$^{142}Nd/^{144}Nd$ variations in mantle-derived rocks and implications for mantle mixing

EUGENIA HYUNG[1] AND STEIN B. JACOBSEN[2]

[1]California Institute of Technology, 1200 E. California Blvd, Pasadena, CA 91125 (ehyung@caltech.edu)
[2]Harvard University, 20 Oxford St., Cambridge, MA 02138

Early silicate differentiation events for the terrestrial planets can be traced with the short-lived ^{146}Sm-^{142}Nd system (~100 Myr half-life). Owing to the lack of radiogenic ingrowth beyond the first 500 Myrs of Solar System formation, $^{142}Nd/^{144}Nd$ variations are also an excellent tracer of mantle mixing. Evidence for early silicate differentiation has been provided by $^{142}Nd/^{144}Nd$ measurements of Hadean (4.6 to 4.0 Ga) rocks that show both higher and lower values than the present day mantle, demonstrating major silicate Earth differentiation within the first 100 Myr of the Solar System. We present $^{142}Nd/^{144}Nd$ measurements with a 2σ at ±1.7 ppm external precision to constrain $^{142}Nd/^{144}Nd$ heterogeneity in the mantle for the last 2 Ga. We found that most modern MORBs and OIBs as well as continental crustal rocks as old as 2 Ga are within ±1.7 ppm of the average Earth $^{142}Nd/^{144}Nd$-value, in contrast to the Archean where $^{142}Nd/^{144}Nd$ heterogeneities (~±20 ppm) are the rule rather than the exception. Thus, it may be deduced that the mantle has largely developed a homogeneous $^{142}Nd/^{144}Nd$ signature at the level of ±1.7 ppm. The rapid changeover of large $^{142}Nd/^{144}Nd$ variations to a relatively homogeneous signature between 2 and 2.7 Ga is a reflection of mixing processes that have persisted in the mantle through the Archean and Hadean, rather than evidence for a change in the mode tectonics following this time. Existing crustal formation and recycling models are demonstrated to be inadequate in describing the expression of $^{142}Nd/^{144}Nd$ heterogeneity throughout the Archean. Applying a stochastic mantle mixing model, we show that the $^{142}Nd/^{144}Nd$ evolution of the mantle is consistent with a mantle stirring time of about 500 Myr since the early Hadean, with a preference for faster mixing rates having persisted since then. Such a scenario may be considered to be consistent with the Earth's thermal and chemical evolution being largely regulated by plate tectonics for most of its history.