Early differentiation of terrestrial reservoirs and extinct radioactivities

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The formation of the core, the atmosphere and the isolation of the first proto-crust in the Earth seem to have taken place in the first hundred million years after the beginning of the Solar System. Yet, these timescales of these events are probably overlap and hence, the isotopic systems that are used for the respective chronology are not independent. For example, it has been argued that core formation requires a partially molten mantle and crust formation could result from the late stage of magma ocean crystallization

The timescale of the first crustal extraction (4,460±115 Ma) as evidenced by recent measurements of ^{142}Nd anomalies in Isua rocks (Caro et al. 2003), is not very precisely defined but if it predates 4,48 Ga, then this event could have affected Hf-W systematics in the silicate Earth and should be taken into account for assessing the age of core formation. Crustal extraction is also likely to affect I-Xe systematics since I is efficiently extracted during in melts.

In this contribution, we examine with a three-box model including accretion (with equilibration) how an early crustal growth would affect Hf-W systematics. An early crustal formation could result in Hf/W fractionation in the crust-mantle system and W anomalies detectable in Archean rocks.

Reference

G. Caro, B. Bourdor, JL Birck, S. Moorbath, (2003) *Nature* 6938, 428-431.

Remains of an enriched Hadean protocrust in modern mantle

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Applications of short-lived ^{146}Sm-^{142}Nd (half-life of 103 Ma) and long-lived ^{147}Sm-^{143}Nd (half-life of 106 Ga) coupled isotope systems in early Archaean rocks have indicated that mantle differentiation occurred 50 to 200 Ma after the formation of the earth and produced depleted silicate reservoirs with high Sm/Nd ratios. The nature and fate of the protocrust, with complementary low Sm/Nd ratios, is unknown. Two relevant models are: (1) a stagnant lithospheric lid of the magma ocean consisting dominantly of depleted mafic-ultramafic lithologies. This model proposes that the low Sm/Nd protocrust did not form and therefore no terrestrial sample should display a deficit in ^{142}Nd. (2) Burial of early enriched (low Sm/Nd) crust into the deep mantle. This model suggests that early crust was foundered into the lower mantle leaving behind a depleted upper mantle. If protocrust is preserved in the lower mantle some of the lower mantle derived plume material should possess negative ^{142}Nd anomalies.

Here, we present ultraprecise measurements of Nd isotopes in 65 Ma old Deccan Traps lavas, which sample the deep mantle, the asthenospheric mantle and the subcontinental lithospheric mantle. We show that samples representing magma from deep mantle plume give no evidence of the existence of the protocrust at the core-mantle boundary and that the samples with lithospheric component give a negative ^{142}Nd anomaly with μ^{142}Nd $(=[(^{142}Nd/^{144}Nd)_{meas} / (^{142}Nd/^{144}Nd)_{nNd\text{-}\beta} -1)] \times 10^6)$ values ranging from -10 to -12 ppm. It follows that if the Deccan starting plume was isotopically homogeneous, a portion of Hadean protocrust resided in the ancient Indian subcontinental lithospheric mantle.