

The influence of source heterogeneity on OIB melting, evidence from U-Th-Pa systematics of Sao Miguel, Azores

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Despite the potential power of U-series analyses for investigating melting processes, the interpretation of U-series disequilibria remains in some dispute. In order to improve our understanding of the variations in disequilibria we conducted an investigation on the scale of a single island, to place global variations in a better context. Previously interest has focused on ^{238}U - ^{230}Th disequilibrium, but simultaneous measurement of ^{235}U - ^{231}Pa disequilibrium should provide stronger constraints on the melting process. ^{231}Pa has a shorter half life (32ka) relative to ^{230}Th (75 ka), but both share a common parent, and the ^{235}U - ^{231}Pa pair should be more sensitive to changes in the dynamics of melting.

We have analysed a suite of young (< 6500a) samples from Sao Miguel, Azores, for U-Th-Pa isotopes together with a range of other geochemical tracers. Basalts from Sao Miguel show some very intriguing geochemical features, notably an unusually large range in $^{87}\text{Sr}/^{86}\text{Sr}$ isotope ratios, suggesting significant source heterogeneity. Of particular interest is how disequilibrium in the lavas varies with this striking geochemical signature, and the implications this has for the cause of elevated $^{87}\text{Sr}/^{86}\text{Sr}$ ratios.

Samples from this study have $^{87}\text{Sr}/^{86}\text{Sr}$ ratios of 0.7034 up to 0.7054, covering almost the whole range previously observed for the island (White *et al.*, 1979; Hawkesworth *et al.*, 1979; Turner *et al.*, 1997; Widom *et al.*, 1997). This is one of the largest ranges of $^{87}\text{Sr}/^{86}\text{Sr}$ found within lavas from a single island. The Azores are located on very young oceanic crust, which minimises the chance of shallow level crustal or lithospheric contamination. Moreover in order to increase the Sr isotope ratios from 0.7032 to 0.7055 by crustal contamination in these alkali lavas, with high Sr contents, requires large amounts of sediment addition, which would be evident in the major element compositions (see also Hawkesworth *et al.*, 1979).

The 'enrichment' in $^{87}\text{Sr}/^{86}\text{Sr}$, and associated incompatible element ratios, is thus attributed to mixing of different components of the Azores plume. ^{230}Th excesses for the lava suite range from 15 to 19% but do not correlate with enrichment. Furthermore, the ^{231}Pa excesses show no systematic variations with increasing $^{87}\text{Sr}/^{86}\text{Sr}$. Previously Widom *et al.*, 1997 reported some low $^{87}\text{Sr}/^{86}\text{Sr}$ samples with greater degrees of disequilibrium than we observe, that are similar to lavas from other islands of the archipelago (Turner 1997). We do not have any such samples in our current dataset, but as stressed above our study does cover almost the complete range of $^{87}\text{Sr}/^{86}\text{Sr}$ 0.7032–0.7054 (White *et al.*, 1979; Hawkesworth *et al.*, 1979; Turner *et al.*, 1997; Widom *et al.*, 1997). Thus our work relates to the effects on disequilibrium of sources with increasing $^{87}\text{Sr}/^{86}\text{Sr}$ rather than variations within the low $^{87}\text{Sr}/^{86}\text{Sr}$ samples.

The two Sao Miguel source components must have been very similar in source mineralogy. Variations in mineralogy are likely to affect bulk partition coefficients, melting rates and even dihedral angle and thereby porosity, which should all have an effect on the degree of disequilibrium. It seems highly unlikely that any combination of these processes can have equal and opposite effects on both U-Th and U-Pa systems. Thus, the absence of variations of either ^{231}Pa or ^{230}Th excesses with increasing $^{87}\text{Sr}/^{86}\text{Sr}$ implies pre-melt enrichment of parts of the Sao Miguel source with a small degree melt. This melt has a cryptic metasomatic effect that does not influence the melting behaviour, and is perhaps most plausibly attributed to a melt derived from recycled sediment. Addition of a very small amount of such a melt could strongly influence the incompatible elements without significantly changing the source mineralogy.

It is interesting to note that Lundstrom *et al.* (1995) have argued that beneath mid-oceanic ridges, source

heterogeneity has a significant effect on U-series nuclide behaviour. This suggests that the enrichment process associated with elevated $^{87}\text{Sr}/^{86}\text{Sr}$ in the Azores plume is very different to those acting on the upper mantle.

References

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