Clastic Cave Sediments and Speleogenesis of the Buraca Escura Archaeological Site (Western–Central Portugal)

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Abstract A new geomorphological and structural cave survey, as well as a sedimentological and stratigraphic analysis of clastic cave sediments and local post-Jurassic siliciclastic covers, was performed at the Buraca Escura archaeological site (Poio Novo valley, Sicó Massif, western–central Portugal). Provenance and endokarstic transport were investigated by examining clastic cave sediments and making comparisons with new and published data on the siliciclastic regional covers. A framework for speleogenesis, beginning during the Late Cretaceous–Miocene, is established.

Keywords Clastic cave sediments · Speleogenesis · Paragenesis · Alluviation · Middle and Upper Palaeolithic

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Introduction

There is now an increasing awareness of the potential of continental deposit stratigraphy for providing high-resolution records of palaeoenvironmental and climatic changes at a regional scale. Caves can preserve different sediments, including: autochthonous deposits (e.g., collapsed blocks and insoluble bedrock remains); allochthonous materials with water- and gravity-driven transport; and chemical deposits (e.g., secondary cave minerals, such as speleothems). The first and second categories are termed clastic cave sediments (CCSs).

The complex polyphase speleogenesis indicated by the main carbonate massifs of western–central Portugal includes Mesozoic episodes, but the main phase was due tectonic activity and palaeoclimate during the Cenozoic (Cunha 1990). This study of Buraca Escura Cave includes new geomorphological and structural data, and sedimentological and stratigraphic analyses of both CCSs and local post-Jurassic siliciclastic covers, which are related to previous geoarchaeological findings. The study aims to inform the geological and geomorphological evolution of the region, including depositional, tectonic, and palaeoclimatic events, as well as Neanderthal and Modern Human occupation of the cave and surrounding territory.

Buraca Escura Cave is located in the western margin of the Sicó Massif at an altitude of 223 m, along the southern slope of the Poio Novo fluviokarst canyon cut into the Middle Jurassic carbonates. The E–W orientation of the valley is clearly structurally controlled, and almost perpendicular to the major fault zone that constitutes the western border of the Sicó Massif.

The archaeostratigraphy of the CCSs of Buraca Escura Cave includes lithic and faunal remains attributed to the Middle Palaeolithic, Upper Palaeolithic (Early and Late Gravettian, Proto-Solutrean), and Late Neolithic as confirmed by ^{14}C and U–Th dating, and records several depositional, erosive, weathering, and stabilization phases that occurred during the Late Pleistocene (five geoarchaeological complexes are recognized, GC1–GC5) (Aubry et al. 2011). Short-term human use of the cave alternated with occupation by birds, small vertebrates, and carnivores. The data for Buraca Escura Cave were included in a regional chronostratigraphic framework for the Middle–Upper Palaeolithic transition by Aubry et al. (2011).

The CCSs (siliciclastic fraction only) and Lower Cretaceous (in situ and recycled sediments) and Pliocene samples were studied. The compositions of ca. 100 (1.0–0.5 phi fraction) grains were determined per sample using a binocular microscope. The surface aspect (frosted or bright) and roundness of quartz grains were measured, and heavy minerals in the 3–4 phi fraction were also estimated using X-ray diffraction. Grain-size data were obtained by ½ phi sieving coupled with a laser particle sizer. The clay mineral assemblage of the >9 phi fraction was estimated by X-ray diffraction. The $CaCO_3$ content of the >-2 phi fraction was obtained with a Bernard calcimeter.

Results

The axis of Buraca Escura Cave follows a regional set of NNW-trending faults, probably with minor dextral slip and western downthrow. A set of N–S joints seems to be critical for the location of the main karstic conduits, namely a feeding chimney (at the intersection with the NNW-trending fault) and a western escape pipe. Secondary modifications of the cave walls by corrosion are observed, including solution niches developed at the contact between the sediments and the rock walls, etched boxwork features on existing bare walls, and ceiling solution cups; these have formed due to moisture in the sediment and water condensation in the air. Rocky wall features resulting from freeze–thaw rock fragmentation also exist near the present-day entrance to the cave. The transverse cross-section of the cave displays a "pear-type" profile where the initial opening along a guiding bedding-plane is at floor level. CCSs probably entered the cave along the chimney, which is now almost blocked by cemented siliciclastic sand and autochthonous calcareous fragments, as well as through the entrance since the cave's connection with the valley.

As in previous work on the Cretaceous rocks (Soares 1966; Dinis 2001) and Pliocene covers (Dinis and Soares 2007a, b), the studied samples show a kaolinite-dominated clay association, with significant mica–illite and rare vermiculite (goethite and gibbsite are common accessory minerals). The CCS samples present the same pattern, with the exception of the uppermost samples, which are enriched in smectite. Quartz is the main sand mineral, with ubiquitous minor feldspar and commonly some alterites (unidentified dark, heavy grains of presumable weathering origin). The heavy minerals are dominated by tourmaline, followed by zircon and alterites. The topmost sample is again an exception, with an increase in alterites and carbonate content.

Cretaceous samples are composed mainly of angular grains and most are dominated by bright sands (except lowermost in situ levels), whereas Pliocene sands are more rounded and on average more frosted. Most of the CCS samples have no clear trends (some are very similar to the Pliocene samples, but others have an intermediate morphoscopic character), although the lowermost CCS sample shows roundness and surface aspect similar to the Cretaceous, with the topmost clearly presenting as rounded and bright. Cretaceous sample grain sizes have multimodal signatures, whereas Pliocene distributions are usually unimodal and have clearly more constrained distributions. All CCS grain-size signatures are similar to those of the Cretaceous samples, with an upward decrease in the proportion of coarser sand. The exceptions are the samples from the cave entrance and the middle of the topmost GC1 complex (both of which are similar to the Pliocene deposits) and the very poorly calibrated silt from the base of the GC4 complex.

Interpretation

General affinities indicate that the CCSs are remobilized Lower Cretaceous and Pliocene deposits, occasionally with some admixture. The Cretaceous-like CCSs seem to have undergone an intra- and/or extra-endokarstic transport, unlike the levels with Pliocene-like CCSs, apparently reworked from quite close sources or even deposited directly in the cave. According to the stratigraphy and texture, the GC5 complex is probably pre-Pliocene. Thus, a Late Cretaceous to Miocene speleogenetic inception can be deduced, following fractures created by NE–SW Pyrenean transpression and later opened by Betic N–S compressive stress (with paroxysm during the Late Miocene). The early cave speleogenesis was characterized by a phreatic/epiphreatic tube, which was oriented along the intersection line between a guiding bedding-plane and local vertical fractures, and which probably developed at (or very near to) the hydrographic base-level. Phreatic sedimentation promoted contemporaneous upward erosion (paragenesis sensu Farrant and Smart 2011), developing a narrow slot. Subsequently, vadose conditions allowed phases of alluviation and flushing to occur as the cave was uplifted above base-level and the valley became incised. Inflowing sediments filled the cave and promoted corrosion, not only laterally but also at the contact between the sediments and the rock walls. The latest morphological modifications were generated by freeze–thaw and condensation corrosion actions, leading to overprinting of prior (paragenetic-type and suballuvial) morphologies.

The older CCSs (GC5 complex) had an exclusive Cretaceous provenance, until the Pliocene marine transgression most likely flooded a pre–Poio Novo valley. Some of these nearshore sediments remained in the endokarstic system, partially in situ or reworked and mixed with the Cretaceous. During the Pleistocene, the cave records episodic deposition and flushing, as well as sporadic human occupation, as mentioned above. Autochthonous calcareous angular fragments (GC3 and GC2 complexes) are interpreted as being linked to cold, humid phases, namely to Heinrich Events 3 and 2, in accordance with absolute dates. Finally, the topmost GC1 complex shows pedogenetic features and composition compatible with the Holocene climate.

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