Further Hf isotope evidence for Hadean continental crust

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Recent laser ablation (LA) and solution MC-ICPMS measurements of initial $^{176}Hf/^{177}Hf$ ratios of Hadean zircons from Jack Hills, Western Australia, revealed large positive and negative $\varepsilon_{Hf(T)}$ deviations that challenge the long-favoured paradigm of progressive growth of continental crust beginning at ~4 Ga. Specifically, negative ε_{Hf} values indicate development of a Lu/Hf reservoir consistent with continental crust formation, perhaps by 4.5 Ga. Positive ε_{Hf} deviations were interpreted to indicate early and widespread depletion of the upper mantle, consistent with inferences from $\Delta^{142}Nd$ studies. The diminution of $\varepsilon_{Hf(T)}$ deviations by ~4 Ga supports the Armstrong (1981) model in which ca. 4.5 Ga continental crust is rapidly recycled back into the mantle.

One strength of our analytical approach is the use of both LA and solution methods as the former permits spatially-resolved analysis with 60-80 μm diameter spots while the latter doesn't require peak stripping to correct for isobaric interferences. However, a source of uncertainty in our LA method is the need to relate an ion microprobe age – determined from an analysis pit ~2 orders of magnitude smaller than that sampled by LA – with the measured $^{176}Hf/^{177}Hf$. Previously we utilized the uniformity of the time-resolved $^{176}Hf/^{177}Hf$ signal, imaging studies, and a Pb-Hf mixing model to assess the reliability of assignment of $\varepsilon_{Hf(T)}$.

We carried out LA $^{176}Hf/^{177}Hf$ analyses using a Neptune MC-ICPMS on a further 67 Jack Hills zircons, largely in the age range 3.91-4.15 Ga, to enhance resolution of the transition between highly heterogeneous Hadean $\varepsilon_{Hf(T)}$ and the Archean. Most analyses involved coupled measurements of Hf and Pb isotopes during LA drilling. Typically this approach yields precise Hf isotope ratios (±45 ppm) and highly uniform and precise $(^{207}Pb/^{206}Pb)^*$ ages that are within uncertainty of the ion microprobe U-Pb date, thus confirming the general validity of our earlier approach. In such cases, we have a very high degree of confidence in relating initial $^{176}Hf/^{177}Hf$ to crystallization age. These results support our earlier interpretation that significant deviations in $\varepsilon_{Hf(T)}$ that developed during the early Hadean were largely re-homogenized by the onset of the Archean. No clear correlation between $\varepsilon_{Hf(T)}$ and temperature (from Ti thermometry) is seen in this dataset. Further analyses by solution MC-ICPMS are currently being undertaken.