Extinct Nuclide Decay Product Heterogeneities in the Earth: Their Creation and Destruction

STEIN B. JACOBSEN[1]

[1]Dept. of Earth & Planetary Sciences, Harvard University, Cambridge, MA, 02138, USA (jacobsen@neodymium.harvard.edu)

Isotopic variations due to decay of extinct nuclides (^{129}I ($t_{1/2}$=15.7 Myr), ^{244}Pu ($t_{1/2}$=80 Myr), ^{182}Hf ($t_{1/2}$=8.9 Myr) and ^{146}Sm ($t_{1/2}$ = 68 Myr)) record differentiation processes active primarily during the first ~240 Myrs of Earth history. The now well established ^{129}Xe, ^{136}Xe, ^{182}W and ^{142}Nd variations in the Earth are the preserved record of accretion, core formation, magma ocean differentiation and early crust formation. They were produced when I/Xe, Pu/Xe, Hf/W and Sm/Nd ratios were fractionated between distinct reservoirs at very early times when the parent nuclides (^{129}I, ^{244}Pu, ^{182}Hf and ^{146}Sm) were still live. If such reservoirs did not experience significant inter-reservoir transport and isotopic rehomogenization, then chronological information of the early reservoir-forming differentiation would be imprinted into the isotopic composition of the reservoir and remain *indestructible* with respect to all intra-reservoir processes. While heterogeneities in ^{182}W and ^{142}Nd are only found in Hadean and Archean rocks, heterogeneities in ^{129}Xe and ^{136}Xe persist up to the present in zero-age MORBs and OIBs. This suggests that some heterogeneities are destroyed and some are not. According to the "deep magma ocean" core formation process, the early Earth would have a two-reservoir mantle structure with different ^{129}Xe/^{130}Xe, ^{136}Xe/^{130}Xe, ^{182}W/^{183}W and ^{142}Nd/^{144}Nd ratios in each reservoir. A model for such a scenario has been developed for evaluating the evolution of such an initially layered mantle into a heterogeneous mantle by convection. This model uses a mantle heterogeneity scale that is exponentially decreasing over time, due to deformation and stretching of the initial reservoirs by mantle turbulence. A characteristic time scale of stirring of ~500 Myrs is consistent with the ^{182}W and ^{142}Nd isotopic data. The persistence of the Xe isotope heterogeneities up to the present requires isolation, at least partial, of a portion of the primordial lower mantle from the main convective part of the mantle. It is this early isolated part of the lower mantle that is now contributing to the extinct Xe isotopic variations in modern basalts.