Coupled U-series and radiocarbon dating of a Chinese stalagmite from 15 to 33 ka: testing calibration applicability and dead carbon correction variability

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A high purity stalagmite from South China with minimal detrital component (based on $^{230}Th/^{232}Th$ ratios >4000) and an average growth rate of ~50 mm/ka has been carefully sampled along its growth axis for both U-series and radiocarbon measurements in a study to investigate its applicability for improving the database of radiocarbon calibration for the pre-dendro period (~12.4 ka). Our preliminary assessment is based on a set of 15 high-precision AMS ^{14}C-and 6 TIMS U-series samples spaced over the 37 cm length of the stalagmite to confirm an age range of 15 to 33 ka. TIMS U-series dates over this age range can be obtained to 0.5% at 2σ errors and as speleothems are composed of dense crystalline calcite, they are often less vulnerable to post-depositional alteration than corals. However an issue of serious concern in such an analysis is to evaluate whether the variability of the dead carbon fraction (DCF) over this time range reduces the reliability and quality of a speleothem-based calibration of atmospheric radiocarbon. The DCF represents the fraction of carbon derived from host limestone surrounding the cave that contains negligible ^{14}C and therefore offsets the ^{14}C date towards older ages. An assumption of a constant DCF, estimated by others to be ~16% for speleothems (based on matching to a well-constrained radiocarbon calibration curve from 11-15 ka) requires case-by-case verification.

Calendar ages for the positions taken for AMS ^{14}C samples were interpolated from adjacent U-series dates on the growth curve. These absolute ages were compared to the measured AMS ^{14}C ages and then overlain on the IntCal04 calibration curve. In broad terms, our preliminary results indicate that the growth rate, although continuous, was not linear over the period from 15 to 33 ka. In order to minimise the difference between our ^{14}C-ages and the IntCal04 curve from 26 ka to 15.6 ka, we required an average DCF of 18%. However, this value causes the younger half (<22 ka) to be 'too old' and the upper section (>22 ka) to be too 'young' indicating that DCF over the LGM period was probably not constant.

To further qualify the status of this stalagmite and decouple growth rate variability from that of the DC, a new set of 30 paired ^{230}Th - AMS ^{14}C-ages are in progress.