Non-chondritic ^{142}Nd and Archean ^{142}Nd and ^{182}W variability reconciled by magma ocean crystallization and overturn

STEPHANIE BROWN[1], LINDA T. ELKINS-TANTON[2] AND RICHARD J. WALKER[3]

[1]MIT, Cambridge, MA 02139, USA (brownsm@mit.edu)
[2]DTM, Carnegie Inst. Science, DC 20015, USA
[3]UMD, College Park, MD 20742, USA

The best mechanism to explain the observed Archean coupled evolution of the short-lived ^{146}Sm → ^{142}Nd and ^{182}Hf→ ^{182}W systems is crystal-liquid fractionation. Thus, magma ocean processes could explain both Archean isotopic variability and the deviation of ^{142}Nd between the Earth's accessible mantle and chondrites. The model presented here indicates that generating the isotopically-required early reservoirs is a likely outcome of magma ocean crystallization and overturn of shallow enriched dense (i.e. gravitationally unstable) cumulates. The magma ocean solidification code of [1] and a modified Monte Carlo algorithm, designed to randomly choose physically reasonable trace element partition coefficients in crystallizing mantle phases, are used to model the isotopic evolution of potential early Earth reservoirs. Successful runs in the Hf-W system suggest that the most likely timespan for core formation on Earth is between 30 and 80 Myr after Solar System formation, with a peak at 40 Myr. This time window shifts earlier when more W is included in the bulk silicate Earth composition. The high iron-composition and density of the enriched reservoir is compatible with large low-shear velocity provinces (LLSVPs) seismic observations (i.e. [2]), and any melts are likely to remain isolated deep (i.e. [3]), suggesting that the presently observed LLSVPs could be fully or partially composed of remnants of an early enriched reservoir.

[1] Elkins-Tanton (2008) *EPSL* **271**, 181-191 [2] Trampert *et al* (2004), *Science* **306**, 853 [3] Thomas *et al* (2012) *JGR* **110**, B10206.