Goldschmidt2017 Abstract

Growth of Earth's earliest crust: the perspective from the depleted mantle

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One of the tenets of solid Earth geochemistry is that the lithosphere has been extracted from the mantle. Thus, the record of depleted mantle evolution provides important constraints on the growth of the continents through time. The focus of this study is the Hf isotope record preserved in zircons from magmatic rocks. The reason for this is two-fold. First, by focusing on magmatic zircons we can constrain the crystallization age of the zircons—even in complexly-zoned grains. Second, we can tie the Hf isotope composition to the magmatic age. It is not possible to do this *unambiuously* for many detrital zircons. We highlight data from two well-studied remnants of Eoarchean crust: Greenland and Acasta. Greenland samples have relatively simple U-Pb and Hf isotope systematics with homogeneous ages and Hf isotope compositions. Ages range from ~3.82 to 3.64 Ga and all rocks in this period have initial Hf isotope compositions that are broadly chondritic. In contrast, the rocks and zircons at Acasta record a more complicated history. Zircons often have multiple age components that can span over 1 Ga. Initial Hf isotope compositions of the oldest samples imply a pre-4 Ga chondritic source that becomes more subchondritic with decreasing age [1-3] in a pattern reminiscent of the data from Jack Hills zircons [4]. There is no evidence for the existence of a depleted mantle reservoir in Eoarchean zircons from Greenland or Acasta. Globally, the best-constrained data from magmatic zircons illustrates a rather simple Hf isotope evolution for the Earth with growth of the depleted mantle beginning ($\varepsilon_{Hf} = 0$) at ~ 3.8 Ga and evolving to $\varepsilon_{Hf} \sim +16$ at present. This corresponds to $^{176}Hf/^{177}Hf = 0.283238$ and $^{176}Lu/^{177}Hf = 0.03976$ for the present-day depleted mantle reservoir. Finally, and most significantly, we see no evidence for widespread mantle depletion throughout most of the Eoarchean. These data argue against significant stabilization of continental crust prior to 3.8 Ga, in contrast to predictions from detrital zircons.

[1] Amelin et al. (2000) GCA 64, 4205-4225. [2] Iizuka et al. (2009) Chem Geol 259, 230-239. [3] Bauer et al. (2014) EPSL 458, 37-48. [4] Kemp et al. (2010) EPSL 296, 45-56.