Growth of continental crust begins in earnest at ~3.8 Ga

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The Hf isotope record provides one of the best constraints on the evolution of the early silicate Earth. Extracting reliable Hf isotope data from the Earth's oldest materials, however, is not always straightforward. Foremost among these is determining robust ages corresponding to the Hf isotope composition of a rock or zircon. This is particularly challenging for ancient gneisses which have been subjected to multiple tectonothermal events after their initial formation that may have introduced additional Hf components or, more commonly, affected the U-Pb zircon systematics.

Compilation of the best-constrained Hf isotope data (i.e. unambiguous age constraints, uncompromised by multiple components or open-system behavior) yields a relatively simple Hf isotope record. The most radiogenic Hf isotope compositions in this record are ~ chondritic from 4.5 to ~ 3.8 Ga and define a nearly linear evolution beginning with $\varepsilon_{Hf} = 0$ at 3.8 Ga to $\varepsilon_{Hf} \sim +16$ at present. We find no evidence for widespread mantle depletion—or extreme Hf isotopic heterogeneity—from the oldest samples.

Clearly there was formation of zircon-bearing crust in the Hadean as evidenced by the Jack Hills zircon data (e.g., [1] [2]) and the oldest crustal rocks such as at Acasta (e.g., [3-5]). Based on the Hf isotope record, however, the volume of this crust was minor. Two other lines of evidence support this: lack of older crust or inherited Hadean zircon cores in the geological record (e.g., [6]); and lack of Hadean zircons in nearly all Archean sedimentary rocks. If zircon-bearing crust existed in large volumes prior to 4.0 Ga, it was removed from the surface of the Earth, virtually without a trace.

Thus, the best constrained Hf isotope data show that the depleted mantle does not diverge from a CHUR-based silicate Earth until 3.8 Ga. This provides important limitations on the volume of stable crust that could have existed prior to 3.8 Ga.

[1] Amelin et al. (1999) Nature 399, 252-255. [2] Kemp et al. (2010) EPSL 296, 45-56. [3] Amelin et al. (2000) GCA 64, 4205-4225. [4] Iizuka et al. (2009) Chem Geol 259, 230-239. [5] Bauer et al. (2014) Fall AGU, V31A-4723. [6] Kemp et al. (2015) Precamb Res 261, 112-126.