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Ancient residual lithosphere at the Marion Rise: Evidence from Hf-Nd isotope systematics in basalts and peridotites

DOMINIC WOELKI[1], CHRISTOPH BEIER[2], HENRY J B DICK[3], ANDREAS STRACKE[4] AND VINCENT SALTERS[5]

[1]Texas A&M University
[2]University of Helsinki
[3]Woods Hole Oceanographic Institution
[4]Universität Münster
[5]National High-Magnetic Field Laboratory/FSU

Presenting Author: dominikwoelki@tamu.edu

The Marion Rise (MR) at the Southwest Indian Ridge (SWIR) is an ultraslow spreading ridge with thin oceanic crust, shallow ridge depth, low volcanic activity and oceanic mantle exposed. The eastern SWIR is deeper and has wide areas of exposed peridotite (Sauter et al., 2013). Clinopyroxenes from peridotites show large variations and extend to extreme e_{Nd} values of 93.7 and e_{Hf} of 451.5. These are some of the most extreme values for oceanic mantle and confirm the ultra-depleted nature of the MR mantle. Yb in clinopyroxene (0.2 – 2.4) is negatively correlated with Cr# of the spinel (11 to 52) but not with $e_{Hf,}$ indicating an ancient depletion event. The MR basalts show large variations in Hf-Nd isotopic compositions, with highly radiogenic e_{Nd} up to 9.1. Hf-isotopic compositions are decoupled from Nd with e_{Hf} up to 25.2, at relatively unradiogenic Nd resulting in a deviation of Δe_{Hf} = 15. These are some of the most depleted isotopic compositions recorded in Indian Ocean MORB. The depleted isotope signatures of the peridotites combined with the strongly decoupled Hf-Nd systematics in the basalts is best explained by the presence of ancient residual lithosphere (ReLish).

Recently found highly vesicular off-axis basalts tend towards low e_{Nd} of -8.0 and e_{Hf} of -8.7, overlapping with crustal granulites from the African craton. The MR basalts seem to be a mixture of several lithologies, of which one has unradiogenic Hf-Nd isotope systematics, and one with an ultra-depleted character. Apart from proving mantle heterogeneity, it also indicates the presence of an ultra-depleted mantle. The occurrence of this ultra-depleted mantle in the basalts indicate this mantle is a volumetrically significant portion (>50%) of the sub ridge mantle. This depleted less dense mantle is refractory and enhances the melting of more enriched components present in low abundance and is likely the explanation for the shallow ridge depths and high heterogeneity along the MR.

Ultra-depleted mantle has now been observed at multiple locations, indicating it is a ubiquitous component in the sub-ridge mantle and its thermal implications on melting processes need to be considered.