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The Early History of the Silicate Earth

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Because unlike Mars and the Moon, the first ˜500 Ma of Earth's history has left no rock-record, the first stage evolution of the planet is a subject of intense debate. On Earth, with the exception of U-Pb and Hf-W that are affected by core formation, the effect of early differentiation of the silicate earth on conventional radiometric systems (Rb-Sr, Sm-Nd, Lu-Hf, and U-Th-Pb) is sufficiently subtle that it has been masked by the continuing differentiation of Earth's interior caused by growth of the continental crust. Sm-Nd systematics with its two decay schemes, 146Sm-142Nd (T1/2=103 Ma) and 147Sm-143Nd (T1/2=106 Ga) represents one of the most powerful tracers of the early differentiation. The detection of excess 142Nd in all terrestrial rocks compared to chondrites suggests that the silicate earth experienced an early differentiation event prior to ˜4.51 Ga. Since this event, the outer portion of the Earth slightly would be depleted in refractory incompatible lithophile elements compared to chondritic estimates. If the bulk-silicate earth has chondritic relative abundances of the refractory lithophile elements, then there must exist within Eart's interior an incompatible element enriched reservoir that contains roughly 40% of Eart's 40Ar and heat producing radioactive elements. The existence of this enriched reservoir is also demonstrated by time-varying 142Nd/144Nd in Archean crustal rocks. The data provide the strongest evidence yet for the presence of early-formed incompatible element enriched and depleted reservoirs within the Earth.