New horizons in U-series dating: Looking beyond the last glacial cycle

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A major impedance to understanding Earth's natural climate cycles is that it has only been possible to obtain accurately dated, high-resolution observations back through the last glacial cycle, spanning the last 130,000 years. Therefore, the last glacial cycle has received a disproportionate amount of attention relative to older climate cycles in Quaternary climate studies. For example, the Last Interglacial, or MIS 5.5, occurring ~125,000 years ago (ka) has been emphasized as an analogue of the present interglacial period, whereas the exceptionally long and warm MIS 11 interglacial, occurring at ~400 ka, may represent a more suitable analogue of the present climate regime for the purpose of speculating on future climate trends.

It is exceedingly difficult to obtain reliable age constraints for older climate episodes because of a progressive loss in the resolution of the chronometers as one goes further back in time, coupled to a lack of well-preserved dateable material. For older time periods, many U-series chronologies do not allow the timing of an interglacial maximum to be resolved from the preceding glacial minimum, nor do they allow abrupt climate epsisodes to be identified. The primary challenge is thus to devise new analytical protocols offering enhanced precision, to improve the resolution of the U-series chronometer and constrain the timing of climate change at a fine scale for older time periods.

During the last two decades, U-series measurement has advanced with the development of multiple-collector (MC) TIMS and ICP-MS. Despite this, U-series measurement precision has been limited to the one-permil (‰) level due to the large $>10^4$ atomic ratios between ^{238}U and its daughter nuclides, and the requirement for ^{234}U and ^{230}Th to be measured on electron multiplier detector systems that are inherently unstable.

Here, I present the results of recent MC-ICPMS studies that have focussed on dramatically improving measurement precision by up to an order of magnitude by measuring concentrated solutions at high intensity for a short (1-2 minute) duration. This enables simultaneous data collection on a stable multiple-Faraday array in place of the usual electron multiplier configuration. These new protocols allow 300 ka samples to be routinely measured with age uncertainties of ±1 ka (2σ) compared with previous error limits of up to 10 ka, and extend the upper limit of the U-series chronometer further back in time from ~500 to ~800 ka. Multiple-Faraday techniques therefore offer the potential to resolve the finer details of climate change during and beyond the last four glacial-interglacial cycles.