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Terrestrial variation in ^{142}Nd/^{144}Nd and implications for early mantle dynamics

M. Boyet (1) and R.W. Carlson (2)

(1) Laboratoire Magmas et Volcans, UMR CNRS 6524, OPGC, Université Blaise Pascal, 5 rue Kessler, 63038 Clermont-Ferrand, France, (2) Dep. Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Rd., N.W., Washington, D.C. 20015, USA
(boyet@opgc.univ-bpclermont.fr)

Variations in the 142Nd/144Nd ratio of terrestrial, lunar, martian and asteroidal materials caused by the decay of 103 Myr half-life 146Sm show that early differentiation of the silicate portions of planetary objects is the rule rather than the exception. The transition from 142Nd/144Nd approximately 35 ppm higher than chondritic in early Archean rocks from Isua (Caro et al., GCA, 2006; Boyet and Carlson, EPSL, 2006; Bennett et al., 38th LPSC, 2007) to the 20 ppm excess measured in rocks younger than 3.5 Ga (Boyet and Carlson, Science 2005) suggests that the silicate differentiation generated probably within 30-50 Ma of Earth formation was followed by a period of mixing between LREE enriched and depleted reservoirs. To reach 142Nd/144Nd as high as 35 ppm above chondritic, a147Sm/144Nd ratio of at least 0.22 is needed. Because this value is similar to the Sm/Nd ratio needed to explain the elevated initial 142Nd/144Nd and 143Nd/144Nd of ancient lunar crustal rocks (Boyet and Carlson, EPSL, 2007), we suggest that extensive differentiation of the Earth through a magma ocean event was completed before the Moon formed. Variations of terrestrial 142Nd/144Nd through time could be explained by varying rates of mantle convection in the early Earth. The rapid crystallization of the magma ocean leaves a buoyantly unstable cumulate pile that then overturns rapidly (e.g. Elkins-Tanton et al., EPSL, 2005). After the overturn, the mantle has cold dense material underlying buoyant hot material, which inhibits mantle convection until 3,8 Ga, when internal heating overwhelms the chemical buoyancy. Between 3.8 and 3.5 Ga, the relatively rapid mixing

between high- and low-Sm/Nd reservoirs suggests that by 3.8 Ga, this inhibition had been removed and that convection throughout a large portion of the mantle had begun.