as Balma Margineda, which are associated with access to summer grazing pastures in a mountainous environment in the interior of the Pyrenees, suggests that the organisation of seasonal movements occurs in tandem (or with a slight delay) with the appearance of domesticated ovicaprids in the region. Such an idea has implications regarding the times that these routes were established and the reasons associated with herd movements that suggest complementary seasonal mechanisms on a regional scale.

It has been proposed that the *secondary products* revolution of the Late Neolithic/Early Bronze Age lay behind the consolidation of transhumant routes. It was the answer to insuring pasture throughout the annual cycle for herds of increasingly larger numbers that provided meat and other new products, such as wool and milk (Sherrat, 1983). Although transhumance connected areas with complementary ecosystems that supplied herds with pasture and water throughout the annual cycle, this activity did not necessarily lead to the intensification of animal production, such as dairying, as suggested by Bogucki (1984).

Indeed it has been suggested that herds of ovicaprids were managed to obtain *life time products* (milk) and *final products* (meat) for daily subsistence needs from the earliest phases of the Neolithic in the western Mediterranean, and the practice of milking accompanied the spread of farming cultures across Europe (Vigne and Helmer, 2007). Although some evidence suggests that dairying was present from the beginning of the Neolithic, it was most likely implemented on a small scale and as part of a broad mixed economy (Halstead, 1996; Greenfield, 2010).

This scenario is not at odds with the cave records of the Southern Pyrenees. The picture of large herds at Colomera and Parco is difficult to imagine because the characteristics of these sites seem to better suit the requirements of small communities in the context of short-distance circuits. At Margineda, it is also probable that repeated stabling of small herds occurred in the late Early Neolithic period (Guilaine and Martzluff, 1995), but its topographic position suggests that this period saw the appearance of incipient, long distance routes that connected the Ebro Basin with the Axial Pyrenees.

The causes related to this process have not been well studied. However, well-correlated pollen, hydrological and marine data have demonstrated an increasing aridification from 5500 calBP to the present, and during the middle Holocene in the Western Mediterranean, different dry phases have been detected (approximately 5300–4200 and 4300–3400 calBP) (Jalut et al., 2000, 2009). This change in climatic conditions experienced in Northeastern Iberian Peninsula could imply a significant rise in daily/yearly temperatures, marked seasonality, instability in rainfall, and more frequent long, dry summers. Such environmental conditions indicate an incipient process of aridity that could affect the number and quality of pastures on the periphery of the southern Pyrenees and could have prompted the need to organise seasonal circuits to gain access to summer pastures.

The evidence of sites suggesting seasonal circulation of herds towards mountain pastures along with palaeoclimatic degradation allow us to consider the establishment of transhumance routes from the Early Neolithic Period to reduce the grazing pressure on croplands. Further investigations will explore whether pen deposits excavated in sector P in Cova Gran represent a specialised use of the site as enclosures for large herds in the context of regular transhumant routes between the Ebro Basin and the Pyrenees. It has been suggested that the specialisation of caves and rockshelters as animal pens can be correlated with incipient territorial organisation during the Middle Neolithic period at the beginning of the fourth millennium BC (Bréhard et al., 2010). It is not currently possible to assess such hypotheses at Cova Gran; however, the general living conditions provided by the size and accessibility of the site, as well as the strong regional connections and other indicators revealed during its excavation, suggest that this site could have played such a role in the past. Pen sediments have been identified within a few centimetres of the surface level in all test trenches dug in the more than 2500 m^2 area of the rockshelter platform (Mora et al., 2011) (Fig. 3).

While internal diachrony between different zones can be assumed, the repeated enclosure of animals had a substantial effect on the rockshelter surface. At present, available dates are restricted to pens located in the upper part of profile E (Nb and Nd1), but this sequence presents continuity down the profile (Fig. 4). It has been noted that pen sediments with a temporal range similar to that in Nd1 have been identified in the roof of sector T (more than 20 m away). Such dimensions of the pen area could suggest a specialised use of the site.

In addition, at the base of the pen Nd3 of profile E, a pit containing a fragment of Early Neolithic pottery (Fig. 8) associated with burned acorn seeds (*Quercus* sp.) was recorded. This latter evidence provided a dating of 6020 ± 50 BP (7010–6730 calBP) (Mora et al., 2011), suggesting that animals were kept at the site from the beginning of the Neolithic occupations at the rockshelter.

In Sections 4, 5 and 6, the stratigraphic, microstratigraphic and chrono-cultural direct parameters were discussed to reduce the intrinsic difficulties derived from the study of prehistoric transhumance routes. In this respect, some historical sources contribute indirect evidence of the specialised use of rockshelters as stabling deposits.

It has been shown that, traditionally, the area around Cova Gran was key for winter pasture in the transhumant circuits of Northeastern Iberia (Vila Valentí 1950; Roigé, 1995). Likewise, a recent historical, sociological and ethnographic multidisciplinary project on transhumant routes (Trepat and Vilaseca, 2010) that served as a basis for the preparation of the *Map of Livestock Routes of Catalunya* (ICC, 2010) placed Cova Gran next to the junction of two principal livestock routes, at the interface of the Ebro Basin and the Axial Pyrenees.

It is not easy to assess the sizes of the herds that moved along these circuits. The known historical records are few in number and limited across time. They refer to a period during which the traditional transhumant system of the southern Pyrenean slopes was experiencing a period of crisis, at the beginning of the 1960s, and can only be used as a guide. However, it is interesting to note that a count was made of the arrival of a herd that had left Santa Linya and travelled 100 km in the summer of 1958 at Lladorre (a village at 1000 m a.s.l. in the Axial Pyrenees). During the journey, the herd passed through several localities and was joined by new herds until they formed a group of more than 600 animals, primarily sheep. More than 6500 animals from the southern Pyrenean periphery gathered in the destination pasture area (Cunill, 2010).

Together, the direct and indirect evidence suggests that the area around Cova Gran is covered with regional transhumant routes that began to form during the first phases of the Neolithic period and have lasted practically until the present day. If so, investigations at Cova Gran could contribute significantly to the understanding of the development of pastoralism in Northeastern Iberia.

9. Conclusions

Despite the intrinsic difficulties derived from the study of these pen accumulations, which involve multiple variables that are challenging to clarify, new data about the environmental and cultural formation processes associated with these deposits at Cova Gran shed new light on the analysis and discussion of the pastoralist lifestyle in the past.

Through the identification of thermally altered herbivore excrement, combustion structures and runoff processes that affected the site during and after human occupation, micromorphological analyses begin unravelling the cultural-environmental dynamics and occupation patterns of rockshelters and caves during the Neolithic period in the Pyrenees.

Pen deposits identified at Cova Gran reveal the use of the site as a facility for the enclosure of ovicaprids. The burning of pen residues is a recurrent characteristic in these deposits. Intentional burning was implemented to reduce the volume of waste material, control animal parasites and prepare the site for a new stabling episode.

Micromorphological and stratigraphic data indicate that endokarstic activity was a major taphonomic environmental agent in the post-depositional alteration of pen deposits, as evidenced by the erosion and removal of part of the accumulated sequence.

The time span of these events was determined by a series of radiometric dates. The chronology of the pens analysed indicates the use of the rockshelter as an enclosure for domestic animals between 5000 and 2700 calBP, although stratigraphic and chronometric indicators suggest that the beginning of this practice was even earlier. The limited archaeological assemblage of the enclosure levels provides a temporal range that supports the radiometric framework, placing them in the Late Neolithic (Nd1) and Bell-Beaker/Early Bronze cycle (Nb) (Fig. 4).

The repeated use of Cova Gran as an animal enclosure over time can be related to the strategic regional connections granted to the site by the privileged topographic location of the rockshelter. Other factors, such as size, accessibility and fresh water availability, were most likely also crucial in the role and significance of the site at a regional level. Along with this data, the presence of pen accumulations over an extensive area of the deposit suggests that Cova Gran may have functioned as a major enclosure of large herds.

Future contributions should focus on the assessment of the role of Cova Gran within the network of transhumant routes. Some of the sites referred to in this paper may be associated with local movements. Others can most likely be related to long-distance movements between the Ebro Basin and the Axial Pyrenees in the late Early Neolithic.

This incipient functional variability addresses a key question that has been introduced tangentially in this paper: the analysis of the complementary nature of and interactions between pastoralism, agriculture and exchange relationships, activities that are closely connected in the Mediterranean. From this perspective, although seasonal herding is important, it constitutes more than a specialised system aimed at trade/exchange because it is intimately related to agriculture. How these activities were conducted in the lower valleys of the Prepyrenees in Late Prehistory is a factor that little is know about and deserves future exploration.

In summary, Cova Gran opens new avenues for understanding the origins of transhumant routes and the associated livestock management practices in Northeastern Iberia, an activity that could date back to the late Early Neolithic and that has characterised the lifestyle of many generations of people living in the Pyrenees until virtually the present day.

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