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Multi-proxy constraints on ages of low U-content, young and “dirty" speleothems: Example from southern Portugal cave deposits

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Due to uncertainties in 14C activities of cave CO_2, radiocarbon measurements in "young" speleothems cannot be straightforwardly used for their dating. U-series isotopes remain their unique tools to set a chronology for carbonate accretion. In cases of pristine carbonate deposits with relatively high U-contents, precise ages can be obtained including for very recent formations (e.g., Shen et al, 2013, Nature). However, this is rarely the case. Speleothems often contain low ppb U-contents, part of this uranium linked to detrital contaminants, thus requiring age corrections. Such corrections turn out to be quite difficult when uncertainties on the isotopic composition of the detrital fraction are in the range of the authigenic U-content and in situ grown daughter 230Th. We will examine here ways to address these issues based on seriated measurements in a late Holocene stalagmite from a cave, near Faro (southern Portugal). Mean contents in 232Th and 238U average respectively 116±28 and 12±10 ppb, with 234U/238U and 230Th/234U activity ratios ranging respectively from 1.241 to 1.293 and 0.065 to 0.115. Whatever the applied correction, 232Th is used as a quantitative marker of the detrital contribution. One way to take into account this contribution is based on the assumption of an isotopically uniform contaminant. With the empirical "crustal model" (Ludwig and Paces, 2002 Geochim.Cosmo.Acta), the contaminating fraction is estimated from the mean crustal isotopic composition. However, the large uncertainty in this estimate discards the use of this model in extreme cases (very low authigenic U and young sample). More recently, Hellstrom, 2006 (Quatern. Gechron.) proposed to calculate a theoretical isotopic composition of the detrital fraction, compatible with stratigraphically ordered of dated speleothem samples. Finally, another approach, which we have tested here, consists in determining the isotopic composition of the finest fraction in soils overlying the carbonated karsts system. In the present example, all three approaches are compatible, with the later two yielding more precise age estimates in agreement within standard deviations, and ranging from 6523±186 at the bottom of the speleothem, to 5080±244, at its top. At last, a few-data point isochrons, along given layers might be suggested when the above approaches yield contradictory results.