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The evolution of the early Earth investigated through the ^{147,146}Sm-^{143,142}Nd and ^{176}Lu-^{176}Hf isotope systems

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The early Earth throughout the Hadean eon has been difficult to explore due to the dearth of physical samples preserved from this time. However, isotope signatures preserved in zircons and rocks from the earliest Archean provide a window into the differentiation and evolution of the early Earth. In particular, the short-lived ^{146}Sm-^{142}Nd system is an excellent tracer for early planetary differentiation processes and subsequent mixing, whereas the long-lived ^{147}Sm-^{143}Nd and ^{176}Lu-^{176}Hf systems have been used to trace crust-mantle differentiation processes, and their subsequent evolution through crustal growth and recycling. Crustal growth and recycling is linked to plate tectonics and the onset of this process is under debate.

Crustal growth and the crystallization of a magma oceans leads to different patterns of Sm/Nd and Lu/Hf fractionation during the early Earth. The ε^{143}Nd isotope signatures corresponding to the complementary depleted and enriched reservoirs of the silicate Earth are established to increase and decrease monotonically, respectively. In contrast, negative ε^{176}Hf isotopes are dominant in Hadean detrital zircons in contrast to the Archean. These observations along with ε^{176}Hf signatures, which are decoupled from ^{143}Nd isotopes in early Archean whole rock samples despite their coupling in crustal formation processes later in Earth history, imply a process or a distinct set of conditions during the early Earth.

We investigate the effects of both crustal recycling and mixing subsequent to magma ocean crystallization to understand the underlying processes that would have governed the evolution of the long-lived lithophile ^{147}Sm-^{143}Nd and ^{176}Lu-^{176}Hf systems throughout the Hadean and Archean. The magnitude of ε^{143}Nd and ε^{176}Hf isotopes may be attenuated through crustal recycling, implying the involvement of a process such as plate tectonics. Alternatively, the change of behavior of ε^{176}Hf isotopes from the Hadean through Archean may be attributed to mantle mixing processes that governed the evolution of the ^{142}Nd/^{144}Nd isotope record. The ε^{143}Nd and ε^{176}Hf isotope records of both the enriched (crustal) and depleted (mantle) reservoirs involving the zircon and rock records will be explored.