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Melting beneath the East Pacific Rise, 9º-10º N: Implications from Combined Nd-Hf-Sr-Th Isotopic Measurements

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Mid-ocean ridge basalts show significant excesses of ^{230}Th over ^{238}U. These ^{230}Th excesses require that the mantle source retain U relative to Th during partial melting. Based on existing mineral-melt partitioning data which indicate that U is more compatible than Th in garnet, it is generally believed that these large ^{230}Th excesses indicate melting in the presence of garnet. The extent to which this "garnet signature" represents melting of garnet peridotite versus garnet pyroxenite is an unresolved question in geochemistry which has important implications regarding the depth and dynamics of the melting process.

Interpretation of ^{230}Th excesses in basalts is highly dependent on the bulk partition coefficients for U and Th and therefore the composition of the mantle source. Distinguishing between the effect of melting processes versus the effect of variable source compositions on measured ^{230}Th excesses requires measurement of longer-lived radiogenic isotopes (e.g. Hf, Nd, Sr, and Pb). Here we report Hf, Nd and Sr isotopic measurements for a suite of 20 young MOR basalts from the East Pacific Rise (9º-10º N) which we have previously characterized in terms of ^{238}U-^{230}Th-^{226}Ra and ^{235}U-^{231}Pa disequilibria and major- and trace-element compositions. These samples were collected exclusively within the axial summit caldera trough, between 9º 30'N and 9º 52'N, by the submersible ALVIN, and their young ages (<100 yrs) are confirmed by observed field relations and by Po-Pb ages. ^{230}Th excesses (1.10-1.19) and ^{226}Ra excesses (2.01-2.92) are variable and inversely correlated. ^{231}Pa excesses are less variable (2.49-2.63) and positively correlated with ^{230}Th excesses. ^{226}Ra excesses are negatively correlated with Na_8, Fe_8, and La/Yb and positively correlated with Mg#, whereas ^{230}Th excesses are positively correlated with Na_8, Fe_8 and La/Yb and negatively correlated with Mg#. Th/U (2.45-2.60) and ^{230}Th/^{232}Th (1.36 - 1.43) are also variable and correlated. Nd, Hf, and Sr isotope ratios are constant: ε_{Hf} ranges from 14.3-15.0; ε_{Nd} ranges from 10.2 - 10.7 and ^{87}Sr/^{86}Sr ranges from 0.70244 - 0.70257.

The constant Hf, Nd and Sr isotopic ratios measured in these samples indicate they were derived from a common source. This observation suggests that the measured variations of Th/U and ^{230}Th excesses are best explained by polybaric melting of a homogeneous source and not the mixing of compositionally distinct sources. Thus, it is unlikely that garnet pyroxenite veins (which would have a distinct isotopic signature) have mixed with ambient peridotitic mantle to produce the compositional variability observed in these basalts.