Coupling of radiogenic isotopes and ^{238}U-^{230}Th-^{226}Ra radioactive disequilibria in Historical volcanics from the Azores

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In this study, we present precise ^{238}U-^{230}Th-^{226}Ra radioactive disequilibrium data measured by Thermal Ionisation Mass Spectrometry (TIMS), together with a Sr-Pb isotopic and trace element study for a serie of well-dated, historical volcanics from the Azores Archipelago. Previous works have documented the large geochemical and isotopic diversity within the Azores, interpreted both in term of heterogeneities within the mantle and interactions between the plume activity and the nearby Mid Atlantic Ridge (1-3). Our purpose is therefore to shed some light on the nature and timing of magma genesis related to this complex volcanic region by coupling isotopic and trace element data with the U-series systematics. The combination of both radiogenic isotopes and U-series indeed provides a very useful approach since the former deals directly with sources compositions while the latter focusses on recent trace element fractionation within the mantle. In addition, on a shorter time scale (8 ka), ^{226}Ra-^{230}Th disequilibria can be used to constrain the rate of magma ascent as well as the time for magma storage and differentiation .

Results

The ($^{230}Th/^{232}Th$) activity ratios span a range (from 0.897 in Sao Miguel to 1.382 in Terceira) that is almost as large as the global variation. The ($^{230}Th/^{238}U$) activity as well as Th/U ratios also display important variations (10–40% and 2.92–3.74 respectively). Faial and Pico compositions are intermediate between the two extreme and similar to the nearby Mid-Atlantic Ridge tholeiites (4). Nevertheless they display more radiogenic Sr and Pb isotopic ratios than the tholeiites. In Pico island, the ^{226}Ra excesses reach 60% and decrease during differentiation, which corresponds to approximatively 2500 yr. In addition, the comparative evolution between ($^{226}Ra/^{230}Th$), (^{226}Ra)/Ba and Ba/Th ratios reveals that, during differentiation, Ra and Ba fractionate from Th (with $D_{Ra} << D_{Ba}$). In Terceira and Sao Miguel volcanics, the ($^{226}Ra/^{230}Th$) activity ratio is lower than unity (0.970 $\pm$ 0.007 and 0.841 $\pm$ 0.01, respectively). The Faial sample displays an intermediate value (1.392 $\pm$ 0.02).

Discussion

Th isotopes as well as ^{238}U-^{230}Th disequilibria, vary conjointly with Sr and Pb isotopes and Th/U, Nb/Th and Ba/TiO_2 ratios which documents the occurrence of two distinct signatures in the Azores plume, represented by Terceira (T) and Sao Miguel (S) endmember compositions. The T composition is characterised by high ($^{230}Th/^{232}Th$) and ($^{230}Th/^{238}U$) activity, but low $^{87}Sr/^{86}Sr$ and $^{208*}Pb/^{206*}Pb$ ratios which suggests recycling of crustal material. In contrast, having the opposite properties, S volcanics appears to result from melting of fluid-bearing recycled sediments that completely overwhelm the T-endmember locally. Pico and Faial compositions reflect the interaction between the Azores plume and the depleted upper mantle beneath the Azores Plateau, i.e, the reservoir of the the local MAR tholeiites.

With the exception of Sao Miguel, ($^{230}Th/^{238}U$) and ($^{226}Ra/^{230}Th$) activity ratios show a negative correlation. The coherent variation between U-Th and Ra-Th and source heterogeneities, as indicated by trace element and radiogenic isotopes, hence probably reflects the influence of source enrichment on the production of U-series disequilibria within the plume (5). Similarly, in Sao Miguel, the possibility that the presence of fluid and sediments is responsible for inverse Ra-Th fractionation during melting is examined.

References

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