Early mantle dynamics inferred from ^{142}Nd variations in Archean rocks from southwest Greenland

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Because of the limited geological record, the composition and evolution of the silicate Earth during the Hadean/Eoarchean is widely debated and largely unknown. The short-lived ^{146}Sm-^{142}Nd chronometer applied to 3.7-3.8 Ga old rocks from Greenland has revealed excesses of ^{142}Nd (10-20 ppm) compared to modern samples and terrestrial Nd standards [1-7]. Since the parent isotope, ^{146}Sm, was extant only during the first few hundred million years of the Solar System, this implies that the Greenland samples were derived from a source formed in the Hadean. Combining ^{146,147}Sm-^{143,142}Nd systematics, we have estimated the differentiation age of the reservoir of Greenland rocks (amphibolites from the Isua region) to be between 4.53 and 4.42 Ga [1]. Here we present our ^{146}Sm-^{142}Nd data for a suite of mantle-derived samples with ages of 3.8, 3.7, 3.4 and 3.3 Ga, also collected in the Isua region. Covering over 500 million years of the early history of the Earth, they offer a unique opportunity to constrain the compositional evolution and dynamics of the early Earth mantle. The different groups of rocks were dated with the Sm-Nd and Lu-Hf isotope systems on whole-rocks, and by U-Pb analysis of rare zircons found in some of the samples. Preliminary results reveal ^{142}Nd anomalies in 3.4 Ga rocks, while the ^{142}Nd record of primordial heterogeneities in the Isua mantle source seems to have been completely erased after 3.3 Ga. Therefore, the chemical heterogeneities detected in the southwest Greenland mantle and inferred to have formed during the 4.53-4.42 Ga period appear to have resisted mixing by mantle convection until at least 3.4 Ga. These results add strong constraints on mantle dynamics during Earth's early history and the survival/mixing timescale of mantle heterogeneities.

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Paleo-marine trace element partitioning relationships recorded in Precambrian Iron Formations

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Ancient metalliferous sediments such as Precambrian Iron Formations (IF) retain geochemical signatures of the composition of the seawater from which they precipitated. Recent efforts to back-calculate paleo-marine trace element abundances from these signatures [1,2,3] have utilized the distribution coefficient (K_D), a special case of the Freundlich isotherm where the Freundlich exponent equals one and sediment concentrations (c_s) are linearly related to aqueous concentrations (c) by the factor $K_D = c_s / c$. However, only a few IF-applicable K_D values have been proposed to date, all were adopted from modern seawater [1] or experimentally estimated [2,3], and their applicability to Precambrian oceans has been assumed. The growing IF trace element record itself has not been thoroughly evaluated for geochemical relationships that should exist after trace element adsorption to Fe oxides, for example scaling with Fe. Here we describe the analysis of a large IF geochemical dataset for evidence of partitioning relationships preserved by the rock record itself. As might be expected, insoluble elements such as Al, Ti, Hf, and Sc show inverse Fe scaling behaviour that follows crustal mixing lines, reaffirming their detrital origin. Many trace elements in IF of presumed seawater origin do indeed scale with Fe in a manner consistent with simple partitioning onto iron oxides. Fe scaling relationships are often best represented in the data at maximal c_s, where K_D-respecting trace element partitioning and open system conditions appeared to prevail. Apparent deviations below these maxima may signify that drawdown of trace elements occurred at times as the result of prolonged iron oxide precipitation. From our data it is possible to estimate the lumped factor K_D*c that directly characterizes paleo-marine elemental partitioning; we briefly evaluate the implication of these apparent factors for select trace elements. This work represents a first step towards a more vigorous exploration of metalliferous proxies for paleo-marine trace element evolution.

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