High-precision U/Th dating by MC-ICP-MS and its applications on carbonate samples

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We have set up U/Th dating techniques on a multi-collector inductively coupled plasma mass spectrometer (MC-ICP-MS, a Thermo Scientific Neptune Plus) at the Earth Observatory of Singapore, accompanying with an ultra-clean geochemistry laboratory for actinide element separation and purification. When the instrument is equipped with a large interface pump (OnTool Booster pump), Jet sample cone, and X-skimmer cone, and coupled with a CETAC Aridus II desolvating nebulizer system and a PFA ESI-50 nebulizer, we routinely obtain an ionization efficiency of ~4%. Using the SEM peak-jumping mode, we can achieve a precision of ±1–2‰ (2σ) for abundance determination of ~20 fg ^{234}U or ^{230}Th.

To test the robustness and accuracy of our measurements, we first refined the chemistry processes to reduce procedural blanks, and the chemistry blanks for ^{238}U, ^{232}Th and ^{230}Th can be routinely measured as 0.005 ± 0.005 pmol, 0.0005 ± 0.0005 pmol, and 0.0001 ± 0.0001 fmol, respectively. In addition to run the NBL-112A uranium standard solution on the instrument (δ^{234}U ~ -38.5 ± 1.0 ‰ in a year-long reproducibility), we further tested our chemistry and instrument methods using two carbonate samples with known ages. For a stalagmite sample collected in 2003 A.D. and with a fresh top, we obtained a U/Th age of 1996.8 ± 0.8 A.D. on a subsample about 4-6 bands below its top. For a living coral collected in 2013 A.D., we obtained 2002.5 ± 1.3 A.D. on the year band of 2003 A.D. For a secular equilibrium flowstone sample, we obtained values of δ^{234}U and (^{230}Th/^{238}U)-activity as 1.5 ± 1.5 ‰ and 1.0002 ± 0.0032, respectively. The U/Th dating methods have also been successfully applied to a variety of carbonate samples, including speleothems, corals (shallow water and deep sea), tufa, and soil carbonates.