^{238}U and ^{230}Th excesses in Kolbeinsey Ridge Basalts

K. SIMS[1], N. MATTIELLI[2], T. ELLIOTT[3], P. KELEMEN[1], D. DEPAOLO[4], D. MERTZ[5], C. DEVEY[6],

[1] WHOI, Woods Hole, MA 02543 (ksims@whoi.edu)
[2] Universite de Bruxelles, Brussels, Belgium
[3] Univeristy of Bristol, Bristol, UK
[4] U.C. Berkeley, Berkeley, CA 94720
[5] Universitaet Mainz, Mainz, Germany
[6] University of Bremen, Germany

Here we report new measurements of U-Th disequilibria, coupled with our previous measurements of Nd, Sr and Pb isotopes and major- and trace-element compositions for young basalts (< 10 ka) from the slow-spreading (~1 cm/yr. half-spreading rate) Kolbeinsey Ridge (67°05'– 70 °26'N), north of Iceland. These young basalts show significant ^{238}U excesses {(^{230}Th/^{238}U)<1} and ^{230}Th excesses {(^{230}Th/^{238}U) > 1}, with (^{230}Th/^{238}U) ranging from 0.95 to 1.24. The samples (^{230}Th/^{232}Th) are essentially constant (1.25 – 1.29), but there is a large range in (^{238}U/^{232}Th) (1.00 to 1.32); therefore these data lie on a horizontal array on a (^{230}Th/^{232}Th)- (^{238}U/^{232}Th) isochron plot. Normalized trace element abundances indicate that all samples are highly depleted {e.g. (La/Yb)n < 0.4}. The samples with ^{238}U excesses have the lowest Th concentrations, compatible with either shallow mantle melting or shallow mantle-melt rock reaction. These samples Nd and Sr isotopic compositions are not correlated with (^{230}Th/^{238}U), and fall into two groups, relative to their proximity to Iceland- samples So. of the Spar fracture Zone tend to be more isotopically enriched, whereas samples from No. of the Spar fracture zone seem to come from a more isotopically depleted source.

The lack of a correlation between these samples Nd and Sr IC's and their (^{230}Th/^{238}U), suggests that the measured variability in U/Th and (^{230}Th/^{238}U) is best explained by melting processes and not the mixing of melts from enriched (pyroxenitic) and depleted (peridotitic) mantle sources. This constraint has important implications for models which relate the slope of (^{230}Th/^{232}Th) -(^{238}U/^{232}Th) data arrays, for individual ridge segments (as defined by their first order segmentation data), to their solid mantle upwelling rate, as these models require mixing of enriched and depleted melts from chemically heterogeneous mantle sources.

Consequences of Diffuse and Channelled Porous Melt Migration on Uranium Series Disequilibria.

M. JULL , P. KELEMEN, K. SIMS

[1]Woods Hole Oceanographic Institution, Woods Hole, MA, USA, jull@whoi.edu; peterk@whoi.edu; ksims@whoi.edu.

Magmas erupted at mid-ocean ridges (MORB) result from decompression melting of upwelling mantle. However, the mechanism of melt transport from the source region to the surface is poorly understood. It is debated whether melt is transported through melt-filled conduits or cracks on short time scales (~10^3 yrs), or whether there is a significant component of slow, equilibrium porous flow on much longer timescales (>10^3-10^4 yrs). Radiogenic excess ^{226}Ra in MORB indicates that melt is transported from the melting region on time scales less than the half life of ^{226}Ra (~1600 yrs), and has been used to argue for fast melt transport from the base of the melting column. However, excess ^{226}Ra can be generated at the bottom of the melt column, during the onset of melting, and at the top of the melt column by reactive porous flow.
Determining the depth at which ^{226}Ra is generated is critical to interpreting the rate and mechanism of magma migration. A recent compilation of high quality U-series isotope data show that in many young basalts, ^{226}Ra excess in MORB is negatively correlated with ^{230}Th excess. The data suggest that ^{226}Ra excess is generated independently of ^{230}Th excess, and cannot be explained by ``dynamic'' or fractional melting, where observed radiogenic excesses are all generated at the base of the melt column. One explanation is that the negative correlation of activity ratios is a result of mixing of slow moving melt that has travelled through reactive, low-porosity pathways and relatively fast moving melt that has been transported in unreactive high-porosity channels. We investigate this possibility by calculating U-series disequilibria in a melting column in which high-porosity, unreactive channels form within a low-porosity matrix that is undergoing melting. The results show that the negative correlation of ^{226}Ra and ^{230}Th excesses observed in MORB can be produced if ~60 % of the total melt flux travels through the low-porosity matrix. This melt maintains ^{226}Ra excesses via chromatographic fractionation of Ra and Th during equilibrium transport. Melt that travels through the unreactive, high-porosity channels is not able to maintain significant ^{226}Ra excesses because Ra and Th are not fractionated from each other during transport and the transport time for melt in the channels to reach the top of the melt column is longer than the time scale for ^{226}Ra excesses to decay. Mixing of melt from the high porosity channels with melt from the low-porosity matrix at the top of the melting column can produce a negative correlation of ^{226}Ra and ^{230}Th excesses with the slope and magnitude observed in MORB. This transport process can also account for other aspects of the geochemistry of MORB, such as correlations between La/Yb, $\alpha_{Sm/Nd}$, and Th/U and ^{226}Ra and ^{230}Th excess .