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Mixing times of the Archean mantle: evidence from 2.7 Ga komatiites

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Despite numerous high-precision Nd, Hf, W, and Os isotopic and HSE abundance data obtained for early terrestrial rocks, many questions pertaining to the origin and timing of the primordial differentiation and mixing of the mantle are still open. Recent isotopic studies of Archean komatiites have shown that the terrestrial mantle remained poorly mixed until at least the end of the Archean [1-4]. We present new Nd, Hf, W, and Os isotopic and HSE abundance data for the Boston Creek (BK) komatiitic basalt lava flow in the 2.7 Ga Abitibi belt, Canada. This lava is characterized by strong depletions in heavy REE and Al, enrichment in light REE, and coupled initial ε^{143}Nd = +2.5±0.2 and ε^{176}Hf = +4.2±0.9, indicating derivation from a deep mantle source with time-integrated suprachondritic Sm/Nd and Lu/Hf ratios. The Boston Creek samples plot on the terrestrial Nd-Hf array suggesting minimal involvement of early magma ocean processes in the fractionation of lithophile trace elements in the BK mantle source. This conclusion is supported by an average ^{142}Nd/^{144}Nd that is unresolvable from the terrestrial standard (μ^{142}Nd = −3.9±2.8). At the same time, the lava exhibits a positive ^{182}W anomaly (μ^{182}W = +11.5±4.5 ppm) and is characterized by chondritic γ^{187}Os = +0.1±0.3, while low HSE abundances (36±2% of those estimated for the present-day Bulk Silicate Earth) are inferred for its mantle source. The deficit in HSE in the source of these komatiites, coupled with the chondritic Os isotopic composition and the positive ^{182}W anomaly, are best explained by grainy late accretion of chondritic materials to Earth, as has previously been suggested for early Archean supracrustal rocks [5]. According to our model, the mantle domain that gave rise to the BK lava received only about 36% of the present-day HSE complement of the total BSE budget before becoming isolated from the rest of the convecting mantle until the time of komatiite emplacement at 2.7 Ga. These new data suggest sluggish mixing of the Archean mantle and provide supporting evidence for a stagnant-lid plate tectonic regime prior to the onset of modern-style plate tectonics.

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