^{226}Ra deficits in OIB: a key to the rate of melt extraction in the mantle

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The slow rate of mantle upwelling that has has been inferred from ^{230}Th-^{231}Pa systematics in MORB and OIB contrasts with the fast rate of magma migration that have been recently inferred based on short-lived nuclides such as ^{210}Pb and ^{226}Ra. The mantle is inferred to ascent at rates ranging from 0.01 to 10 m.yr^{-1}, approximately and these figures can be used to constrain the rate of melt production, if the system is assumed to operate continuously and at steady-state. Subsequently, these melts are inferred to be delivered to the surface at velocities that are faster than 4,000 m.yr^{-1}.

Yet, the models that are used to explain these observations are based on equilibrium partitioning that requires long time scales. For example, in order to have diffusive equilibration between a clinopyroxene crystal (0.1 mm) and a melt, the timescale is approximately 3000 yr. Thus, there must be a decoupling between the melt production and melt extraction. If we are to explain U-series by equilibrium partitioning, then the melt must reside in the melting zone over significant timescales before it is extracted.

We have reexamined this question with new ^{238}U-^{230}Th-^{226}Ra data from the fresh alkali basalts Pitcairn seamounts that were collected by submersible during the Polynaut cruise. These samples show ^{230}Th excess (10 to 40%) and surprisingly, ^{226}Ra deficits (up to 20%). These deficits may reflect melting with partial equilibration in the presence of a phase for which the partition coefficients are such that $D_{Ra}>D_{Th}$ (phlogopite or amphibole). This data is examined in the context of a model that takes into account diffusive equilibration as well as the rate of melt extraction. The presence of a ^{226}Ra deficit suggests that the rate of melt extraction was sufficiently slow to produce a deficit but not too fast because in that case, the greater Ra diffusivity compared with Th would produce a Ra excess. These observations thus provide new constraints on the rate of melt production and extraction.