Producing U-series disequilibria through ultraslow crustal accretion

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^{238}U-^{230}Th-^{226}Ra disequilibria measurements on 12 dredged glasses from between 9-25º E on the SW Indian Ridge show highly variable U-series systematics. The suite as a whole exhibits a large range in ^{230}Th/^{232}Th and ^{238}U/^{232}Th, covering nearly the entire extent of variability seen in the global MORB U-series database. Glasses from the oblique supersegment show the most enriched compositions (^{230}Th/^{232}Th = 0.8 and ^{238}U/^{232}Th = 0.76) of any MORB measured but have minor ^{230}Th excesses (<9%) or small ^{238}U excesses (~3.5%). In contrast, Th excesses in lavas from the orthogonal supersegment vary from 2–29%, but show no systematic trend and do not appear to be correlated with any other geochemical tracers. The same holds for (^{230}Th/^{238}U) on the oblique supersegment.

However, ^{230}Th/^{232}Th and ^{238}U/^{232}Th are correlated with Sr, Nd, and Hf isotopic compositions, indicating that Th isotopic compositions and U/Th reflect similar source heterogeneity. δSm/Nd and δLu/Hf are calculated trace element parameters used as proxies for total % melting and % melting in the garnet stability field, respectively. When plotted against Th excess, orthogonal supersegment lavas show variable but increasing (^{230}Th/^{238}U) with slightly increasing δSm/Nd and δLu/Hf. On the other hand, the oblique supersegment lavas show increasing (^{230}Th/^{238}U) correlated with decreasing δSm/Nd and δLu/Hf. This broadly suggests that the deeper the melting the lower the Th excess, and the larger the F the larger the Th excess.

Our data do not support the idea that Th excess is a function of spreading rate or axial depth, as initially proposed by Lundstrom et al., 1998 and Bourdon et al., 1996, respectively. However, SW Indian Ridge ^{230}Th/^{232}Th and ^{238}U/^{232}Th compositions do correlate with Sr, Nd, and Hf isotopic compositions, suggesting temporal equilibration of these isotopic systems.

References

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Diffusive fractionation of ^{226}Ra-^{230}Th in oceanic basalts during shallow level interaction

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Complex melting and percolation models with a two-porosity system have been proposed to explain the high ^{226}Ra excess in oceanic basalts and the observed inverse correlations of the ^{226}Ra excess with the ^{230}Th excess and with the trace element enrichment of MOR lavas [1]. We have offered an alternative hypothesis that interaction of primitive melts with MORB cumulates (troctolites or wehrlites) could be responsible for those geochemical signatures [2]. However, our previous model considered the interaction of a melt with only one solid phase (plagioclase or clinopyroxene). Here, we present the results of a more realistic model that considers the diffusive interaction among a melt and multiple solid phases (plagioclase and clinopyroxene) [3]. Our calculations suggest that diffusive interaction between gabbros and basalts can explain the observed inverse correlation of the (^{226}Ra/^{230}Th) ratios with the (^{230}Th/^{238}U) ratios in MORBs, and with the tarce element enrichment of oceanic basalts. Furthermore, in contrast to the two-porosity model, our model gives a simple explanation for the lack of high ^{226}Ra excess (generally < 1.7) observed in oceanic island primitive melts.

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