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Iron isotopes trace primordial magma ocean cumulates melting in the Earth's upper mantle

HELEN M WILLIAMS[1], SIMON MATTHEWS[2], HANIKA RIZO[3] AND OLIVER SHORTTLE[1]

[1]University of Cambridge
[2]University of Iceland
[3]Carleton University

Presenting Author: hmw20@cam.ac.uk

The differentiation of the Earth ~ 4 Ga is believed to have culminated in magma ocean crystallization, crystal-liquid separation and the generation of mineralogically distinct reservoirs in the mantle [e.g., 1]. However, the magma ocean model remains difficult to validate due to the scarcity of geochemical tracers of lower mantle mineralogy. The Fe isotope compositions (δ^{57}Fe) of ancient mafic rocks can be used to reconstruct the mineralogical evolution of their mantle source regions [2-3]. We present Fe isotope data for well-characterised 3.7 Ga metabasalts from the Isua Supracrustal Belt [4-5]. The δ^{57}Fe signatures of these samples are elevated relative to modern equivalents and define striking correlations with fluid-immobile trace elements and tungsten isotope anomalies (μ^{182}W). Phase equilibria models demonstrate [e.g., 6] that these features can be explained by melting of a magma ocean cumulate component in the upper mantle. Similar processes may operate today, as evidenced by the δ^{57}Fe and μ^{182}W heterogeneity of modern oceanic basalts [7-8].

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