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Precise microsampling of poorly laminated speleothems for U-series dating

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Speleothems are recognised as important palaeoclimate archives partly because of the ability to date them accurately and precisely by uranium-series (U-series) methods. The practicalities of sampling speleothem sections for U-series dating are, in most cases, fairly straightforward due to the presence of visible growth layers. However, not all speleothems possess this property, which depends upon the conditions of calcium carbonate precipitation. In this paper, we describe a method for generating U-series dating samples in which growth layers are resolved from trace-element images produced by laser-ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). We apply this method to a section of an Italian subaqueous speleothem (CD3) that lacks persistent visible growth layering.

The trace-element imaging revealed growth layers that are strongly non-planar in their geometry owing to the speleothem's pronounced euhedral crystal terminations. The most prominent trace-element layers were first digitized as x,y vector contours. We then interpolated these in the growth-axis direction to generate a series of contour lines at $\sim$250-μm increments. The coordinates of these contours were used to guide the sampling via a computerised micromilling lathe. This produced a total of 22 samples for U-series dating by multi-collector ICP-MS. The dating results returned ages in correct stratigraphic order within error. Close inspection of the U-series data suggests that the main sources of age uncertainty are unrelated to the contour sampling. Comparisons between stable oxygen and carbon isotope profiles derived from aliquots of the dating samples and two other stable isotope profiles from CD3 spanning the same time period compare very favourably. Taken together, this suggests that our trace-element contouring method provides a reliable means for extracting samples for dating (and other geochemical analyses), and can be applied to similar speleothems lacking visible growth layering.