High-resolution speleothem growth rate as a palaeoenvironmental proxy

J. HELLSTROM,[1] R. DRYSDALE,[2] J. WOODHEAD,[1] A. GREIG[1] AND G. ZANCHETTA[3]

[1] School of Earth Sciences, The University of Melbourne, VIC 3010 Australia; j.hellstrom@unimelb.edu.au
[2] School of Environmental and Life Sciences, The University of Newcastle, Australia
[3] Department of Earth Sciences, The University of Pisa, Italy

Uranium-thorium dating of speleothems has been predominantly used to apply chronologies to other measured proxy variables. Growth rate measurements have generally been considered as a by-product of this process and of secondary importance, in part due to the micro-hydrological factors which can lead to growth rate variation unrelated to external environmental change, and in part due to the previously great expense of undertaking sufficient U-Th age determinations to obtain detailed growth rate records.

Here we will demonstrate the use of densely-spaced U-Th dating at sub-mm resolution by both micro-milling and laser ablation to obtain redundant high-resolution growth rate records from multiple speleothems over glacial-interglacial timescales. Whilst no single growth rate record should be considered reliable, multiple records from a given site or region are usually found to be broadly similar and can be stacked to produce regional records of speleothem growth probability vs time, seen to have palaeoclimatic significance.

The advantage of high-resolution dating is that growth rate variations can be resolved through periods of very slow and/or discontinuous extension that would previously have been considered difficult to date or otherwise unreliable. For example several short growth intervals of a few hundred microns can usually be found within what had previously been classed as glacial hiatuses in speleothems from Corchia Cave, Italy. Short growth intervals resolved in this way can be used to constrain the timing of the warm interstadial events in which they grew.

An obvious barrier to dating at this resolution, particularly in close proximity to known growth hiatuses, is the potential for post-depositional mobility of uranium isotopes. We have used two-dimensional spatially-resolved laser ablation Q-ICP-MS analysis over a wide range of resolutions to investigate this possibility and find that U is usually only mobile within tens of microns of visible cracks, at least in sound, macrocrystalline calcite. An extension of this procedure is two-dimensional spatially-resolved laser-ablation U-Th dating which whilst slower than trace element imaging allows direct verification that primary age-depth sequences have been preserved.