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Short communication

Rethinking stratigraphy and site formation of the Pleistocene deposit at Cueva Negra del Estrecho del Río Quípar (Caravaca de la Cruz, Spain)

Diego E. Angelucci [a,*], Daniela Anesin [a], Mariano López Martínez [b], María Haber Uriarte [c], Tomás Rodríguez Estrella [d], Michael J. Walker [b]

[a] Dipartimento di Lettere e Filosofia, Università di Trento, via T. Gar 14, I-38122 Trento, Italy
[b] Área de Antropología Física, Departamento de Zoología y Antropología Física, Universidad de Murcia, Spain
[c] Área de Prehistoria, Departamento de Prehistoria, Arqueología, Historia Antigua, Historia Medieval y Ciencias y Técnicas Historiográficas, Universidad de Murcia, Spain
[d] Escuela de Ingeniería Minera, Geológica y Cartográfica, Universidad Politécnica de Cartagena, Spain

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ABSTRACT

Cueva Negra del Estrecho del Río Quípar (Caravaca de la Cruz, Murcia, Spain), hereinafter Cueva Negra, is a key-site for understanding the early peopling of Europe. Since 1990, systematic excavation has revealed an intriguing assemblage of lithic and faunal remains, and hominin teeth. It was deposited 0.99–0.78 Ma according to palaeomagnetic and biostratigraphical data; pollen data indicate warm moist conditions. Recently, possible evidence of thermal alteration was detected in a deep part of the deposit. We report here on our revision of the Cueva Negra stratigraphy, and offer information on site formation processes, based on new field observations and preliminary data from soil micromorphology. The Cueva Negra succession comprises three main stratigraphical complexes. Complex 1 is late Holocene. Complexes 2 and 3 are Pleistocene and are formed mainly of alluvial sediment, with subordinate inputs from the cave walls. Complexes 2 and 3 were accumulated almost without interruption, being separated by an erosive surface truncating a thin alluvial soil developed at the top of Complex 3. Our initial micromorphological findings indicate that anthropic inputs are mostly in derived positions, very likely having undergone inward displacement from the mouth of the rock-shelter.

1. Introduction

Cueva Negra del Estrecho del Río Quípar (hereinafter Cueva Negra) is a Pleistocene site beside the hamlet of La Encarnación near Caravaca de la Cruz in the Spanish region of Murcia (Fig. SI-1). Cursory exploration in 1981 (Martínez Andreu et al., 1989) has been followed since 1990 by systematic annual excavation campaigns and a recent account (Walker et al., 2013) corrects inaccuracies in earlier publications, superseding them all. Palaeomagnetic reverse polarity throughout the 5-m depth of sedimentary deposits (Scott and Gibert, 2009) and micromammalian biostratigraphy indicate a late Early Pleistocene age (before the 0.78 Ma Matuyama-Brunhes boundary but later than the end of the Jaramillo polarity event, dated to 0.99 Ma). Possible evidence of thermal alteration was uncovered recently in the lowermost part of the succession (Walker et al., 2013).

Finds include hominin (cf. *Homo heidelbergensis*) teeth, a rich faunal and palynological record demonstrating warm moist environmental conditions (presumably MIS 21 or MIS 25), and a Palaeolithic assemblage comprising a hand-axe, flaked bifacially on a flat limestone cobble, abundant small flake tools on chert, limestone and quartzite, some bearing steep abrupt ('Mousteroid') edge-retouch and facetted striking-platforms, including some struck by recurrent centripetal flaking from small prepared ('Levalloisian') discoidal cores. The lithic assemblage also features stone tools typologically recalling Mousteroid and Levalloisian industries (details in Walker et al., 2013). Much of the chert was afforded by cobbles, available in a nearby outcrop of Miocene marine conglomerate (for details on the geological context and raw material procurement see Zack et al., in press).

The main features of the Cueva Negra succession have been described previously (Walker et al., 2006, 2013; Scott and Gibert, 2009), but here we present the first systematic report that takes account of site formation. Our revised interpretation of the

* Corresponding author. Tel.: +39 0461 282700.
E-mail addresses: diego.angelucci@unitn.it, diego.angelucci@lett.unitn.it (D.E. Angelucci).

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Table 1
Geoarchaeological Complexes at Cueva Negra and correspondence to former lithostratigraphical units and to excavation units. Key: cx – stratigraphical Complex; exc. – excavation; fr(s). – fragment(s).

cx	Main features	Lower boundary	Correspondence to former units and excavation spits
1	Late Holocene slope sediment, formed of silty sand with few limestone frs. showing random orientation pattern; a thin A-C soil profile is under formation at its top	Erosive surface underlined by large limestone boulders	
2	Succession formed of cross-bedded, laminated, silty sand, with few coarser (>2 mm) components (among them limestone frs. from cave roof)	Erosive surface with slightly concave shape	Unit II (see Walker et al., 2006, p. 5); between exc. spits 2a and 3h in W wall of main trench
3	Thick succession made up of fairly regular alternations of silty sand facies, with scarce coarser (>2 mm) components (among them limestone frs. from cave roof) and finer beds (mostly silt) increasing in number and thickness downwards; complex 3 was subdivided into 2 sub-complexes:		
(Sub-complex 3-1) mostly silty sand with very few finer intercalations		Paraconcordant surface	Units III and IV (Walker et al., 2006, p. 8); between exc. spits 3i and 5a in S wall of main trench
(Sub-complex 3-2) silty layers with sandy intercalations, possible evidence of thermal alteration near its base		Rests on limestone (most probably cave bedrock)	Units V and VI (Walker et al., 2006, p. 8); below exc. spit 5b in S wall of main trench

stratigraphy and formation processes draws on new field observations and the first data from soil micromorphology. The main purpose of this study is to characterize the sedimentary and post-depositional dynamics responsible for the formation of cave infilling, which provide important clues about the origin and characteristics of natural and anthropic inputs. The sediments related to possible thermal impingement are described briefly in the supplementary information, whilst the study of the thin sections collected from them is still in progress.

2. Regional setting

Cueva Negra is a rock-shelter in Miocene biocalcarenite on the E side of a short, incised, gorge through which the R. Quípar flows. The gorge links the upper Quípar–Tarragoya basin to the lower drainage basin of the Quípar, which is a tributary of the R. Segura, draining into the Mediterranean. The rock-shelter lies at 740 m asl and 40 m above the river (Fig. SI-1).

The area fringes the Betic chain, a region with complex geological and structural features, significant structural and tectonic control on surface morphologies, and active neotectonics. In geological terms the Quípar valley belongs to the Sub-betic unit, which is made up of Mesozoic, Cenozoic and Quaternary sedimentary formations that include carbonate (limestone and marl) and clastic rocks (conglomerate, sand, clay), as well as gypsum (Walker et al., 2013; Zack et al., in press). The Quípar gorge cuts through Tortonian bioclastic calcarenite (also featuring subordinate quartz and siliciclastic components), which constitutes the cave bedrock. Pleistocene and Holocene sediments, mostly alluvial, are widely exposed in the Quípar gorge (for further information on the morphology and evolution of the Quípar gorge and the formation of Cueva Negra, see Walker et al., 2013).

Today, the area is subject to a semi-arid meso-Mediterranean climate (at Caravaca de la Cruz, mean annual temperature is 16 °C although temperature during winter months can fall below zero, and mean annual rainfall is 367 mm; García Cortés et al., 1999).

3. Materials and methods

In 2011, we began geoarchaeological revision of the site with the aim of systematically describing the succession. During fieldwork, extant exposures of excavation soundings were cleaned and described. The description took into account sedimentary, pedogenetic, stratigraphical and archaeological characteristics, and excavation units were redefined in order to reconstruct the site succession. This led us to rename and group previously-defined excavation units and propose a novel stratigraphical subdivision of the deposit (Table 1 and Fig. 1). Fifteen samples were collected for soil micromorphological observation – already ten thin sections have been analyzed and data collected from them are summarized (see SI-2 and Table SI-1). Thin section description follows the guidelines proposed by Bullock et al. (1985) and Stoops (2003).

4. Stratigraphy

The stratification observed at Cueva Negra corresponds to the infilling at the cave entrance. The deposit is made up of a fairly regular succession of sedimentary layers, which often show sub-horizontal bedding and sometimes contain well-developed sedimentary features. The distinction of sedimentary interfaces is poor by and large, owing to the uniformity of components and the weak differences among the lithofacies that compose the cave deposit.

Three main discontinuities are clearly visible throughout the deposit, allowing us to subdivide the succession into three main geoarchaeological complexes, which are as follows (Table 1 and Fig. 1):

- Complex 1 – recent, late Holocene, slope sediment, at the top of which a thin A–C soil profile is under formation; this complex outcrops at the E side of cave entrance and has no interest for Pleistocene archaeology;
- Complex 2 – ca 1.5-m-thick succession formed of cross-bedded, laminated, silty sand, with few coarser components, resting on a clear erosive surface;
- Complex 3 – ca 3.5-m-thick succession made up of fairly regular alternations of silty sand facies with scarce coarser (>2 mm) components, and finer beds, whose number and thickness increase downwards; furthermore, Complex 3 was subdivided into two sub-complexes, the lower one resting on limestone, most probably cave bedrock (see Table 1 for details and for correspondence between this stratigraphical subdivision and previous naming of units).

Complexes 2 and 3 show clear similarities as far as their components and main features are concerned, both at macro- and micro-scale. Basic coarse components (>2 mm; see SI-1.1) are almost the same throughout the sediments of both complexes and do not show any significant change as far as their presence/absence is concerned, even though their relative quantity may vary. The sand fraction is also fairly homogeneous throughout the succession: carbonate components are dominant, while quartz is present in fine and medium sand. Other characteristics that are common to

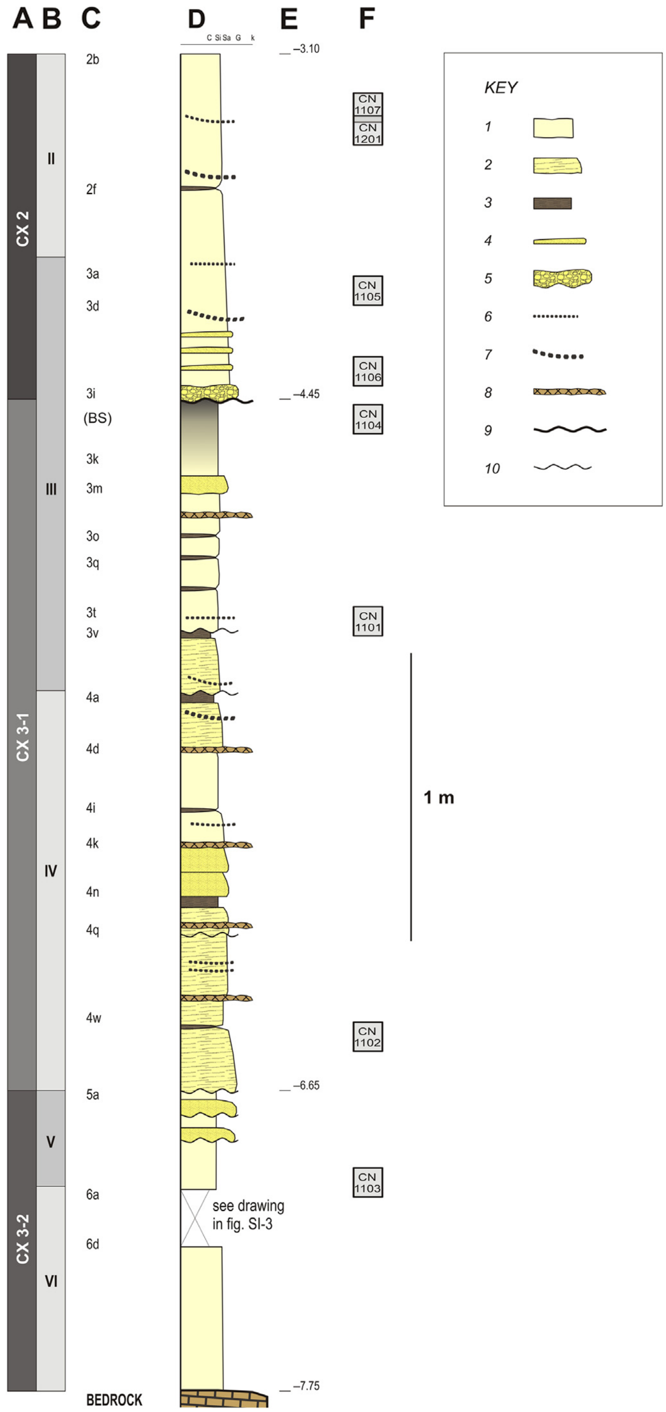

Fig. 1. Cueva Negra. Simplified stratigraphical column: (A) stratigraphical subdivision in this paper (key: cx – Complex or Sub-complex); (B) former lithostratigraphical units (Walker et al., 2006); (C) excavation spits (key: BS – buried soil); (D) stratigraphical column (key: C – clay; Si – silt; Sa – sand; G – granules and gravel; K – carbonate crusts or flowstones; stones are not represented in the column); (E) approximate depth below datum point, in meters; (F) stratigraphical position of soil micromorphological samples. Key: 1 – silty sand, massive or poorly laminated; 2 – silty sand with flat lamination or cross-bedding; 3 – silt or clayey silt, massive or with flat lamination; 4 – sand; 5 – gravel; 6 – stone-lines formed of fine granules; 7 – fine lenses of granules to fine gravel; 8 – calcium carbonate crusts; 9 – main erosive surface between Complex 2 and Complex 3; 10 – minor erosive surfaces.

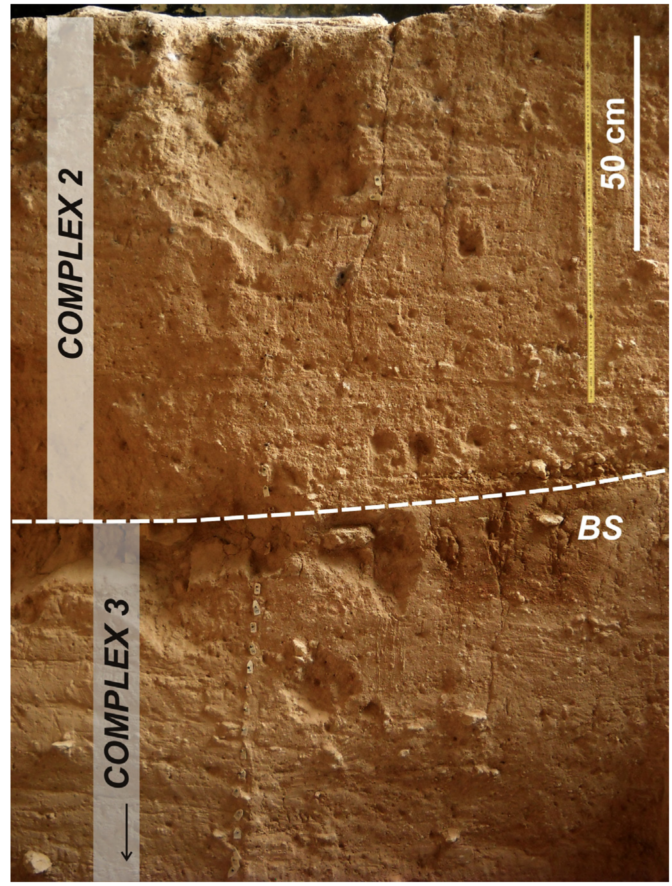

Fig. 2. Cueva Negra. Partial view of W excavation wall, depicting Complex 2 and the upper part of Complex 3. The dashed line corresponds to the erosive surface separating Complex 2 and Complex 3; the thin buried soil is marked by "BS". Notice the bedding – vague but recognisable – and the fragments of limestone coming from roof spalling. Scale bar is 50 cm.

all the units of the succession are: low porosity, except for the presence of serrated vertical planes, along which biological channels run sometimes, and well-developed, recent sub-vertical 'cracks' affecting the uppermost part of the succession; there is enrichment of secondary carbonate that increases, on average, inwards and downwards.

The sediments of Complex 2 fill a smoothly-shaped canal with concave erosive base, which truncates the top of Complex 3-1. Complex 2 is formed of alternations of beds of silty fine sand, silty medium sand and weakly silty coarse sand. All these facies are moderately- to almost well-sorted, well-packed and may contain scarce mm-sized grains. Porosity is low, whilst colour varies from 10YR 5.5/6 to 10YR 6.5/6 (yellowish brown to yellow). Intercalations of both coarser and finer sediment are also found (see SI-1.2 for details). The whole sequence of Complex 2 shows clear cross-bedding, with alternations of low angle and flat lamination within beds. The erosive interface at the base of Complex 2 dips weakly SE, and its main axis is orientated NW-SE (Fig. 2). At the microscopic scale, three main sedimentary inputs can be recognised according to lithology, size and roundness: (1) dominant subrounded to rounded sand grains, which include reddish-brown clayey clumps; (2) scarce to common angular to sub-angular coarser, mm-size biocalcarenite fragments, usually lying flat; (3) occasional angular to sub-angular chert fragments of knapped artefacts (Angelucci, 2010), as well as fragments of bone and coprolite (Fig. SI-2a, b and c; see SI-2.2 for details). Fine material is scarce and

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micritic. Rare silty-clay coatings occur in voids, whereas Fe–Mn and Fe oxi-hydroxides nodules and impregnations are widespread; evidence of bioturbation is detected throughout the complex.

Complex 3-1 is formed of sub-horizontal beds, dipping E with very low angle. At its top, a poorly developed, A-C soil profile is found (Fig. 2): the A horizon is silty loam, light yellowish brown, with poor coarse prismatic structure and low porosity, while the C horizon is flat-laminated silty fine sand (SI-1.2). In micromorphological terms, the soil is characterized by intense bioturbation (Fig. SI-2d; see SI-2.2). Below the soil profile, Complex 3-1 includes several sedimentary cycles and events, with thickness and characteristics (e.g. grain size, sedimentary features) that vary. Most cycles exhibit upward-fining and direct grading and are formed of one or more lithofacies as follows (top to bottom): very thin silty loam bed; thin silty very fine sand, well-sorted; silty medium to coarse sand with few coarser grains, massive or with weakly-recognizable bedding; very coarse sand with few fine granules, clast-supported, with weakly erosive base. The cycles and related sedimentary features are also recognised in thin section (Fig. SI-2e and f). Micromorphological observation on samples from Complex 3 also shows increase of clayey pedofeatures and of the amount of micromass, along with decrease of the gravelly-sized fragments of limestone and chipped chert, with respect to Complex 2; on the other hand, bone fragments are common (SI-2.2).

Complex 3-2 resembles Complex 3-1 except for an increase of finer intercalations. The complex is made up of alternating beds of laminated silt with very fine sand (often overconsolidated), and medium to coarse sand (with few fine granules), with intercalations of thin dark, organic silt (SI-1.2). In thin section, the changes observed in Complex 3-1 are detected as well in Complex 3-2 (SI-2.2). At the base of the complex, distinct layers were observed of materials resembling ash, sometimes resting on reddened belts, and containing white conjoined longitudinal spalls of calcined long-bone, charred bone fragments, and lustreless chert that shows both "pot-lid" fracturing and in situ conjoined splintering, all of which are caused typically by intense heat (Walker et al., 2013; see Fig. SI-3).

5. Concluding remarks

The data collected from Cueva Negra, both on site and from thin sections, allow us to revise the stratigraphical succession at the site and to provide us with the first clues about site formation processes. Present evidence shows that the Pleistocene succession at Cueva Negra is mainly an alluvial deposit, with subordinate inputs from the cave walls and roof and a scarce, though significant, anthropogenic input, in particular in the lowermost part of the sequence.

The sedimentary deposit at Cueva Negra is articulated into three main stratigraphical complexes, one of which dates from the Holocene (Complex 1 – see Table 1 for the correlation between former units and the present stratigraphical subdivision). The layout of the Pleistocene Complexes 2 and 3 indicates their mainly alluvial origin, as far as their geometry and sedimentary features are concerned (see SI-1.2 for description). Complex 3 is composed of an upward-coarsening sequence, the accumulation of which was almost continuous over time, culminating in a short stable phase leading to the formation of the thin soil at its top. Complex 2 also constitutes an alluvial sequence that shows neither any significant hiatus nor interruption during its deposition; the total thickness of this complex is unknown owing to erosive truncation of its top. The good organization and the alternation of sedimentary lithofacies within the deposit of both Complexes 2 and 3 is a result of cyclical shifting of the energy of alluvial dynamics – the sand and silty-sand facies observed at the site are typical of low- and medium-energy tractive mechanisms, whilst the finer ones are the result of accumulation by decantation. At the macro scale, the layout and sedimentary lithofacies observed at Cueva Negra match the 'typical' alluvial ones, yet at the microscopic scale the sediment shows a degree of organization that is less than expected in a fluvial milieu: on average, textural maturity is moderate, as is observed often in Mediterranean alluvial settings, subject to torrential high-energy events, though intensity can be attenuated by site location.

The sedimentary sources of the deposit (see list of components at SI-1.1) are mainly exotic to the cave and come from the Quípar–Tarragoya basin upstream from the cave (Walker et al., 2006). Only a limited part of the inputs comes from the cave, namely the calcarenite fragments that derive from roof spalling, as well as part of the sand and silt fractions, which come from the degradation of the calcarenite bedrock. Several geomorphological indicators (such as the presence of nearby *tafoni* and other wind-related erosive morphologies) suggest a possibility of some aeolian input, the existence and proportion of which will be determined, if possible, by further thin-section observation. It is worth taking note that no significant change of sedimentary inputs has been observed in the succession, which points to the homogeneity of the sedimentary basin feeding the cave during the accumulation. Furthermore, it was noticed that the sequence does not show any significant evidence of physical alteration, chemical weathering or long-term surface stabilization, except for the buried soil on top of Sub-complex 3-1, from which we conclude that the accumulation process was fairly rapid and without major hiatuses within the individual stratigraphical complexes. The profile on top of Sub-complex 3-1 is a moderately developed alluvial soil and is related to a short phase of stabilization – its weak development may indicate that soil formation took place over a short time span, possibly in the order of 10^2–10^3 years. In fact, the buried soil, and the erosive surface that separates Complexes 2 and 3, are the only major evidence of discontinuity throughout the Cueva Negra succession, even though the duration of the time interval which corresponds to the soil profile and the erosive interface cannot be evaluated.

Our research thus confirms the main alluvial nature of the deposit; moreover, our micromorphological observations show that most layers possess sedimentary characteristics (rather than "pedogenic microfabric", thus Scott and Gibert, 2009: 84), that post-depositional processes were relatively scarce at the site, and that soil formation was limited to the single episode mentioned above.

Archaeological evidence is scattered throughout the succession at Cueva Negra. Preliminary micromorphological data show that anthropogenic inputs are more common in the sand facies than in the fine ones. Taken together with that observation, the sedimentary characteristics of the deposit and the degree of preservation of artefacts (Walker et al., 2013) indicate that several artefacts and ecofacts are in slightly derived position with respect to their original one, very likely having been laid down at the cave mouth and transported inwards, maybe swept or thrown towards the back wall. Nevertheless, that in situ splintering of chert and calcined bone also took place is demonstrated by excavation of undisturbed fragments with corresponding spalls still in conjunction (Walker et al., 2013). Furthermore, throughout the Pleistocene sediment the ubiquitous presence of knapping spalls of razor-sharp chert and absence of rolled edges reinforce the foregoing conclusion that displacements were of the order of no more than a few metres.

In the bottom layers of the stratigraphical Sub-complex 3-2, a reddened belt, covered by two beds made up of carbonate-rich material resembling ash was observed. This sequence is found commonly in archaeological features at sites of many periods (Courty et al., 1989) and could be produced by combustion.

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Geoarchaeological and micromorphological research at Cueva Negra will continue in the next years, in order to shed further light on the dynamics of site formation, the timing of the events recorded in the succession and, in particular, the actual nature of the possible thermal alteration features identified at the site.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.quascirev.2013.09.009.

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