Hadean mantle differentiation and early onset of plate tectonics: Evidence from ISB, SW Greenland

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The early chronology of Earth's crust-mantle system and the time of onset of mobile lid tectonics are matters of intense geological debate. The most insightful evidence for early evolution of Earth's mantle comes from the application of ^{146}Sm-^{142}Nd chronometer to Archean rocks carrying ^{142}Nd/^{144}Nd anomalies relative to modern terrestrial mantle. The large range in the reported μ^{142}Nd compositions, however, point to the possible effect of analytical artefacts. Moreover, the revision of Bulk Silicate Earth Nd-isotope composition warrants that the early chronology of silicate Earth derived using ^{146}Sm-^{142}Nd systematics be revisited [1].

We report the Nd-isotope composition of Eoarchean amphibolites and gneisses as well as Paleoarchean Ameralik dykes sampled from Isua Supracrustal Belt, SW Greenland and measured using an ultra-high-precision MC-ICPMS analytical protocol [2]. The ~3.8 Ga rocks record identical μ^{142}Nd compositions within uncertainties, defining a mean value of 11.0±0.5 ppm (n=11, 2σ). These data indicate the existence of a pervasive and homogenous ^{142}Nd signal in ~3.8 Ga Isua rocks irrespective of lithology. Similarly, the ~3.4 Ga Ameralik dykes carry small and identical μ^{142}Nd excesses corresponding to a mean of 4.8±0.5 ppm (n=11, 2σ), in contrast to an ealier study that reported μ^{142}Nd compositions as negative as -10 ppm for Ameralik dykes [3]. We interpret the time-varying μ^{142}Nd signature preserved in the ~3.8 and ~3.4 Ga Isua rocks to represent gradual homogenization of a mantle reservoir created in the Hadean. The coupled ^{146,147}Sm-^{142,143}Nd systematics for the metabasalts yield a model age for the formation of Isua mantle reservoir of 4440±50 Myr, coinciding with the estimated ages for the putative Moon-forming giant impact. We suggest that the Isua mantle reservoir represents crustal extraction in the magma ocean that followed the giant impact. Using a statistical crust-mantle model, we find that the mantle mixing timescale of ~1 Ga defined by the Isua Archean rocks is consistent with crustal residence times on the order of ~200 Myr. Such mantle mixing rates are best explained by onset of plate tectonic-like geodynamics near to the Hadean-Archean boundary.

[1] Burkhardt *et al*. (2016) *Nature* **537**, 394 [2] Saji *et al*. (2016) *JAAS* **31**, 1490 [3] Rizo *et al*. (2012) *Nature* **491**, 96

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