PROGRESS REPORT FOR ALNGRA10148

Assessment of climatic influences on 14C activity in a Holocene stalagmite from Flores, Indonesia

In this study we expand on the promising results of our previous work (AINGRA08146) on a speleothem from Flores, Indonesia. This work explores the environmental and climatic factors that control the proportions of radioactively dead carbon (i.e. the dead carbon fraction, or DCF) incorporated into tropical speleothems at the time of deposition, and the relationship between the speleothem DCF and local hydrology. This study will be carried out over two time-slices: 2.4-2.8 thousand years before present (ka) and 0 to 0.8 ka. This work is important because speleothems offer a means by which we can refine the radiocarbon calibration curve.

PROGRESS REPORT and RESEARCH OUTCOMES

In this study, we have used radiocarbon measurements, stable-isotope and trace-element geochemistry, and U-series ages from a previously studied speleothem from Flores, Indonesia, to examine DCF variations and its relationship with above-cave climate over the late-Holocene to modern interval.

Initial findings of this research show a strong association between the DCF and other hydrologically controlled proxy data such that more dead carbon is being delivered to the speleothem during periods of higher cave recharge (i.e. lower $\delta^{18}O$, $\delta^{13}C$ and Mg/Ca values; Diagram0) and hence a stronger summer monsoon. One possible explanation is a higher contribution from the bedrock under such conditions. Although one might expect a concurrent increase in stable carbon isotope values as DCF increases (not observed here), it is possible that such an increase in $\delta^{13}C$ may be more than offset by the effect of increased recharge on the rate of carbon dioxide degassing. But, a higher proportion of bedrock carbon is not the only possible explanation: when the monsoon is stronger, a greater proportion of less mobile ‘older carbon’ may be leached from the soil thus diluting the ‘younger carbon’ fraction. This would produce an ‘apparent’ increase in DCF.
To help confirm the above interpretation, we analysed 25 14C measurements in the Flores speleothem over the past 800 years to effectively: (1) investigate the timing of the bomb peak and the structure of the radiocarbon bomb curve within stalagmite LR06-B1 to determine soil-to-speleothem carbon transfer dynamics (Diagram 1a); (2) use (1) to provide the input parameters for an inverse carbon model simulation (undertaken by ANSTO scientist Dr. Matthew Fischer), which estimates the relative contribution and residence time of different SOM reservoirs using an objective function minimum; (3) examine whether we see similar 14C-hydrological relationships over the past 800 years (Diagram 1b), as compared with the 2.4-2.8 ka interval; and (4) employ (1) and (2) to make robust interpretations of the climatic controls on DCF over the intervals 2.4 – 2.8 ka and 0 – 0.8 ka.

Calcite powders used for the 14C measurements were micromilled at continuous increments of 300 microns (representing ~3 years of growth) from the top of the stalagmite (i.e. 2006) down to ~7 mm from the tip (~1945, based on our previously published U/Th age-model. Currently 11 14C samples have been run through the bomb peak (Diagram 1a). While the bomb peak is somewhat discernable, there is considerable uncertainty as to the precise timing of it (i.e. could occur between 1970 and 1980). Constraining the timing of the bomb peak is essential for a good determination of soil-to-speleothem carbon transfer dynamics and estimation of the relative contribution and residence time of different SOM reservoirs that impinge upon the cave system.

The incorporation of additional modern 14C analyses into the radiocarbon inverse model will help to improve our understanding of soil-to-speleothem carbon transfer. This will greatly improve our interpretation and thus result in a more significant publication.
Diagram 1. a) $^{14}$C data through the bomb peak. The red line is a polynomial fit to the data. The yellow shading indicates the region where the additional $^{14}$C measurements are needed to constrain the position of the bomb peak. b) 25 $^{14}$C measurements over the longitudinal distance of 70 mm (~800 years based on initial U/Th age model) from the top of the stalagmite (x-axis). These values will be placed on an age scale once we have the final U/Th age model.

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