



## **Speleothem precipitation at the water table of Holocene meteoric-marine mixing zones in Mallorca (Western Mediterranean). Strengths and limitations as palaeoenvironmental and palaeoclimatic archives.**

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In the caves of Mallorca (Western Mediterranean) brackish pools corresponding to the current water table are common all over the coastal karst areas, being a clear result of the Holocene rise of the sea level. Pool waters typically show little vertical variation of temperature or pH, but display an increase in salinity and a decrease of dissolved oxygen concentration with depth. At the surface of these cave pools, phreatic carbonate precipitates are currently forming (calcite rafts) and meanwhile crystalline overgrowths seem to be produced today at and just below the water-air interface. Rhombohedral calcite (Cova de Cala Varques A) and acicular aragonite (Cova des Pas de Vallgornera) are likely precipitating during Holocene times as horizontal bands encrustating the perimeter of the pools and ringing vadose speleothems (stalactites and stalagmites) that are located near the fluctuating pool water surface. Since the water table is at about the same elevation as sea level (even being affected by the microtidal oscillations of the Western Mediterranean), it can be assumed that present-day Phreatic Overgrowths on Speleothems (POS) mark the current position of sea level and provide an excellent analogue to use in the interpretation of past bands of POS now located above or below modern sea level.

With the aim of testing the strength of mixing-zone precipitates as indicators of present and past sea levels, two speleothems, now located at current water table in Cova de Cala Varques A and Cova des Pas de Vallgornera, have been collected. Nineteen subsamples have been drilled from transects oriented along or transversal to growth layers in order to be ICP-MS U-series dated and analysed for oxygen and carbon isotopic composition.

From a total of twelve subsamples belonging to the calcite POS from Cova de Cala Varques A, and two additional subsamples from the substrate (inner vadose stalactite), a substantial stratigraphic consistency has been found. The phreatic carbonate precipitation took place from about 2900 up to 1100 years B.P., suggesting also a very slight rise of sea level during that period. The shape and development of growth layers (gradually diverging from the inner stalactite vertical axis) support this hypothesis. The discovery of a drowned prehistoric construction, at a depth of 1 m below current sea level in a cave from the vicinity, and its chronological temporal attribution at about 4000 years B.P. seem to be in good agreement with the obtained age of calcite precipitation at the water table. Dating of the inner vadose stalactite, forming at the same elevation at least from 20000 to 7000 years B.P., further validate the dataset. On the other hand, five subsamples from the aragonite overgrowth collected at Cova des Pas de Vallgornera analogously provided chronological data that are stratigraphically consistent. In this case the aragonite precipitation took place from 1950 to 600 years B.P.

$\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  of speleothems, along with chemical composition of cave pool waters, suggest that mixing ratio between meteoric and marine waters was not the primary control on precipitation, but the proximity to the water table and degassing of  $\text{CO}_2$  at the interface seems to be the major control. Almost constant initial uranium activity ratios of calcite phreatic overgrowths (1.4-1.5) and notably lower, but unchanged, values in vadose speleothems (1.16-1.17) from Cova de Cala Varques A could suggest the involvement of microbial activity in uranium fractionation, rather than an enrichment of  $^{234}\text{U}$  for recoil phenomena due to longer residence time of fluids.

In conclusion, Phreatic Overgrowths on Speleothems have been forming at the water-air interface of cave pools in coastal caves of Mallorca at least from 3000 years BP up to the present. Since the water table of investigated coastal caves is placed at about the same elevation as present sea level, these modern phreatic overgrowths register the position of sea level from that time and constitute an excellent counterpart for the investigation of ancient bands of POS now located above or below modern sea level. Stable isotope and uranium isotopic composition of marine-mixing zone speleothems, together with detailed mineralogical and crystallographic study of their growth layers, show good potential for palaeoenvironmental and palaeoclimatic reconstructions.