Sulphate speleothems in Canelobre Cave (Alicante, SE Spain)

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THE CANELOBRE CAVE

The Canelobre Cave is one of the most representative caves of the southern part of the Valencia Community. The cave is situated in the central eastern part of Alicante province, in the Sierra del Cabeçó d'Or. Its entrance is located high on the south-west slopes of the sierra, 3 km from the village of Busot.

The cave was possibly discovered by the Arabs in the eleventh century. During the Spanish Civil War it was used like refuge, warehouse of weapons and repair workshop for aeroplane motors, reason for which the cave was subjected to an intense deterioration (tunnelling, stone facing,...etc). After the war, rehabilitation and fitting out were undertaken to open the cave for tourism. Currently, circa 80,000 people visit this cave each year. Its natural entrance is 700 m above sea level, although visits are made via a man-made tunnel at a lower level.

The cavity mainly consists of a single huge chamber with a length of about 100m depth and a very high roof (approximately 60m), resembling that of a cathedral. From its roof a spectacular display of a large number of dripstones (stalactites) emerges, some of which exceed 10 metres in length and which may be attached one to another, forming sheets and complex formations, some of them looking like a 'candelabra', for what is thought that the cave takes its name.

The Sierra del Cabeçó d'Or belongs to the southern Prebetic domain of the External Zones of the Betic Cordillera and is composed of a 650m-thick sequence of Jurassic and Lower Cretaceous massive limestones with interbedded marls, sandstones and calcarenites. In terms of tectonics, the area corresponds to an asymmetric anticline running approximately N-S whose eastern flank dips of 45°-50°, and whose western flank shows a more vertical disposition, which at certain points is even inverted. The Jurassic limestones outcrop at its centre whilst the rest of the Cretaceous series is arranged along both flanks.

Because of their composition and structure, the Jurassic-Cretaceous sequence in the zone behave as an aquifer, in which the principal recharge comes from direct infiltration of the precipitation which falls on the outcrops of permeable rocks in the zone. Climatological studies indicate that the mean precipitation within the area is generally lower than 500 mm/year corresponding to a mesothermic climate (according to Thornthwaite's classification). Only significat rainfall episodes produce dripping in the Canelobre cave. The flows produced are relatively low (less than 0.1 l/min) and the dripping waters correspond to the calcium biacarbonate type, in contrast to those belonging to the saturated zone of the aquifer that correspond to a calcium sulphate type (Andreu et al., 1999). This fact could be an evidence of the presence of sulphate evaporite rocks in the region.

SPELEOTHEMS

Besides the aforementioned stalactites, the Canelobre Cave presents a remarkable collection of speleothems, such as coralloids, stalagmites, flowstones, draperies, columns, helictites, gours, spars, crusts and flowers. Most of them are calcitic in composition, however, recently gypsum and celestite-bearing calcite speleothems have been found in some lower chambers in the cave.

Gypsum appears as white, uniform crusts, 2-4 cm in thickness, covering both the limestone bedrock and older carbonate speleothems (coralloids, flowstones). These crusts are made of equant to tabular crystals or of acicular crystal aggregates. Fibrous gypsum crystals are arranged perpendicular to substrate. Gypsum flowers (antholites) are also developed in association with these crusts. Occasionally, gypsum crusts show globular or hemispherical mound-like forms, centimetric in scale, that are made up of an external thin crust over inner earthy masses composed of calcite, gypsum and celestite crystals. These forms are similar to the gypsum balls or blisters described by Calaforra (1998) and Hill and Forti (1997). Some of these morphologies appear broken, probably indicating they flake and collapse from the wall as crusts grow thicker and heavier.

Celestite is present as tiny (<0,5mm in length) prismatic colorless crystals in association with calcite brotryoidal crusts and/or earthy masses located below gypsum crusts. XRD analysis indicate celestite proportion

FIGURE 1. *Detail of gypsum globular crust coating corralloid (calcite) speleothems.Scale bar: 5cm.*

FIGURE 2. *Detail of broken gypsum crust showing inner microcrystalline masses composed of calcite and celestite.*

ranges from 18 to 30%. Calcite is low-magnesian with a $MgCO_3$ content ranging from 0.5 to 2 mol%.

Flowing and seeping water evaporation appears to be the main mechanism for gypsum crust formation in Canelobre Cave. Microclimate oscillations, concretely short-period (seasonal) variations in humidity, could also be considered as a factor in their genesis (Maltsev 1996). Likewise, globular forms may be related with zones of preferential capillarity flows in the substrate and with the alternation of solution–precipitation processes from seepage water in walls and ceilings (Calaforra 1998). The dissolution of limestone hostrock, keeping in mind celestite veins has also been described in the area, it is the most probable source of strontium for precipitation of celestite in Canelobre Cave.

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